Experimental and Numerical Investigation of Timber Structures for the Validation of an Orthotropic Plasticity Model

Martin FLEISCHMANN*, Herbert W. MÜLLNER*, Harald KRENN, Josef EBERHARDSTEINER***

* Institute for Mechanics of Materials and Structures, TU Vienna, http://www.imws.tuwien.ac.at

** Institute for Timber Engineering and Wood Technology, TU Graz, http://www.lignum.tu-graz.ac.at

Overview

Although wood is used as a favourite building material among concrete and steel, the mechanical behaviour was not scientifically investigated yet as one would expect. To be able to perform more realistic simulations of timber structures by means of modern numerical simulation methods like the Finite Element Method (FEM), a suitable constitutive material model is required. Such a material model was developed by Mackenzie-Helnwein in for clear spruce wood and was extended by Fleischmann [1] considering the influence of knots and the deviation of the fibre direction around the knots on the strength properties. Further an implementation of the material model in a Finite Element software was done. For the validation of the material model numerical simulations of wooden structures using FEM and comparison of the obtained results with those of corresponding experiments were done for two test series. The results of these tests will be presented in this poster.

Literature: [1] Fleischmann, M.: Numerische Berechnung von Holzkonstruktionen unter Verwendung eines realitätsnahen orthotropen elasto-plastischen Werkstoffmodells, PhD-Thesis, Institute for Mechanics of Materials and Structures, Vienna University of Technology, 2005.

Orthotropic Single-Surface Plasticity Model

Orthotropic Single-Surface Plasticity Model (by MACKENZIE-HELNWEIN) **Including Basic Wood Characteristics (Knot Effects)** (by FLEISCHMANN) **applied for Examples 1 and 2**

Initial TSAI-WU Yield Surface and Evolution Laws (Plane Stress)

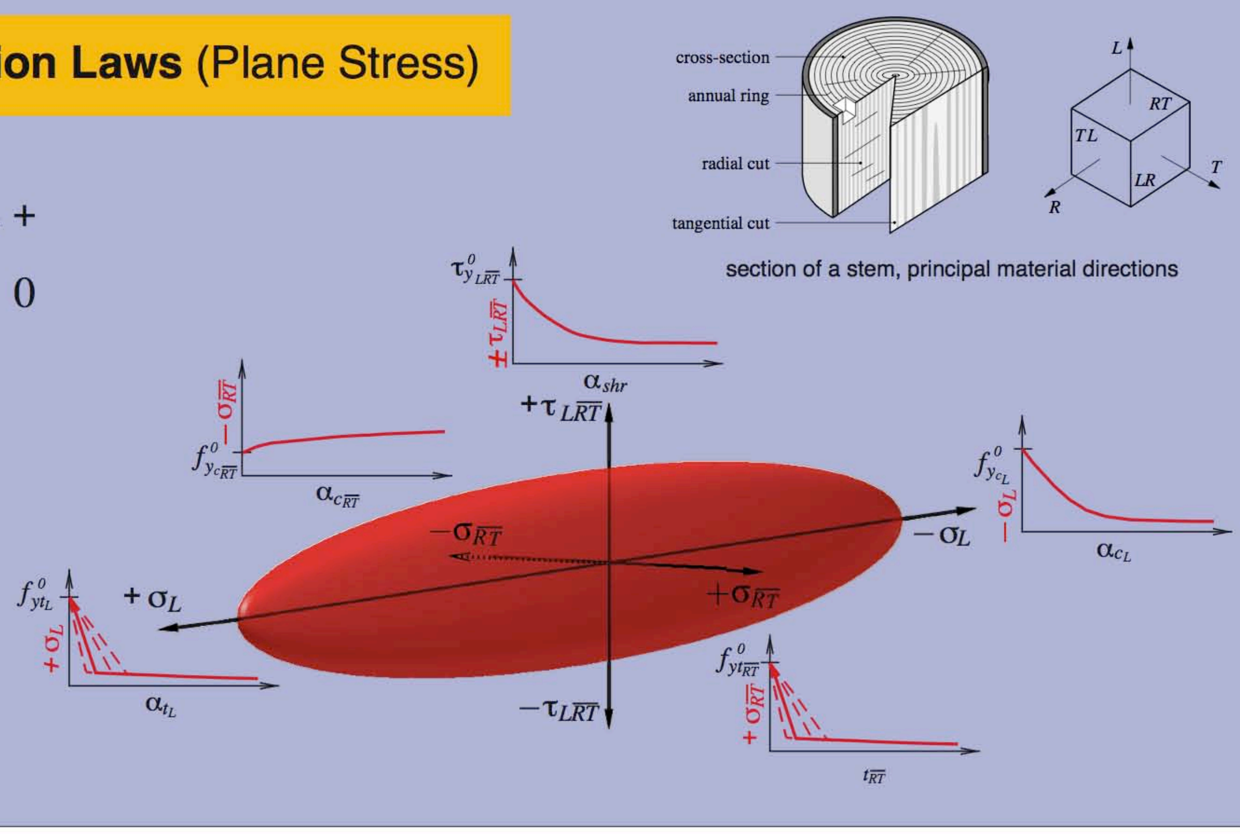
$$f(\sigma,p) = a_{LL}\sigma_L + a_{\overline{RT}\,\overline{RT}}\sigma_{\overline{RT}} + b_{LLLL}\sigma_L^2 + b_{\overline{RT}\,\overline{RT}\,\overline{RT}\,\overline{RT}}\sigma_{\overline{RT}}^2 + 2b_{LL\overline{RT}\,\overline{RT}}\sigma_L\sigma_{\overline{RT}} + 4b_{L\overline{RT}L\overline{RT}}\tau_{L\overline{RT}}^2 - 1 = 0$$

