Experimental determination of the rotational stiffness and moment capacity of connections in CLT buildings

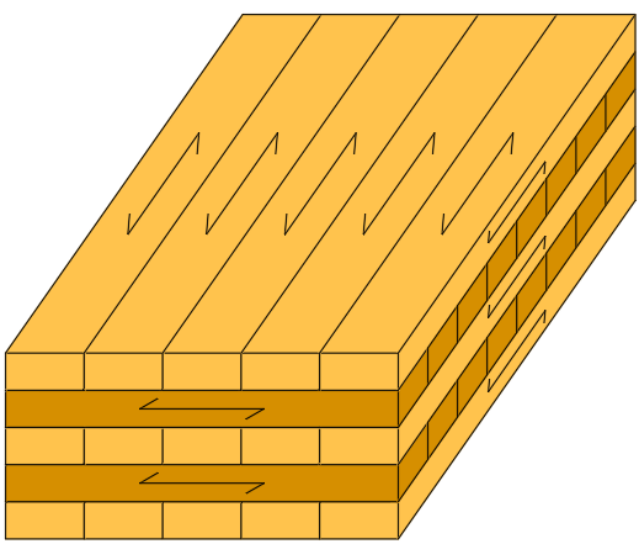
Jenny Abrahamsson and Filip la Fleur

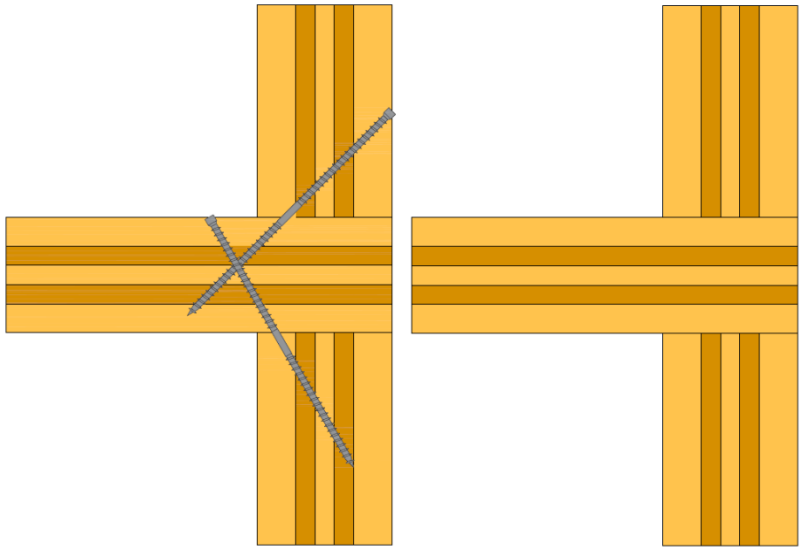
Agenda

- Introduction and problem description
- Aim and purpose
- Experimental investigation
  - Method
  - Results
- Discussion
- Conclusions

Introduction and problem description

- CLT – Cross laminated timber.
- Semi-rigid behavior.
- Rotational stiffness and moment capacity in connections.
- Wall-floor-wall connection.





Motivation to the work

- Usually these connections are assumed as hinged connections
- In reality some clamping force on the wall will affect the connection in some extent
- Effects by the rotational stiffness
  - Load distribution
  - Deflection of floor
  - Dynamic behavior

Aim and purpose

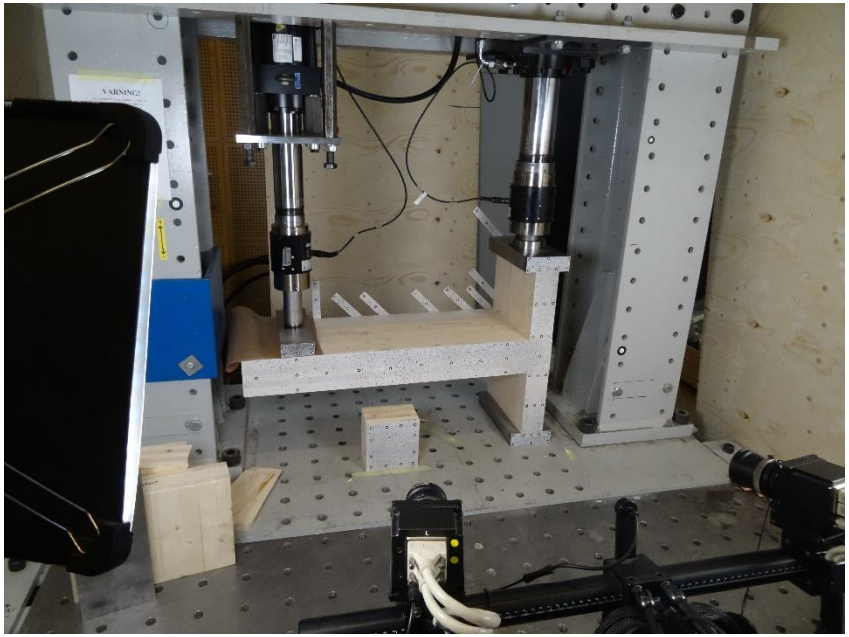
The aim with the study was to:

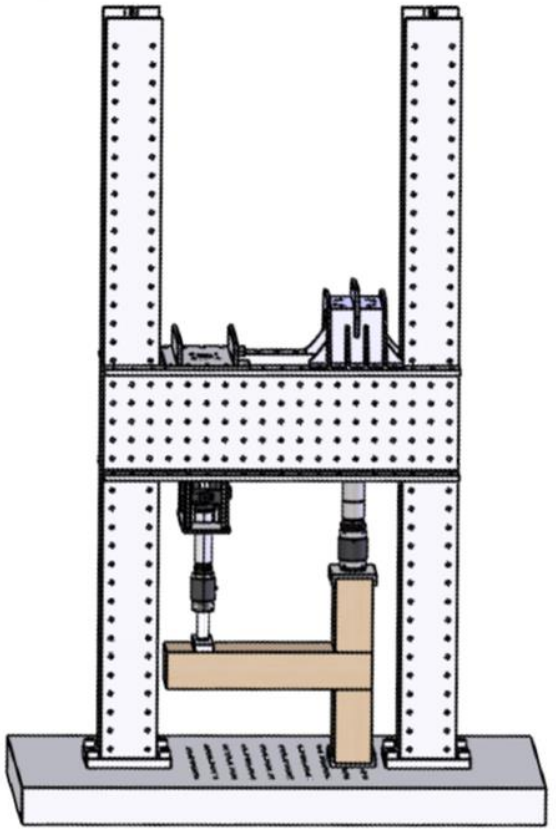
- Determine the rotational stiffness and moment capacity of the wall-floor-wall connection.
- Gain knowledge on how the stiffness is influenced by the thickness of the wall, the floor and the load level on the wall.

The purpose was to create a better understanding of the load-displacement behavior of a CLT connection.

