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**HAMK**



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*10 metų*



Cracow University  
of Technology



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UNIVERSITY OF APPLIED SCIENCES

**SUSTAINABLE, HIGH-PERFORMANCE  
BUILDING SOLUTIONS IN WOOD**

2020-1-LV01-KA203-077513

## Building Site Management & Building Process in Timber

### Group 5:

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## Last year project

- Located in Stegersbach, a town in the Austrian state of Burgenland.
- Livingspace for young people and families
- 48 Flats 46/95 square meters





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# Digital processes applied

## BIM

**Design** – Intelligent 3D model of a building that reacts in a real-time to changes

**Workflow planning** – Everyone involved in the project can collaborate to make cost and timeline estimates while improving processes

**Construction** - Contractors and construction workers can upload changes in real-time

**Operation** – After construction, the model is given to the client and manager, enabling simplified building operation, renovation and repairs



23.03.2023



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# Level of prefabrication

- All main construction of a building is made of CLT panels - includes: external walls, internal walls, slabs, and roof.
- Internal walls, internal and external finish is constructed on site.

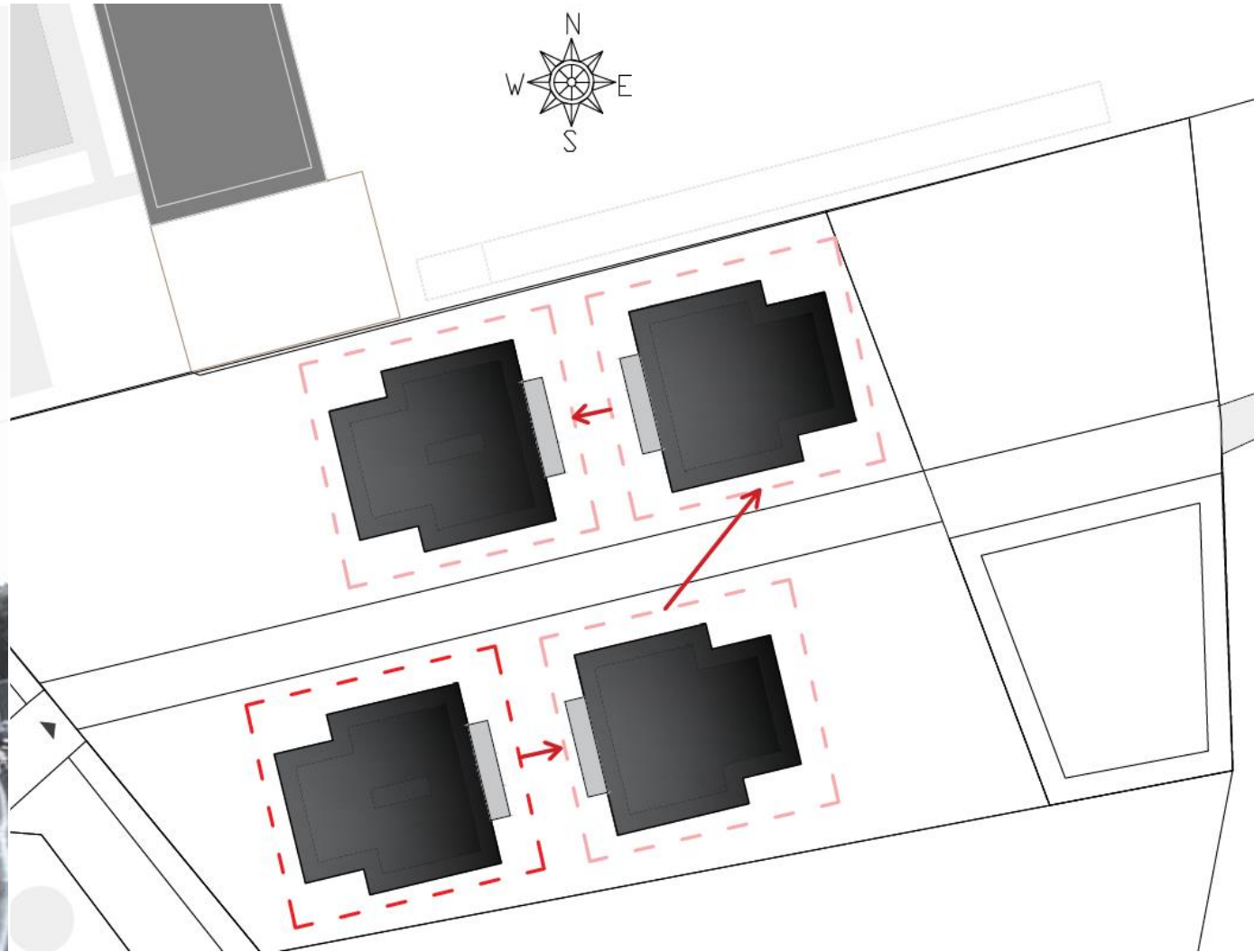




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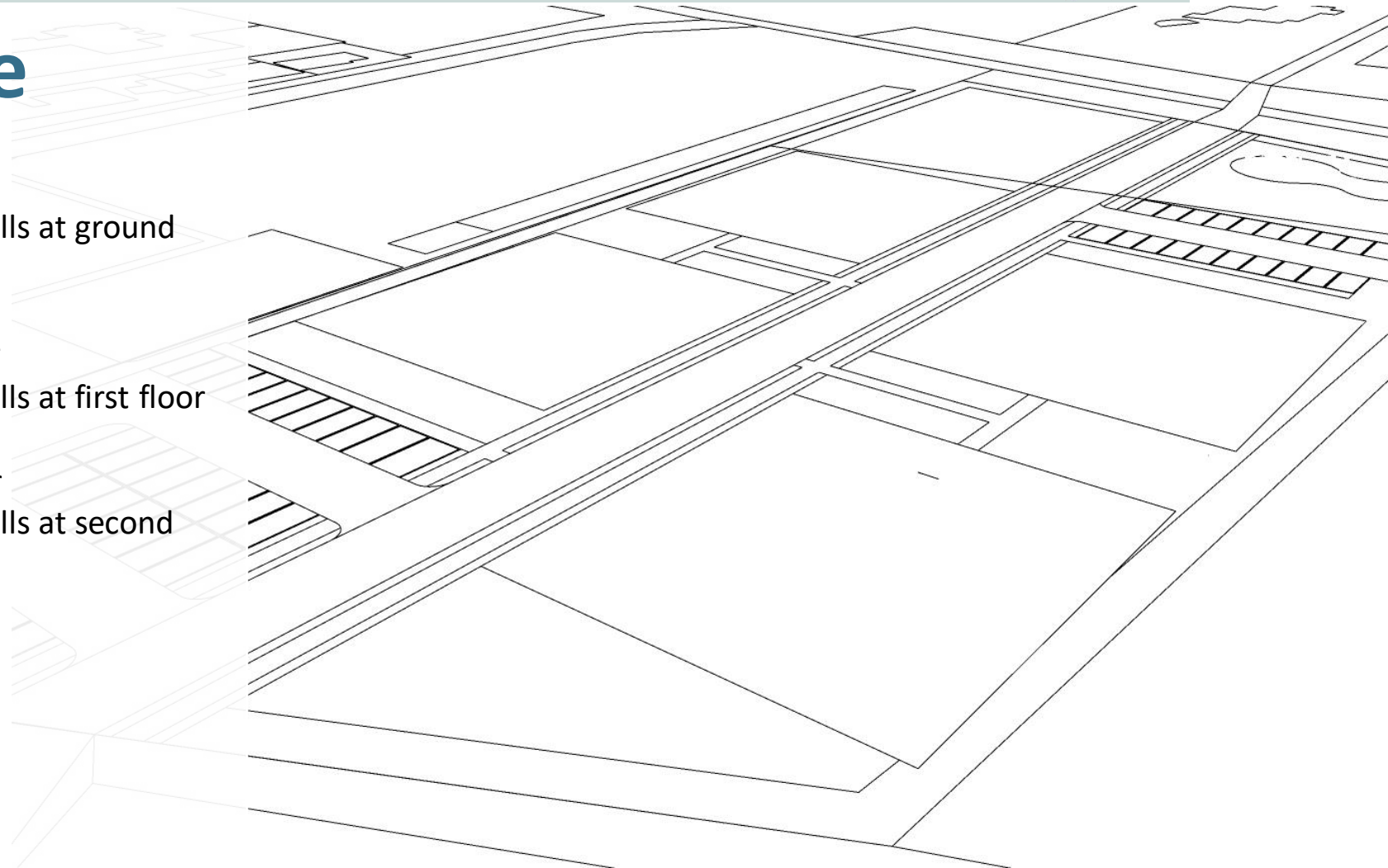
# Moisture protection





