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POTENTIAL OF HARDWOODS HARVESTED IN CROATIAN FORESTS FOR THE PRODUCTION OF GLUED LAMINATED TIMBER

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STRUCTURAL TIMBER IN EUROPE

EN 338 Structural timber – Strength classes

Softwood (Coniferous)

- Bending strength classes C16, C18, C24, C30,...
- Tension strength classes T8, T9, T10, T11,...
- With more than 90% share, spruce is the most significant wood species in the production of glulam, the rest is mostly from fir, pine and larch



Hardwood (Deciduous)

- Bending strength classes D24, D30, D40, D50,...
- Most commonly used as structural timber are beech, oak, chestnut and ash
- No harmonized standard for the production of glulam, no tension strength classes



STRUCTURAL TIMBER IN EUROPE

The distribution of tree species in Europe

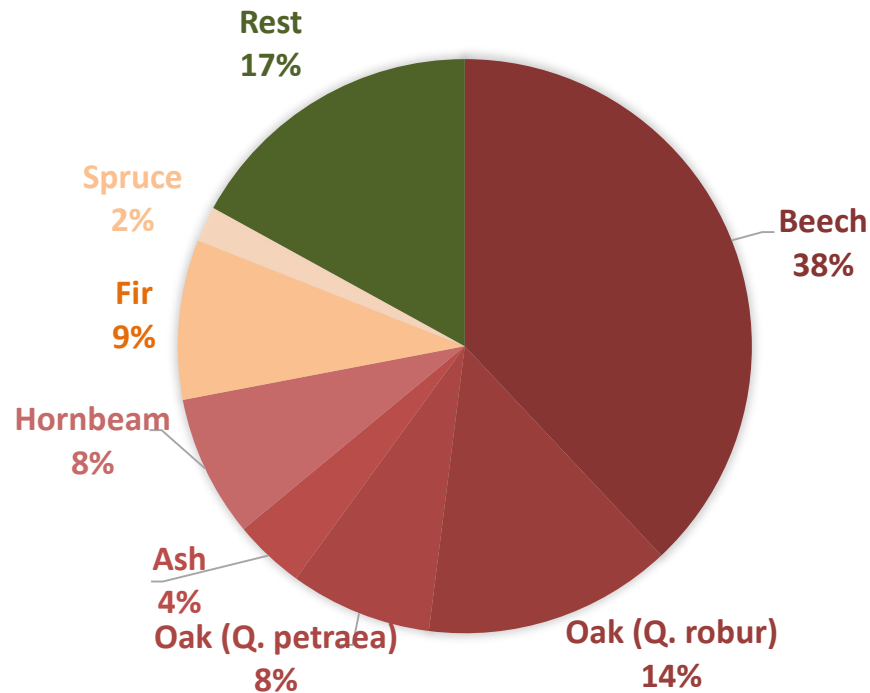
- 40 % forests areas in Europe are made of hardwood
- The proportion of hardwoods increases from north to south
- In northern European countries (Norway, Sweden, Finland), hardwoods cover 10-14% of total forest area, in central and southern Europe about one third of forest area, while in some southeastern countries they cover more than half of forest area
- Due to environmental factors, hardwoods are continuously increasing their share compared to softwoods



STRUCTURAL TIMBER IN EUROPE

The distribution of tree species in Croatia

- According to data from the 2017. volume of wood stock in Croatia is 315.8 million m³