Experimental investigation: Method

- MTS 300kN load frame
- 800 mm distance between pistons
- Load level on wall: 0.5, 1.0, 1.5 and 2.0 MPa
- Relative displacement on the floor: 20 mm





Wall 140mm, floor 120mm

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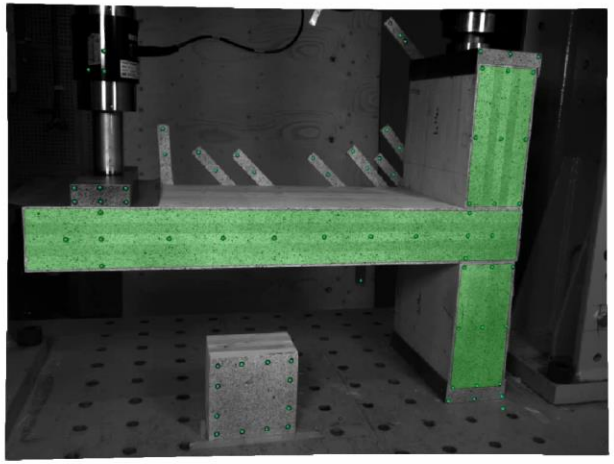
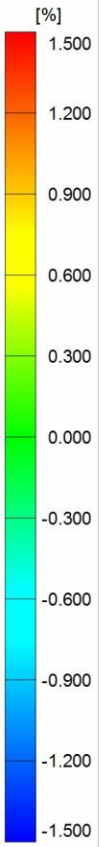
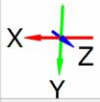
Geometry reference: 1

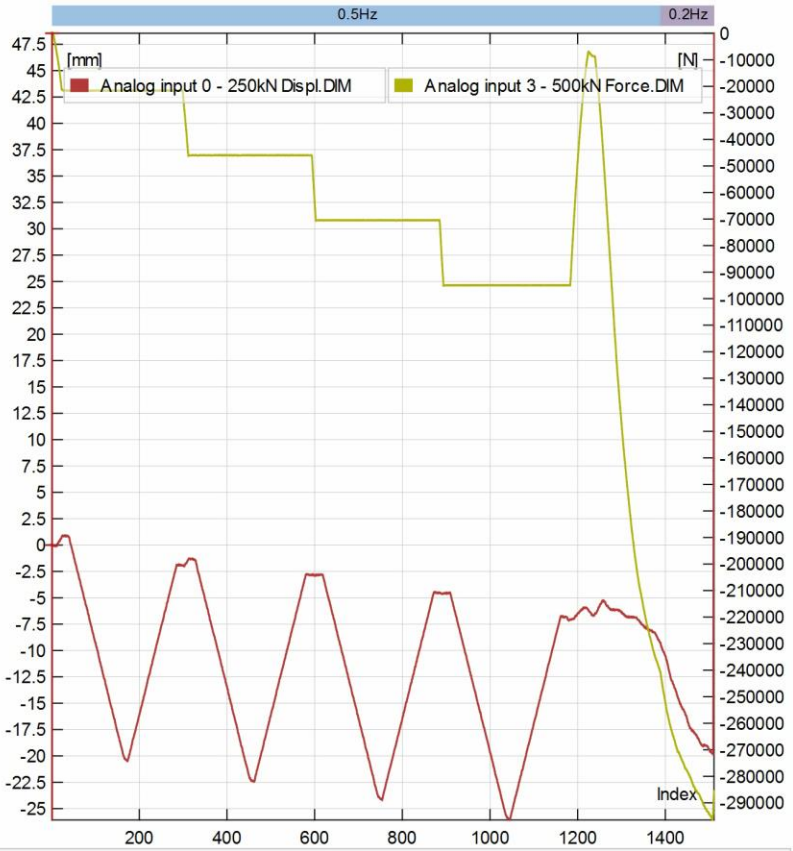
Analog input 0 - 250kN Displ	
DIM	+0.000 mm

Analog input 3 - 500kN Force	
DIM	+0.000 N







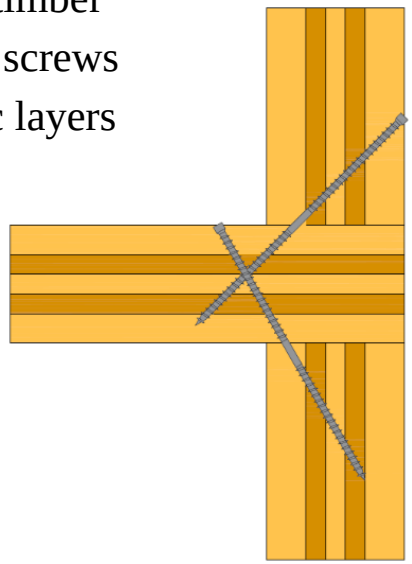


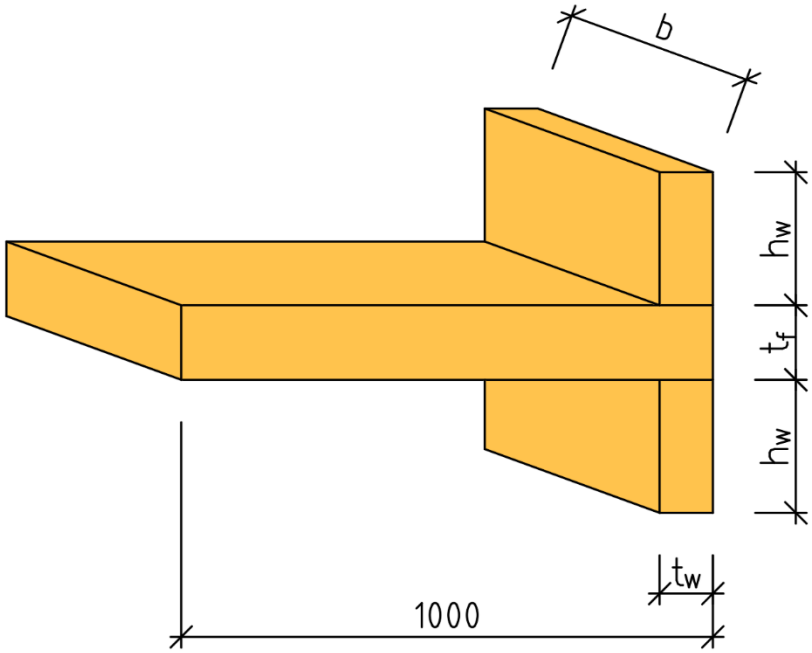
3-2-1 alignment wall

11.11.2020

Test series

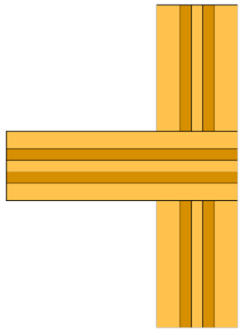
- 60 test and 8 test setups
- C24 in spruce and pine
- Wall thicknesses: 80, 100 and 140 mm
- Floor thicknesses: 120 and 140 mm
- Connections:
  - Timber-timber
  - Inclined screws
  - Acoustic layers