# Assembly sequence

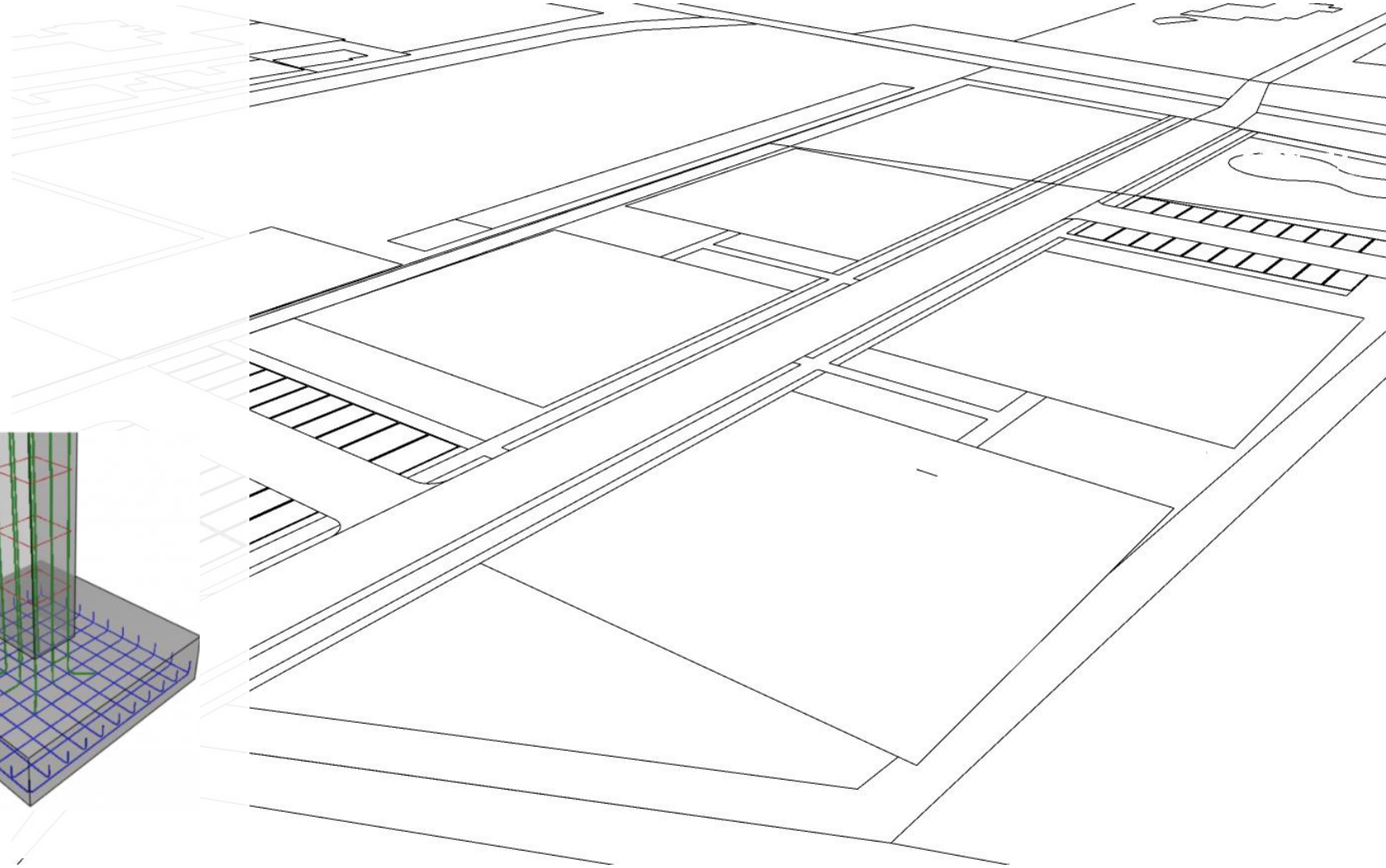
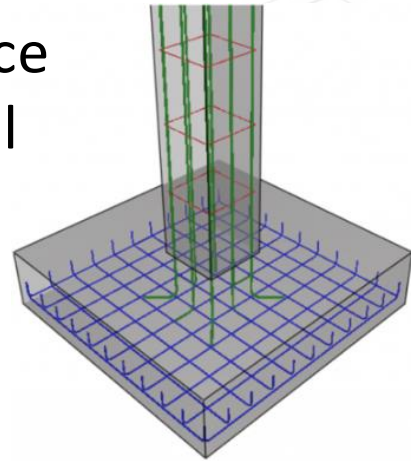
- The foundations
- The load-bearing external and internal walls at ground level
- Ground level floor
- Stairs between ground level and first floor
- The load-bearing external and internal walls at first floor
- Slabs above first floor
- Stairs between first floor and second floor
- The load-bearing external and internal walls at second floor
- Balconies construction
- Roof construction
- Separating walls
- External finish layers, windows and doors
- Internal finish





# The foundations

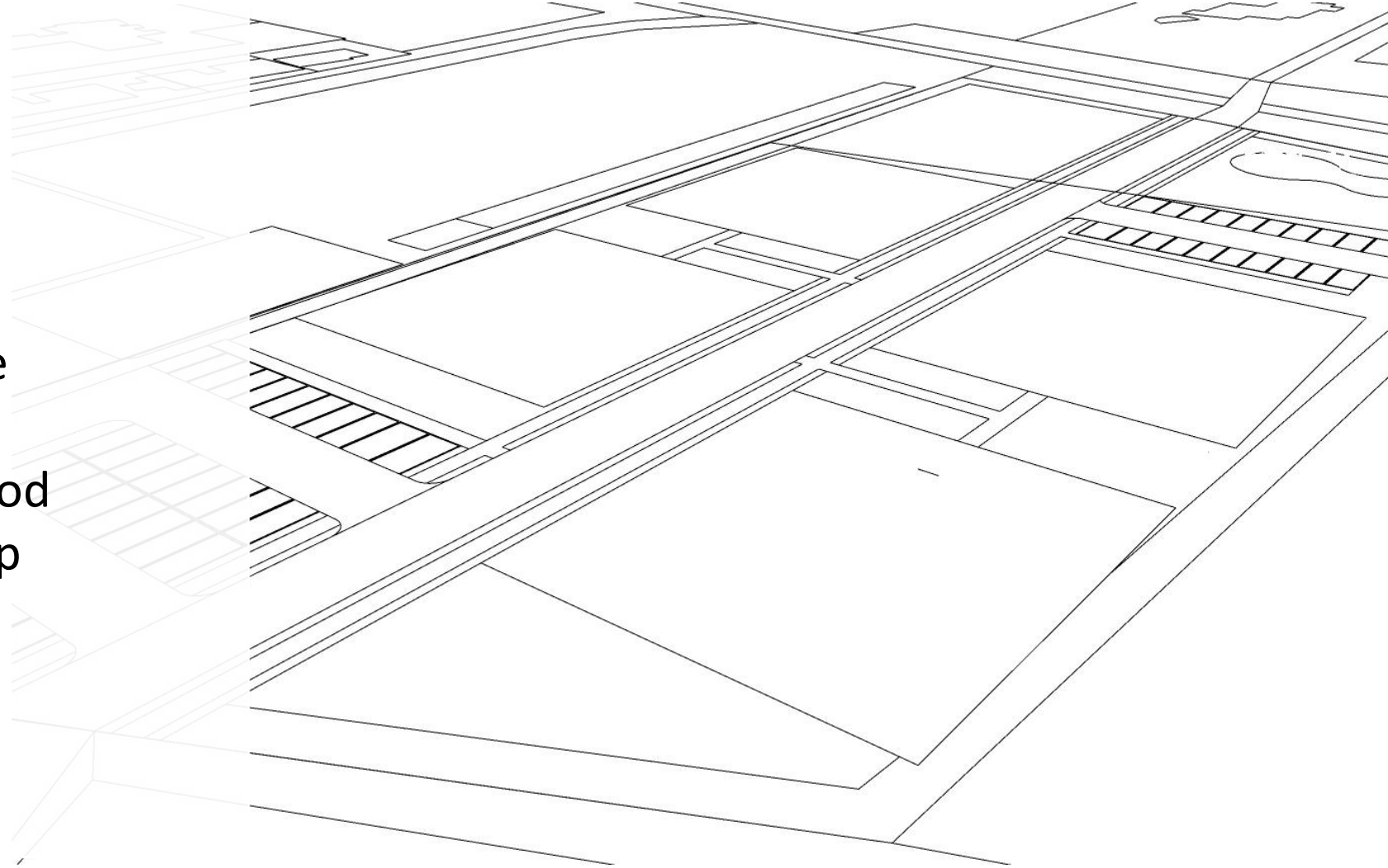
- Main purpose is to carry the loads of the whole building
- Made with wooden moulds and cast in place
- Concrete includes steel reinforcement





# Ground floor

- The ground floor is made layer by layer
- The main materials used are concrete and steel
- The top layer is made of wood
- The floor is insulated to keep the floor warm







