

COST Action FP1101

Assessment, Reinforcement and Monitoring of Timber Structures

Start: November 2011 | End: November 2015

Roadmap of Activities 2015

Dina D'Ayala
Action Chair
University College London
UK

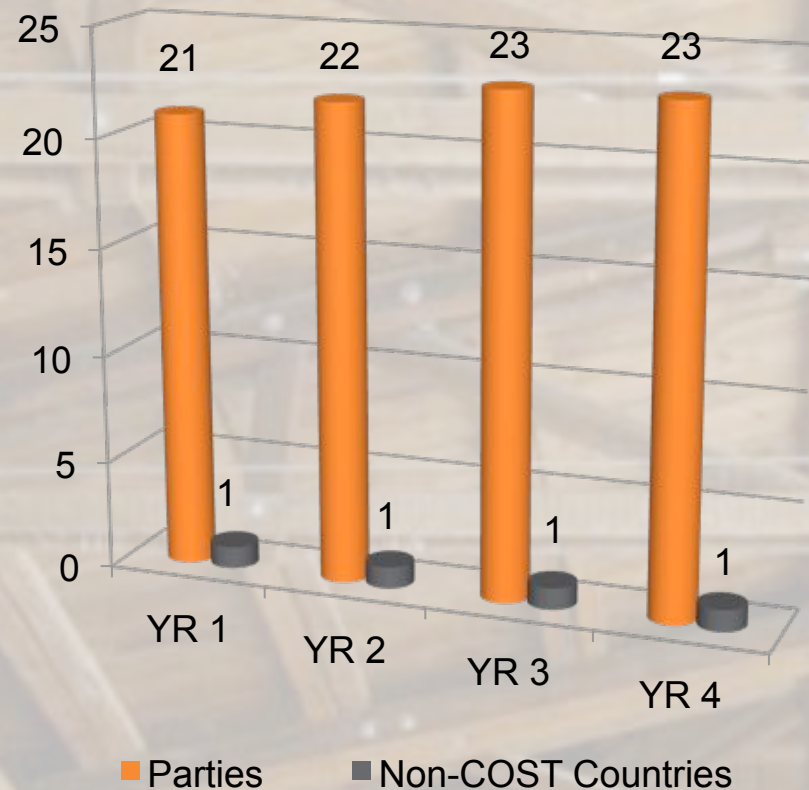
Action Parties

Grant Holder:

University College London

Prof. Dina D'Ayala

United Kingdom



Core Group



- Chair: Dina D'Ayala, UK
- V-Chair: Jorge Branco, Portugal
- STSM officer: Thierry Descamps, Belgium
- WG1 leader : Mariapaola Riggio, Italy
 - TG1 leader : Eleftheria Tzatzanika, Greece
 - TG2 leader: Jose' Saporiti, Portugal
 - TG3 leader: Karel Sobra, Czech Republic
- WG2 leader: Annette Harte, Ireland
- WG3 leader: Jochen Kurz, Germany

Scientific context and objectives



- **Background / Problem statement:**

Timber structures represent a very substantial part of the European built environment, yet as a new form of construction has limited acceptance and it is not used widely across Europe. Moreover there is a wealth of timber historic and existing structures which need appraisal and preservation.

- **MoU objectives:**

To advance methods and disseminate knowledge regarding the assessment, reinforcement and monitoring of timber structures

Improve the maintenance of existing timber structures and make them fit for future use;

Disseminate up-to-date results to the industry, code writers, policy makers and society;

Optimise collaboration of involved stakeholders in research and industry.

- **Research directions:**

Provide a network for collaboration within ongoing projects financed by various national and international bodies;

Promote complementary research;

Encourage communication between scientists, industry and all other involved stakeholders;

Create opportunities for patenting new technologies and products

Working groups

1. Assessment of Timber Structures – 3 Task Groups

TG1 – Synthetic methods for the assessment of historical/existing timber structures (joint activities with WG3)

TG2 – Combination of NDT/SDT for the assessment of timber structures on site (joint activities with WG3)

TG3 – Methods for the characterization of timber connections (joint activities with WG2)

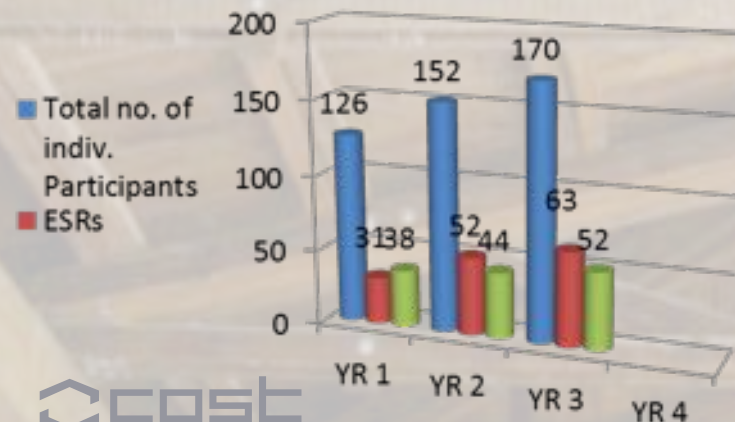
Total – 85 members from 15 countries; 22% Female, 27% ESR