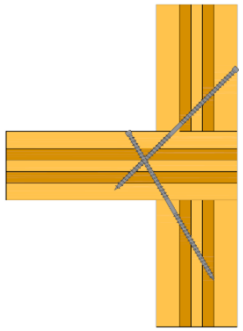


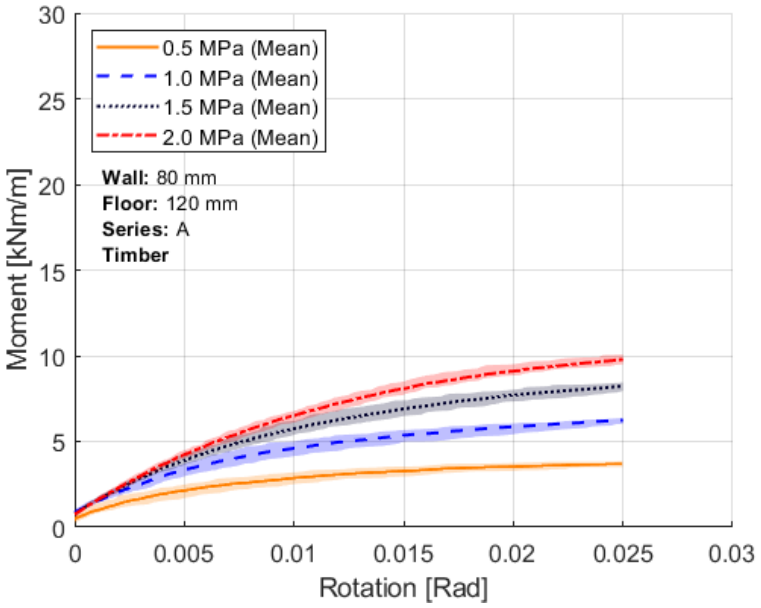
Results from experiments
Influence of connection type

