Physical and Mechanical Properties of Small Diameter Logs (SDL)
Utilization of SDL from Sustainable Source of Bio-Composite Products.
(Terminal Report)

INTRODUCTION

A knowledge of the basic physical and mechanical properties of wood is of major importance in promoting the use of would be substitute for commercial or traditionally used timbers which are now in depletion. Information on these properties would facilitate their utilization as structural materials, substitute species for specific end-use, and for possible new wood application.

The more important physical properties of timber are moisture content (MC), relative density and shrinkage. Of equal importance are its mechanical properties such as static bending, compression parallel and perpendicular to grain, shear parallel to grain, hardness and toughness.

To date, information on the physical and mechanical properties of some fast growing plantation species in the Philippines like the Eucalyptus citriodora, E. europhylla and *Alstonia macrophylla* G. Don are still lacking. Since this is an introduced species in the Philippines, it is only imperative to study yheir physical and mechanical properties to enhance its most efficient utilization specifically for bio-composite products.

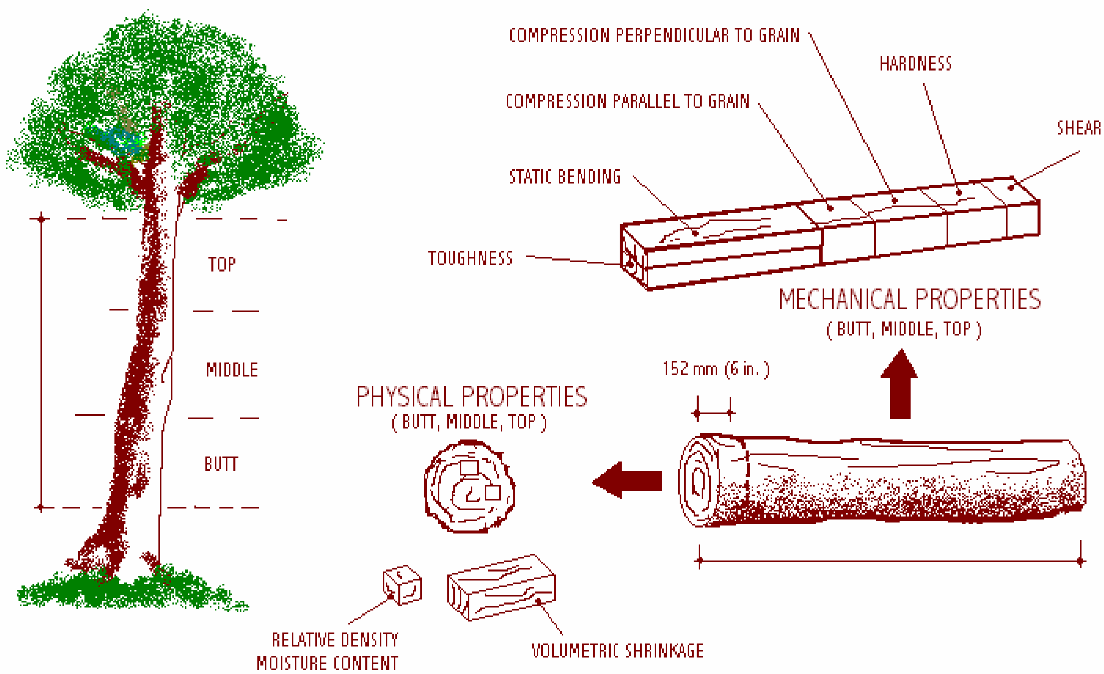
The project aimed to: 1. determine the physical properties viz; relative density, moisture content and shrinkage characteristics; 2. evaluate the mechanical properties viz; static bending, compression parallel and perpendicular to grain, shear, hardness and toughness; and 3. determine the potential of the species for bio-composites.

METHODOLOGY

The ASTM and the FPRDI Random Sampling Method in the preparation of samples for physical and mechanical properties were used. All tests followed the procedure specified in the ASTM D 143-52 (1998).

From each tree, three bolts 3 m long were taken starting from the ground level of merchantable height. Disc 152 mm (6”) thick was cut from the end portion of each bolt where the physical properties specimens from pith to bark were taken. The remaining portion of the bolt were sawn and reprocessed for mechanical properties evaluation (Fig. 1).

The data were computed and statistically analyzed using a Simple Complete Randomized Design (CRD).



Physical and Mechanical Properties	Dimensions (mm) T x W x L
Moisture Content (MC) and Relative Density (RD)	25 x 25 x 25
Volumetric Shrinkage (VS)	25 x 25 x 100
Static Bending (SB)	25 x 25 x 400
Compression Parallel to Grain (C //)	25 x 25 x 100
Compression Perpendicular to Grain (C ⊥)	50 x 50 x 150
Shear (S)	50 x 50 x 60
Hardness (H)	50 x 50 x 150
Toughness (To)	20 x 20 x 280

Fig. 1. Sampling scheme used in the study.

RESULTS AND DISCUSSION

Eucalyptus citriodora

The mean MC of the species ranged from 58.42 - 65.35% while relative density from 0.740 – 0.770. The MC and RD trend was inverse, relative density increased as MC decreased (Figs. 2 & 3). On the other hand, the ranges of strength properties were as follows: MOR, 85.27 – 92.72 MPa; SPL, 34.09 – 43.13 MPa; MOE, 12.72 – 13.77 GPa; MCS, C//, 38.51 – 44.80 MPa; SPL, C/, 4.08 -7.72; Shear, 9.37 -9.69 MPa; Hardness Side, 7.41 – 8.34; Hardness End, 7.41 – 8.34; Toughness Radial , 41.29 – 41.40 and Toughness Tangential, 39.40 – 42.36 Joule/specimen.

