THE ART FACTORY

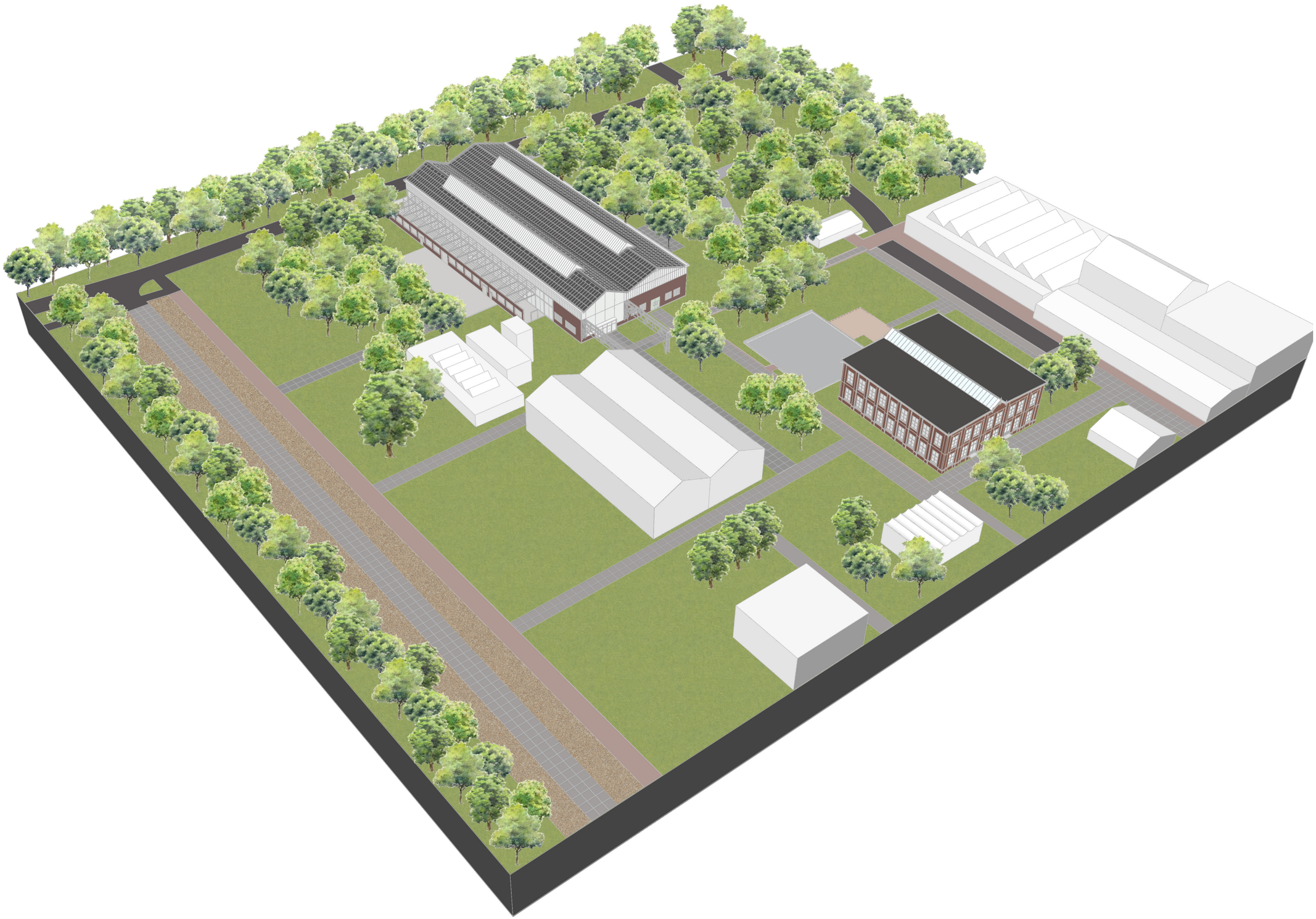
THE CULTURAL CENTRE FOR THE FINE AND PERFORMING ARTS

TECHNICAL DRAWINGS

Melanie Kwaks

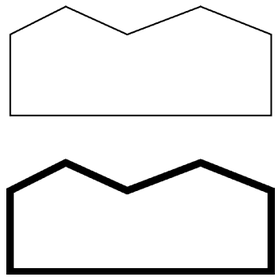
CONTENT

I Situation

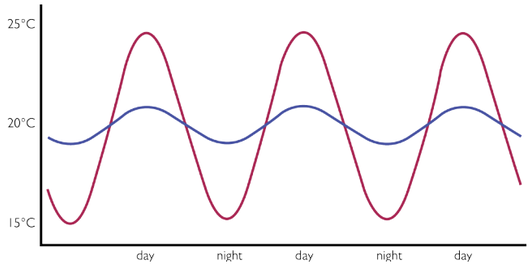


Reduce

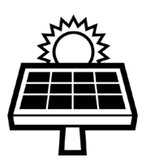
Reducing the energy demand



Stabilisation of the inside temperature



solve the remaining energy
demand sustainably



Solar energy

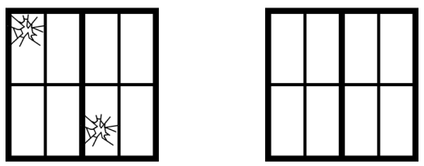
Earth energy

Reuse

Reuse an existing building

make it future proof

Reuse demolished materials/elements



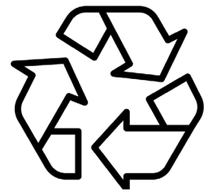
Reuse the rest energy & rain water

Heat exchanger

Filter rainwater
to flush toilets

Recycle

Use recycled materials

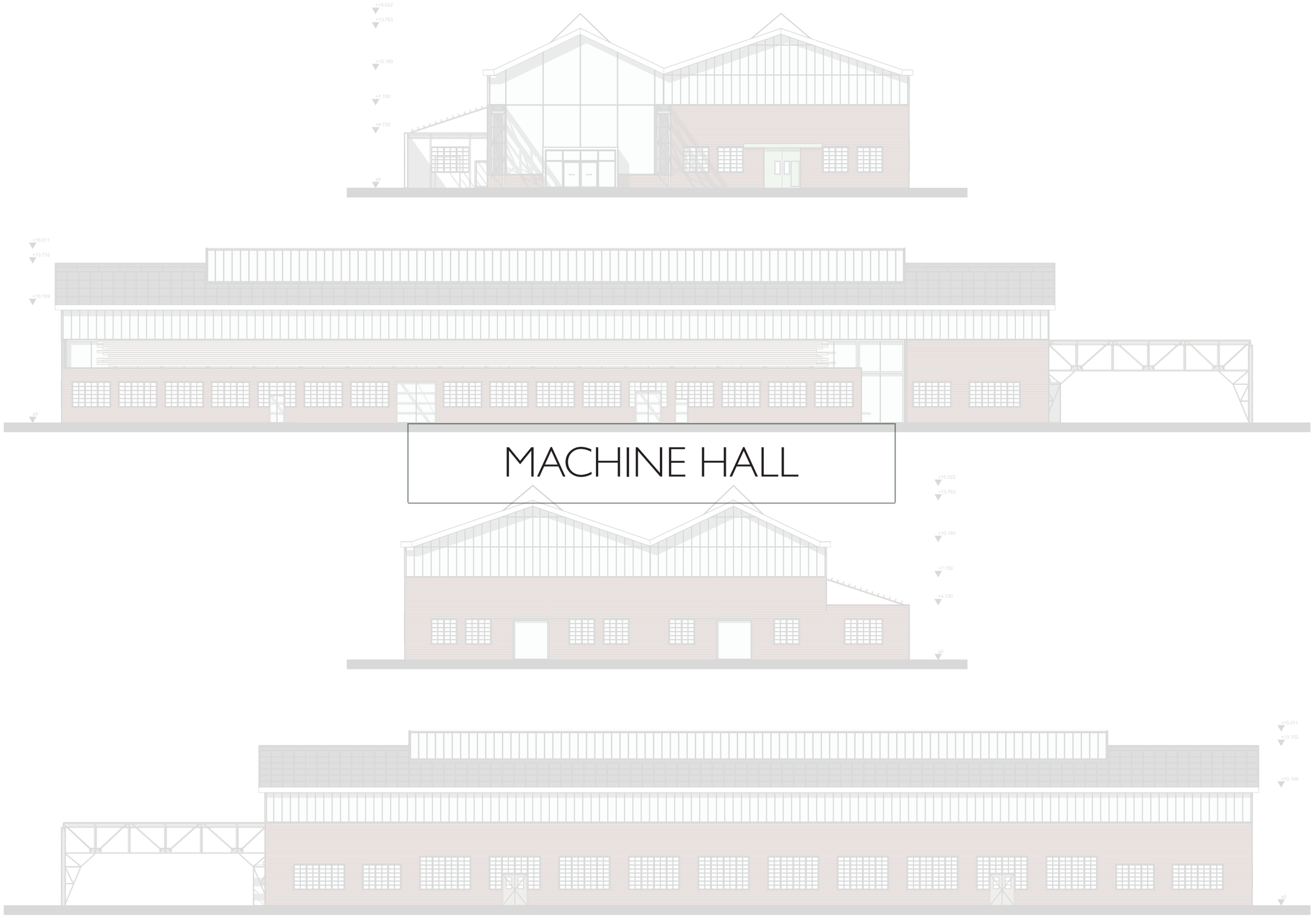


Use sustainable materials

Easy recyclable/reusable

Use eco-friendly materials

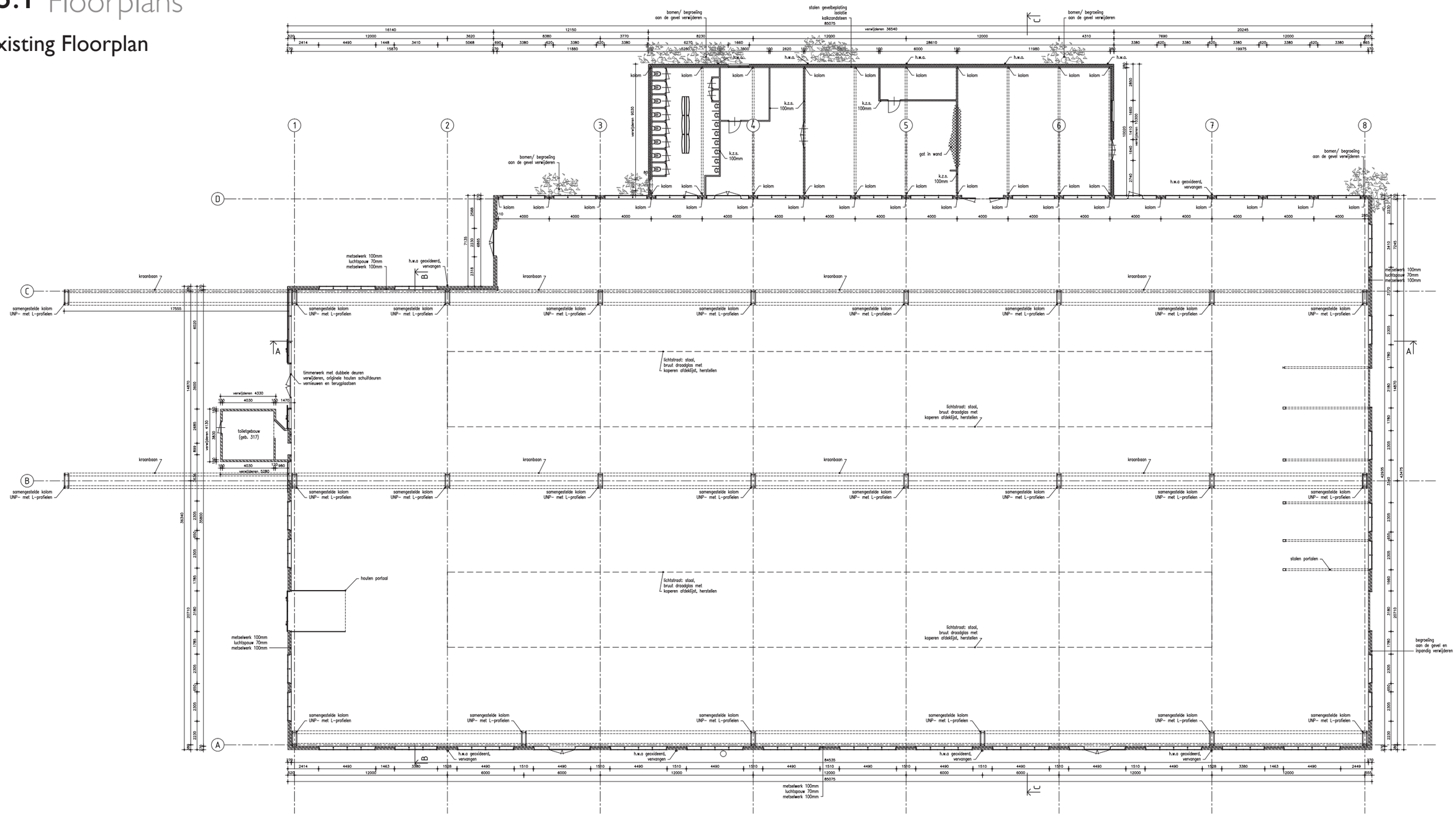
minimal negative impact
on our environment



MACHINE HALL

3.1 Floorplans

Existing Floorplan



Begane grond bestaand

* Alle kleuren en materialen als bestaand.
* Alle kozijnen incl. ramen en deuren vervangen.

RENVOOI GEVELS

- metselwerk gevel aanzicht
- stalen gevelbeplating
- bitumineuze dakbedekking
- aanzicht beton
- begroeiing aan de gevel

RENVOOI PLATTEGRONDEN/DOORSNEDEN

- doorsnede beton
- doorsnede metselwerk

LET OP: MATEN IN HET WERK CONTROLEREN!

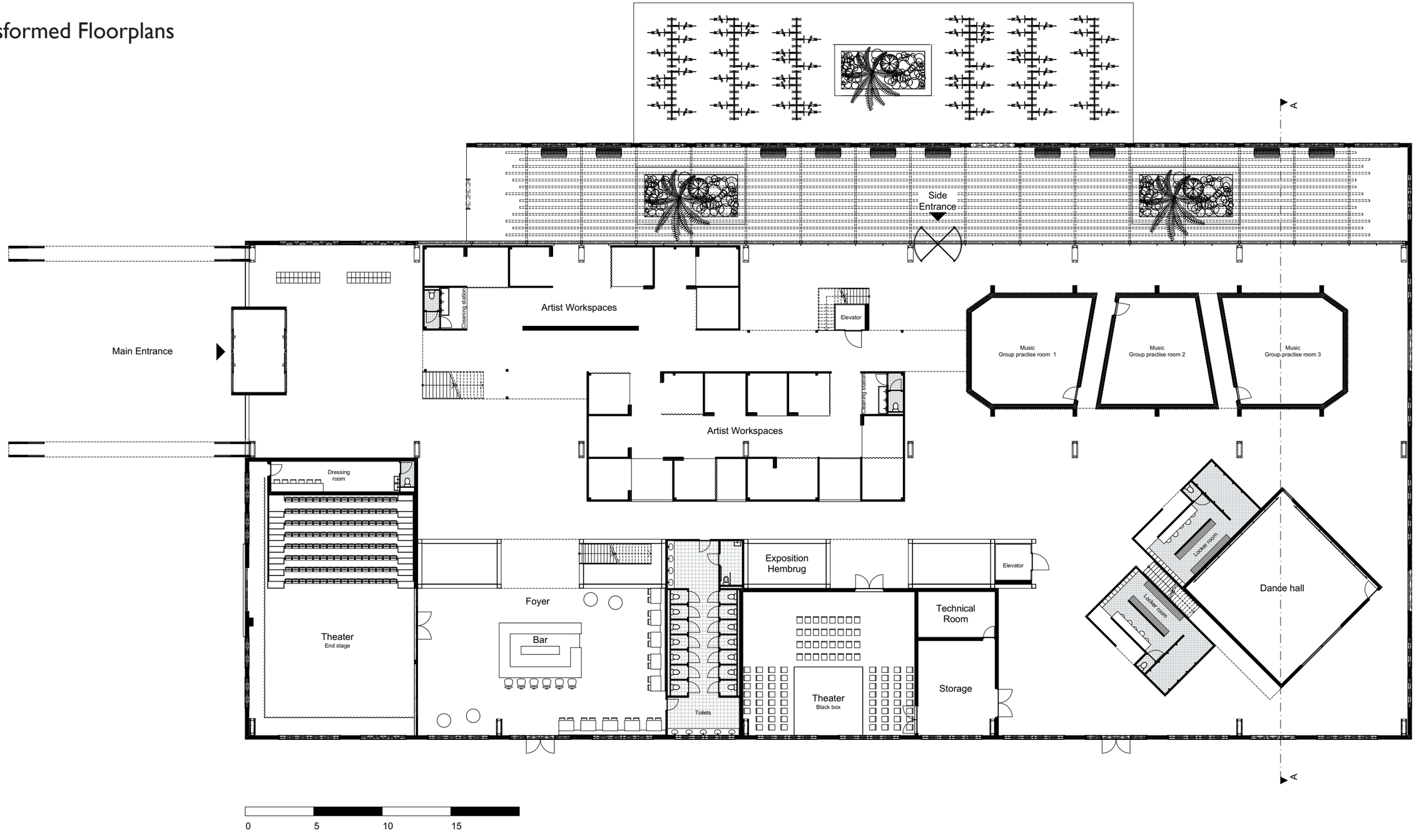
GEBOUW 320

ADD ARCHITECTEN B.V.
ARCHITECTURE DESIGN DEVELOPMENT

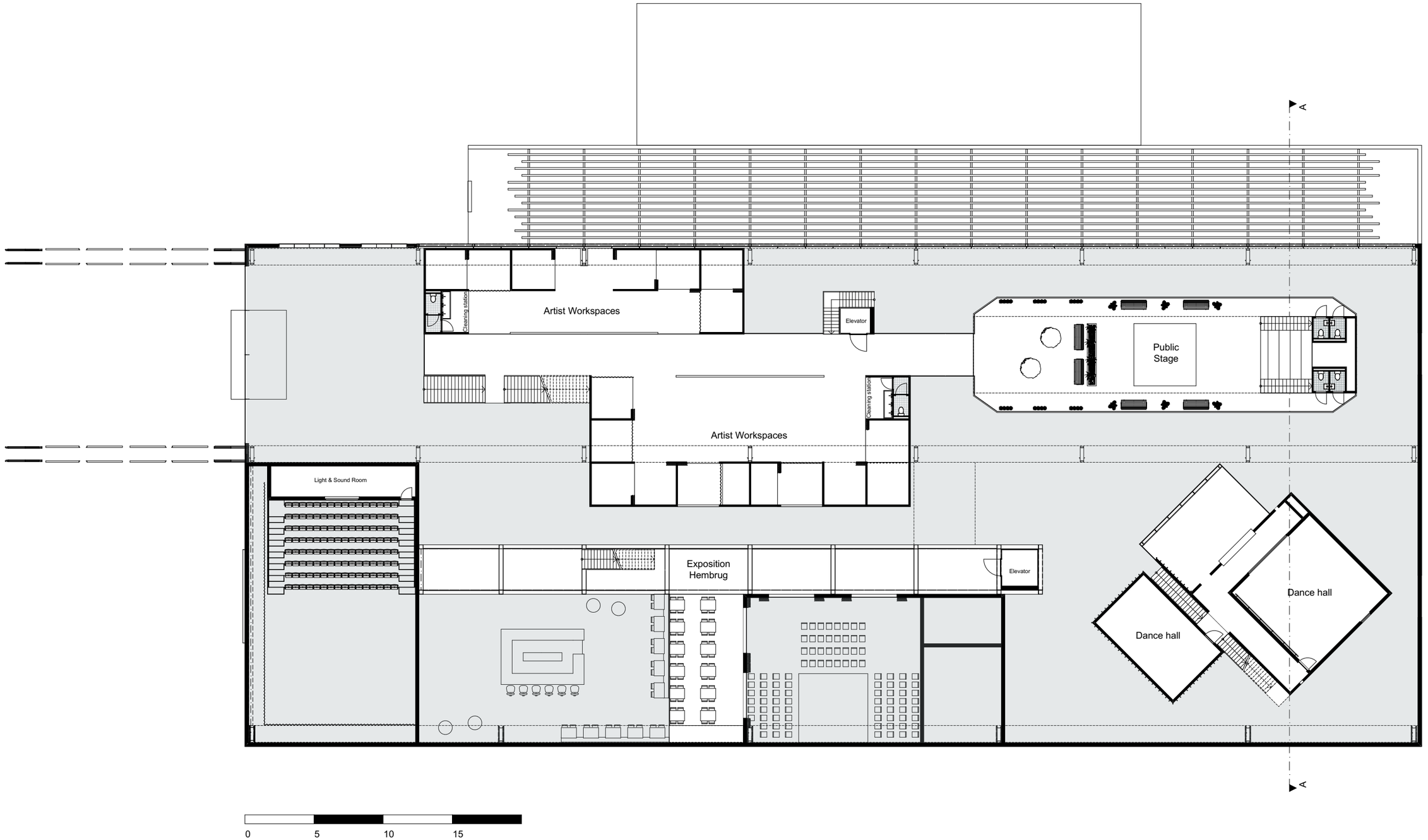
Project	HET WIND- EN WATERDICHT MAKEN VAN GEBOUW 320, HEMBRUGTERREIN TE ZAANDAM
Opdrachtgever	Rijksvastgoed- en ontwikkelingsbedrijf
Onderwerp	Bestaand: plattegrond
Ontwerp:	Getekend: P. Buijsman
DATUM	10-02-2012
WIJZ. 1	
WIJZ. 2	
WIJZ. 3	
WIJZ. 4	
WIJZ. 5	
WIJZ. 6	
Formaat:	A0
Schaal:	1:100
Werknummer	110095
Bladnummer	320-01

