JOINT CONVENTION
FOREST PRODUCTS SOCIETY
SOCIETY OF WOOD SCIENCE & TECHNOLOGY
JUNE 15-20, 2025
FORT COLLINS, COLORADO
Wood for a Sustainable Future: Strengthening the Connection Between Industry and Science

Mass Timber Alternatives in Construction with Flexible Adhesives Joints

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FLEX AND ROBUST SYSTEMS

Cracow University of Technology

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MEZeroE project is a project receiving funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 953157.

MEZeroE

OUTLINE

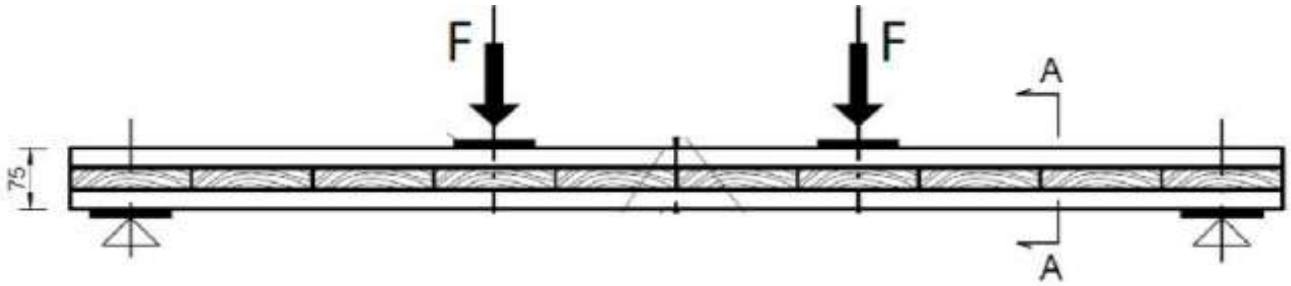
1. Brittle and flexible adhesives
2. Replacement of steel dowels by flexible adhesives
3. EU project H2020 MEZeroE
4. Tightness in fire
5. Fire tests under tensile and shear loads

Stress concentrations generated by stiff adhesives

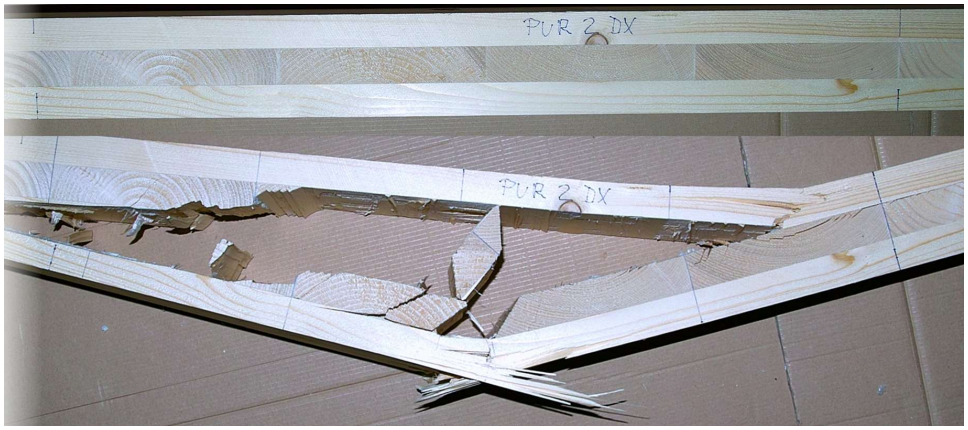
CLT

with stiff PUR

and with flexible PU



Stiff PUR adhesive (one-component)

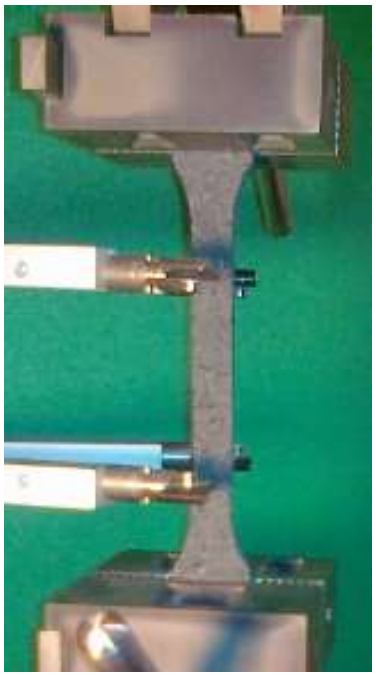


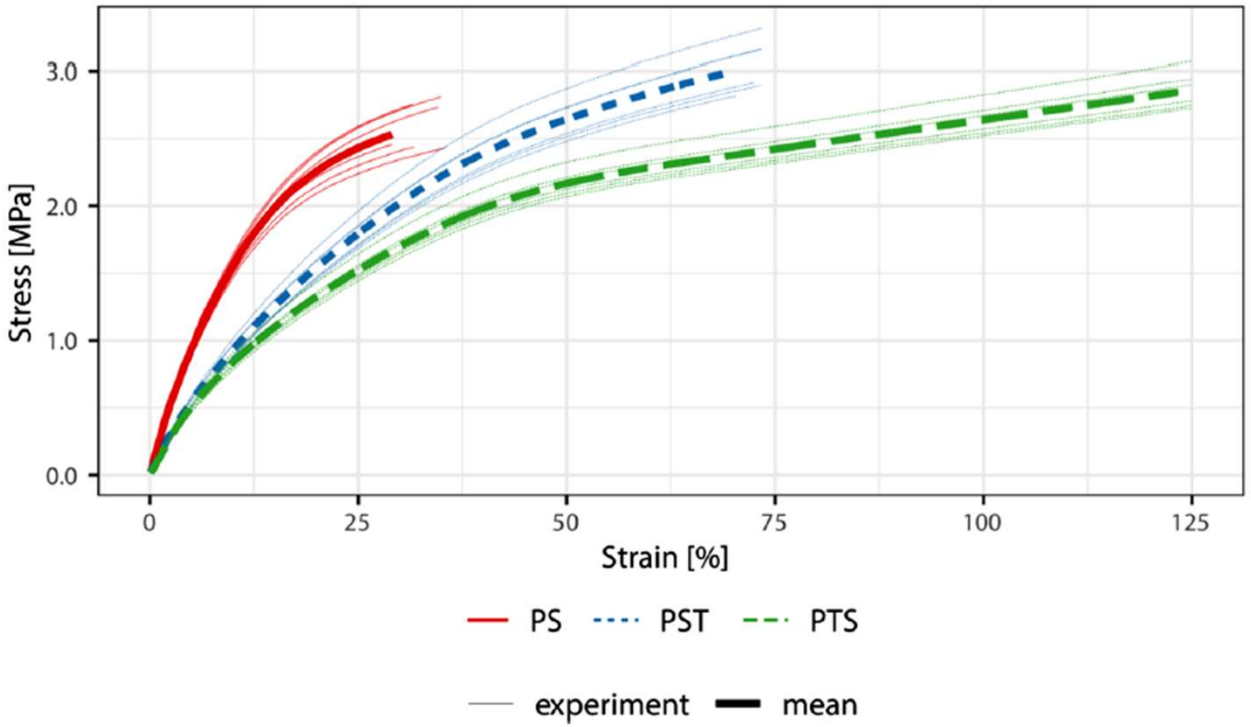
brittle and sudden – stiff adhesives

Flexible PU adhesive (two-component)