Based on FPRDI classification (1980), the species exhibited high RD (Class I, 0.700 above) while strength properties from moderately high (Class II) to High (Class I). The trend of strength properties variations along the height level was not consistent, either increasing from butt to mid and slightly decreasing toward the top (MOR, MOE, MCS and Hardness Side), slightly decreasing from butt to mid and increasing toward the top (SPL, SB; SPL, C/; and Shear), or increasing form butt to top (Hardness End) (Figs. 4 – 9).

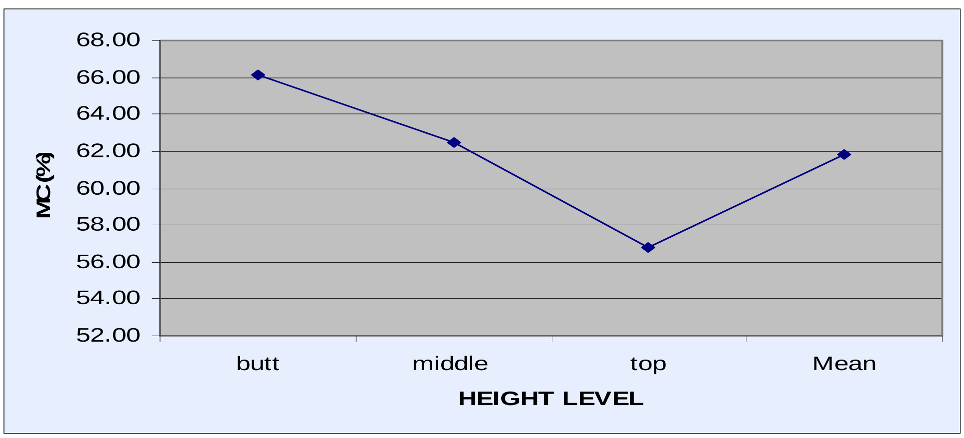


Fig.2. Moisture Content (MC, %) of *E. citriodora* at different height levels.

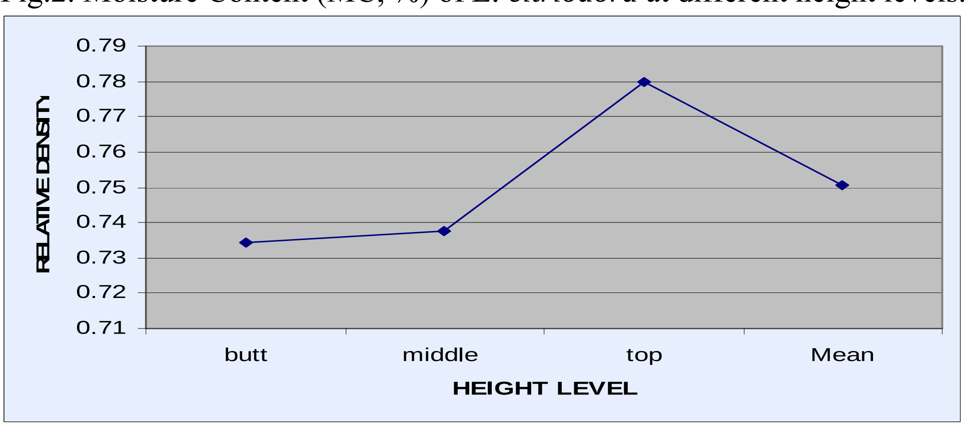


Fig.3. Relative Density of *E. citriodora* at different height levels.

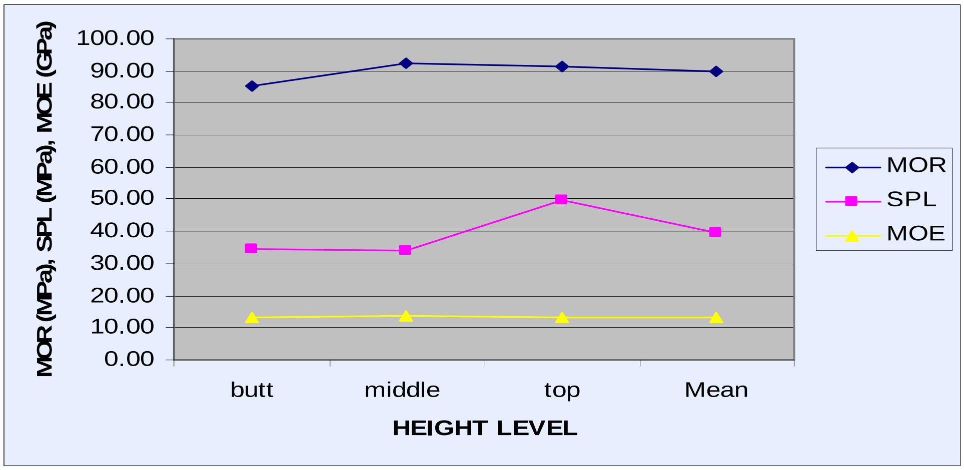


Fig. 4. Static Bending Properties (MOR, SPL, MOE) of *E. citriodora* at different height levels.

