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COUPLED MECHANICS – PROBABILISTIC METHODOLOGY FOR RELIABILITY ASSESSMENT OF TIMBER STRUCTURE WITH CRACKS SUBJECTED TO THERMO-VISCO-HYDROMECHANICAL

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Abstract: This study is carried out within the framework of the ANR JCJC CLIMBOIS project which aims is to assess the reliability of timber structures with cracks subjected to thermo-visco-hydro-mechanical (TVHM) from experimental data. The principle is to use coupled mechanics-probabilistic approach to generate database for constructing a Bayesian Network (BN) representing for structural performance. An experiment on a beam Douglas wood exposed to external environment was developed to obtain real data about the variation of temperature and deflections of the beam. These data are introduced into BN for updating structural reliability. The results showed that this methodology is useful for reliability assessment of structures from experimental data.

1. Introduction

In timber structure, cracking initiation is frequently recognized as a main cause leading to structural failure [1]. Especially, mechanical behaviors of timber are affected by environmental conditions: moisture, temperature, ... These hydrothermal conditions could produce higher risk of crack growth in timber structures [2]. The fracture studies in timber structure therefore should take into accounts these conditions. In numerical modeling, the crack initiation and crack propagation is studied in terms of computing energy release rates [3]. A limit state representing the collapse event of timber structures could be defined from the energy rate. However, in real practice it is difficult to obtain these parameters. The objective of this research is to propose a methodology for reliability assessment of timber structures from experimental data by coupling mechanics-probabilistic models. Data from these couplings is then used to construct a Bayesian Network (BN) representing for structural performance and reliability of structures could be updated by introducing information from experimental data.

2. Results

In mechanical stage, a Finite Element Method (FEM) model on Cast3m is constructed for modeling a timber beam with cracking subjected to TVHM. In this model, the invariant integral A (including a temperature variation) are generalized to crack propagation in orthotropic media by using the MMCG (Mixed Mode Crack Growth) specimen which ensures the stability of the propagation path during the process in mode I, mode II or mixed mode. The modified Gtheta procedure (field independence), VDF (Virtual displacement field), the integral A (integral TVHM) are implemented in the codes Cast3m by means of a suitable algorithms. In probabilistic stage, a number of simulations are performed and in each simulation, a vector of random variables representing for a set of input parameters is generated for processing the FEM model. The output from each FEM processing is the displacement and the restitution energy of the beam. The input and output data from coupled mechanics-probabilistic are used to construct the Bayesian Network (BN) representing for structural performance. Structural reliability of the beam therefore could be updated by introducing measurements data into BN as evidences

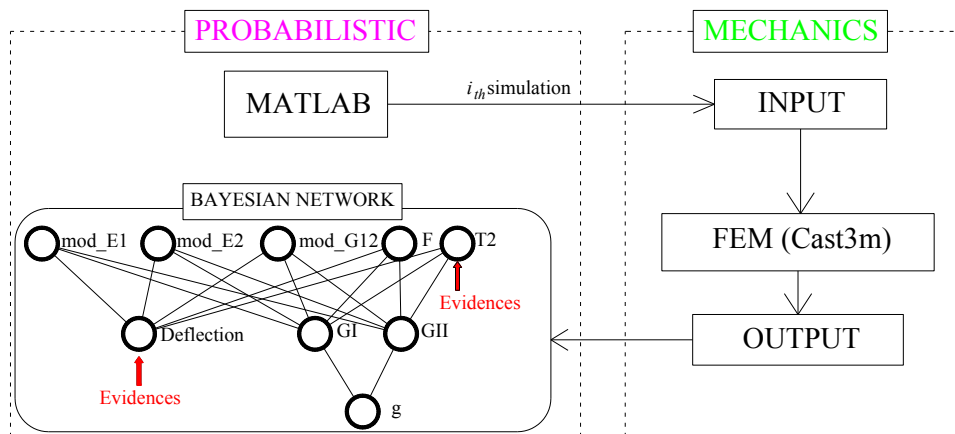


Figure 1. Coupled mechanics-probabilistic methodology for reliability assessment

Real data from experiments (temperatures and deflections) (Figure 2a) are introduced into BN as evidences for updating the probability of failure. Results from BN updating presented in Figure 2b reveals that the increasing in temperature and deflection will increase significantly the failure risk of the timber structures subjected to crack.

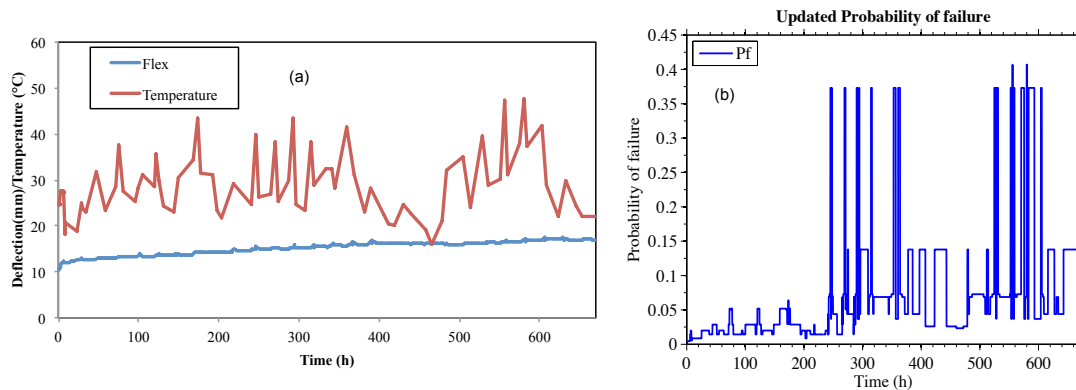


Figure 2. (a) The measurements of temperature and deflection; (b) The updated probability of failure.

3. Conclusions

In timber structures subjected to cracking, the variations of temperature and deflections have important influences on its serviceability and safety. This research proposed a coupled mechanics-probabilistic methodology with BN to facilitate the representation of structural performance. The obtained results showed that this approach is useful for reliability assessment of timber structure from experimental data.

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