ductile and safe – flexible adhesives

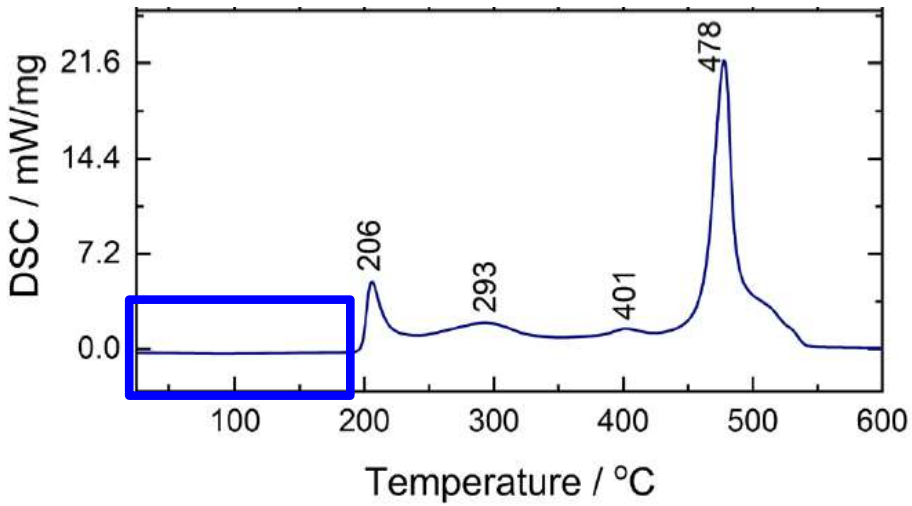
F&R P polyurethanes using as flexible adhesives of non-linear characteristic



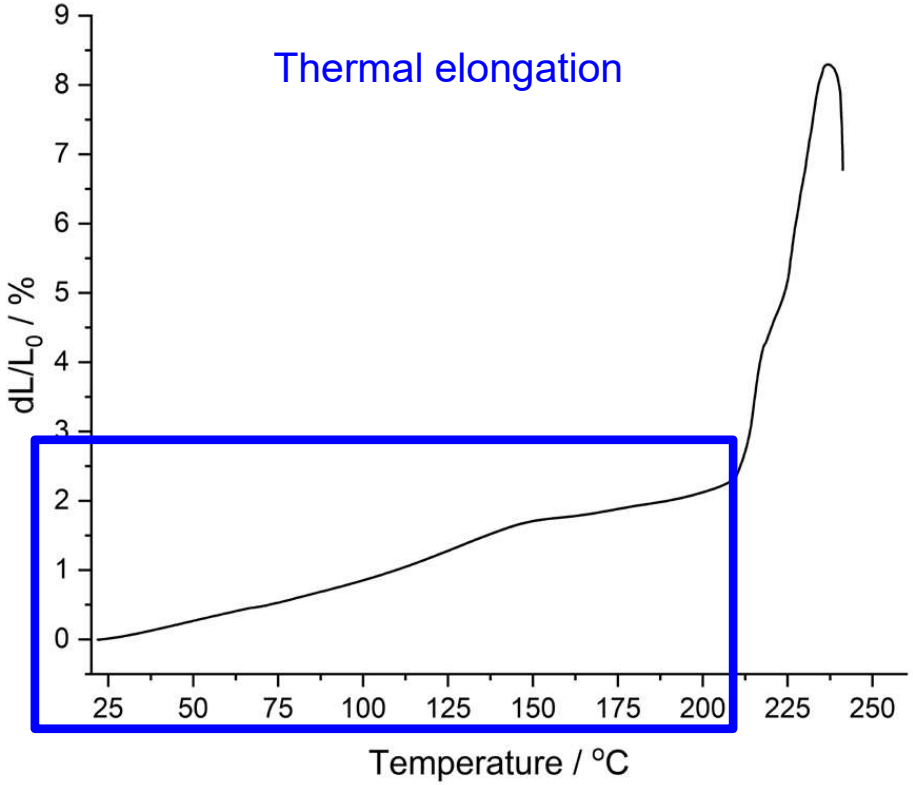


Thermal stability of F&R P polyurethanes

DSC results and dilatometric curve



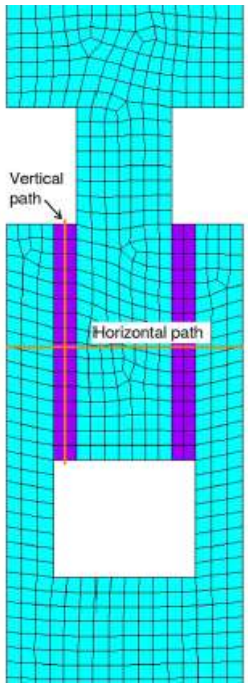
Thermal elongation

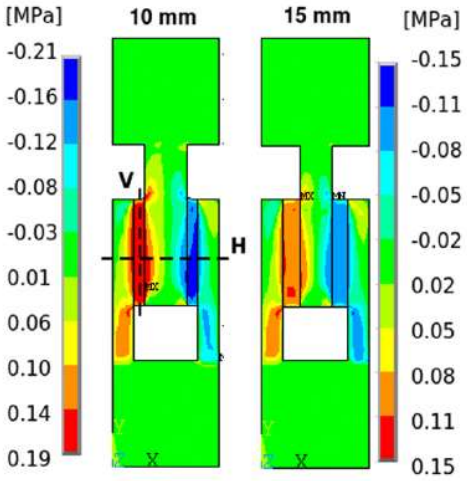


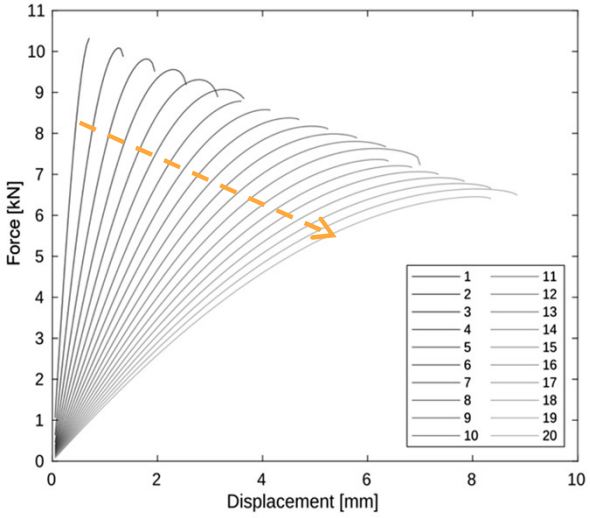
Epoxy – unstable > 40°C

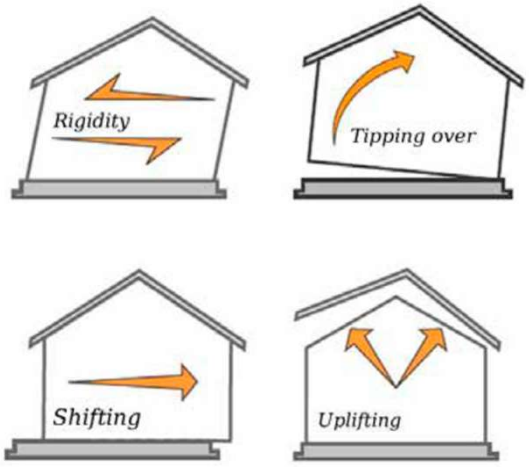
PU – stable even up to 200°C

Thickness influence on stiffness and stress distribution in flexible adhesives







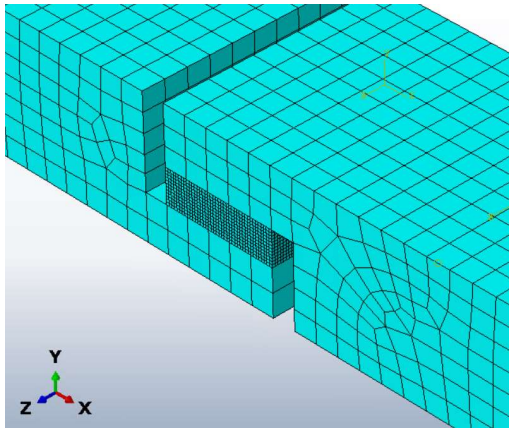


Pečnik J.G., et al.: Mechanical performance of timber connections made of thick flexible polyurethane adhesives. Engineering Structures 247 (2021) 113125, pp. 1-12.

