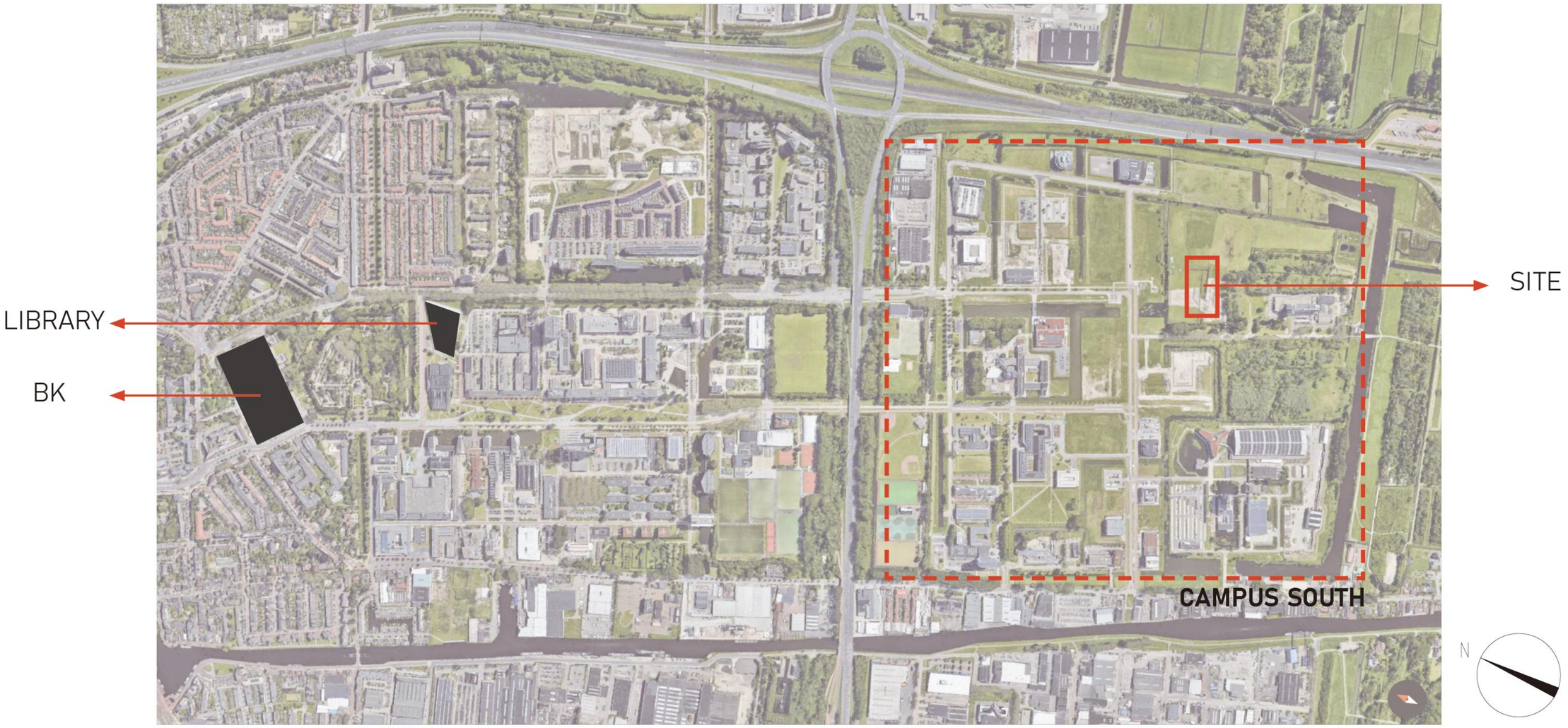


ADAPTABLE TIMBER COMPLEX

From Student Housing To Mixed-use

Yanzhen Wu (Wendy) 5584981
Architecture Engineering
Tutors:
Thomas Offermans
Paddy Tomesen
Gilbert Koskamp
Christien Janssen

SITE LOCATION



Heertjeslaan, TU Delft Campus South (Google Earth)

PROBLEM STATEMENT

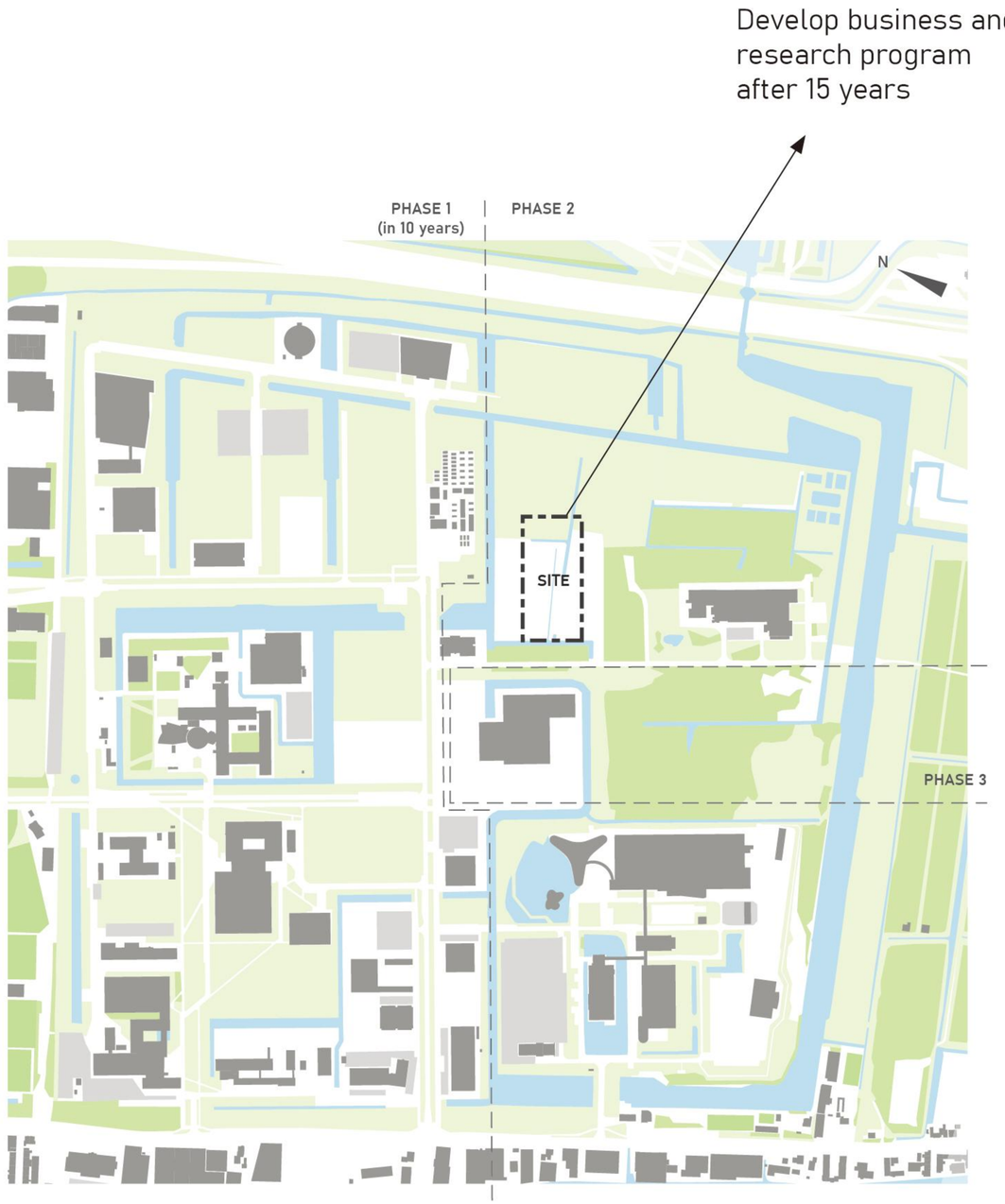
Housing demand will increase in the future; unreasonable to demolish the existing student housing

Longer service time for higher benefits

Student housing

DUWO

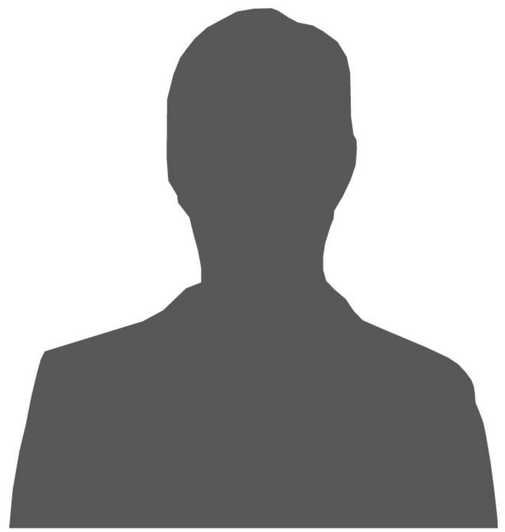




Student housing can only stay for 15 years

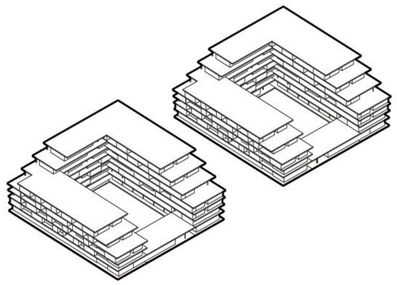
'Innovative hub' for institutes and companies

TU Delft Campus Development Plan

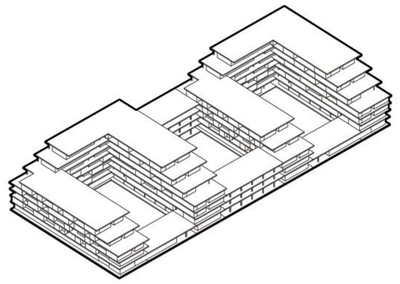


DESIGN OBJECTIVE

Student Housing + Research & Companies = Mixed-use Complex



add business & research program



15 years

PHASE 1: STUDENT HOUSING

affordable and livable
at least 660 student housing units
+ communal spaces

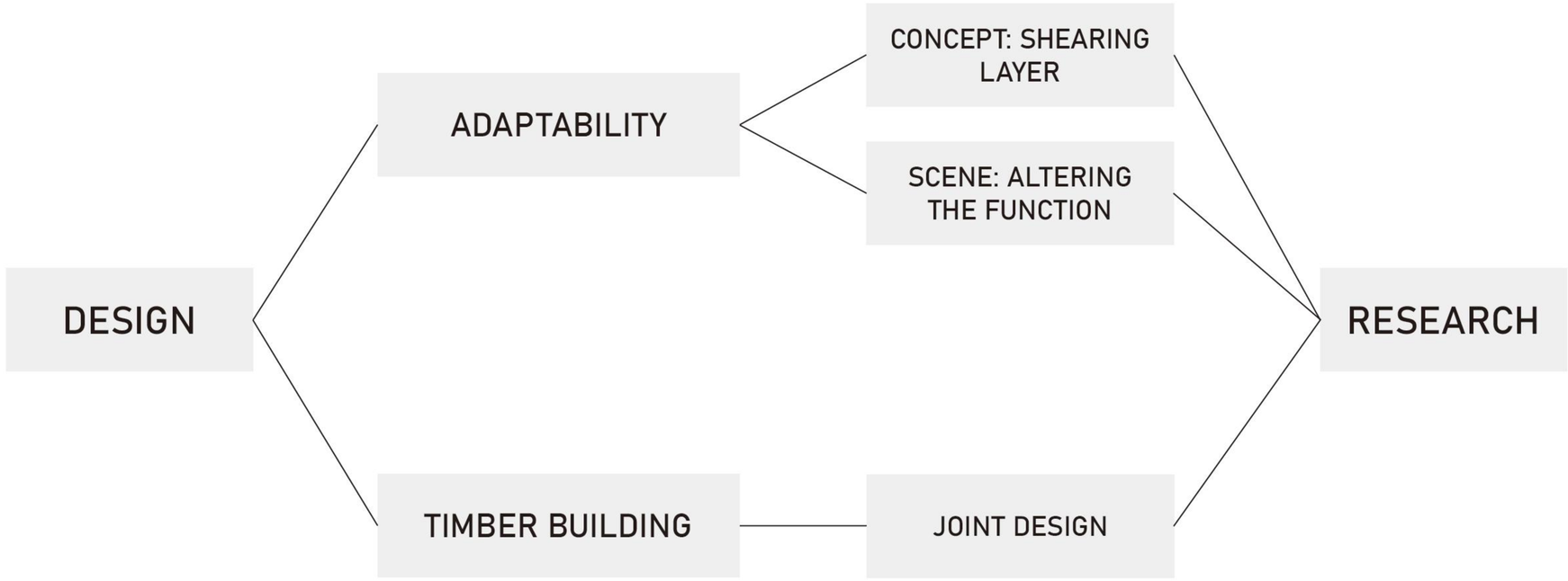
PHASE 2: MIXED-USE COMMUNITY

develop working spaces
offices, studios, labs for institutes and companies
residential and business, co-exist

DESIGN QUESTION:

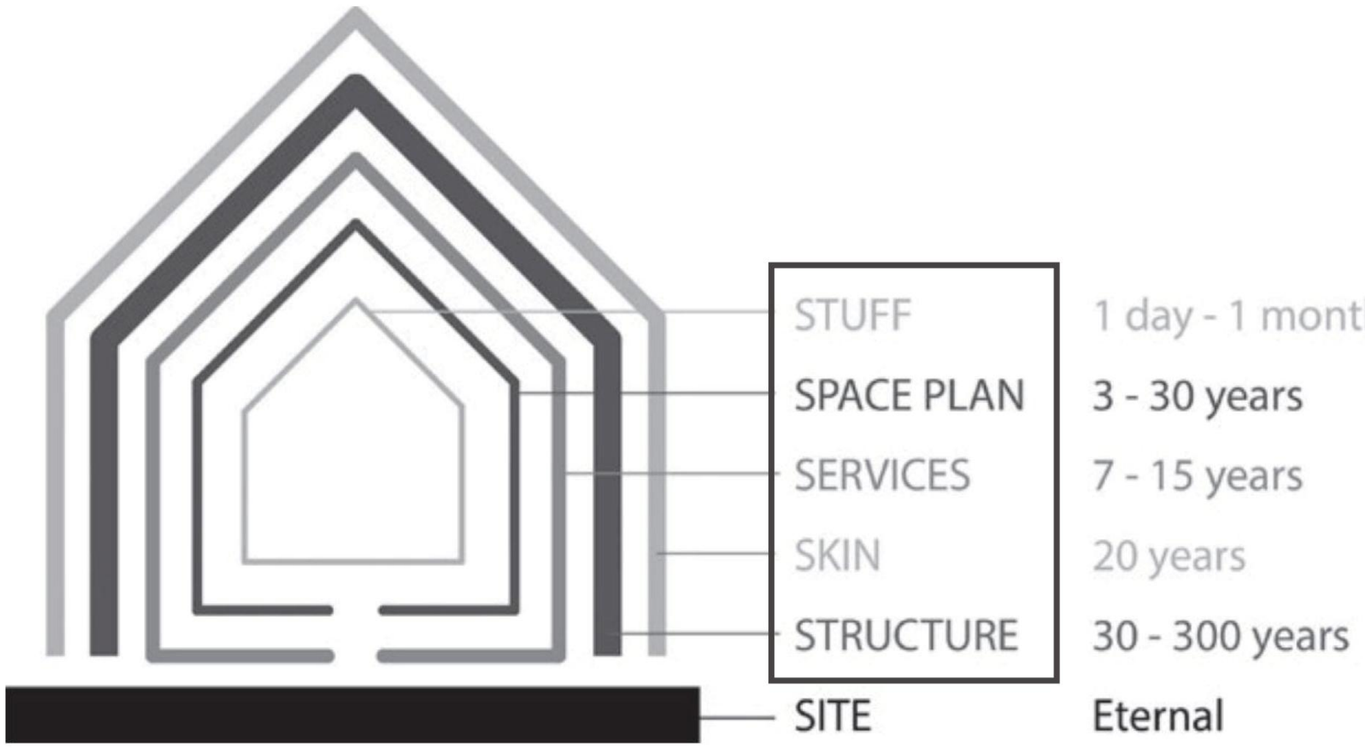
How can we design an adaptable timber building that is convertible and expandable from student housing towards a mix-use complex with a low cost?

RELATIONSHIP BETWEEN RESEARCH AND DESIGN



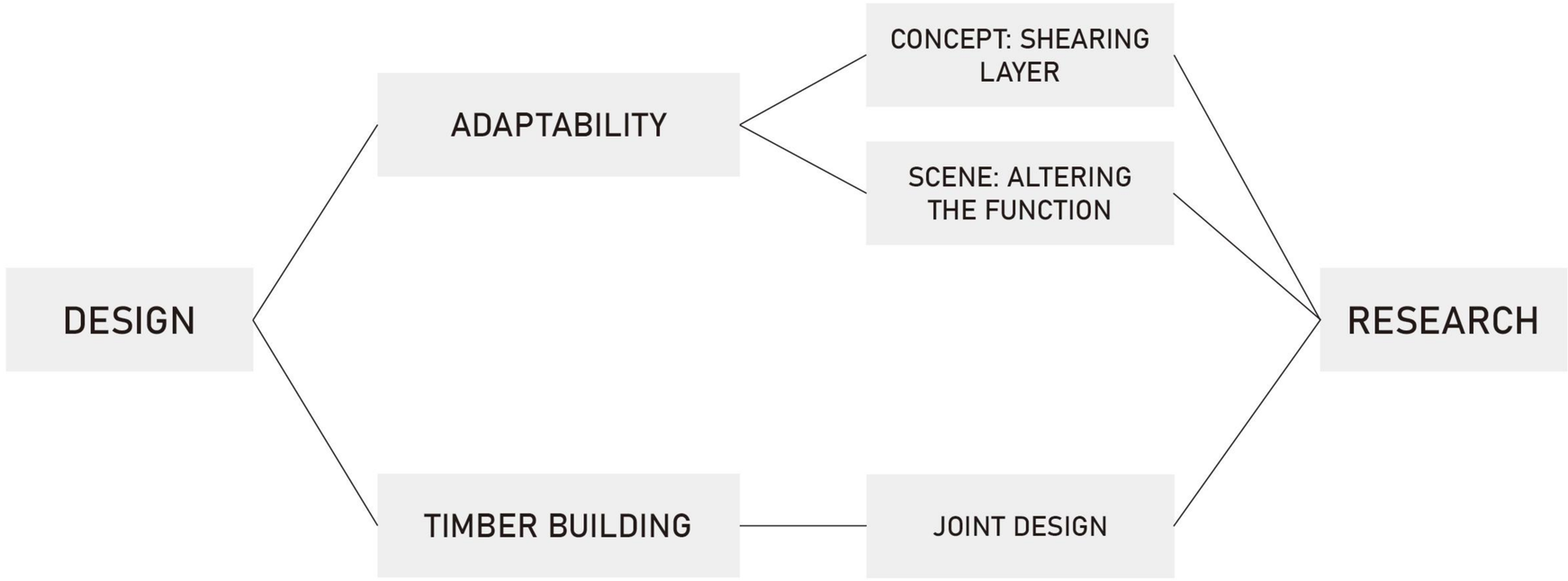
RESEARCH QUESTION:
How does joint design affect the independence of shearing layers to achieve an adaptable timber building under the scene of altering the function?

SHEARING LAYERS MODEL



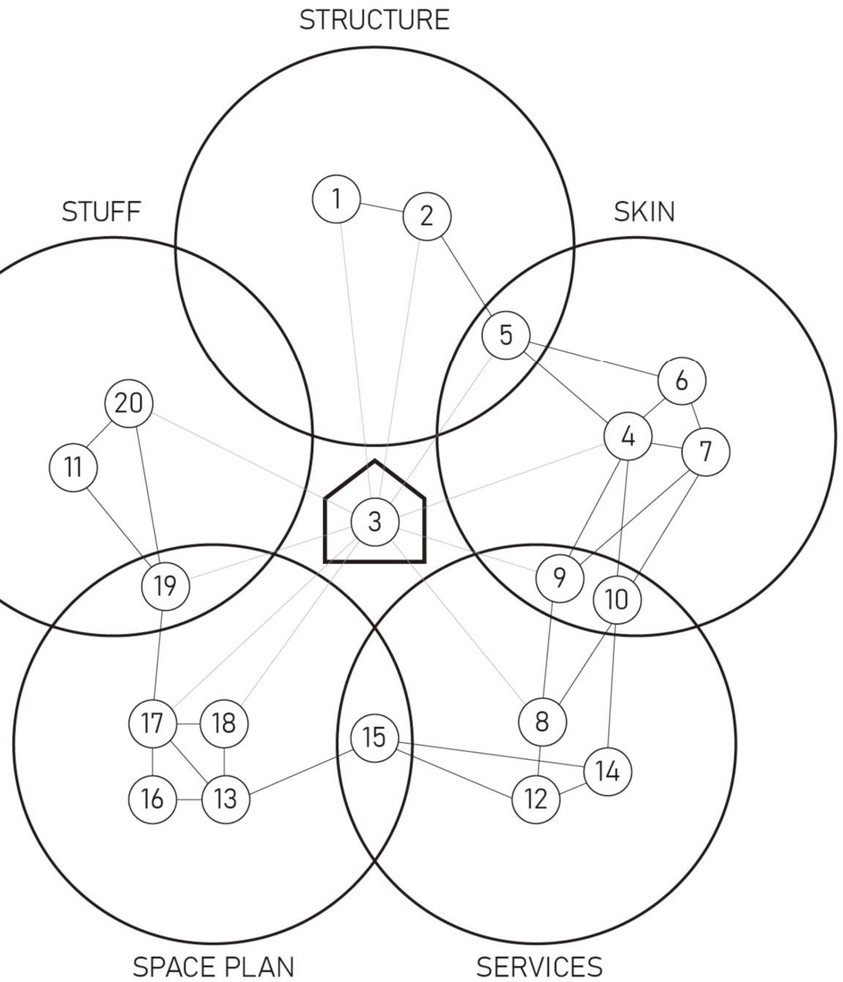
Shearing layers model. (Brand, 1994)

RELATIONSHIP BETWEEN RESEARCH AND DESIGN

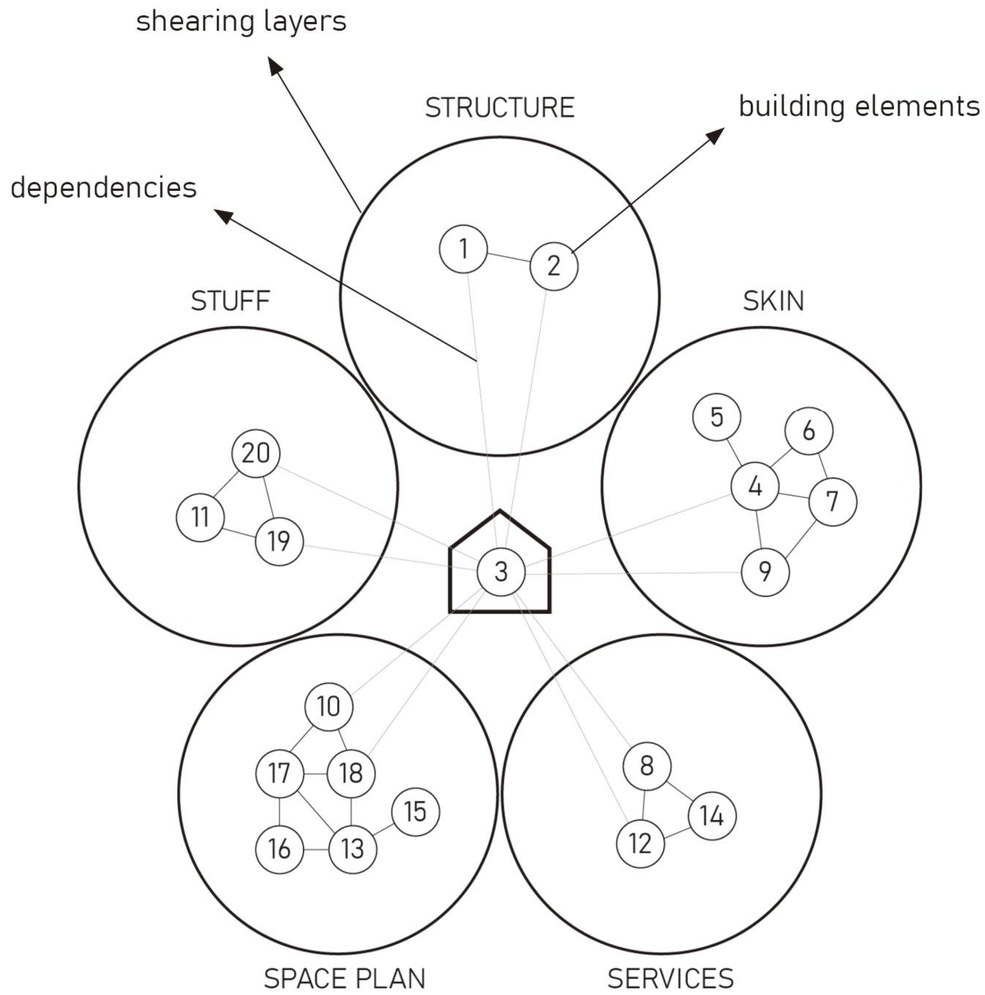


RESEARCH QUESTION:
How does joint design affect the independence of shearing layers to achieve an adaptable timber building under the scene of altering the function?

DEVELOPED RESEARCH MODEL



DEPENDENT

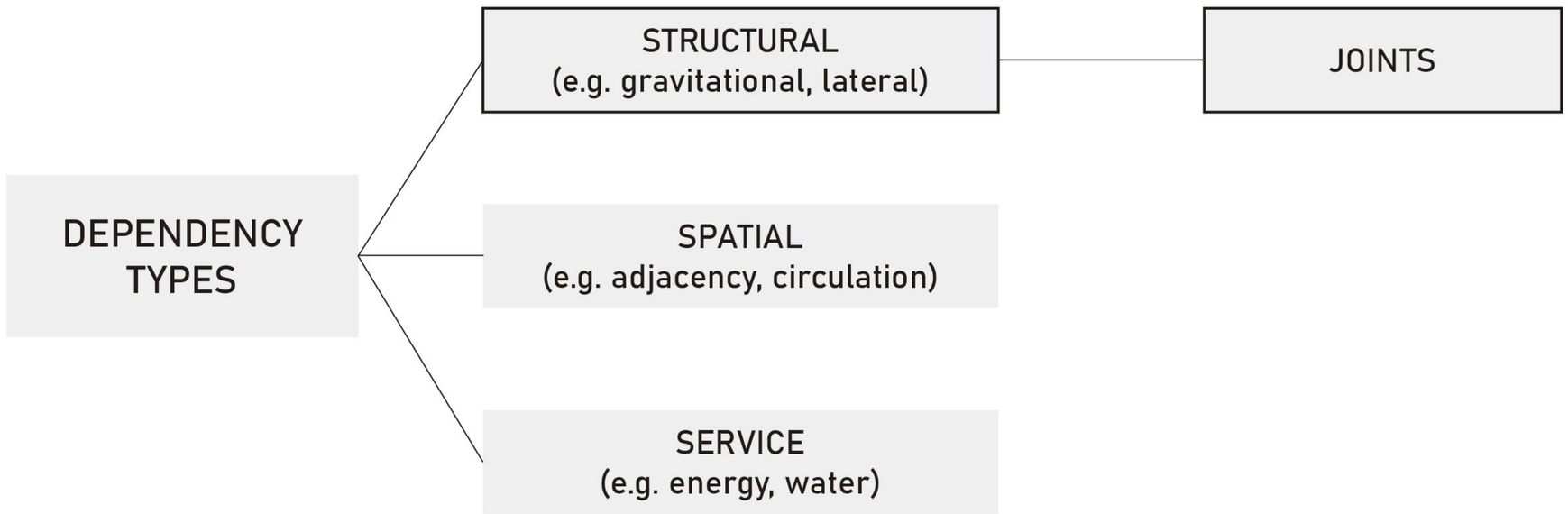


INDEPENDENT

Shearing layers and building elements (self made)

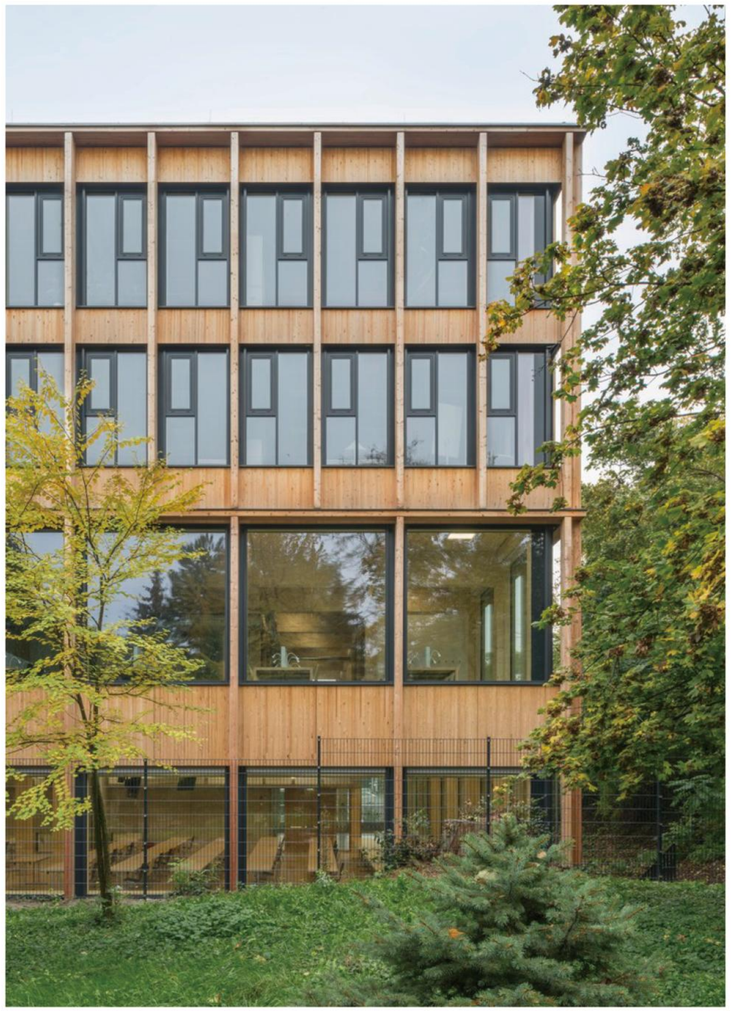
Which elements belong to which layers?
Which dependencies between elements have the greatest influence on the dependencies between layers?

DEPENDENCY TYPES



Three dependency types (Schmidt and Austin, 2016)

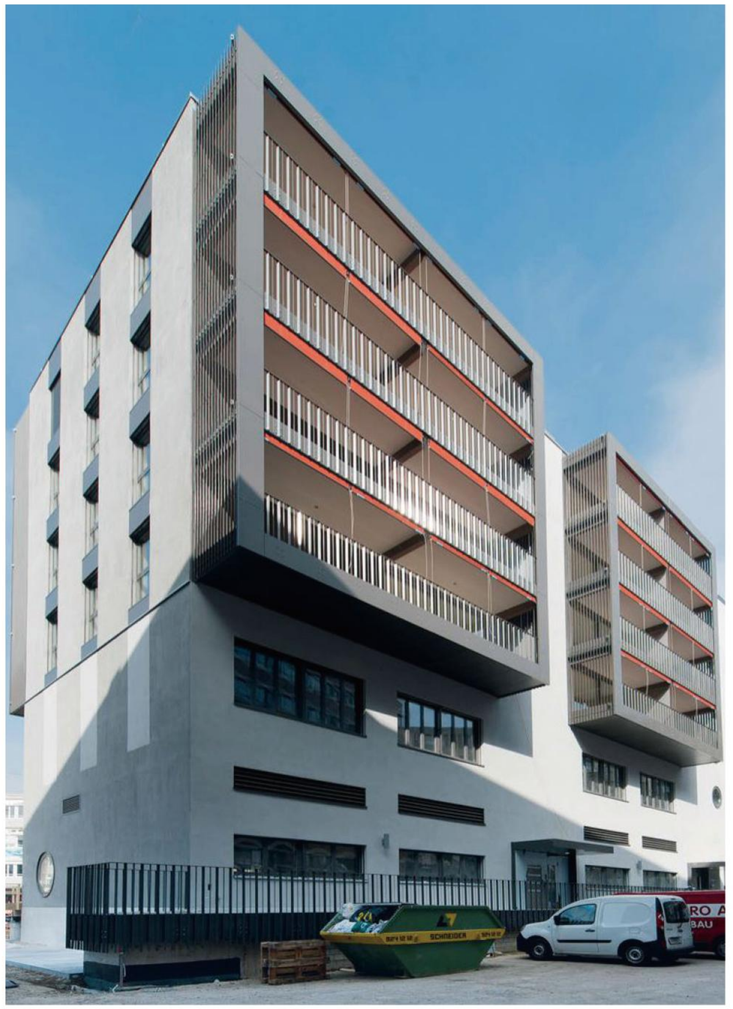
METHODOLOGY - CASE STUDY



Case 1: Library and Seminar Centre BOKU

adaptable, multi-storey timber building
with concrete base and staircase

https://www.archdaily.com/955587/library-and-seminar-centre-boku-vienna-swap-architekten-plus-delta?ad_medium=gallery



Case 2: Pile Up Giesshübel

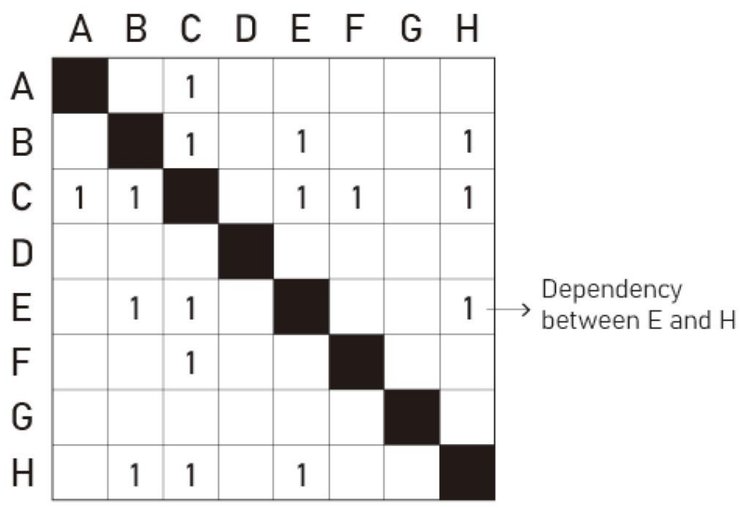
non-adaptable, multi-storey timber building
with concrete base and staircase

https://oxid-architektur.ch/projekt/2/pile-up-giesshuebel

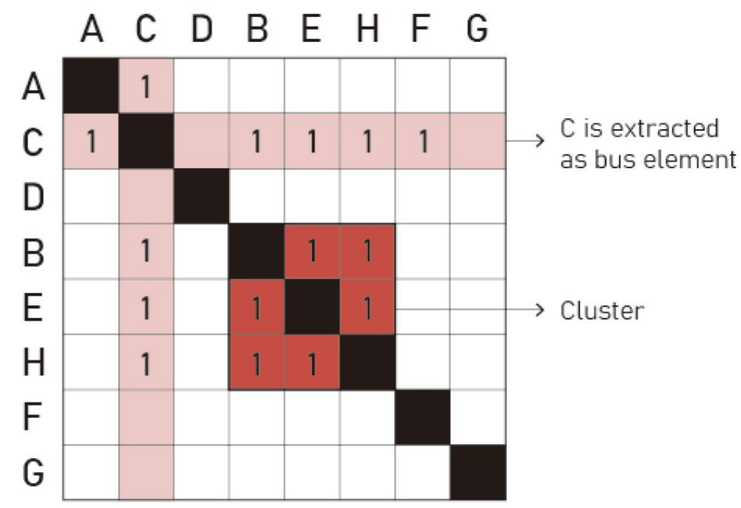
METHODOLOGY - DSM

Dependency Structure Matrix (DSM):
a powerful tool to reveal the complex interdependencies between elements in a building system

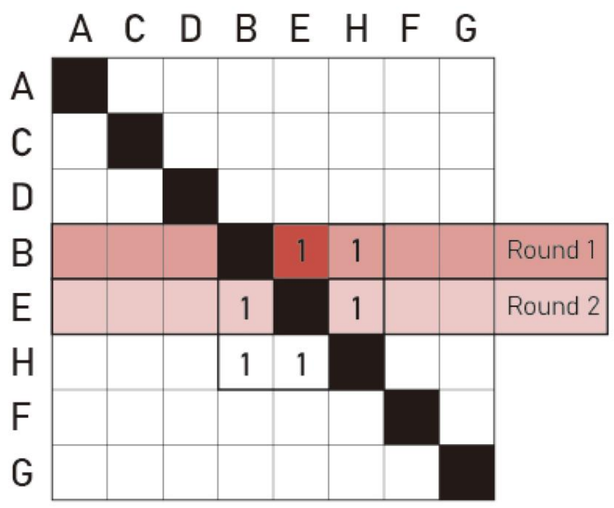
A square cell matrix, having the same elements in rows and columns
Dependencies between every two elements are marked as '1'



AN INITIAL DSM



CLUSTERING ANALYSIS



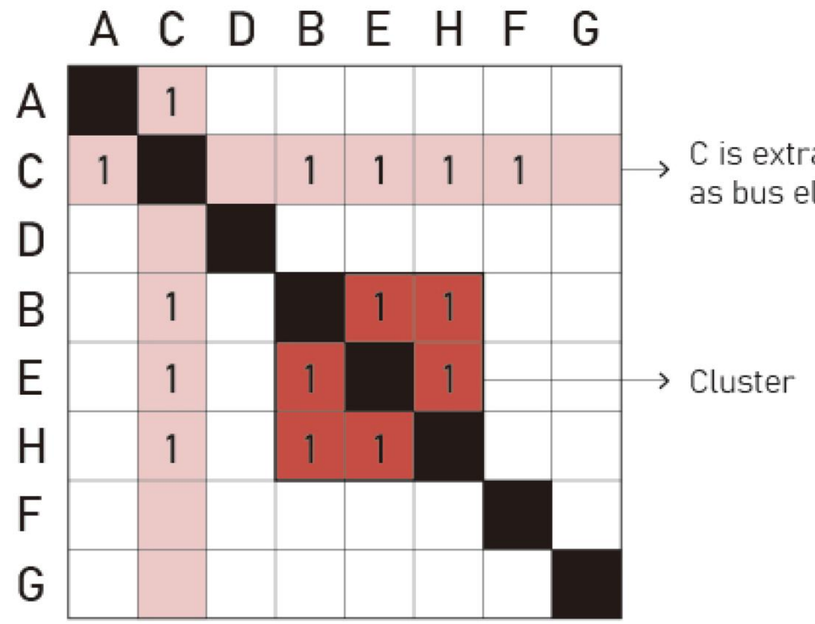
IMPACT ANALYSIS

Examples of how DSM works (self made)

CLUSTERING ANALYSIS

How:
1. rearranges building elements into clusters which have high dependency internally and low dependency externally
2. isolate elements that have high dependencies with all the clusters as bus elements

Why:
1. to find out if the two cases can be decomposed into layers and how independent their layers are
2. to determine which elements belong to which layers

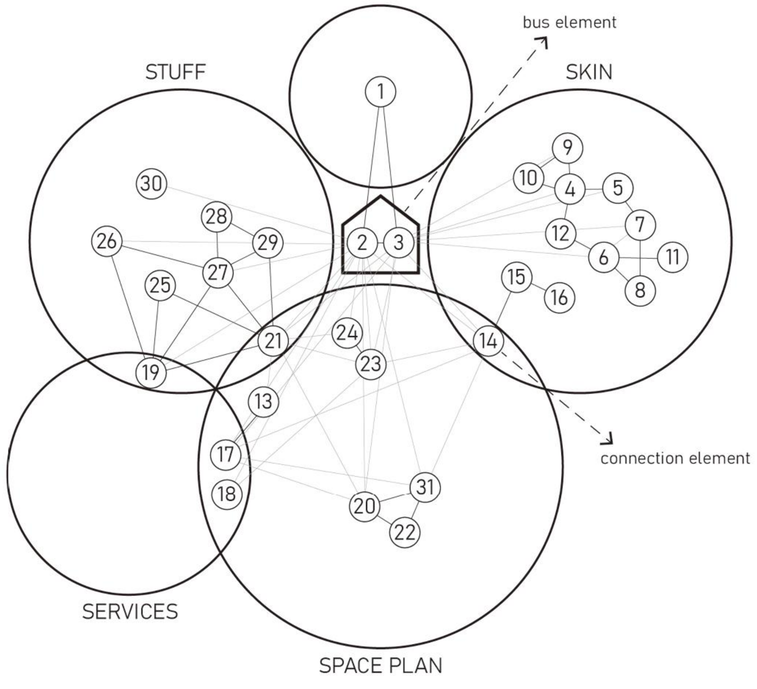


CLUSTERING ANALYSIS

CLUSTERING ANALYSIS - CASE 1

Findings:

1. Most elements can be well clustered and several clusters can be included in one layer;
2. Some elements are divided into different layers in two charts;
3. Some elements are marked in two layers simultaneously - connection elements;
4. Service elements are combined with space plan and stuff layers;
5. The structural elements are extracted as bus elements.



