Circular Economy of Wood Construction

Sustainable Building Technologies

Research activities Salzburg UAS

FH Salzburg

JADEHOCHSCHULE
Wilhelmshaven Oldenburg Elsfleth

Karelia

Sustainable Building Technologies

Objectives, research topics, project partners

Karelia UAS	Spatial Modelling for Climate Wise Construction Competitiveness of wood construction
Jade UAS	Life cycle analysis Building information modelling
Salzburg UAS	Mechanical properties of used wood Indoor air quality of wooden wall elements & recycled materials

Circular Economy of Wood Construction

Building sector:

- responsible for approximately 36% of the energy-related greenhouse gas emissions (European Commission- Energy efficiency in buildings, 17 February 2020)
- consumes 50% of all extracted raw materials (European Commission-COM(2020) 98 final, 11 March 2020)

Wood:

- 1m³ wood stores approx. 1 t of CO^2

Benefits of reusing structural timber

- Shorter transportation distances
- Less energy consumption for production
- CO_2 storage effect over longer duration

Current Situation of Reuse/Recycling

Circular economy			
	Smarter product use and manufacture	R0 Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
		R1 Rethink	Make product use more intensive (e.g. through sharing products, or by putting multi- functional products on the market)
		R2 Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials
	Extend lifespan of products and parts	R3 Re- use	Re- use by another consumer of discarded product which is still in good condition and fulfils its original function
		R4 Repair	Repair and maintenance of defective product so it can be used with its original function
		R5 Refurbish	Restore an old product and bring it up to date
		R6 Remanufacture	Use parts of discarded product in a new product with the same function
		R7 Repurpose	Use discarded product or its parts in a new product with a different function
	Useful application of materials	R8 Recycle	Process materials to obtain the same (high grade)or lower (low grade) quality
Linear economy		R9 Recover	Incineration of materials with energy recovery

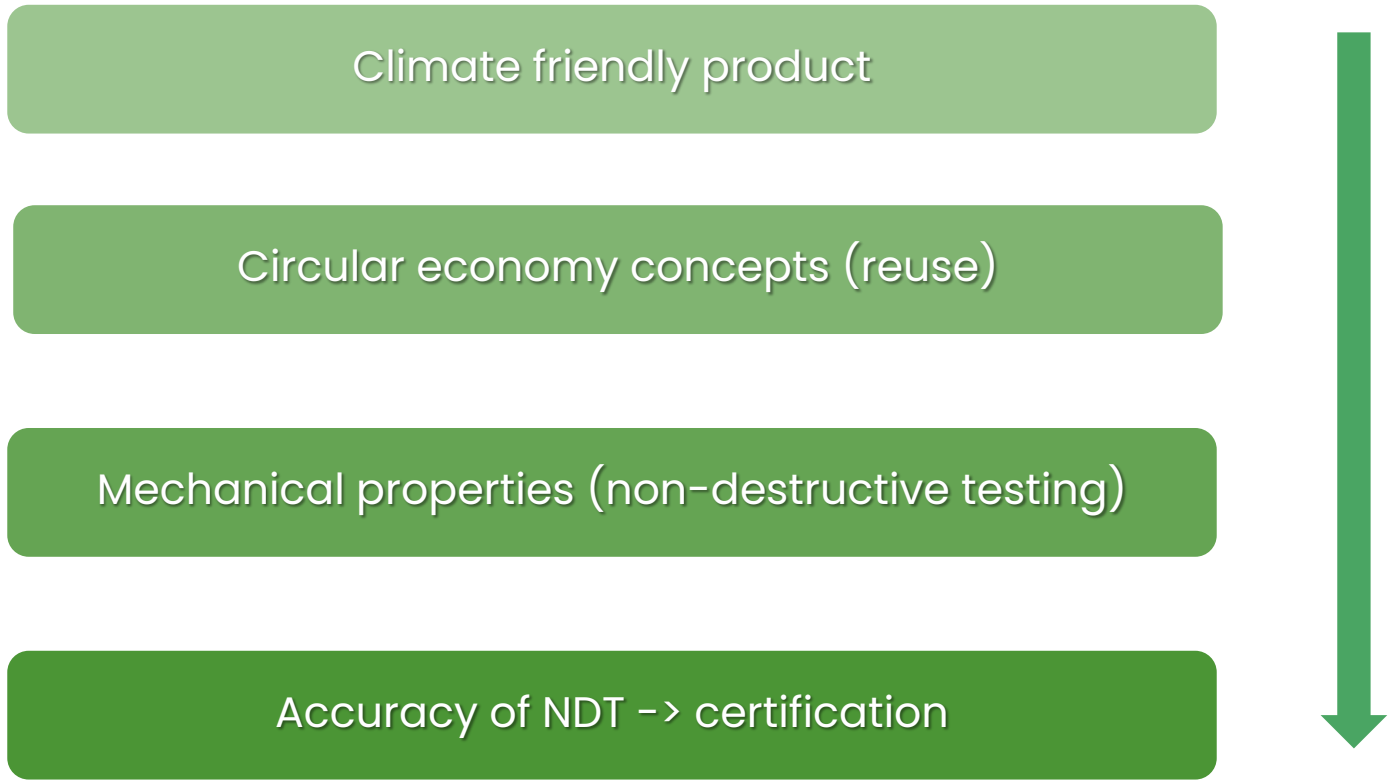
Circular Economy: Measuring innovation in product chains | PBL Planbureau voor de Leefomgeving