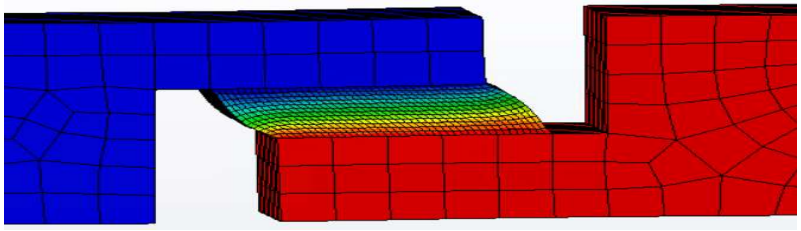
Almost even stress distribution in flexible joint

Shear failure mode

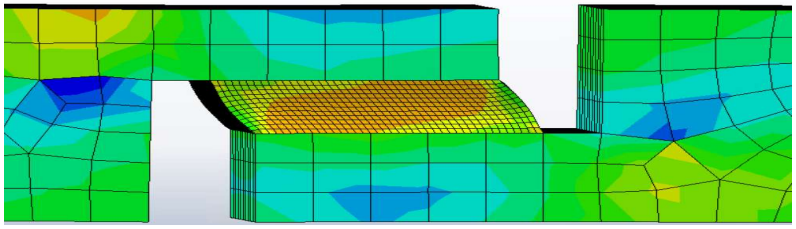
Numerical model



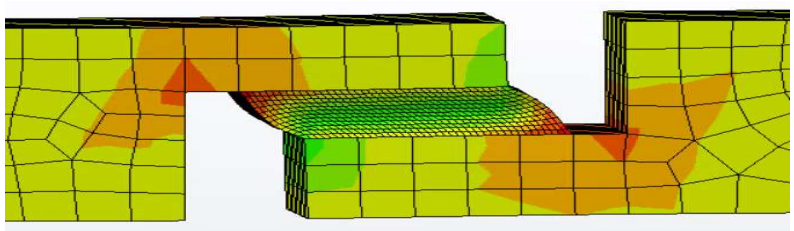
Nonlinear displacement



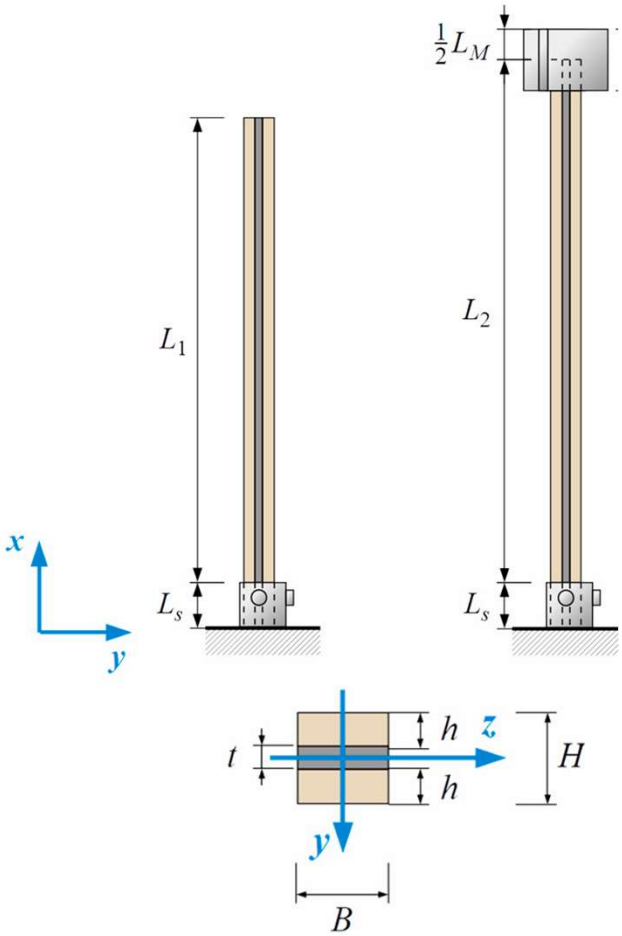
Shear stress



Normal stress



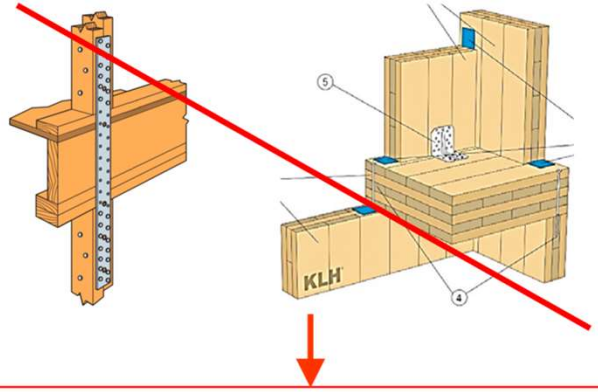
Shake table excitation

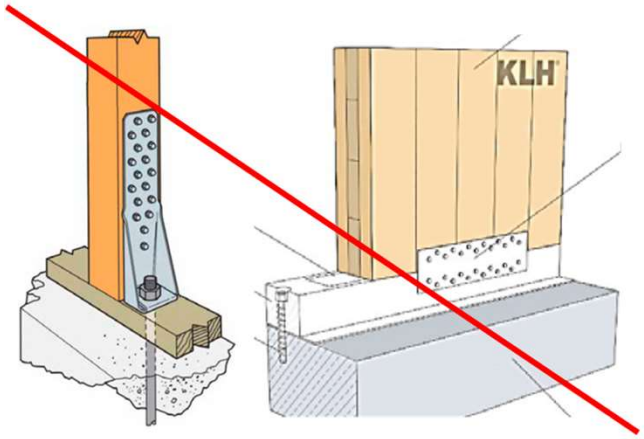


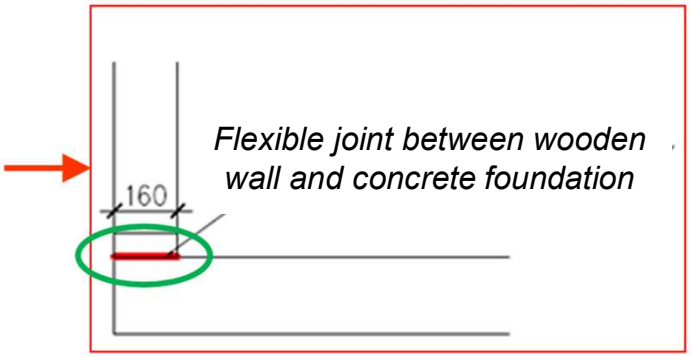
Replacement of steel dowels by flexible polyurethane adhesives

