Lumber Tower, Kristiansand and Valle Wood Office Towers, Oslo: Using Steel Connections to Enable Complex Geometries

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Council on Tall Buildings and Urban Habitat
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Steel-Timber Conference

CASE STUDY OF TIMBER COMPOSITE SOLUTIONS FOR MATERIAL EFFICIENCY AND ARCHITECTURAL POTENTIAL

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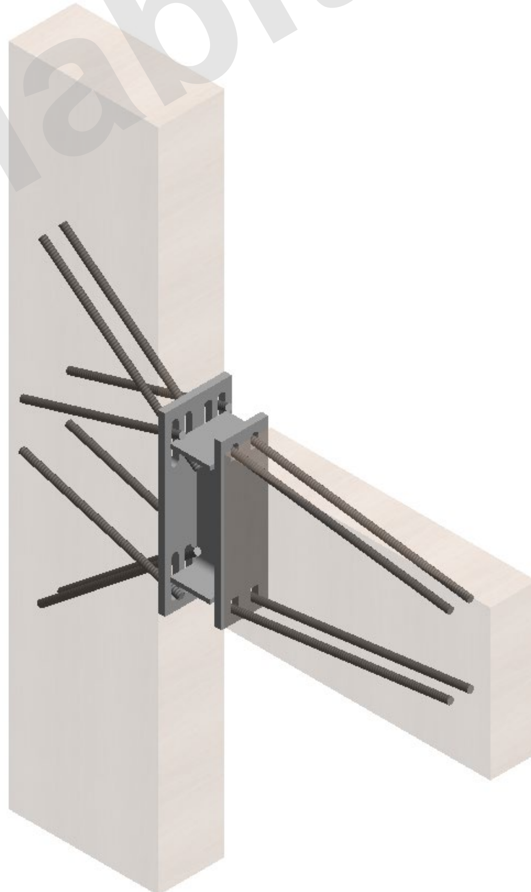
DR.-ING. AIVARS VILGUTS

SCOPE OF PRESENTATION:

1. Lumber, 6-storey timber building
2. Moment-resisting connections with threaded rods



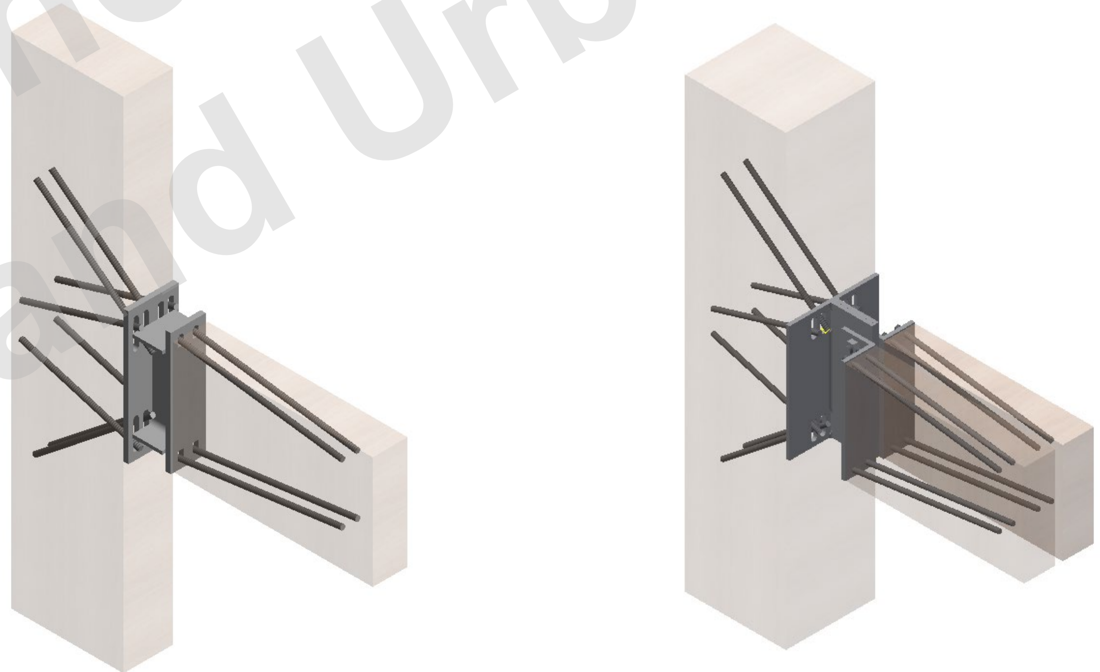
ABOUT ME

Education:

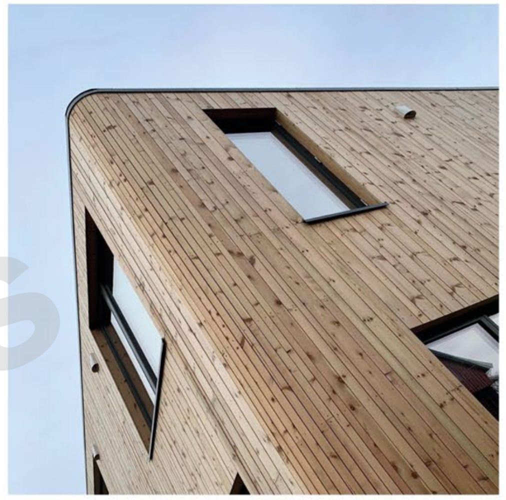
1. Bachelor degree, 2013. Rigas Technical University
2. Master degree, 2014. Rigas Technical University
3. Doctoral degree, 2021. Norwegian University of Science and Technology

Work experience:

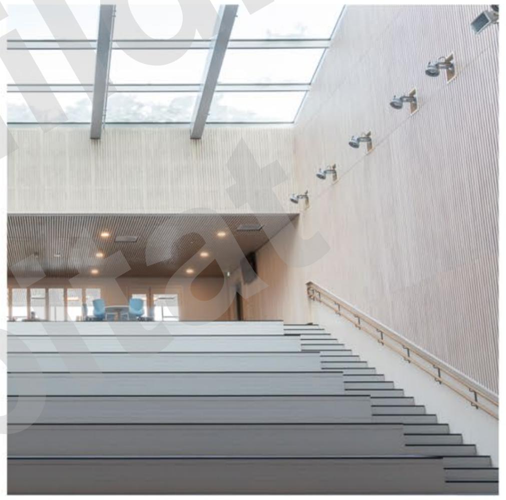
1. 5 years as a structural engineer
2. Lecturer at Norwegian University of Science and Technology from 2016 to 2021
3. Structural engineer at Oslotre AS, Norway since 2020
4. Lecturer at Vidzeme University of Applied Sciences since 2021