2. Repair and Strengthening of Timber Structures

68 members from 20 countries; 32% Female, 27% ESR

3. Monitoring of Timber Structures

42 members from 10 countries; 26% Female, 28% ESR



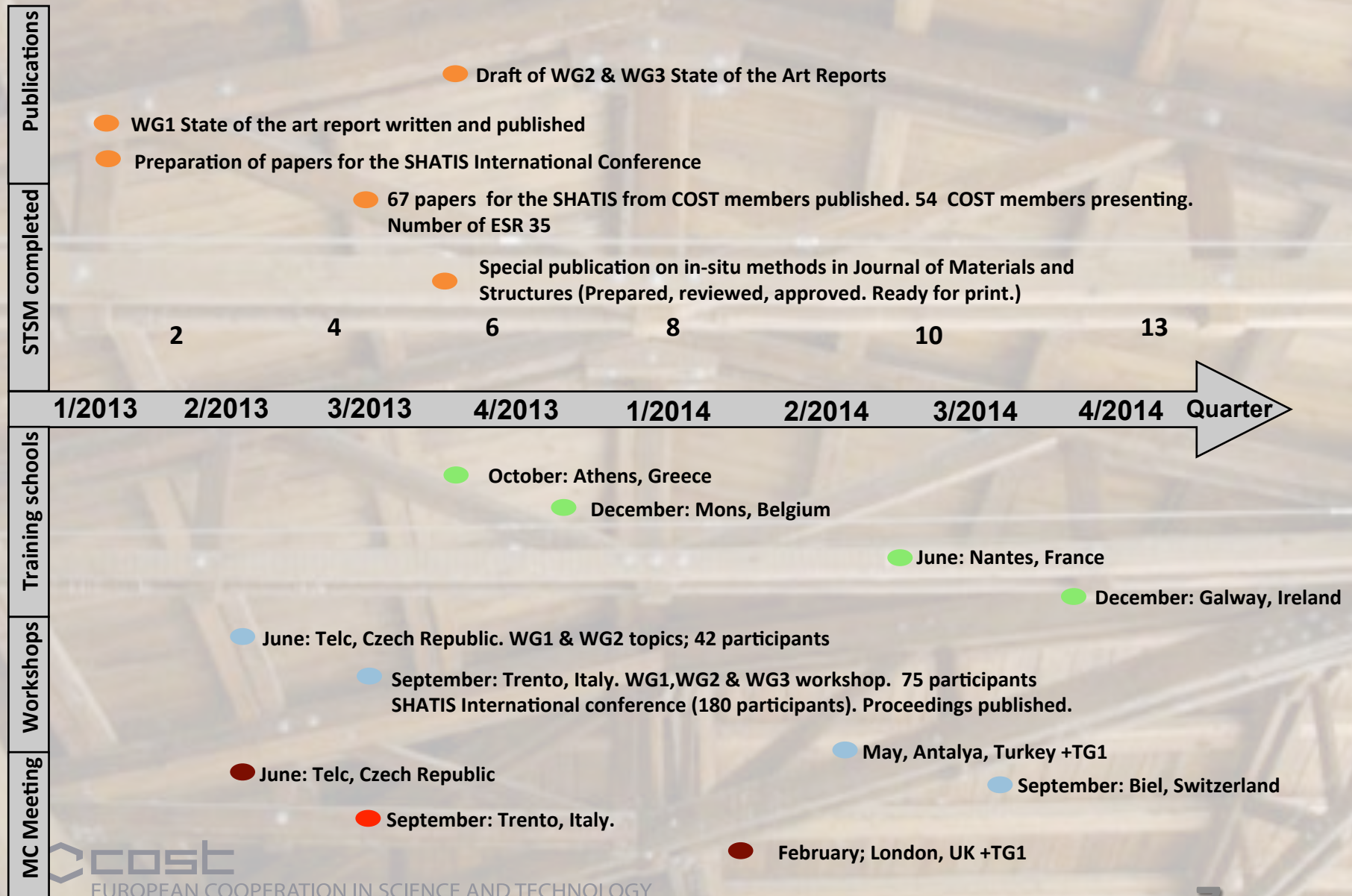
Activity (No.)	Year 1	Year 2	Year 3	Year 4
MC/WG Meetings	1	2	3	2
STSMs	1	5	7	8
Training Schools	0	2	1	2
Workshops or Conferences	1	1	2	1
Joint Publications	40	72	45	n/a

FP1101 in numbers



Measures at December 2014	WG 1	WG 2	WG 3	Total
Number of members	85	68	42	195
Number of publications produced by the COST members since the FP1101 inception (<i>numbers correct as of end 2013</i>)	174*	81*	43*	298*
STSM (<i>including those approved for final GP – 2 STSMs remain</i>)	11	7	1	19
Workshop participants, Wroclaw, Poland	28	16	11	52
Workshop participants, Telc, CZ	16	21	5	42
Workshop participants, Trento, Italy	37	25	13	75
Workshop participant in Antalya, Turkey	18	21		39
Workshop in Biel + Conference on Bridges Joined FP1004	7	20	20	47+46
Trainees registered for Training school in Athens				27
Trainees registered for Training school in Mons				31
Trainees registered for Training school in Nantes				25
Trainees registered for Training school in Galway				27

Roadmap to current GP



TS Athens, NTUA

October 7th -10th 2013



Assessment of historical timber structures, analysis of restoration works: on site experience.



Day 1 : Survey and constructional analysis, a tool for understanding existing structures

Day 2: NDTs , Timber reinforcement methods

Day 3: Reinforcement of the building against earthquakes using timber

Day 4: Visual inspection – visual grading. Structural analysis as an assessment tool

-18 of the 24 trainees were ESRs (75%), with 22 Greek post-graduate participants at the Training School, disseminating scientific and technological knowledge on a topic for which in Greece there is limited experience.

-Knowledge sharing between scientists from 12 different countries and from different scientific fields, with architects, civil engineers, archaeologists, wood technologists and conservators participating as trainees or trainers.