Challenges of reusing structural timber

- Damage resulting from deconstruction
- Damage during the period of use
- Currently still high duration of deconstruction and removing of screws or other fastening elements
- Storage possibilities
- Lack of certification

Research approach

Key aspects for the reuse of structural timber



Material - Used construction timber

- In Austria mostly **30 – 50 years** old construction timber of roof structures
- Untreated wood (**Grade A**)
- Preferably **large cross-sections** (e.g. min. 50 x 100 mm x 3 m for structural use)
- **Non technically dried** timber was used (MC 20-25%)

- Shrinkage cracks, deformations, warping

Properties of used timber

Natural aging process

- Effect of time (30-50y.) has no significant influence on mechanical properties.
- Properties of timber remain unchanged in optimal environment conditions (dry air, low temperatures and low UV radiation)

Shrinkage cracks and deformation

- Changes in moisture content
- Cracks deeper than half of the width and
- Longitudinal curvature greater than 8mm per 2m of length are not allowed

Duration-of-load effect

- Long-term and punctually high loads on timber can reduce the bending strength due to formation of microcracks

Mechanical properties of used/salvaged wood

Pic. 1: Used rafters of old roof truss

Pic. 2: Sample preparation of the wood

Pic. 3: Samples, cut and planed

Pic. 4: Testing with TOF method

Dynamic modulus of elasticity

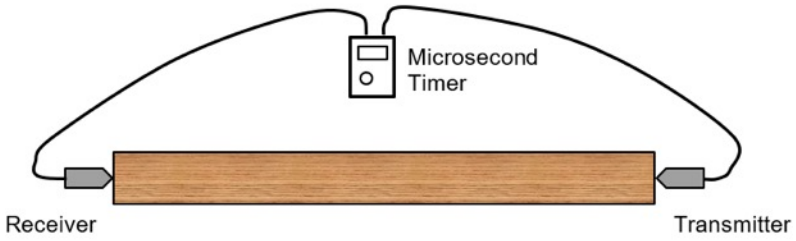
Time of flight method

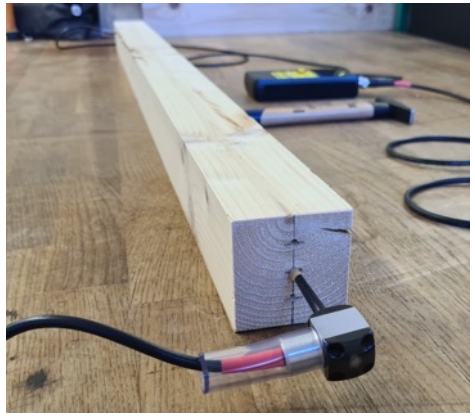
$$MOE_{dyn} = v^2 * \rho$$

v = sound propagation velocity

ρ = density

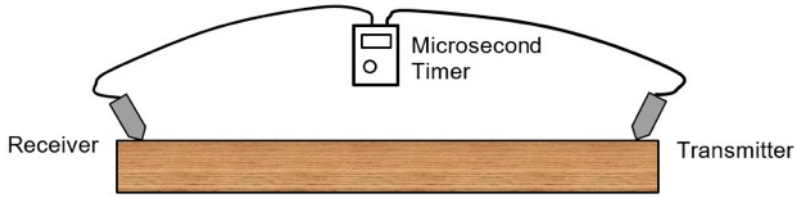
Direct measurement

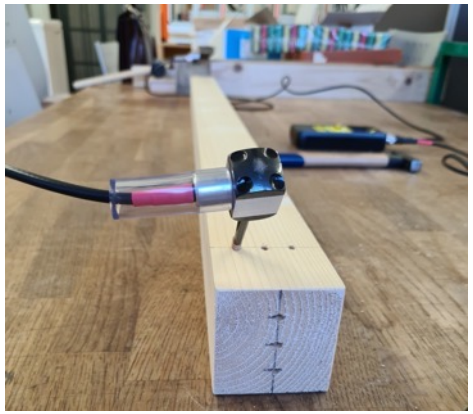




TOF fiber parallel

Indirect measurement



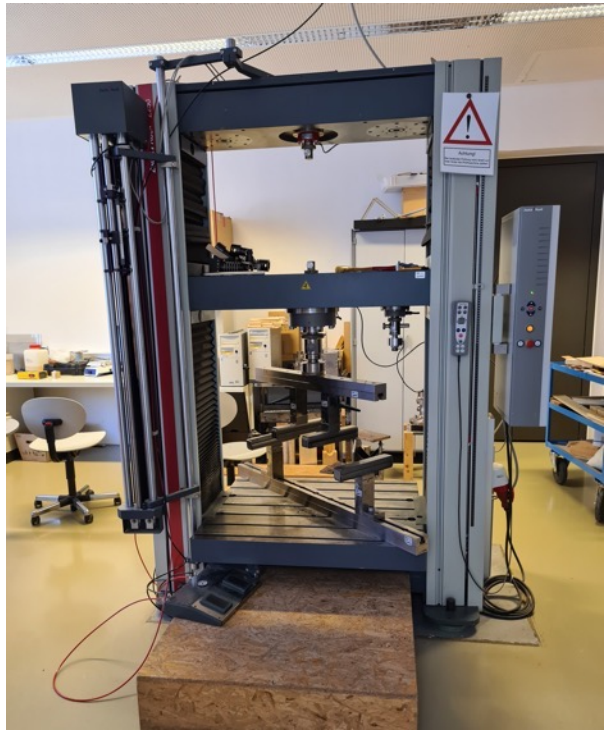


TOF 45˚ to fiber

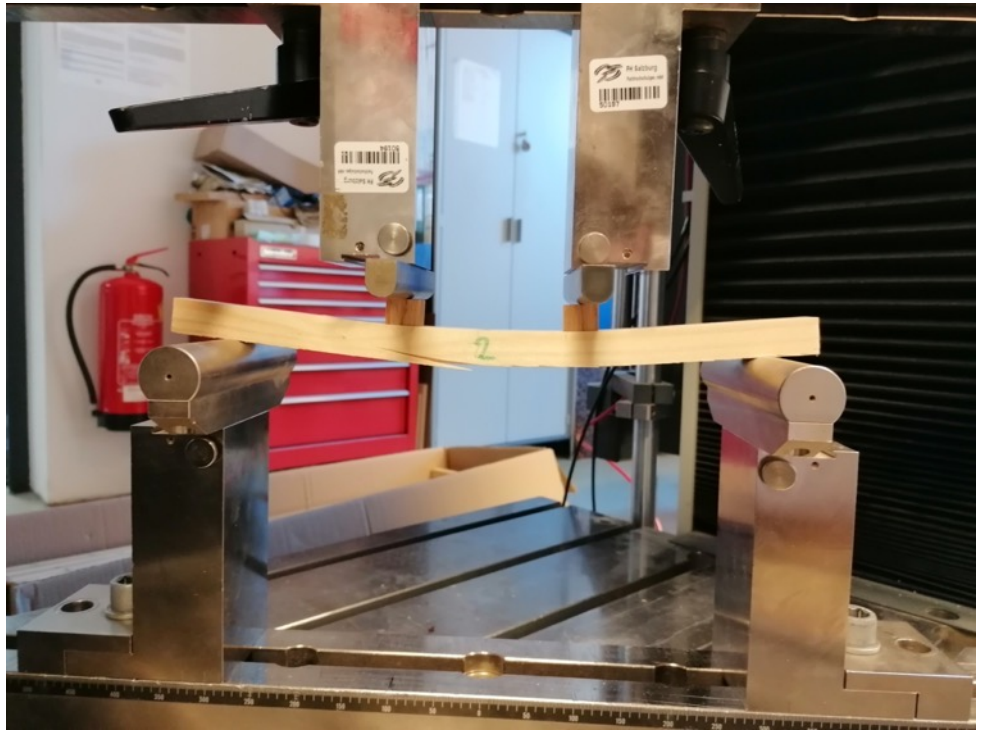
Static modulus of elasticity

4-point bending test (DIN 52186)

