



**HAL**  
open science

# FRACTURE OF WOOD UNDER THERMO-VISCO-HYDRO-MECHANICAL LOADINGS

Rostand Moutou Pitti, S E Hamdi, Frédéric Dubois

► **To cite this version:**

Rostand Moutou Pitti, S E Hamdi, Frédéric Dubois. FRACTURE OF WOOD UNDER THERMO-VISCO-HYDRO-MECHANICAL LOADINGS. 14th International Conference on Fracture (ICF 14) , Jun 2017, Rhodes, Greece. hal-01616969

**HAL Id: hal-01616969**

**<https://hal.science/hal-01616969>**

Submitted on 15 Oct 2017

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

## FRACTURE OF WOOD UNDER THERMO-VISCO-HYDRO-MECHANICAL LOADINGS

R. Moutou Pitti<sup>1,2,3</sup>, S.E. Hamdi<sup>1,2</sup>, F. Dubois

<sup>1</sup> *Université Clermont Auvergne, Université Blaise Pascal, Institut Pascal, BP 10448, F-63000 Clermont Ferrand, France*

<sup>2</sup> *CNRS, UMR 6602, Institut Pascal, F-63171, Aubière, France*

<sup>3</sup> *CENAREST, IRT, BP 14070, Libreville, Gabon*

**Abstract:** The identification crack initiation and crack growth process is very important in mechanical and civil engineering materials as wood in order to avoid the total collapse of structures. In consequence, the utilization of wood (Douglas Fir in this work) in external conditions more or less protected constitute an important outlet. However, in presence of climatic variations, the long terms loads and especially the crack initiations, the mechanical behaviour of these structures is found highly modified disturbing their implementation and shortening their life in service. In this specific case, it appears necessary to study these species submitted to extreme loadings conditions and crack growth process. However, the crack growth rate in wood-based structures is commonly expressed as a function of stress intensity factor  $K$  or energy release rate  $G$ . It is shown that for a stable crack propagation ( $G$  is a decreasing function of crack length), crack growth resistance is not constant, but changes with crack propagation. Temperature ( $T$ ) and moisture content appears to be responsible for the changes, and leads to the formation of the so-called process zone [1] with time dependent effects. For an unstable crack growth, the effect of the process zone even more dramatic [2]. The aim of this paper is to investigate the effect of  $T$  and  $MC$  changes on wood fracture properties, focusing on crack driving forces, such as viscoelastic energy release rate during the humidification process.

### 1. Results and analysis

Mixed-mode crack growth analysis coupling mechanical and thermal loads in orthotropic MMCG (Mixed Mode Crack Growth) wood-based specimen is conducted through an incremental finite element approach [3]. The main goal of this specimen is to provide the stability of crack growth by giving the decrease of the energy release rate during the process. This fact induces simultaneously the possibility to separate the fracture process and viscoelastic effect in order to know more precisely the impact of time-dependent in the durability and the collapse of wood material.

The effect of Thermo-Visco-Hydro-Mechanical (TVHM) loading coupling with viscoelastic effect is shown in wood material for all mixed mode configurations. In this case, Fig. 1 illustrates the impact of  $T$  effects on the viscoelastic  $Gv$  in opening (a) and shear (b) modes for different moisture content rate under the fiber point saturation. This result confirms also the efficiency of the model to show the sensitivity of  $MC$  when the  $T$  increases significantly. The evolutions of  $Gv$  vs. crack length for various  $MC$  rates are presented in Fig. 2. We note that the sensitivity of  $Gv$  is more important in the case of mode II; also,  $Gv$  increases when  $MC$  increases as confirmed by some experimental results posted in the literature [4].

---

<sup>1</sup> Corresponding author

E-mail address: [Rostand.moutou\\_pitti@univ-bpclermont.fr](mailto:Rostand.moutou_pitti@univ-bpclermont.fr) (R. Moutou Pitti)