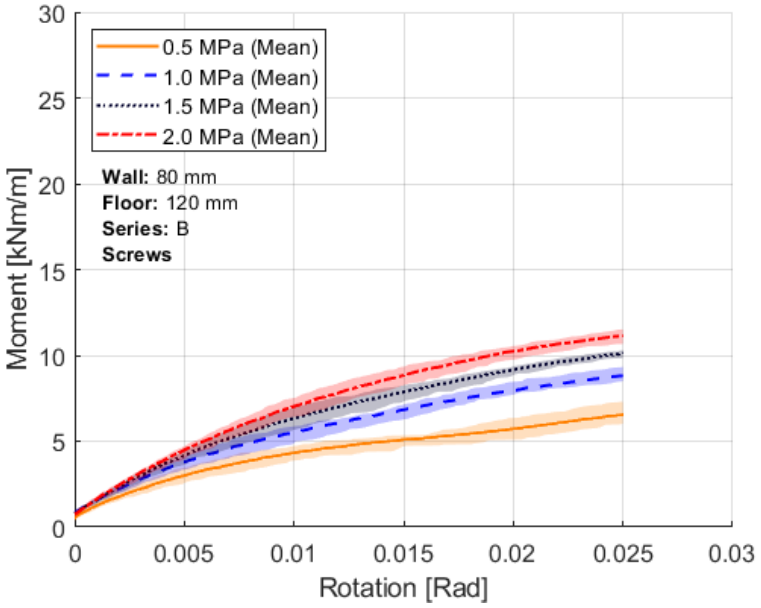
Series A



Series B



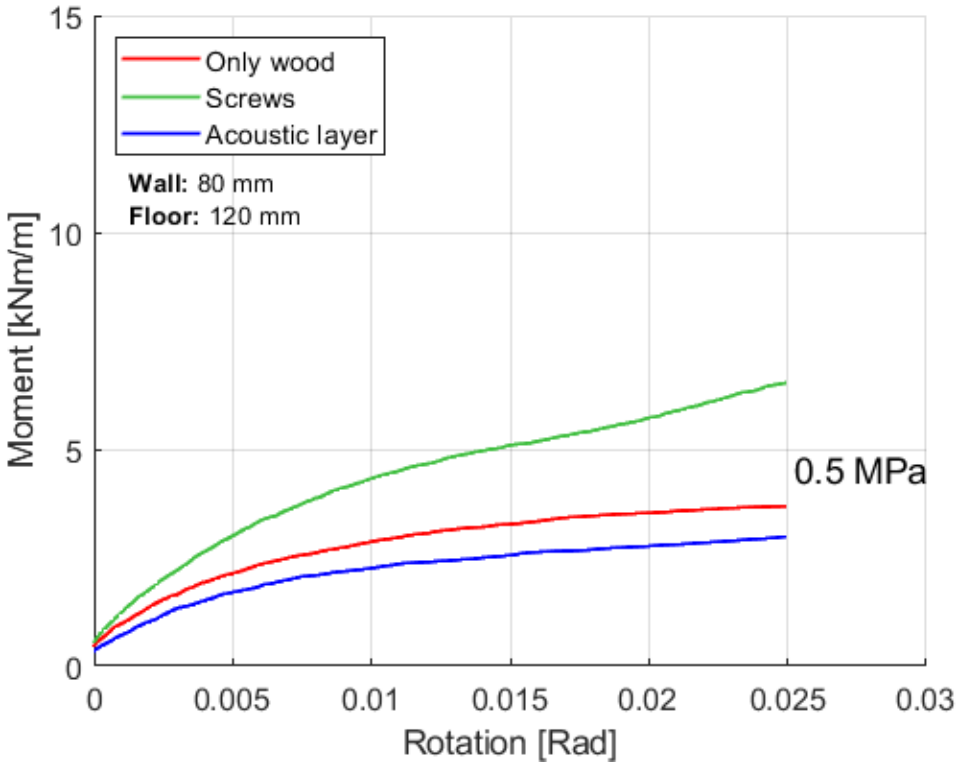




Influence of connection type

80 mm wall

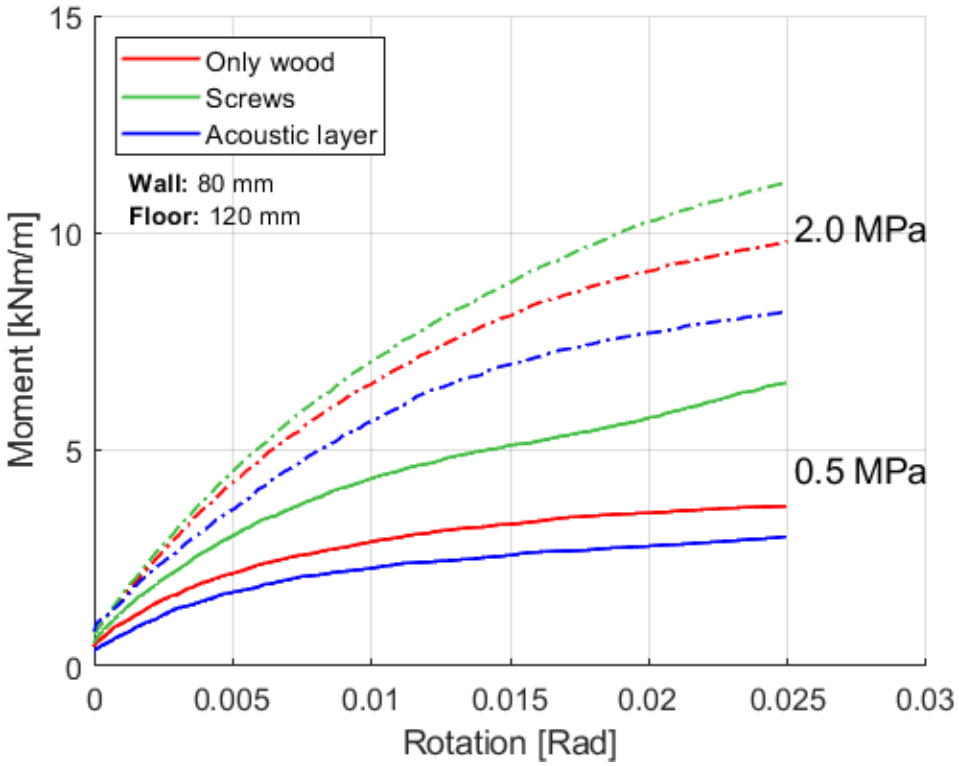
- More contribution on lower load level from the screws



Influence of connection type

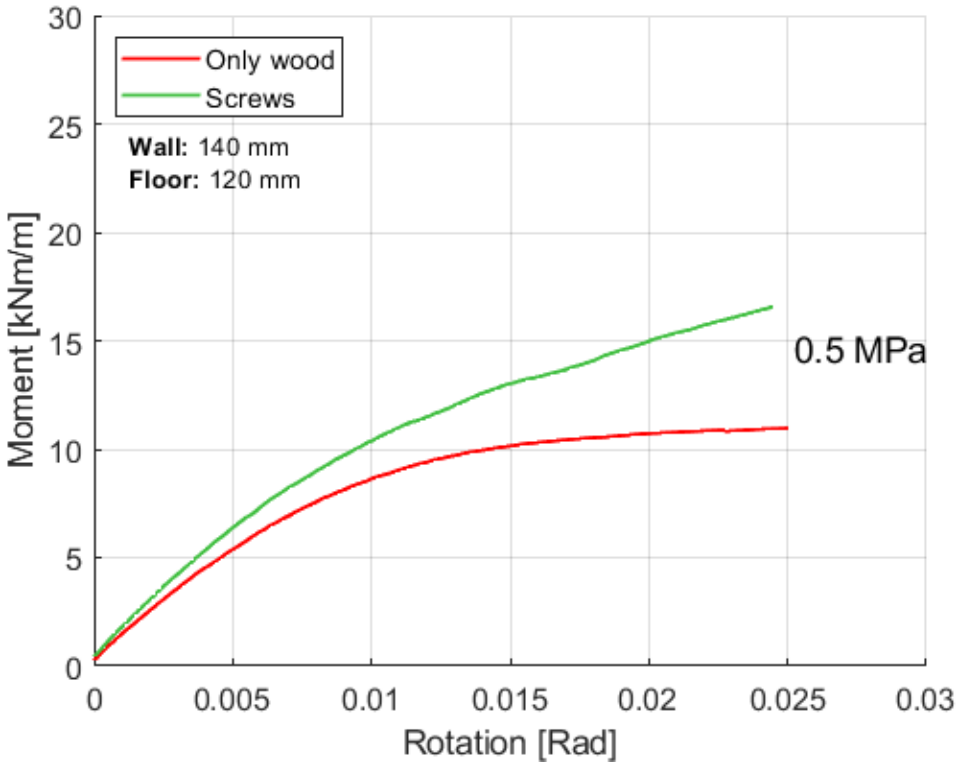
80 mm wall

- More contribution on lower load level from the screws
- Acoustic layer about the same difference in percentage



Influence of connection type

140 mm wall



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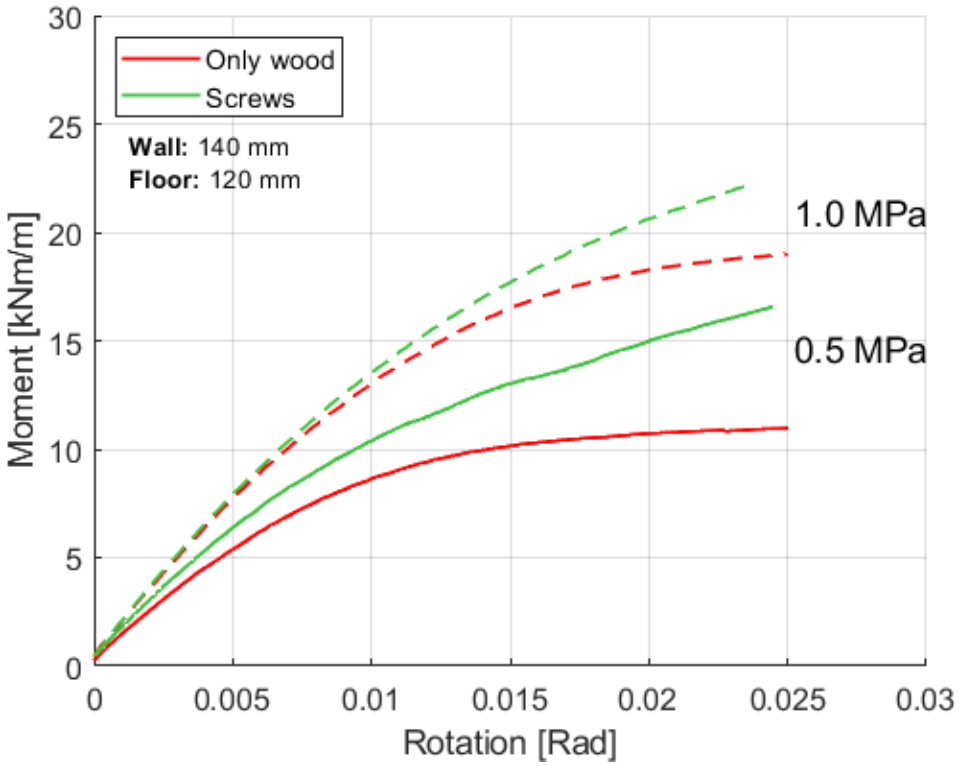