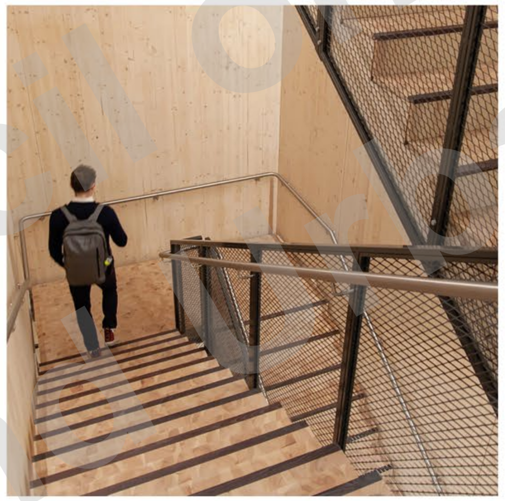
CONSTRUCTION



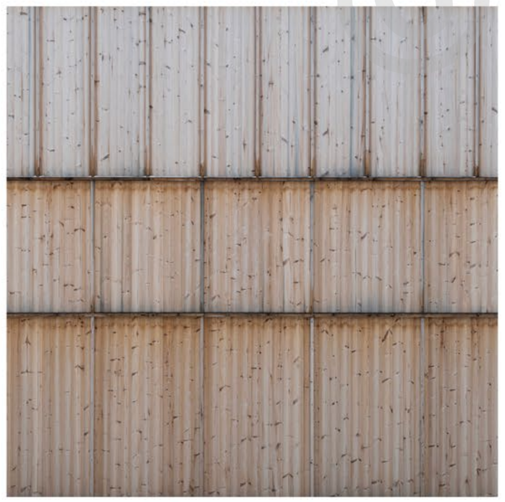
ASSEMBLY



TIMBER-DESIGN



ARCHITECTURE



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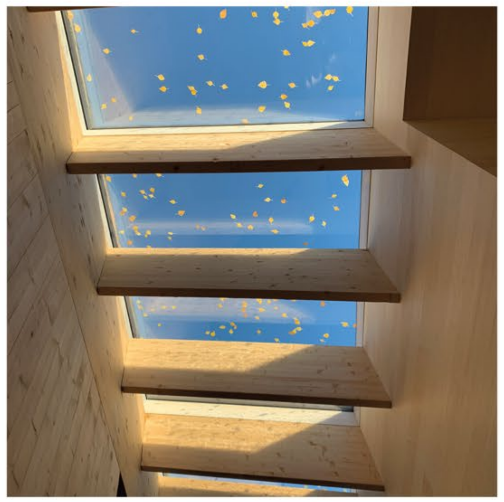
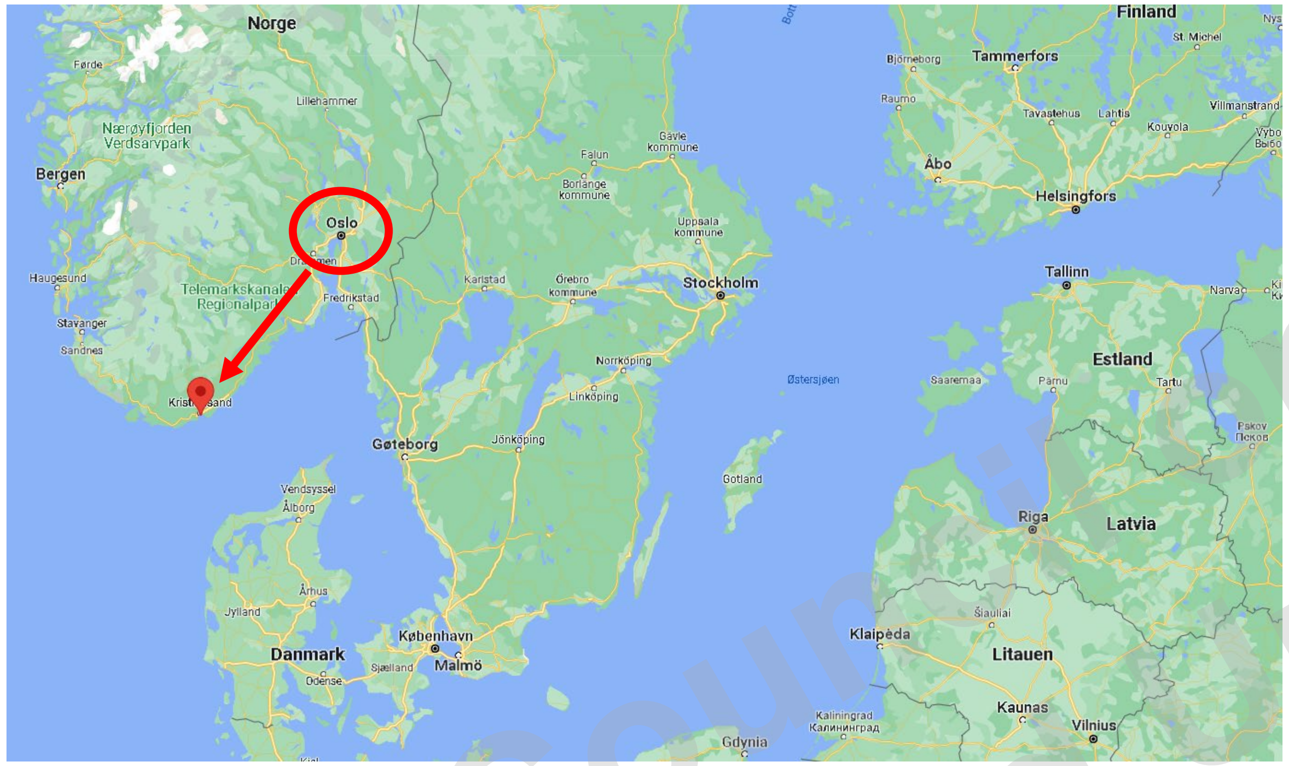


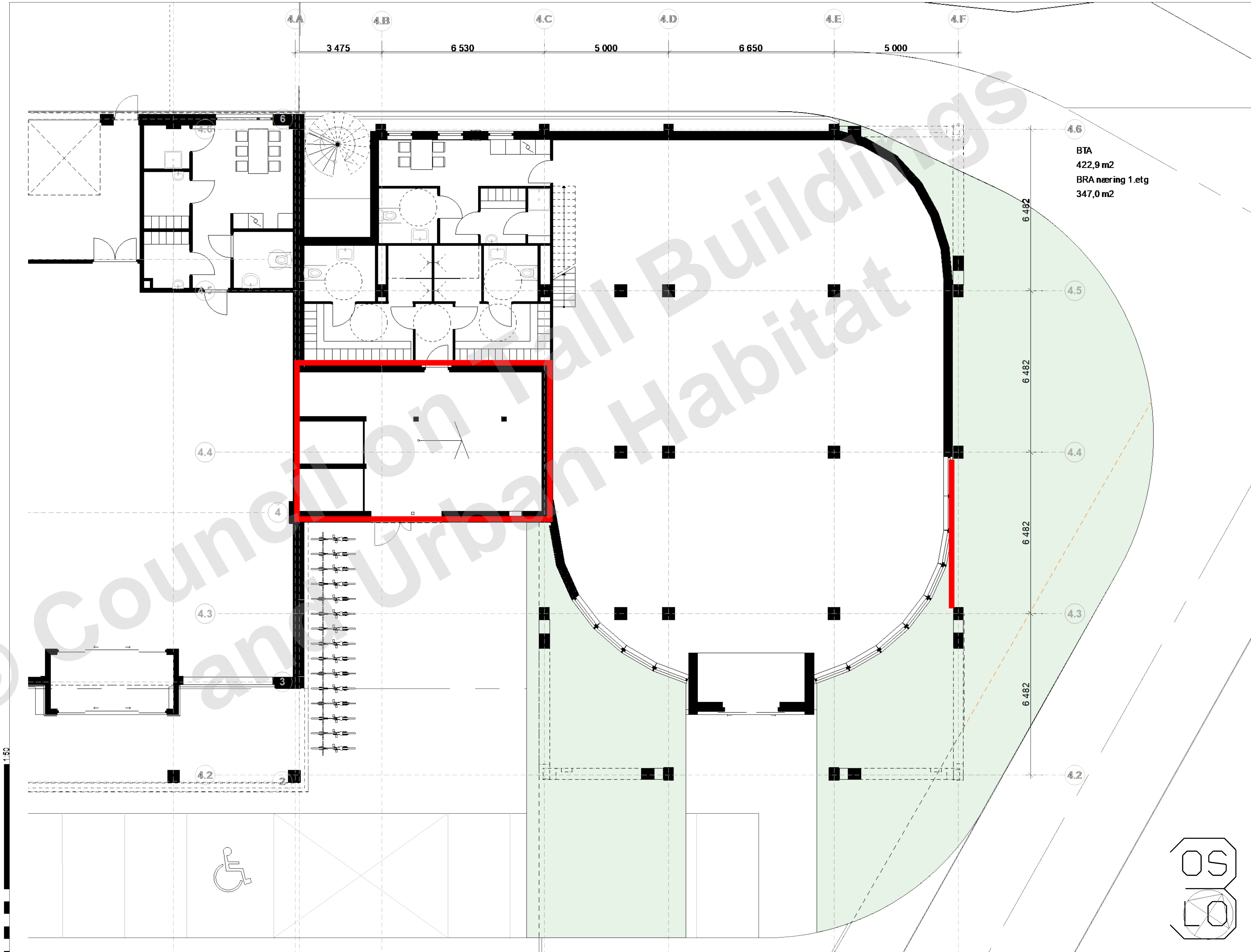
LUMBER

CONCEPT MATERIALS AND HISTORY



SITUATION EXISTING AND NEW BUILDING

PLAN GROUND FLOOR



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TYPICAL FLOOR PLAN

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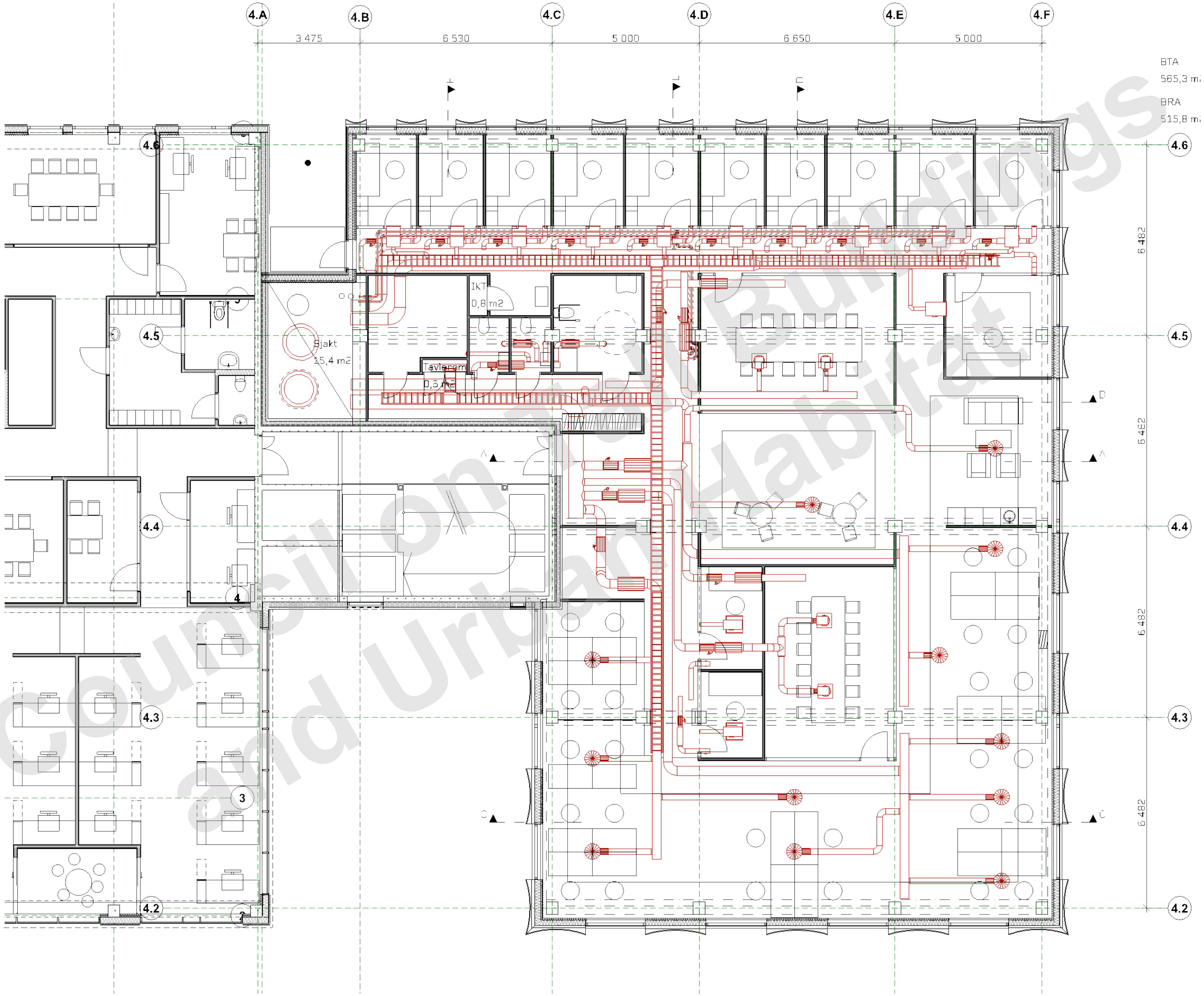
PLAN TECHNICAL COMMUNICATIONS