Kantoor Limmen: Schipperslaan 1/C Postbus 9 1906 ZG Limmen T. +31(0)72 50 52 842 F. +31(0)72 50 53 823
Kantoor Den Helder: Torplaan 2/A Postbus 252 1780 AG Den Helder T. +31(0)223 66 92 29 F. +31(0)223 66 92 32
www.add-architecten.nl info@add-architecten.nl

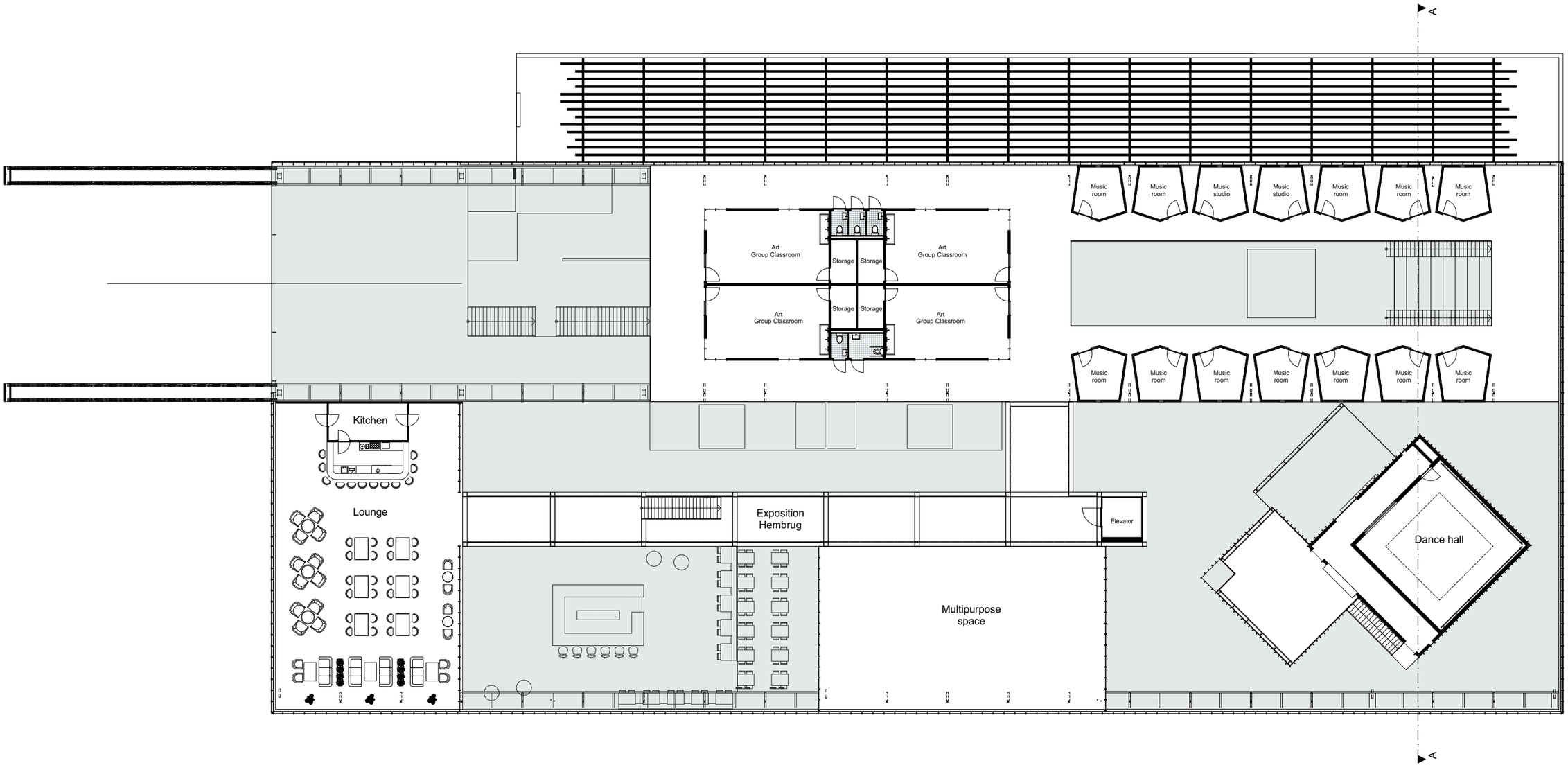
Transformed Floorplans



Ground floor
Scale: see scalebar



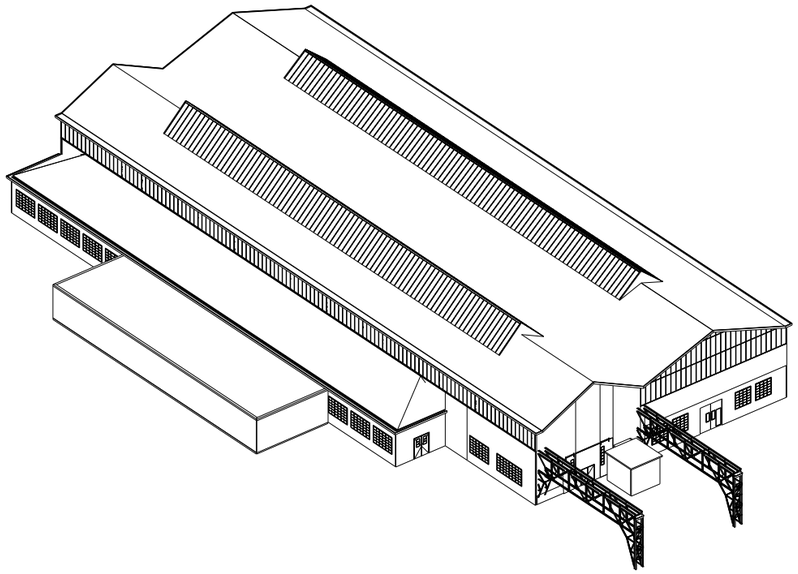
First floor
Scale: see scalebar



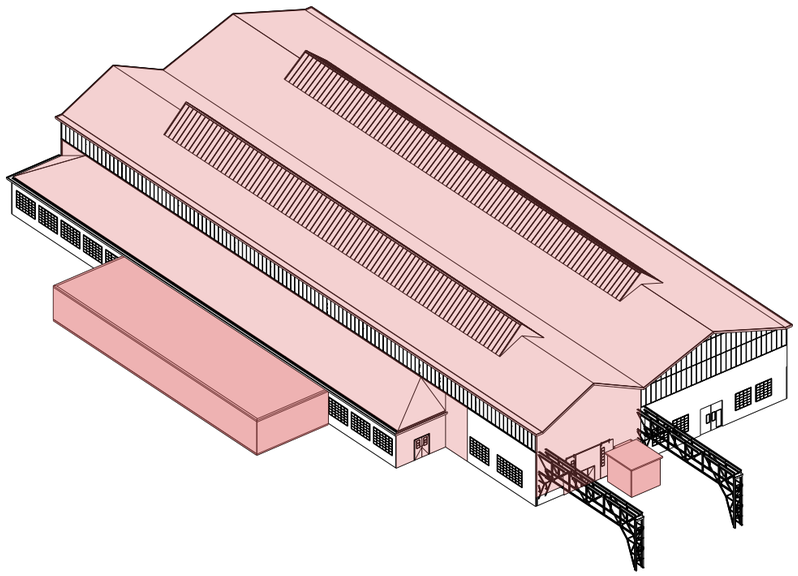
Second floor
Scale: see scalebar

3.2 Facade elevations

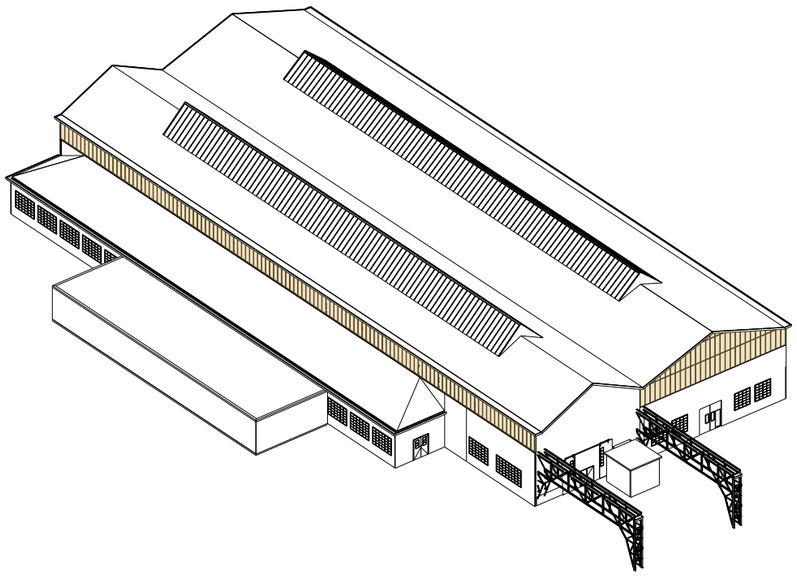
EXISTING



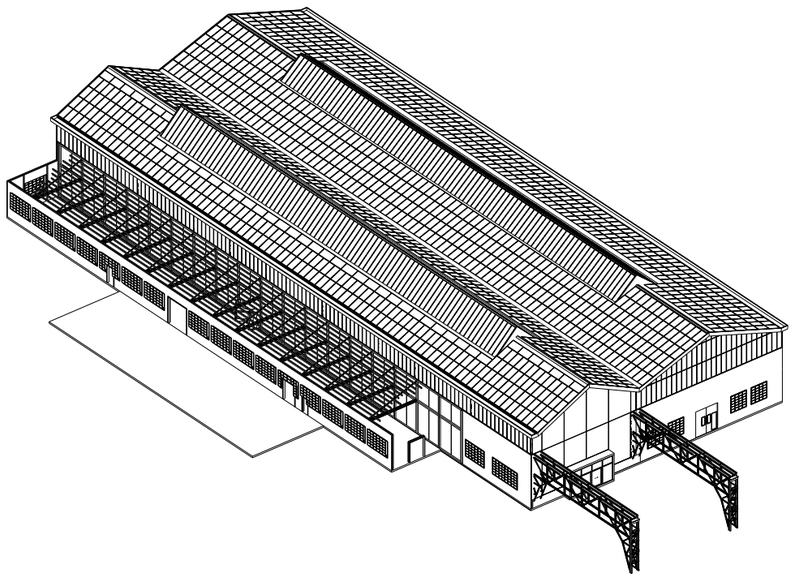
DEMOLITION



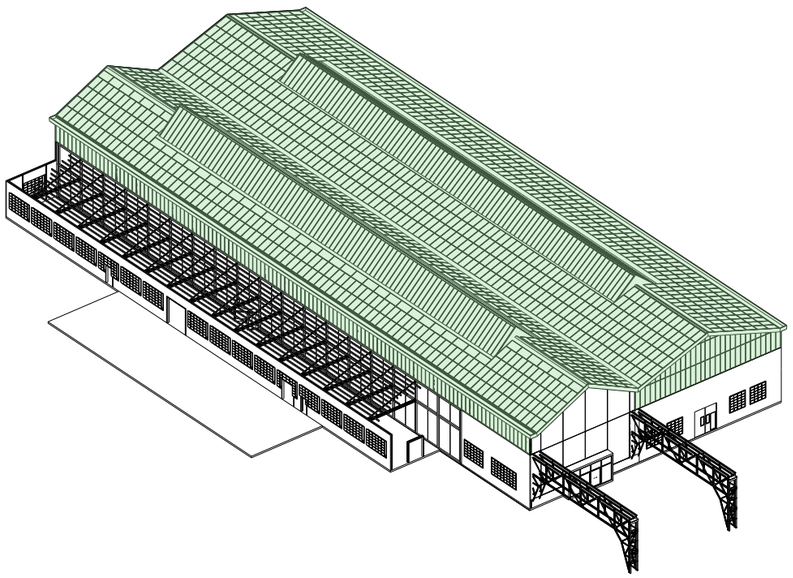
REUSE



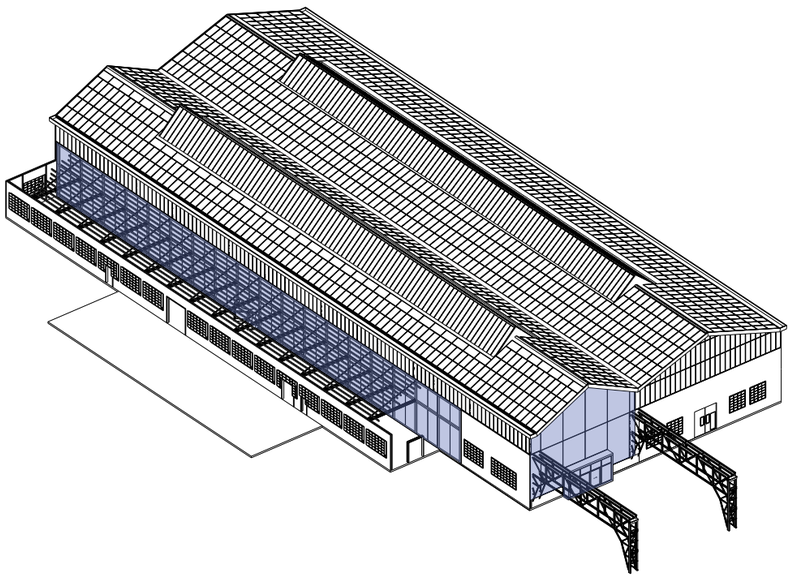
NEW



RENOVATED

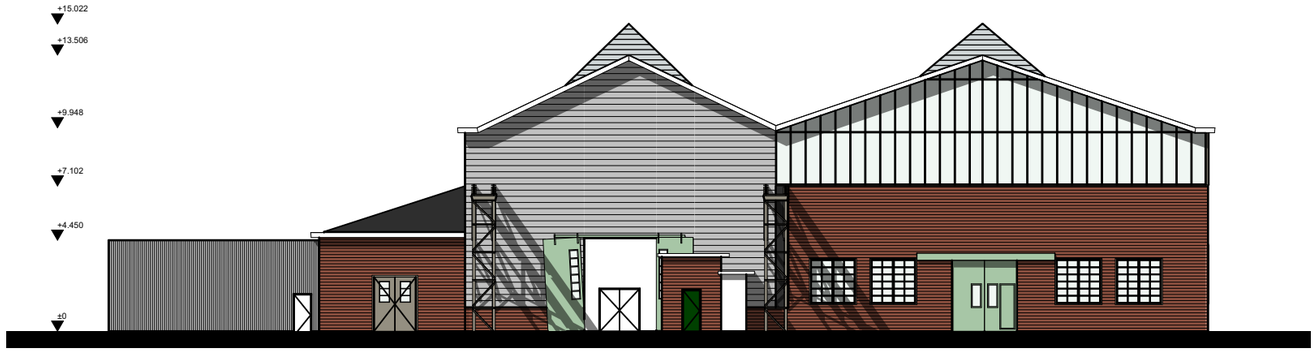


INTERVENTION

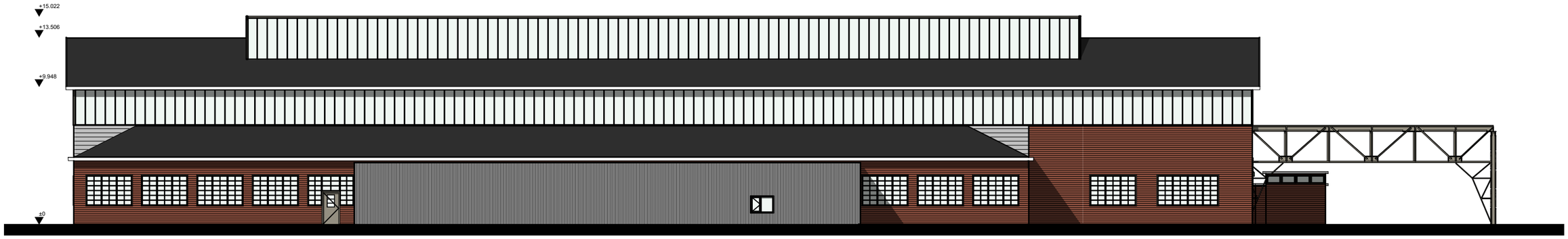


3.2 Facade elevations

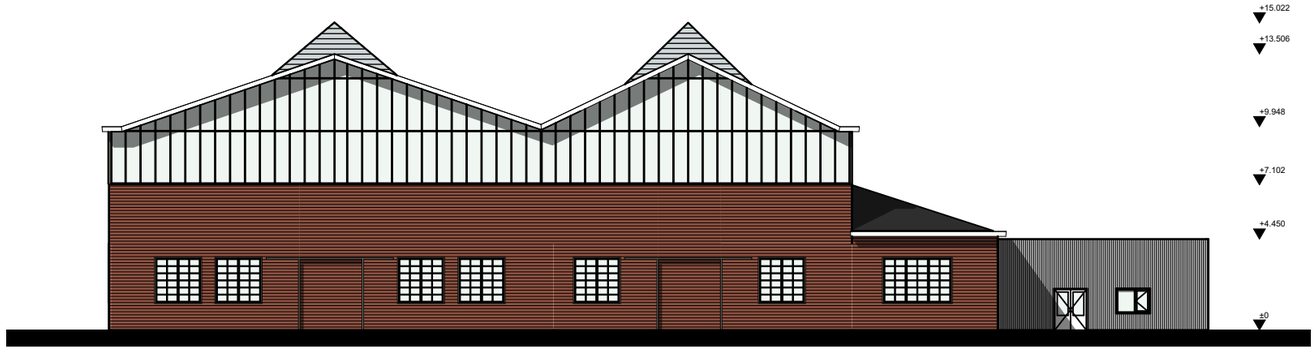
Existing Facades



