On-going R&D Projects in COST Member Countries

(Nov. 2011)

Countries H-P

Ireland

National University of Ireland, Galway

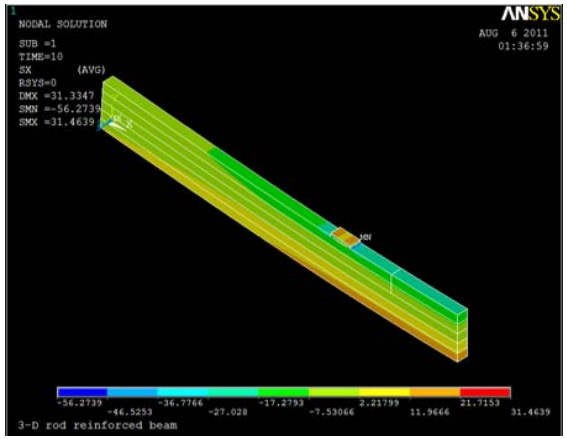
College of Engineering and Informatics

Bonded-in GFRP rods for repair and strengthening of glulam beams

Objective: Investigate the use of NSM GFRP rods for reinforcement of glulams made with low-grade Sitka spruce

- Compare strength and stiffness of reinforced and unreinforced specimens (EN408)
- Different reinforcement percentages examined (single and double)
- Different groove geometry examined
- 3-D non-linear finite element analysis
- Investigate repair of artificially fractured glulams

Bonded-in GFRP rods for repair and strengthening of glulam beams



NSM BFRP rods for the repair and strengthening of glulam beams

Objective:

Investigate the use of NSM BFRP rods for reinforcement of glulams made with low-grade Sitka spruce

- Evaluation of adhesives for bonding BFRP rods to wood
- Strength and stiffness of reinforced and unreinforced glulams (EN408)
- Strength and stiffness evaluation of repaired artificially fractured glulams

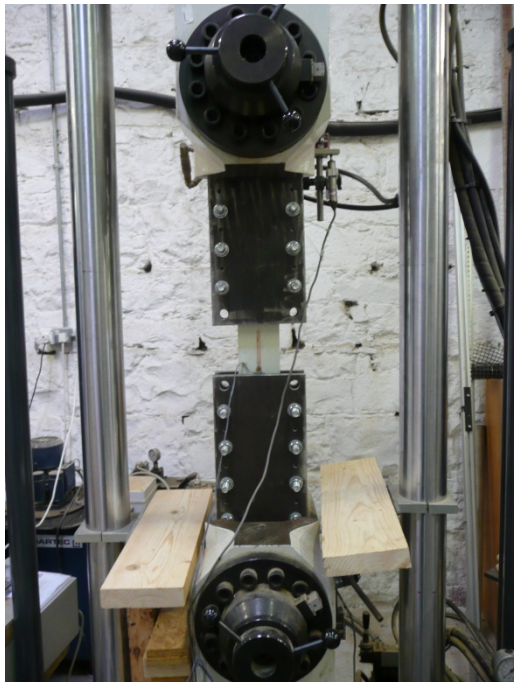
NSM BFRP rods for the repair and strengthening of glulam beams

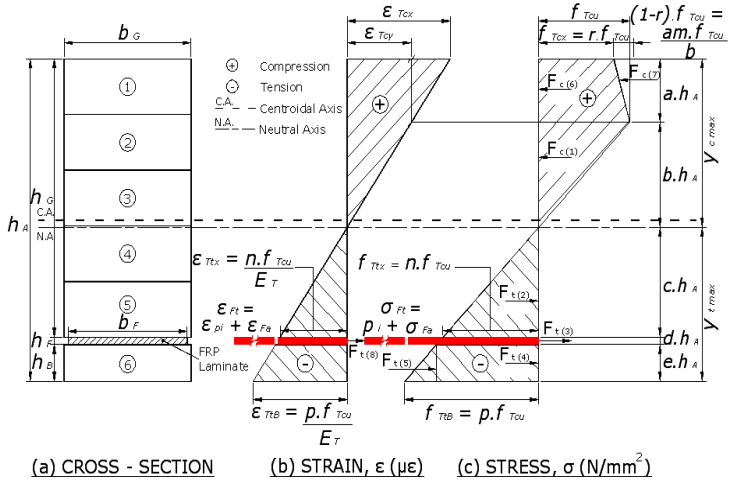
Prestressed FRP flexural reinforcement of glulam beams

Objective: Investigate the use of prestressed pultruded GFRP laminates for reinforcement of glulams made with low-grade Sitka spruce

- Develop analytical model to predict structural behavior of prestressed glulam beams
- Design and manufacture rig to prestress pultruded GFRP plates
- Investigate bondline behavior at FRP-wood interface
- Manufacture and test glulam beams reinforced with FRP plates with different levels of prestress

Prestressed FRP flexural reinforcement of glulam beams





Italy

Universities of Sassari & Trieste

Ivalsa Trees and Timber Institute

FederlegnoArredo & CNR Ivalsa

University of Trento

Mechanical and Structural Engineering

Universities of Sassari & Trieste
Ivalsa Trees and Timber Institute

Seismic resistance of XLam walls and connections

- Objectives: to characterize the hysteretic behavior of coupled and single Xlam walls, and typical connections (angle brackets, hold-downs, screwed joints)
- Cyclic Tests: Investigated properties include deformations, ductility, dissipated energy, impairment of strength, overstrength

Further on-going work:

- Further experimental tests on coupled walls with optimized connections
- Development of an analytical model for the prediction of the backbone (nonlinear monotonic) curve of single and coupled walls

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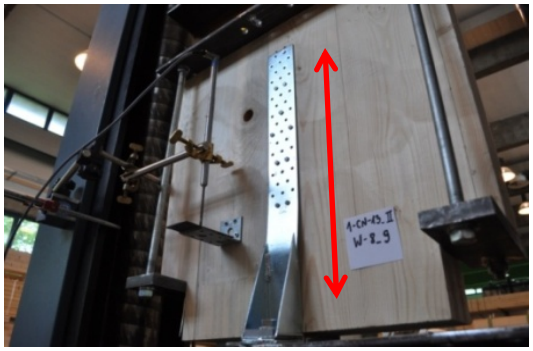
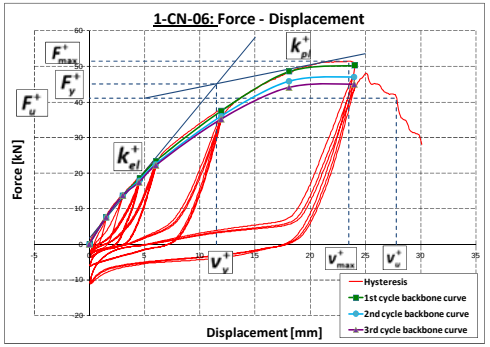
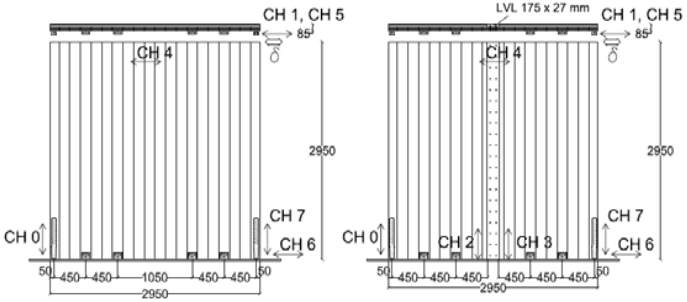
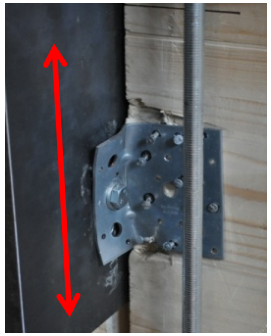
Ivalsa Trees and Timber Institute

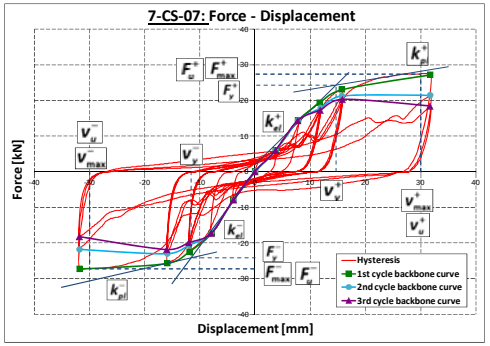
Seismic resistance of XLam walls and connections











Univ. of Sassari, Trieste & Eindhoven
FederlegnoArredo & CNR Ivalsa

Innovative seismic resistant multi-storey buildings made of glulam

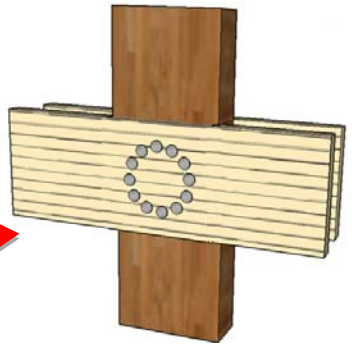
- Objectives: to develop new glulam solutions for seismic resistant multi-storey buildings for non residential applications
- Use of different lateral load resistant systems: moment-resisting frames with high ductility joints, and cantilevered walls
- Preliminary design of a case-study 4-storey building undertaken

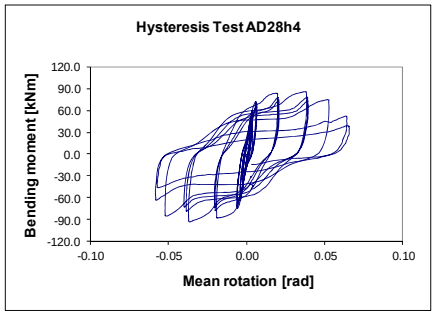
Further on-going work:

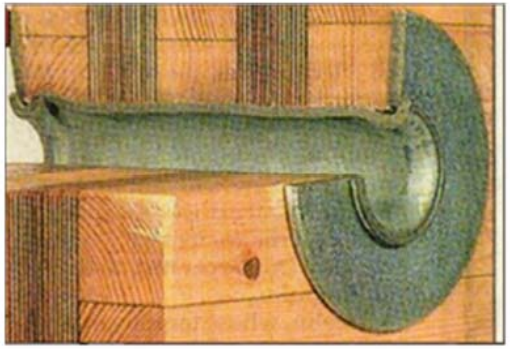
- Experimental cyclic tests on cantilevered glulam and Xlam walls
- Numerical (time-history and pushover) analyses of the entire building under seismic actions to assess the behavior factor *q*