CASE 1: Library and Seminar Centre

Layers	Element Names		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
STRUCTURE	Concrete foundation	1		1	1																												
	Concrete core with staircase	2	1		1						1					1			1	1	1	1	1		1	1		1	1			1	1
	Glulam timber structural frame	3	1	1		1	1	1		1						1			1			1	1		1								
SKIN	Larch facade panels	4			1		1			1	1		1																				
	Insulation and sealant (exterior wall)	5			1	1			1																								
	Curtain walls (triple glazing in spruce frame)	6			1				1	1			1	1																			
	CLT walls (exterior)	7			1		1	1		1					1								1										
	Doors (exterior)	8						1	1																								
	Larch lesene	9			1	1						1																					
	Larch mullion with sheet metal coping	10				1					1																						
	Window blinds (indoor)	11						1																									
	Window blinds (outdoor)	12				1		1																									
	Spruce window seats	13							1										1				1										
	CLT ceiling (roof)	14		1	1												1		1						1								1
	Insulation and sealant (roof)	15														1		1															
	Aluminum coping (roof)	16															1																
SERVICES	Electrical wiring and data cables	17		1	1										1	1														1			1
	Ventilation system	18		1																					1								
	Water pipes	19		1																		1					1	1	1				
SPACE PLAN	CLT floor panels	20		1	1																	1	1	1								1
	Flooring finishes and insulation	21		1	1				1						1						1	1		1	1	1		1		1		
	Acoustic ceiling	22																				1											1
	Partition walls (timber frame and various panels)	23		1	1											1				1		1	1			1							
	Doors (interior)	24		1																			1		1								
STUFF	Toilet fixtures	25																			1		1										
	Plumbing accessories (faucet, pipes)	26		1																	1							1					
	Kitchen cabinets and sinks	27		1																	1		1						1		1		
	Appliances	28																	1											1		1		
	Furnitures	29																					1								1		
	Hanging greenery	30		1																													
	Lighting	31		1												1			1			1		1									

Appendix 1. Initial DSM of Case 1: Library and Seminar Centre. (self made)

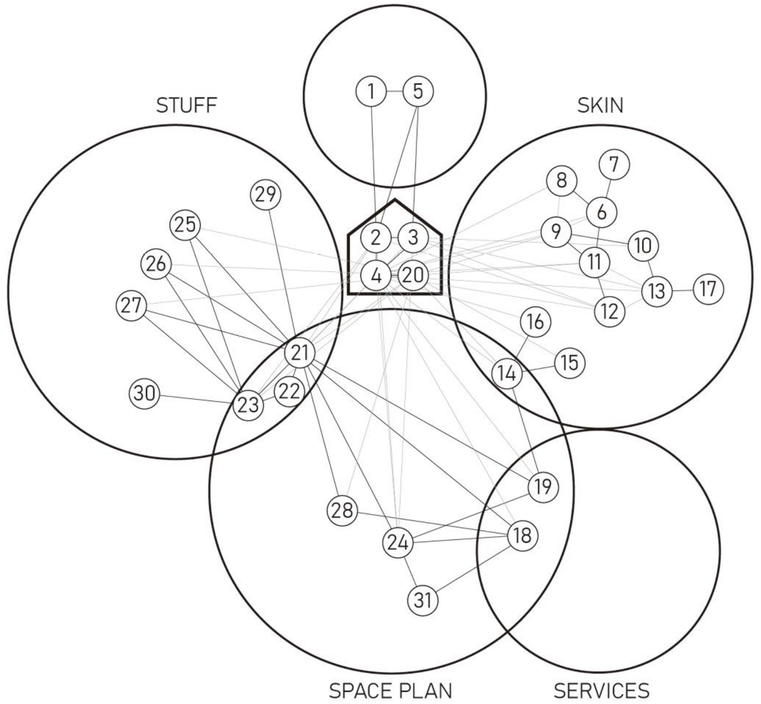
Layers		Element Names		1	2	3	9	10	4	12	5	6	7	8	11	15	16	14	24	23	18	13	17	31	22	20	21	19	27	25	26	28	29	30
STRUCTURE		Concrete foundation	1		1	1																												
		Concrete core with staircase	2	1		1													1	1	1	1	1	1		1	1	1	1		1			1
		Glulam timber structural frame	3	1	1		1		1		1	1	1						1		1		1			1	1							
SKIN (facade)		Larch lesene	9			1		1	1																									
		Larch mullion with sheet metal coping	10				1		1																									
		Larch facade panels	4			1	1	1		1	1																							
		Window blinds (outdoor)	12						1			1																						
		Insulation and sealant (exterior wall)	5			1			1				1																					
		Curtain walls (triple glazing in spruce frame)	6			1				1				1	1	1																		
		CLT walls (exterior)	7			1					1	1		1																				
		Doors (exterior)	8									1	1																					
		Window blinds (indoor)	11									1																						
SKIN (roof)		Insulation and sealant (roof)	15														1	1																
		Aluminum coping (roof)	16													1		1																	
	SPACE PLAN	CLT ceiling (roof)	14		1	1										1				1			1	1										
		Doors (interior)	24		1															1							1							
		Partition walls (timber frame and various panels)	23		1	1													1	1		1				1	1							
	SERVICES	Ventilation system	18		1																1													
	SPACE PLAN	Spruce window seats	13																				1				1							
	SERVICES	Electrical wiring and data cables	17		1	1													1			1		1		1						1	
		Lighting	31		1														1				1		1	1								
		Acoustic ceiling	22																					1		1								
		CLT floor panels	20		1	1															1		1	1	1		1						
		Flooring finishes and insulation	21		1	1														1	1		1			1		1	1	1			1	
STUFF	SERVICES	Water pipes	19		1																						1		1	1	1			
		Kitchen cabinets and sinks	27		1																						1	1			1	1		
		Toilet fixtures	25																								1	1						
		Plumbing accessories (faucet, pipes)	26		1																							1	1					
		Appliances	28																				1						1					
		Furnitures	29																								1						1	
		Hanging greenery	30		1																													

Appendix 2. Clustered DSM of Case 1: Library and Seminar Centre. (self made)

CLUSTERING ANALYSIS - CASE 2

Findings:

1. The building elements of Case 2 cannot be well organized in clusters;
2. Except for structural elements, the service element 'Drainage and pipes (20)' is extracted as a bus element;
3. The 'skin (balcony)' layer is independent of other layers;
4. The cluster with elements '21, 22, 23' connects the 'space plan' and 'stuff' layer.



CASE 2: Pile up Giesshübel

Layers	Element Names		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	24	17	18	19	20	21	22	23	25	26	27	28	29	30	31
STRUCTURE	Existing concrete storeys and foundation	1		1			1																										
	Extended concrete cores (lifts and stairwells)	2	1		1	1	1							1									1		1	1							
	Glulam timber structural frame (beams and supports)	3		1		1	1					1		1	1								1			1							
	Timber box ceiling with three-layer panel cladding	4		1	1		1	1		1	1		1	1	1	1		1		1	1	1	1		1	1							
	Steel beams (structural transition)	5	1	1	1	1																											
SKIN	Facade panel assemblies	6				1			1	1	1		1																				
	Steel railing	7						1																									
	Sun blinds	8				1		1			1																						
	Balcony timber floor	9				1		1		1		1	1										1										
	Balcony partitions	10			1						1				1																		
	Balcony water-proofing layer	11				1		1			1			1	1								1										
	Timber sliding doors	12		1	1	1							1		1																		
	Exterior walls (timber stud+insulation+plasterboard)	13			1	1						1	1	1					1				1		1	1							
	Roof finishes and insulation	14				1											1	1			1	1											
	Extensive vegetation (roof)	15														1						1											
	Parapet wall	16				1										1																	
	Windows	17													1																		
SERVICES	Electrical cables	18				1																1									1		1
	Ventilation system	19				1										1							1		1								
	Drainage and pipes	20				1					1		1			1	1			1			1			1	1	1	1	1			
SPACE PLAN	Partition walls (timber stud+insulation+plasterboard)	21		1	1	1									1						1	1		1	1	1	1	1	1	1	1	
	Doors (interior)	22																					1		1								
	Flooring finishes	23		1		1									1						1		1	1			1	1	1			1	
	Ceiling finishes	24		1	1	1									1					1	1	1	1										1
STUFF	Bathroom pods	25																				1	1		1								
	Toilet fixtures	26																				1	1		1								
	Cabinet with sink (toilet)	27																				1	1		1								
	Integrated kitchen cabinets	28																		1		1	1										
	Built-in wardrobe	29																					1										
	Furnitures	30																								1							
	Lighting	31																		1							1						

Appendix 3. Initial DSM of Case 2: Pile up Giesshübel. (self made)

Layers		Element Names		1	5	2	3	4	20	7	6	8	9	11	10	12	13	17	16	15	14	19	24	18	31	28	21	23	22	25	26	27	29	30
	STRUCTURE	Existing concrete storeys and foundation	1		1	1																												
		Steel beams (structural transition)	5	1		1	1	1																										
		Extended concrete cores (lifts and stairwells)	2	1	1		1	1								1							1				1	1						
		Glulam timber structural frame (beams and supports)	3		1	1		1							1	1	1						1				1							
		Timber box ceiling with three-layer panel cladding	4		1	1	1		1		1	1	1	1		1	1		1		1	1	1				1	1						
	SERVICES	Drainage and pipes	20					1					1	1						1	1		1			1	1	1		1	1	1		
	SKIN (balcony)	Steel railing	7						1																									
		Facade panel assemblies	6					1		1		1	1	1																				
		Sun blinds	8					1			1		1																					
		Balcony timber floor	9					1	1		1	1		1	1																			
		Balcony water-proofing layer	11					1	1		1		1			1	1																	
		Balcony partitions	10				1						1				1																	
		Timber sliding doors	12			1	1	1						1			1																	
		Exterior walls (timber stud+insulation+plasterboard)	13				1	1						1	1	1		1																
		Windows	17														1		1															
	SKIN (roof)	Parapet wall	16					1												1		1												
		Extensive vegetation (roof)	15						1											1		1												
		Roof finishes and insulation	14					1	1											1	1		1											
SPACE PLAN	SERVICES	Ventilation system	19					1														1		1			1							
		Ceiling finishes	24			1	1	1	1														1		1	1	1							
	SERVICES	Electrical cables	18					1																1		1	1	1						
		Lighting	31																					1	1									
		Integrated kitchen cabinets	28						1																1		1							
		Partition walls (timber stud+insulation+plasterboard)	21			1	1	1	1														1	1	1		1		1	1	1	1	1	
		Flooring finishes	23			1		1	1																		1		1	1	1			1
		Doors (interior)	22																								1	1						
STUFF		Bathroom pods	25						1																		1	1						
		Toilet fixtures	26						1																		1	1						
		Cabinet with sink (toilet)	27						1																		1	1						
		Built-in wardrobe	29																								1							
		Furnitures	30																									1						

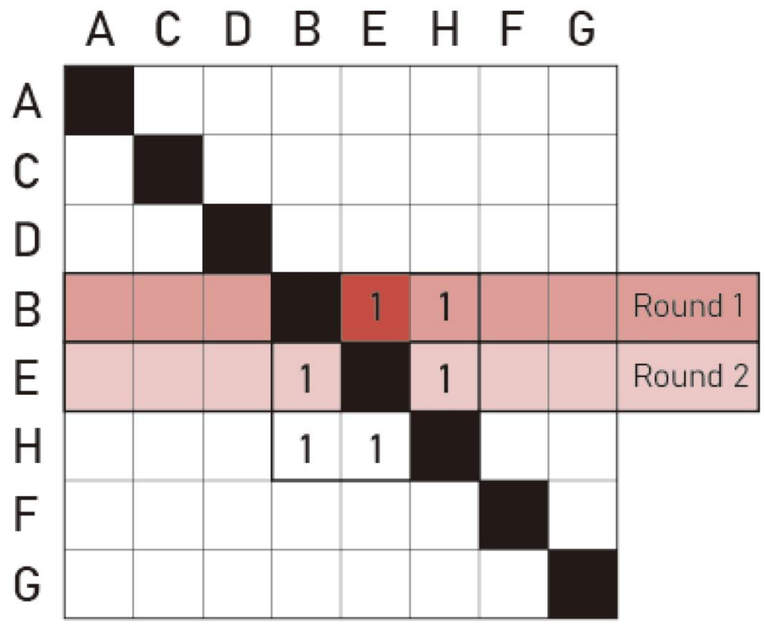
Appendix 4. Clustered DSM of Case 2: Pile up Giesshübel. (self made)

IMPACT ANALYSIS + JOINT ANALYSIS

How:
1. Highlight the propagation impact when changing an element in red colours from dark to light, indicating the sequences
2. Dependencies that trigger the propagation are marked in the darkest red
3. The joint details are analysed in the same colours as the DSM, illustrating why the dependencies trigger or do not trigger the propagation

Why:
1. To show if the impact would pass across layers and which joint positions promote or prevent propagation
2. To verify if the two cases can adapt to the changes and to find what joint design helps or hinder the adaptability

What:
1. Space plan. (partition wall)
2. Skin. (facades)
3. Services. (electricle cables and water system)

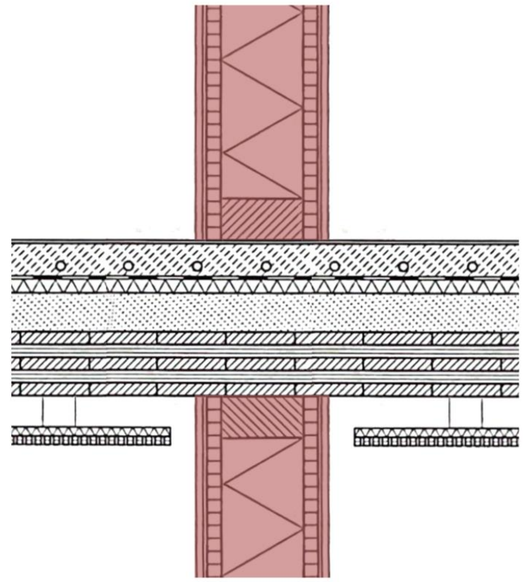


IMPACT ANALYSIS

IMPACT ANALYSIS - SPACE PLAN (CASE 1 + CASE 2)

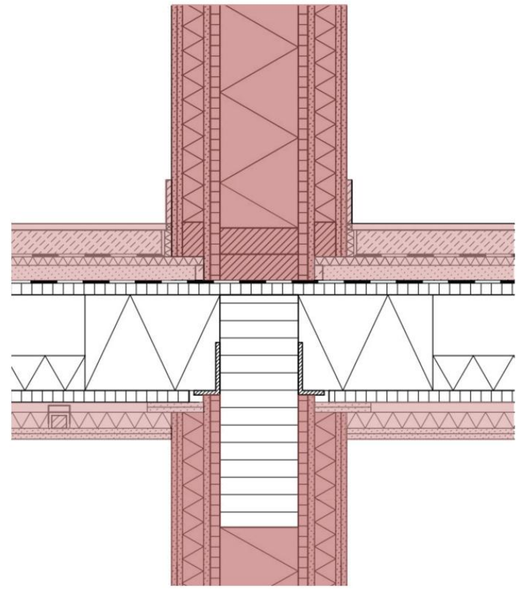
Layers			Element Names		1	2	3	9	10	4	12	5	6	7	8	11	15	16	14	24	23	18	13	17	31	22	20	21	19	27	25	26	28	29	30	
		STRUCTURE	Concrete foundation	1		1	1																													
			Concrete core with staircase	2	1		1												1	1	1	1		1	1		1	1	1	1		1			1	
			Glulam timber structural frame	3	1	1		1		1		1	1	1					1		1			1			1	1								
		SKIN (facade)	Larch lesene	9		1			1	1																										
			Larch mullion with sheet metal coping	10				1		1																										
			Larch facade panels	4			1	1	1		1	1																								
			Window blinds (outdoor)	12						1			1																							
			Insulation and sealant (exterior wall)	5			1			1				1																						
			Curtain walls (triple glazing in spruce frame)	6			1				1				1	1	1																			
			CLT walls (exterior)	7			1					1	1	1		1																				
			Doors (exterior)	8									1	1	1																					
			Window blinds (indoor)	11									1																							
		SKIN (roof)	Insulation and sealant (roof)	15														1	1	1																
			Aluminum coping (roof)	16													1																			
	SPACE PLAN		CLT ceiling (roof)	14		1	1										1				1				1	1									
			Doors (interior)	24		1														1	1							1								ROUND 2
			Partition walls (timber frame and various panels)	23		1	1												1	1		1					1	1								ROUND 1
		SERVICES	Ventilation system	18		1															1														
			Spruce window seats	13																				1				1								
		SERVICES	Electrical wiring and data cables	17		1	1												1				1		1		1						1		
			Lighting	31		1													1					1		1	1								
			Acoustic ceiling	22																					1	1	1								
			CLT floor panels	20		1	1				1										1			1	1	1	1								
			Flooring finishes and insulation	21		1	1													1	1		1			1		1	1	1	1			1		
		SERVICES	Water pipes	19		1																						1	1	1	1	1				
			Kitchen cabinets and sinks	27		1																						1	1			1	1			
STUFF			Toilet fixtures	25																								1	1							
			Plumbing accessories (faucet, pipes)	26		1																							1	1						
			Appliances	28																				1						1				1		
			Furnitures	29																								1						1		
			Hanging greenery	30		1																														

Appendix 5. Impact analysis on Case 1: Library and Seminar Centre (partition walls). (self made)



Layers			Element Names		1	5	2	3	4	20	7	6	8	9	11	10	12	13	17	16	15	14	19	24	18	31	28	21	23	22	25	26	27	29	30	
		STRUCTURE	Existing concrete storeys and foundation	1		1	1																													
			Steel beams (structural transition)	5	1		1	1	1																												
			Extended concrete cores (lifts and stairwells)	2	1	1		1	1								1							1				1	1							
			Glulam timber structural frame (beams and supports)	3		1	1		1							1	1	1						1				1								
			Timber box ceiling with three-layer panel cladding	4		1	1	1		1		1	1	1	1		1	1			1		1	1	1	1			1	1						
		SERVICES	Drainage and pipes	20					1					1	1							1	1	1		1			1	1	1		1	1	1			ROUND 3
		SKIN (balcony)	Steel railing	7								1																								
			Facade panel assemblies	6					1		1		1	1	1																						
			Sun blinds	8					1			1		1																							
			Balcony timber floor	9					1	1		1	1		1	1																					
			Balcony water-proofing layer	11					1	1		1		1			1	1																			
			Balcony partitions	10				1						1				1																			
			Timber sliding doors	12			1	1	1						1			1																			
			Exterior walls (timber stud+insulation+plasterboard)	13				1	1						1	1	1		1																		
			Windows	17														1																			
		SKIN (roof)	Parapet wall	16					1													1														
			Extensive vegetation (roof)	15						1												1														
			Roof finishes and insulation	14					1	1											1	1		1												
		SERVICES	Ventilation system	19					1														1		1				1							
			Ceiling finishes	24				1	1	1	1													1		1	1		1								ROUND 2
		SERVICES	Electrical cables	18					1																1		1	1								ROUND 2
	SPACE PLAN		Lighting	31																				1	1											ROUND 3
			Integrated kitchen cabinets	28						1															1				1							ROUND 2
			Partition walls (timber stud+insulation+plasterboard)	21				1	1	1	1													1	1	1		1		1	1	1	1	1	1	ROUND 1
			Flooring finishes	23				1		1	1																		1		1	1	1			1	ROUND 2
			Doors (interior)	22																									1	1						
STUFF			Bathroom pods	25						1																			1	1						
			Toilet fixtures	26						1																			1	1						ROUND 3
			Cabinet with sink (toilet)	27						1																			1	1						
			Built-in wardrobe	29																									1							ROUND 2
			Furnitures	30																										1						ROUND 3

Appendix 6. Impact analysis on Case 2: Pile up Giesshübel (partition walls). (self made)

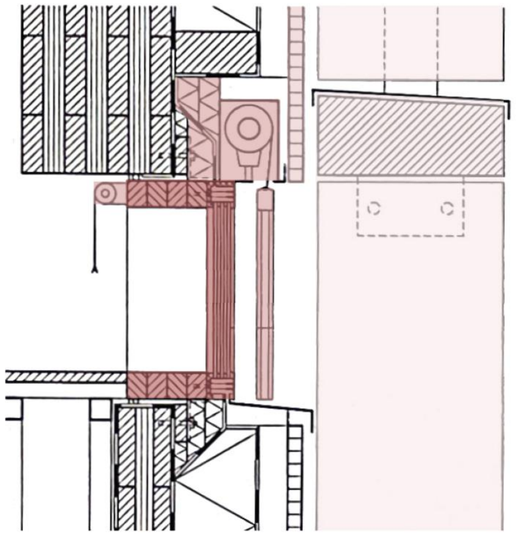


Appendix 7. Details of partition walls of Case 1 (left) and Case 2 (right). (self analysed on drawings from Sandra, H., 2022 and Kaufmann, H., Krötsch, S. & Winter, S., 2018)

IMPACT ANALYSIS - SKIN (CASE 1)

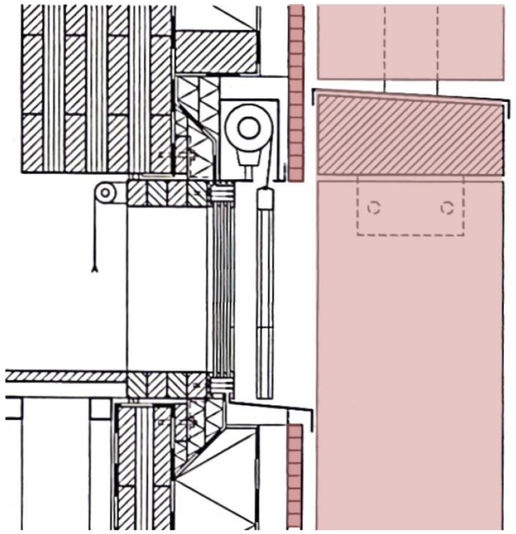
Layers			Element Names		1	2	3	9	10	4	12	5	6	7	8	11	15	16	14	24	23	18	13	17	31	22	20	21	19	27	25	26	28	29	30	
		STRUCTURE	Concrete foundation	1		1	1																													
			Concrete core with staircase	2	1		1												1	1	1	1		1	1		1	1	1	1		1			1	
			Glulam timber structural frame	3	1	1		1		1		1	1	1					1		1			1			1	1								
		SKIN (facade)	Larch lesene	9			1		1	1																										ROUND 4
			Larch mullion with sheet metal coping	10				1		1																										
			Larch facade panels	4			1	1	1		1	1																								ROUND 3
			Window blinds (outdoor)	12						1			1																							ROUND 2
			Insulation and sealant (exterior wall)	5			1			1				1																						
			Curtain walls (triple glazing in spruce frame)	6			1				1				1	1	1																			ROUND 1
			CLT walls (exterior)	7			1					1	1		1																					
			Doors (exterior)	8									1	1																						ROUND 2
			Window blinds (indoor)	11									1																							
		SKIN (roof)	Insulation and sealant (roof)	15														1	1	1																
			Aluminum coping (roof)	16													1																				
			CLT ceiling (roof)	14		1	1										1				1				1	1										
			Doors (interior)	24		1															1								1							
			Partition walls (timber frame and various panels)	23		1	1												1	1		1					1	1								
	SPACE PLAN	SERVICES	Ventilation system	18		1															1														
			Spruce window seats	13																				1				1								
		SERVICES	Electrical wiring and data cables	17		1	1												1				1		1		1						1		
			Lighting	31		1													1					1		1	1								
			Acoustic ceiling	22																					1		1								
			CLT floor panels	20		1	1														1			1	1	1		1							
			Flooring finishes and insulation	21		1	1													1	1		1				1		1	1	1			1		
STUFF		SERVICES	Water pipes	19		1																					1		1	1	1				
			Kitchen cabinets and sinks	27		1																					1	1			1	1			
			Toilet fixtures	25																							1	1							
			Plumbing accessories (faucet, pipes)	26		1																							1	1					
			Appliances	28																				1						1			1		
			Furnitures	29																							1						1		
			Hanging greenery	30		1																													

Appendix 8. Impact analysis on Case 1: Library and Seminar Centre (curtain walls). (self made)



Layers			Element Names		1	2	3	9	10	4	12	5	6	7	8	11	15	16	14	24	23	18	13	17	31	22	20	21	19	27	25	26	28	29	30	
		STRUCTURE	Concrete foundation	1		1	1																													
			Concrete core with staircase	2	1		1												1	1	1	1		1	1		1	1	1	1		1			1	
			Glulam timber structural frame	3	1	1		1		1		1	1	1					1		1			1			1	1								
		SKIN (facade)	Larch lesene	9			1		1	1																										ROUND 2
			Larch mullion with sheet metal coping	10				1		1																										
			Larch facade panels	4			1	1	1		1	1																								ROUND 1
			Window blinds (outdoor)	12						1			1																							
			Insulation and sealant (exterior wall)	5			1			1				1																						
			Curtain walls (triple glazing in spruce frame)	6			1				1				1	1	1																			
			CLT walls (exterior)	7			1					1	1		1																					
			Doors (exterior)	8									1	1																						
			Window blinds (indoor)	11									1																							
		SKIN (roof)	Insulation and sealant (roof)	15														1	1																	
			Aluminum coping (roof)	16													1																				
			CLT ceiling (roof)	14		1	1										1				1				1	1										
			Doors (interior)	24		1															1								1							
			Partition walls (timber frame and various panels)	23		1	1												1	1		1					1	1								
	SPACE PLAN	SERVICES	Ventilation system	18		1															1														
			Spruce window seats	13																				1				1								
		SERVICES	Electrical wiring and data cables	17		1	1												1				1		1		1						1		
			Lighting	31		1													1					1		1	1								
			Acoustic ceiling	22																					1		1								
			CLT floor panels	20		1	1														1			1	1	1		1							
			Flooring finishes and insulation	21		1	1													1	1		1				1		1	1	1			1		
STUFF		SERVICES	Water pipes	19		1																					1		1	1	1				
			Kitchen cabinets and sinks	27		1																					1	1			1	1			
			Toilet fixtures	25																							1	1							
			Plumbing accessories (faucet, pipes)	26		1																							1	1					
			Appliances	28																				1						1			1		
			Furnitures	29																							1						1		
			Hanging greenery	30		1																													

Appendix 9. Impact analysis on Case 1: Library and Seminar Centre (larch facade panel). (self made)

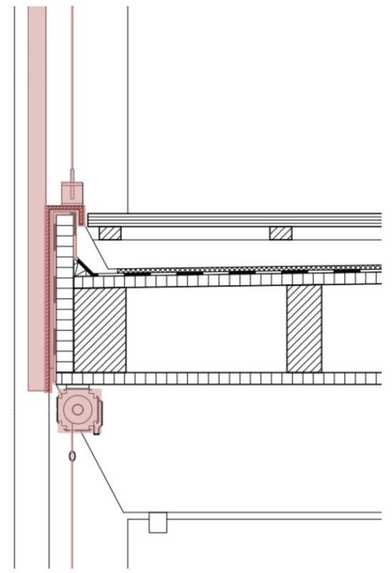


Appendix 12. Details of the facade of Case 1. Analysis on curtain walls (up) and larch facade panel (down). (self analysed on drawings from Sandra, H., 2022)

IMPACT ANALYSIS - SKIN (CASE 2)

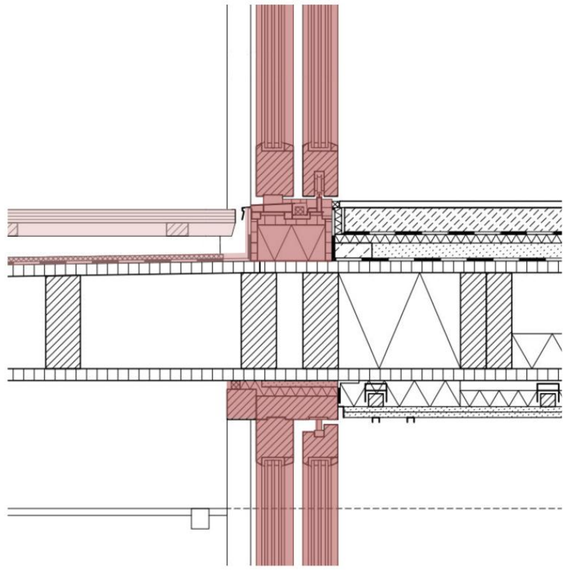
Layers			Element Names		1	5	2	3	4	20	7	6	8	9	11	10	12	13	17	16	15	14	19	24	18	31	28	21	23	22	25	26	27	29	30	
		STRUCTURE	Existing concrete storeys and foundation	1		1	1																												
			Steel beams (structural transition)	5	1		1	1	1																											
			Extended concrete cores (lifts and stairwells)	2	1	1		1	1								1							1				1	1							
			Glulam timber structural frame (beams and supports)	3		1	1		1							1	1	1						1				1								
			Timber box ceiling with three-layer panel cladding	4		1	1	1		1		1	1	1	1		1	1		1		1	1	1	1				1	1						
		SERVICES	Drainage and pipes	20					1					1	1						1		1		1			1	1	1		1	1	1		
		SKIN (balcony)	Steel railing	7								1																							ROUND 2
			Facade panel assemblies	6					1		1		1	1	1																				ROUND 1
			Sun blinds	8					1			1		1																					ROUND 2
			Balcony timber floor	9					1	1		1	1		1	1																			
			Balcony water-proofing layer	11					1	1		1		1			1	1																		ROUND 2
			Balcony partitions	10				1						1					1																
			Timber sliding doors	12			1	1	1						1			1	1																
			Exterior walls (timber stud+insulation+plasterboard)	13				1	1							1	1	1		1															
			Windows	17														1																	
		SKIN (roof)	Parapet wall	16					1													1													
			Extensive vegetation (roof)	15						1												1													
	SPACE PLAN		Roof finishes and insulation	14					1	1										1	1		1												
		SERVICES	Ventilation system	19					1													1		1				1							
			Ceiling finishes	24			1	1	1	1													1		1	1			1						
		SERVICES	Electrical cables	18					1															1		1	1	1							
			Lighting	31																				1	1										
			Integrated kitchen cabinets	28						1															1			1							
			Partition walls (timber stud+insulation+plasterboard)	21			1	1	1	1													1	1	1		1		1	1	1	1	1	1	
			Flooring finishes	23			1		1	1																		1	1	1	1	1	1		1
			Doors (interior)	22																								1	1						
STUFF			Bathroom pods	25						1																		1	1						
			Toilet fixtures	26						1																		1	1						
			Cabinet with sink (toilet)	27						1																		1	1						
			Built-in wardrobe	29																								1							
			Furnitures	30																									1						

Appendix 10. Impact analysis on Case 2: Pile up Giesshübel (facade panel assembles). (self made)



Layers			Element Names		1	5	2	3	4	20	7	6	8	9	11	10	12	13	17	16	15	14	19	24	18	31	28	21	23	22	25	26	27	29	30	
		STRUCTURE	Existing concrete storeys and foundation	1		1	1																												
			Steel beams (structural transition)	5	1		1	1	1																											
			Extended concrete cores (lifts and stairwells)	2	1	1		1	1								1							1				1	1							
			Glulam timber structural frame (beams and supports)	3		1	1		1							1	1	1						1				1								
			Timber box ceiling with three-layer panel cladding	4		1	1	1		1		1	1	1	1		1	1		1		1	1	1	1				1	1						
		SERVICES	Drainage and pipes	20					1					1	1						1		1		1			1	1	1		1	1	1		
		SKIN (balcony)	Steel railing	7								1																							
			Facade panel assemblies	6					1		1		1	1	1																					
			Sun blinds	8					1			1		1																						
			Balcony timber floor	9					1	1		1	1		1	1																				ROUND 3
			Balcony water-proofing layer	11					1	1		1		1			1	1																		ROUND 2
			Balcony partitions	10				1						1					1																	ROUND 4
			Timber sliding doors	12			1	1	1						1			1	1																	ROUND 1
			Exterior walls (timber stud+insulation+plasterboard)	13				1	1							1	1	1		1																
			Windows	17														1																		
		SKIN (roof)	Parapet wall	16					1													1														
			Extensive vegetation (roof)	15						1												1														
	SPACE PLAN		Roof finishes and insulation	14					1	1										1	1		1													
		SERVICES	Ventilation system	19					1													1		1				1								
			Ceiling finishes	24			1	1	1	1													1		1	1			1							
		SERVICES	Electrical cables	18					1															1		1	1	1								
			Lighting	31																				1	1											
			Integrated kitchen cabinets	28						1															1			1								
			Partition walls (timber stud+insulation+plasterboard)	21			1	1	1	1													1	1	1		1		1	1	1	1	1	1	
			Flooring finishes	23			1		1	1																		1	1	1	1	1	1		1
			Doors (interior)	22																								1	1						
STUFF			Bathroom pods	25						1																		1	1						
			Toilet fixtures	26						1																		1	1						
			Cabinet with sink (toilet)	27						1																		1	1						
			Built-in wardrobe	29																								1							
			Furnitures	30																									1						

Appendix 11. Impact analysis on Case 2: Pile up Giesshübel (timber sliding doors). (self made)

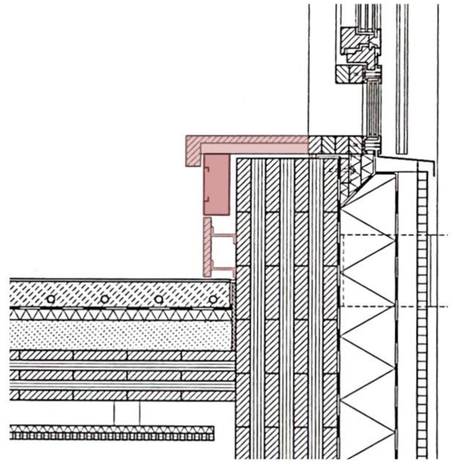


Appendix 13. Details of the balcony of Case 2. Analysis on facade panel assembles (up) and timber sliding doors (down). (self analysed on drawings from Kaufmann, H., Krötsch, S. & Winter, S., 2018)

IMPACT ANALYSIS - SERVICES (CASE 1)

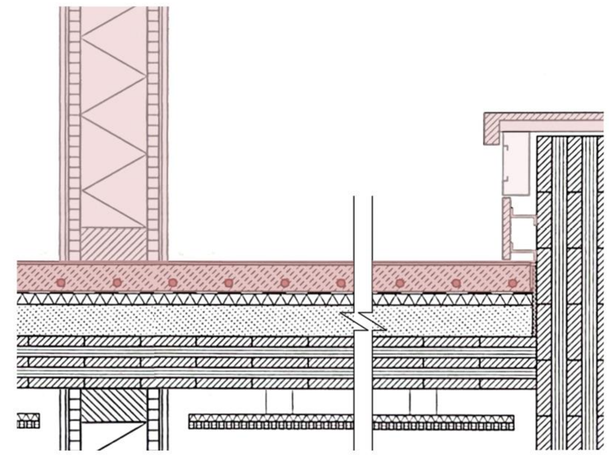
Layers			Element Names		1	2	3	9	10	4	12	5	6	7	8	11	15	16	14	24	23	18	13	17	31	22	20	21	19	27	25	26	28	29	30	
		STRUCTURE	Concrete foundation	1		1	1																													
			Concrete core with staircase	2	1		1												1	1	1	1		1	1		1	1	1	1		1			1	
			Glulam timber structural frame	3	1	1		1		1		1	1	1					1		1			1			1	1							
		SKIN (facade)	Larch lesene	9			1		1	1																										
			Larch mullion with sheet metal coping	10				1		1																										
			Larch facade panels	4			1	1	1		1	1																								
			Window blinds (outdoor)	12						1			1																							
			Insulation and sealant (exterior wall)	5			1			1				1																						
			Curtain walls (triple glazing in spruce frame)	6			1				1			1	1	1																				
			CLT walls (exterior)	7			1					1	1		1																					
			Doors (exterior)	8									1	1																						
			Window blinds (indoor)	11									1																							
		SKIN (roof)	Insulation and sealant (roof)	15														1	1	1																
			Aluminum coping (roof)	16													1																				
	SPACE PLAN		CLT ceiling (roof)	14		1	1										1				1			1	1											
			Doors (interior)	24		1															1							1								
			Partition walls (timber frame and various panels)	23		1	1												1	1		1					1	1								
		SERVICES	Ventilation system	18		1															1															
			Spruce window seats	13																			1	1				1								ROUND 2
		SERVICES	Electrical wiring and data cables	17		1	1												1				1		1		1						1		ROUND 1
			Lighting	31		1													1					1		1	1								
			Acoustic ceiling	22																					1		1									
			CLT floor panels	20		1	1														1			1	1	1										
			Flooring finishes and insulation	21		1	1													1	1		1				1	1	1	1	1		1		
STUFF		SERVICES	Water pipes	19		1																						1		1	1				
			Kitchen cabinets and sinks	27		1																						1	1			1	1			
			Toilet fixtures	25																								1	1							
			Plumbing accessories (faucet, pipes)	26		1																							1	1						
			Appliances	28																				1						1				1		
			Furnitures	29																								1					1			
			Hanging greenery	30		1																														

Appendix 14. Impact analysis on Case 1: Library and Seminar Centre (electrical wiring and cables). (self made)



Layers			Element Names		1	2	3	9	10	4	12	5	6	7	8	11	15	16	14	24	23	18	13	17	31	22	20	21	19	27	25	26	28	29	30	
		STRUCTURE	Concrete foundation	1		1	1																													
			Concrete core with staircase	2	1		1												1	1	1	1		1	1		1	1	1	1		1			1	
			Glulam timber structural frame	3	1	1		1		1		1	1	1					1		1			1			1	1							
		SKIN (facade)	Larch lesene	9			1		1	1																										
			Larch mullion with sheet metal coping	10				1		1																										
			Larch facade panels	4			1	1	1		1	1																								
			Window blinds (outdoor)	12						1			1																							
			Insulation and sealant (exterior wall)	5			1			1				1																						
			Curtain walls (triple glazing in spruce frame)	6			1				1			1	1	1																				
			CLT walls (exterior)	7			1					1	1		1																					
			Doors (exterior)	8									1	1																						
			Window blinds (indoor)	11									1																							
		SKIN (roof)	Insulation and sealant (roof)	15														1	1	1																
			Aluminum coping (roof)	16													1																				
	SPACE PLAN		CLT ceiling (roof)	14		1	1										1				1			1	1											
			Doors (interior)	24		1															1							1								ROUND 4
			Partition walls (timber frame and various panels)	23		1	1												1	1		1					1	1								ROUND 3
		SERVICES	Ventilation system	18		1															1															
			Spruce window seats	13																			1	1				1								ROUND 3
		SERVICES	Electrical wiring and data cables	17		1	1												1				1		1		1						1		ROUND 4
			Lighting	31		1													1					1		1	1								
			Acoustic ceiling	22																					1		1									
			CLT floor panels	20		1	1														1			1	1	1										
			Flooring finishes and insulation	21		1	1													1	1		1				1	1	1	1	1		1		ROUND 2
STUFF		SERVICES	Water pipes	19		1																						1		1	1	1			ROUND 1
			Kitchen cabinets and sinks	27		1																						1	1			1	1			
			Toilet fixtures	25																								1	1							ROUND 2
			Plumbing accessories (faucet, pipes)	26		1																							1	1						
			Appliances	28																				1						1				1		ROUND 3
			Furnitures	29																								1					1			
			Hanging greenery	30		1																														