σ_L . . . stress in *L*-direction

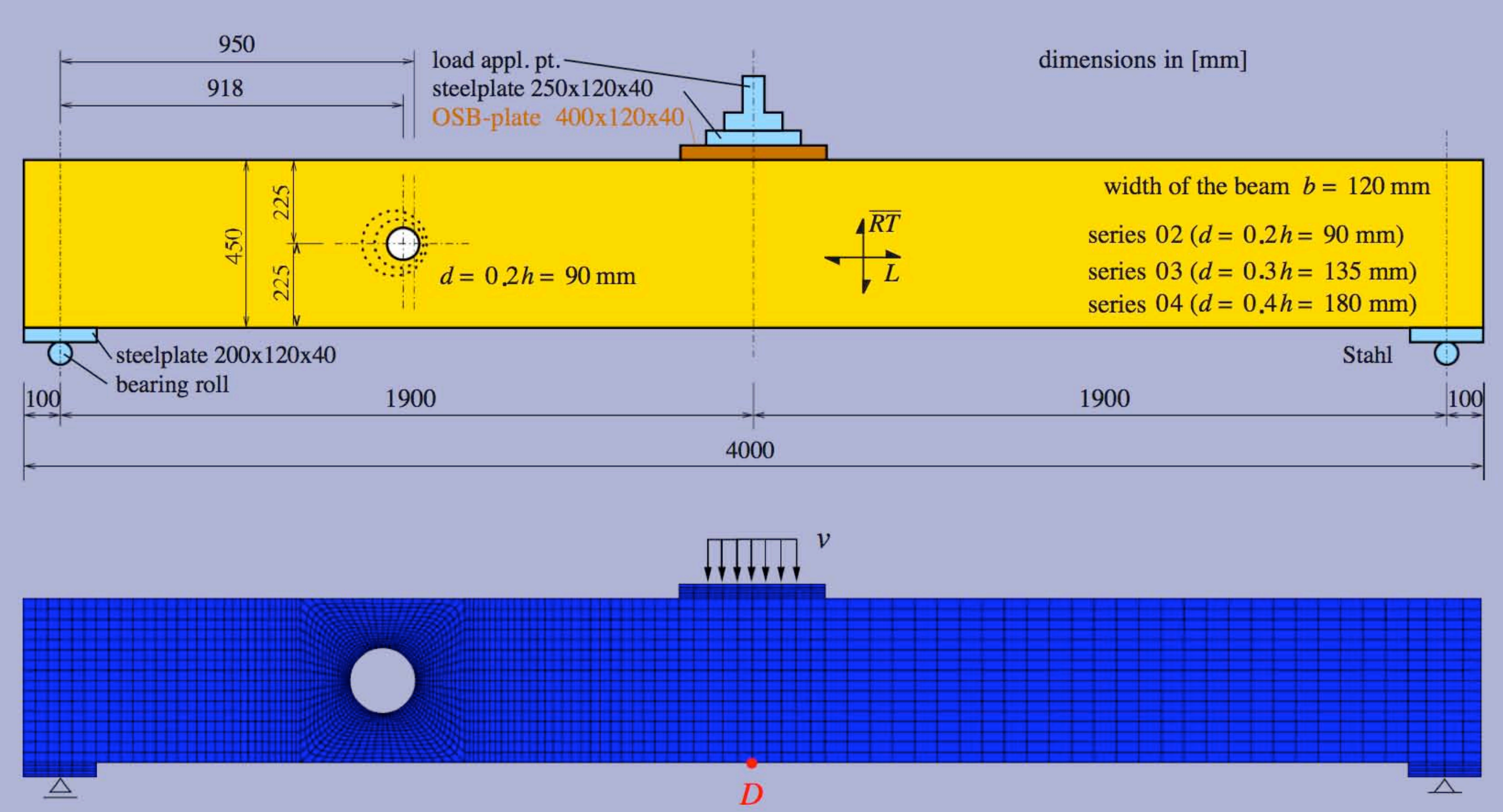
$\sigma_{\overline{RT}}$ . . . stress in $\overline{RT}$-direction ($\overline{RT}$-equivalent)

