4^{rd} COST E55 Workshop

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WG2 - Moisture induced stresses

Moisture induced stresses in dowel joints

A computational study

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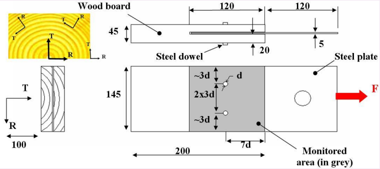
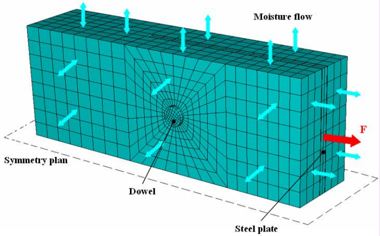
Research project:

Improved Moisture (WoodWisdom-Net)

3D moisture-stress analysis of a 2–dowel connection (wood: *Norway spruce*, d=12 mm).





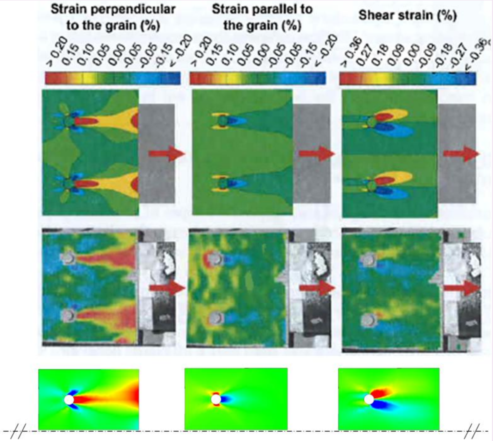
Background on the computational analysis

- **3D orthotropic viscoelastic-mechanosorptive model implemented in the Umat subroutine of the code Abaqus (Fortino, Mirianon and Toratti, 2008 - `http://www.vtt.fi/inf/pdf/publications/2008/P687.pdf`).**
- **Moisture transfer modeled by the 3D Fick equation. Equations for moisture flow implemented in the Dflux subroutine of Abaqus. Temperature effect neglected.**
- **Coupled moisture-stress analysis performed by Abaqus/Standard. Validation of the computational model by comparisons with existing experimental data:**
  1. **small size wood specimens (Toratti and Svensson, 2002; Leivo, 1991)**
  2. **small glulam sections (Jönsson, 2005)**

  and by comparison with other 3D computational models (Ormarsson, 1999; Santaoja et al., 1991).

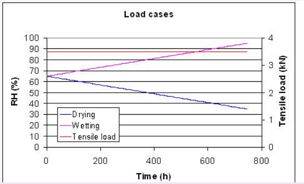
F=14 kN (just under the experimental elastic limit). Load applied for 1 minute. Constant MC=12%.

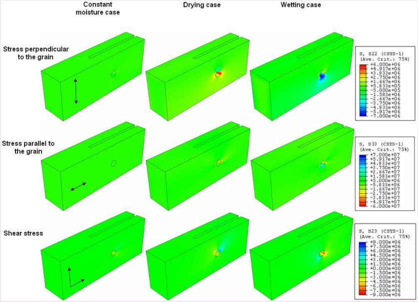
- **Top: 2D computational results (Sjödin, 2008). Center: experimental results by the ARAMIS-system (Sjödin, 2008). Bottom: 3D computational results (viscoelastic creep taken into account).**

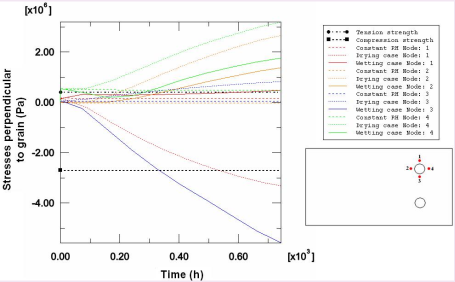


F=3.5 kN (25% of the experimental elastic limit). Load applied for 1 month. Cases of drying and wetting.

Computational results: in both the drying and the wetting cases, the stresses perpendicular to grain exceed the characteristic values for glulam beams GL28c (Eurocode 5).

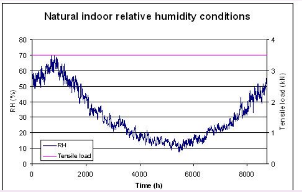


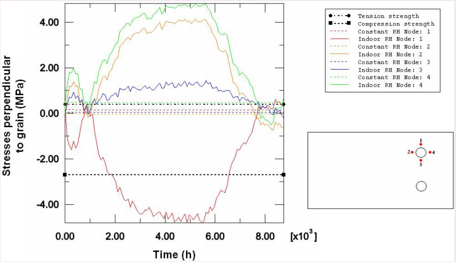


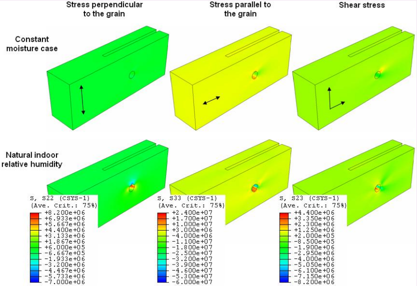


F=3.5 kN (25% of the experimental elastic limit). Load applied for 1 year. Natural indoor relative humidity conditions.

Relative humidity measured in the Sibelius hall, Finland, starting from July (Koponen, 2002). Computational results: the stresses perpendicular to grain exceed the characteristic values for glulam beams GL28c (Eurocode 5).



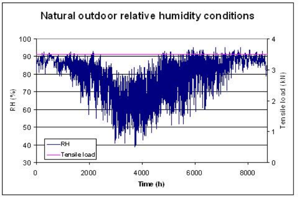




⇐ Stress state of the connection at time 5550 hours (middle of winter).

Conclusions and future work

- The computational results have shown that, by using the proposed model, the stresses are strongly increased under natural indoor relative humidity conditions.
- The same type of analysis can be performed for outdoor conditions. The following figure shows the outdoor relative humidity measured during 1 year in Jyväskylä, Finland, starting from January (Koponen, 2002).



- **Suggestions for accurate design codes:**
  - improvement of the existing constitutive models: more work for modeling 3D moisture transfer and for defining more general 3D mechanosorptive models (Frandsen and Svensson, 2007);
  - validation of the models by comparisons with experimental results for real size timber connections;
  - definition of general reference curves for natural indoor and outdoor relative humidity;
  - definition of the moisture induced stress σ_Q for the design code on the basis of new information coming from the previous steps;
  - ...?