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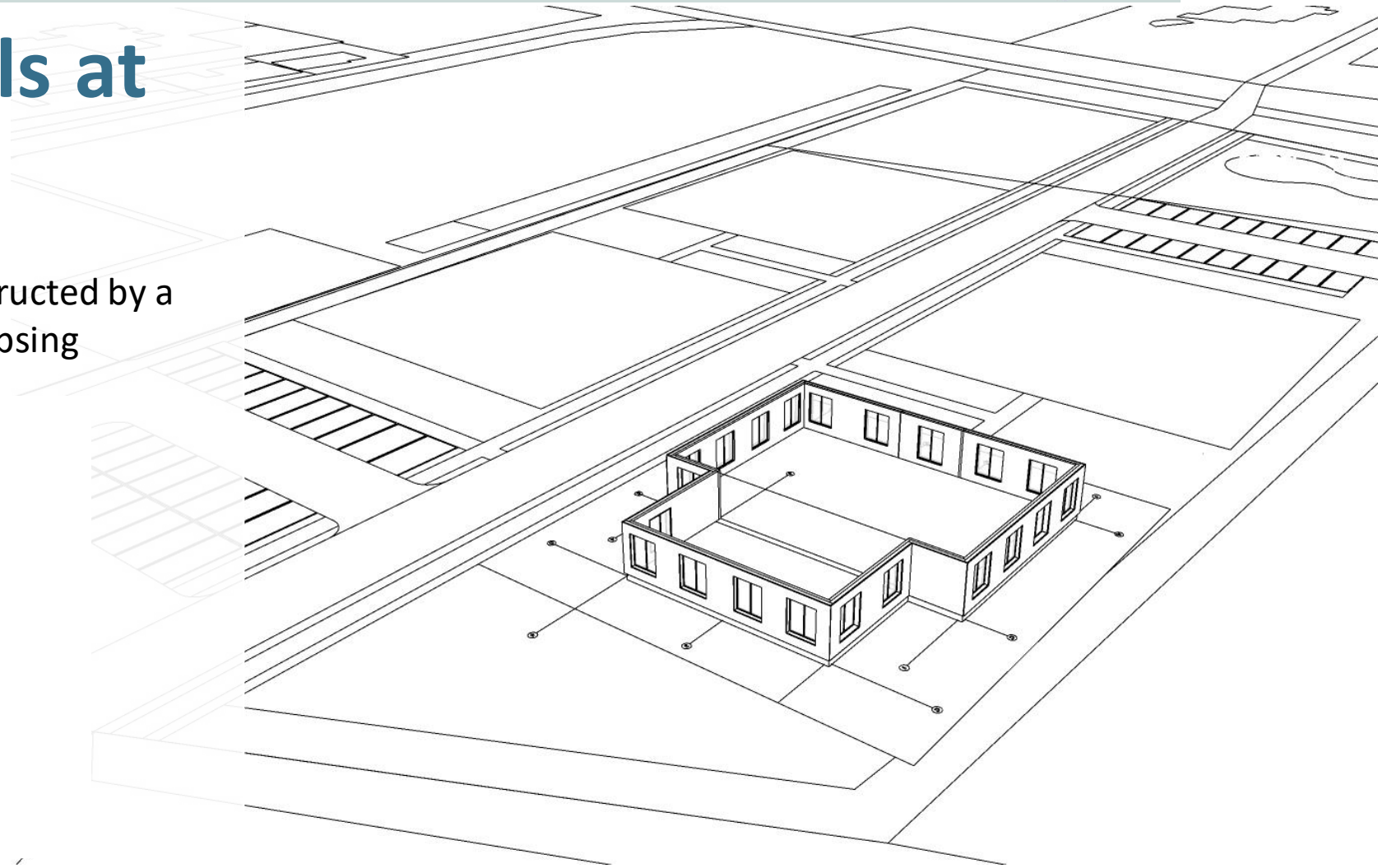
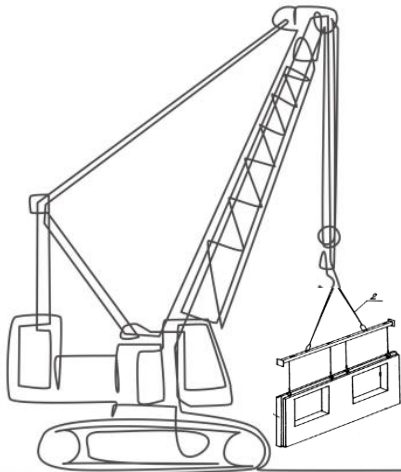


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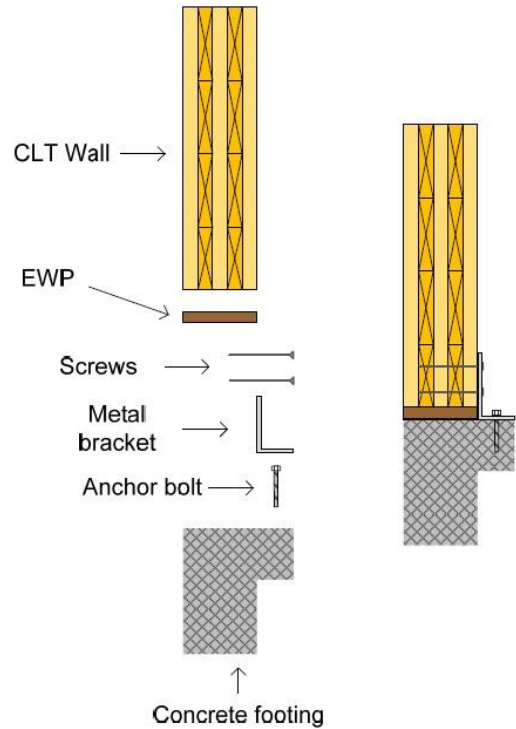
# Load – bearing walls at ground level

CLT panels for external walls shall be constructed by a crane and then supported to prevent collapsing



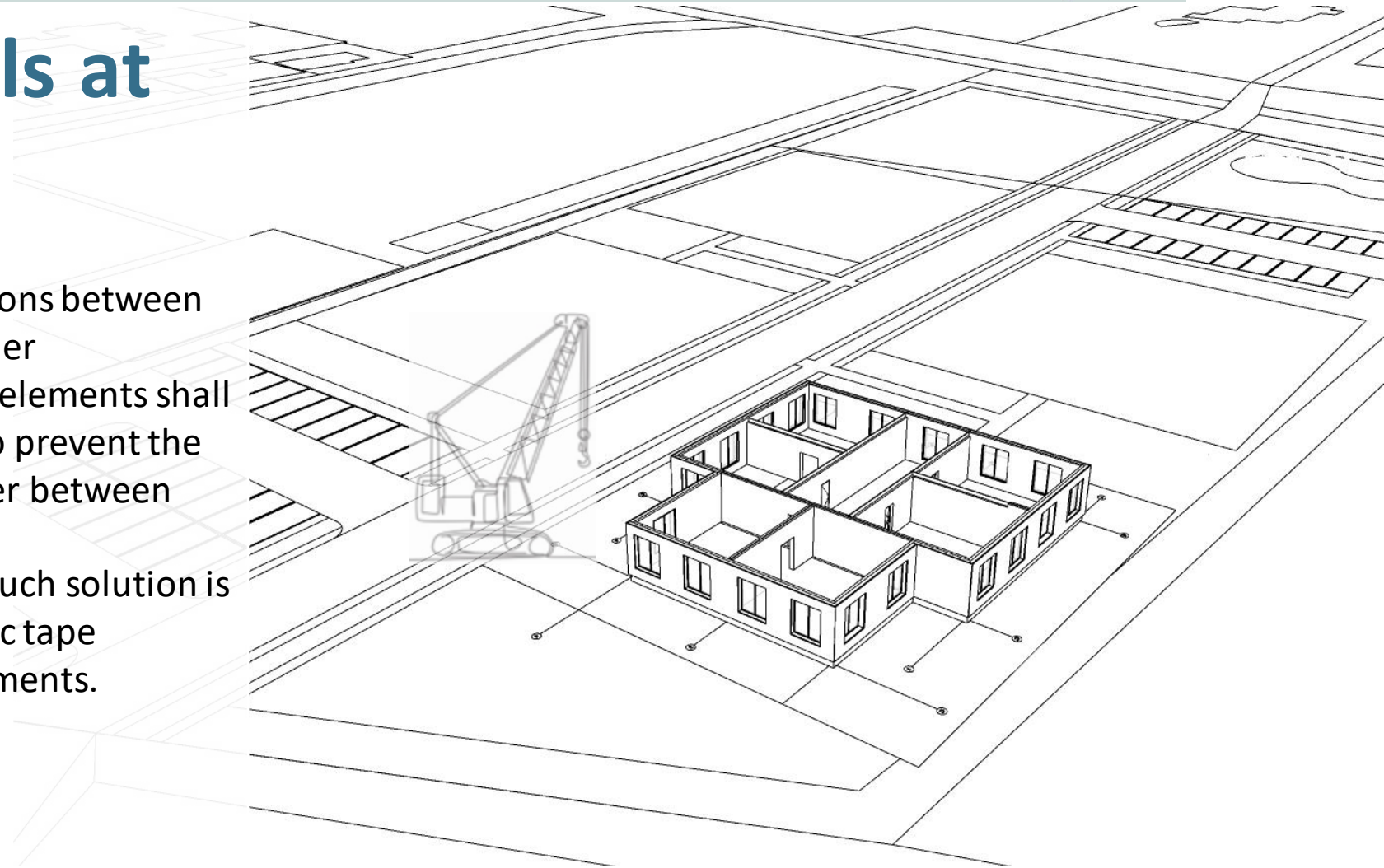


# Load – bearing walls at ground floor



The connections between walls and other construction elements shall be isolated to prevent the sound transfer between elements.

Example of such solution is putting elastic tape between elements.





