

A framework for sustainable growth; Redesign of building 22

Architectural Engineering Graduation Studio

2022-2023

Mick van de Leur

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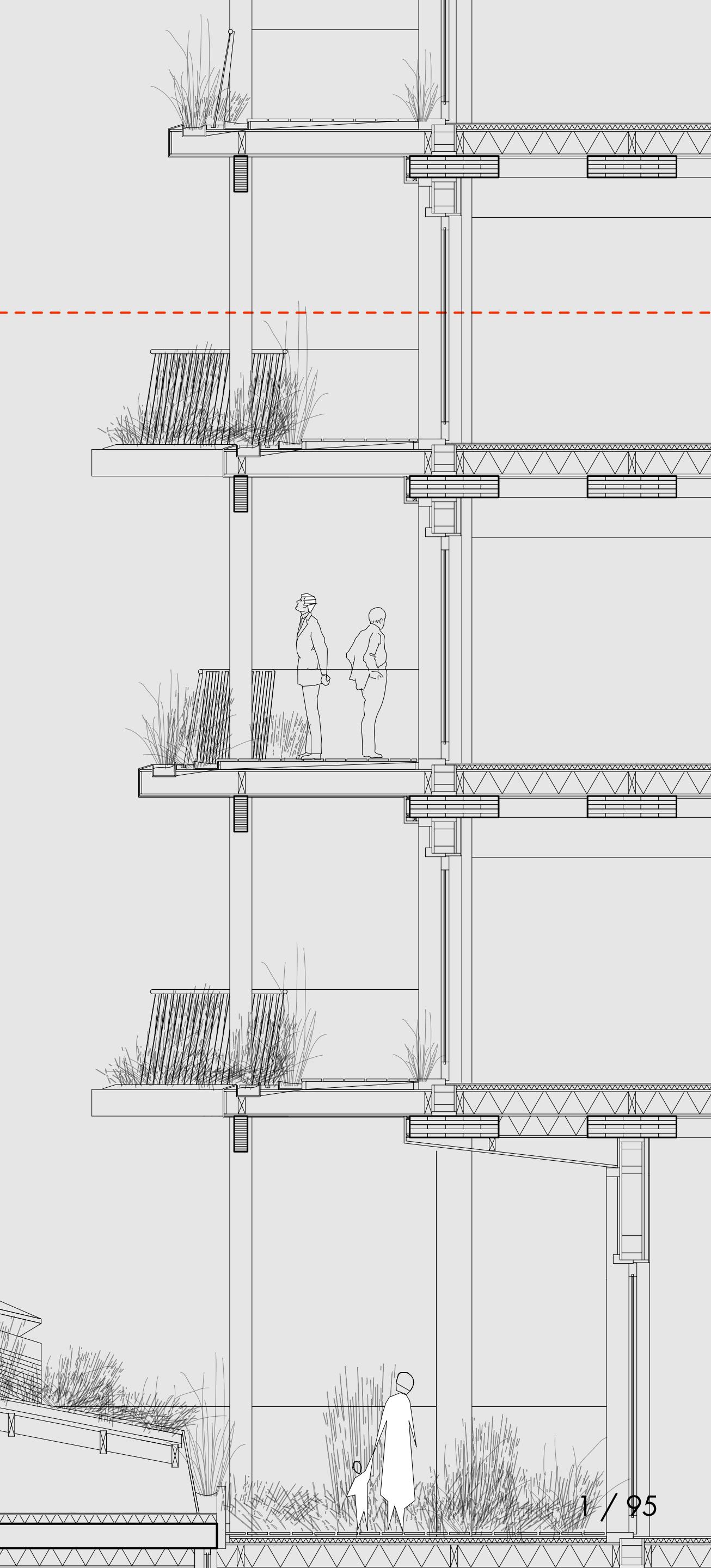
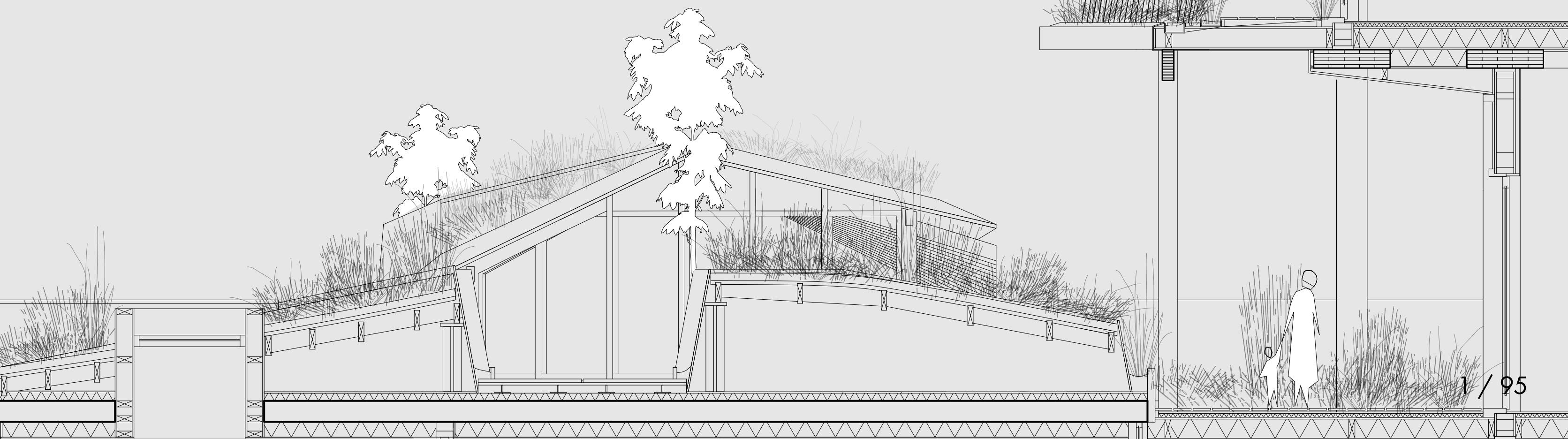
Under the guidance of:

Ir. S.H. (Stephan) Verkuijen - Architecture

Ir. P.H. (Paddy) Tomesen - Building Technology

Ir. G. (Gilbert) Koskamp - Research

Prof.dr.ir. M.G. (Marja) Elsinga - Delegate of the Board of Examiners



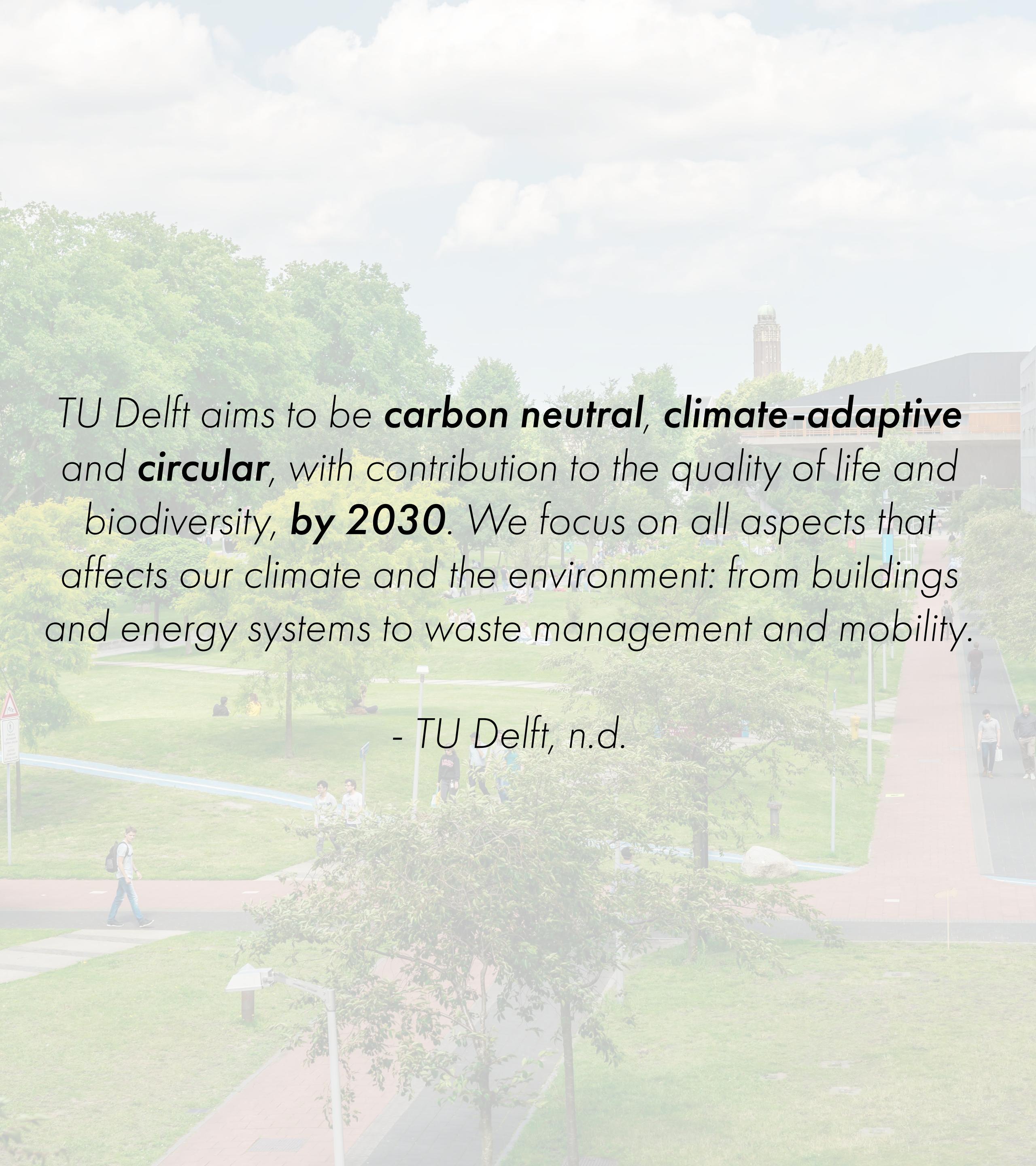


An aerial photograph of the TU Delft campus in Delft, Netherlands. The image shows a dense cluster of modern and traditional buildings, including the iconic red and white tower. The campus is surrounded by green trees and lawns, with a highway visible in the background. The overall scene is a mix of urban architecture and natural greenery.

'Impact for a better society'.

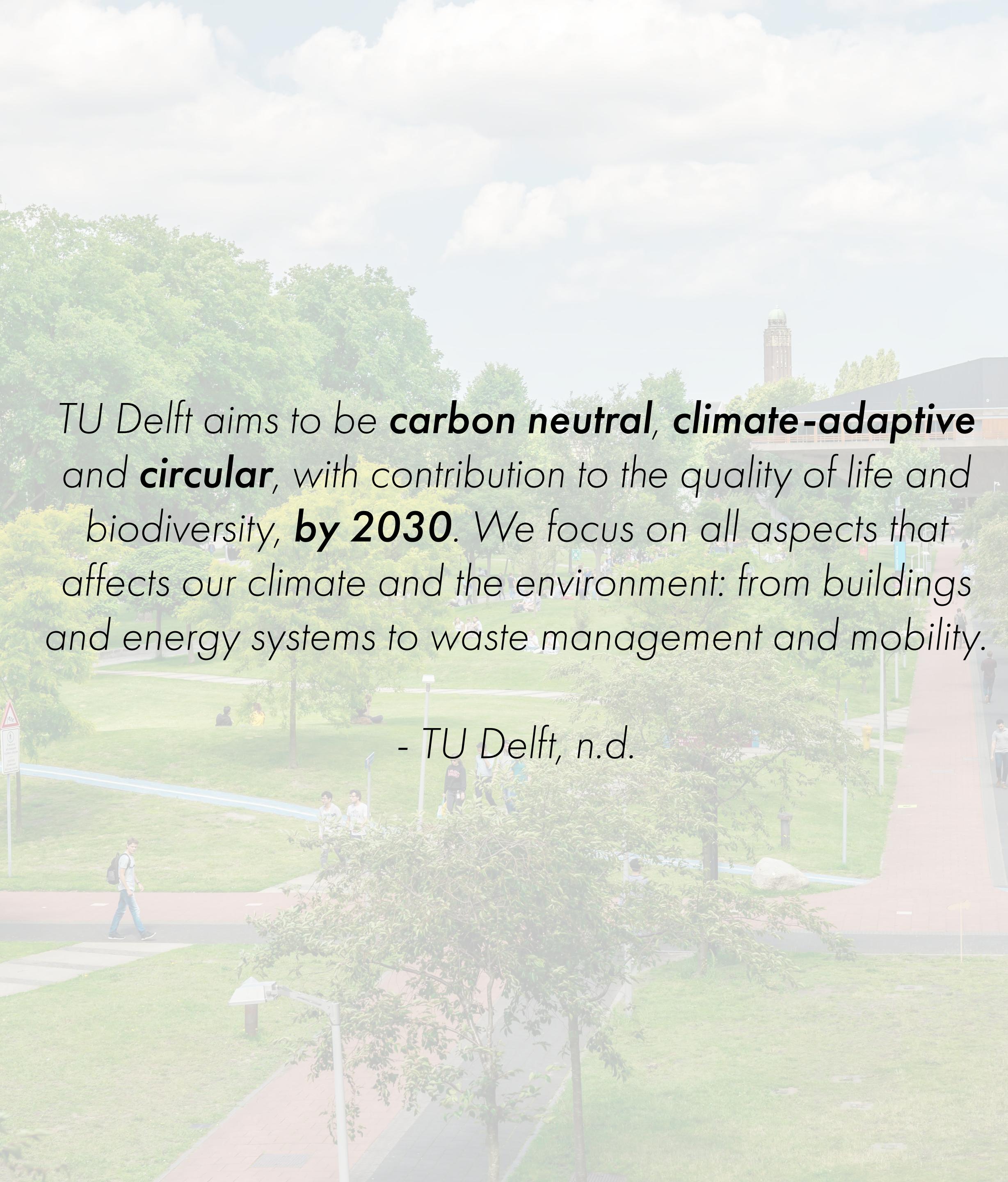
Society can rely on our university to become better. Through science, engineering and design TU Delft vows to contribute to a better world, a civilisation that needs to become sustainable for mankind's own sake.

- TU Delft, 2022



TU Delft aims to be **carbon neutral, climate-adaptive** and **circular**, with contribution to the quality of life and biodiversity, **by 2030**. We focus on all aspects that affects our climate and the environment: from buildings and energy systems to waste management and mobility.

- TU Delft, n.d.



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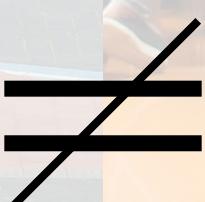
Engineers have a vital role to play in solving the major societal issues of this century. ...The domestic demand for engineers is as high as ever. ... By **increasing our student** numbers to **40,000**, we can aim for 5,500-6,000 engineering graduates a year.

- TU Delft executive board, 2022



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Ambitious sustainability goals 



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- TU Delft executive board, 2022

Projected growth

Design question:

How can the TU Delft accommodate the growing student population whilst complying with its own sustainability goals?

Specific

Design question:

How can the TU Delft accommodate the growing student population whilst complying with its own sustainability goals?

Specific

Is it really?

2.3 billion

New urban dwellers by 2050

230 billion m²

of new buildings by 2060



United Nations Department of Economic and Social Affairs. (2018).
United Nations Environment Programme. (2018).

2.3 billion

New urban dwellers by 2050

230 billion m²

of new buildings by 2060



1.8 earths

Needed to sustain ourselves

2400 gigatons CO₂

emitted since 1850



The World Counts. (n.d.).
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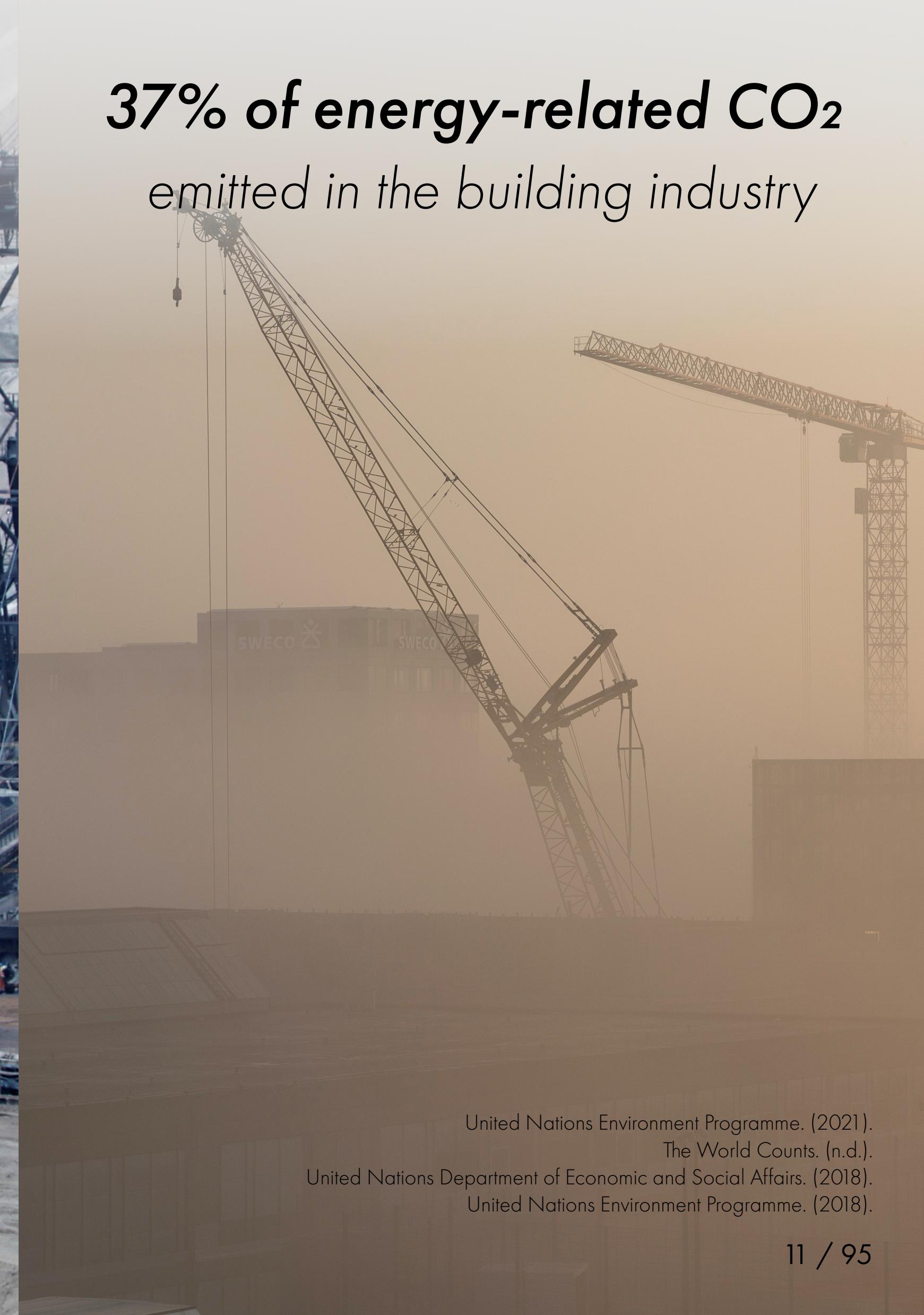


2400 gigatons CO₂

emitted since 1850

36% of global energy

used in built environment



37% of energy-related CO₂

emitted in the building industry

United Nations Environment Programme. (2021).
The World Counts. (n.d.).
United Nations Department of Economic and Social Affairs. (2018).
United Nations Environment Programme. (2018).

Design question:

How can the TU Delft accommodate the growing student population whilst complying with its own sustainability goals?

Specific

General question:

we

How can the ~~TU Delft~~ accommodate the growing ~~student~~ population
whilst complying with ~~its~~ own sustainability goals?

our

and increasing
urbanization

Generic

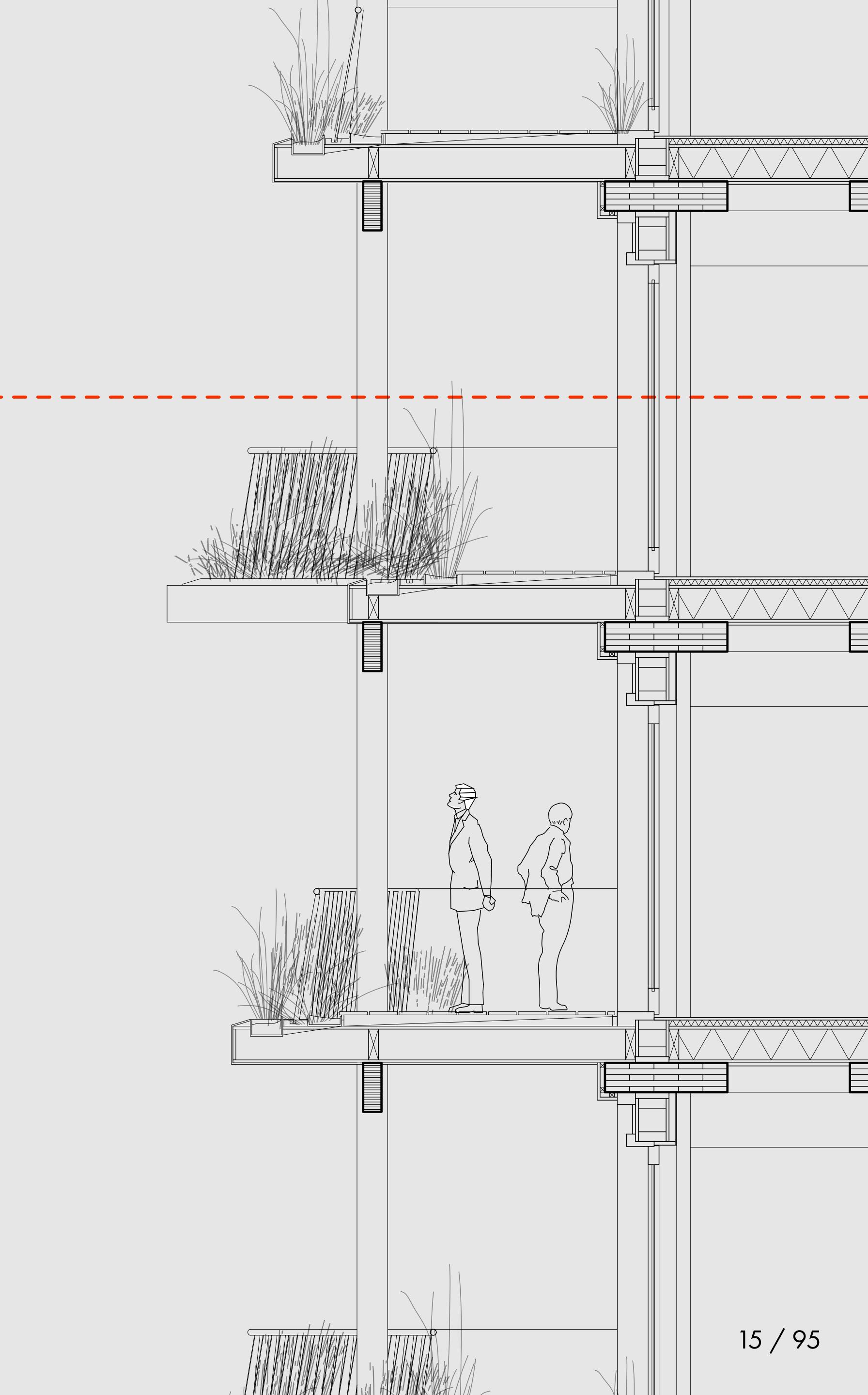
Research question:

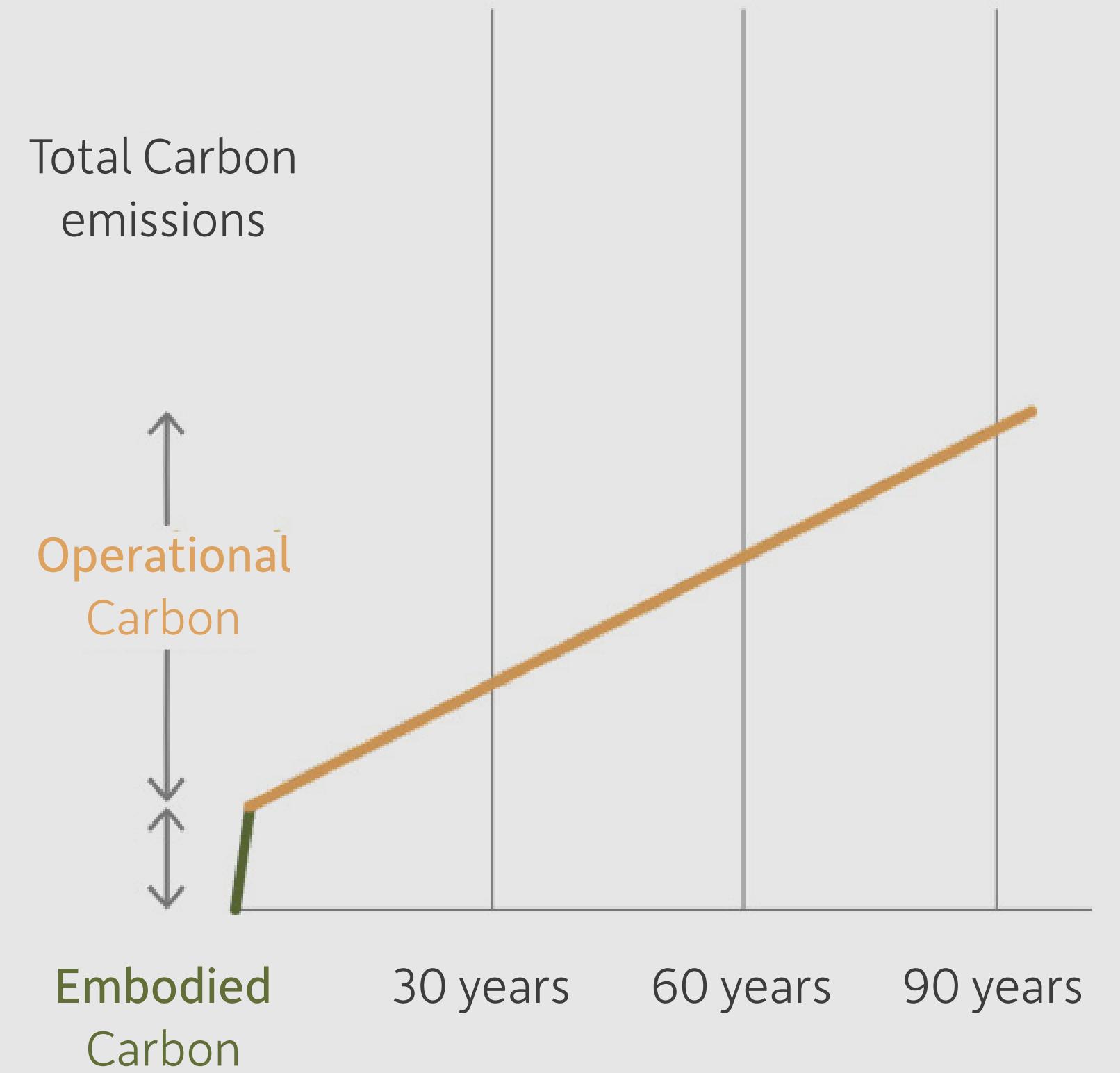
How can the structure of multistorey timber buildings be designed when taking material efficiency as a guiding principle?

Generic and specific

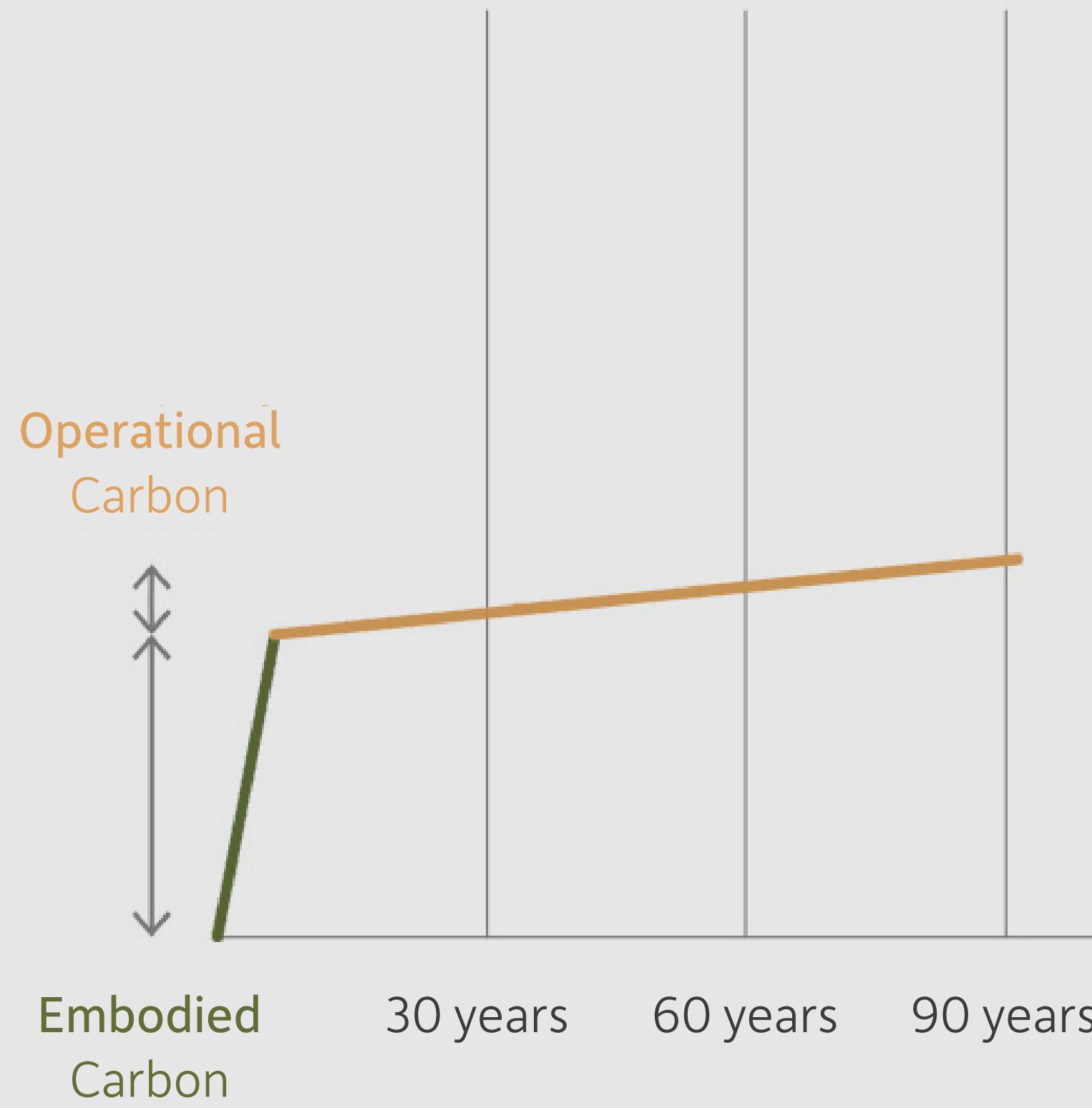
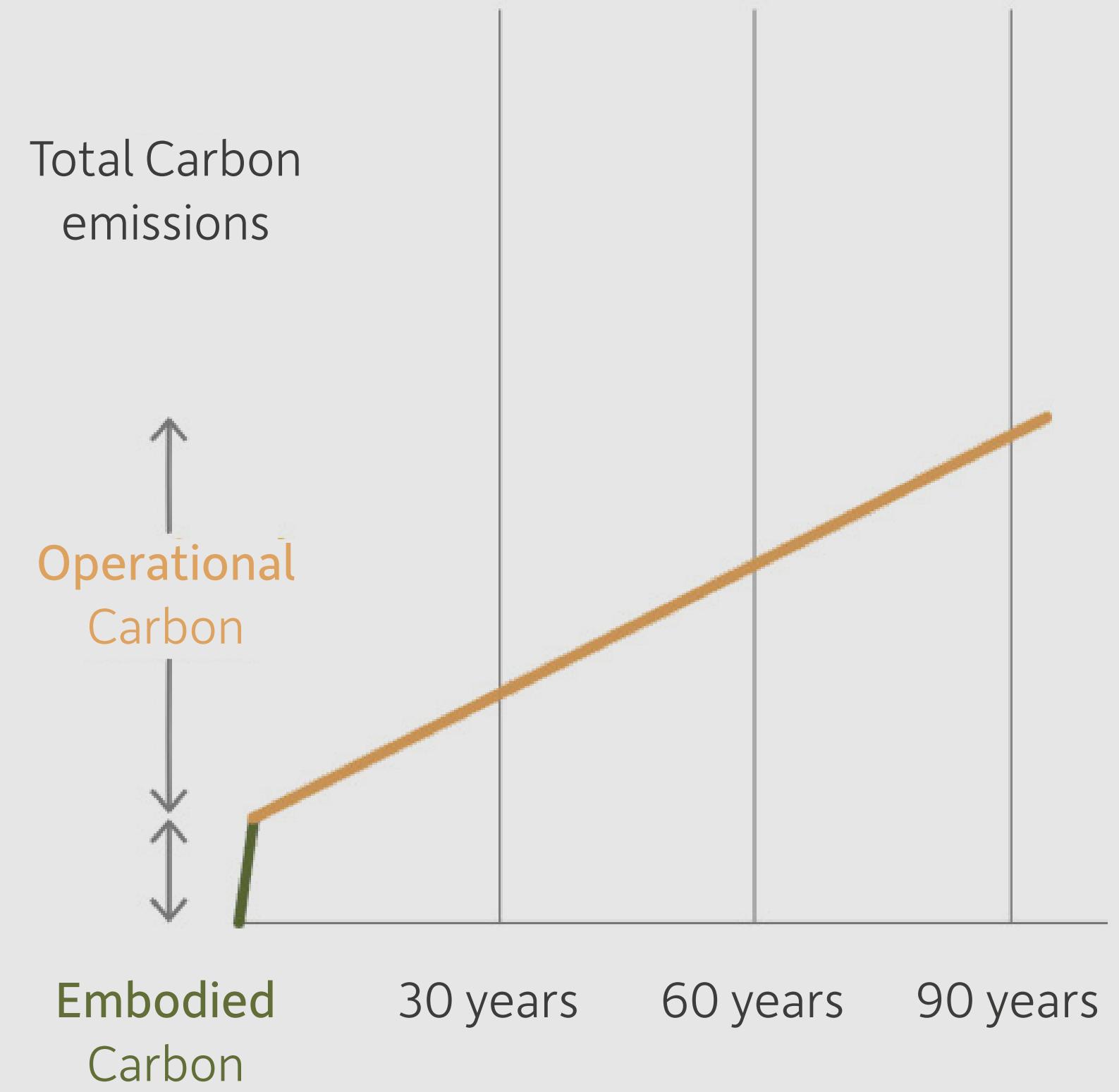
Research

Semester 1









Problem statement:

1. Continuing to build energy-efficient buildings with materials that have a high embodied environmental impact could cause irreversible damage to the environment. (Accumulation of damage)
2. The IPCC warns that reductions are needed now, and not just in 30 years' time.
3. Building with biobased products like wood could provide the solution. But the sustainability of wood is not absolute.

Research question

What constitutes a multistorey timber building and why is it significant?

1. Energy use and urban density are related
2. An optimal building height exists somewhere between 10 and 20 stories*
3. Using timber reduces embodied emissions significantly

(Bohne et al., 2017; Pomponi et al., 2020; Resch et al., 2016)



Research question

Which parameters govern the structural design of multistorey timber buildings?

1. Eurocode: strength, stability and stiffness
2. Versatility of timber, inherent fire-performance, acoustic and thermal properties = efficient
3. Nevertheless, we should always try to reduce the amount of material used

(European Committee for Standardization (CEN), 2004; Herzog et al., 2004; Kaufmann et al., 2018)



Research question

How can material efficiency be quantified and by which criteria is it defined?

1. Material efficiency = reduce production of energy-intensive materials (reduce the environmental impact)

2. Quantification through Life-Cycle-Assessment (LCA)

(Allwood et al., 2013; Gulck et al., 2022; London Energy Transformation Initiative (LETI), 2020)

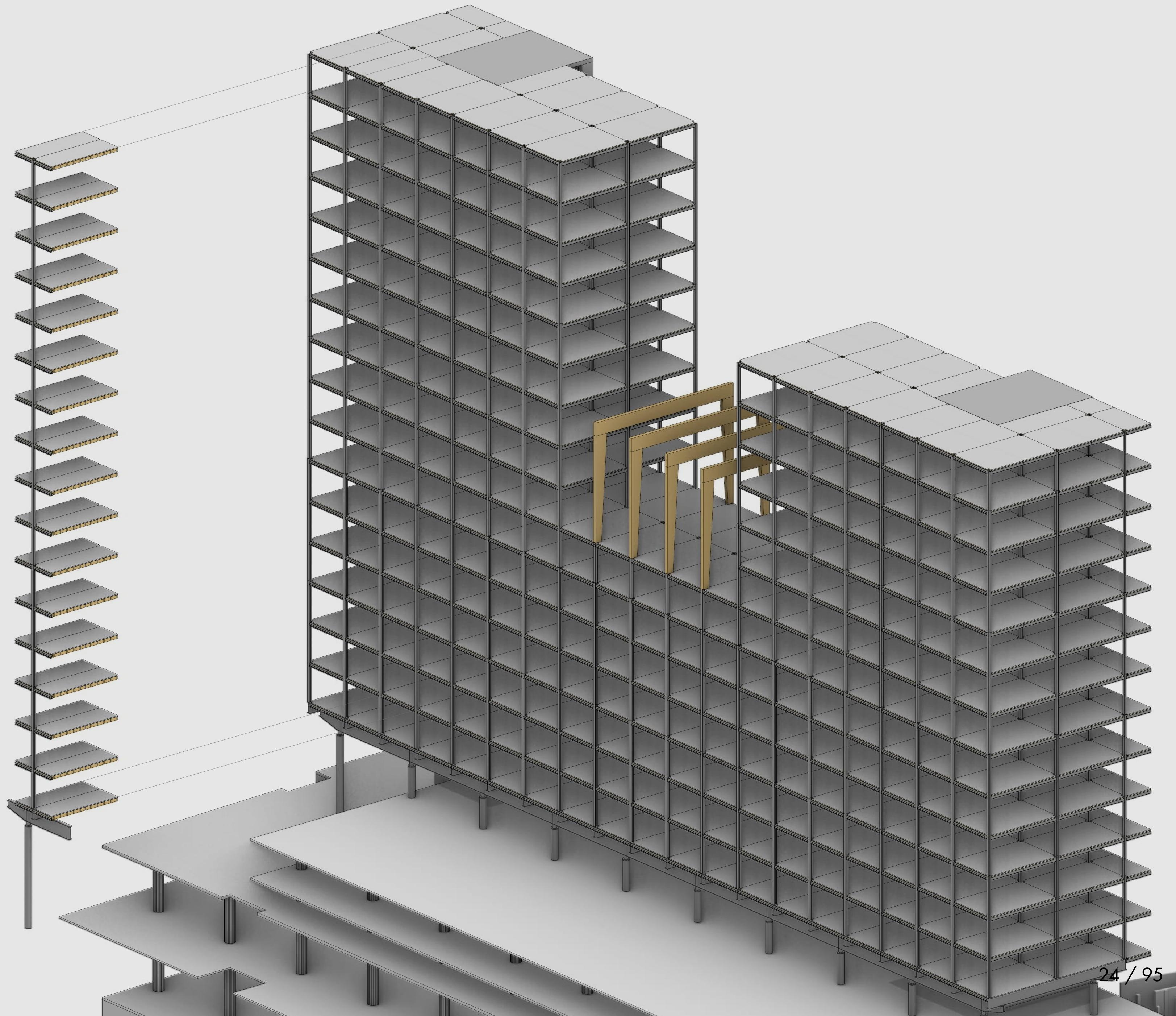


Research question

Which structural design is more efficient in terms of material use?

1. Assess one building, but with several alternative structural systems
2. How much more efficient is timber truly?



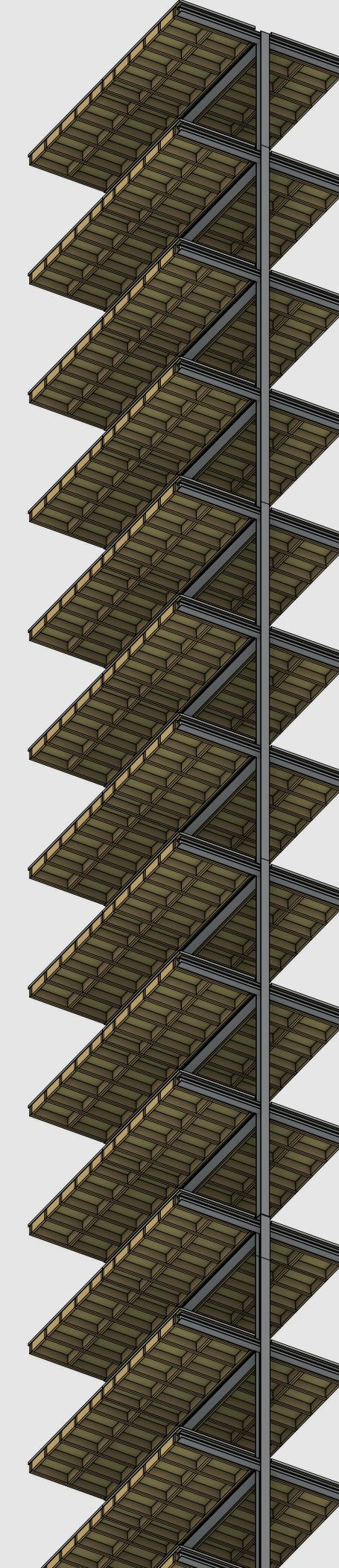


Variant E5 (base)

Floors:
Spruce joists and
beams, spruce plate
and concrete topping

Beams:
Steel HE220A,
S355

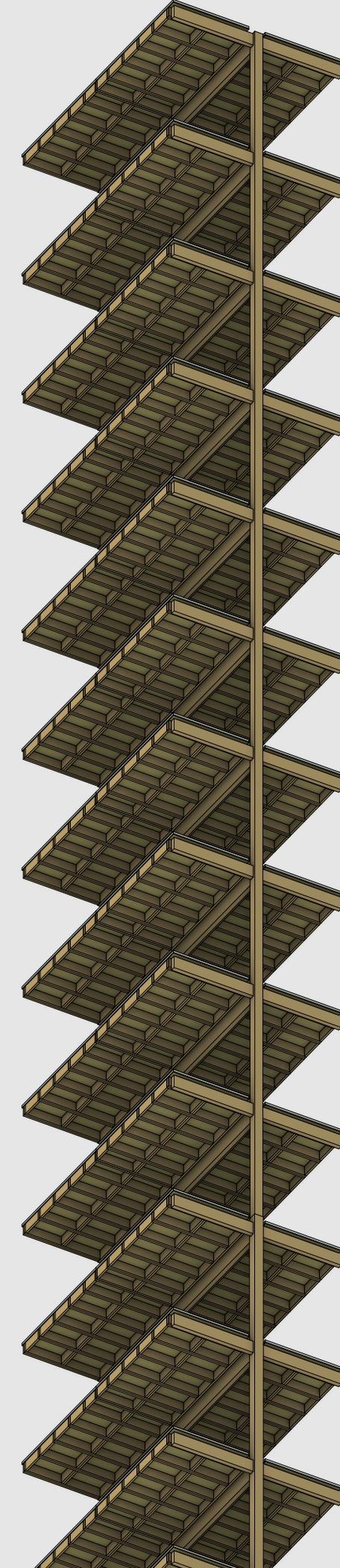
Columns:
Steel HE220B,
S355

**Variant A1.1**

Floors:
Spruce joists and
beams, spruce plate
and concrete topping

Beams:
Beech LVL,
GL75

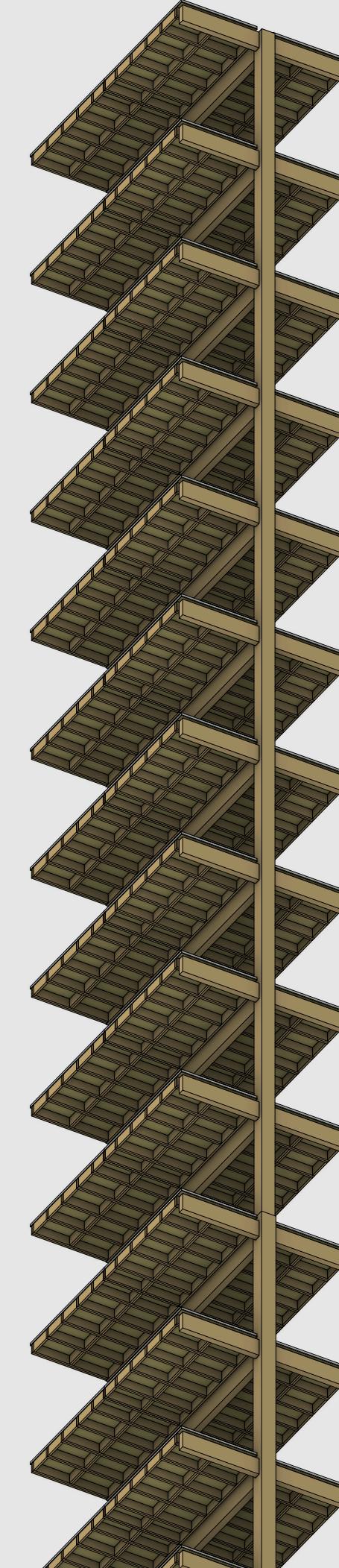
Columns:
Beech LVL,
GL75

**Variant A1.2**

Floors:
Spruce joists and
beams, spruce plate
and concrete topping

Beams:
Spruce LVL,
GL28

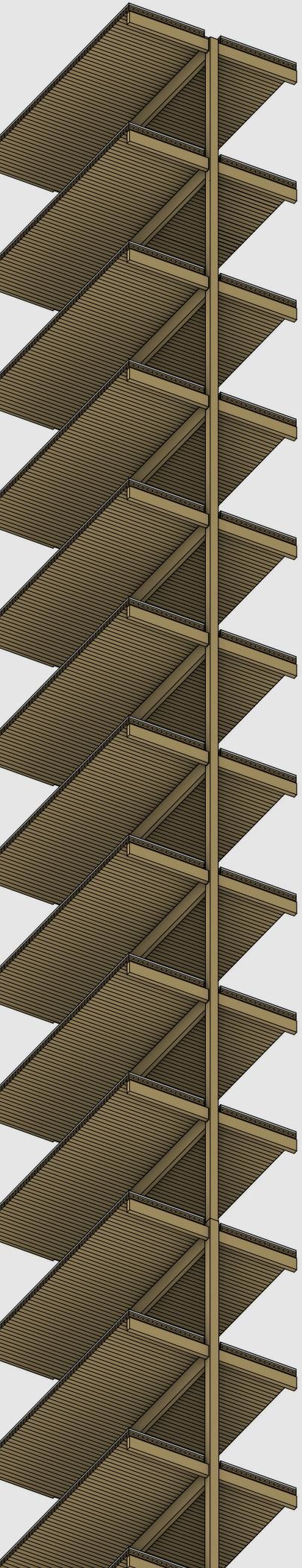
Columns:
Spruce LVL,
GL28

**Variant A4.1**

Floors:
120mm-3s spruce
CLT and concrete
topping

Beams:
Beech LVL,
GL75

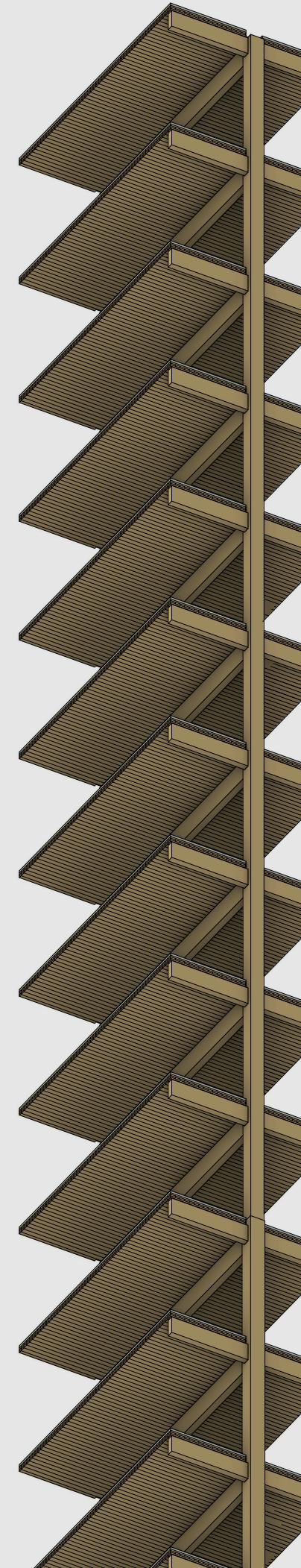
Columns:
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GL75

