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Block Research Group
Dr. Philippe **Block**

LUCIEN WIDMER

HS 2021
master thesis

Master Thesis Lucien Widmer : Durability

This Master Thesis is dedicated to the research on durability. The chair of Professor Mike Guyer with the assistance of the Block Research Group pursue a holistic approach to the topic with focus on the structural and materialistic aspects of durability. Throughout the diploma semester it became evident that not only the durability in construction but also a programmatic and social durability had to be achieved.

This insight lead to the conclusion that we need to rethink the way we are designing and planning architecture today. Decisions concerning durability have to be integrated into the development process from the very beginning and onwards.

However, what is the point of durability if time is running out? If our future can be durable, it also needs to be sustainable. The ambition/aim of my project is to consider all these aspects of durability and its effects.

Programmatic Durability

The Werkstadt Zürich is an industrial site in the midst of rapid change of the built environment and constant architectural debate. Due to the popularity and ever rising estate prices in the city of Zürich, industrial areas are being pushed towards the outskirts of the city. Thereby directly affecting the diversity and cultural experience of the neighborhood. Owned and developed by the Swiss Railway company SBB, the desire to keep the Werkstadt as a site of urban production was critical. Keeping in mind the constant economic pressure urban production is facing, it has to be redefined to meet todays requirements. My approach is based on the idea of optimizing it's efficiency by introducing a circular economy through sharing. The exchange of expertise and knowledge by specialists of various professions as well as sharing machines and infrastructure, allows to me to reach my goal to develop a creative hub of contemporary urban production. This densification results in the shape of a high-rise building enabling me to realize the programmatic and architectural intervention on a minimal footprint, preserving the existing buildings in their current use and structure.

Social Durability

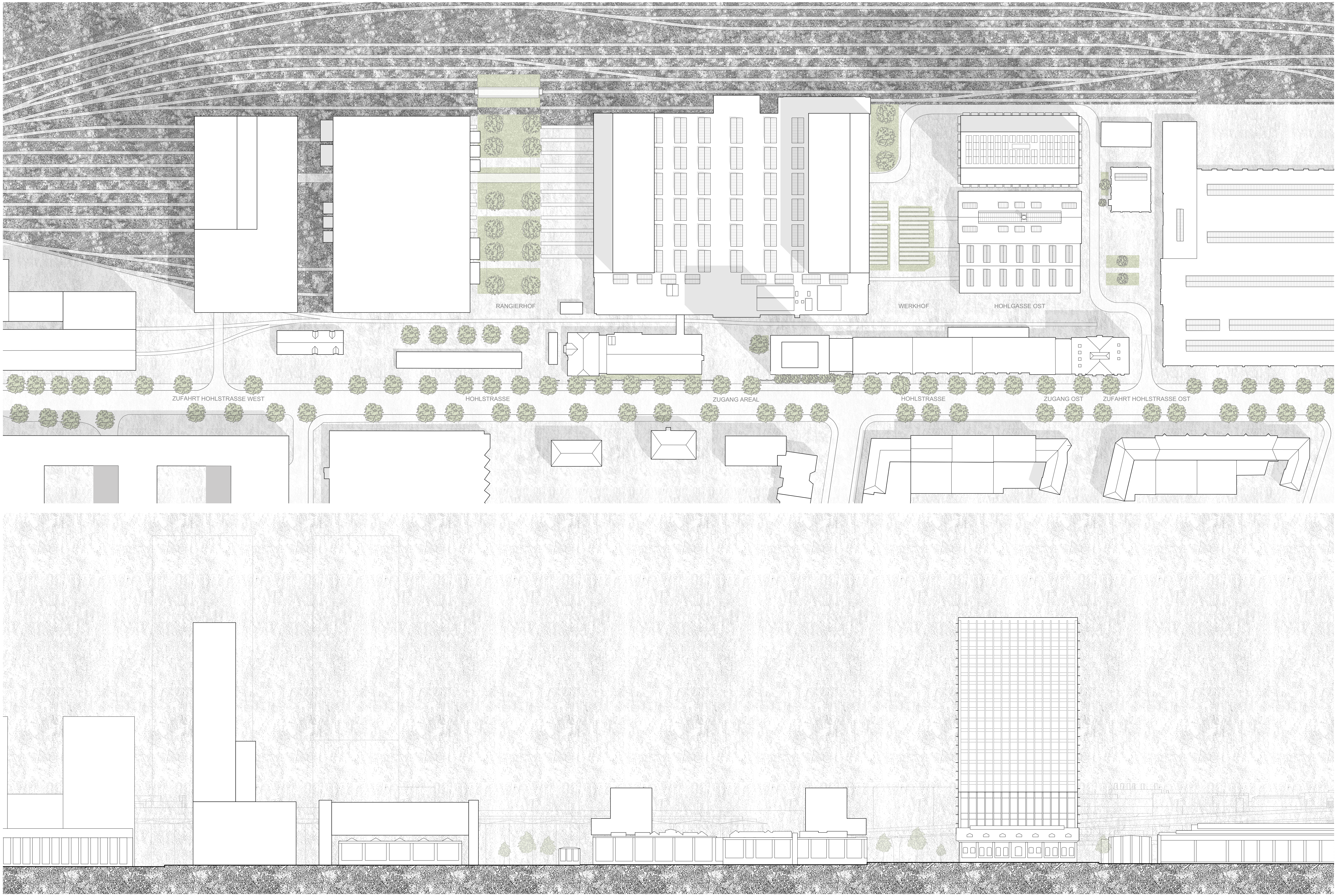
By leaving the industry a key aspect in the site, an urbanistic development of diversity and communication can be achieved. With further integration of housing options and community spaces inside the building, a lively exchange of people working and living can take place.

Structural Durability

Are the objectives and regulations concerning sustainability in the building industry set by the state able to influence the current architectural practice sufficiently? What is the lifespan of todays buildings and how can their structure be durable not only from an engineer's perspective but in a broader approach?
To find answers to these questions, the Chair of Annette Gigon and Mike Guyer has collaborated with the Block Research Group of the Institute of Technology in Architecture.
With their guidance the Rippmann Floor System RFS was integrated into the project and builds the foundation of this project. Through geometrical optimization and structural separation, a highly modular and resource efficient system can be obtained. Similarly to the RFS, the second structure on the upper floors of the building is completely made out of wood with metal dry connections. Choosing dowel laminated timber floor DLT avoids the use of binding glue that contributes immensely the CO_2 emissions of timber construction. By using the two floor systems, around 46 percent of the building's CO_2 emissions can be saved compared to a more conventional hollow core system. These systems are also highly modular with dry connections only, meaning the assembly and end of life disassembly are possible with minimal energy. This makes the structure adaptable to future changes as it can be used in various programmatic scenarios. Because these systems are not sturdy enough themselves to resist horizontal wind forces, a global structural system of lateral stability is introduced. The so-called outrigger system is located in the upper third of the building and occupies a whole floor. It directs horizontal forces through trusses and a rigid frame to the core of the building. In this manner the concrete core needs less material and can be prefabricated and post tensioned. This results in the benefits of faster installation and a reduction of foundation material. The façade follows a similar logic to the floor system with its highly modular characteristics and can be assembled off site. Through a frame construction each panel can be lifted in place and bolted to the metal connectors in the column head. Each panel can therefore easily be replaced and interchanged with different modules. The hull of the façade consists of large ceramic plates that are attached the façade element. The use of ceramics is a valuable contribution to the reduction of CO_2 emissions when compared to more conventional materials used high-rise buildings such as steel or glass.

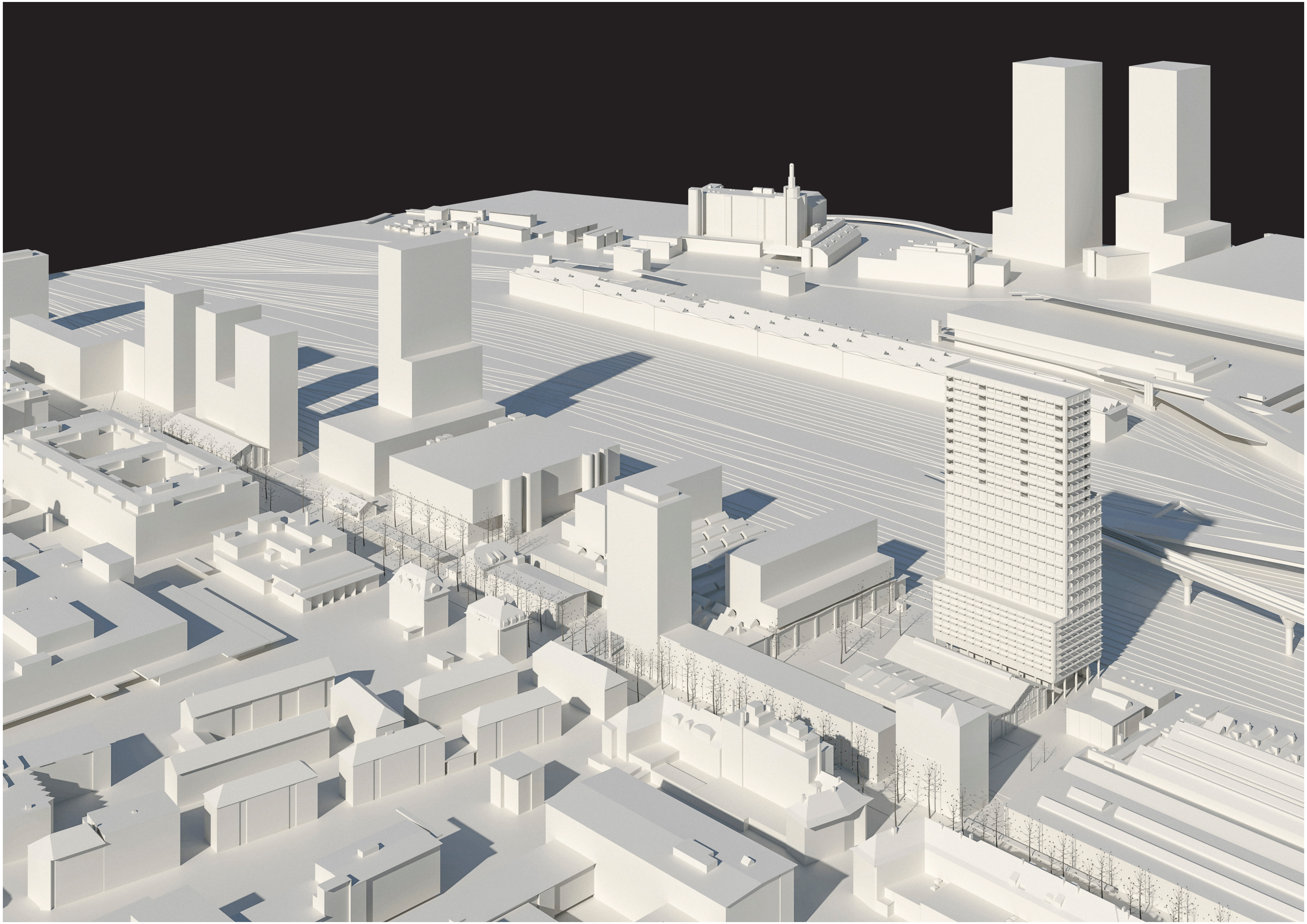
Energy Durability

With a predicted continuation of rising energy consumption, the demand for renewable energy is greater than ever. By replacing the existing oil heating plant on the site, it was most reasonable to integrate a hybrid photovoltaic module into the façade. Using horizontal solar panels, the total energy and thermal demand of my building is generated and covered with a surplus of 12% and therefore accomplishes the goal of an energy positive house that can contribute to the neighboring buildings needs. In addition, the panels serve as a brise soleil that provide shade during summer and keep the building from overheating.