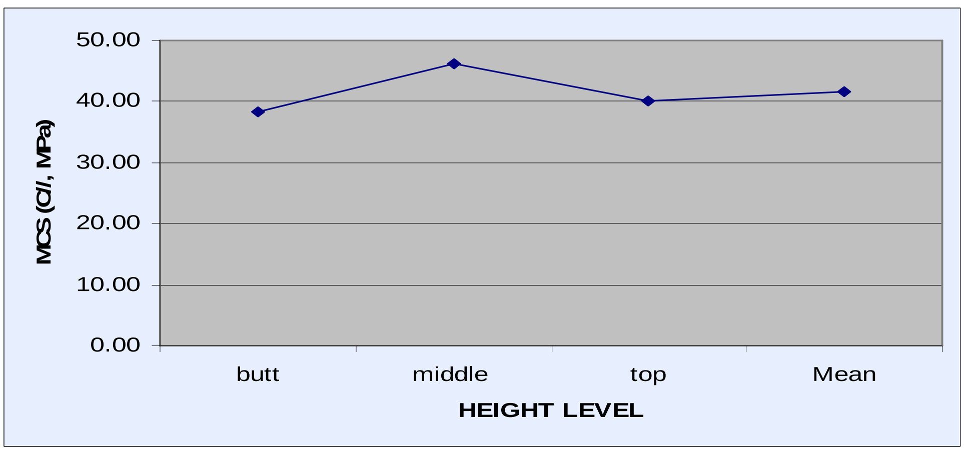


Fig. 5. Maximum Crushing Strength in Compression Parallel-to-Grain (MCS, C//) of *E. citriodora* at different height levels.

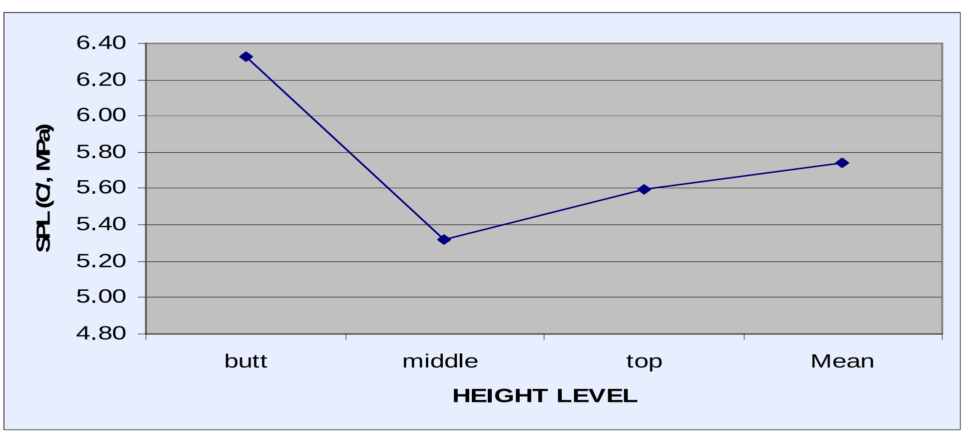


Fig. 6. Stress at Proportional Limit in Compression Perpendicular-to-Grain (SPL, C/) of *E. citriodora* at different height levels.

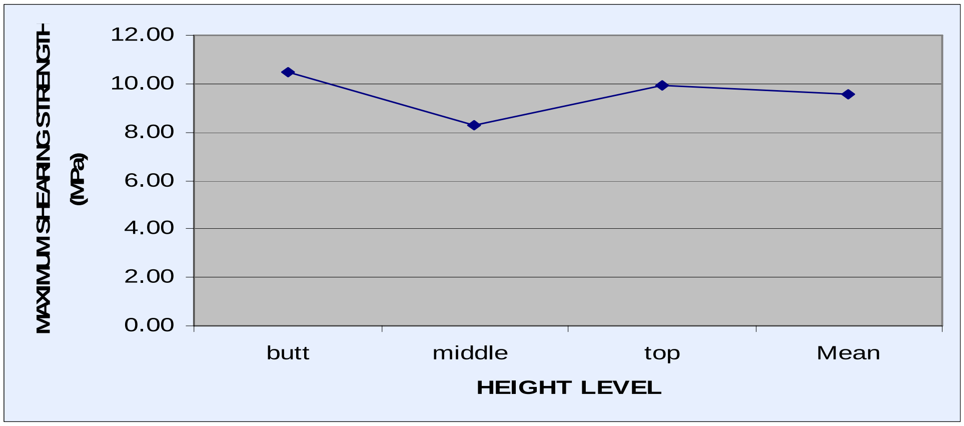


Fig. 7. Maximum Shearing Strength of *E. citriodora* at different height levels.

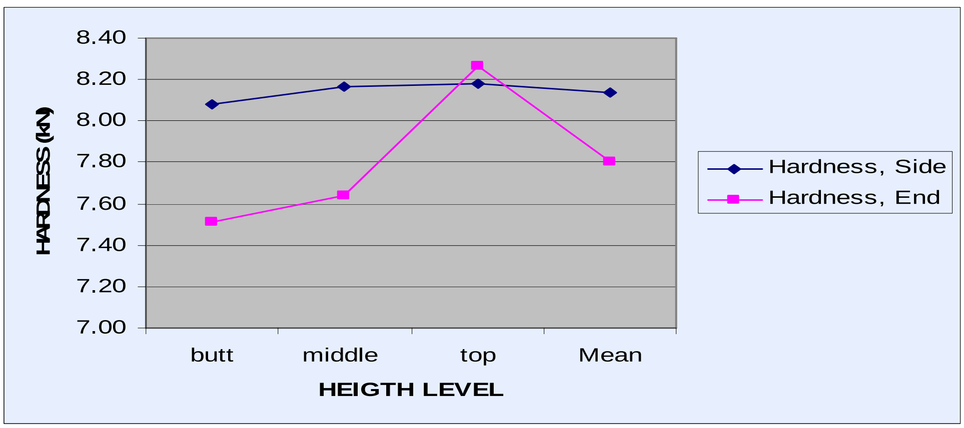


Fig. 8. Hardness of *E. citriodora* at different height levels.