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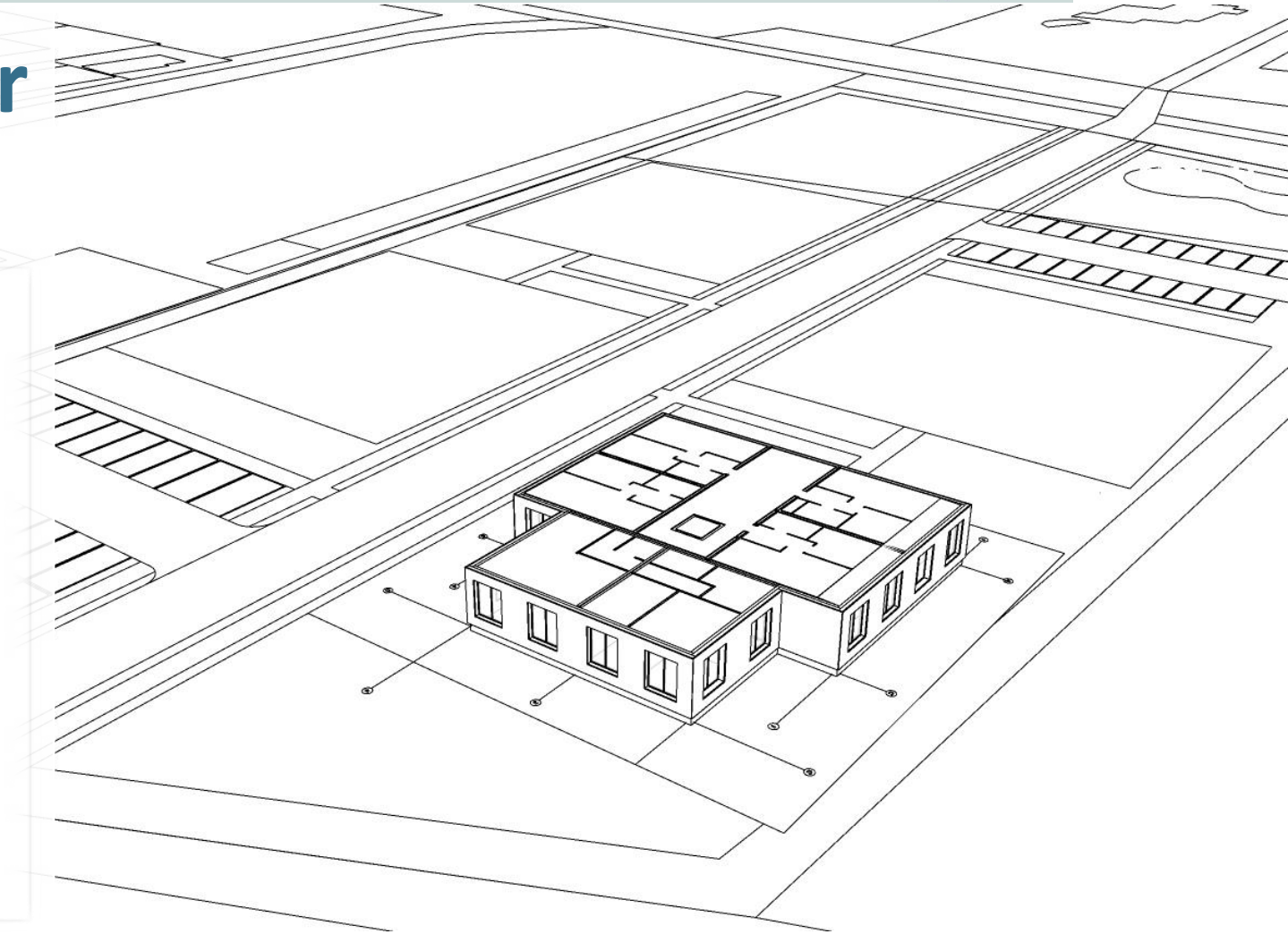
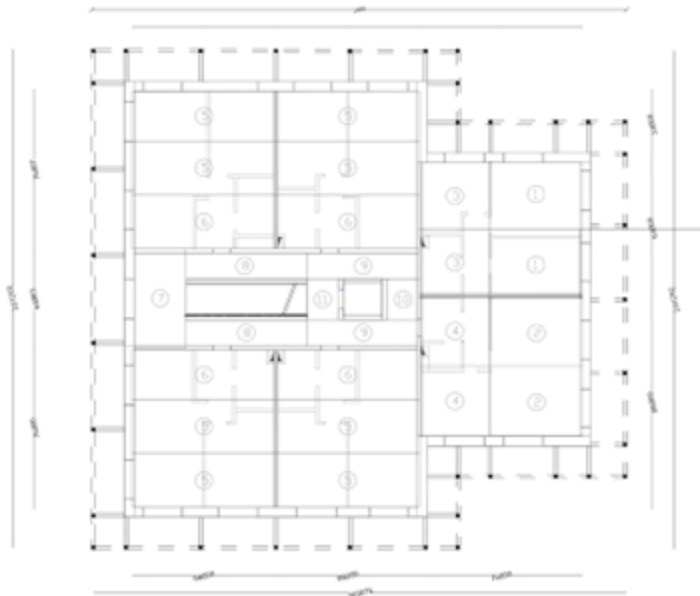


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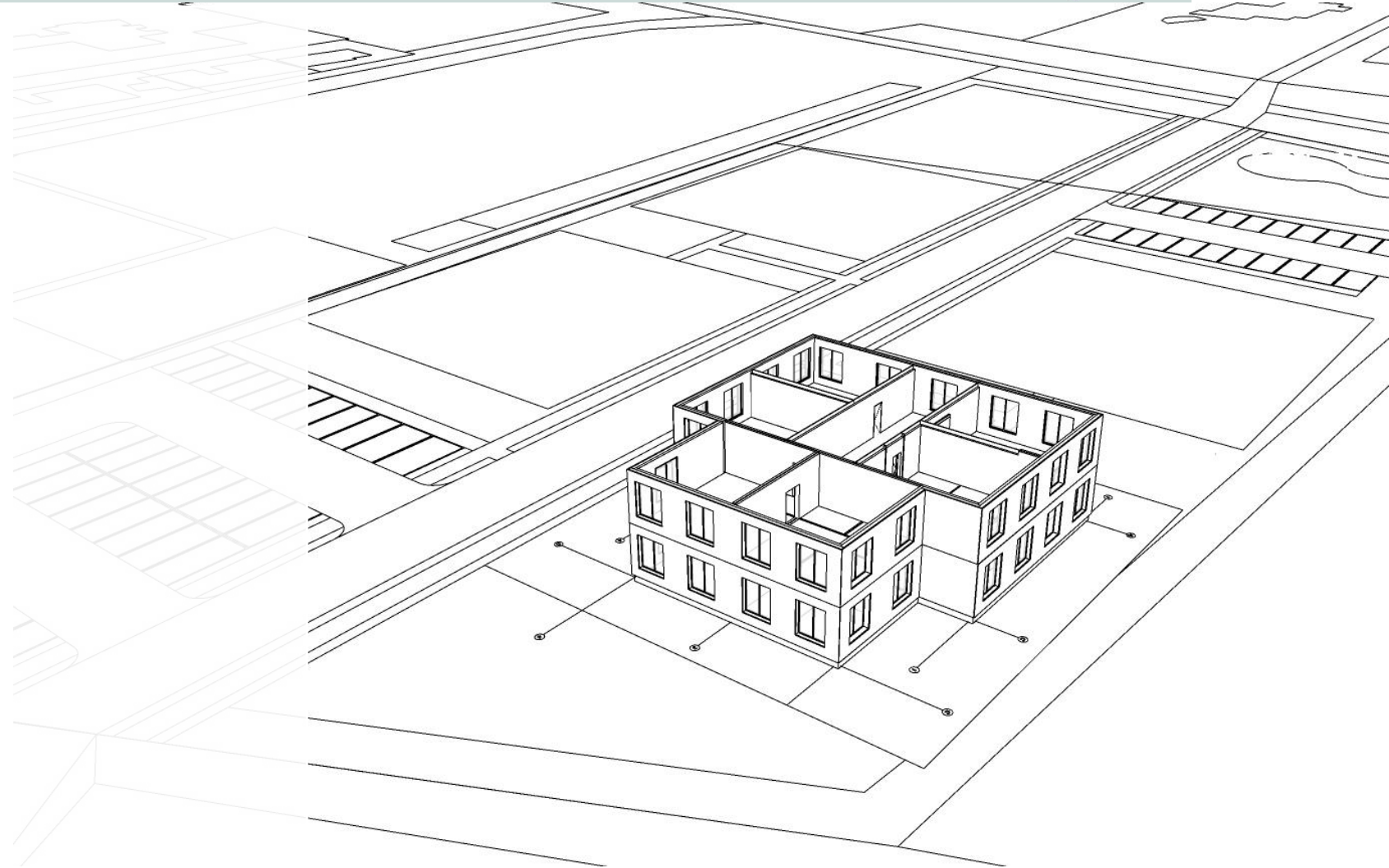
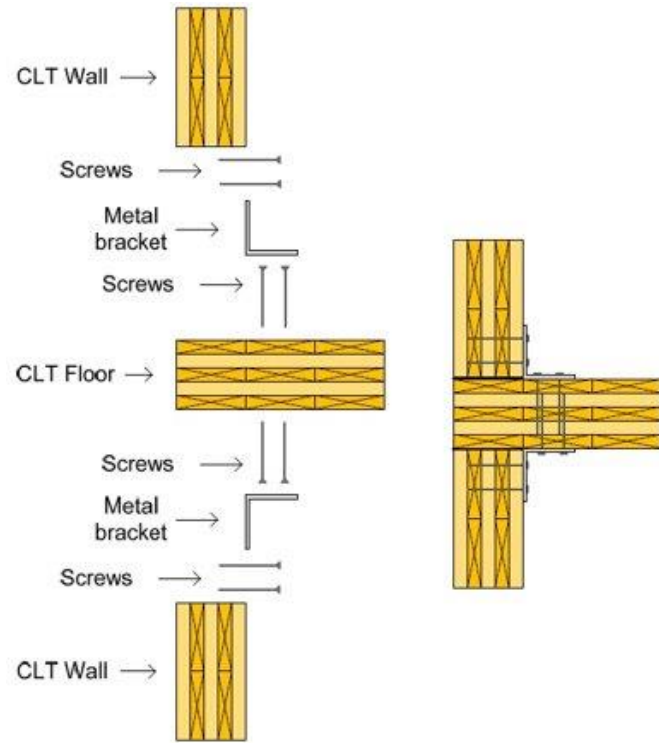
# Slabs above ground floor

Slab CLT panels will be installed by crane and workers.  
Rest of slab elements will be installed by workers.