**Variant A4.2**

Floors:
120mm-3s spruce
CLT and concrete
topping

Beams:
Spruce LVL,
GL28

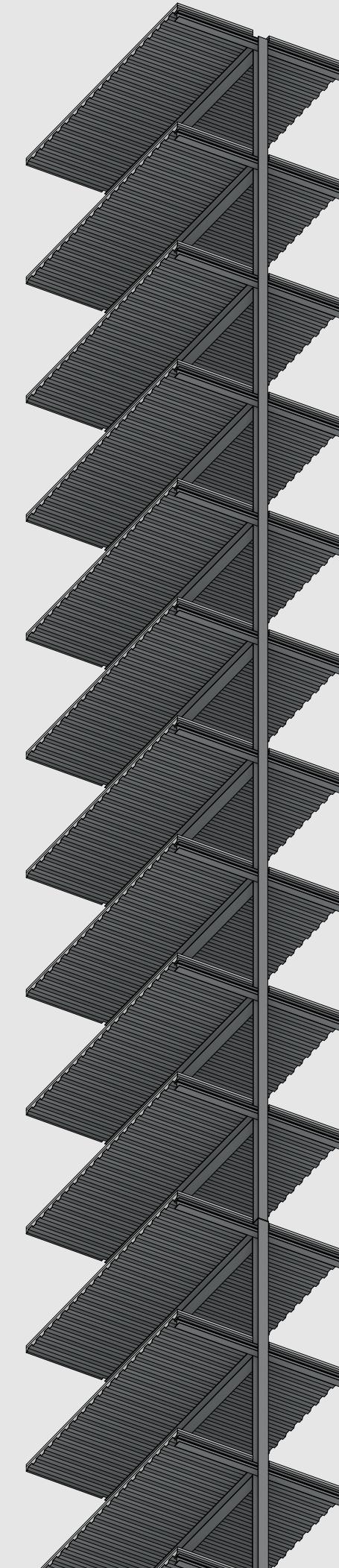
Columns:
Spruce LVL,
GL28

**Variant E8**

Floors:
Steel-concrete
composite slab and
concrete topping

Beams:
Steel HE240A,
S355

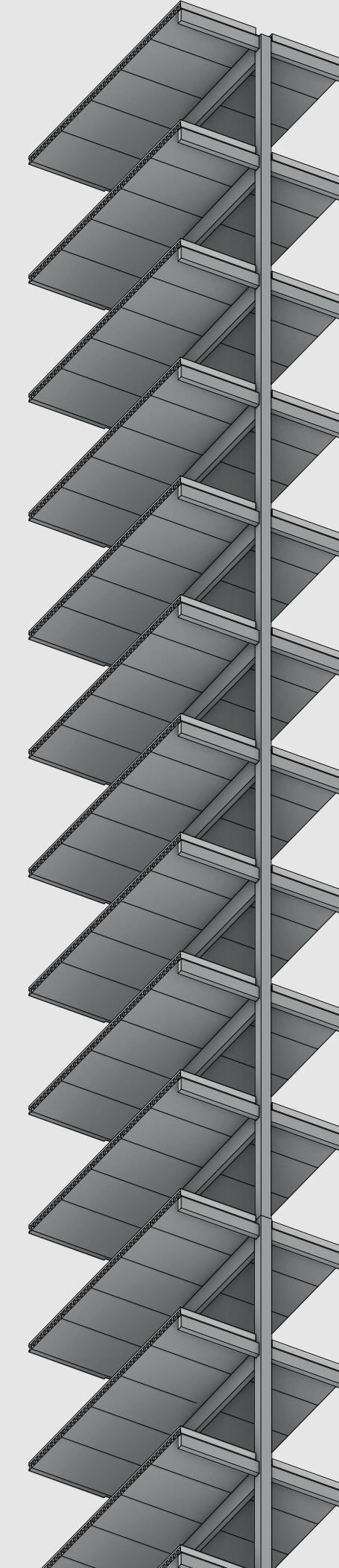
Columns:
Steel HE240B,
S355

**Variant F9.1**

Floors:
Hollow-core slabs and
concrete topping

Beams:
Concrete,
C90/105

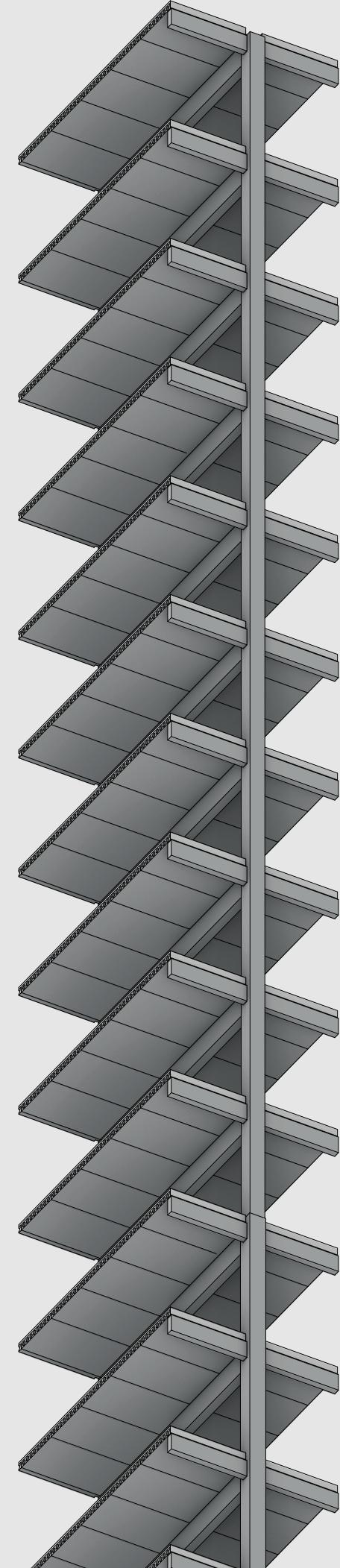
Columns:
Concrete,
C90/105

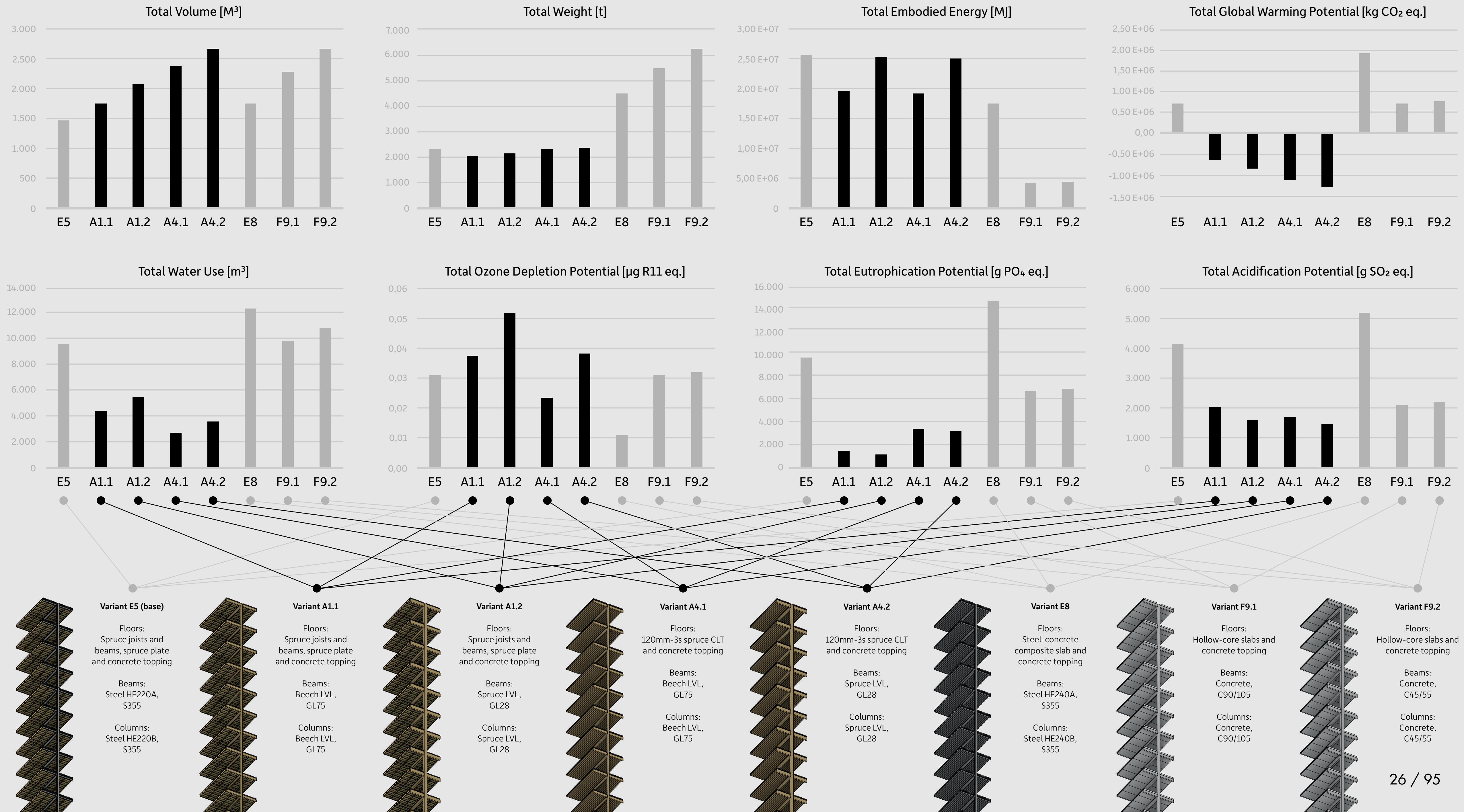
**Variant F9.2**

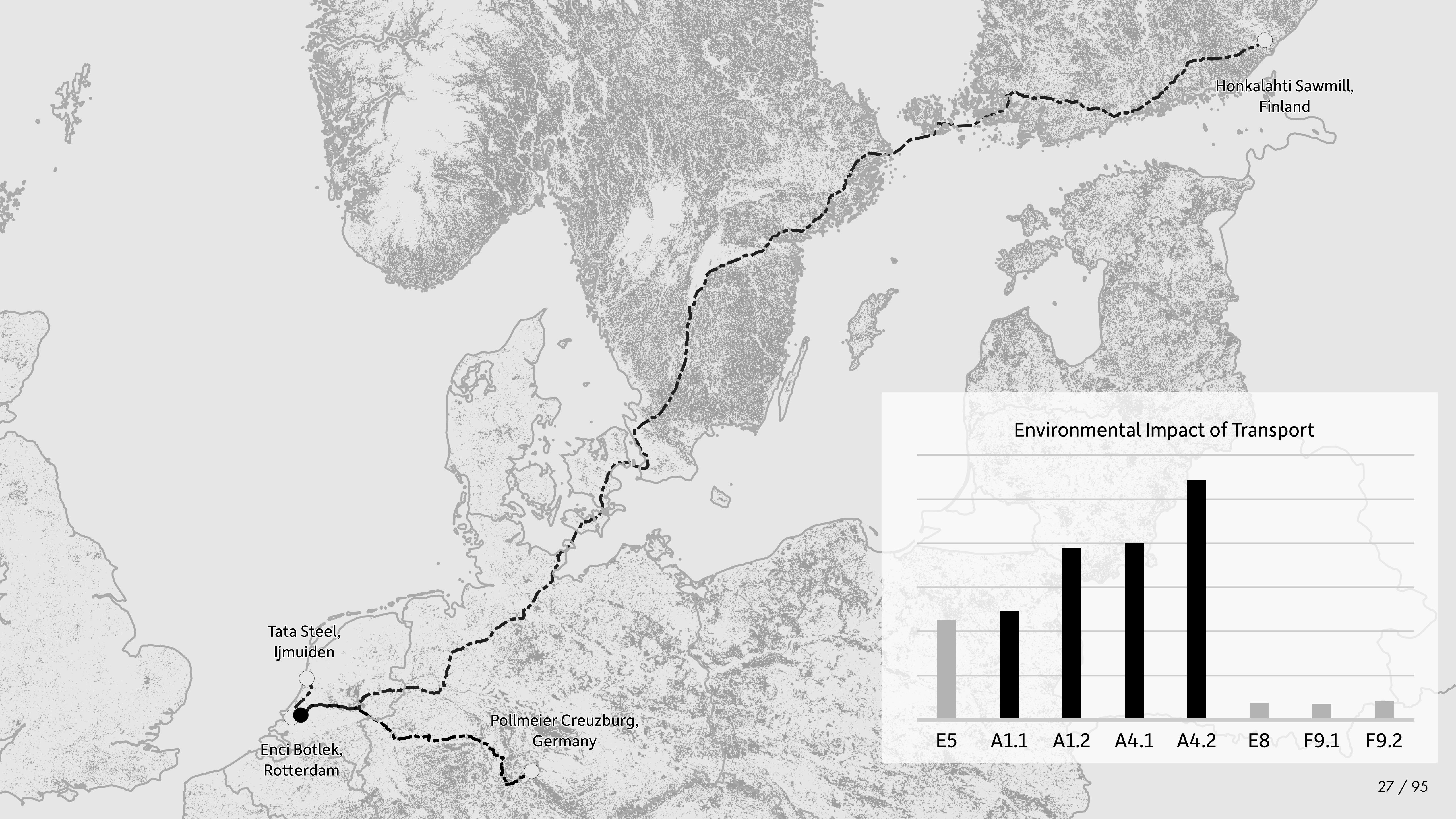
Floors:
Hollow-core slabs and
concrete topping

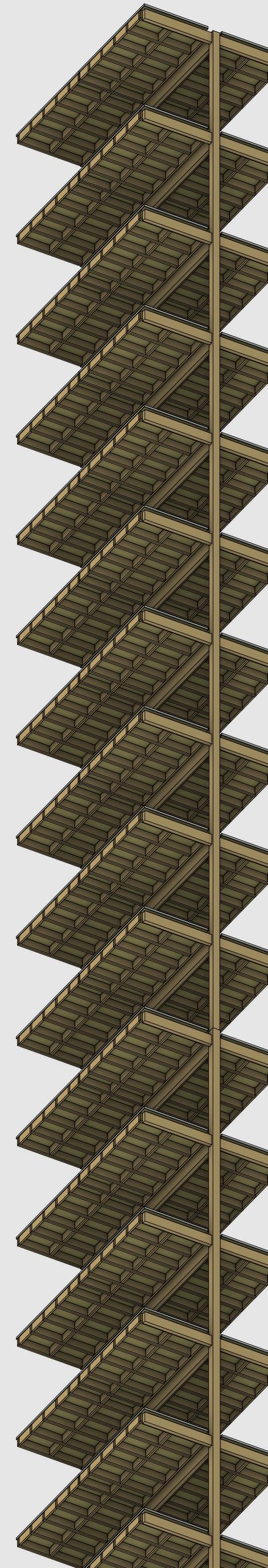
Beams:
Concrete,
C45/55

Columns:
Concrete,
C45/55

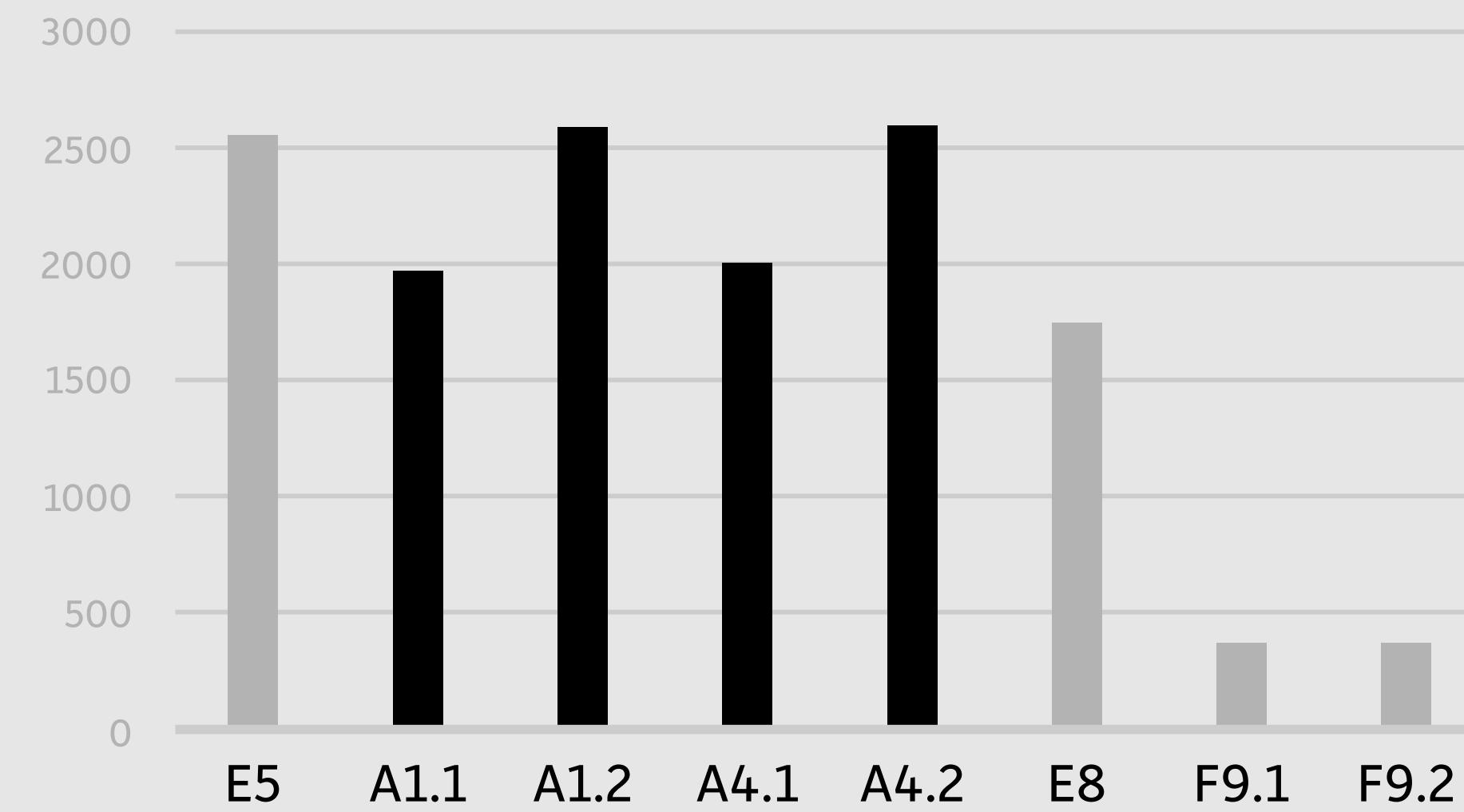




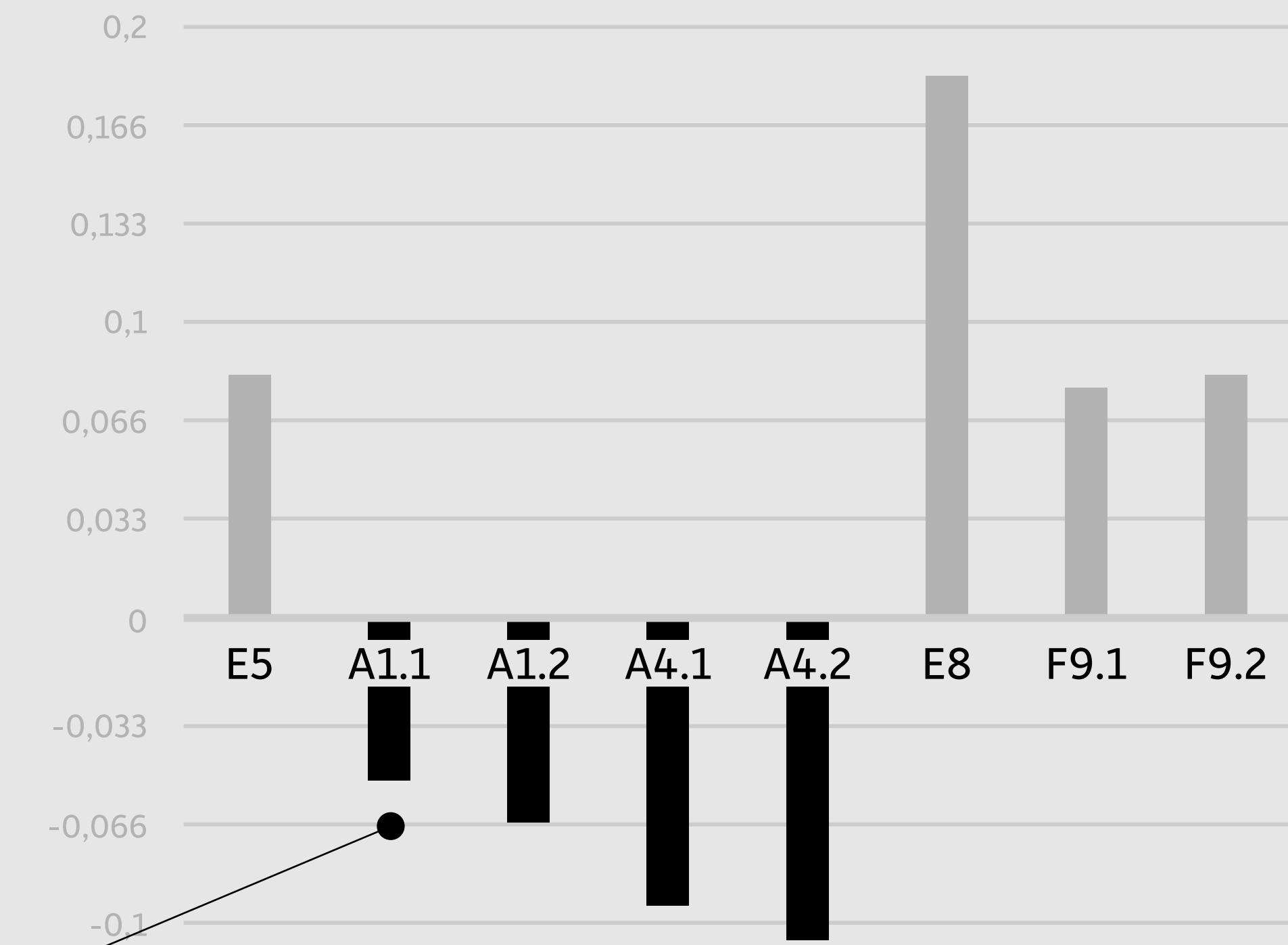




Total Embodied Energy [MJ / m² GFA]



Total Embodied Carbon [t CO₂ eq. / m² GFA]



Can be reduced

Conclusion Research:

Timber buildings have a lower environmental impact, even if the material has to be transported considerably further.

Generic



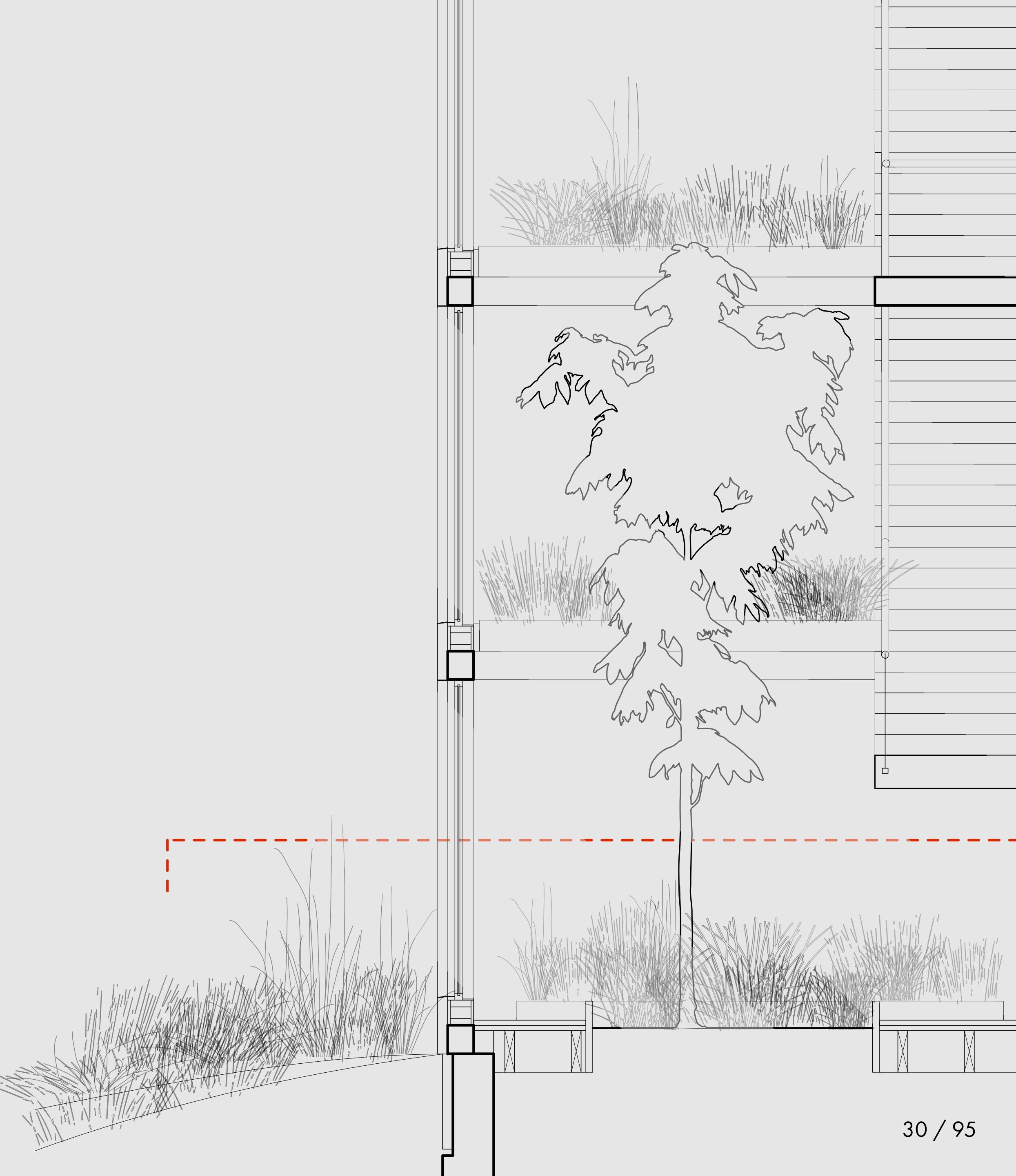
Design question:

How can the TU Delft accommodate the growing student population whilst complying with its own sustainability goals?

Specific

Design

Semester 2



TU Delft aims to be **carbon neutral, climate-adaptive** and **circular**, with contribution to the quality of life and biodiversity, **by 2030**.

- TU Delft, n.d.

6.5 years...

“Humanity is on a highway to climate hell”...

- UN secretary general, 2022

With every **increment of warming**, climate change impacts and risks will become **increasingly complex** and more difficult to manage.

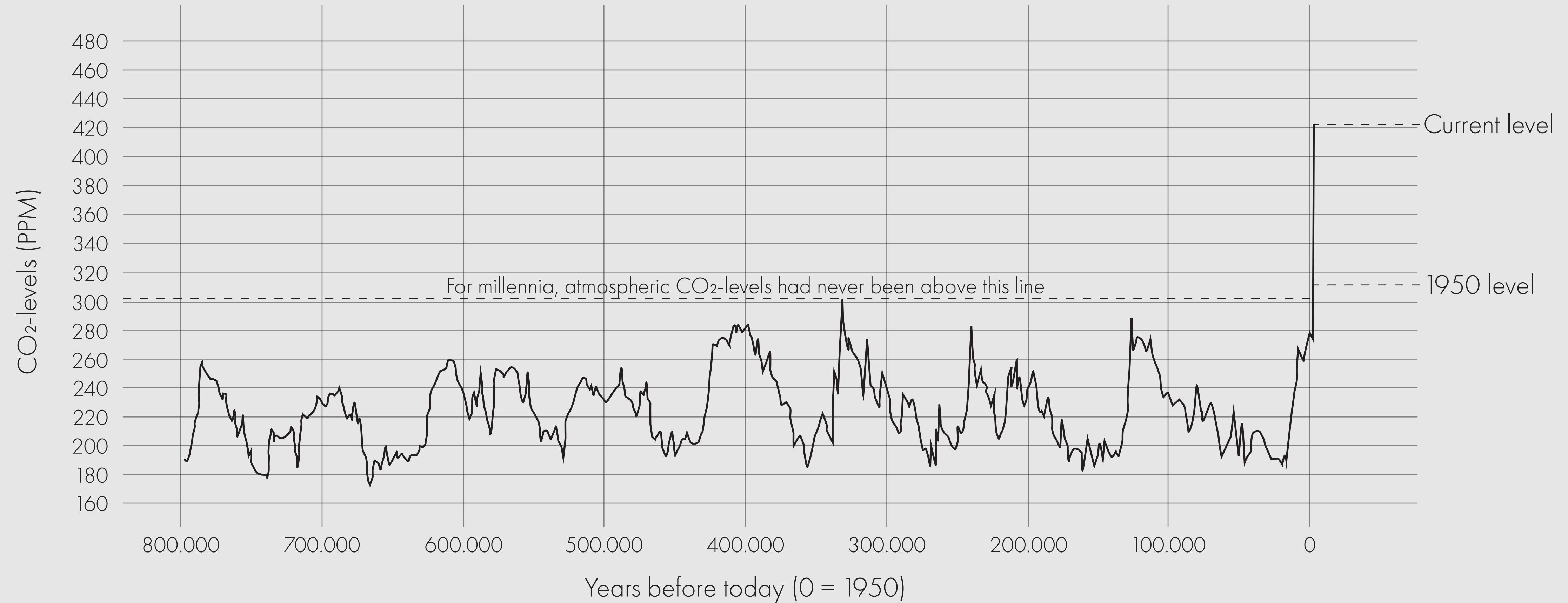
There is a **rapidly closing** window of opportunity to secure a liveable and sustainable future for all...

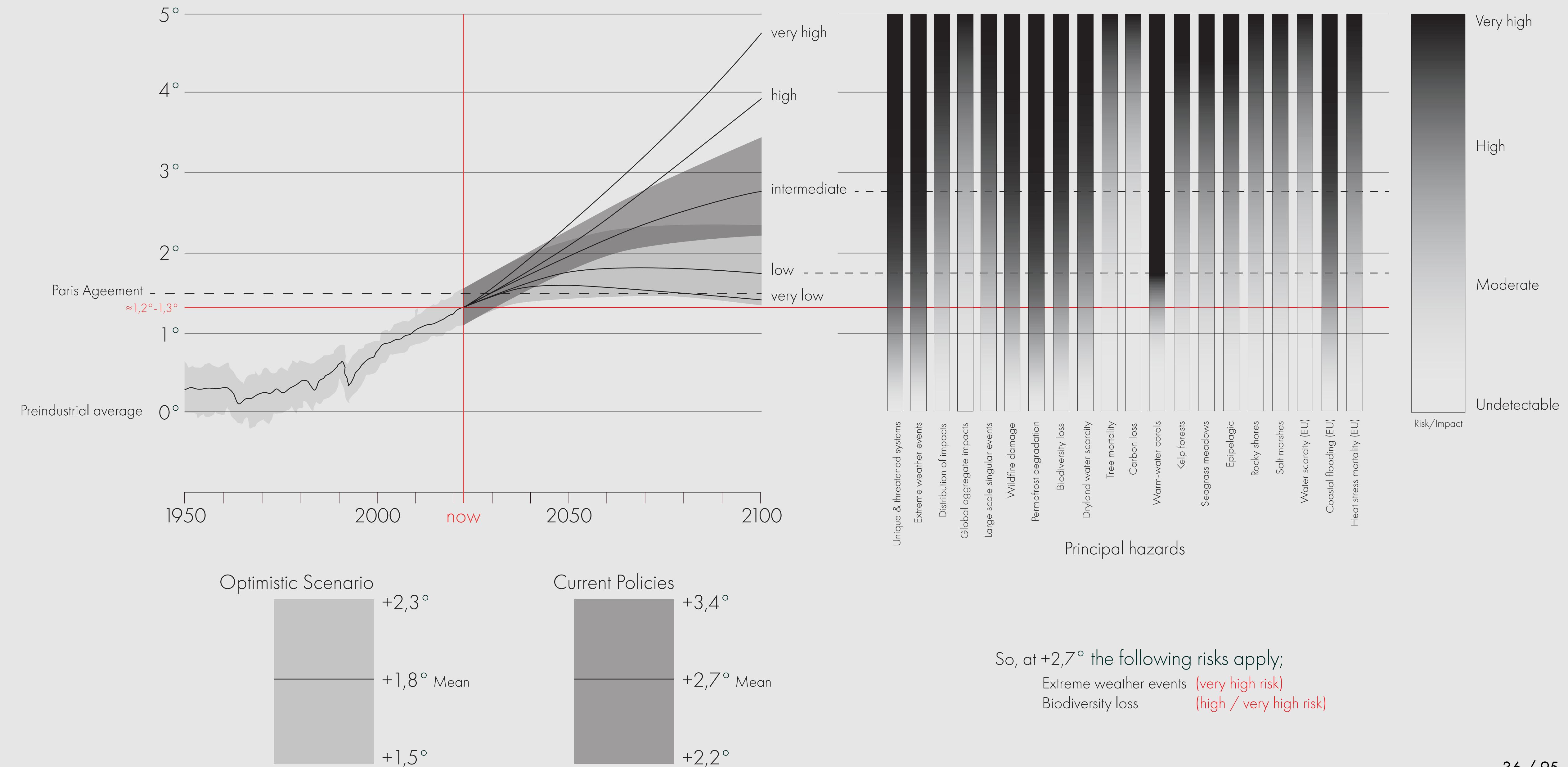
- IPCC Synthesis Report, 2023

Additional design question:

What if we do not meet our sustainability goals?

Generic





Principal hazards: (Western-Europe)

1. Increased intensity and frequency of **hot extremes** and **dangerous heat-humidity conditions**, with increased human mortality, morbidity, and labor productivity loss (**high confidence**)
2. Increasing frequency of marine heatwaves will increase risks of **biodiversity loss** in the oceans, including from mass mortality events (**high confidence**)
3. More intense and frequent **extreme rainfall and associated flooding** in many regions including coastal and other low-lying cities (**medium to high confidence**)
4. Continued sea level rise and increased frequency and magnitude of **extreme sea level events** encroaching on coastal human settlements and damaging coastal infrastructure (**high confidence**), committing low-lying coastal ecosystems to submergence and loss (**medium confidence**), expanding **land salinization** (**very high confidence**), with cascading to **risks to livelihoods**, health, well-being, cultural values, food and water security (**high confidence**)
5. Climate change will significantly increase **ill health and premature deaths** in the near- to long-term (**high confidence**). Further warming will increase climate-sensitive food-borne, water-borne, and vector-borne disease risks (**high confidence**), and **mental health challenges** including anxiety and stress (**very high confidence**)
6. The projected increase in frequency and intensity of heavy precipitation (**high confidence**)

And many more...

Principal hazards: (Western-Europe)

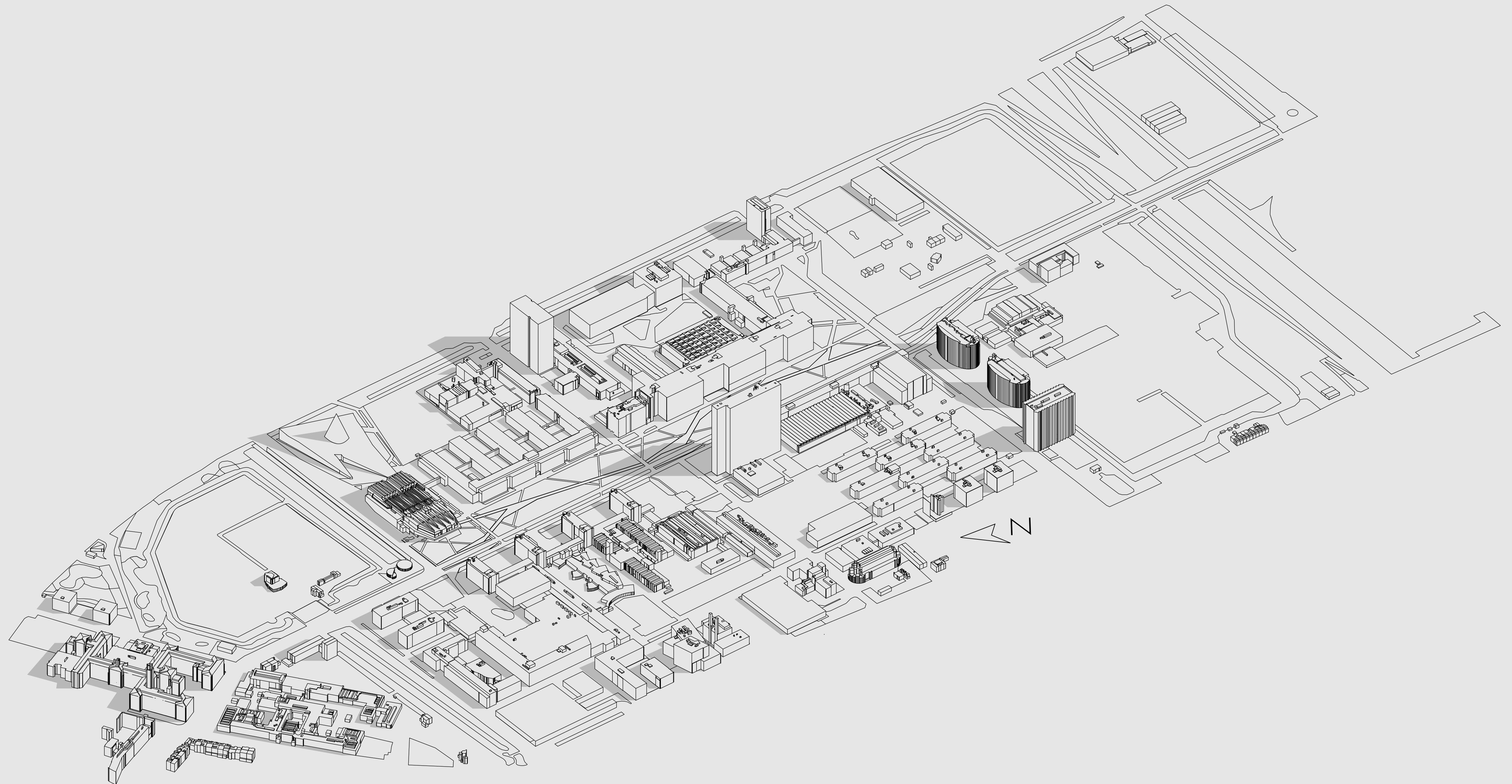
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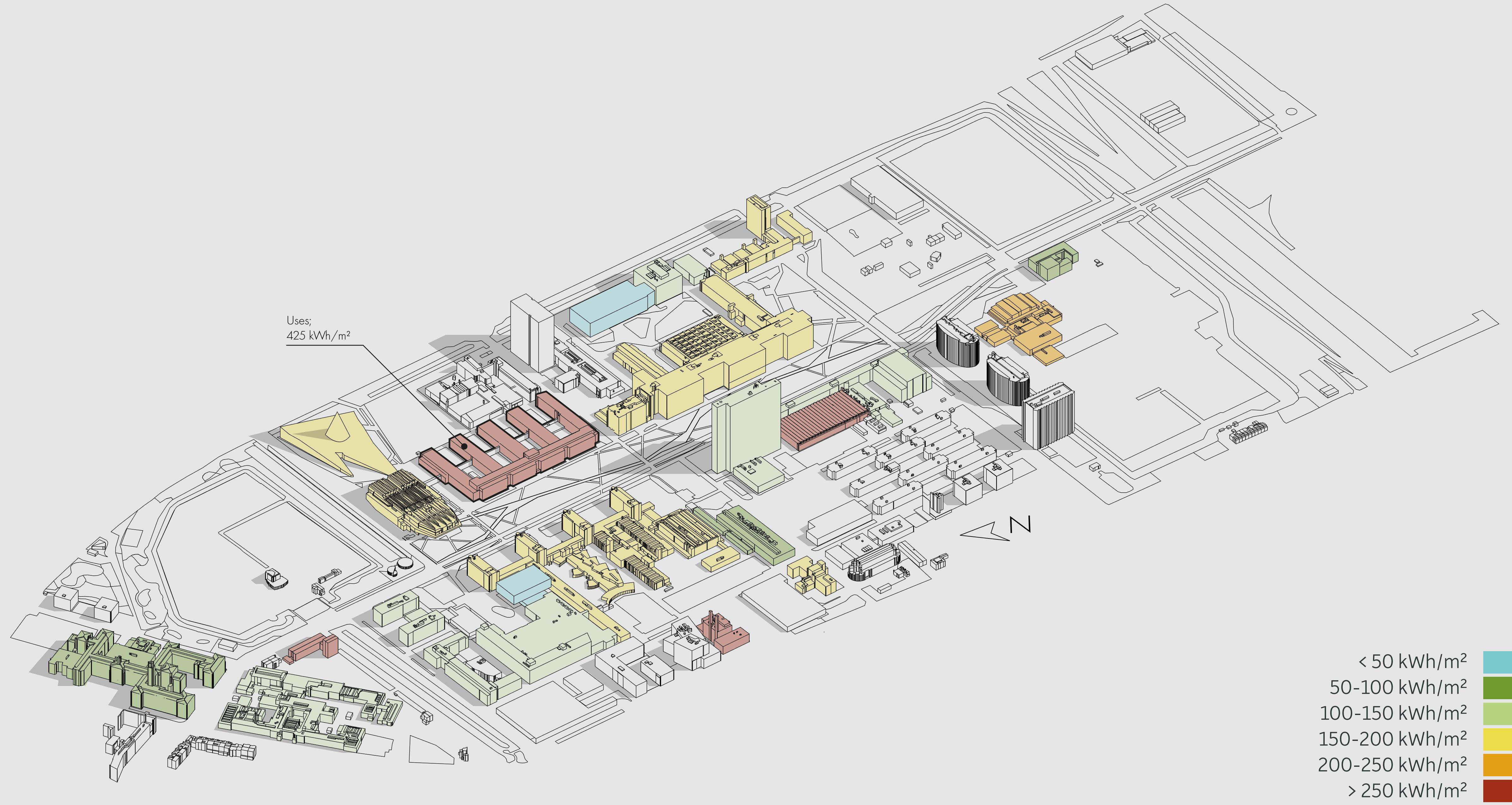
And many more...

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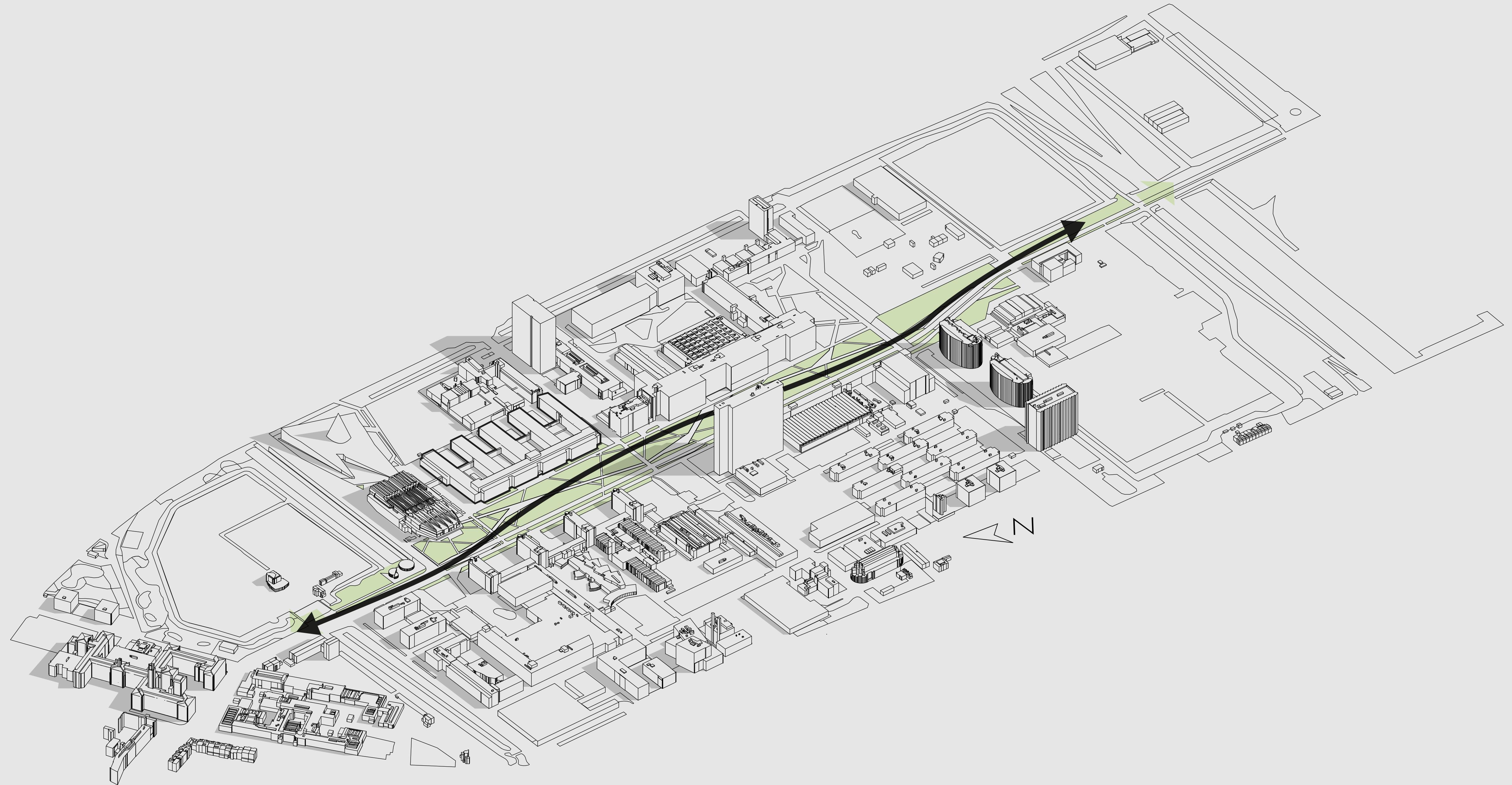
- TU Delft, n.d.