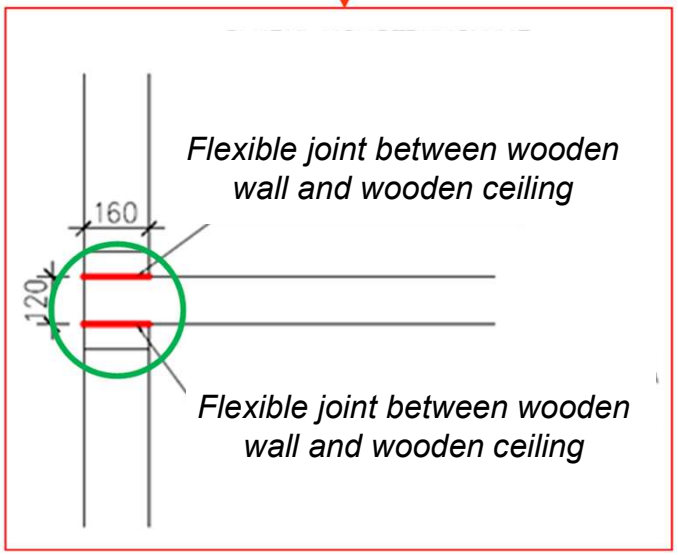
New flexible polyurethane adhesive:

- *blocks the transfer of moisture and thermally insulates from the ground*
- *enables quick assembly and disassembly (by a saw) of elements made of various materials*
- *ensures tightness of connections along their entire length*
- *ensures stability of deformation properties under cyclic loads*



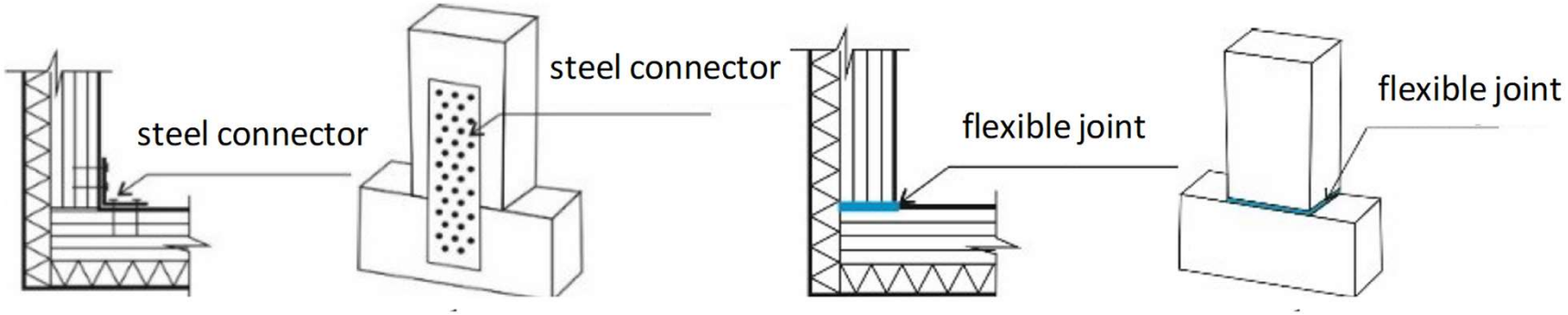




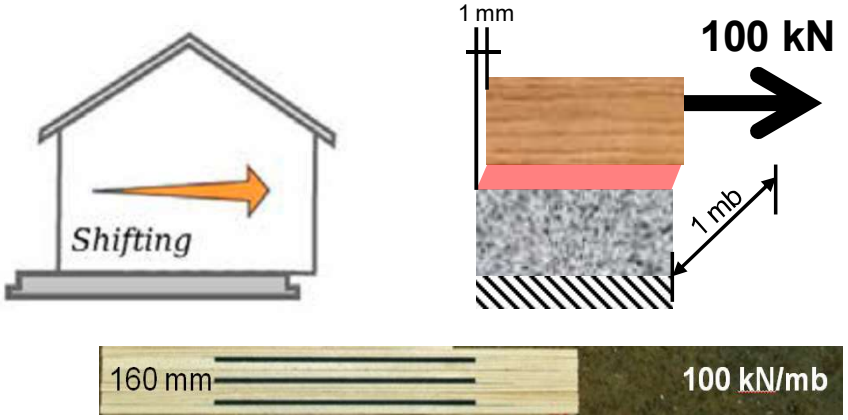


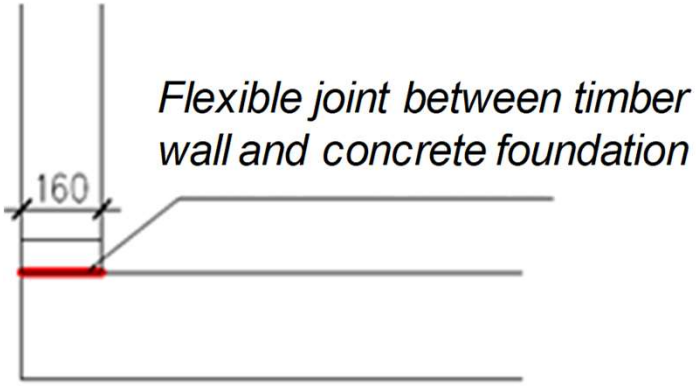
Efficiency of flexible polyurethane adhesives

Steel dowels replaced by flexible joints

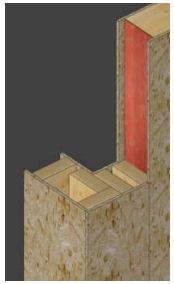


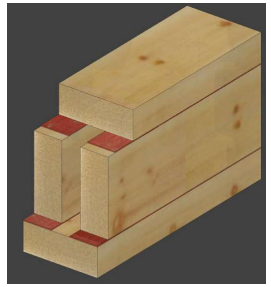
Deformable structural connectors transferring high loads and high deformations simultaneously





Prefabricated timber houses with PUFJ (injected and prefabricated)





MEZeroE project - virtual market place for innovative products in nZEB envelopes

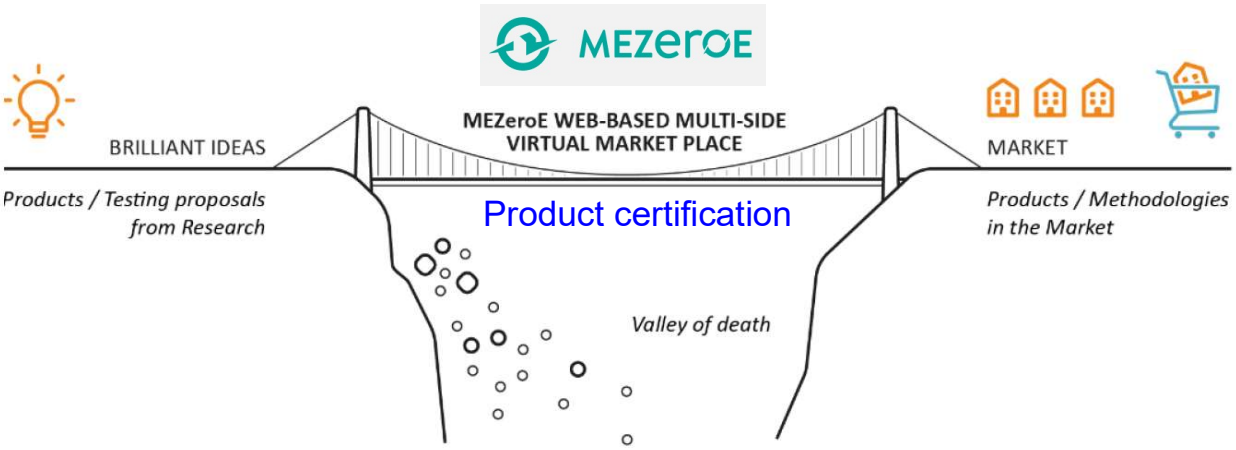
HORIZON 2020

Measuring Envelope products and systems contributing to next generation of healthy nearly Zero Energy Buildings