Technological and Cultural park of Lavrio

1

COST FP 1101: Assessment, Reinforcement and Monitoring of Timber Structures - 1st Training School 7-10/10/2013, Athens Greece
 "Assessment of historical timber structures, analysis of restoration works : an field experience"



Pyrgos Vasilissis (Queen's Tower) (Ilion- Athens)

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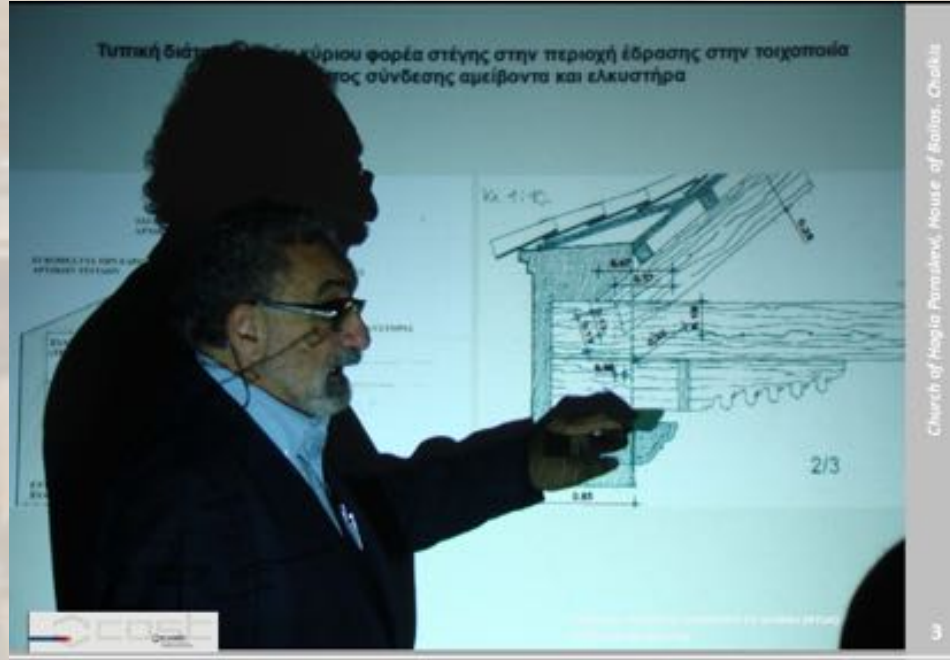
COST FP 1101: Assessment, Reinforcement and Monitoring of Timber Structures - 1st Training School 7-10/10/2013, Athens Greece
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Church of Hagia Paraskevi, House of Bailias, Chalki

3

COST FP 1101: Assessment, Reinforcement and Monitoring of Timber Structures - 1st Training School 7-10/10/2013, Athens Greece
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COST FP 1101: Assessment, Reinforcement and Monitoring of Timber Structures - 1st Training School 7-10/10/2013, Athens Greece
 "Assessment of historical timber structures, analysis of restoration works : an field experience"





Training School on Assessment and Reinforcement of Timber Elements Mons, Belgium - December 2013





	Monday	Tuesday	Wednesday	Thursday	Friday
8:30	Welcoming 8:20				
9:00 – 9:50	B. Kasal (Braunschweig, Germany): In situ assessment, Part 1	Keynote lecture: Ron Anthony , Anthony & Associates, Inc, Fort Collins, CO, USA	Keynote lecture: T. Tannert , University of British Columbia, Vancouver, Canada	B. Parmentier (CSTC – Belgium): stability of wood frames	Keynote lecture: Milan Valovec , Simpson Gumpertz & Heger, NY, USA
Coffee break					
10:10 – 11:00	B. Kasal (Braunschweig, Germany): In situ assessment, Part 2	A. Harte (Galway, Ireland): FRP, intro., basis of design, materials.	L. Bleron (ENSTIB Epinal, France) : Wooden reinforcement	W-S Chang (Bath, UK): Timber columns and walls	R. Crocetti (Lund, Sweden): Bridges: static, reinforcing techniques I
11:10 – 12:00	B. Kasal (Braunschweig, Germany) : In situ assessment, Part 3	A. Harte (Galway, Ireland): FRP, flexural design, prestressed FRP	D. Lathuilière (ENSTIB Epinal, France): Supports reinforcements.	W-S Chang (Bath, UK): All wood connections.	R. Crocetti (Lund, Sweden): Bridges: static, reinforcing techniques II
Lunch (on your own)					
13:10 – 14:00	T. Descamps (Mons, Belgium): Carpentry Connections	K-U Schober (Mainz, Germany): Glued in rods	A. Harte (Galway, Ireland): FRP, applications and examples	G. Raftery (Auckland, New Zealand): enhancements using FRP profiles.	J-W. Van de Kuilen (Delft, Netherlands): Dowel Type Connections, Part I
14:10 – 15:00	P. Hoffsummer (Liège, Belgium): Dendrochronology	K-U Schober (Mainz, Germany): Composite concrete/timber floors	K-U Schober (Mainz, Germany): modeling of historical connections.	Lieven De Boever (CTIB, Belgium): sandwich panels.	J-W. Van de Kuilen (Delft, Netherlands): Dowel Type Connections, Part II
15:20 – 16:10	Demonstration on site: Visit to the town Hall of Mons. Demos and discussions: B. Kasal , P. Hoffsummer and R. Anthony	Workshops : <i>Glued in Rods, wood thermography and new devices for assessment (parallel sessions)</i> Demos and discussions: D. Smedley , D. Carpentier and M. Kloiber .	Coffee break		R. Widmann (EMPA, Switzerland): Delaminated gluelam
16:20 – 17:10			Practitioner's view: F. Rinn (FinnTech, Germany) "Concept of timber inspection". "How wood anatomy influences inspection"	Practitioner's view: A. Angeli (Rothoblast, Italy) "Timber-timber floor". "Reinforcement of joints with self tapping screws in existent roof".	R. Widmann (EMPA, Switzerland): Notched beams.
Diner in town (7 PM)					



Monday

Tuesday

Wednesday

Thursday

Friday

8:30

9:00 – 9:50

10:10 – 11:00

11:10 – 12:00

13:10 – 14:00

14:10 – 15:00

15:20 – 16:10

16:20 – 17:10

- 5 days
- Trainees:
 - ✓ 31 ESR and Phd Students, from 16 countries (COST Action helps for the attendance : 18 100 euros)
 - ✓ 12 Master thesis students from Belgium
 - ✓ 8 professionals coming from Belgian and French Engineering companies and glulam producers.
- Speakers:
 - ✓ 3 keynote lecturers from USA and Canada (supported by the Belgian National Fund for Scientific Research and the University of Mons).
 - ✓ 14 lecturers from Germany, New Zealand, Netherlands, Ireland, Sweden, France, Switzerland, and Belgium. (8 have been supported by COST FP1101).
 - ✓ 4 wood experts from Czech Republic, UK, Italy and Germany.