Appendix 15. Impact analysis on Case 1: Library and Seminar Centre (water pipes). (self made)

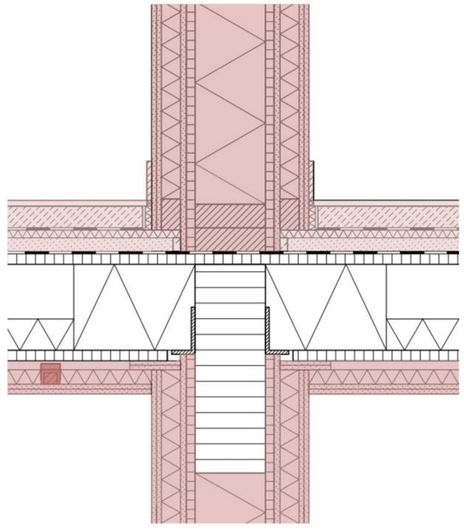


Appendix 18. Details of Case 1.
Analysis on electrical cables (up) and water pipes (down). (self analysed on drawings from Sandra, H., 2022)

IMPACT ANALYSIS - SERVICES (CASE 2)

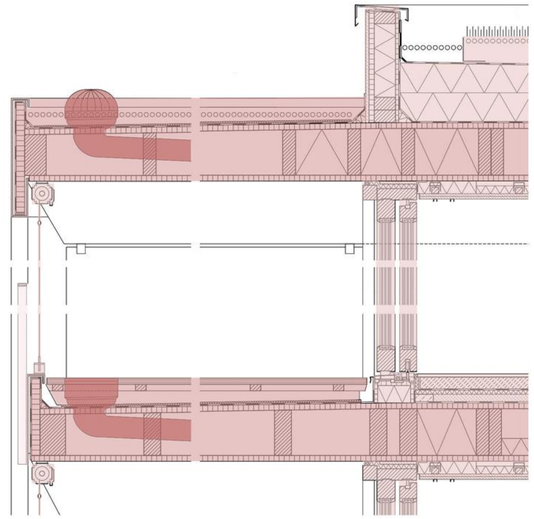
Layers			Element Names		1	5	2	3	4	20	7	6	8	9	11	10	12	13	17	16	15	14	19	24	18	31	28	21	23	22	25	26	27	29	30	
		STRUCTURE	Existing concrete storeys and foundation	1		1	1																													
			Steel beams (structural transition)	5	1		1	1	1																												
			Extended concrete cores (lifts and stairwells)	2	1	1		1	1								1							1				1	1							
			Glulam timber structural frame (beams and supports)	3		1	1		1							1	1	1						1				1								
			Timber box ceiling with three-layer panel cladding	4		1	1	1		1		1	1	1	1		1	1		1		1	1	1	1			1	1							
		SERVICES	Drainage and pipes	20					1					1	1						1	1		1			1	1	1		1	1	1			ROUND 4
		SKIN (balcony)	Steel railing	7							1	1																							
			Facade panel assemblies	6					1			1	1	1	1																					
			Sun blinds	8					1			1	1		1																					
			Balcony timber floor	9					1	1		1	1			1	1																			
			Balcony water-proofing layer	11					1	1		1		1				1	1																	
			Balcony partitions	10				1						1					1																	
			Timber sliding doors	12			1	1	1						1				1																	
			Exterior walls (timber stud+insulation+plasterboard)	13				1	1						1	1	1			1																
			Windows	17														1																		
		SKIN (roof)	Parapet wall	16					1													1														
			Extensive vegetation (roof)	15						1												1														
			Roof finishes and insulation	14					1	1											1	1		1												
		SERVICES	Ventilation system	19					1														1		1				1							ROUND 3
			Ceiling finishes	24			1	1	1	1														1	1	1		1								ROUND 2
		SERVICES	Electrical cables	18					1															1				1								ROUND 1
	SPACE PLAN		Lighting	31																				1	1											
			Integrated kitchen cabinets	28						1															1												ROUND 2
			Partition walls (timber stud+insulation+plasterboard)	21			1	1	1	1													1	1	1		1		1	1	1	1	1	1		
			Flooring finishes	23			1		1	1																		1		1	1	1	1		1	ROUND 3
			Doors (interior)	22																								1	1							
STUFF			Bathroom pods	25						1																		1	1							
			Toilet fixtures	26						1																		1	1							ROUND 4
			Cabinet with sink (toilet)	27						1																		1	1							
			Built-in wardrobe	29																								1								ROUND 3
			Furnitures	30																									1							ROUND 4

Appendix 16. Impact analysis on Case 2: Pile up Giesshübel (electrical cables). (self made)



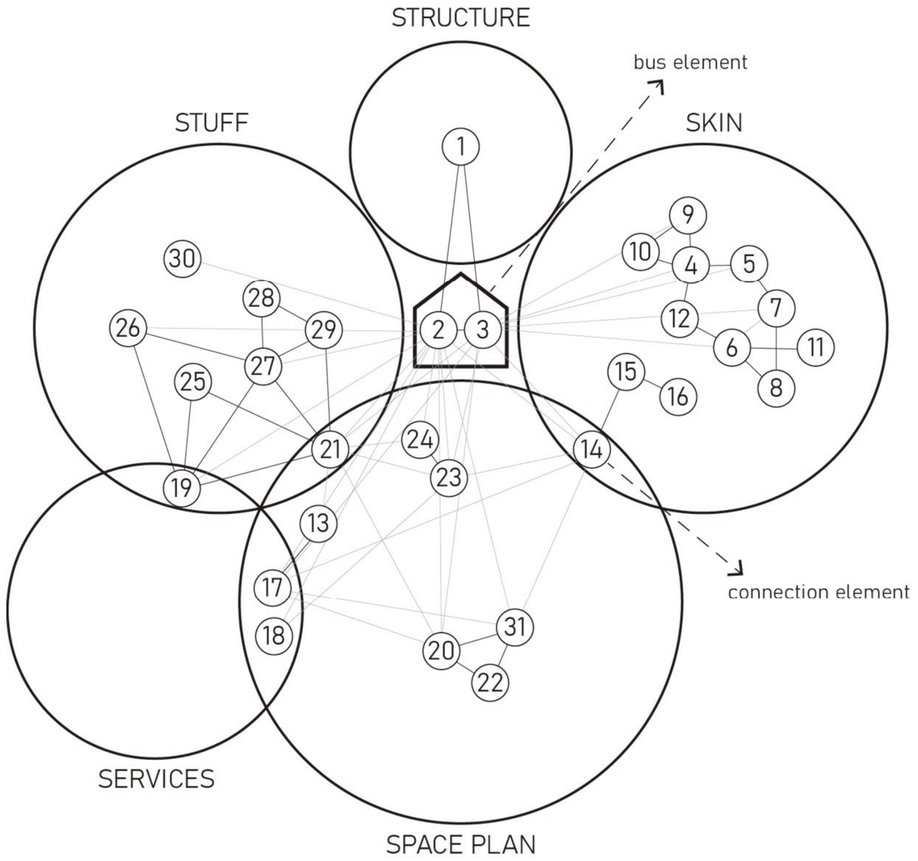
Layers			Element Names		1	5	2	3	4	20	7	6	8	9	11	10	12	13	17	16	15	14	19	24	18	31	28	21	23	22	25	26	27	29	30	
		STRUCTURE	Existing concrete storeys and foundation	1		1	1																													
			Steel beams (structural transition)	5	1		1	1	1																												
			Extended concrete cores (lifts and stairwells)	2	1	1		1	1								1							1				1	1							
			Glulam timber structural frame (beams and supports)	3		1	1		1							1	1	1						1				1								
			Timber box ceiling with three-layer panel cladding	4		1	1	1		1		1	1	1	1		1	1		1		1	1	1	1			1	1							ROUND 2
		SERVICES	Drainage and pipes	20					1					1	1						1	1		1			1	1	1		1	1	1			ROUND 1
		SKIN (balcony)	Steel railing	7							1	1																								ROUND 4
			Facade panel assemblies	6					1			1	1	1	1																					ROUND 3
			Sun blinds	8					1			1	1		1																					
			Balcony timber floor	9					1	1		1	1			1	1																				ROUND 2
			Balcony water-proofing layer	11					1	1		1		1				1	1																	
			Balcony partitions	10				1						1					1																	
			Timber sliding doors	12			1	1	1						1				1																		ROUND 3
			Exterior walls (timber stud+insulation+plasterboard)	13				1	1						1	1	1			1																
			Windows	17														1																		ROUND 4
		SKIN (roof)	Parapet wall	16					1													1														ROUND 3
			Extensive vegetation (roof)	15						1												1														ROUND 2
			Roof finishes and insulation	14					1	1											1	1		1												
		SERVICES	Ventilation system	19					1														1		1				1							ROUND 3
			Ceiling finishes	24			1	1	1	1														1	1	1		1								ROUND 2
		SERVICES	Electrical cables	18					1															1				1								
	SPACE PLAN		Lighting	31																				1	1											ROUND 3
			Integrated kitchen cabinets	28						1															1											
			Partition walls (timber stud+insulation+plasterboard)	21			1	1	1	1													1	1	1		1		1	1	1	1	1	1		ROUND 2
			Flooring finishes	23			1		1	1													1					1		1	1	1	1		1	ROUND 3
			Doors (interior)	22																								1	1							
STUFF			Bathroom pods	25						1																		1	1							
			Toilet fixtures	26						1																		1	1							ROUND 2
			Cabinet with sink (toilet)	27						1																		1	1							
			Built-in wardrobe	29																								1								ROUND 3
			Furnitures	30																									1							ROUND 4

Appendix 17. Impact analysis on Case 2: Pile up Giesshübel (drainage and water pipes). (self made)

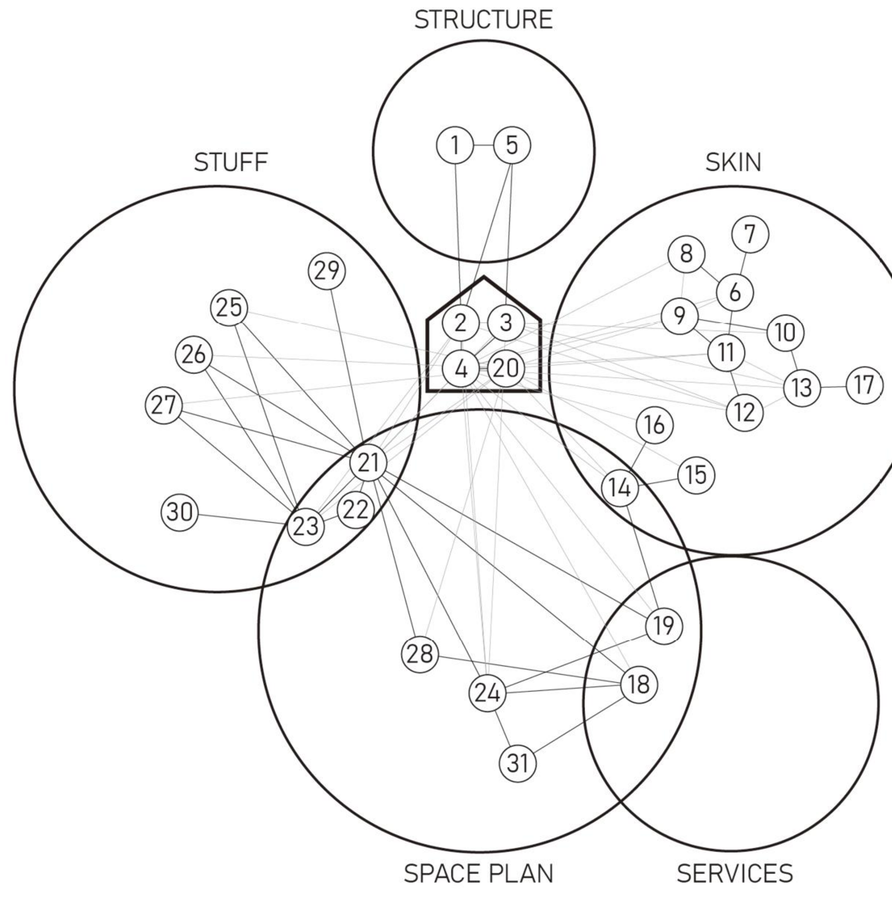


Appendix 19. Details of Case 2.
Analysis on electrical cables (up) and drainage & water pipes (down).
(self analysed on drawings from Kaufmann, H., Krötsch, S. & Winter, S., 2018)

CONCLUSION



CASE 1: Library and Seminar Centre



CASE 2: Pile up Giesshübel

1. The bus elements and connection elements need to be paid more attention to, having more extensive impacts;
2. Detached joint designs around them can considerably reduce propagated impacts;
3. Even though having detached joints around, the change of the bus elements still impacts all the elements depending on them.

FROM RESEARCH TO DESIGN

What can I learn from the research?
How does the results help my design?



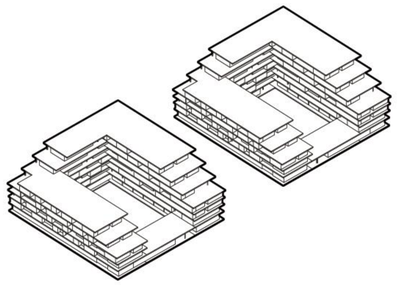
A methodology that can assess adaptability of an existing building;

Help locate the critical joint positions that affect adaptability under specific change scenes when designing a new project;

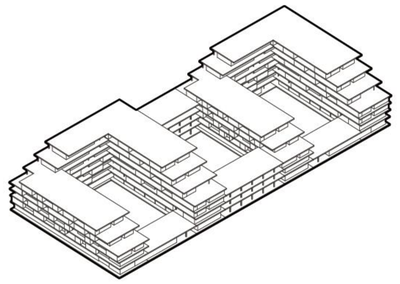
Detached joint design in these positions can greatly help the building to adapt future changes, while it is unnecessary in other unimportant positions.

DESIGN OBJECTIVE

Student Housing + Research & Companies = Mixed-use Complex



add business & research program



15 years

PHASE 1: STUDENT HOUSING

affordable and livable
at least 660 student housing units
+ communal spaces

PHASE 2: MIXED-USE COMMUNITY

develop working spaces
offices, studios, labs for institutes and companies
residential and business, co-exist

DESIGN QUESTION:

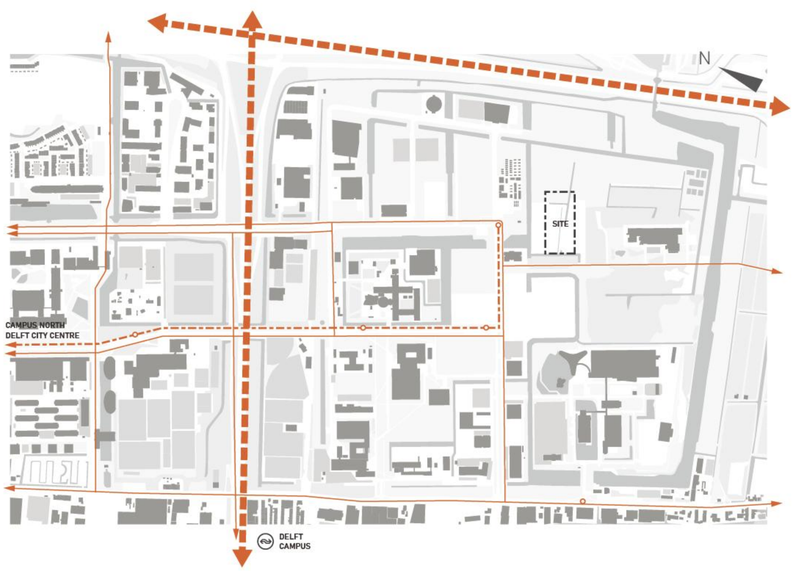
How can we design an adaptable timber building that is convertible and expandable from student housing towards a mix-use complex with a low cost?

SITE ANALYSIS

CURRENT (PHASE 1)





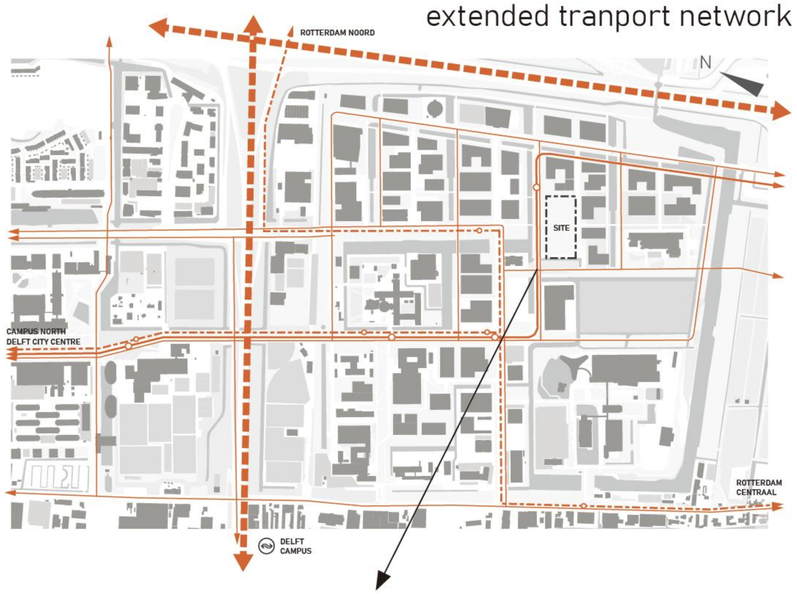


FUTURE (PHASE 2)

extended tranport network







- Housing
- Research & Companies
- Education & Research
- Public Service & Entertainment
- Infrustructure

extended green belt

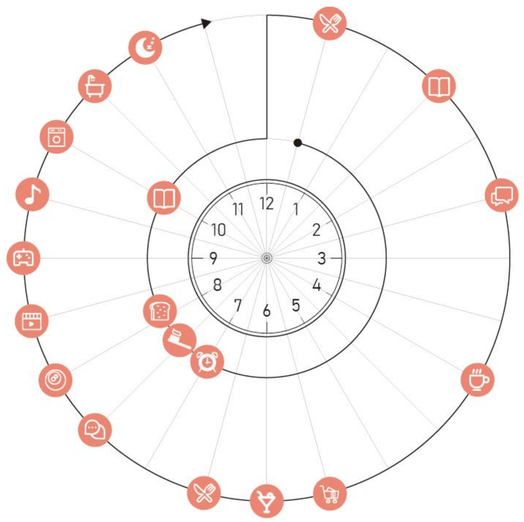
- Buildings
- Water
- Grassland
- Greenery
- Sport Fields

new tram line
beside the site

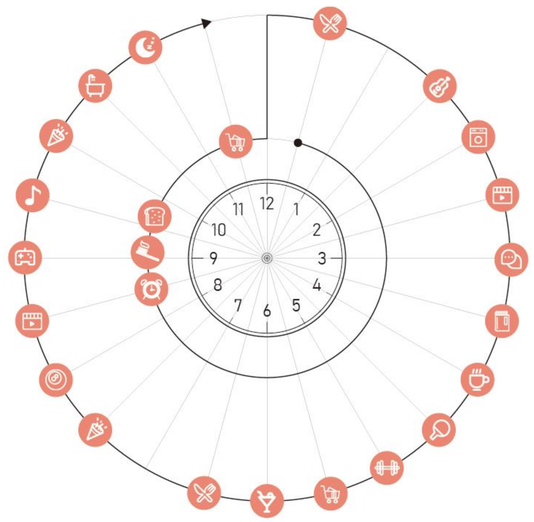
- Bicycle Lanes
- Highway
- Bus Lines
- Tram Lines

OCCUPANT & DEMAND ANALYSIS

PHASE 1



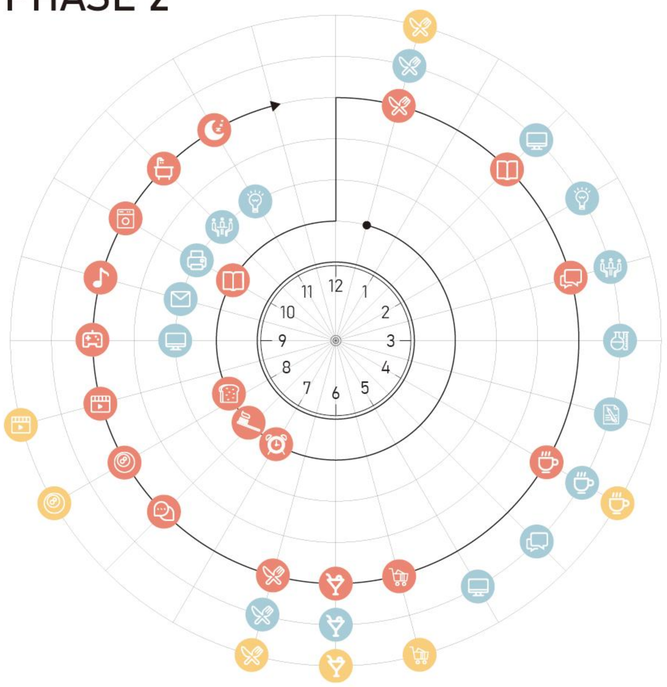
WORKDAY



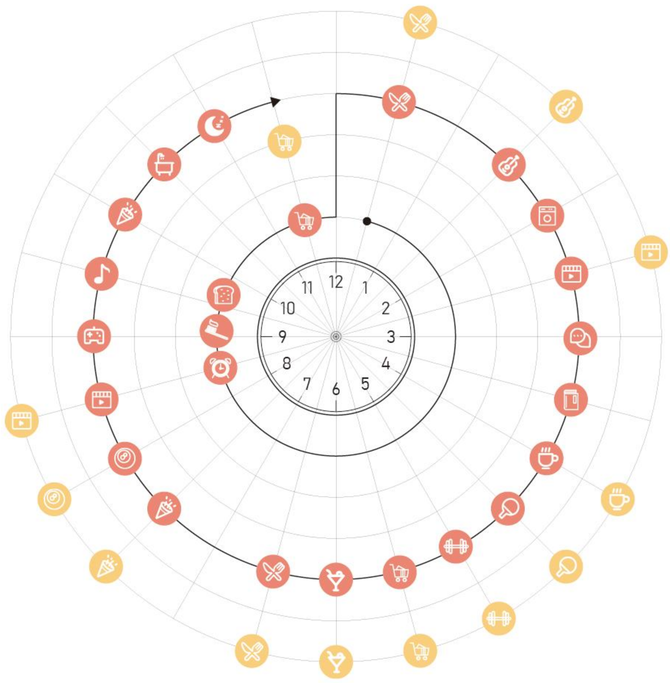
WEEKEND

residential rooms
basic services (mailbox, parking...)
self-study rooms
multi-functional spaces for
entertainment and communication
grocery, cafe

PHASE 2



WORKDAY



WEEKEND

add research & business
offices, labs, meeting rooms...

some communal spaces open to the public
can also add more entertainment and
commercial programs
restaurant, store...

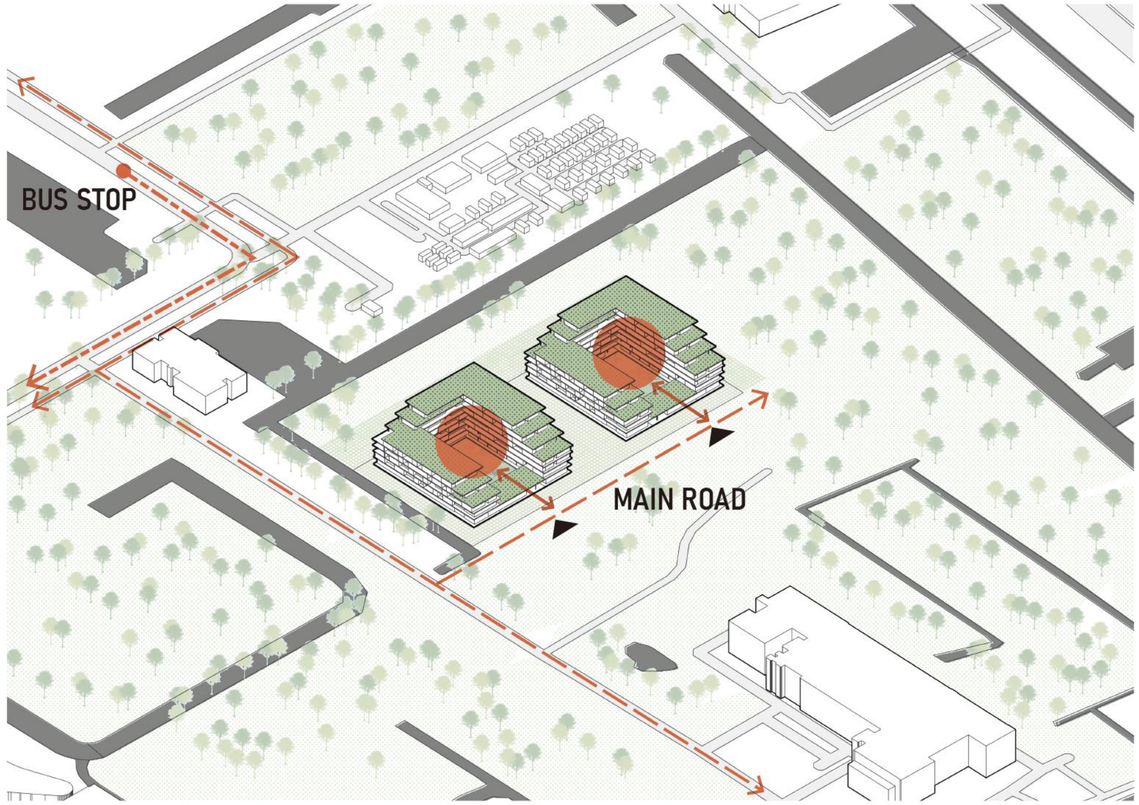
Students

Employees

Publics

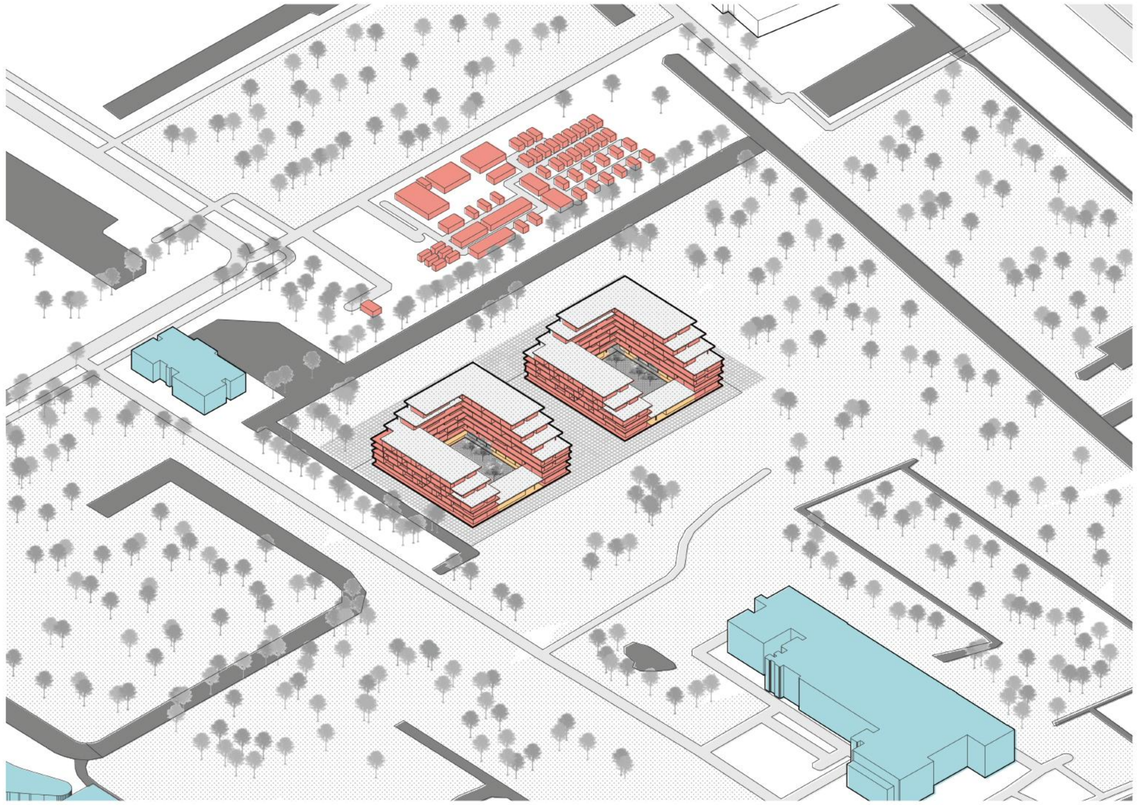
PROJECT PLANNING - PHASE 1

CIRCULATION

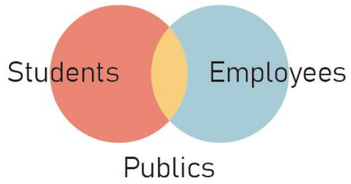


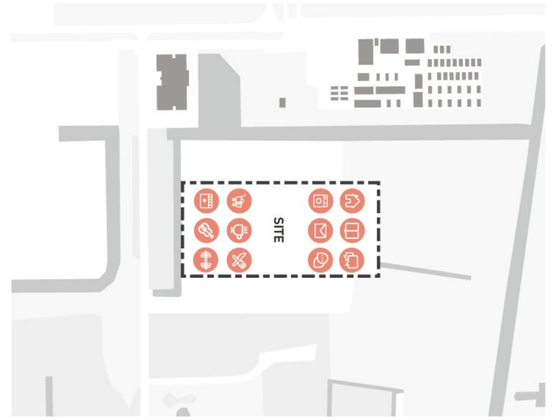
Circulation
Courtyard
Entrance
Bus Line
Tram Line
Bicycle Lane

PROGRAM



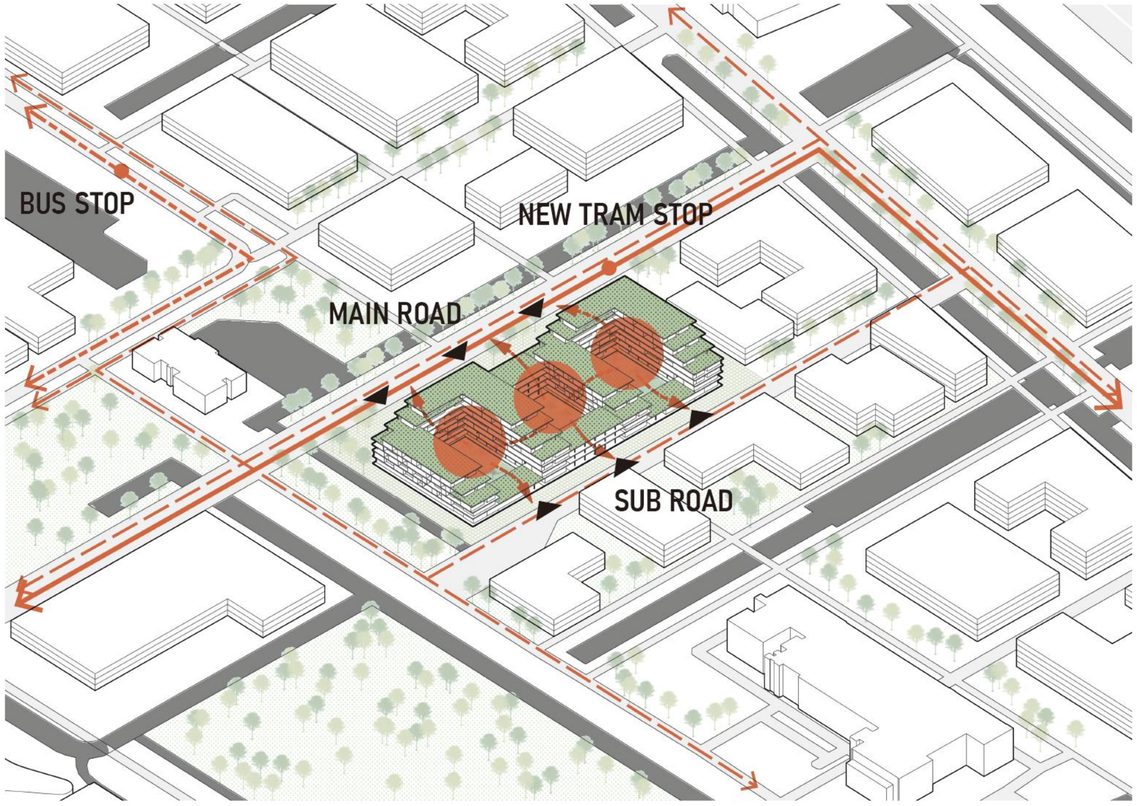
Housing
Research & Companies
Public Service & Entertainment