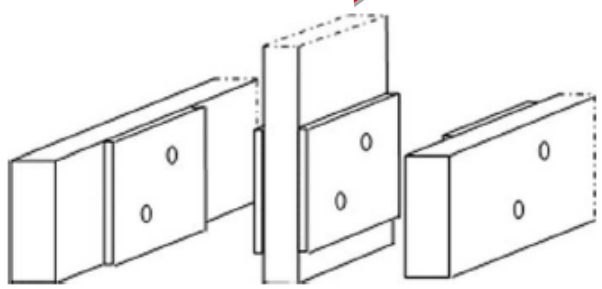
Univ. of Sassari, Trieste & Eindhoven
FederlegnoArredo & CNR Ivalsa

Innovative seismic resistant multi-storey buildings made of glulam









Universities of Sassari & Trieste
Kassel University

Optimization of timber multi-storey buildings against earthquake

- Objectives: to optimize the seismic performance of multi-storey (lightframe and XLam) timber buildings via suitable connections
- Investigation of some case study buildings
- Extensive experimental program (under monotonic and cyclic loading) of connections, lightframe and XLam walls (Univ. of Kassel)
- Development of an advanced hysteretic model for connections

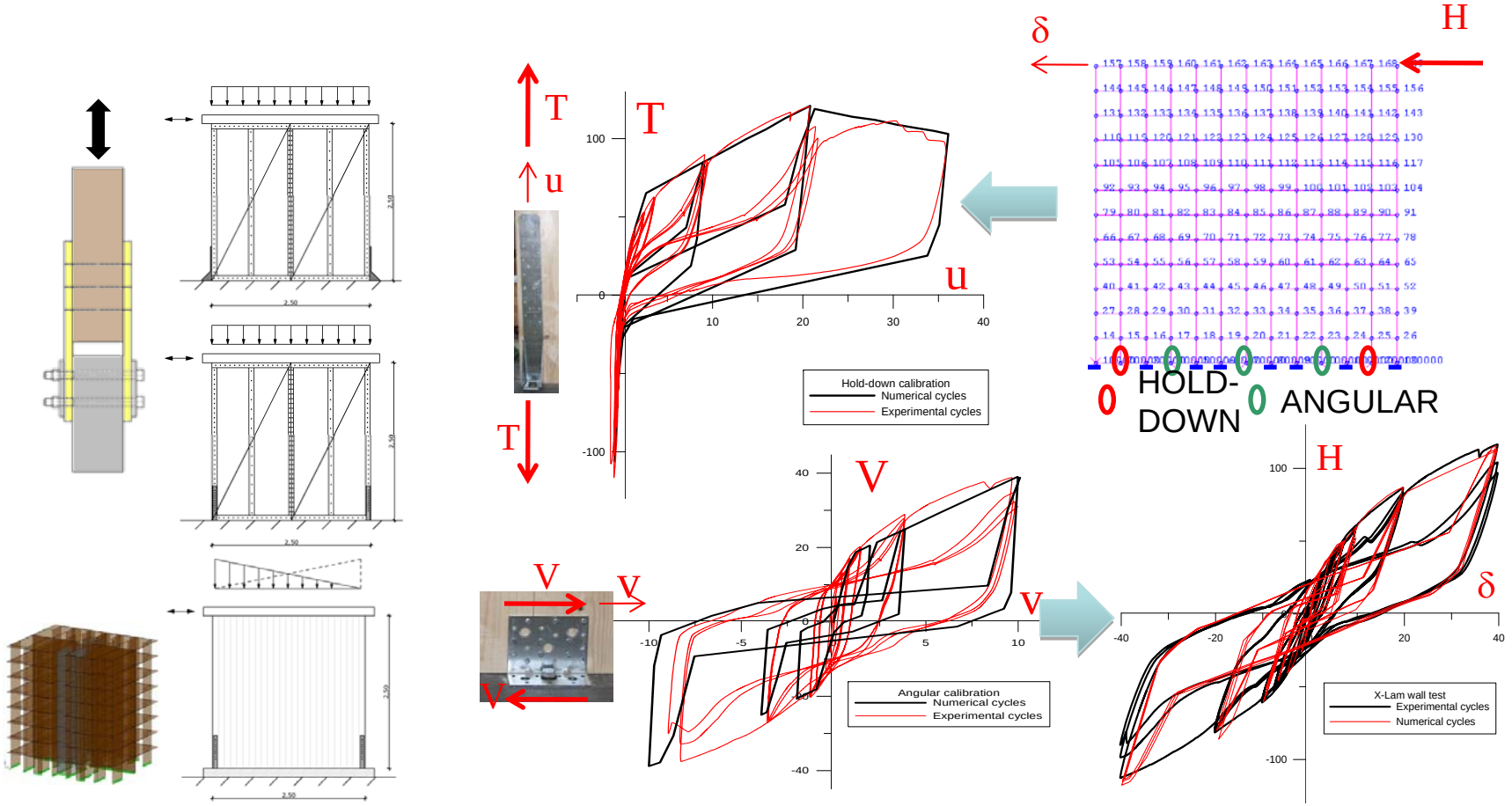
Further on-going work:

- Completion of experimental program, model calibration
- Parametric study on entire buildings using the numerical model, optimization of the seismic performance, and evaluation of *q*-factor

Universities of Sassari & Trieste

Kassel University

Optimization of timber multi-storey buildings against earthquake



Seismic behavior of timber frame multi-storey buildings

- Objectives: to characterize the mechanical behavior of connections system and structural components in timber frame multi-storey buildings, with special regard to their seismic performance;
- Monotonic and cyclic test on connection system and shear walls, shaking table test of three storey full scale building

Further on-going work, next steps etc.

- Development of a force displacement model for different geometrical configuration of timber frame shear walls;
- Data analysis of shaking table test, validation of the numerical models.

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Mechanical and Structural Engineering

Seismic behavior of timber frame multi-storey buildings

1 Connection systems → 2 Shear walls → 3 Shaking table test

EXPERIMENTAL PHASES

Seismic behaviour of XLam multi-storey buildings

- Objectives: to characterize the mechanical behavior of connections system (hold-down and angle brackets) and structural components, with special regard to seismic performance
- Monotonic and cyclic test on connection system and shear walls

Further on-going work

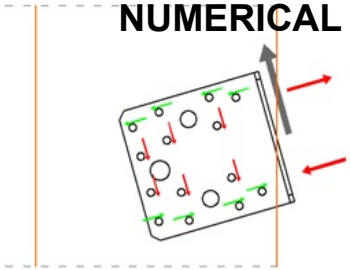
- Experimental data analysis
- Validations of simple engineering model and FEM model in order to characterize the stiffness properties of connections system
- Estimate the seismic dissipation energy and the over-strength factor of connection systems

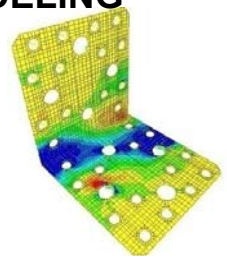
Seismic behaviour of XLam multi-storey buildings

EXPERIMENTAL

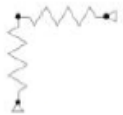
HOLD - DOWN

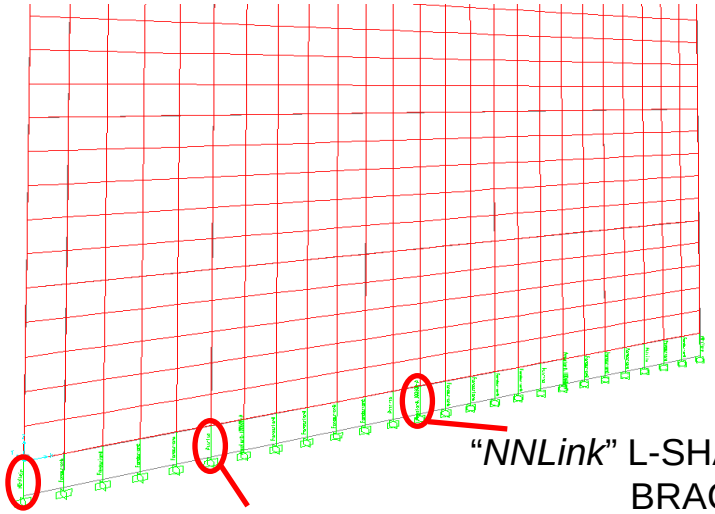
NUMERICAL MODELING





L-SHAPED BRACKETS





System devoted to attain timber components with ductile behavior

- Objectives: to investigate method and technologies aimed to increase local and global ductility on structural elements and components;
- Semi-rigid steel to timber end joint have been investigated adopting a “component method” approach.

Further on-going work

- Push-over analysis on multi-storey timber framework with semi-rigid steel to timber end joint (determine behavior factor for design)
- Extend the “component method” and the capacity design approach to other connections system in order to apply modern seismic design principia to timber structures

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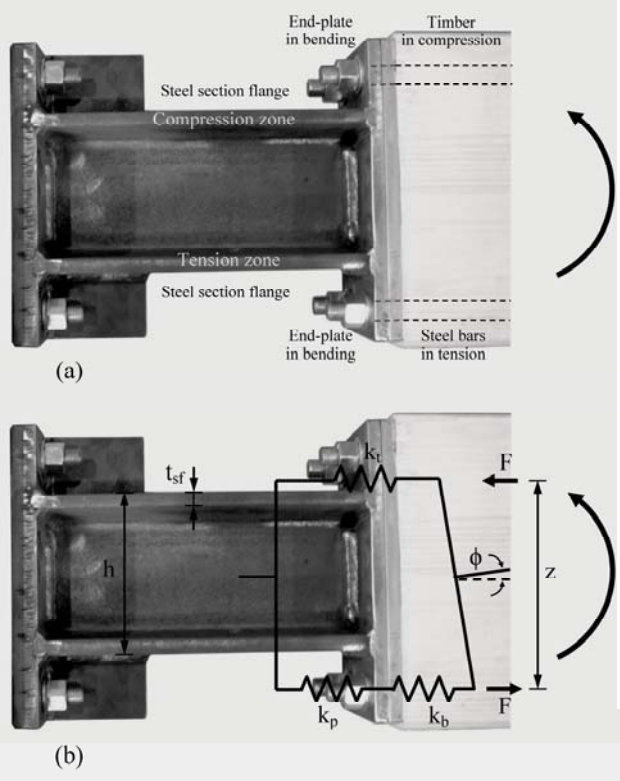
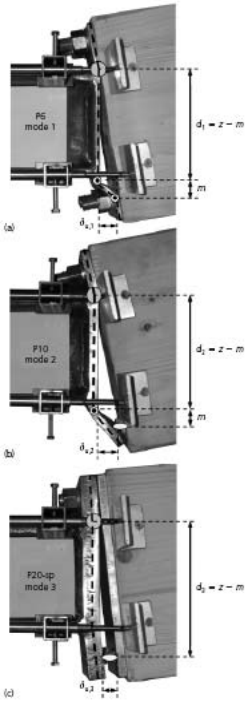
Mechanical and Structural Engineering

