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Moisture content and temperature effects on reinforcements in timber structures

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Aim of study : Information on short-term and long-term durability of connections by glued-in rods in timber structures. Experimental and numerical investigations.

Background



Damage of wood by biological agents

Reduction of its mechanical properties

Need to repair

Glued-in rods

- ◆ Process developed in 1970's
- ◆ Decayed wood substituted by sound one
- ◆ Structural loads transferred by means of threaded steel bars bonded to wood

Great conservation of the original material



Experiments



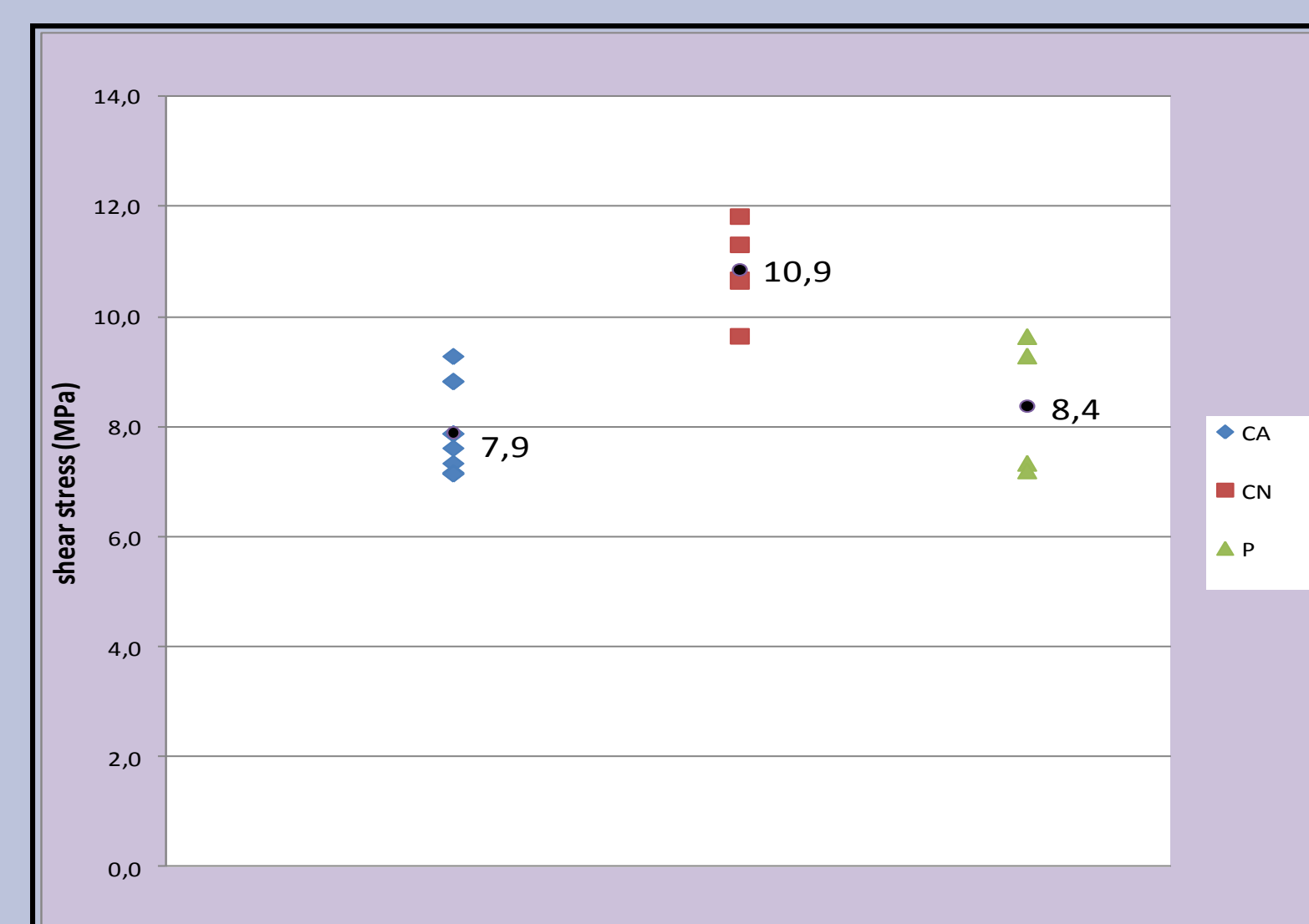
3 types of wood performed: ancient oak, new oak and fir
 Small size specimens: cubic shape (50 mm edge)
 Use of threaded steel bars and epoxy adhesive
 Short-term tests on « pull-compression »