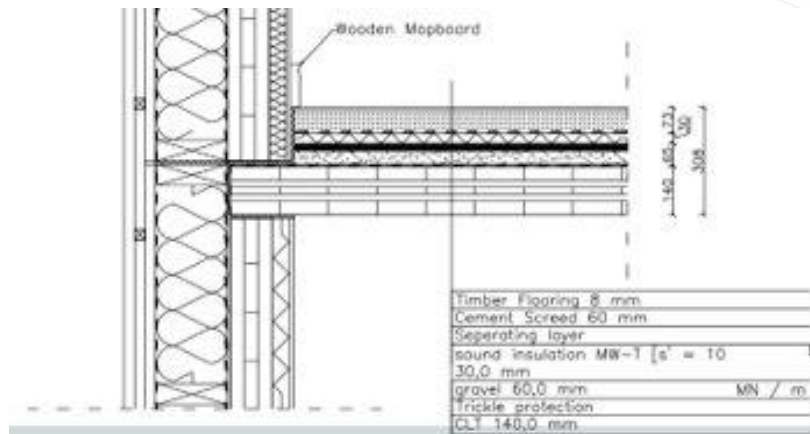
# Walls at first floor

## Exterior walls and CLT floor connection



# Slabs above first floor

## Slab and wall connection



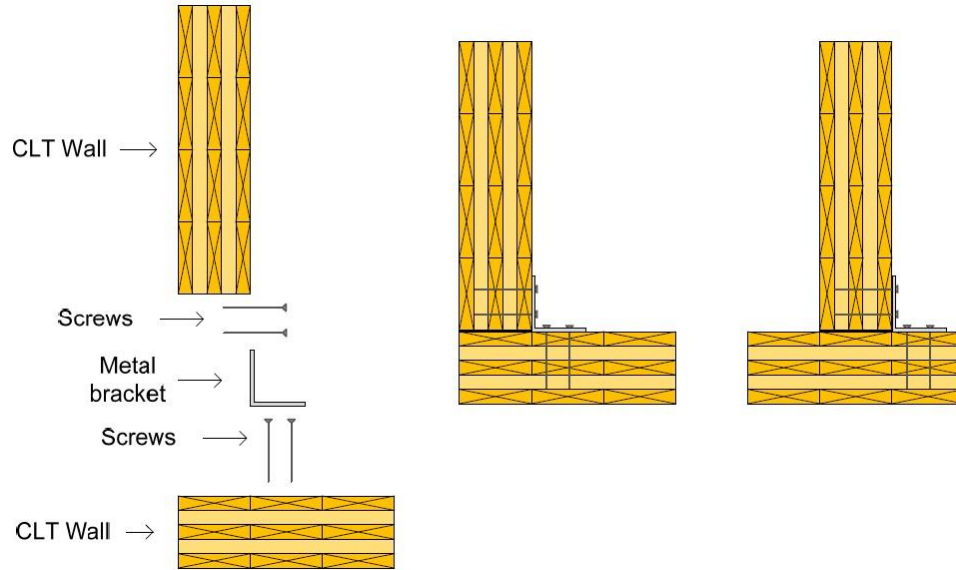


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# Walls at second floor

## Connection between walls



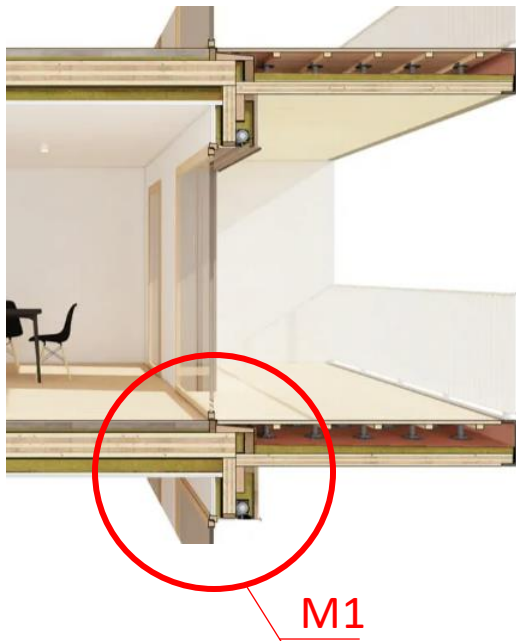


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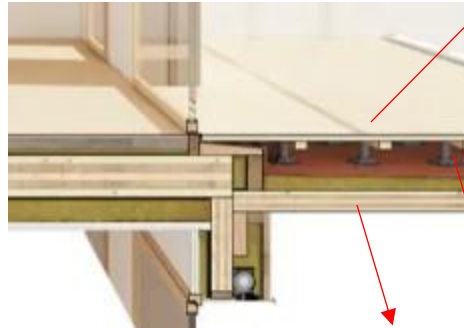


# Balconies

Connection between exterior wall and balcony



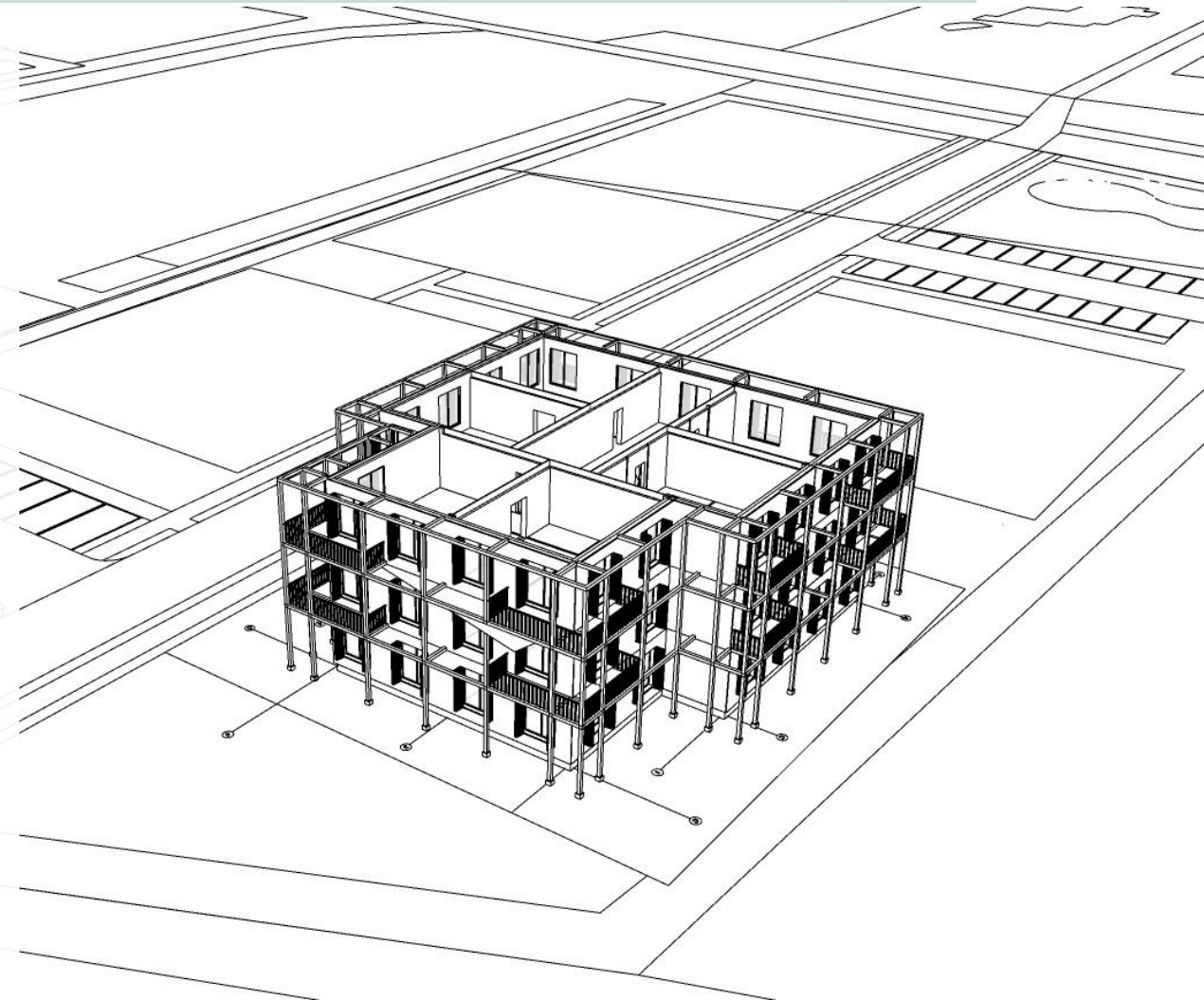
M1



Embossed Extrusion Decking

CLT

Adjustable terrace support



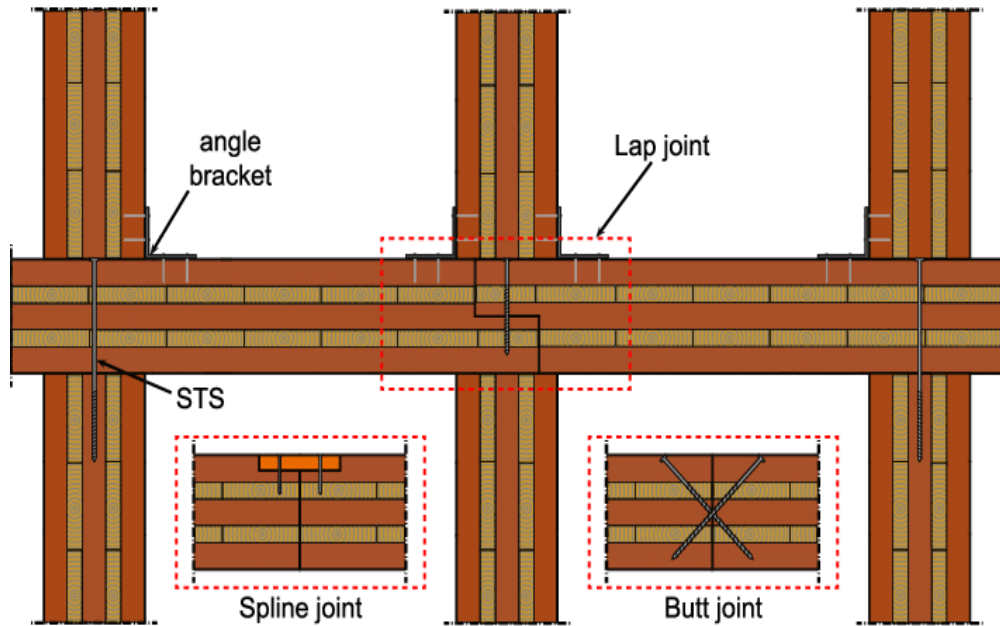
Balconies are connected to the exterior wall using steel brackets or connectors that are screwed into CLT panels. These brackets are designed to transfer the load from the balcony to the wall, providing a secure connection.



