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

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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:

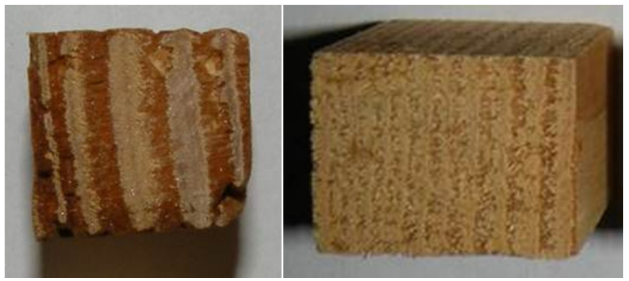
- growth ring specific characterization and mechanical testing

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 (*Gloephyllum trabeum*)
- White rot (*Trametes versicolor*)

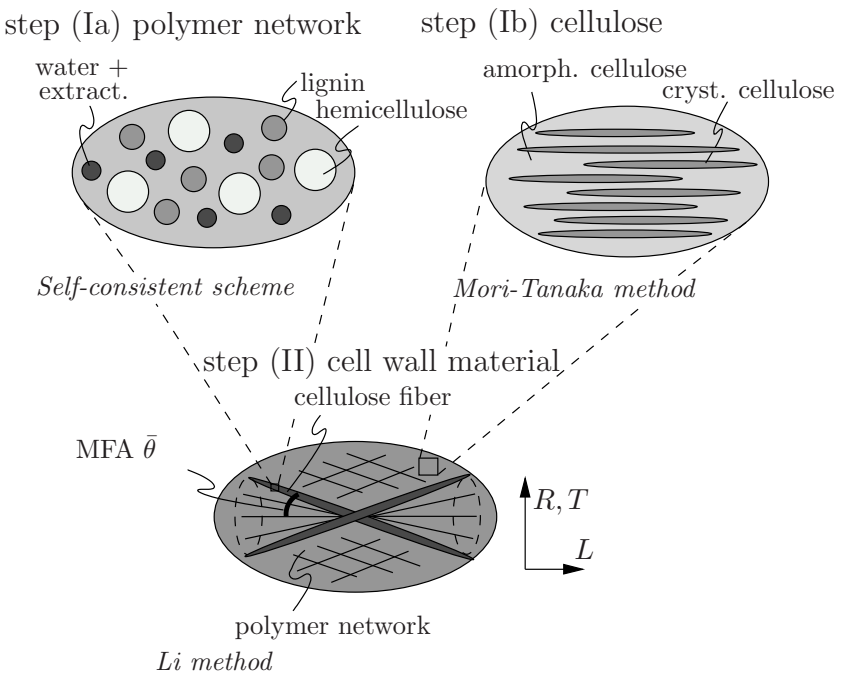
- mass, mass density, EMC determined on solid wood samples
- C_{iiii} (i ... L,R,T) and E_L measured on solid wood samples



brown rot white rot

Micromechanical model

[Bader et. al. (2010), *Acta Mech.*, Hofstetter et. al. (2005), *Eur. J. Mech. A/Solids*]



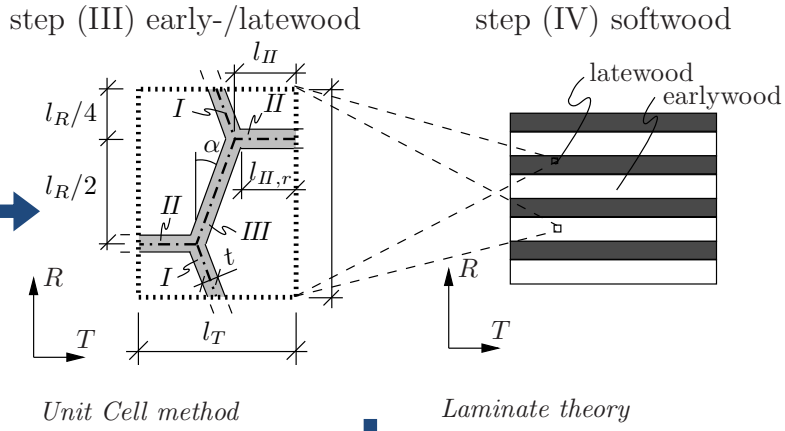
predicted cell wall stiffness C^{hom}_{CWM}

Anisotropic indentation theory

[Jäger et. al. (2011), *Composites Part A*]

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

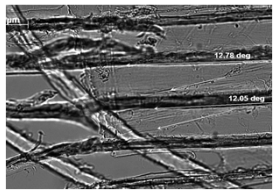
predicted indentation modulus M_{pred}



predicted softwood stiffness C^{hom}_{SW}

Chemical and microstructural characterization:

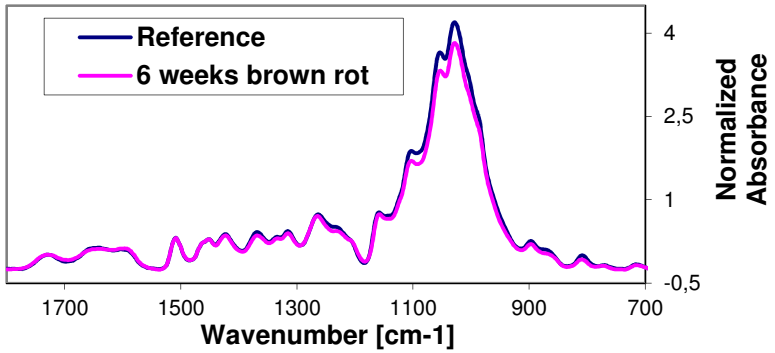
Microstructure:



