FCTUC DEPARTAMENTO DE ENGENHARIA CIVIL
FACULDADE DE CIÊNCIAS E TECNOLOGIA
UNIVERSIDADE DE COIMBRA

Instituto Politécnico de Castelo Branco
Escola Superior de Tecnologia

COST E55 – Modelling the Performance of Timber Structures – Final Conference

The effect of ductile connectors on timber-concrete composite beams

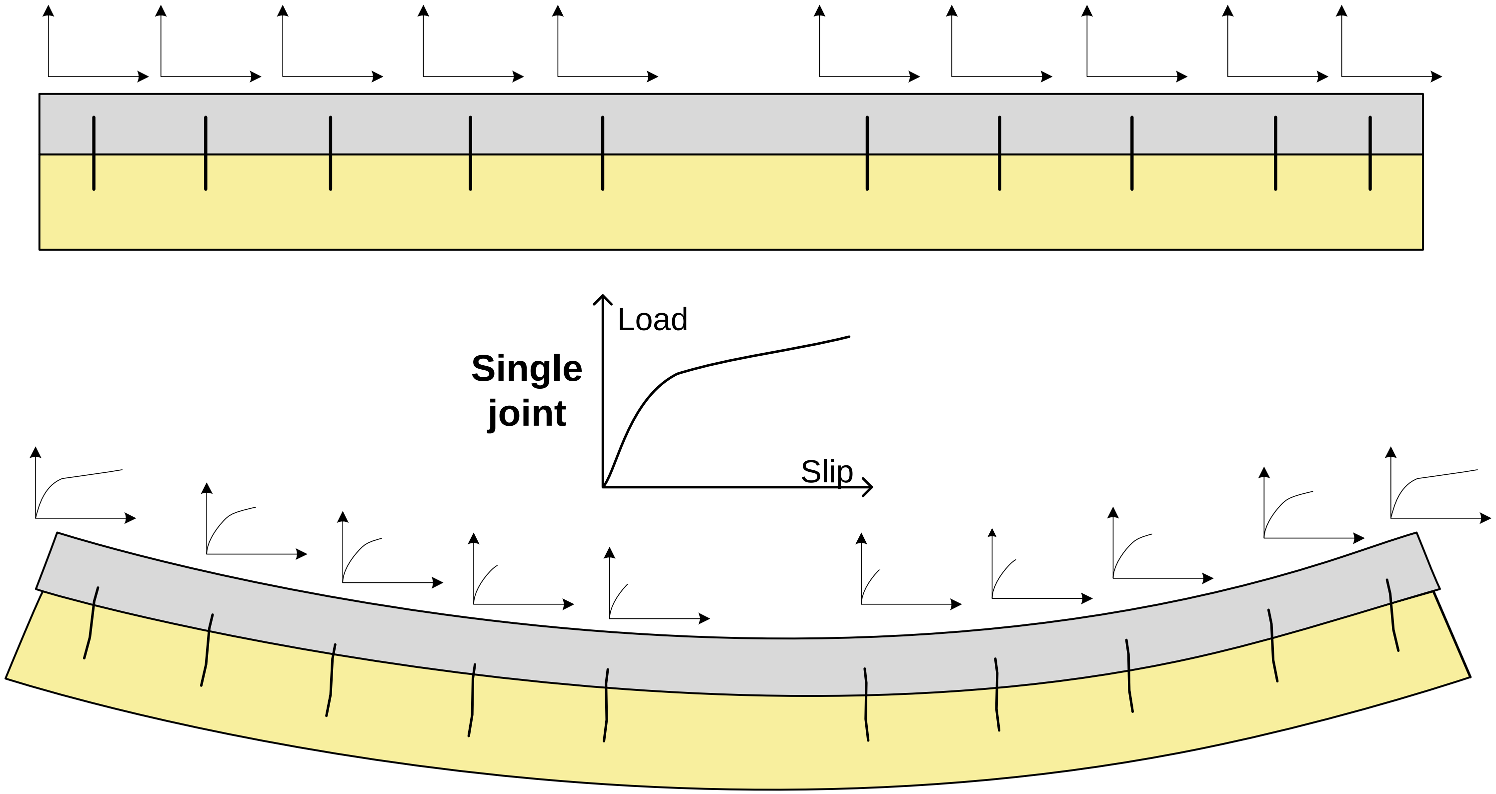
Alfredo Dias - Luís Jorge

Summary

1. Slip between timber and concrete in composite systems
2. Ductility evaluation with non-linear FEM analysis
3. Connection design
4. Concluding remarks