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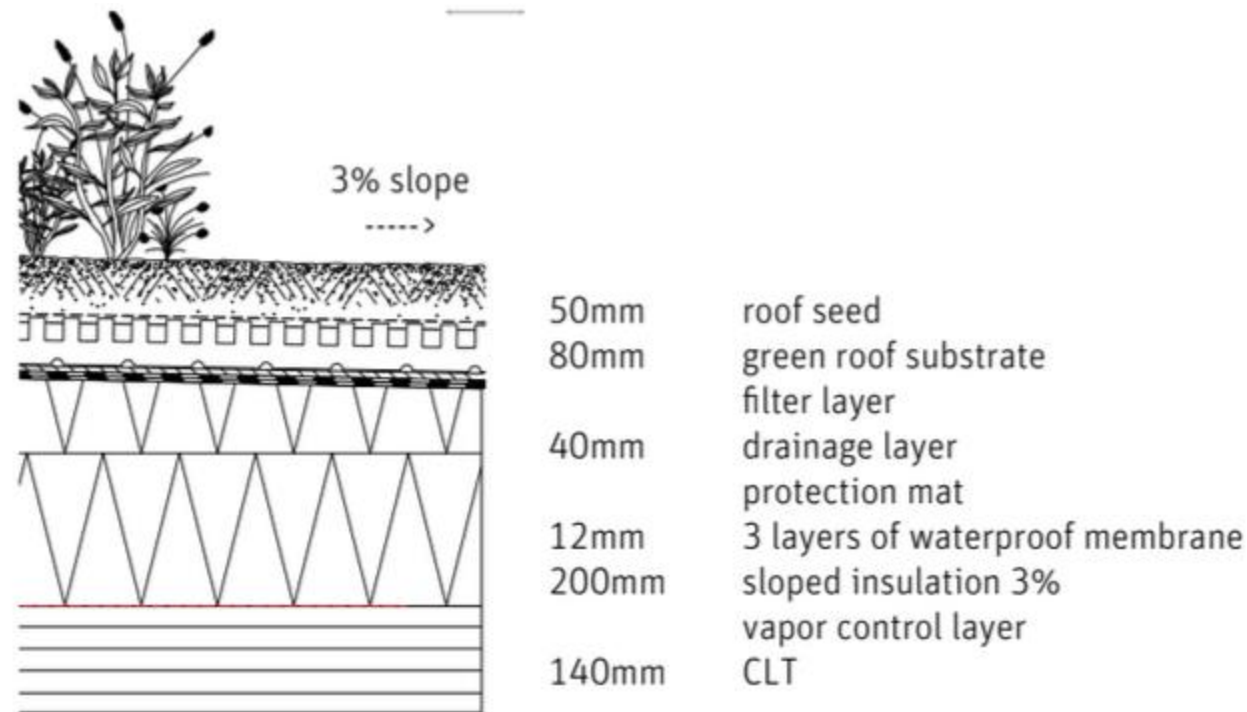
# CLT Roof panels instalation







# Roof layers





# External finish

This part of work includes:

- Adding thermal insulation to all the parts of a building
- Waterproof and windproof layers
- Green roof instalation
- Finishing layers for balconies
- External cladding
- Windows and doors installation





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# Assembling all the buildings + internal finish

The internal finishes can be done in one buildings while the others are being constructed by another team

Internal finish stage includes:

- Erecting internal non-bearing walls
- Putting installations
- Internal finishes for walls, floors and ceilings



# Cost estimation – foundation and ground floor

Floor	Material	Thickness, m	Area, m2	Area, m3	Price, EUR	Amount	Total price, EUR
1	Timber flooring	0.08	350		55€/m2	350 m2	19250
2	Cement screed	0.06	350	21	18€/m2	21 m3	6300
3	Separating layer	0.002	350		1.85€/m2	350 m2	647.5
4	Sound insulation	0.255	1050	267.75	19.7€/m2	1050 m2	20685
5	Trickle protection	0.002	350		0.42€/m2	350 m2	146.65
6	Concrete	0.2	350	70	128€/m3	70 m3	8960
7	Reinforcement mesh	0.008	350		153.5€/pcs	30pcs	4605
8	XPS	0.1	350	35	19.7€/m2	350 m2	6895
<b>TOTAL FOR 1 BUILDING , EUR</b>							<b>67489.15</b>
<b>TOTAL FOR 4 BUILDINGS , EUR</b>							<b>269956.6</b>

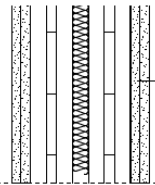
Column	Material	Thickness, m	Area, m2	Area, m3	Price, EUR	Amount	Total price, EUR	x14, EUR
1	XPS	0.1	0.3		19.7€/m2	0.3 m2	5.91	82.74
2	Bitumen membrane	0.03			1€/m	1.8 m	1.8	25.2
3	Concrete	0.3	0.45	0.135	128€/m3	0.135 m3	17.28	241.92
4	Rebar	0.01			1.57€/m	6 m	9.42	131.88
5	Stirrups	0.008			0.7€/m	5 m	3.5	49
6	XPS	0.1	0.168		19.7€/m2	190 m2	3743	52402
<b>TOTAL FOR 1 BUILDING , EUR</b>							<b>52932.74</b>	
<b>TOTAL FOR 4 BUILDINGS , EUR</b>							<b>211730.96</b>	

Footing	Material	Thickness, m	Area, m2	Area, m3	Price, EUR	Amount	Total price, EUR	x14, EUR
1	Concrete	0.6	0.18	0.108	128€/m3	0.108 m3	13.83	193.62
2	Rebar	0.01			1.57€/m	2.4 m	3.77	52.78
3	Reinforcement mesh	0.008	0.36		153.5€/pcs	1 pcs	153.5	773.64
4	Gravel	0.47-1.45	408.4	190	33.9€/t	418 t	14170.2	-
5	Phenolic plywood	0.012	27		33.6€/m2	27 m2	907.2	-
6	Sawn timber				1.99€/m	160 m	318.4	-
<b>TOTAL FOR 1 BUILDING , EUR</b>							<b>16415.84</b>	
<b>TOTAL FOR 4 BUILDINGS , EUR</b>							<b>65663.36</b>	

<b>TOTAL FOR 1 BUILDING , EUR</b>	<b>270,128.45€</b>
<b>TOTAL FOR 4 BUILDINGS , EUR</b>	<b>1,080,513.80€</b>

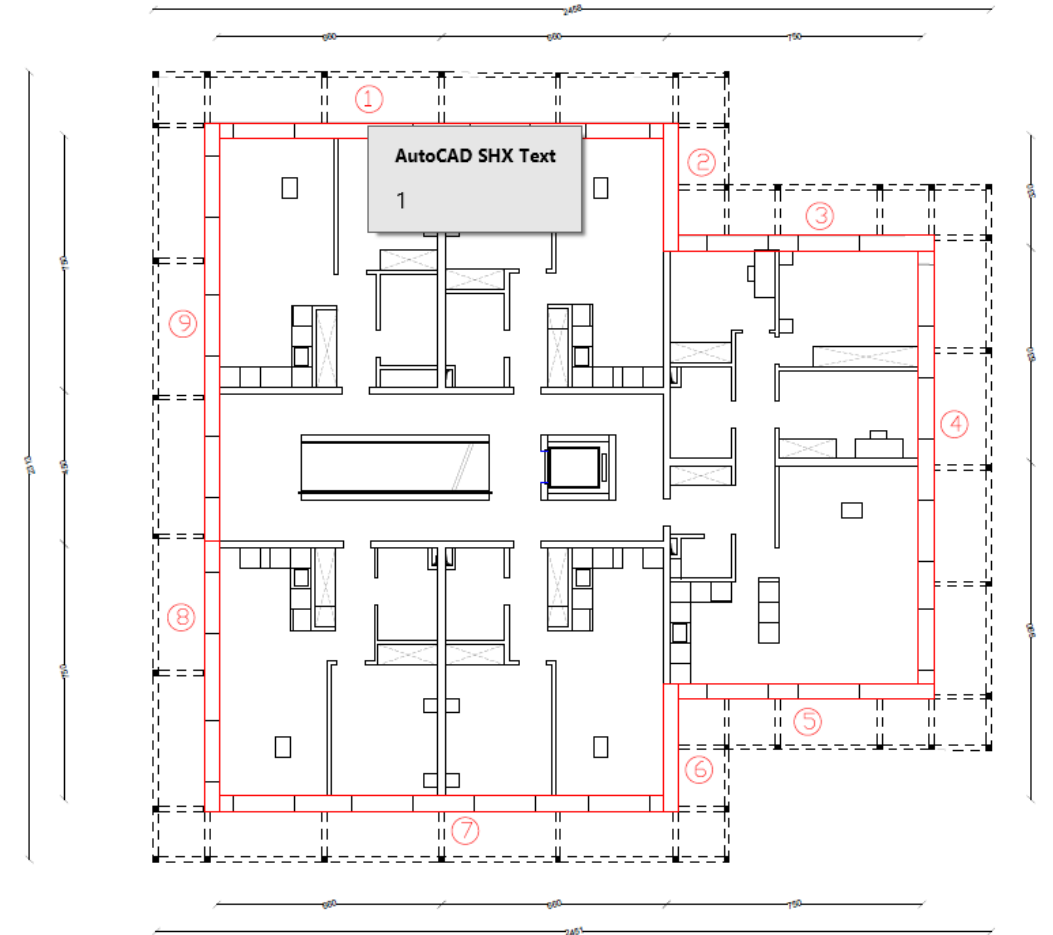


# Cost estimation – external walls



Gypsum plaster board 12.5
CLT 80 mm
Insulation material 30mm
CLT 80 mm
Gypsum plaster board 12.5