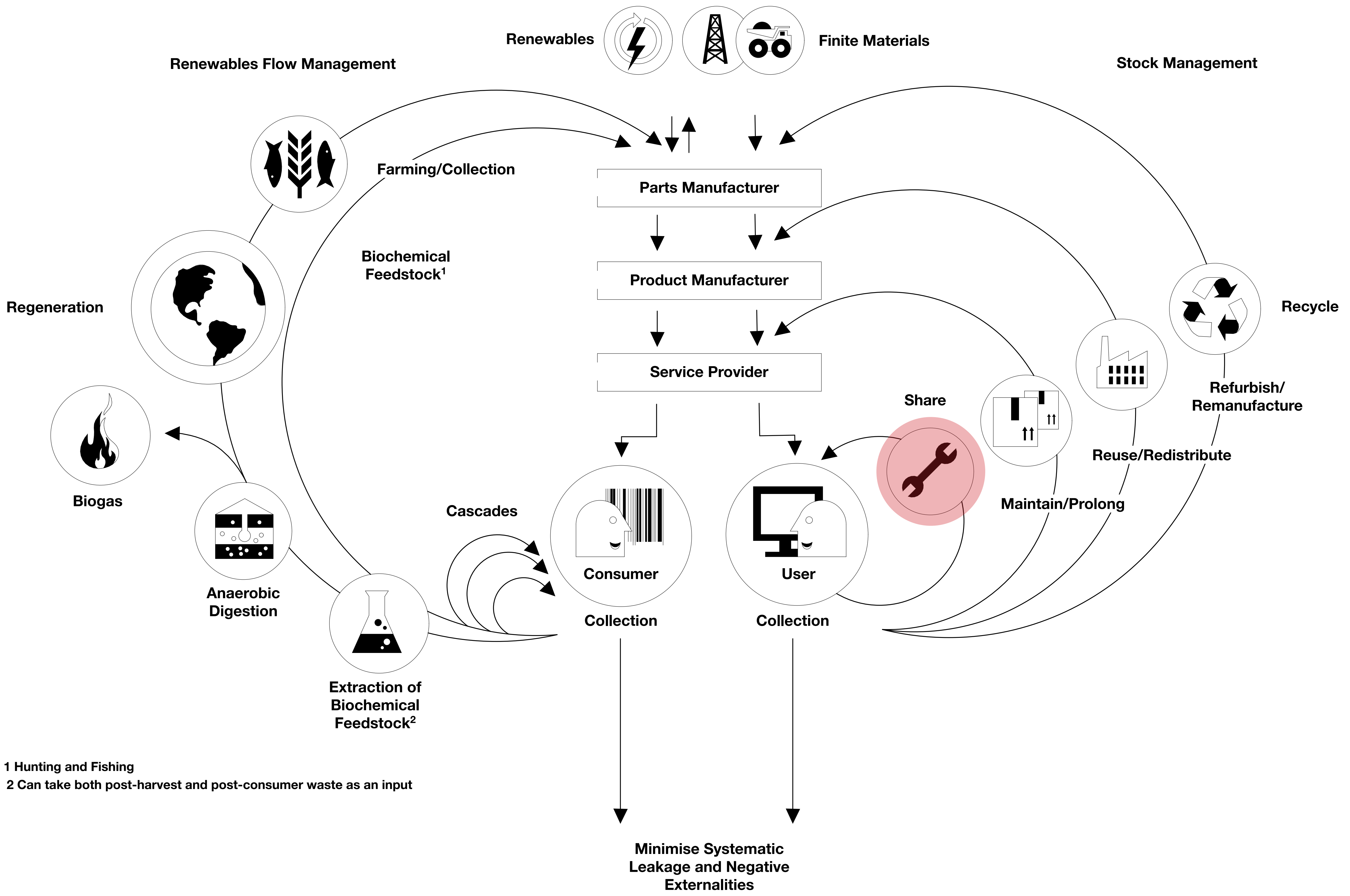


Situationsplan Areal

Situation Werkstadt Züich

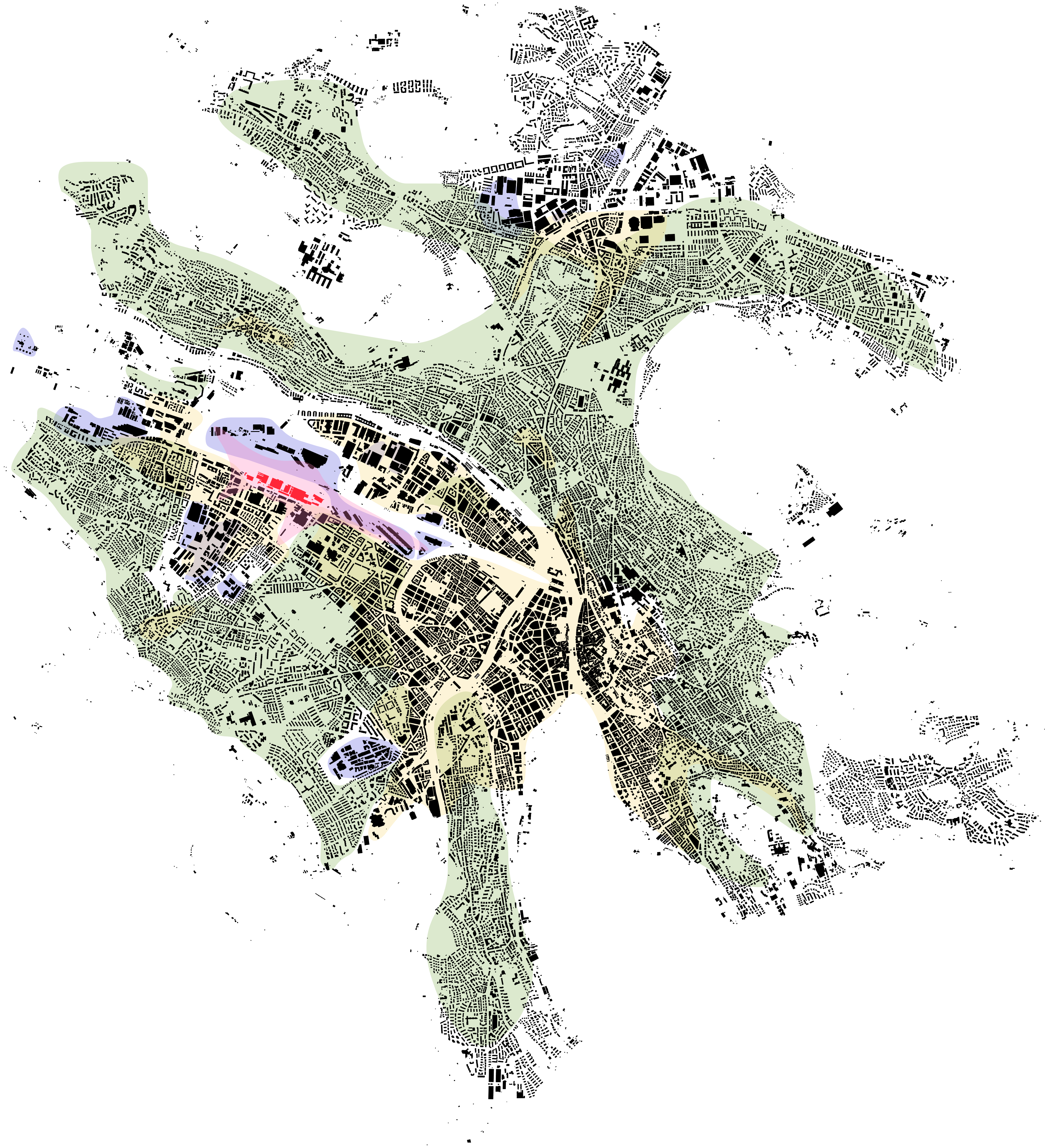


Situationsmodell



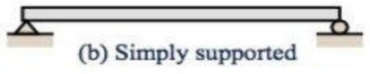
1 Hunting and Fishing
2 Can take both post-harvest and post-consumer waste as an input

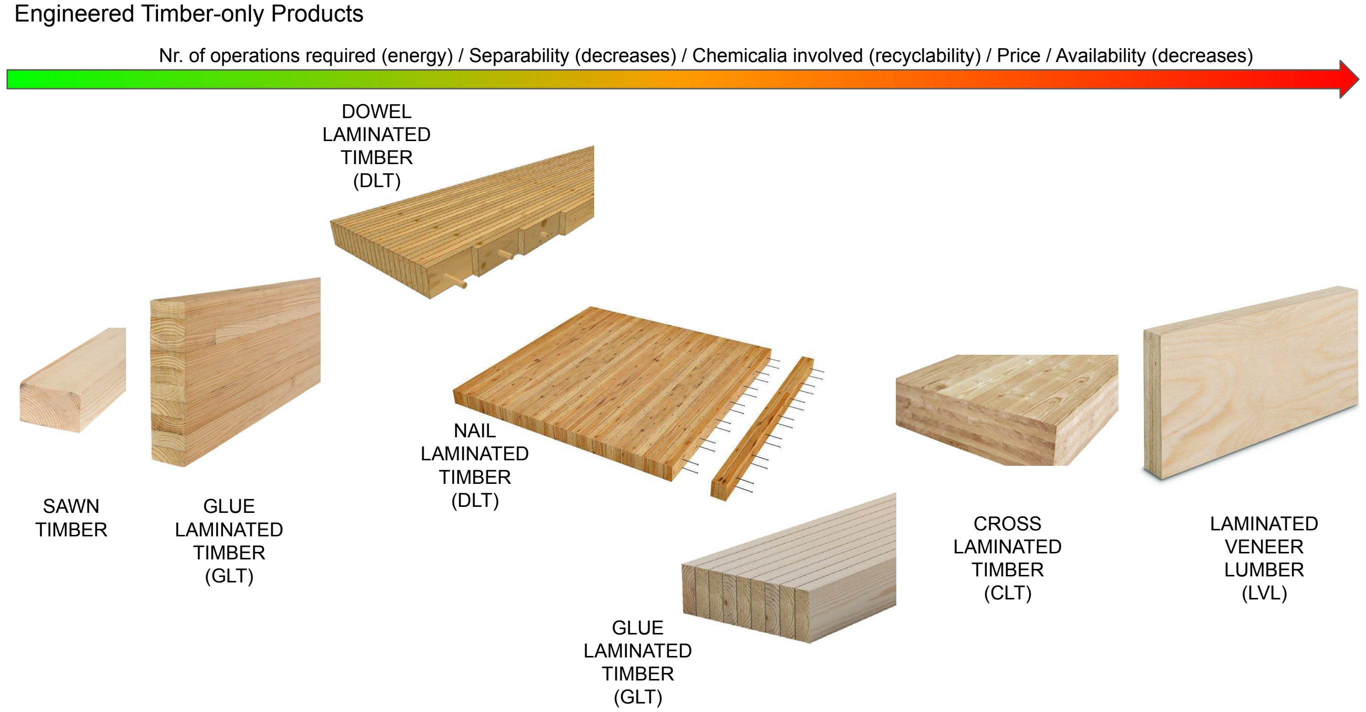
Circular economy systems diagram



Nutzungsanalyse Zürich

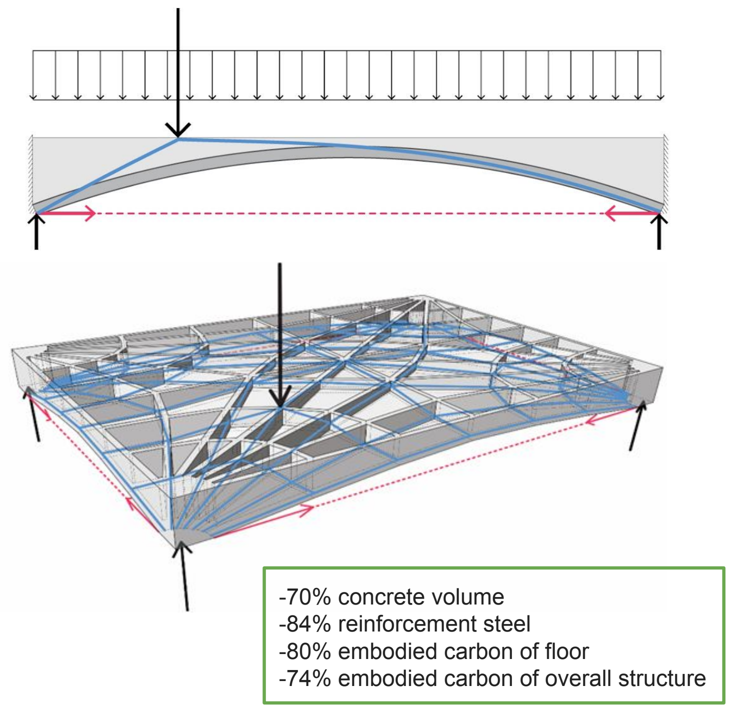
Dowel Laminated Timber DLT



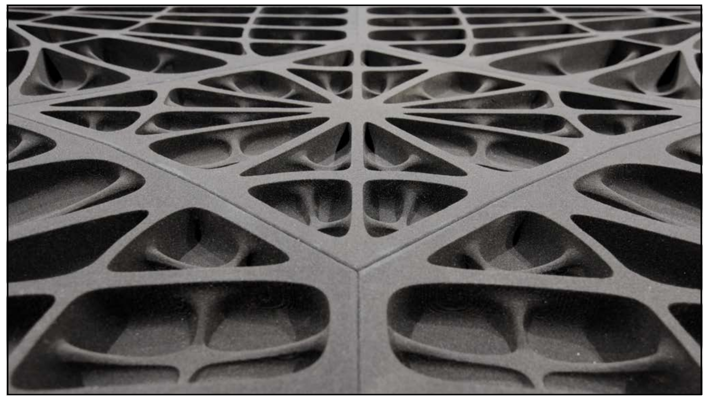


Rippman Floor System RFS

"Strength through Geometry"