System devoted to attain timber components with ductile behavior

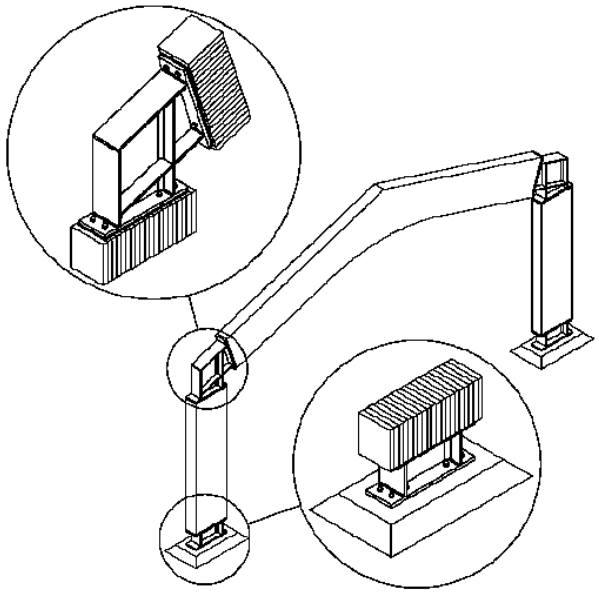
COMPONENT METHOD





Failure modes

PUSH-OVER ANALYSIS ON MULTI-STOREY TIMBER FRAMEWORK



Self-tapping screws in timber joints and elements

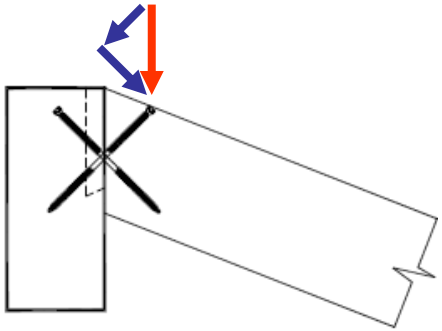
- Objectives: to investigate method and technologies aimed to increase mechanical performance of timber joints and elements by means of self-tapping screws
- Calculation of the load-bearing capacity and stiffness of screws placed in an inclined position with respect to the shear plane
- An application on refurbishment of timber floor has been proposed

Further on-going work

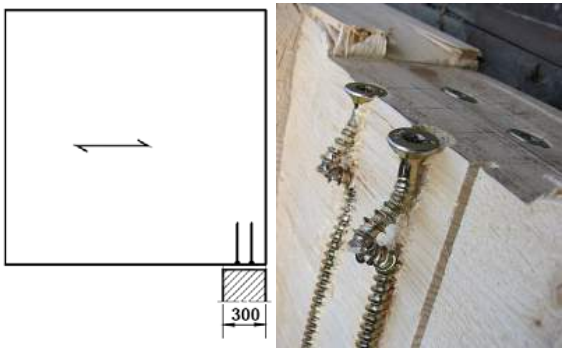
- Explore usage of self-tapping screws on weak zone in timber structures
- Apply engineering methods for component design in weak zone

Self-tapping screws in timber joints and elements

SECONDARY BEAM CONNECTION

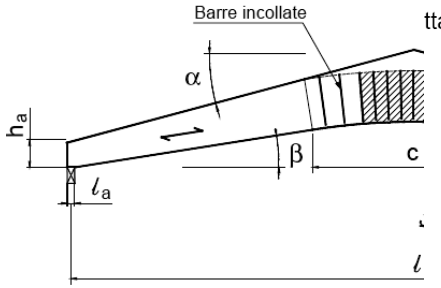


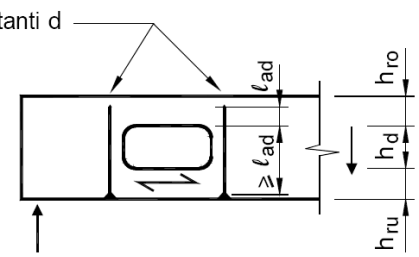
COMPRESSION PERP. TO THE GRAIN

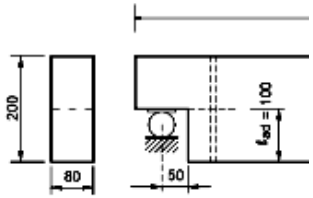


REFURBISHMENT OF EXISTING TIMBER FLOOR WITH WOOD-WOOD COMP. STRUCT.

TENSION PERPENDICULAR TO THE GRAIN







Splitting strength of timber beams

Objectives: investigate the parameters which affect the splitting strength of timber beams;

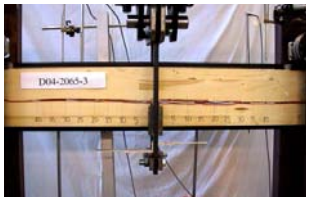
Physical tests and numerical parametric analyses have been performed and a reliable semi-empirical prediction formula has been derived.

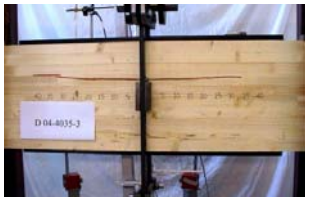
Further on-going work, next steps etc.

- investigate, by means of new numerical analyses in LEFM framework, the influence of different joint configurations and new parameters;
- compare the results of the numerical analyses with the outcomes of tests performed by different researchers and with predictions of different approaches.

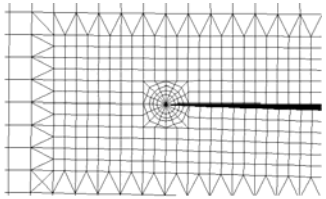
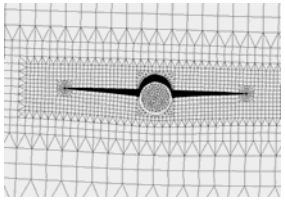
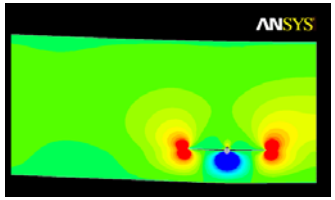
Splitting strength of timber beams

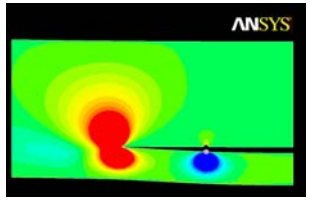
EXPERIMENTAL TESTS



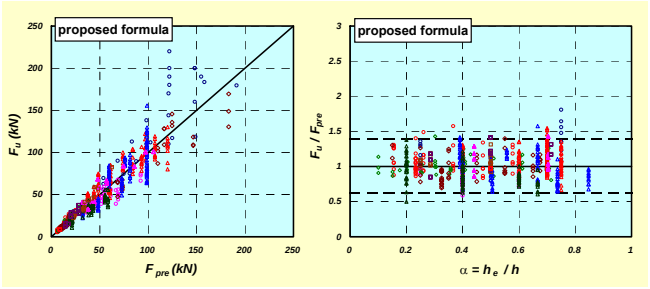


NUMERICAL ANALYSES

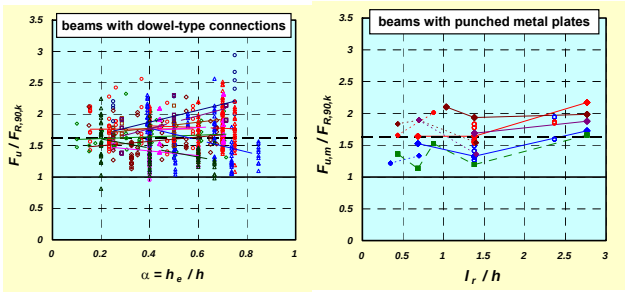






FAILURE DATA vs PRED. STRENGTHS



FAILURE DATA vs PRED. CHARACTERIC VALUES



Effective bending capacity of dowels and self-tapping screws

Objectives: determine the “effective plastic moment” of dowel-type fasteners needed for the evaluation of the load carrying capacity of dowel-type timber joints;

The definition of a physical test set-up able to provide the overall moment-rotation curve of fasteners has been already done as well as a number of physical tests on dowels and self-tapping screws.

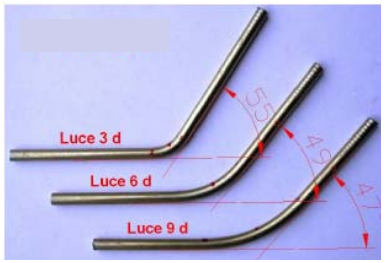
Further on-going work, next steps etc.

- extend the physical investigation to different fasteners;
- derive a relationship between the actual plastic moment of fasteners and the “effective ones” for dowel-type strength evaluation.

Effective bending capacity of dowels and self-tapping screws

EXPERIMENTAL MACHINE

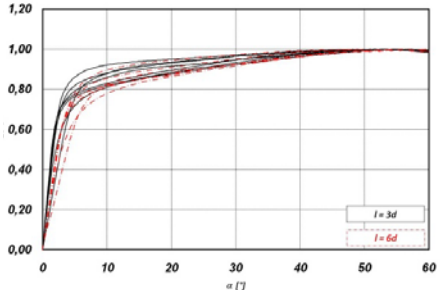
INVESTIGATED FASTENERS



NORMALIZED BENDING CAPACITY

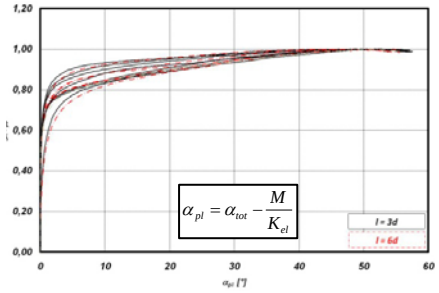
$$g_i(\alpha) = \frac{M_i(\alpha)}{M_{\max,i}}$$

VS TOTAL ROTATION



$$g_i(\alpha) = \frac{M_i(\alpha)}{M_{\max,i}}$$

VS PLASTIC ROTATION



Embedding strength of European spruce for different load / grain direction angles and fasteners – dowels or self-tapping screws

Objectives: investigate the influence of loading angles and of type of fasteners on the load-displacement relationship and on the load carrying capacity;

Experimental tests: different fasteners (dowel and self-tapping screws), different grain orientation with respect to loading direction, and different ways to fastener positioning.