$\tau_{L\overline{RT}}$ . . . shear stress

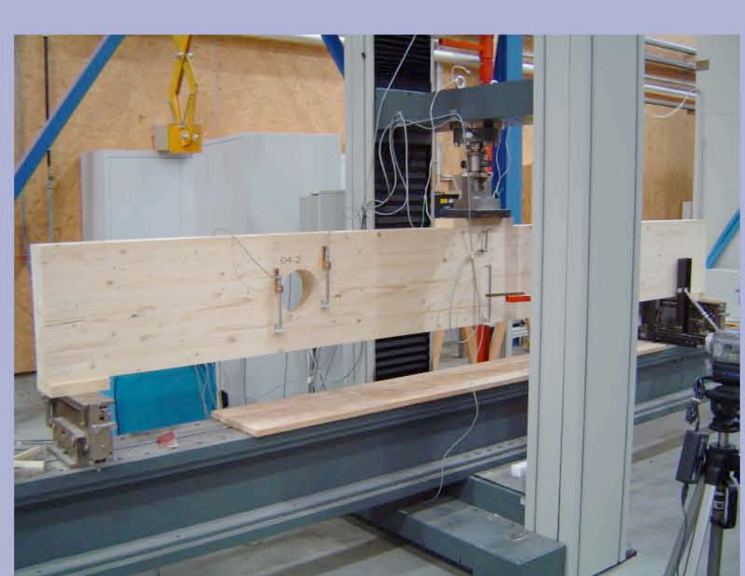
$a_{LL}, a_{\overline{RT}\,\overline{RT}}, b_{LLLL}, b_{\overline{RT}\,\overline{RT}\,\overline{RT}\,\overline{RT}}, b_{LL\overline{RT}\,\overline{RT}}, b_{L\overline{RT}L\overline{RT}}$ . . . Tsai-Wu material parameters, $= f(ksa)$ ksa . . . knotfactor