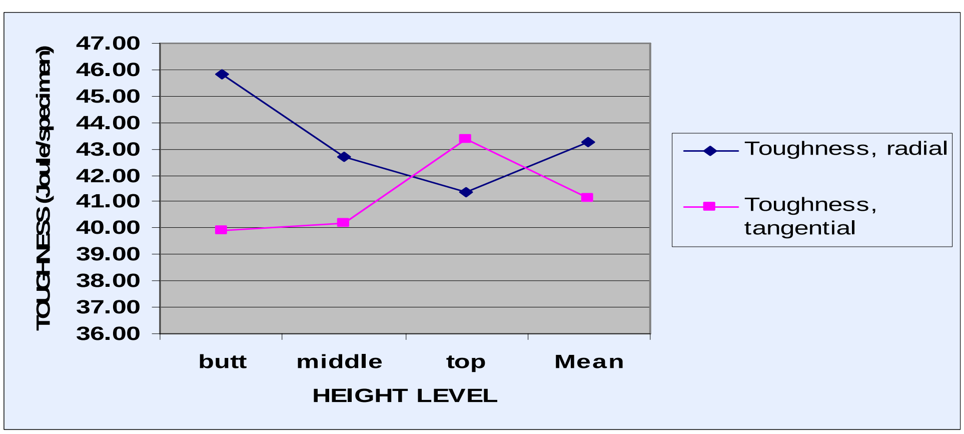


Fig. 9. Toughness of *E. citriodora* at different height levels.

Eucalyptus europhylla

The mean MC of the species ranged from 71.05 – 78.19 % while relative density from 0.663 – 0.713. The MC and RD trend was inverse, relative density increased as MC decreased (Figs. 10 & 11). On the other hand, the ranges of strength properties were as follows: MOR, 76.47 – 78.76 MPa; SPL, 27.17 – 39.23 MPa; MOE, 11.04 – 13.25 GPa; MCS, C//, 32.50 – 40.29 MPa; SPL, C/, 6.42 – 8.50; Shear, 7.88 – 10.71 MPa; Hardness Side, 6.03 – 6.69; Hardness End, 6.42 – 6.77; Toughness Radial , 34.37 – 53.38 and Toughness Tangential, 41.99 – 57.75 Joule/specimen.

Based on FPRDI classification (1980), the species exhibited Moderately High RD (Class II,) while strength properties from Moderately High (Class II) to High (ClassI). The trend of strength properties variations along the height level was increasing from butt to top except in the following: MOE and C/, decreasing from butt to mid and increasing toward the top (highest) and Toughness, increasing from butt to mid (highest) and decreasing toward the top (Figs.10 – 17).

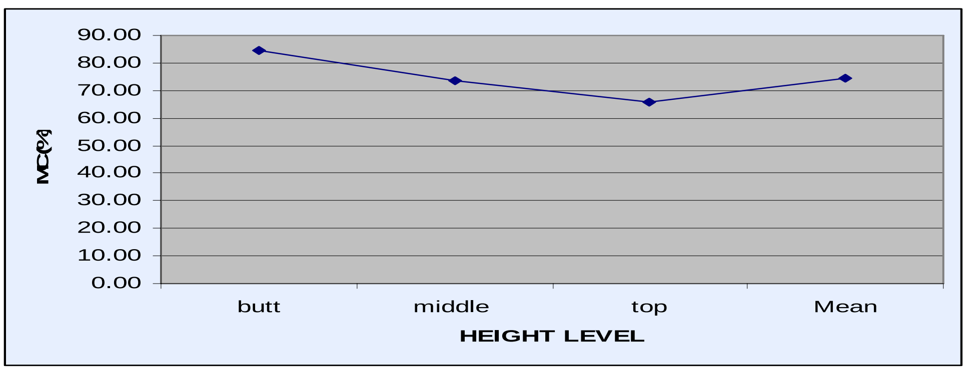


Fig. 10. Moisture Content (MC, %) of *E. urophylla* at different height levels.

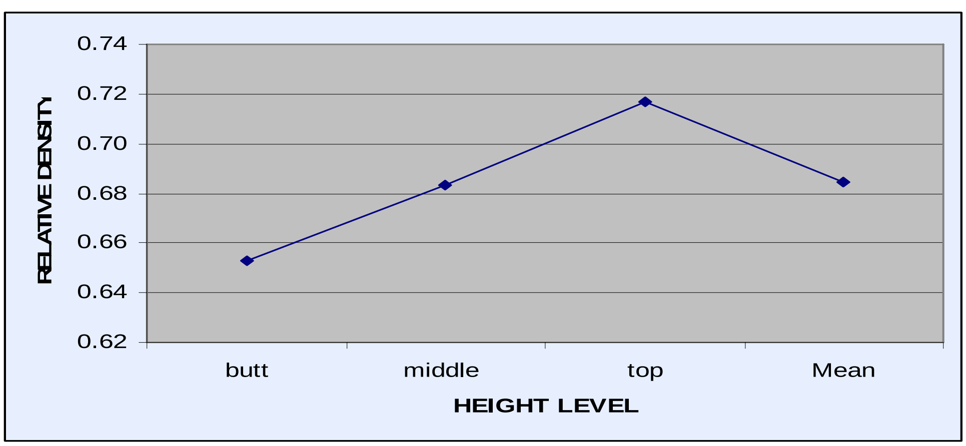


Fig. 11. Relative Density of *E. urophylla* at different height levels.