1 - Slip between timber and concrete

Composite timber-concrete structures mechanical behaviour



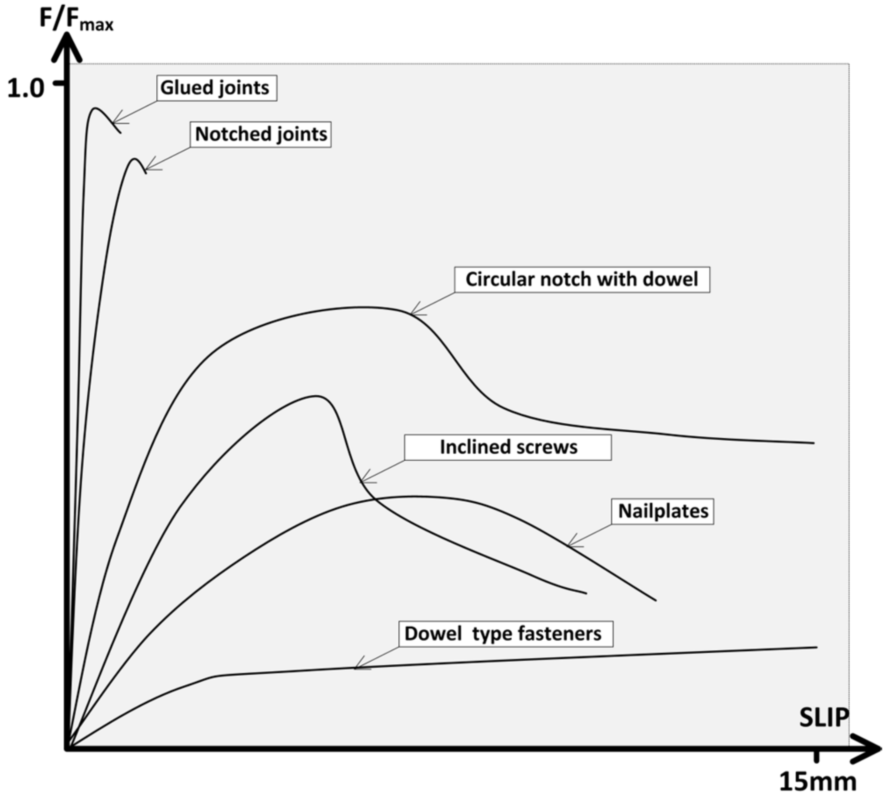
1 - Slip between timber and concrete

Maximum timber-concrete slip at the beam end is influenced by:

- **Materials mechanical properties**
- **Connections mechanical properties**
- **Geometric configuration of the system**