(Comparison with 25-storey flat slab construction, 30cm thick, 8.10m x 8.10m span)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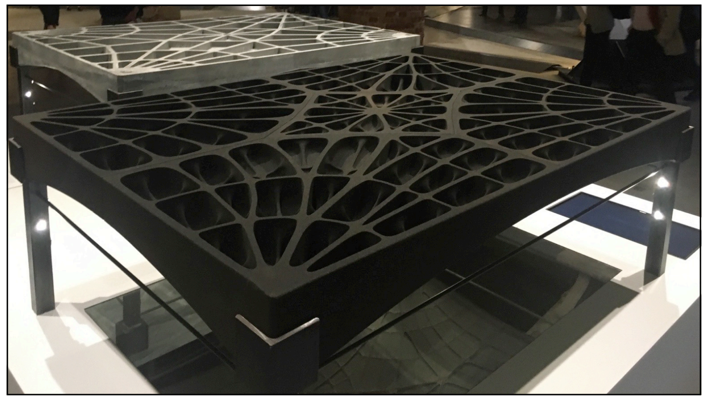
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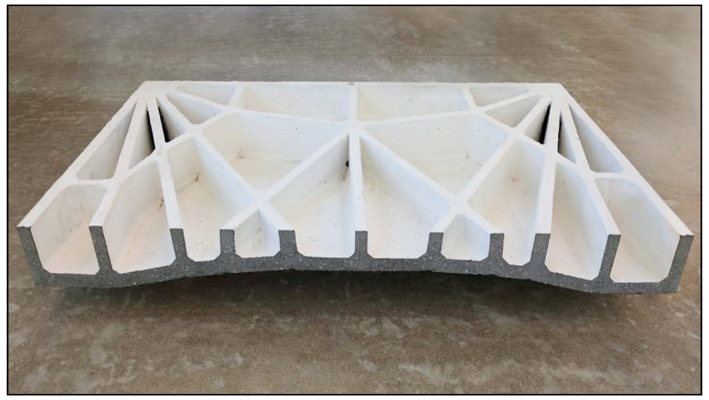
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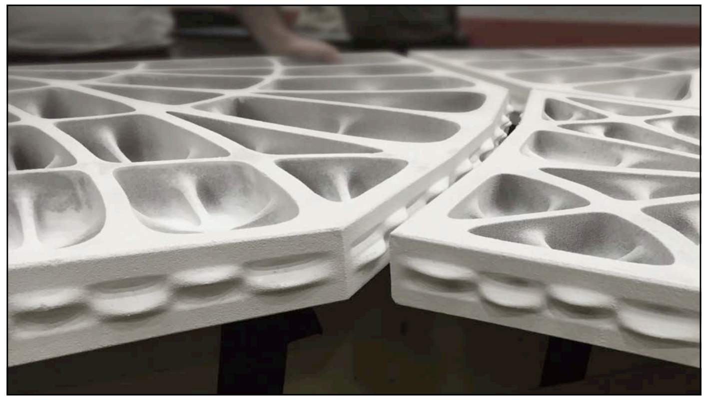
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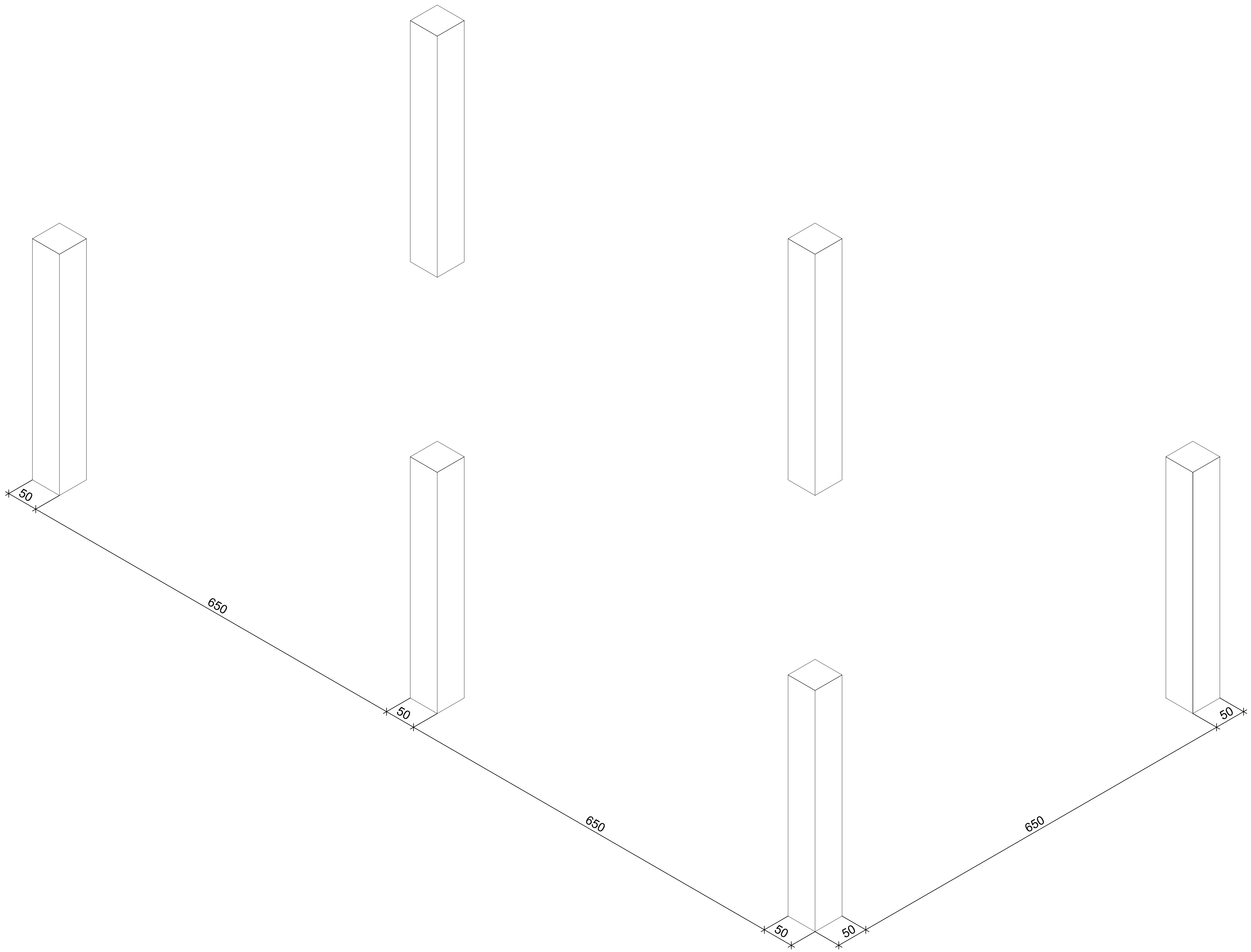
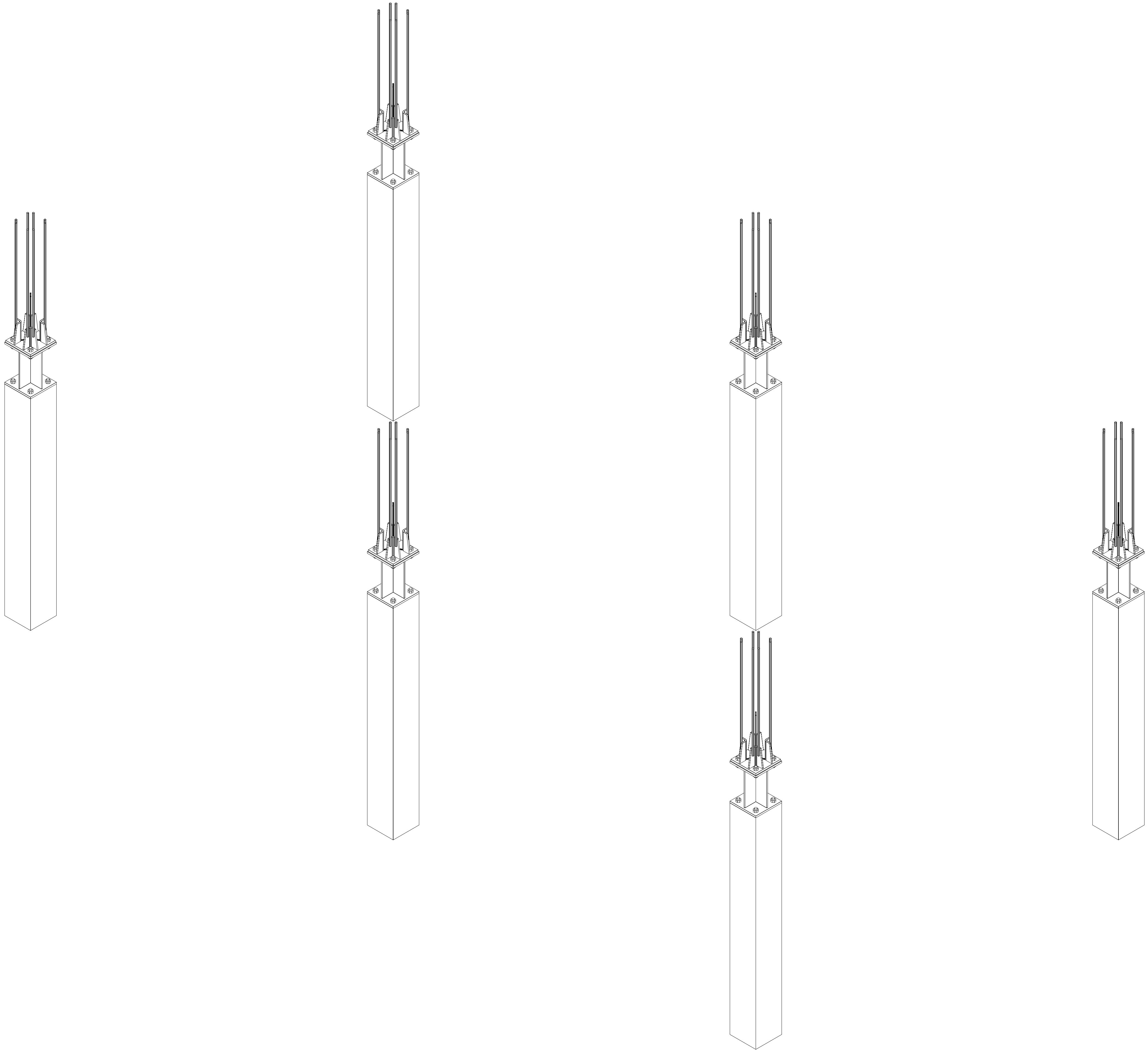


