Carmo Wood: about the Portuguese experience in timber construction
CARMO STRUCTURES
Carmo Wood: about the Portuguese experience in timber construction

Carmo Group

30
Years of history

10
Companies based in Portugal

4
Production units

400
workers

60
million euros in sales
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PRESENCE IN THE WORLD

- ONE OF THE EUROPEAN LEADERS IN INDUSTRIAL WOOD PRESERVATION
- DELEGATIONS IN SPAIN AND FRANCE
- EXPORT FOR MORE THAN 27 COUNTRIES
Carmo Wood is made up of a group of 12 companies based in Portugal, including a whole process of transformation, product creation and technical development.

Carmo Wood offers a wide range of products in sectors as agriculture, equestrian world, construction, tourism, leisure, security, and telecommunications.
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Carmo Structures emerges as response to a growing market

Carmo Structures not only provides structural solutions but it also conception/execution solutions

Treated wood as a key response (H4 as minimum)
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Agriculture  Garden and Urban Furniture  Playgrounds  
Woods  Wood Structures
C.C. PALACE OF ICE (VISEU)
HOTEL PESTANA PORTO SANTO (MADEIRA)
S. MARTINHO DO PORTO BRIDGE (LEIRIA)
PARC CADERA MERIGNAC OFFICES (FRANCE)
WALKWAYS PARQUE EDUARDO VII (LISBOA)
FIJO TÉCNICA
COBERTURA PISCINA QUARTEIRA (PORTUGAL)
Cliente: Comunidad Quarteira Pórtico: 31m
Área: 2000m²
Materia: Madera laminada
SWIMMING POOL OF PORTELA (LISBON)
PAIVA WALKWAYS – AROUCA
ALVOR RESTAURANT - ALGARVE

HOTEL DAKAR (SHERATON AND CLUB MED)
Glulam structures: some Portuguese case studies

A. Feio, P. Cruz & A. Pinto
Timber played a role in the collective life of medieval societies: festive events, military constructions, maritime expansion during the XV century.

Great relevance of carpenters during the period of the reconstruction of downtown Lisbon (1755).

Internal timber wall and floor arrangement in a composite timber-masonry wall of the “Pombalino” system.
Composite wooden structure of plummets, crosspieces and diagonal lines, filled by masonry, constituting a 3D frame of very high ductility and with an excellent anti-seismic behaviour.
Throughout the history, some unforeseen events have severely damaged important historical cities, causing important heritage losses.

In these situations, the intervention is urgent in order to protect cultural objects, as well as to reestablish people’s security and restore the natural balance of the affected communities.
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Experimental Research with Timber (Carmo Wood/LNEC/UMinho)

Traditional timber carpentry joints: monotonic tests and modeling
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Destructive test set-up

Legend

LVDT

Extendable Threaded System

Support Plate

Load Cell

Metal Plate

A - A'

View 1

1

2

View 1

4; 5

25°

Rigid Bars

Support Plate

Extendable Threaded System
Timber structural design was dominated by carpenter know-how, resulting from tradition and empirical knowledge.

The bearing capacity of mortise and tenon joints is a function of the: 1) angle of the connection, 2) length of the toe and mortise depth.

Objectives:
1. The behaviour of a traditional mortise and tenon timber joint using physical testing of full-scale specimens.

2. Nonlinear finite element analysis to better understand the behaviour observed in the full-scale experiments, in terms of failure mode and ultimate load
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Experimental failure patterns observed: a) joint collapsed in compression, with damage localized at the toe, b) joint collapsed in compression, with uniform distribution of damage, c) joint collapsed in compression, with out-of-plane bulging and d) combined failure in compression and shear parallel to the grain at the toe.
Traditional timber carpentry joints: monotonic tests and modeling

The values have been obtained from the experimental tests

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<th>$E_x$</th>
<th>$E_y$</th>
<th>$G_{xy}$</th>
<th>$\nu_{xy}$</th>
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<th>$f_{c,x}$</th>
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<td>45 N/mm$^2$</td>
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</table>
Traditional timber carpentry joints: monotonic tests and modeling

Stiffness of the IE has influence in the yield strength and global behaviour of the joints.

Numerical results, with adjusted stiffness for the IE, provide very good agreement with the experimental results.

With $K_{\text{inf}}$ increase of the yield strength (+ 266.7%) and of the stiffness (+ 17%).
Traditional timber carpentry joints: monotonic tests and modeling

Effects of the Material Parameters

- Variation of the normal stiffness of the interface ($k_n$)
  - reduction 50% $\leftrightarrow$ decreases 6% the strength of the joint and 25% the stiffness
  - increasing 100% $\leftrightarrow$ increases 6% the strength of the joint and 25% the stiffness

- Variation of the tangential stiffness of the interface ($k_s$)
  - ultimate strength is insensitive
  - reduction/increasing of 15% the stiffness of the joint
Traditional timber carpentry joints: monotonic tests and modeling

- Strength is almost insensitive to $E_{xx}$ and $E_{yy}$ variation

- Reduction/increasing of $E_{xx}$ and $E_{yy}$ ↔ reduction/increasing of 14% of the stiffness of the joint

- Strength and stiffness of the joint are insensitive to $f_{c,x}$ variation

- Variation of $f_{c,y}$
  - stiffness is insensitive to the variation
  - reduction of 50% and increasing of 100% ↔ reduction/increasing $\approx 26\%$ of the strength
Despite the wide use of mortise and tenon joints in existing timber structures scarce information is available for design and in situ assessment.

Two different wood groups have been used: reducing the defects to a minimum, no influence could be attributed to service time. Thus, safety assessment of new timber structures, made from old or new wood elements, can be made using similar mechanical data.

The failure mechanism and load-displacement diagrams observed in the experiments are well captured by the used non-linear finite element analysis.

The parameters that affect mostly the ultimate load of the timber joint are the compressive strength perpendicular to the grain and the normal stiffness of the IE.