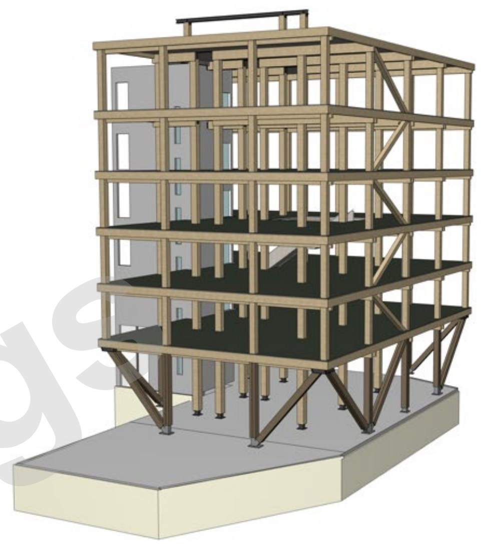


INTERIOR OFFICE

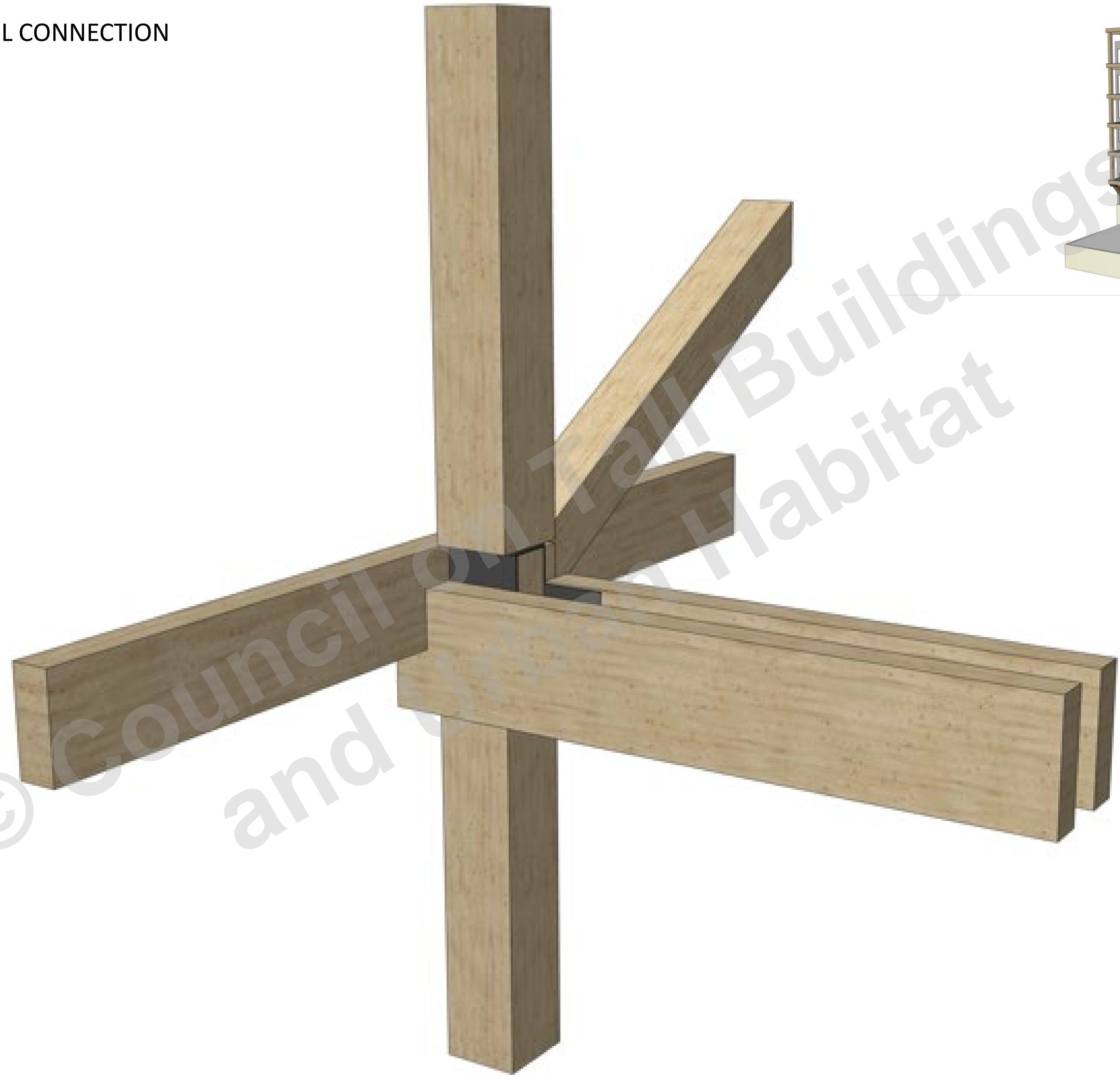
INTERIOR ATRIUM

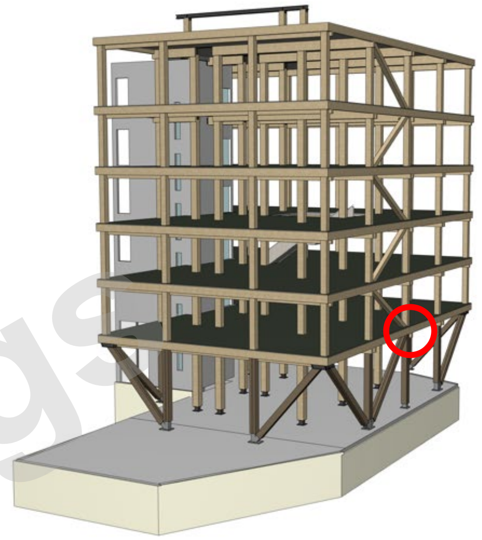
CONSTRUCTION SYSTEM CONCRETE FOUNDATION

SLAB CLT

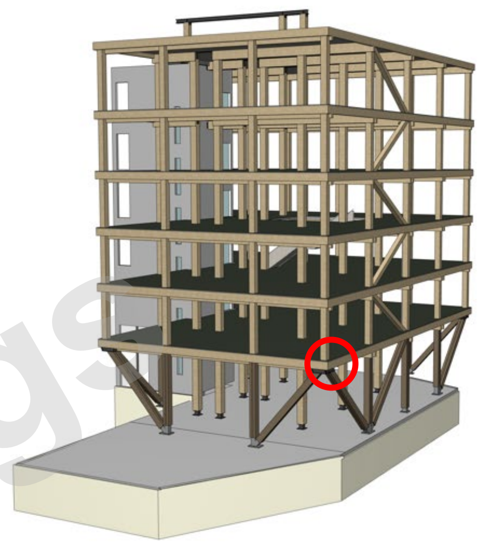


JOINERY STEEL CONNECTION

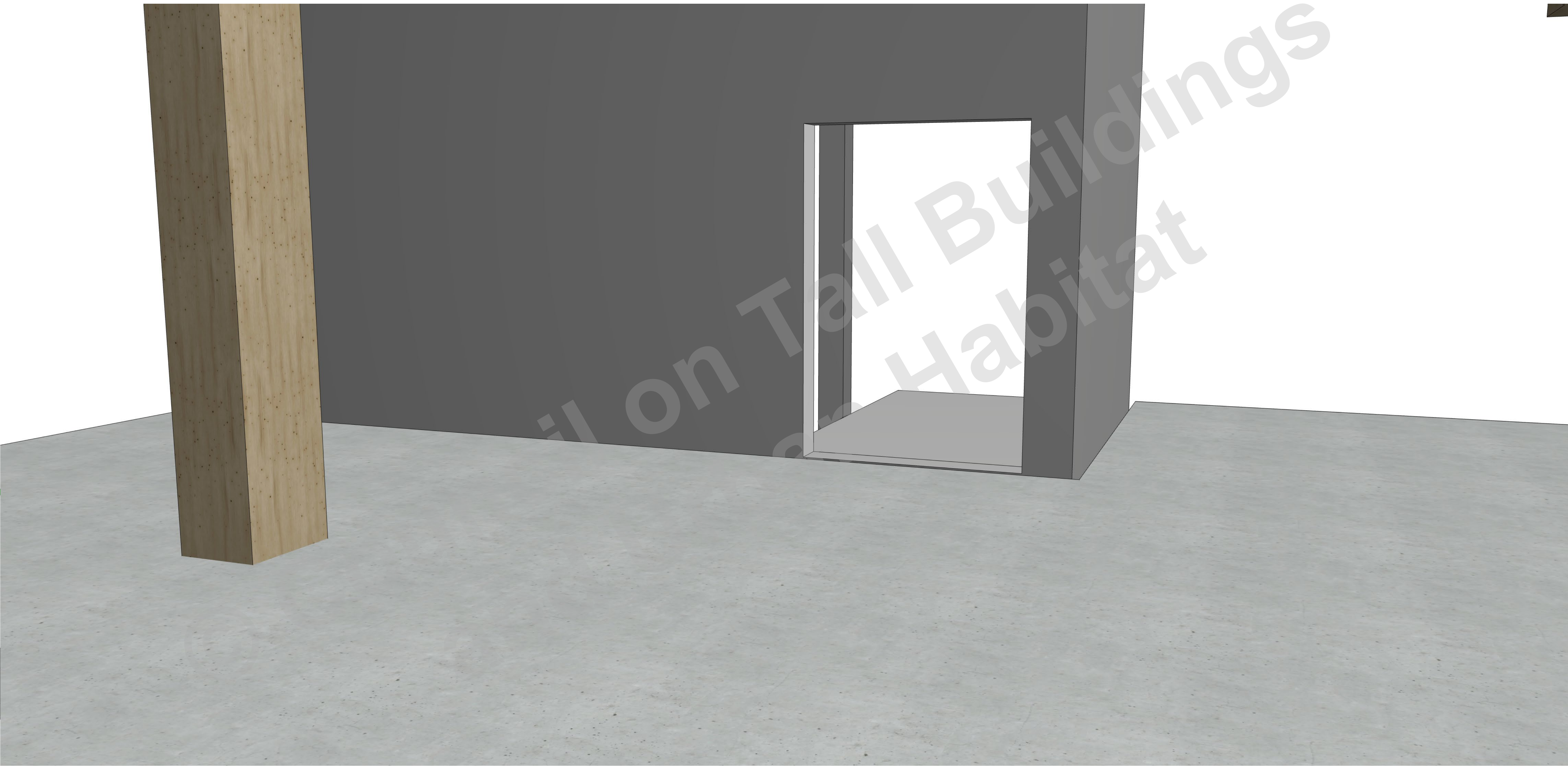




JOINERY STEEL CORNER CONNECTION