Axonometrie Deckensystem RFS



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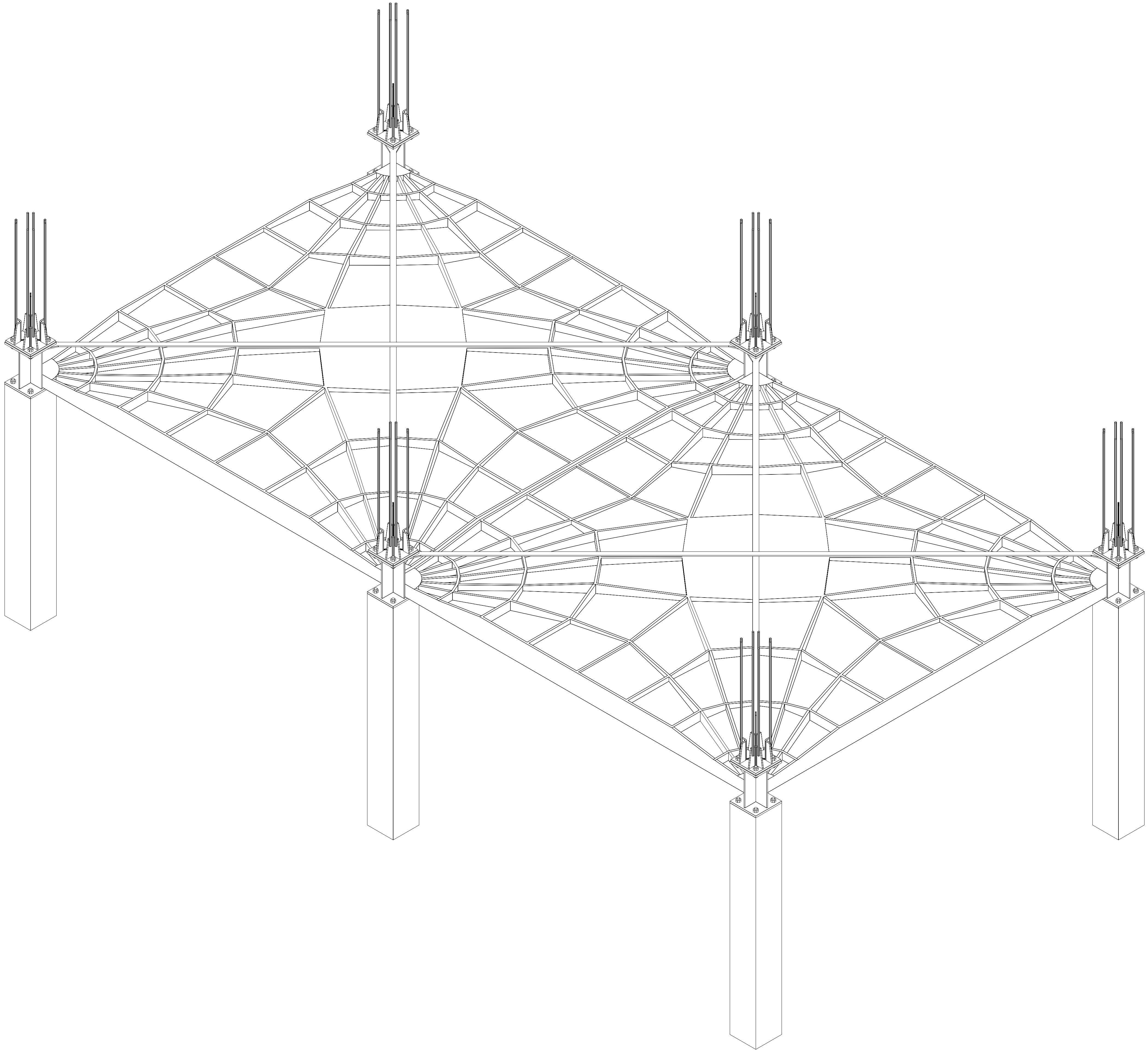

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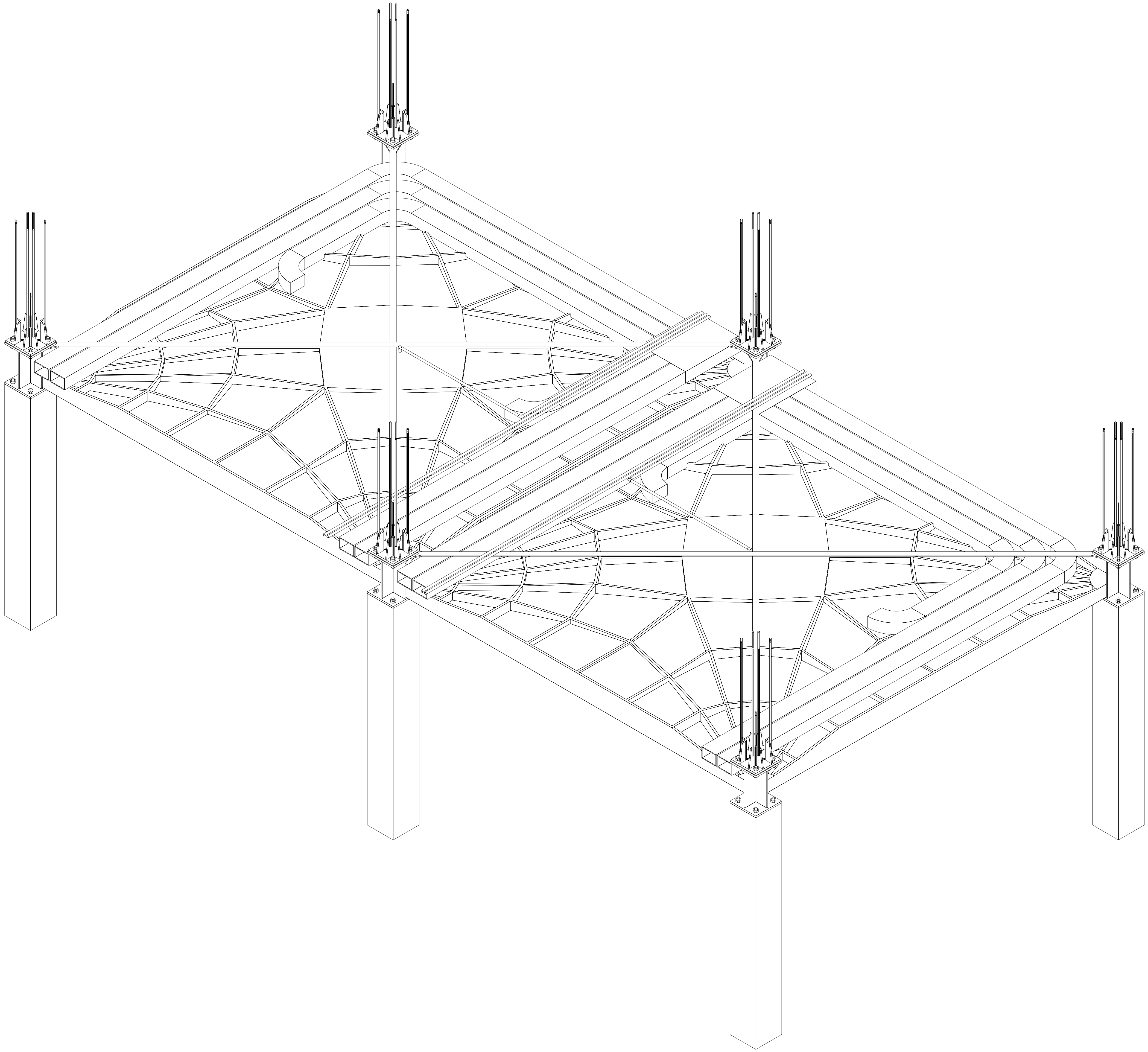

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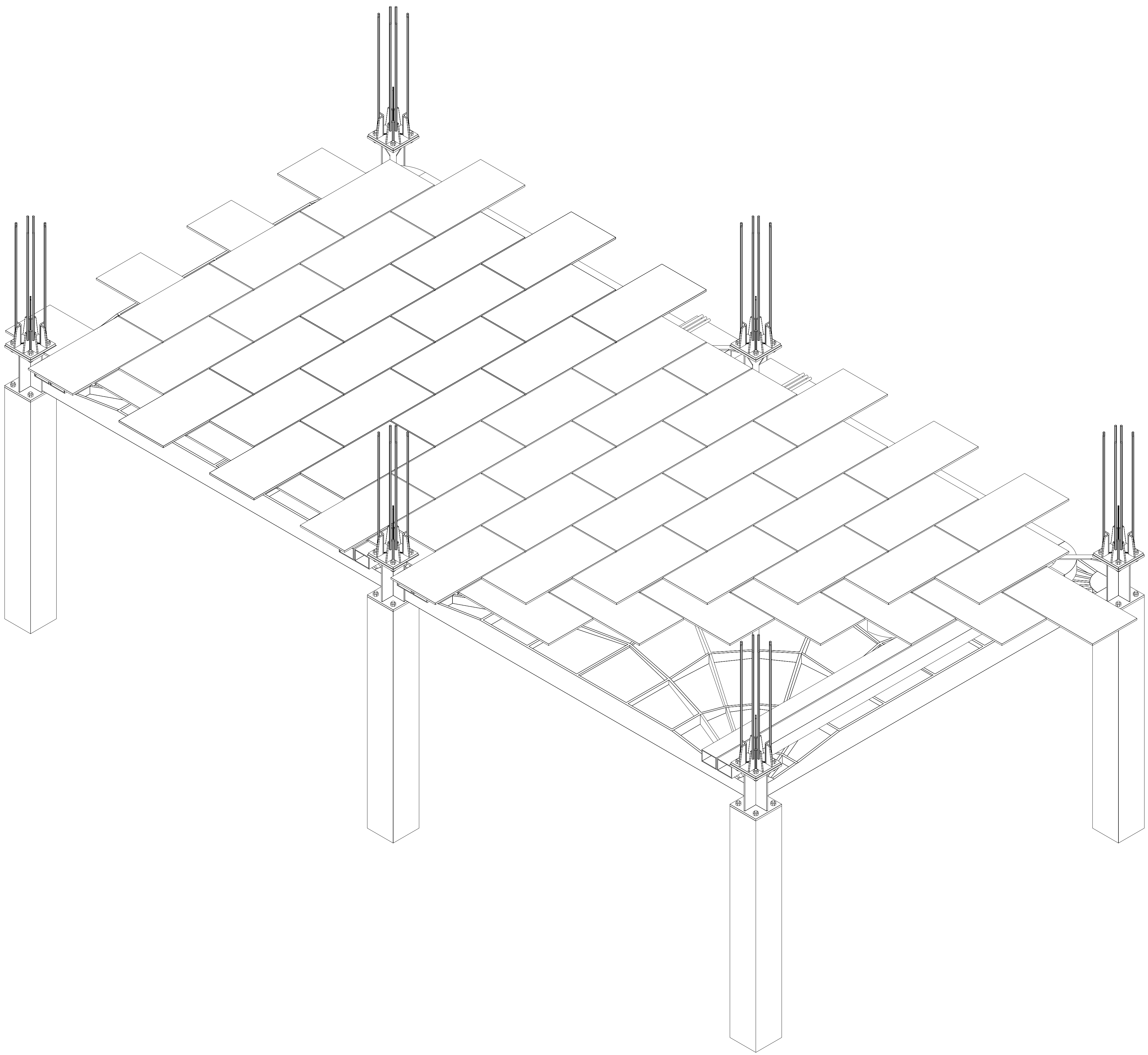