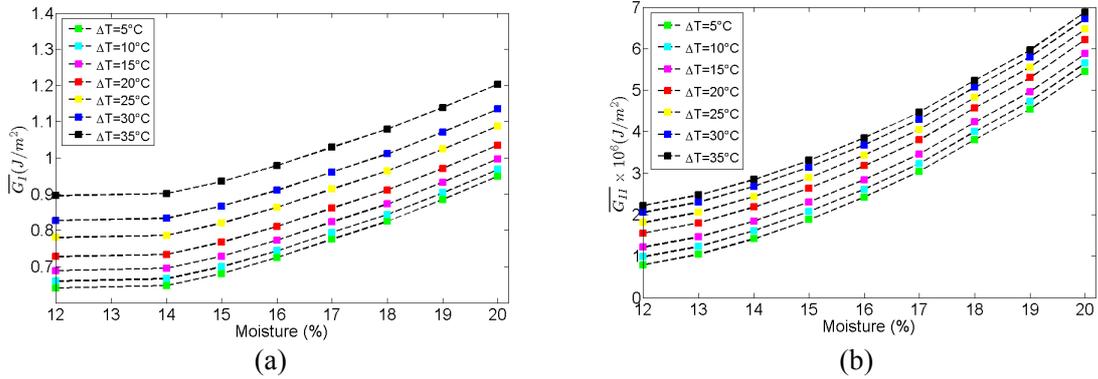


Figure 1. Effect of temperature variation ( $\Delta T$ ) on energy release rate ( $G_v$ ) in mixed mode configuration for various moisture content: Opening mode part (a), Shear mode part (b).

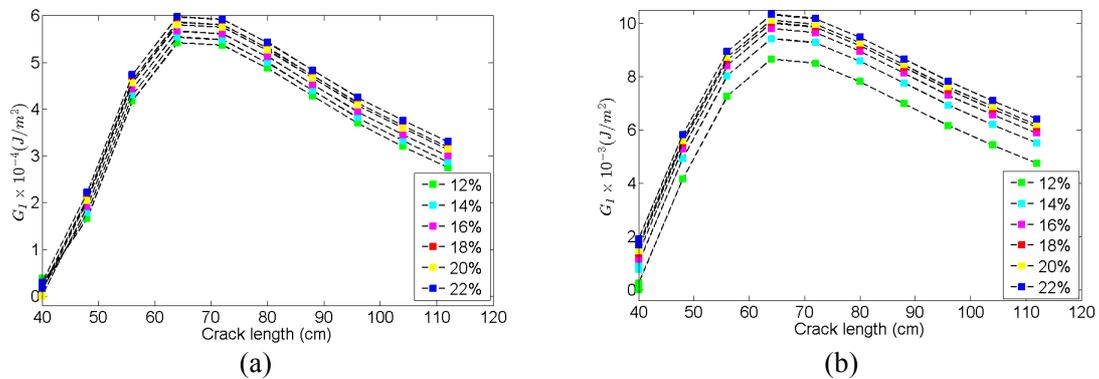


Figure 2. Effect of moisture content (MC) variation on energy release rate ( $G_V$ ) vs. crack length during heating process:  $\Delta T = 10^\circ\text{C}$  (a),  $\Delta T = 30^\circ\text{C}$  (b).

### 3. Conclusions

In the coming works, the Griffith criteria will be introduced in order to perform automatic crack growth process by using critical time and dichotomy method. Also, the impact of drying process will be introduced in order to take into account the mécanosorptive effects. At the end, the numerical results will be compared to experimental data in order to validate the THVM routine.

### Acknowledgements

The authors wish to strongly acknowledge the National Agency of Research (ANR) for its financial support of this work through the project CLIMBOIS N° ANR-13-JS09-0003-01 labeled by ViaMeca.

### References

- [1] Riahi H., Moutou Pitti, R., Dubois, F., Chateauneuf A. Mixed-mode fracture analysis combining mechanical, thermal and hydrological effects in an isotropic and orthotropic material by means of invariant integrals. *Theor. Applied Fract. Mech.*, 2016; 85:424-434
- [2] Hamdi, S., Moutou Pitti, R., Dubois, F. Impact of Hydro-Mechanical Loadings On Rupture Process In Wood Material, *Springer International Publishing*, 2016; 2:127-137
- [3] Moutou Pitti, R., Dubois, F., Petit, C. Generalization of T and A integrals to time-dependent materials: analytical formulations. *Int. J. Fract.*. 2010; 161:187-198.
- [4] Phan N.A. Morel S., Chaplain M. Mixed-mode fracture in a quasi-brittle material: R-curve and fracture criterion – Application to wood. *Engineering Fracture Mechanics*. 2016; 156:96-113.