Whole beam (3000 mm)



Clear sample (360 mm)



Assignment to the strength classes

- Dynamic MOE 31% higher than static MOE
- Level compensation of dynamic MOE
- 50% of values in strength classes C16 and C18

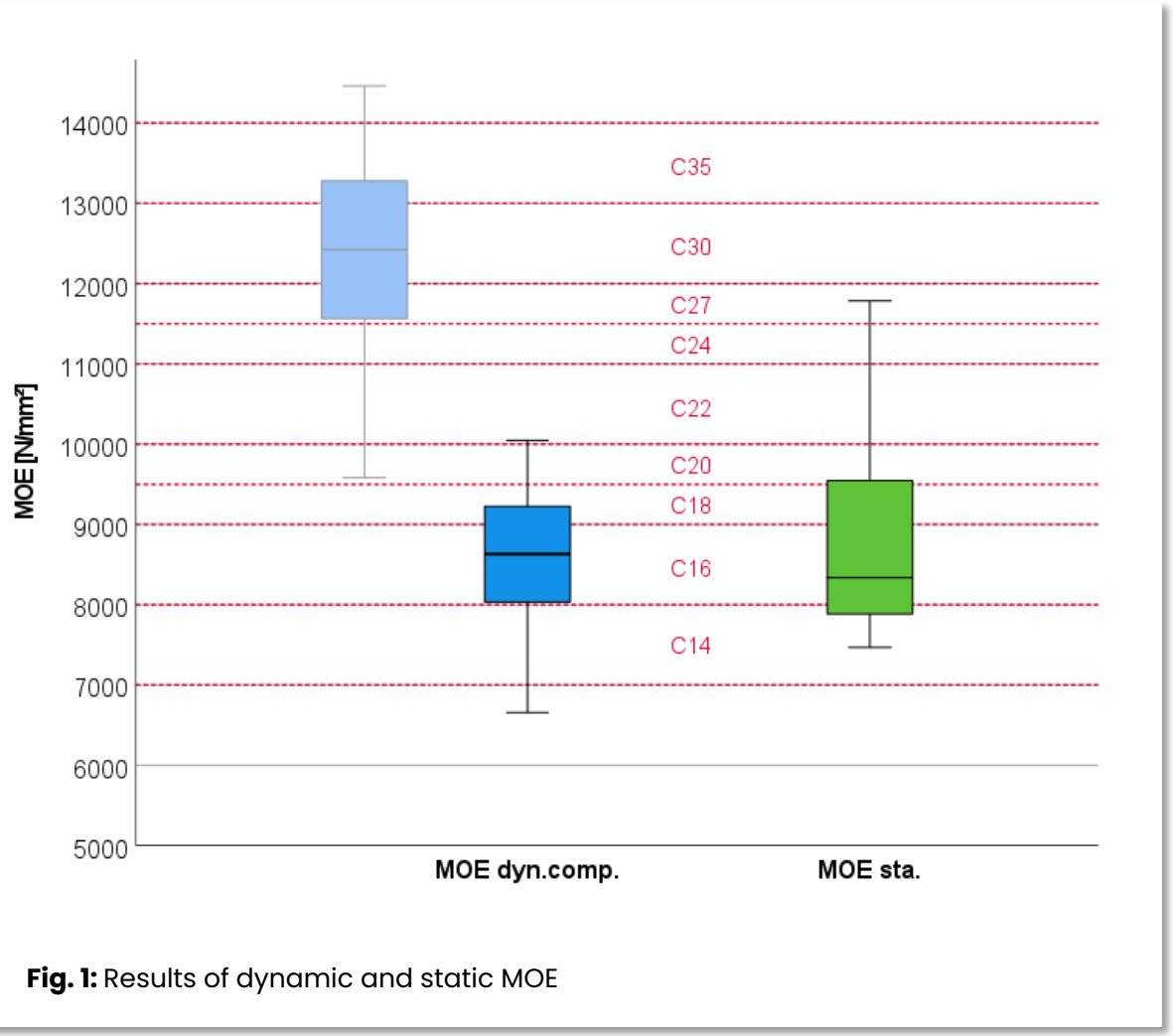


Fig. 1: Results of dynamic and static MOE

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Correlation between testing methods