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(EMPA,
Switzerland); Notched
beams.

Diner in town (7 PM)


Lectures, Demonstrations, On-Site Visit and Assessment





cost
FP1101

ASSESSMENT, REINFORCEMENT AND
MONITORING OF TIMBER STRUCTURES

 **Fraunhofer**
IZFP



Training School on Monitoring of Timber Structures

**2014, June 23rd to 25th, École
Supérieure du Bois à Nantes,
FRANCE**

Topics

- General methods used in monitoring of timber structures
- Ground penetrating radar and applications to timber
- Ultra-sonic testing of timber structures
- Acoustic echo monitoring
- Monitoring systems and concepts
- Dynamic testing of timber structures
- Global energy consumption and environmental monitoring
- Monitoring of timber connections | wireless data to internet concepts

State of the Art application of ultrasonic-echo to identify rotten timber

Specific issues with timber:

- a) Polarization of shear wave is parallel to fibre direction
- b) Shear wave movement is perpendicular to fibre direction
- Total reflection at the back wall => undamaged case
- Missing back wall echo => suspicious fact
- Change of time of flight (back wall echo) => suspicious fact

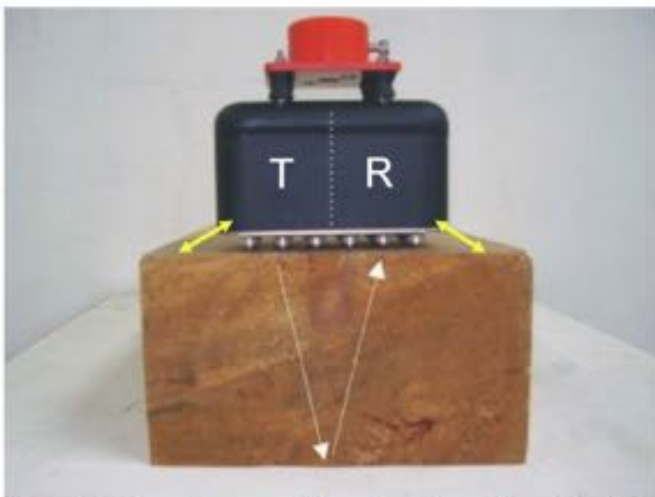
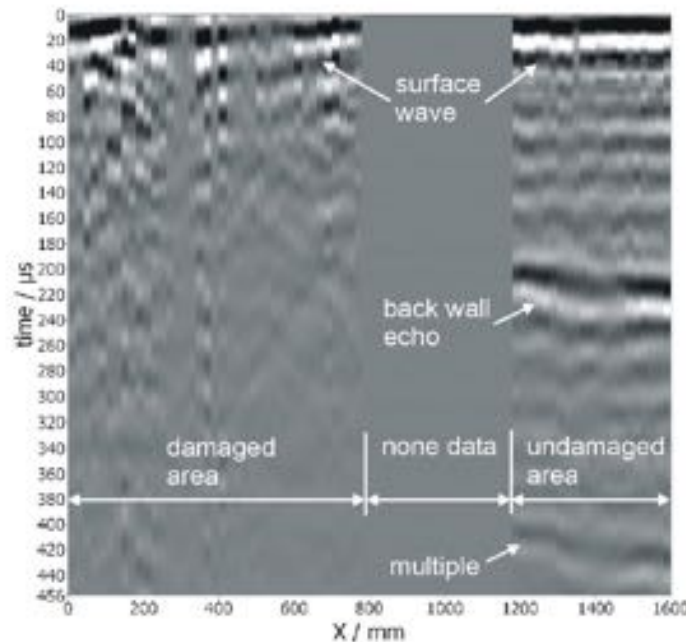


Figure 12: Schematic representation of route from ultrasonic impulse

Anisotropy of wood: Shear wave polarisation parallel longitudinal axis



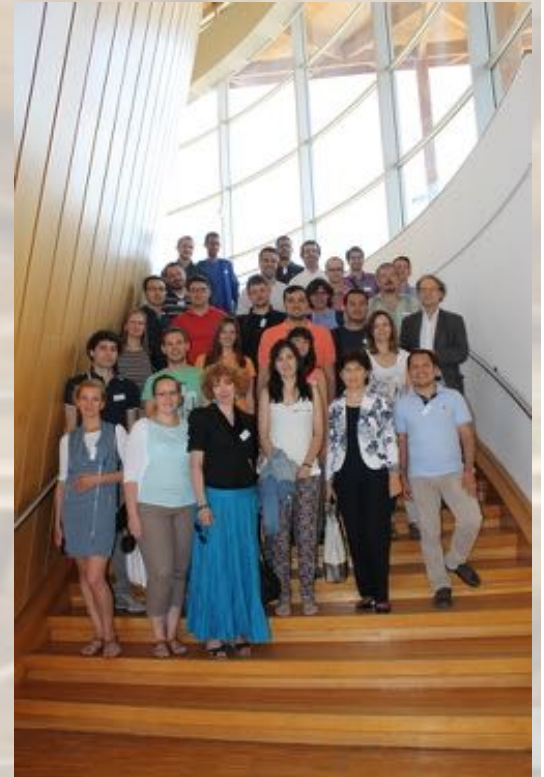
Church (Cultural heritage)

- Step width 2,0 cm
- Clear back wall echo from $x = 1,2$ m (transit time approx. $210 \mu\text{s}$)



Figure 19: Heart rot damaged head in load-bearing joist at opened brick work

Lectures, Demonstrations, On-Site Visit and Assessment



BY



Training School Galway Dec 14

- Design methods for reinforcement of timber structures using STSs and GIRs
- Design, build, test format
- Lectures, design workshop, lab testing
- 40 trainees from 14 countries (27 funded)
- 10 trainers (5 funded)

