Karlsruhe Institute of Technology

Load-bearing behaviour of partially threaded screws in hardwood

Elisabet Kuck and Carmen Sandhaas

Introduction

- Today: complex buildings
  - Taller constructions, larger spans, higher loads

- **Solutions for MORE efficient buildings**
  - Hardwood: high potential construction material

- Project hardwood_joint
  - Innovative solutions for connection design
  - Knowledge gap: hardwood ⟷ softwood?

  → Use full potential of hardwood members

  → Obtain high-performance connections

[pollmeier.com]

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Challenges

- Connection behaviour
  - Failure modes → ductility criterion
- Appropriate design rules
  - Load-bearing capacity → $F_{V,R}$
  - Geometric conditions → spacing, edge distances, timber thickness

→ Connection tests

- Single screws (Multi-stage tests)
  - Deformation process of screws
  - Initial adhesion
- Groups of screws

?

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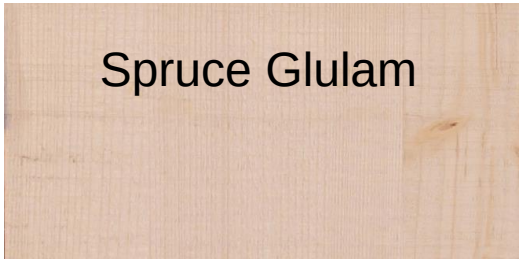
Materials

- Partially threaded self-tapping screws:
  - **Predrilled** insertion
    8x160/80mm, countersunk head

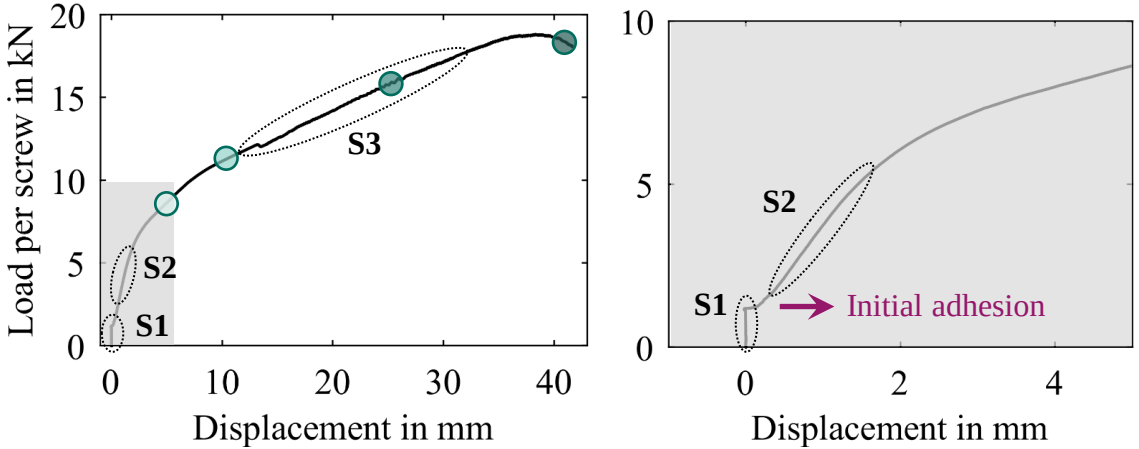
  - **Non predrilled** insertion
    8x160/100mm, washer head

- Wood species and products



Multi-stage tests

- Single-shear connection tests
- Test termination after reaching displacement stages
  - 5, 10, **25** mm and **failure**



- Initial adhesion = Load at detaching point
- Stiffness and connection behavior: section S1 – S3