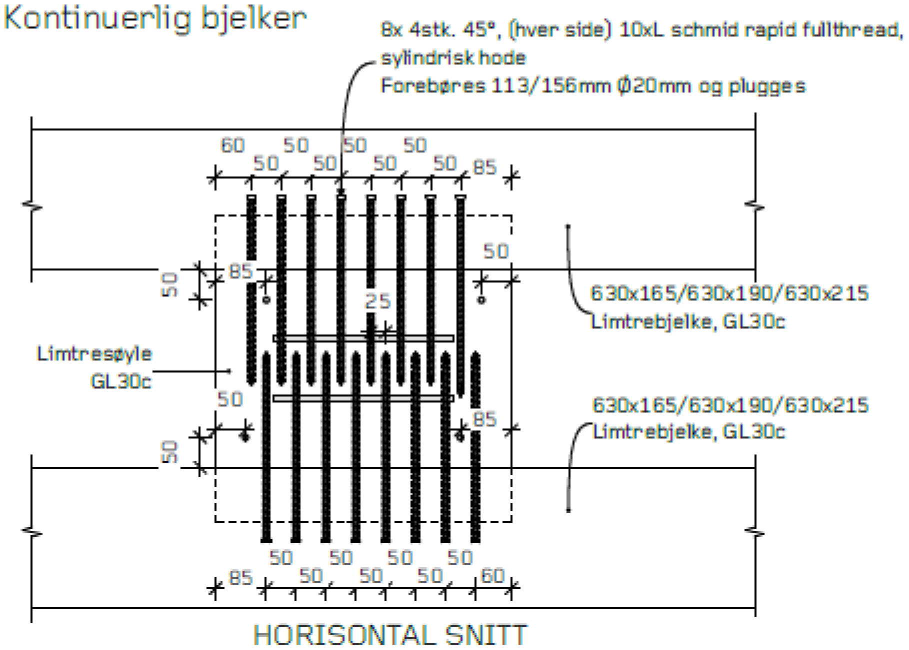
CONNECTION BETWEEN EXISTING STRUCTURE ANGLE BRACKETS

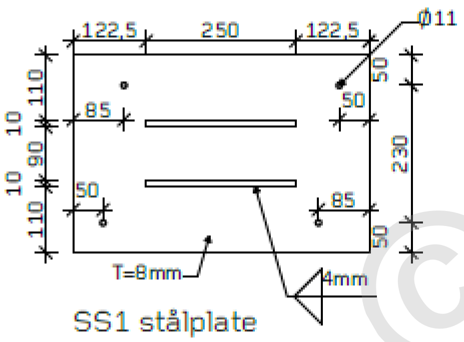


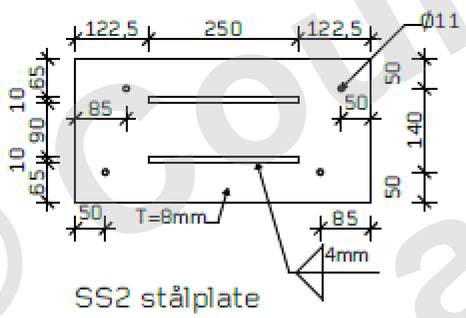
COLUMN TO BEAM TO COLUMN CONNECTION

L1a

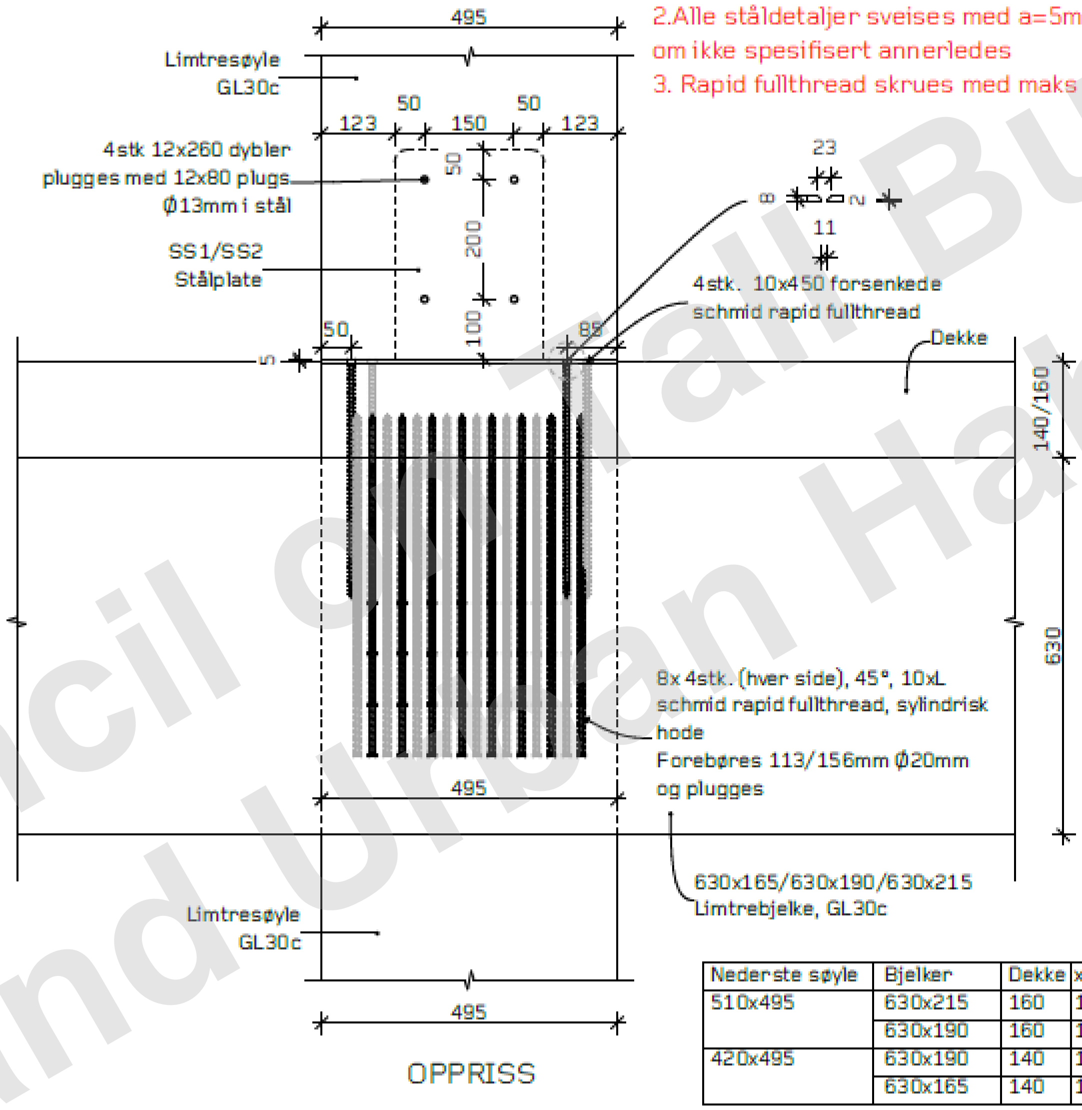
Kontinuerlig bjelker



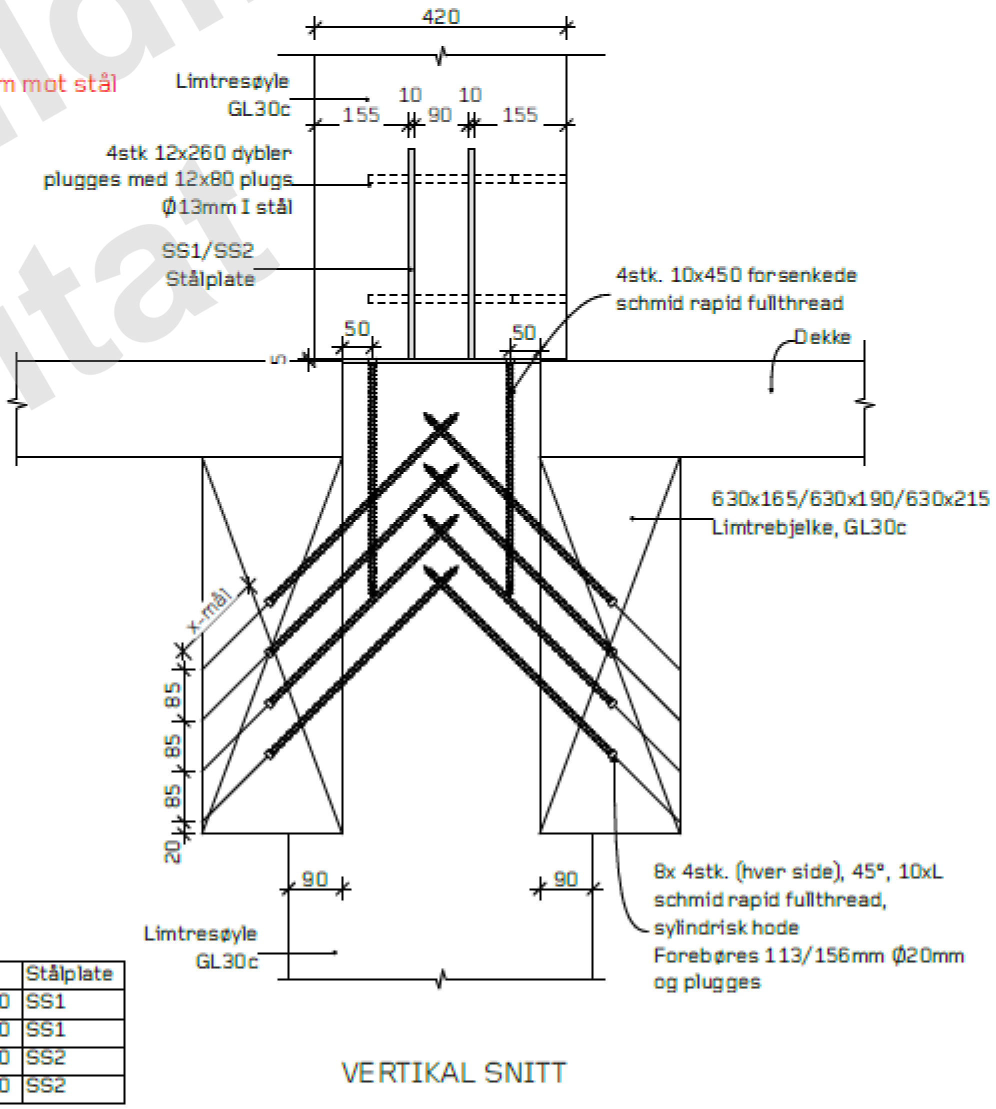




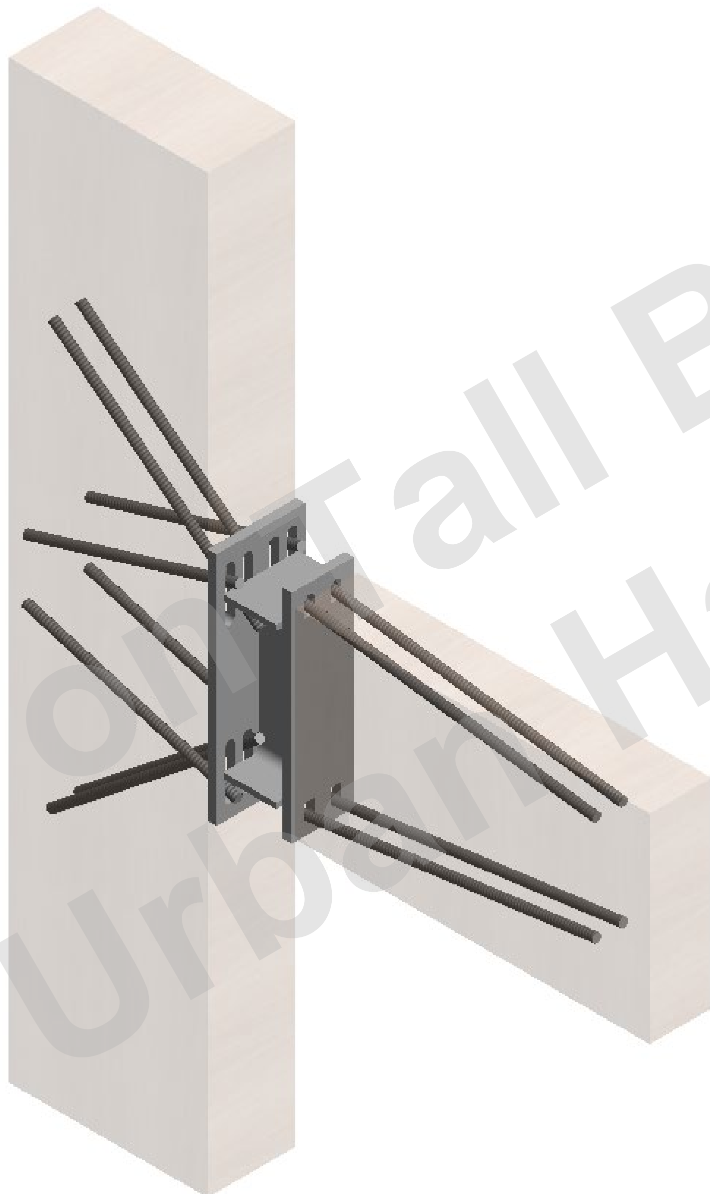
OBS!
1.Alle ståldeler har fasthetsklasse S355
2.Alle ståldetaljer sveises med a=5mm om ikke spesifisert annerledes
3. Rapid fullthread skrues med maks T=26 Nm mot stål



Nederste søyle	Bjelker	Dekke	x-mål	L	Stålplate
510x495	630x215	160	156	450	SS1
	630x190	160	156	450	SS1
420x495	630x190	140	113	400	SS2
	630x165	140	113	350	SS2



