Numerical simulation of full-culm bamboo structural member connections

Theodora Mouka[†*] and Elias G. Dimitrakopoulos[†]

[†]Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, moukath@gmail.com, ilias@ust.hk

Bamboo is an inexpensive, functionally graded material, that in many cases possesses a strength-to-weight ratio comparable to that of steel [1]. In addition to that, as a grass species, it is essentially fast-growing and environmentally friendly. These remarkable characteristics suggest that it can potentially be a very advantageous alternative to conventional construction materials, which is also showcased by recent developments in architecture [2], [3]. One main issue that needs to be overcome in order to facilitate a more widespread use of bamboo is the lack of reliable bamboo structural member connections. Herein we examine the failure modes of a bolted bamboo-to-steel connection that allows the utilization of more than one culms [4]. To that end, a detailed finite element model of such a connection is developed, that simulates all the pertinent joint components (gusset plate, steel bolts, bamboo culm) (Figure 1). The model incorporates failure laws for both materials. The failure law for bamboo specifically is calibrated using experimental data. Particular emphasis is given on capturing crack initiation and propagation using the eXtended Finite Element Method (XFEM, Figure 2) [5]. The orthotropic nature of the material and the high deformations that take place due to its relatively low Young's modulus are also taken into account. The analysis results are compared with pertinent experimental results and the model is calibrated accordingly until an acceptable error margin is achieved. The final outcome is a reliable, experimentally calibrated FEM model, that can be used to predict how the examined connection system is going to fail and, subsequently, be implemented to further improve its efficiency.

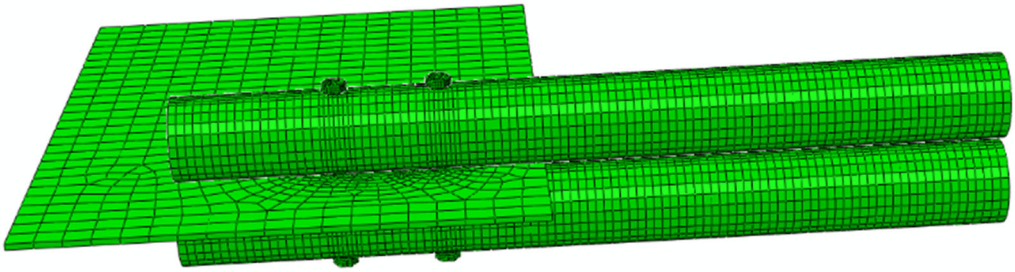

Figure 1: Two-culm member connection

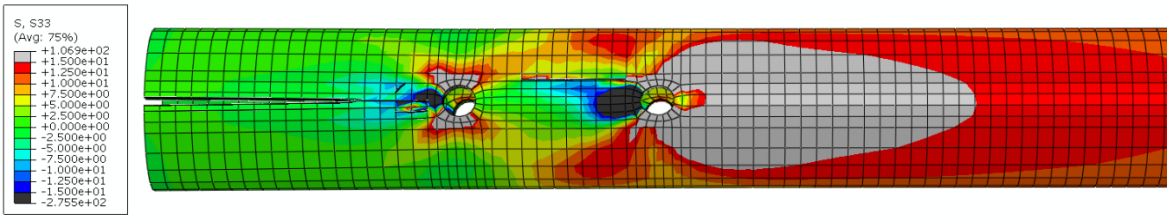

Figure 2: Axial stress (legend in MPa) and longitudinal splitting of the culm at displacement=2.5mm

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