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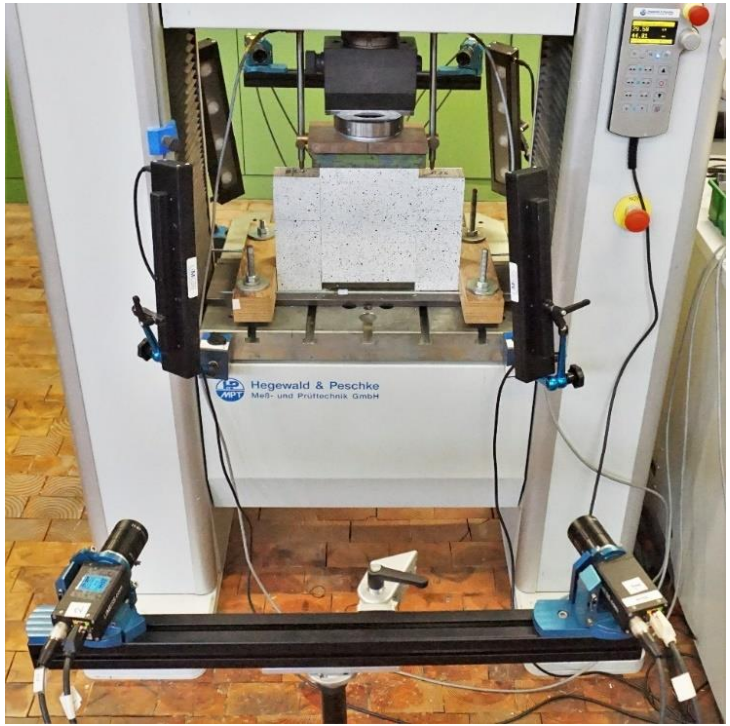
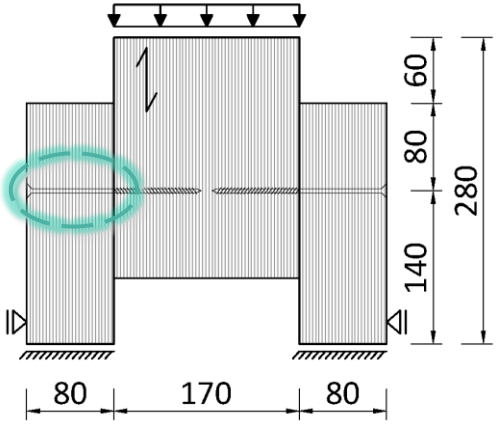
Test setup

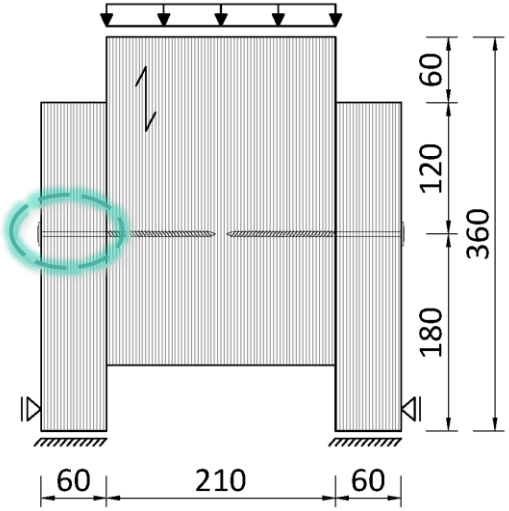


predrilled



non predrilled

[mm]