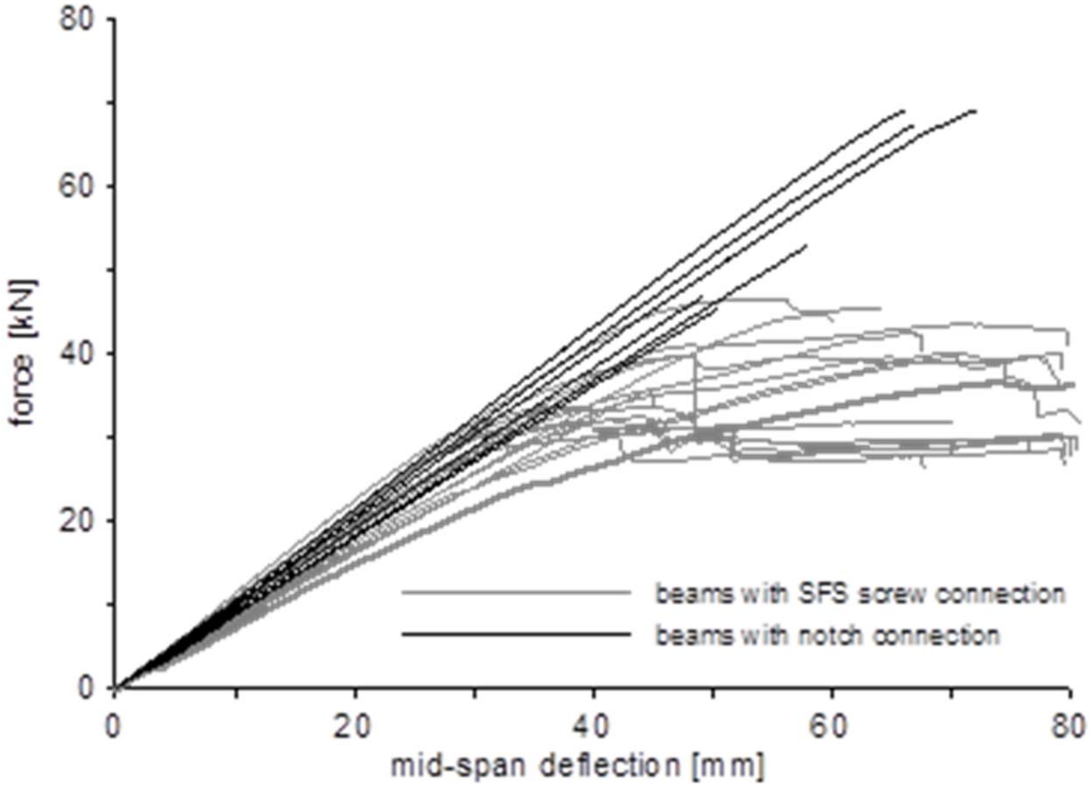
1 - Slip between timber and concrete

- Mechanical behavior of the connections highly dependent its configuration



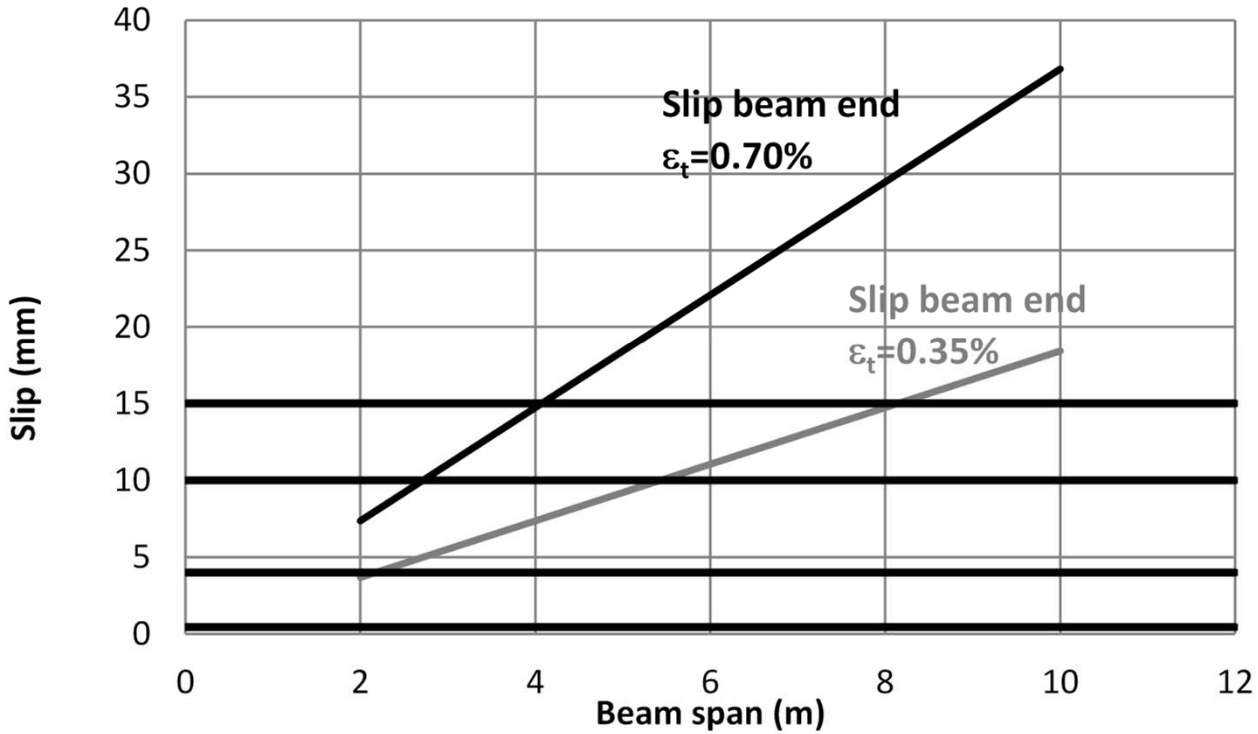
1 - Slip between timber and concrete

- Non linear behaviour of the connection is reflected on the mechanical behaviour of the composite systems



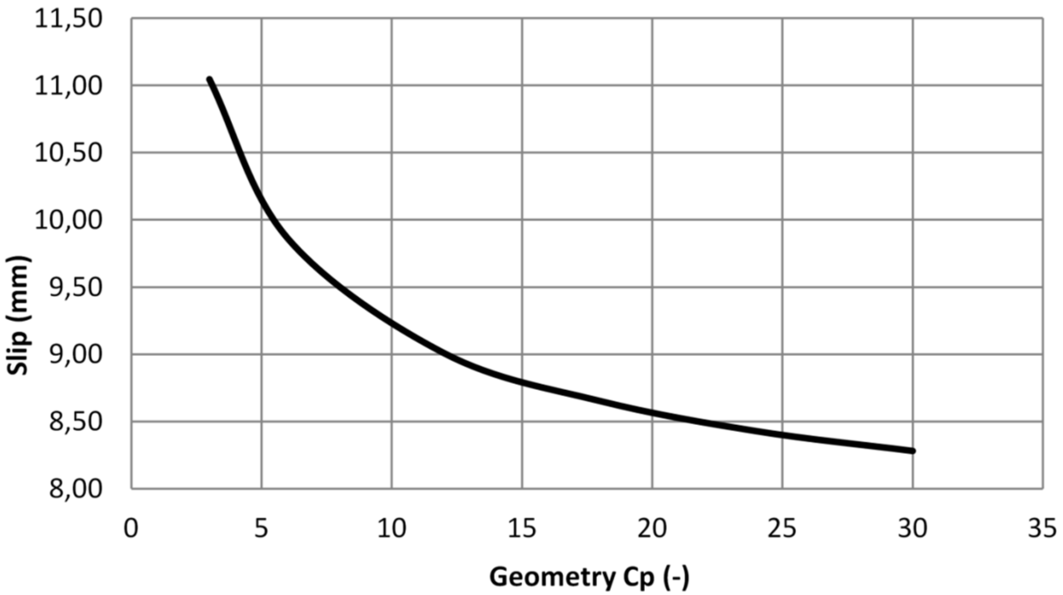
1 - Slip between timber and concrete

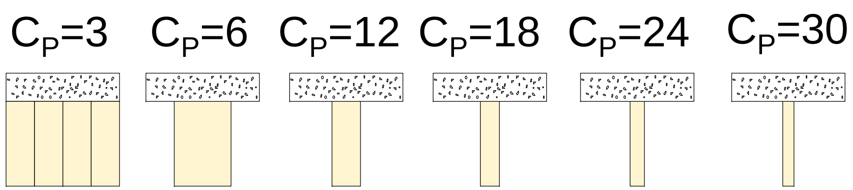
- **Maximum slip at the beam end highly sensitive to the timber failure strain and beam span**