Means something
else now

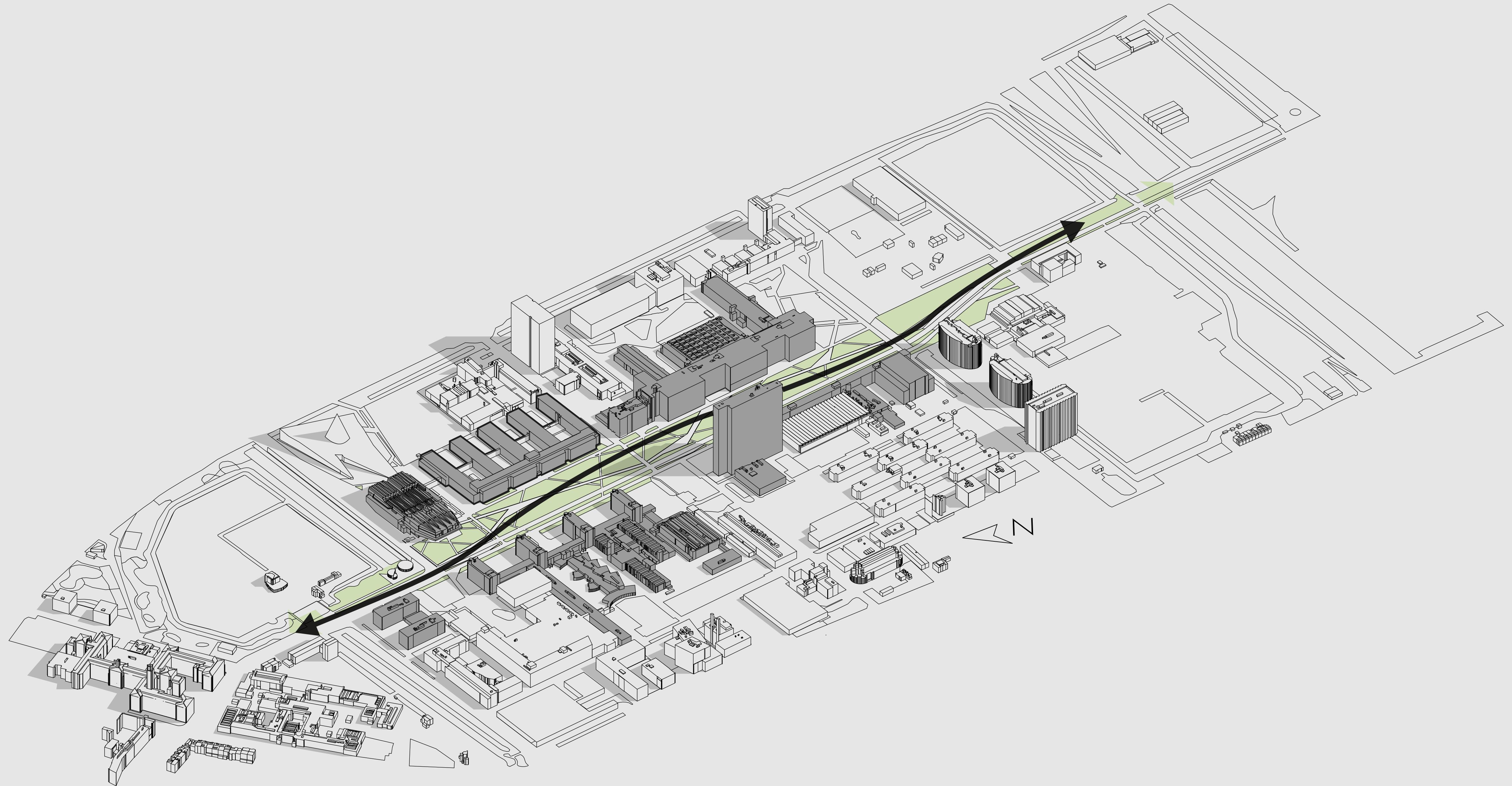




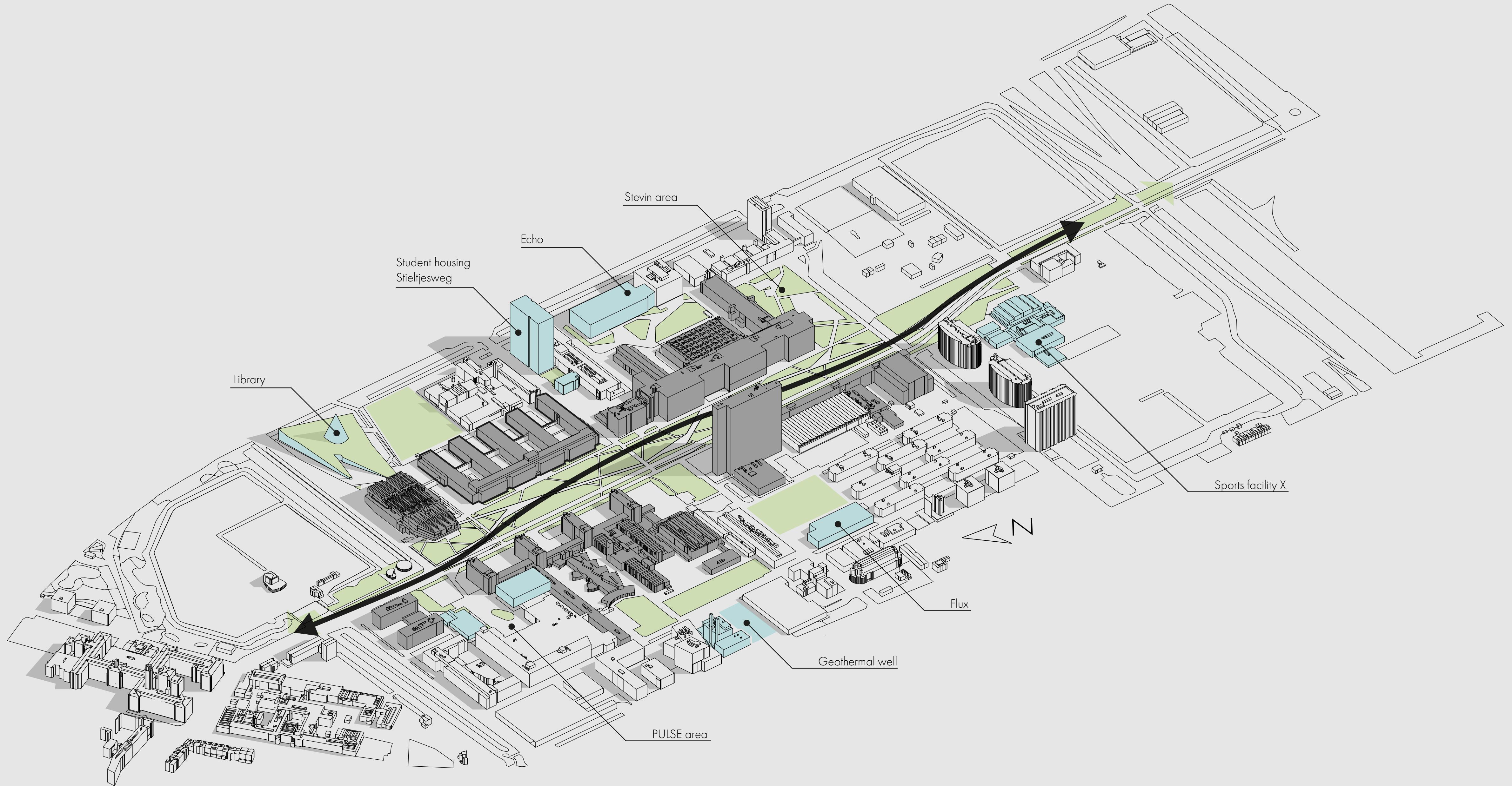




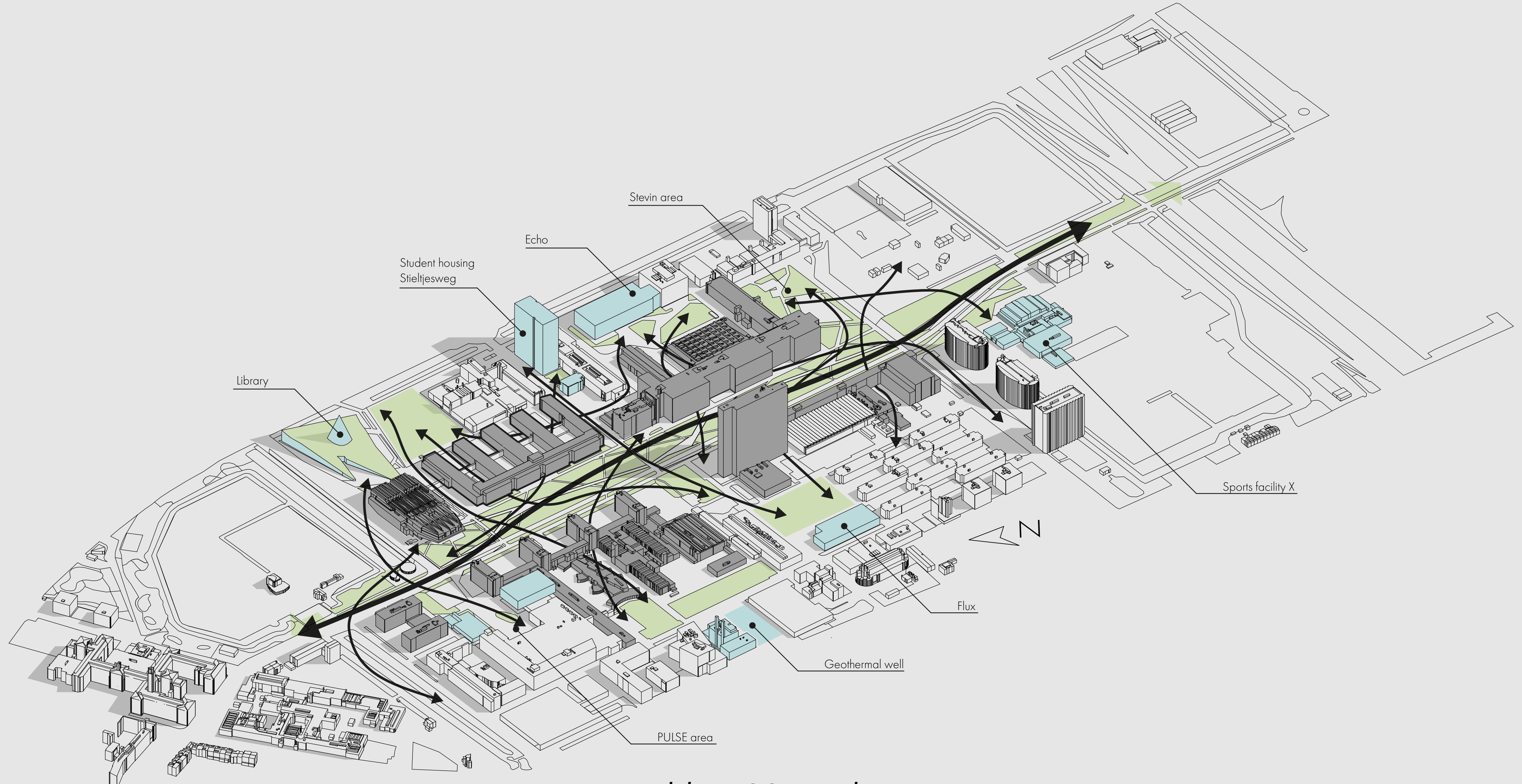




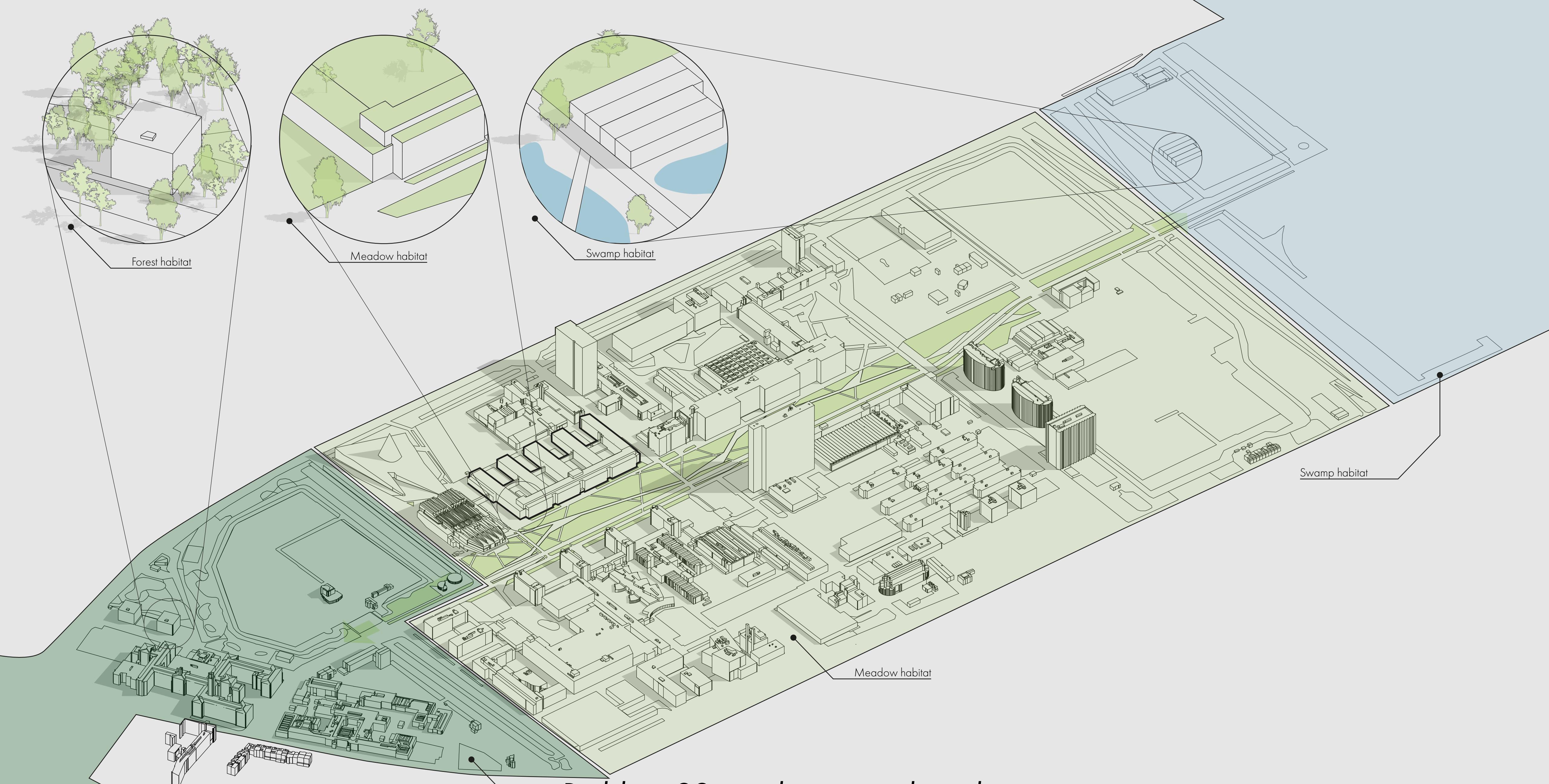








Building 22 needs
1. Porosity

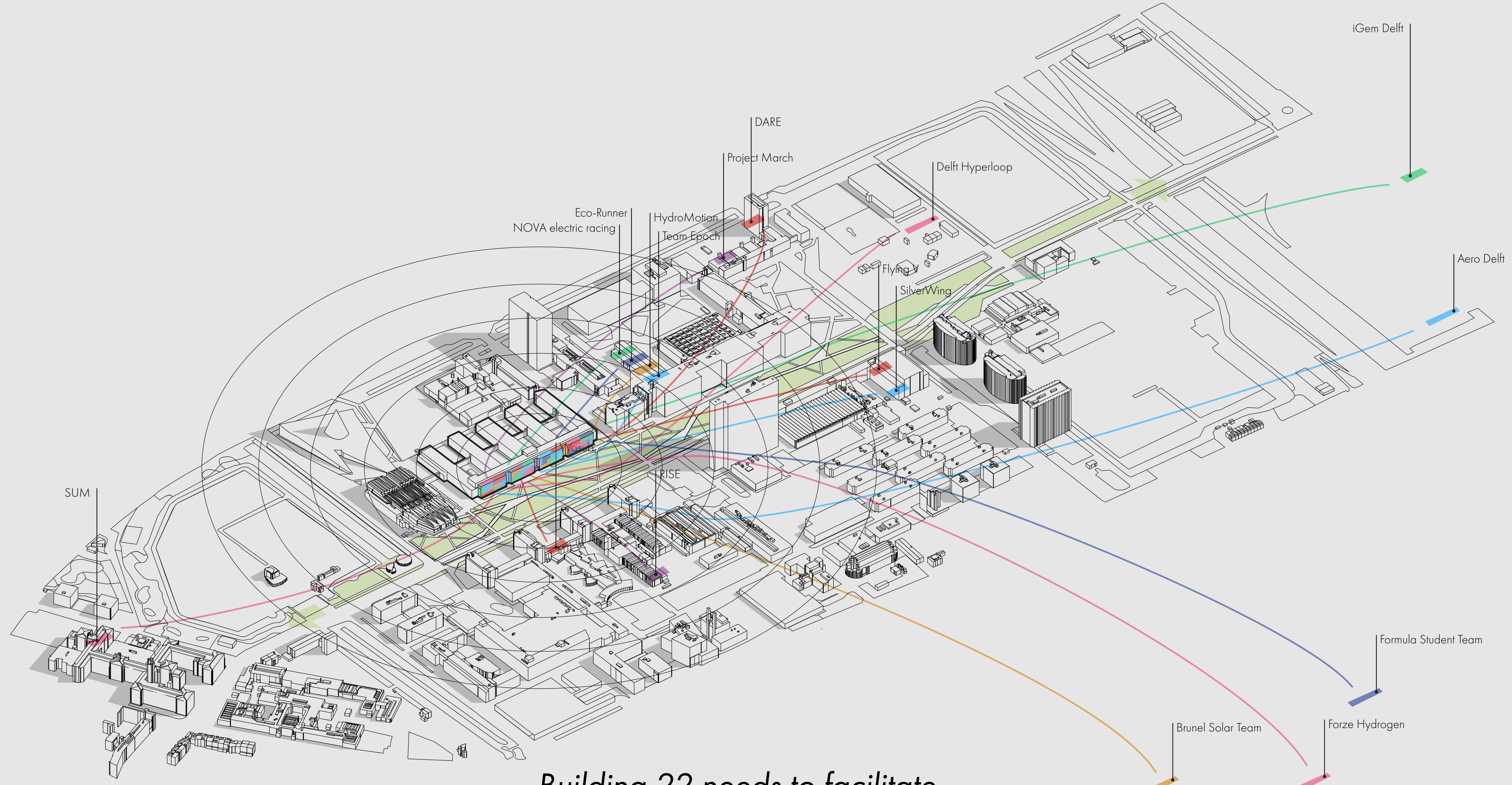


Building 22 needs to comply with
2. Ecocampus vision

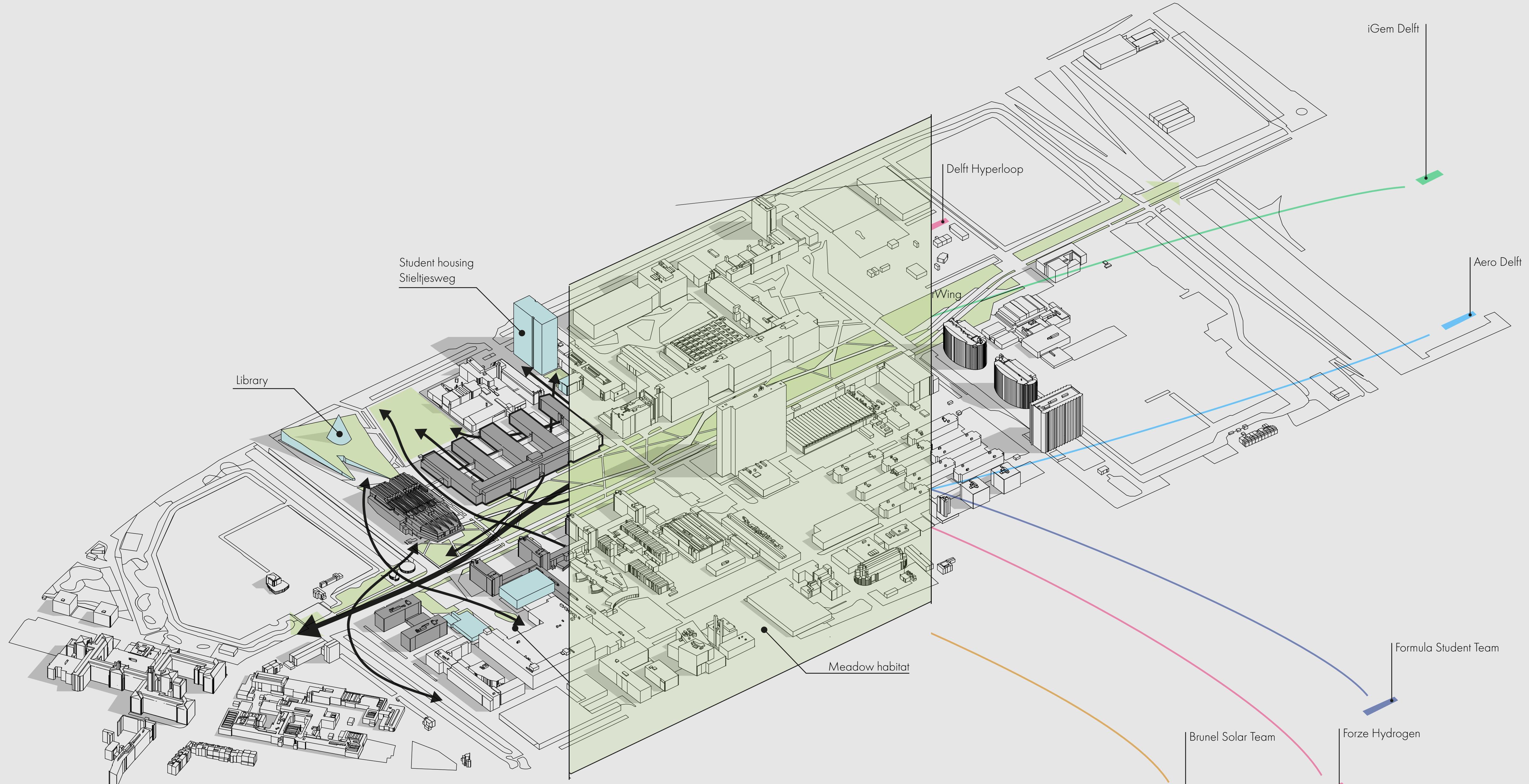
Any new idea is the product of:

$$\dot{x}_i = \sum_{j=1}^n x_j * q_{ji} * f_i(x)$$

all ideas, creativity, diversification



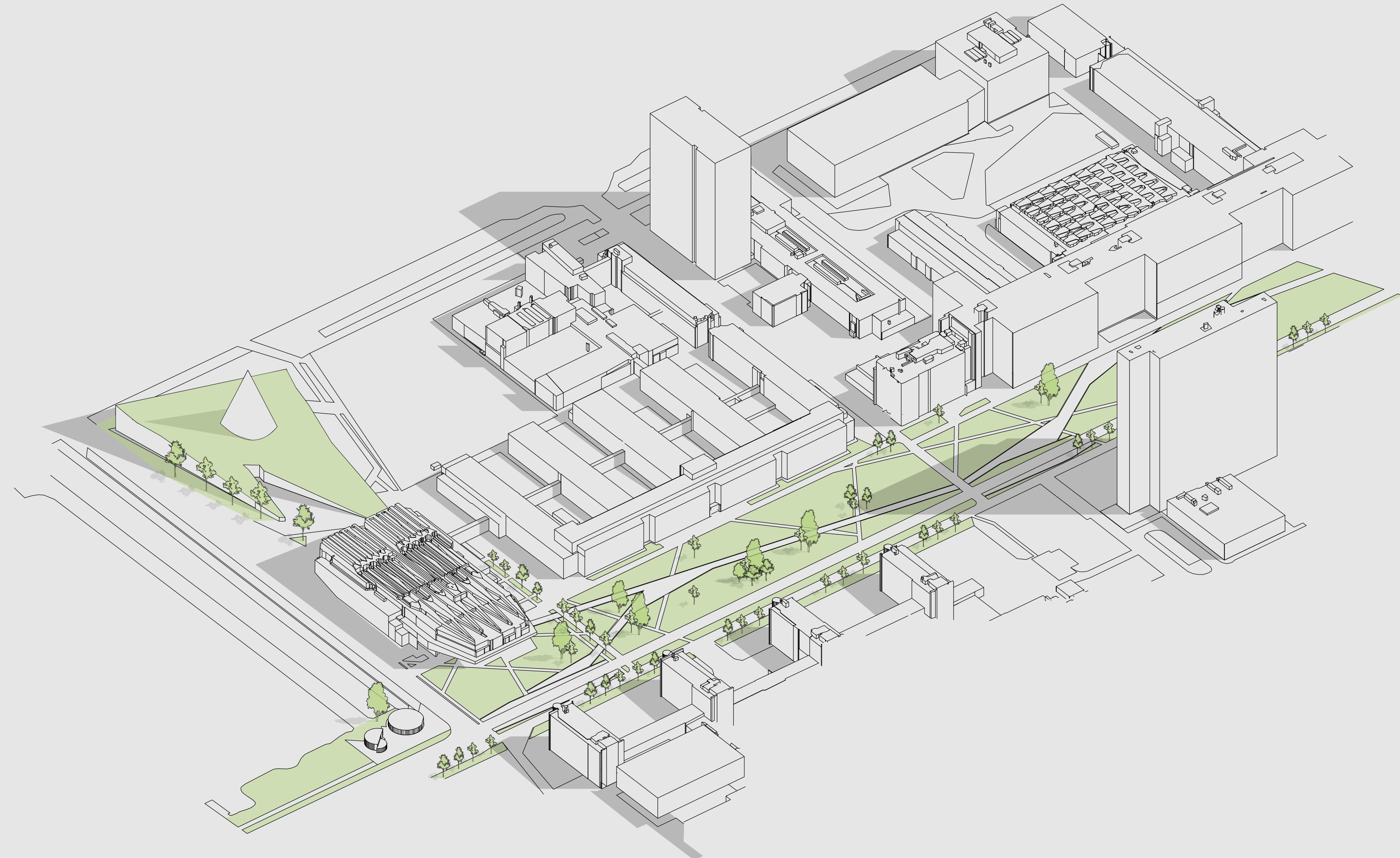
Building 22 needs to facilitate
3. Cross-pollination

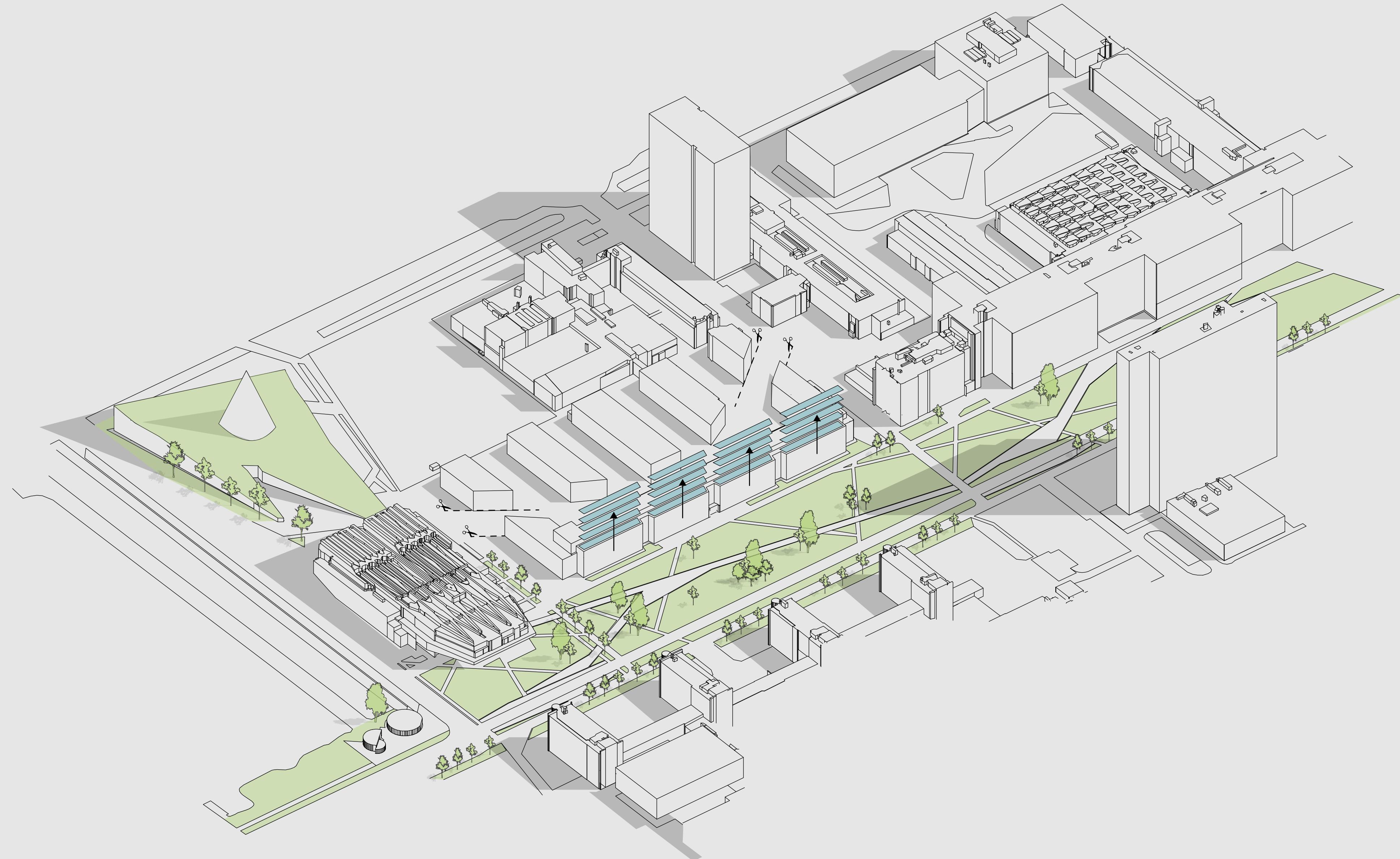


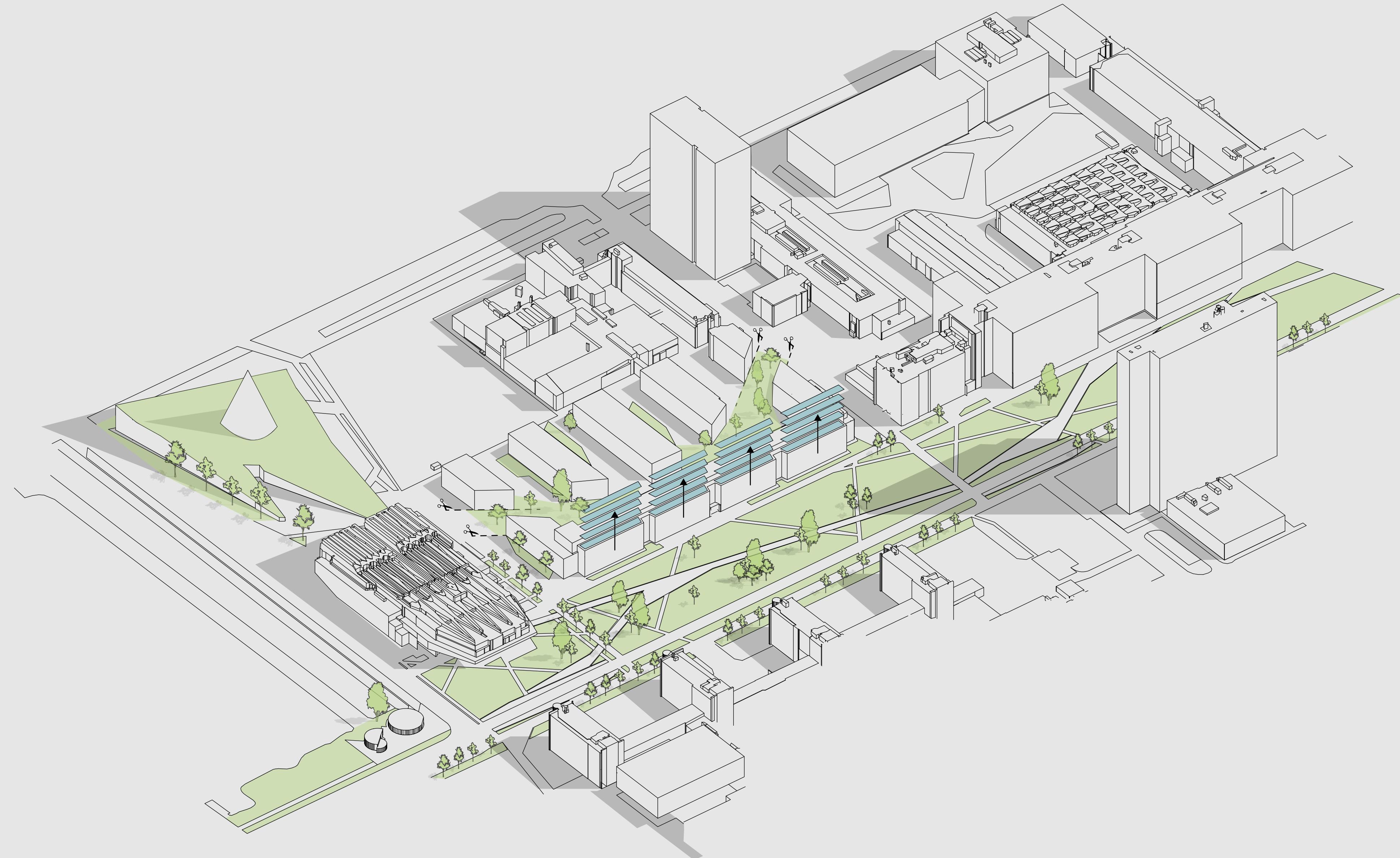
1. Porosity of buildings

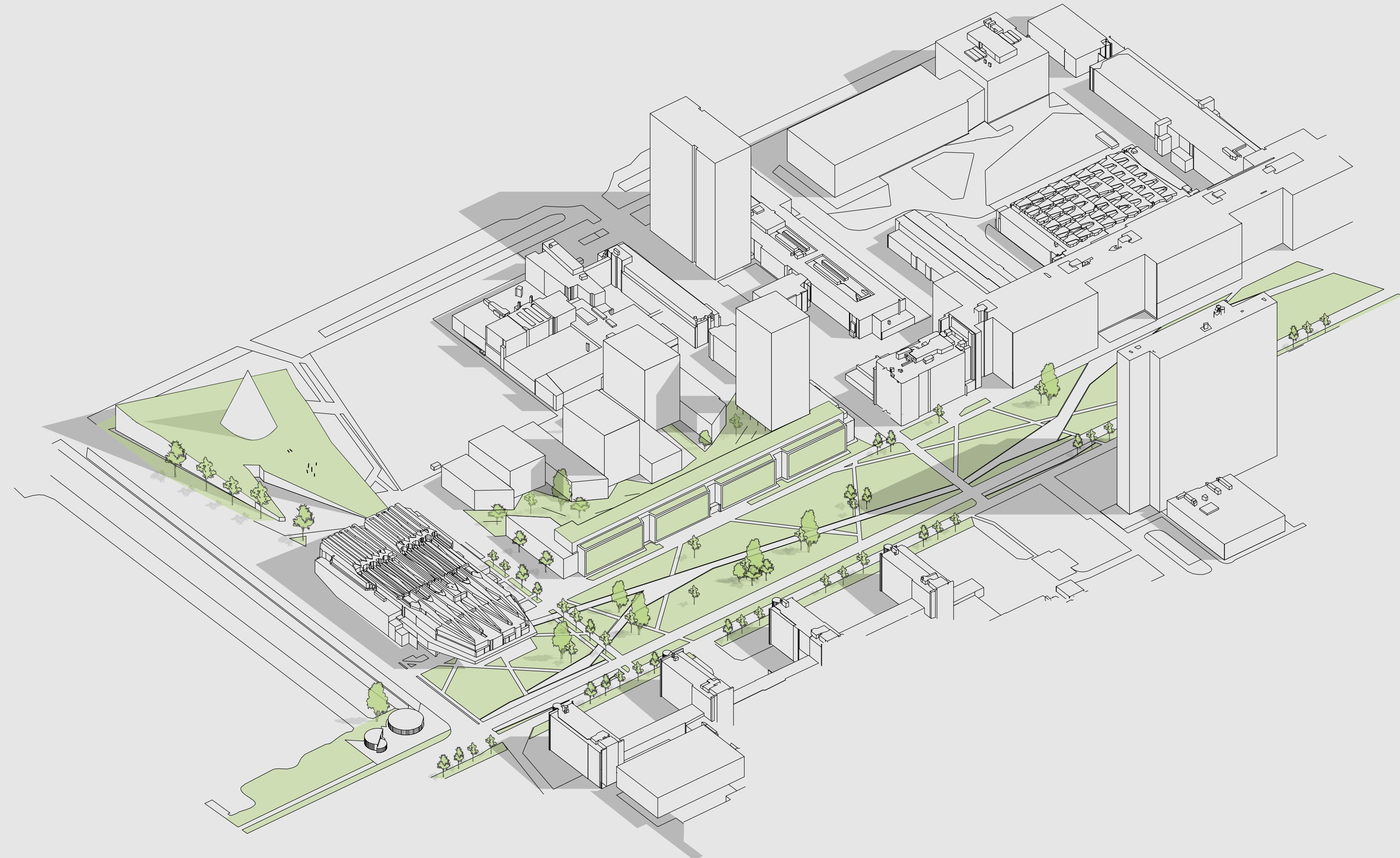
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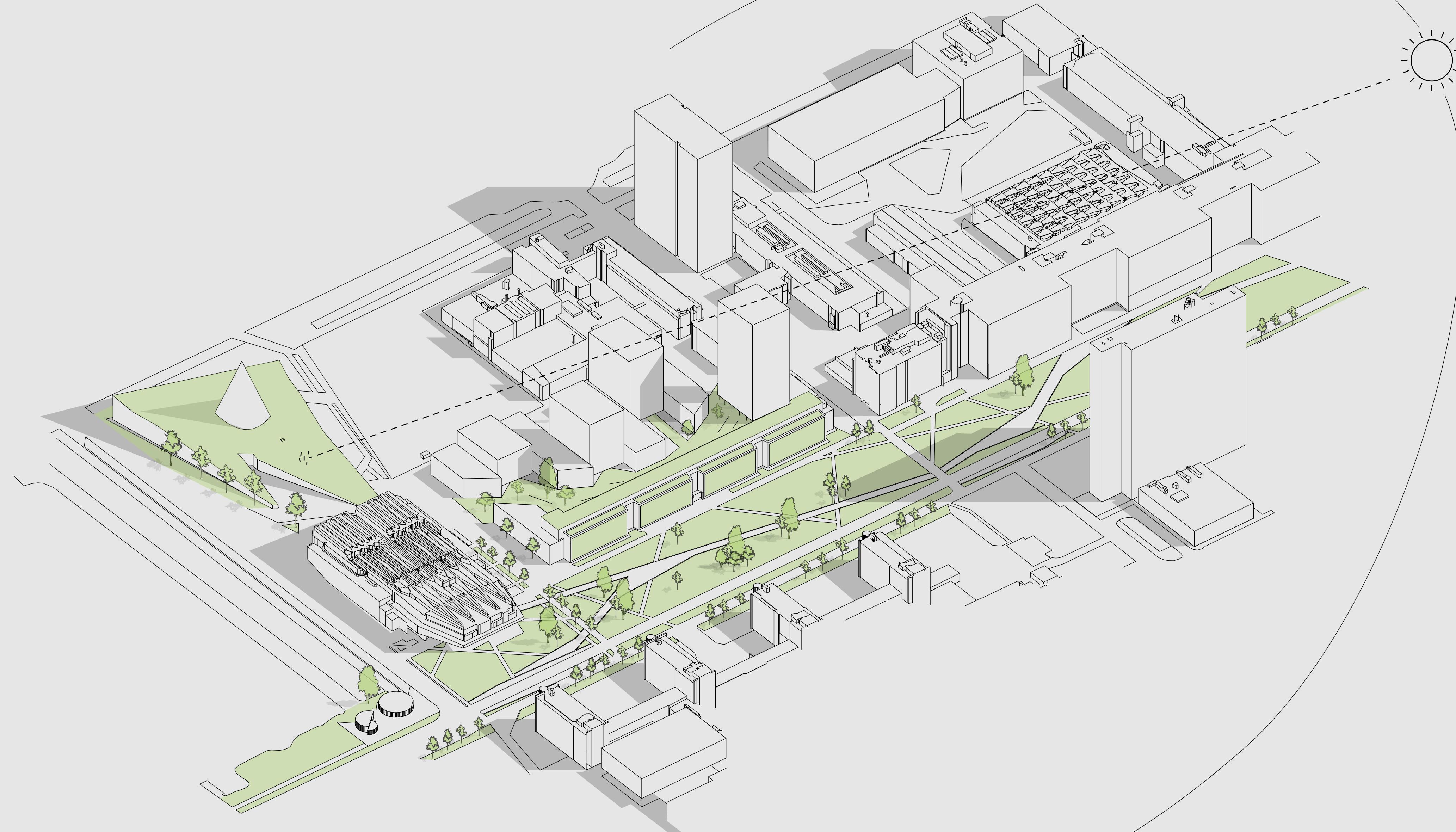
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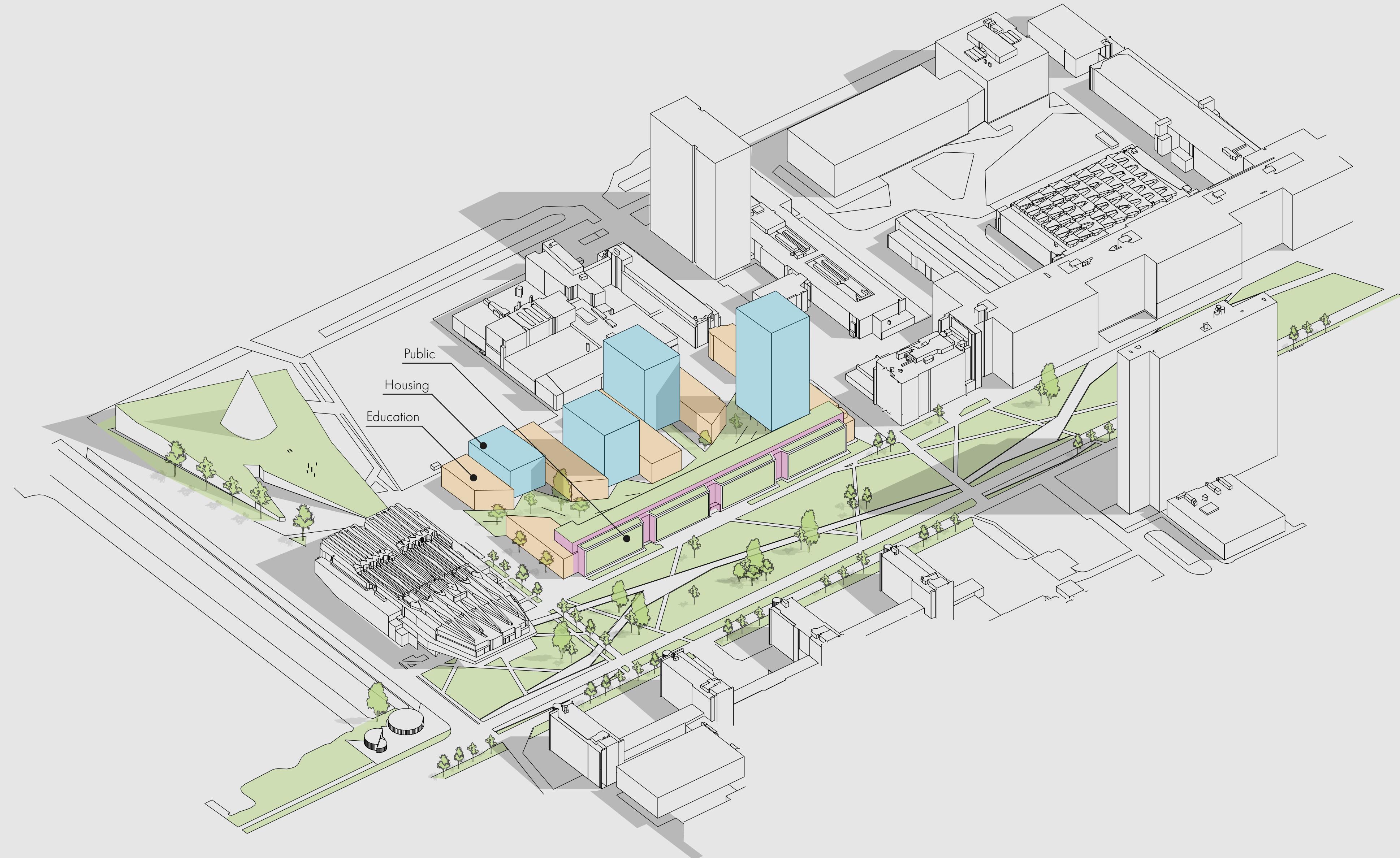