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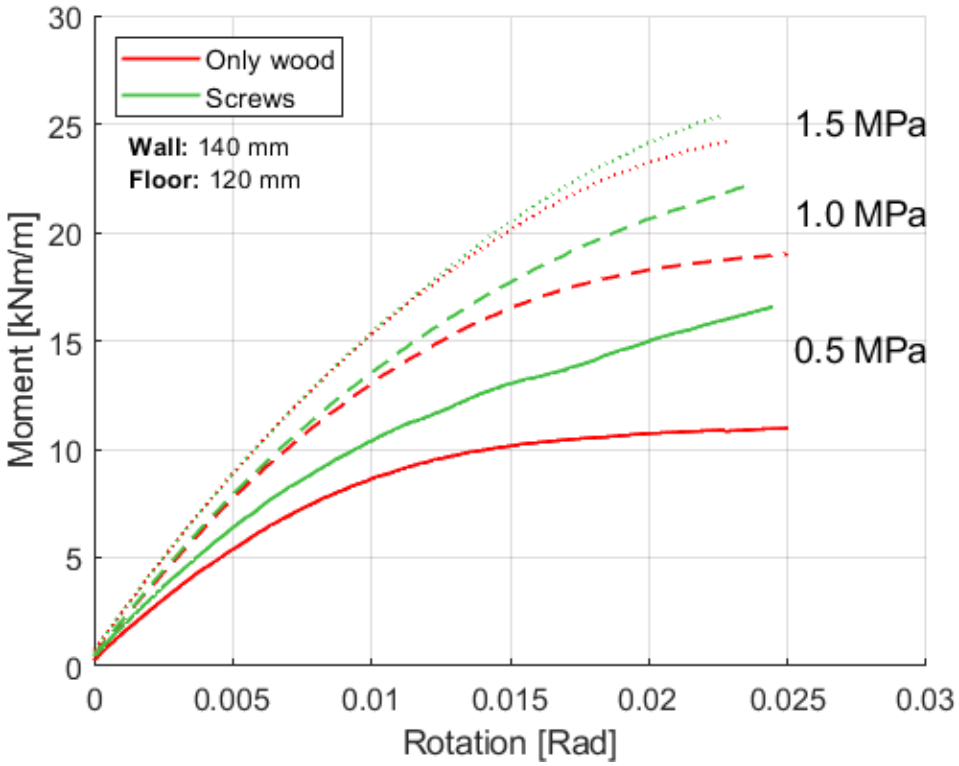
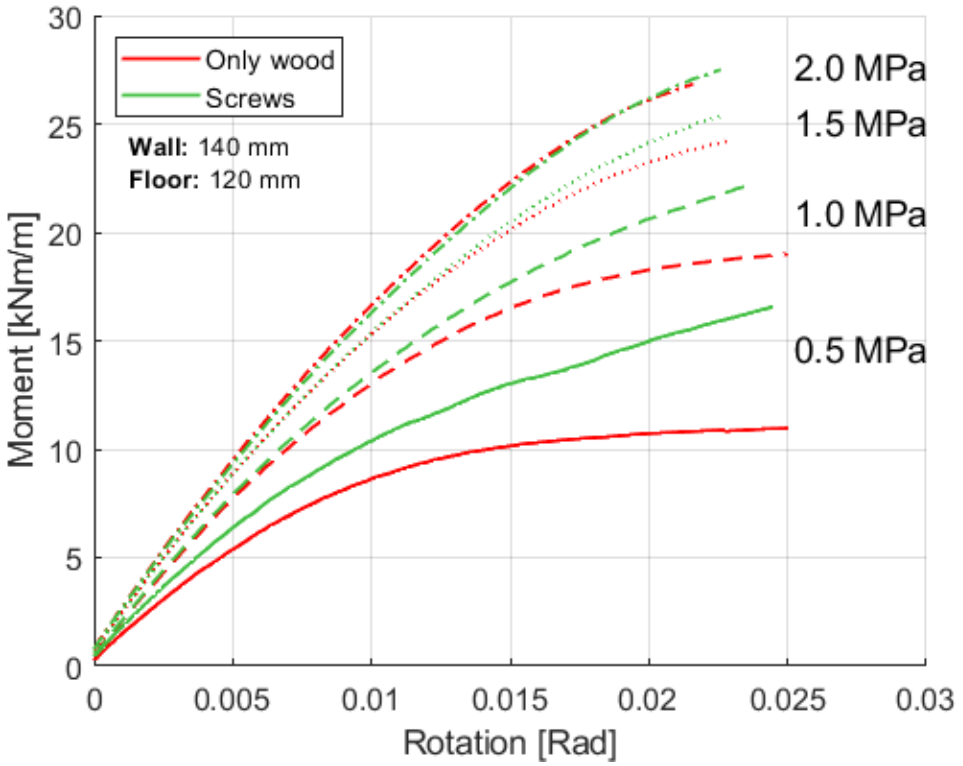
140 mm wall