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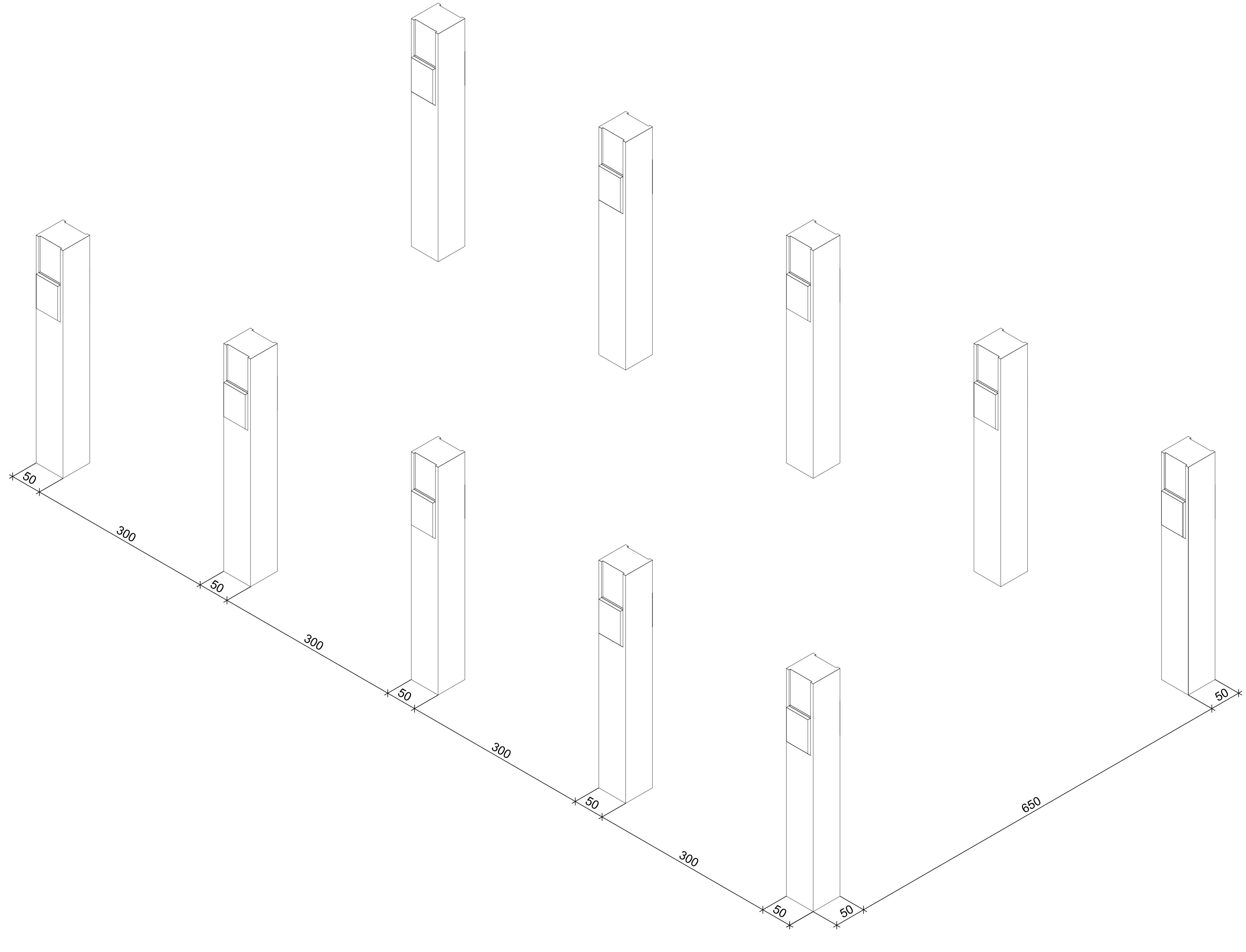

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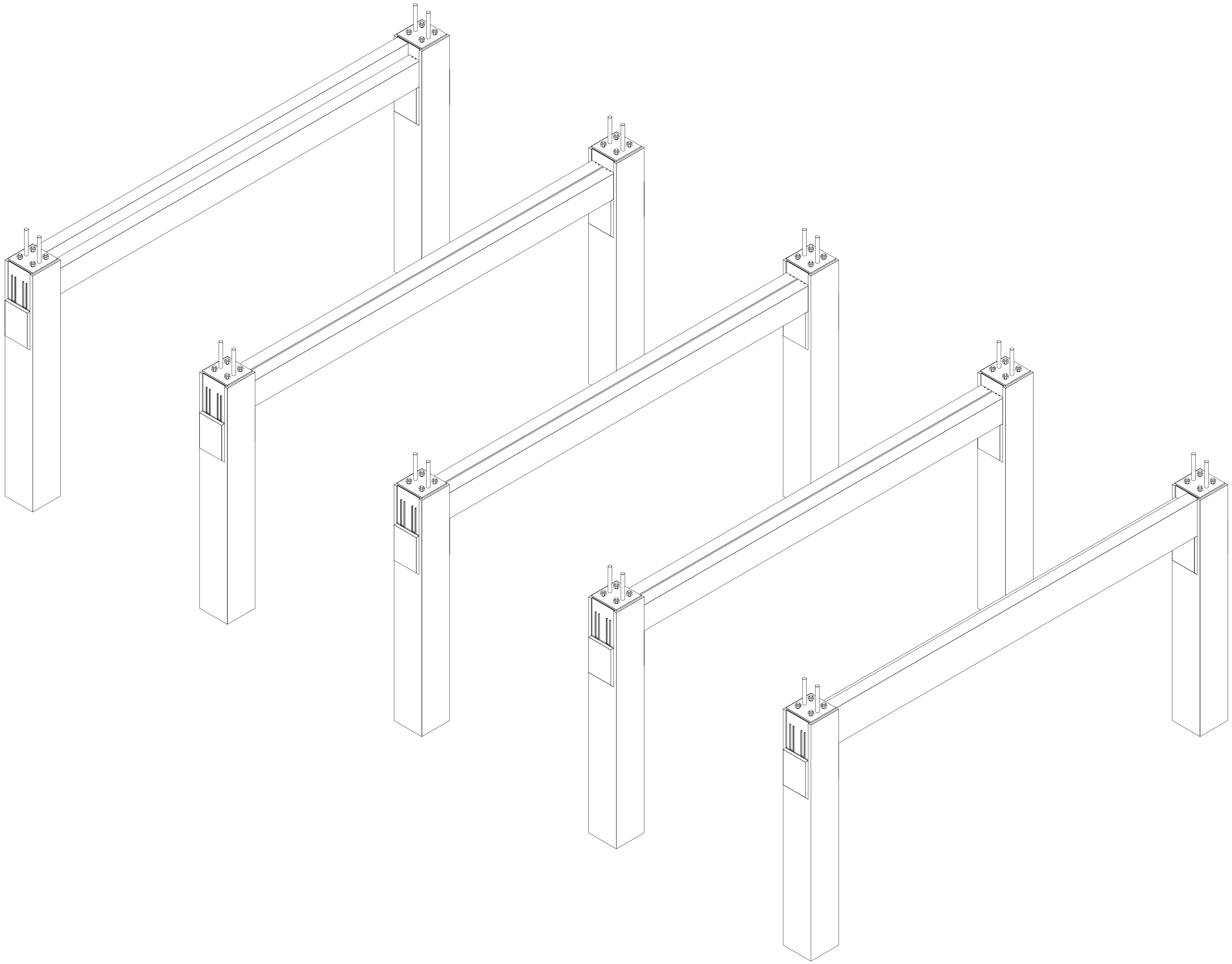

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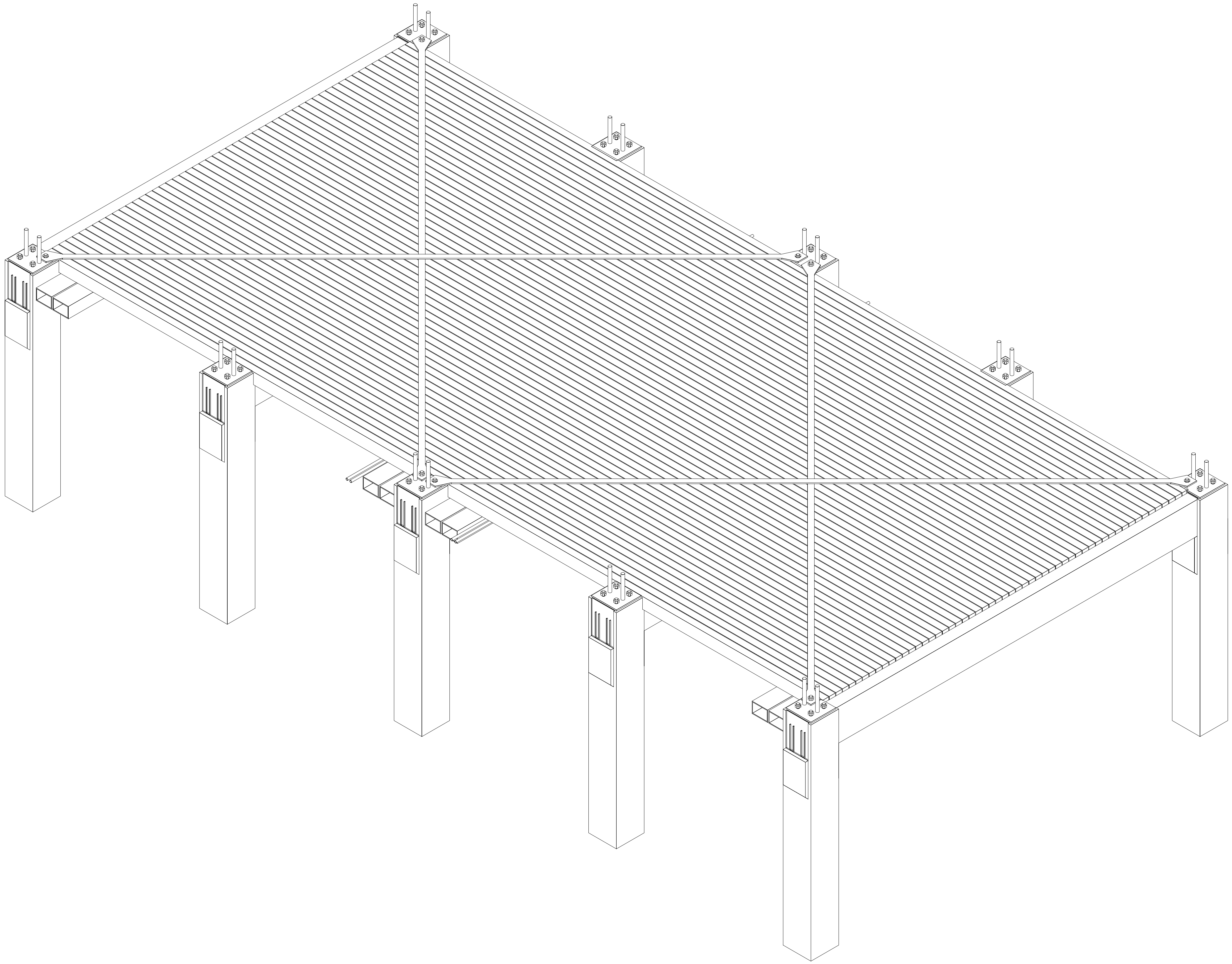