1 - Slip between timber and concrete

- **Maximum slip at the beam end increases with the width/height ratio**

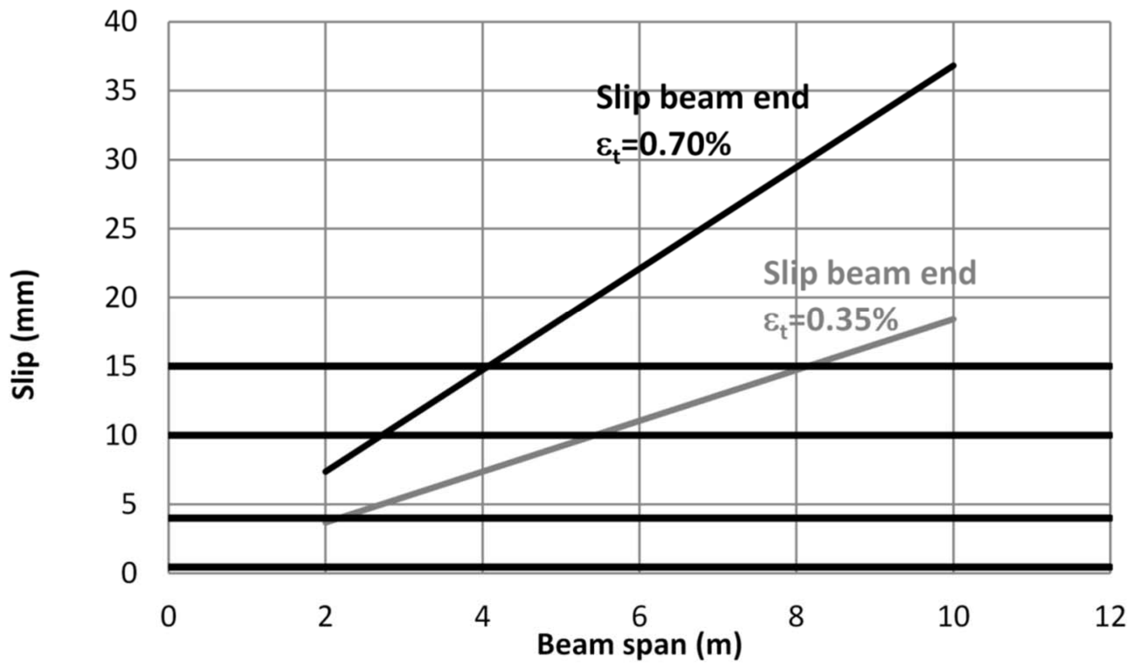




1 - Slip between timber and concrete

- **Connection ultimate deformation capacity within the values of the slip between timber and concrete at the beam end**

Connection	δ_{ult} (mm)
Nails	15
Screws	15
Dowels	15
Nail plates	10
Inclined screws	5
Steel mesh	4
Circular notch combined with dowels	15
Rectangular notches	0.5
Inclined glued-in rebar	2



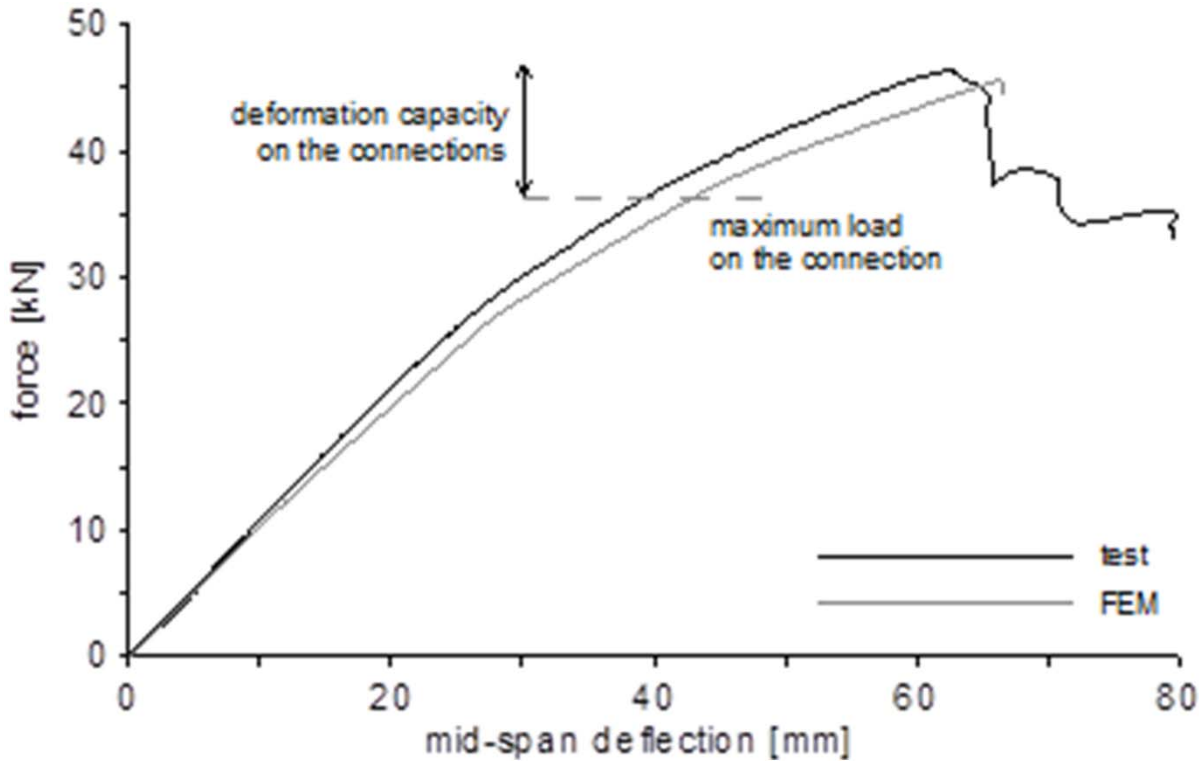
2 - Ductility evaluation with non-linear FEM

Assumptions of the analysis

- Non linear material behaviour of the connections
- Linear elastic behaviour of the materials
- Geometric configuration of the system corresponding to C_p equal to 3, 6, 12 and 24