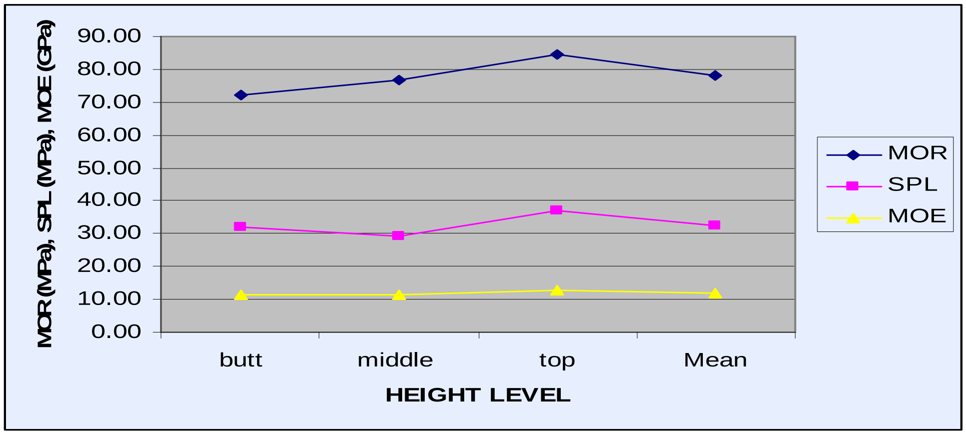


Fig. 12. Static Bending Properties (MOR, SPL, MOE) of *E. urophylla* at different height levels.

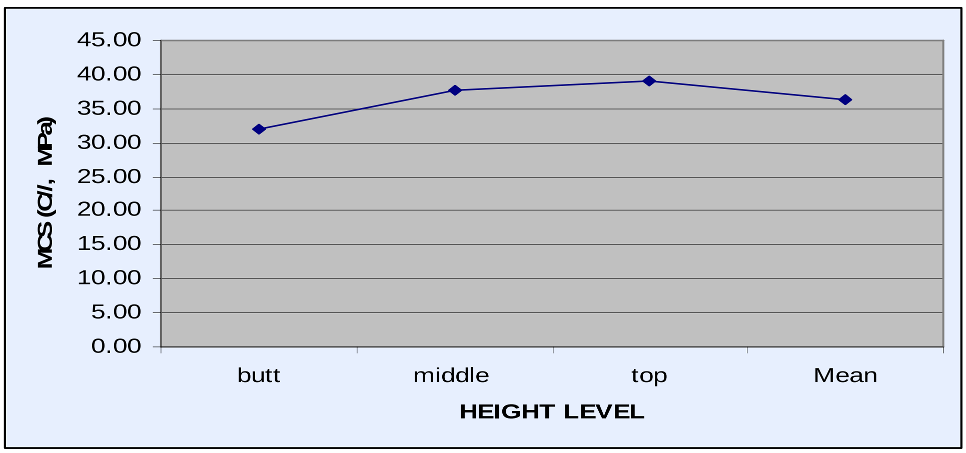


Fig. 13. Maximum Crushing Strength in Compression Parallel-to-Grain(MCS, C//) of *E. urophylla* at different height levels.

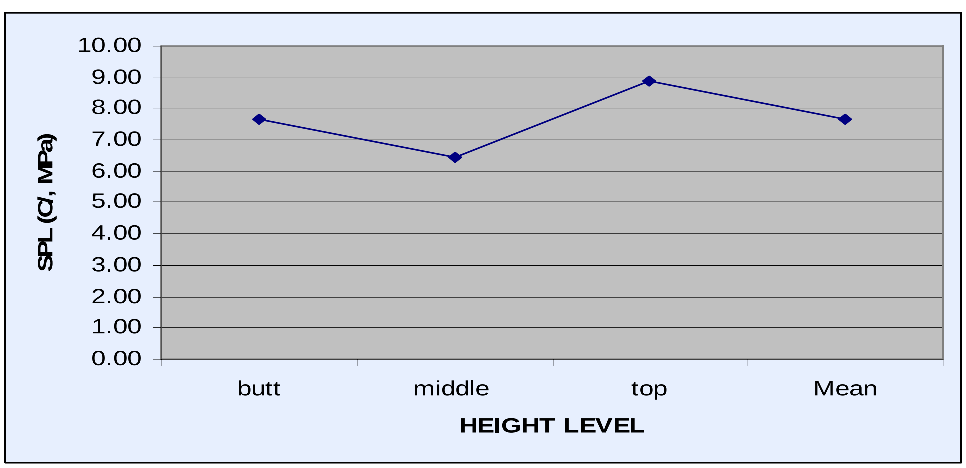


Fig. 14. Stress at Proportional Limit in Compression Perpendicular-to-Grain (SPL, C/) of *E. urophylla* at different height levels.