EUROPEAN COMMISSION
Directorate-General for Research and Innovation
RTD.F – Prosperity
F.4 – Materials for Tomorrow

Technical requirements	Requirements categories under EU Regulation 305/11	Requirements implementation
Safety	Mech. resistance and stability	Statics, durability, Seismic resistance
	Safety in case of fire	Reaction to fire, fire resistance, propagation
	Safety and accessibility in use	Building as a safe to use system
Health	Hygiene, health, environment	High IEQ, water tightness, vapour permeability
	Protection against noise	Airborne sound insulation, soundscape, vibration
Efficiency	Energy economy, heat retention	nZEB, SRI, air permeability
	Sustainable use of nat. sources	GPP, envelope circular economics

https://www.mezeroe.eu/



MEZeroE

Measuring Envelope systems for Zero Energy buildings

SERVICE PROVIDERS

eurac research
POLITECNICO MILANO 1863
LEITAT managing technologies
universität innsbruck
ZAG
Cracow University of Technology
ITeC
Danmarks Tekniske Universitet DTU
tecnalia
compáz

INDUSTRIAL PARTNERS

FOCCHI SINCE 1914
VELUX
window master
Flexbrick
Heliatek
TECNAN
FLEX AND ROBUST
rothoblaas
RIKO Riko Hiše
INDRESMAT
arbnco
greenTEG
Nuvap
Pellini

MEZeroE project is a project receiving funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 953157.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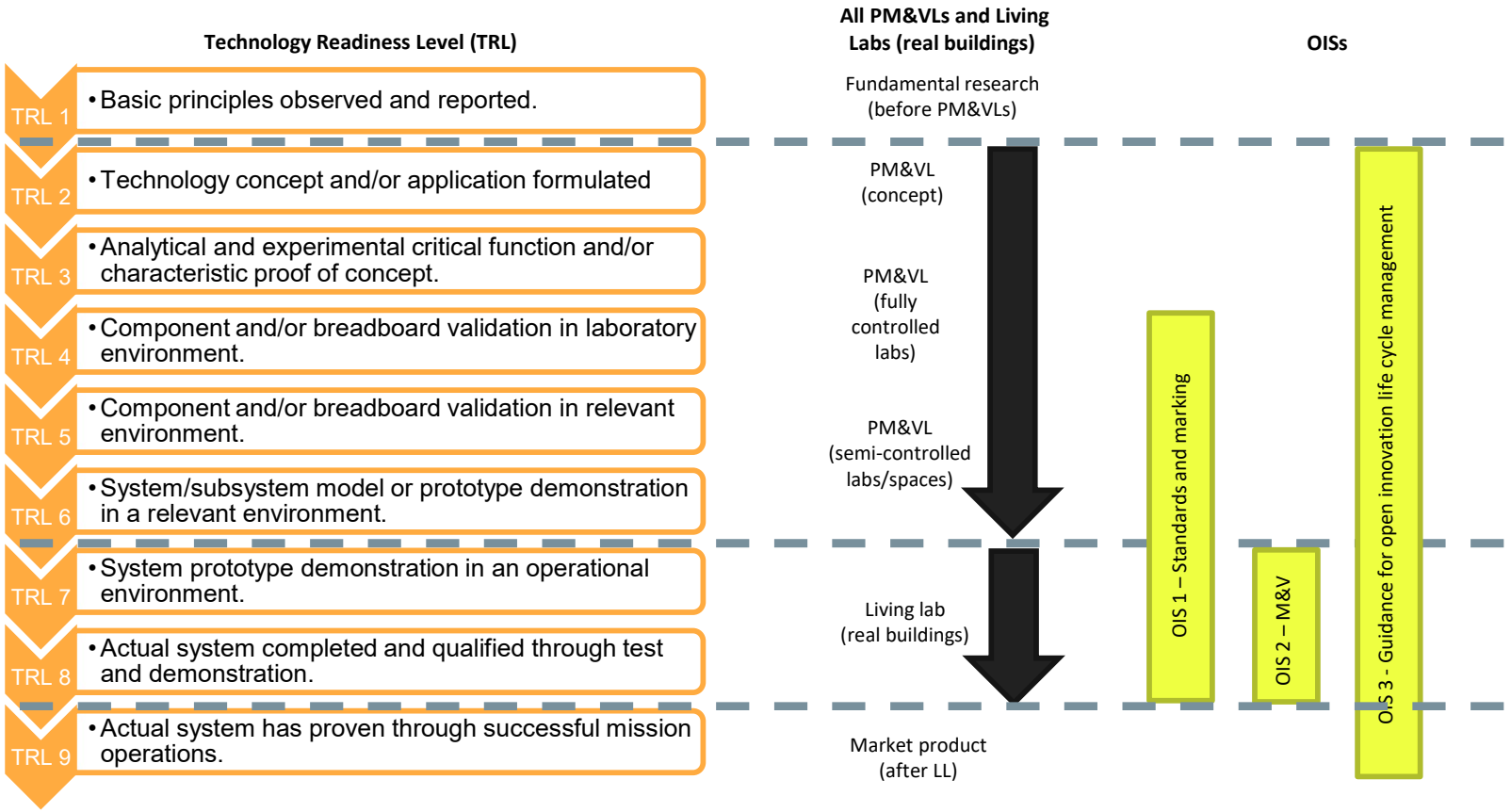
Procedure steps at the MEZeroE platform

