Promotion of Eucalyptus Hybrid Species as Utility Poles for Electricity Transmission: The Mechanical Strength Properties of *Eucalyptus urograndis* Grown in Ghana

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Abstract

Electricity transmission is vital for the supply and distribution of energy for both domestic households and industrial usage. The most common wood species used as poles for electricity transmission in Ghana are Teak and Pines, which are unable to meet the demand for rural electrification programmes. Eucalyptus plantations have been set up in Ghana and are readily available. The suitability of the eucalyptus trees as an alternative to Teak and Pines for electricity transmission was assessed in this study. Five trees of four-year old eucalyptus hybrid species (*Eucalyptus urophylla + Eucalyptus grandis = Eucalyptus urograndis*) were used for the study. The bending strength (Modulus of rupture, MOR and Modulus of elasticity, MOE) and Density were determined according to British Standard BS 373. Results were analyzed using Origin statistical software. The eucalyptus hybrid species recorded mean MOE and MOR values of 11,980 N/mm^2 and 89 N/mm^2 respectively. Sectional (longitudinal) comparison for all the trees investigated suggests uniform distribution of the strength properties along the height of the poles of Eucalyptus species. Strength properties (MOE and MOR) of Eucalyptus hybrid species from MIRO plantations in Ghana compares well with other eucalyptus species from other countries. Eucalyptus trees are therefore recommended for use as transmission poles in Ghana.

Introduction

- Species mostly used to augment the use of Teak as transmission poles for electrification over the years are Afina, Kusia, Pines and Kusibri (Ofori et al. 2008).
- Volume of species used in electrification have reduced drastically posing challenges to the industry and the nation at large.
- As substitute, Eucalyptus known for their fast growing, high density and bending strength properties becomes a viable option. Eucalyptus species are being used as transmission poles in other countries and in Africa in the east and southern parts.
- The density and bending strength properties of eucalyptus ranges from 470 kg/m^3 to 980 kg/m^3 and 10500 N/mm^2 to 18220 N/mm^2 respectively (Loulidi et al. 2012, Doran and Wongkaew 2008, Santos et al. 2004).
- MIRO Forestry Limited has planted over 5000 hectares of Eucalyptus species in Ghana. The species planted by MIRO include *E. pellita, E. urophylla, E. grandis, E. camaldulensis and E. urograndis (hybrid of urophylla and grandis)*
- The objective of the study was to determine the mechanical strength properties (MOE and MOR) of the hybrid species and assess their suitability for use as transmission poles to augment Teak and other species for the industry

Materials and Methods

- Five trees were extracted from the MIRO plantations in Agogo, Ashanti region of Ghana and were coded G1, H10, K1, W2, and Z16, transported to CSIR-FORIG, Kumasi for processing and laboratory tests. Each tree was sectioned into Butt (B), Middle (M) and Top (T) with 20 specimens each
- Samples were prepared according to BS 373 standard for testing small clear specimens
- The samples were conditioned in a climate chamber at a temperature of 20^{o}C and a relative humidity of 65%.
- Test were conducted using a Universal Testing Machine (Instron, model no. 4482)
- Test results were extracted into Microsoft excel format and were analysed using Origin Lab software version 9.0
- The Fibre stress was determined by the use of adjustment factors as adopted in ANSI 05.1 standard 1997.

