Effect of interlocked grain on wood mechanical behaviour in *Bagassa guianensis* in French Guiana.

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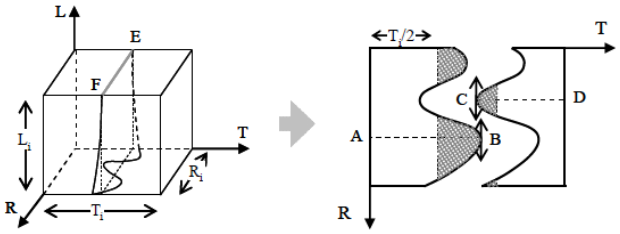
1 Introduction

Wood, as building material enabling tree growth, is optimised to answer conductive and mechanical needs of tree. It is therefore useful to understand the adaptive functions, for tree, of peculiar structures or organisations in wood, to use wood specificities more efficiently and create new optimised wood-based materials inspired by natural mechanisms. Wood properties are modulated during tree life at several levels, from macroscale, with respect to tissues organisation, to macromolecular scale, regarding cell-wall organisation and composition. During tree growth, specific mechanisms of cell arrangement can control wood fibres inclination [3]. Fibers grain angle from longitudinal axis can alternate from negative to positive values: it is named interlocked grain (IG). This property is shared by numerous species, especially in tropical forest but its function is poorly studied and consequences for mechanical property are sparsely described. The present study focuses on *Bagassa guianensis* Aubl. (Moraceae), a singular tree from French Guiana, referred as "paradoxical" as it combines fast growth, high quality wood and longevity. We wondered how can it possibly grow so fast and reach such large diameters without suffering wood quality and stability damages. Thus, the aim of this study is to understand the effect of IG on wood mechanical properties.

2 Material and methods

We sampled 11 *B. guianensis* trees in French Guiana and characterised changes in interlocked grain during tree life. IG was measured by visual assessment from pith to bark and described through geometric parameters on split wood pieces (Fig.1). On paired samples, we measured wood specific gravity, ratio between dry mass and saturated volume [4], Young modulus of elasticity using forced vibrations method [5] and microfibril angle (MFA) by X-ray diffraction. We evaluated IG's effect on wood tenacity measuring fracture toughness, on a sub-sampling covering a large range of IG.



$$MDA = \text{Atan}\left(\frac{AB-\frac{Ti}{2}}{2}\right) + \text{Atan}\left(\frac{CD-\frac{Ti}{2}}{Li}\right) \quad (1)$$

$$GI = \frac{\text{Grey Area}}{Ri} \quad (2)$$

Fig.1 Geometric parameters of split samples and interlocked grain indicators

3 Results

Results showed that wood specific gravity increases from pith to bark whereas MFA slightly decreases near the pith and then remains constant at a low value (around 10°) up to the bark. IG follows a sinusoidal pattern characterized by almost constant periods and increasing amplitudes from the pith outward (Fig.2).

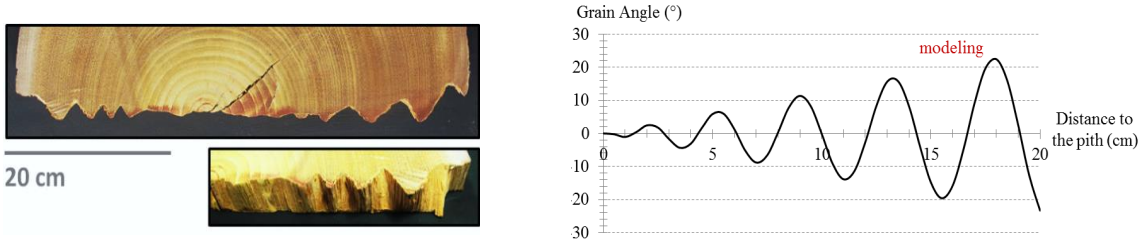


Fig. 2 Interlocked grain in *B. guianensis*. Sinusoidal model of grain angle variations characterized by period and amplitude increasing with the radial position (Xr).

At microscale, our results evidenced the strong impact of IG on elasticity modulus, negatively linked to fiber angle deviation. Both changes in specific gravity or MFA are not enough to compensate decrease in modulus of elasticity produced by IG. Reversely, at a larger scale, interlocked grain was positively related to wood tenacity, with a strong relationship between grain index and fracture energy. Therefore, one can hypothesized that *B. guianensis* tree is subjected to trade-off between wood modulus of elasticity and resistance to fracture.

3 Conclusion

Our findings on *B.guianensis* illustrate the potential gain of interlocked grain for fast growing trees subject to higher risks of cracks when getting larger. Considered as a flow for wood quality at microscale, this characteristic turned out to be an advantage at tree scale: its specific crossed fibers organization prevents cracks propagation from the pith that could occur during bending under external load, such as wind or lianas, when reaching canopy. The present study highlights the potential value of interlocked grain species, enabling both the handling of a lighter material and its use in structure material subject to failure risks. Interlocked grain is also suspected to improve flexibility. Some tests are under way to test this assumption.

References

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