HARDWOOD IN GLULAM - REGULATIONS

Hardwood glulam in Europe

trends in forest
menagement



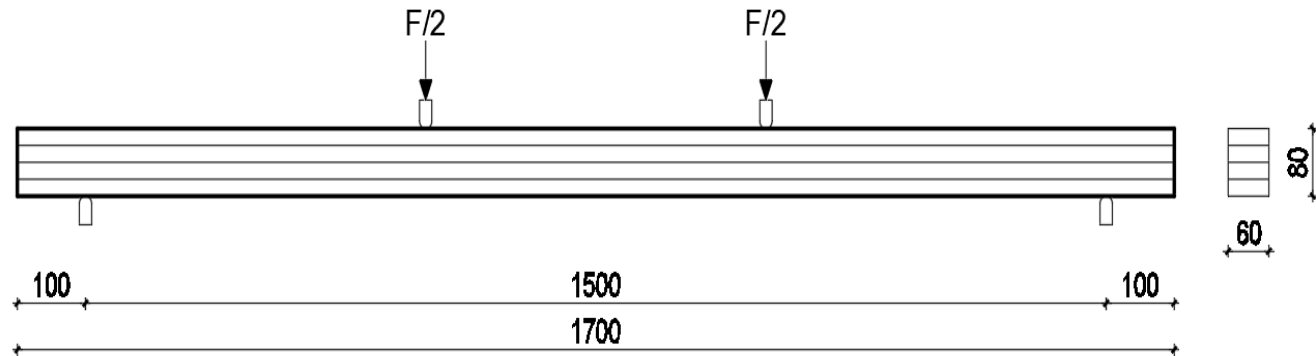
technical requirements
for construction products

- In 2010 scientists at the Technical University of Munich have shown that beech lamela can be glued successfully - paving the way for hardwood glulam
- Hardwood glulam is still a non-standard construction product – European Assessment Document (EAD), cited in 2021, is limited to certain hardwood species
- Glulam from species not included in EAD are left to a fully experimental basis.

SELECTION OF STRUCTURAL TIMBER

Hardwood species from Croatian forests

- Selection of species for which there is no published performance assessment, but are available in Croatian forests
- **Turkey oak** (lat. *Quercus Cerris L.*)
- **European hornbeam** (lat. *Carpinus Betulus L.*)
- **Maple** (lat. *Acer Campestre L.*)



SELECTION OF STRUCTURAL TIMBER

Hardwood species from Croatian forests

- Lamellas were glued with melamine-urea adhesive (Prefere 4535) and hardener (Prefere 5035)
- In consultations with the manufacturer of the adhesive, for the application of this adhesive on hardwood species, pot life was assumed to be 30 minutes.

Turkey oak	European hornbeam	Maple
Planed	Planed	Planed
Planed + S60	Planed + S60	Planed + S60
Planed + S80	Planed + S80	Planed + S80

PRODUCTION OF GLULAM

Planing of the lamellae



PRODUCTION OF GLULAM

Application of the adhesive



PRODUCTION OF GLULAM

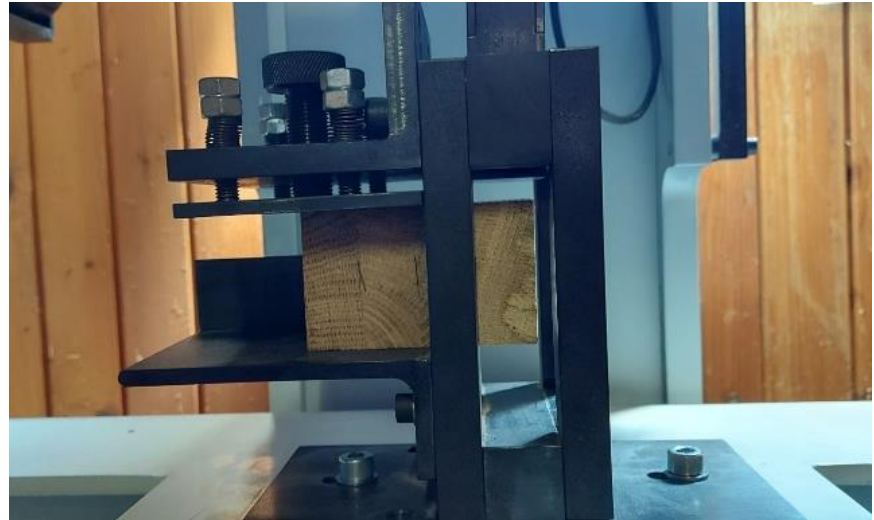
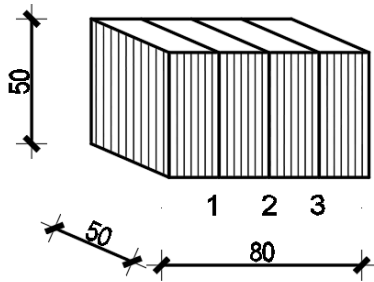
Joining laminations together with cramping pressure