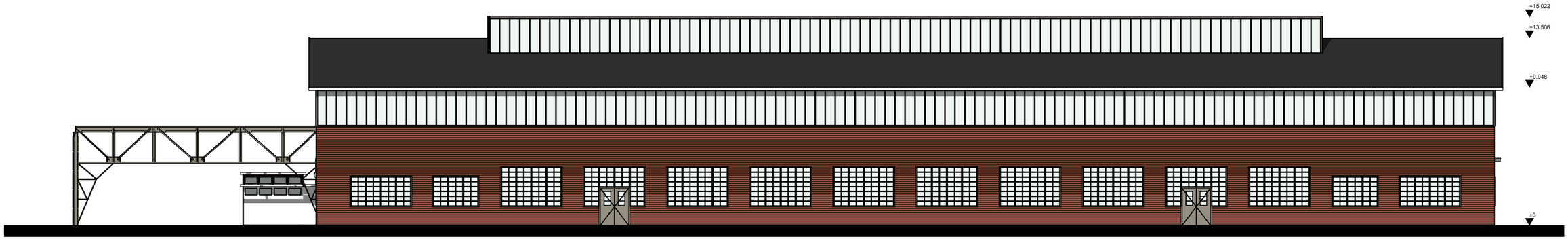
South - Front Facade



West - Left Facade



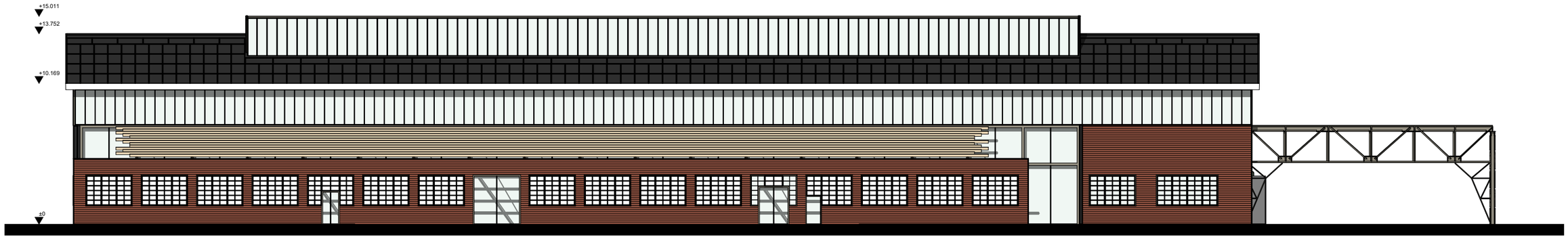
North - Back Facade



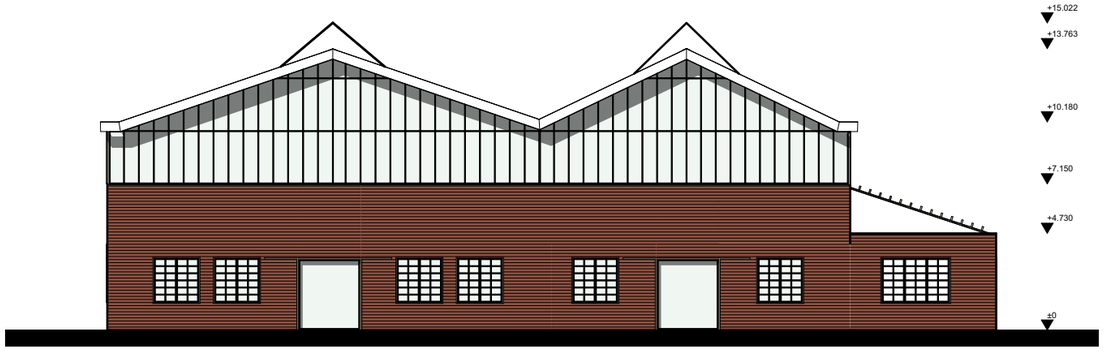
East - Right Facade

Transformed Facades

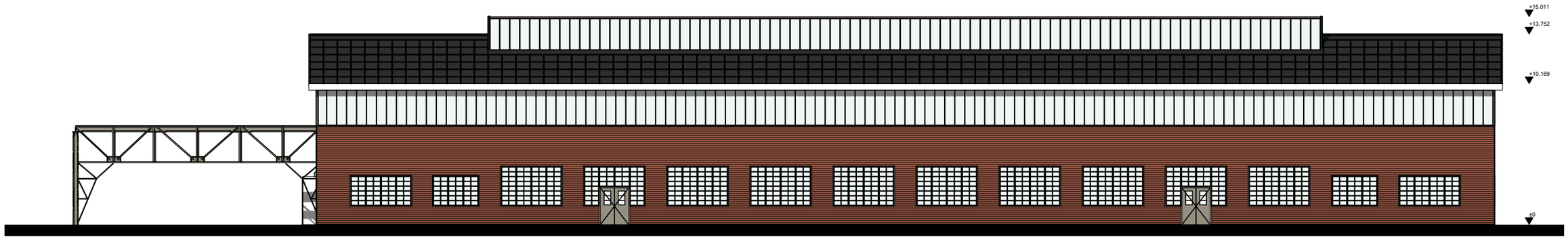
South - Front Facade



West - Left Facade



North - Back Facade



East - Right Facade

3.3 Materials

Wood

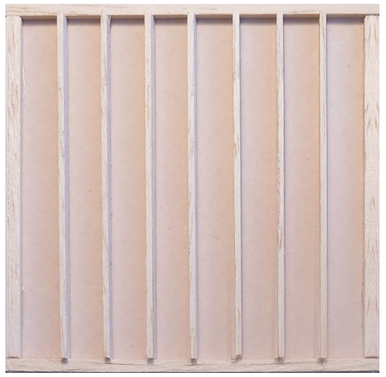
Music

Bamboo planks
Ecofriendly bulding material

Artist

CLT & OSB
OSB: recycled pressed wood flakes

Dance



CLT & Wooden beams

Performance

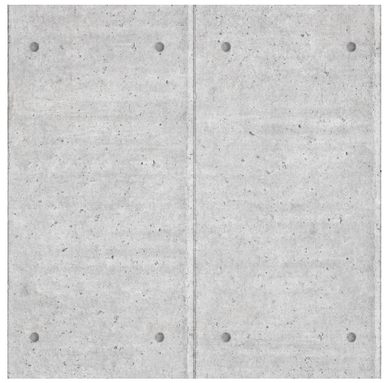
Recycled wooden planks

Concrete

Music

Poured concrete and
concrete plaster

Artist



Poured concrete

Dance

Concrete plasterwork

Performance

Poured concrete

Insulation

Flooring general area

Floated concrete floor

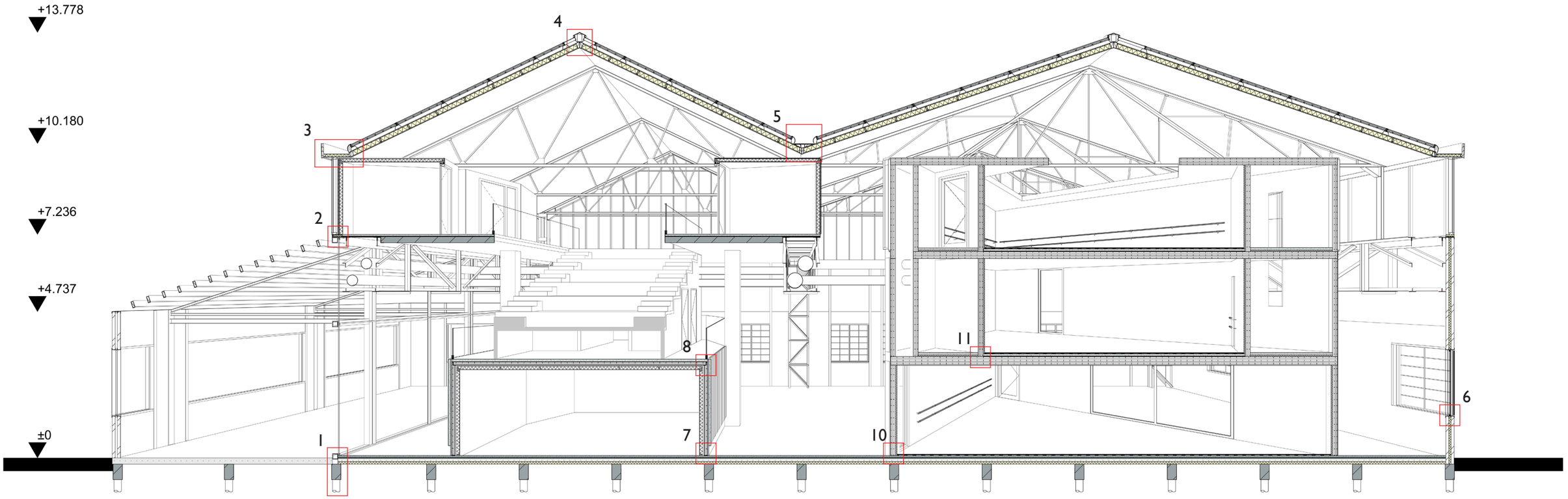
Post-insulation

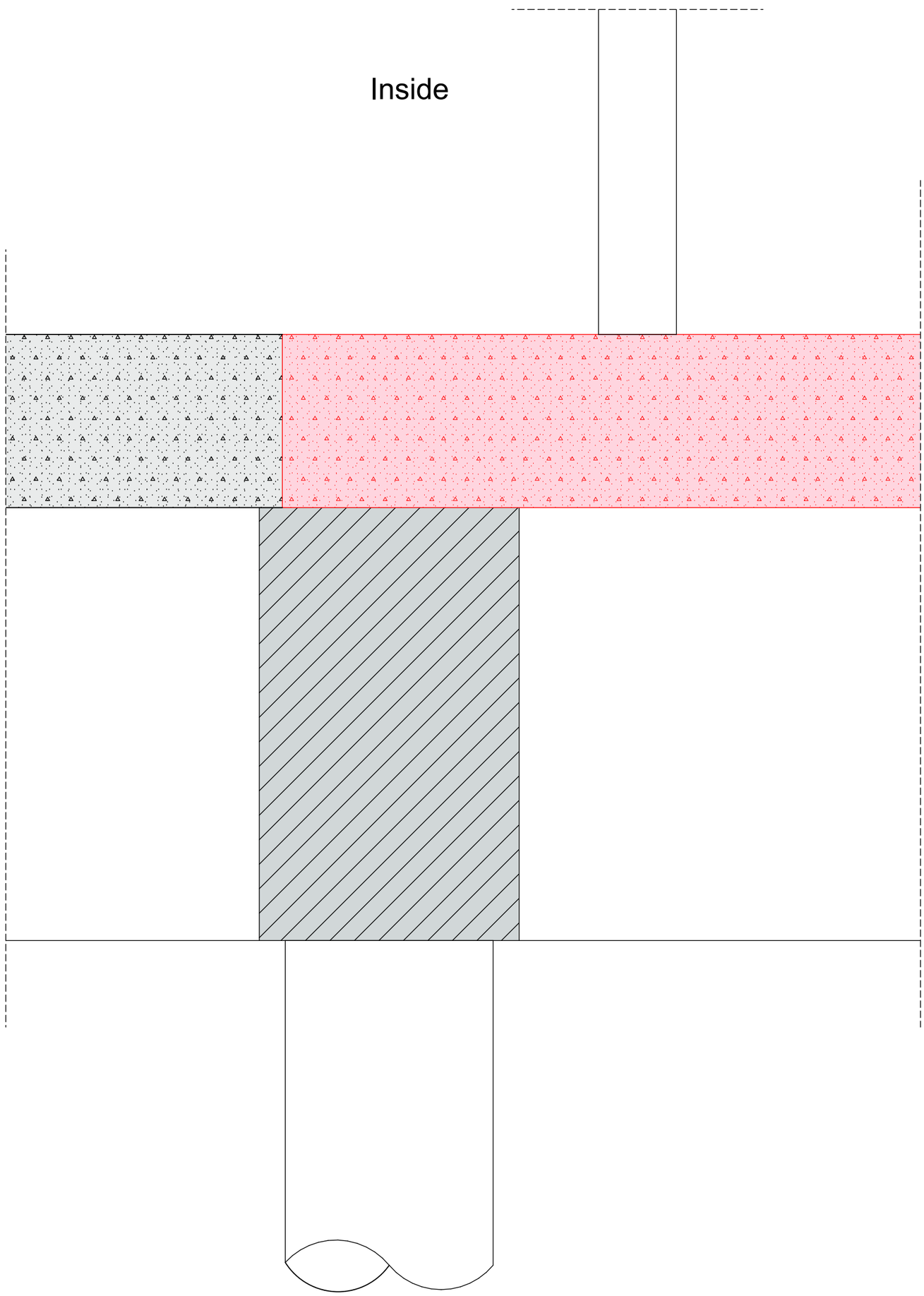
Paper flakes insulation