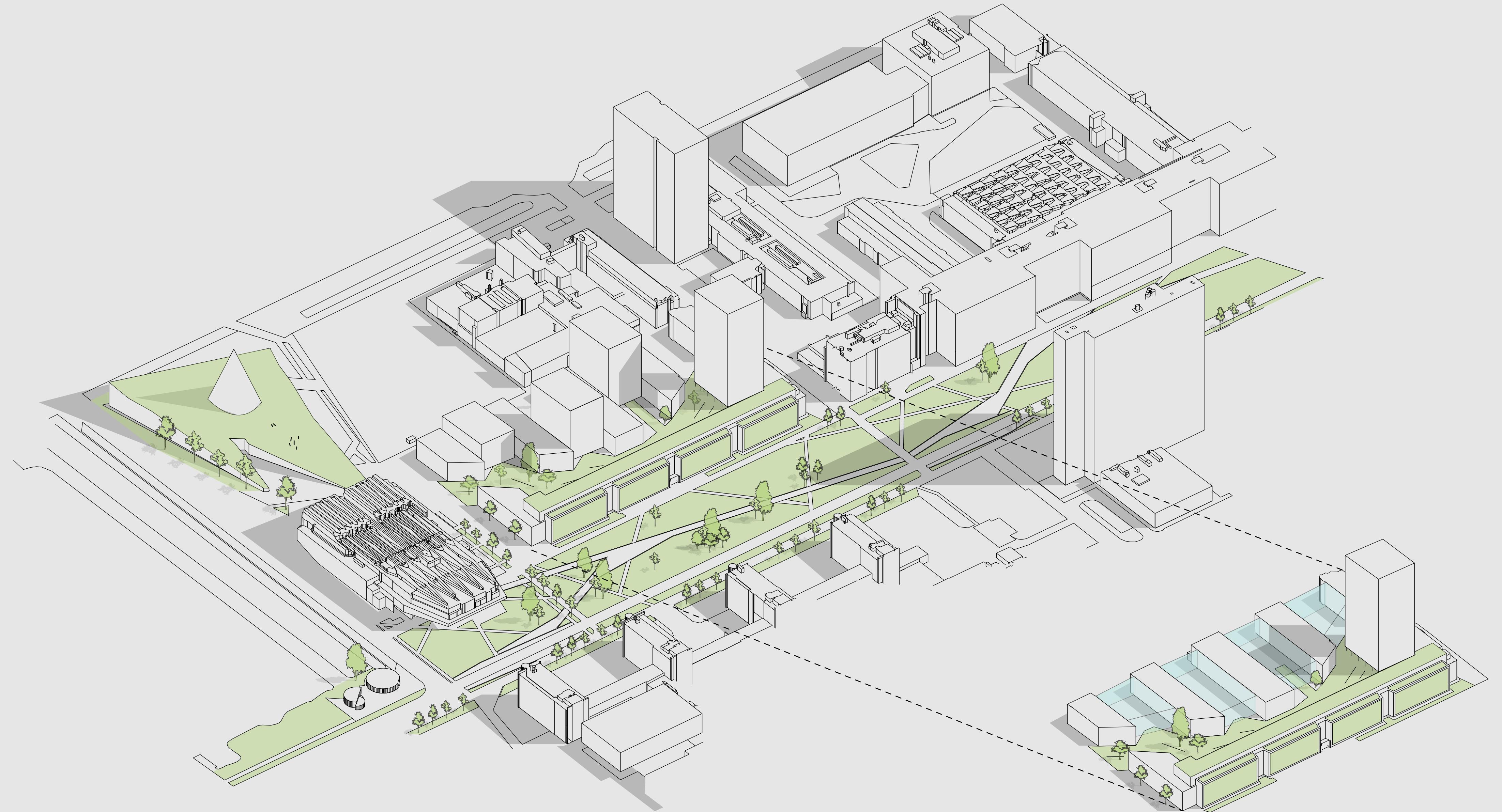










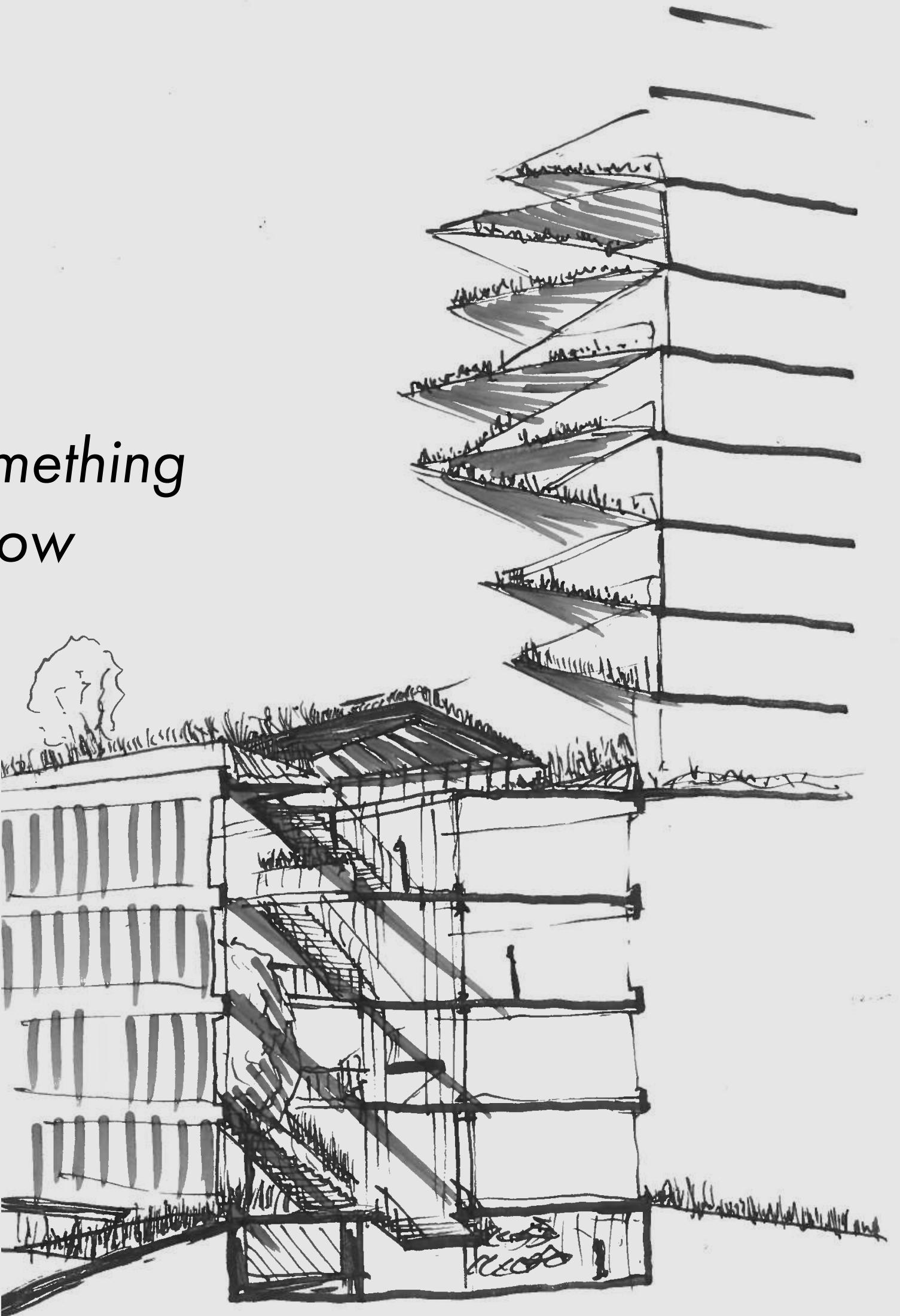


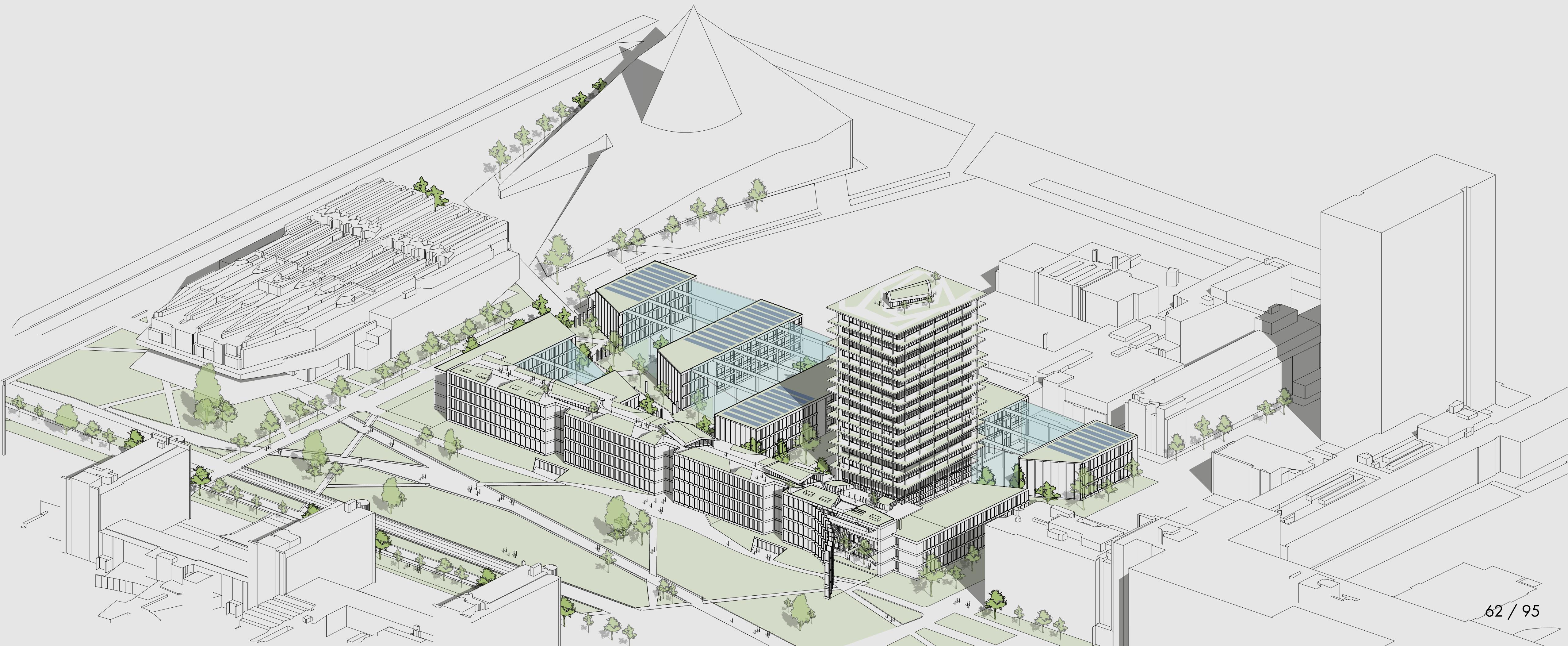
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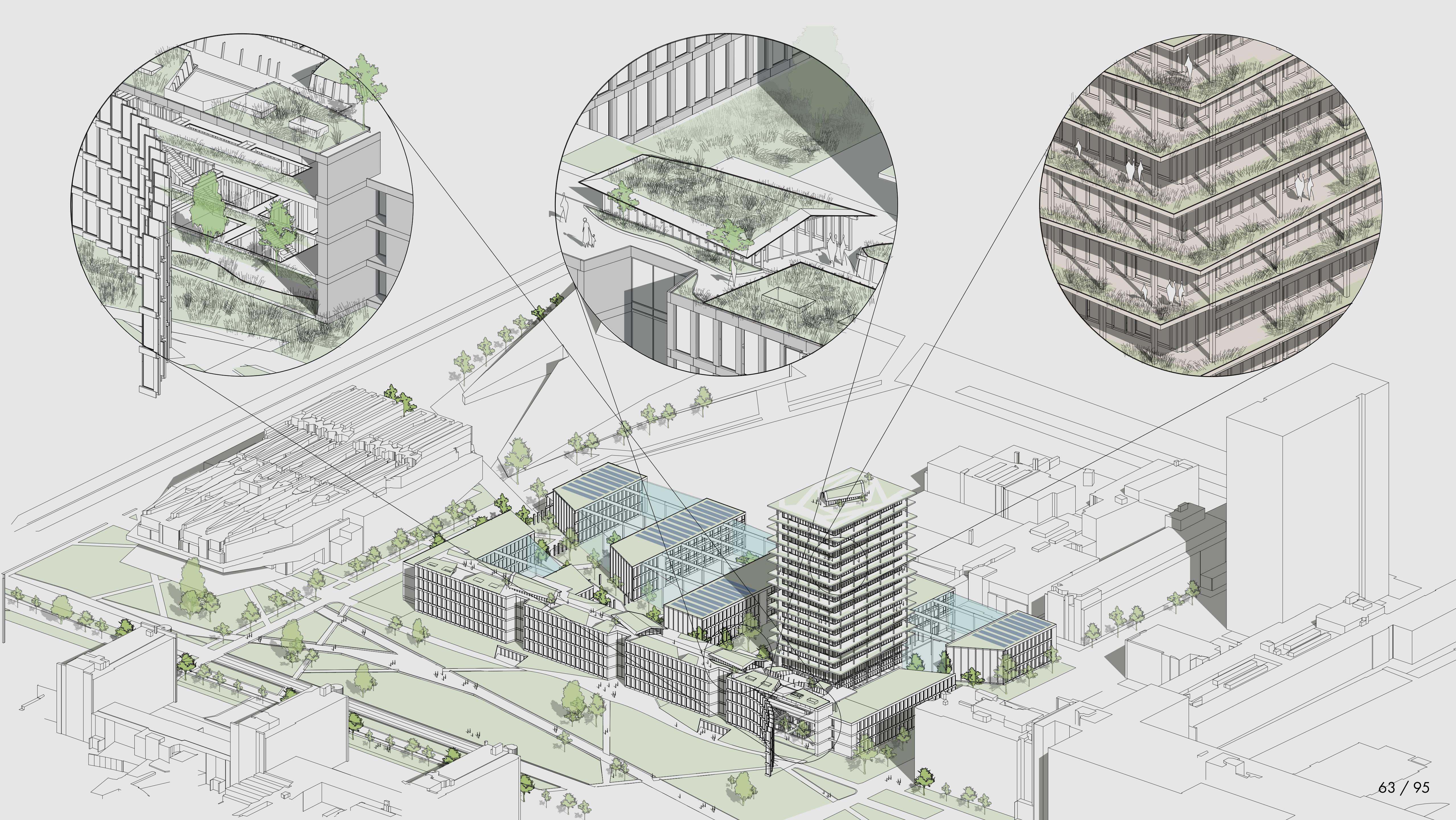
- TU Delft, n.d.

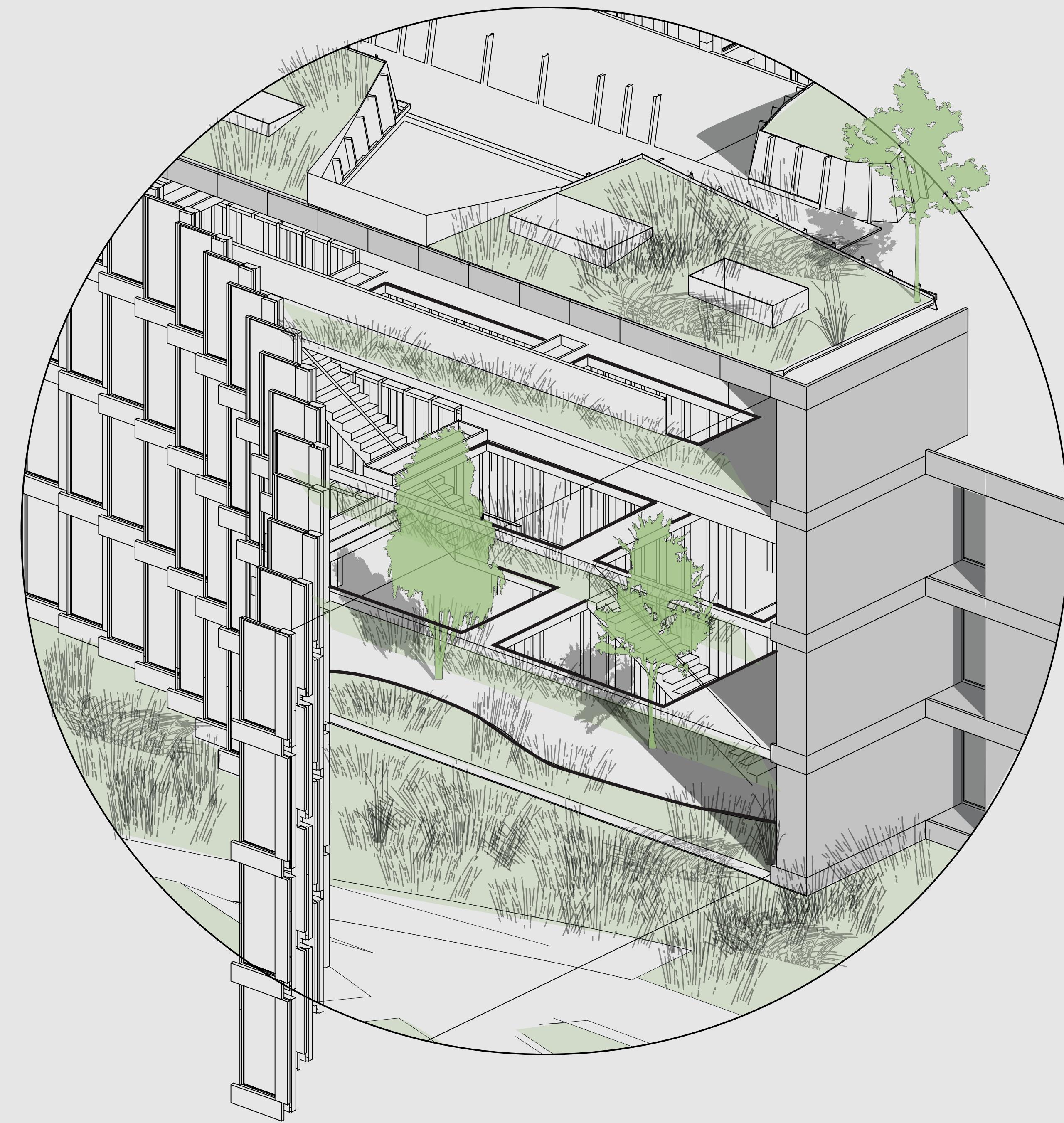
Protect against an increasingly hostile climate