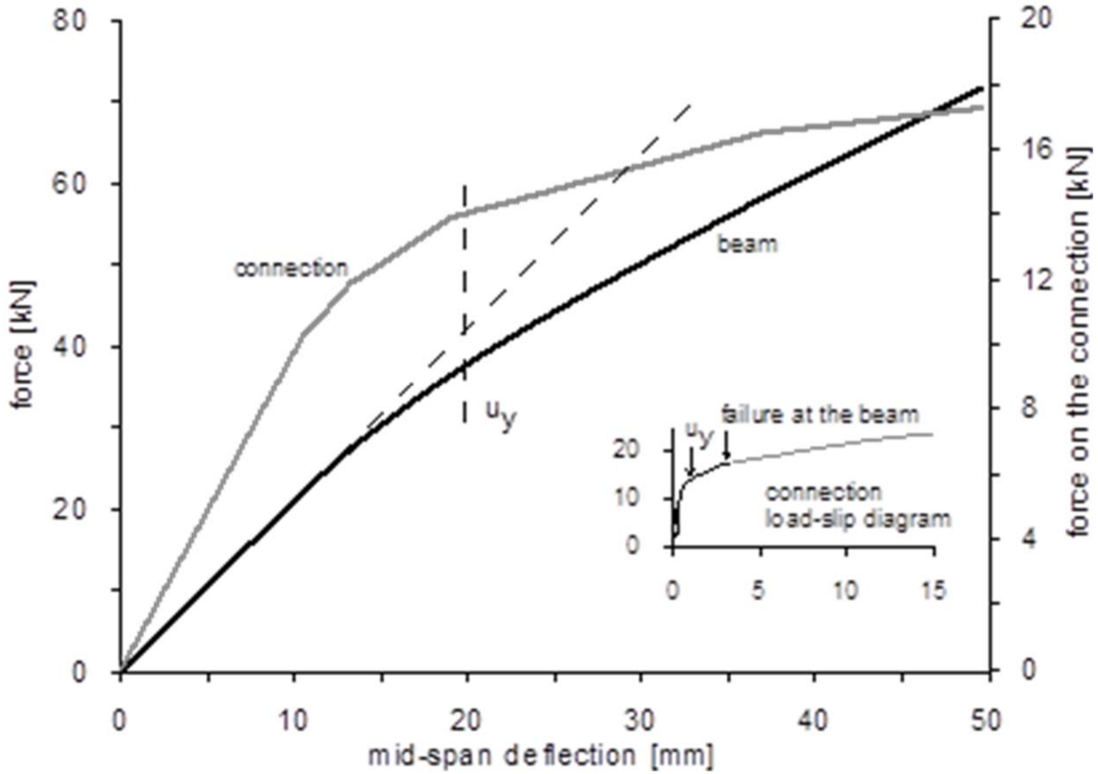
2 - Ductility evaluation with non-linear FEM

- **Significant increase in the load carrying capacity of the system after the joint maximum load carrying capacity is reached**



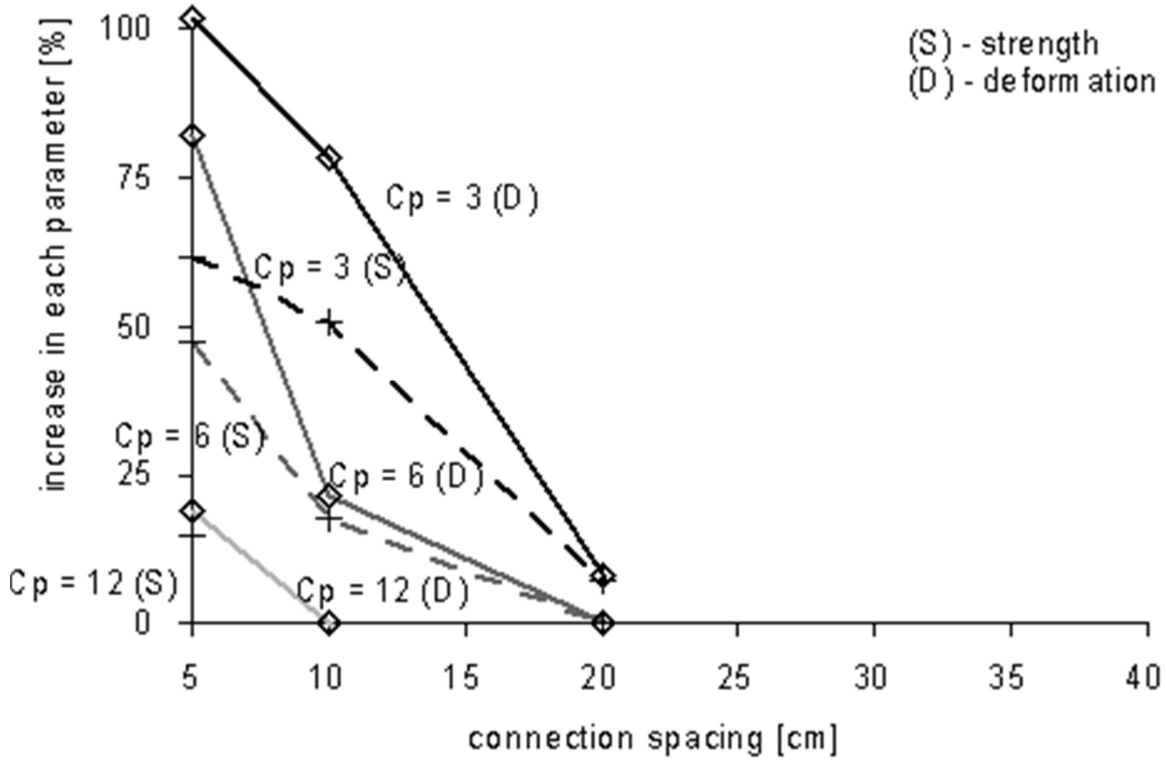
2 - Ductility evaluation with non-linear FEM