MFA from thin sections

cell geometry, early- and latewood content from NI sample

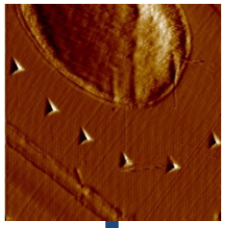
Chemical characterization:



Experimental validation:

Cell wall level: Nanoindentation

[Oliver & Pharr (1992), *J. Mat. Res.*]

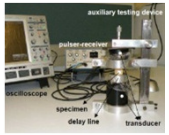


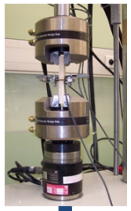
indentation modulus M_{exp}

predicted indentation modulus M_{pred}

Softwood level: Ultrasonic tests [Bucur (2006), *Springer, New York*]

& quasistatic tensile tests



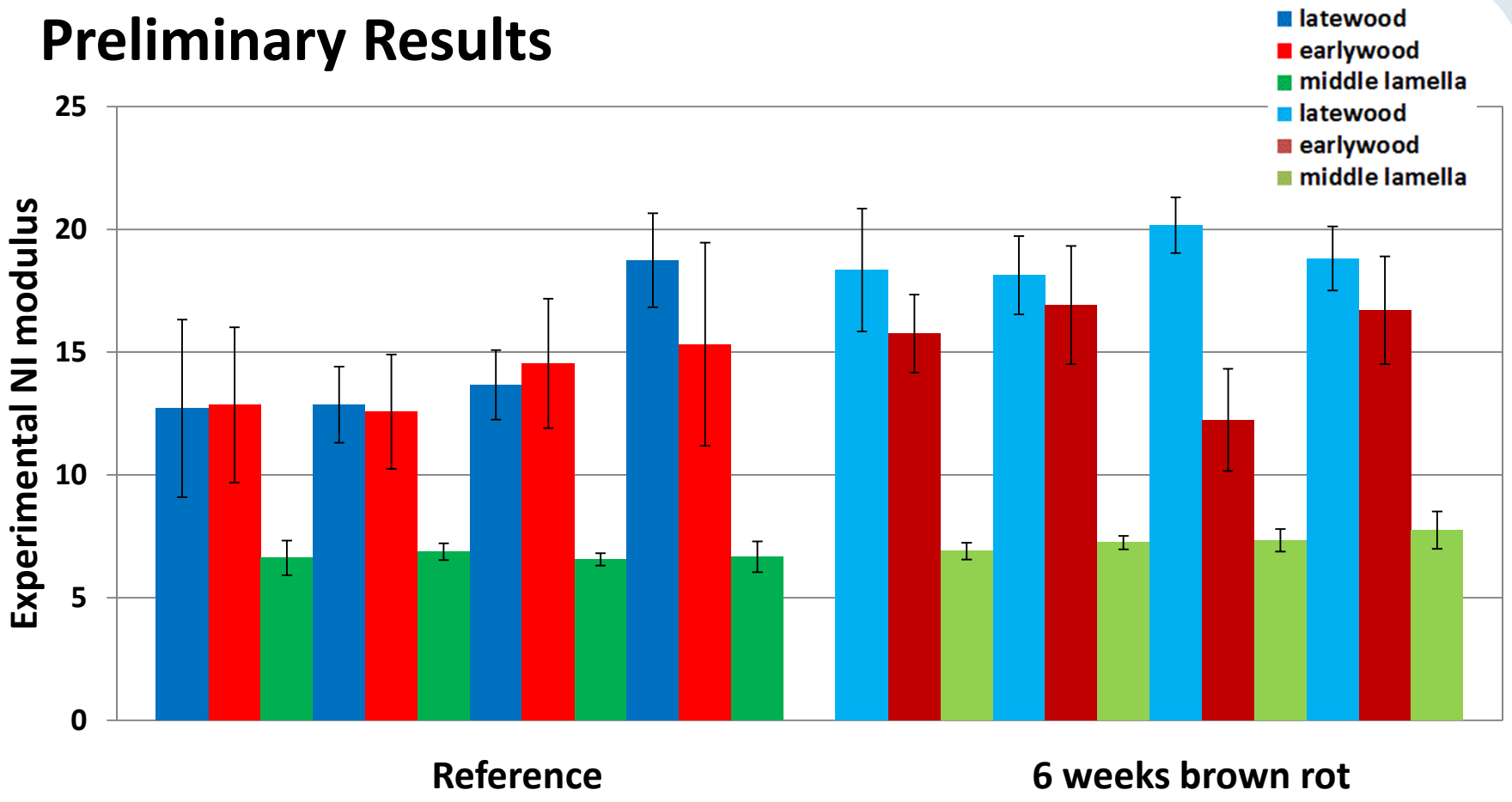


elastic stiffnesses C_{iiii} *(i… L,R,T)*

elastic modulus E_L

predicted softwood stiffness C^{hom}_{SW}

Preliminary Results



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