Influence of type of wood on mechanical behavior

First results on experiments



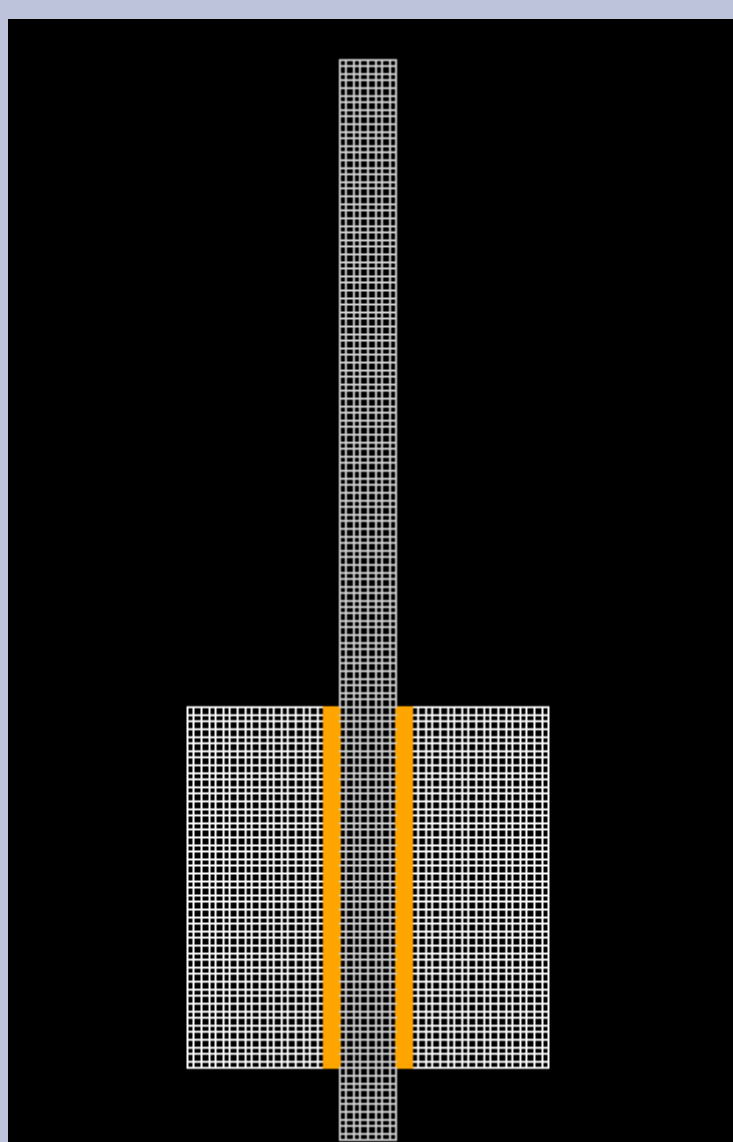
Failure at timber/glue interface



CA : ancient oak
 CN : new oak
 P : fir

Shear stress : $\tau = P_{max} / (\pi d_{hole} L)$

Finite element modeling

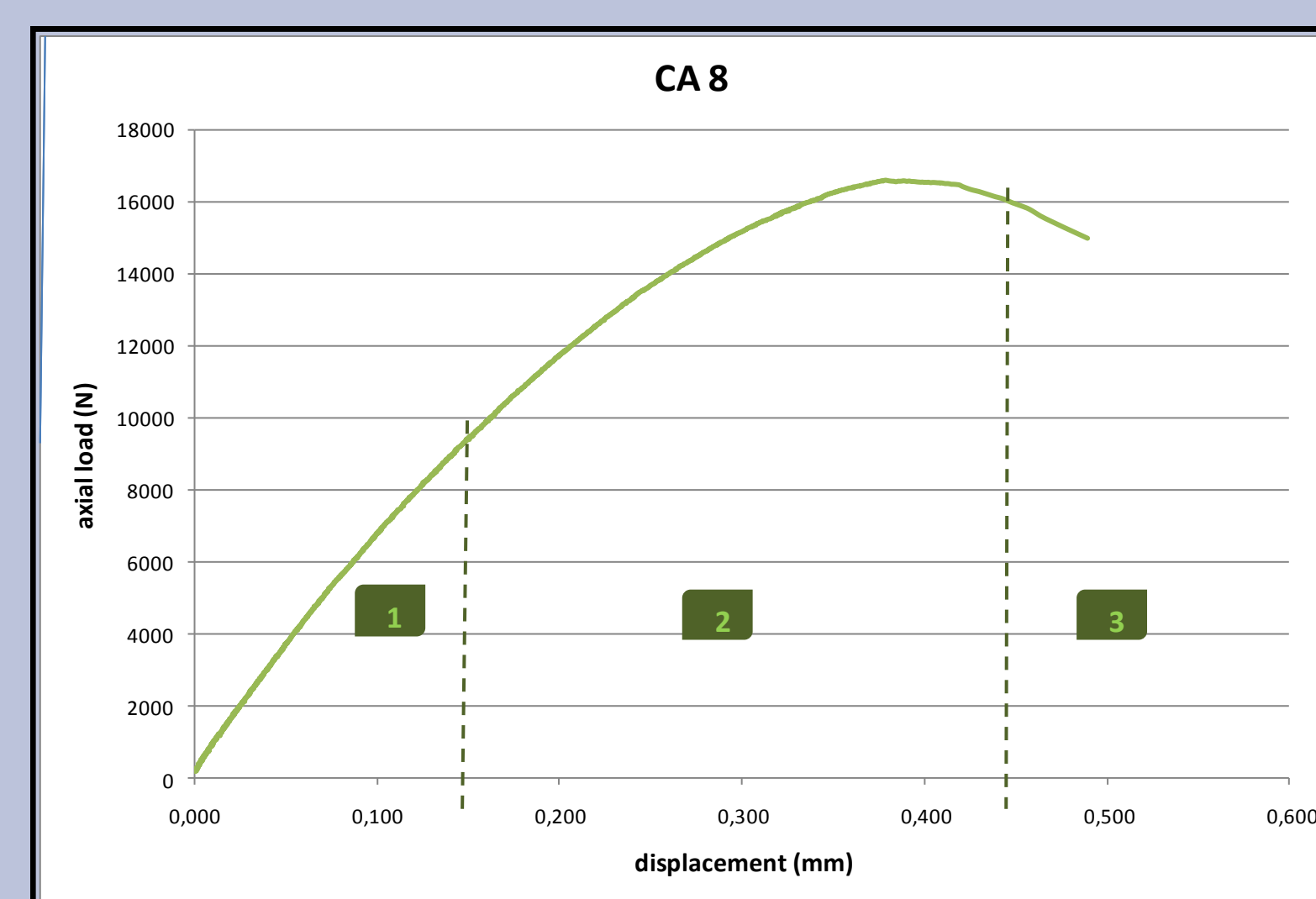


- ◆ Calibration on elasticity
- ◆ 2D axial-symmetric model
- ◆ Meshing improved on joints' elements

Wood	Steel	Epoxy
$E_L = 14\ 400\ \text{MPa}$	$E = 210\ 000\ \text{MPa}$	$E = 1\ \text{GPa}$
$G_{LR} = 1\ 260\ \text{MPa}$		

Influence of E_L , G_{LR} and E_{glue} on stiffness of the connection (k_{ass})

Setting up of an **experimental design**
 Analysis of variance



- 1 : Elastic zone**
 Linear part of the curve
 Slope is the stiffness of the connection
- 2 : Damage zone**
 Decrease of the stiffness
 Beginning of damage in glued interface
- 3 : Failure**

First results on modeling

Mechanical properties	Influence on k_{ass}
Modulus of elasticity of wood: E_L	18 %
Shear modulus of wood: G_{LR}	34 %
Modulus of elasticity of glue: E_{glue}	48 %

Conclusion and perspectives

- ◆ Failure occurred only in the wood close to the glue line, in all samples (adhesive failure)
- ◆ Ancient oak samples revealed lower pullout strength than new oak (lower of 25%)
- ◆ The experimental design indicated a significant impact of E_{glue} on stiffness of the connection
- ◆ Samples made with massive epoxy will be tested on tensile test, in order to really know its mechanical properties
- ◆ Series of experiments, taking account of new parameters (T and MC) will be carried out