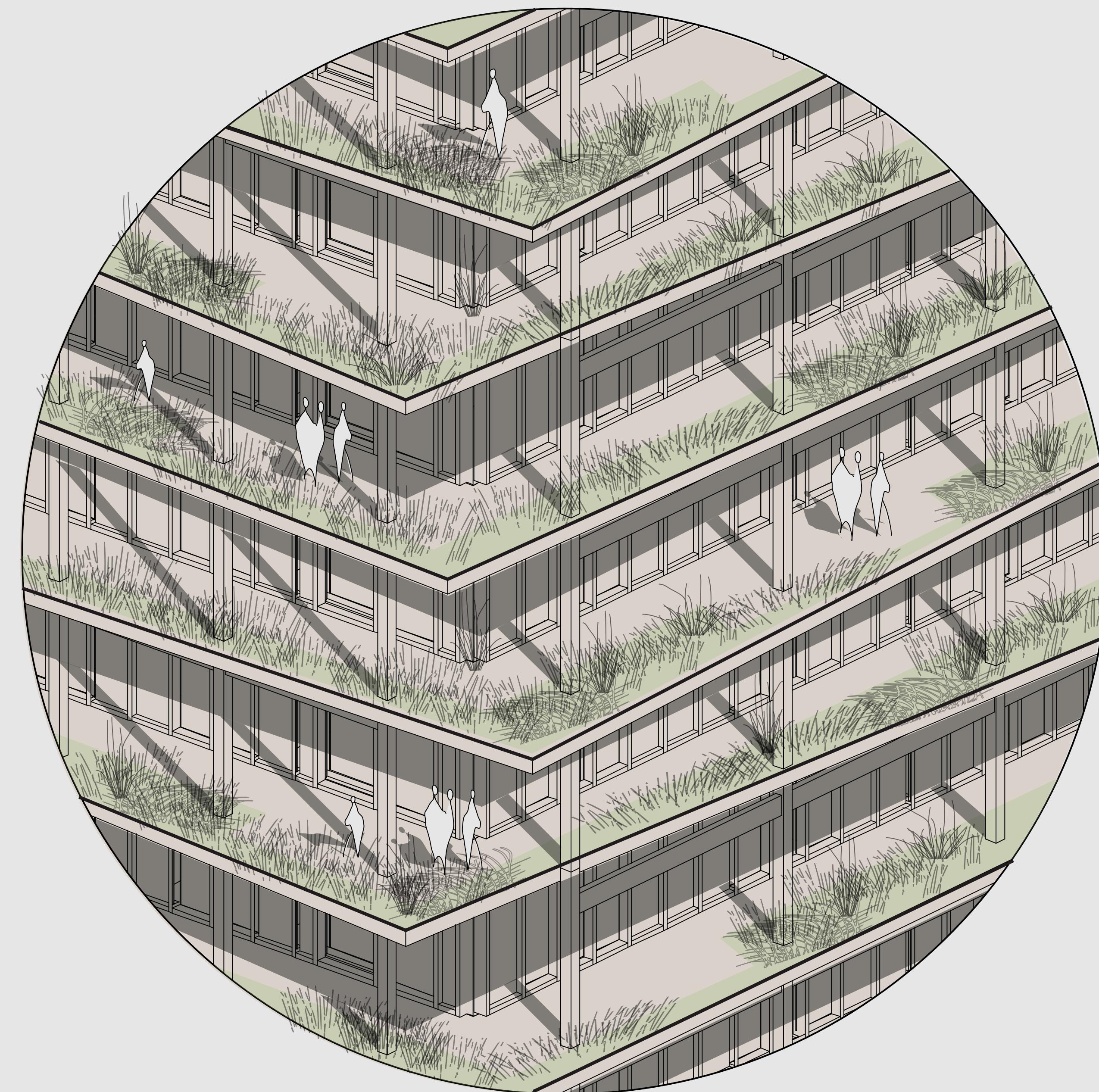
Means something else now

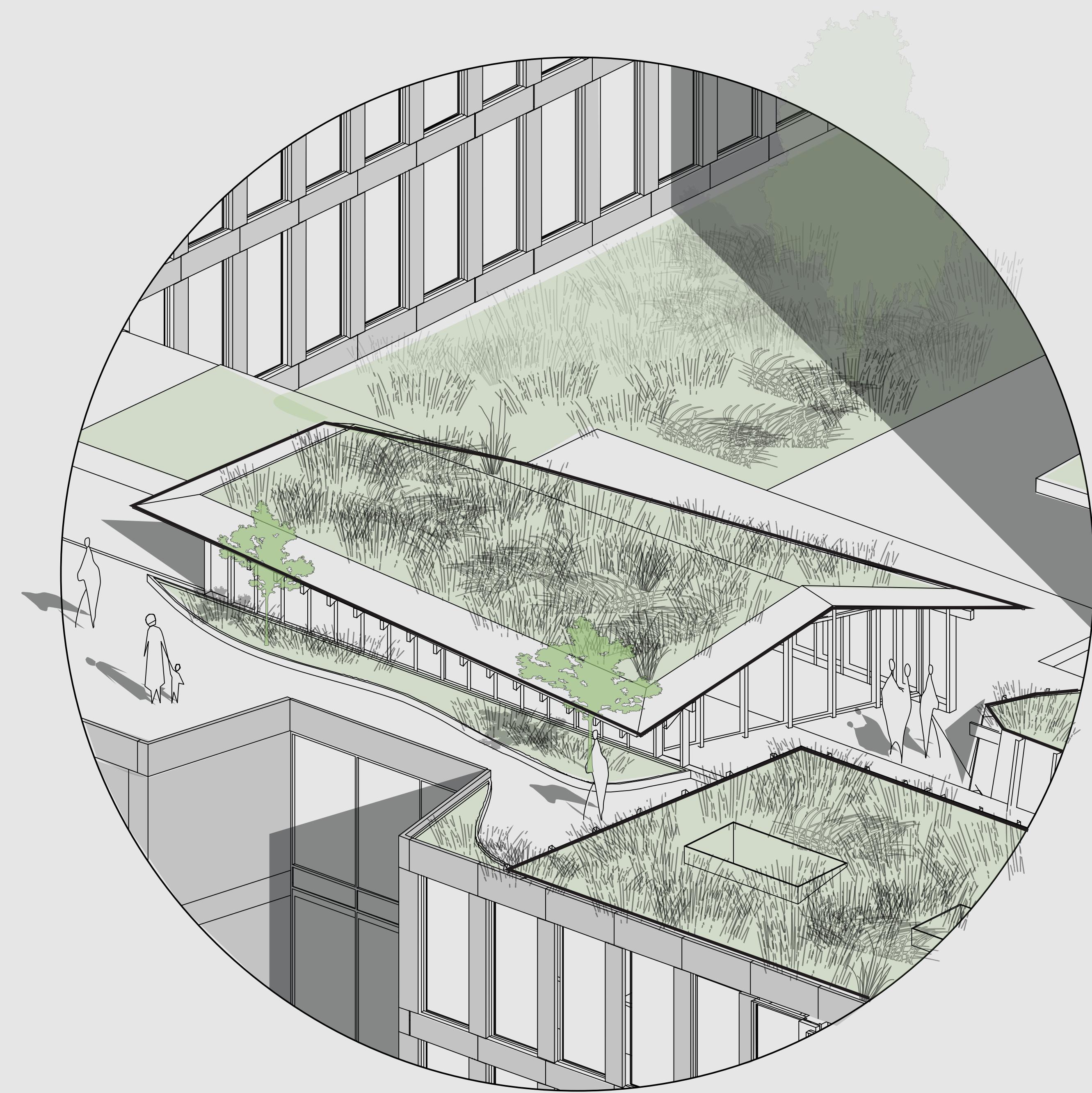


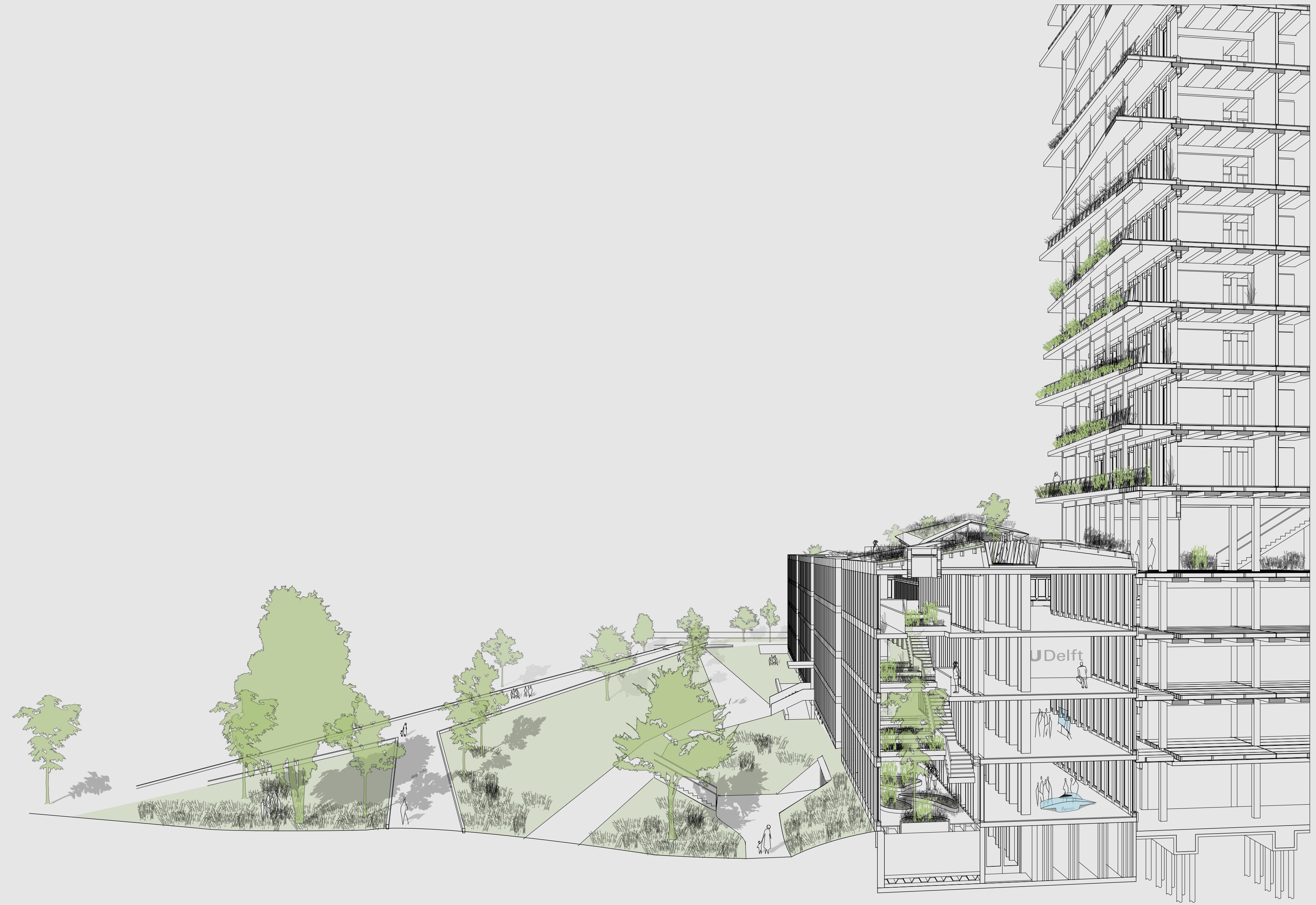


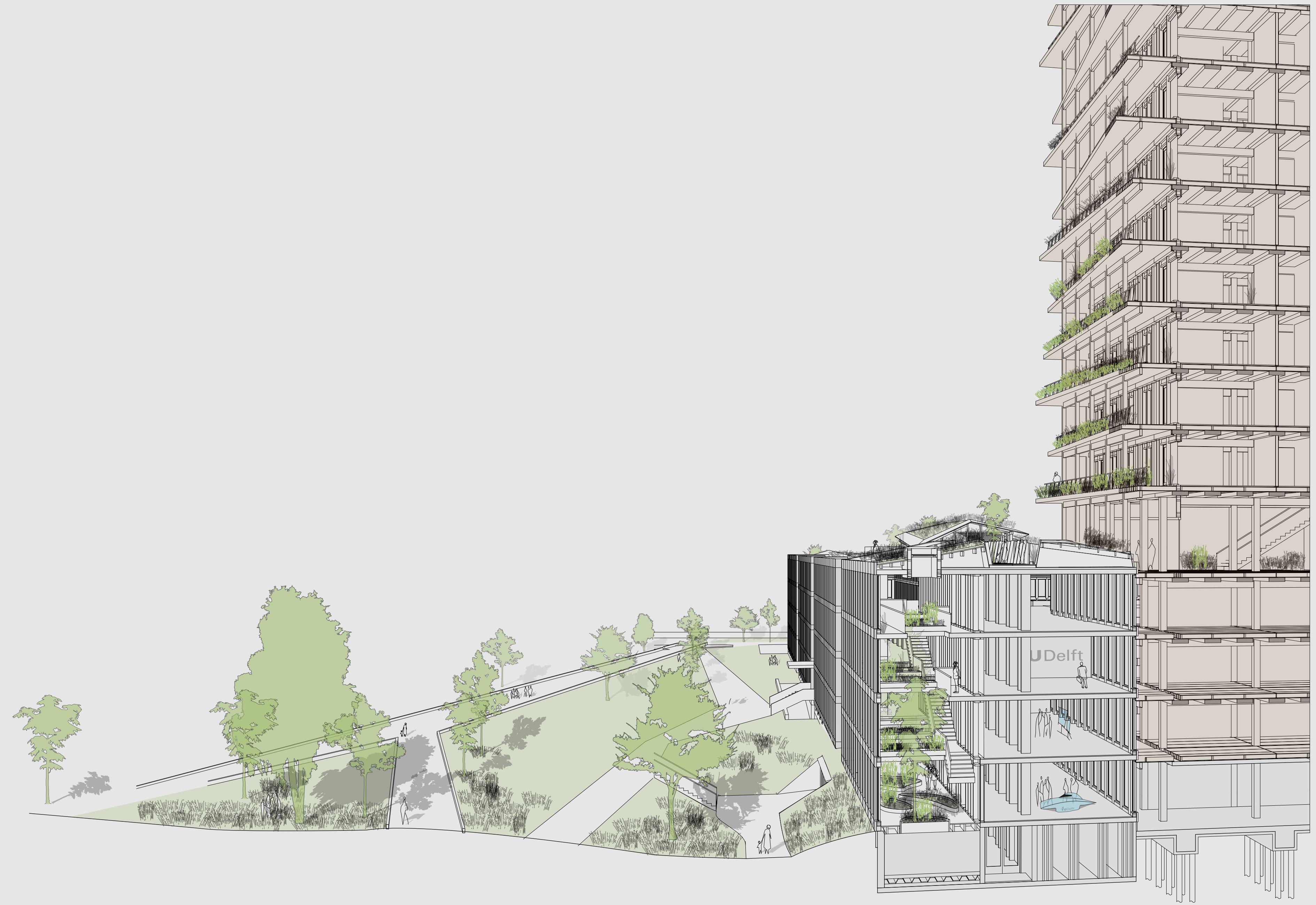


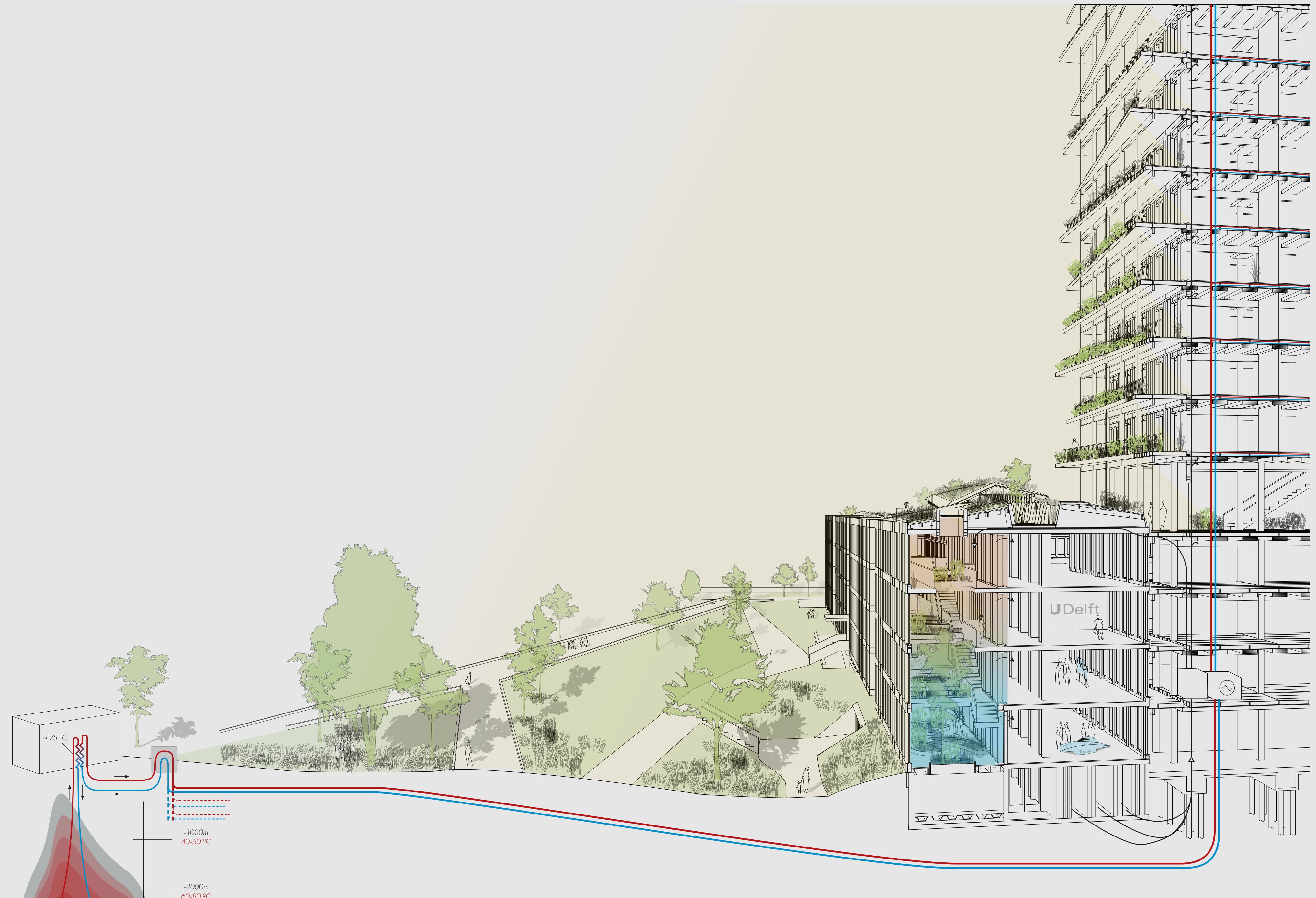


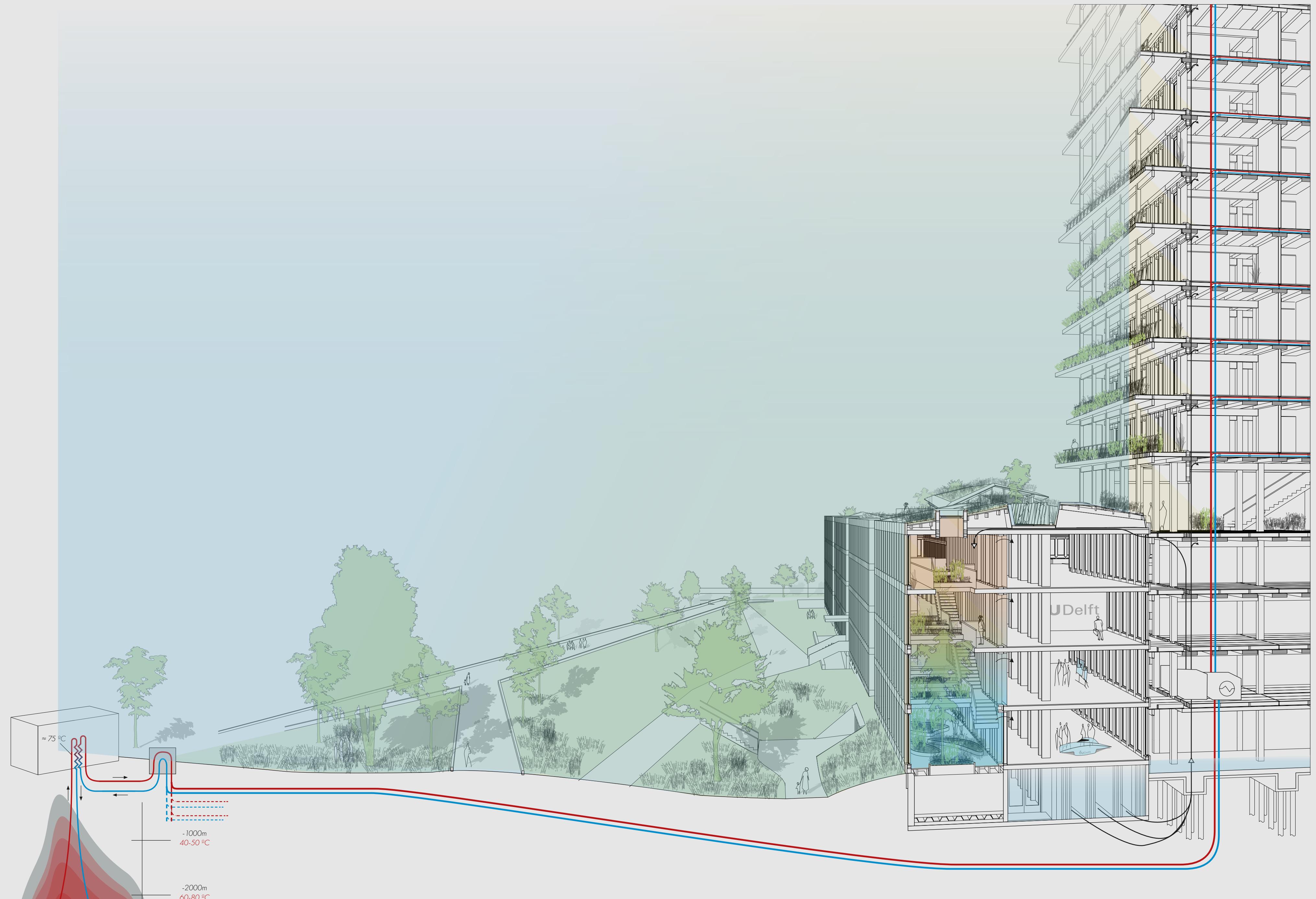


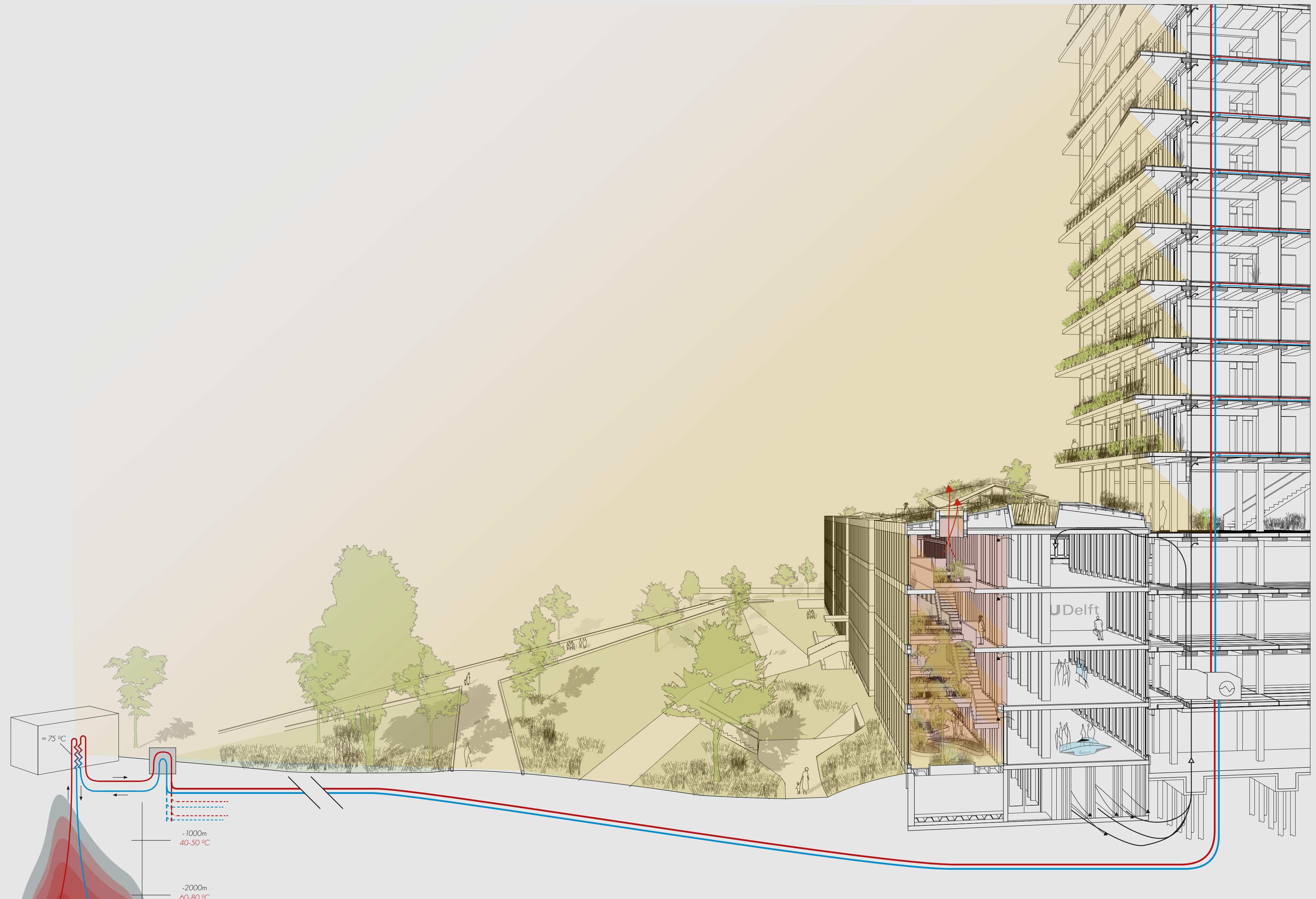


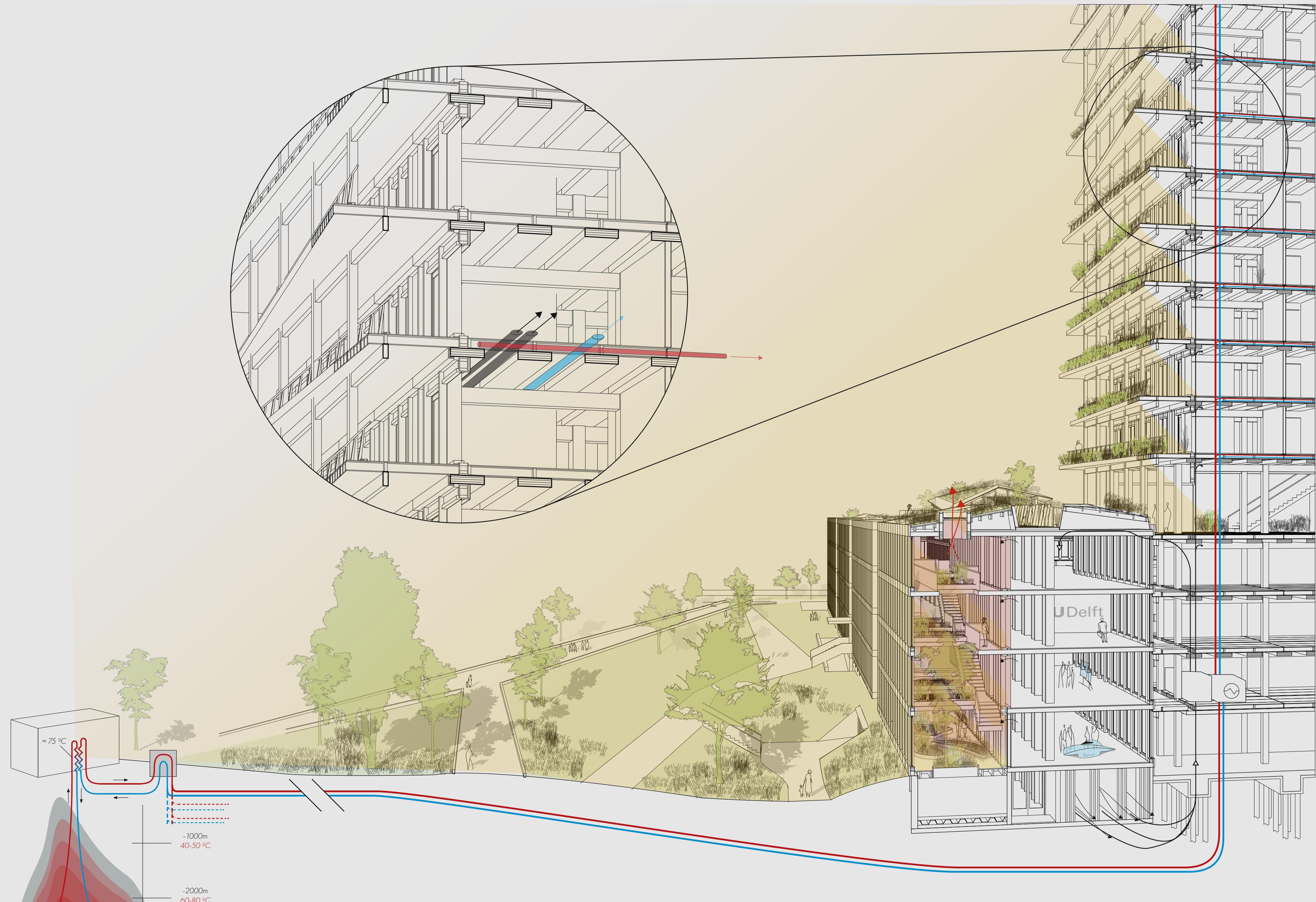


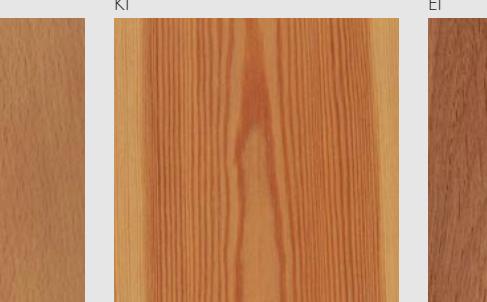
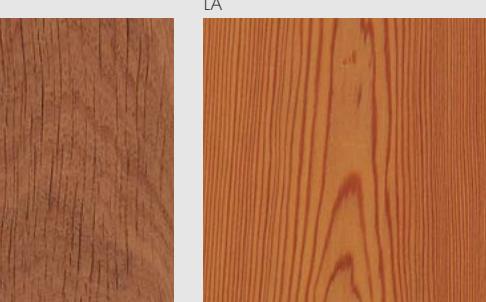
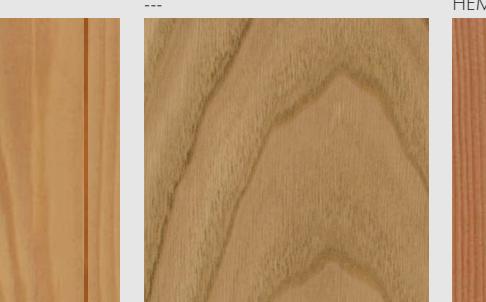
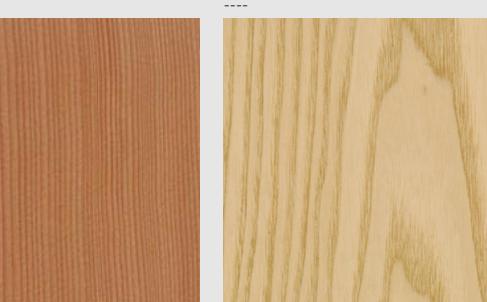
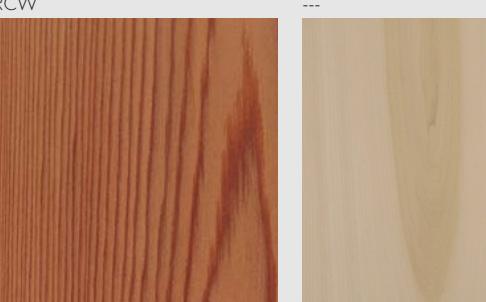
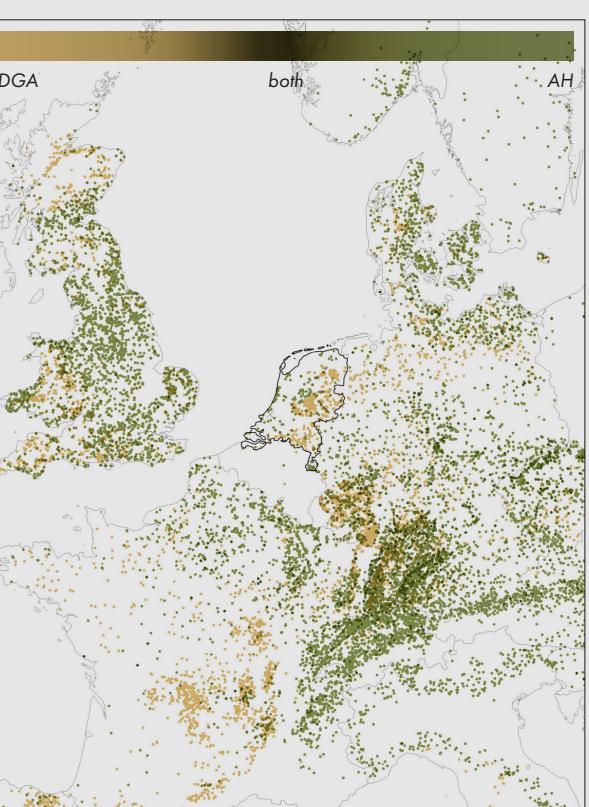
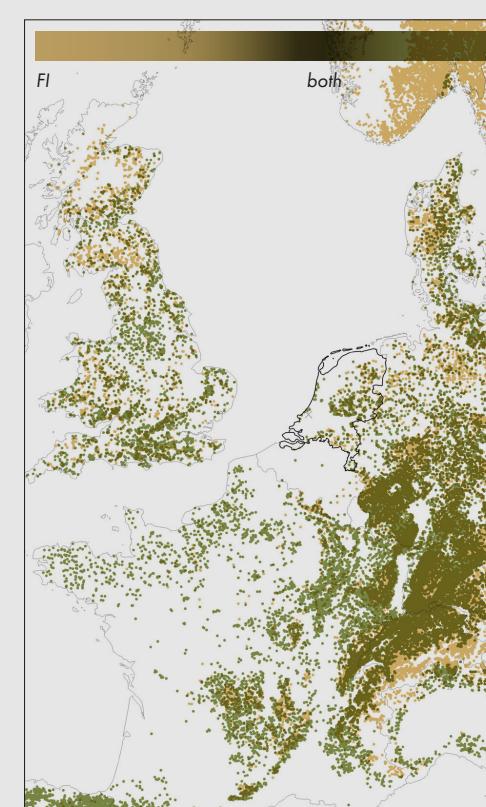
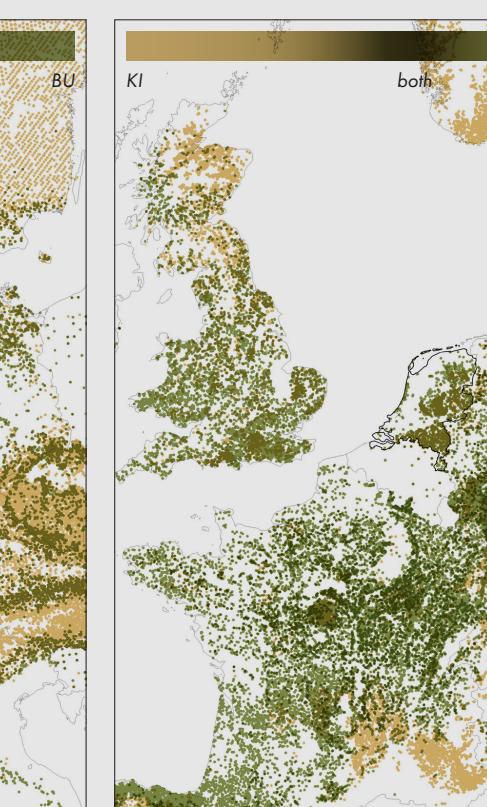
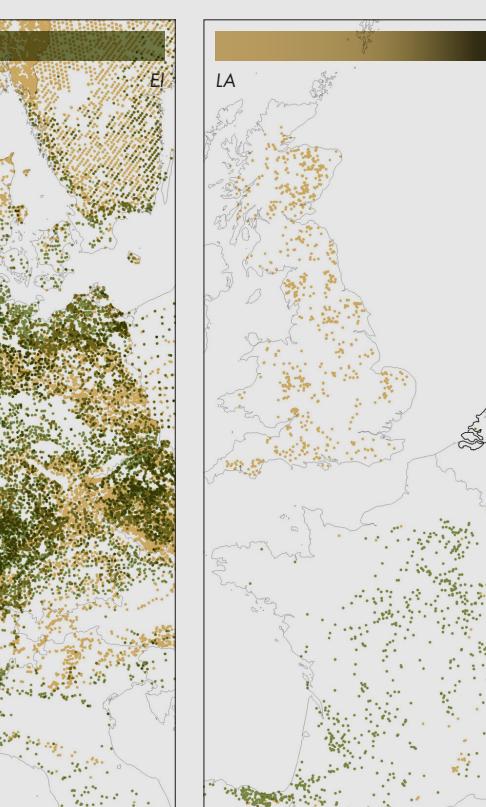
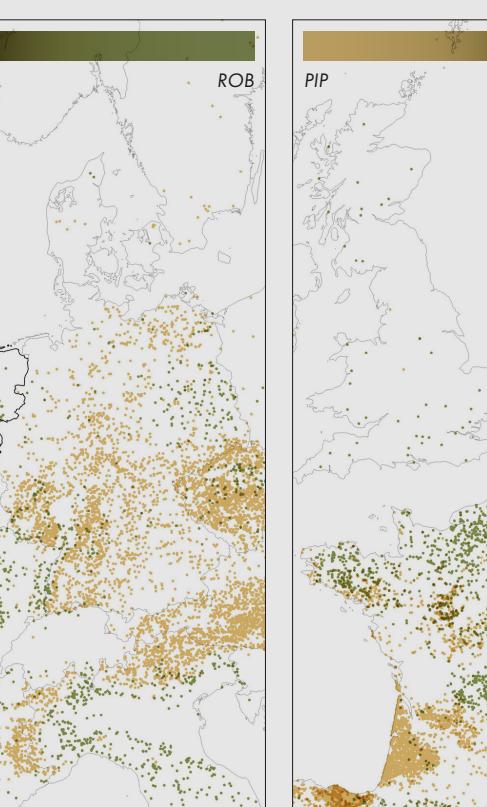
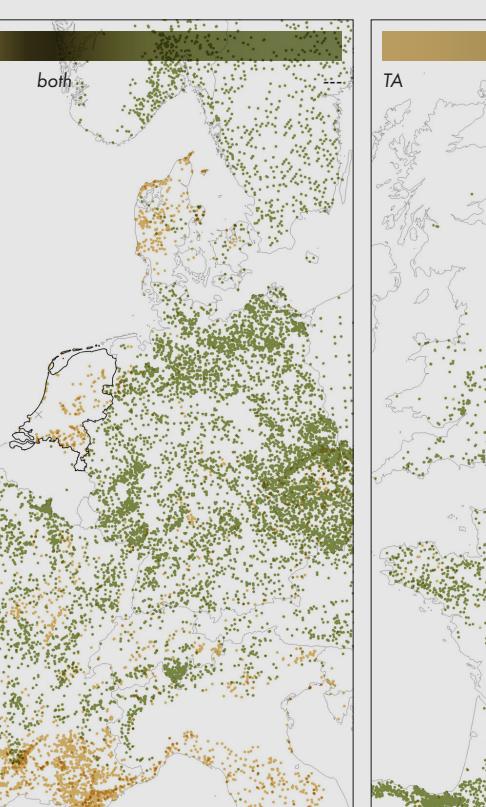
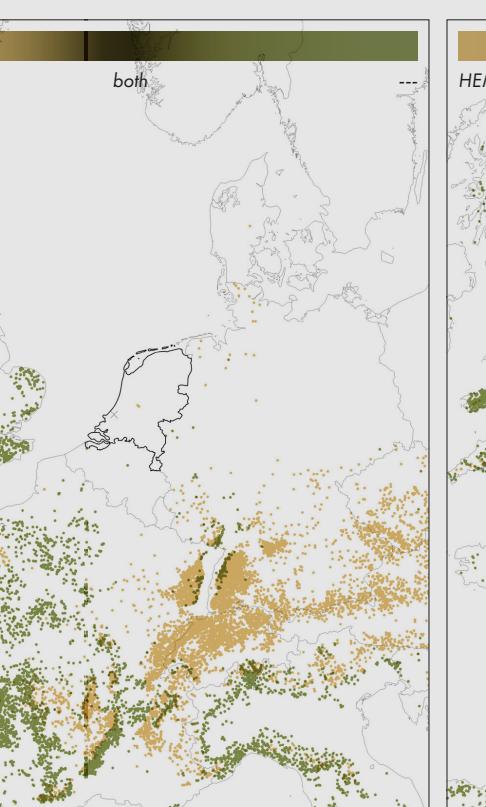
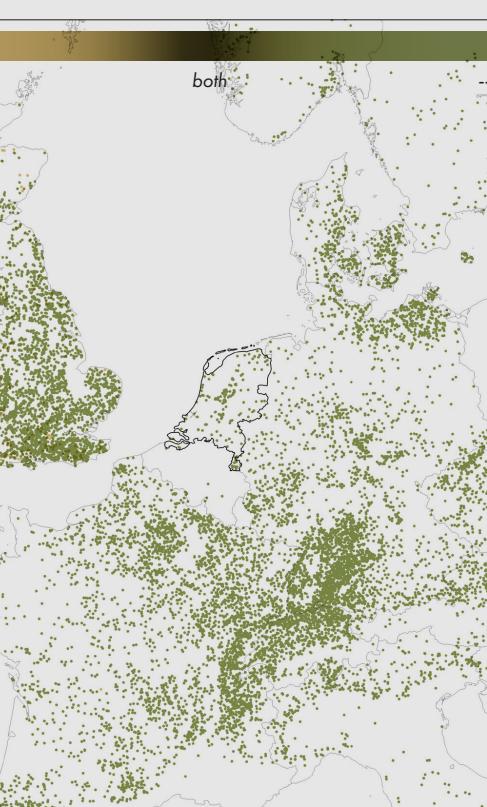
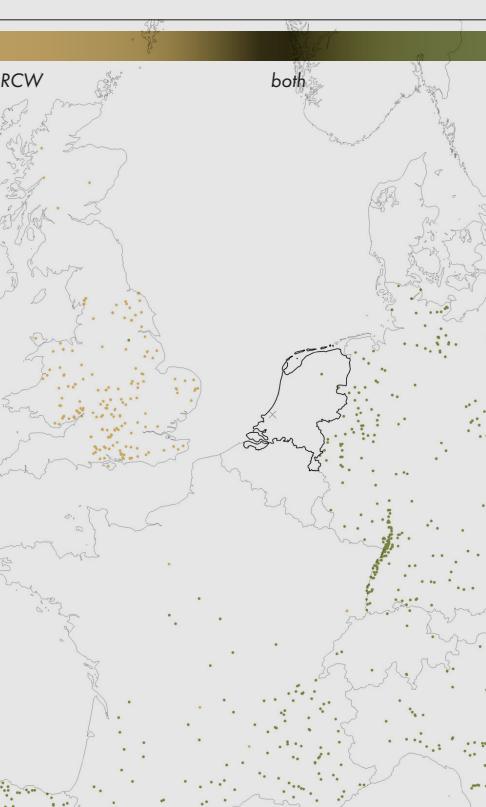




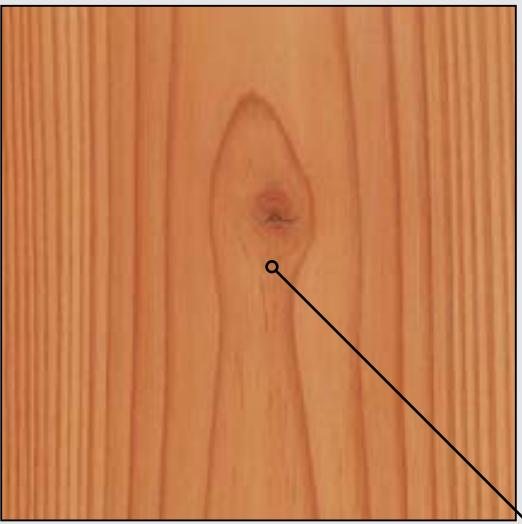




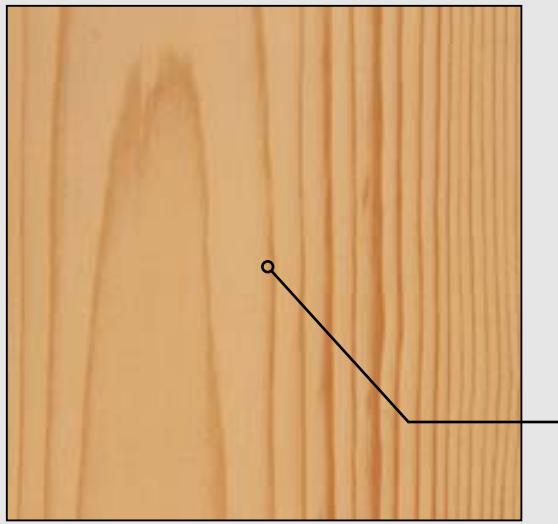


Common name, botanical name, DIN 4076 abbreviation												Common name, botanical name, DIN 4076 abbreviation												
Douglas fir, <i>Pseudotsuga menziesii</i> , DGA	Maple, <i>Acer pseudoplatanus/plata</i> , AH	Spruce, <i>Picea abies</i> , Fl	European beech, <i>Fagus sylvatica</i> , BU	Scots pine, <i>Pinus sylvestris</i> , KI	Oak, <i>Quercus robur, Q. petraea</i> , EI	European larch, <i>Larix decidua</i> , LA	Robinia, <i>Robinia pseudoacacia</i> , ROB	Pine, <i>Pinus palustris, P. rigida, + 4</i> , PIP	Birch, <i>Betula pendula L.</i> , TA	Fir, <i>Abies alba</i> , ---	Chestnut, <i>Castanea sativa Mill.</i> , HEM	Western hemlock, <i>Tsuga heterophylla</i> , ---	Ash, <i>Fraxinus excelsior</i> , ---	Western red cedar, <i>Thuja plicata D.</i> , RCW	Poplar, <i>Populus Nigra L.</i> , ---									
																								
Colour of wood, sapwood/heartwood																								
Yellowish white/reddish brown, darkening satin shine	Yellowish white, tendency to yellow, early wood yellowish white, late wood reddish yellow	light yellowish to reddish grey, often speckled, cloudy red-brown	light yellowish white/reddish white, turning to brown	grey/grey-yellow, darkening to light to dark brown	yellowish/reddish brown, darkening, late wood very dark brown	light yellow to greenish yellow/greenish yellow to olive yellow	yellowish/reddish yellow to reddish brown/late wood dark	yellowish-white or reddish-white to light brownish	early wood almost white, late wood pale reddish	sapwood grey-white to yellowish-white, heartwood yellow-brown	early wood light brownish grey, occasionally lighter streaks	single-coloured yellowish-light to reddish	white/red-brown, darkening, late wood darker	Sapwood grey-white to yellowish-white, heartwood lightbrown										
Average density [kg/m³]																								
480...500...540	530...630...960	350...400...500	540...720...910	500...520...540	430...690...960	470...600...650	720...740...800	530...540...550	510...650...830	350...450...550	570...630...660	440...490...520	450...690...860	330...370...390	410...450...560									
Theoretical differential shrinkage in % per 1% moisture change, radial/tangential																								
0.15...0.19/0.24...0.31	0.10...0.20/0.22...0.30	0.15...0.19/0.27...0.36	0.19...0.22/0.38...0.44	0.15...0.19/0.25...0.36	0.18...0.22/0.28...0.35	0.14...0.18/0.28...0.36	0.13...0.15/0.24...0.29	0.18/0.29...0.33	0.18...0.24/0.26...0.31	0.12...0.16/0.28...0.35	0.18...0.24/0.26...0.31*	0.11...0.13/0.24...0.25	0.17/0.26	0.07...0.09/0.20...0.24	0.18...0.24/0.26...0.31*									
Dimensional and form stability																								
Good	moderate to good	good	low	low	moderate	good	very good	moderate to good	good	good	good	good	good	good	very good	good	very good	low						
Resistance to fungal attack																								
moderate	very low	low	very low	low to moderate	high	moderate to low	very high	sapwood low, heartwood moderate	low	low	high	low to moderate	low	very high	low									
Resistance to insect attack																								
moderate	very low	low	low	low	high	moderate to high	very high (termite-resistant)	low to moderate	low	low	high	low	low	high	low	high	low	high	low	high	low			
1) Availability of Sawn lumber/finger jointed and bending strength [N/mm²]																								
yes/yes	no/no	yes/yes	yes/no	yes/yes	yes/no	yes/yes	yes/yes	yes/yes	yes/no	yes/yes	yes/no	yes/yes*	yes/no	yes/yes*	yes/no	yes/yes*	yes/no	yes/yes*	yes/no	yes/yes*	yes/no	yes/yes*		
2) Availability of Glued laminated timber and bending strength [N/mm²]																								
yes	no	yes	yes...28.0-48.0	yes	yes...31.5/59.0	yes	no*	yes	yes	yes	yes...30.0	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		
3) Availability of Cross laminated timber and bending strength [N/mm²]																								
yes	no	yes	no	rarely	no	yes	no*	rarely	yes...38.0	yes	no	no	no	no	no	no	no	no	no	no	no	no		
4) Availability of Laminated veneer lumber and bending strength [N/mm²]																								
yes	no	yes	yes...75.0	yes	no	no	no*	yes	no	no	no	no	no	no	no	no								
5) Availability of Structural plywood/OSB																								
yes/yes*	no/no	yes/yes	yes/no...80.0	yes/yes	no/no	no/no*	no*	yes/yes	yes/no...42.9-36.8	yes/yes	no/no	no/no*	no/no	no/no*	no/no	no/no*	no/no	no/no*	yes/yes...18.0-14.8					
Burnrate (1-5) [mm/min]																								
0.65/0.65/0.65/0.65/0.65*	-/-/-/-/-	0.65/0.65/0.65/0.65/0.65*	0.50/0.65/-/0.65/1.0	0.65/0.65/0.65/0.65/0.65*	0.50/0.50/-/-/-	0.65/0.65/0.65/-/-*	0.50/-/-/-/-*	0.65/0.65/0.65/0.65/0.65*	0.50/0.50/0.50/-/0.90	0.65/0.65/0.65/-/0.65*	0.50/0.50/-/-/-	0.65/0.65/-/-/-*	0.50/0.50/-/-/-	0.65/0.65/-/-/-*	0.50/0.50/-/-/-	0.65/0.65/-/-/-*	0.50/0.50/-/-/-	0.65/0.65/-/-/-*	0.50/0.50/-/-/-					
Thermal conductivity (1-5) [W/mK]																								
0.12/0.13/0.13/0.13	-/-/-/-	0.09/0.13/0.13/0.13	0.13/0.17/-/0.17/0.13	0.12/0.13/0.13/0.13	0.13/0.17/-/-	0.11/0.13/0.13/-/-	0.13/-/-/-/-*	0.12/0.13/0.13/0.13	0.13/0.17/0.17/-/0.13	0.10/0.13/0.13/-/0.13	0.13/0.17/-/-/-	0.09/0.13/-/-	0.13/0.17/-/-/-	0.09/0.13/-/-	0.13/0.17/-/-/-	0.09/0.13/-/-	0.13/0.17/-/-/-	0.09/0.13/-/-	0.13/0.17/-/-/-					
Water vapour diffusion resistance (1...2/3...4/5) [μ]																								
50...20/50...20/50...20	-/-/-/-	50...20/50...20/50...20	200...50/220...90/300...200	50...20/50...20/50...20	200...50/-/-	50...20/50...20/-	200...50/-/-	50...20/50...20/50...20	200...50/220...90/300...200	50...20/-/50...20	200...50/-/-	50...20/-/-	200...50/-/-	50...20/-/-	200...50/-/-	50...20/-/-	200...50/-/-	50...20/-/-	200...50/-/-					
Highest durability class																								
DC3/moderately durable	DC5/not durable	DC4/slightly durable	DC4/slightly durable	DC3/moderately durable	DC1/very durable	DC3/moderately durable	DC1/very durable	DC4/slightly durable	DC5/not durable	DC1/very durable	DC4/slightly durable	DC5/not durable	DC4/slightly durable	DC5/not durable	DC2/durable	DC5/not durable	DC2/durable	DC5/not durable						
																								

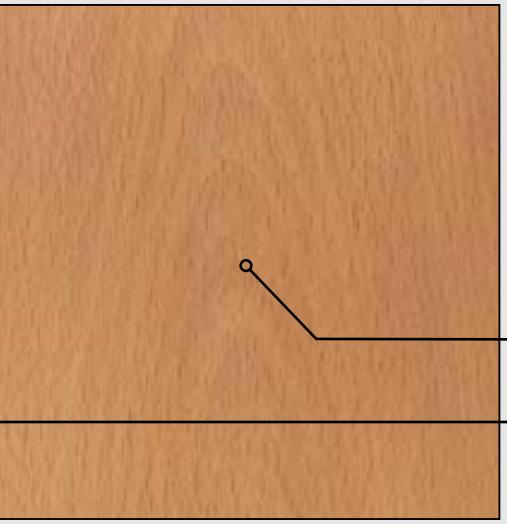
Douglas fir, *Pseudotsuga menziesii*



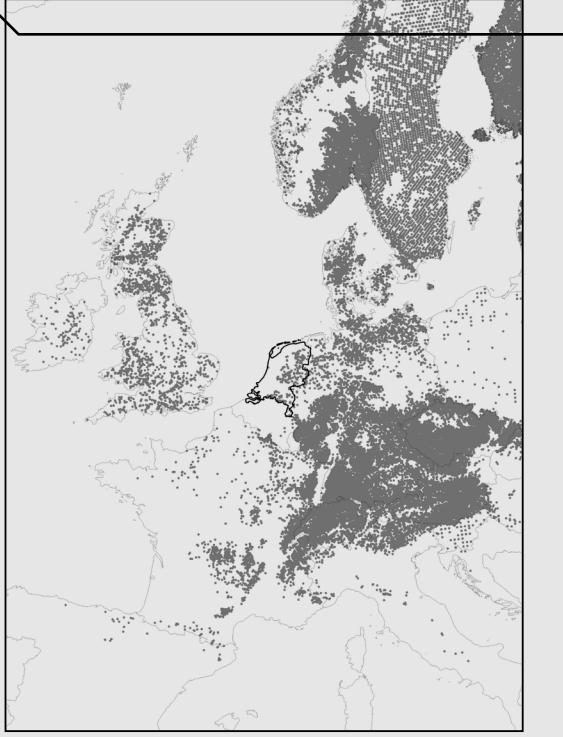
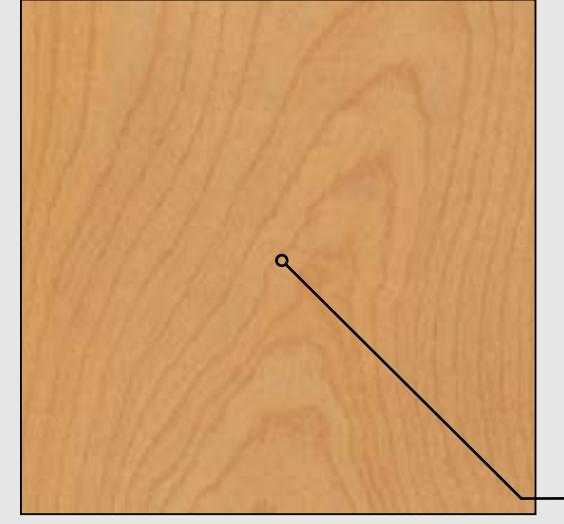
Spruce, *Picea abies*



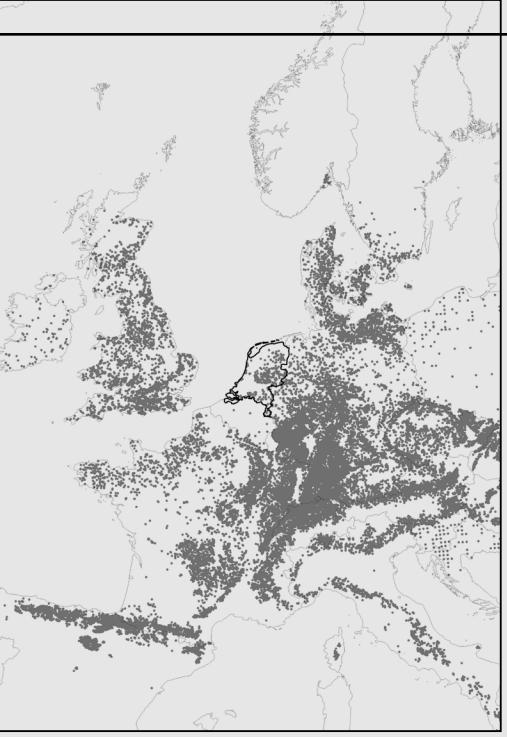
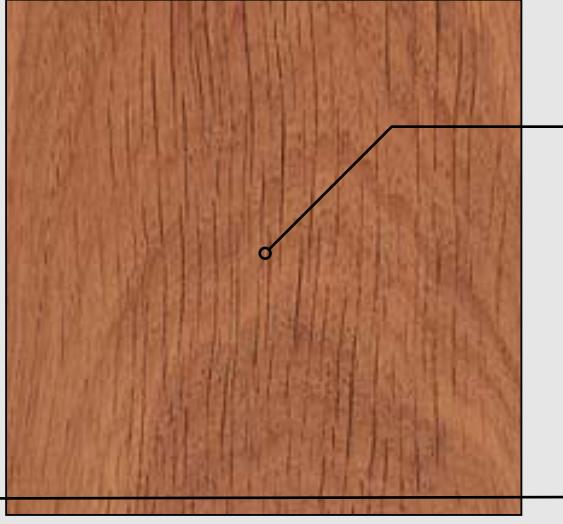
European beech, *Fagus sylvatica*



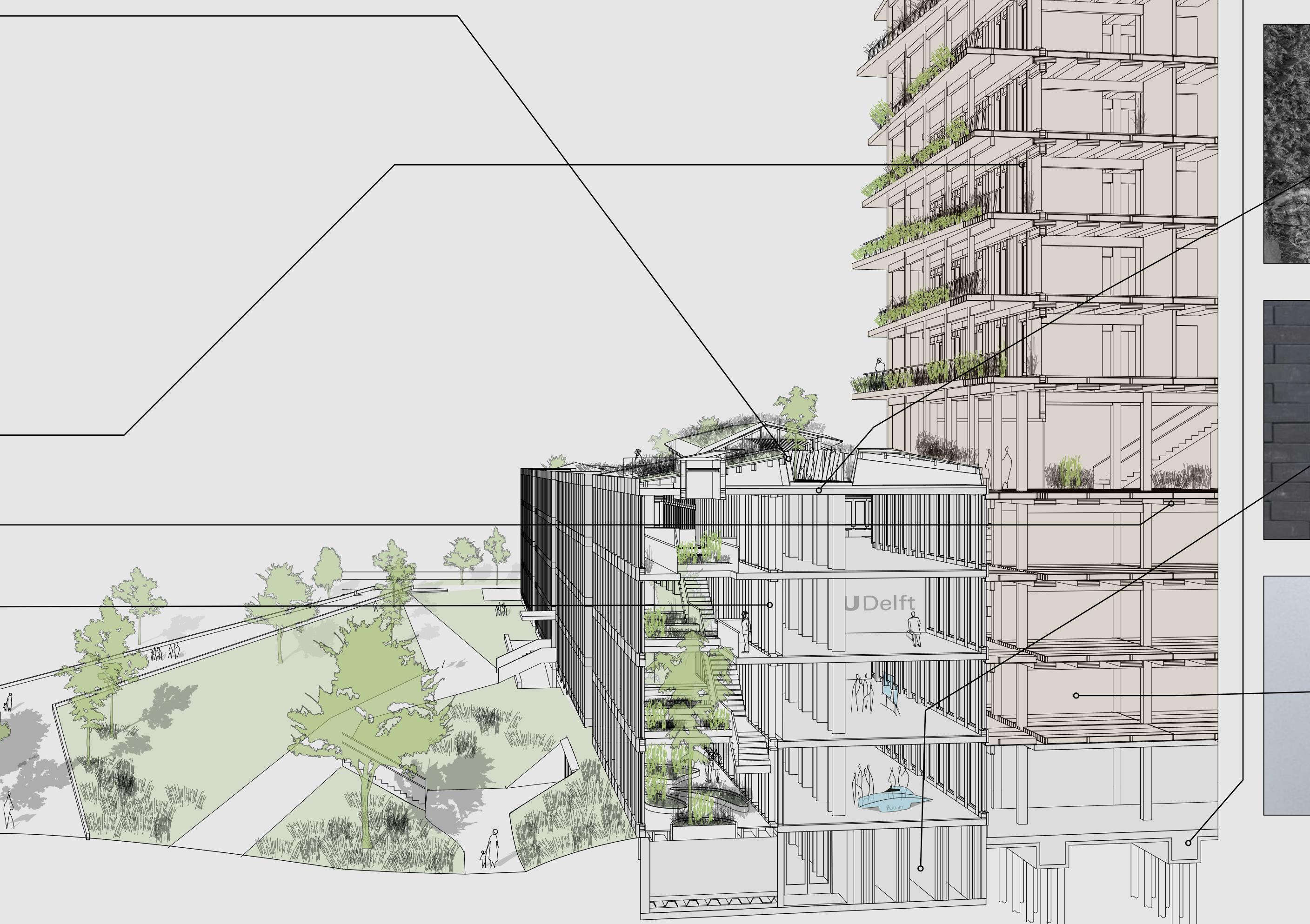
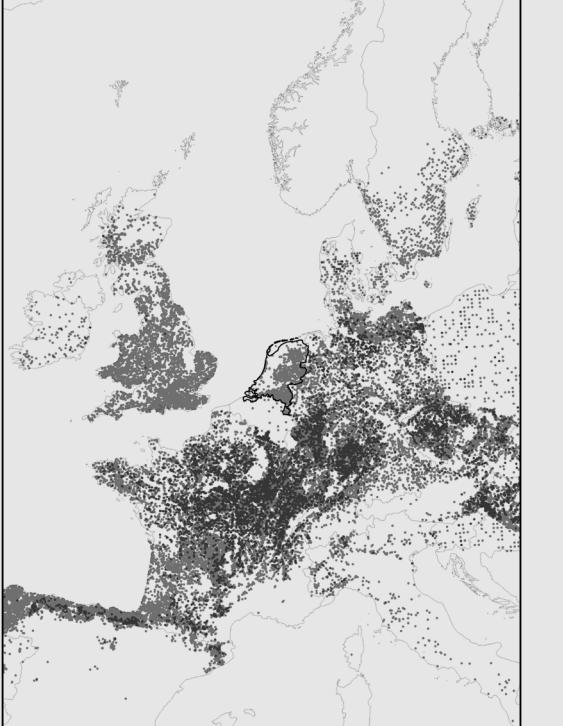
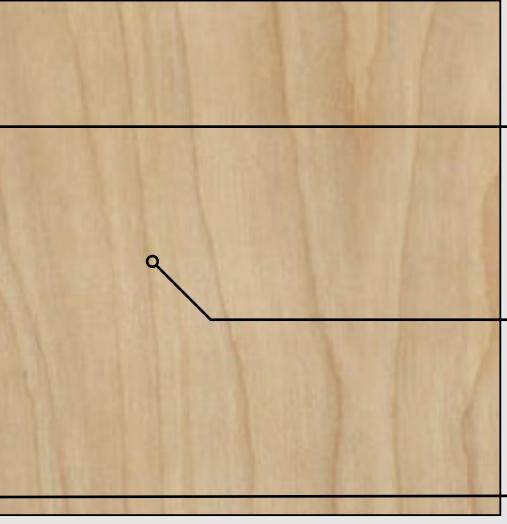
Maple, *Acer pseudoplatanus/plata*



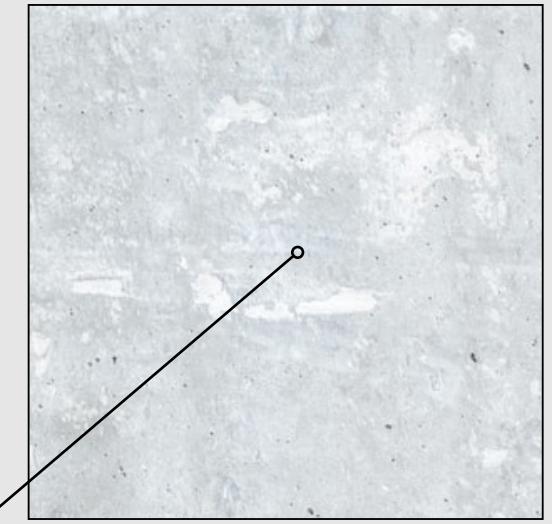
Oak, *Quercus robur, Q. petraea*



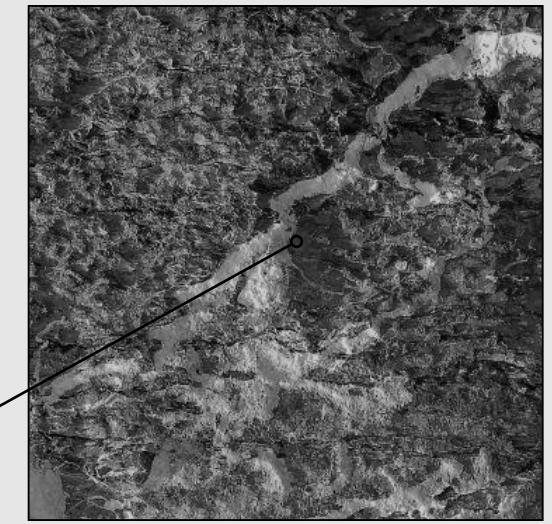
Birch, *Betula pendula L.*



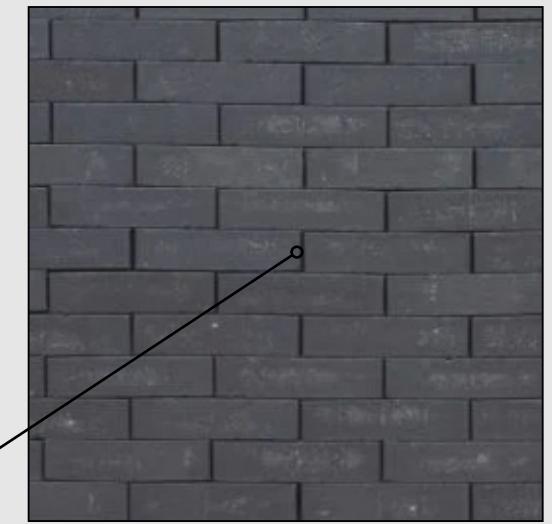
Concrete - Structure



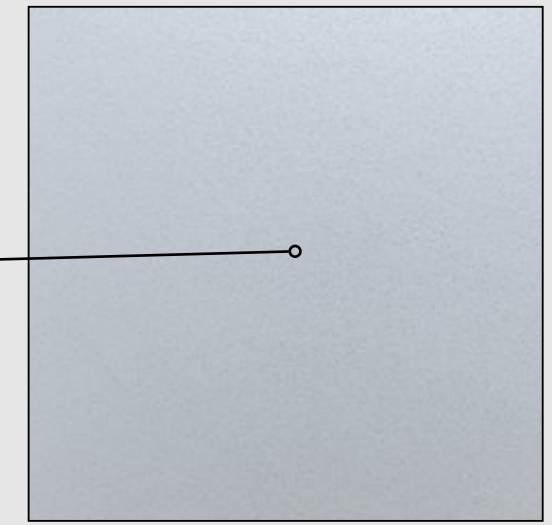
Natural stone - Facade



Poroso Brick - Facade



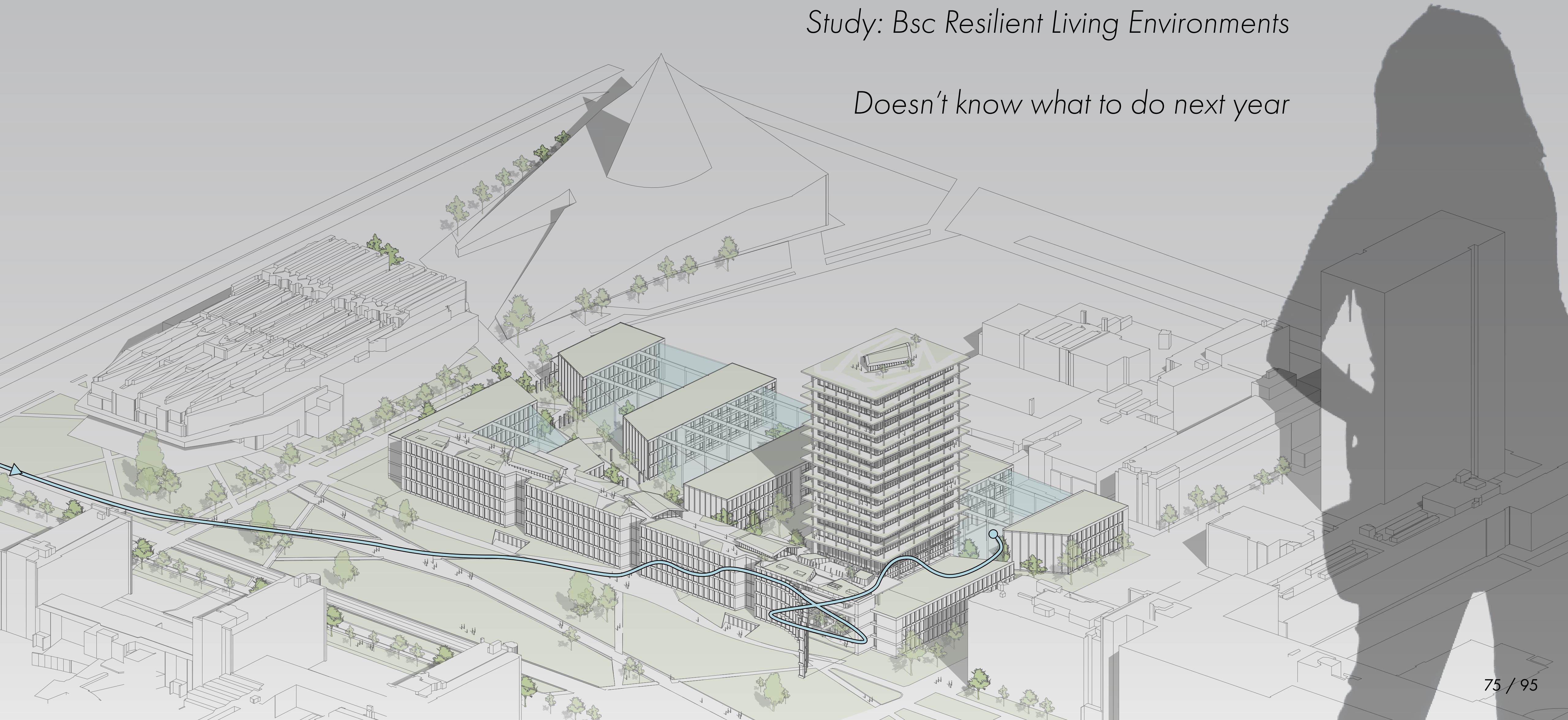
Glass - Facade



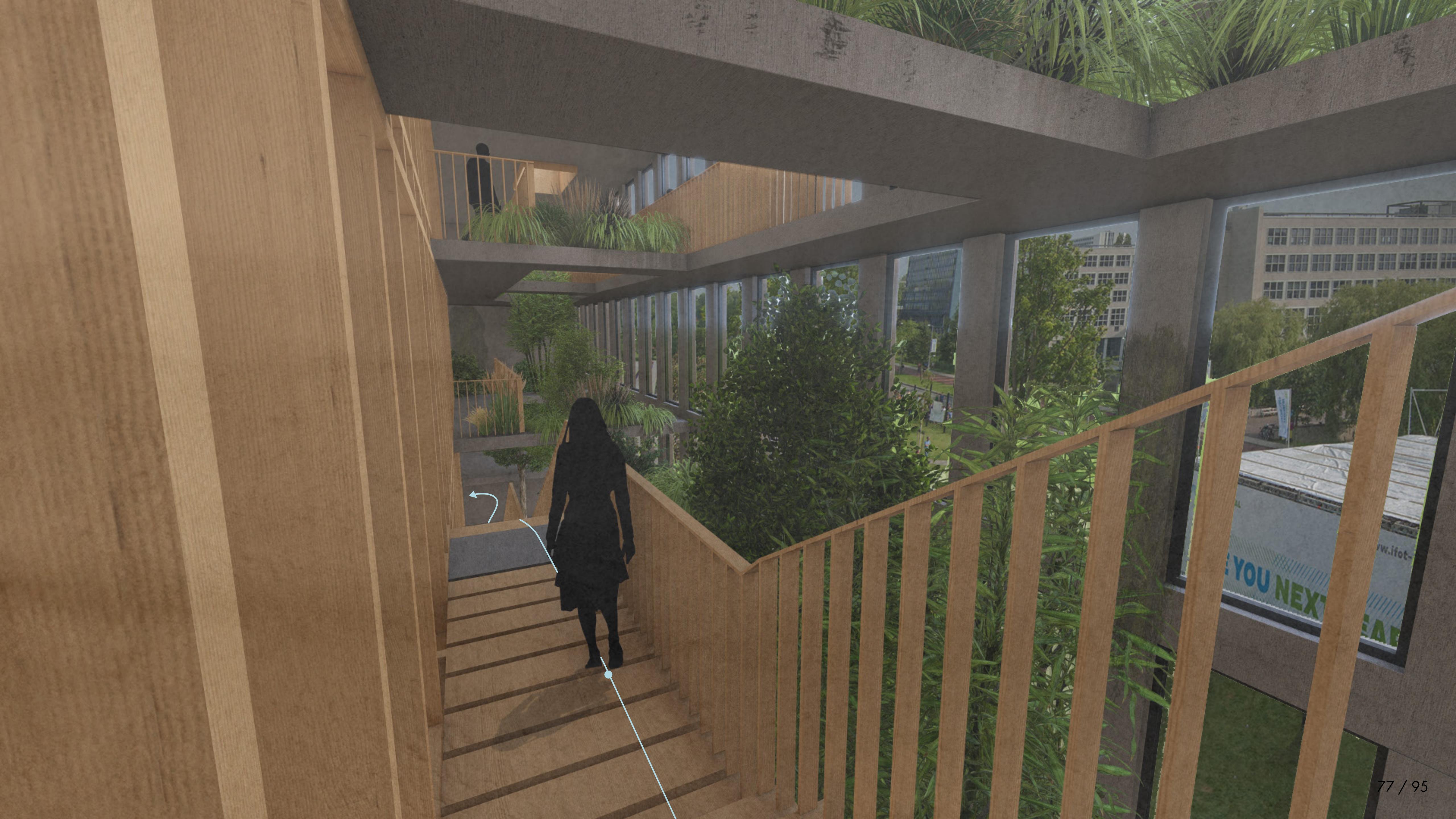
Name: Susan

Study: Bsc Resilient Living Environments

Doesn't know what to do next year













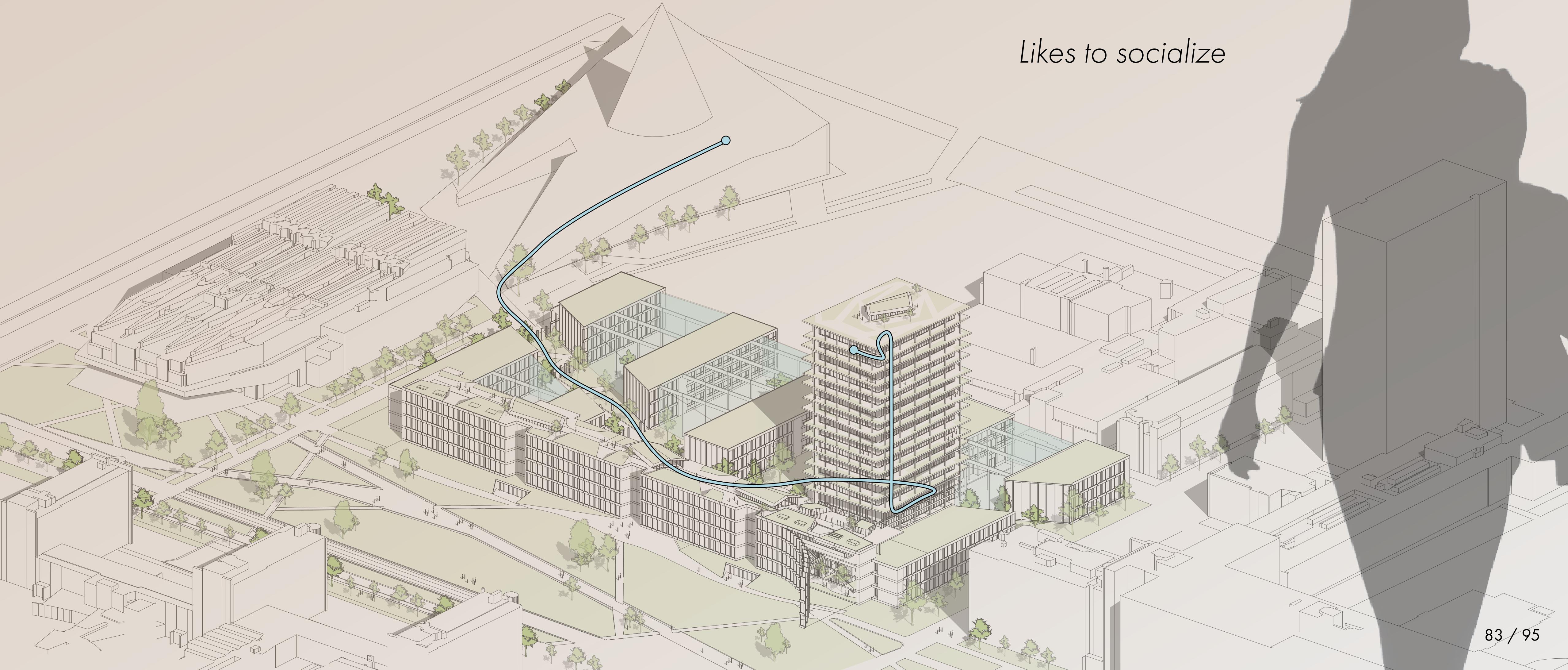




Name: Kate

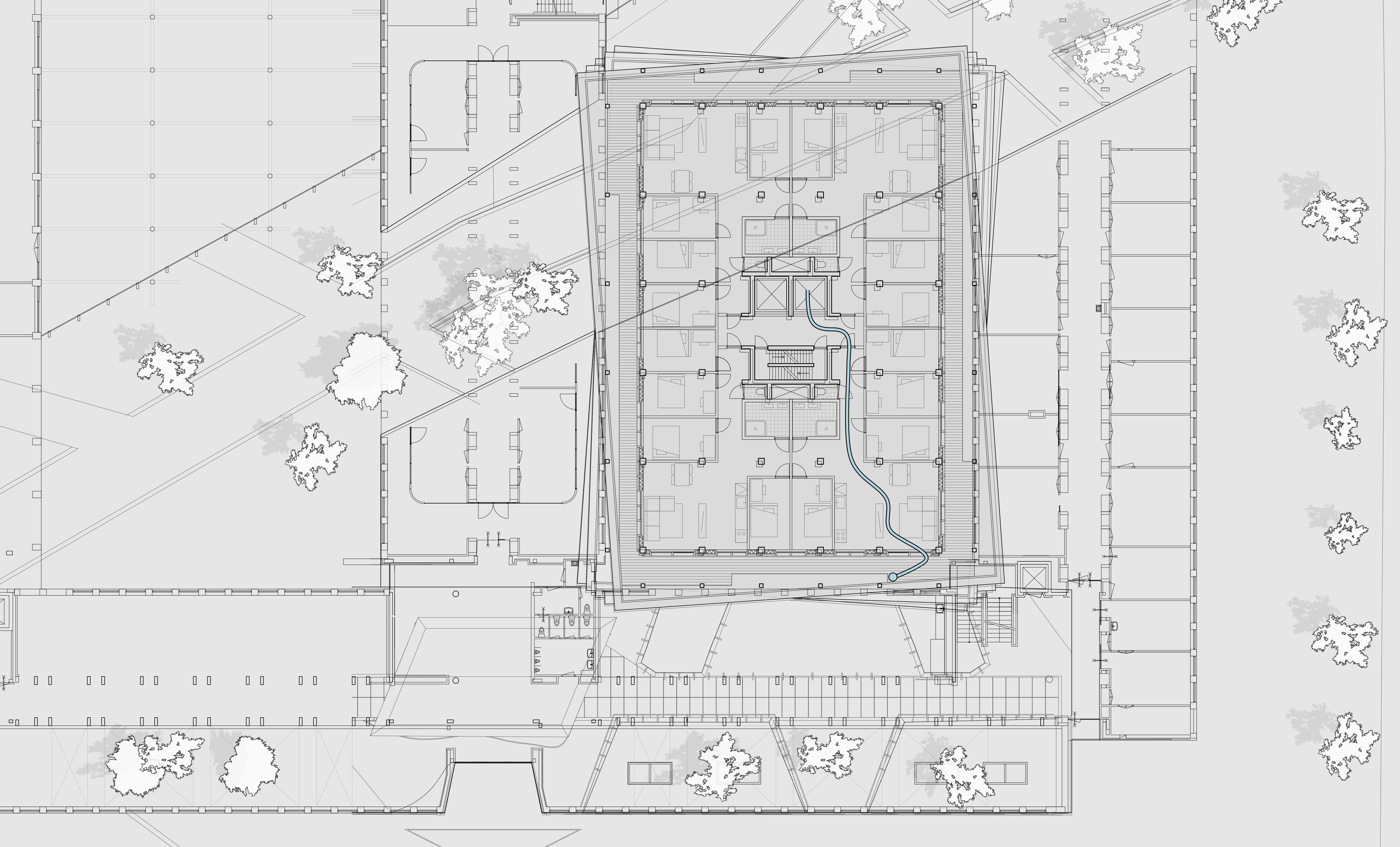
Work: Flowmotion (TU Delft startup)