Further on-going work, next steps etc.

- perform a detailed analysis of experimental data;
- derive a relationship able to take into account the influence of different investigated parameters.

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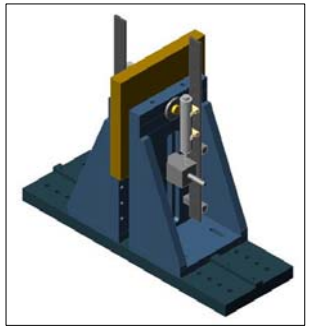
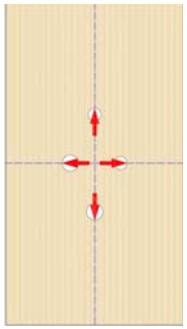
Mechanical and Structural Engineering

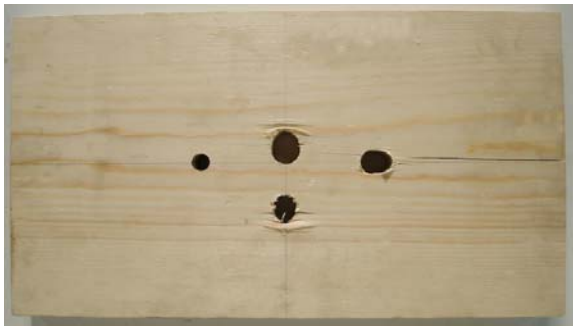
Embedding strength of European spruce for different load / grain direction angles and fasteners – dowels or self-tapping screws

EXPERIMENTAL MACHINE



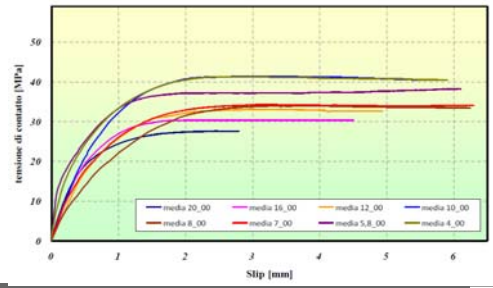
SPECIMENS GEOMETRY



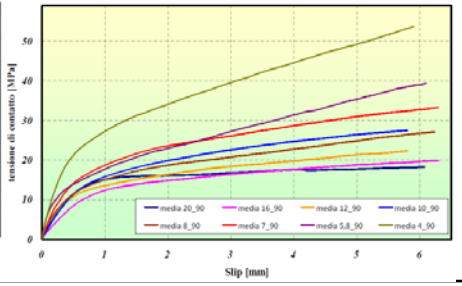


DOWEL FASTENERS
AVERAGE BEARING STRESS – SLIP CURVES

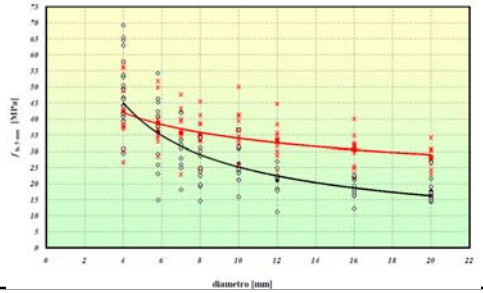
PARALLEL-TO-GRAIN



PERPENDICULAR-TO-GRAIN



DOWEL FASTENERS
EMBEDDING STRENGTH
vs FASTENER DIAMETER

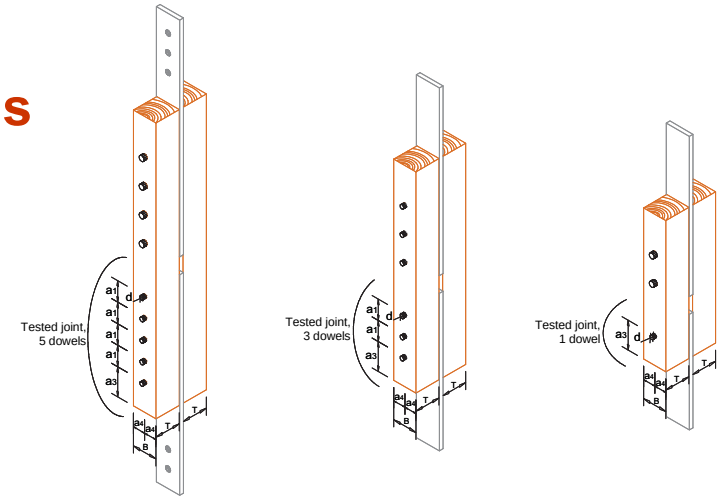


Netherlands

Delft University of Technology

Civil Engineering Department

Double-shear timber joints with slotted-in steel plates and high strength steel dowels



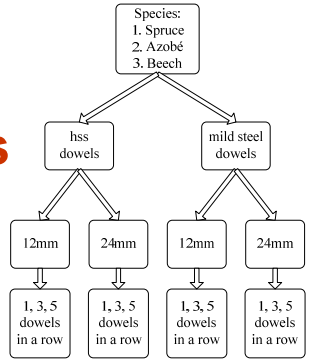
Objective:

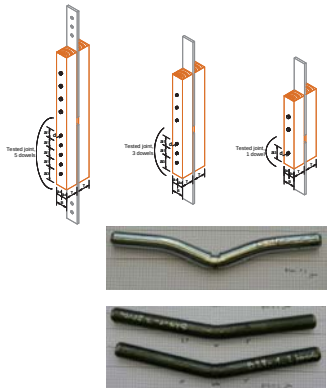
Enhance load-carrying capacity by replacing mild steel dowels with HSS dowels

- Show that joints with HSS dowels are able to reach failure modes 2 or 3 where plastic hinges develop in the dowels
- Compare behavior and results of identical joints except for the steel grade of the used dowels, mild steel and high strength steel
- Look into multiple-dowelled joints → with 1, 3 and 5 dowels in a row
- Use other wood species than softwood → beech, azobé

Delft University of Technology
Civil Engineering Department

Double-shear timber joints with slotted-in steel plates and high strength steel dowels

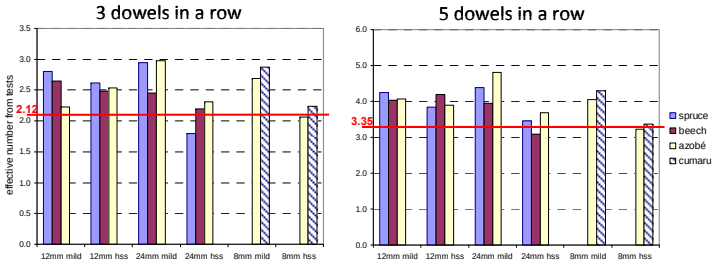




- Evaluate effective number of fasteners
- Validate FEM modeling approaches

Further on-going work, next steps etc.

- FEM modeling to describe joint behavior in both SLS and ULS
- Derive enhanced expression for fastener yield capacity of HSS fasteners



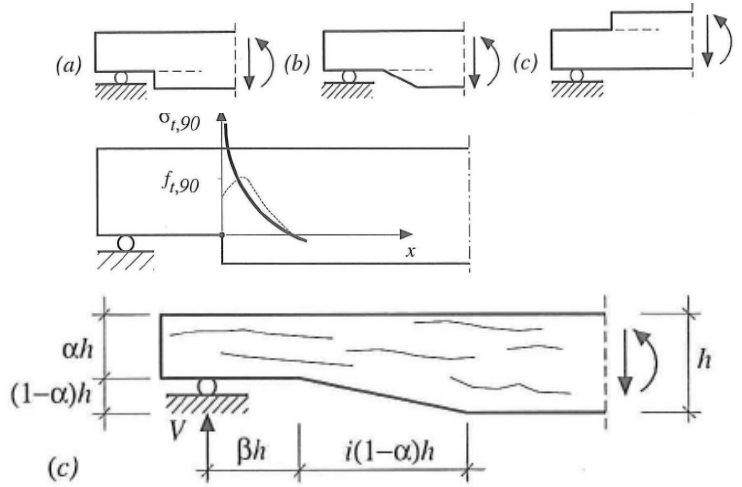
	number of dowels	F(hss)/ F(mild)	
		12mm dowel	24mm dowel
spruce	1	1.38	1.50
	3	1.29	0.92
	5	1.25	1.18
beech	1	1.18	1.44
	3	1.10	1.29
	5	1.22	1.13
azobé	1	1.26	1.69
	3	1.43	1.31
	5	1.21	1.30

Capacity of notched beams

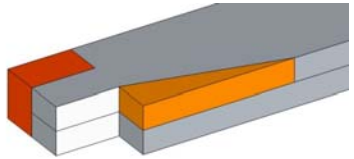
Objectives:

- Development of technical specs for tropical species of hardwood
- Study influence of notch geometry for sawn sections of tropical hardwoods

- Frequently used connection detailling in lock gates of Azobé (Ekki)
- Engineers encounter capacity problems when designing acc. to EC5

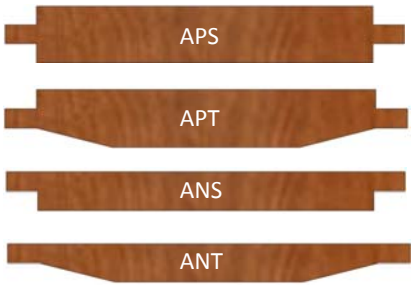


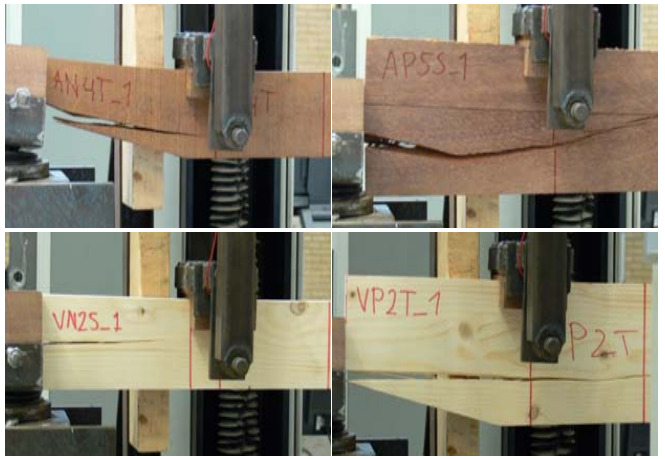
Capacity of notched beams



- EC5 reduction factor k_v based on tests on softwood
- Compare results of identical joints for Spruce, Azobé (Ekki)
- Shear strength figures in EN338 for Ekki (D70) are reduced, compared to 'old national values'

$$\tau_d = \frac{3V_d}{2b\alpha h} \leq k_v f_{v,d}$$

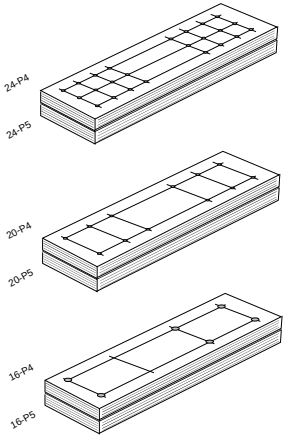


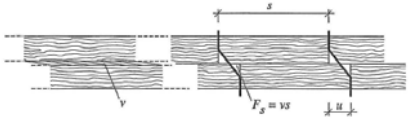


Further on-going work, next steps etc.