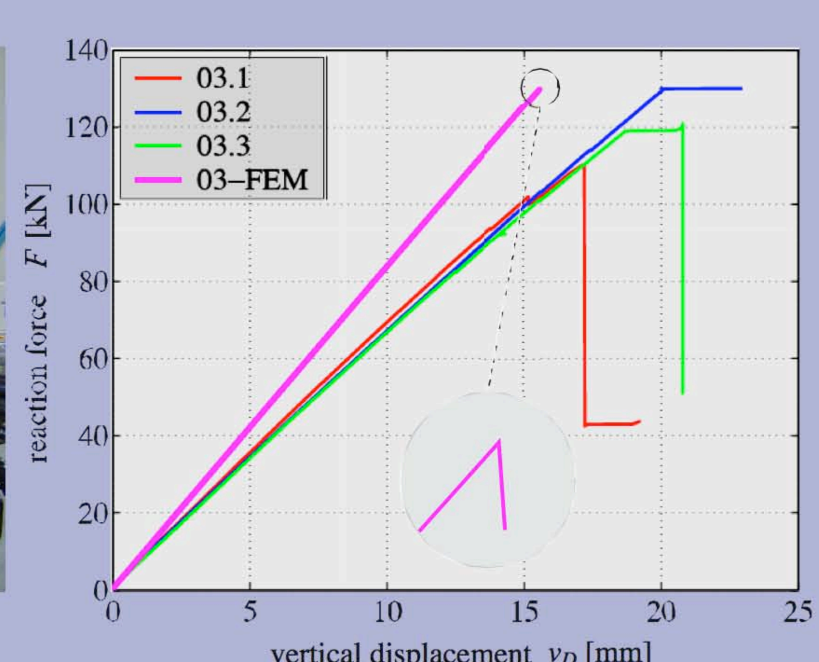
Example 1: Beam with a Circular Opening



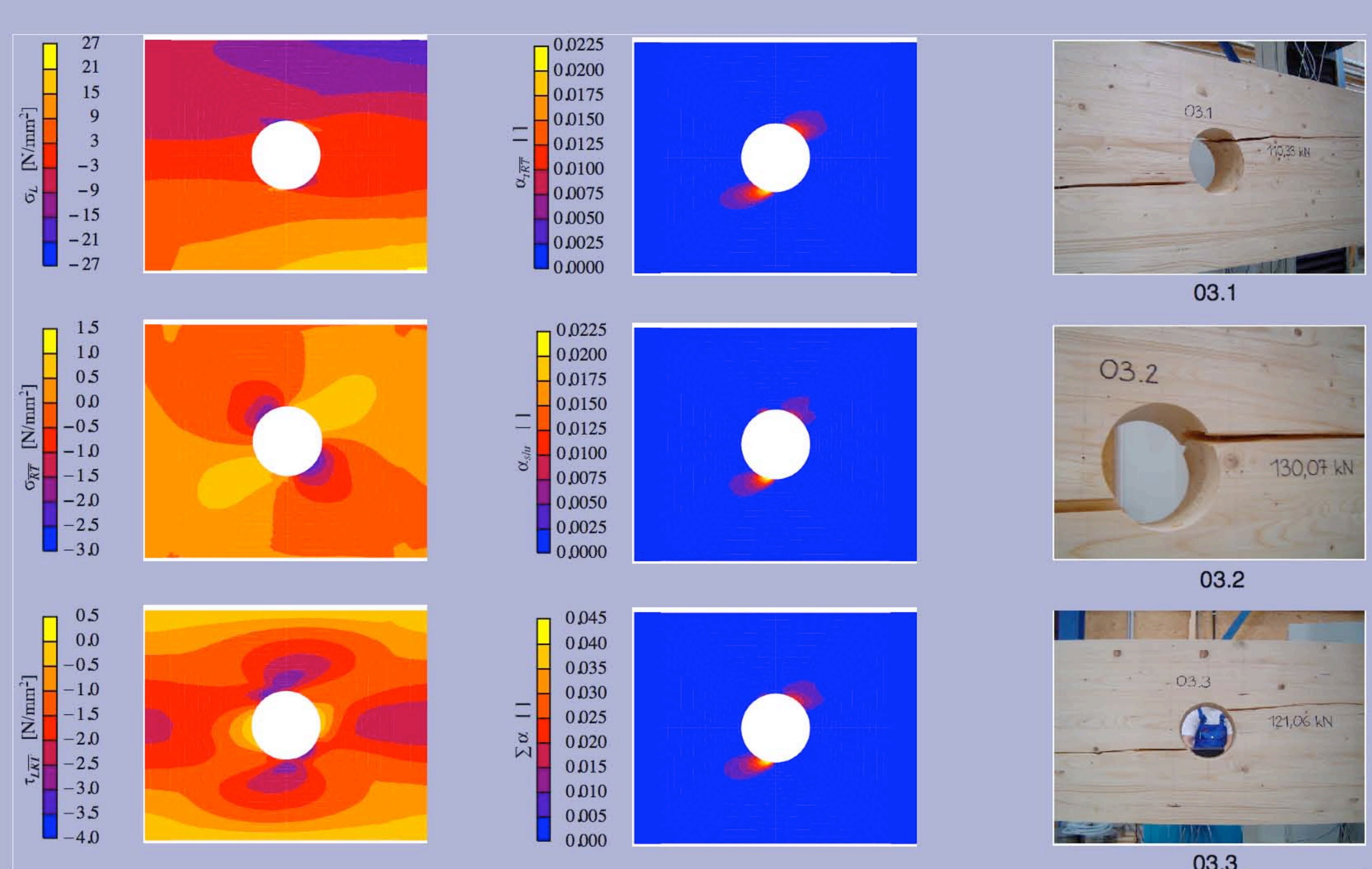
dimensions of the beams, FE-mesh, resp.