Training School Galway

PROGRAMME

	Monday, 8/12	Tuesday, 9/12	Wednesday, 10/12	Thursday, 11/12	
8:30-9:00	Registration				
9:00-10:30	<p>Welcome by Prof. Gerard Lyons, Dean of Engineering & Informatics, NUI Galway</p> <p>Annette Harte, NUI Galway Reinforcement of Timber Structures</p> <p>Helmut Stoll, SPAX Screw properties, common design rules, Reinforcement for compression perpendicular to grain</p>	<p>Albino Angel, Rothoblaas Screw properties & Reinforcement of connections</p> <p>Roberto Tomasi/Ivan Giorgio, University of Trento Theory of timber composite structures with semi-rigid connection</p>	<p>Donald Melrose, Rodafix Introduction to bonded-in rods for reinforcement of timber structures Characteristics of materials, selection criteria, Site constraints, Case studies</p>	<p>Robert Widmann, EMPA Design models for bonded-in rods Different design models for BIR will be presented and discussed. On base of some examples the calculated performance of BIR will be compared.</p>	
10:30-11:00	Coffee break				
11:00-12:30	<p>Philipp Dvetsch, TUM Tensile stresses perpendicular to the grain – typical details and standardized approaches for reinforcement Typical details in which tensile stresses perpendicular to the grain occur. Approaches to reinforcement in combination with a design method, internal reinforcement and external reinforcement techniques.</p>	<p>Roberto Tomasi/Ivan Giorgio, University of Trento Case studies of floor refurbishment techniques via timber-concrete and timber-timber composite structures</p> <p>Roberto Tomasi/Ivan Giorgio, University of Trento Reinforcement with inclined self-tapping screws</p>	<p>Ian Jones, Ian Jones and Associates, Consulting Engineers, UK Reinforcement of timber members using bonded-in rods Design methods for flexural strengthening of beams, beam end repair and truss end repair, Case studies.</p>	<p>Karol Sikora, NUI Galway Robert Widmann, EMPA LAB TESTING: Pull-pull tests of bonded-in rod specimens. The results will be compared to literature values and design models</p>	
12:30-13:30	Lunch break				
13:30-14:15	<p>Philipp Dvetsch, TUM Design of shear reinforcement for timber beams Design methods for timber beams, featuring shear reinforcement. Design approaches for the uncracked and the cracked (failed) state. Effect of reinforcement on moisture induced stresses in timber elements.</p>	<p>Roberto Tomasi/Ivan Giorgio, University of Trento Internal stress in timber elements due to self-tapping screws</p>	<p>Ian Jones, Ian Jones and Associates Karol Sikora, NUI Galway LAB TESTING: Testing of unreinforced beam and beam reinforced with bonded-in rods – MOE, MOR</p>	<p>TOUR OF ENGINEERING BUILDING, NUI Galway</p>	
14:15-17:00	<p>Karol Sikora, NUI Galway Helmut Stoll, SPAX LAB TESTING: Beam with notch – tested with and without reinforcement</p>	<p>All trainers DESIGN WORKSHOP: Design of beams for reinforcement in tension perpendicular to grain, shear reinforcement, compression perpendicular to grain</p>	<p>Albino Angel, Rothoblaas Karol Sikora, NUI Galway LAB TESTING: Elastic test of a timber to timber composite beam with and without reinforcement (inclined screws)</p> <p>All trainers DESIGN WORKSHOP: Design of a timber composite structure</p>	<p>All trainers DESIGN WORKSHOP: Design of BIR reinforcement for timber reinforcement</p>	<p>DEPARTURE</p>

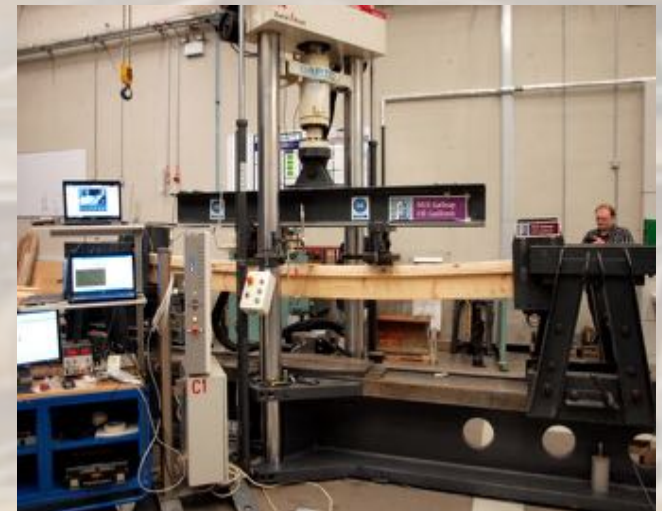
Training School Galway



Training School Manual

8th to 11th December, 2014

Hosted by the National University of Ireland, Galway,
College of Engineering and Informatics,
New Engineering Building, University Road, Galway, Ireland



GENERAL DESCRIPTION OF DAMAGES AND FAILURES



Mechanical failures

Cracks
Slip
Excessive deflections
Excessive deformations
Vibration
Stability



decay,
insect attack,
corrosion of metal parts
ageing



The recording of damage must be made for

- **Structural members** (wood or other components of a timber element as adhesives. Metal members etc.)
- **Joints** : timber elements, metal elements (metal fasteners, metal plates)
- **Overall structural system**

CAUSES OF DAMAGES OR FAILURES → → DIAGNOSTIC

- **POOR INITIAL DESIGN of the original structural system** (architectural – e.g. durability by design, structural - e.g. mistake of the original structural conception -mistakes in calculation, *other.....*)
- **POOR CONSTRUCTION** (poor quality of materials, poor seasoning, poor treatment, poor detailing, *other*)
- **OVERLOADING** (vertical loads, wind, earthquake, settlements, *other.....*)
- **ENVIRONMENTAL FACTORS** (accumulation of moisture, changes in moisture content - hydro-thermal fluctuations, insects, *other*)
- **HUMAN INTERVENTIONS DURING ITS LIFETIME** (improper change of use, former repairs, alterations that change the original structural system, *other*)