- experiments to be continued
- other hardwood species

Slip modulus of doweled connections for tropical species

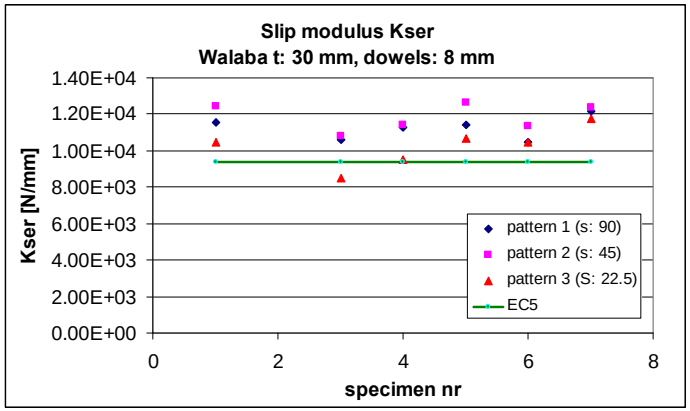




Development of technical specs for tropical species of hardwood

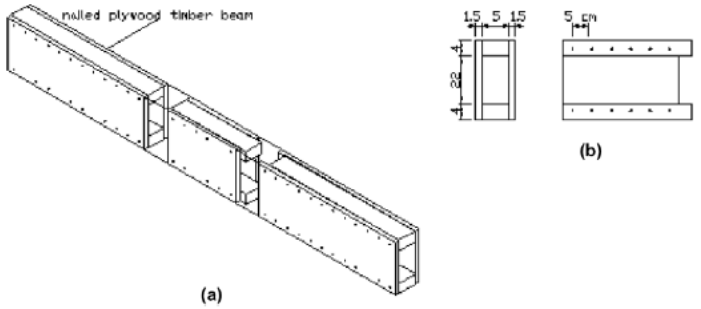
- Validate the EC5 expression for slip modulus K_{ser} for steel dowels in hardwoods
- Evaluate effective bending stiffness of simple composites for different connection arrangements
- Use other wood species than softwood
  → Walaba, Azobé (Ekki) and compare

Slip modulus of doweled connections for tropical species



Further on-going work, next steps etc.

- Experiments on LVL
- Combine high density species with wood based panel (LVL) in a beam with a box-section
- Experiments on other tropical species
- Examine effective joint stiffness in SLS and ULS (K_{ser} vs. K_u)



Norway

Norwegian University of Science and Technology

Department of Structural Engineering Trondheim

NTNU
Norwegian University of Science and Technology

Department of Structural Engineering,
Trondheim, Norway.

Rigid joints for large timber structures

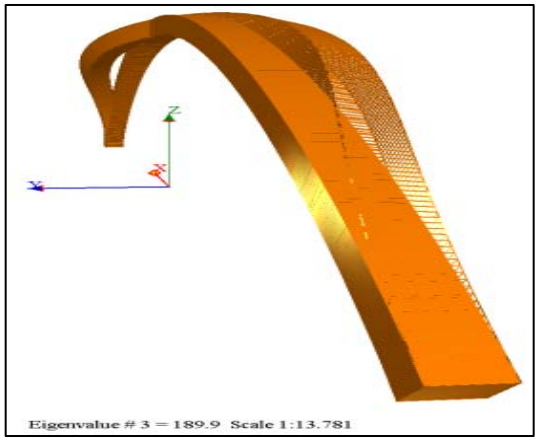
Objective is to develop technology for high stiffness of joints in large timber structures.

- Rotational stiffness
- Moment carrying joints
- Prefabrication

Rigid joints for large timber structures

Applications are:

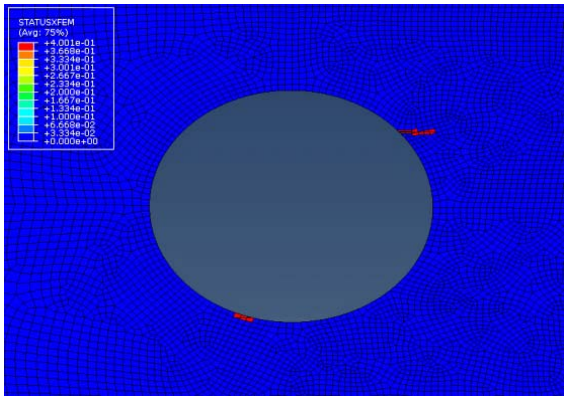
- Multistory timber structures
- Cantilevered beams
- Clamped columns at the footing in large timber buildings
- Sideway stiffening of arches at the footing of timber bridges
- Splicing of large arches
- Joining wood components to steel- or concrete-parts

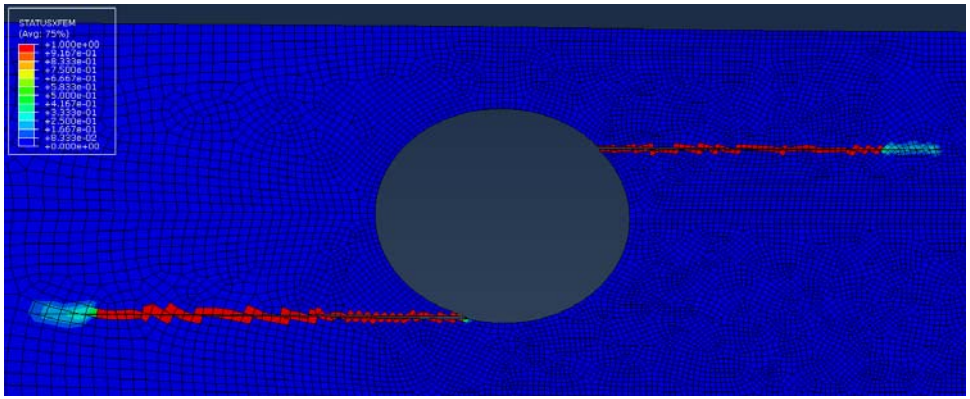


Modeling of connectors in wood

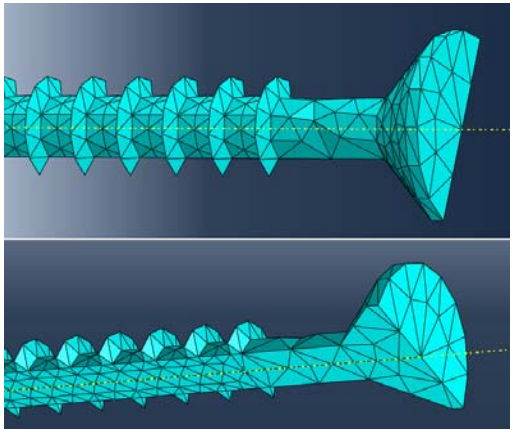
Objective is to explore the FEM technology for metal connectors (screws) in wood materials

- FEM orthotropic parameters
- Contact and interaction of wood and metal connector
- Fracture mechanics and XFEM crack modeling



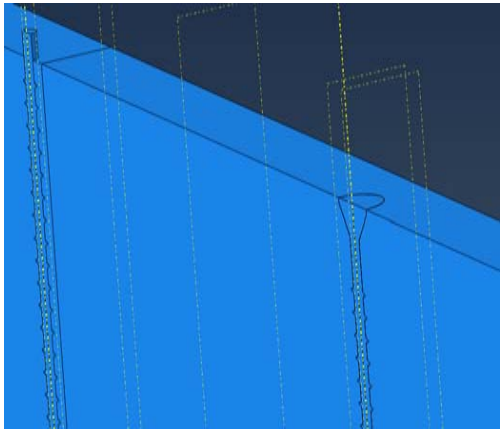


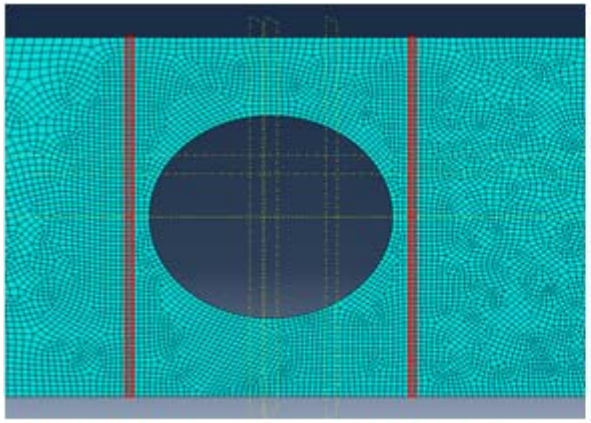
Modeling of connectors in wood



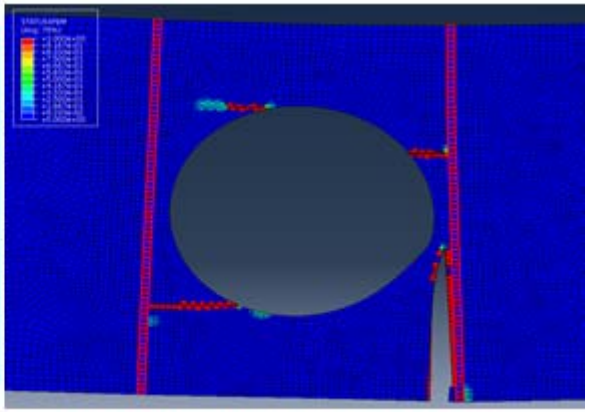
Applications are:

- Fastening wood to other material (wood?)
- Reinforcement around holes
- Reinforcement for local contact forces





i) Bjelkegeometri, med skrueregioner markert i rødt.



ii) Sprekkutvikling ved slutt av analyse for B5_p3.