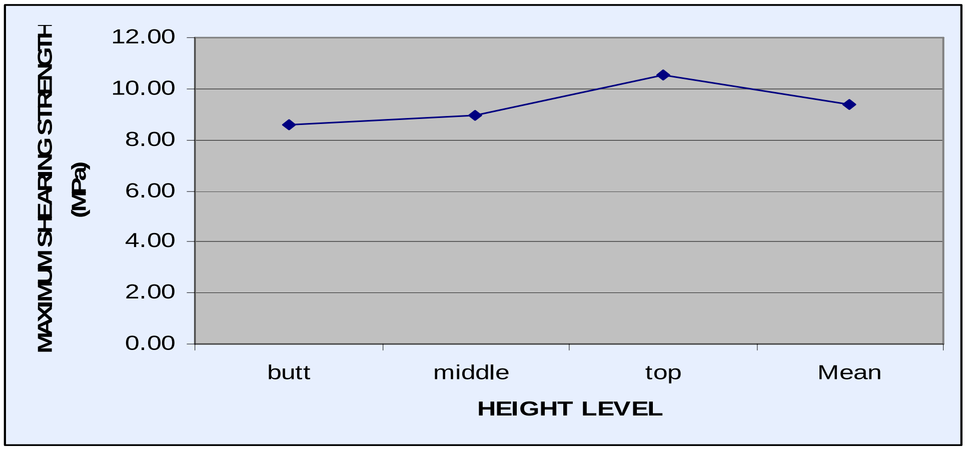


Fig. 15. Maximum Shearing Strength of *E. urophylla* at different height levels.

Fig. 16. Hardness of *E. urophylla* at different height levels.

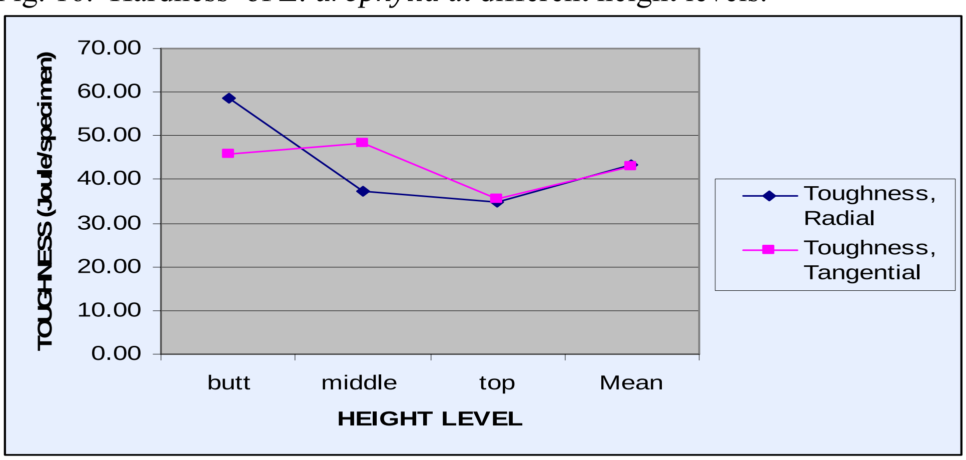


Fig. 17. Toughness of *E. urophylla* at different height levels.

Alstonia macrophylla G. Don

The mean MC of the species ranged from 99.84 – 105.35% while relative density from 0.551 – 0.560. The MC and RD trend was inverse, relative density increased as MC decreased (Figs. 9 & 10). On the other hand, the ranges of strength properties were as follows: MOR, 55.31 – 75.86 MPa; SPL, 22.12 – 26.18 MPa; MOE, 9.29 – 10.08 GPa; MCS, C//, 27.08 – 29.43 MPa; SPL, C/, 5.43 – 5.81; Shear, 8.11 – 8.93 MPa; Hardness Side, 3.90 – 4.30 kN; Hardness End, 4.49 – 5.06 kN; Toughness Radial , 40.13 – 45.50 and Toughness Tangential, 40.70 – 45.47 Joule/specimen.

Based on FPRDI classification (1980), the species exhibited Medium RD (Class III) while the strength properties from Medium (Class III) to Moderately High (Class II).
The trend of strength properties variations along the height level was not consistent, either decreasing from butt to top (MOR and Hardness), decreasing from butt (highest) to mid (lowest) and slightly increasing toward the top (SPL), decreasing from butt to mid (lowest) and increasing toward the top (highest) (MOE), increasing from butt to mid (highest) and decreasing toward the top (lowest) (C// and Toughness Tangential), increasing from butt (lowest) to mid (highest) and decreasing toward the top (slightly higher than the butt) (C/ and Shear) and decreasing from butt to top (Toughness Radial) (Figs 18 – 25).

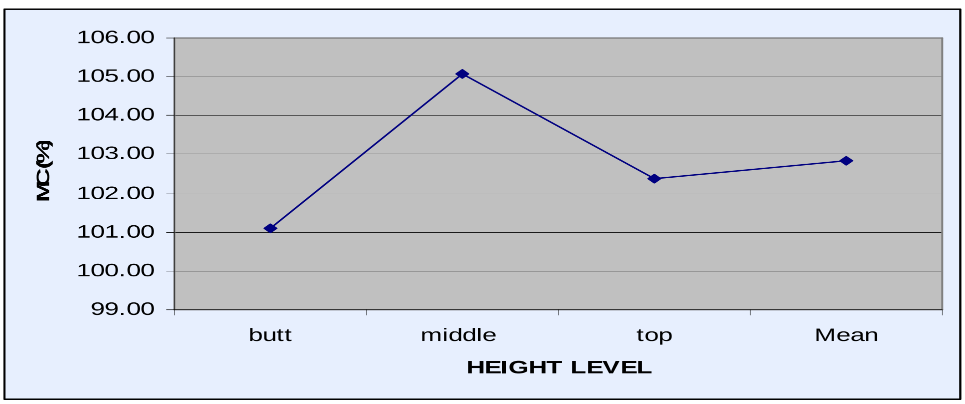


Fig. 18. Moisture Content (MC, %) of *A. macrophylla* (at different height levels).