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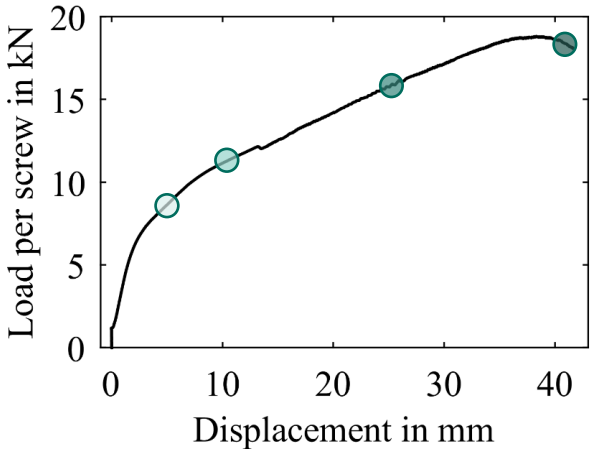
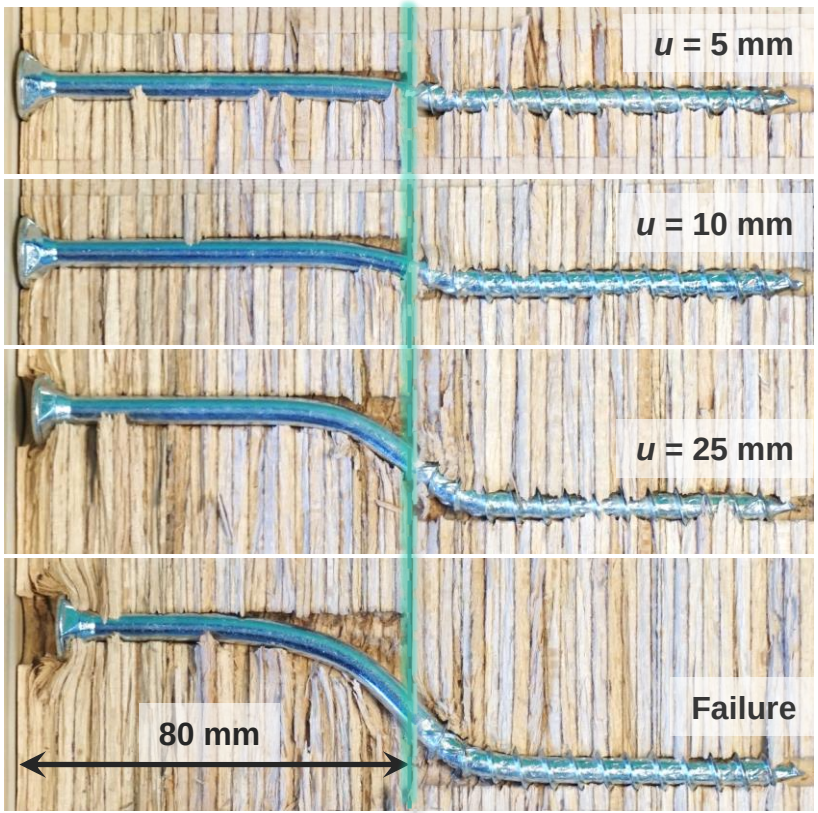
Results in Beech LVL

- Incremental deformation process
  - Plastic hinges starting at u = 10mm
  - Larger displacements: head pull-in
  - Difference: shank and thread





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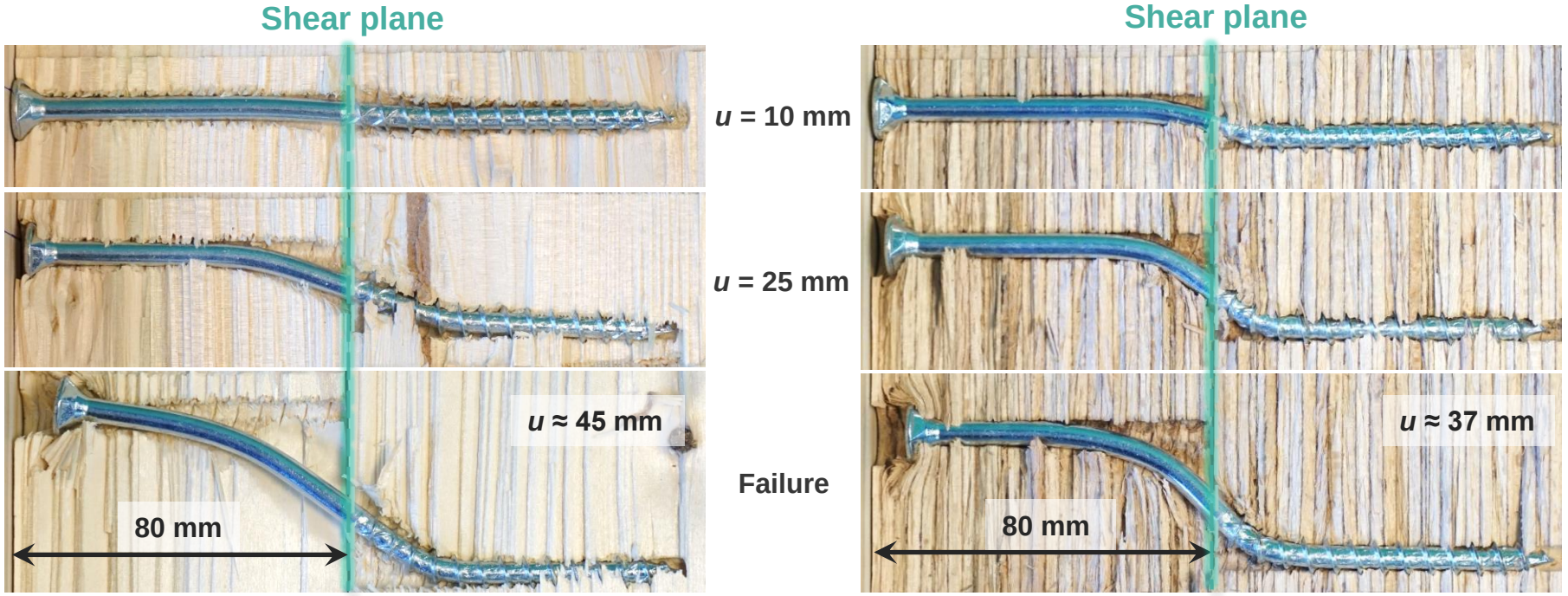
softwood – hardwood