SHEAR TEST OF GLUE LINES

Hardwood species from Croatian forests

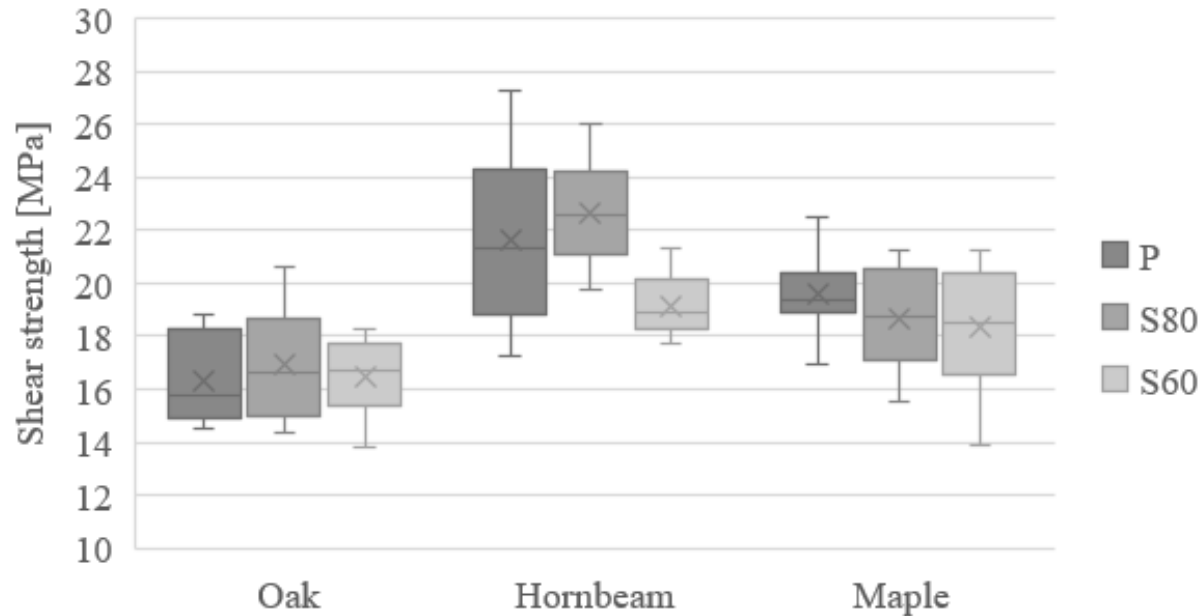
- For GLT made of softwood used in service classes 1 and 2 bonding strength of glue lines is verified by shear test
- EAD provides two options for bond shear strength test, at dry conditions for service class 1, and at wet conditions for service classes 1, 2 and 3.



SHEAR TEST OF GLUE LINES

Hardwood species from Croatian forests

- Experimental results for shear strength of the glue lines (P – planing, S80 – fine sanding, S60 – rough sanding).



SHEAR TEST OF GLUE LINES

Hardwood species from Croatian forests

- Experimental results for shear strength of the glue lines (P – planing, S80 – fine sanding, S60 – rough sanding).

	Maple			Turkey oak			Hornbeam		
	P	S80	S60	P	S80	S60	P	S80	S60
n	9	9	9	6	6	6	6	6	6
$f_{v,b,mean}$ [MPa]	19.60	18.67	18.31	16.32	16.91	16.49	21.63	22.67	19.16
$f_{v,b,mean}$ [MPa]	21.89	21.89	21.89	14.07	14.07	14.07	22.98	22.98	22.98
WFP_{mean} [%]	81	59	59	100	95	91	95	100	73
$rel f_{v,b,mean}$	0.90	0.85	0.84	1.16	1.20	1.17	0.94	0.99	0.83
$f_{v,b,05}$ [MPa]	16.15	14.40	12.99	12.55	12.18	12.91	14.55	17.99	16.35
$f_{v,w,05}$ [MPa]	18.70	18.70	18.70	8.61	8.61	8.61	12.12	12.12	12.12
WFP_{10} [%]	15	5	5	100	80	80	90	100	20
$rel f_{v,b,05}$	0.86	0.77	0.69	1.46	1.42	1.50	1.20	1.48	1.35

SHEAR TEST OF GLUE LINES

Hardwood species from Croatian forests

Typical shear failure, with all photos related to planed samples.



Maple



Turkey



European hornbeam

RESEARCH PROJECT

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**THANK YOU FOR YOUR
ATTENTION!**