Long-term finite element analysis of timber-steel composite joint

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The long-term behaviour of timber structures under service loading conditions is significantly influenced by timber creep which depends on fluctuations of relative humidity (RH), temperature and level of service load. Accordingly, accurate deflection control and analysis of timber, timber-concrete and timber-steel composite members under service load is not possible, unless the coupling of hygroscopic behaviour, temperature effect and mechanical loads on timber behaviour are adequately considered. The material models used for predicting long-term behaviour of timber elements are mostly formulated in the framework of visco-elasticity assuming that the stress in timber elements subject to long-term service load remains well within the elastic range of timber behaviour [1,2]. The visco-elastic material models have been incorporated into 1D beam [3] or 2D/3D continuum-based [4,5] finite element models to predict the global and local behaviour of timber/timber-concrete composite beams and connections, respectively. The 1D beam finite element models are effective in predicting the global long-term behaviour, but their accuracy heavy rely on the empirical models adopted for predicting the complex time-moisture-temperature dependent behaviour of the mechanical connectors. However, the 3D finite element models can predict the long-term behaviour of the mechanical connectors embedded in timber.

The results of long-term test (over 18 months period in uncontrolled in-door conditions) conducted on cross laminated timber (CLT) to steel connections with coach screws are briefly discussed. A 3D orthotropic visco-elastic model of predicting creep deformation developed and implemented [4,5] in ABAQUS finite element software is employed to predict the long-term behaviour of CLT-steel composite joints. In the finite element simulations, the elastic deformation, plastic deformation, hygroexpansion deformation, visco-elastic deformation and mechano-sorptive deformation were taken into account and the variation of moisture and temperature were also considered. It is shown that the adopted finite element model can predict the slip versus timber response of the composite joints with reasonable accuracy.

References

[1] Z.P. Bazant. Constitutive equation of wood at variable humidity and temperature. *Wood science and Technology* 19(2), (1985), 159-177.
[2] E.L. Schaffer. 1982. Influence of heat on the longitudinal creep of dry Douglas-fir. In Structural uses of wood in adverse environments, edited by R. W. Meyer and R. M. Kellog, 20–52. New York: Society of Wood Science and Technology, Van Nostrand Reinhold
[3] N. Khorsandnia. Finite element analysis for predicting the short-term and long-term behaviour of timber-concrete composite structures [PhD]. Australia: University of Technology, Sydney; 2013.
[4] S. Fortino, M. Florian, and T. Toratti. A 3D moisture-stress FEM analysis for time dependent problems in timber structures. *Mechanics of time-dependent materials.* 13(4), (2009), 333.
[5] F. Morianon, S. Fortino, and T. Toratti. A method to model wood by using Abaqus finite element software. Part 1: Constitutive model and computational details. VTT Technical Research Center of Finland-Report 687, (2008).

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