Influence of connection type

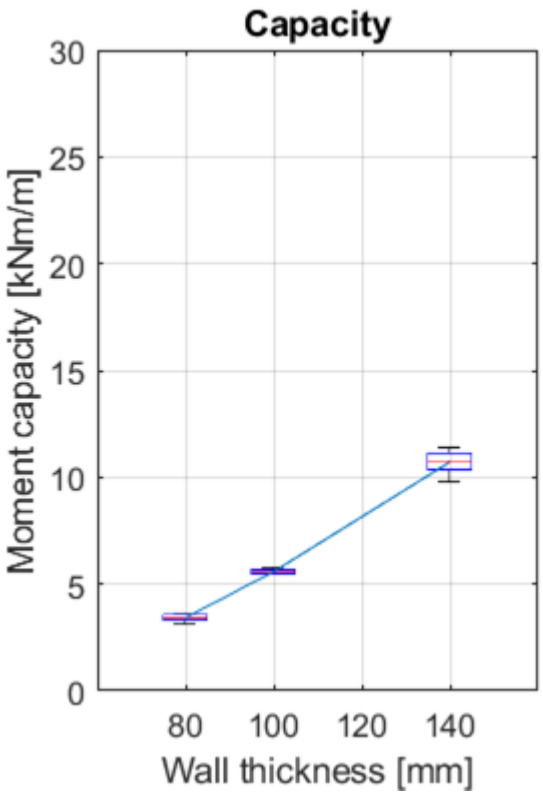
140 mm wall

- Almost no contribution from screws on higher load

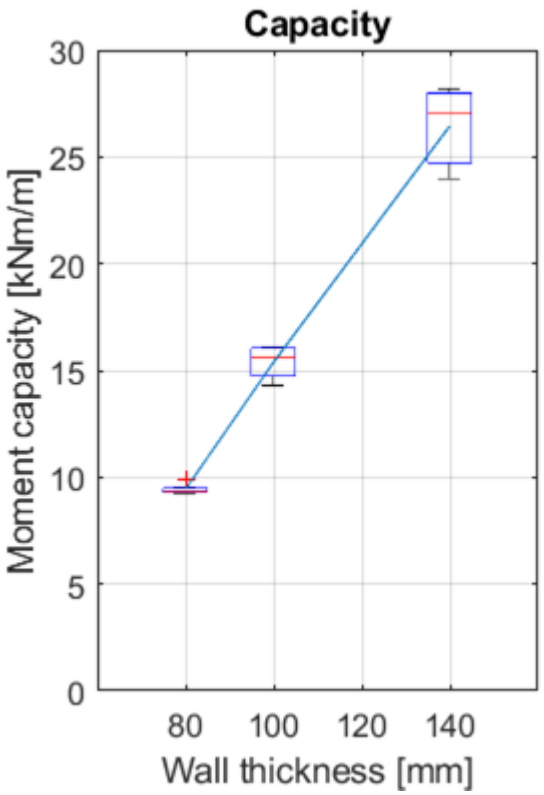


Moment capacity influenced by the wall thickness

0.5 MPa

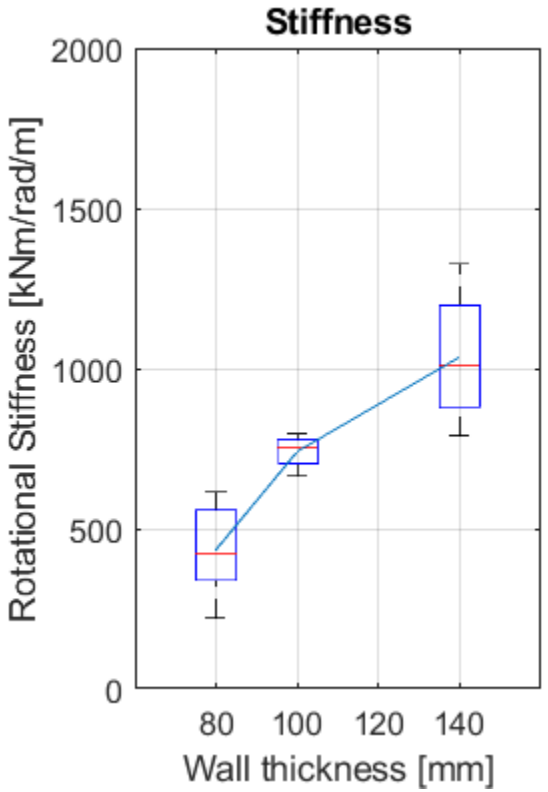


2.0 MPa



Rotational stiffness influenced by the wall thickness

0.5 MPa



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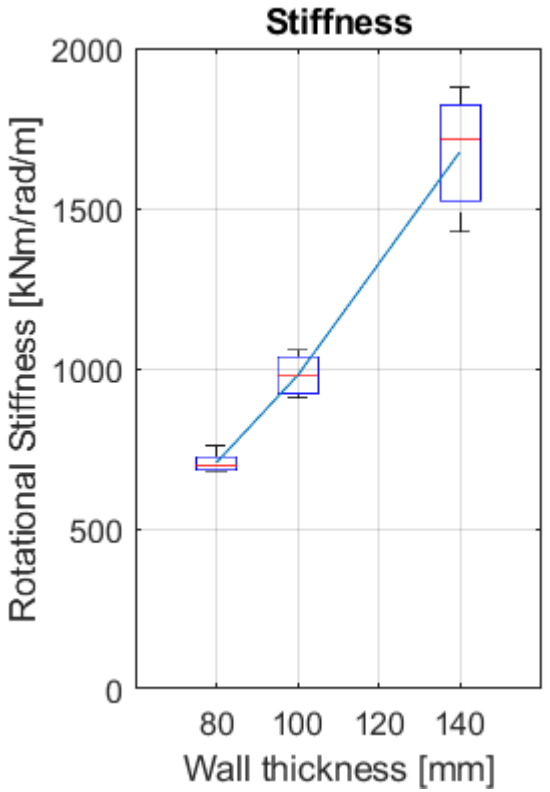
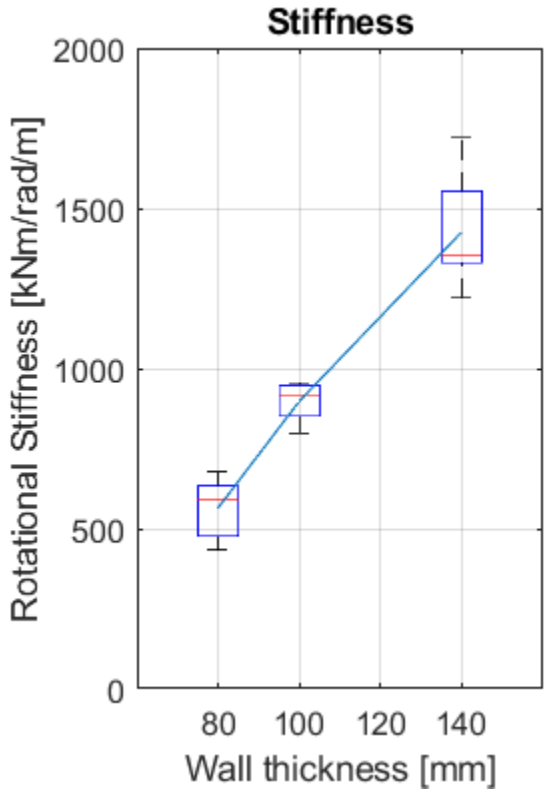
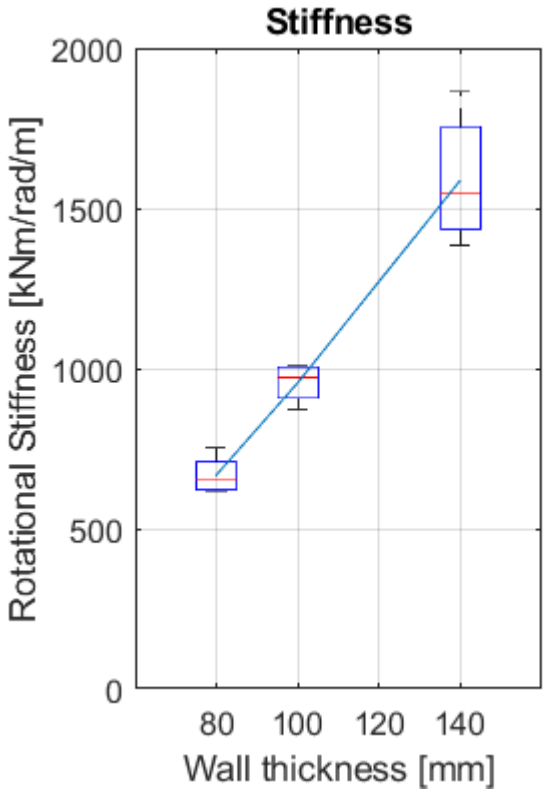