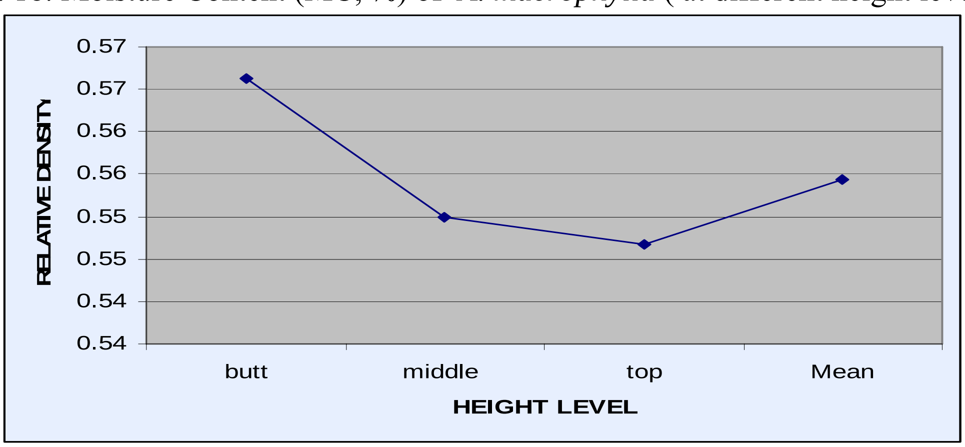


Fig. 19. Relative Density of *A. macrophylla* at different height levels.

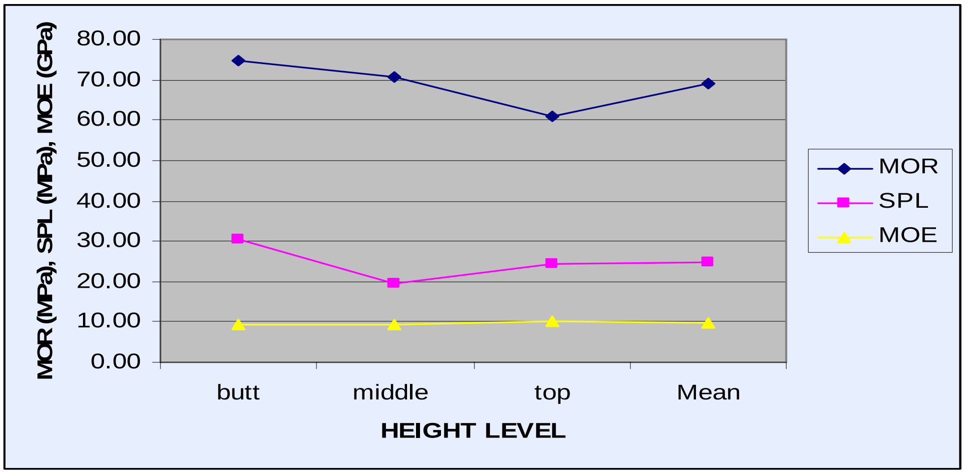


Fig. 20. Static Bending Properties (MOR, SPL, MOE) of *A. macrophylla* at different height levels.

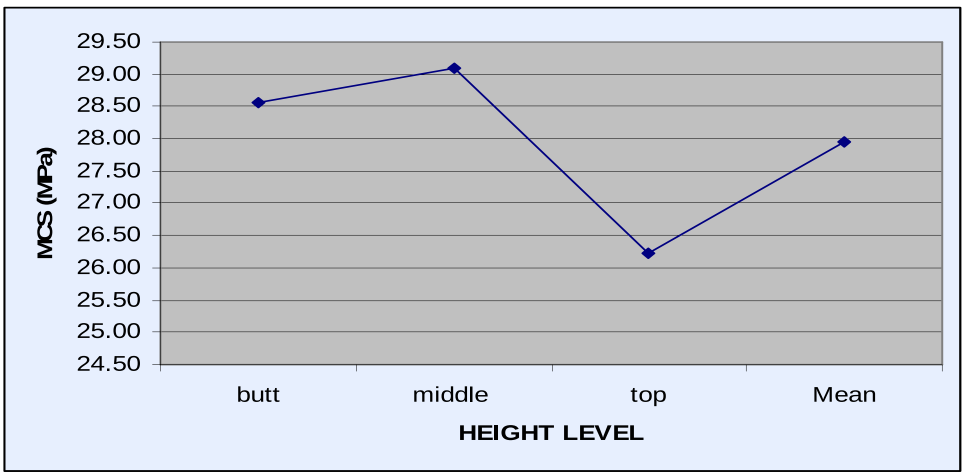


Fig. 21. Maximum Crushing Strength in Compression Parallel-to-Grain (MCS, C//) of *A. macrophylla* at different height levels.

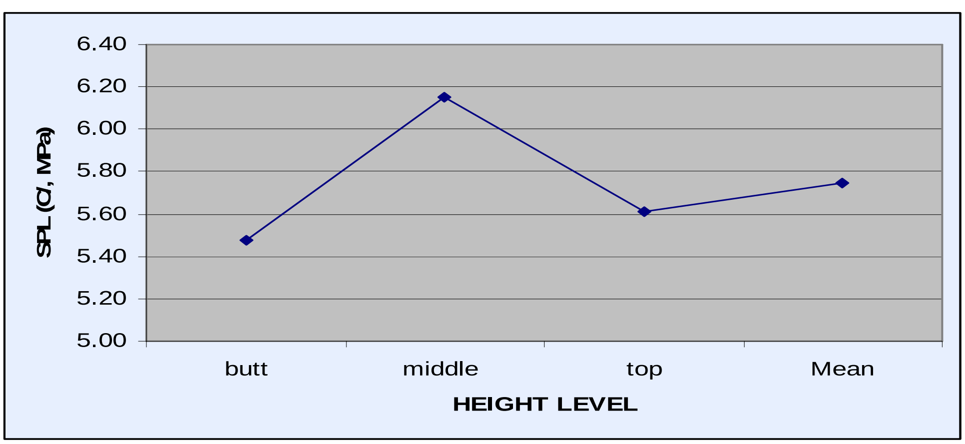


Fig. 22. Stress at Proportional Limit in Compression Perpendicular-to-Grain (SPL, C/) of *A. macrophylla* at different height levels.