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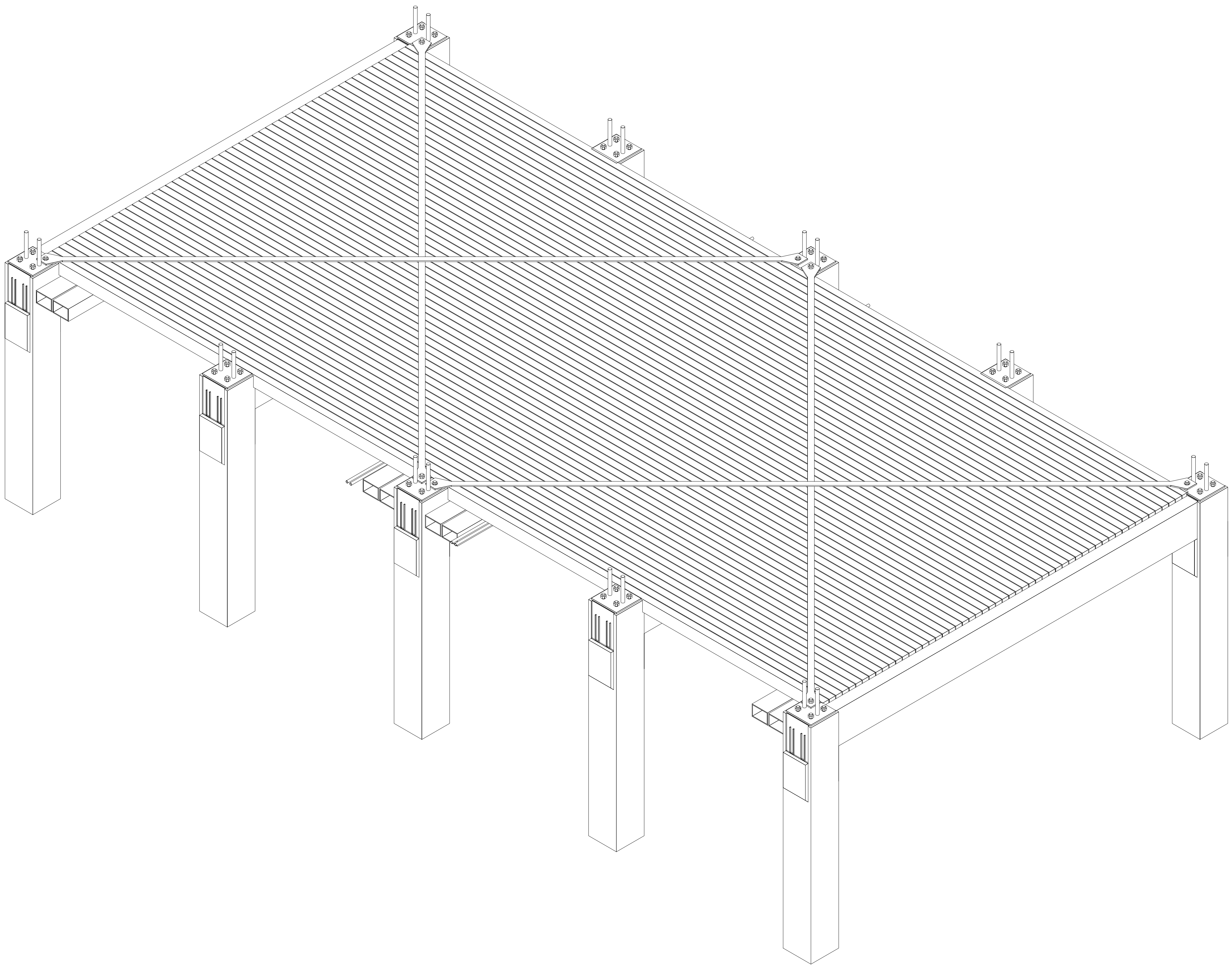

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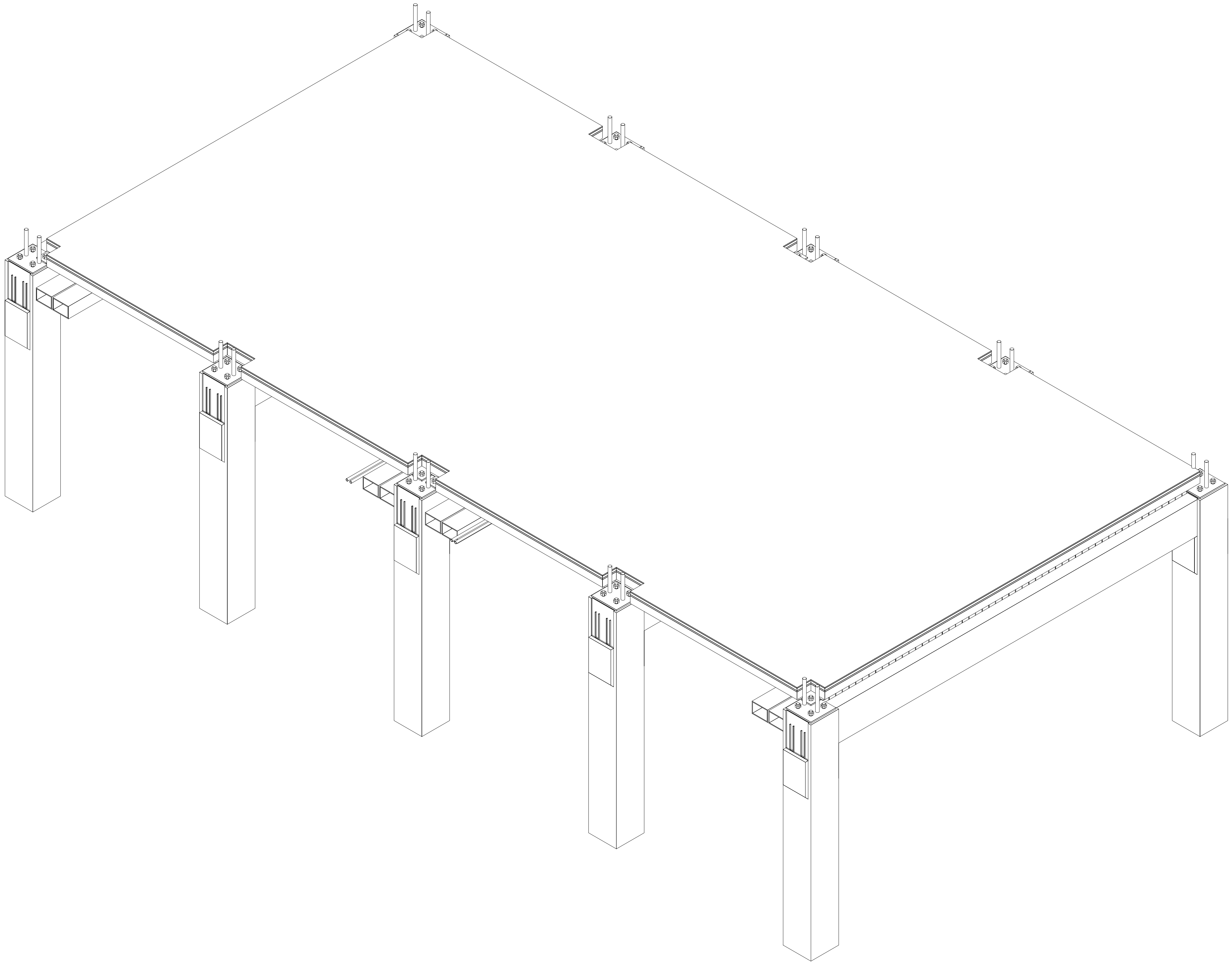

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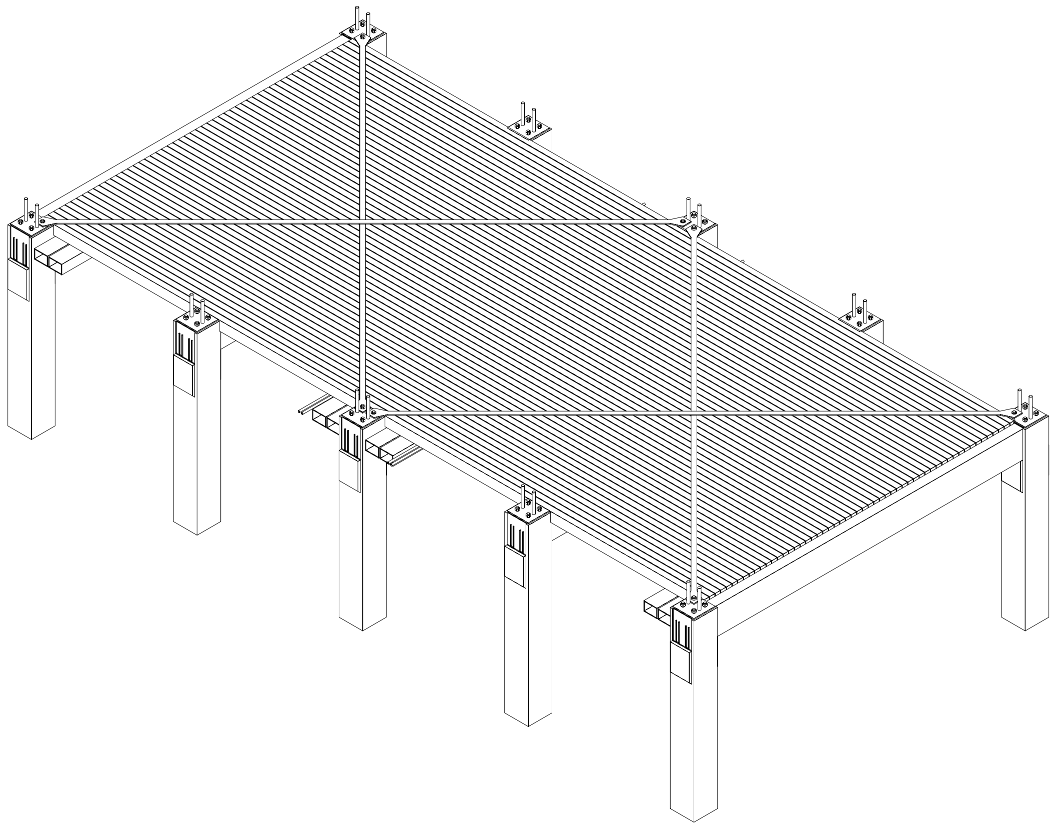
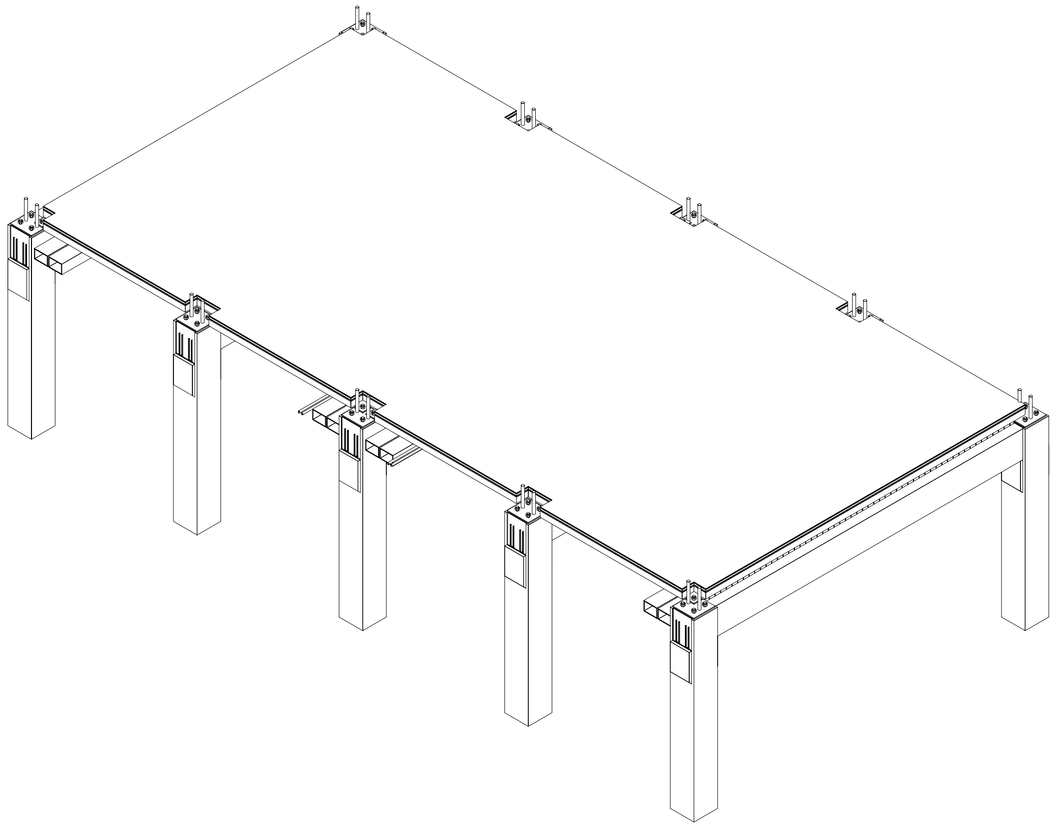
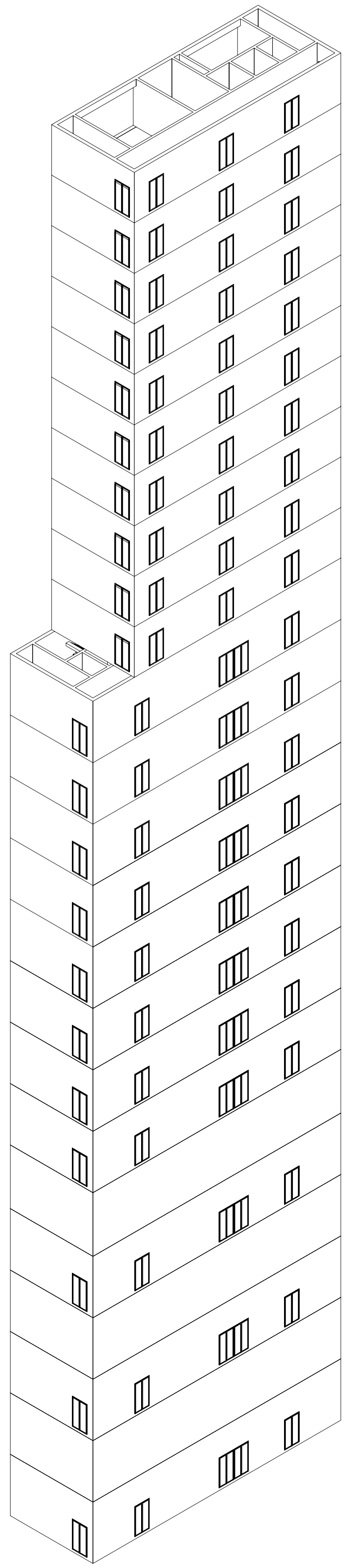