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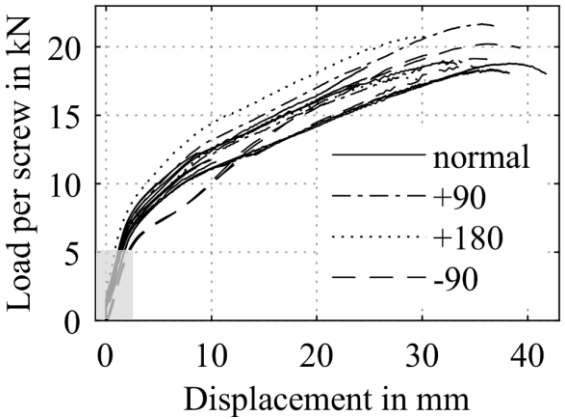
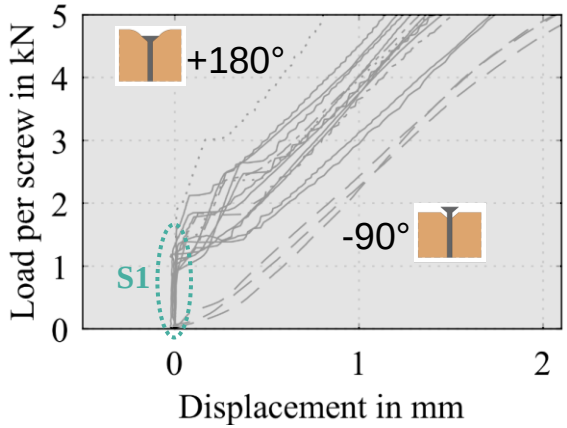
Initial adhesion

- Prestress of screws → adhesive forces in shear plane
  - Manual modification of screw insertion

screw 90°/180° overtightened +90° / +180° →

screw 90°/180° turned back -90° / -180° →





Results of predrilled screws

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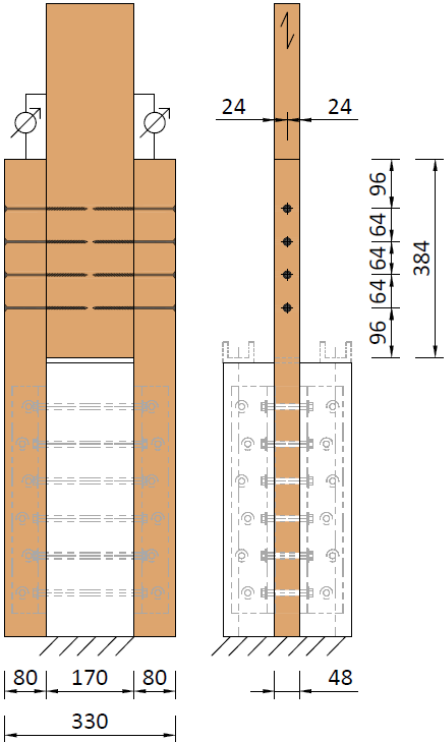
Groups of screws

