Nanoindentation and micromechanical modeling to explore the mechanical performance of deteriorated softwood

L. Wagner†, T. K. Bader†, K. Hofstetter†, K. Fackler‡, T. Ters‡

†Institute for Mechanics of Materials and Structures
Vienna University of Technology, Austria

‡Institute of Chemical Engineering
Vienna University of Technology, Austria
Motivation

Micromechanical modeling of deteriorated softwood:
- enhance understanding of decay effects on wood microstructure and mechanical properties
- study microstructure - function relationships of deteriorated wood

Novel aspect:
- growth ring specific characterization and mechanical testing

Starting Point

Scots pine (*Pinus sylvestris* L.) sapwood samples from earlier study: [Bader et al. (2011), *IRG-WP 11-40570*]
- in initial (=reference) condition
- Brown rot (*Gloeephyllum trabeum*)
- White rot (*Trametes versicolor*)
- mass, mass density, EMC determined on solid wood samples
- $C_{\text{iii}} (\text{L}, R, T)$ and $E_L$ measured on solid wood samples
Micromechanical model


Anisotropic indentation theory
[Jäger et. al. (2011), Composites Part A]

\[ M_{\text{pred}} = \mathcal{F}(MFA, C_{11}, C_{22}, C_{12}, C_{13}, C_{44}) \]

predicted indentation modulus \( M_{\text{pred}} \)

predicted cell wall stiffness \( C_{\text{hom}}^{\text{CWM}} \)

predicted softwood stiffness \( C_{\text{hom}}^{\text{SW}} \)
Chemical and microstructural characterization:

Microstructure:
- MFA from thin sections
- Cell geometry, early- and latewood content from NI sample

Experimental validation:

Cell wall level: Nanoindentation

& quasistatic tensile tests

- Indentation modulus $M_{exp}$
- Predicted indentation modulus $M_{pred}$
- Elastic stiffnesses $C_{iii} (i... L,R,T)$
- Elastic modulus $E_L$
- Predicted softwood stiffness $C_{homSW}$

Chemical characterization:

- Absorbance graph
- Wavenumber [cm⁻¹]
- Reference
- 6 weeks brown rot
Preliminary Results

- difficult to draw conclusions only from NI tests
- characterization of sample specific microstructure (MFA, chemical composition, …) is essential for interpretation