Fig. 1. Sample preparation at the Laboratory

Fig. 2. Samples cut into specified dimensions

Fig 3. Samples being conditioned in the climate chamber

Fig. 4. Bending test setup

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Results

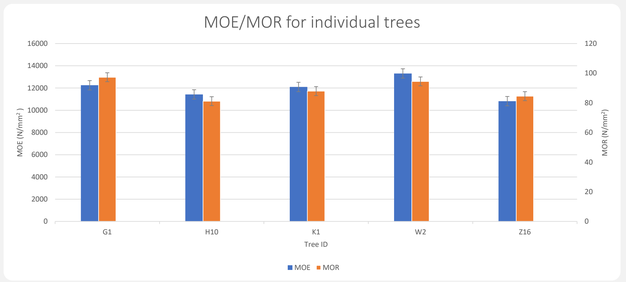

Fig. 5. MOE/MOR at Moisture Content of 14% determined for individual trees

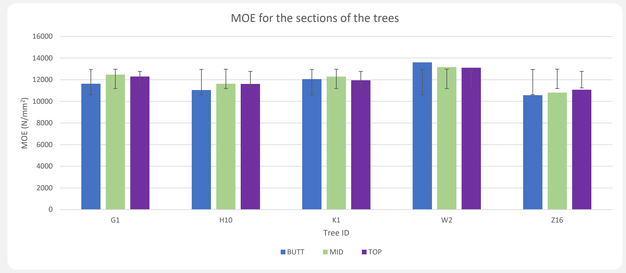

Fig. 6. MOE/MOR at Moisture Content of 14% determined for sections of the trees

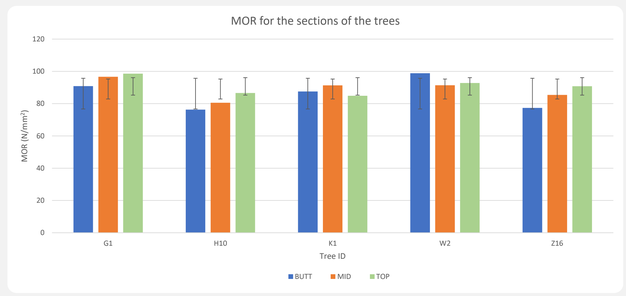

Fig. 7. MOE/MOR at Moisture Content of 14% determined for sections of the trees

Table 1. Comparison of Eucalyptus hybrid (MIRO) to other Eucalyptus species

Species		Age (years)	MOE (Nmm^{-2})	MOR (Nmm^{-2})	M.C. %	Year
Eucalyptus hybrid	Ghana (MIRO)	4	11980	89.15	12	2018
Eucalyptus umbra	Brazil	28	14310	84.10	12	Marta et al, 2018
Eucalyptus grandis	Uganda		8207	33.90	12	Zziwa et al, 2010
Eucalyptus marginata	Asia	u	13000	111.70	12	David et al, 1999
Eucalyptus hybrids clones	Argentina	9	15491-19947	89-116	12	Acosta et al, 2003
Eucalyptus genotypes	Argentina	13-17	13924-24015	97-143	12	Acosta et al, 2003

Discussions

- Results of MOE ranged from 10818 N/mm^2 to 13310 N/mm^2 with a mean MOE of 11980 N/mm^2 for all the trees. Results of MOR ranged from 81.15 N/mm^2 to 97.28 N/mm^2 with a mean MOR of 89.07N/mm^2 . The values obtained for the 4-year-old *Eucalyptus hybrid* were higher than values of *Eucalyptus grandis* and competes well with some other species from Brazil, Asia and Argentina (Table 1).
- One-Way ANOVA conducted indicated that the MOE and MOR values obtained were not significantly different along the tree height (i.e. Butt, Middle, Top) for all the 5 trees. Thus longitudinal variations in results of the trees were not significant at $p<0.05$.
- Adjustments were made to the 'characteristic' MOR to take into consideration, the change from small clear bending strength to full-size pole strength, change in moisture content due to drying of in-service poles, and pre-treatment conditioning effects, which led to a designated fibre stress value of 78.84 N/mm^2.

Conclusions

- The longitudinal comparison of the individual trees suggests uniform distribution of strength (MOE/MOR) along the tree height from Bottom to the Top.
- Sectional (longitudinal comparison) for all the 5 trees equally suggests uniform distribution of the species of Eucalyptus extracted from MIRO plantations.
- Inter tree comparison, however, suggests significant differences among their mean difference.
- The strength properties of plantation-grown Eucalyptus species coupled with the estimated fibre stress render it suitable for use as poles for electric support lines

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