Rotational stiffness influenced by the wall thickness

1.0 MPa



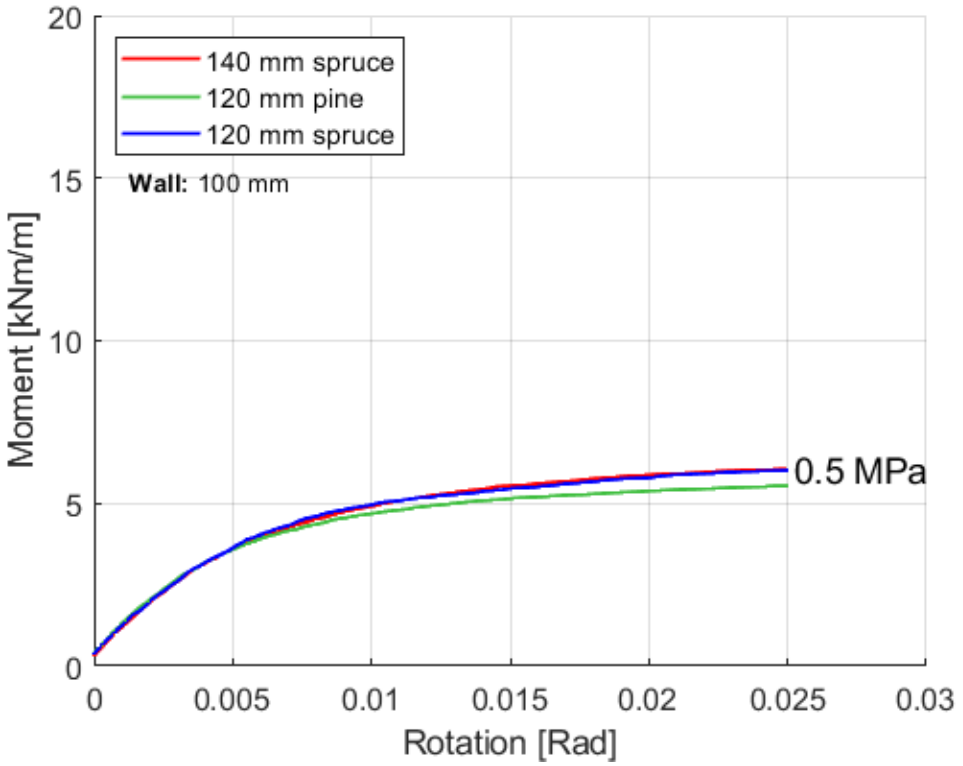
1.5 MPa



Influence of connection type

Floor variations

- Comparison between different floors
  - Spruce and pine
  - 120 and 140 mm thickness



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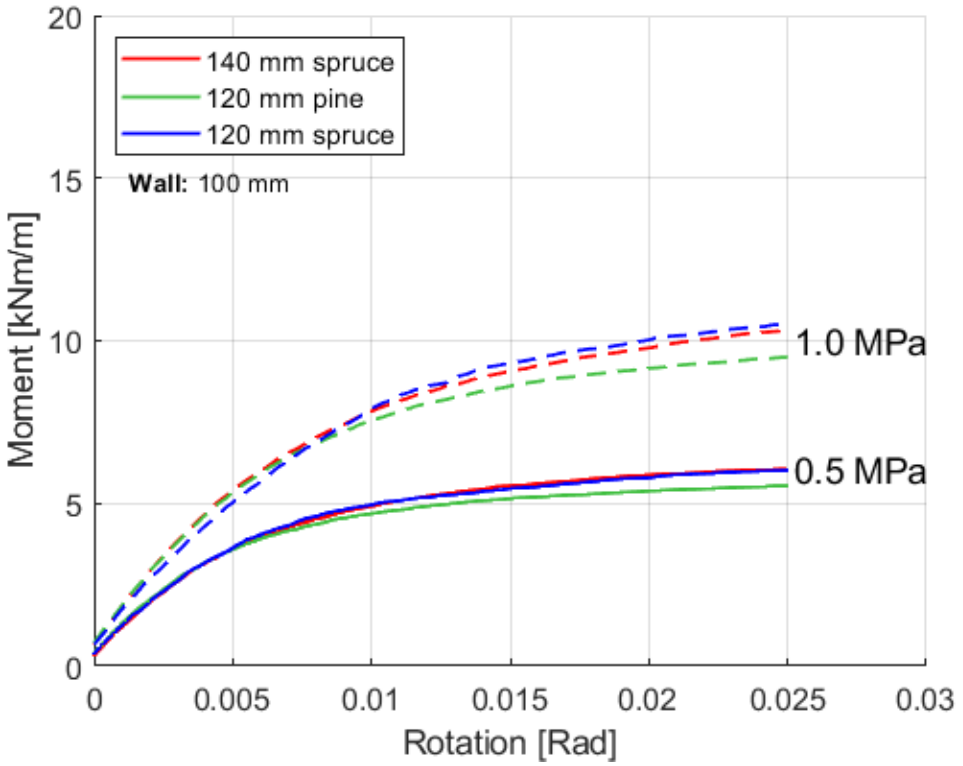

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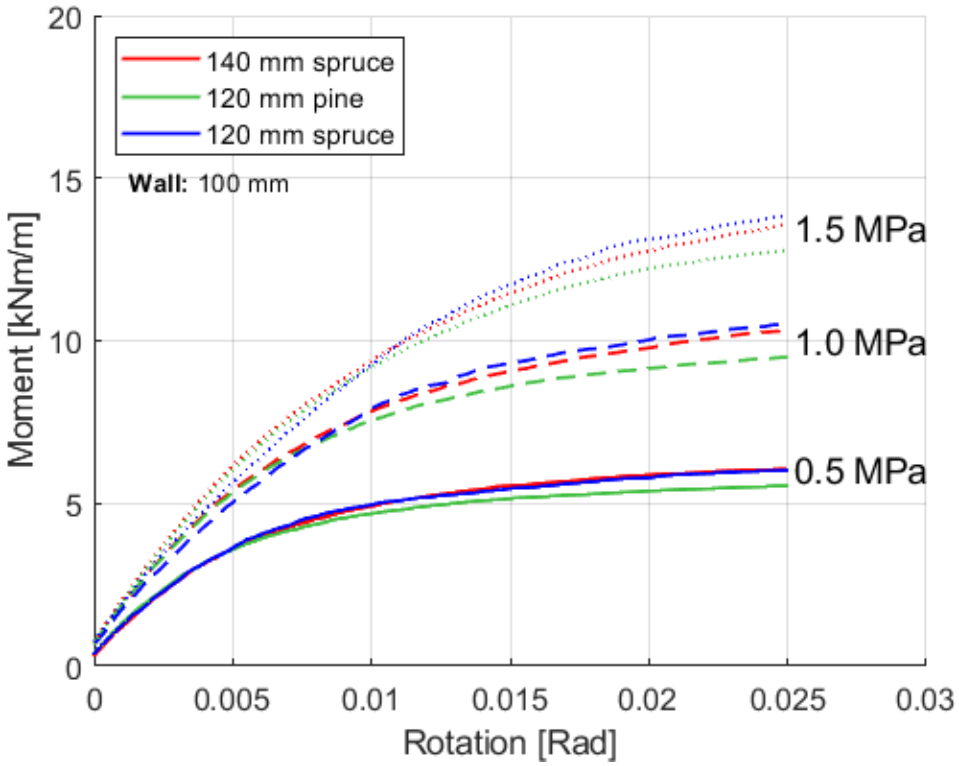
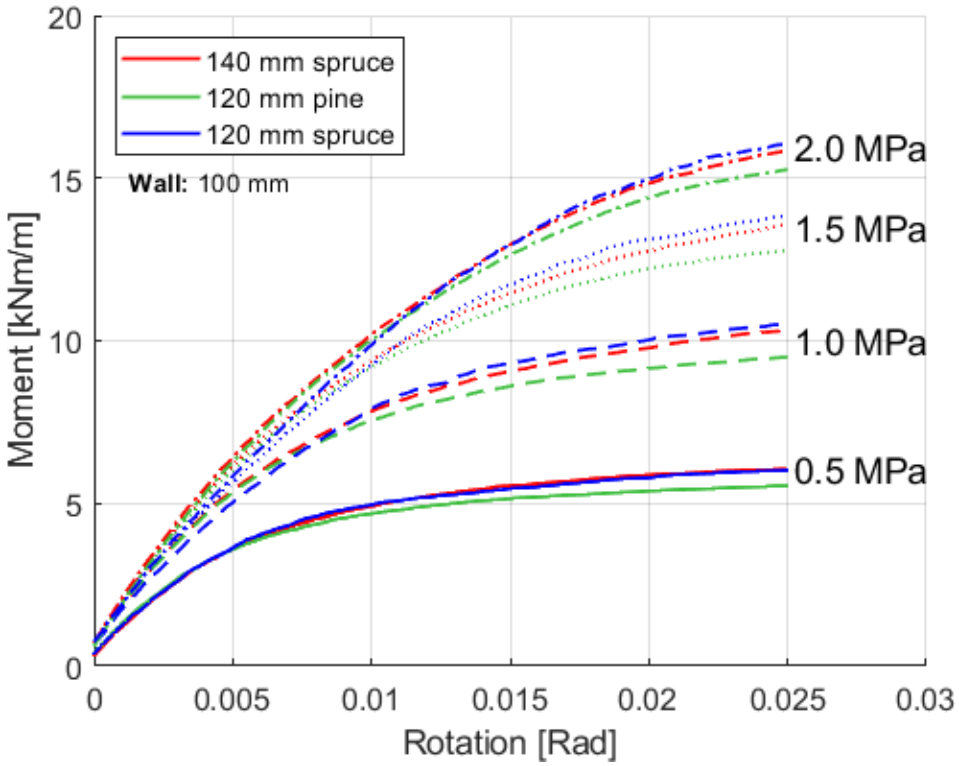