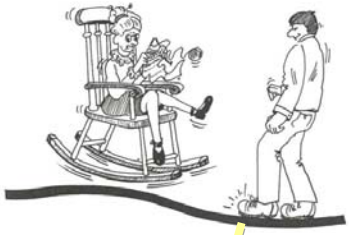
NTNU
Norwegian University of Science and Technology

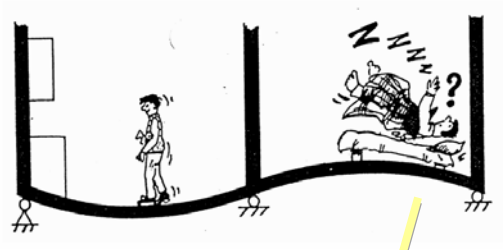
Department of Structural Engineering,
Trondheim, Norway.

Vibration and comfort properties of timber structures

Objective is to explore the damping mechanism in timber structures and develop FEM models for vibration problems.

- Measurements
- Characterization of wood
- Characterization of connections and interface elements





NTNU
Norwegian University of Science and Technology

Department of Structural Engineering,
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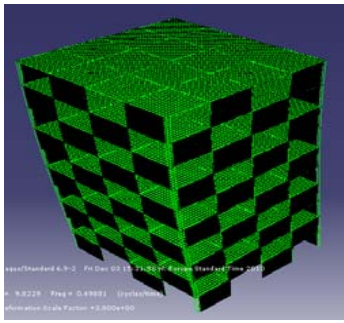
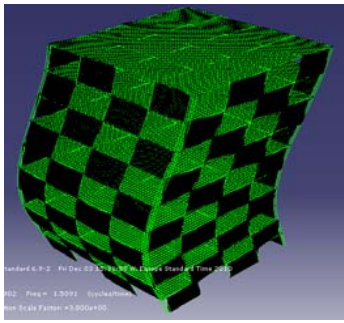
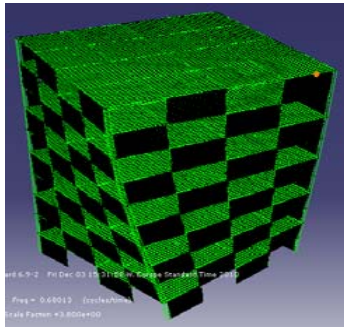
Vibration and comfort properties of timber structures



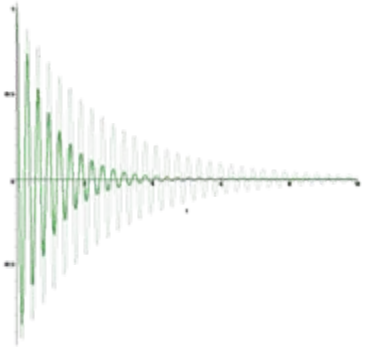




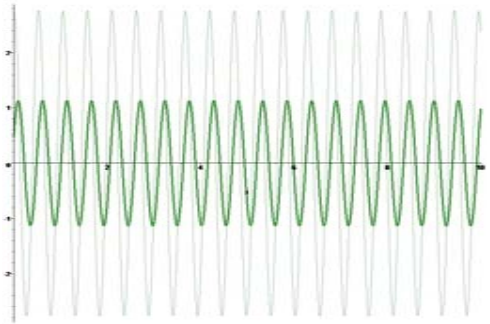
Applications are:

- Human and wind induced vibrations
- Timber floors and multi-storey timber buildings

Transient vibrations

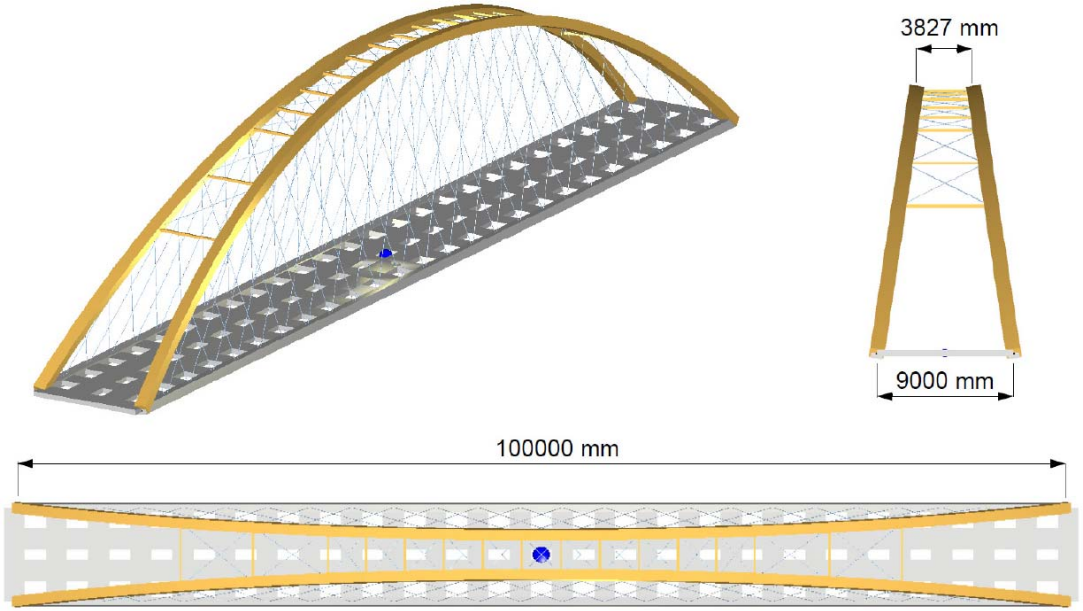


Periodic excitation



Long span timber arch bridges

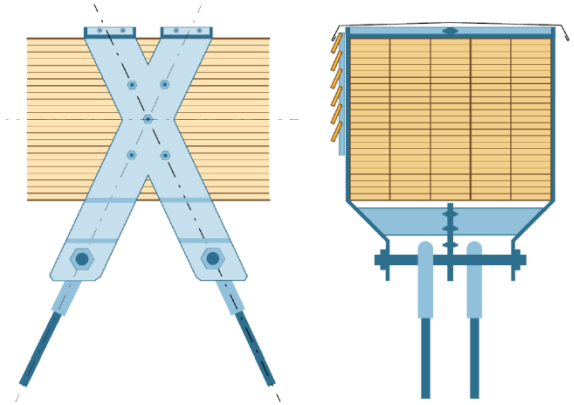
The objective is to develop efficient structural systems, e.g. network arches:



Long span timber arch bridges

and also

- efficient and durable details,
- transverse stiffness,
- manufacturing long arches (joining techniques)



Fundamental problems to be resolved:

- volume factor (k_{vol})
- combination of moment induced tension perpendicular to grain and shear

Nonlinear (geometric) analysis as basis for design

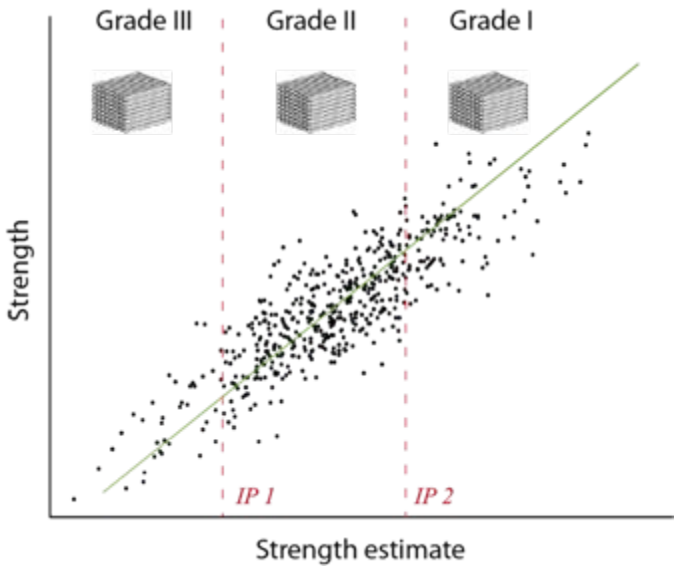
What are

- appropriate material stiffness parameters (*E* and *G*)?
- appropriate geometric imperfection – shape and size?
- appropriate design criteria for combined bending and axial compression?

Timber grading

- is an efficient way to reduce variability in material properties.
- This project is focused on the probabilistic modelling of the grading process and the implementation of advanced ICT in the entire grading procedure.

→ Decrease uncertainty
→ Enhance performance



Strength of glued laminated timber

- Glued laminated timber is a promising high performance engineered material.
- Variable experience, especially with high strength classes.
- The objective is to find better ways for the reliable strength prediction and classification.

Approach:

- Literature and data surrey, Experiments
- Probabilistic modelling / response surface methodology
- Quality Control

→ Increase knowledge → Enhance performance

Poland

Warsaw University of Life Sciences
Faculty of Wood Technology

Wrocław University of Technology
Institute of Building Engineering

Mechanical properties of thermally modified polish sawn timber

- Testing mechanical properties MOR, MOE according EN 408
- Sawn timber made of pine, oak, beech and ash wood
- Testing properties using ultrasounds

Status: going

Polish sawn timber local reinforcment using composite tapes

- Testing mechanical properties MOR, MOE according EN 408
- Testing mechanical properties using Timber Grader
- Sawn timber made of pine wood
- Testing sawn timber with holes in botom zone with and without reinforcment
- Reinforcment made of glass fiber and resin

Status: going

Mechanical properties of modified sawn timber beams

- Testing mechanical properties MOR, MOE according EN 408
- Sawn timber made of pine wood reinforce using innovative methods
- Optimization of reinforcement using FEM

Status: planned

Inovative methods of modifications of timber glulam girders by using internal reinforcement

Objectives:

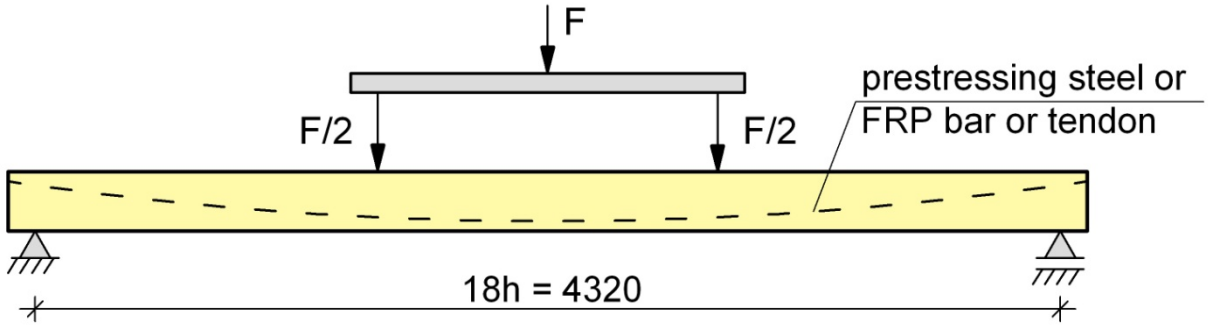
- Determine the static behaviour of glulam beams reinforced during their production by means of innovative technologies
- Assess the suitability of the proposed technologies for the industry

By reinforcing glulam beams through prestressing and using reinforcing surface (SRG, FRP) inserts it will be possible to use poorer quality timber and timber of smaller cross-sectional size (from small-size wood) for glulam structural elements.