specimen 04.2
reference configuration

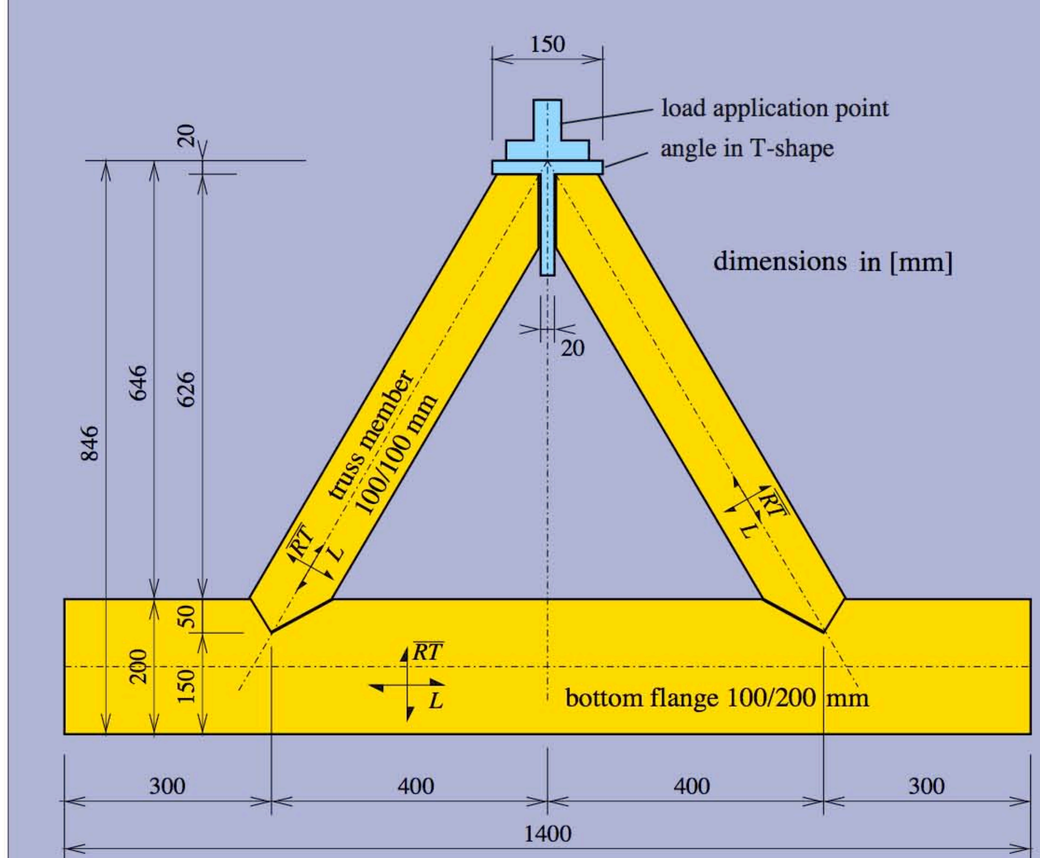


load-displacement diagram (series 03)

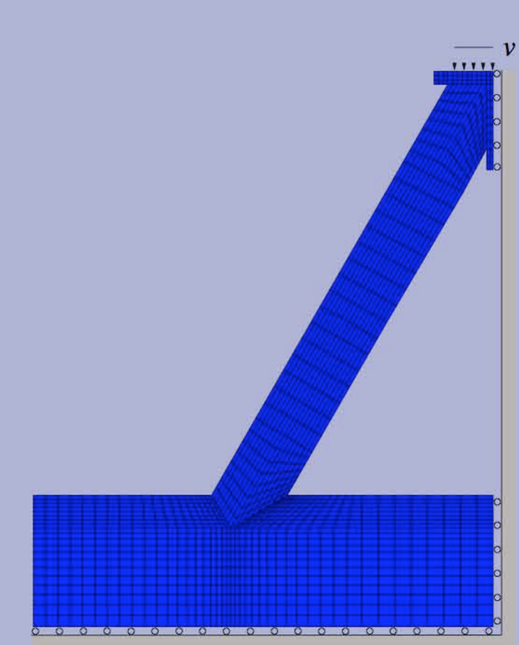


stress distributions, zones of plastic deformations, fracture images, resp. around the opening of test series 03