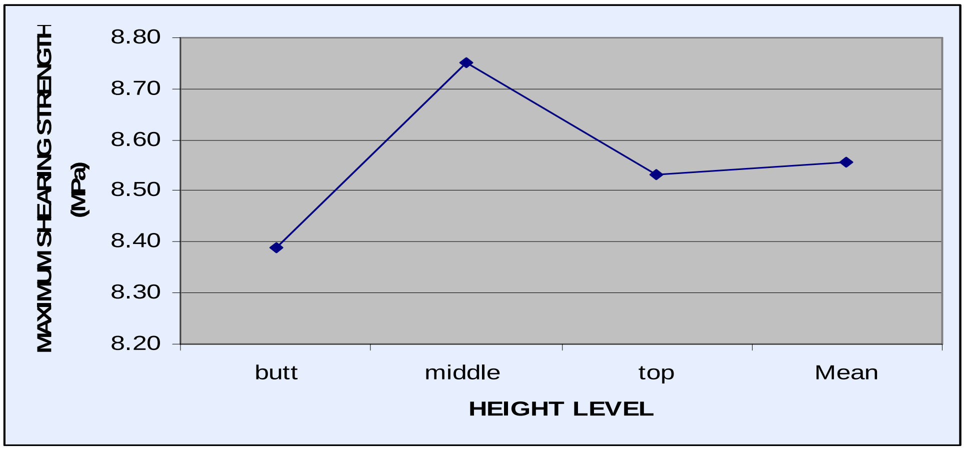


Fig. 23. Maximum Shearing Strength of *A. macrophylla* at different height levels.

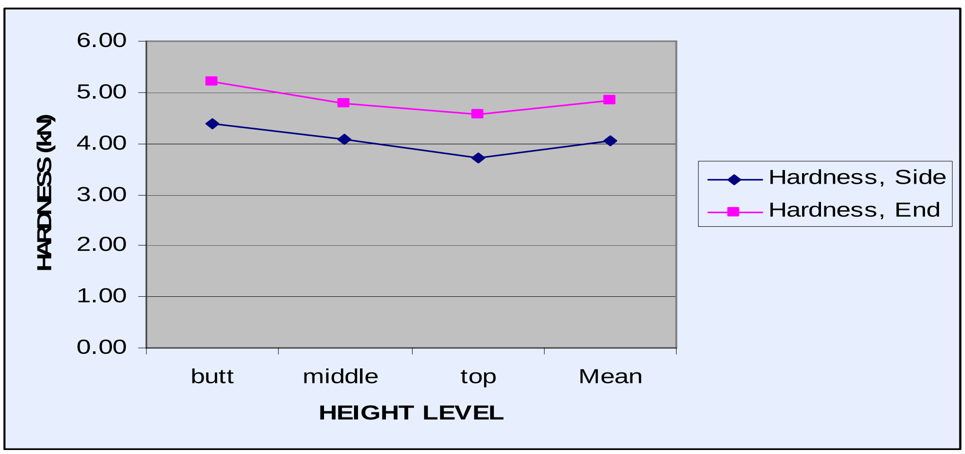


Fig. 24. Hardness of *A. macrophylla* at different height levels.

Fig. 25. Toughness of *A. macrophylla* at different height levels.

Between species, *E. citriodora* generally exhibited the highest strength properties except in C/and Toughness (Tangential), lower than *E. urophylla.* Although the ranges of strength properties of *E. citriodora* and *E. urophylla* both fall under Class I to II, the former had more properties falling under Class I than the latter. *A. macrophylla* had lower strength (Class II to III) than the former 2 species.

CONCLUSION AND RECOMMENDATION

E. citriodora and *E. urophylla* exhibited favorable strength properties for construction uses requiring high (Class I) to moderately high strength (Class II) while *A. macrophylla* for moderately high to medium strength (Class III*).*

Although the trend of properties variations along the height levels was generally not consistent, there was no change in properties classification along the height levels. Hence, any portion of the specie's tree trunk (stem) may be used for similar purposes requiring the possessed strength.

Due to favorable physical and mechanical properties of the species for high to medium construction purposes, the cost analysis for converting the wood species to lumber versus grinding into particles for composites is recommended.

LITERATURE CITED

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Forest Products Research and Industries Development Commission (FORPRIDECOM). 1980. Guidelines for the Improved Utilization and Marketing of Tropical Wood Species. FORPRIDECOM, NSDB, College, Laguna.

Rojo, J.P. 1999. Lexicon of Philippine Trees. Forest Products Research and Development Institute (FPRDI), College, Laguna, Philippines. p. 56.

Batino Alstonia macrophylla G. Don - A medium to large tree found in open primary and secondary forests and thickets at low and medium altitudes, Malay Peninsula, Borneo, New Guinea, Philippines(Northern Luzon to Palawan and Mindanao).