→ reduction in construction costs and management of timber resources

Inovative methods of modifications of timber glulam girders by using internal reinforcement

- Example of specimen



- Deformations measuring methods:
  strain gauges, photoelastic coating technique (PCT),
  video extensometers, digital close range photogrammetry,
  3D laser scanning, structural light and computer image analysis.

  Status: on-going project

Portugal

Polytechnic Institute of Castelo Branco

University of Coimbra

Department of Civil Engineering

Laboratório Nacional de Engenharia Civil, Lisboa

Timber Structures Division

University Lusíada

Department of Architecture

Polytechnic Institute of Castelo Branco & University of Coimbra, Dep. of CE

Cross-laminated timber

This project intend to monitor a swimming-pool totally build with cross-laminated timber elements.

Special details and characteristics will be addressed:

- Flat slab under service class 2 conditions;
- Walls and ceilings made with CLT visible elements in the dressing rooms and all others;
- Point load in walls;
- Suspended CLT panels in the swimming-pool hall;
- Effect of high moisture in CLT elements.

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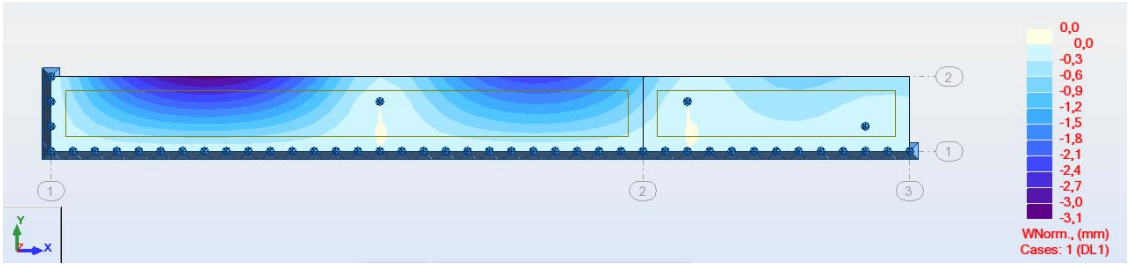
Cross-laminated timber








Further on-going work and next steps:

- Seismic performance;
- Behavior under extreme conditions of service class 2;
- Tension/compression perpendicular to the grain;
- Durability and preservation needs

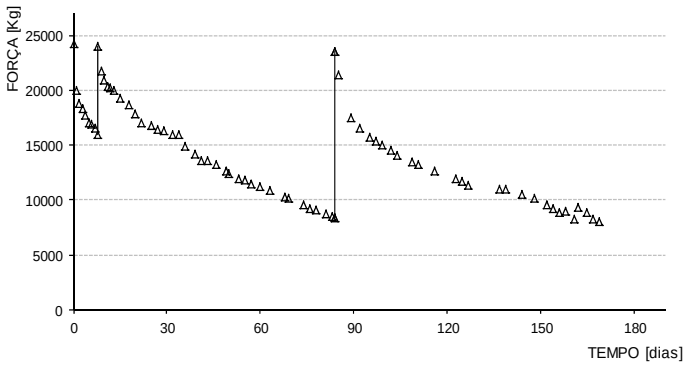
Polytechnic Institute of Castelo Branco & University of Coimbra, Dep. of CE

Stress-laminated timber bridge

Objective: Evaluate the feasibility of stress-laminated timber decks made with Portuguese raw material.

Laboratory prototype was built and some key issues were addressed with emphasis to:

- Use of maritime pine;
- Evaluation of losses of prestress force;
- Scheduling for re-stressing;
- Behavior in transverse direction (2D);
- Influence of prestress force in deflections



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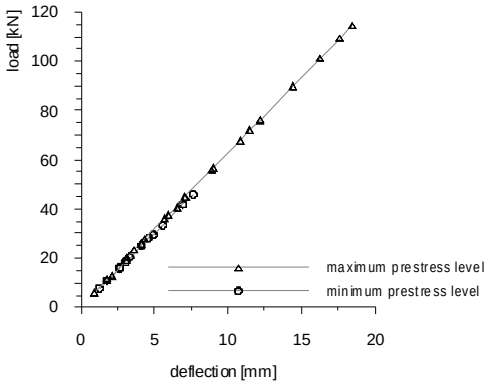
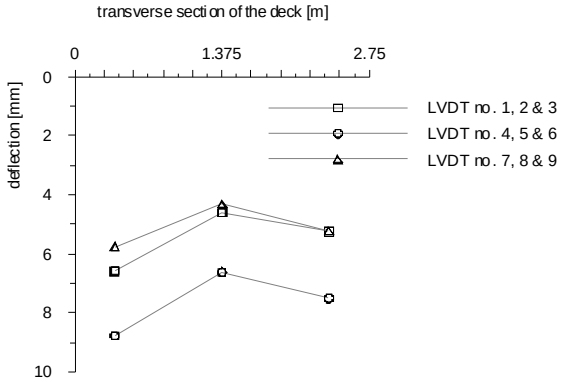
Stress-laminated timber bridge





Further on-going work and next steps:

- Evaluate field performance and advance modeling;
- Use of other species;
- Durability and preservation needs;
- Comparison with other construction systems

Polytechnic Institute of Castelo Branco & University of Coimbra, Dep. of CE

Cyclic behavior of timber joints from roof structures under the wind load

Objective: Evaluate wind-induced fatigue in selected case study structures. Slender roof timber structures located in mountain elevations or sea side places are elected for the study.

The main goals are:

- Determine the ratio of stress, R, caused by wind load;
- Develop a fatigue life prediction for the structures/connections;
- Evaluate stress state and damage of the structures

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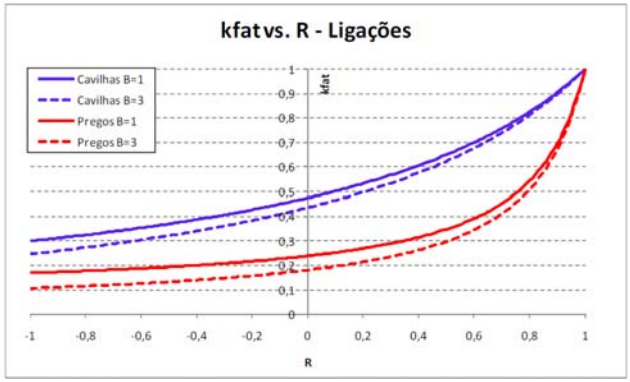
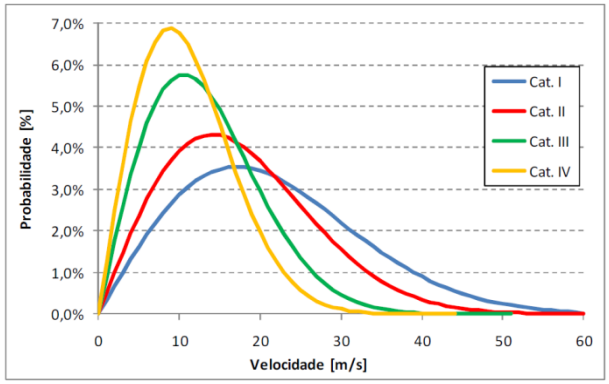
Cyclic behavior of timber joints from roof structures under the wind load





Further on-going work and next steps:

Produce S-N curves database for timber connections

Reinforcement through the use of timber-concrete composite floors

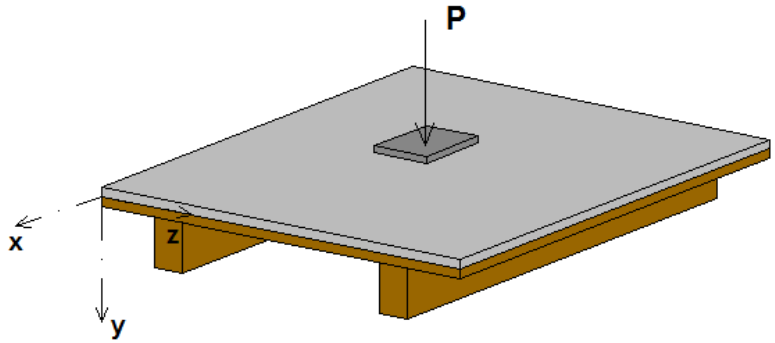
The main aims of this work include:

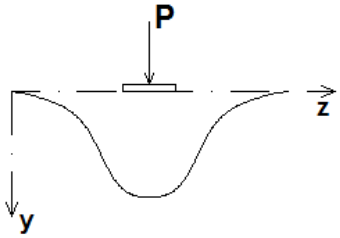
- To analyze timber-concrete composite floors subjected to concentrated point and line loads, intending to understand how the distribution of internal forces is performed in those structures, namely in the orthogonal direction, and in the longitudinal direction on structures with multiple spans (hogging zones)
- To develop technical solutions, contributing in this way to make the use of this technique feasible in wider set of reinforcement and rehabilitation situations.