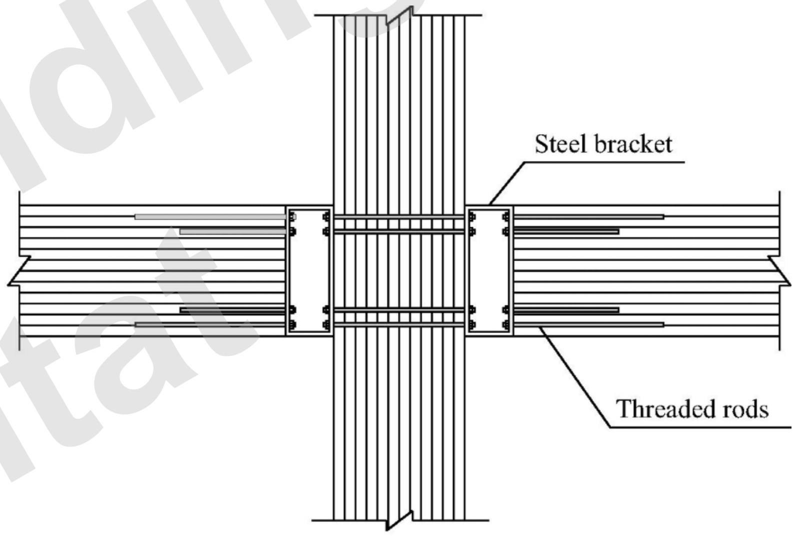
CONSTRUCTION SITE 29.04.2022

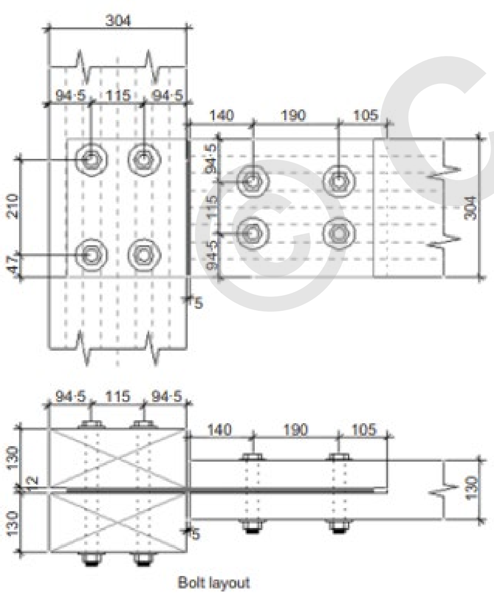


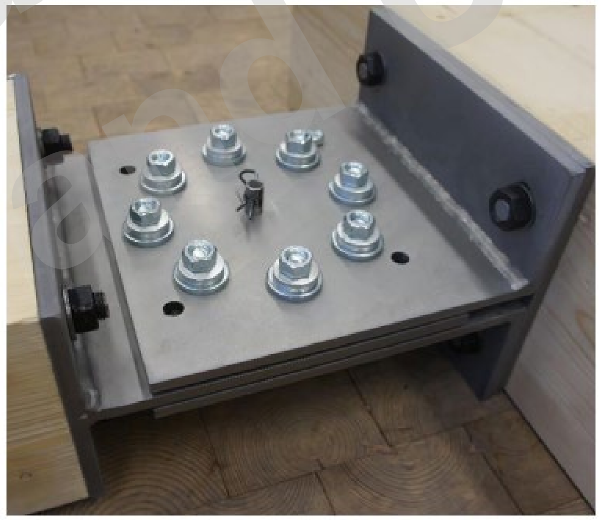
MOMENT RESISTING CONNECTIONS WITH THREADED RODS

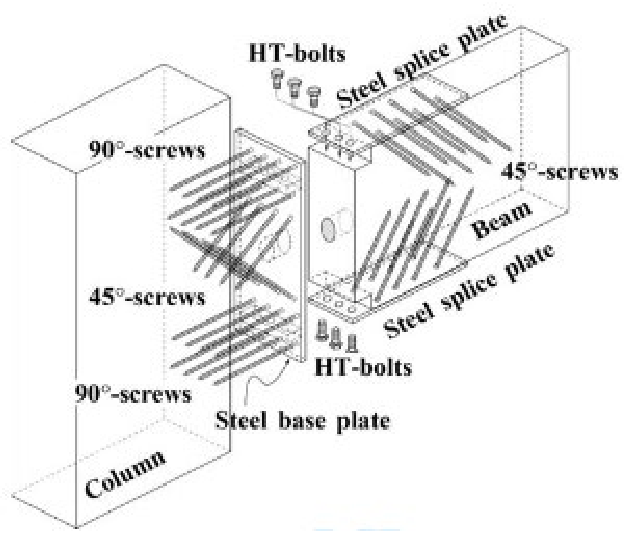
MOMENT RESISTING CONNECTIONS WITH THREADED RODS

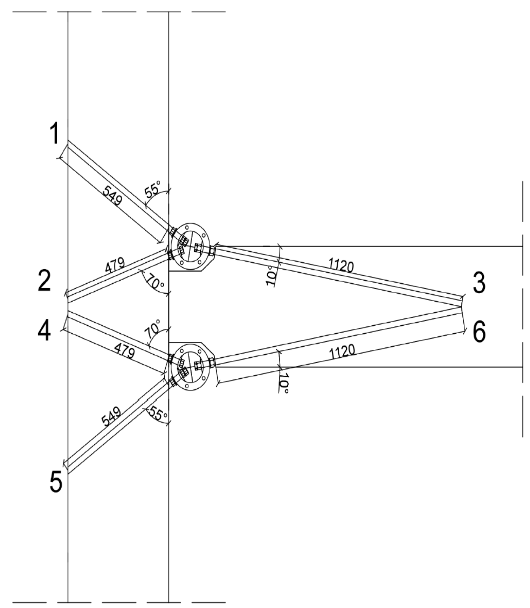
- Beam-to-column connections
  - Laterally loaded fasteners
    - Slotted-in steel plates with dowel-type fasteners
    - *Connections with friction bolts
  - Axially loaded fasteners
    - Connections with self-tapping screws
    - Connections with glued-in rods
    - Connections with screwed-in threaded rods



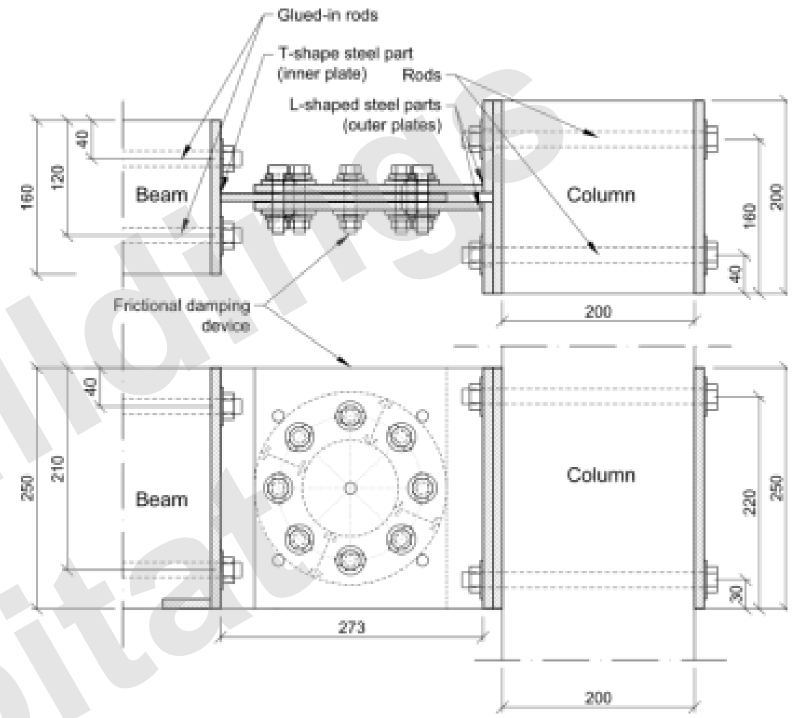


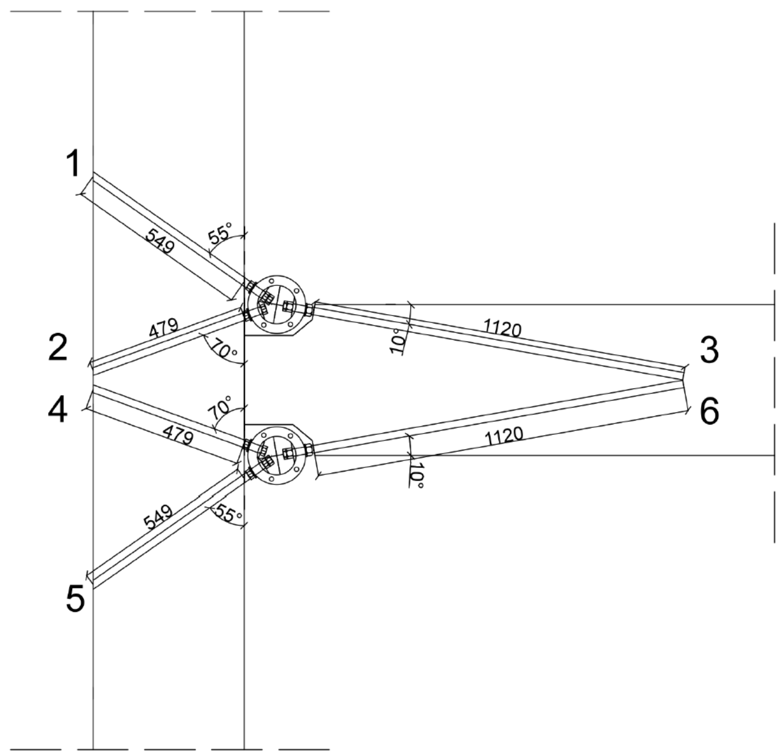


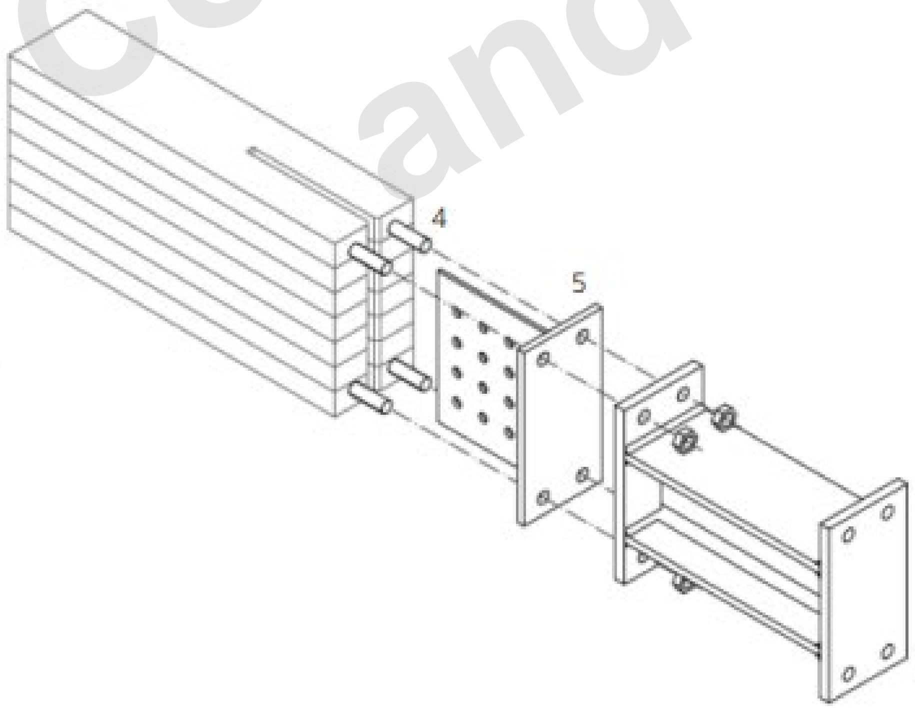




Connection type	Rotational stiffness (K_θ)/beam height (z_b), [kNm/rad]/[mm]		Relative stiffness (K_θ/z_b^2), [kN/rad·mm]	
Dowel-type connections with slotted-in steel plates	696/300	2060/304	7.73	22.30
Connections with friction bolts	2300/250	475/240	36.80	8.25
Connections with self-tapping screws	1250/362	2737/304	9.54	29.61
Connections with glued-in rods	2240/240	2900/495	38.90	11.84
Connections with threaded rods	1230/270	9079/450	16.87	44.83