Comparison of 4-point bending to TOF method

- High coefficient of determination R=0,809 and R=0,979
- Clear sample correlation higher than whole beam correlation
- Wood characteristics as knots and cracks are only partially measured
- Additional testing methods Visual grading (DIN 4074)

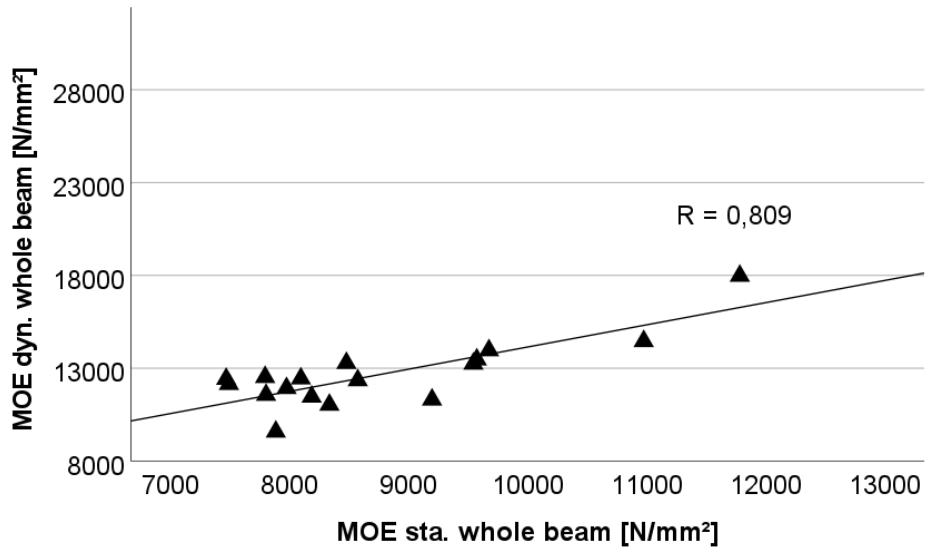

Fig. 1: Linear regression of 4-point bending test and TOF-method – whole beam

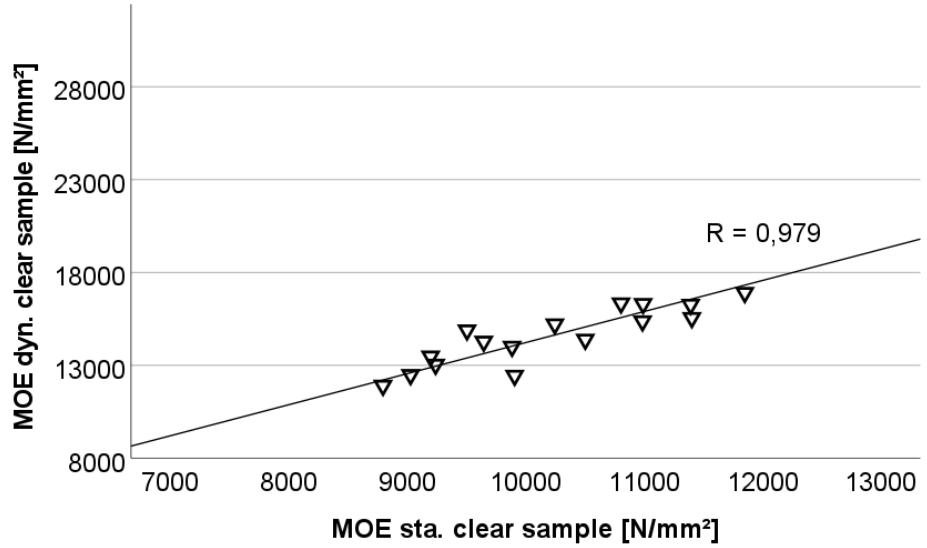

Fig. 2: Linear regression of 4-point bending test and TOF-method – clear sample

Further research topics

- Influence of
  - > moisture content on TOF-measurement
  - > screw- and nail holes on TOF-measurement
- Assignment of TOF-values to strength classes – EN 338
  - > Limits for strength classes
- Which other parameters interfere with the TOF-measurement?

Thank you

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Community of Practices

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