Influence of connection type

Floor variations

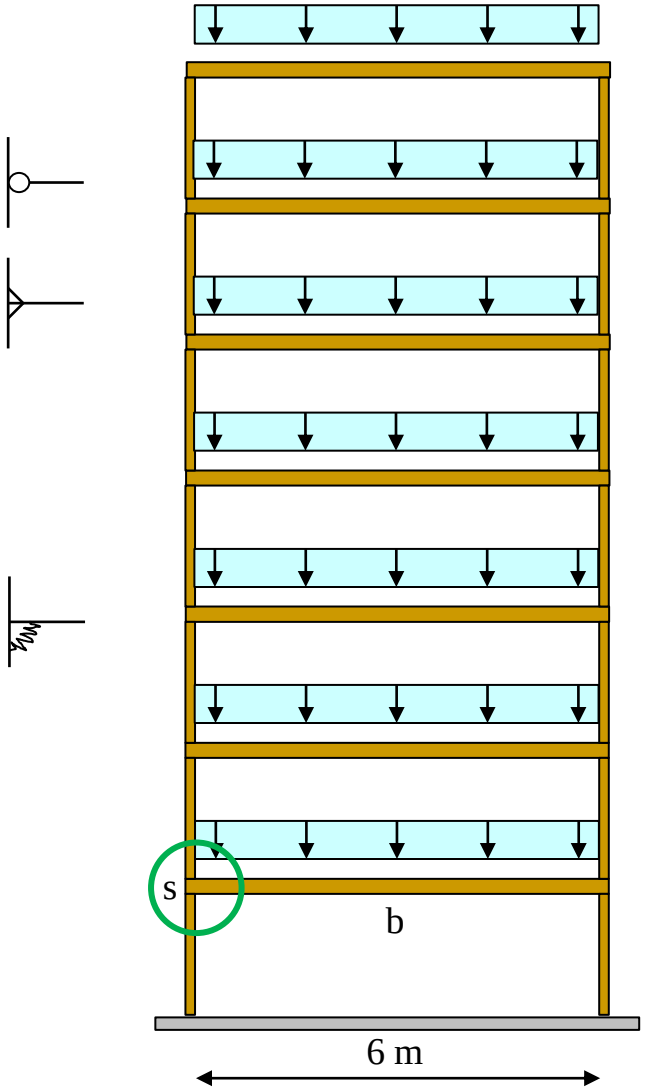
- Comparison between different floors
  - Spruce and pine
  - 120 and 140 mm thickness
- Small difference in behavior



Numerical study

Boundary condition	u [mm]	M_b [kNm/m]	M_s [kNm/m]	f_1 [Hz]
Hinged	34.2	26.02	0.0	3.74
Clamped	7.6	8.66	-17.34	8.01

Model	Stories	u [mm]	M_b [kNm/m]	M_s [kNm/m]	f_1 [Hz]
1	2	26.8	21.22	-4.80	4.16
2	2	27.0	21.81	-4.06	-
1	3	24.4	19.61	-6.42	4.34
2	3	24.7	19.85	-6.04	-
1	4	22.1	18.10	-7.93	4.55
2	4	22.4	18.20	-7.68	-
1	5	20.3	16.95	-9.08	4.73
2	5	20.7	16.99	-8.90	-
1	6	19.6	16.47	-9.55	4.82
2	6	19.6	16.16	-9.73	-
1	7	18.9	16.05	-9.88	4.89
2	7	18.9	15.64	-10.25	-



Conclusions

- Wall pressure and wall thickness high influence
  - Pressure increase on 80 mm wall, from 0.5 to 1.0 MPa
    - Moment capacity increased 70 %
    - Rotational stiffness increased 30 %
  - Thickness from 80 to 140 mm
    - Moment capacity increased 200 %
    - Rotational stiffness increased 140 %

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  - Thickness from 80 to 140 mm
    - Moment capacity increased 200 %
    - Rotational stiffness increased 140 %
- Floor material and thickness low influence
  - 120 mm floor with either spruce or pine
    - Moment capacity increased 10 % for spruce
    - Rotational stiffness increased 15 % for pine

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  - Pressure increase on 80 mm wall, from 0.5 to 1.0 MPa
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    - Rotational stiffness increased 30 %
  - Thickness from 80 to 140 mm
    - Moment capacity increased 200 %
    - Rotational stiffness increased 140 %
- Floor material and thickness low influence
  - 120 mm floor with either spruce or pine
    - Moment capacity increased 10 % for spruce
    - Rotational stiffness increased 15 % for pine
- Ductile behavior in the connection

Thank you for listening

Thesis work:
The impact of connection stiffness on the global structural behavior in a CLT building: A combined experimental-numerical study

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