Material	RFS Gewerbe 700 x 700			Hollow Core Gewerbe 700x 700				Vergleich
	RFS Beton	RFS Stahl	Total	HC Deckenelement	Träger	Metallkreuz	Total	
Materialstärke				0.25	0.6	0.02		
Rohdichte kg/m3		7850		2500	2500	7850		
Rohdichte kg/m2	280	19.7	299.7	286	64.75	4.5	355.25	
Treibhausgasemmission kg CO2-eq		0.734		0.172	0.172	0.734		
Treibhausgasemmission kg CO2-eq/m2	18	14.46	32.5	49.19	11.14	3.30	63.6	
Anteil von Total	55%	45%	100%	77%	18%	5%	100%	
Gewicht pro Geschoss t	288.12	20.2713	308.4	294.3	66.6	4.6	365.6	
Geschossfläche	1029	1029		1029	1029	1029		
Anzahl Geschosse	12	12		12	12	12		
Total Gewicht t	3457	243	3701	3532	800	56	4387	119%
Total CO2 t	222	179	401	607	138	41	786	196%

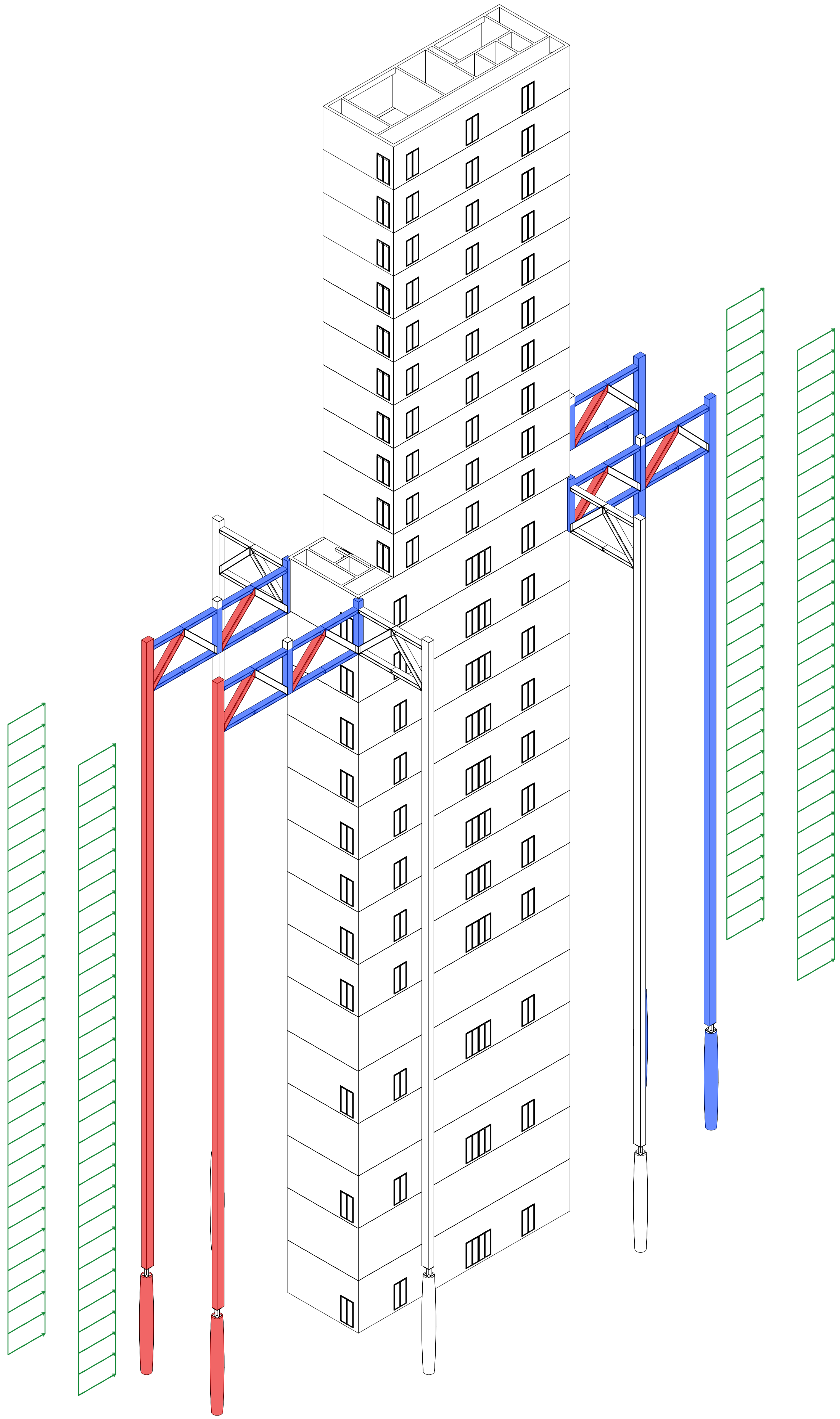


Material	DLT Wohnen 700 x 350					Hollow Core Wohnen 700 x 350				Vergleich
	DLT Deckenelement	Träger BSH	Metallknoten	Metallkreuz	Total	HC Deckenelement	Träger	Metallkreuz	Total	
Materialstärke	0.2	0.4		0.02		0.15	0.6	0.02		
Rohdichte kg/m3	470	465	7850	7850		2500	2500	7850		
Rohdichte kg/m2	81	25	6.5	4	116.5	176	117	4	297	
Treibhausgasemmission kg CO2-eq	0.143	0.446	0.734	0.734		0.172	0.172	0.734		
Treibhausgasemmission kg CO2-eq/m2	11.58	11.15	4.77	2.94	30.4	30.27	20.12	2.94	53.3	
Anteil von Total	38%	37%	16%	10%	100%	57%	38%	6%	100%	
Gewicht pro Geschoss t	54.1	16.7	4.3	2.7	77.8	117.6	78.2	2.7	198.4	
Geschossfläche	668	668	668	668		668	668	668		
Anzahl Geschosse	9	9	9	9		9	9	9		
Total Gewicht t	487	150	39	24	700	1058	703	24	1786	255%
Total CO2 t	70	67	29	18	183	182	121	18	321	175%

