IDENTIFICATION OF FOUNDATION MODULUS OF BOLTED TIMBER JOINTS USING FULL-FIELD DISPLACEMENT MEASUREMENTS

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ABSTRACT

The design of bolted joints of timber structures is currently based on the Yield Model of Johansen, published in 1949 [1]. Although the fundamental concepts remain unchanged over the years, the Yield Model has suffered several revisions supported by an extensive testing, and was included in the European design code for timber structures [2]. In the framework of the Yield Model, the elastic foundation modulus ($K_e$) is one of the inputted material parameters. The identification of this parameter is covered by the EN 383 (1993) standard [3], which suggests embedding tests in the directions parallel and perpendicular to the grain. Although the test principles and the specimen geometry are well defined (Figure 1), the standard does not provide a precise operational definition of $K_e$, leading to widely different assessments of this parameter [4]. The main goal of this paper is to present a finite element analysis and an experimental study of the embedding tests of EN 383 (1993) standard, focusing on the proper evaluation of the elastic foundation modulus under compression loading (Figure 1).

The ANSYS software was used to create 3D finite element models of the embedding test in compression along and perpendicular to the grain. A typical finite element mesh is shown in Figure 2a, which includes SOLID95 quadratic brick elements. In order to model the contact effects between the fastener and the wood specimen special contact elements available in ANSYS was used along with the Coulomb friction law. The elastic constitutive behaviour was considered for both wood specimen (\textit{Pinus pinaster} Ait.) and fastener (steel).

Twenty specimens for each test configuration (compression parallel and perpendicular to the grain, Figure 1) were tested in an INSTRON 1125 universal testing machine, using a stiff loading rig. The displacement field of the surface of the specimens were measured by Digital Image Correlation Technique, using a Dolphin F201C CCD camera with a spatial resolution of 1660(V)x1200(H) pixels. Additional point-wise relative displacements were also measured using LVDT displacement transducers.

The results show the dependency of $K_e$ on the base points selected for the measurement of relative displacement between the loading rig and the wood specimen, confirming the lack of uniqueness of this parameter arising from different interpretations of the EN 383 (1993) standard. Moreover, the knowledge of the displacement field allows the definition of a reproducible and meaningful $K_e$ value.
Figure 1 – Specimen geometries for the embedding test parallel and perpendicular to the grain.

Figure 2 – (a) Finite element model and (b) numerical v-displacement field at the specimen surface.

References