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Updating the Reliability of cracked timber structures by using experimental results and numerical fracture model

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Introduction

In timber structure, cracking initiation is frequently recognized as a main cause leading to structural failure (Riahi et al 2016). Especially, mechanical behaviors of timber are affected by environmental conditions: moisture, temperature, etc. These hydrothermal conditions could produce a higher risk of crack growth in timber structures (Dubois et al 2009). The fracture studies in timber structure therefore should take into accounts these conditions. In numerical modelling, the crack initiation and crack propagation are studied in terms of computing energy release rates (Moutou Pitti et al 2010). 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.

This study aims to propose a methodology for assessing and updating the reliability of timber structures with cracks from experimental data and by coupling probabilistic approach and numerical fracture models. The proposed approach is based on updating of prior information by newly obtained measurements which is conducted by a Bayesian approach. The principle is to use coupled mechanical-probabilistic approach to generate a 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.

Results

In the 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. In the 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 energy release of the beam. The input and the output data from the numerical model are used to construct the Bayesian Network (BN). Structural reliability assessment is updated by introducing measurement data into BN as evidences. Real data from experiments (temperatures and deflections) (Figure 1a) are introduced into BN as evidences for updating the probability of failure. Results from BN updating presented in Figure 1b reveals that the increasing in temperature and deflection will increase significantly the failure risk of the timber structures subjected to crack.

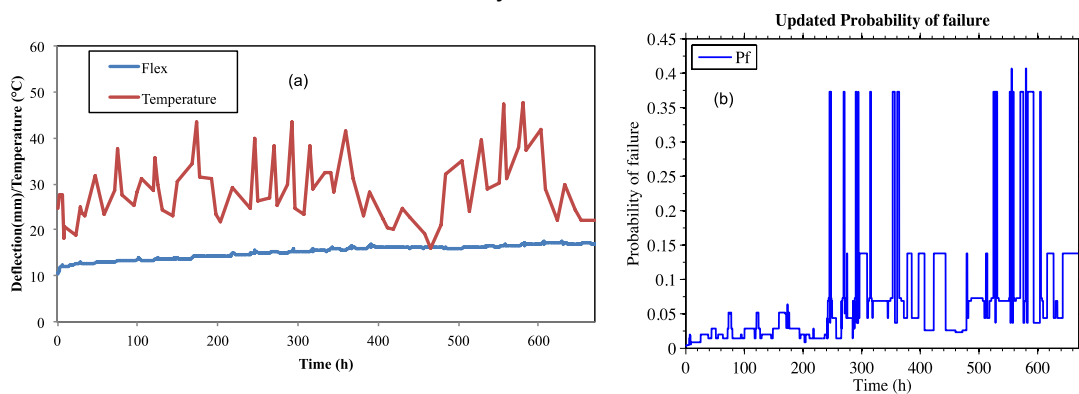


Figure 1. (a) The measurements of temperature and deflection; (b) The updated probability of failure.

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 mechanical-probabilistic approach with Bayesian Network (BN) to facilitate the representation of the structural performances. The obtained results showed that this approach is useful for assessing and updating the reliability of timber structure from experimental data.

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