Material	Thickness, m	mass (kg/m2)	price E/m2
Gypsum plaster board	1,25cm	8,4	2
cellulose insulation	0,05	1,25	20
<b>CLT panel</b>	<b>0,12</b>	<b>66</b>	<b>120</b>
breathable layer	0,03	0	0
	0,2	6,6	2,5
cellulose insulation/supporting timber		5	20
moisture protection			1,76 /1m2
batten	0,03	1	
counter-batten	0,03	1	
timber cladding	0,03	5,5	2,5
summary			167
data for calculation			170
External walls - CLT panels			all materials
nr	length (m)	weight (kg)	material cost (Euro)
1	13	2831	7293
2	3,8	827	2131,8
3	7,5	1633	4207,5
4	12,7	2766	7124,7
5	7,5	1633	4207,5
6	3,8	827	2131,8
7	13	2831	7293
8	8	1742	4488
9	12,3	2679	6900,3
summary	81,6	17769	45777,6
for all storeys	244,8	53307	137332,8
for 4 buildings	979,2	213 223	549,331.20

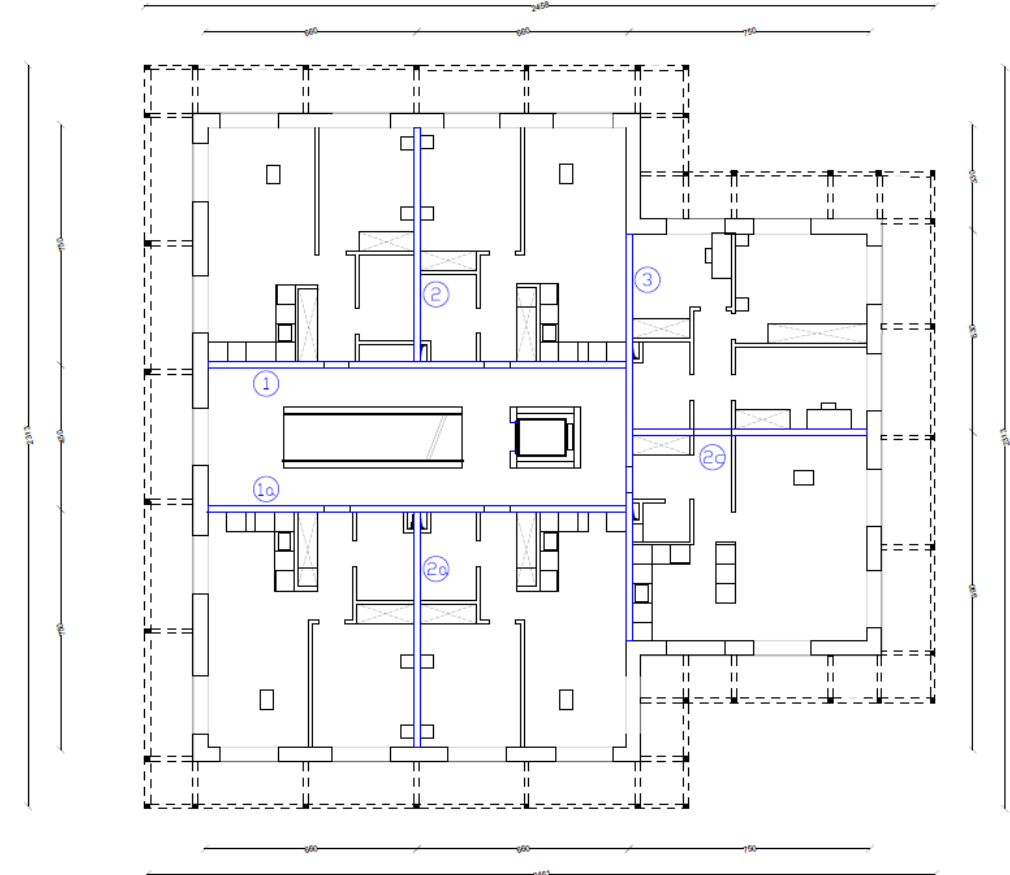




Work on site cost						
work type	workload cost (euro/hour/person)	people on site	effectiveness of work/hour/person	Area of walls/storey	work will take	cost, EUR
framing, insulating and	15	4	6m <sup>2</sup> /h	294	16 h	960Euro
external finish	15	4	8m <sup>2</sup> /h	294	12h	720Euro
internal finish			6m <sup>2</sup> /h	294	16h	960Euro
				for one storey	6 days	2640Euro
				one building	18 days	7940 Euro
				4 buildings	72 days	30560
Windows						
	Amount/storey	Price, EUR	effectiveness of	people working	workload cost, EUR	
	20	200	1 piece/h	2	15E/h	
	for one storey	4000		for one storey	600Euro	
	one building	12000		one building	1800Euro	
	4 buildings	48000	20 hours	4 buildings	7200	

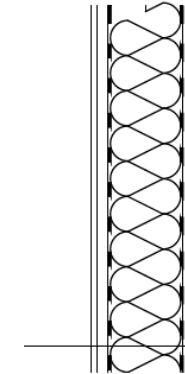
# Cost estimation – internal walls

Material	Thickness (m)	mass (kg/m2)	price E/m2		
Gypsum plaster board	1,25cm	8,4	2		
CLT panel	0,08	44	80		
cellulose insulation	0,03	1	20		
CLT panel	0,08	44	80		
Gypsum plaster board	1,25cm	8,4	2		
summary		105,8	184		
data for calculation		110	190		
separating walls between apartments - panels - one storey					
nr	length (m)	weight (when 3,3m-opt material cost)			
1	13	4719	8151		
1a	13	4719	8151		
2	7,3	2548,72	4432,56		
2b	7,3	2548,72	4432,56		
2c	7,3	2548,72	4432,56		
3	12,7	4434,07	7711,44		
				two floors (one building)	4 buildings
summary		21518,24	37,311.12	74622.24	298488.96
comment		requires 1 truck/storey			
	workload cost(crane)	workload cost (people)			
one hour of renting for one storey	160 Euro 1 280 Euro	one hour of work/person people on site	15 Euro	4	
		salary/all people/day		480	
For one building	3840		1440	5760	
For 4 buildings	15360			5760	



# Cost estimation – separating walls

Material	Thickness, m	mass (kg/m2)	price E/m2			
Gypsum plaster board	1,25cm	8,4	12			
OSB board	1,25cm	8	14			
timber construction/rock wool	0,12	20,2	20			
OSB board	1,25cm	8	14			
Gypsum plaster board	1,25cm	8,4	12			
		total price	<b>72E/m2</b>			
length of internal walls/one store	73,5m	price for one st	17463,6			
		price for one building	52 390,8			
area of internal walls/one store	242,55m2					
total area of internal walls/one building	727,65m2	price for 4 build	209563.2			
<b>Work on site cost</b>						
work type	workload cost	people on site	effectiveness of work/h	Area of walls/	work will take	cost, EUR
framing, insulating and putting	15	4	6m2/h	727,65	48 h	2880Euro
internal finish	15	4	6m2/h	1 455,3	96h	5760Euro
				one building	18 days	7940 Euro
				4 buildings	72 days	<b>30560</b>



gypsum plaster board (2x12,5 mm)  
 OSB board  
 construction timber (60/120)  
 rock wool 120 mm  
 OSB board  
 gypsum plaster board (2x12,5 mm)

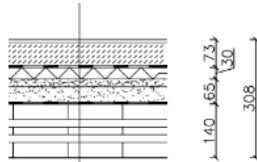




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# Cost estimation – floor slabs



Thickness: 308 mm  
Fire: REI60  
Sound:  $R_w = 60$  dB  
 $L_{n,w} = 57$  dB

- Timber Flooring 8 mm
- Cement Screed 60 mm
- Separating layer
- sound insulation MW-T 30,0 mm
- gravel 60,0 mm
- Trickle protection
- CLT 140,0 mm

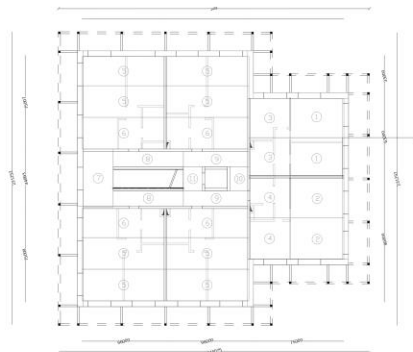
Total material price per floor (€)	Total transportation price per floor (€)	Total material price per building (€)	Total transportation price per building (€)	Total work cost per building (€)
56466.91	400	112933.83	800	3262.35

Total material price per all buildings (€)	Total transportation price per all buildings (€)	Total work cost per all buildings (€)
451735.31	3200	13049.4

Total price per building (€)	Total price per all buildings (€)
116996.18	467984.71

Work on site cost per building						
Work type	Workload cost (euro/hour/person)	People on site	Effectiveness of work/hour/person (m <sup>2</sup> /h)	Area of floors/building (m <sup>2</sup> )	Work will take (h)	Cost (€)
Installing CLT panels	15	4	6	217.49	9	543.73
Installing trickle protection	15	4	6	217.49	9	543.73
Installing gravel	15	4	6	217.49	9	543.73
Installing sound insulation	15	4	6	217.49	9	543.73
Installing cement Screed	15	4	6	217.49	9	543.73
Installing timber flooring	15	4	6	217.49	9	543.73
<b>Total:</b>					<b>54</b>	<b>3262.35</b>