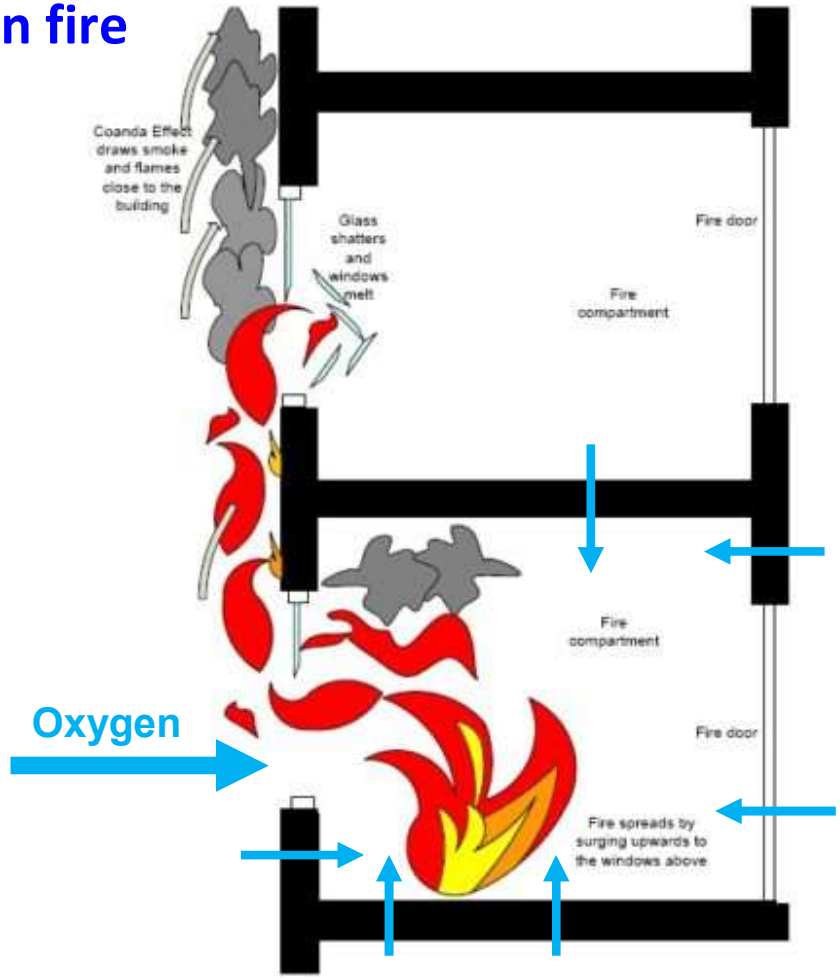


Lack of tightness – problem in fire

Injected

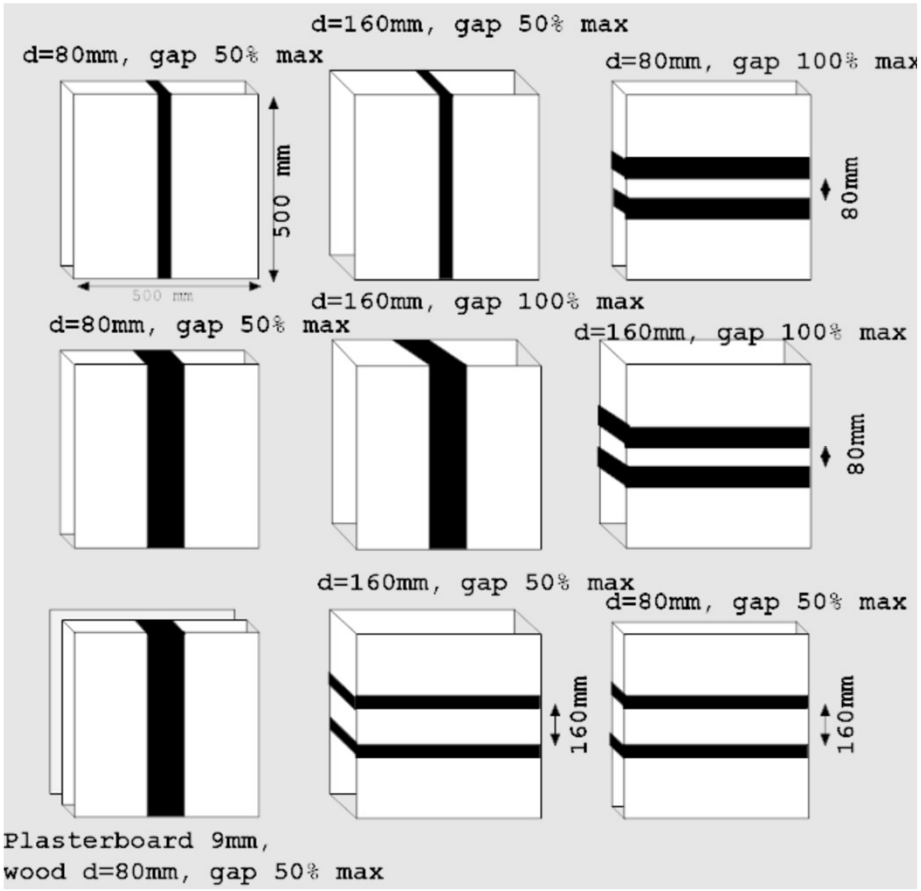
Prefabricated

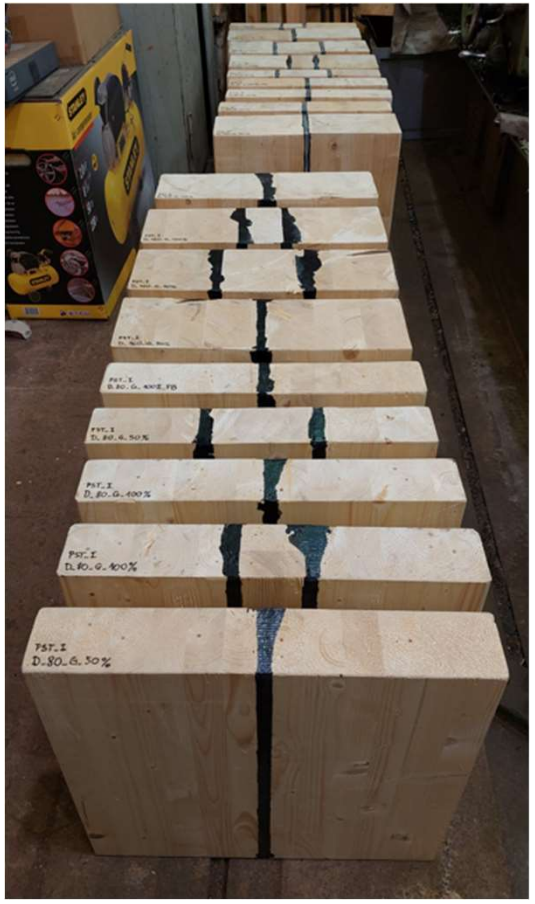
Min-juan H., Hui-fen L.: Comparison of glulam post-to-beam connections reinforced by two different dowel-type fasteners. Construction and Building Materials. Volume 99, 30 November 2015, Pages 99-108



http://pensher-skytech.com/opinion-piece-grenfell-tower/

Timber specimens with polyurethane flexible adhesives tested in fire



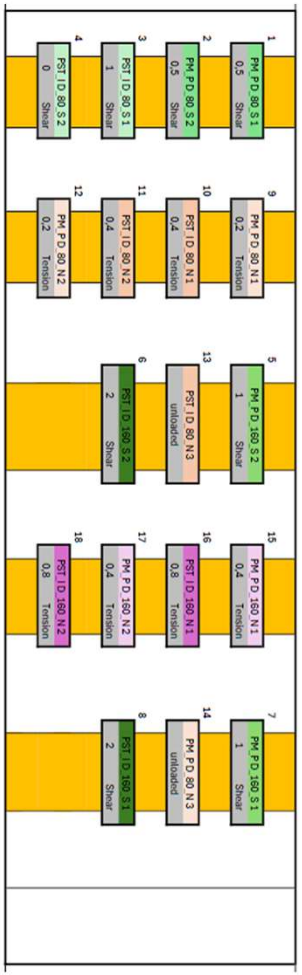


Fire resistance test

Fire resistance test of mechanically loaded samples was performed on 500 x 500 mm samples including one (**loaded in tension**) and second **(loaded in shear**) in two thicknesses: 80 and 160 mm.
Fire resistance test was performed **for 43 minutes**.