- **FIRE**
- **OTHER.....**



Tension, compression, shear, bending

Edge distances

Shrinkage cracks

Other



Examples

- *Shear failure of timber element or joint due to overloading, and inadequate dimensions of the members*



- *Shear failure due to grain inclination*

- *Tension perpendicular to grain due to*

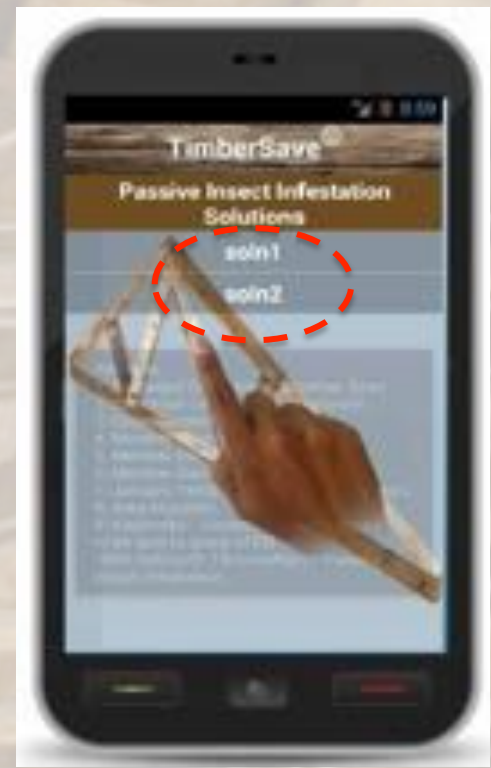
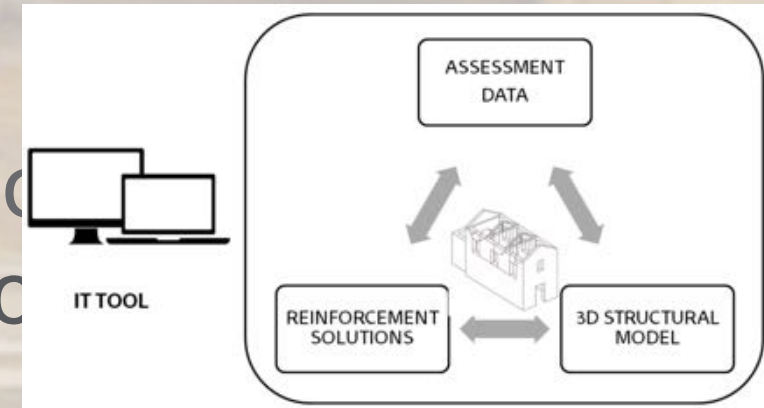
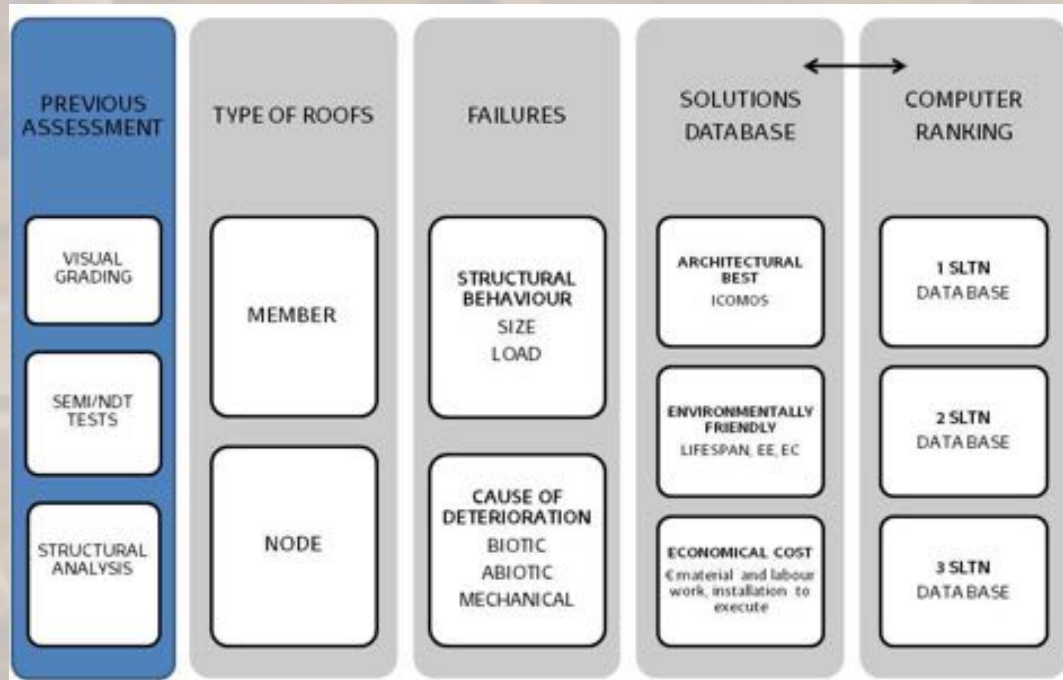


- *Decay due to moisture accumulation caused by poor initial design and construction or ...*

- *Failure of glue at gluelines due to*

- *Missing of structural elements (cutting of timber elements due to human interventions)*

