MODE I FRACTURE OF TROPICAL SPECIES USING THE GRID METHOD IN CONSTANT ENVIRON- MENTS: EXPERIMENTAL RESULTS

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MODE I FRACTURE OF TROPICAL SPECIES USING THE GRID METHOD IN CONSTANT ENVIRONMENTS: EXPERIMENTAL RESULTS

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ABSTRACT

The aim of this work is to study cracking appearance and propagation in various tropical wood of Gabon, such as Iroko (Milicia excelsa), Okume (Aucoumea klaineana) and Padouk (Pterocarpus soyauxii). In this paper, only the results obtained with Padouk are presented. An experimental device composed of wood Mixed Mode Crack Growth (MMCG) specimen combining wood sample and steel Arcan system and a Zwick press, are described. Results present the force-displacement and the forces-crack opening curves. The crack growth is obtained with the images of grid recorded by the camera during the test. Tests performed in crack opening mode (I) plane RL direction of wood are posted. The critical energy release rate is obtained versus crack by the compliance method.

INTRODUCTION

Gabon's forest plays an important role in the regulation of global warming. Indeed, 85% of the area of this country is covered by forest. This contributes to the regulation of the climate changes. However, despite the importance of climate change and high rainfall, tropical woods are many used by locals. Their mechanical properties remain today still unknown and their use in timber structures is as negligible. The purpose of this study is to characterize the mechanical behavior of these species and guide local population in their choice of their building's material, which are usually concrete and steel. This work is focused on the crack growth process in opening mode of Padouk 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. Pictures are processed by the grid method [2]. They enable us to measure the opening and the length of crack during the tests.

MATERIAL AND METHODS

The wood specimens' with dimensions (Lxhxb) 105x70x15 mm^3 are tested, Fig. 1 (a). The initial crack, with length a_i = 20 mm is placed along the longitudinal direction (L) (see Fig. 1 (b)). On one face of the specimen, a grid of pitch 200 µm is deposited, see Fig. 1 (c). The density and the internal moisture content of the specimen are equal to 0.79 and 7.29 % respectively. The room temperature is 21° C and the relative humidity is about 35%.

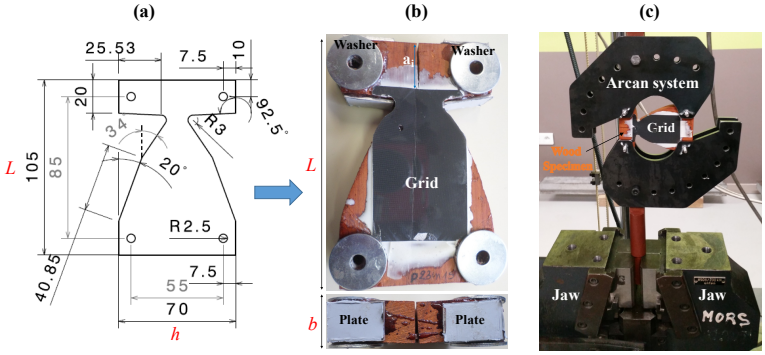

Figure 1: dimensions of specimen (a), Wood specimen (b); experimental device (c)

Four washers in galvanized steel of a diameter of 6 mm were used to reinforce the holes, through which the load was applied, as shown if Fig. 1 (b). The lower and upper parts of the specimen have also been reinforced by thin aluminum plates, Fig. 1 (b). The camera was placed at 675 mm of 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 on Fig. 1 (c).

RESULTS AND DISCUSSION

Typical results obtained with two specimens for Padouk (Specimen 1 and Specimen 2) are shown in Fig. 2. The displacements maps obtained with the grid method are present in Fig. 2 (a). In both tropical specimens, the cracks progress following the fiber orientation.

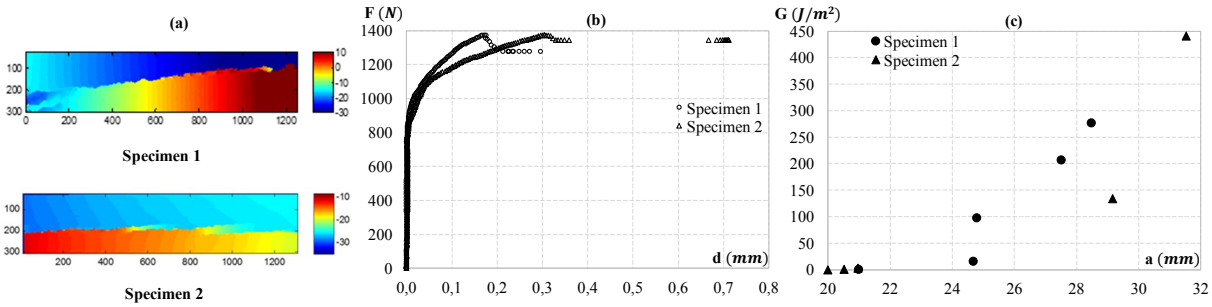

Figure 2: displacement maps (a), force-displacement curves (b), Critical energy release rate (c)

The force-displacement curves of two specimens are depicted in Fig. 2. It is worth noting that the maximum peak of the curve Padouk is reached when the strength at failure is F_{RP} = 1373 N for both specimens. However the corresponding displacement is d_P = 0.308 mm for Specimen 2 and d_P = 0.175 mm for Specimen 1. The total breaking of the specimen occurs quickly in the case of Specimen 1. This is a consequence of the heterogeneity of this species. According to the failure load, the thickness and the crack length, the critical energy release rate is computed with the compliance method with imposed displacement by the following equation:

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

We note that during the crack growth process, the critical energy release rate G_c increases until the total collapse of the specimen of both specimens, see Fig. 2 (c). For Specimen 2, the fracture toughness is significant compared with Specimen 1 (G_C = 445 J/m^2 compared to G_c = 140 J/m^2). The low value of G_c in Specimen 1 can be explained by the heterogeneities of Padouk such as the orientation of fiber, the presence of node and its important density. The type of observation is already reported by some authors [3] in the case of non-tropical species.

CONCLUSION

In this study, the crack growth process in opening mode of two tropical species of Padouk (Pterocarpus soyauxii) has been investigated with the grid method. The displacement maps, the force-displacement curves and the crack length are obtained. The results illustrate the heterogeneity and the strength of this specie. The evolutions of the critical energy release rate G_c have been calculated with the compliance method. We note that the fracture toughness is significant in Padouk due the high value of G_c despite the material heterogeneity. In forthcoming work, tests will be performed in mixed mode configuration for different moisture content rates in order to study the environmental impact of this parameter on the facture process of such tropical species.

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