in HSB elements

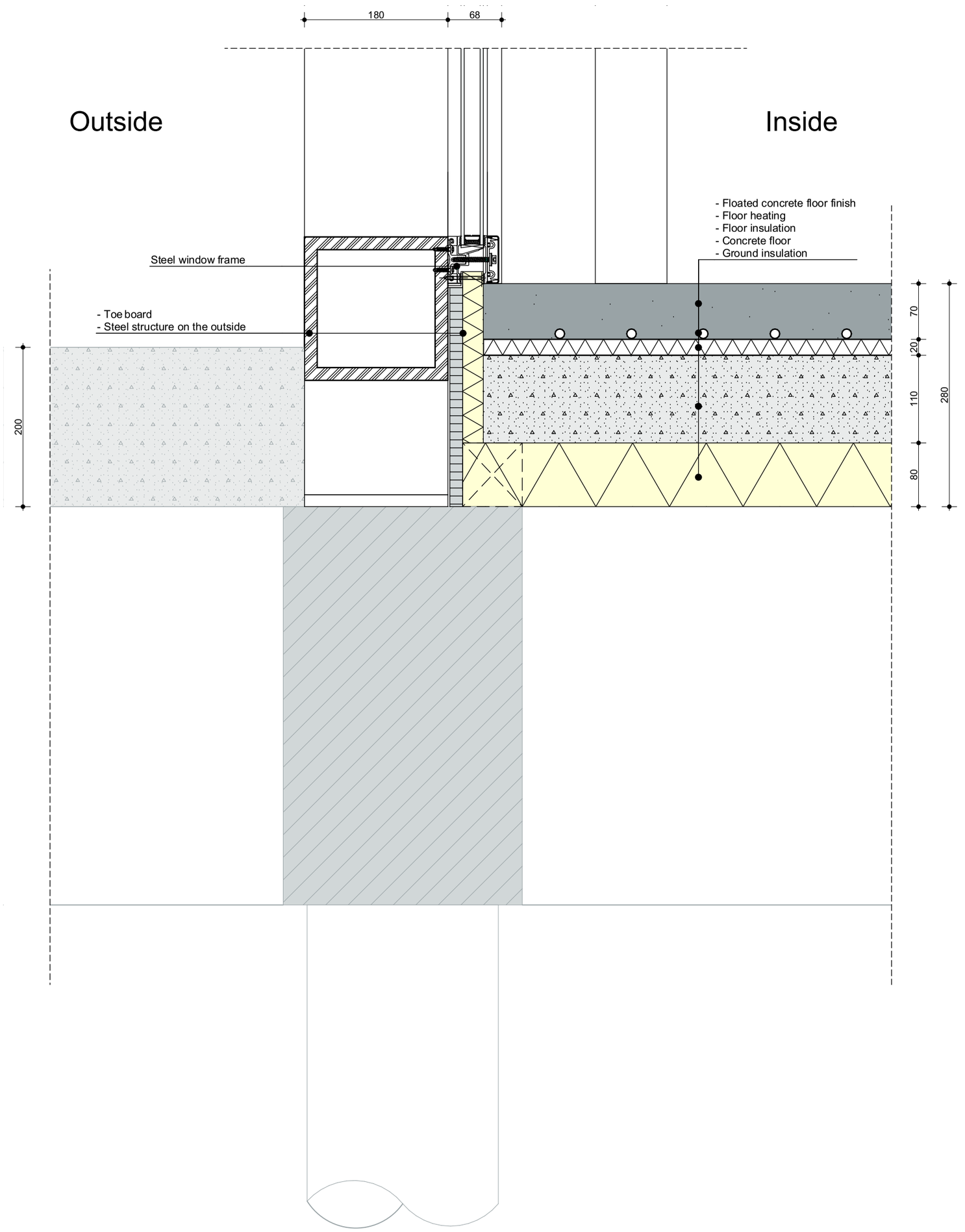
Ecological woodwool

3.4 Section A-A





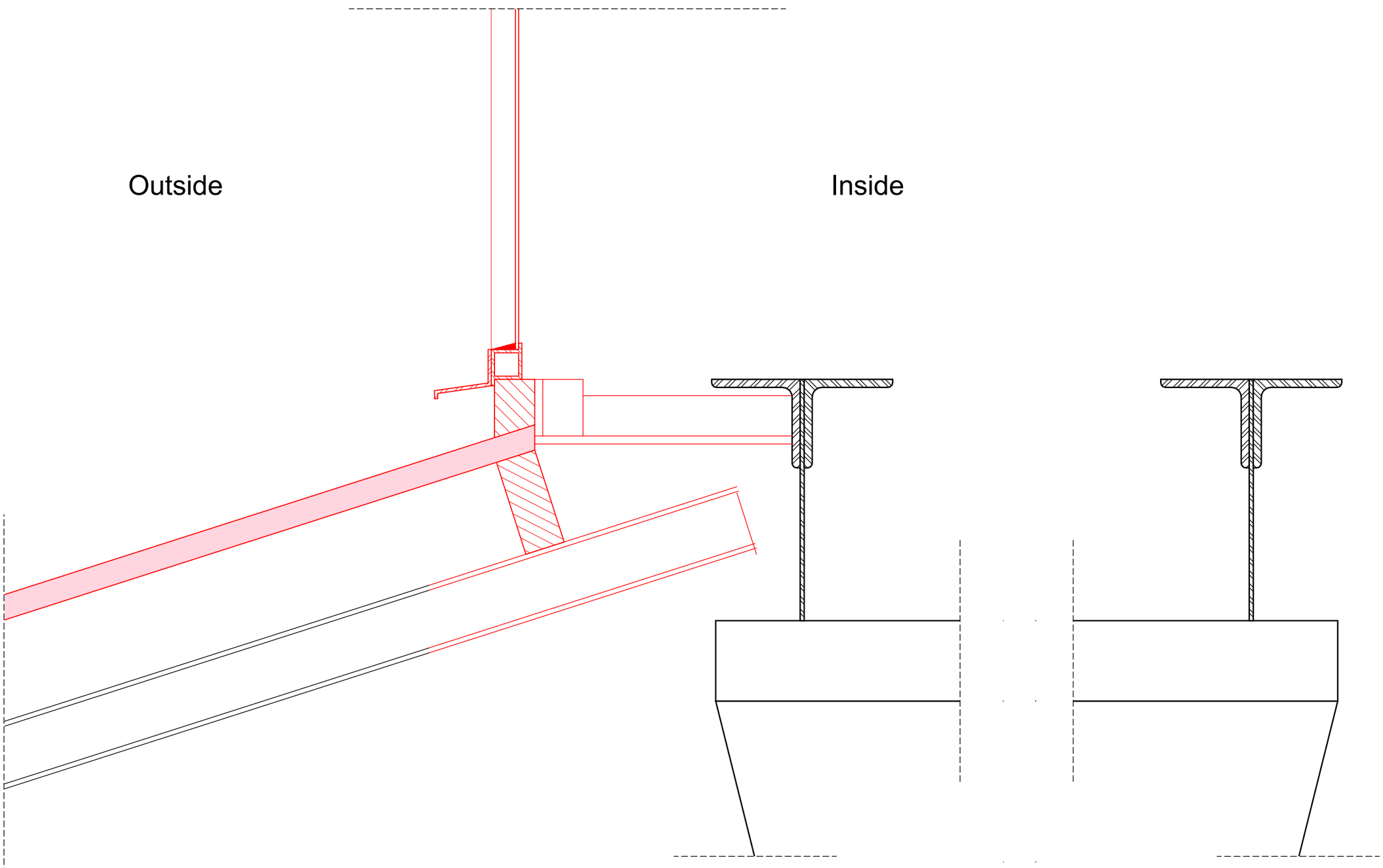
Detail 1 - existing
Scale: 1:5



Detail 1 - transformed
Scale: 1:5

Outside

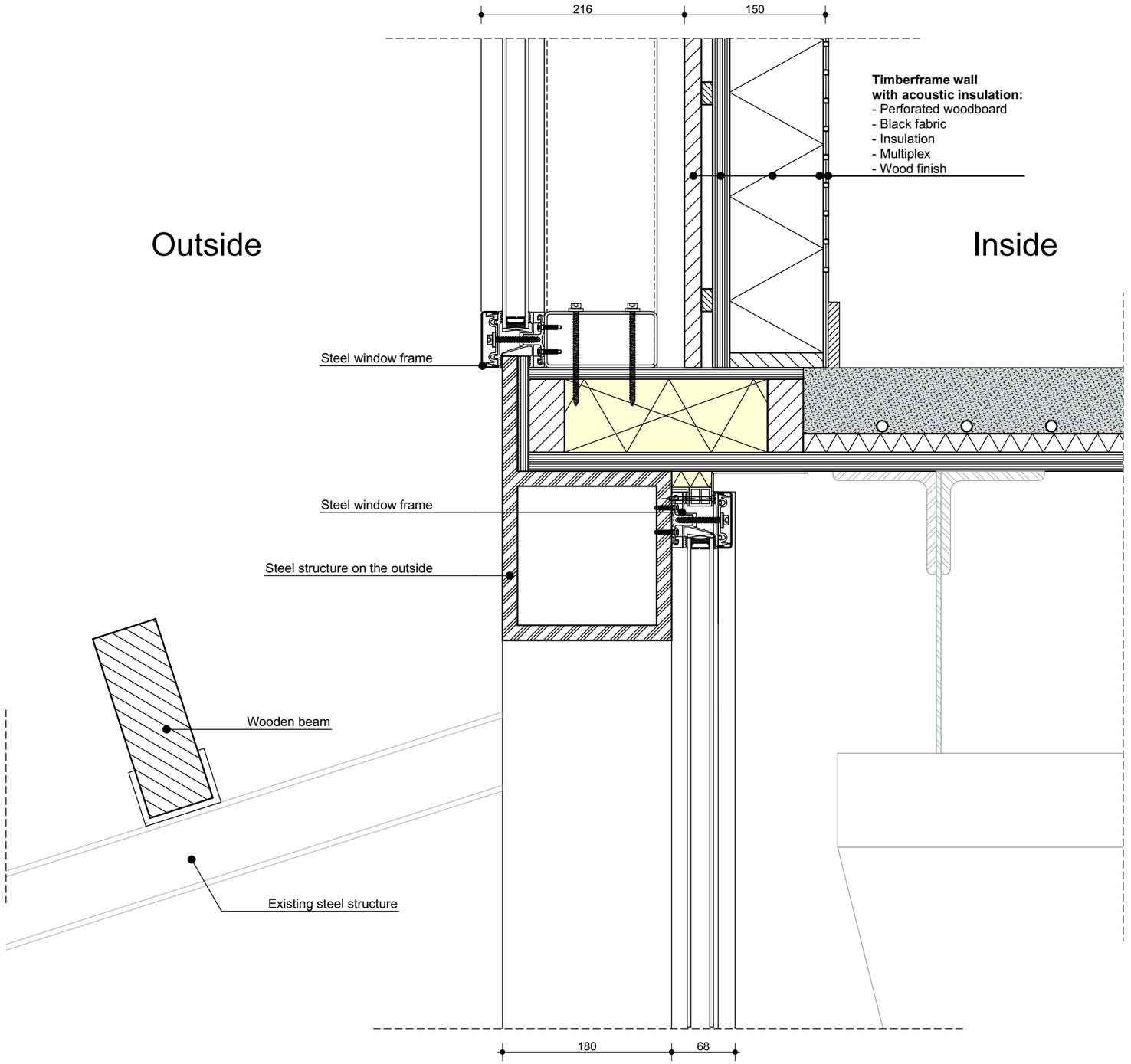
Inside

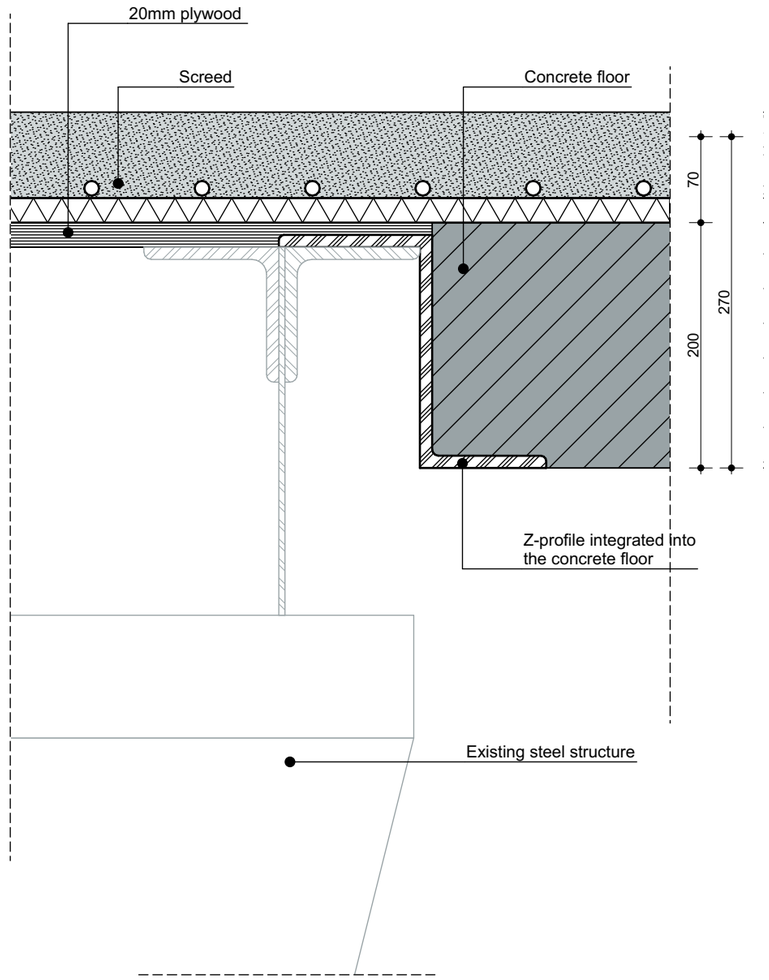


Detail 2 - existing
Scale: 1:5

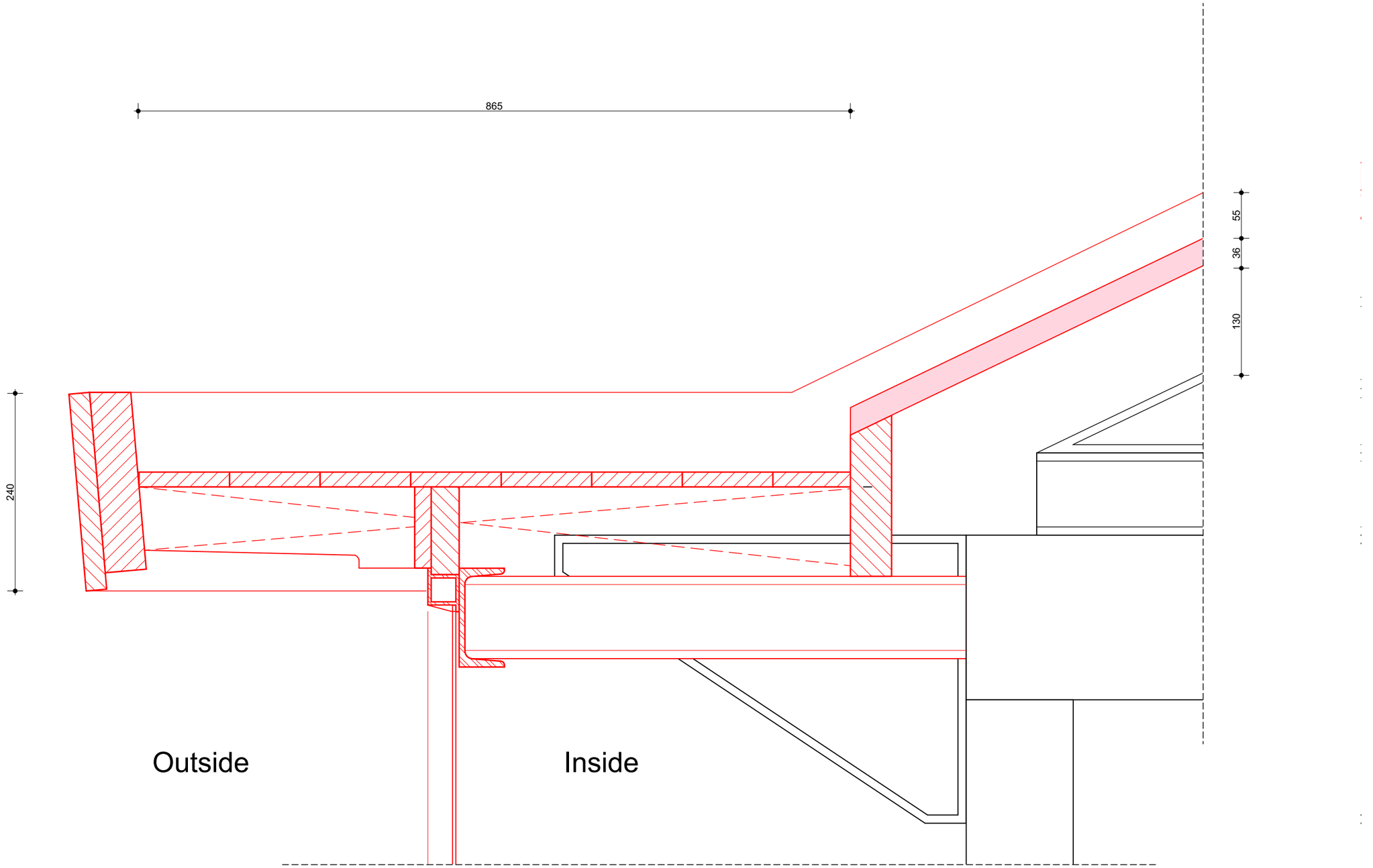
Outside

Inside





Detail 2 - transformed
Scale: 1:5



Detail 3 - existing
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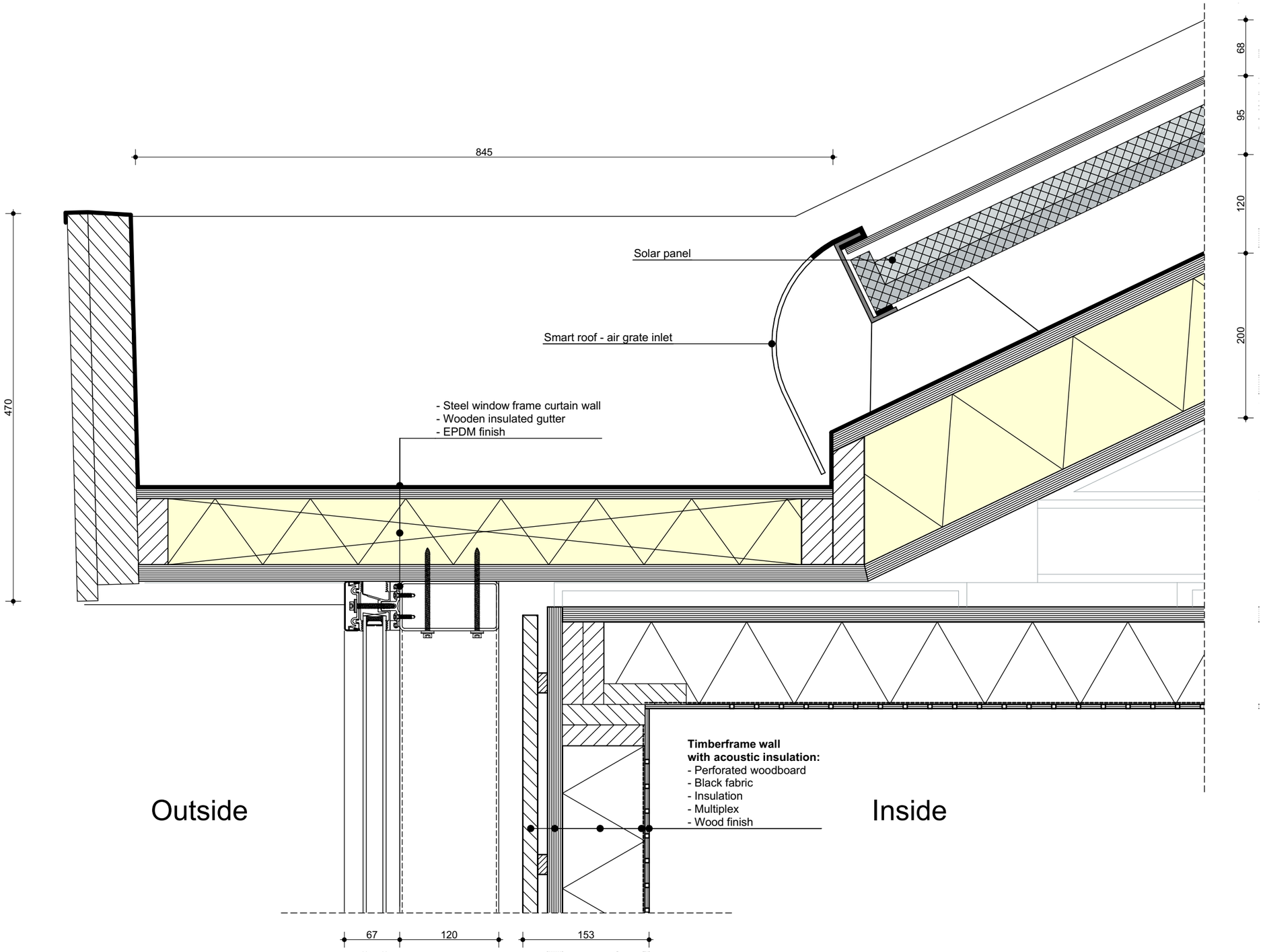
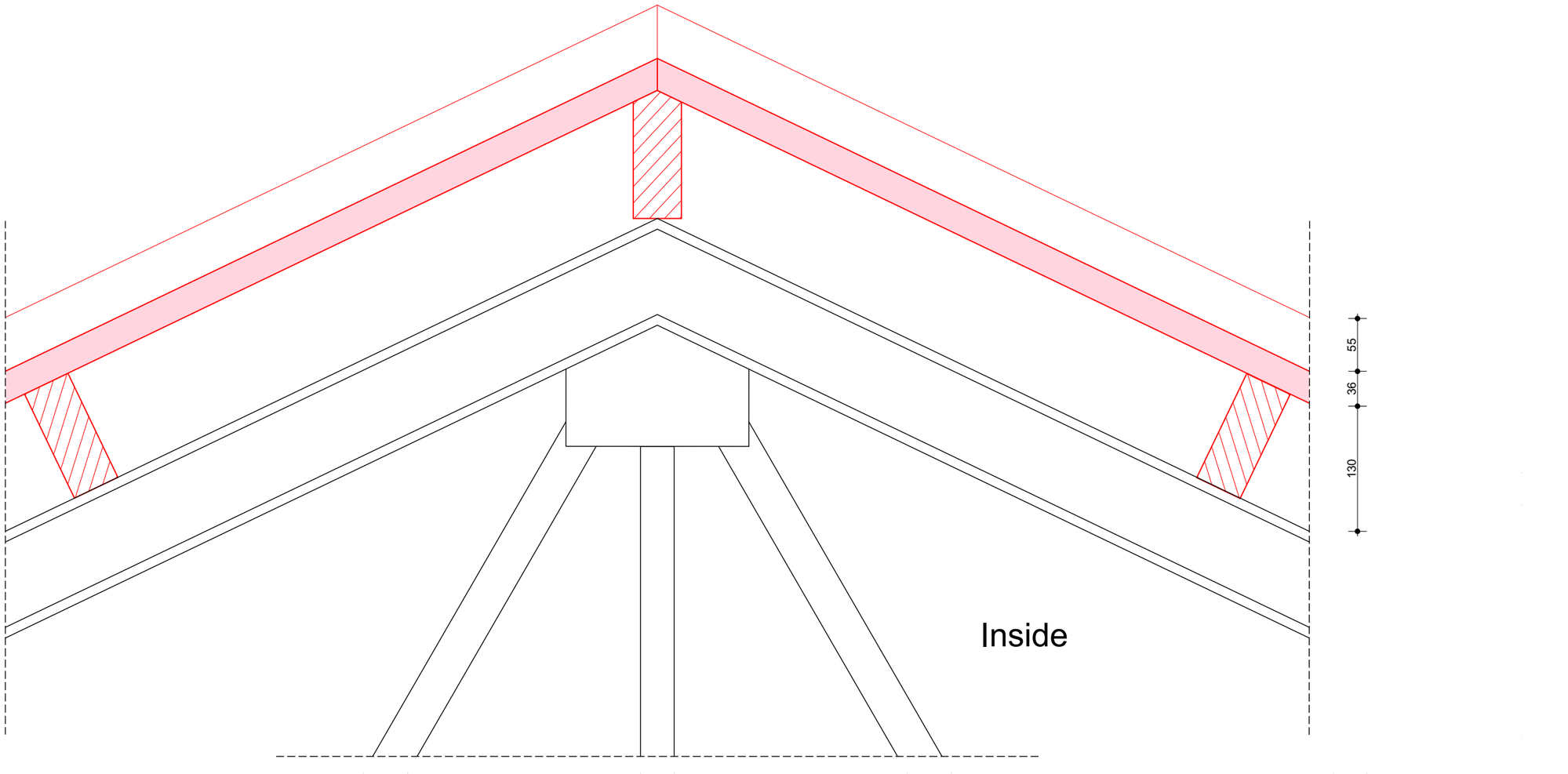
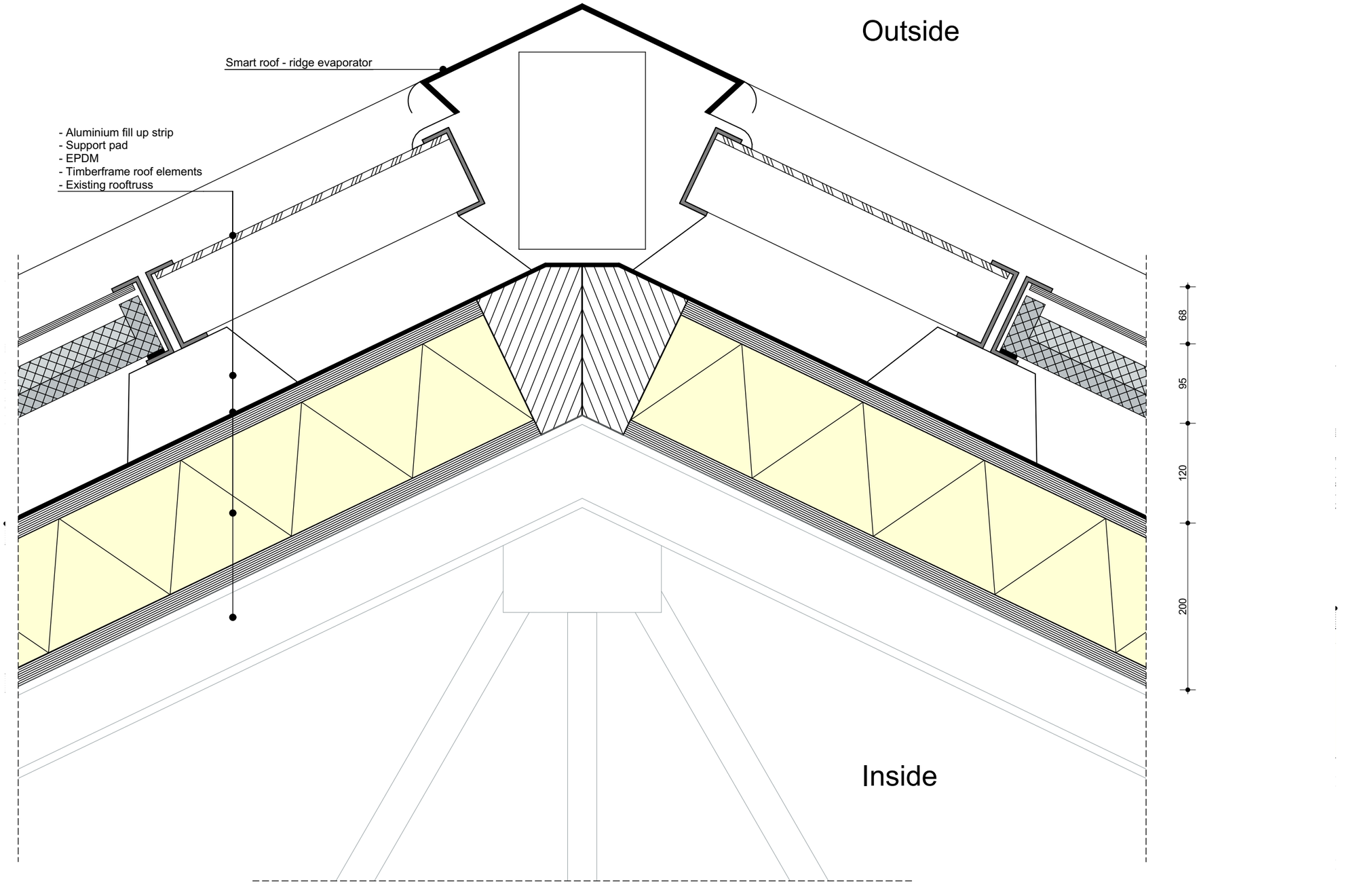


Detail 3 - transformed
Scale: 1:5

Outside

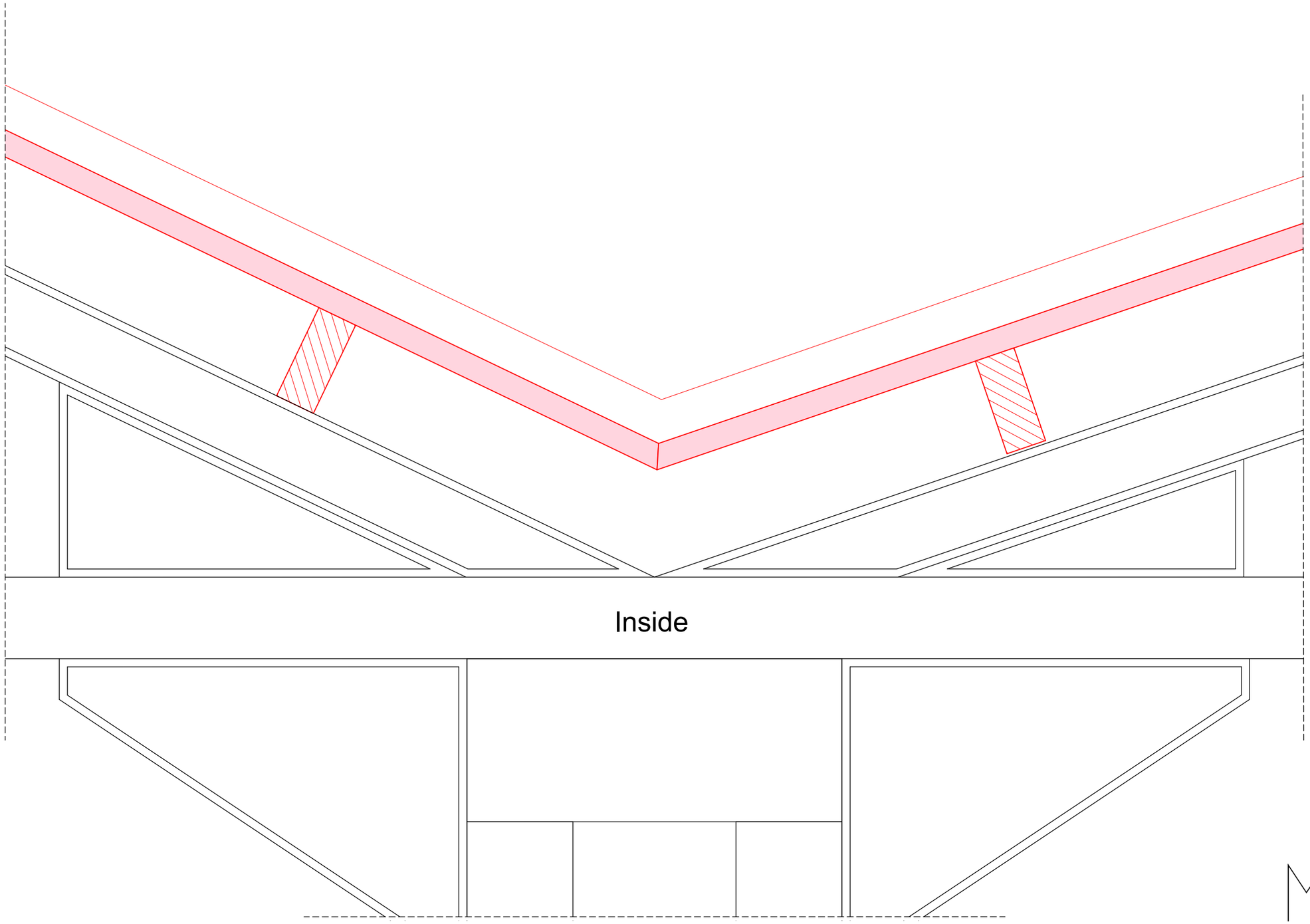


Detail 4 - existing
Scale: 1:5



Detail 4 - transformed
Scale: 1:5

Outside



Inside

Detail 5 - existing
Scale: 1:5

Outside

- EPDM
- Multiplex 20mm
- Gutter construction
- Timberframe roof elements
- Existing rooftrusses

