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A COMPARATIVE STUDY ON THE CRACKING OF TROPICAL WOOD SPECIES BY THE GRID METHOD

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Abstract: The present study focuses on the cracking of tropical species of the Gabonese forest such as Milicia excelsa (Iroko) and Pterocarpus soyauxii (Padouk). The critical energy release rate is computed with a modified Mixed Mode Crack Growth (MMCG) specimen. An electromechanical testing machine and an Arcan fixture are used in order to apply the load in opening mode (mode I) to the specimen. The force-displacement curves, the crack growth process as well as the opening crack are deduced from images of the specimen taken during the tests. These images are processed by the grid method. The energy release rate is estimated by the compliance method. The results are given for the two wood species and two different specimen thicknesses. We conclude that the thickness has an influence on the energy release rate which is estimated.

1. Introduction

The Gabonese forest covers a significant part of the Congo Basin. It is the second largest forest in the world after Amazonia. However wooden structures made of species from this forest are scarce, mainly because the lack of knowledge on the mechanical behavior of the corresponding woods. The aim of the present work is to study the cracking behavior of tropical species, in particular the crack growth process in opening mode of the Iroko and of Padouk species using MMCG specimen [1]. Specimens are mounted in an Arcan system and placed in an electromechanical testing machine. A CCD camera records images during the test. These pictures are processed by the grid method [2]. This enables us to measure the crack width and length during the tests. The values of the energy release rate are then calculated.

2. Results

Wood specimens with dimensions (Lxhxb) 105x70x15 mm^3 were tested see Fig. 1 (a). The initial notch had a length equal to a_i = 22 mm. This notch was machined along the longitudinal direction (L) (see Fig. 1 (b)). A grid with a pitch of 200 µm was deposited on one face of the specimen see Fig. 1 (b). The values of the density of these woods are 0.64 and 0.79, for Iroko and Padouk, respectively. The room temperature (T) was 21 °C and the relative humidity (RH) 35%.

Four washers in galvanized steel of diameter 6 mm were used to reinforce the holes through which the load was applied, as shown if Fig. 1 (c). The lower and upper parts of the specimen were also reinforced by thin aluminum plates. The camera was placed 675 mm away from the specimen in order to record pictures. Displacement and strain fields were deduced from the images using the grid method. The MMCG specimen and the experimental device are presented in Fig. 1 (c).

The different stress-displacement curves show that the stress at failure of Padouk is twice greater then that of Iroko see Fig. 2 (a). The critical load of Padouk reaches almost F_{RP}=1400N,

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while that of Iroko is almost 50% lower, just under F_{RI}=600N. In the same way, a lower displacement at failure is obtained for Padouk ($0.4\ mm$) than for Iroko ($0.6mm$).

The compliance method in imposed displacement was used to calculate the critical energy release rate, see Equation 1 below:

$$G_c = \frac{F_C^2}{2 \cdot b} \cdot \left(\frac{\Delta C}{\Delta a}\right) \quad (1)$$

We observe in Fig. 2 (b) that the values obtained for Padouk are greater than those obtained for Iroko. Indeed, we have: $G_{C1} = 266J/m^2$ and $G_{C2} = 415J/m^2$ for Padouk. For Iroko we have $G_{C1} = 192J/m^2$ and $G_{C2} = 265J/m^2$. The first and second values relate respectively to thickness 1 and thickness 2. Designated by Padouk 1, Padouk 2 and Iroko 1 and Iroko 2. The compliance method in imposed displacement was used to calculated the critical energy release rate, see Equation 1.

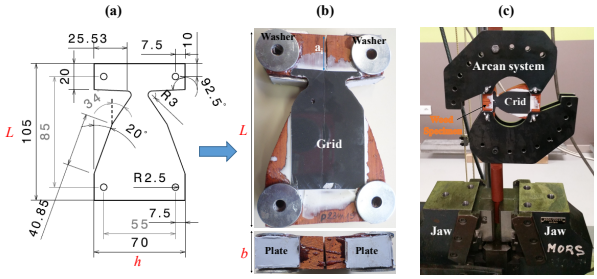


Figure 1. dimensions of specimen (a); side view of the notched specimen equiped with a grid (b), experimental device (c)

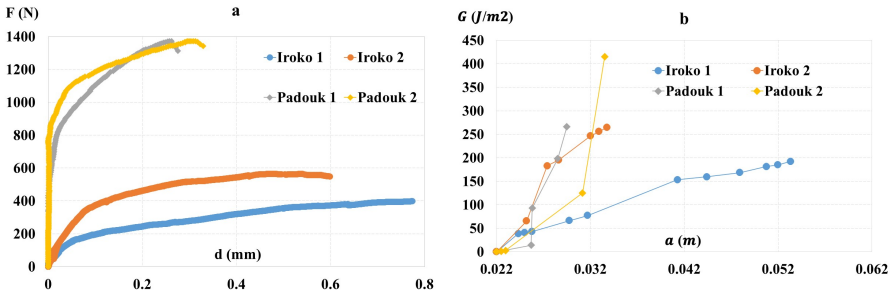


Figure 2. Force-displacement curves (a) and critical energy release rate- crack length curves (b). Padouk 1 and Iroko 1 specimens of thickness 15mm and Padouk 2 and Iroko 2 specimens of thickness 20mm.

3. Conclusions

In this work, tests were performed on Iroko and Padouk tropical species with MMCG specimens for various thicknesses and densities. The crack opening and the crack growth process were analyzed with the grid method. The energy release rates presented here show that the greater the wood density, the greater the critical energy rate at failure. The apparent energy release rate also increases proportionally to the thickness of the tested specimen.

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