PROJECT PLANNING

CIRCULATION



Circulation

Courtyard

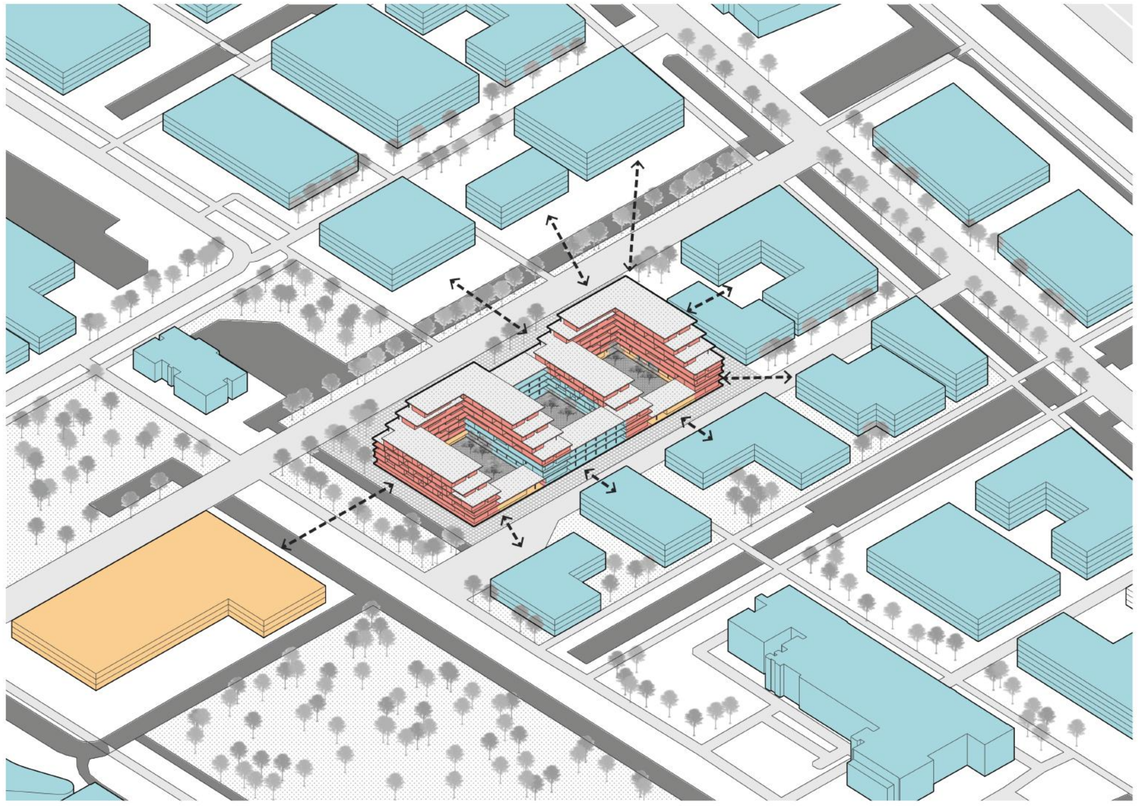
Entrance

Bus Line

Tram Line

Bicycle Lane

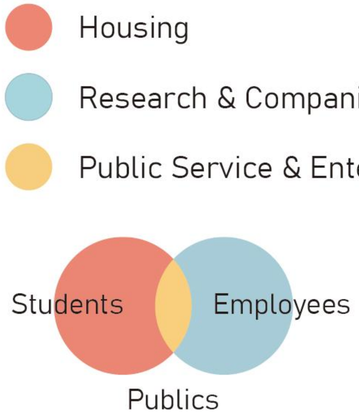
PROGRAM



Housing

Research & Companies

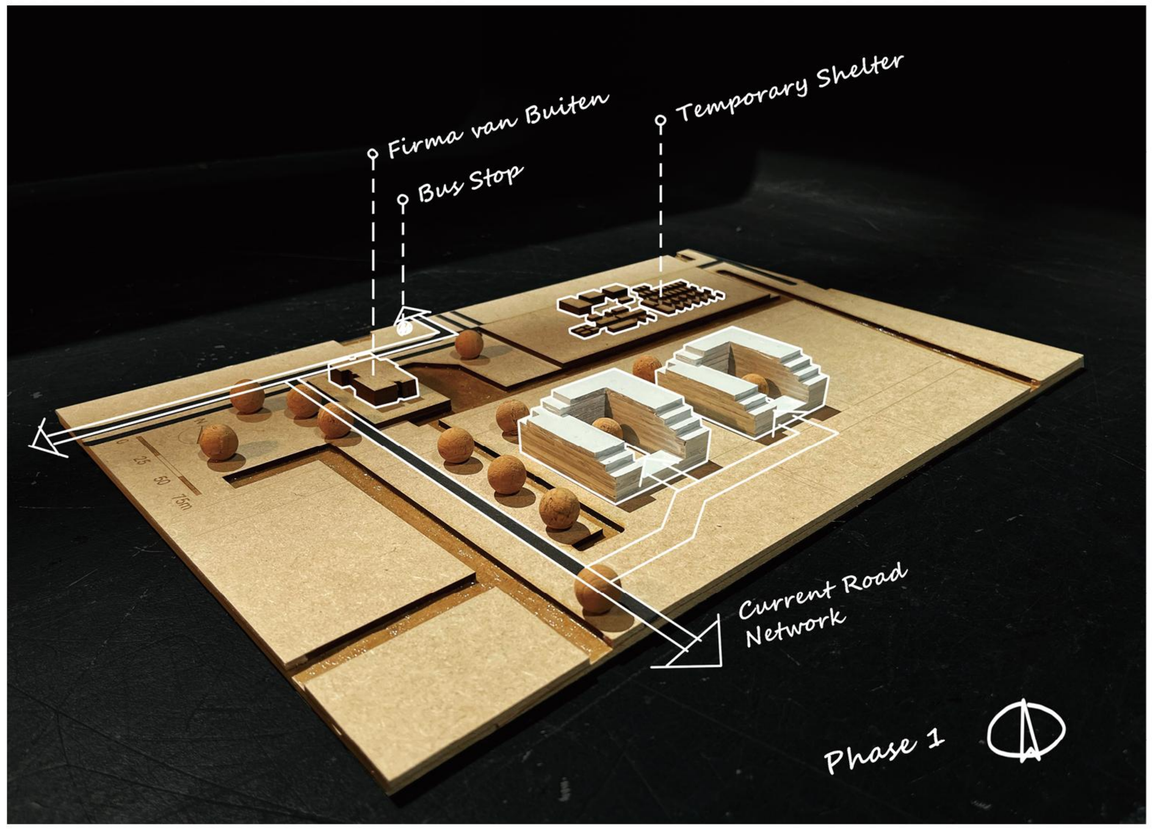
Public Service & Entertainment



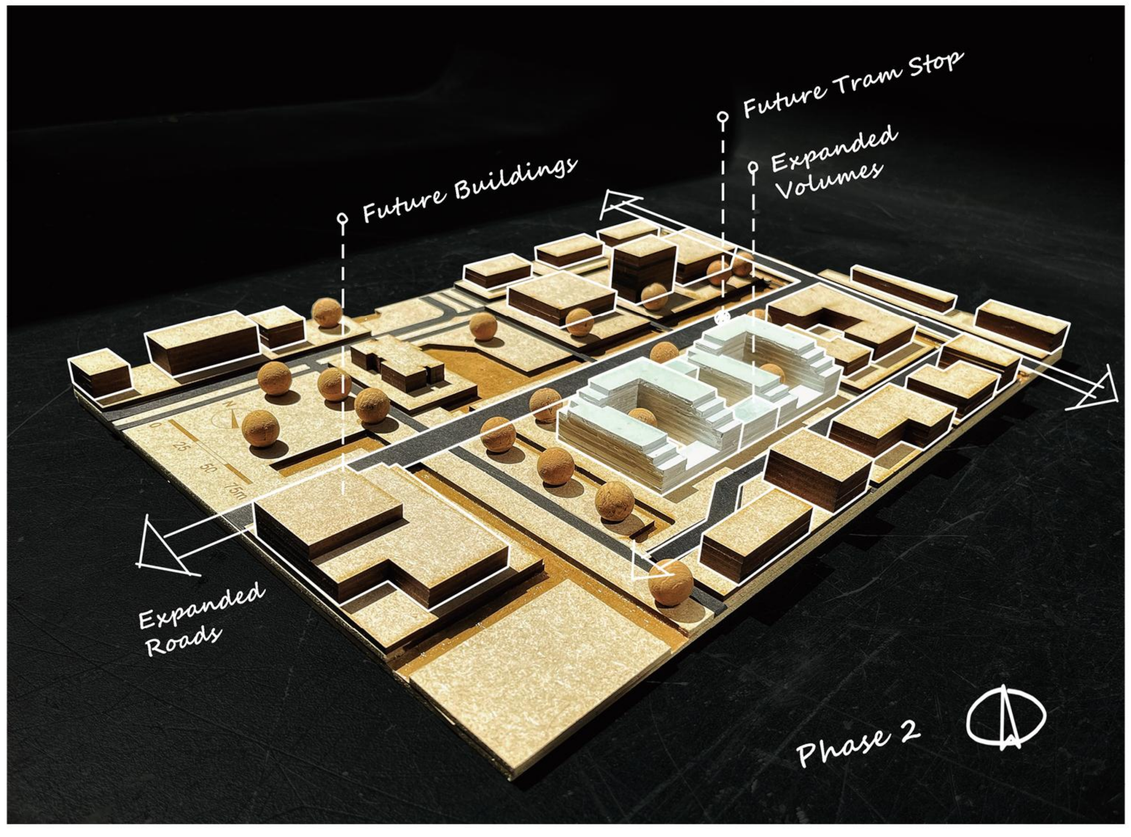


PROJECT PLANNING

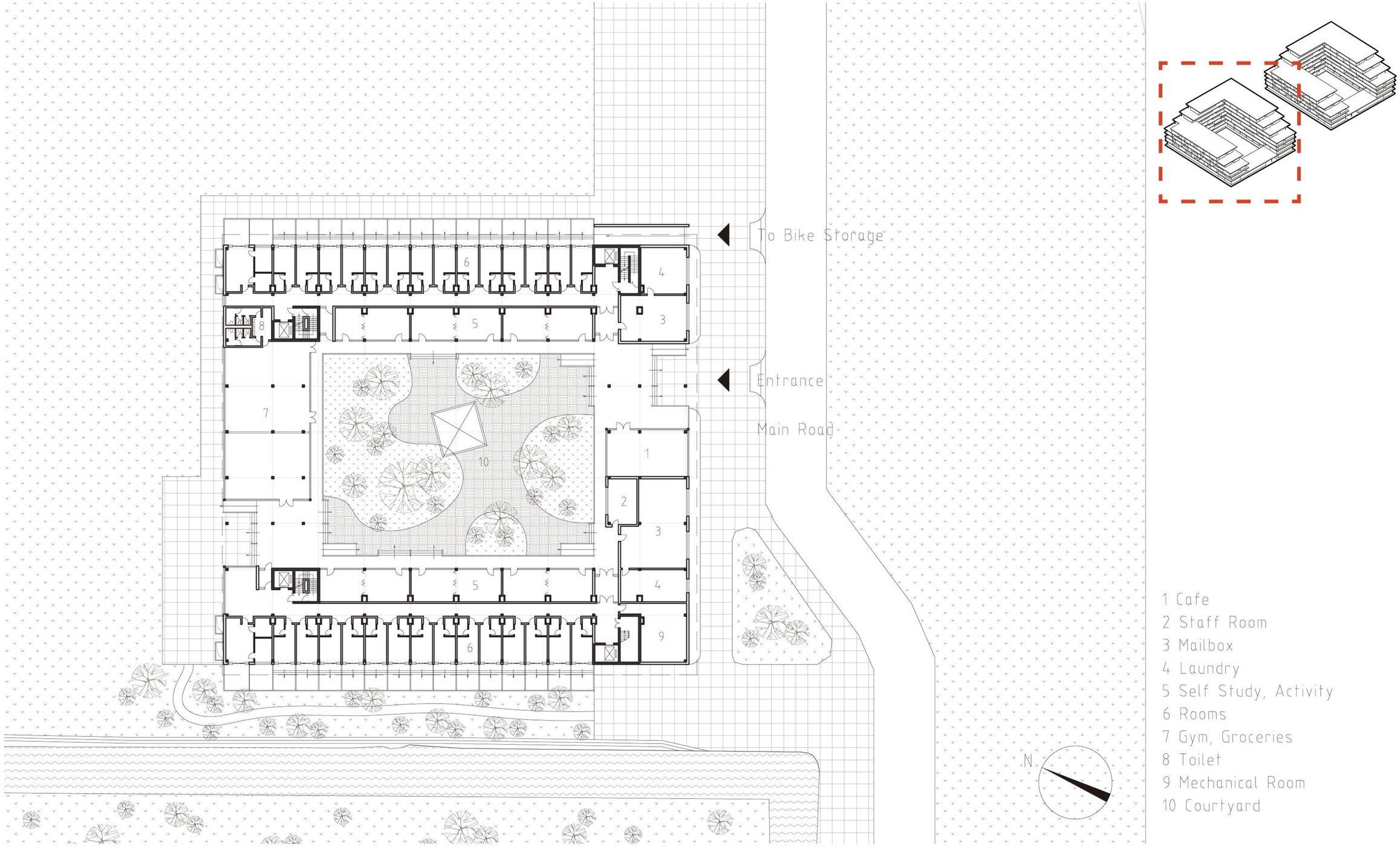
PHASE 1



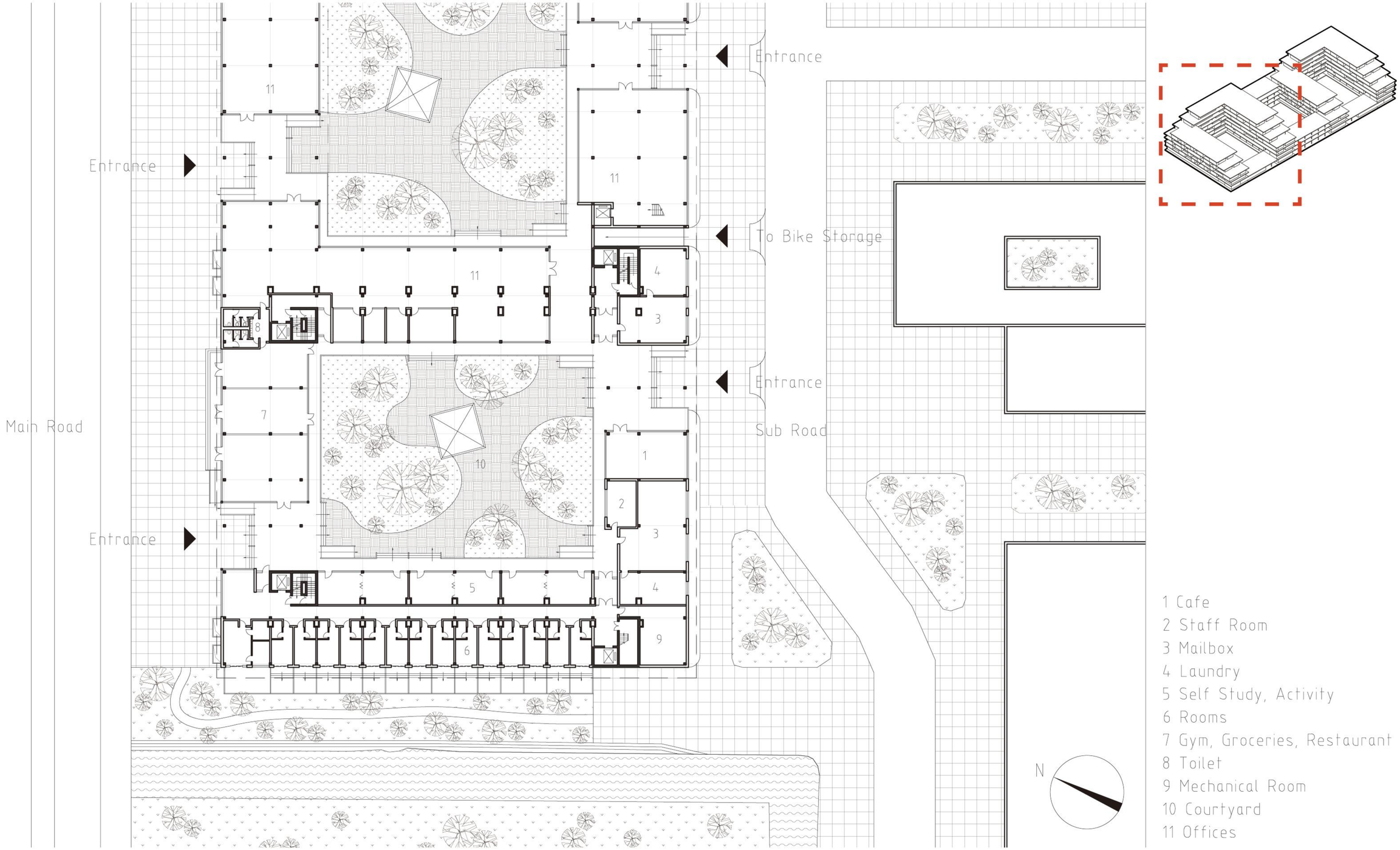
PHASE 2



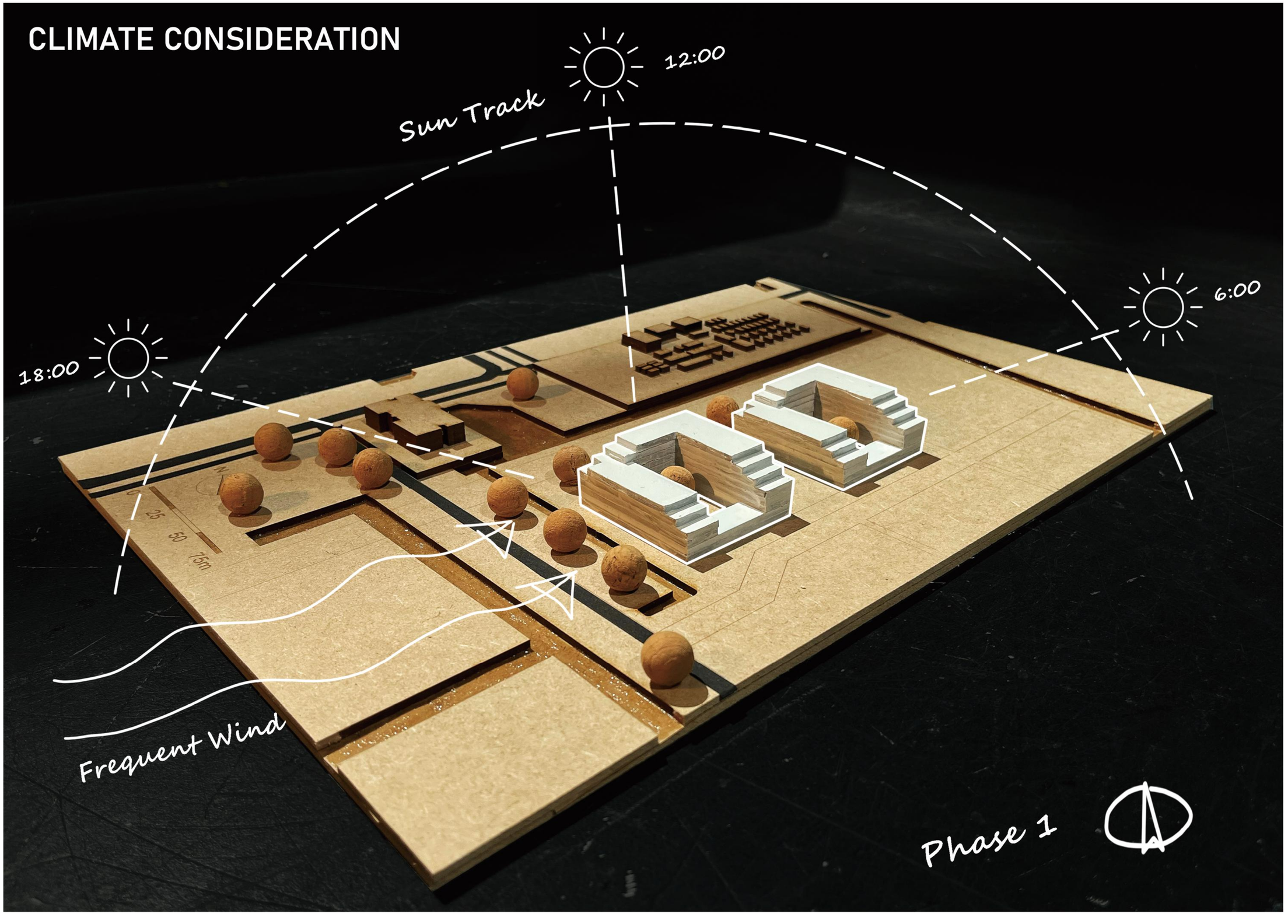
GROUND FLOOR PLAN - PHASE 1



GROUND FLOOR PLAN - PHASE 2

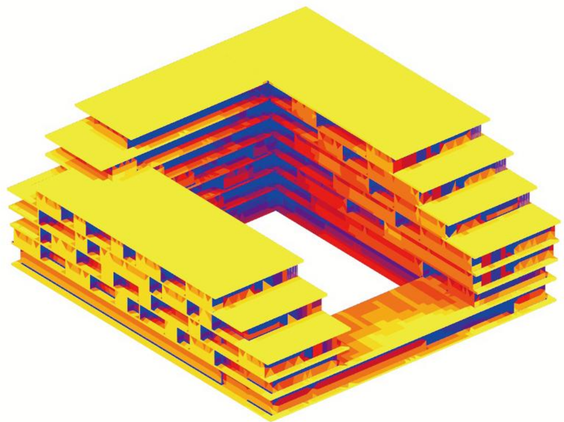


CLIMATE CONSIDERATION

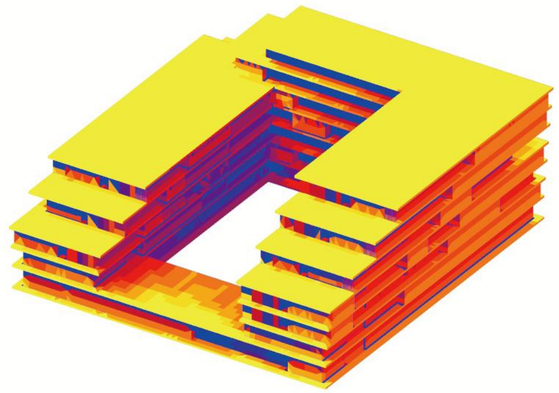


SUNLIGHT ANALYSIS

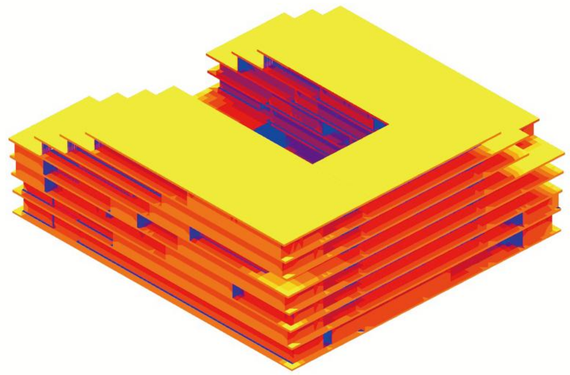
SUN HOUR ON SUMMER SOLSTICE



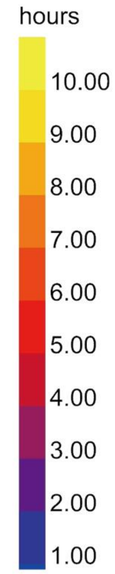
SOUNTH-WEST



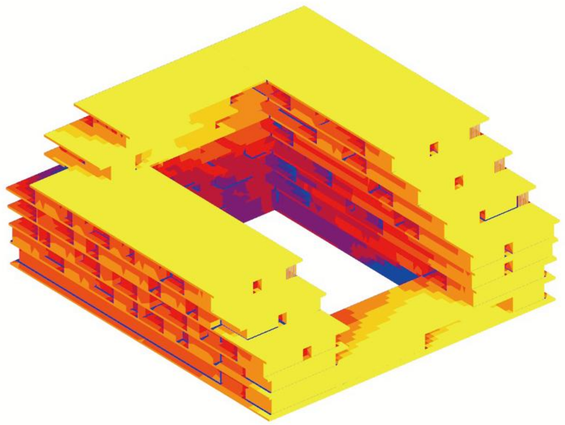
SOUNTH-EAST



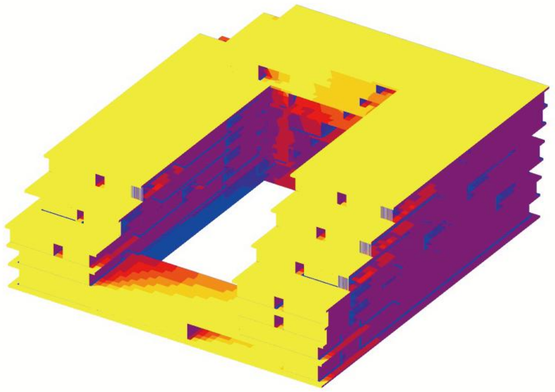
NORTH-EAST



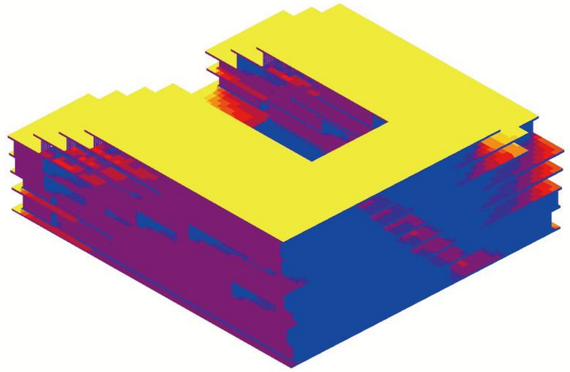
SUN HOUR ON WINTER SOLSTICE



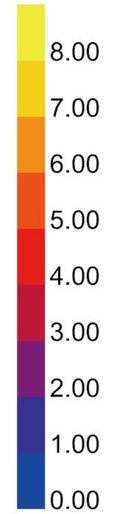
SOUNTH-WEST



SOUNTH-EAST



NORTH-EAST

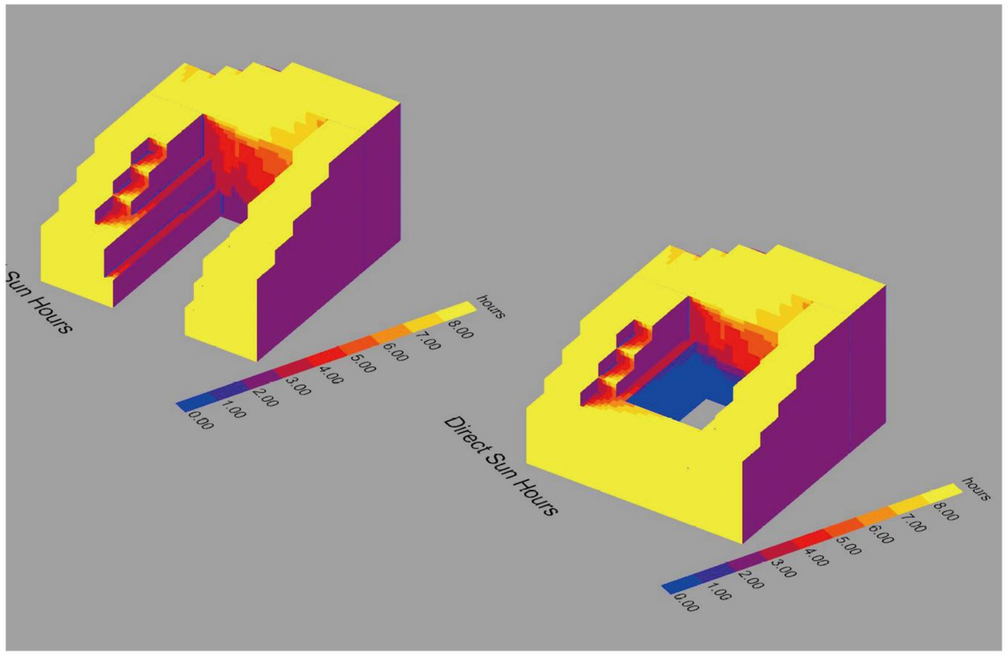


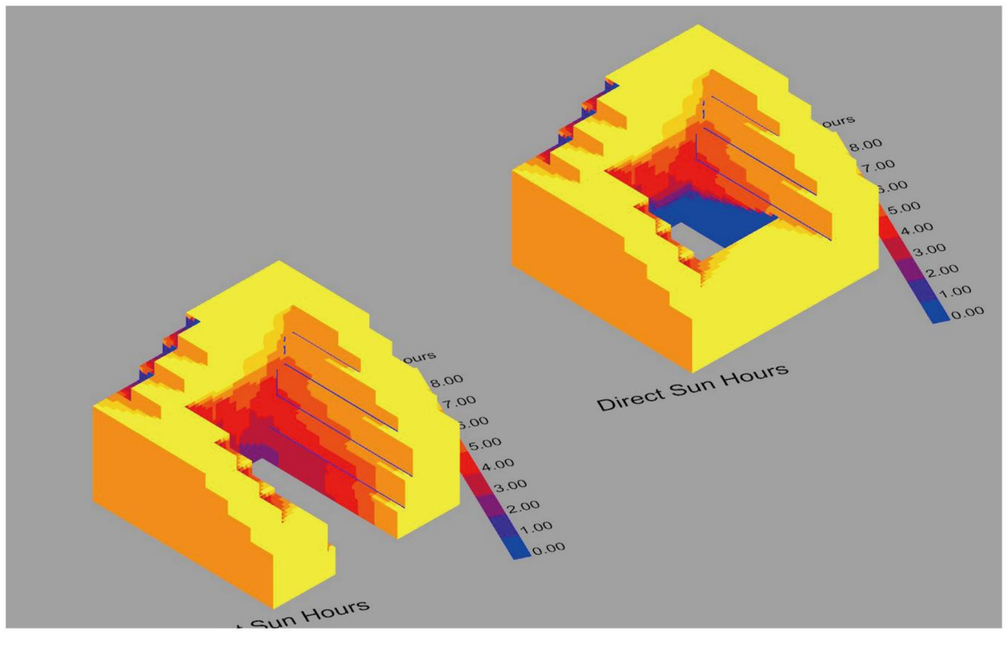
Influence on:
Volume (size, direction, height, distance...)
Space Arrangement (room location...)
Facade (overhang, adaptable facade...)

Aim:
Enough sunlight in winter
Less direct sunlight in summer

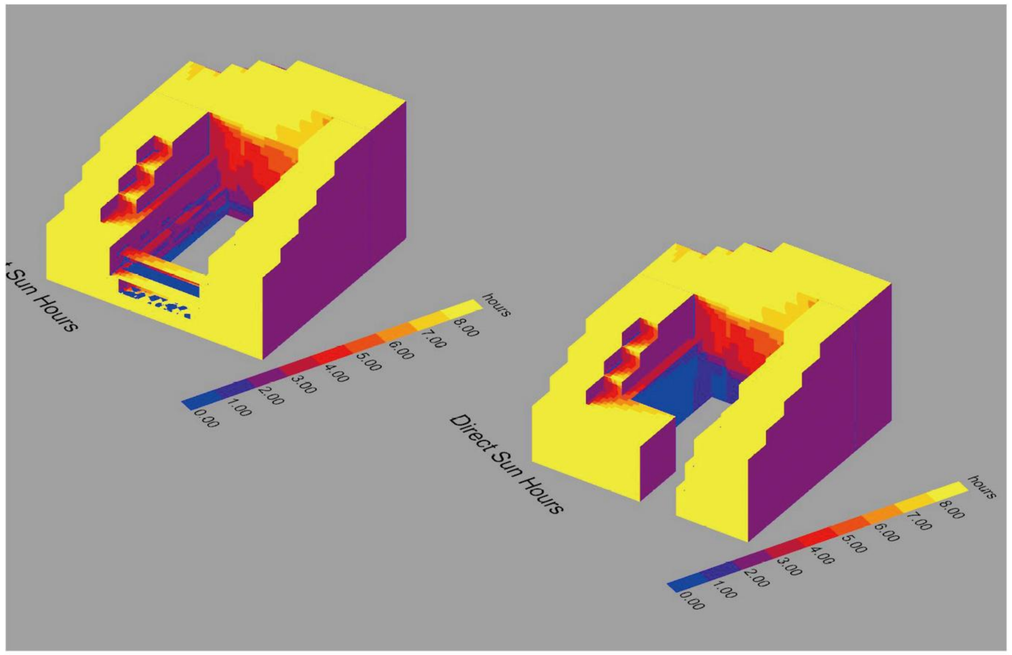
COMPARISON DURING DESIGN

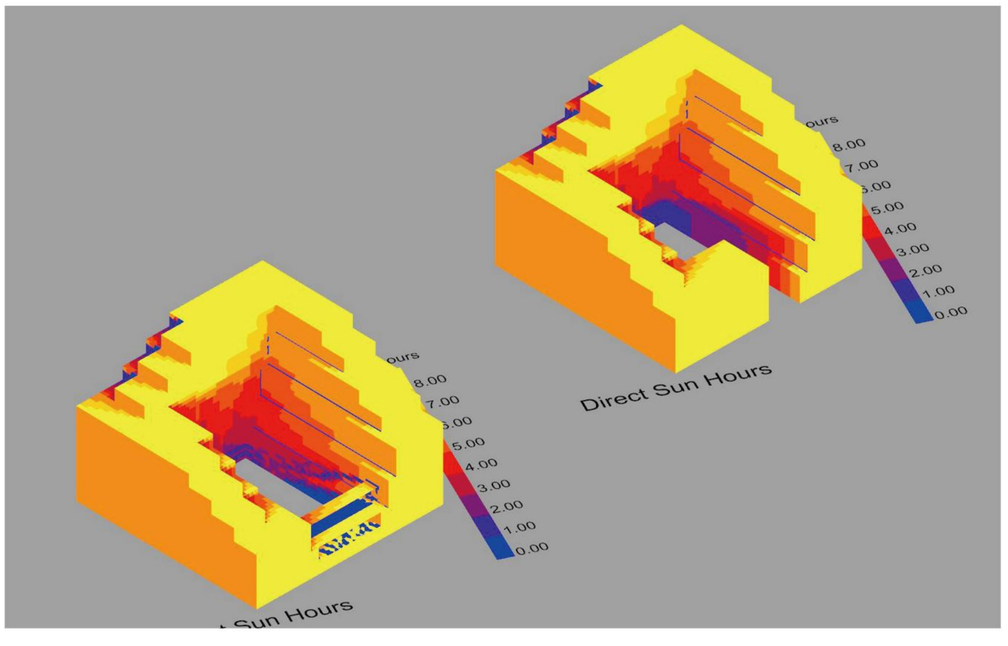
COMPARISON 1





COMPARISON 2

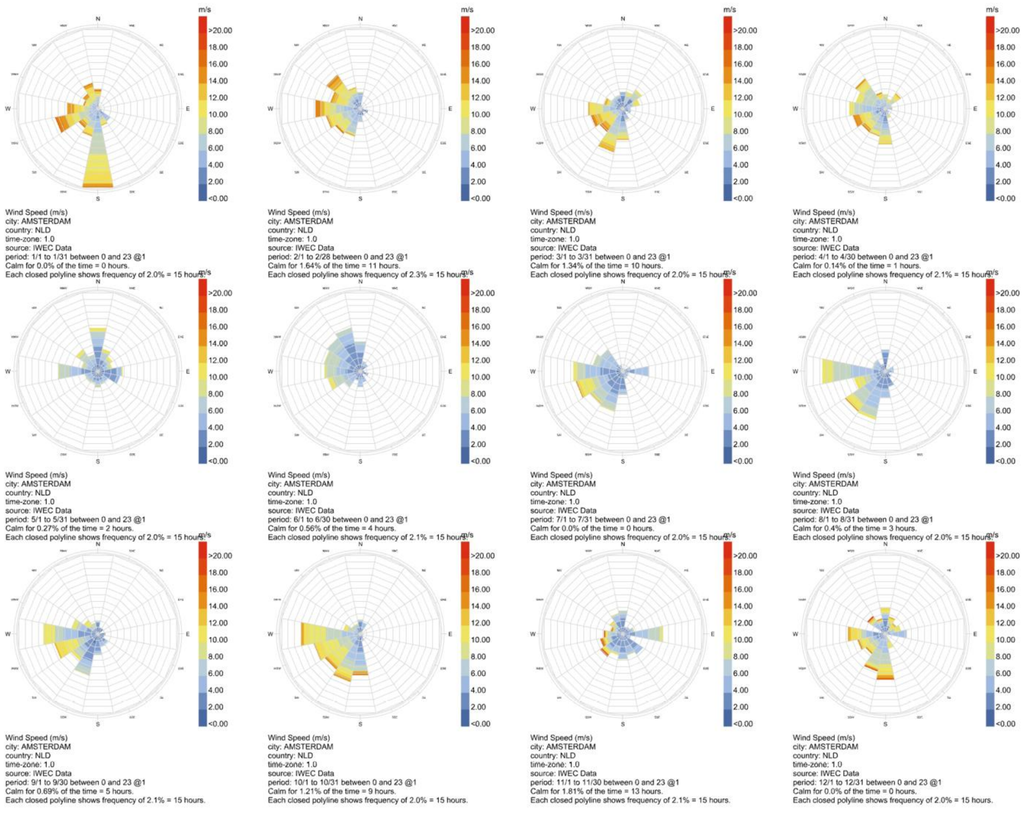


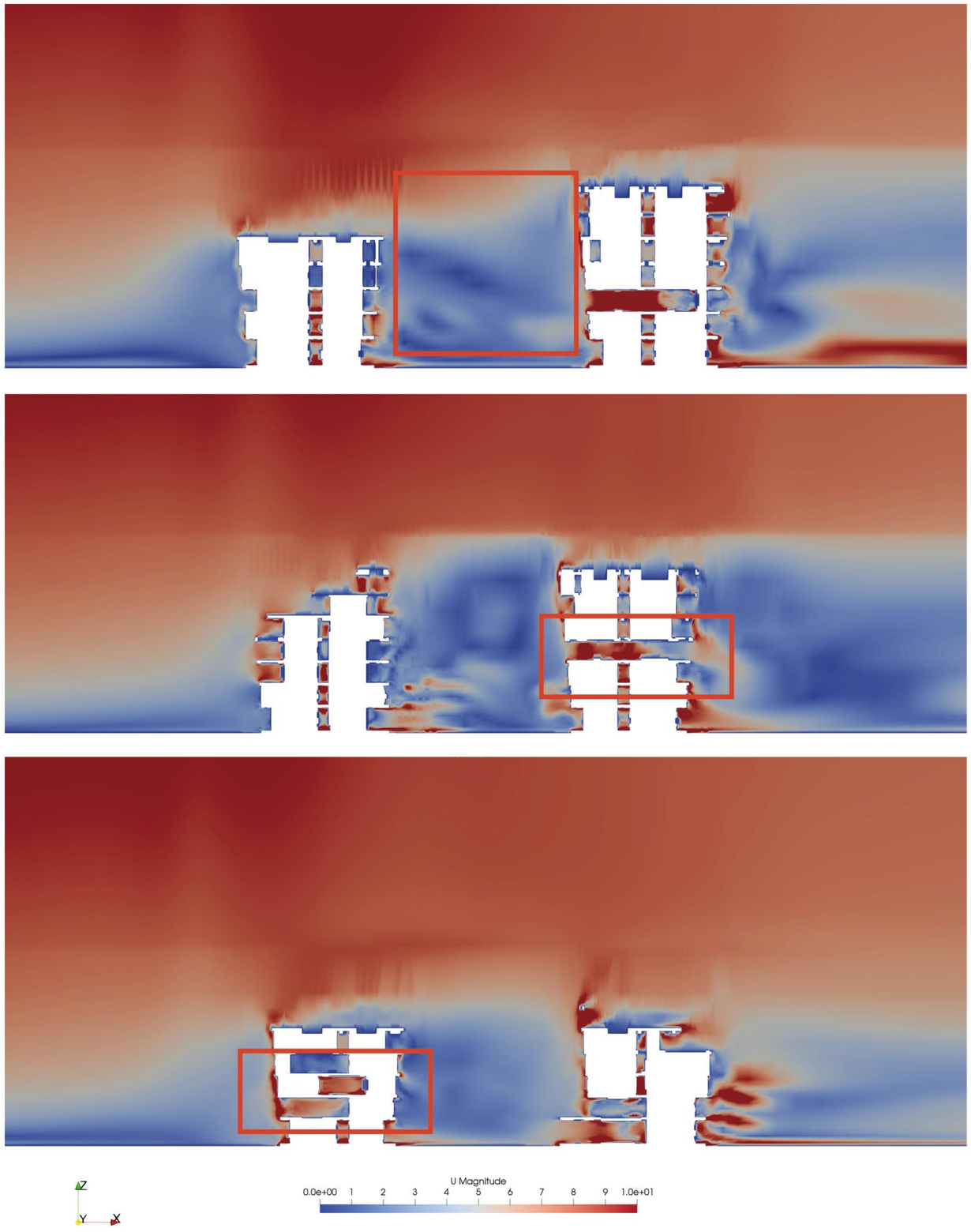


WIND ANALYSIS

Wind Speed (m/s) Simulation
Location of Data: Amsterdam
Frequent Wind Direction: from west to east
Average Wind Speed: 6m/s

Courtyard - slow down wind speed for comfort
Communal Spaces - as wind channel helping natural ventilation in summer