- Slip in the connection usually moderate



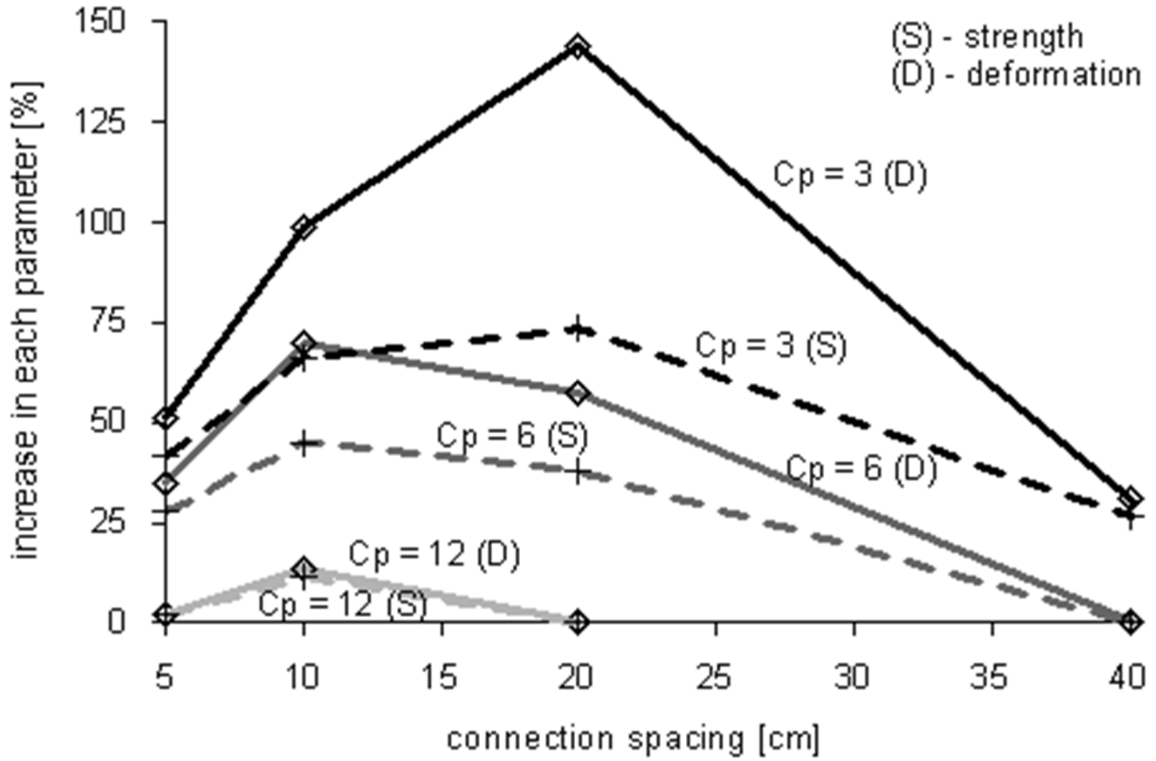
2 - Ductility evaluation with non-linear FEM

- **Significant increase in the load carrying capacity and mid span deformation for the glued-in rebars**



2 - Ductility evaluation with non-linear FEM

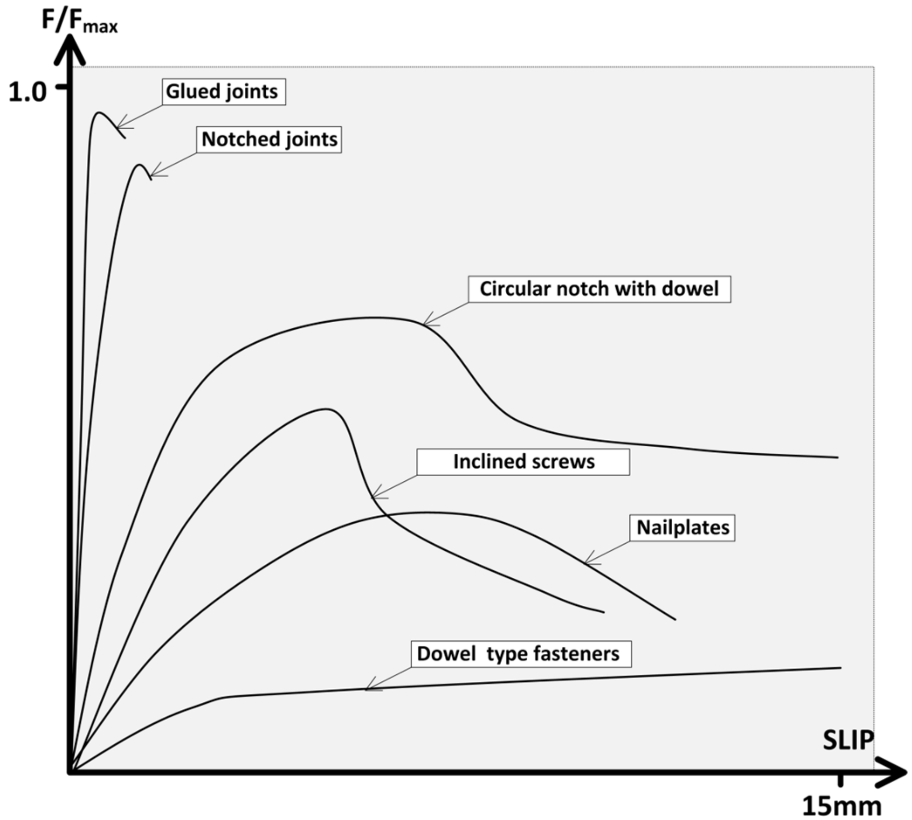
- Even higher increase in the load carrying capacity and mid span deformation for the inclined screws



2 - Ductility evaluation with non-linear FEM

- Ductility of the connection is reflected on the increase of the system load carrying capacity and mid-span deflection

Connection	Increase in the load-carrying capacity [%]	Increase in the mid-span deflection [%]
Glued rebar	62	102
Inclined screws	73	144
Dowel	87	143
Notch	0	0



3 - Connection design

Connection design

$$\begin{cases} K_s - \text{Stiffness} \\ F_{\max} - \text{Load carrying capacity} \\ \delta_{ult} - \text{Ultimate deformation capacity} \end{cases} \xrightarrow{Design} S - \text{Spacing}$$

3 - Connection design

What is the maximum ultimate deformation required in the joints in order to optimize the system load carrying capacity and eventually the mid span deflection?

