Parallel Talks

Adhesive Free Timber Structures - AFTB Project (chaired by A. Makradi, S. Belouettar, M. Oudjene, G. Zhongwei)

167 | An orthotropic multi-surface yield with damage model for 3D FEM analysis of adhesively bonded wood-steel elements

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Composite elements, made of adhesively bonded steel sheet between wood lamellas, can be employed as structural element in building engineering, thanks to their favorable ratios of strength and stiffness to mass. To predict the mechanical behavior of these composites, under loading, numerical analysis modeling, within the framework of the Finite Element Method (FEM), can be employed. Accordingly, to obtain reliable results, a proper material constitutive model should be adopted for each constituent of the composite. To this aim, in the present work, a generalized numerical model of material, with an orthotropic elastic-viscous-plastic constitutive law and failure/damage, is proposed. The model is formulated within the theories of continuum mechanics and irreversible thermodynamics of deformation, finite strains and kinematics of large displacements. It aims to address the coupled effect of irreversible strains and damage propagation in the post-failure path. The elastic-viscous-plasticity is formulated by a multi-surface yield, where each yield surface operates disjointedly each other, at a level of stress component. This approach can account different and complex material behavior, for instance ductile in compression and brittle in tension. The mechanical behavior of a steel-wood adhesively assembled is significantly influenced by damage effects. Therefore, appropriate variables are applied close to the Continuum Damage Mechanics, as progressive reduction of the mechanical properties (stiffness tensor). Damage is computed on the basis of a distinguished failure criterion for each stress-strain tensor component. Thus, each failure criterion can be defined as limit value of a stress and/or strain tensor component. Given that the finite strains approach is adopted, subsequently, the multiplicative decomposition is applied to the deformation gradient. To solve the constitutive equations an approximate general return mapping procedure is applied. A tangent operator, consistent with the integration algorithm, is used in a Newton–Raphson procedure. The integration is carried out with a backward Euler scheme, fully implicit in time, and an exponential mapping of the plastic deformation gradient. The integration is referred to an intermediate configuration to assure the objective principle, which is the material frame indifference under any rigid-body motions. The principal axes of the material are updated to account for rotations respect to the reference frame. The solution of the Finite Element Method system of nonlinear equations is searched by an incremental procedure, strain driven by a discretized loading history into time steps. The material model is implemented and built in a general purpose FEM computational code. The validity of the proposed model and of its computational technique is revealed by FEM analyzing the stress-strain path until failure of a composite element, an assemblage of a steel sheet adhesively bonded between wood lamellas. The obtained numerical results are compared with the experimental data in tension tests of that composite element. Accordingly, this model demonstrates to adequately represent the mechanical behavior, for ductile or brittle mode, of each constituent of the composite. The numerical model, being quite general, can be almost powerful to describe complex states of different materials and composite, such as anisotropy, elasticity and viscoplasticity, brittle crack, ductile and brittle damage. However, other validations on experimental basis can be an objective of a future work.

315 | Finite Element Modelling and Analysis of Adhesive Free Laminated Timber Beams with Compressed Wood Fasteners

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Engineered Wood Products (EWPs) are commonly used structural materials because of their good mechanical properties, ease of fabrication and low cost. However, there are environmental issues with some EWPs (such as glue laminated timber beams) due to the high quantity of petrochemical adhesives present in them, which are also dangerous to the environment. This has led to the increased interest in the development of a novel and more sustainable EWP, namely Adhesive Free Laminated Timber (AFLT) beam. This paper describes an investigation of the structural properties of AFLT beams, fabricated from solely timber sections, and fastened with Compressed Wood (CW) dowels. Using the elastic moduli and strength properties of the timber laminae (uncompressed wood)

and the compressed wood dowels (compressed wood), together with their geometry, Finite Element (FE) models were set up and analysed using ABAQUS software to investigate the stiffness and load carry capacities of AFLT beams. In addition, the FE models, which involved the analysis of different dowel patterns, sizes, and configurations of the CW dowels, aided the design and structural optimisation of the AFLT beams. The FE results were also compared and validated with the experimental test results obtained from four-point bending tests on the AFLT beams. The study thereby provides useful analyses of a novel and sustainable AFLT, which can be used for structural applications, and could potentially serve as an alternative to some EWPs, such as glue laminated timber beams.

327 | Mathematical simulation of composite wooden roof slab based on different-modulus theory

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Roof slabs from wood and composite materials are lightweight structure designs of industrial production. The advantages of using such structures are the light weight and the great load bearing capacity. They are girders and decks at the same time. Moreover, they provide thermal protection of a structure. There is a typical kind of such roof slabs. It consists of longitudinal wooden ribs with upper and lower panels. Experimental results of mechanical properties for wood and laminated veneer lumber (LVL) show that materials are different-modulus, i.e. tension modulus and compression modulus are different. The following parameters of the roof slab are analyzed: thicknesses of upper and lower panels, height and width of longitudinal rib, quantity of these ribs. Strength calculation for the roof slab is based on composite beam theory for different-modulus materials. The numerical comparison of the different-modulus theory and the classical beam theory is presented. The results based on different-modulus theory allow to safe on material of lower panel up to 50- 80%.

338 | Experimental study of the feasibility to use compressed wood dowels as joint elements for structural bearing capacity

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More than 5 million m3 of EWPs were produced in the EU in 2013/14 and the market is growing, as EWPs provide a ‘green' alternative to steel and concrete in construction. However, about 600 tonnes of toxic adhesive are currently used in the manufacturing of 1 million m3 of EWPs (glulam and CLT). The aim of this research is to demonstrate new adhesive free EWPs using new technology. Providing confidence in the structural properties of adhesive free EWPs using compressed wood is the key issue which requires an appropriate experimental testing program. The advantages of using compressed wood dowels in comparison to using hardwood dowels (not compressed) are tight fitting after the spring back regardless of moisture-dependent swelling as well as minimised stress relaxation problem. Engineered wood products connected with by hardwood dowels would gradually loss the initial tight fitting with moisture escaping through their service life. In contrast, EWPs jointed by compressed wood dowels would not suffer the same problem as the spring back would be maintained through their service life. The main purpose of this work is to demonstrate the relative performance of those adhesive free products for structural bearing capacity, by means an appropriate experimental program. First of all, the densified wood was experimentally characterized under three-point bending tests and the results were compared to those obtained for the normal wood (not densified). After that, double shear push-out connections made with compressed wood dowels are characterized experimentally according to the EN 26891 and the results are compared to similar connections assembled using normal oak dowel (not densified). Several three-laminated beams assembled using compressed wood dowels are also tested according to the EN 408 standard requirements. Experimental results obtained demonstrate that compressed wood dowels are convenient as joint elements and exhibit good and acceptable stiffness and strength characteristics.