FLOOR PLAN



wind channel

room direction

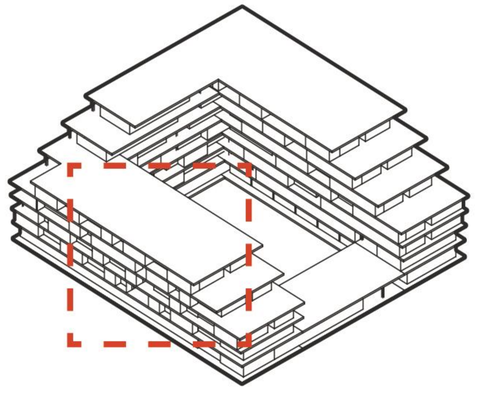
1 Rooms
2 Communal Space

N

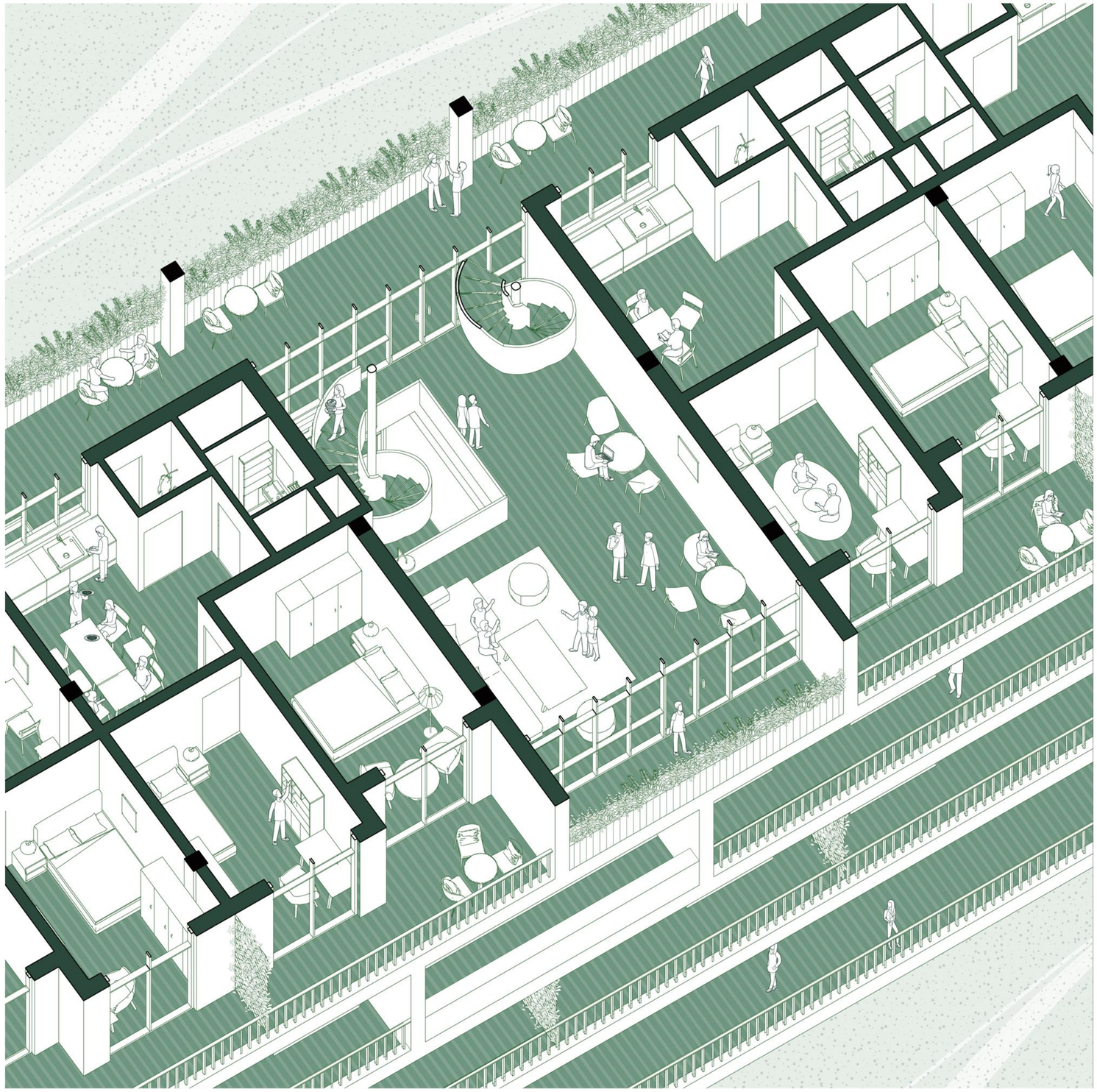
SECOND FLOOR PLAN

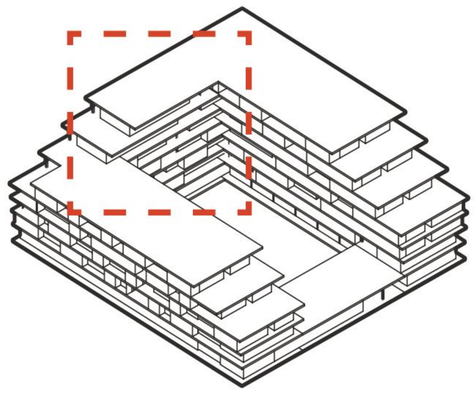
SPACE DESIGN - WEST/EAST WING



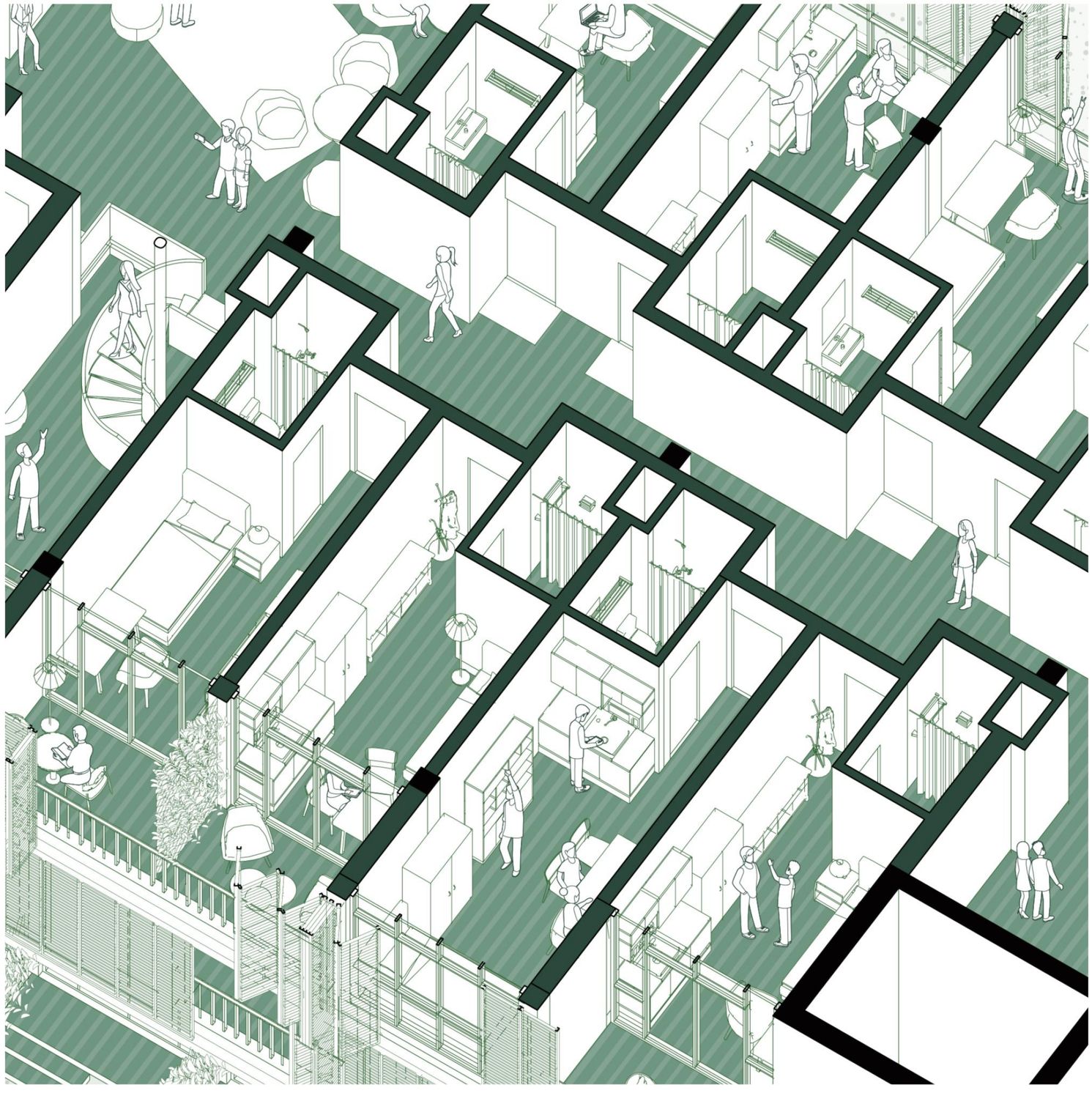


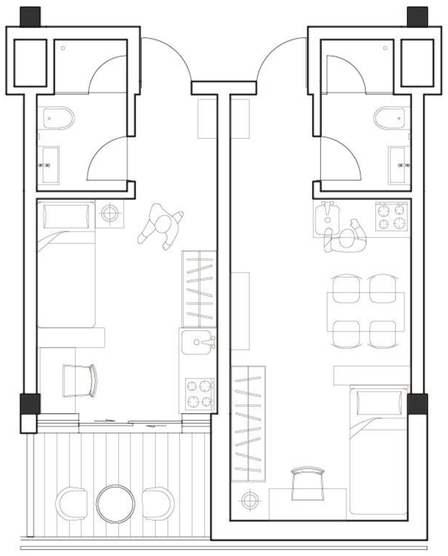
SPACE DESIGN - NORTH/SOUTH WING





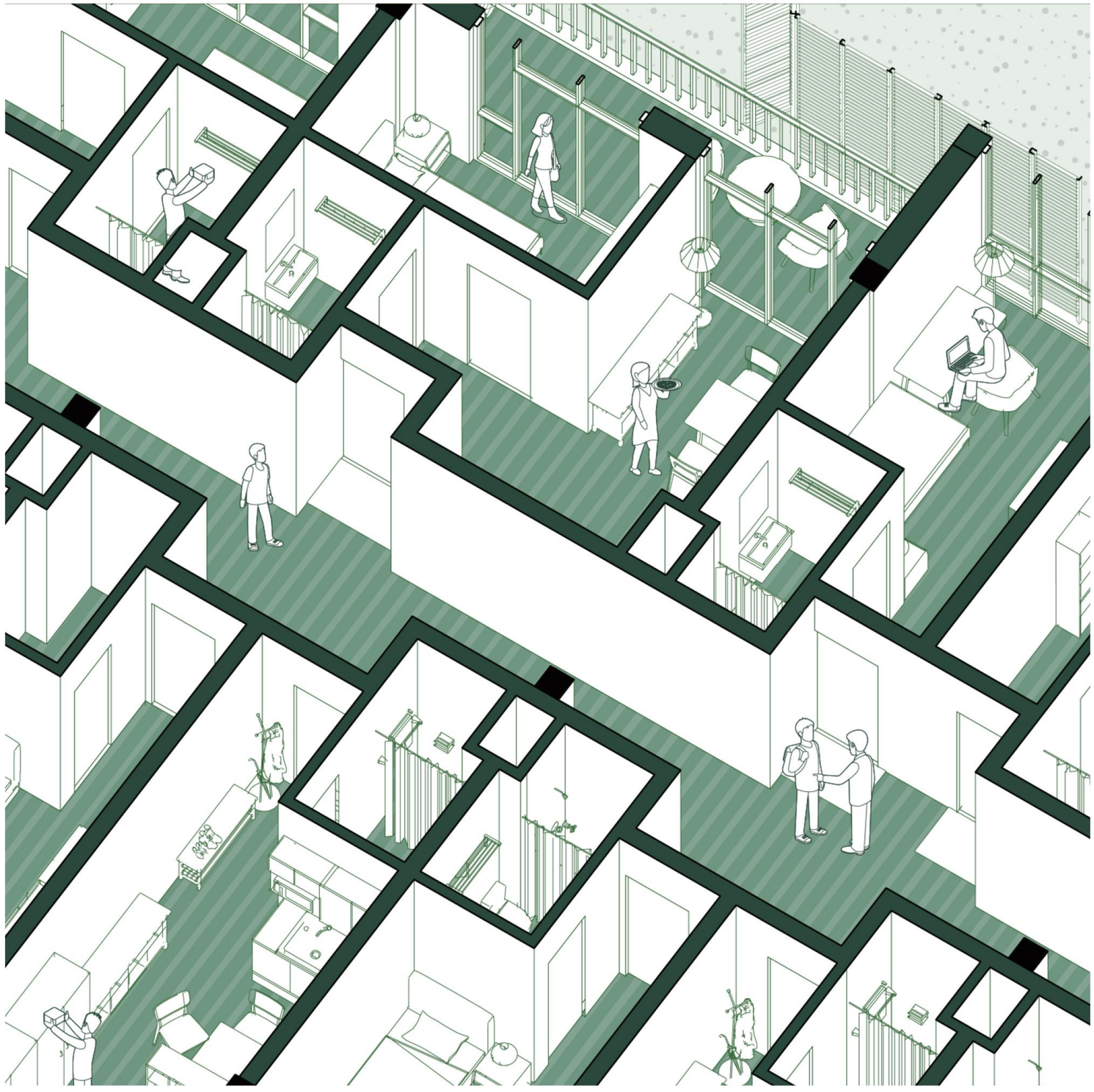
ROOM TYPE - STUDIOS

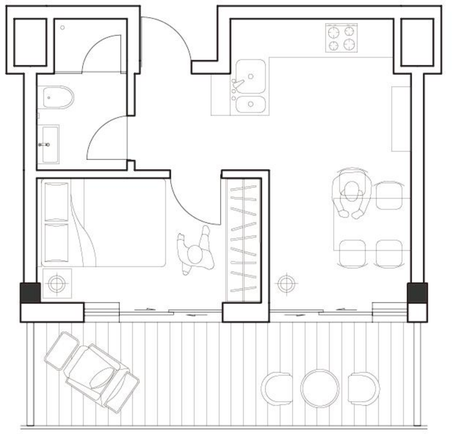




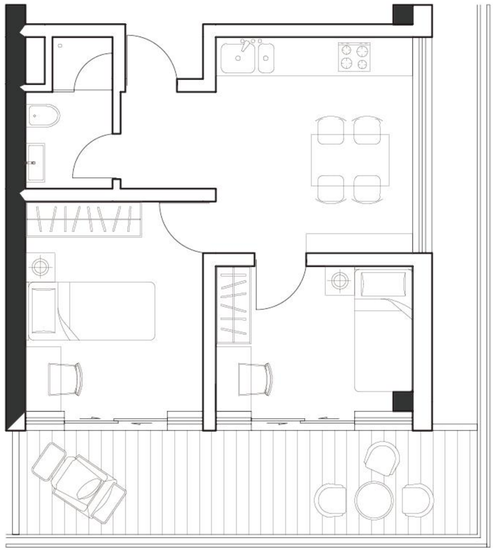
STUDIOS

ROOM TYPE - SHARED



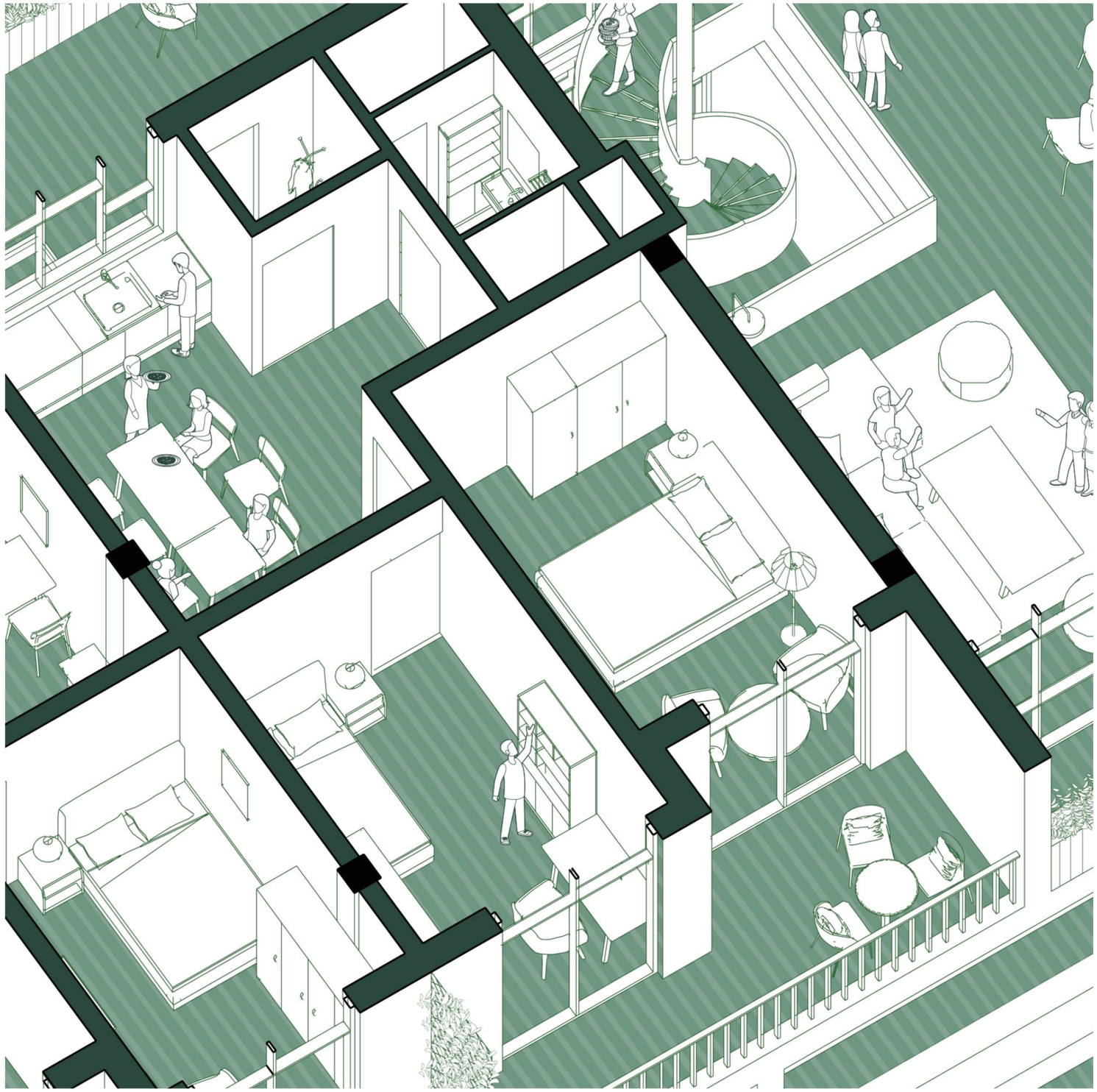


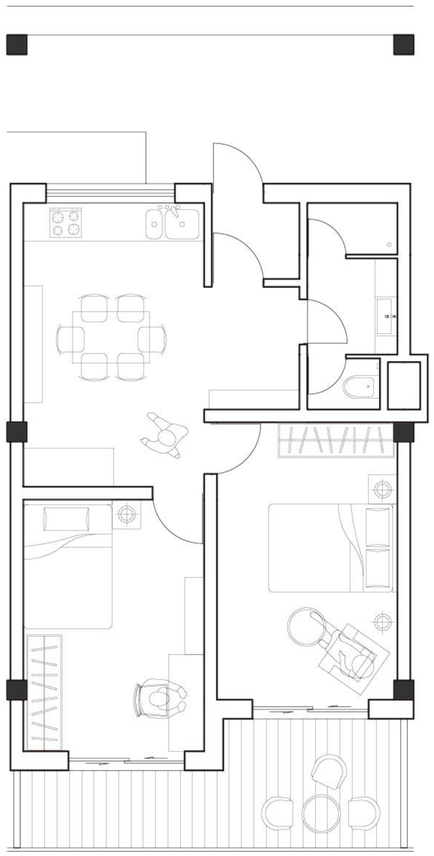
DOUBLE



SHARED 1

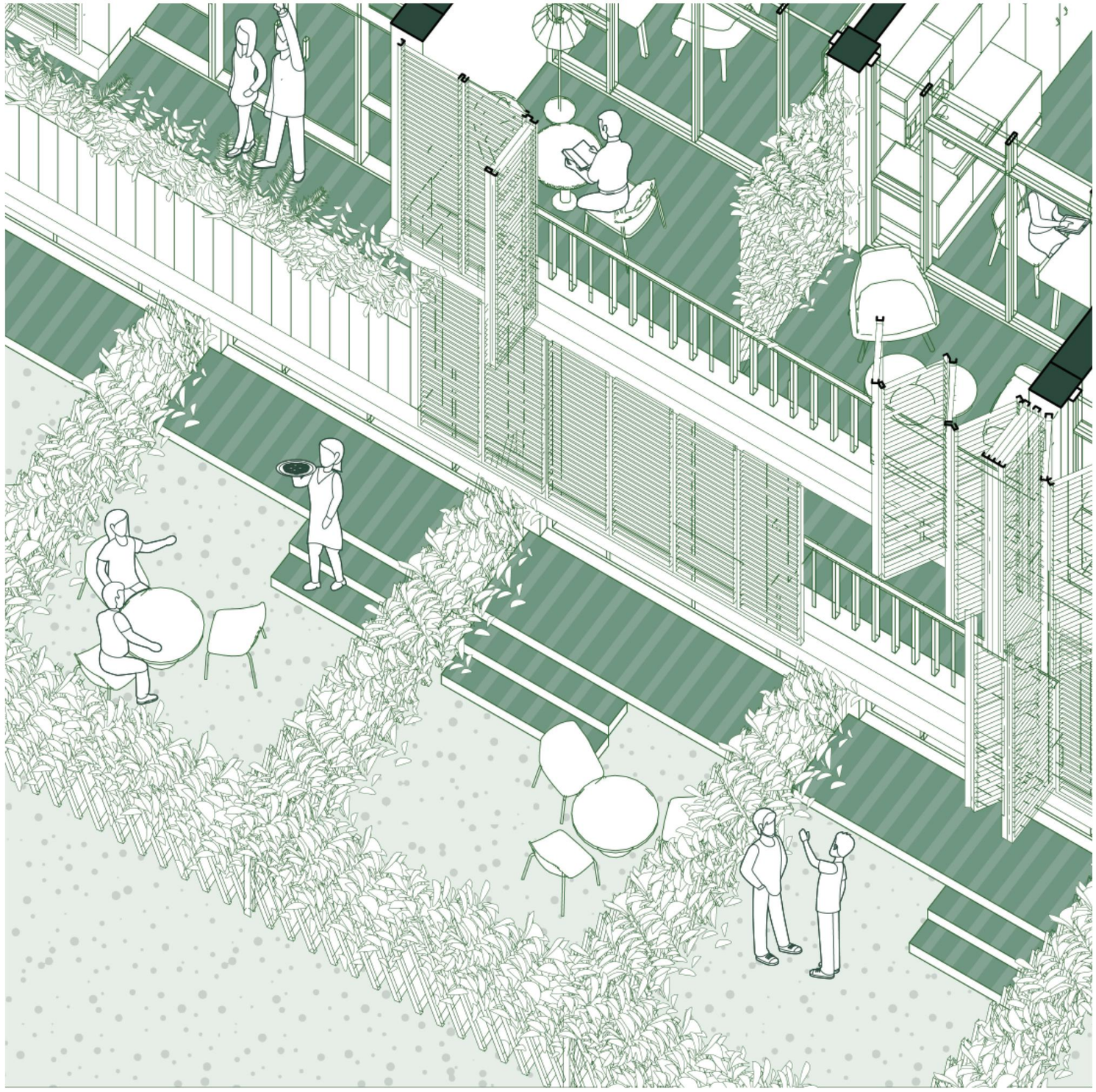
ROOM TYPE - SHARED

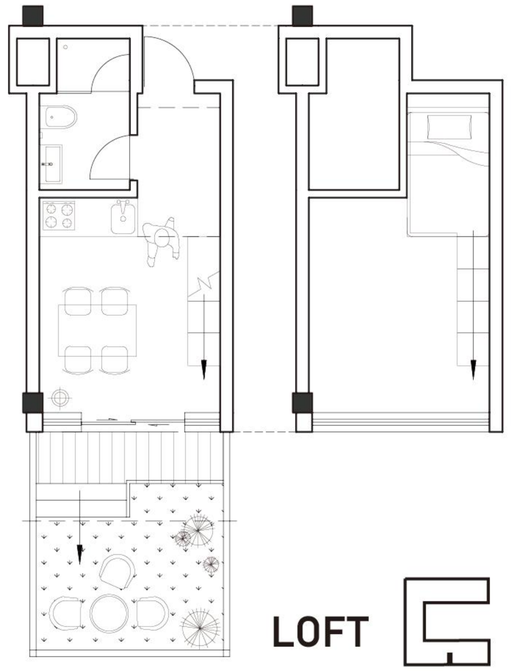




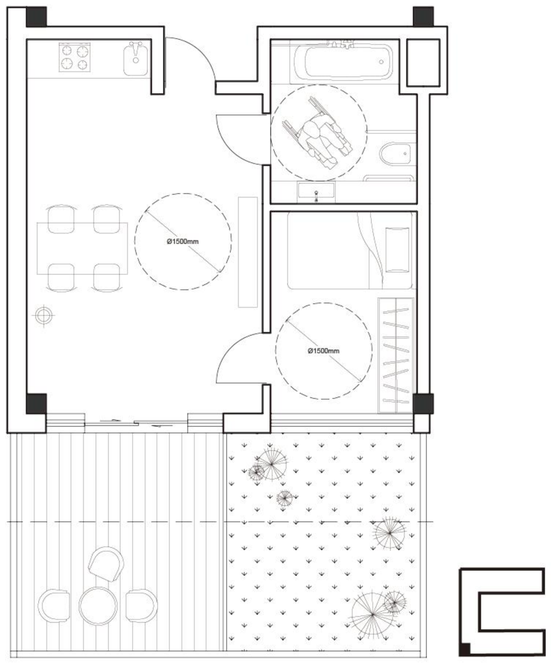
SHARE 2

ROOM TYPE - GROUND FLOOR



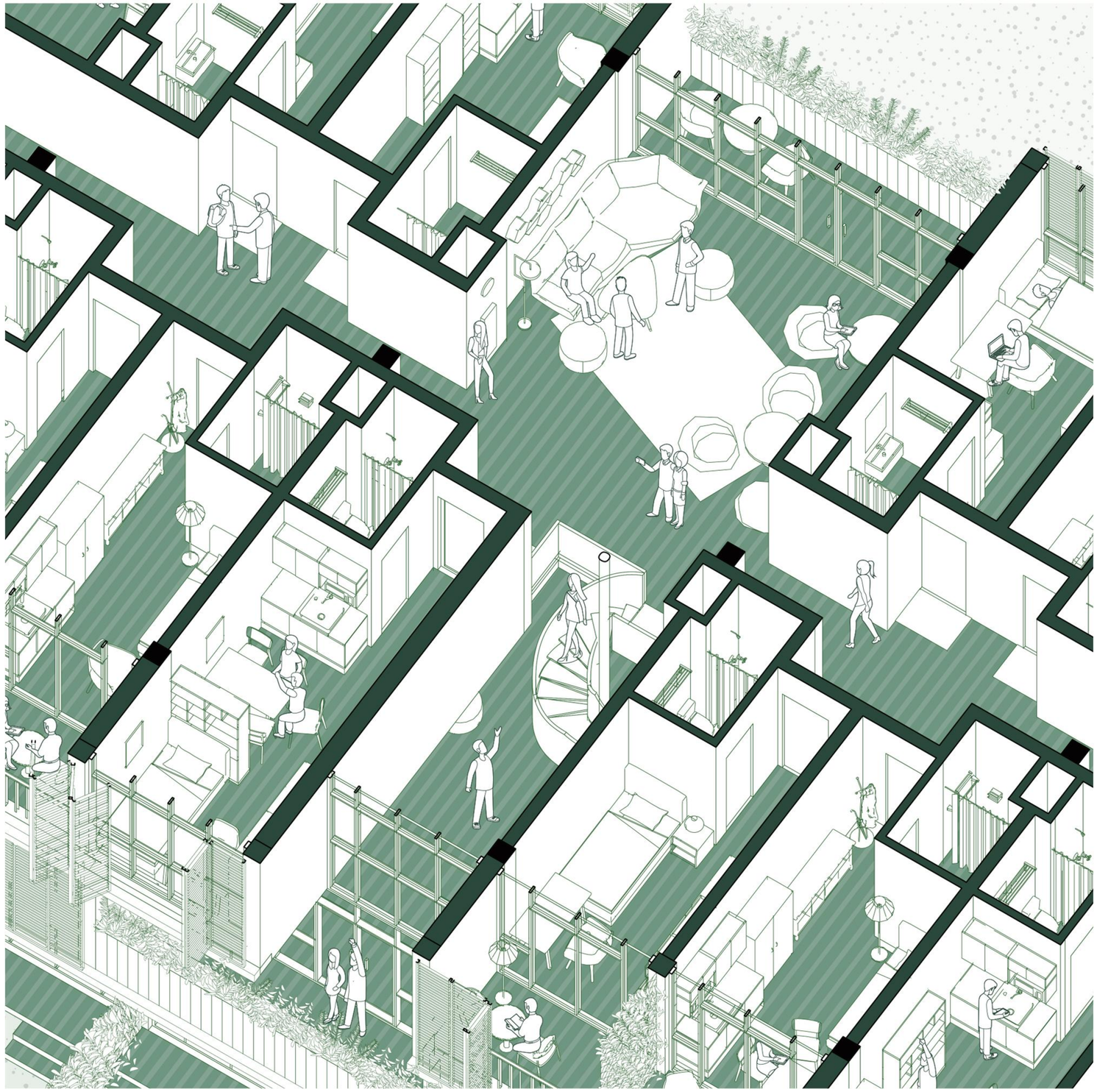


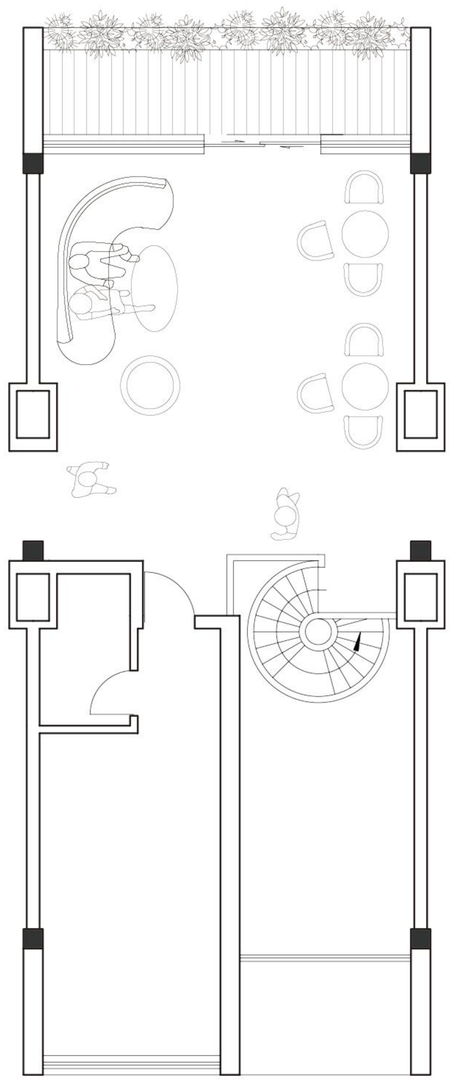
LOFT



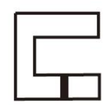
DISABLED

COMMUNAL SPACE - WEST/EAST WING





COMMUNAL 1



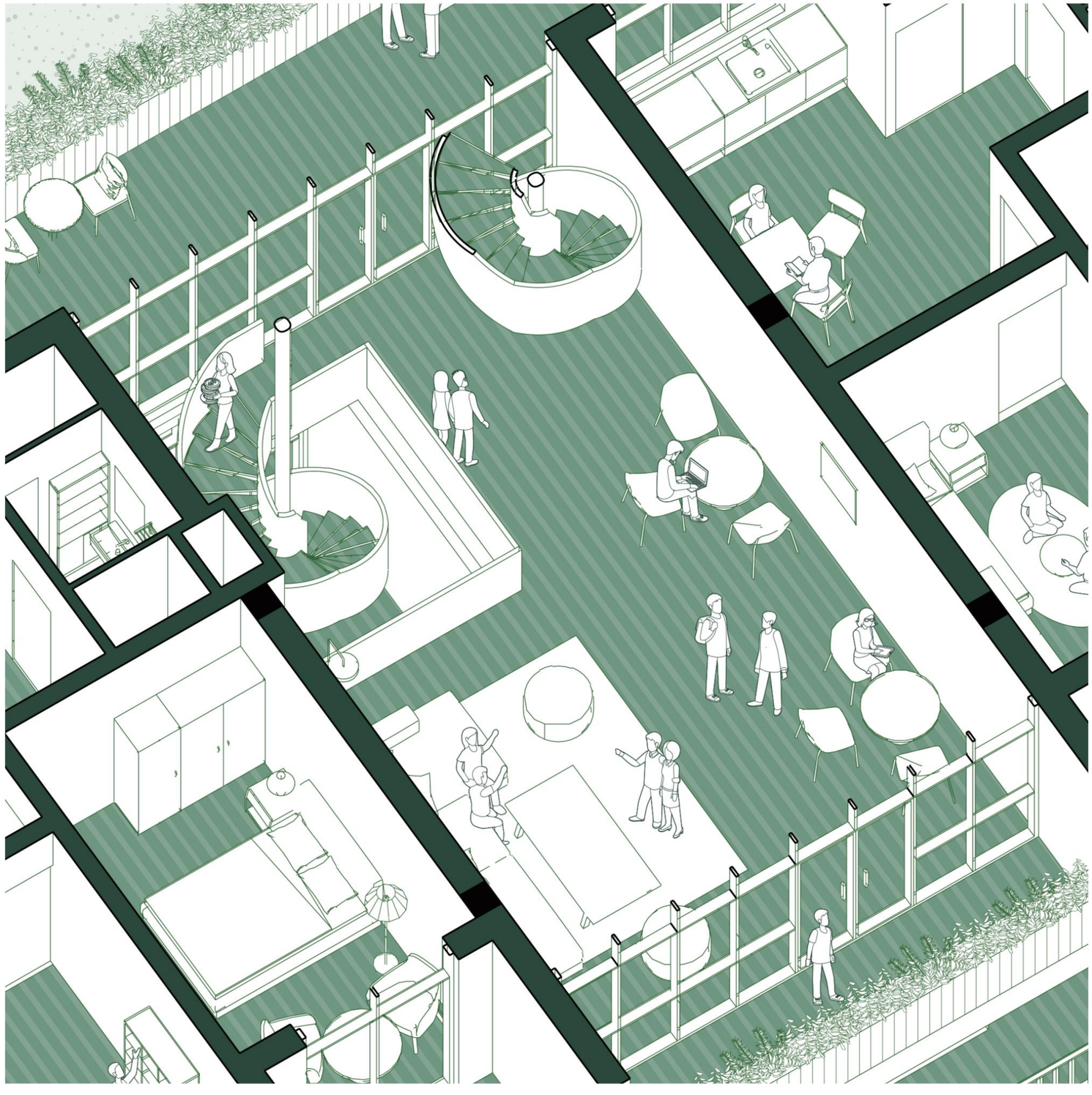
IN THE MORNING

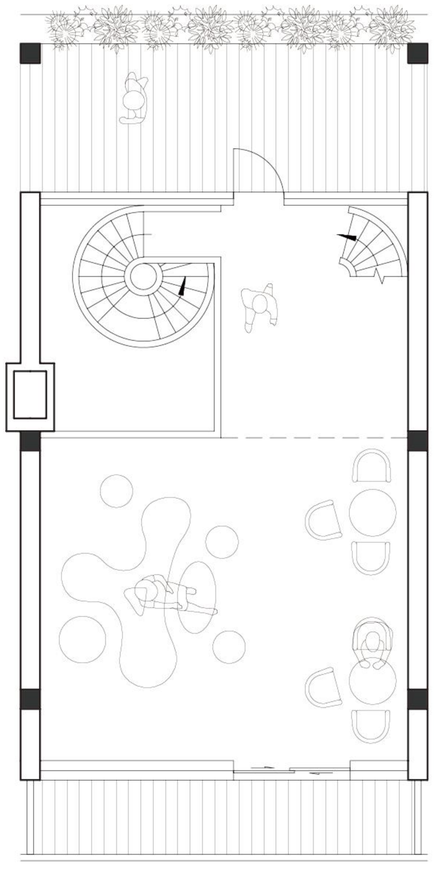