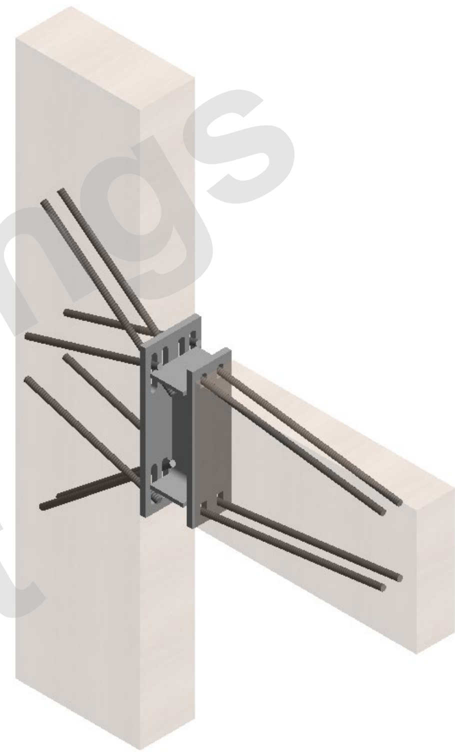


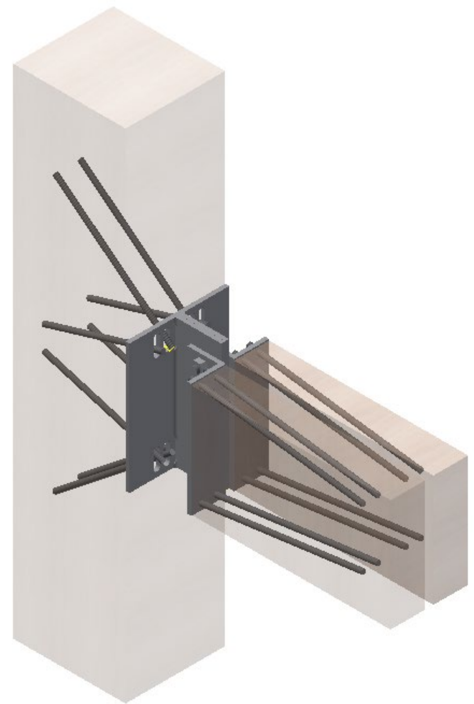




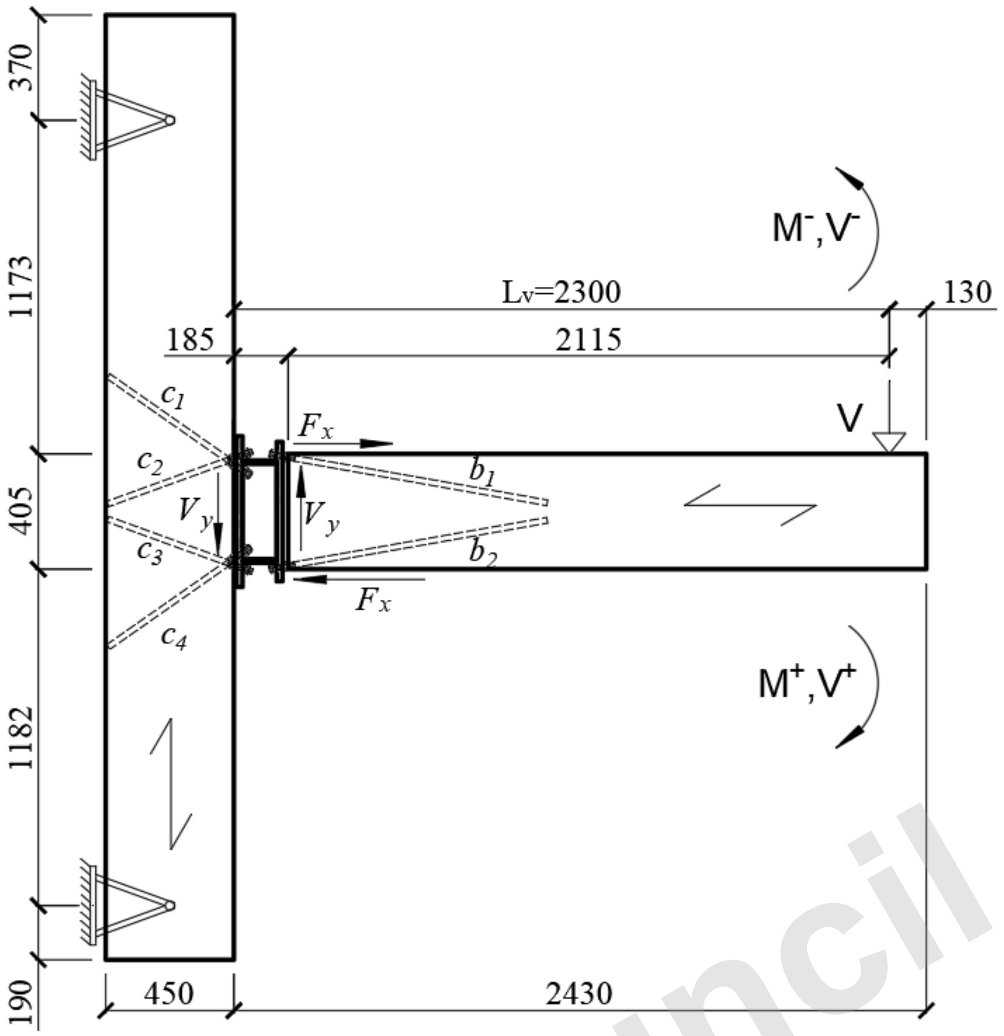
Design principles:

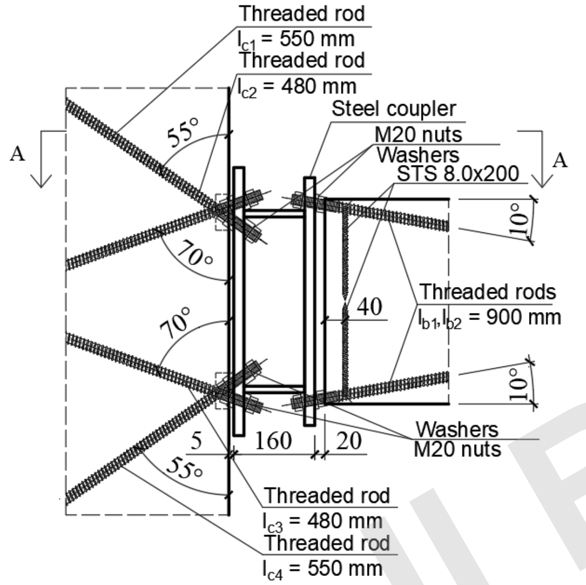
1. Utilization of large withdrawal stiffness and capacity of screwed-in threaded rods;
2. Simple and fast assembly without need of special tools;
3. The tension and compression forces from beam to column are transferred only by the steel parts and the threaded rods;
4. The shear forces between columns and beams are carried by friction between the steel coupling part and threaded rods;
5. Failure mode of the connection is limited by withdrawal of threaded rods and friction for connection.