Solar panel

Smart roof - air grate inlet

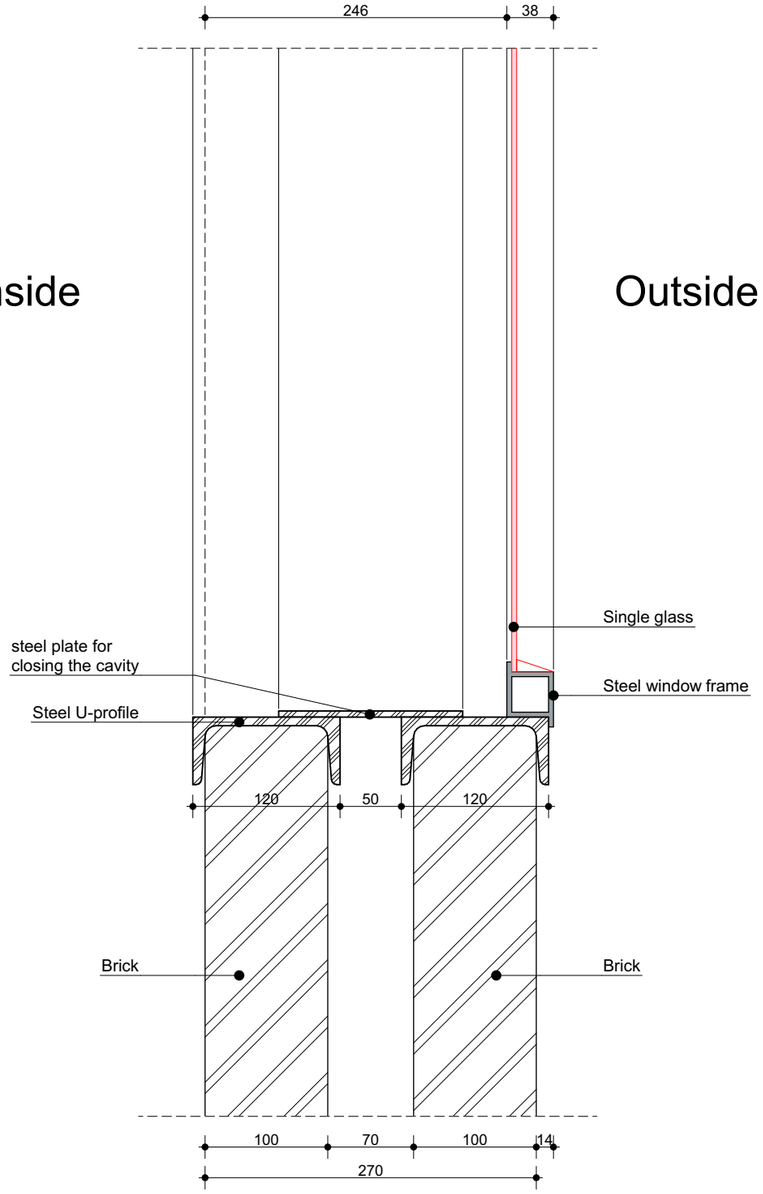
68
95
120
200

Inside

Detail 5 - transformed
Scale: 1:5

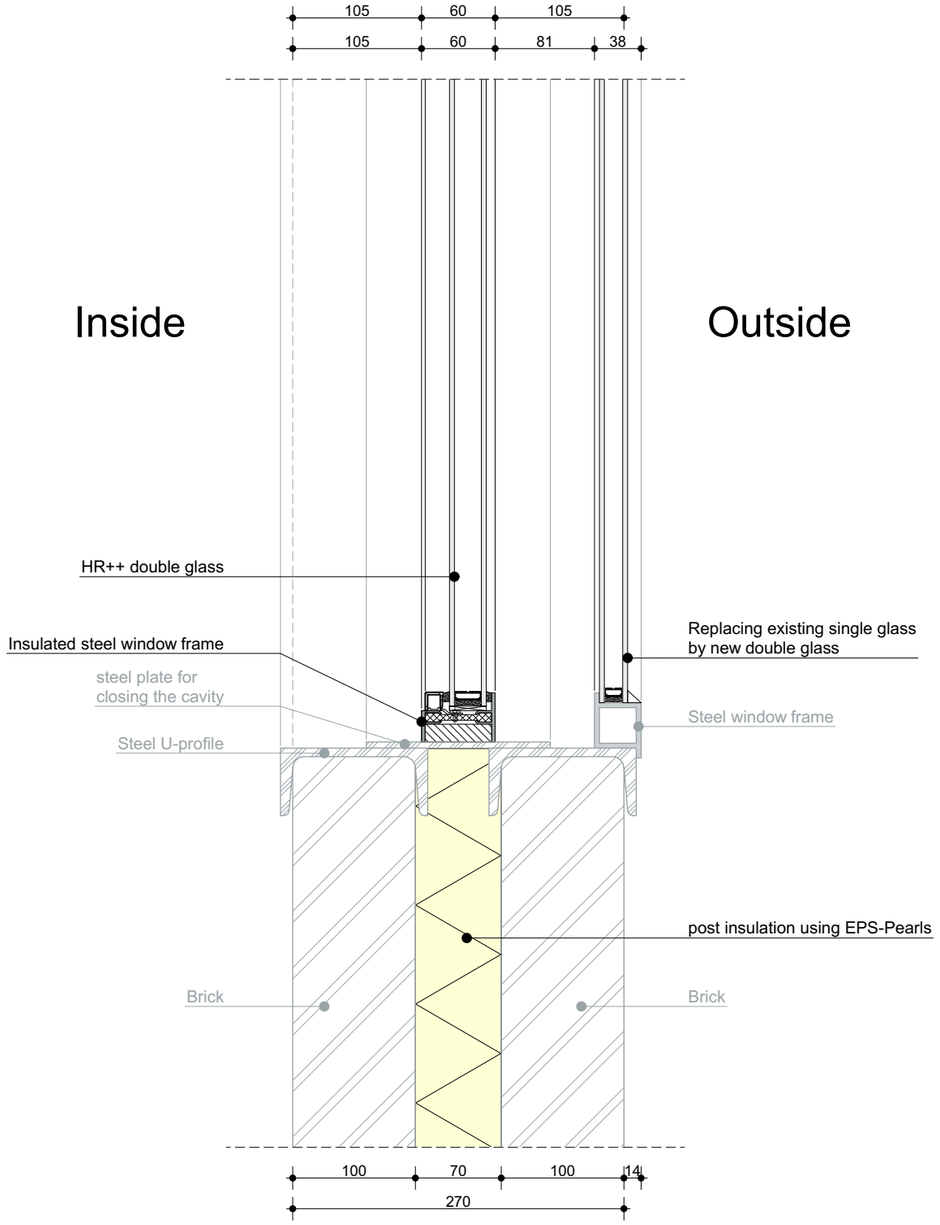
Inside

Outside

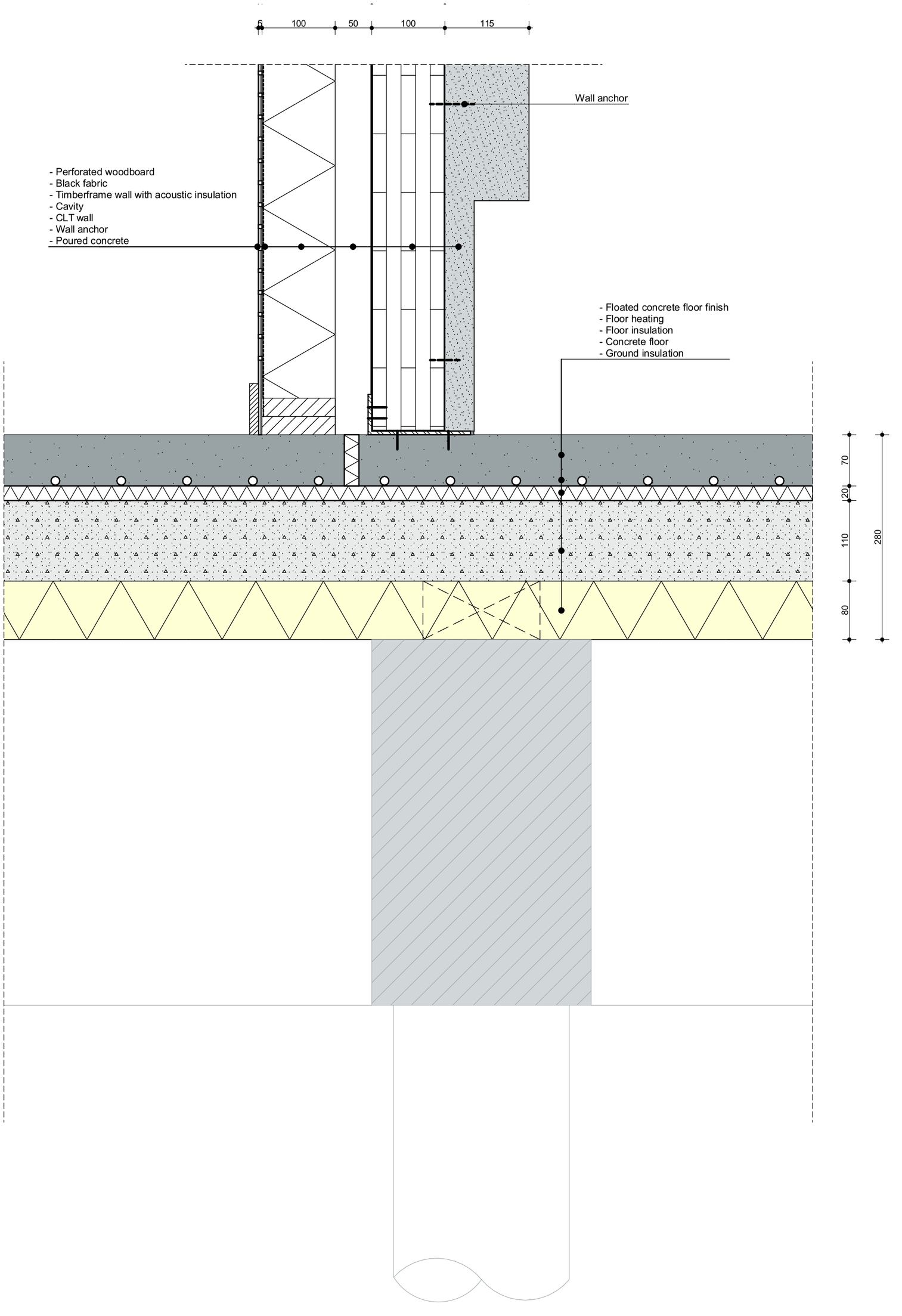


Inside

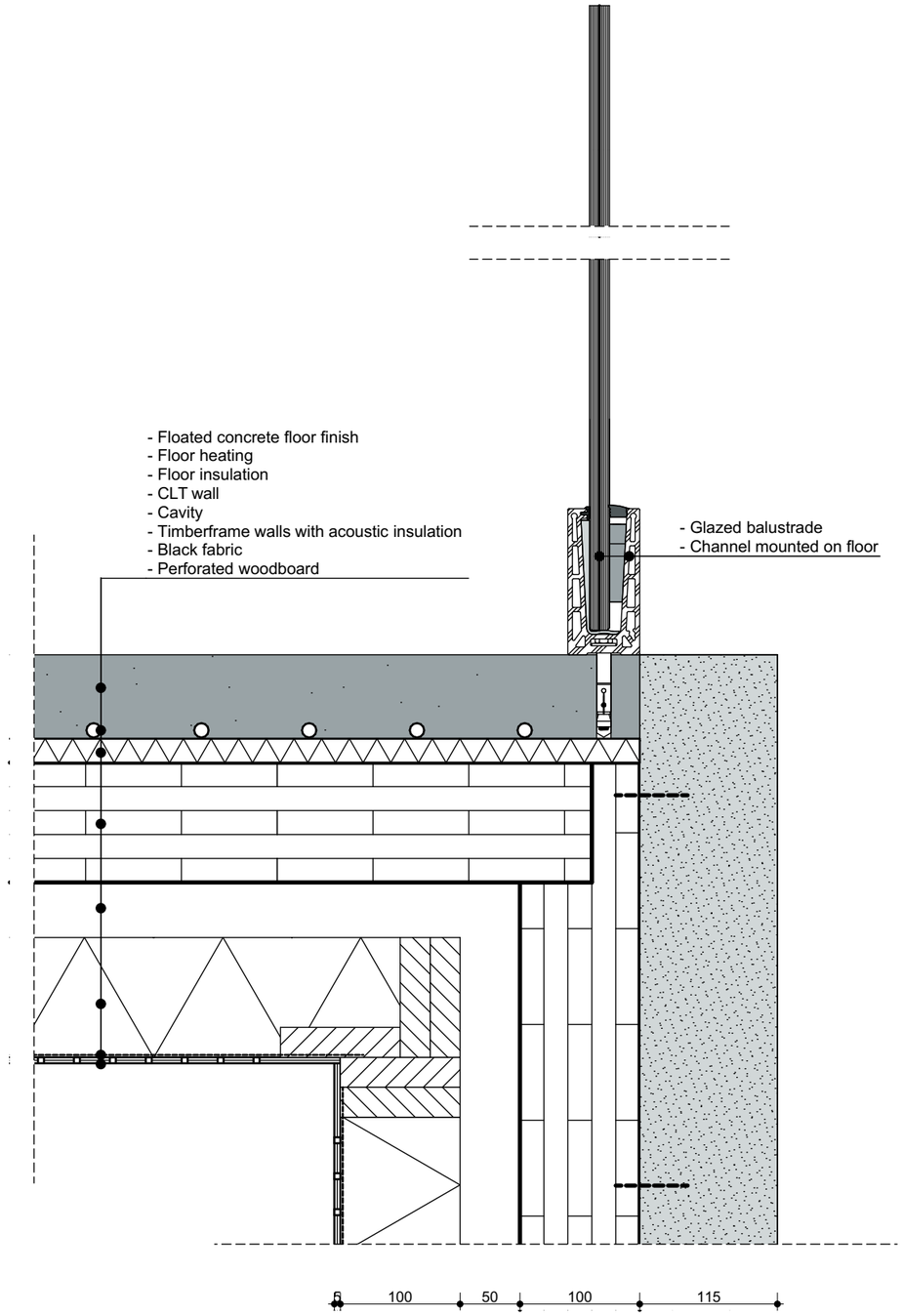
Outside



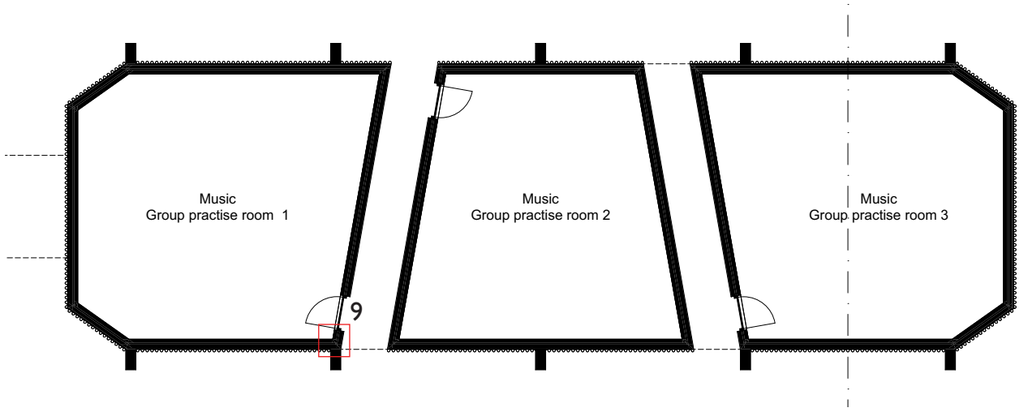
Detail 6 - existing & transformed
Scale: 1:5