IN THE AFTERNOON



COMMUNAL SPACE - NORTH/SOUTH WING





COMMUNAL 2

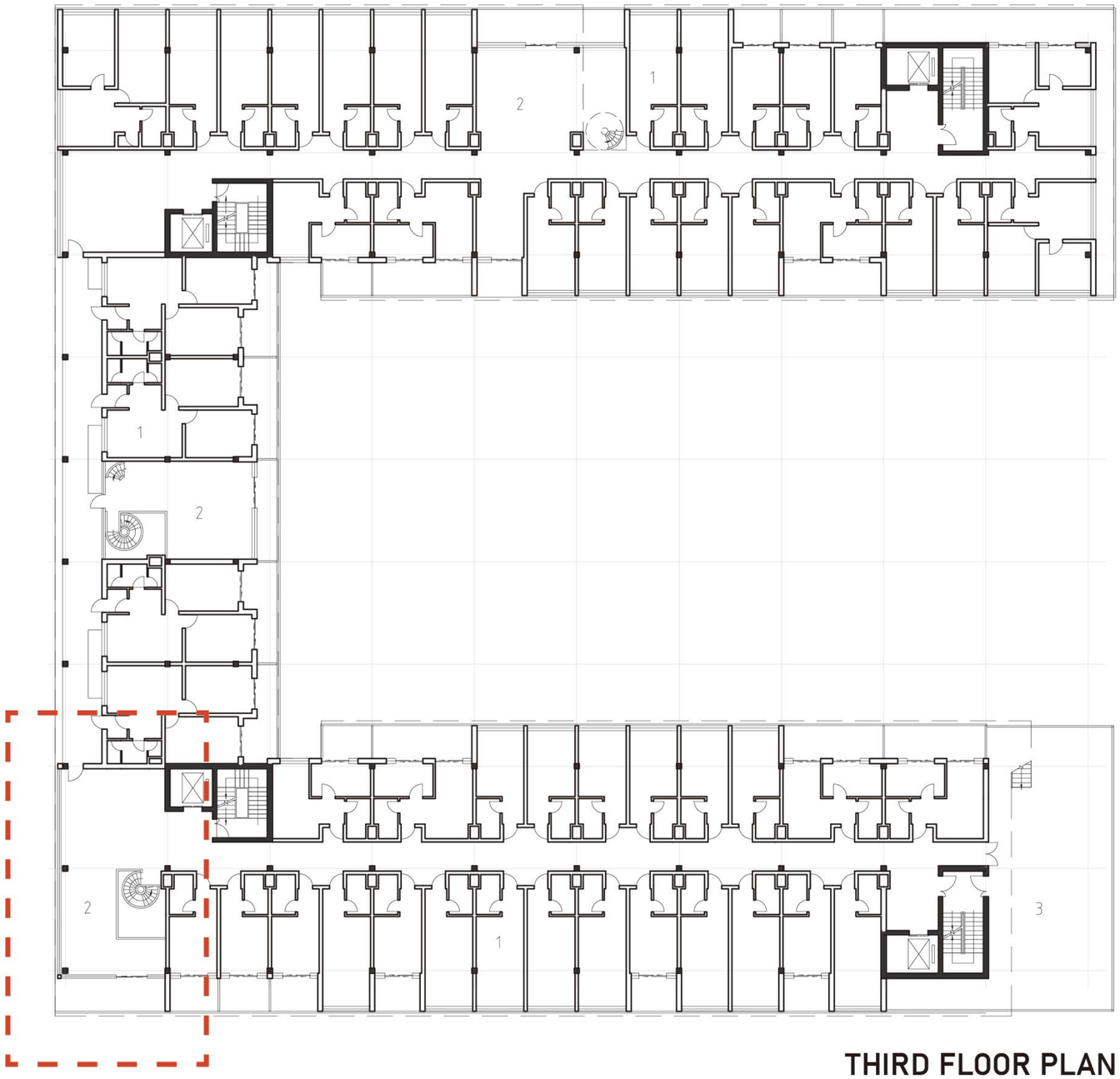
IN THE SUMMER



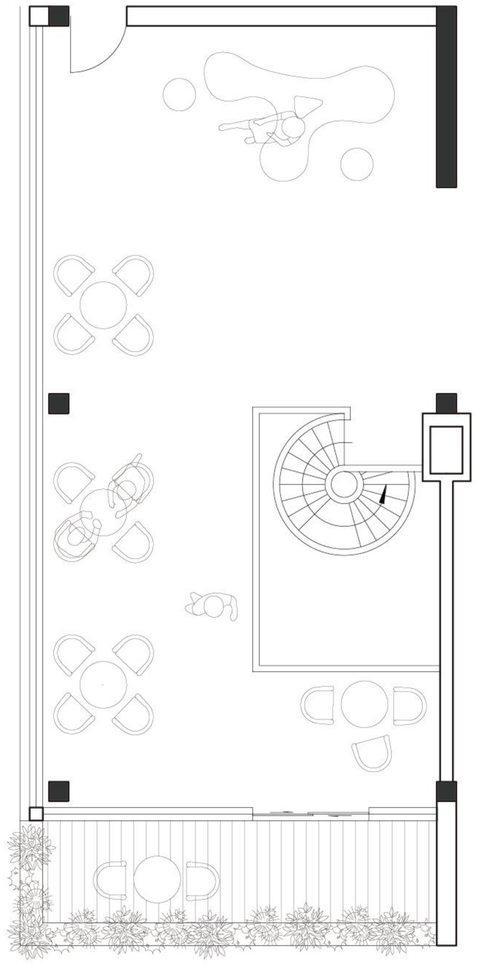
IN THE WINTER



COMMUNAL SPACE - CORNER



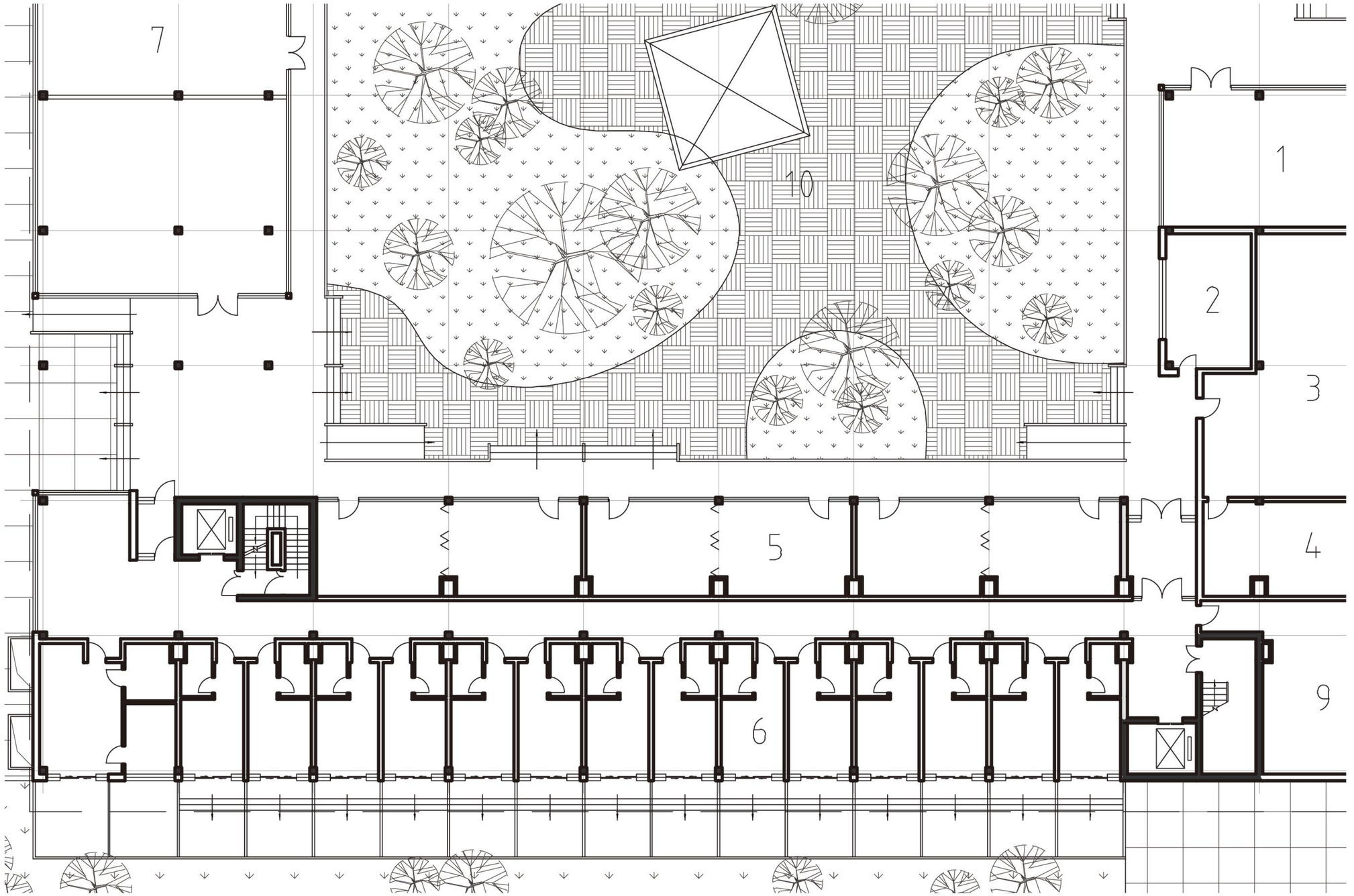
THIRD FLOOR PLAN



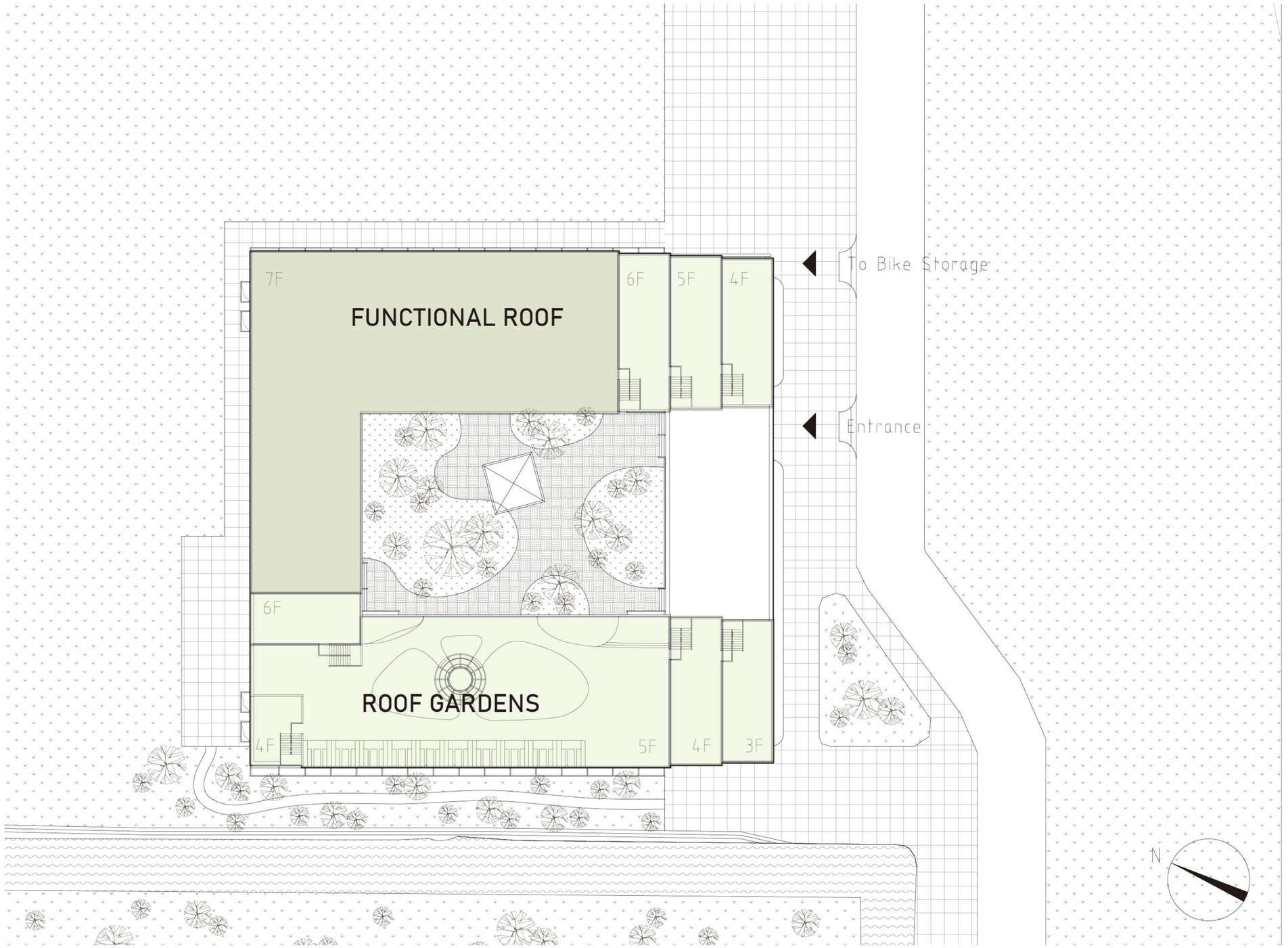
COMMUNAL 3



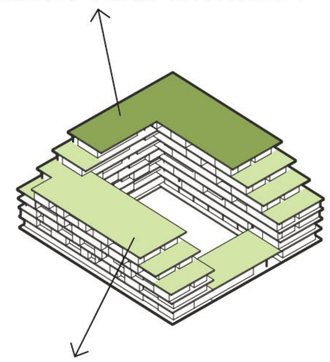
COMMUNAL SPACE - GROUND FLOOR



GREEN ROOFS



FUNCTIONAL ROOF
GREEN TECHNOLOGY

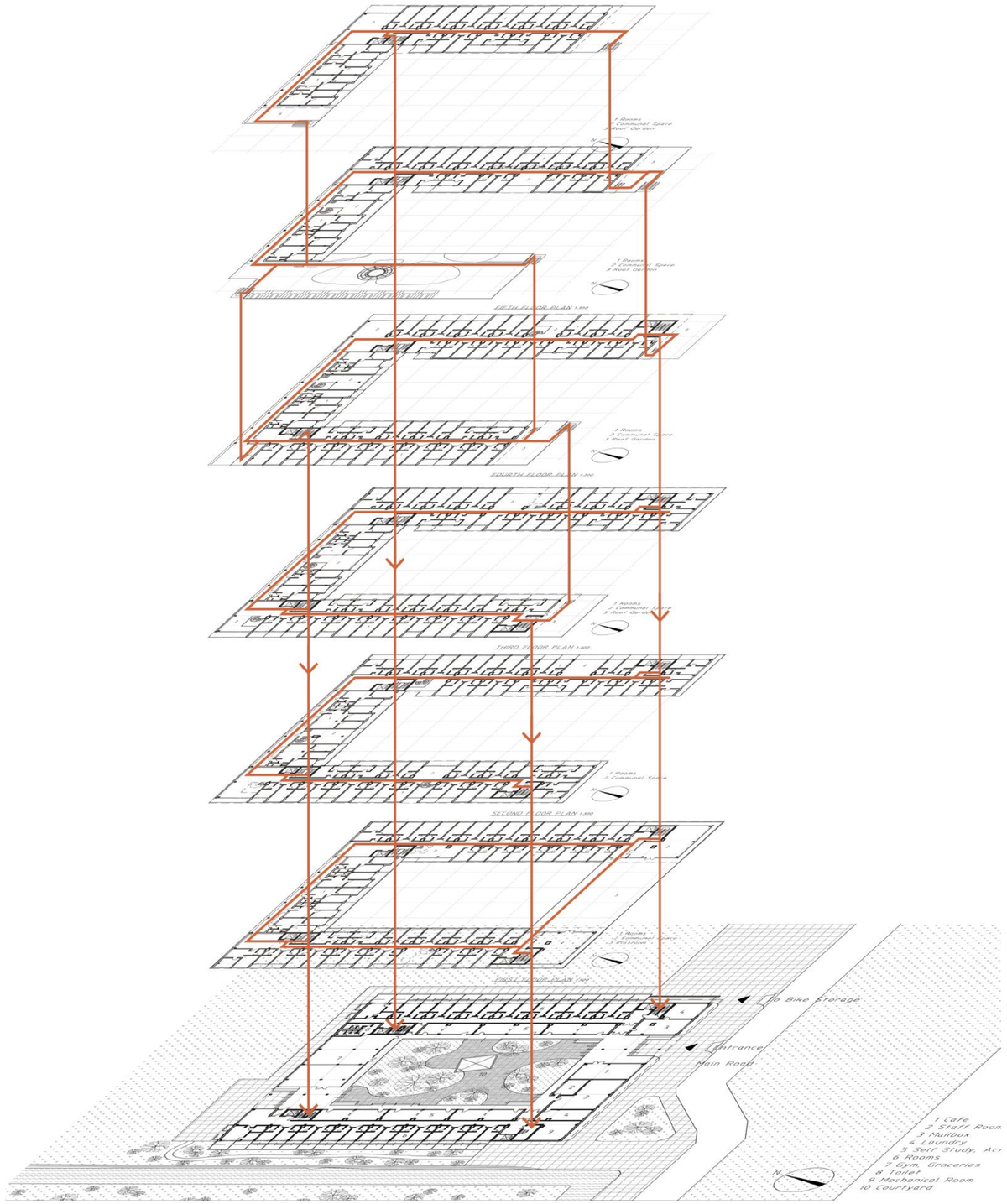


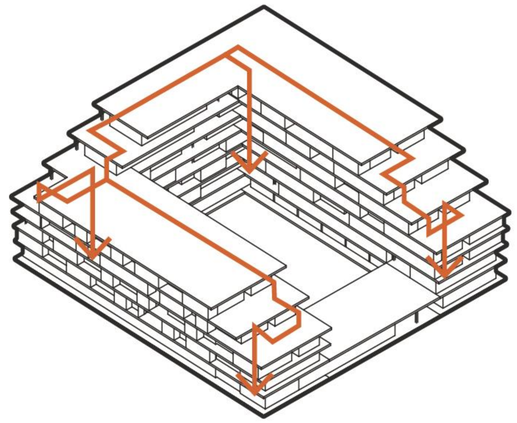
ROOF GARDENS
FOR ACTIVITIES

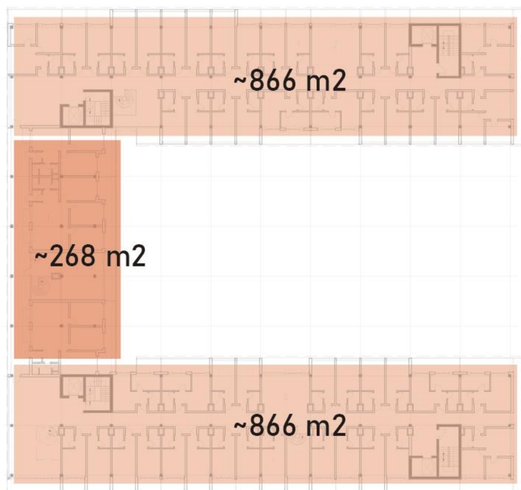
ROOF GARDENS



FIRE ESCAPE CIRCULATION

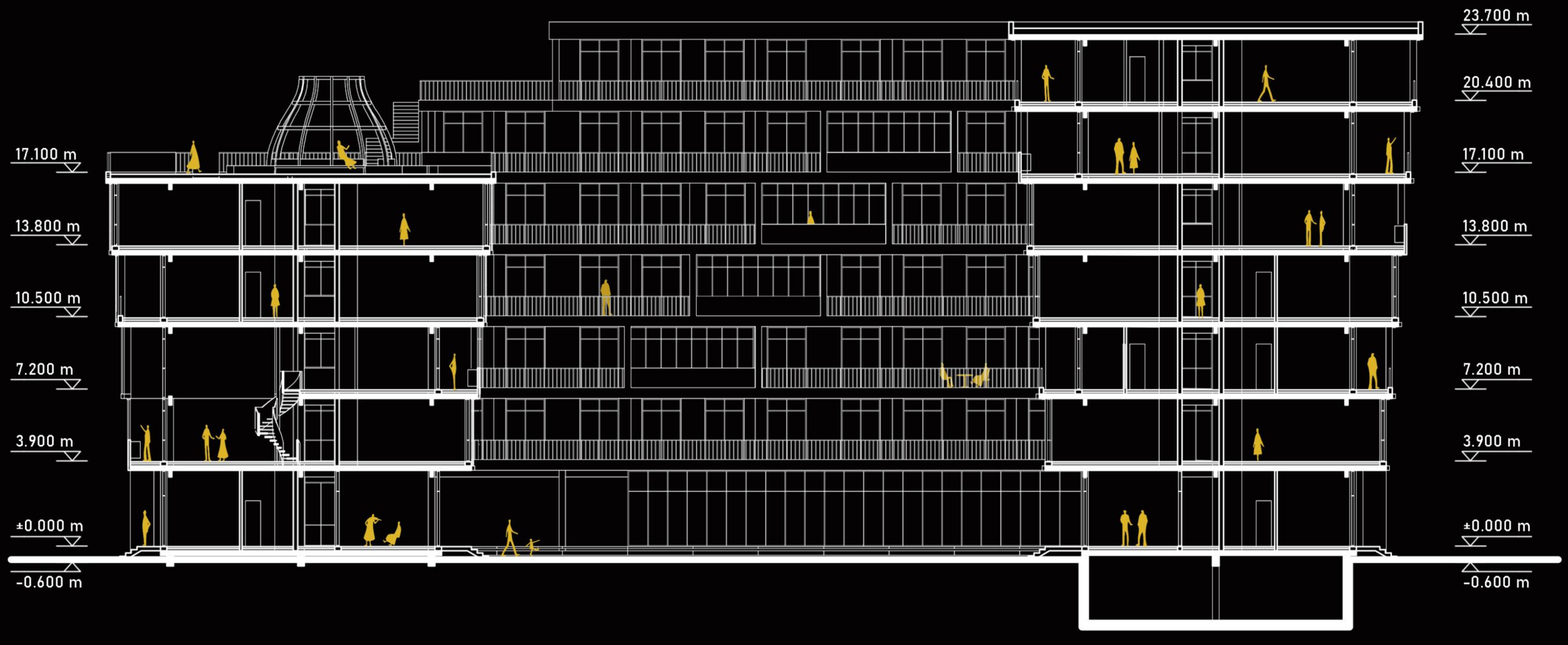




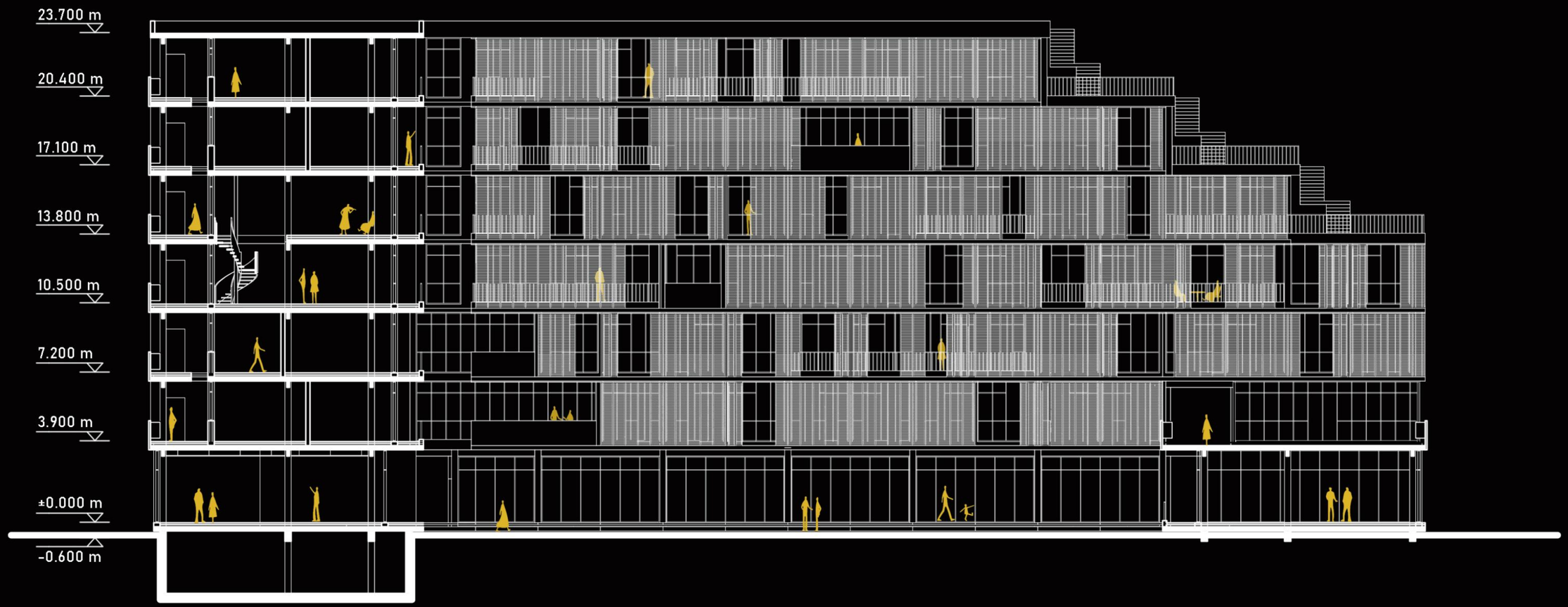


FIRE COMPARTMENT

SECTION 1-1


23.700 m
20.400 m
17.100 m
13.800 m
10.500 m
7.200 m
3.900 m
±0.000 m
-0.600 m
17.100 m
13.800 m
10.500 m
7.200 m
3.900 m
±0.000 m
-0.600 m
WEST
EAST

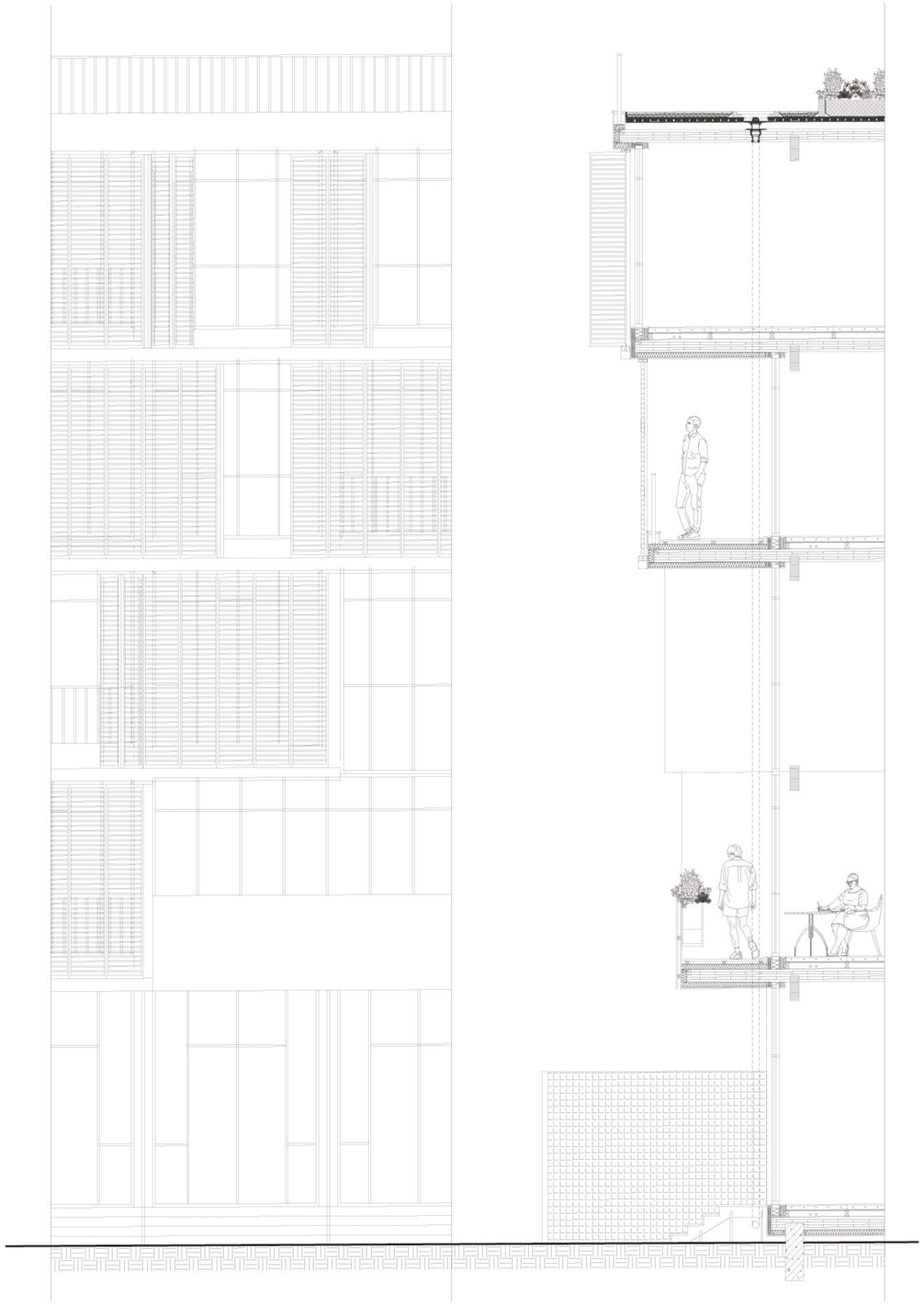
SECTION 2-2

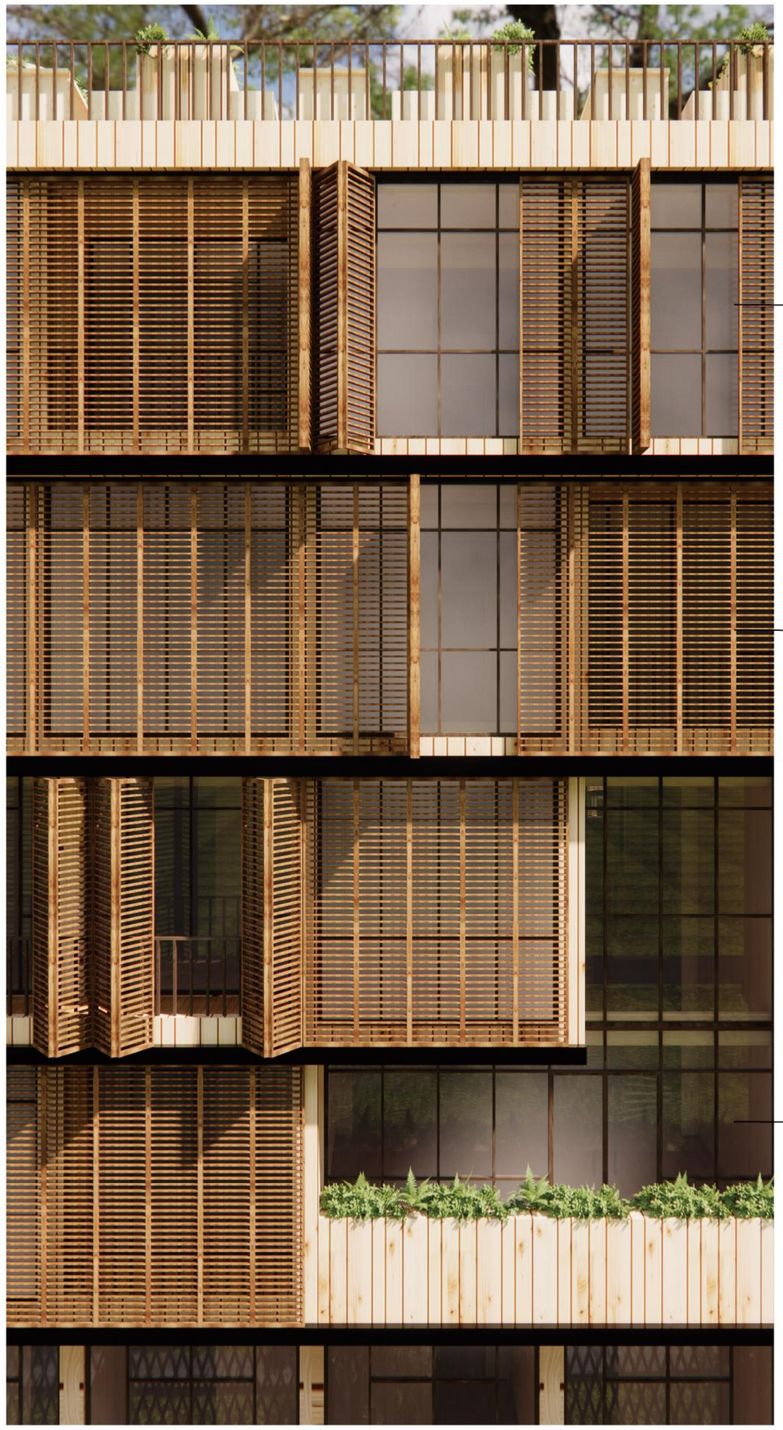

23.700 m
20.400 m
17.100 m
13.800 m
10.500 m
7.200 m
3.900 m
±0.000 m
-0.600 m
NORTH
SOUTH