$$\delta_{ult,connection} \geq \delta_{\max,beam-end}$$

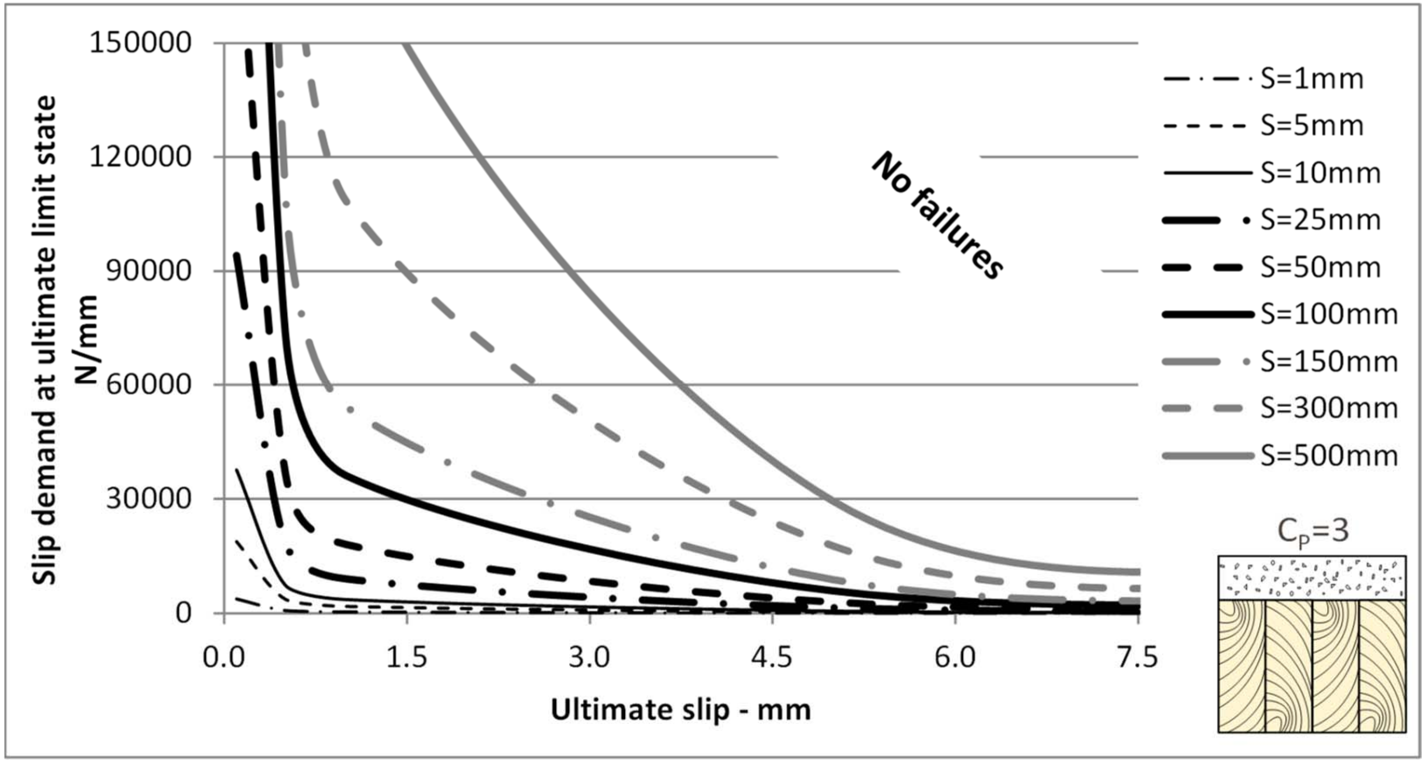
3 - Connection design

Assumptions of the analysis

- linear elastic behavior for materials and connections
- maximum load-carrying capacity of the composite system governed by a limit strain on the timber (ε_t=0.35)
- timber and concrete dimensions so as a C_p ratio equal to 3, 6, 12, 18 and 24 is obtained