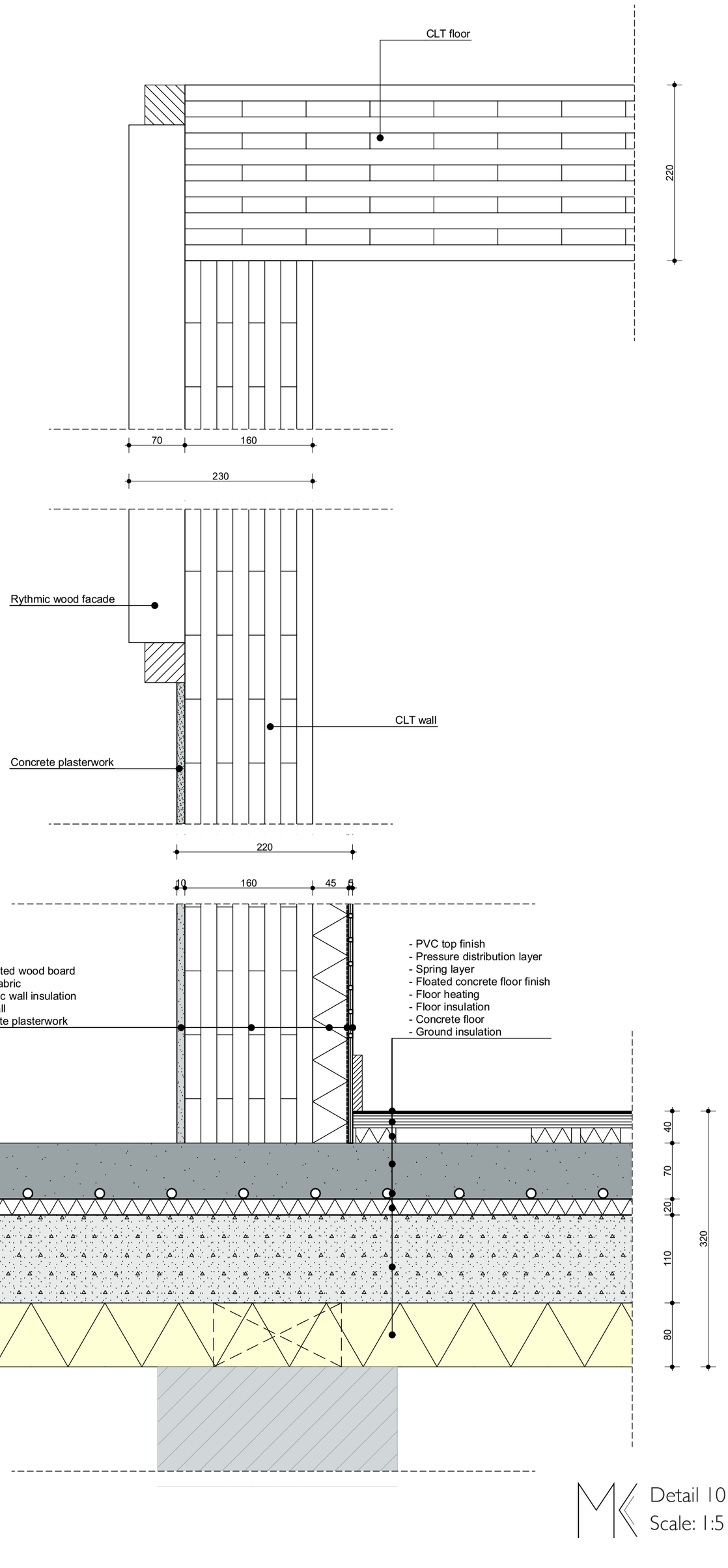
Detail 7
Scale: 1:5



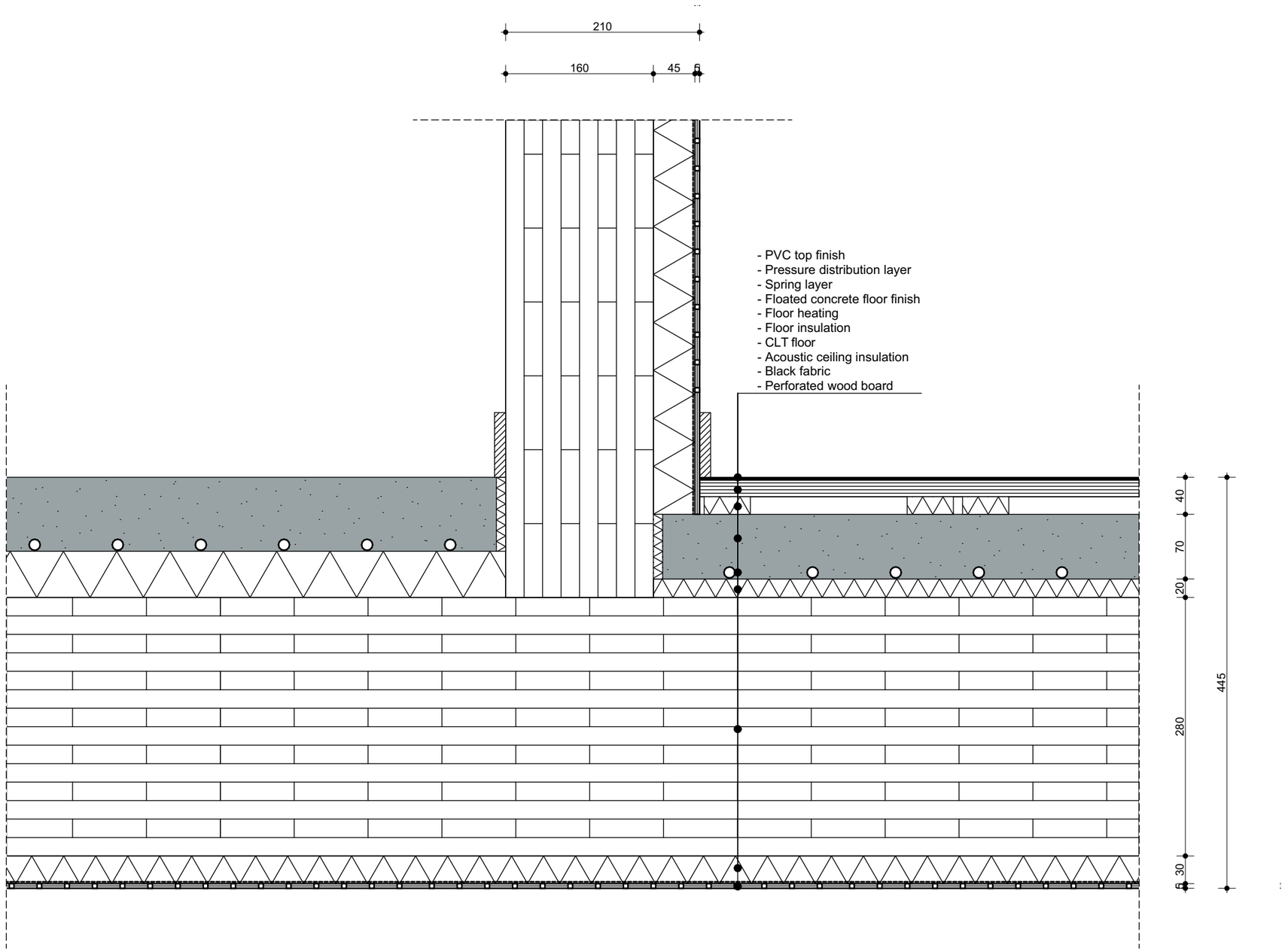
Detail 8
Scale: 1:5



Detail 9
Scale: 1:5

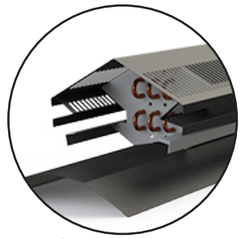


Detail 10
Scale: 1:5

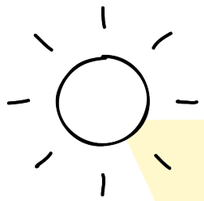


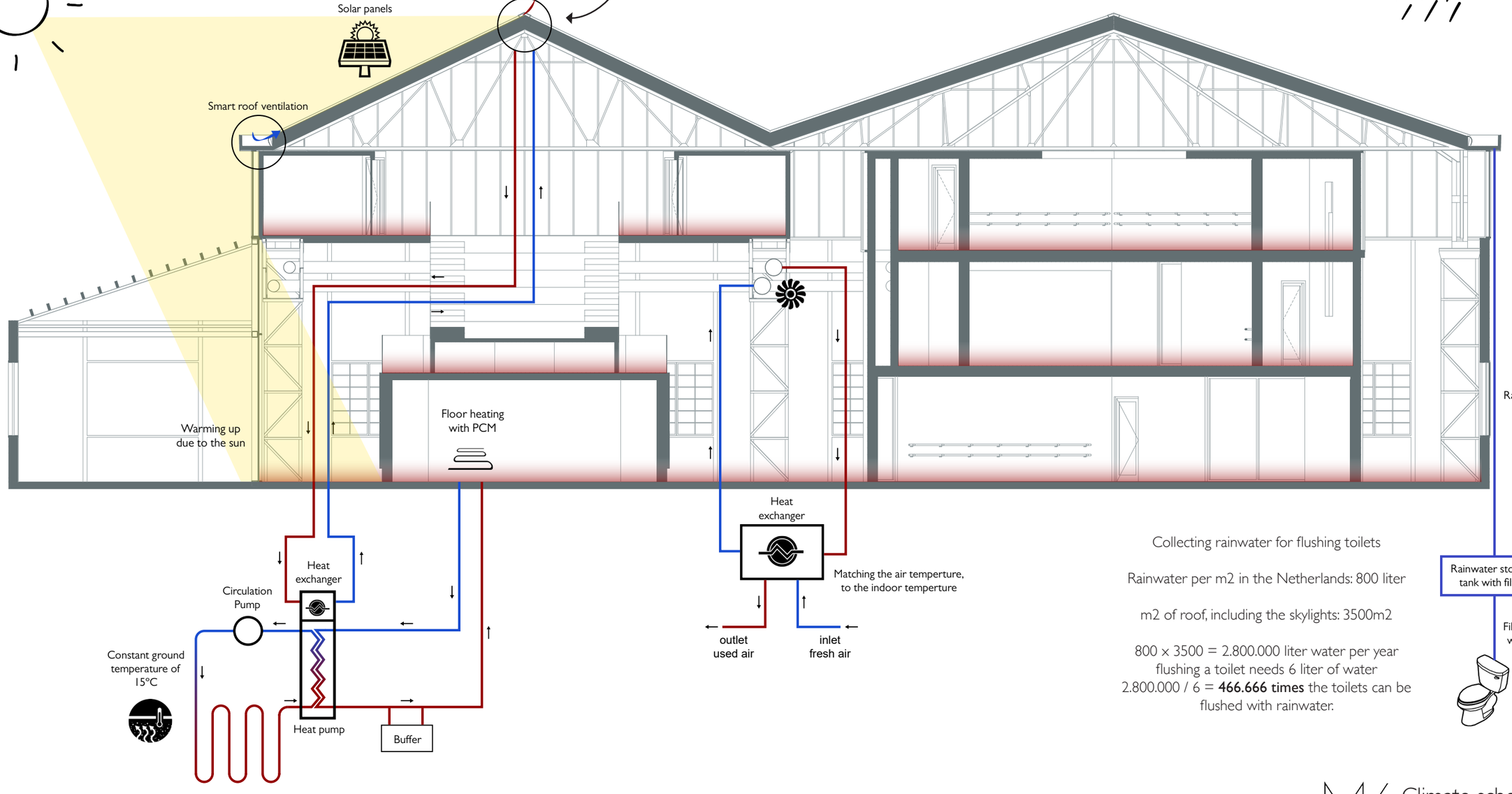
Detail 11
Scale: 1:5

3.6 Climate schemes



Ventilated ridge so that the smart roof can be ventilated and cooled in order to make the PV-panels more efficient. This way, the roof acts like a solar chimney. In the ridge, pipes with water runs through it. The warm airflow heat up this water and can be used to heat up the building through a heat exchanger that is connected to the heatpump.





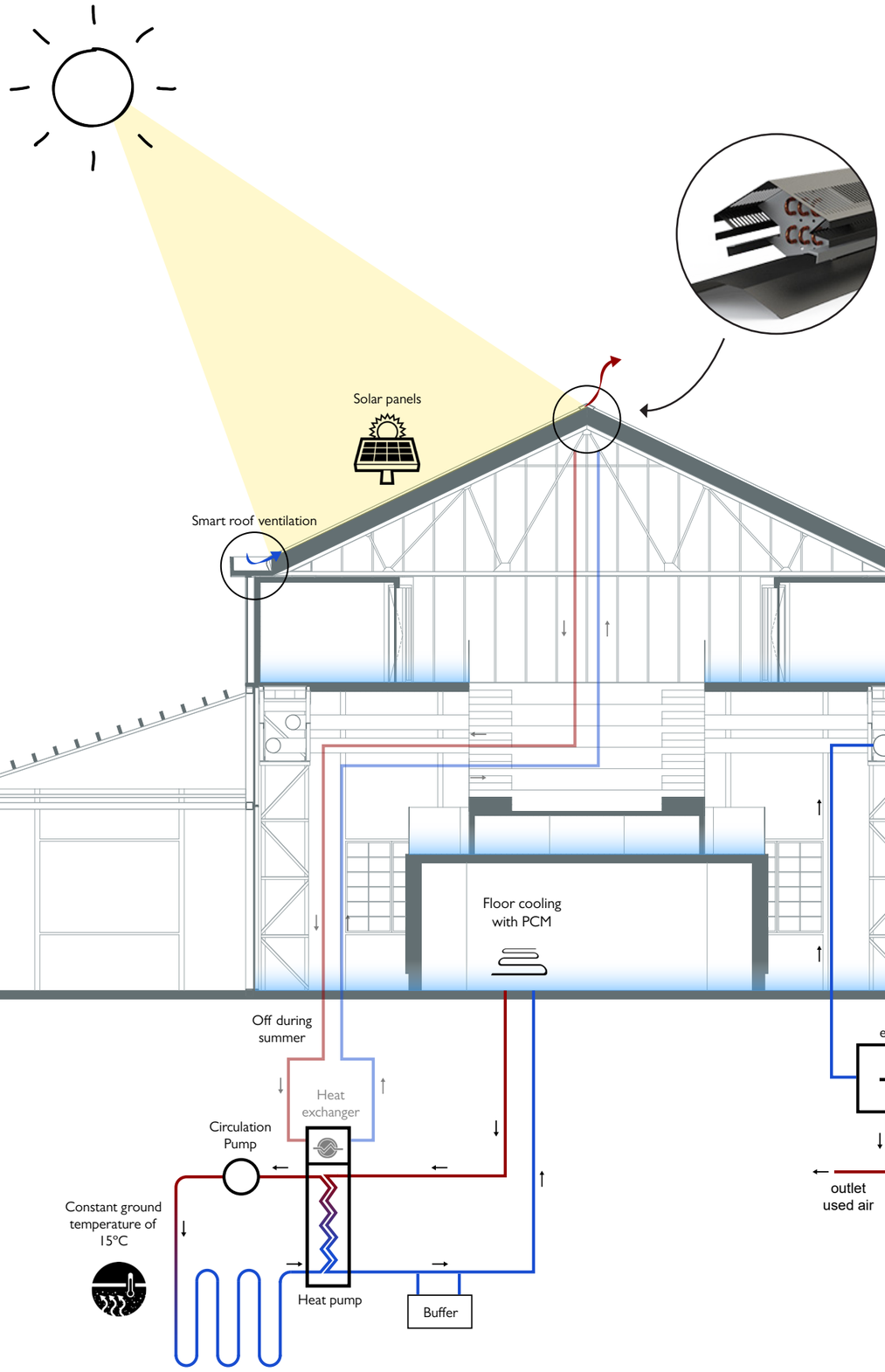
Collecting rainwater for flushing toilets

Rainwater per m2 in the Netherlands: 800 liter

m2 of roof, including the skylights: 3500m2

800 x 3500 = 2.800.000 liter water per year
flushing a toilet needs 6 liter of water
2.800.000 / 6 = **466.666 times** the toilets can be flushed with rainwater.

Climate scheme
Winter



Ventilated ridge so that the smart roof can be ventilated and cooled in order to make the PV-panels more efficient. This way, the roof acts like a solar chimney. In the ridge, pipes with water runs through it.
In summer the extra heat that is generated by the roof is not necessarily. So there is a bypass on this system that stops the water from going to the heat exchanger.

Collecting rainwater for flushing toilets

Rainwater per m2 in the Netherlands: 800 liter

m2 of roof, including the skylights: 3500m2

800 x 3500 = 2.800.000 liter water per year
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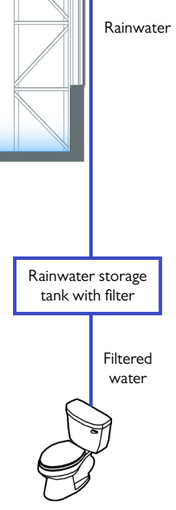


Climate scheme
Summer

3.7 Ventilation

For the Machinehall I have chosen mechanical ventilation. To succesfully apply this in the Machinehall I need to know how much fresh air is needed, and how to get this from the Technical Room towards the spaces where this is needed.

I looked in the "bouwbesluit" how much fresh air is needed and what the speed is in the ducts and shafts. In the main ducts, the air will flow at a high speed to get the fresh air where it's suppose to be. From the main ducts to the different spaces the speed will be lower in order to have a minimum to no sound disturbance.

The main duct will consists out:

1. from the technical room towards the truss beam in middle of the building.
2. In the truss beam the main duct will split into two smaller main ducts. One to the left and one to the right. This also applies to the output of air.
3. from these smaller main ducts it will split-off towards the 2 different departments, from there it will go further towards the dancehalls in secondairy ducts.
4. Another main duct will go towards the truss beam near the facade to get the air from and to the theaters.

From the main duct, secondairy ducts will go to the different spaces where the air is needed. These spaces are named in the table below.

The suction outlet happens in the general area of the building, so the inlet of air is in the space itself and will escape the space underneath the door. However there are exeptions where extra suction is needed:

- in the toilets, lockerrooms because of the moisture.
- in the theaters, because of the quantity of people in those spaces.
- in the music rooms, because of acoustic insulation, so that the sound doesn't leave the room.

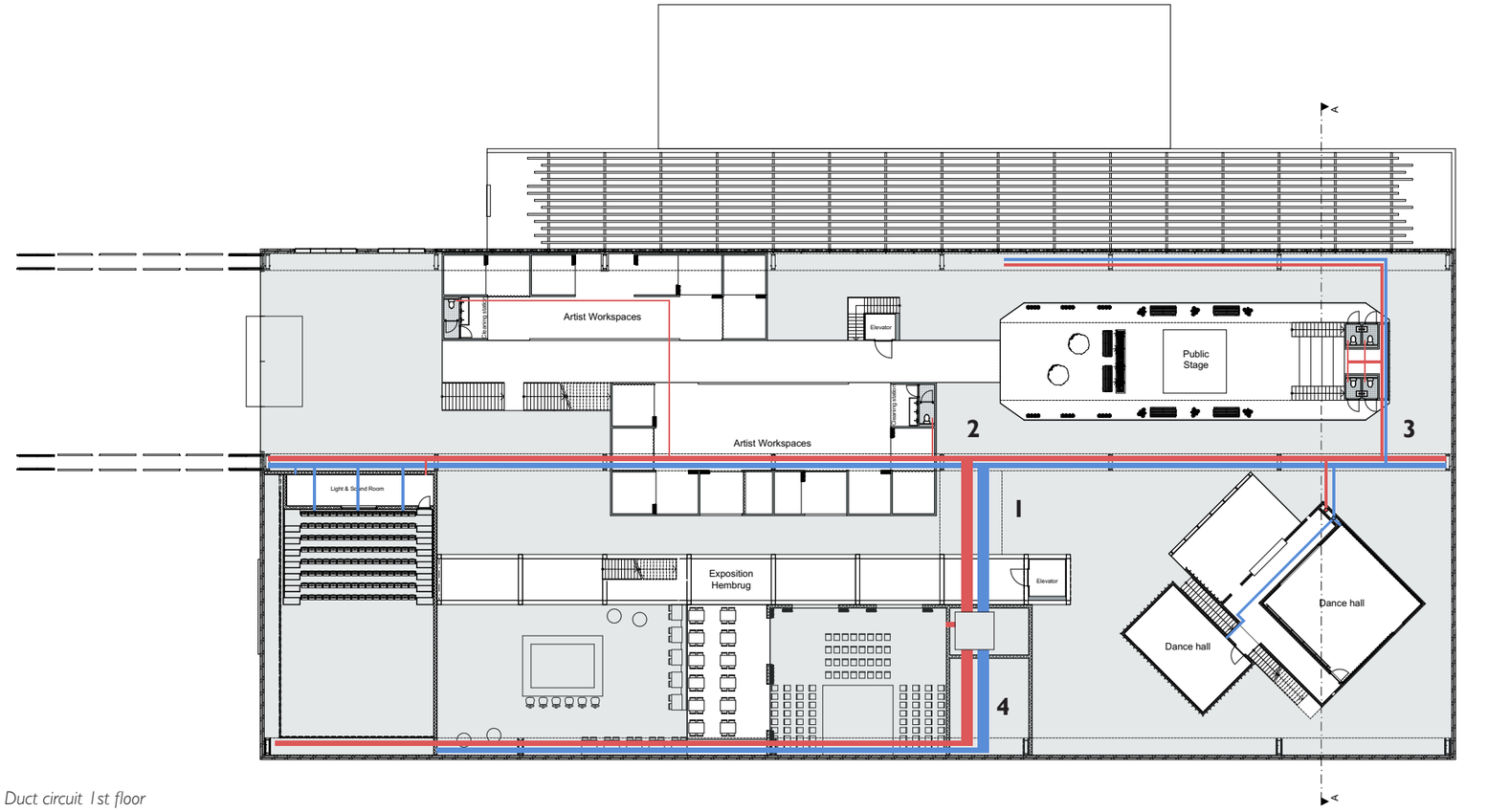
The ventilation circuit starts and end in the technical room where a heat exchanger is placed. This way the warm air can warm up the fresh air that comes in the building.

Building parameters

Theater 1		350 persons	240 m²
Theater 2		150 persons	130 m²
Music group practise room 1		40 persons	62 m²
Music group practise room 2		35 persons	54 m²
Music group practise room 3		40 persons	62 m²
Individual music rooms (14x)	4x14=	56 persons	140 m²
Dance hall Large		40 persons	100 m²
Dance hall Medium(2x)	30x2=	60 persons	128 m²
Dance hall Small		20 persons	40 m²
Restaurant		80 persons	240 m²
Artist ateliers		20 persons	465 m²
Artist ateliers		20 persons	465 m²
Kitchen		10 persons	20 m²
Main hall	0,125 persons/ m²	375 persons	3000 m²
Single Toilets		16 persons	32 m²
Toiletgroup		20 persons	78 m²

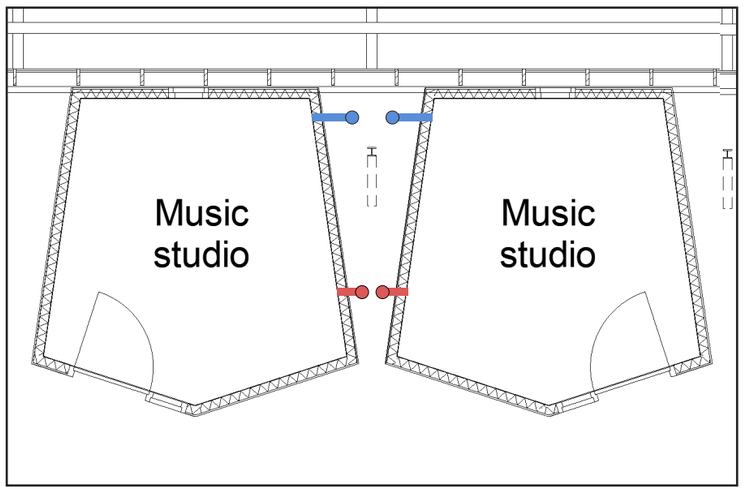
Ventilation Regulations and Speed

Ventilation regulation spaces:	6,5 dm³/s per person
Ventilation regulation toilets:	7,0 dm³/s per person
Ventilation regulation hall:	0,5 dm³/s per person
Ventilation regulation kitchen:	21 dm³/s per person
Ventilation speed in main & secondairy ducts:	3 m/s
Ventilation speed in shafts:	8 m/s



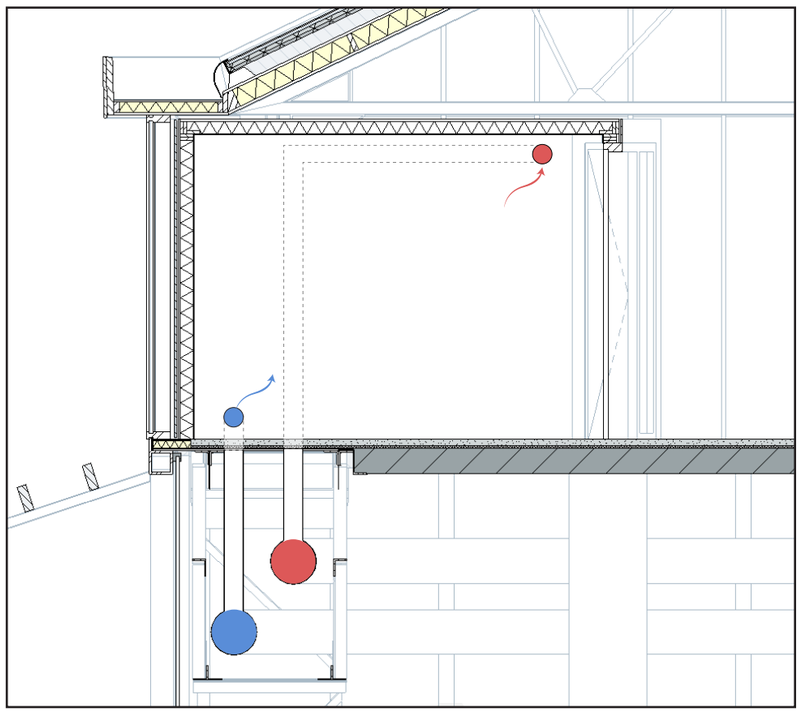
Duct circuit 1st floor

Blue is inlet fresh air
Red is outlet



Duct routing to the different music studio's, above in floorplan, on the right in section.