WEST FACADE

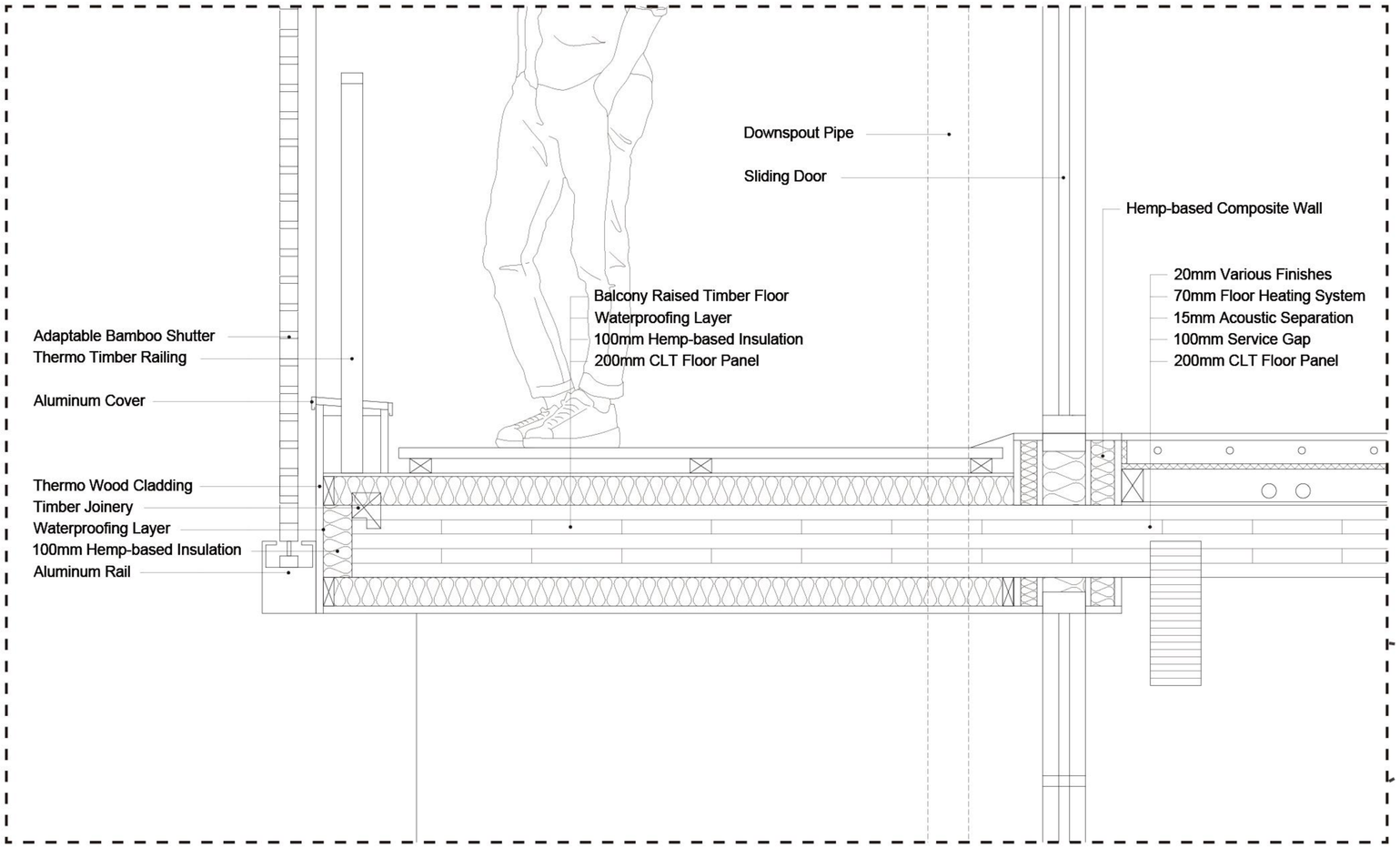


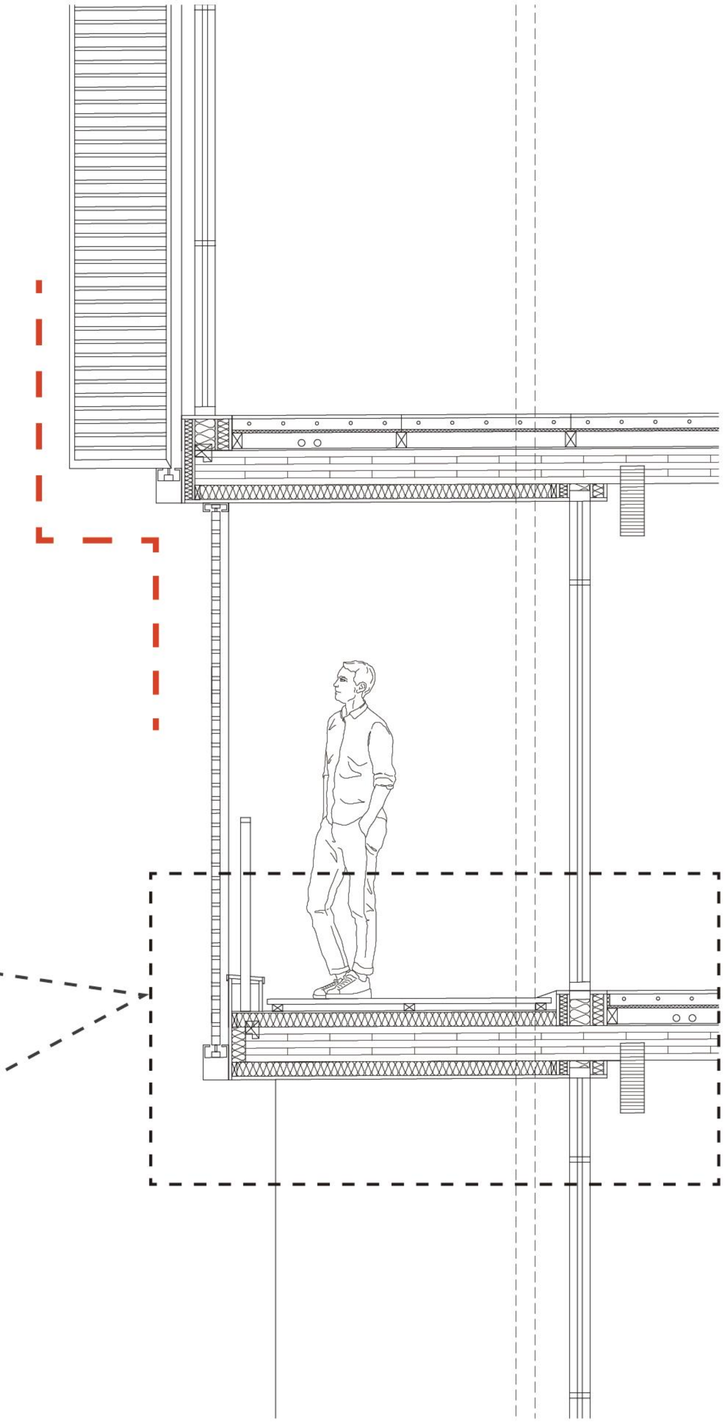
WEST / EAST FACADE





WEST / EAST FACADE

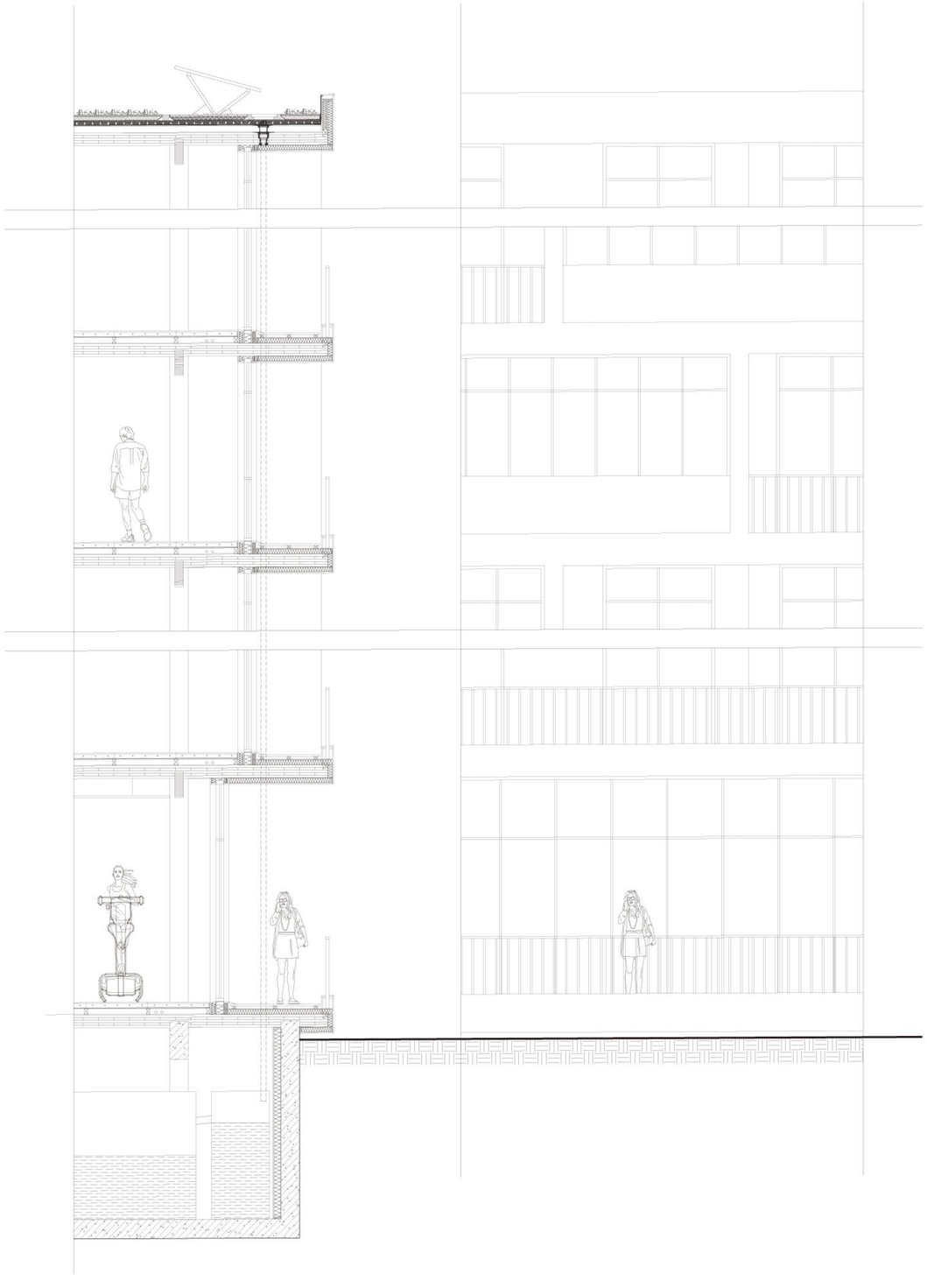


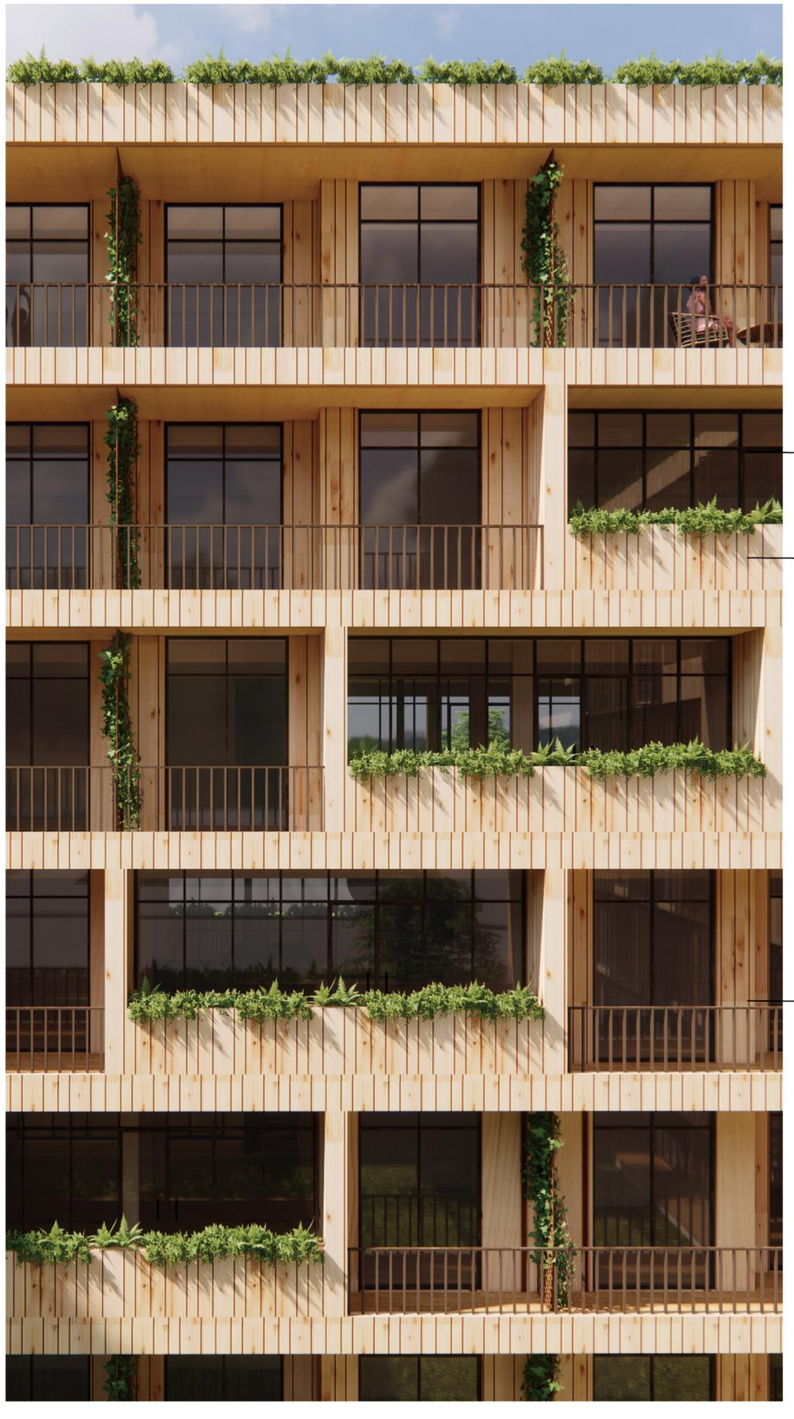


SOUTH FACADE



SOUTH FACADE

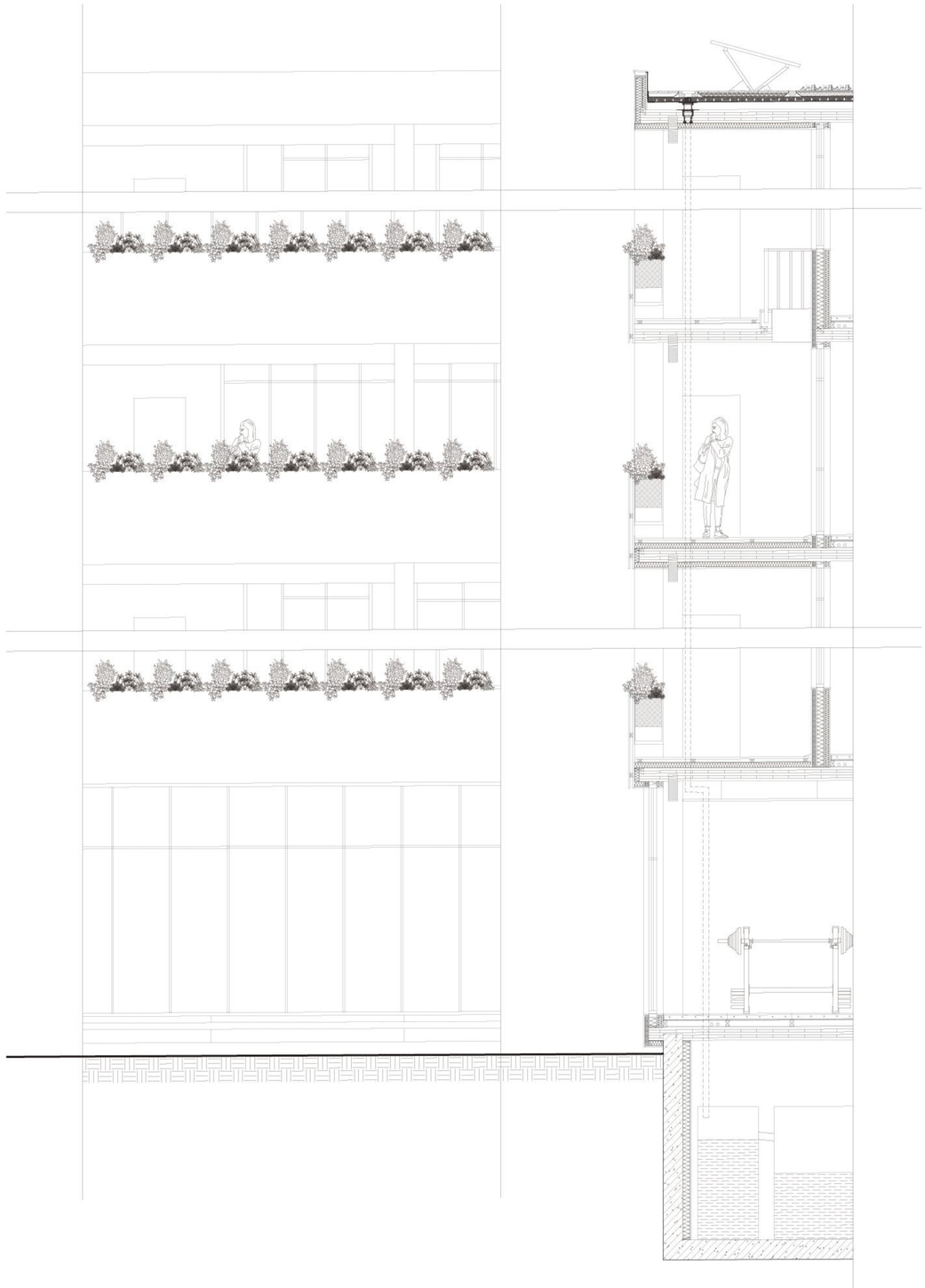




NORTH FACADE

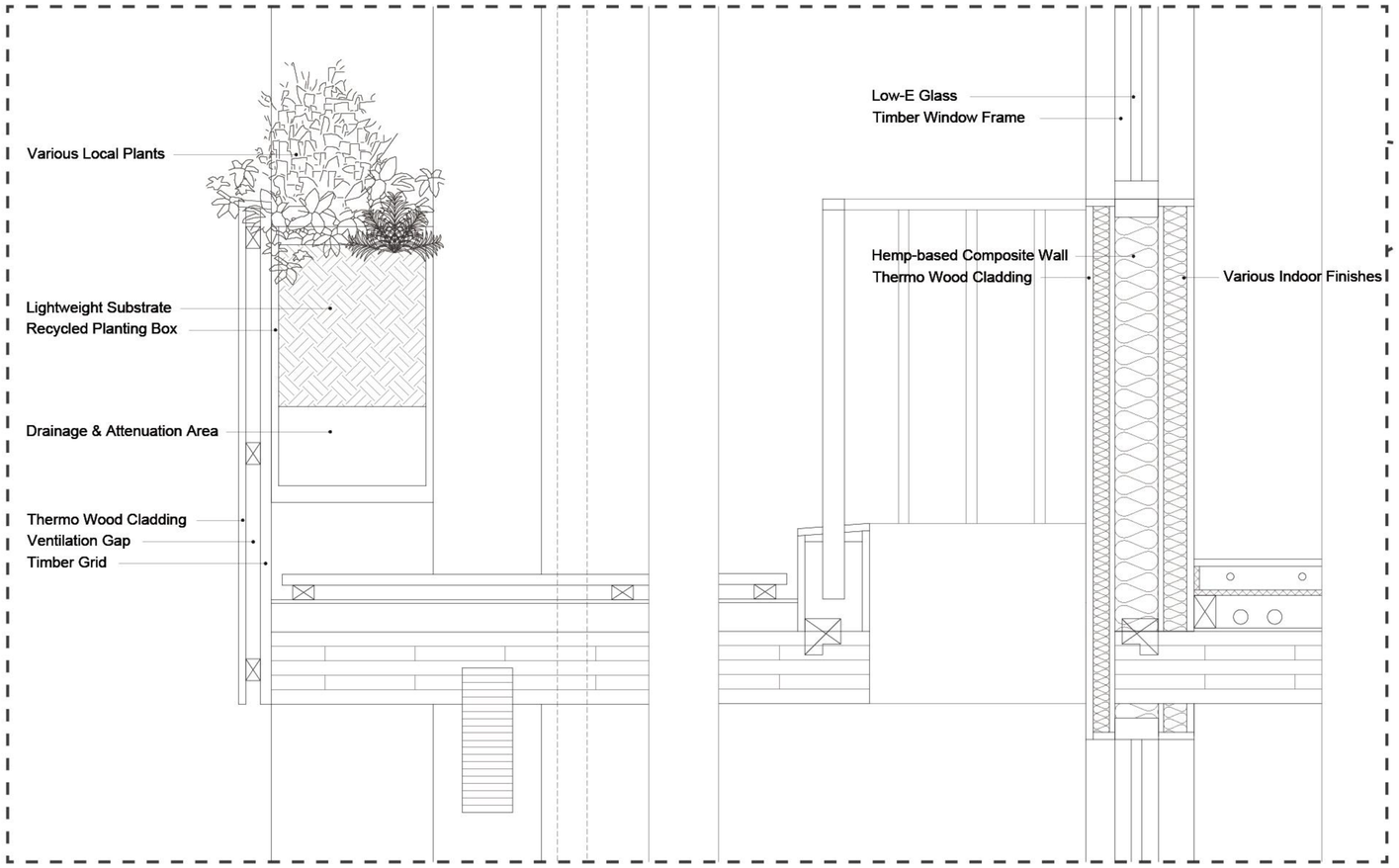


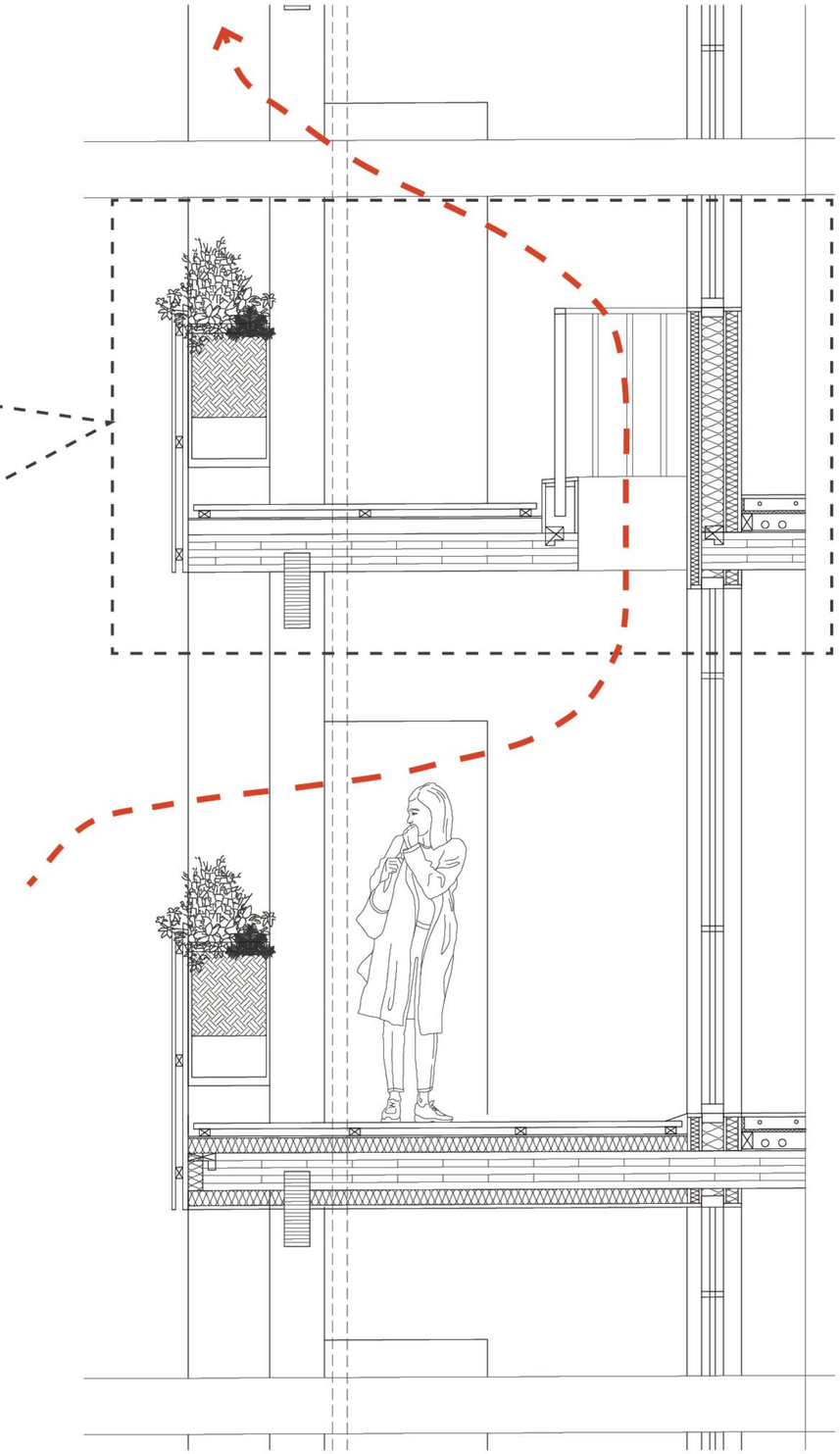
NORTH FACADE





NORTH FACADE





STREET VIEW



BIO-BASED MATERIALS & COMMUNITY CONNECTION

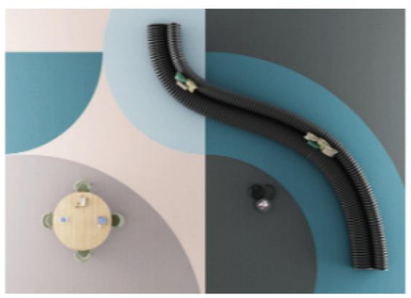
THERMO WOOD, BAMBOO... for facade

HEMP, MYCEILIUM... for insulation & indoor finishes





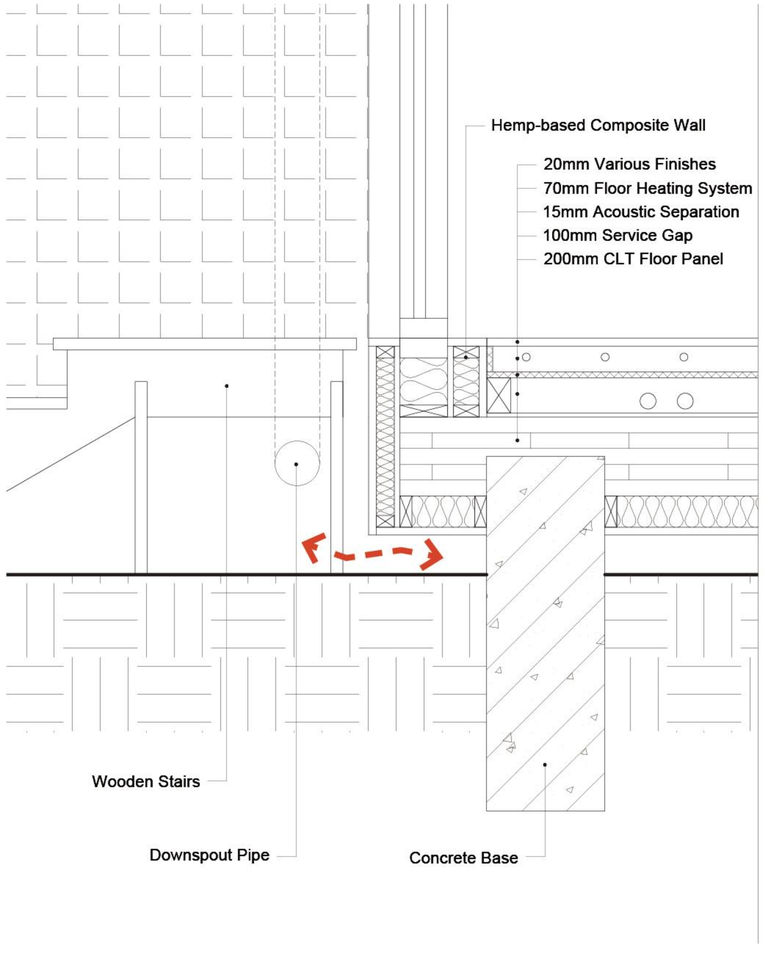


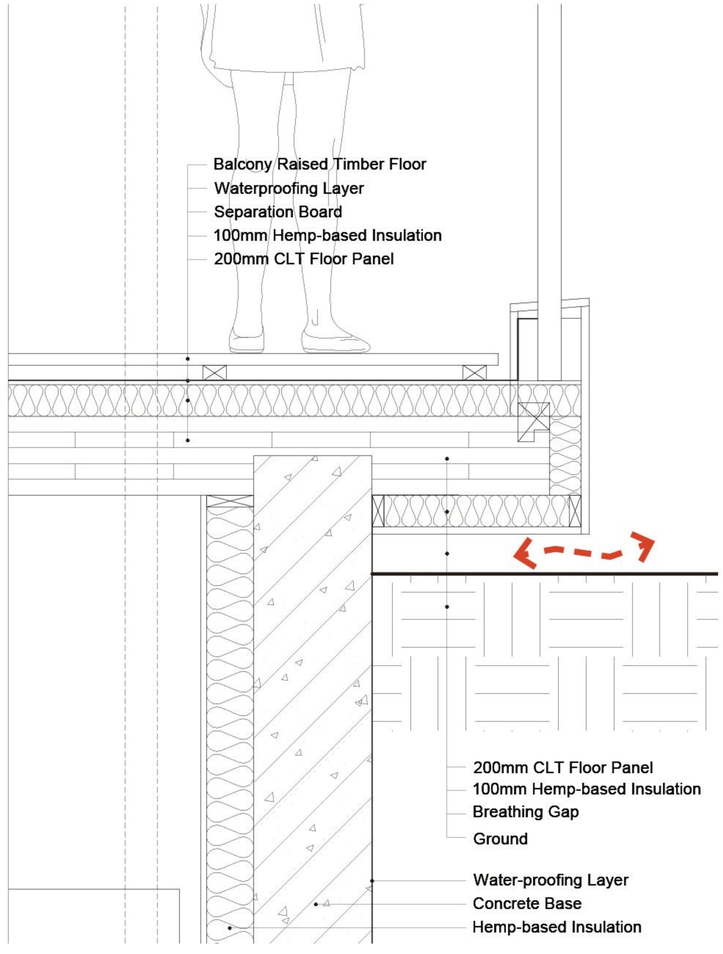


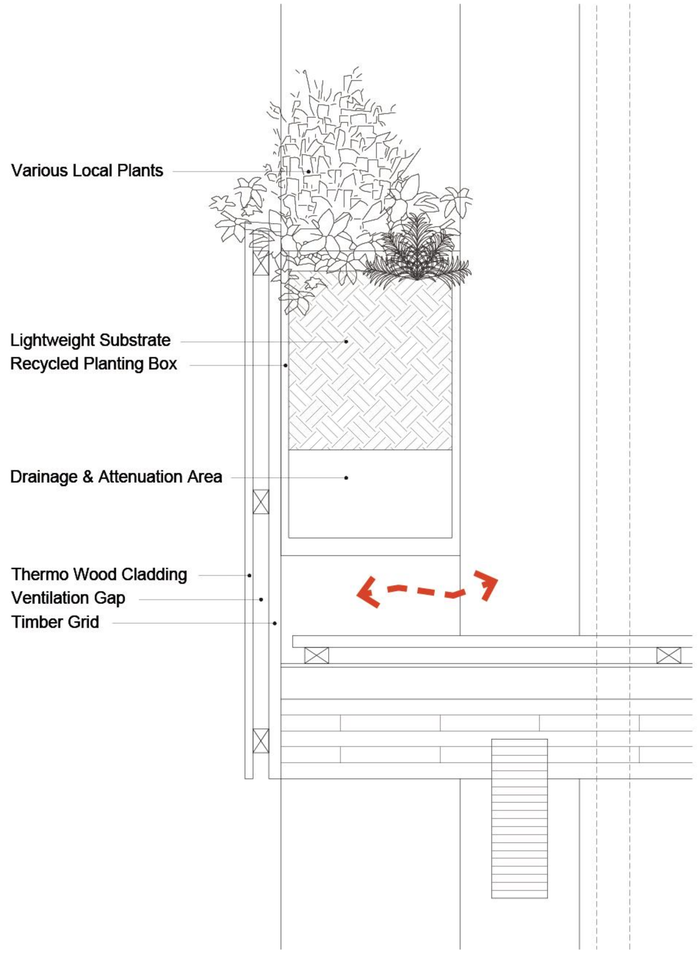



Opportunity to local start-up company
Further connected to neighbourhood
Part of the 'innovative hub'

DETAILS FOR BREATHING

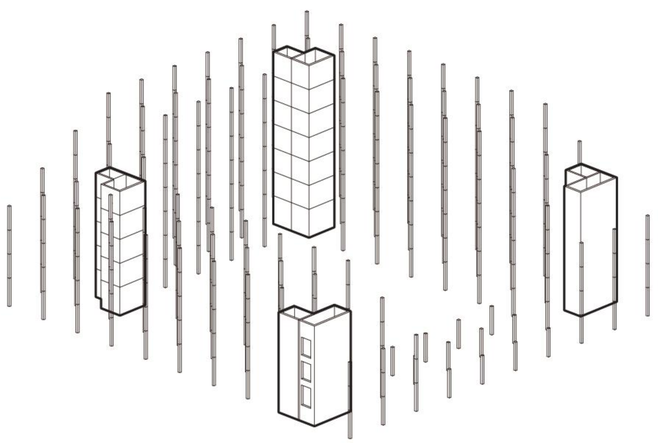


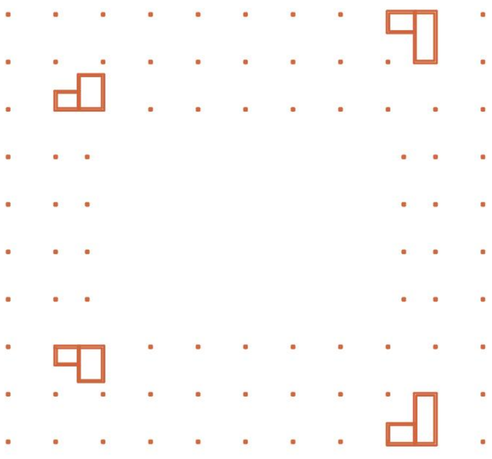




space for drying, air flowing

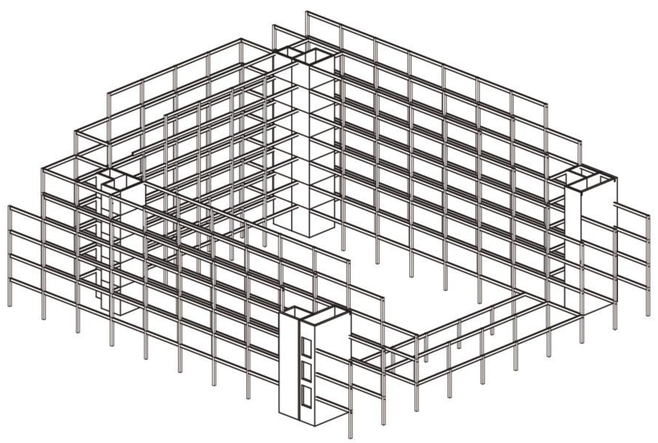
TIMBER STRUCTURE

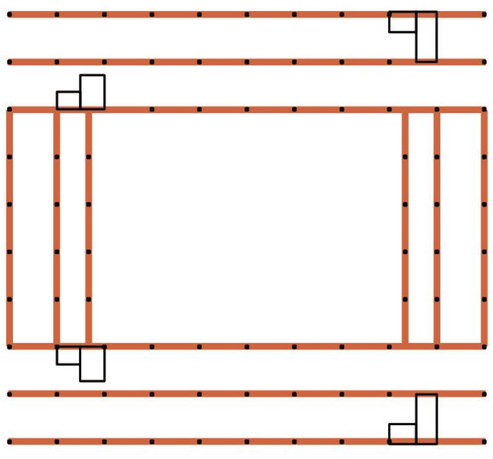




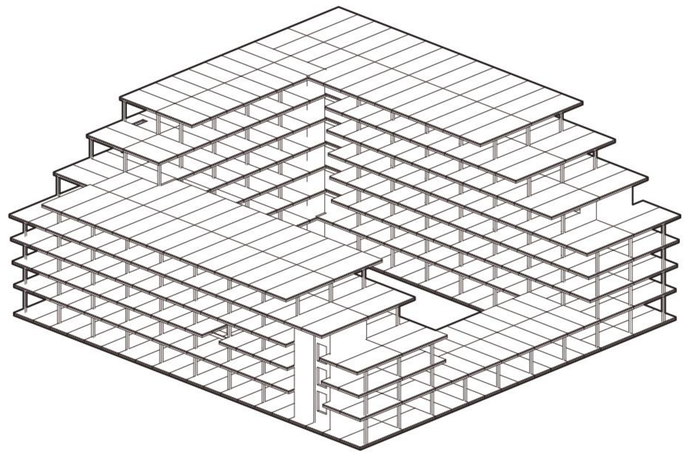
COLUMNS & CORES

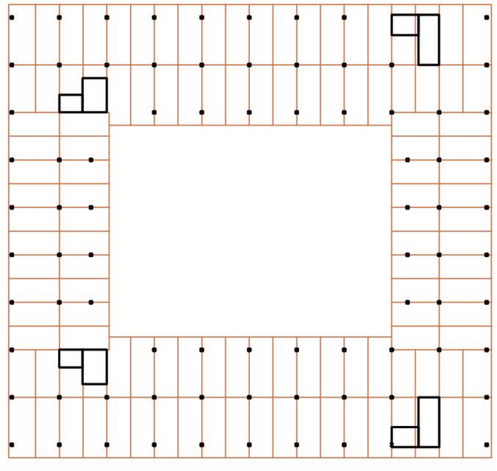
GLT columns and beams
CLT floor panels, overhang
CLT core, increase stiffness





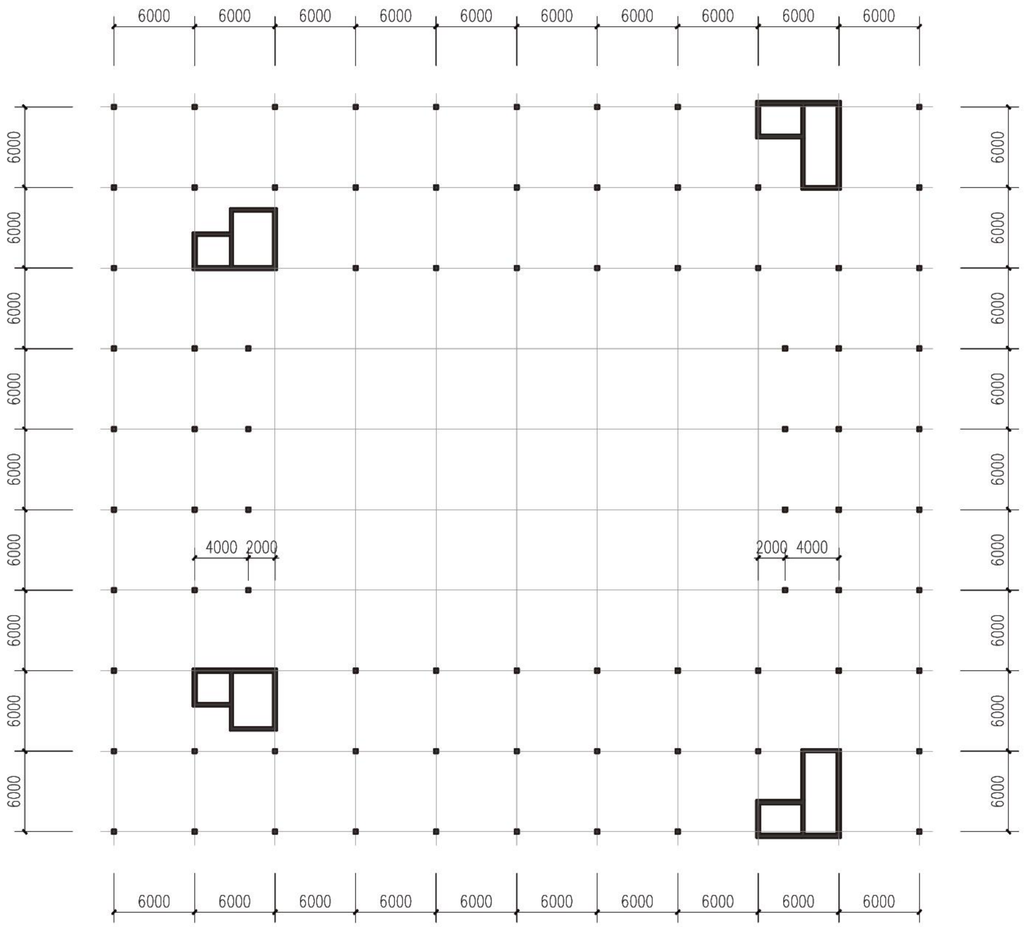
ONE-SIDE BEAMS

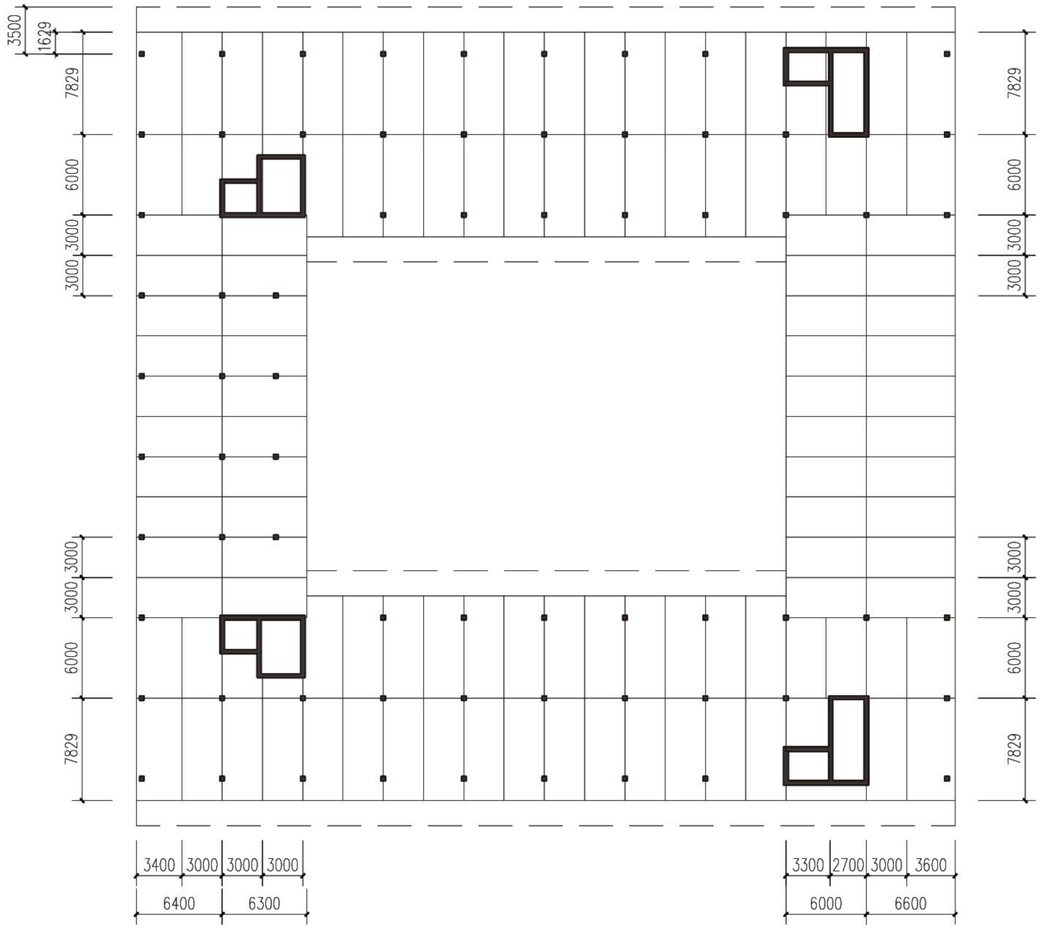




SLABS

TIMBER STRUCTURE

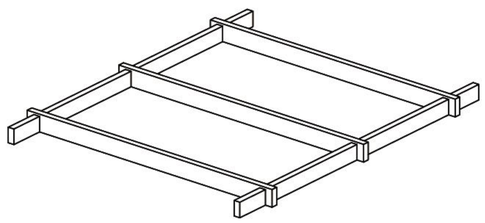




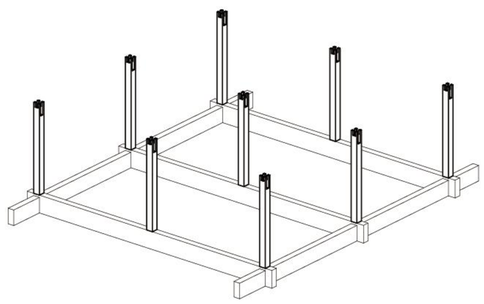
Column spacing: 6m
Largest CLT floor panel: 3.6m * 9.5m
Largest overhang: 3.5m