Example 2: Truss

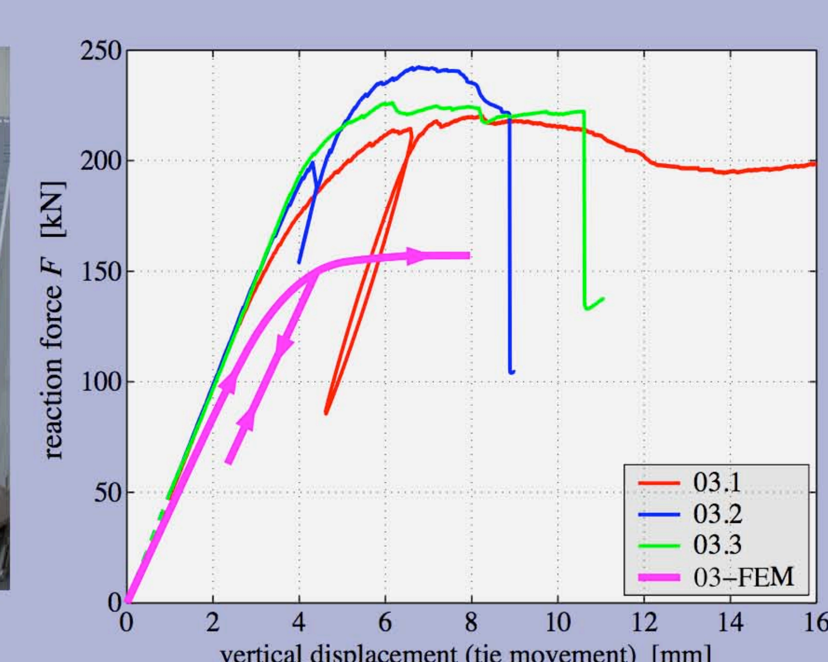


dimensions of the truss

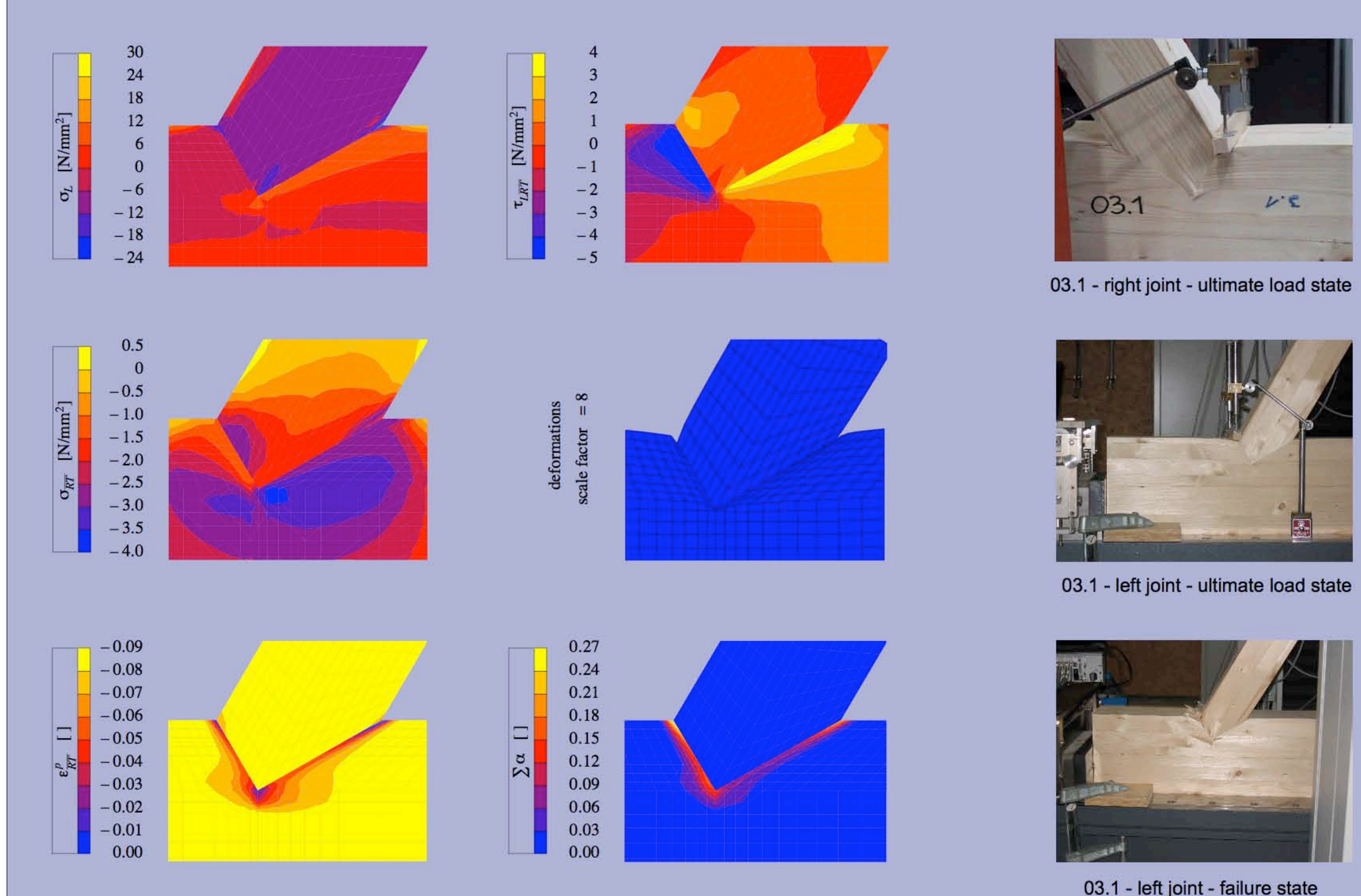


FE-mesh

reference configuration



load-displacement diagram



stress distributions, zones of plastic deformations, deformed images, resp. in the joint area