Blue is inlet fresh air
Red is outlet



Ventilation Calculations

MAIN DUCTS FROM TECHNICAL ROOM TOWARDS THE MIDDLE OF BUILDING

People in spaces		**406 persons**	**Fresh air required:**						**3,29 m³/s**
	Music group 1	*40*	*406 x*	6,5 dm³/s	=	*2639 dm³/s*	=	*2,64 m³/s*
	Music group 2	*30*	*10 x*	21 dm³/s	=	*210 dm³/s*	=	*0,21 m³/s*
	Music group 3	*40*	*375 x*	0,5 dm³/s	=	*187,5 dm³/s*	=	*0,19 m³/s*
14x	*Individual music rooms*	*56*	*36 x*	7,0 dm³/s	=	*252 dm³/s*	=	*0,25 m³/s*
	Dance hall large	*40*						
2x	*Dance hall medium*	*60*	**Minimum diameter ventilation duct:**						**647 mm**
	Dance hall small	*20*	*3,29 m³/s*	/	10 m/s	=	*0,33 m²*		
	Restaurant	*80*	*surface circle = radius² x π*						
	Artist ateliers	*40*	*radius = √ (surface circle / π)*						
People in kitchen		**10 persons**	*diameter = √ (surface circle in mm² / π) x 2*			=	*647 mm*		
	Kitchen	*10*							
People in mainhall		**375 persons**							
	Main hall	*375*							
People in toilets		**36 persons**							
(Total)	*Single toilets*	*16*							
	Toiletgroup	*20*							

MAIN DUCTS TO THE THEATERS AND FOYER ALONG FACADE

People in spaces		**450 persons**	**Fresh air required:**						**3,08 m³/s**
	Theater 1	*300*	*450 x*	6,5 dm³/s	=	*2925 dm³/s*	=	*2,93 m³/s*
	Theater 2	*150*	*300 x*	0,5 dm³/s	=	*150 dm³/s*	=	*0,15 m³/s*
People in mainhall		**300 persons**							
	Foyer	*300*	**Minimum diameter ventilation duct:**						**626 mm**
			3,08 m³/s	/	10 m/s	=	*0,31 m²*		
			surface circle = radius² x π						
			radius = √ (surface circle / π)						
			diameter = √ (surface circle in mm² / π) x 2			=	*626 mm*		

MAIN DUCTS IN THE MIDDLE OF BUILDING

LEFT

People in spaces		**120 persons**	**Fresh air required:**						**1,30 m³/s**
	Restaurant	*80*	*120 x*	6,5 dm³/s	=	*780 dm³/s*	=	*0,78 m³/s*
	Artist ateliers	*40*	*10 x*	21 dm³/s	=	*210 dm³/s*	=	*0,21 m³/s*
People in kitchen		**10 persons**	*200 x*	0,5 dm³/s	=	*100 dm³/s*	=	*0,10 m³/s*
	Kitchen	*10*	*30 x*	7,0 dm³/s	=	*210 dm³/s*	=	*0,21 m³/s*
People in mainhall		**200 persons**							
	2/3 Main hall	*200*	**Minimum diameter ventilation duct:**						**407 mm**
People in toilets		**30 persons**	*1,30 m³/s*	/	10 m/s	=	*0,13 m²*		
(Total)	*Single toilets*	*10*	*surface circle = radius² x π*						
	Toiletgroup	*20*	*radius = √ (surface circle / π)*						
			diameter = √ (surface circle in mm² / π) x 2			=	*407 mm*		

RIGHT

People in spaces		**286 persons**	**Fresh air required:**						**4,20 m³/s**
	Music group 1	*40*	*286 x*	6,5 dm³/s	=	*1859 dm³/s*	=	*1,86 m³/s*
	Music group 2	*30*	*175 x*	0,5 dm³/s	=	*87,5 dm³/s*	=	*0,09 m³/s*
	Music group 3	*40*	*322 x*	7,0 dm³/s	=	*2254 dm³/s*	=	*2,25 m³/s*
14x	*Individual music rooms*	*56*						
	Dance hall large	*40*	**Minimum diameter ventilation duct:**						**731 mm**
2x	*Dance hall medium*	*60*	*4,20 m³/s*	/	10 m/s	=	*0,42 m²*		
	Dance hall small	*20*	*surface circle = radius² x π*						
People in mainhall		**175 persons**	*radius = √ (surface circle / π)*						
	1/3 Main hall	*175*	*diameter = √ (surface circle in mm² / π) x 2*			=	*731 mm*		
People in toilets		**322 persons**							
(Total)	*Single toilets*	*6*							

MAIN DUCT TO OTHER SIDE MUSIC DEPARTMENT

Ducts to 4 toilets and 7 individual music rooms:

People in spaces		**138 persons**	**Fresh air required:**						**0,94 m³/s**
7x	*Individual music rooms*	*28*	*138 x*	6,5 dm³/s	=	*897 dm³/s*	=	*0,90 m³/s*
	Music group 1	*40*	*6 x*	7,0 dm³/s	=	*42 dm³/s*	=	*0,04 m³/s*
	Music group 2	*30*						
	Music group 3	*40*	**Minimum diameter ventilation duct:**						**346 mm**
People in toilets		**6 persons**	*0,94 m³/s*	/	10 m/s	=	*0,09 m²*		
(Total)	*Single toilets*	*6*	*surface circle = radius² x π*						
			radius = √ (surface circle / π)						
			diameter = √ (surface circle in mm² / π) x 2			=	*346 mm*		

MAIN DUCT TO THE DANCE HALLS

People in spaces		**124 persons**	**Fresh air required:**						**0,82 m³/s**
	Dance hall large	*40*	*124 x*	6,5 dm³/s	=	*806 dm³/s*	=	*0,81 m³/s*
2x	*Dance hall medium*	*60*	*2 x*	7,0 dm³/s	=	*14 dm³/s*	=	*0,01 m³/s*
	Dance hall small	*20*						
People in toilets		**2 persons**	**Minimum diameter ventilation duct:**						**323 mm**
(Total)	*Single toilets*	*2*	*0,82 m³/s*	/	10 m/s	=	*0,08 m²*		
			surface circle = radius² x π						
			radius = √ (surface circle / π)						
			diameter = √ (surface circle in mm² / π) x 2			=	*323 mm*		

SECONDAIRY DUCTS TO THE DIFFERENT SPACES

People in spaces							**Fresh air required:**							
	Theater 1	*300 people*	*300 x*	6,5 dm³/s	=	*1950 dm³/s*	=	*1,95 m³/s*						
	Theater 2	*150 people*	*150 x*	6,5 dm³/s	=	*975 dm³/s*	=	*0,98 m³/s*						
	Music group 1	*40 people*	*40 x*	6,5 dm³/s	=	*260 dm³/s*	=	*0,26 m³/s*						
	Music group 2	*30 people*	*30 x*	6,5 dm³/s	=	*195 dm³/s*	=	*0,20 m³/s*						
	Music group 3	*40 people*	*40 x*	6,5 dm³/s	=	*260 dm³/s*	=	*0,26 m³/s*						
14x	*Individual music rooms*	*4 people*	*4 x*	6,5 dm³/s	=	*26 dm³/s*	=	*0,03 m³/s*						
	Dance hall large	*40 people*	*40 x*	6,5 dm³/s	=	*260 dm³/s*	=	*0,26 m³/s*						
2x	*Dance hall medium*	*60 people*	*60 x*	6,5 dm³/s	=	*390 dm³/s*	=	*0,39 m³/s*						
	Dance hall small	*20 people*	*20 x*	6,5 dm³/s	=	*130 dm³/s*	=	*0,13 m³/s*						
	Restaurant	*80 people*	*80 x*	6,5 dm³/s	=	*520 dm³/s*	=	*0,52 m³/s*						
	Artist ateliers GF	*20 people*	*20 x*	6,5 dm³/s	=	*130 dm³/s*	=	*0,13 m³/s*						
	Artist ateliers First	*20 people*	*20 x*	6,5 dm³/s	=	*130 dm³/s*	=	*0,13 m³/s*						
People in kitchen														
	Kitchen	*10 people*	*10 x*	21 dm³/s	=	*210 dm³/s*	=	*0,21 m³/s*						
People in mainhall														
	Main hall left	*200 people*	*200 x*	0,5 dm³/s	=	*100 dm³/s*	=	*0,10 m³/s*						
	Main hall right	*175 people*	*175 x*	0,5 dm³/s	=	*87,5 dm³/s*	=	*0,09 m³/s*						
	Foyer	*300 people*	*300 x*	0,5 dm³/s	=	*150 dm³/s*	=	*0,15 m³/s*						
People in toilets														
	Single toilets	*1 people*	*1 x*	7,0 dm³/s	=	*7 dm³/s*	=	*0,01 m³/s*						
	Toiletgroup	*20 people*	*20 x*	7,0 dm³/s	=	*140 dm³/s*	=	*0,14 m³/s*						

Minimum diameter ventilation duct:

Theater 1	*1,95 m³/s*	/	3 m/s	=	*0,65 m²*	*diameter = √ (surface circle in mm² / π) x 2*	=	*910 mm*
Theater 2	*0,98 m³/s*	/	3 m/s	=	*0,33 m²*	*diameter = √ (surface circle in mm² / π) x 2*	=	*643 mm*
Music group 1	*0,26 m³/s*	/	3 m/s	=	*0,09 m²*	*diameter = √ (surface circle in mm² / π) x 2*	=	*332 mm*
Music group 2	*0,20 m³/s*	/	3 m/s	=	*0,07 m130*	*diameter = √ (surface circle in mm² / π) x 2*	=	*288 mm*
Music group 3	*0,26 m³/s*	/	3 m/s	=	*0,09 m130*	*diameter = √ (surface circle in mm² / π) x 2*	=	*332 mm*
14x Individual music rooms	*0,03 m³/s*	/	3 m/s	=	*0,01 m130*	*diameter = √ (surface circle in mm² / π) x 2*	=	*105 mm*
Dance hall large	*0,26 m³/s*	/	3 m/s	=	*0,09 m130*	*diameter = √ (surface circle in mm² / π) x 2*	=	*332 mm*
2x Dance hall medium	*0,39 m³/s*	/	3 m/s	=	*0,13 m130*	*diameter = √ (surface circle in mm² / π) x 2*	=	*407 mm*
Dance hall small	*0,13 m³/s*	/	3 m/s	=	*0,04 m130*	*diameter = √ (surface circle in mm² / π) x 2*	=	*235 mm*
Restaurant	*0,52 m³/s*	/	3 m/s	=	*0,17 m130*	*diameter = √ (surface circle in mm² / π) x 2*	=	*470 mm*
Artist ateliers GF	*0,13 m³/s*	/	3 m/s	=	*0,04 m131*	*diameter = √ (surface circle in mm² / π) x 3*	=	*235 mm*
Artist ateliers First	*0,13 m³/s*	/	3 m/s	=	*0,04 m132*	*diameter = √ (surface circle in mm² / π) x 4*	=	*235 mm*
Kitchen	*0,21 m³/s*	/	3 m/s	=	*0,07 m130*	*diameter = √ (surface circle in mm² / π) x 2*	=	*299 mm*
Main hall left	*0,10 m³/s*	/	3 m/s	=	*0,03 m130*	*diameter = √ (surface circle in mm² / π) x 2*	=	*206 mm*
Main hall right	*0,09 m³/s*	/	3 m/s	=	*0,03 m130*	*diameter = √ (surface circle in mm² / π) x 2*	=	*193 mm*
Foyer	*0,15 m³/s*	/	3 m/s	=	*0,05 m130*	*diameter = √ (surface circle in mm² / π) x 2*	=	*252 mm*
Single toilets	*0,01 m³/s*	/	3 m/s	=	*0,00 m130*	*diameter = √ (surface circle in mm² / π) x 2*	=	*55 mm*
Toiletgroup	*0,14 m³/s*	/	3 m/s	=	*0,05 m130*	*diameter = √ (surface circle in mm² / π) x 2*	=	*244 mm*

3.8 Solar energy

As stated before, for a sustainable design I have to solve the remaining energy demand sustainably, meaning, without fossil energy sources. Therfore the roof of the Machinehall will be filled with solar panels. I used known data of electricity use in different types of buildings, for electricity and gas.

Because the machinehall will be using a heatpump instead of gas, I calculated this back to the kWh heat that a heatpump generates and compared that to the kWh gas that is needed per m2 to heat a building.

To be able to ventilate the roof, since it will generate a lot of heat and therefore it will be a fire hazard. I chose to use a smartroof. The heat that will be generated by the solar panels kan be used by the heatpump to warm up the building. I haven´t found any data about how much heat this will generate so in my electricity use I did not take this into account. I can only conclude that the kWh that I now have calculated will be less with the addition of the smartroof. So the kWh electricity needed by the machinehall is a maximum.

#	Branche en/of rubriek	Gebouwtype	Gas-intensiteit m3/m2	Elek-intensiteit kWh/m2	Totaal kWh/m2
01	kantoor	kantoor	17	60	223
02	zorgsector	ziekenhuis	23	49	278
03	zorgsector	tehuis met overnachting	19	55	243
04	zorgsector	opvang zonder overnachting	20	59	258
05	zorgsector	medische (groeps)praktijk	18	56	229
06	onderwijs	basisschool	15	28	172
07	onderwijs	voortgezet onderwijs	13	37	166
08	onderwijs	MBO/HBO/ universiteit	15	50	193
09	detailhandel	supermarkt	20	254	453
10	detailhandel	winkel zonder koeling	16	100	252
11	horeca	café/restaurant	34	214	549
12	horeca	hotel	25	84	330
13	horeca	vakantiepark	19	39	223
14	horeca	sauna	34	143	478
15	cultuur	museum	17	53	216
16	cultuur	theater	15	115	261
17	sport	sportaccommodatie binnen	16	63	216
18	sport	sportaccommodatie buiten	16	84	240
19	sport	zwembad	51	136	635
20	bedrijfshal	datacenter	10	2003	2104
21	bedrijfshal	garage/showroom	15	50	197
22	bedrijfshal	autoschadeherstelbedrijf	15	54	204
23	bedrijfshal	groothandel met koeling	13	131	254
24	bedrijfshal	groothandel zonder koeling	10	42	140

Illustration: Electricity use
https://publicaties.ecn.nl/PdfFetch.aspx?nr=ECN-E--15-068

Richting	Hellingshoek						
	10°	20°	36°	50°	60°	70°	85°
West	90	90	85	80	75	70	65
Zuidwest	95	95	100	95	90	85	80
Zuid	95	100	100	100	95	90	80
Zuidoost	95	95	95	95	90	85	80
Oost	90	90	85	80	75	70	65
Noordoost	85	80	70	60	55	50	45
Noord	85	75	60	50	45	40	35
Noordwest	85	80	70	60	55	50	45

Optimal angle:
36° South orientation

Machinehall
roof angles: 25° & 18°
West & East orientation

still 90% optimal

Illustration: generated energy in percentages
https://www.minder.nl/blog/opbrengst-zonnepanelen-hoeveel-wekken-je-panelen-op

ELECTRICITY NEEDED

General:
Machinehall total floorarea = ca. 4820 m^2
Theater = ca. 370 m^2
Cultural center (sport/education/museum) = ca. 2660 m^2
Hal / open space = ca.1790 m^2

Electricity use in a theater per year= 115 kWh / m^2
Electricity use in a culture center per year= 55 kWh / m^2
Electricity use in the main hall per year = 20 kWh / m^2
(sport/education/museum = 63/50/53 kWh / m^2 avarage = 55 kWh / m^2)

theater: 370 x 115 = 42.550 kWh
culture center: 2660 x 55 = 146.300 kWh
hal: 1790 x 20 = 35. 800 kWh
total: 42.550 + 146.300 + 35.800 = **224.650 kWh**

Heatpump:
1 kWh generated by gas = 5 kWh heat with the heatpump.

kWh / m^2 (gas) heat needed:
Theater: 261 kWh - 115 kWh = 146 kWh / m^2
Cultural center (sport/education/museum) = 153 kWh / m^2
Hall / open space = 100 kWh / m^2

theater: 370 x 146 = 54.020 kWh
culture center: 2660 x 153 = 406.980 kWh
hall: 1790 x 100 = 179.000 kWh
total: 54.020 + 406.980 + 179.000 = 640.000 kWh

kWh electricity needed with heatpump:
640.000 / 5 = **128.000 kWh** electricity is needed for the heatpump to generate 640.000 kWh of heat.

Machinehall needs: 224.650 + 128.000 = 352.650 kWh electricity per year

ELECTRICITY GENERATED

1 m^2 solarpanel of 320 Wp can generate 165 kWh per year

Solar panels on the closed part on the roofs:
2480 m^2 solar panels
2480 x 165 = 409.200 kWh
90% solar panel efficiency = 368.280 kWh generated per year

100% of the energy that is needed can be generated by the solar panels

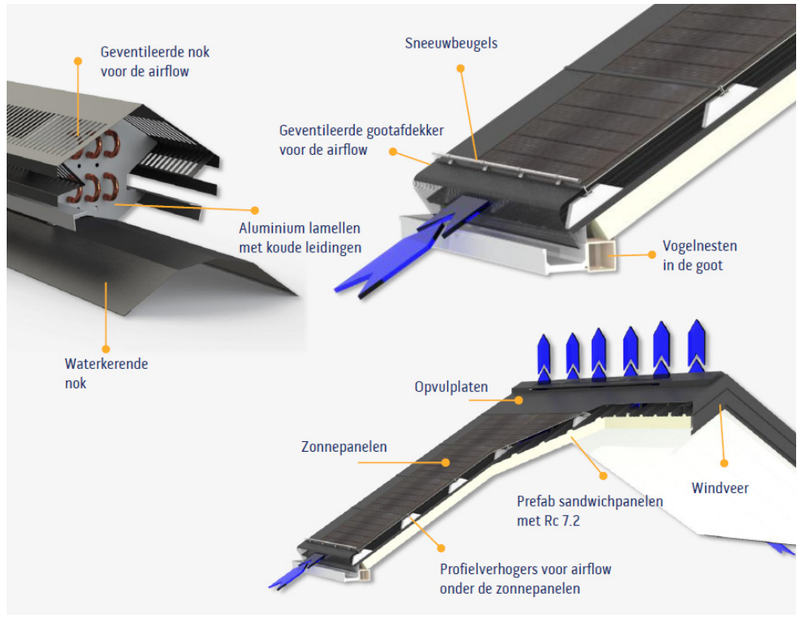


Illustration: Functioning Smartroof
source: Tegnis smartroof

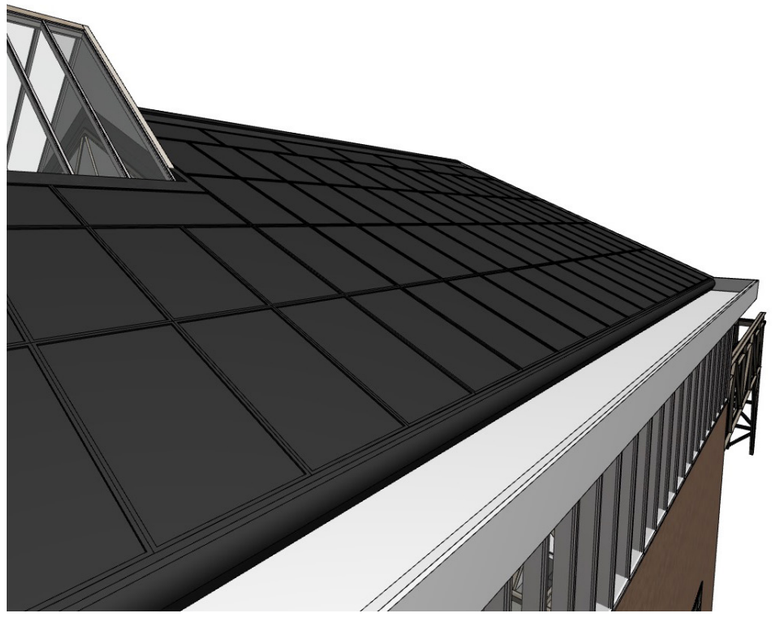


Illustration: machinehall smartroof
own illustration

3.9 Heating

The goal I have set for the building is to stabilize the temperture inside. When there is a constant temperature inside the energy efficiency will go up, and less resources are needed to create a comfortable indoor climate.

Normally, a building will cool off at night and in the morning the heater will be turned on again in order to get the building to a comfortable temperature. This is what I try to prevent. Because you lose a lot of energy by doing so.

In the chart below you can see what normally is the case for the temperature in buildings in red. In blue is the temperature flow that I try to achieve.

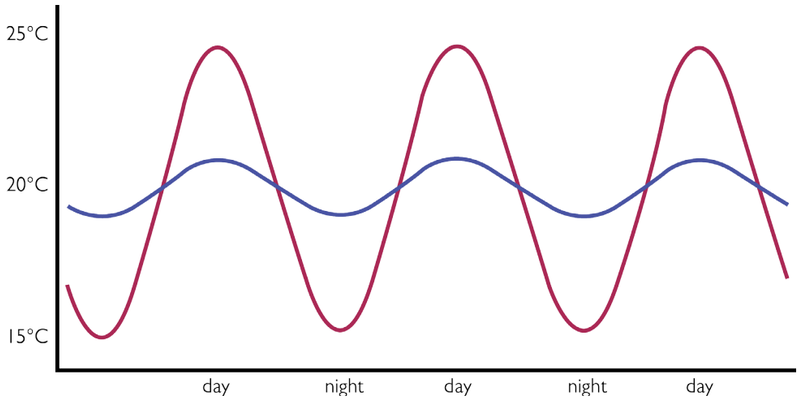
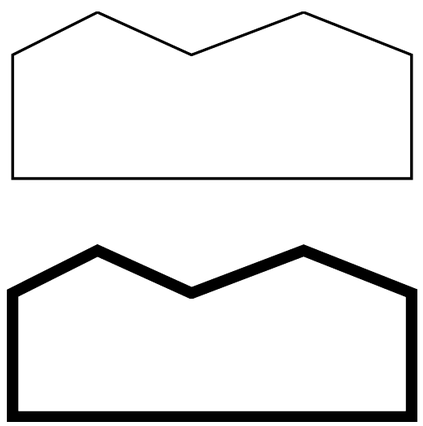


Illustration: Stabilisation of the inside temperature
own illustration

THERMAL LAYER

In order to do so, a few interventions are needed. To remain a constant inside temperature, the building needs to be well insulated in order for the temperature to stay inside the building.

1. post insulating the existing cavities with the ecological insulation
2. replacing the existing steel framed row windows and the skylight to reduce the thermal bridge.
3. replacing the existing wooden roof for a highly insulated roof.
4. using front windows behind the existing steel framed windows



PCM CLIMATE FLOOR

I need floorheating throughout the building to be able to distribute the heating/ cooling. To create a constant indoor temperture PCM elements will be implemented into the floorheating system in 25% of the floor surface.

Phase Change Materials, also called phase transition materials, are non-flammable inorganic thermal salts whose phase changes from solid to liquid and vice versa used to store and relinquish heat / cold. In PCM, energy is stored for use on a later moment. PCMs behave like thermal batteries here and are therefore very suitable as heat / cold buffer to function.

A correctly applied PCM climate floor has a damping effect on the indoor temperature. The principle of phase transition materials as heat accumulating materials is as follows: by heat absorption from the environment melts the material. The environment is cooled. When the temperature drops, the material solidifies again by heat release to the environment. The environment is heated.

The result is a "more even temperature" in the building reducing the cooling and heating capacity. In some cases it is no longer necessary, so you save energy and limit the CO2 emissions.