Likes to socialize











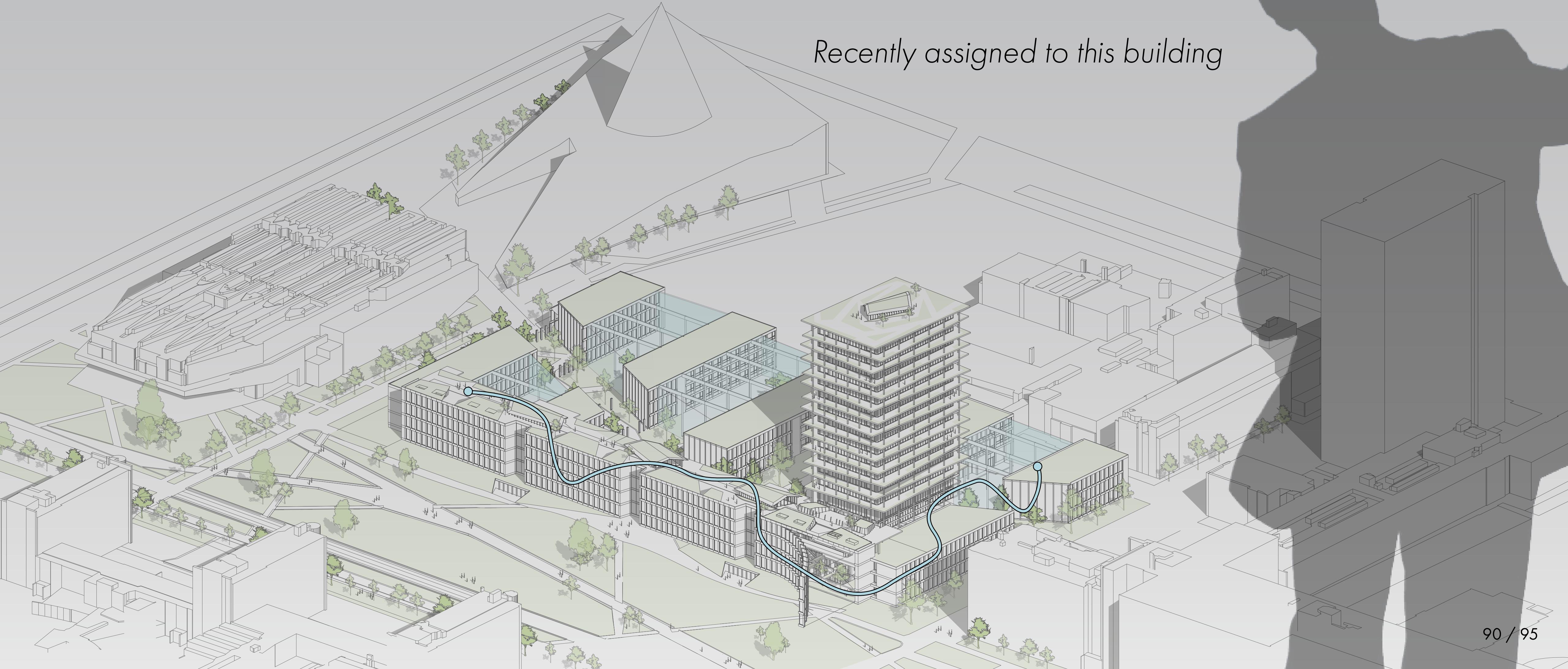




Name: John

Work: Facility manager TU Delft

Recently assigned to this building





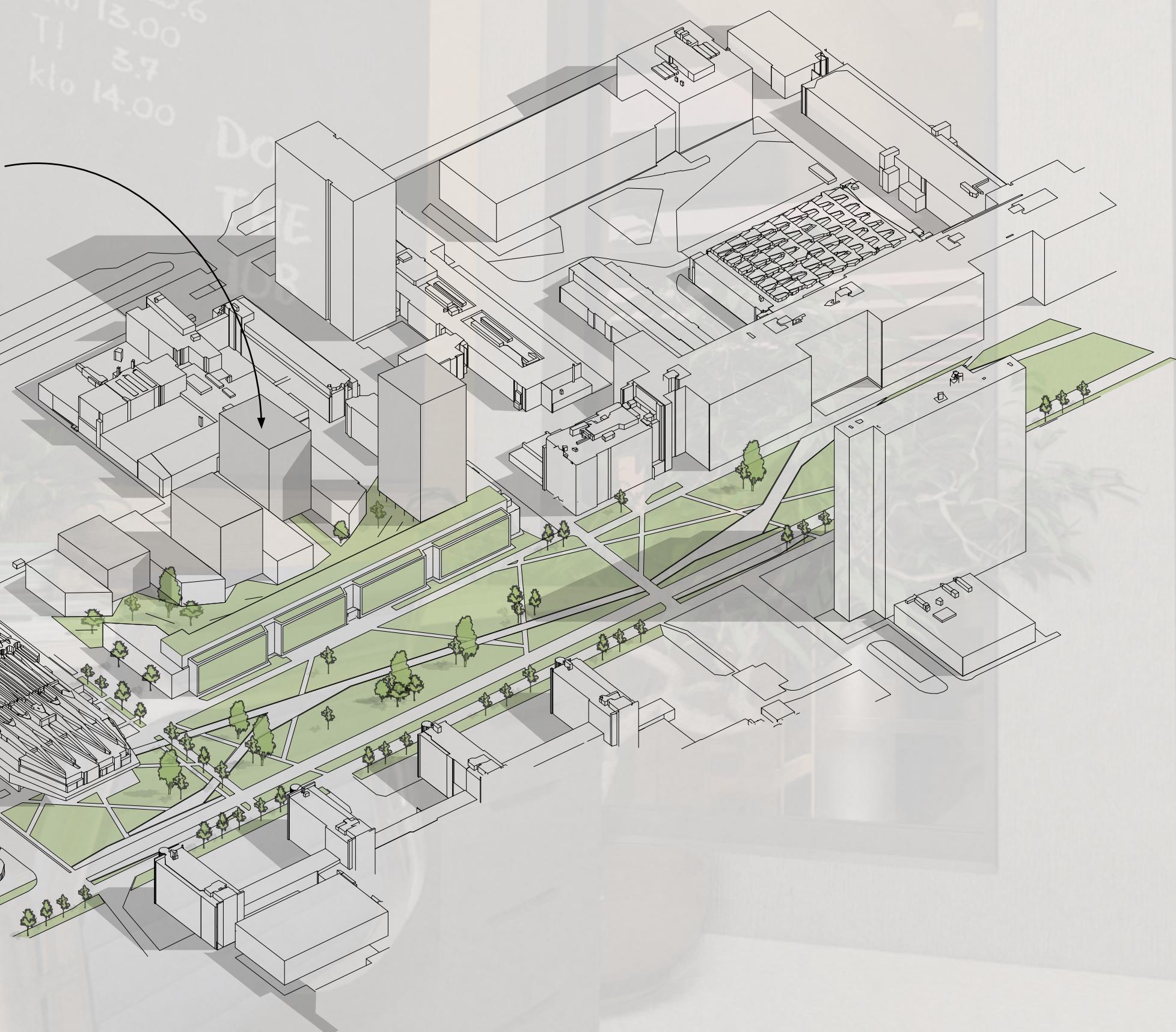




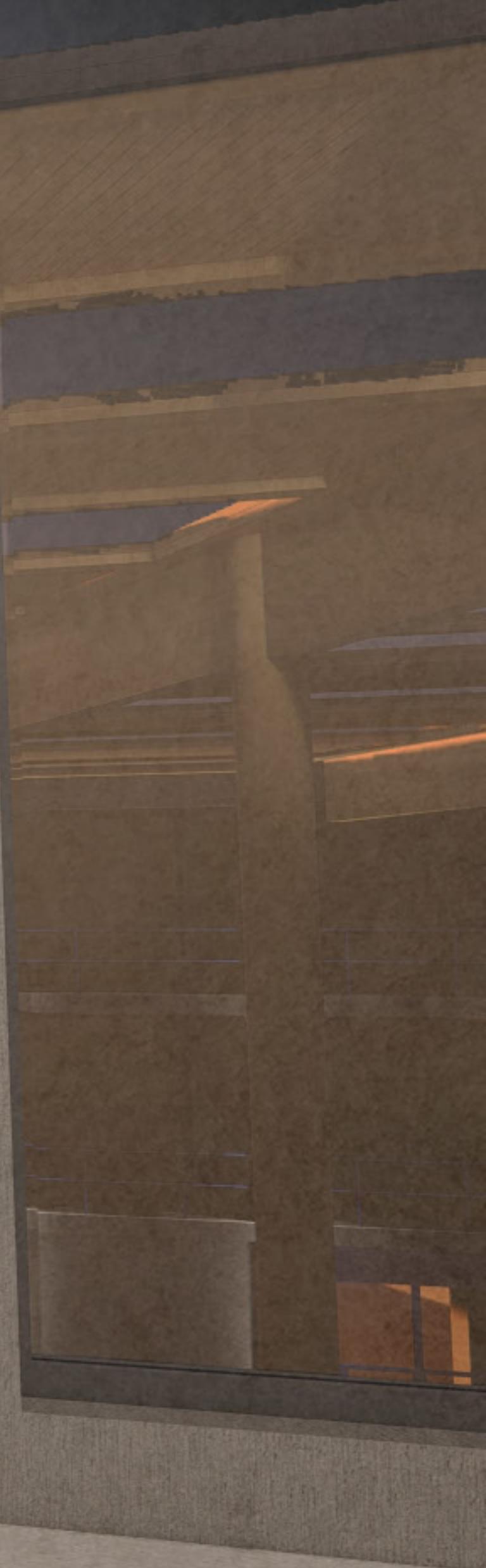
TI
klo 19.6
MA
klo 10.00
TI
klo 25.6
TI
klo 13.00
klo 3.7
TI
klo 14.00

DO
THE
JOB

Phase 2



T1 19.6
klo 10.00
MA 25.6
klo 13.00
T1 3.7
klo 14.00



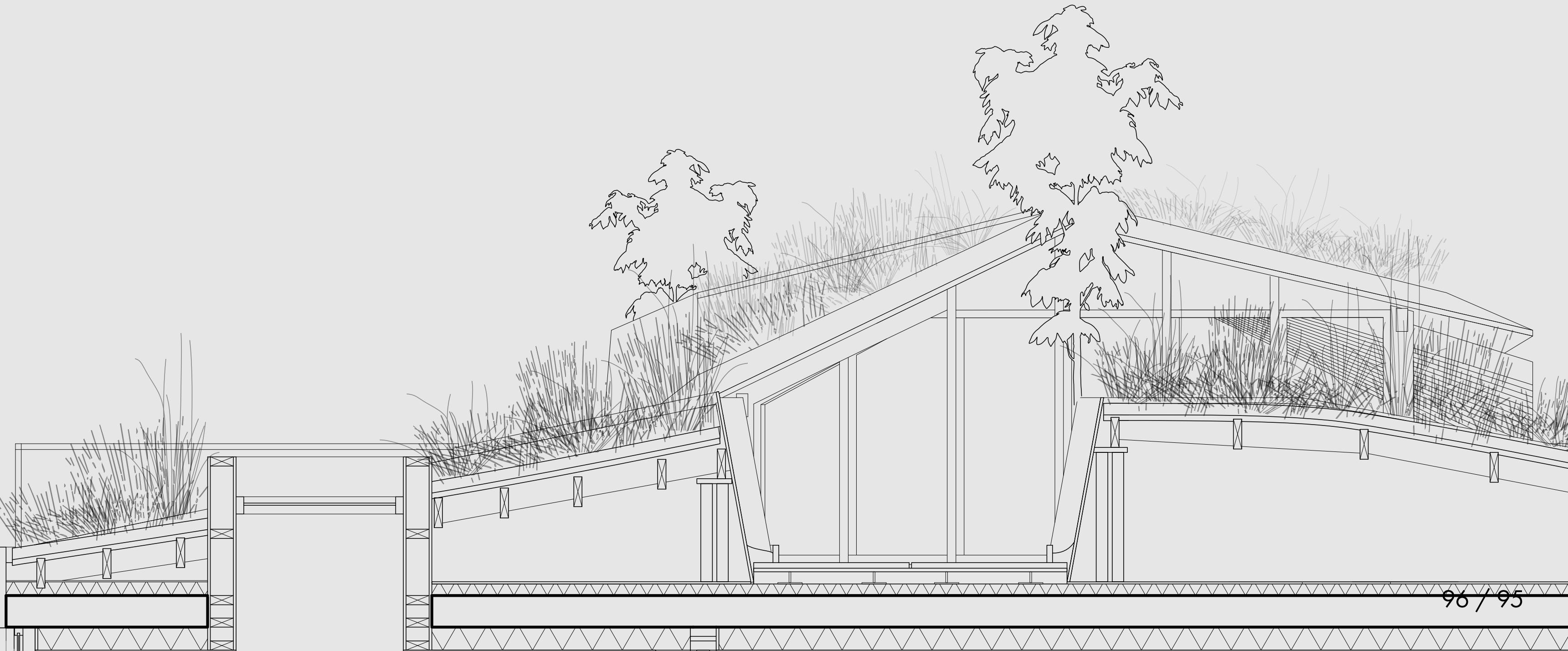
A photograph of a person with a black umbrella walking through a modern wooden structure in the rain. The structure is made of light-colored wood with a curved roof and a glass door. The person is walking away from the camera. In the background, there are green plants and a wooden fence. The sky is overcast and rainy.

The problem is complex and urgent - but we have no other choice than to be optimistic.

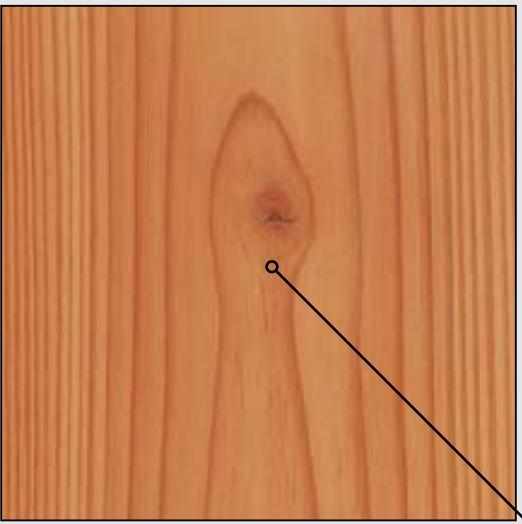
- TU Delft, 2022

Appendix

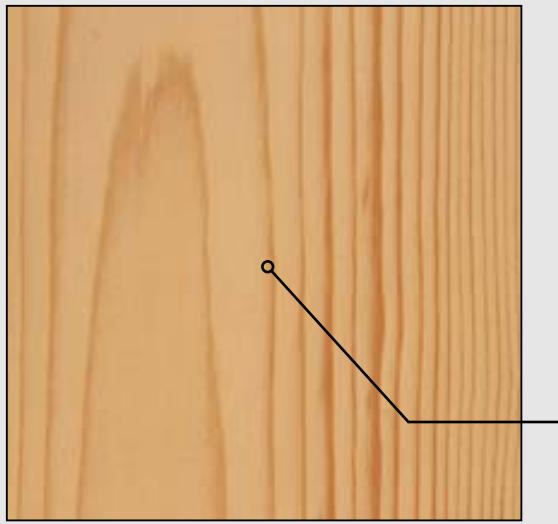
Semester 1/2



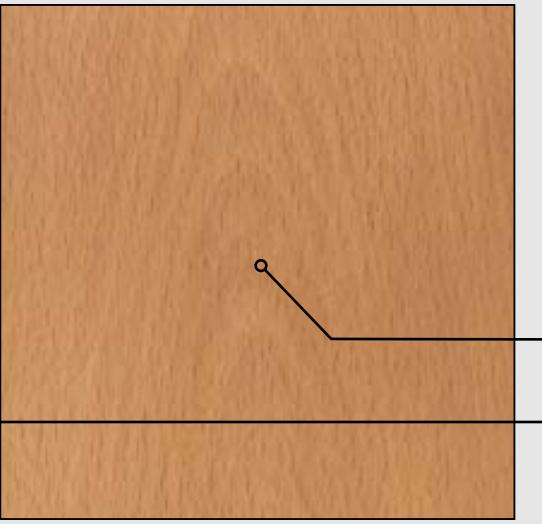
Douglas fir, *Pseudotsuga menziesii*



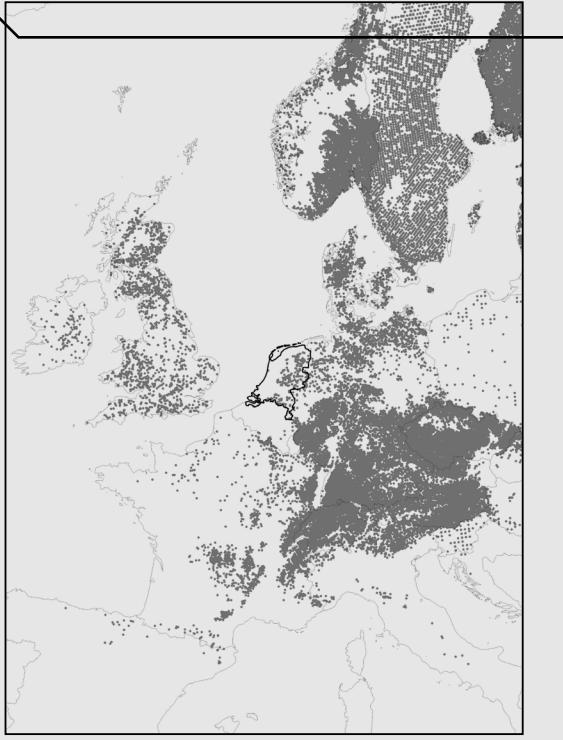
Spruce, *Picea abies*



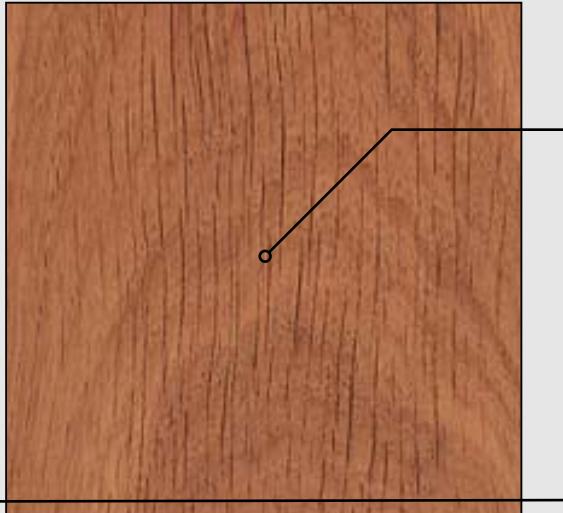
European beech, *Fagus sylvatica*



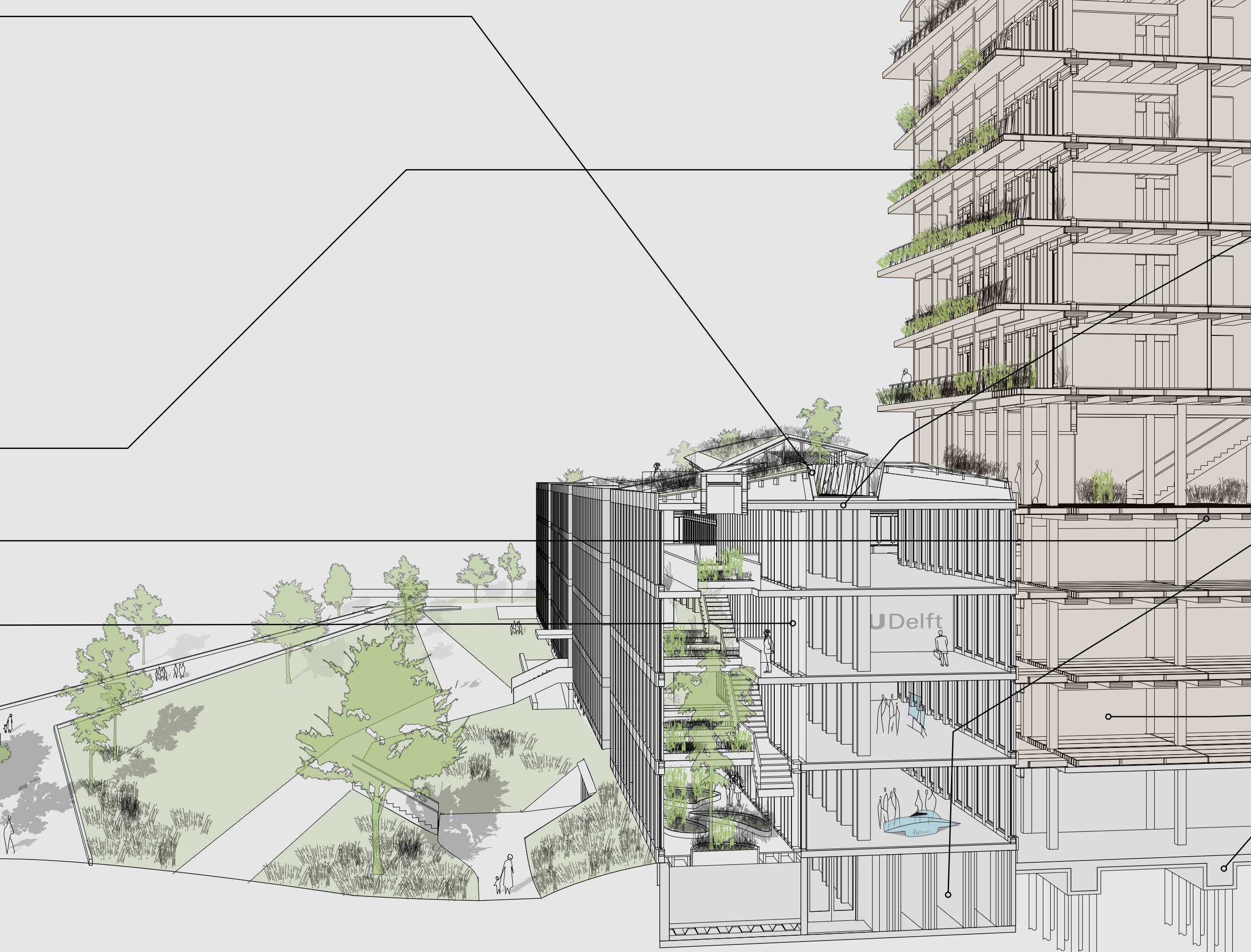
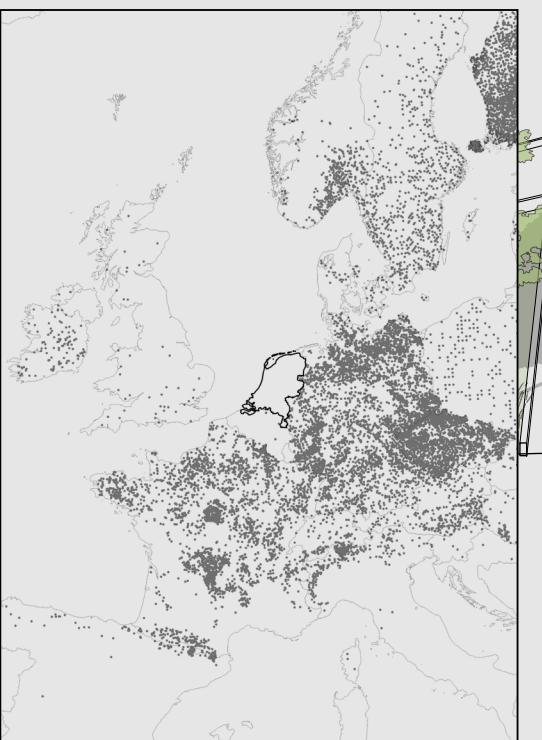
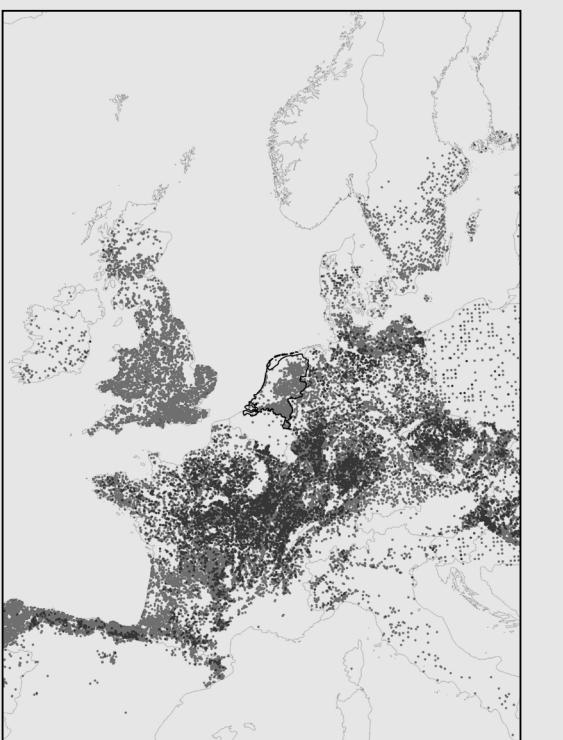
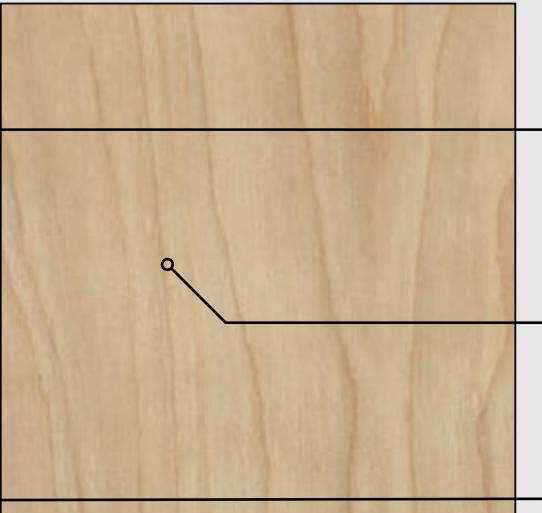
Maple, *Acer pseudoplatanus/plata*