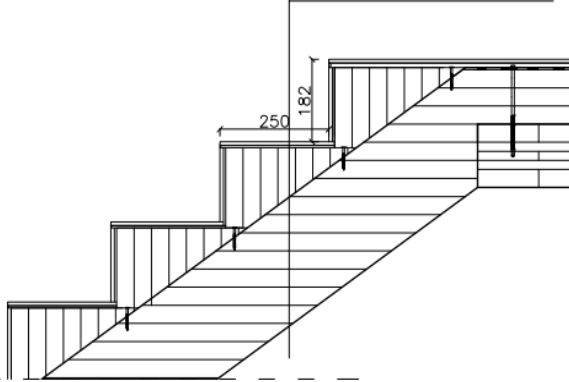
Material	Thickness, m	Area per floor (m <sup>2</sup> )	Volume per floor (m <sup>3</sup> )	Total area (m <sup>2</sup> )	Total volume (m <sup>3</sup> )	Price per floor (€)	Total Price (€)
Timber Flooring	0.008	108.745	0.86996	217.49	1.73992	5980.98	11961.95
Cement Screed	0.06	108.745	6.5247	217.49	13.0494	1957.41	3914.82
Separating layer	0.005	108.745	0.543725	217.49	1.08745		
Sound insulation	0.03	108.745	3.26235	217.49	6.5247	2142.28	4284.55
Gravel	0.06	108.745	6.5247	217.49	13.0494	100.54	201.08
Trickle protection	0.005	108.745	0.543725	217.49	1.08745	45.67	91.35
CLT	0.14	108.745	15.2243	217.49	30.4486	46240.04	92480.08





# Cost estimation - stairs

Gres tiles—80 mm  
Montage Glue 20 mm  
Glulam steps  
CLT 232,2 mm



	Material	Thickness, m	Total for stairs (x16)	Total for stairs (x16)	Material price per m3	Material price per m2	Total price, EUR	x2 (two stairs in one)
1	Gres tiles	0,08	12,06	0,96		33,41	402,82	805,64
2	Montage Glue	0,02	12,06	0,24		2,98	35,93	71,86
3	Glulam (glued laminated timber)			0,83776	1000		837,76	1675,52
4	CLT (Cross Laminated Timber)	0,2322	1,2079	0,1208	1000		120,79	241,58
	Total area, m2	8,46						
	<b>TOTAL, EUR</b>							<b>2794,59</b>
	<b>TOTAL FOR 4 BUILDINGS , EUR</b>							<b>11178,38</b>

Work on site cost		
One hour of renting crane	160eur/h	
One hour of work/person	15eur/h	2

	Work will take, h	Salary for one worker, EUR	Salary for two workers, EUR
Stairs installation (The CLT panels lift into place using cranes)	1	15	30
Finishing (the stair treads and risers)	48	720	1440
For 1 building ( 2 stairs)	51	735	1470
<b>For 4 buildings ( 8 stairs)</b>	<b>204</b>	<b>2940</b>	<b>11760</b>

4 hour of renting crane, EUR	640
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<b>TOTAL (renting crane+salary for workers)</b>		<b>12400,00</b>
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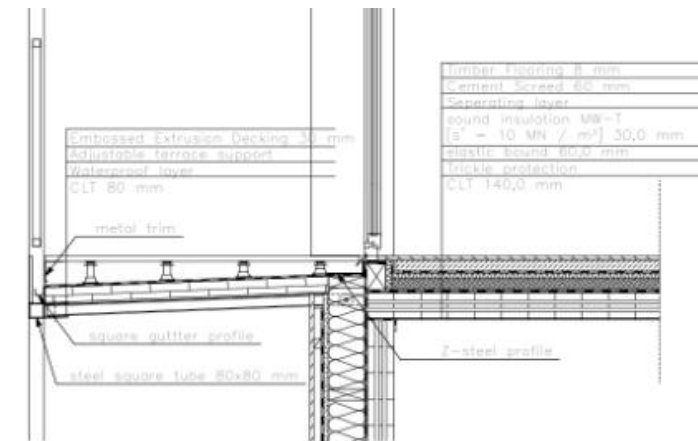


# Cost estimation - balconies

	Material	Thickness, m	Area, m2	Area, m3	Price, EUR	Amount	Total price, EUR	x2(two balconies in one building), EUR
1	Embossed Extrusion Decking	0.03	135.8	4.07	20,42 /1 m2	135.8 m2	2 773	5 546
2	Adjustable terrace support				per one 3.56	350 pcs	1 246	2 492
3	Waterproof layer		135.8		1.76 /1m2	135.8 m2	239	478
4	CLT (Cross Laminated Timber)	0.08	135.8	10.86	1000/m3	10.86 m3	10 860	21 600
	Total area of balconies on one floor			135.8				
	TOTAL FOR 1 BUILDING, EUR							30 116
	TOTAL FOR 4 BUILDINGS, EUR							120,464.00

Work on site cost			
	Costs	People on site	
One hour of renting crane	160eur/h		
One hour of work/person	15eur/h	4	
	work will take	Salary for one worker, EUR	Salary for four workers, EUR
Embossed Extrusion Decking	2 days, 16 h	240	
Adjustable terrace support	6h	90	
Waterproof layer	8h	120	
CLT (Cross Laminated Timber)	2-3 days, 20h	300	
In total for one balcony	50h	750	3000
FOR 1 BUILDING ( 2 BALCONIES )	100h	1500	6000
For 4 BUILDING ( 8 BALCONIES )	400h	6000	24000

10 hour of renting crane, EUR	1600
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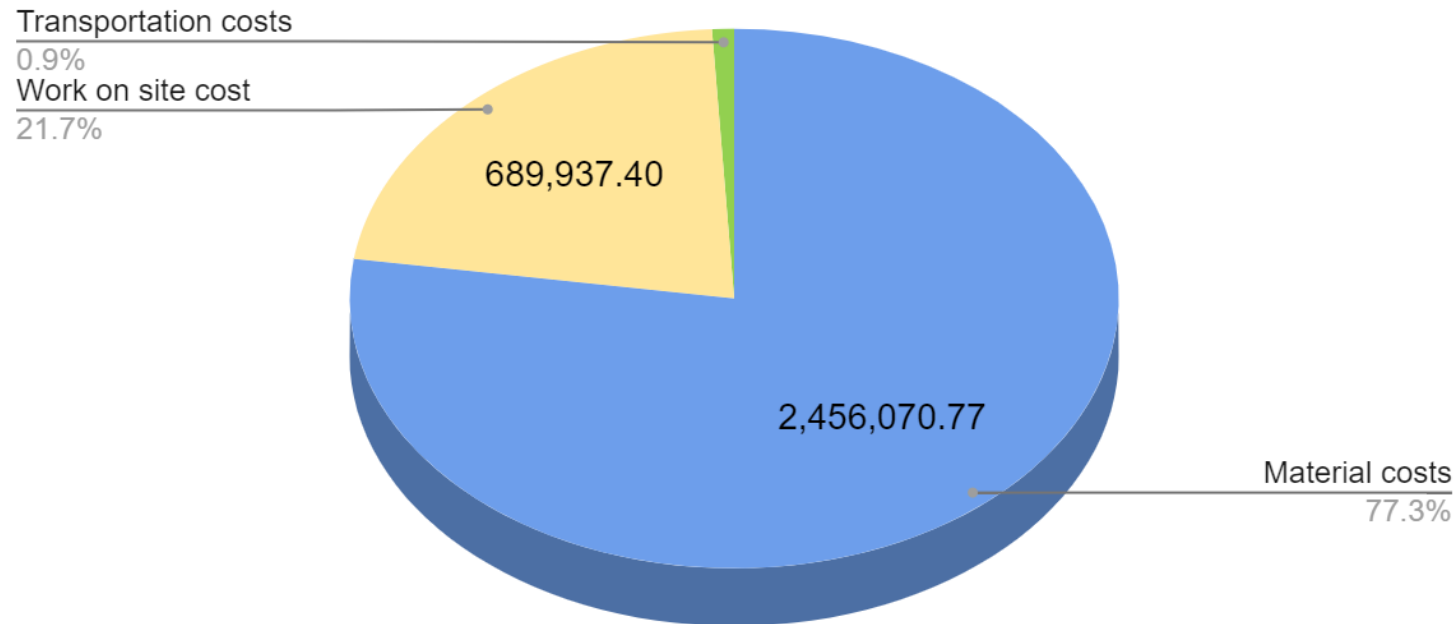


# Cost estimation - roof

Layers	m2/eur	m3/eur	Weight (kg)	terial cost (Euro)
Vapor control layer	2			706,8
sloped insulation 3%		60		21204
Waterproof membrane (3layers)	4			4240,8
protection mat	2			706,8
drainage layer	2,5			883,5
filter layer	2			706,8
green roof substrate		32	1130	904
roof seed	5		500	1767
			<b>Total:</b>	<b>31119,7</b>
			<b>4 buildings</b>	<b>124478,8</b>

Roof - CLT panels				all materials
Panels number	lenght (m)	weight (kg)	material cost (Euro)	
6	6.6	7623	13860	
5	4.8	4482	8150	
6	6.6	7623	13860	
<b>Total</b>			19728	35870
<b>For 4 buildings</b>			78912	<b>143480</b>

# Cost estimation – summary



Material costs, EUR	Work on site cost, EUR	Transportation costs, EUR	TOTAL, EUR
2 456 070,77	689 937,40	29 322,88€	3 175 331,05





# Sustainability concept

## Sustainable materials:

**Bendable concrete** - it can be infused with carbon dioxide, which strengthens the concrete while using less cement and lowering carbon emissions.

**Timber** - Using mass timber instead of conventional building materials can significantly reduce emissions.

**Reusing materials** - Doing so gives construction materials a second life and helps keep waste out of landfills.

**Green roof** - Helping out the environment; Increased roof lifespan





# Lessons learned

- CLT
- Planning
- Sustainability
- Importance of transportation in design
- Groupwork