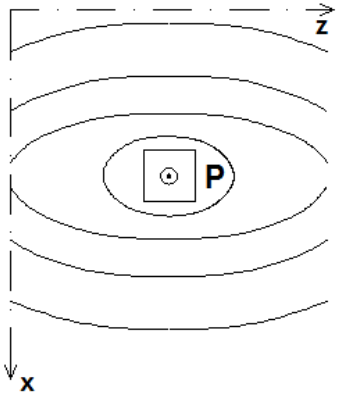
Reinforcement through the use of timber-concrete composite floors

Approaches to attain the main aims:

- Experimental tests;
- Numerical modeling, of timber-concrete composite decks and beams under the mentioned conditions.







Connections for roundwood timber members

Objective: To develop optimized connection configurations for roundwood timber members.

The project is focused on the following issues:

- Enhance the connections strength and ductility
- Decrease the occurrence of cracks in the connection surroundings and their effects on the connection mechanical performance

Connections typologies under study:

Glued-in rods, Dowel-nut, Bolted connections

Connections for roundwood timber members

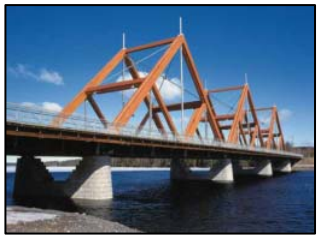
Further work

- Optimization of the connection configuration
- Numerical modeling of the connections
- Experimental assessment of the connection mechanical properties

Composite timber-concrete bridges solutions

Worldwide use of composite timber-concrete bridges,
Identifying the reasons as to why this structural solution is used worldwide.

Ragoztobel Bridge, Switzerland



Vihantasalmi Bridge, Finland

Caminho do Mar Bridge, Brazil

Enhancements related with the use of timber-concrete solutions

- Increased load-carrying capacity;
- Improved serviceability performance;
- Increased the durability.

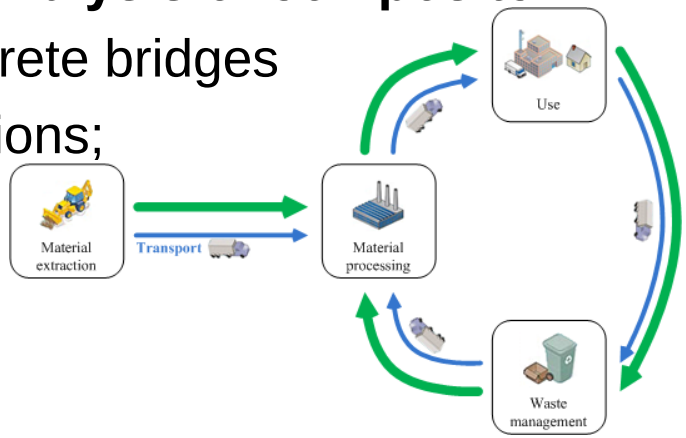
Composite timber-concrete bridges solutions

On-going: Optimization of composite timber-concrete bridges

- Enhance the performance by means of innovative connections
- Increase the level of prefabrication and study of new shapes and technologies for enhancing the structural performance.

Sustainable design and integral life-cycle analysis of composite

- Timber-concrete and composite timber-concrete bridges
- Evaluate the sustainability of proposed solutions;
- Compare with different construction systems



Durability of bonded-in rod connections

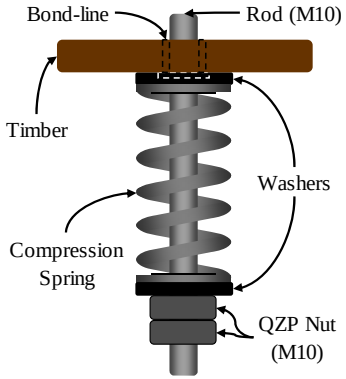
This project investigates the adhesion phenomena involved in bonding timber with structural adhesives. More specifically:

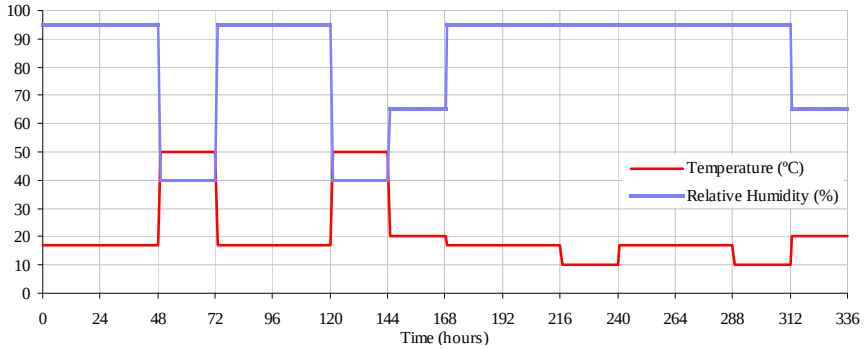
Typical environmental service conditions expected for these repair and strengthening systems

- Effect of the service conditions on the performance and durability of commercial two-component structural epoxy adhesives, as well as their effect on bonded joints
- Effect that type of mixing, curing, postcuring, and the presence of moisture have on the adhesives mechanical properties
- Ways of improving the bonded joint durability

Durability of bonded-in rod connections

- Method to assess the long-term behaviour of bonded-in connections (RPAT – realistic performance assessment test).





Further work / On-going work

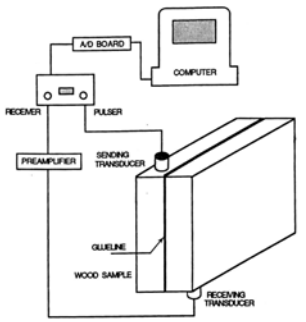
- Use the RPAT with other material combinations.
- Compare RPAT results with behaviour of full-sized specimens.
- Investigate service conditions in other structures and countries.

Influence of delamination and fissures on bending strength

This project investigates the influence of delamination of glulam beams on their mechanical performance, namely bending strength.

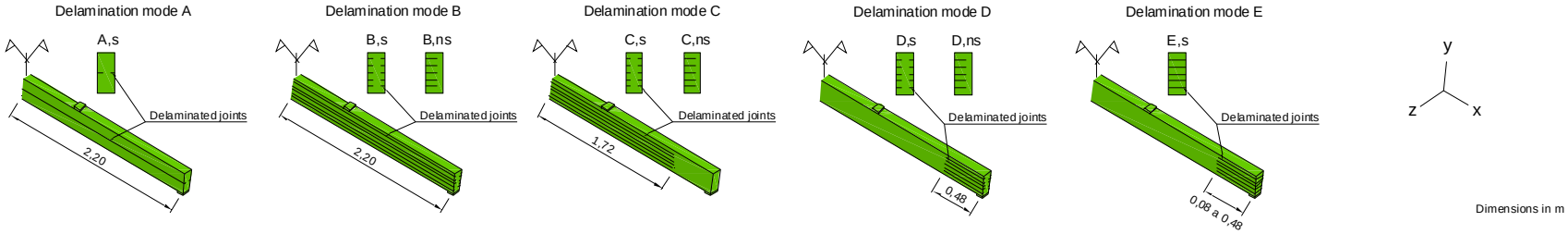
Main objectives:

- Study delamination of glulam beams (different species and adhesives) under natural and artificial ageing;
- Investigate the use of NDT to assess delamination;
- Investigate the use of NDT to assess loss of strength due to ageing / delamination;



Influence of delamination and fissures on bending strength

Assess the influence of delamination on the mechanical performance of glulam beams by numerical modelling + testing.



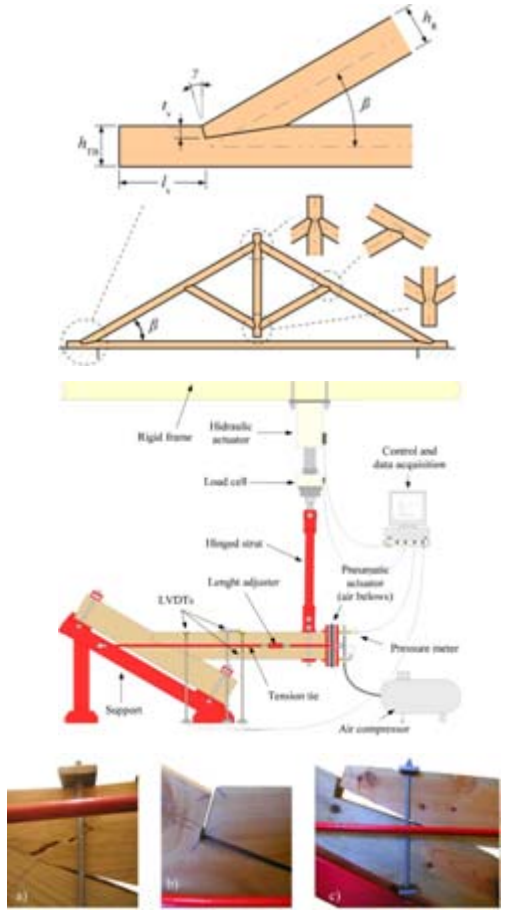
Further work

- Study the efficacy of delamination repair and strengthening methods;
- Evaluate the influence of drying fissures on solid timber members in the scope of assessing old structures.

Laboratório Nacional de Engenharia Civil
Timber Structures Division

Behavior and repair / reinforcement of carpentry connections

- Moment-rotation monotonic and cyclic tests of carpentry connections
- Influence of geometry, metal parts, moisture content, workmanship, loading
- Simple joints and with bolted steel side members, external clamp, through bolt, glued-in rod
- Effectiveness of traditional and modern repair and reinforcement techniques



Behavior and repair / reinforcement of carpentry connections

Further on-going work

- Fire behaviour of carpentry connections
- Influence of materials, geometry, metal parts, workmanship
- Protection with intumescent coatings

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Structural behavior of traditional timber joints

In order to assess the safety of timber structures, *in situ* inspection and evaluation of actual mechanical properties represent a first step towards structural analysis and the definition of possible remedial measures.

Objectives:

- To characterize the elastic and inelastic properties of (chestnut) wood under compression and tension parallel and perpendicular to the grain (static behavior, lobal deformation, failure pattern etc.)
- To validate the nonlinear model by comparing the predicted behavior with the experimental results.

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Structural behavior of traditional timber joints

- Prediction of failure mode and ultimate load with reasonable accuracy
- Parametric analysis to indicate the most relevant parameters for the structural response

Further on-going work

- Assess the influence of the geometry of the tenon / mortise, as well as the influence of the angle of the connection.
- Evaluation of influence of localized defects in the joint neighborhood
- Introduction of horizontal loads in the connections (needed to analyze the behavior under cyclic loading)