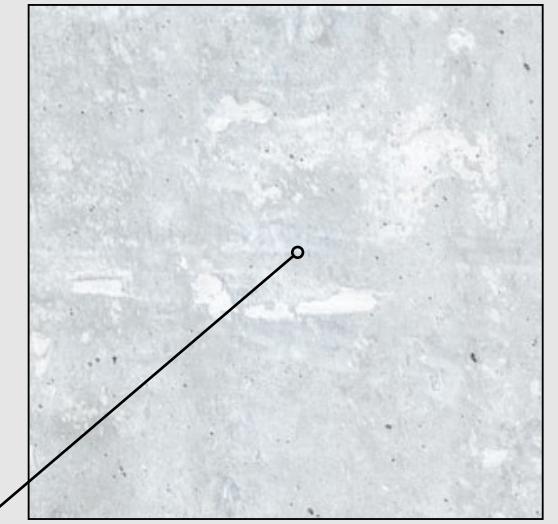
Oak, *Quercus robur, Q. petraea*



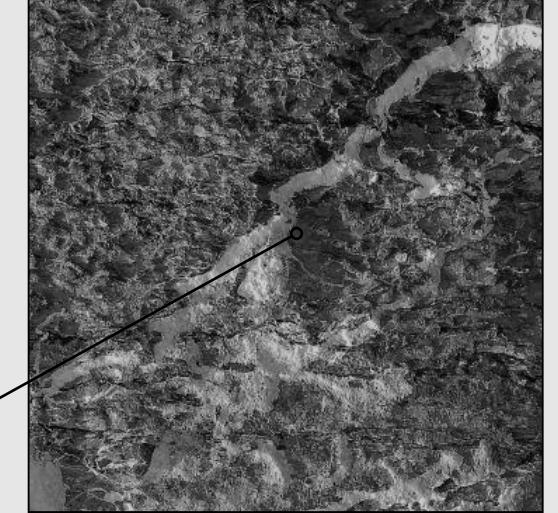
Birch, *Betula pendula L.*



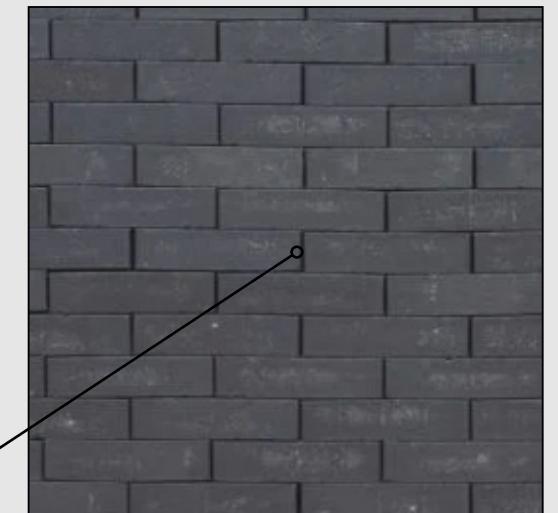
Concrete - Structure



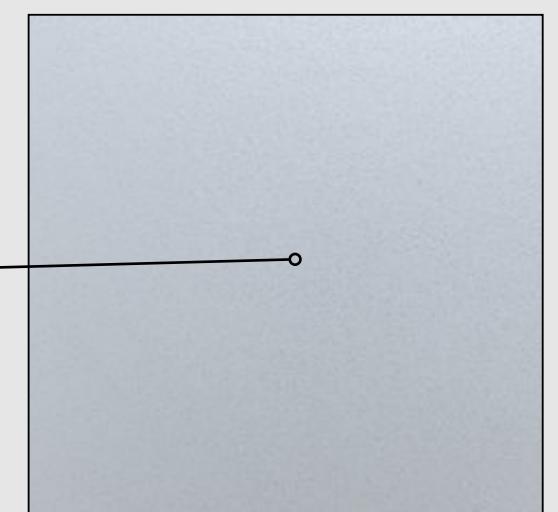
Natural stone - Facade

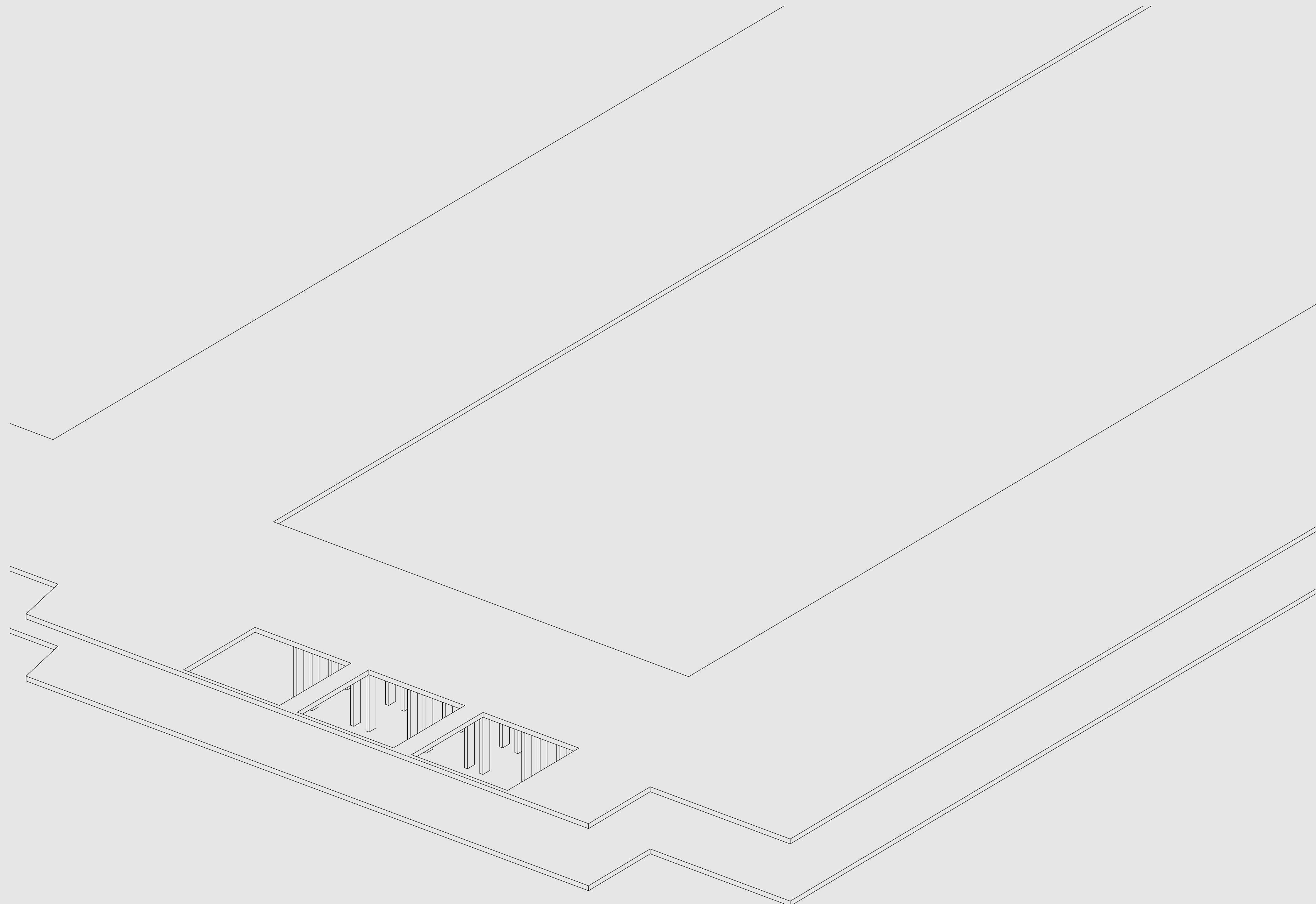


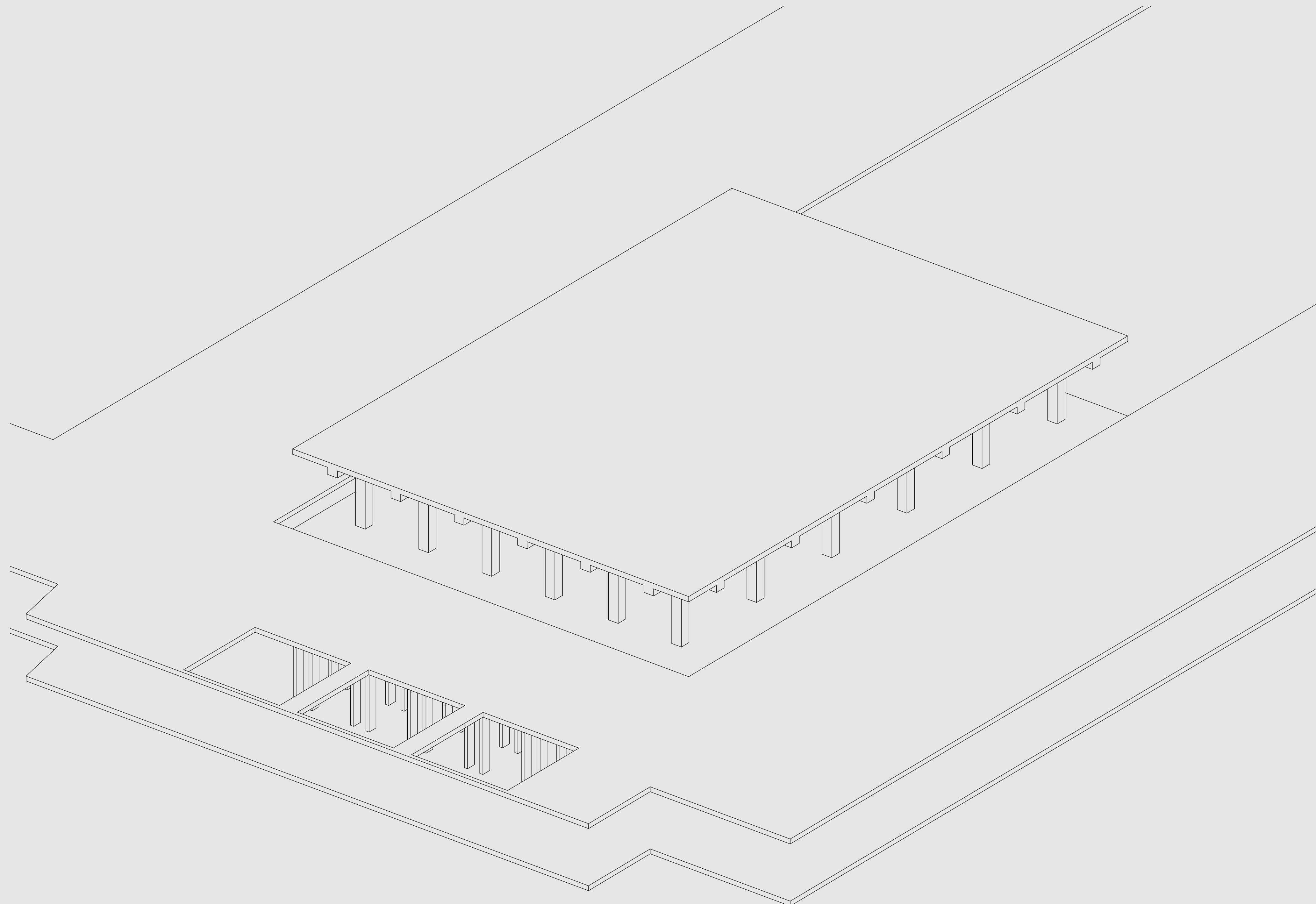
Poroso Brick - Facade

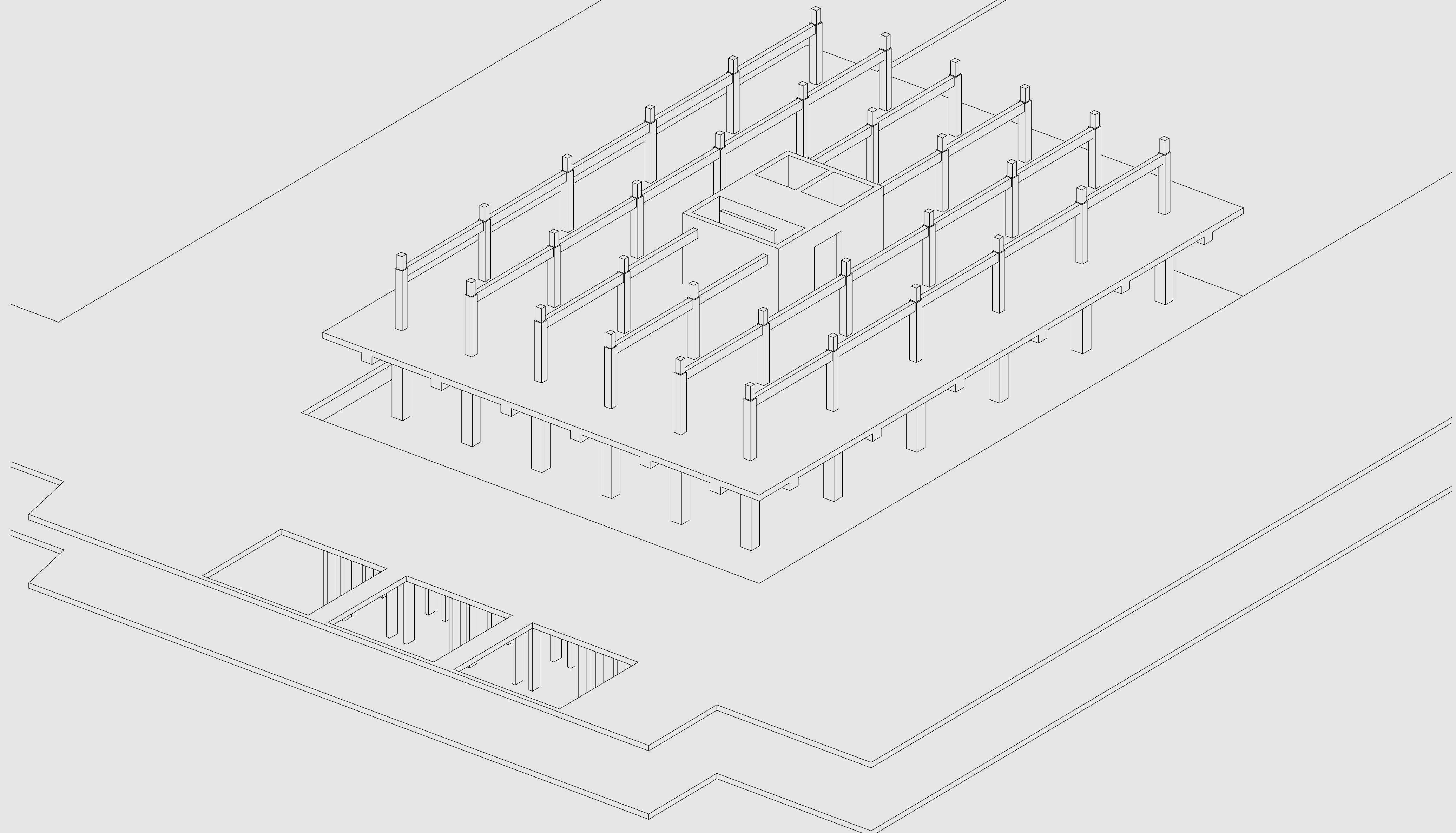


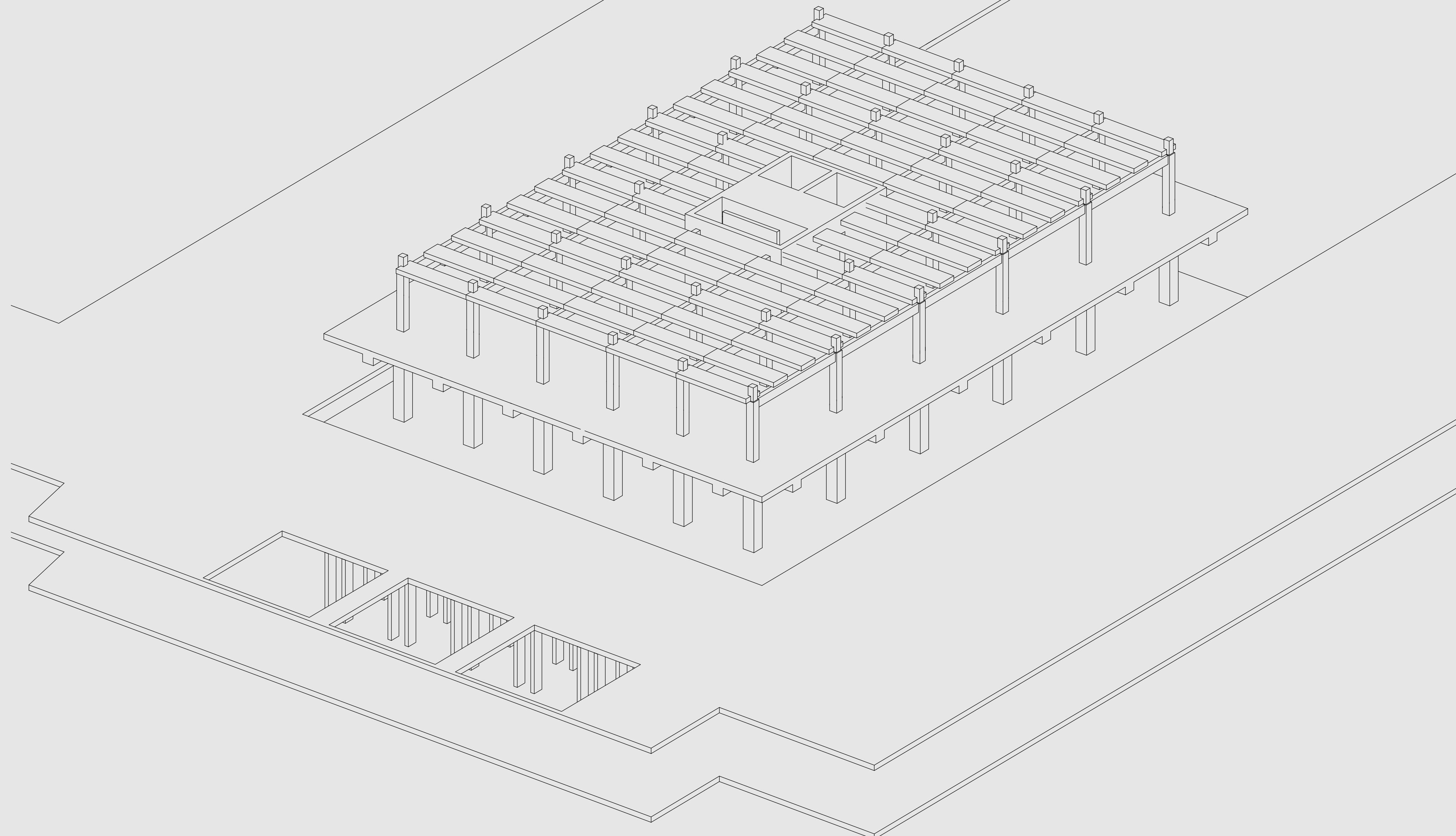
Glass - Facade

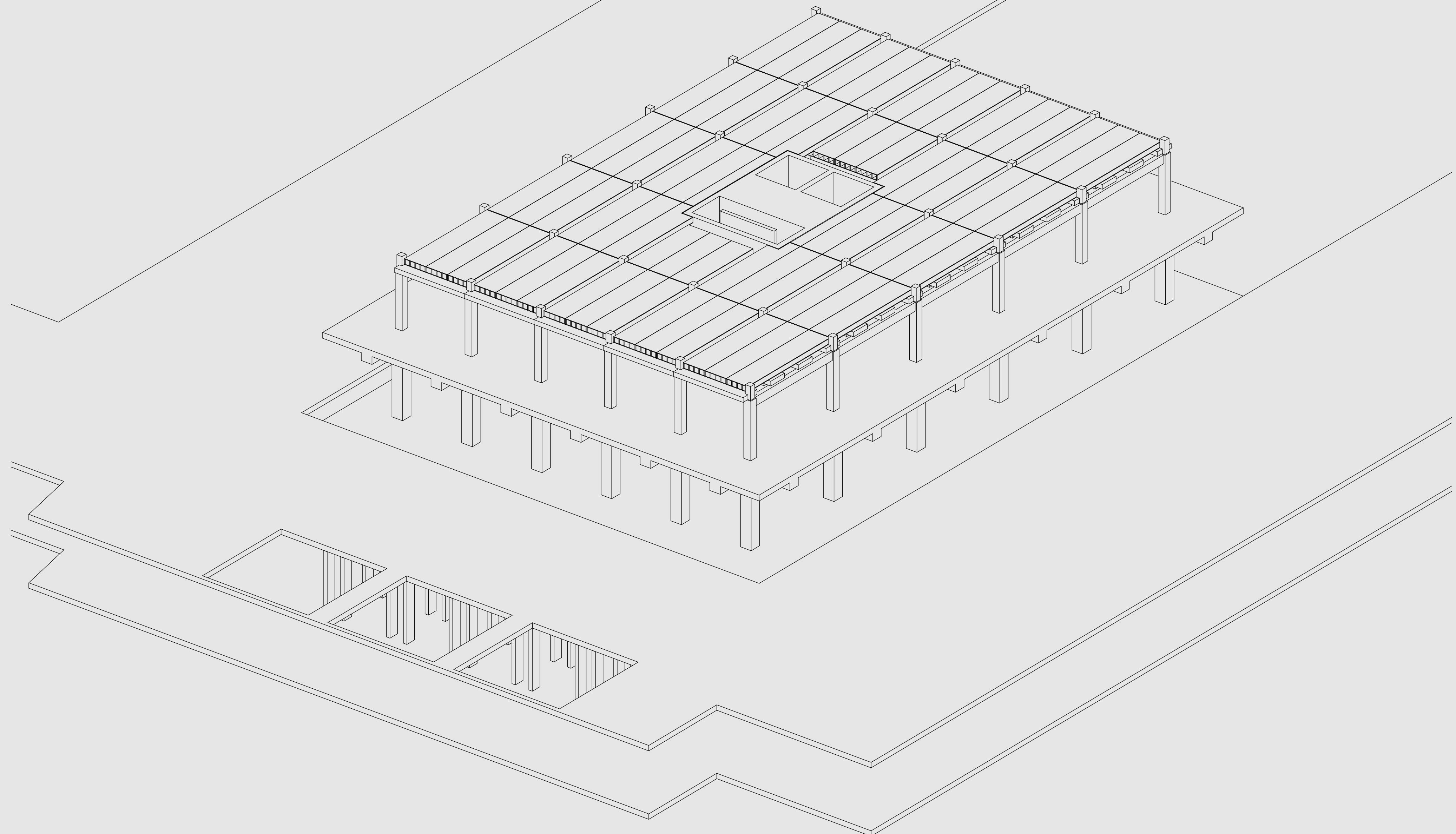


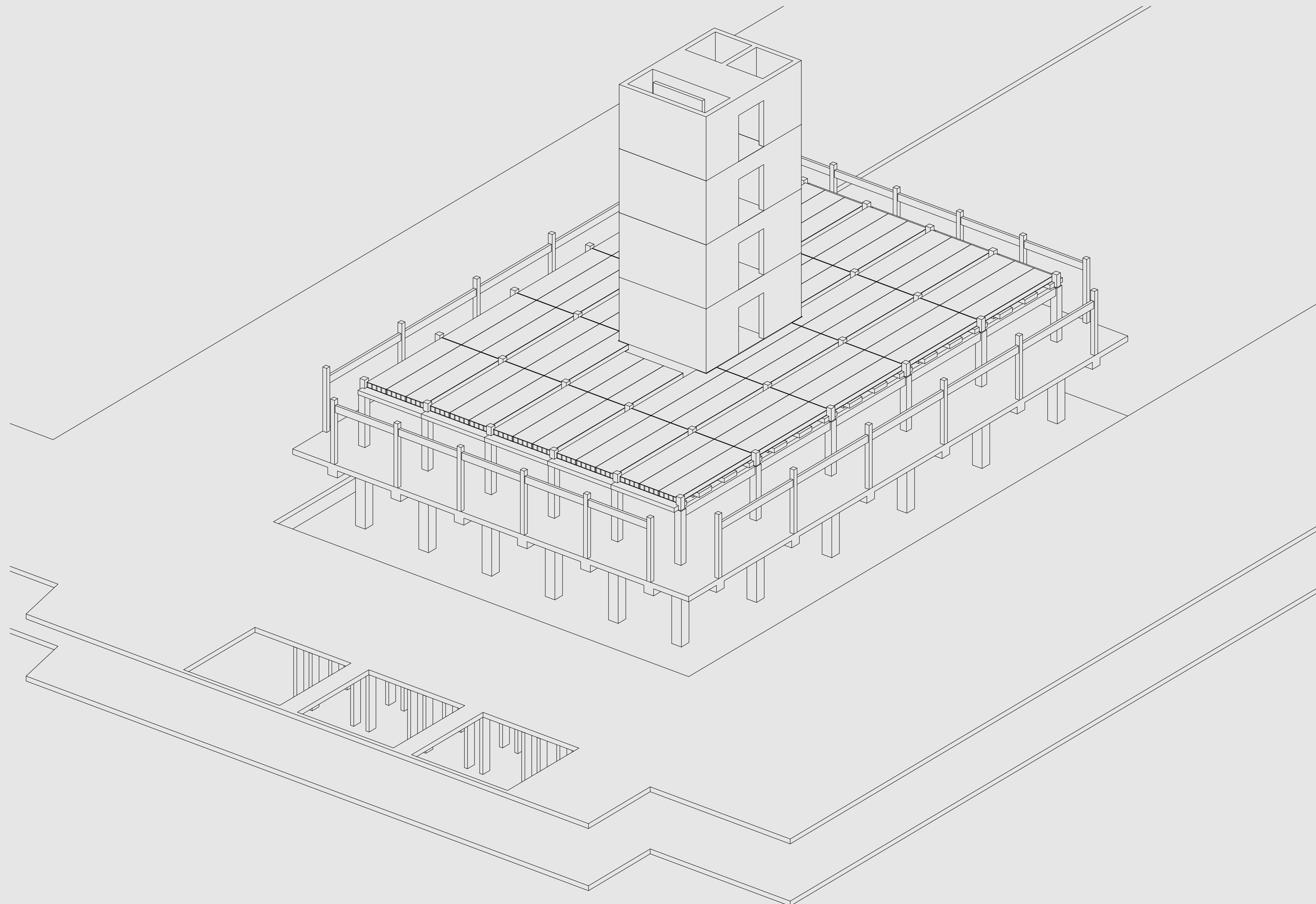


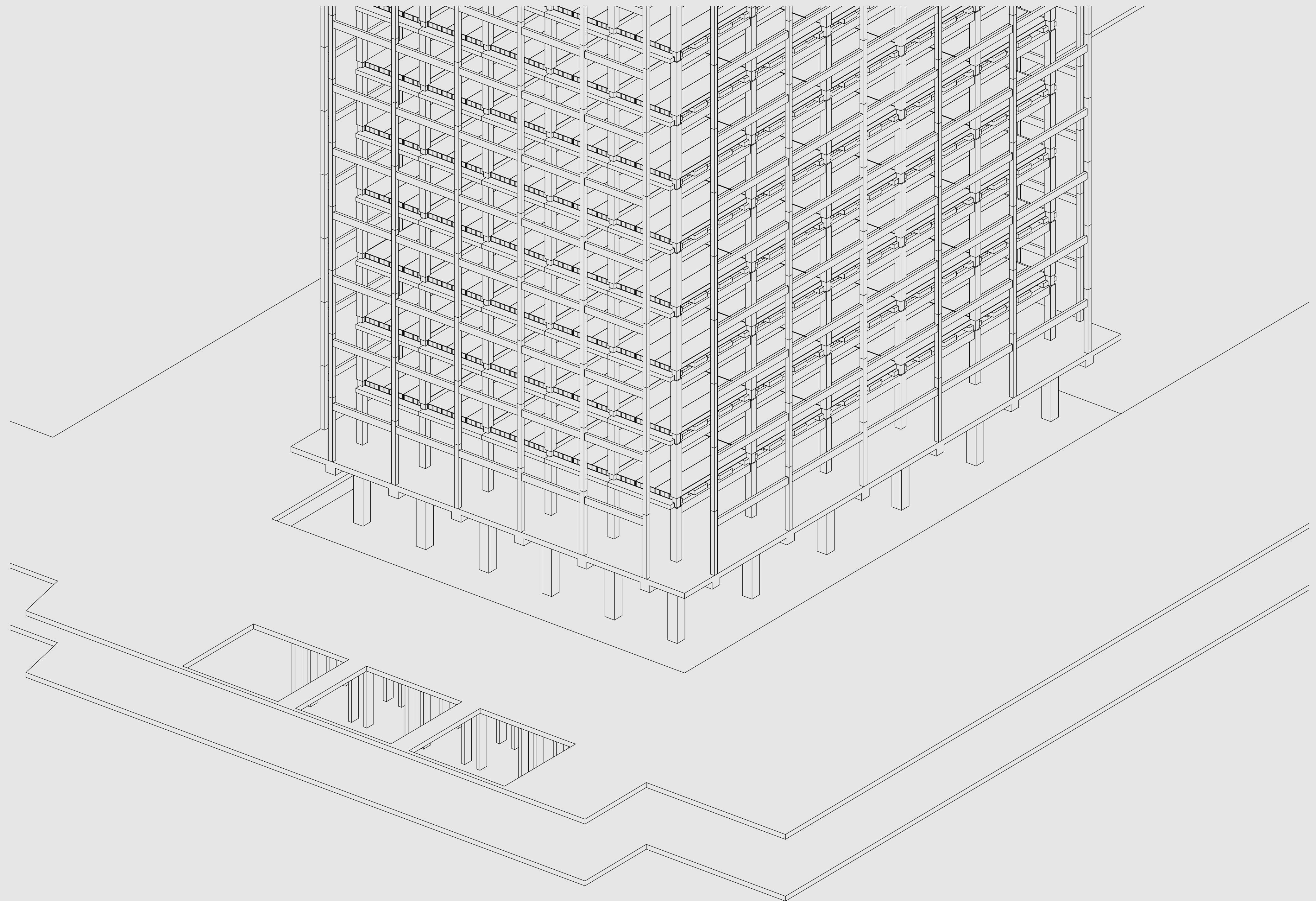


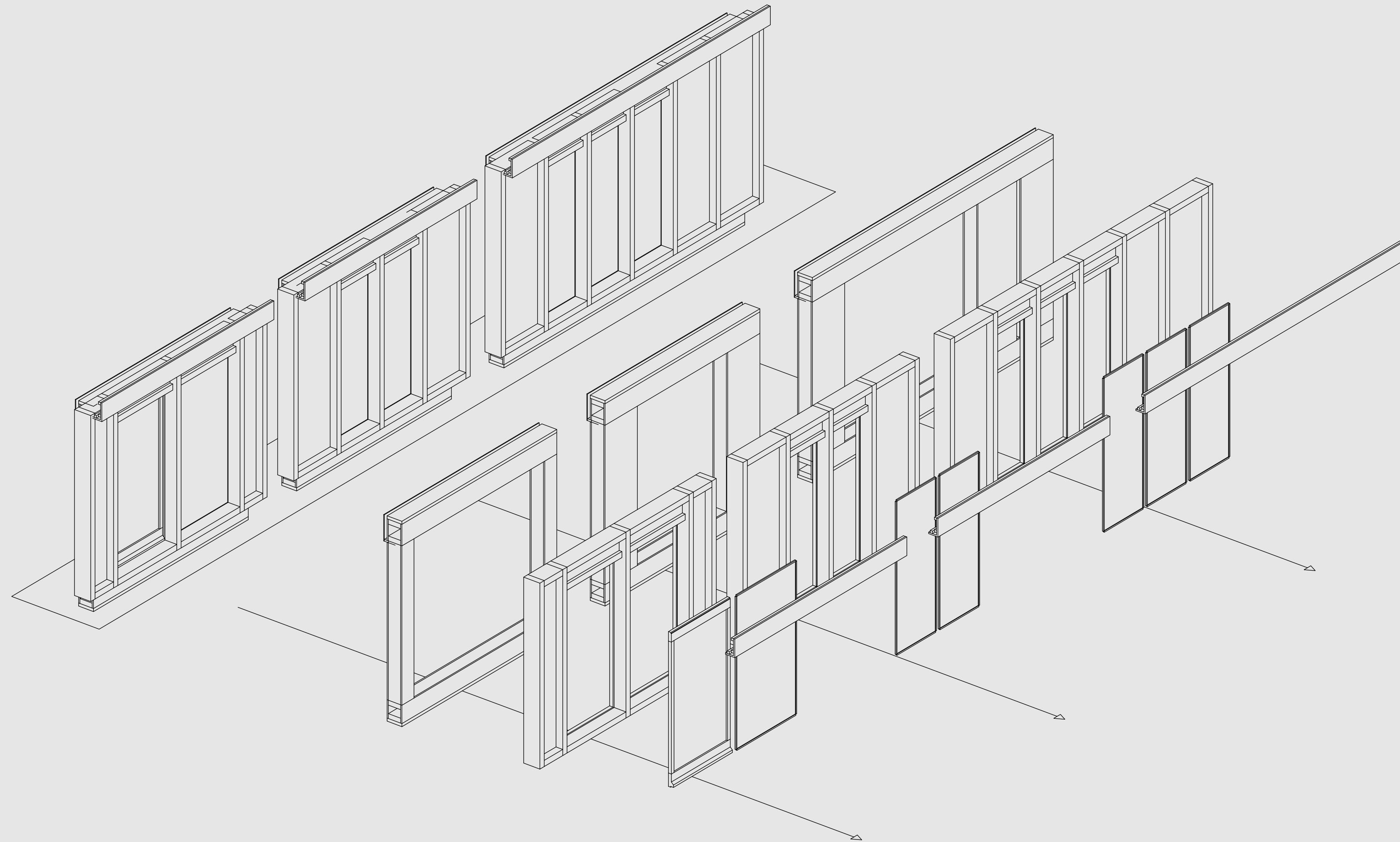


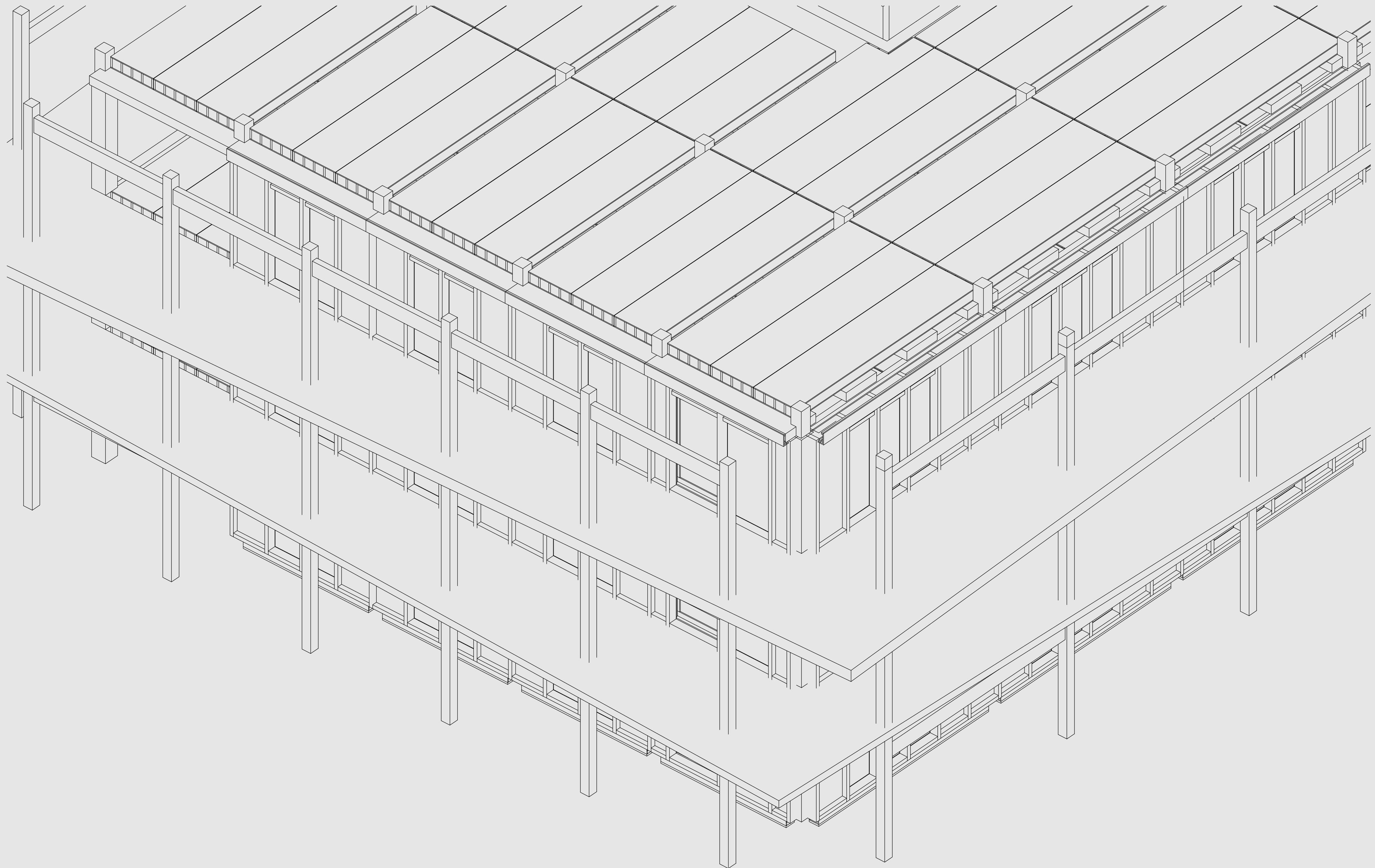


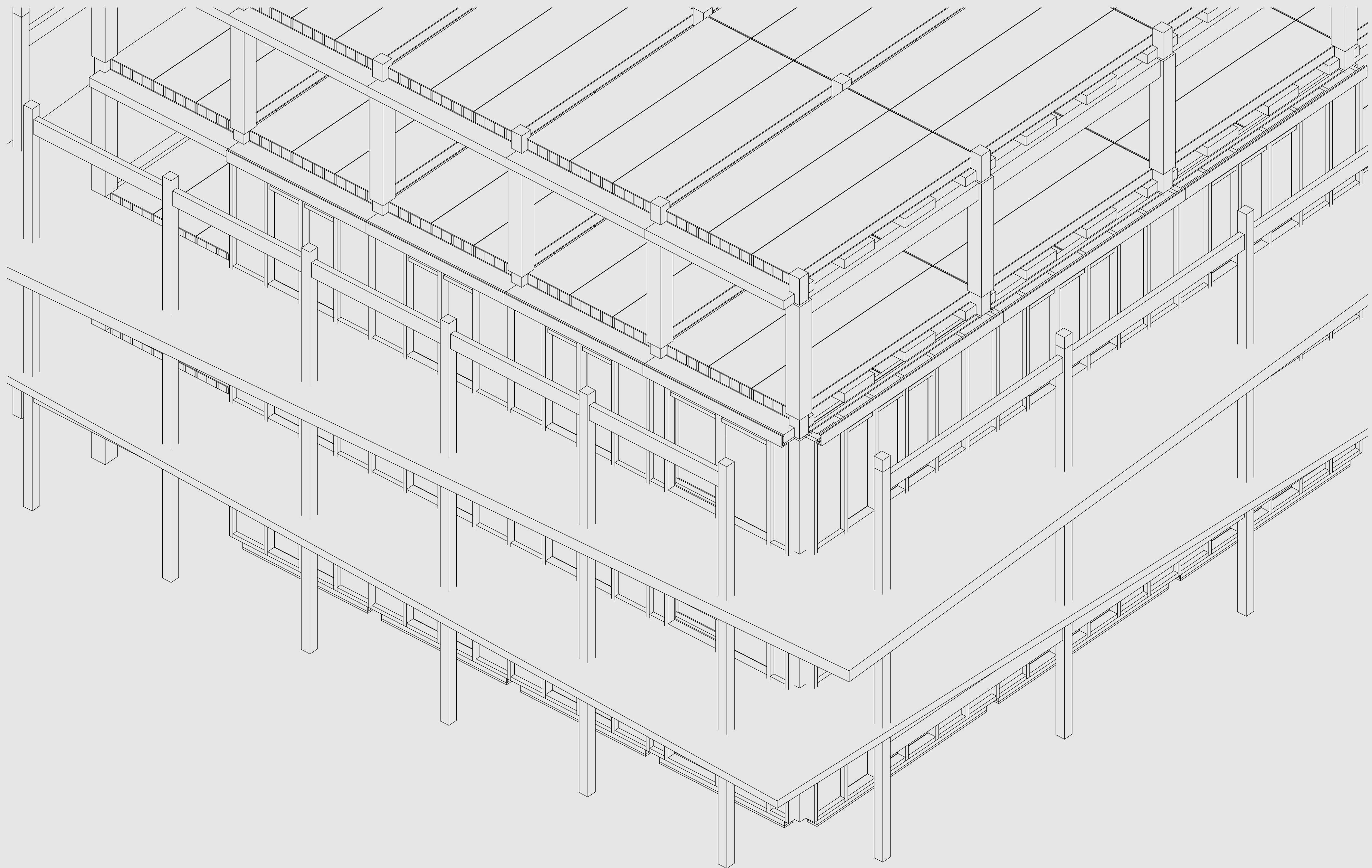


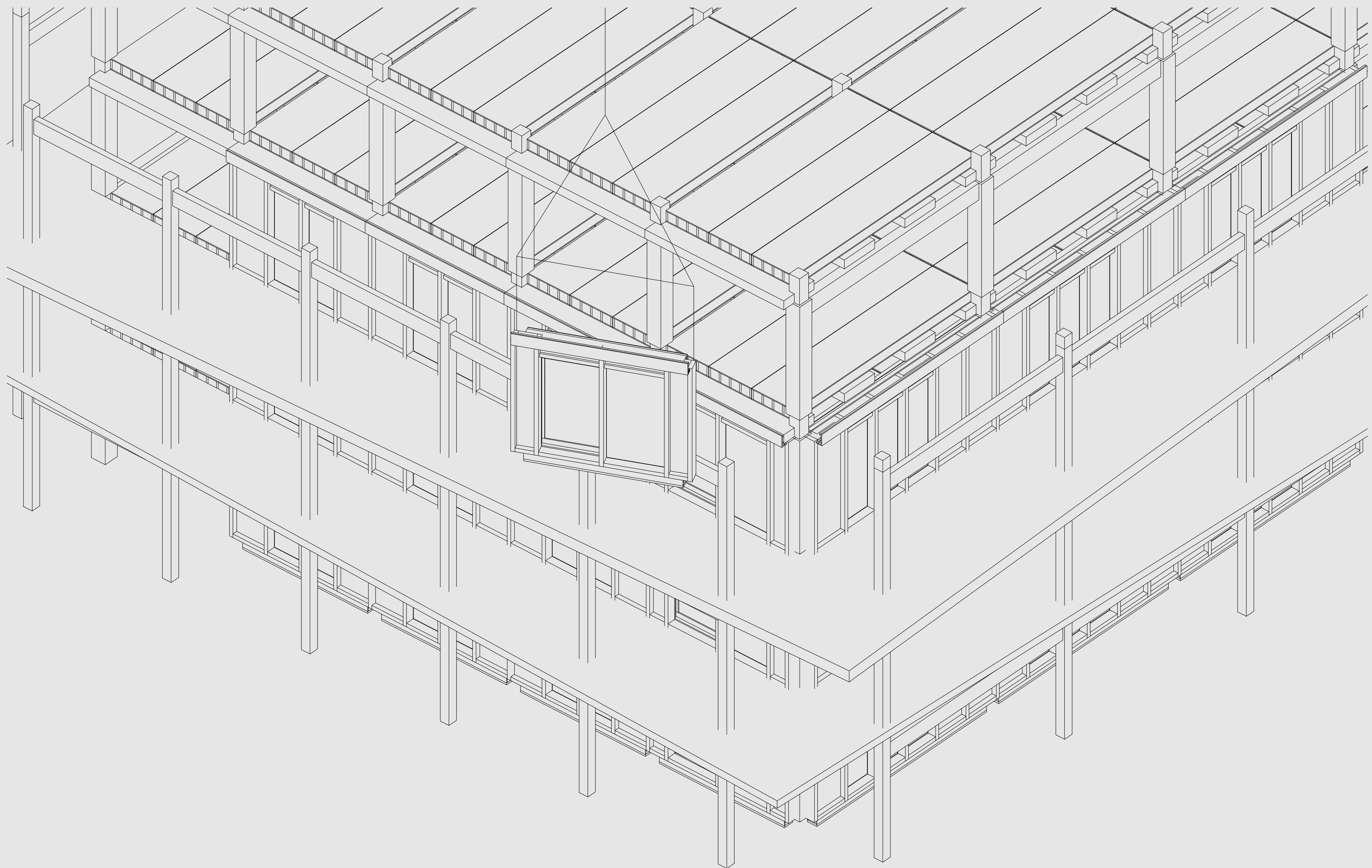


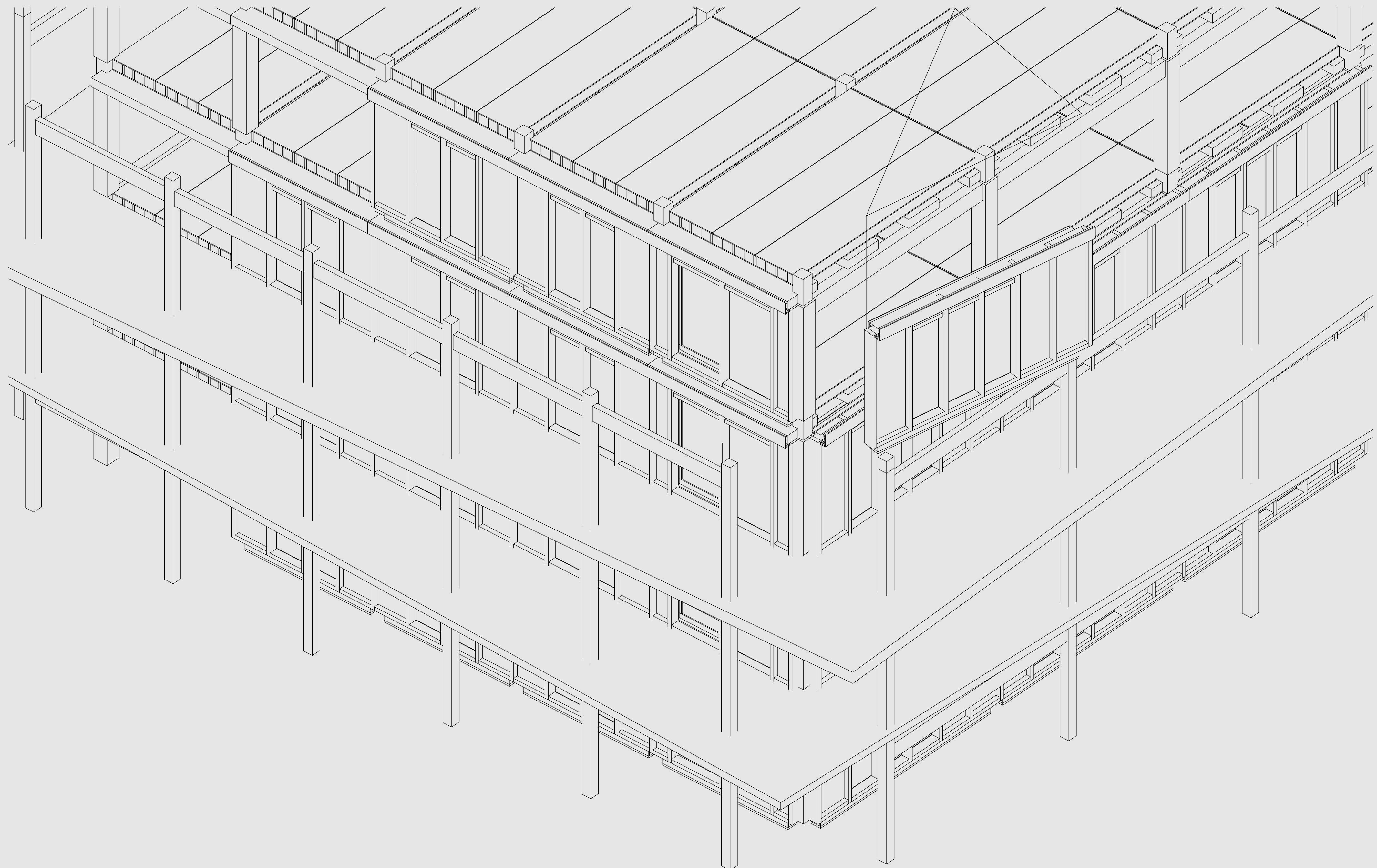


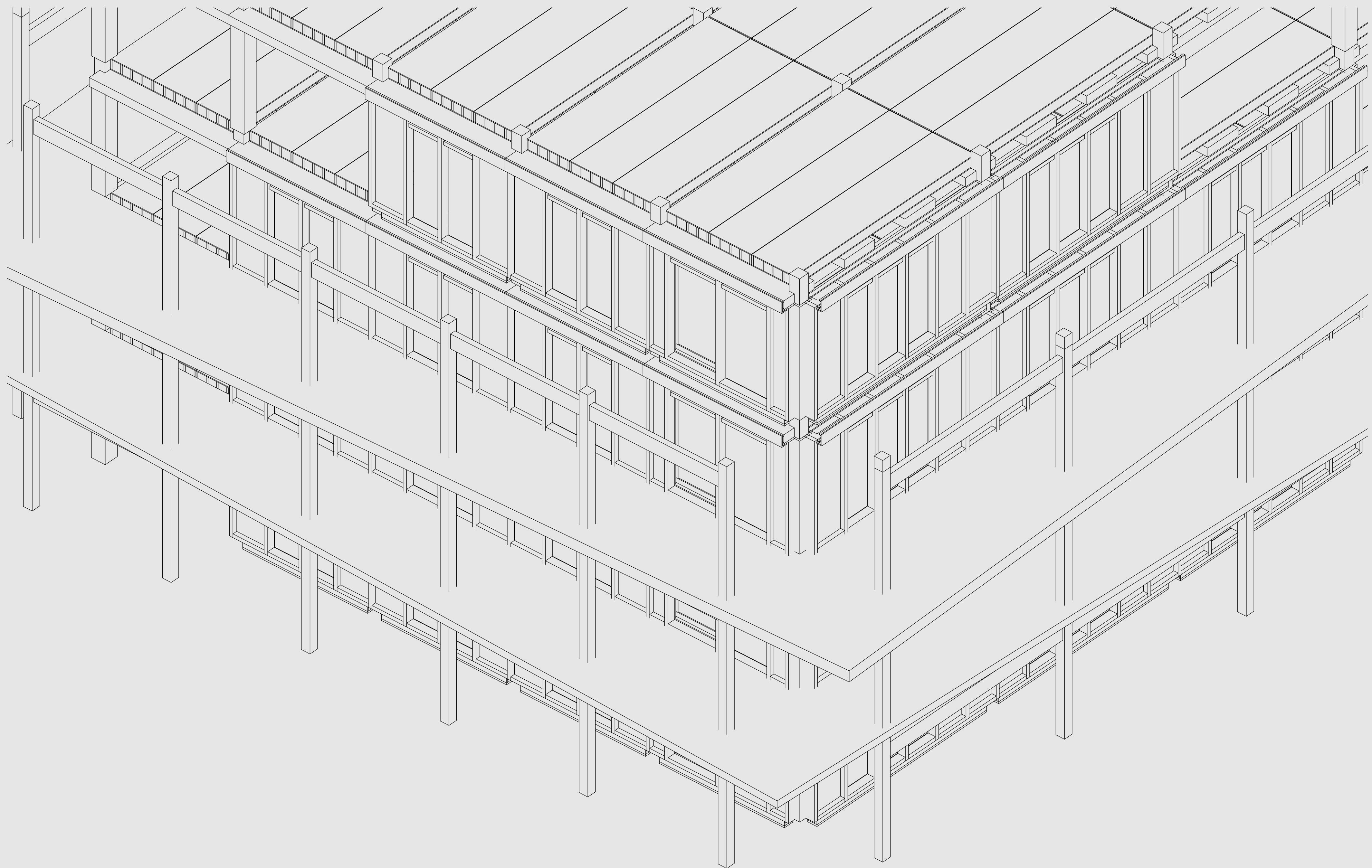


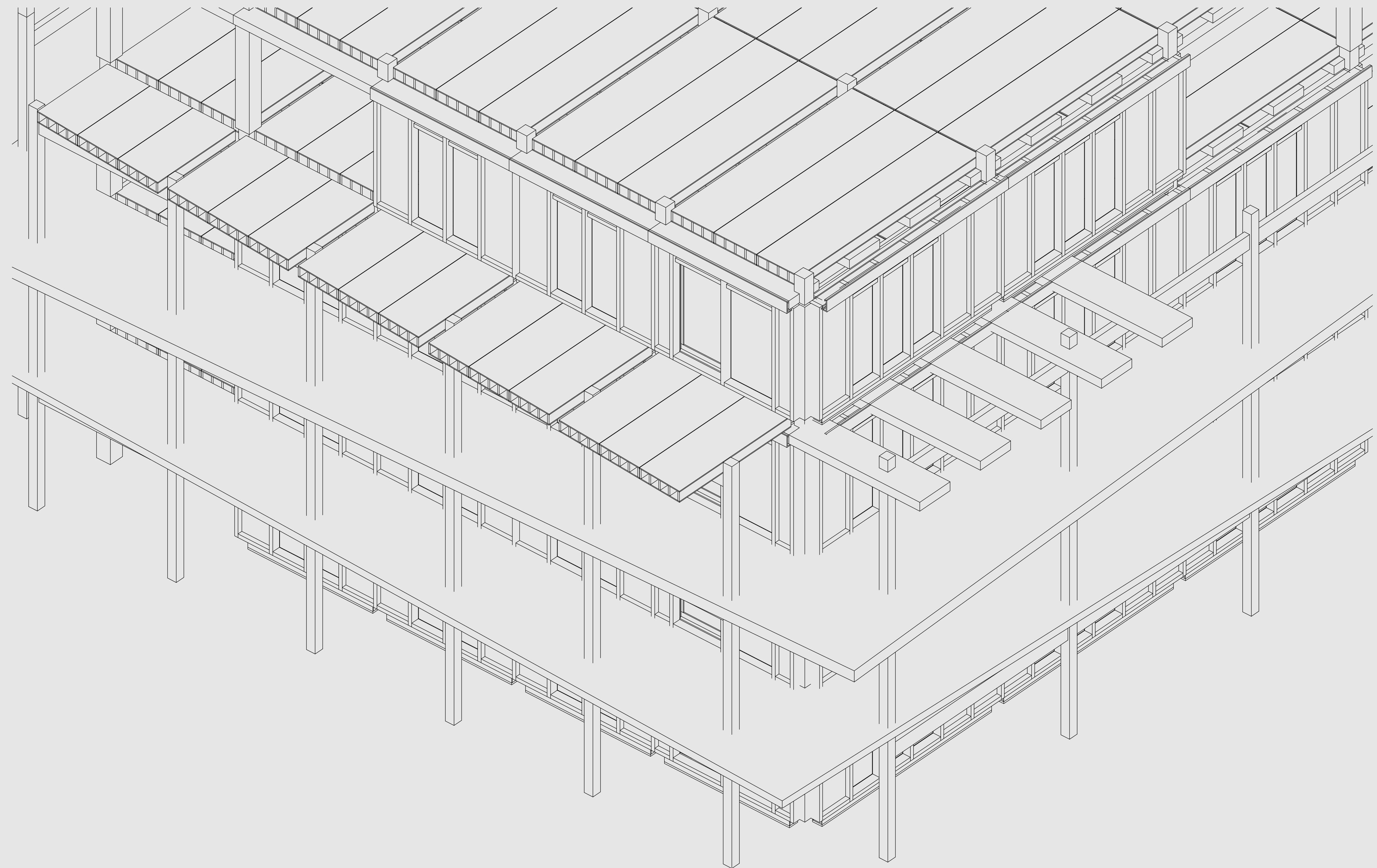


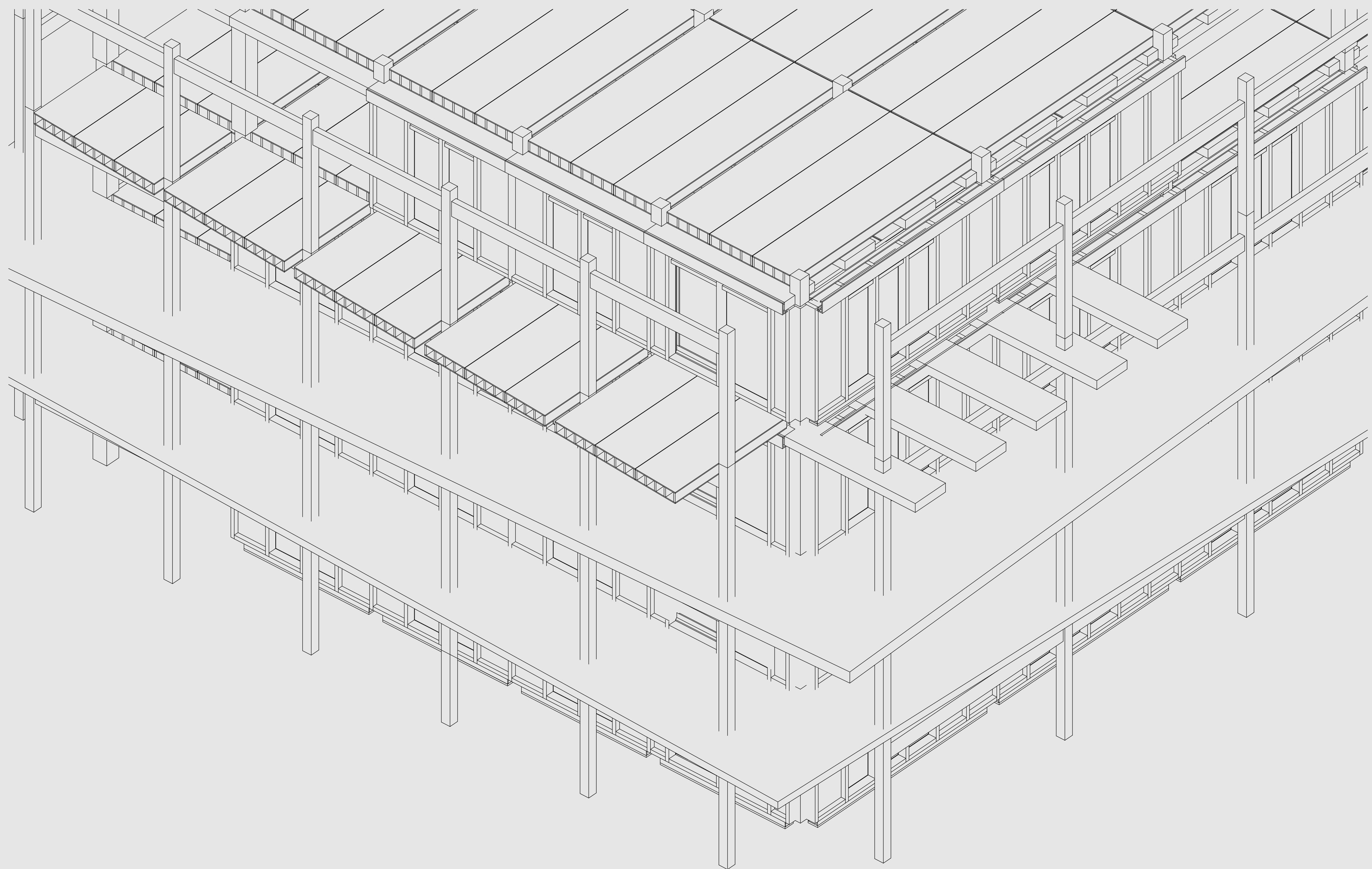










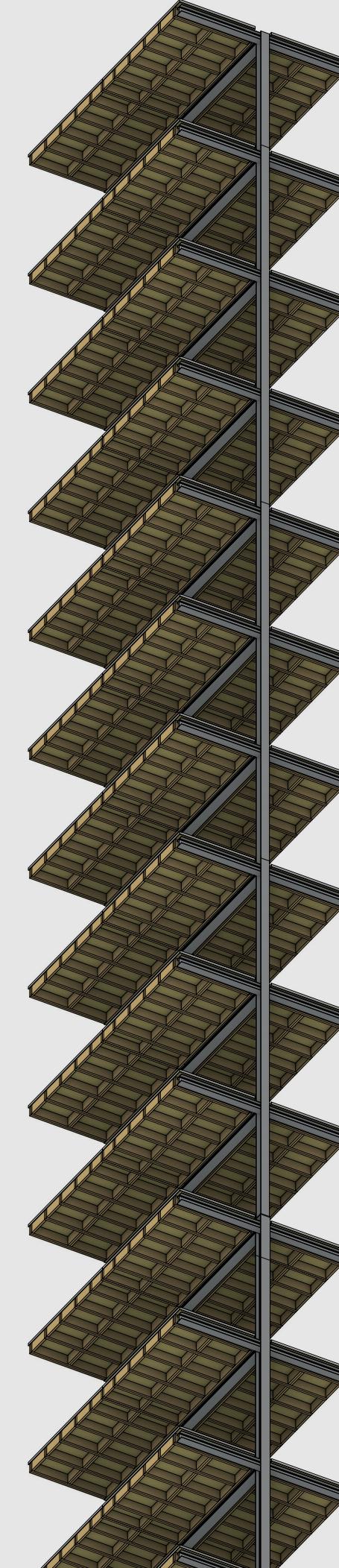


Variant E5 (base)

