Analysis of Natural Materials and Structures by Non-Contact Strain Measurements Methods

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Abstract

Non-contact strain measuring methods were applied to the study of mechanical properties of wood and mud materials. Focusing on the shear properties, from the macrostructure (millimeters, at the annual growth scale), to their application in timber structures.

The shear testing device, called single cube apparatus [1,2,3] (SCA) provides with a large central area of near-to-pure shear strains (Figure 1). It was used in combination with digital speckle photography (DSP) to study the transverse shear modulus (G_{RT}) of Norway spruce (*Picea abies*). Thus, a micromechanical model based on geometrical hexagonal cells[4,5], relating the density gradient to the G_{RT} was developed. It was found a strong dependence of G_{RT} to the relative density (Figure 2). This makes the average G_{RT} of spruce lower than other softwood species of similar average density and different density gradient[6]. Moreover, digital image analysis was use to obtain the elastic mechanical properties of natural and compressed Japanese cedar (*Cryptomeria japonica* D. Don). These properties were included in a finite elements model (FEM) of a wooden-bricks shear wall. It was designed as an interlocking system, which takes advantage of the properties of compressed softwood[7]. The stiffness of the wall was successfully increased by adding prismatic compressed elements, recovering their radial dimension due to springback properties.

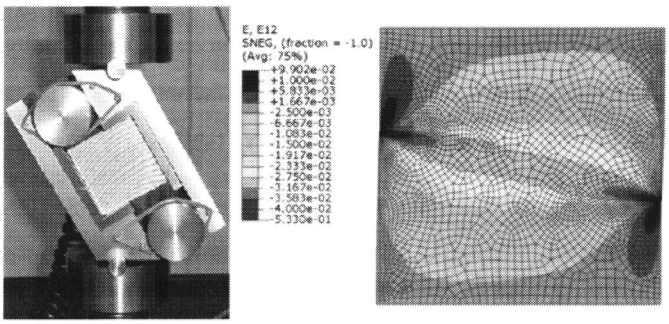

Figure 1. Right: Single cube apparatus. Left: In-plane shear strain field, FEA results.

Mud material, main component of traditional Japanese walls[8,9], presents several difficulties for testing, due to their high porosity and brittleness. Digital strain measurements were introduced in combination with digital image correlation, as an adequate method for obtaining the material properties. DSP was directly applied to the analysis of prefabricated mud shear wall units (PMWU). Extensive scrutiny on their performance relative to the number of connectors linking the PMWU to the external timber frame was carried out. Furthermore, a FEM including the detailed characteristics of the composition of the PMWU's was created. The model produced results that agreed accurately with the experimental outcomes.

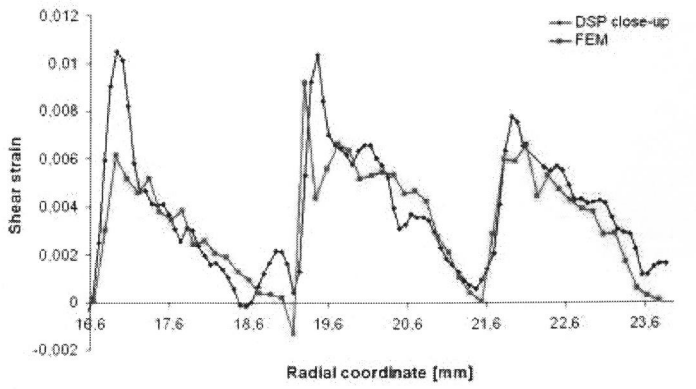

Figure 2. Shear strain profiles. Experimental DSP shear strain measurements and predicted shear strain using finite element analysis.

Non-contact strain measuring methods allowed to accurately obtaining the basic properties of wood and mud

materials. Porosity and heterogeneity at the mm-scale were successfully avoided. It also helped improving the understanding of failure mechanism of softwoods due to annual ring effects. Furthermore, digital image analysis was directly applied to strain measurements of timber and mud shear walls. And FEM including the obtained properties are a powerful tool for predicting the behavior of such structures.

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