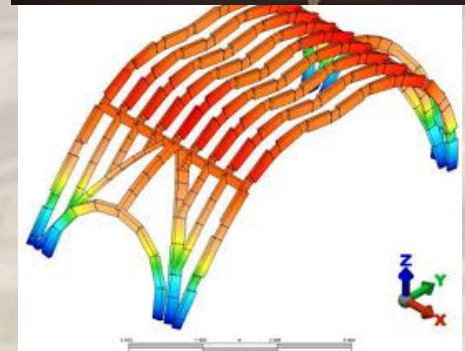
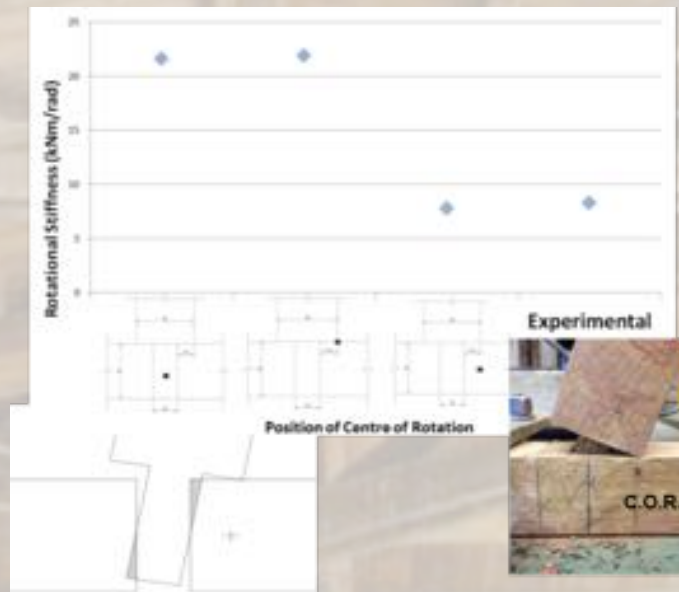
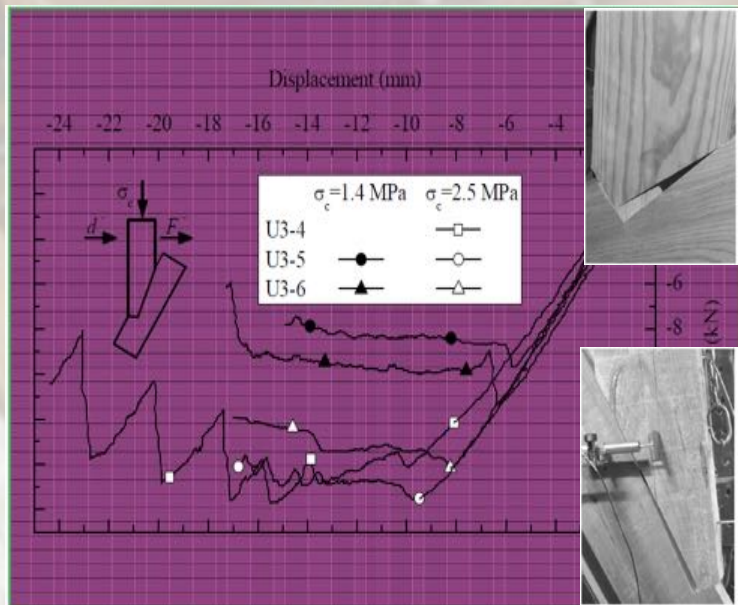
Decision Support Tool for Reinforcement Selection (Teresa Artola, WG2)



Catalogue of carpentry joints and appropriate assessments methods



- To create a repository of relevant publications
- To create a lexicon with drawings and proportional dimension of joints and their use in specific structures.
- To build a database, containing details on Research Institution/s; Type of carpentry joint studied; Type of reinforcement applied, if any; Method used for joint analysis (e.g. numerical, analytical and experimental approaches); Characteristics/parameters investigated; Problems and limitations encountered.