- Test setup
  - Beech LVL & Birch Glulam
  - Single shear connections
  - Geometry

	distance		in mm
predrilled	a_1	8*d*	64
	a_2	3*d*	24
	$a_{3,t}$	12*d*	96
	$a_{4,c}$	3*d*	24
non predrilled	a_1	15*d*	120
	a_2	7*d*	56
	$a_{3,t}$	20*d*	160
	$a_{4,c}$	7*d*	56



One row

Two rows

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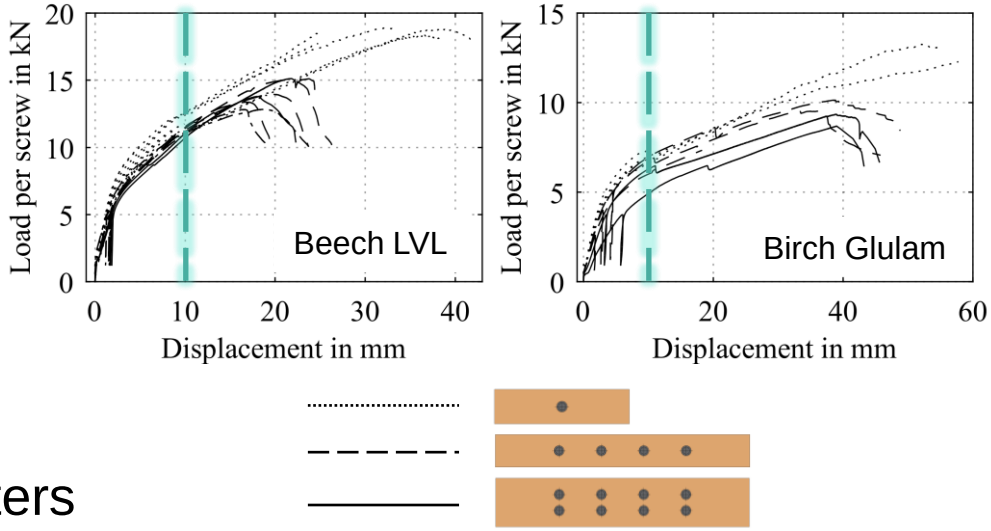
Groups of screws

- Results for predrilled screws

Load per screw and shear plane	Beech LVL	Birch Glulam
	Load in kN at u = 10 mm	
multi-stage tests	12.0	7.02
	11.4	6.59
	10.9	5.63
$F_{V,R}$	9.69	5.74



- $F_{V,R}$ calculated with input parameters
  - Tests: f_h, M_y, f_{ax}, f_{head}
  - Rope effect min (100% F_V; 25% F_{ax})

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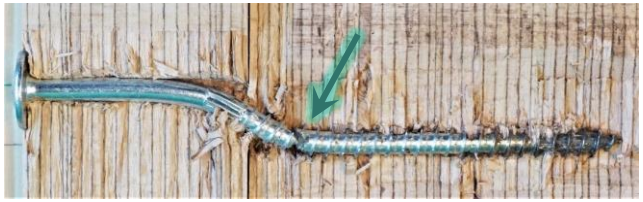
Failure modes

- Splitting in grain direction
- Tension perp. to grain in middle member, followed by block-shear failure (birch glulam)



- Screw failure in shear plane or plastic hinge

Conclusion

- In general: **Current design rules** are appropriate for hardwood
- Durability of **initial adhesion is debatable**
- Non-predrilled screw insertion in hardwood is difficult
  - → Challenge on site
  - → **Predrilling is recommended**
- **Prevent failure perp. to grain** of the middle member
- Ductile behaviour: ***u* = 10 mm** for screw connections should be achieved
  - → Adjustment of spacing a_1
  - → Guarantee plastic hinges

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Thank you for your attention!

ForestValue

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