Floors:
Spruce joists and
beams, spruce plate
and concrete topping

Beams:
Steel HE220A,
S355

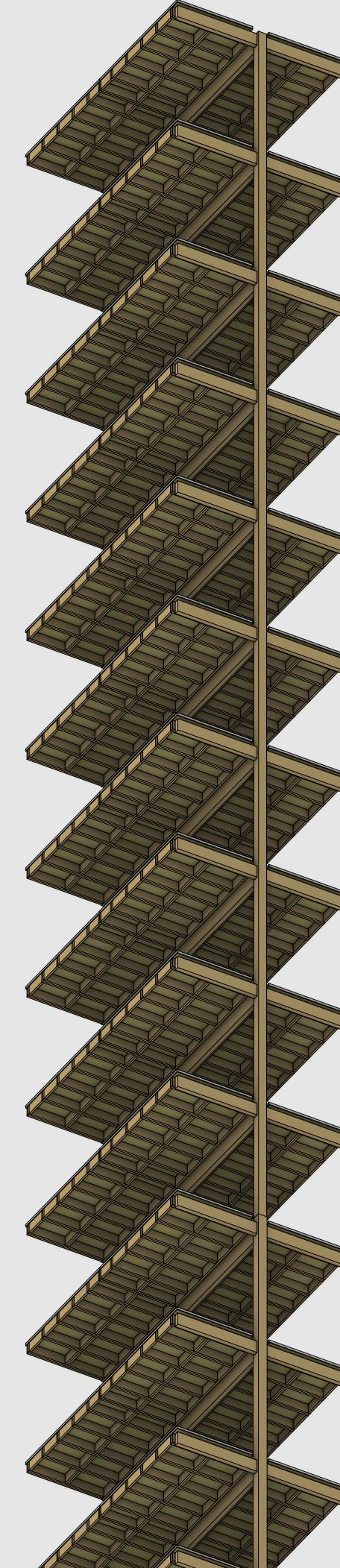
Columns:
Steel HE220B,
S355

**Variant A1.1**

Floors:
Spruce joists and
beams, spruce plate
and concrete topping

Beams:
Beech LVL,
GL75

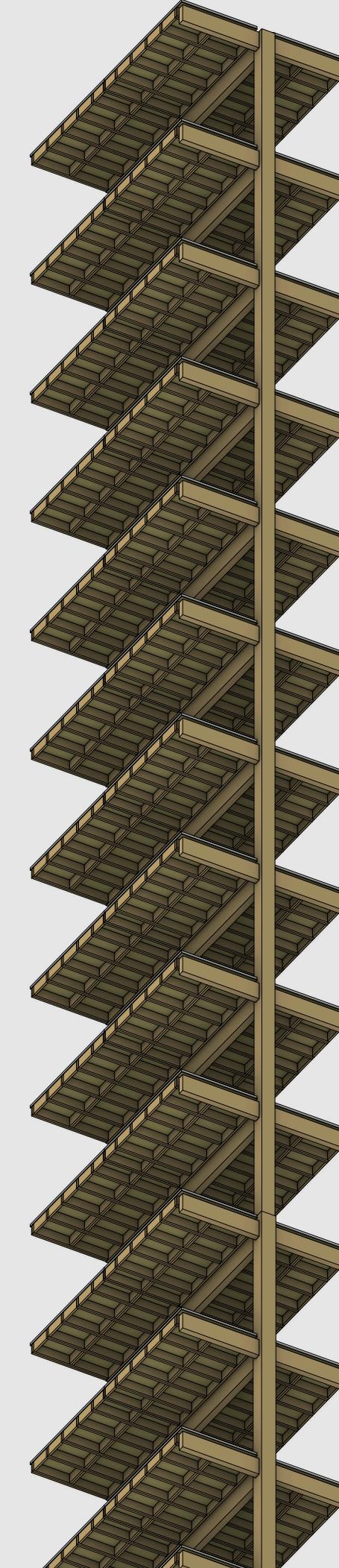
Columns:
Beech LVL,
GL75

**Variant A1.2**

Floors:
Spruce joists and
beams, spruce plate
and concrete topping

Beams:
Spruce LVL,
GL28

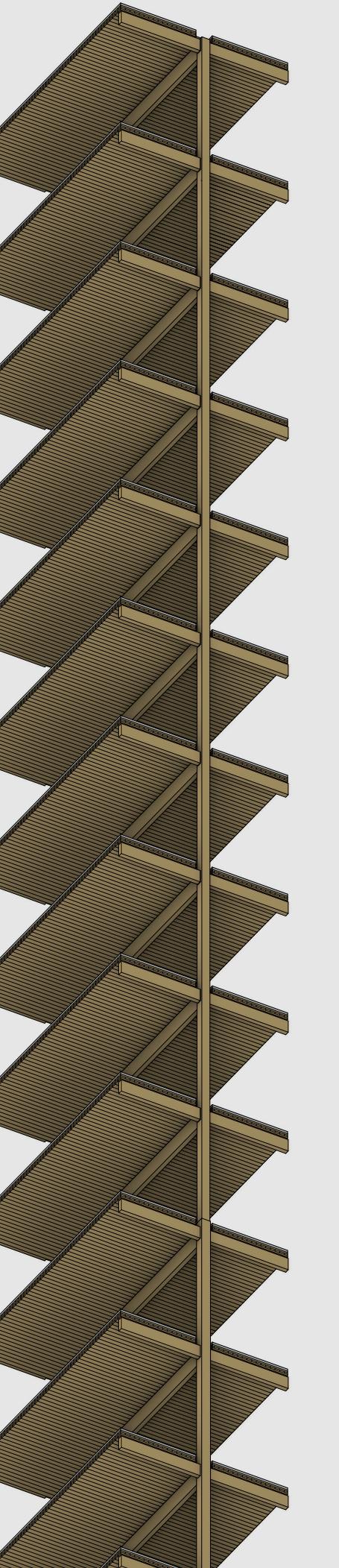
Columns:
Spruce LVL,
GL28

**Variant A4.1**

Floors:
120mm-3s spruce
CLT and concrete
topping

Beams:
Beech LVL,
GL75

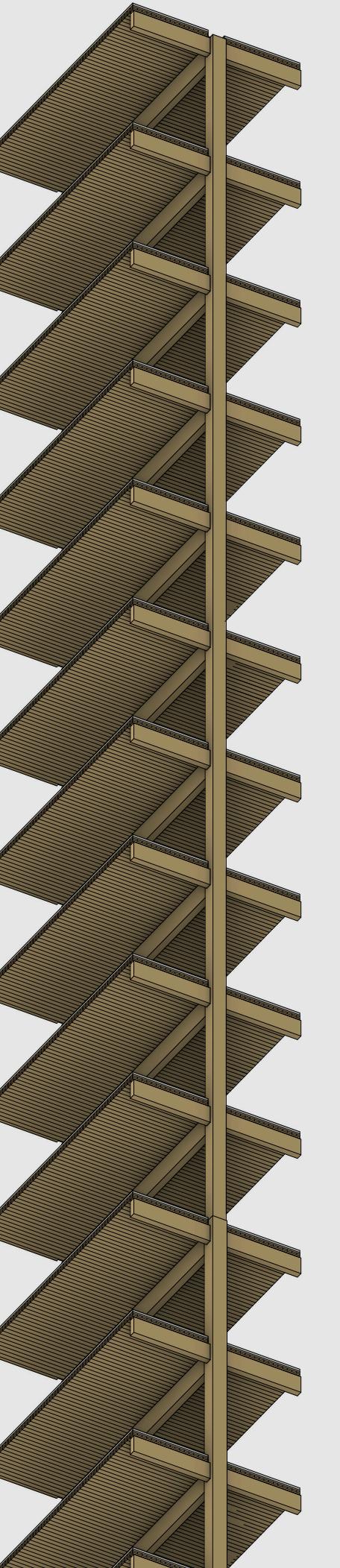
Columns:
Beech LVL,
GL75

**Variant A4.2**

Floors:
120mm-3s spruce
CLT and concrete
topping

Beams:
Spruce LVL,
GL28

Columns:
Spruce LVL,
GL28

**Variant E8**

Floors:
Steel-concrete
composite slab and
concrete topping

Beams:
Steel HE240A,
S355

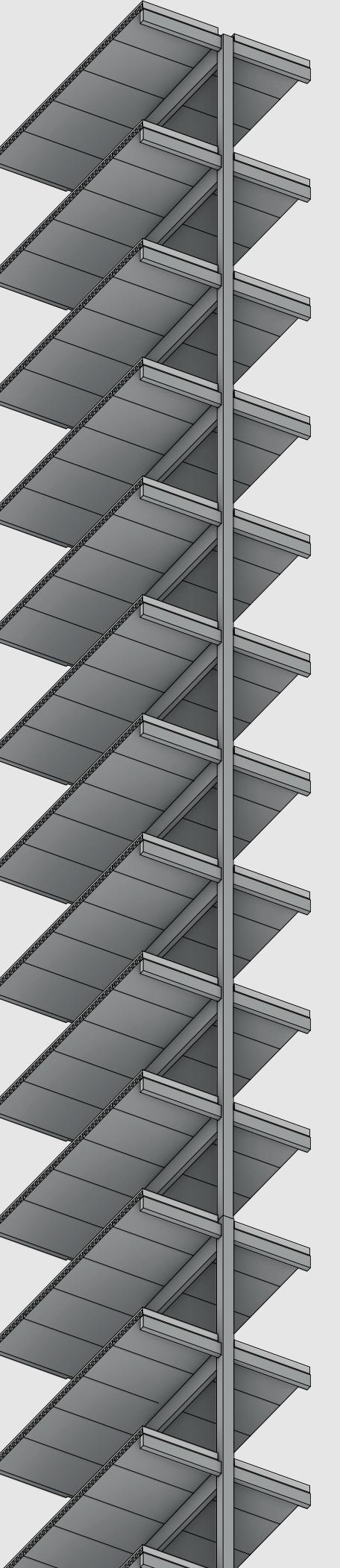
Columns:
Steel HE240B,
S355

**Variant F9.1**

Floors:
Hollow-core slabs and
concrete topping

Beams:
Concrete,
C90/105

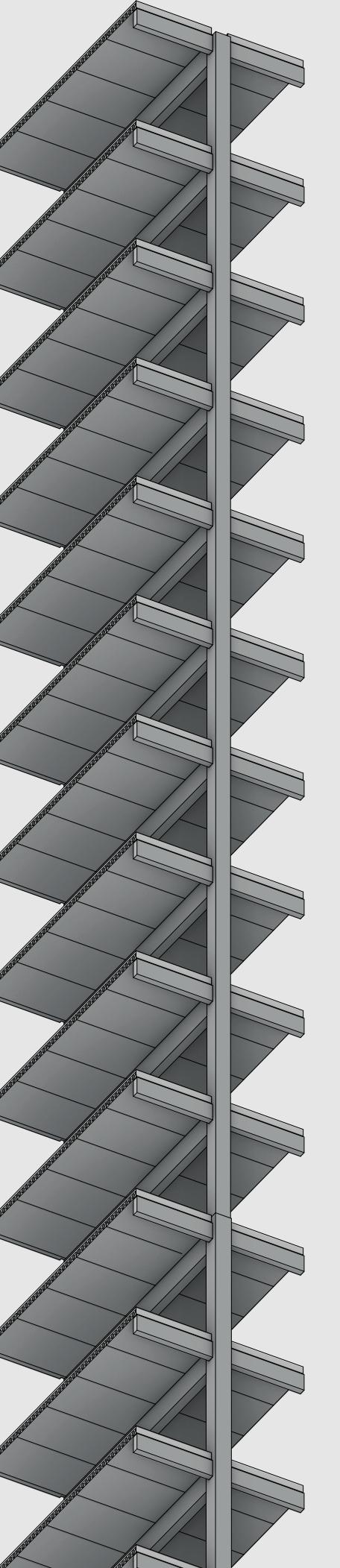
Columns:
Concrete,
C90/105

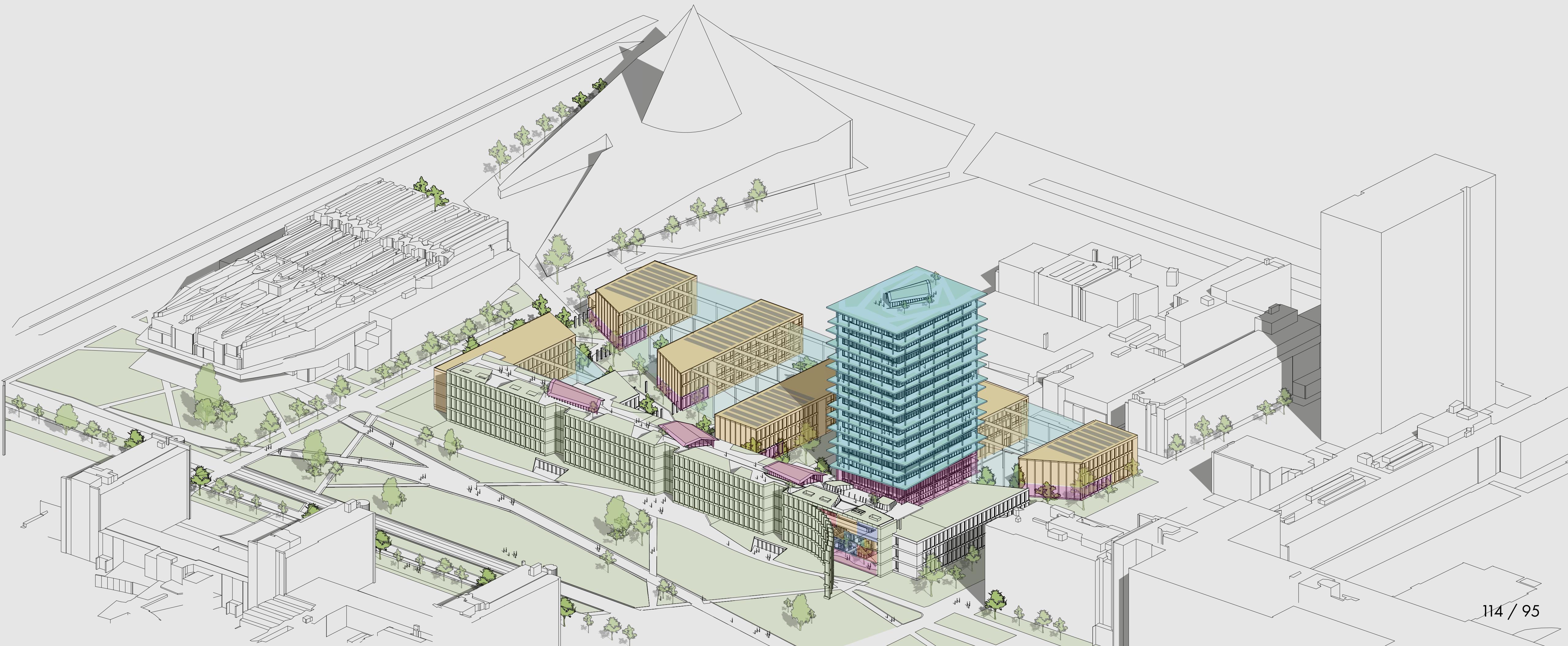
**Variant F9.2**

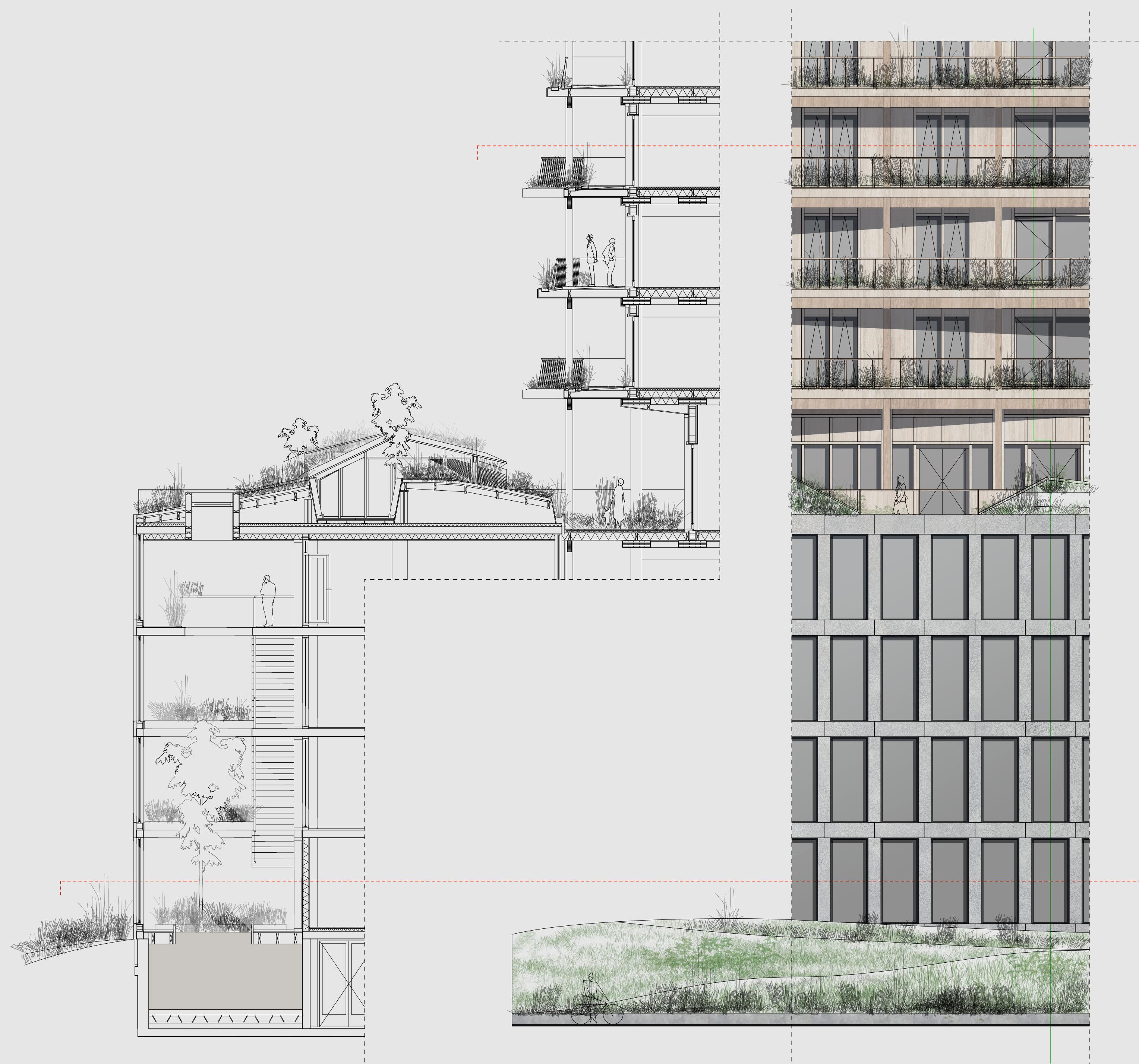
Floors:
Hollow-core slabs and
concrete topping

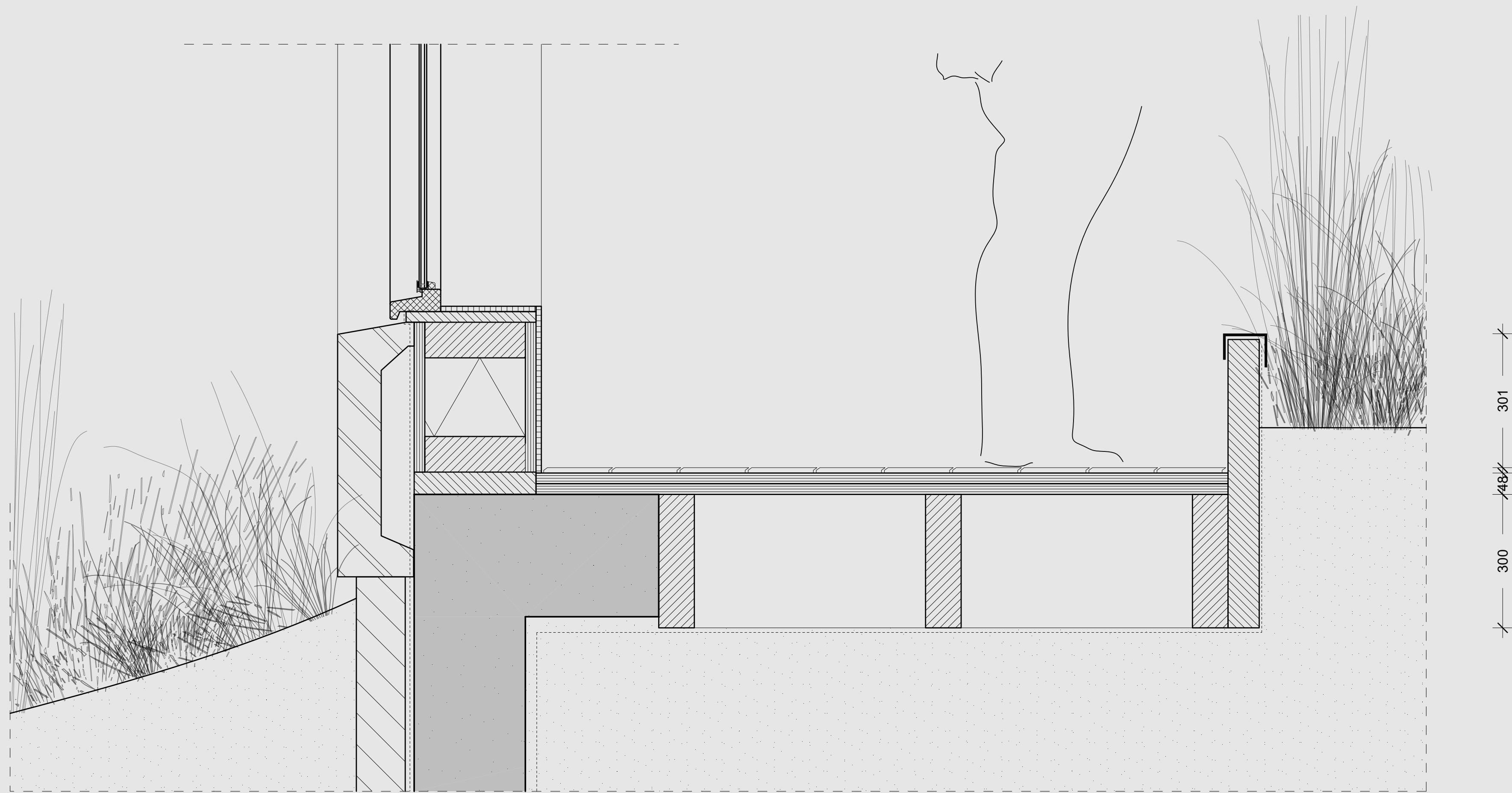
Beams:
Concrete,
C45/55

Columns:
Concrete,
C45/55





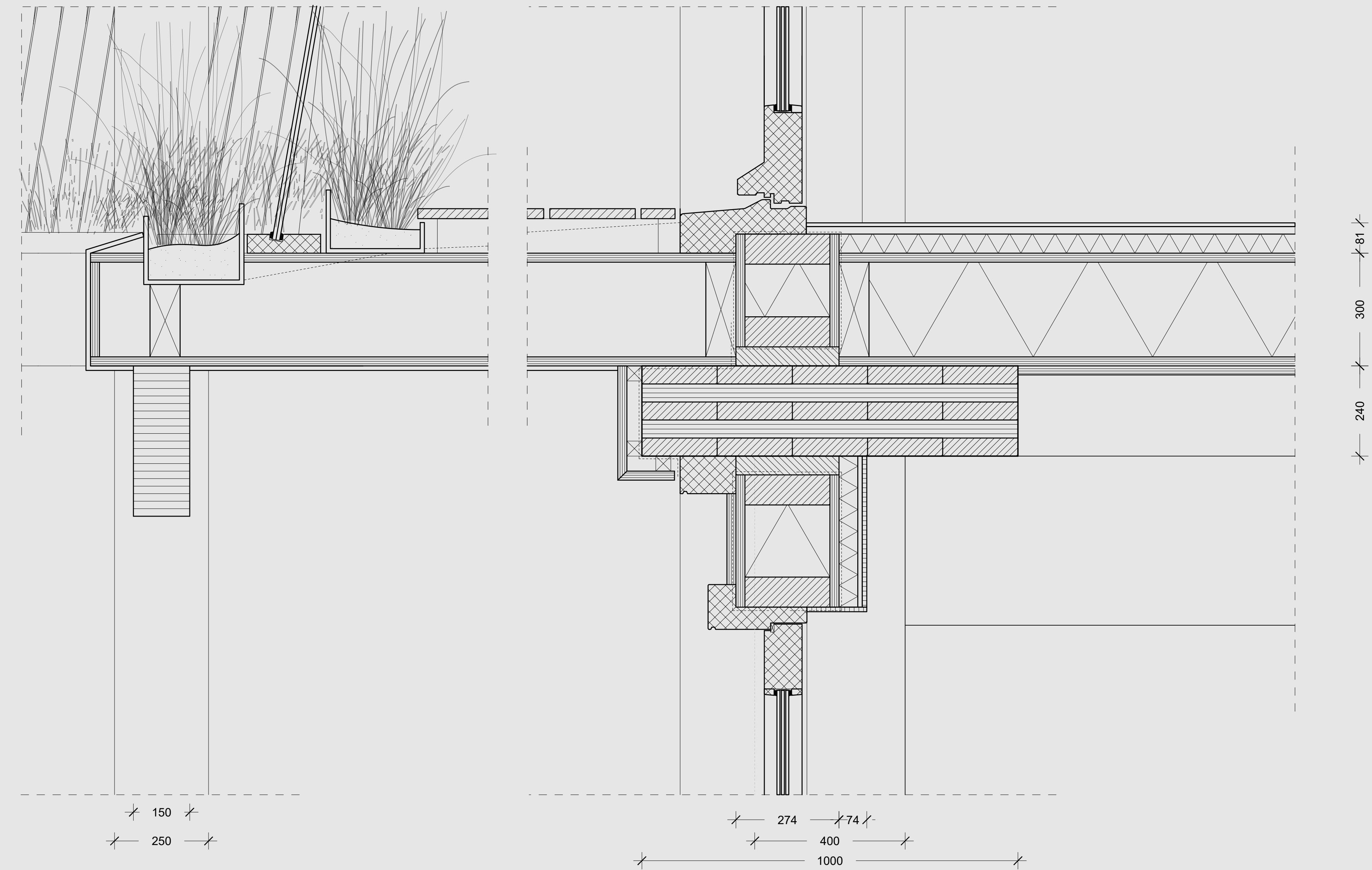


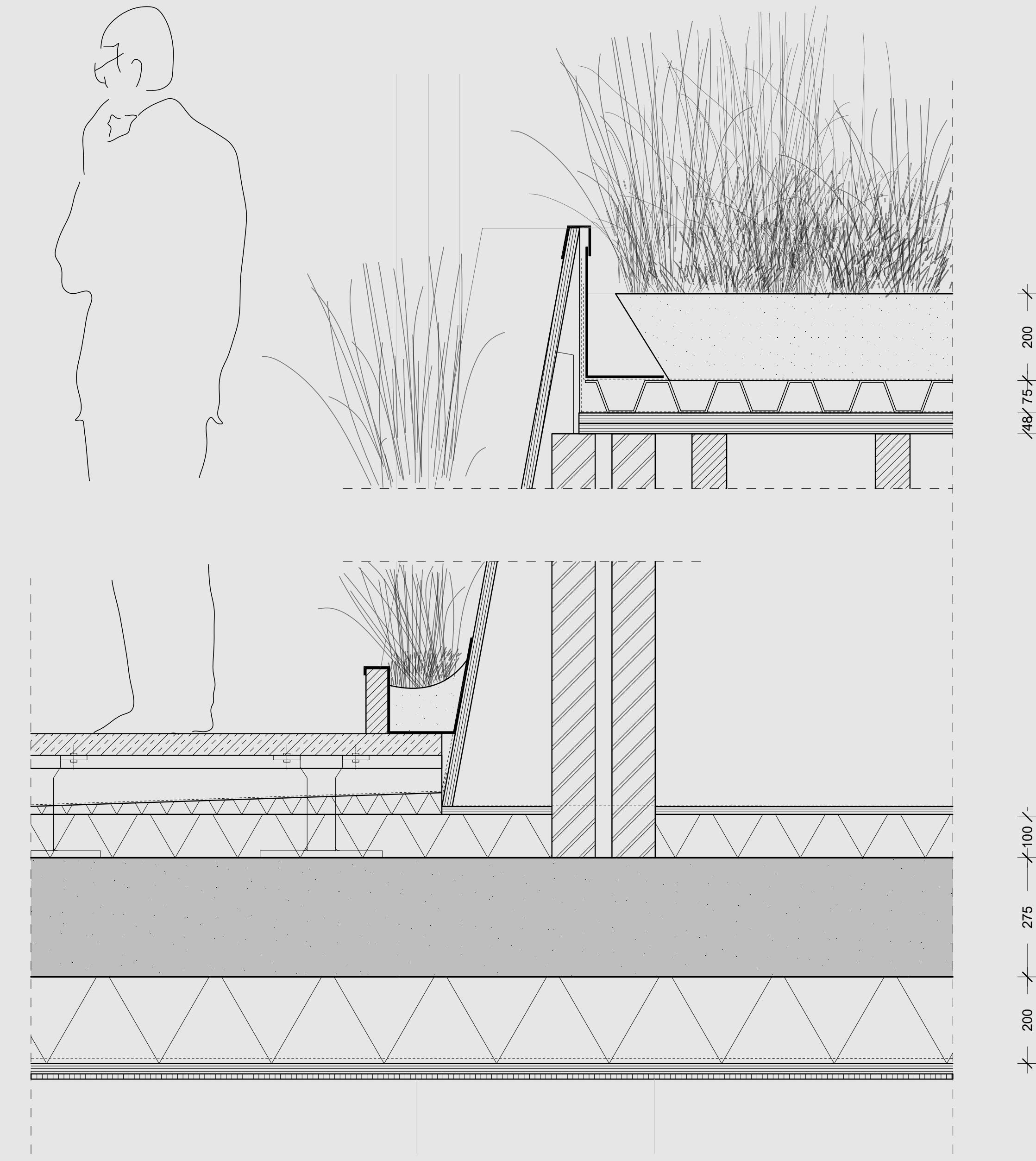


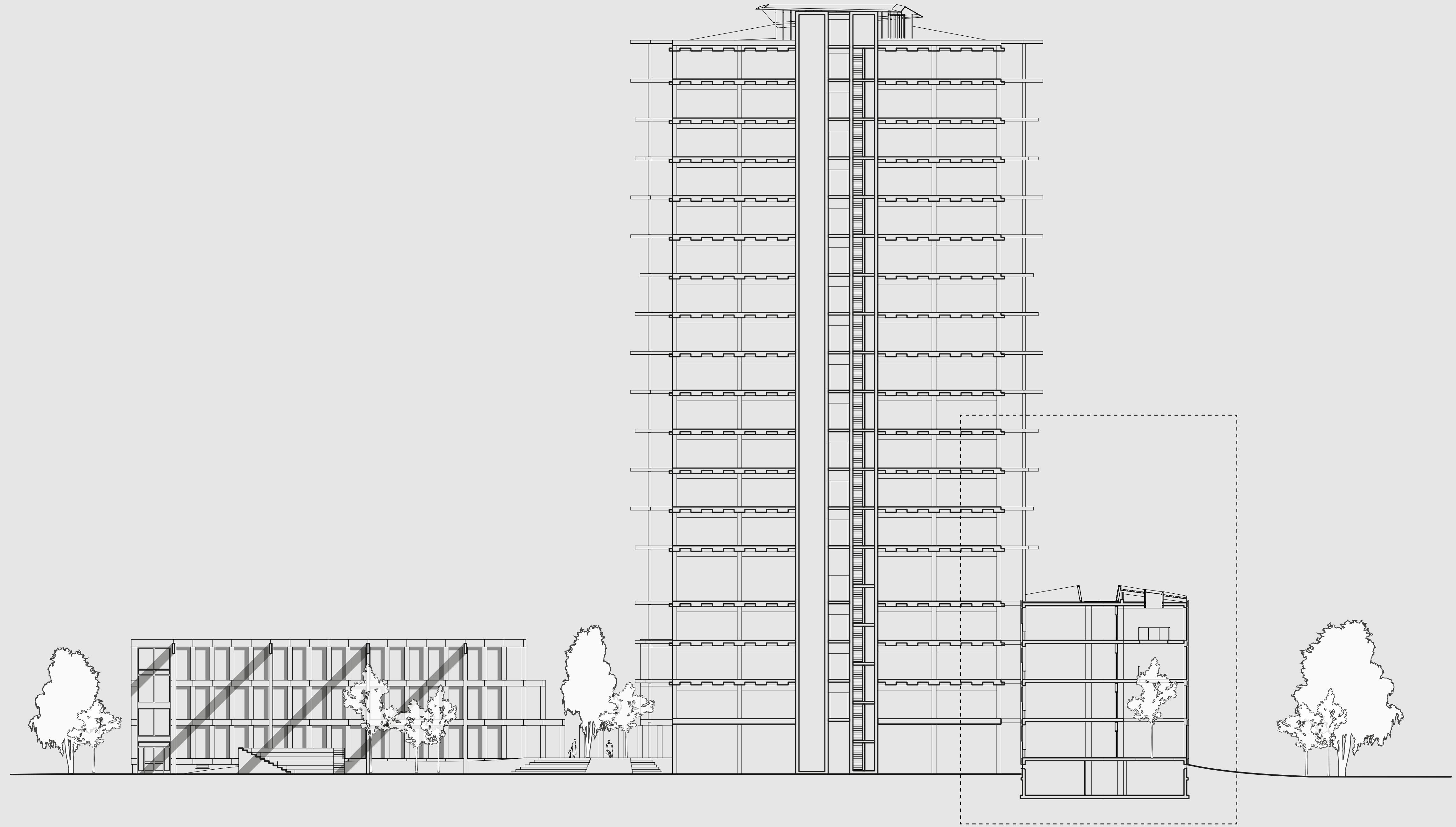
250

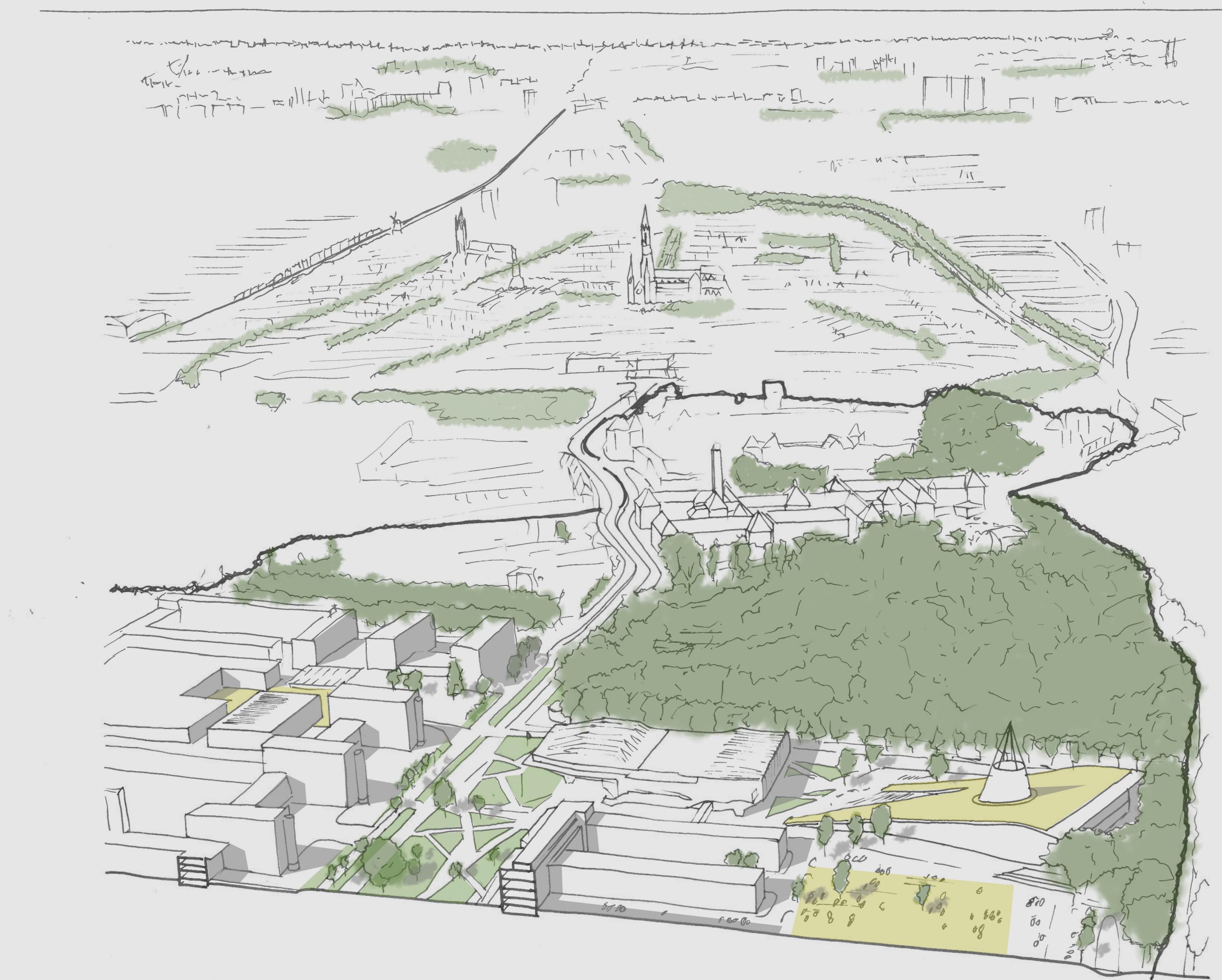
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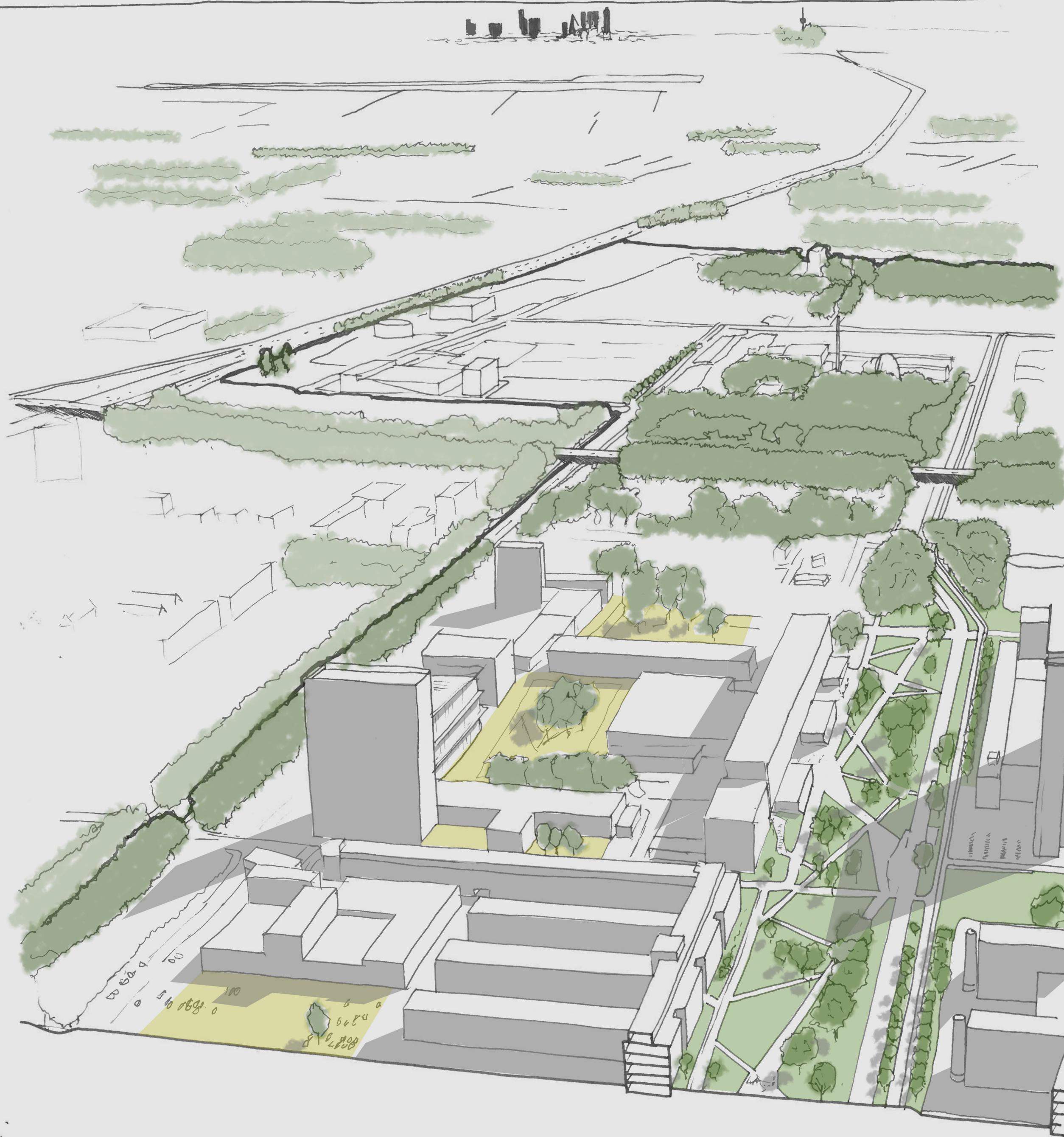
301
148



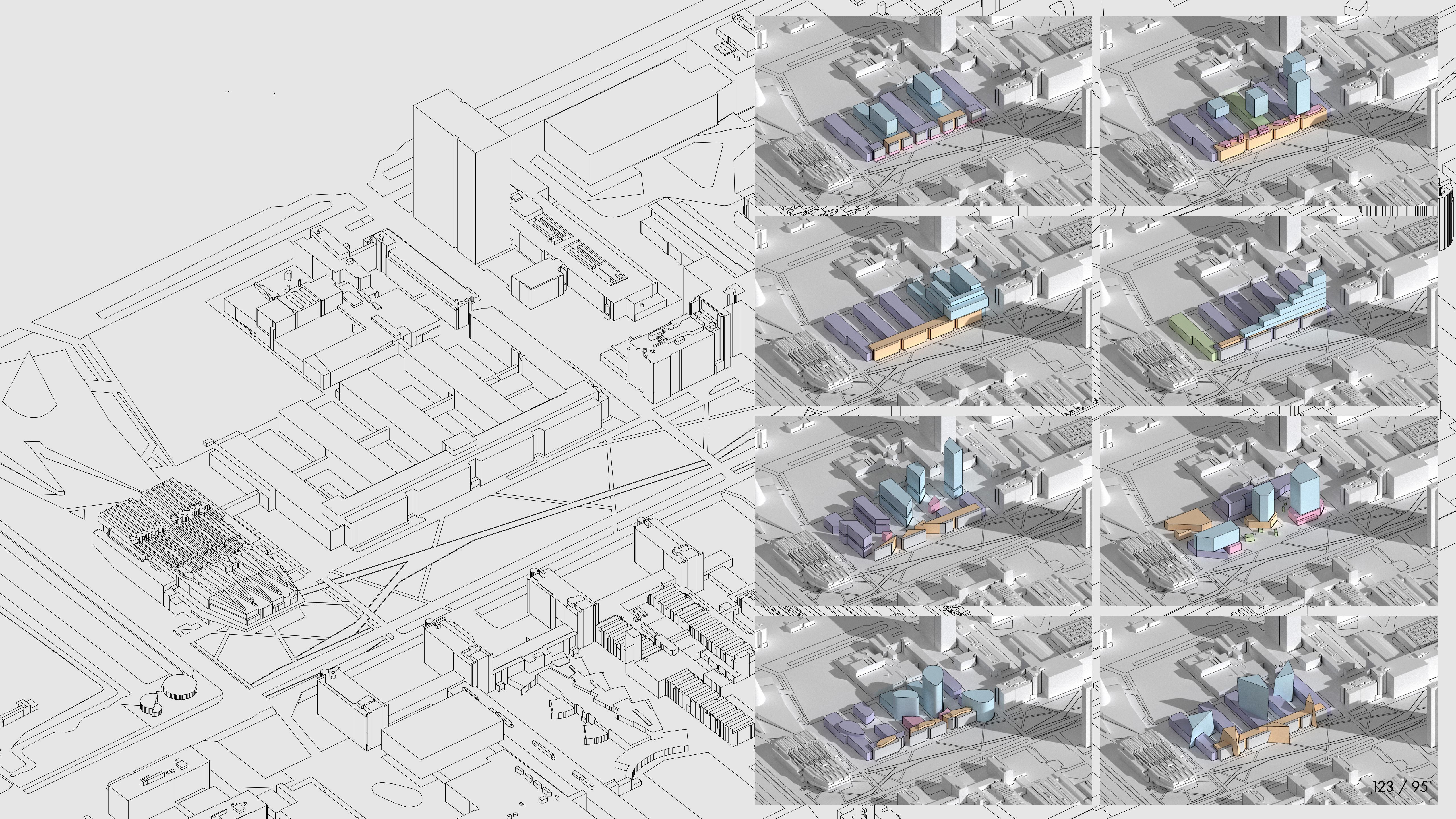


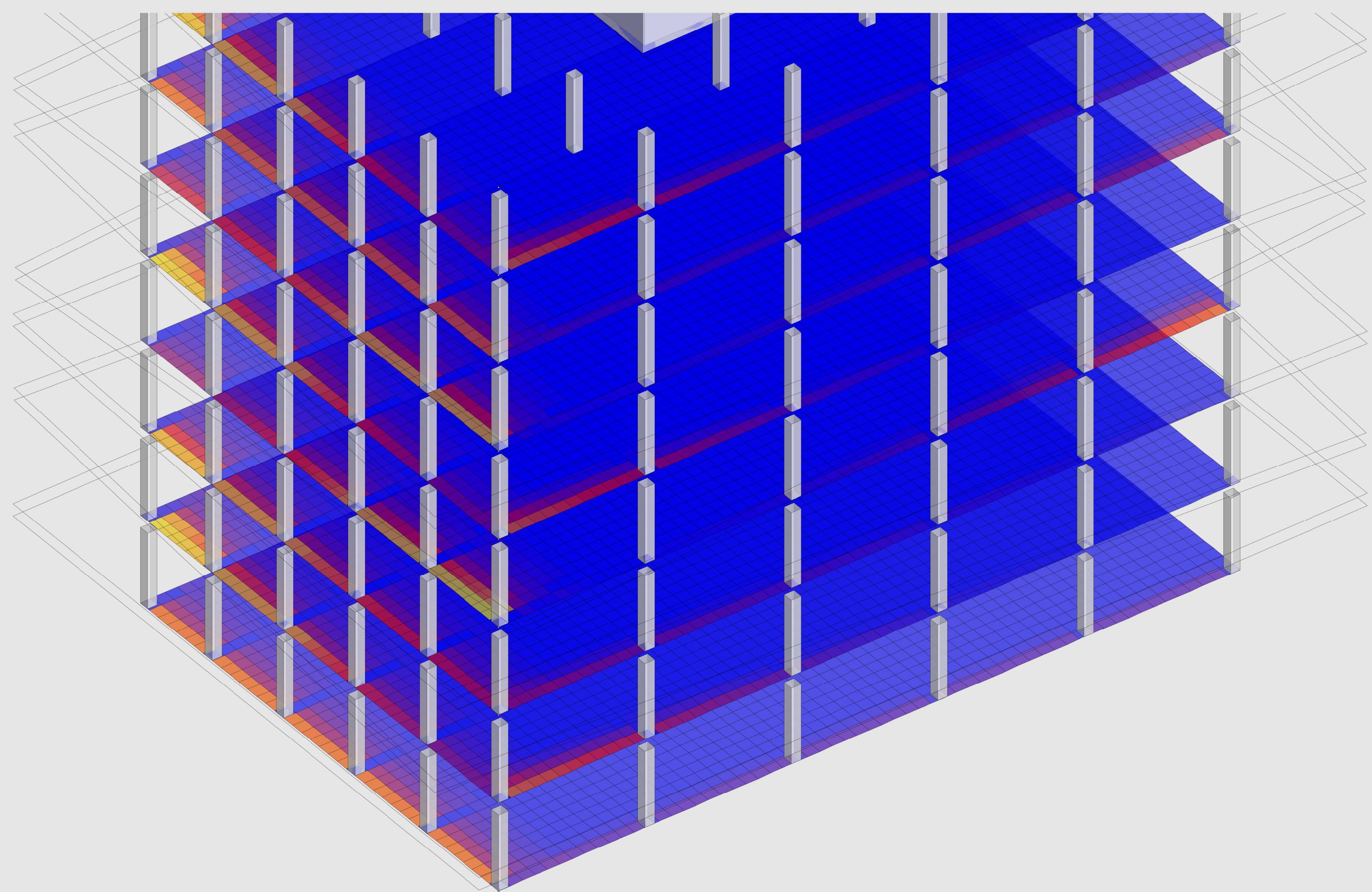
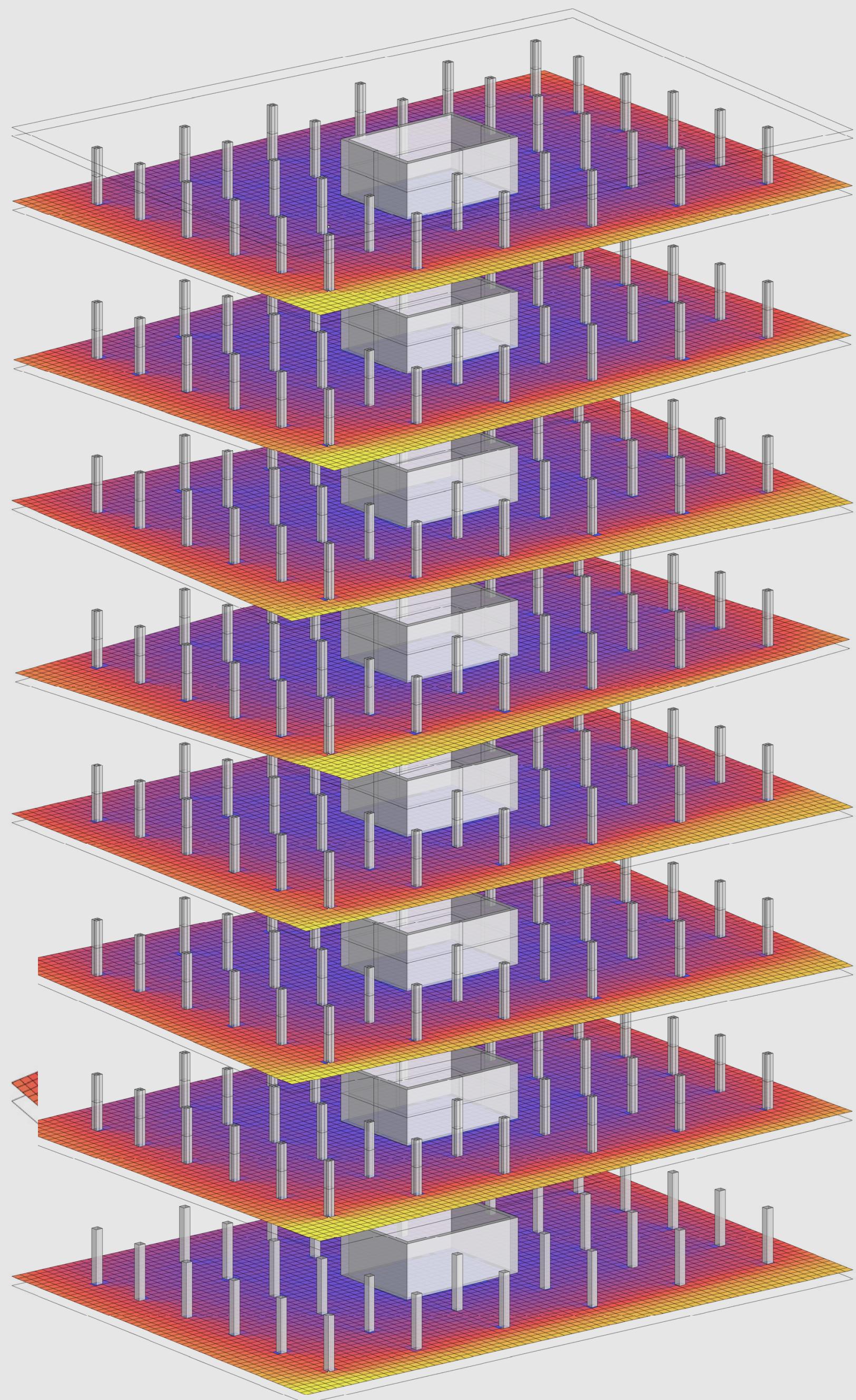












	Students	Increase (Annual)
2016	22.566	-
2017	23.604	+ 4,60%
2018	24.783	+ 4,99%
2019	25.310	+ 2,13%
2020	26.476	+ 4,61%
2021	27.270	+ 3,34%

+ 20,84%



Campus north

2015: GFA education = 71.581 m^2

2022: GFA education = 71.581 m^2

Increase of 0.00%

Campus center

2015: GFA education = 303.848 m^2

2022: GFA education = 304.109 m^2

Increase of 0,09%

Campus south

2015: GFA education = 122.220 m^2

2022: GFA education = 128.694 m^2

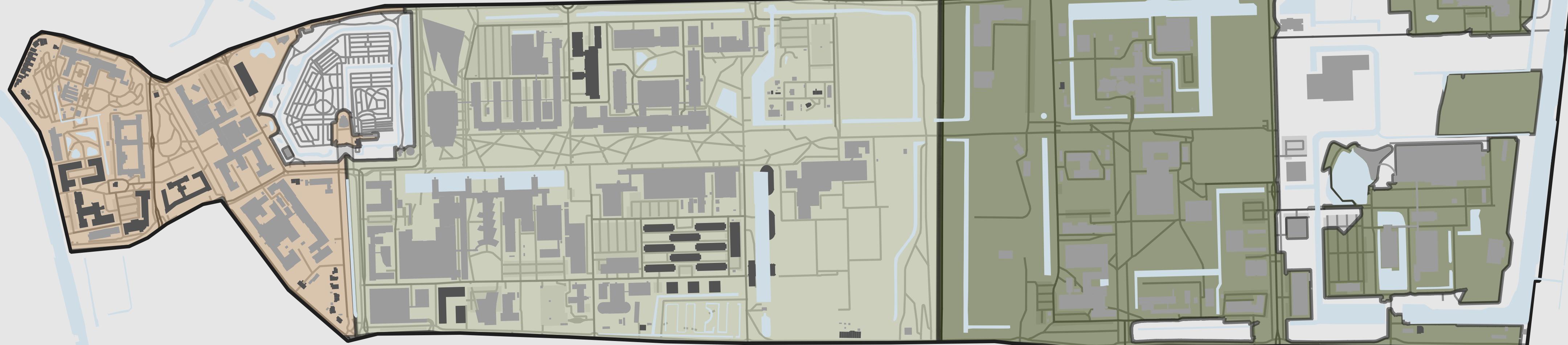
Increase of 5,30%

Student population increased by 20.84% and the GFA of educational spaces by 1,35%

Harbers, A., van Amsterdam, H., & Spoon, M. (2022).
Technische Universiteit Delft 125 (h. 95).

	Students	Increase (Annual)
2016	22.566	-
2017	23.604	+ 4,60%
2018	24.783	+ 4,99%
2019	25.310	+ 2,13%
2020	26.476	+ 4,61%
2021	27.270	+ 3,34%

+ 20,84%



Campus north

2015: GFA dwellings = 38.415 m^2

2022: GFA dwellings = 49.664 m^2

Increase of 29,28%

Campus center

2015: GFA dwellings = 98.820 m^2

2022: GFA dwellings = 111.893 m^2

Increase of 13,23%

Campus south

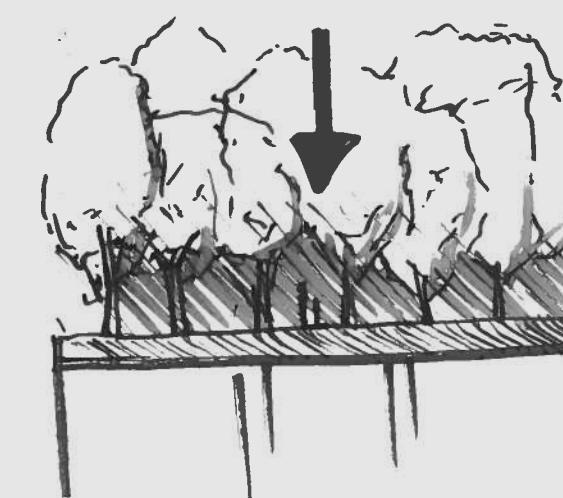
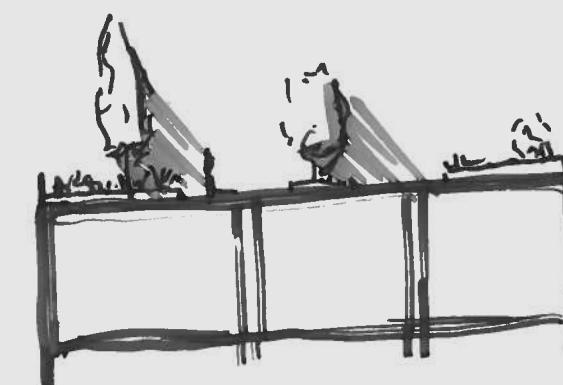
2015: GFA dwellings = 858 m^2

2022: GFA dwellings = 461 m^2

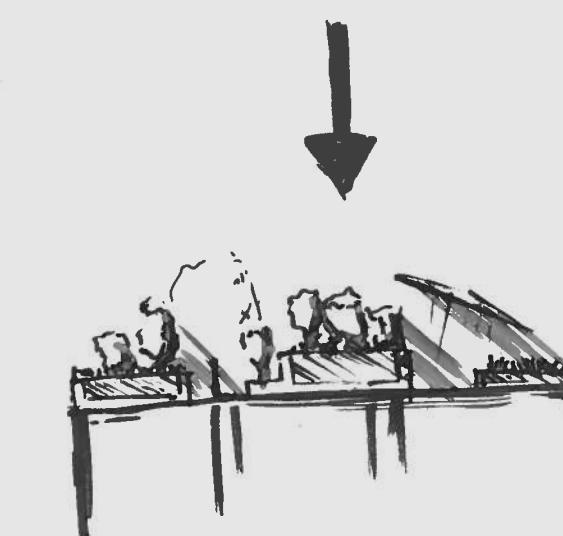
Decrease of 46,27%

Student population increased by 20.84% and the GFA of dwellings by 17,33%

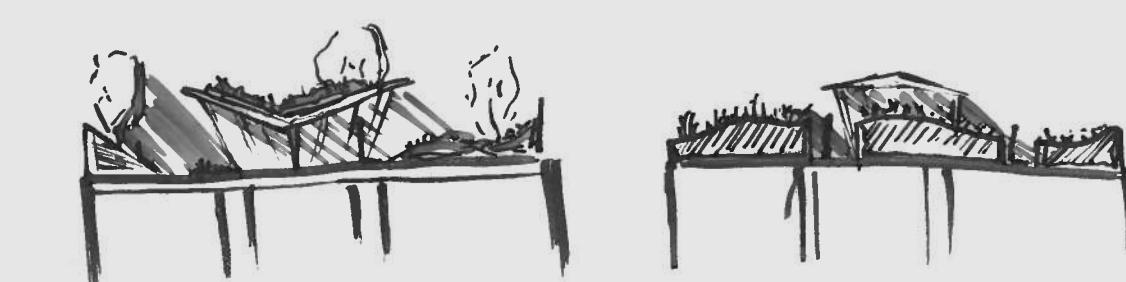
- Extreme heat loads
- Extreme winds
- Extreme rain



We need much more than
green roofs → we need
forests instead.....
Feasibility?



Instead, you can also dig in.
Carve out shelter:



This can take many hours.