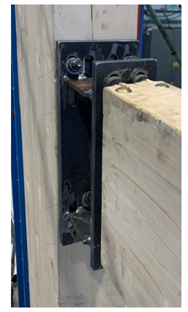


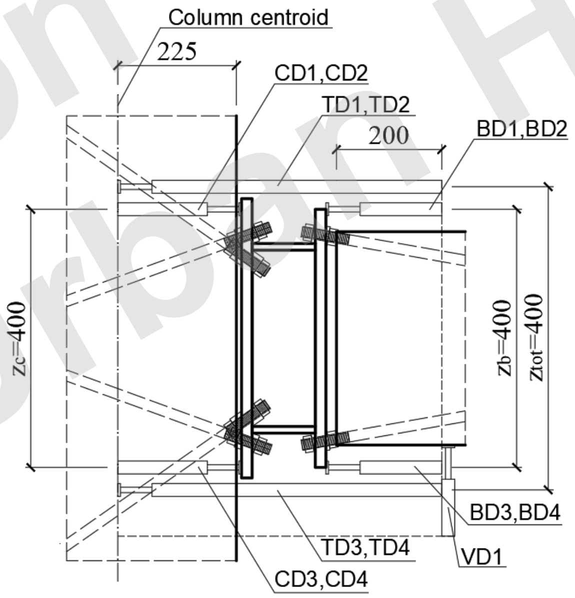


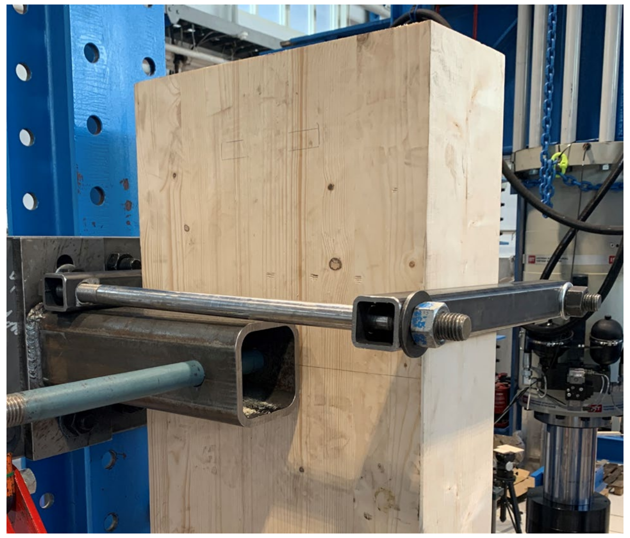
Experimental setup

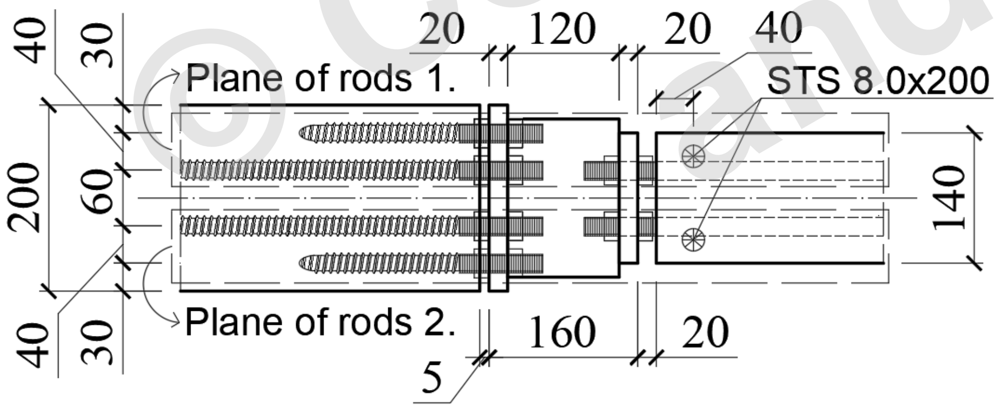




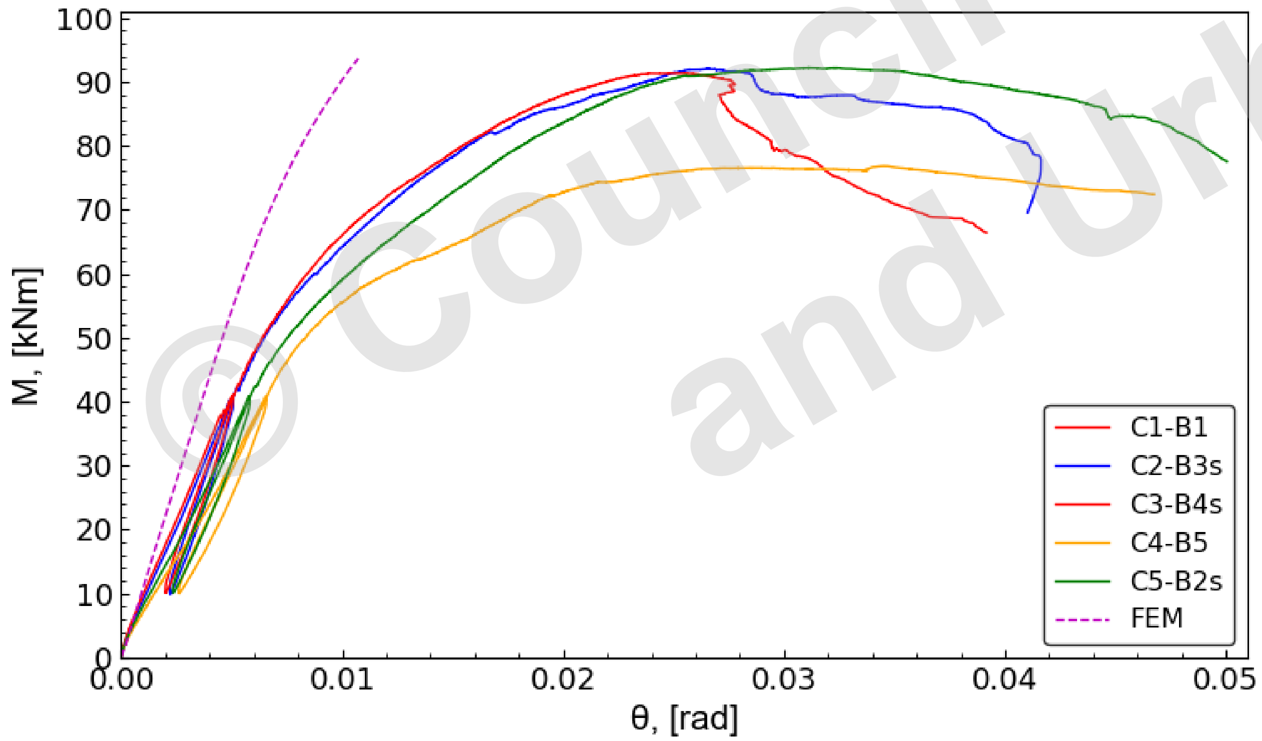






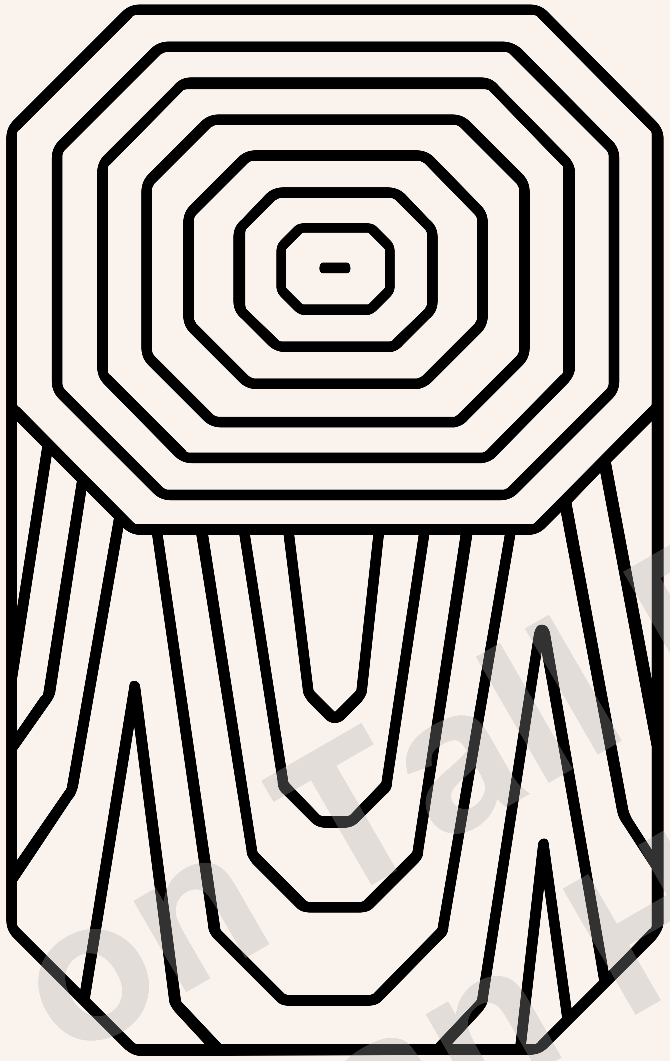


Specimen		C1-B1	C2-B3s	C3-B4s	C4-B5	C5-B2s	Mean	CoV, [%]
Failure force	V, (kN)	37.0	40.0	39.7	33.3	40.1	38.0	7.7
Failure moment	M_u, (kNm)	85.0	92.1	91.4	76.5	92.2	87.4	7.8
Rotational stiffness	$K_{\theta,b}$, (kNm/rad)	14557	16810	18965	17944	16541	16963	9.8
	$K_{\theta,c}$, (kNm/rad)	13224	16399	12725	10712	10887	12789	18.0
	$K_{\theta,tot}$, (kNm/rad)	6109	7949	8049	6131	6858	7020	13.5



Detailed findings:

1. The rotational stiffness from monotonic and fully reversed loading for the tested connections for two planes of rods are on average 7020 kNm/rad and 5926 kNm/rad. The highest recorded rotational stiffness of connection was 8049 kNm/rad;
2. Based on the measured stiffness values a connection of this type will require 3-5 planes of rods to fulfil the stiffness requirement of 10000-15000 kNm/rad, which is needed for 8-10 storeyed buildings using solely moment-resisting frames for horizontal stabilization;
3. The equivalent viscous damping ratio of the connection under service load for fully reversed loading, positive and negative moment found to be in the order of 7.0%, i.e., much greater than the material damping in timber which is in the order of 0.5-1.0%.



THANK YOU !

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