Photo A6.42: Positioning specimens on the supporting structure on the furnace frame *(photo archive 049506d-156)*

Photo A6.46: Positioning of plate thermocouples within the furnace below the specimens *(photo archive 049506d-234)*



Specimen positioning on the furnace

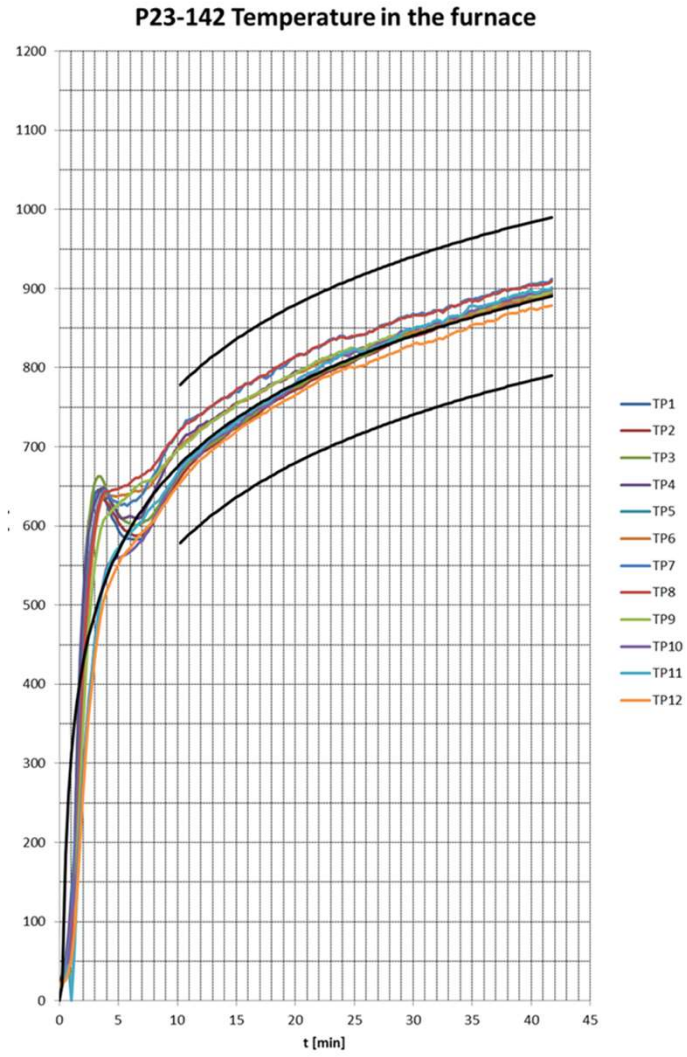


Photo A6.7: specimen no. 7 *(photo archive, left: 049506d-138, middle: 049506d-139, right: 049506d-140)*

Photo A6.45: Hydraulic jack positioning for mechanical shear loading before the fire resistance test
(photo archive, left: 049506d-222, right: 049506d-228)

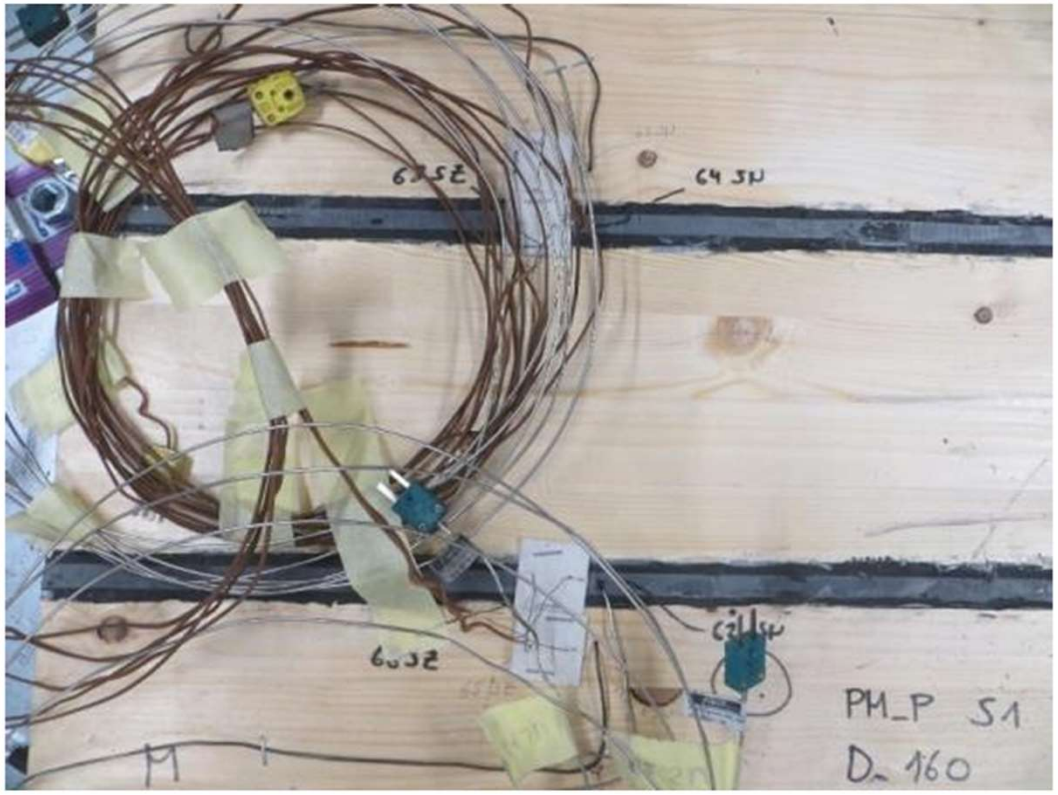


Photo A6.33: Thermocouple placement in specimen no. 7 *(photo archive 049506d-141)*

Table 2: Applied load.

No.	Name	Loading type	Load [tones]
7	PM_P D_160_S1	Shear	1

Photo A6.55: Specimen 7 after the fire resistance test – unexposed side (left) and exposed side (right)
(photo archive left: 049506d-501 and right:049506d-502)

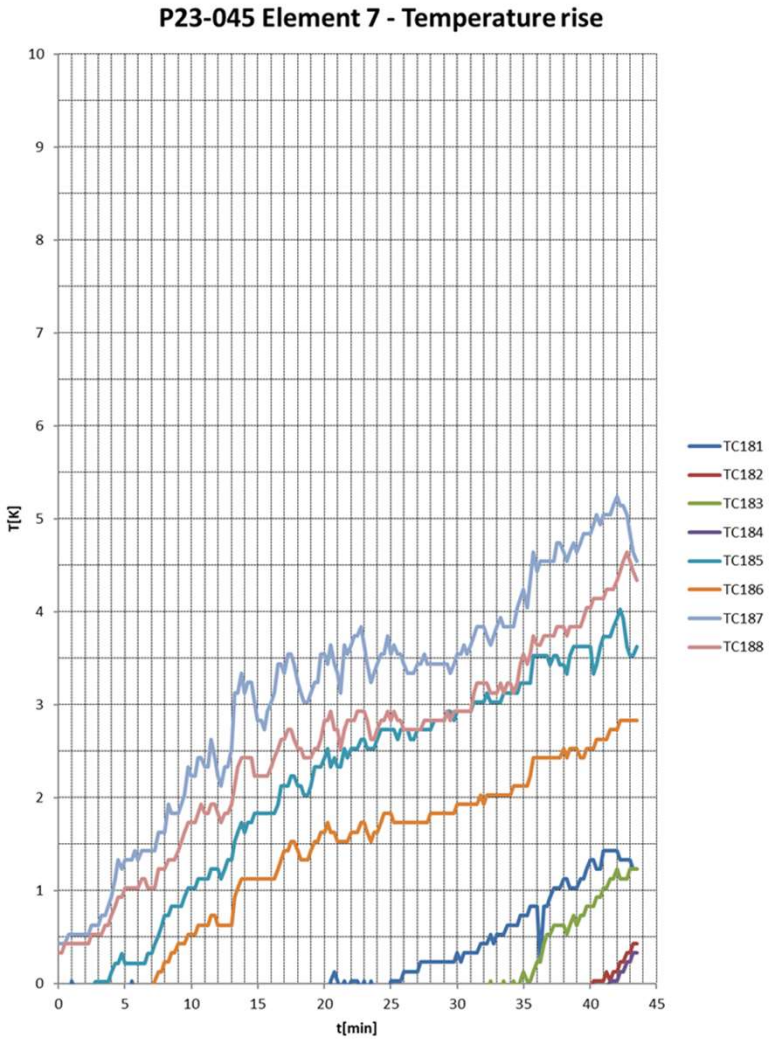


Photo A6.12: specimen no. 12 *(photo archive, left: 049506d-013, middle: 049506d-014, right: 049506d-015)*