suitable for transportation

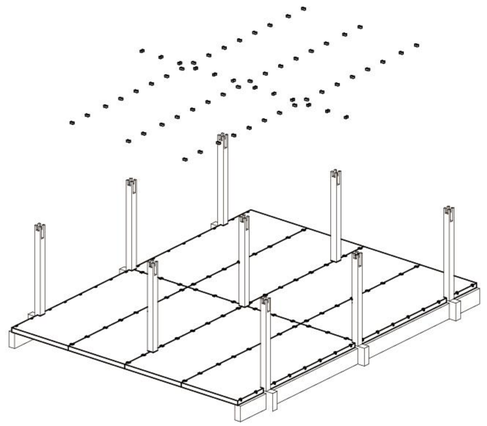
CONSTRUCTION PROCESS



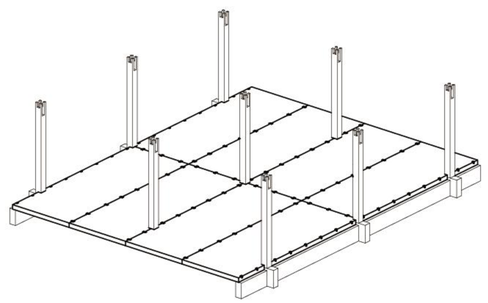
FOUNDATION



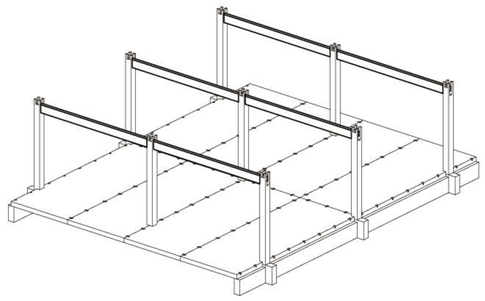
COLUMN



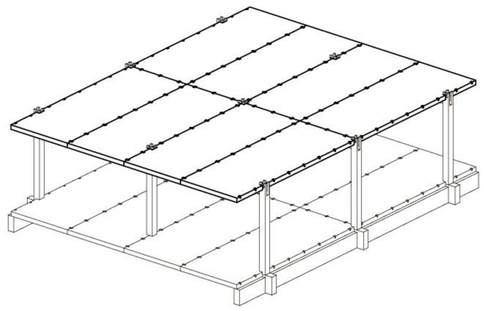
SLAB WITH X-CONNECTOR



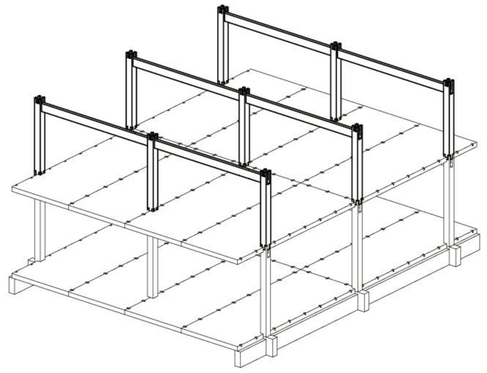
SLAB



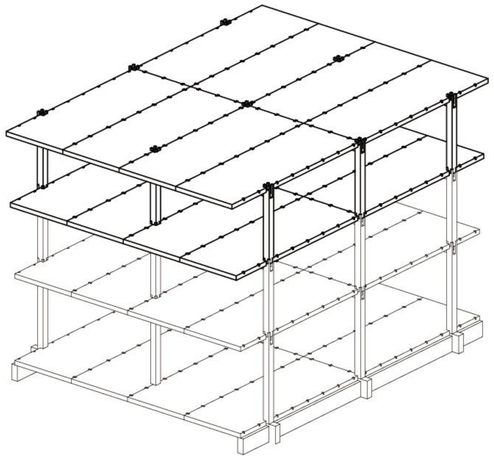
BEAM



SLAB

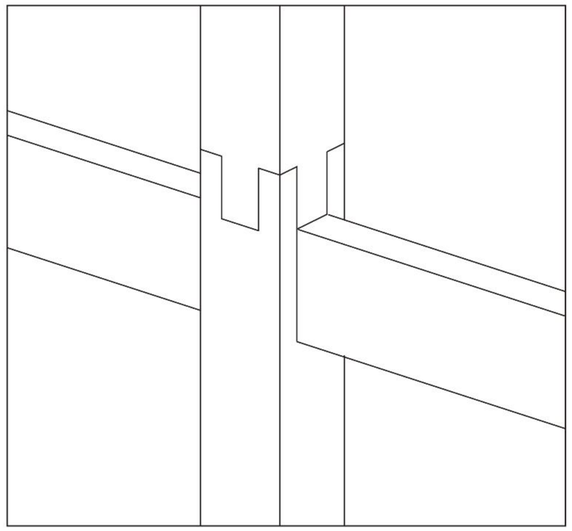


UPPER FLOORS

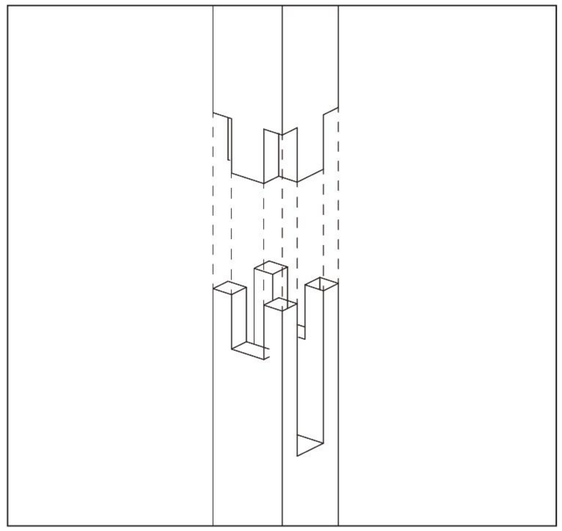


UPPER FLOORS

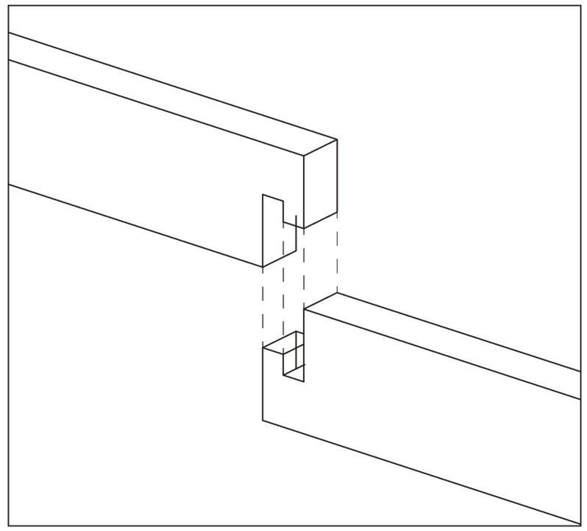
TIMBER JOINERY



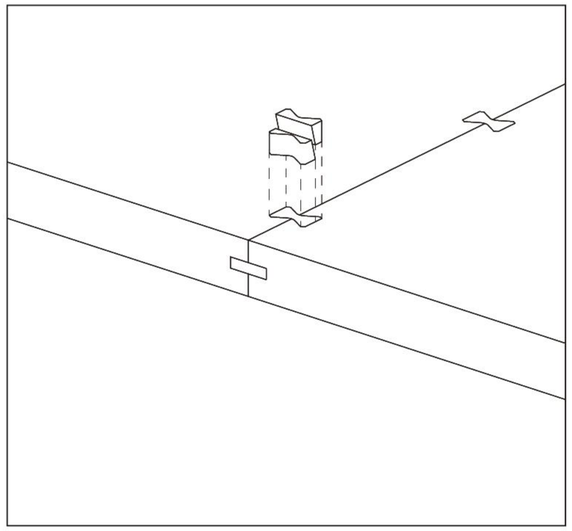
COLUMN & BEAM



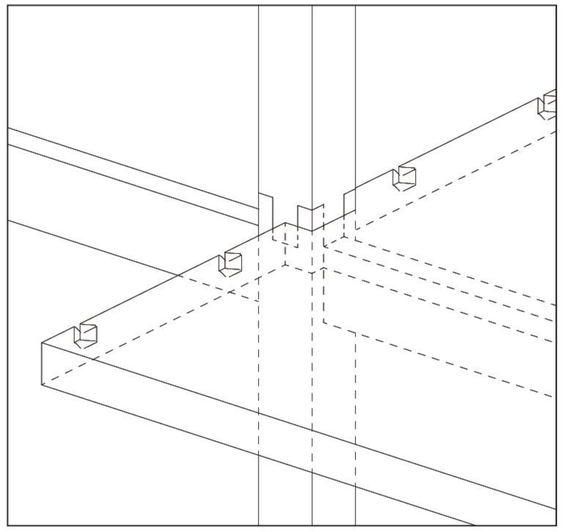
COLUMN & COLUMN

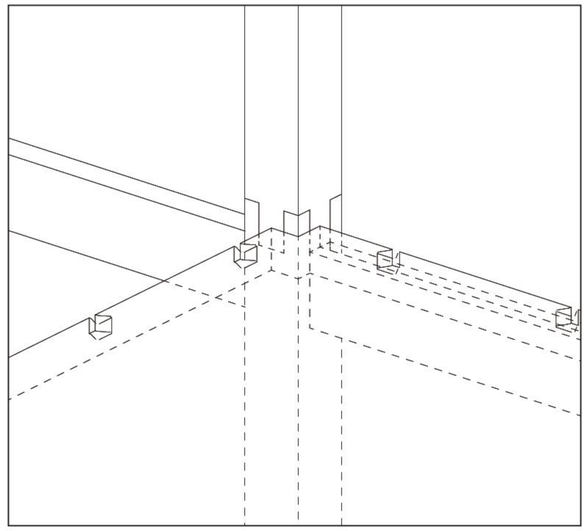


BEAM & BEAM



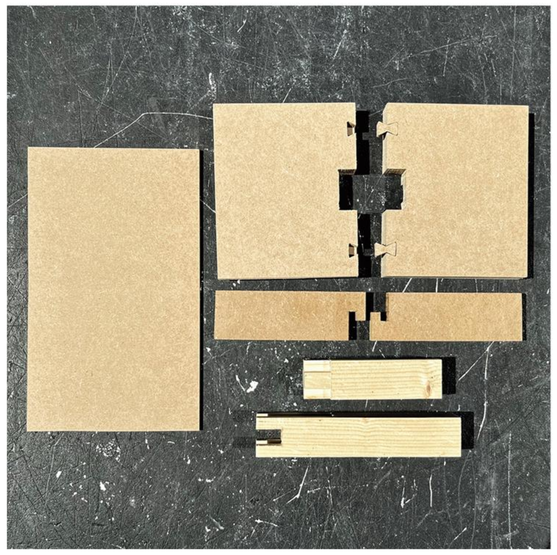
SLAB & SLAB

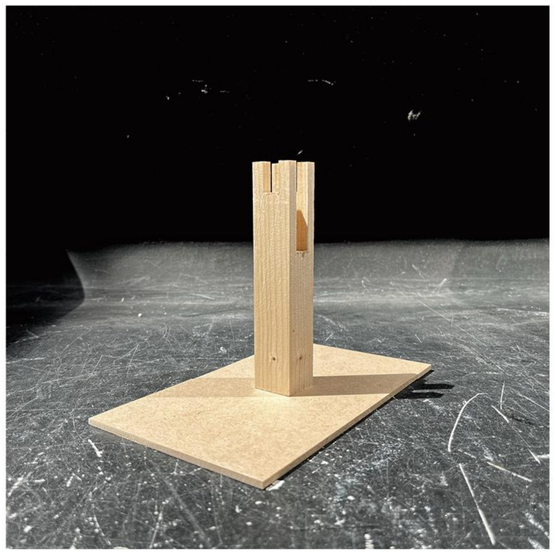


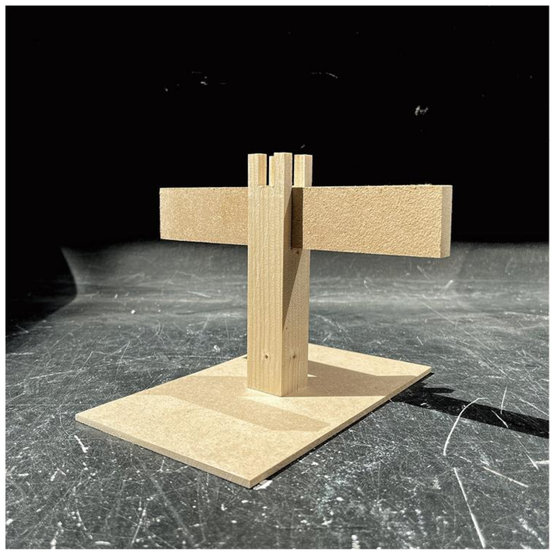


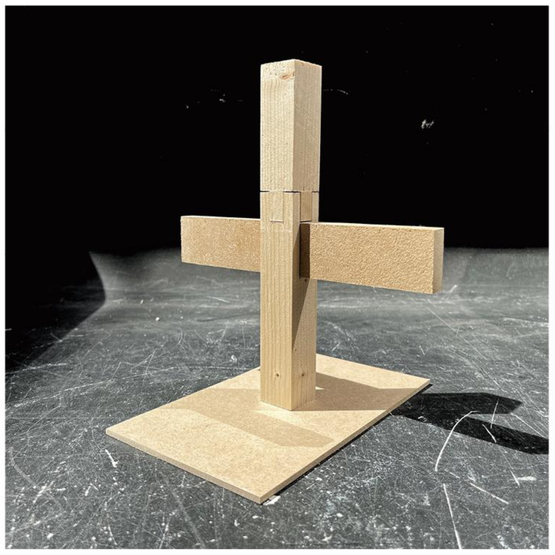
SLAB & COLUMN & BEAM

TIMBER JOINERY

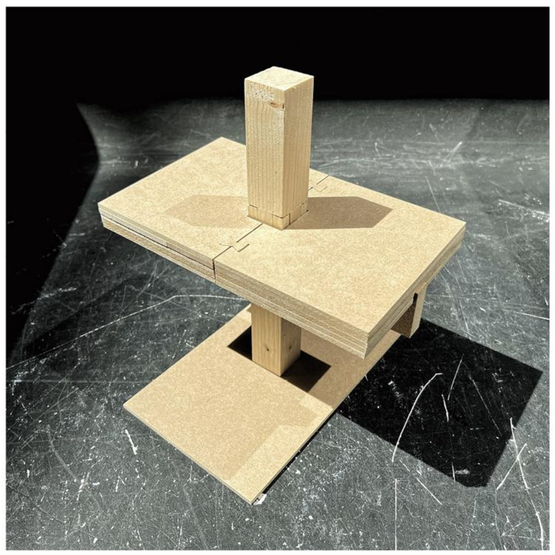


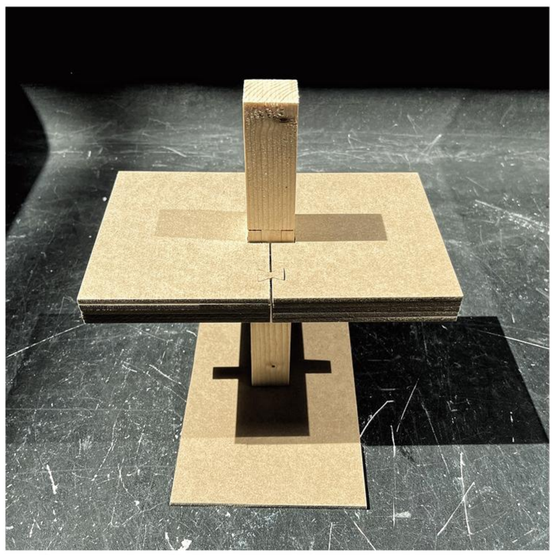






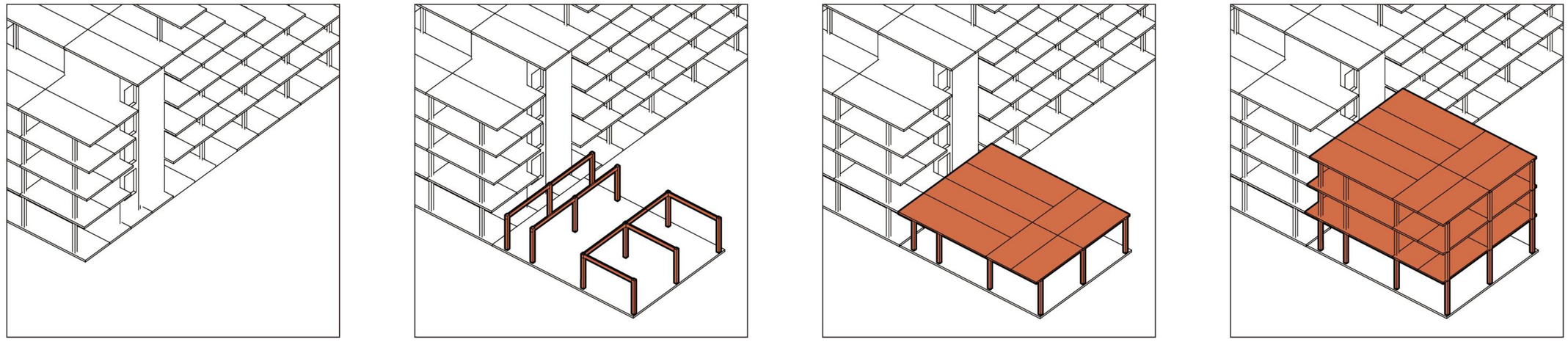


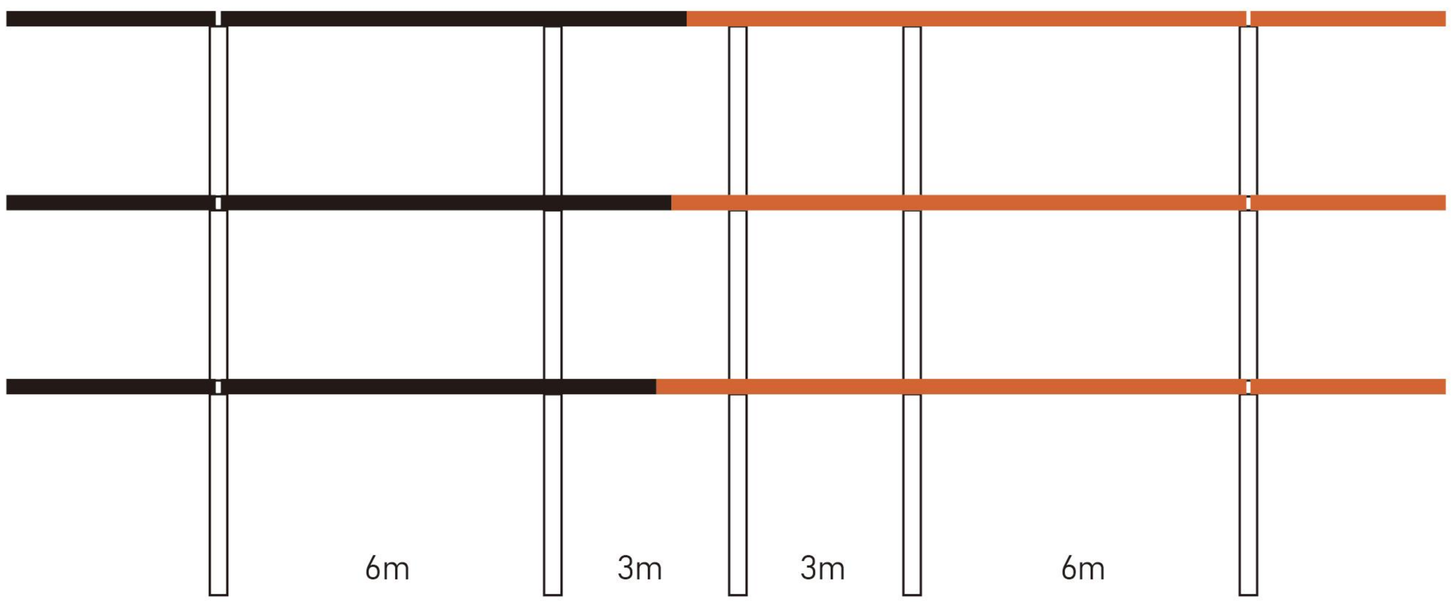






EXTENSION IN PHASE 2



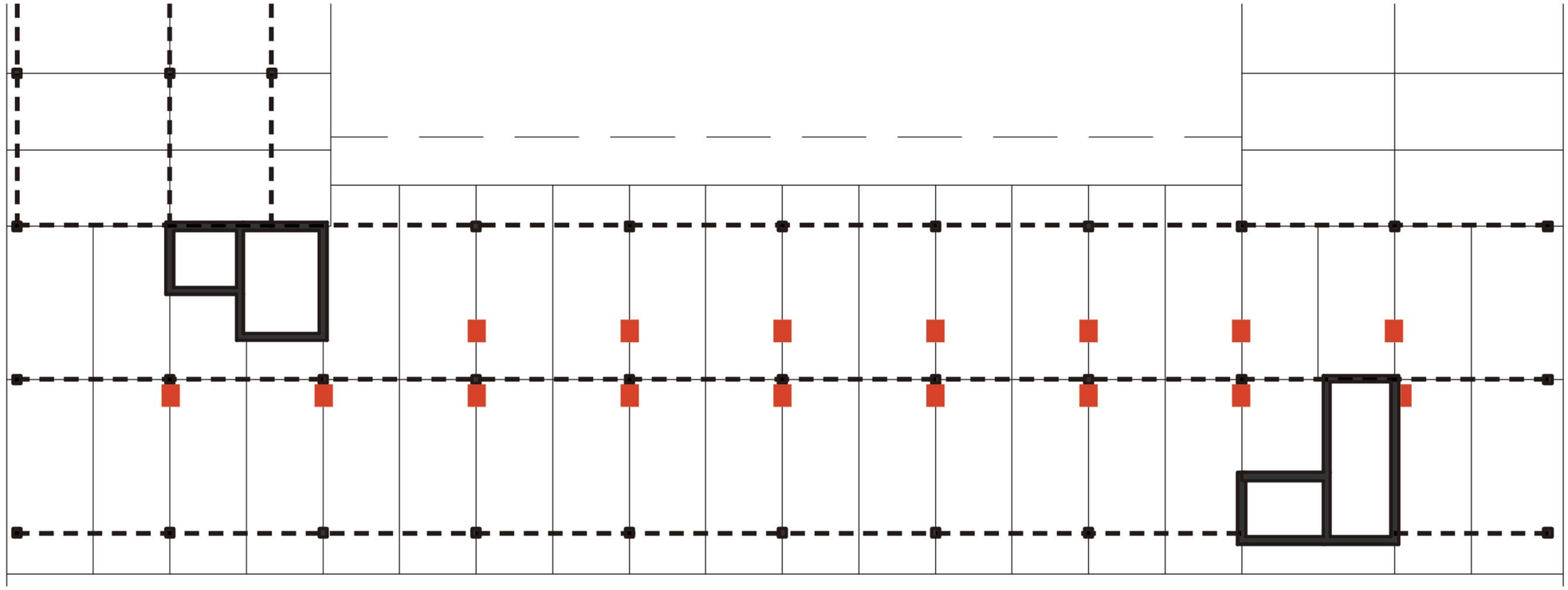


Column

Phase 1 CLT Floor

Phase 2 CLT Floor

INDEPENDENT LAYERS

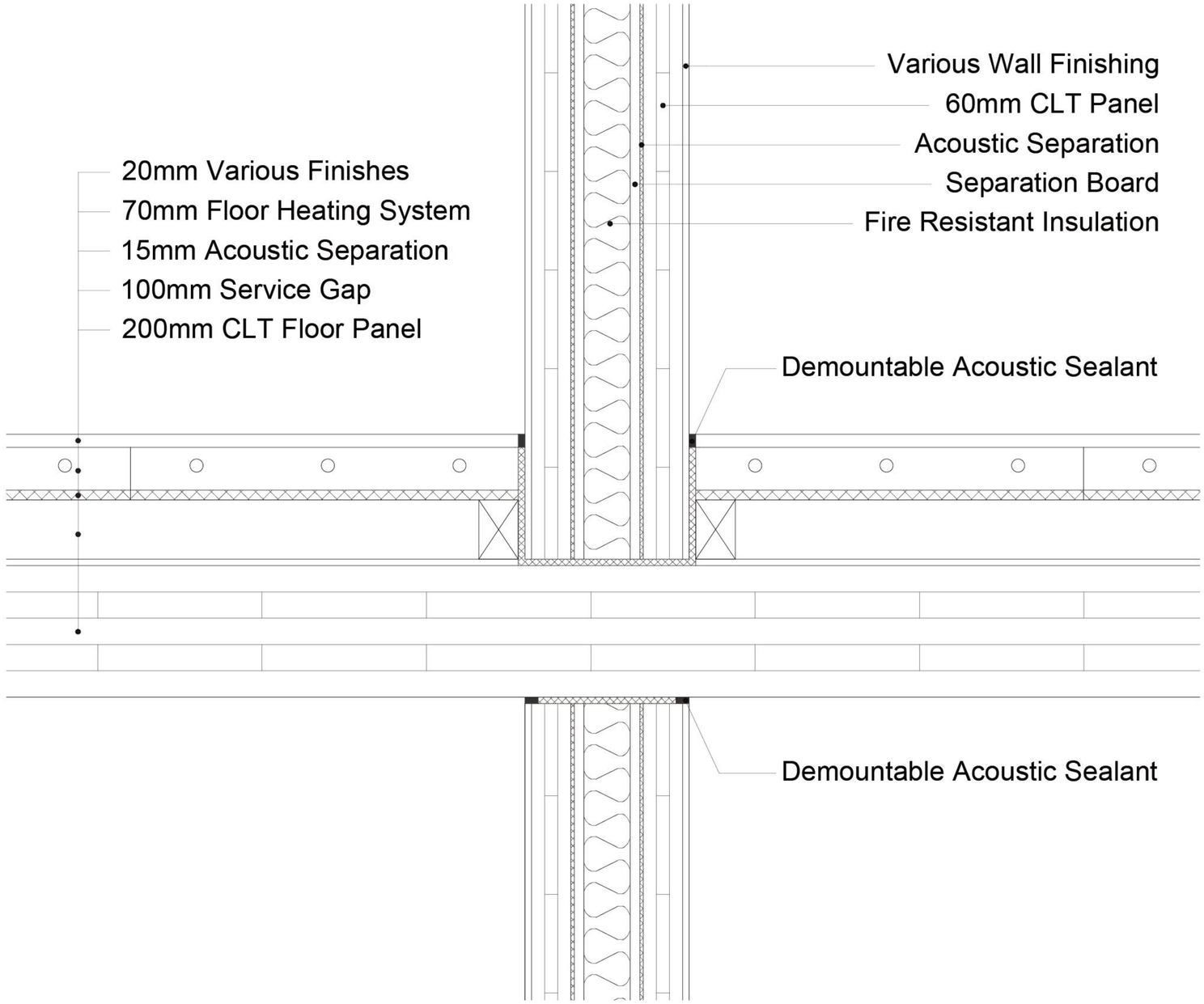


Shafts

Columns

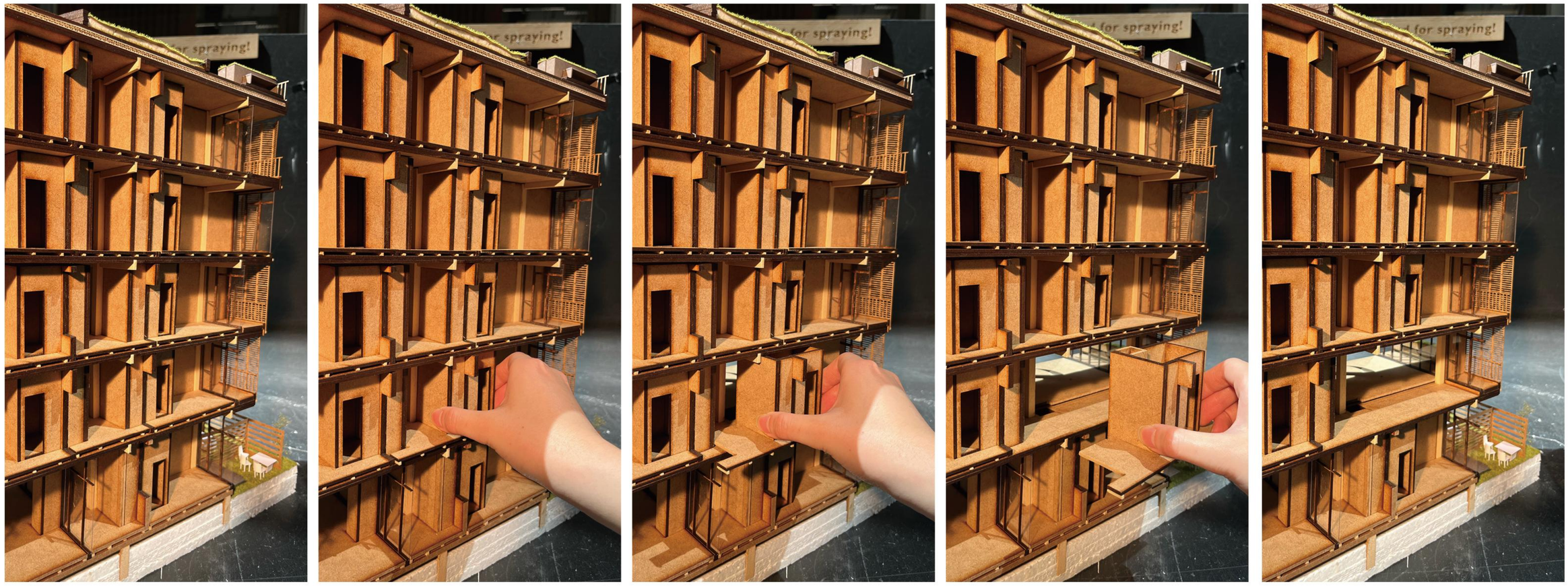
Beams

INDEPENDENT LAYERS



DETAILS OF ROOM SEPARATION WALL

TRANSFORMATION - SPACE PLAN



TRANSFORMATION - SPACE PLAN



TRANSFORMATION - SPACE PLAN





TRANSFORMATION - FACADE



TRANSFORMATION - FACADE





CLIMATE DESIGN

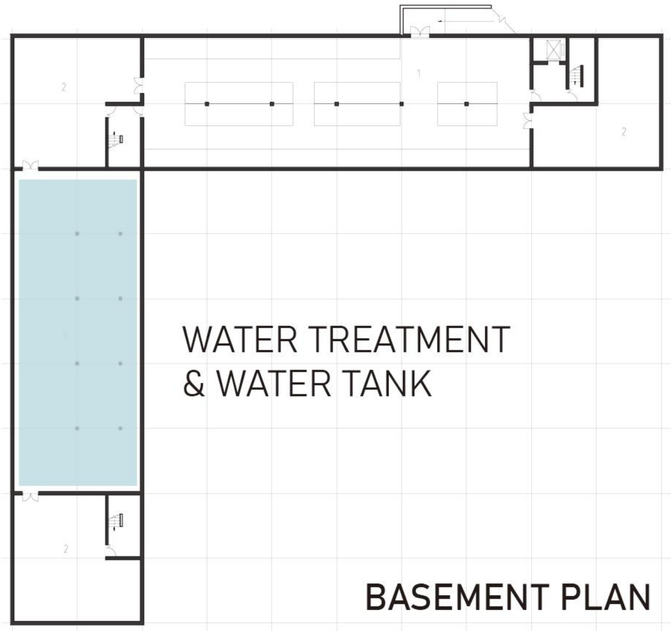
WATER - green-blue roof & water harvesting system
[water management (section diagram), drainage and piping(plan diagram)]

ENERGY - aquathermal energy & Floor heating & solar energy

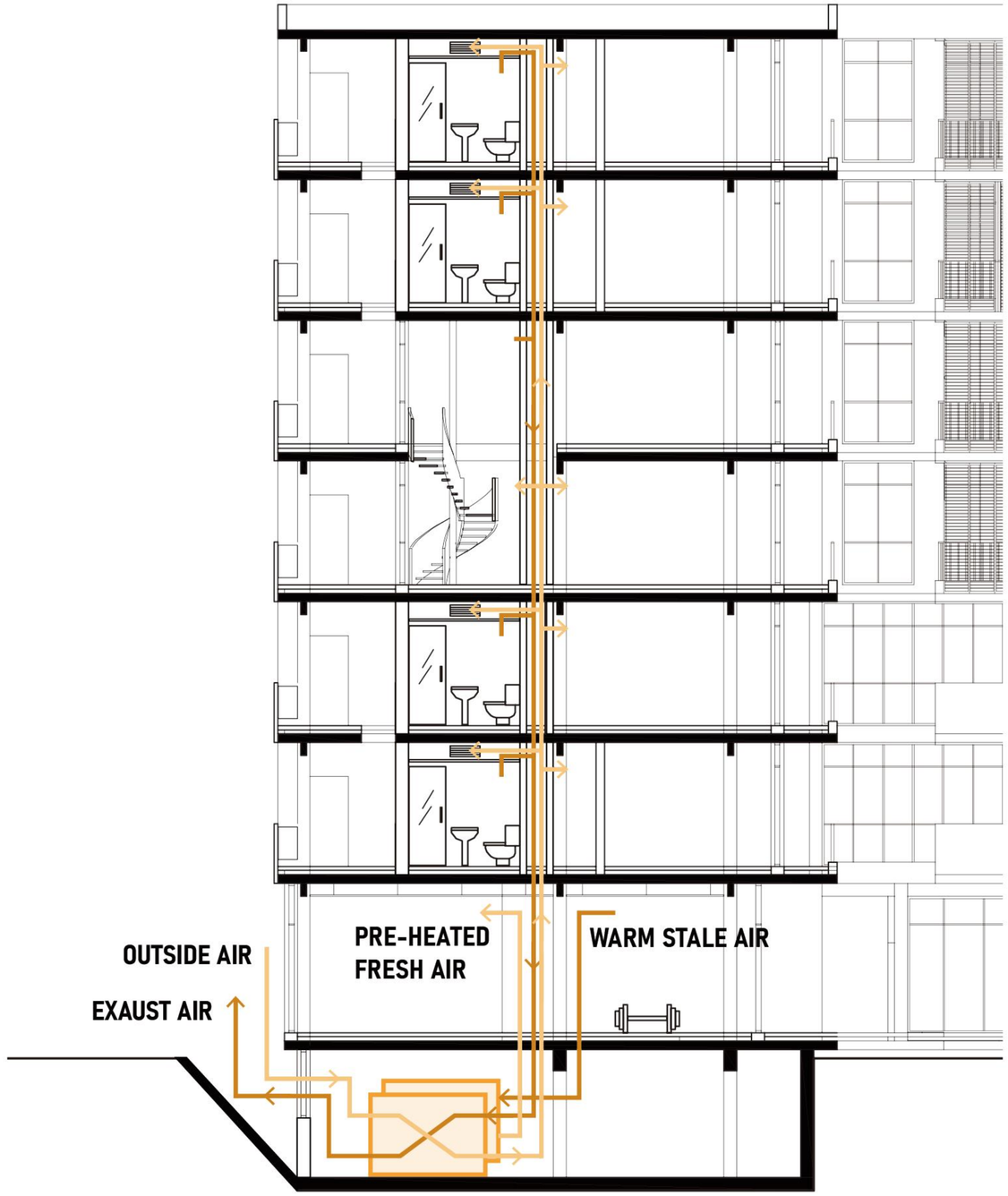
VENTILATION (winter) - Heat recovery system

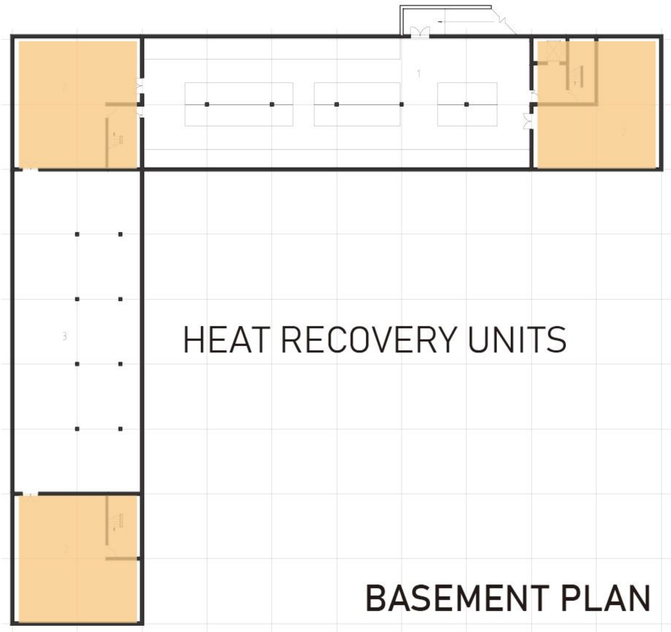
WATER MANAGEMENT



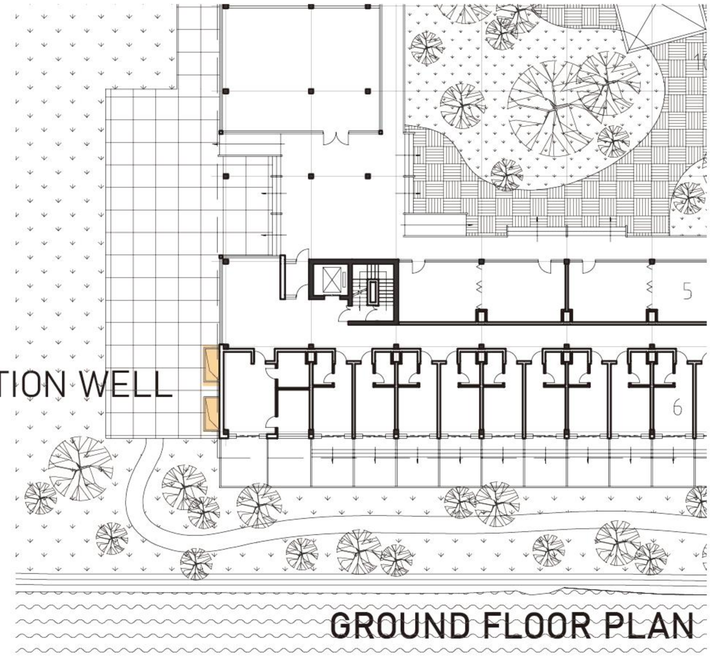


VENTILATION IN WINTER



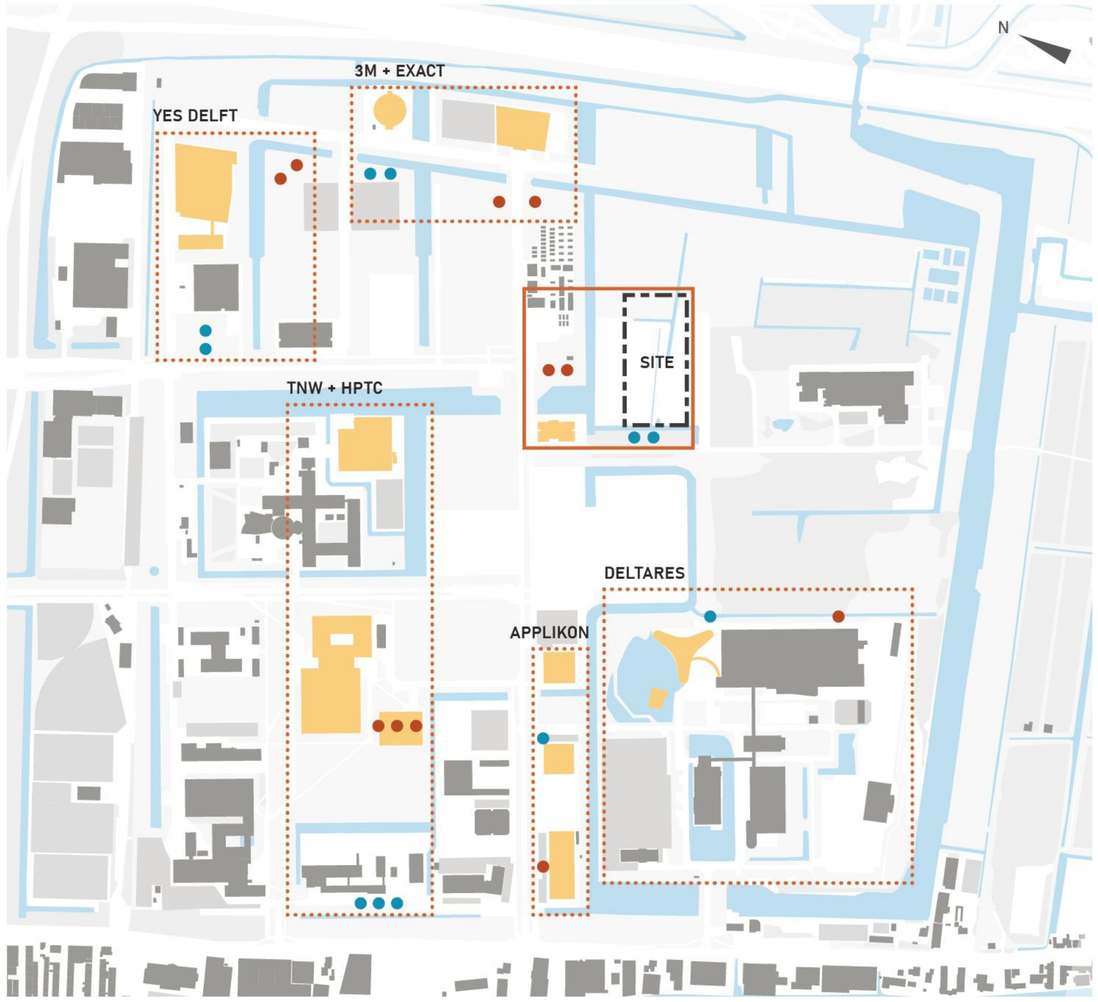


VENTILATION WELL



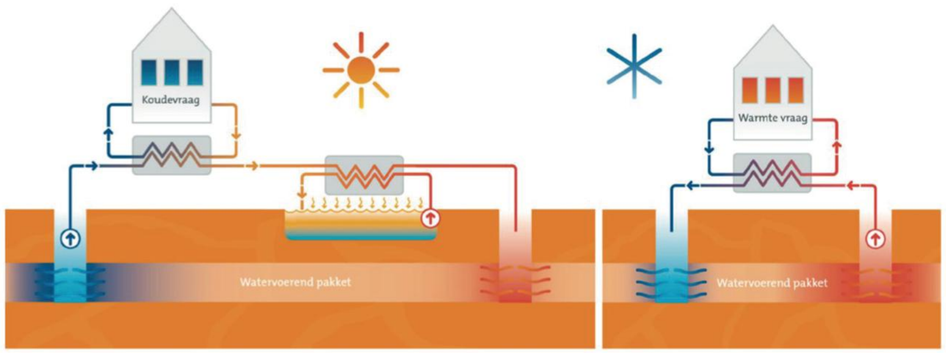
AQUATHERMAL ENERGY

PHASE I



PHASE II



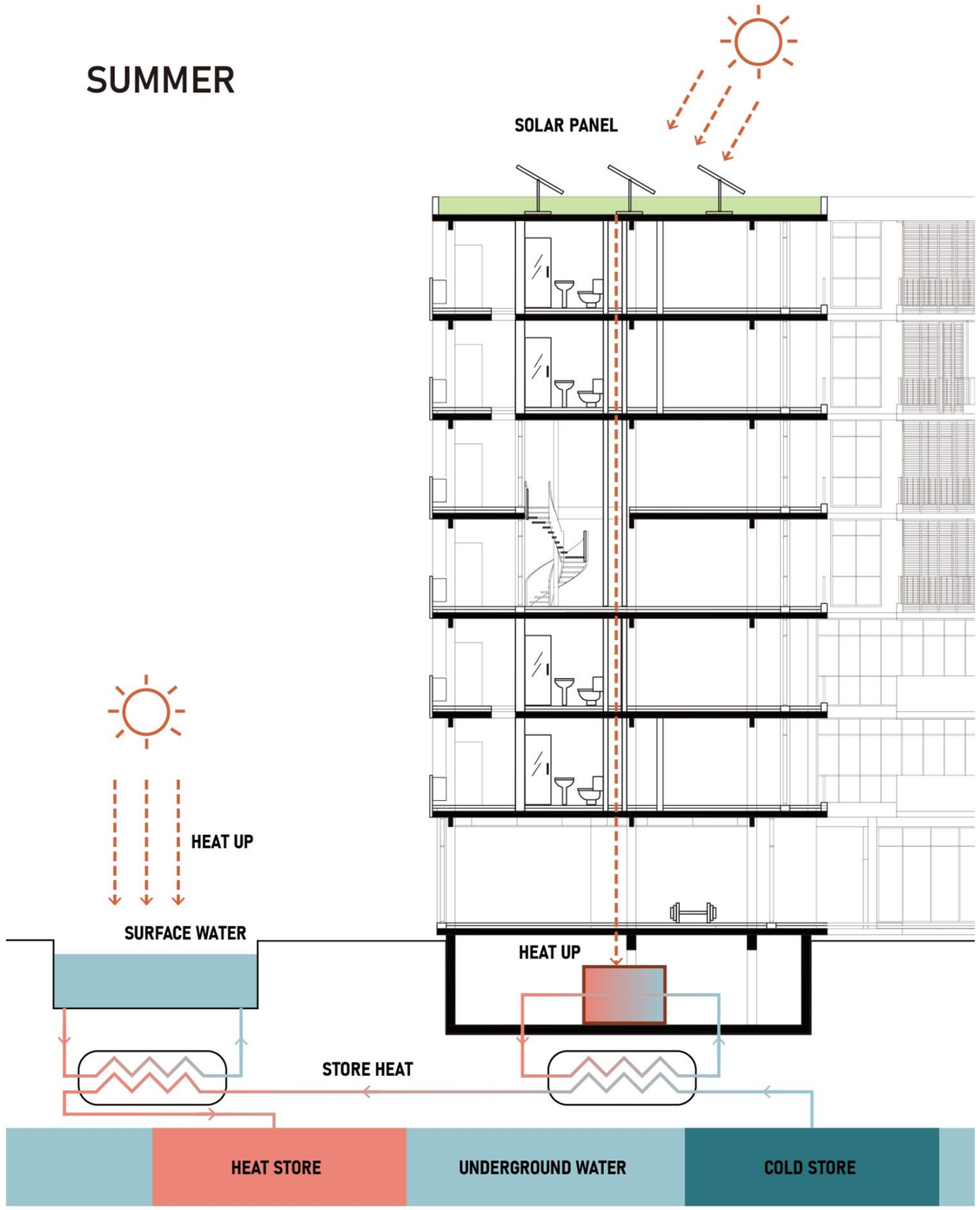


Heat Store

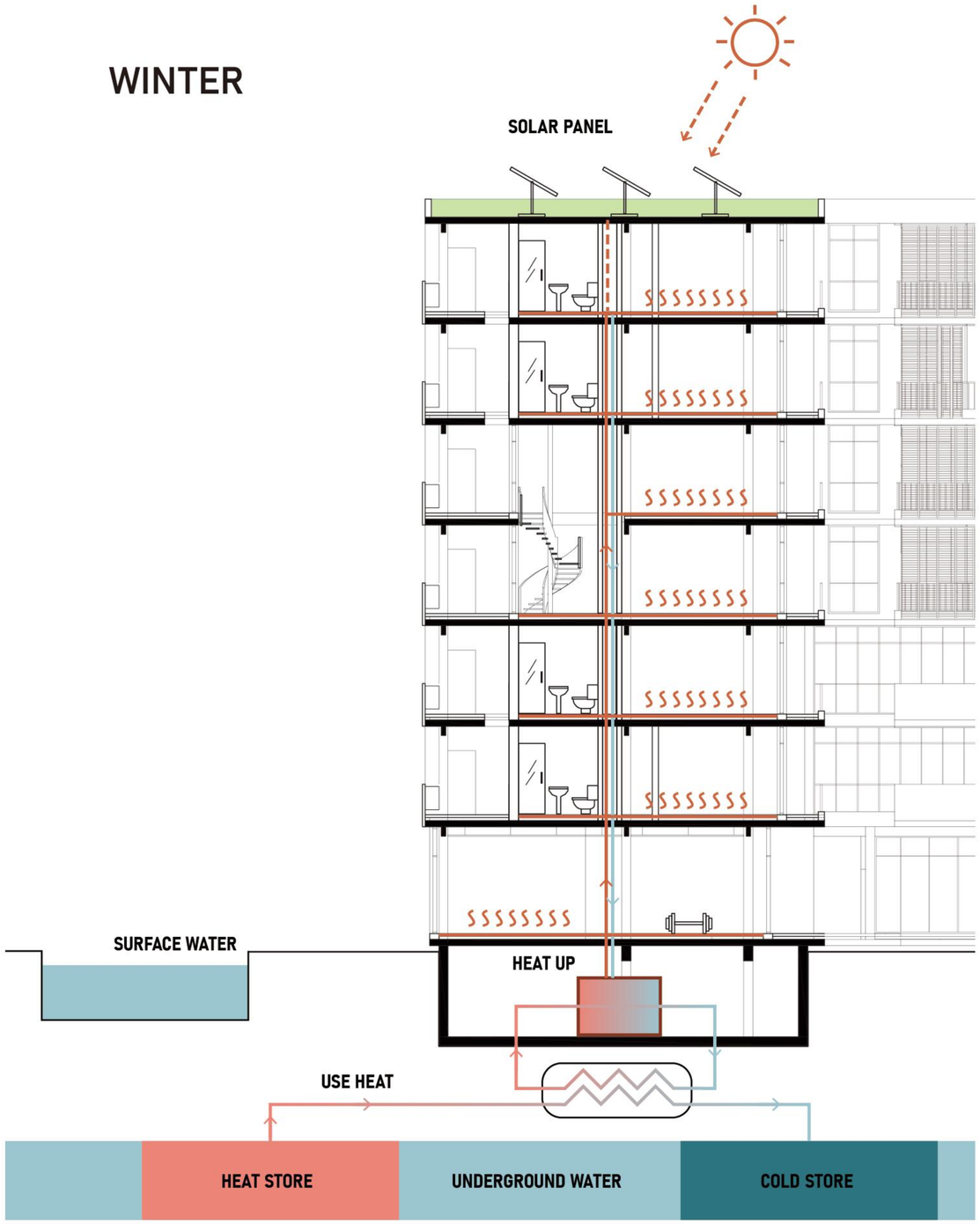
Cold Store

ENERGY SYSTEM

SUMMER



WINTER















THANKS FOR LISTENING!