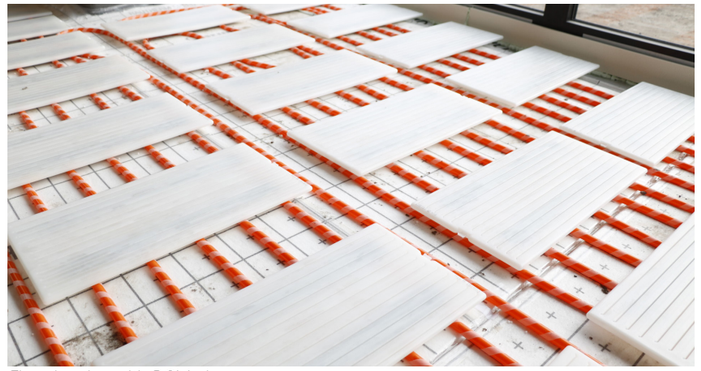


Photo: Floor-heating with PCM elements

WOOD

The reason to use wood has 2 reasons, first is the ecological aspect as mentioned in chapter 3.5. But this material also stores heat and will slowly release this heat to it's environment. This also contributes to the goal of creating constant indoor temperature.

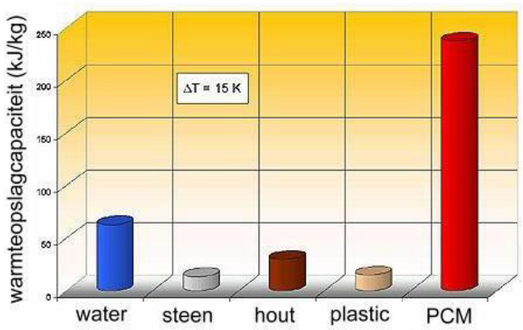
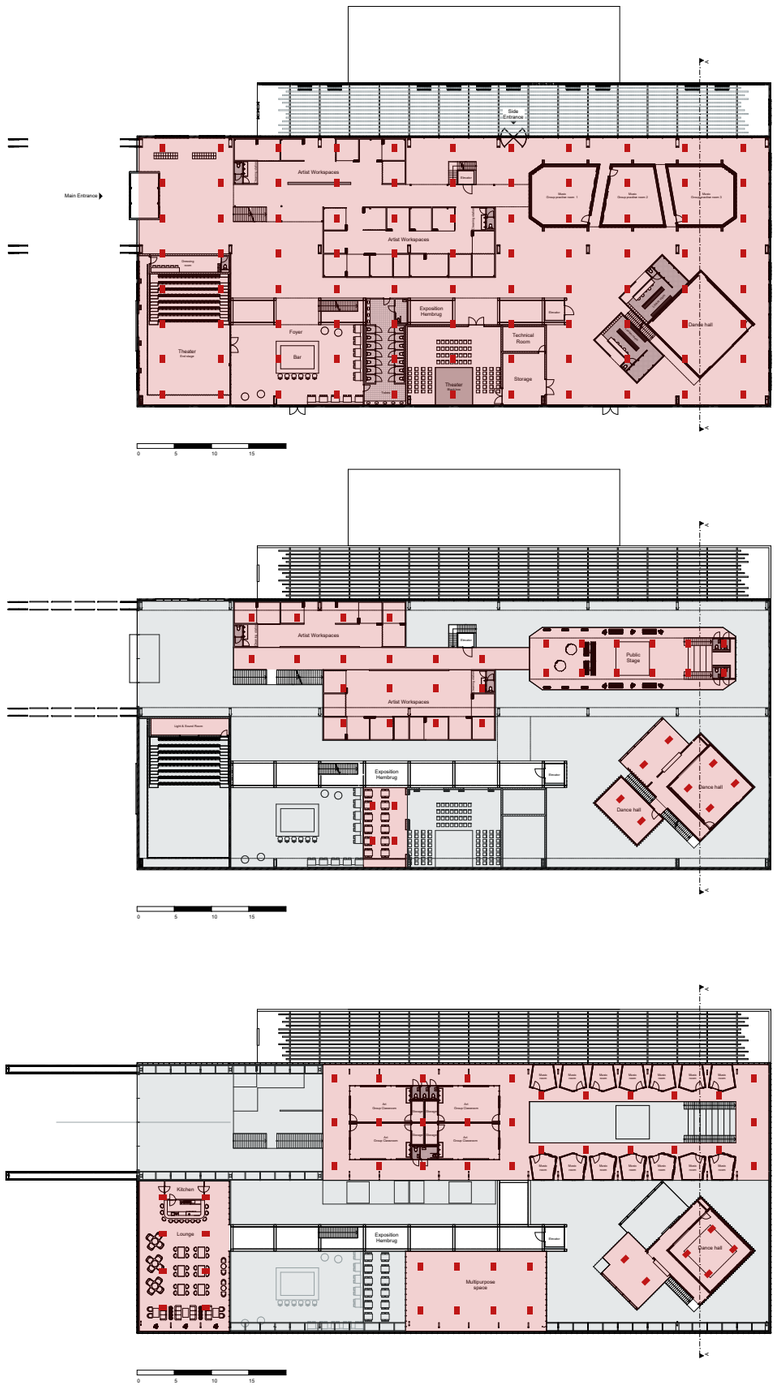


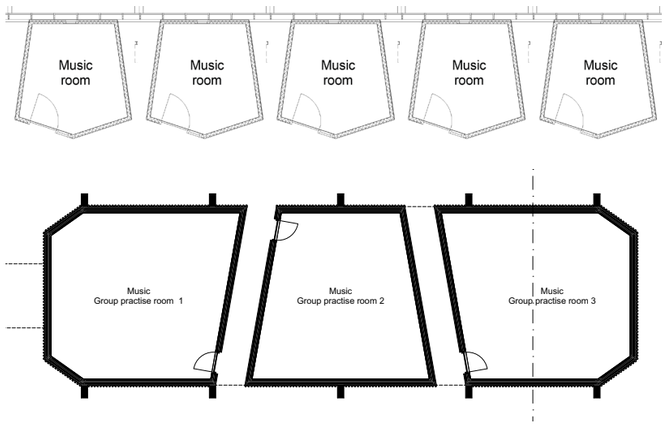
Illustration: Heat storage capacity
source: Rubitherm



In the floorheating system (light red) there are PCM elements (dark red) incorporated into the floor. Only 25% of the floor surface needs to be PCM in order to work right. I devided this equally on the ground floor, since that is the permanent layer of the building. The different departments can be removed and the building can have a new purpose. This way the floor can stay as it is. On the different storeys I divided the PCM elements mainly in the general open space, because that is where the constant temperature will be needed the most. A few closed of spaces also got these PCM elements to ensure a comfortable indoor climate.

3.10 Acoustics

Sound is a very important aspect of the different departments inside this cultural center. Firstly to keep the sound as much as possible in the space where it is created. Secondly the acoustics of this space has to be good.
For the music department I did research on how to get an acousticly optimal space, since it is the most important in this department. Therefore the rooms are shaped as they are, no right-angled corners to avoid resonance. In every room there is acoustic insulation on the inside to eliminate echo and excessive loudness. The dancehalls and theaters also have acoustic insulation on the inside of the different spaces to eliminate this.



For the theaters I took the proportions into account according to height and width to create an acousticly comfortable space. And the performer and audience occupy the same geometric space.

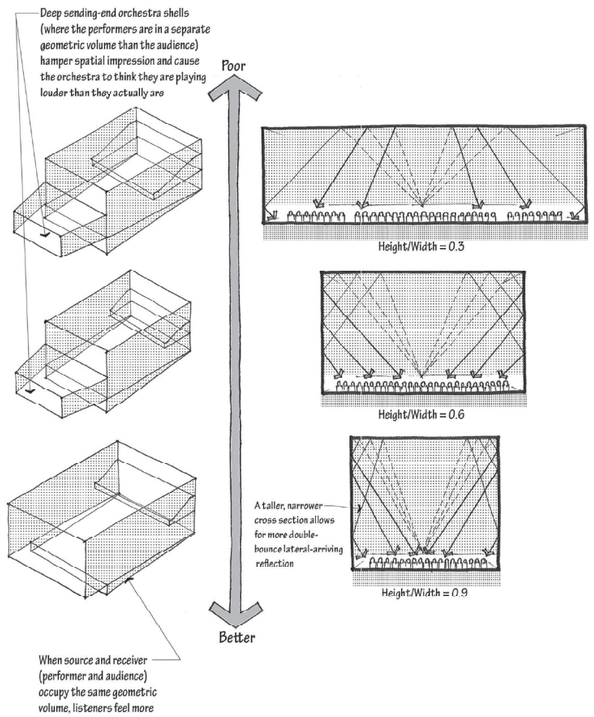
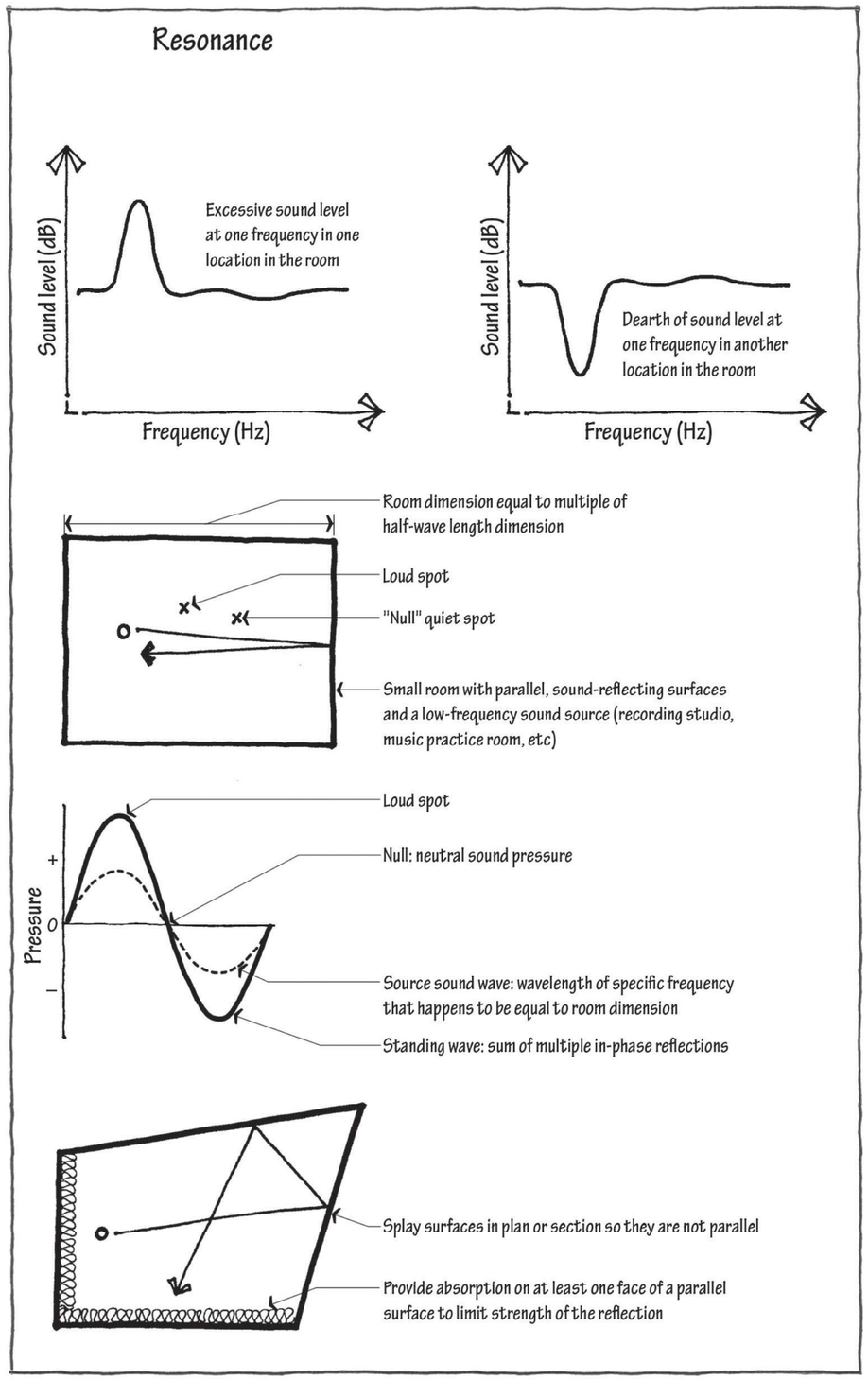


Illustration: acoustics in theater halls
source: M. Ermann in Architectural Acoustics Illustrated, pp. 92

Frequency content

Cause

Solution



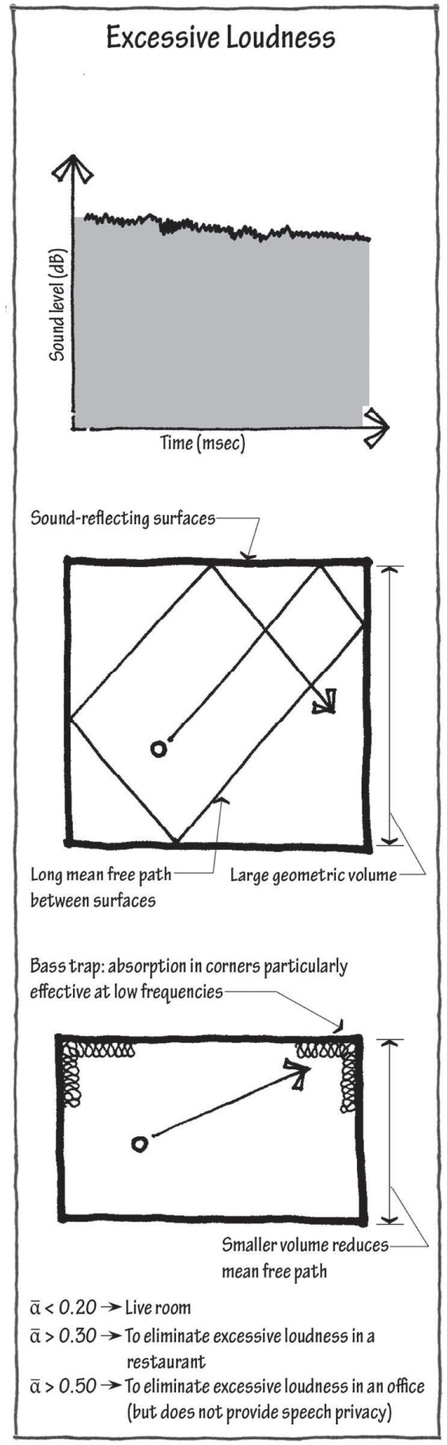
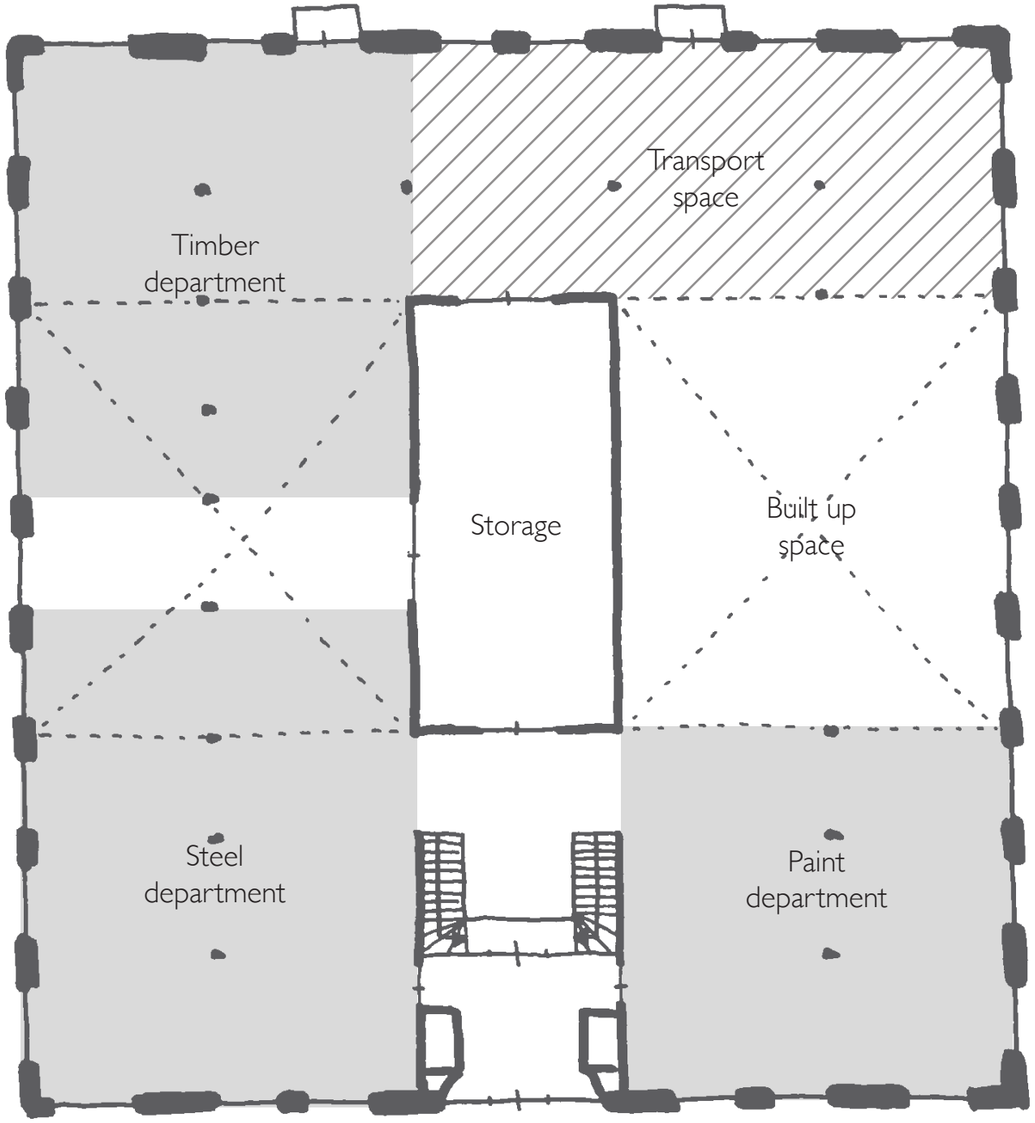


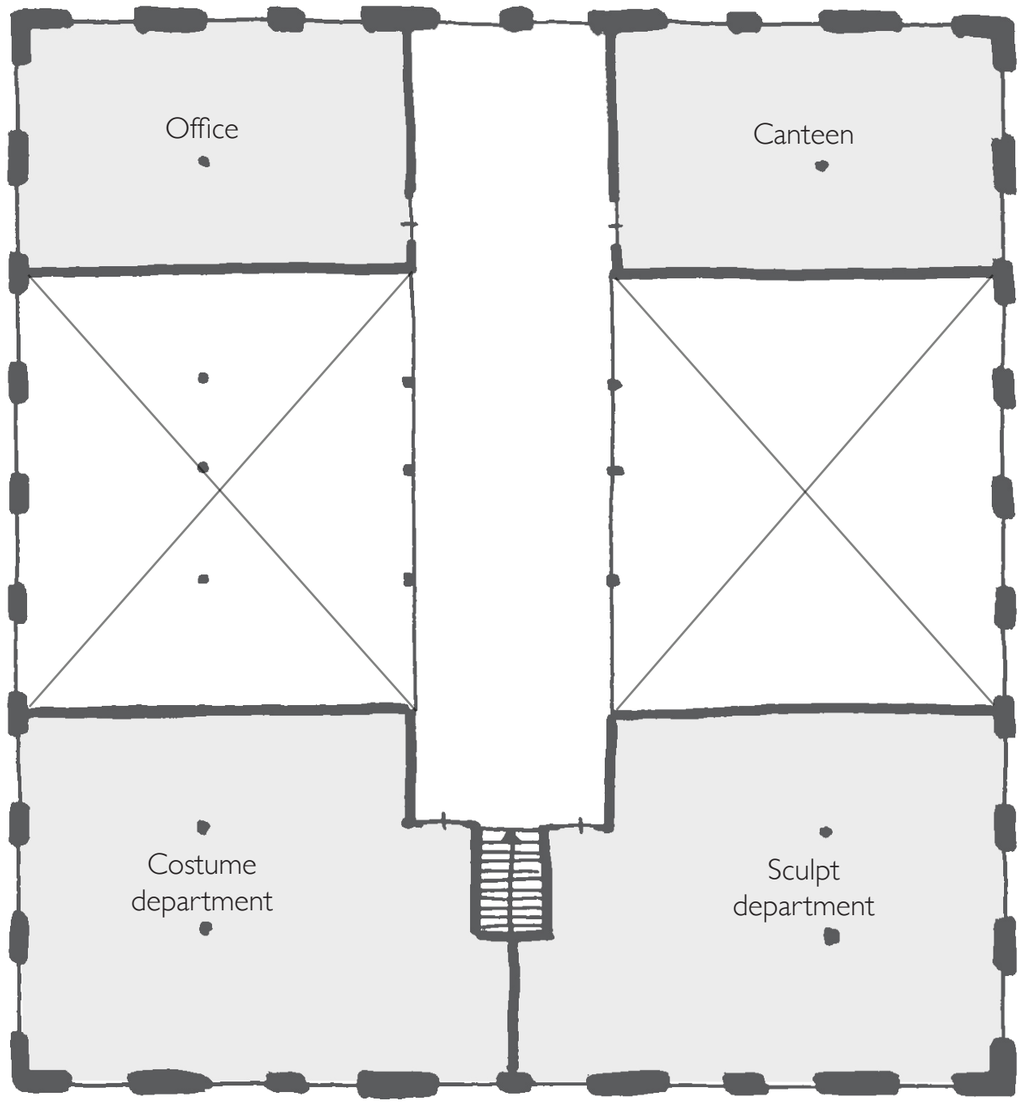
Illustration: how to optimalize acoustics in a space
source: M. Ermann in Architectural Acoustics Illustrated

WEAPON DEPOT

4.1 Floorplans



Ground floor



First floor

North - Front Facade

East - Left Facade

South - Back Facade

West - Right Facade

4.2 Section