Photo A6.22: Mechanical loading of specimen no. 12 in tension *(photo archive 049506d-069)*

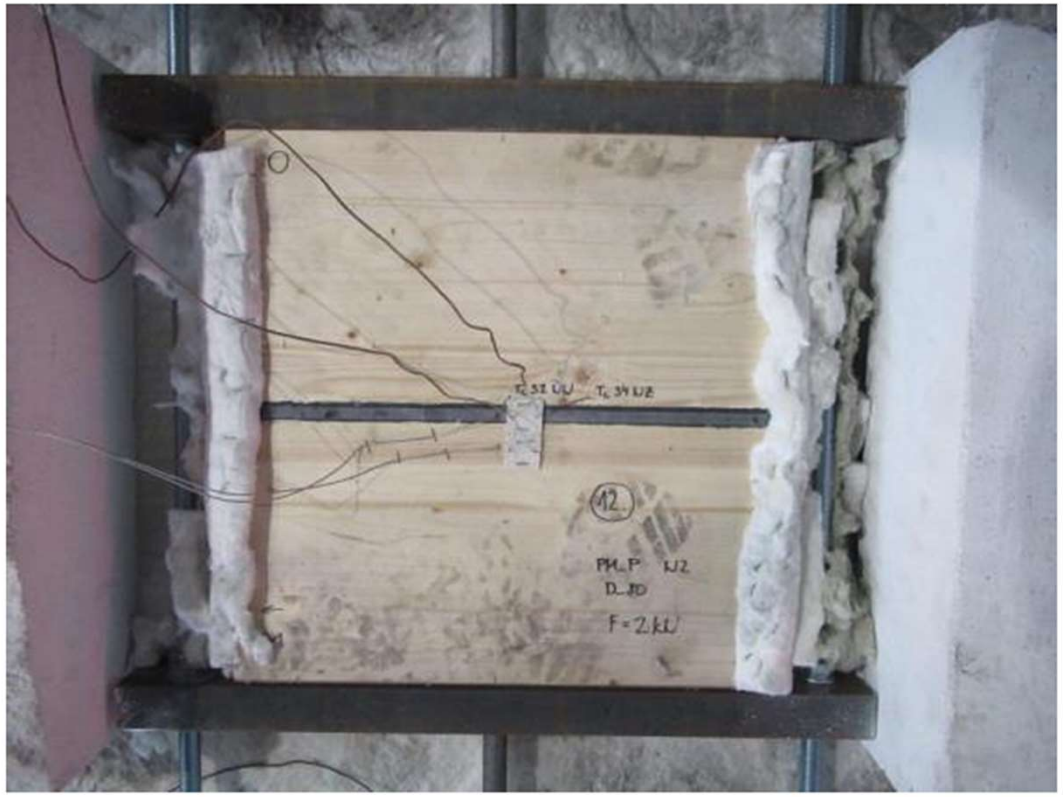
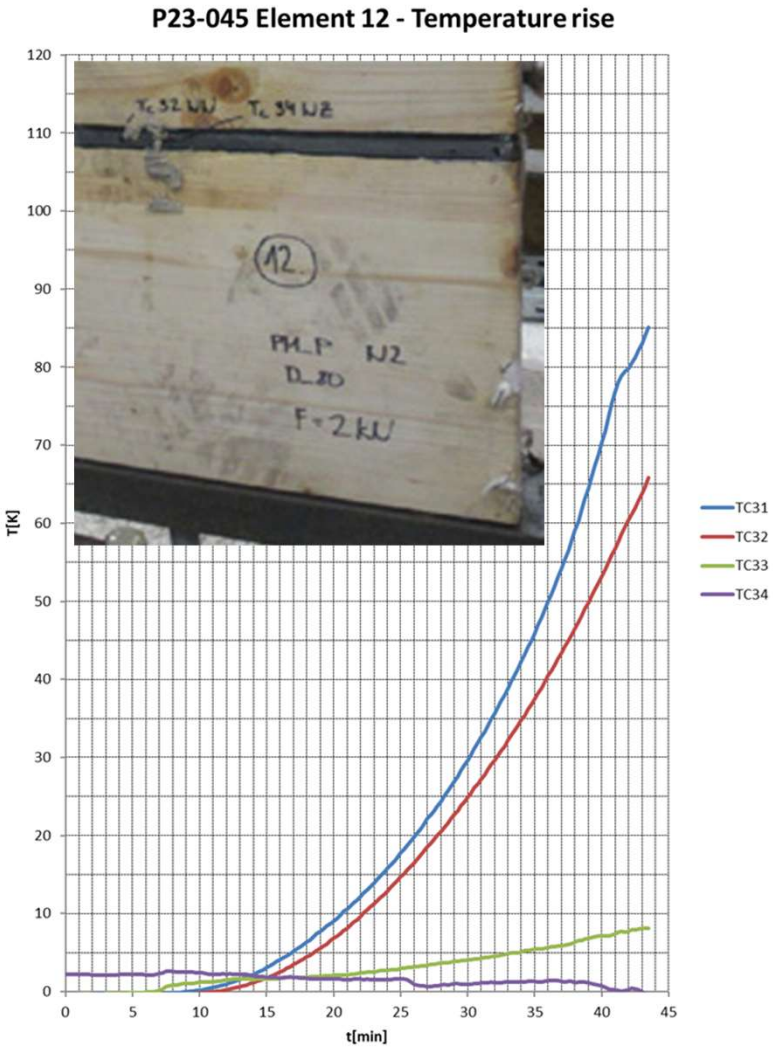


Photo A6.37: Thermocouple placement in specimen no. 12 *(photo archive 049506d-270)*

Table 2: Applied load.

No.	Name	Loading type	Load [tones]
12	PM_P D_80_N2	Tension	0.2

Photo A6.60: Specimen 12 after the fire resistance test – unexposed side (left) and exposed side (right) *(photo archive left: 049506d-447 and right:049506d-448)*



The collapses that occurred were due to exceeded shear strength of the timber and not of the flexible joint. Most of the **flexible joints withstood simultaneous mechanical and fire loading and assured tightness**.

In the fire resistance test it was noticed that timber specimens (with one or two polyurethan joints) **in case of collapse, collapsed through timber**.

The results are of research interest and show that **timber elements of stronger mechanical properties** should be used **to obtain collapse through the flexible joints** in case of fire resistance test.

Thank you for your attention!