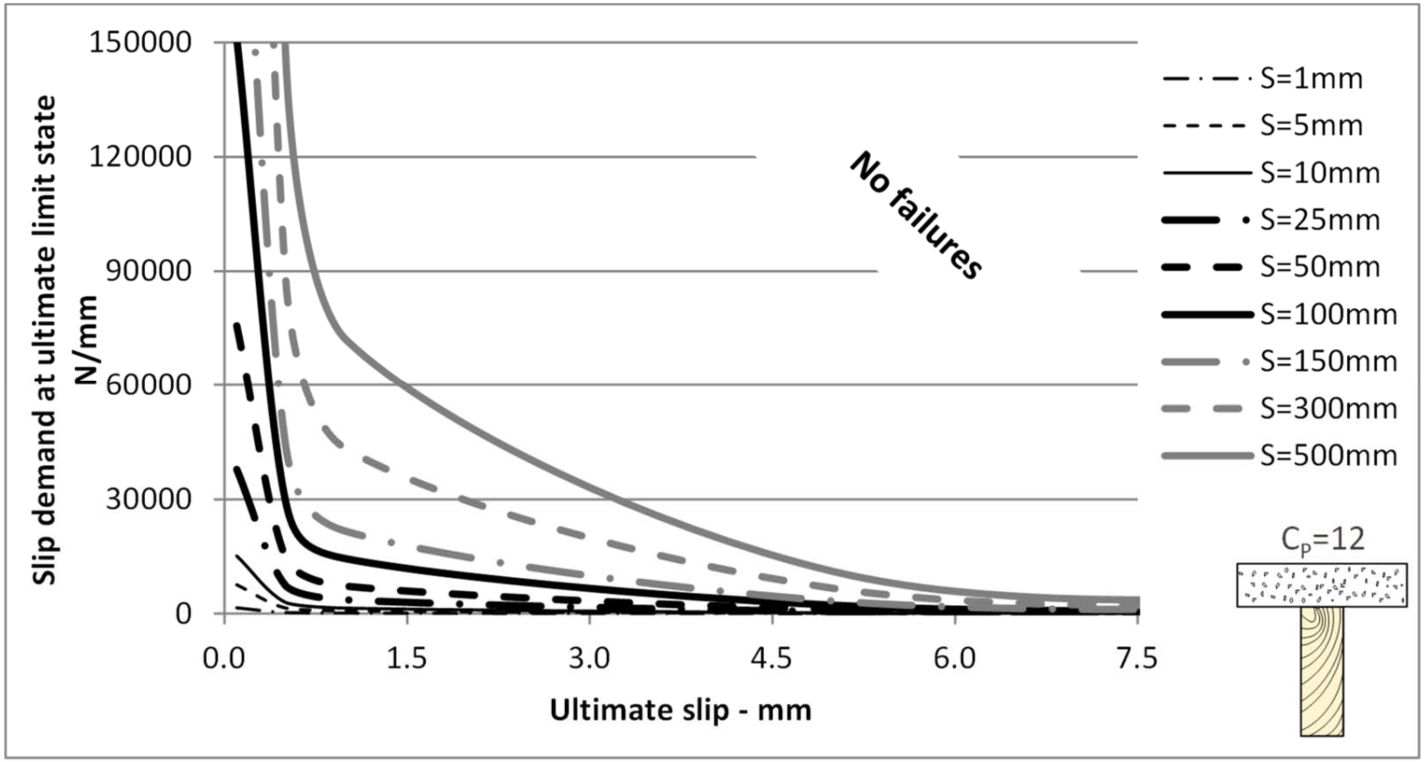
3 - Connection design

C_P=3



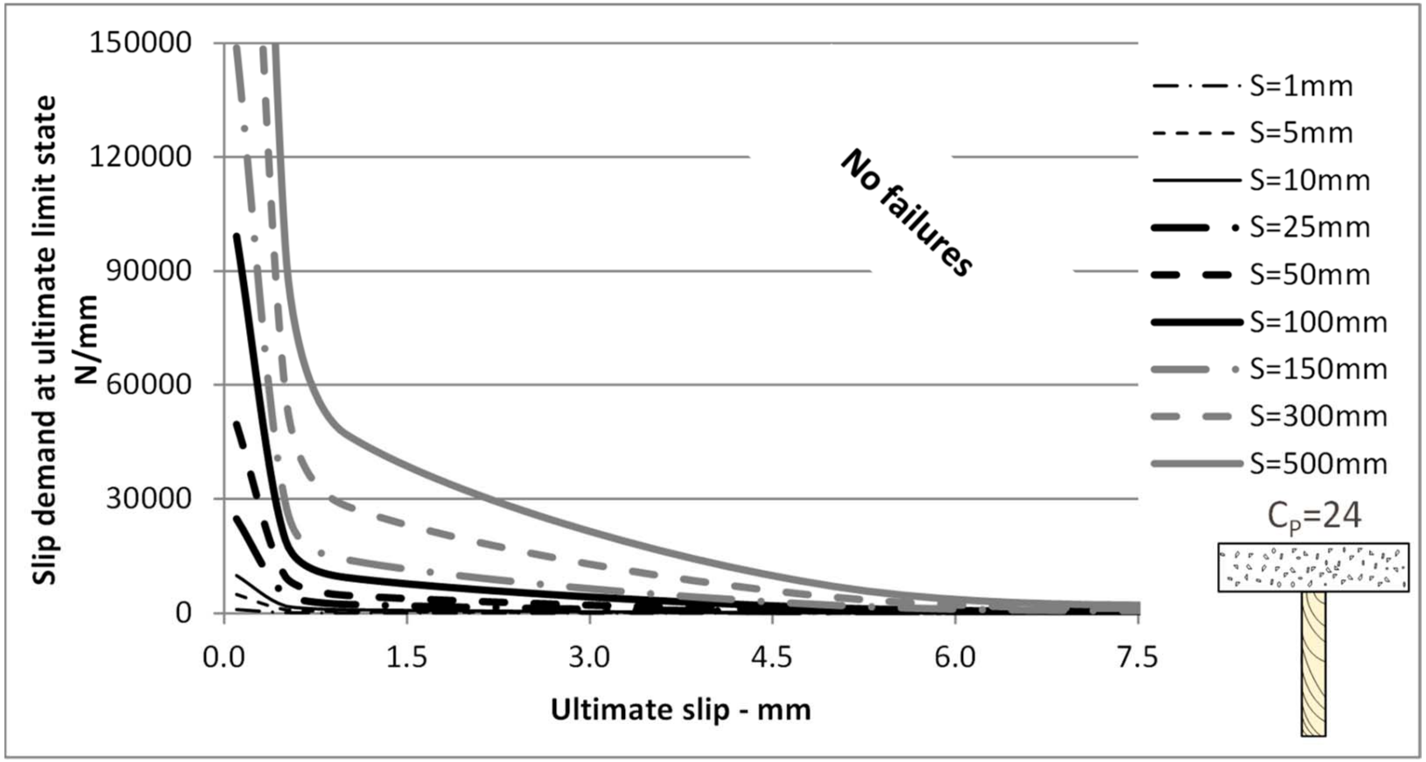
3 - Connection design

C_P=12



3 - Connection design

C_P=24



5 – Concluding remarks

- In some situations the deformation capacity of connections influence significantly the behaviour of composite systems

- The maximum slip at the beam end depends highly on the mechanical properties and on the geometry of the system

- Ductility of the connections can result in significant gains in the system's load-carrying capacity and in the maximum mid-span deflection

5 – Concluding remarks

- **Avoiding failures in connections maximize the system's load-carrying capacity and eventually the ultimate deformation capacity**

- **A connection spacing lower than 150 mm is usually enough to avoid failures in the connections**