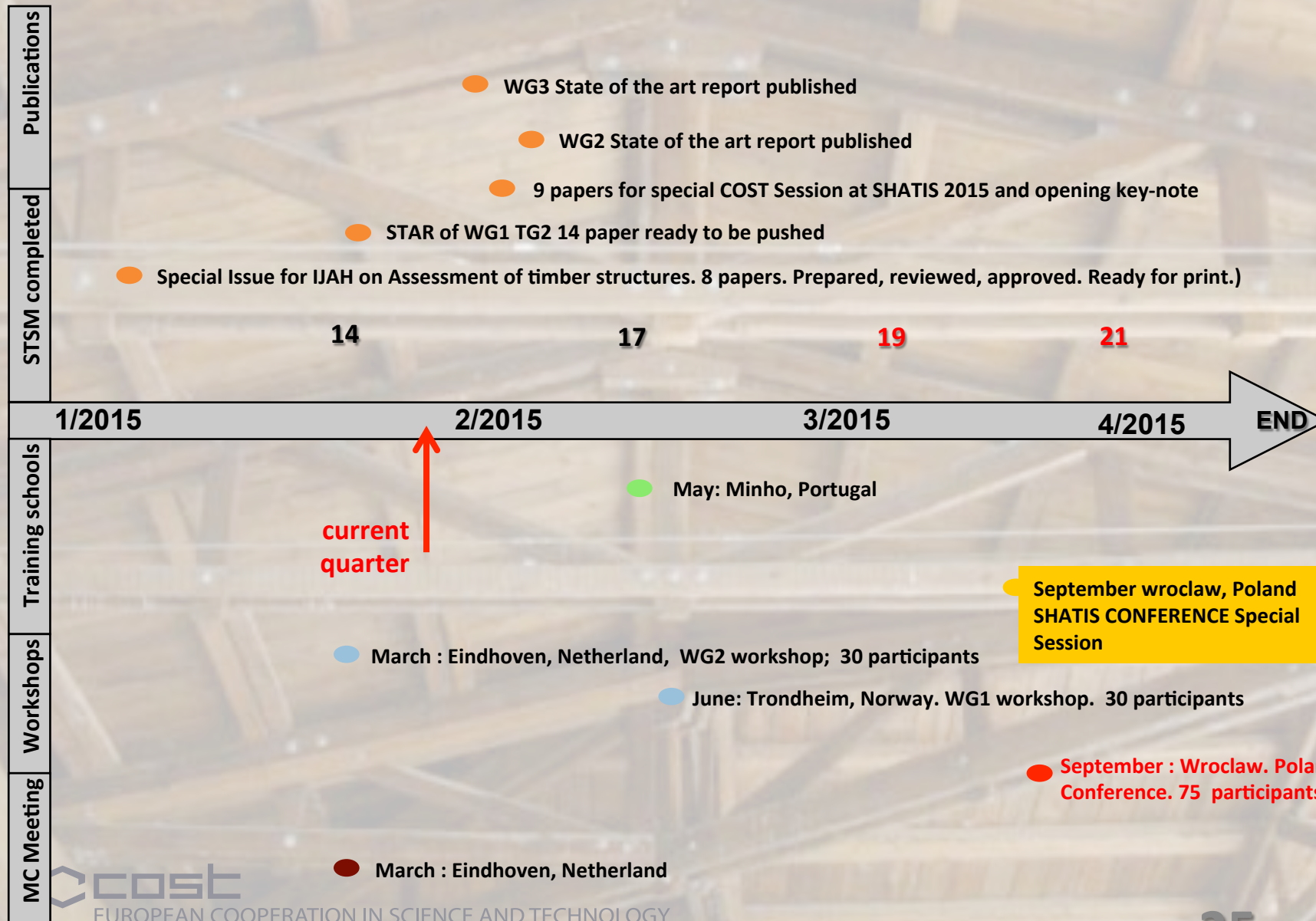


STSMs



STSMs	
<p>Carina Fonseca Ferreira <i>Seismic assessment of historic timber vaults</i> UCL to UPM, 2012</p>	<p>Ivan Giongo <i>Seismic Assessment of Reinforced and Unreinforced Timber Floor Diaphragms</i> University of Trento to University of Auckland, 2014</p>
<p>Natalie Quinn <i>Analysis of Peruvian Mortice and Tenon Joints</i> UCL to MONS, 2013</p>	<p>Karel Sobra <i>Experimental Evaluation of Dovetail Joints</i> University of Basque Country to NUI Galway, 2014</p>
<p>José-Ramón Aira <i>Shear stress distribution in traditional joints</i> UPM to Mons, 2013</p>	<p>Robert Jockwer <i>Fracture mechanics model to account for the impact of wood characteristics on the growth of cracks in glulam beams</i> Empa, CH, to Lund University, SE, 2014</p>
<p>Tomasz Nowak <i>Diagnosis of timber structures with NDT</i> Politechnika Wroclawska to Chalmers, Göteborg, 2013</p>	<p>Izabela Burawska <i>Local reinforcement of timber with D-shape CFRP elements</i> Warsaw University to Empa, CH, 2014</p>
<p>Alexey Vorobyev <i>Characterization of Vasa wood by ultrasound spectroscopy and compression test</i> Uppsala University to University of Montpellier, 2013</p>	<p>Jan Siem <i>Overview of information on design rules for carpenter joints available in EC5</i> NTNU, Norway to Technical University of Eindhoven, 2014</p>
<p>Gerhard Fink <i>Risk based analysis of partly failed or damaged timber constructions</i> ETH Zurich to NTNU Trondheim, 2013</p>	<p>Caoimhe O'Neill <i>Durability of Bonded-In BFRP Rods in Irish Timber</i> Queen's University, Belfast, to NUI Galway, 2014</p>
<p>Teresa Artola <i>Decision support tool selection of timber repairs</i> UBC to NUI Galway, 2014</p>	

Roadmap to current GP



Oncoming Activities



- Training School Guimaraes
- Workshop Trondheim
- Final FP1101 Conference
- Plenary Opening Session at SHATIS 2015

- Publication of special issues
- Publication of Survey and Assessment template
- Publication of lexicon of carpentry joints

Training School Minho, May 2015

“Assessment and Reinforcement of
Timber Elements and Structures”
Guimarães, Portugal, 11-14 April 2015

- [T1] Assessment - Visual inspection and grading
- [T2] Trusses and Joints Analysis
- [T3] Reinforcement
- [T4] Full-scale tests



Training School for 20 ESRs/PhD students will use a traditional timber truss recovered from demolition for full-scale tests of the truss as well as reinforcement of elements and joints.

Apply by 14th April - <http://fp1101tsum.blogspot.pt/>

Final Conference



- 6 presentations in 2 hours, each focusing on one objective that we consider achieved and one on which we would still need work in the future.
- 5 presentations in 2 hours, 1 per training school + Discussion :
 - What did we want to learn; what was the interaction, how do we measure that anything was learned. What we learned. What we did not learn. What is the legacy.
- Showcase of STSM – 3 minutes for oral presentation of all STSM topics plus poster session discussion.
- Final round table session inviting related action chairs or other external relevant people in timber research and innovation with discussion of FP1101 achievements and where to go from here in terms of future joint activities.

Special & plenary session at SHATIS 2015 conference

- Eleftheria Tsakanika: Inscription In the UNESCO world Heritage sites list of the Timber churches of south eastern Poland
- Dina D'Ayala et al: Interdisciplinary knowledge transfer and technological applications for assessment, strengthening and monitoring of timber structures in Europe
- Maria Paola Riggio et al.: Assessment of Traditional Timber Structures: Proposal for a Template to Assist Inspection
- Karel Sobra et al: Taxonomy of Historic Carpentry Joints and Development of a Database
- Annette Harte et al: Needs for standardisation of strengthening of timber structures
- M. Krause et al: Needs for further developing monitoring- and NDT-methods for timber structures
- Jan Siem and André Jorissen: Can traditional carpentry joints be assessed and designed using modern Standards ?
- Annette Harte et al.: Development of an IT tool for timber reinforcement selection
- Thierry Descamps et al.: Active and Quantitative Infrared Thermography Using Frequential Analysis Applied to the Monitoring of Historic Timber Structures
- Karel Sobra et al.: Behaviour of a Dovetail Joint Solved Using Force

STAR Publications



- WG1-TG2: Publication of inspection templates with integration of carpentry joints database in Journal of Construction & Building Materials.
- WG1-TG3: Illustration and publication of timber joint lexicon for examined structures.
- WG2: Special report in soft-cover and e-book tbc 2015 by Springer-Verlag. Publishing costs covered by FP1101, Rotafix & Rothoblaas.
- WG3: Special issue of Journal of Civil Structural Health Monitoring, Springer publishing, April 2015.
50 copies purchased for distribution.