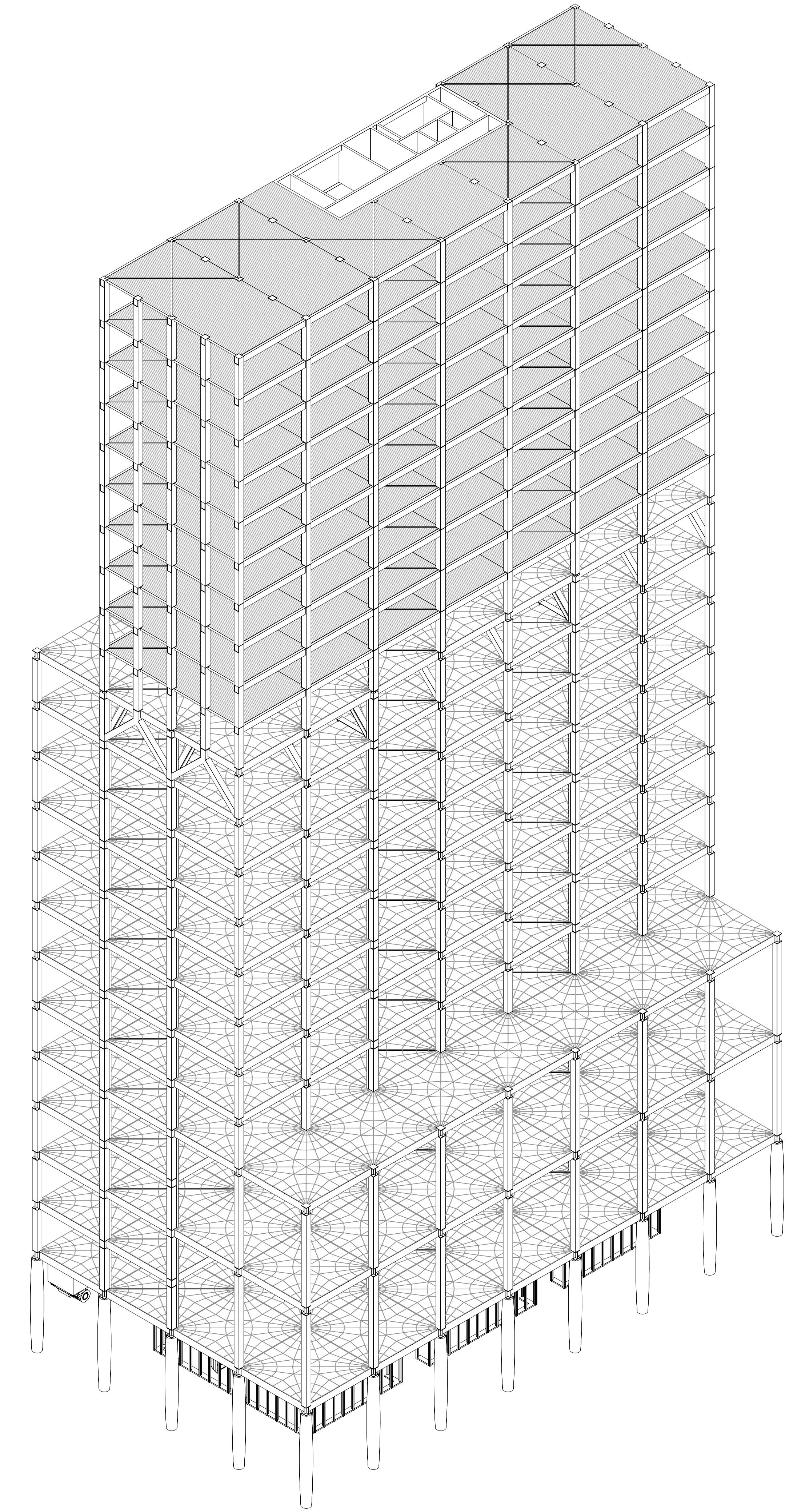
Axonometrie Deckensystem RFS / DLT



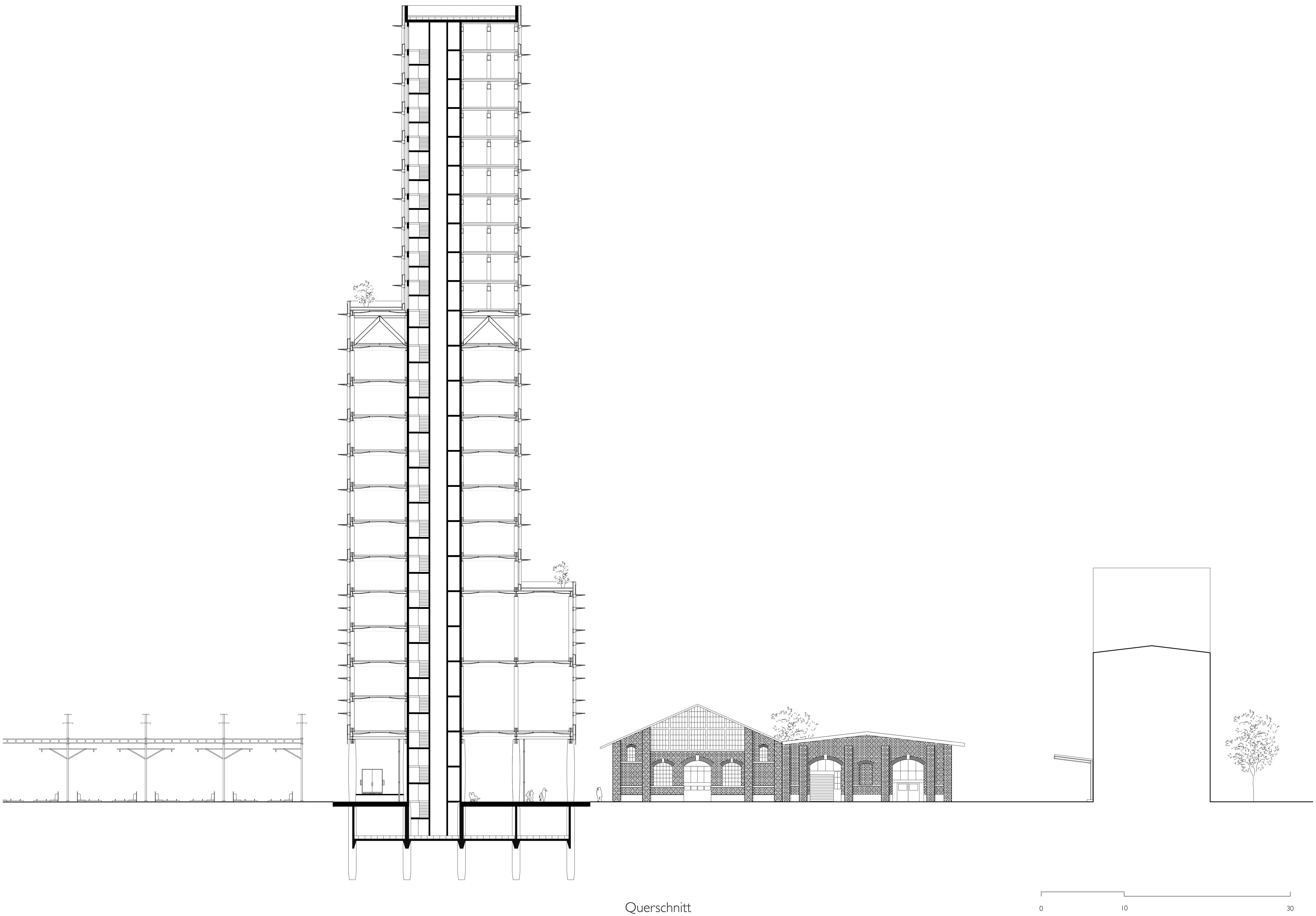
Axonometrie Kern



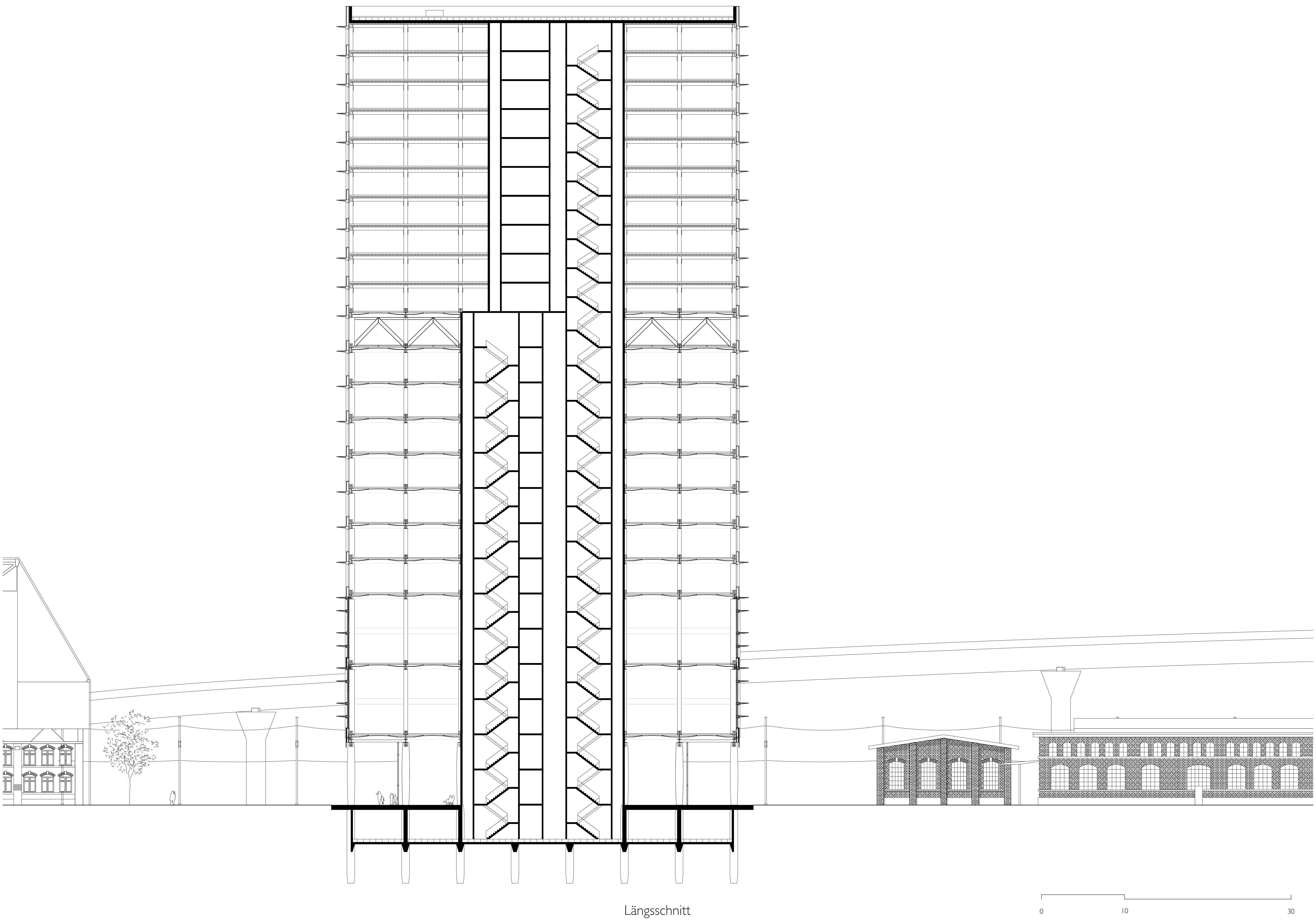
Axonometrie Outrigger System



Axonometrie Tragwerk



Querschnitt



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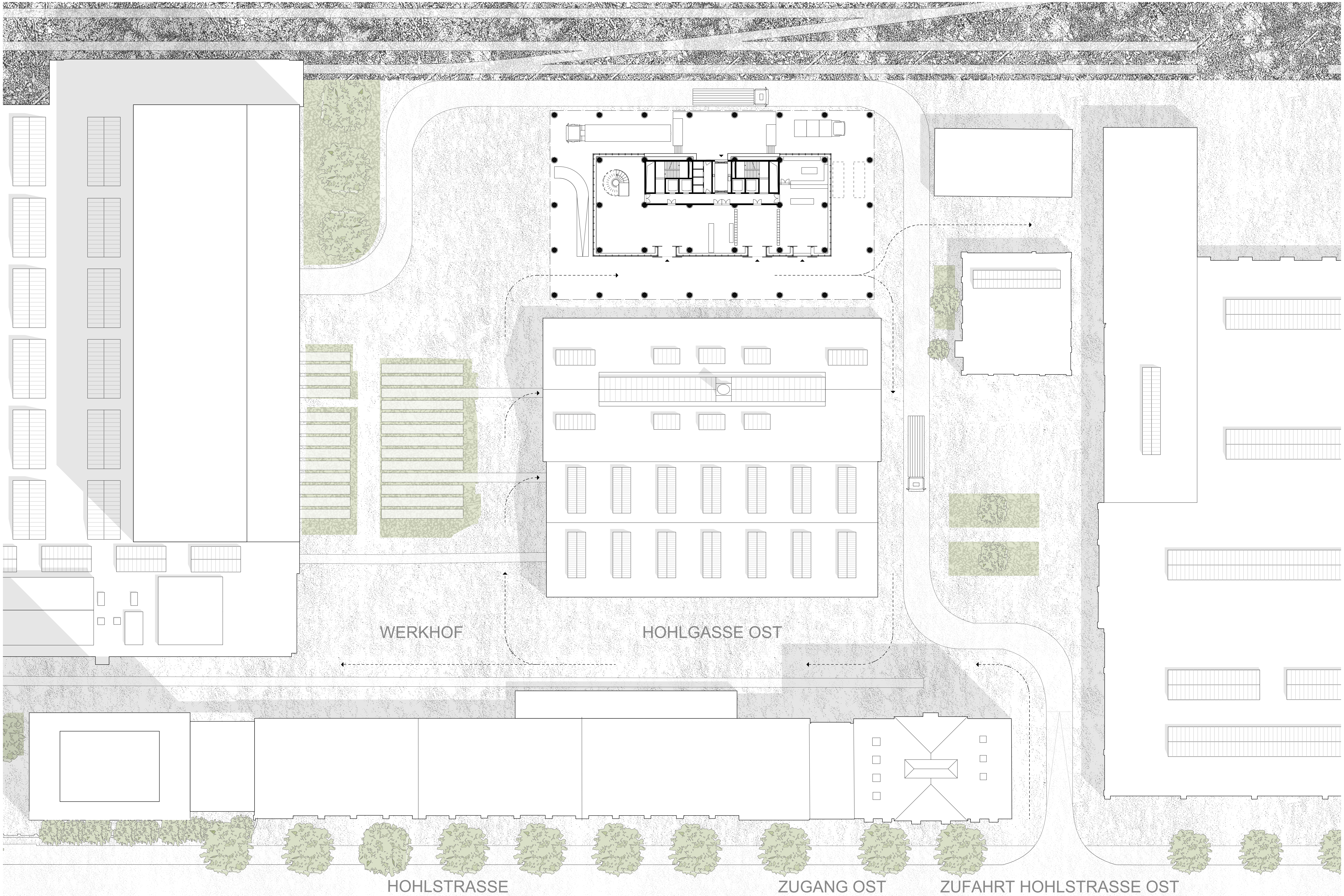
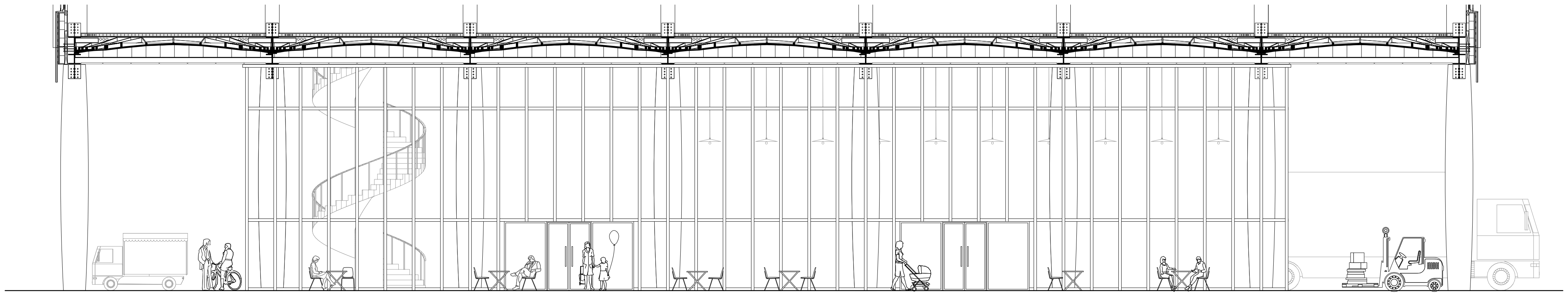
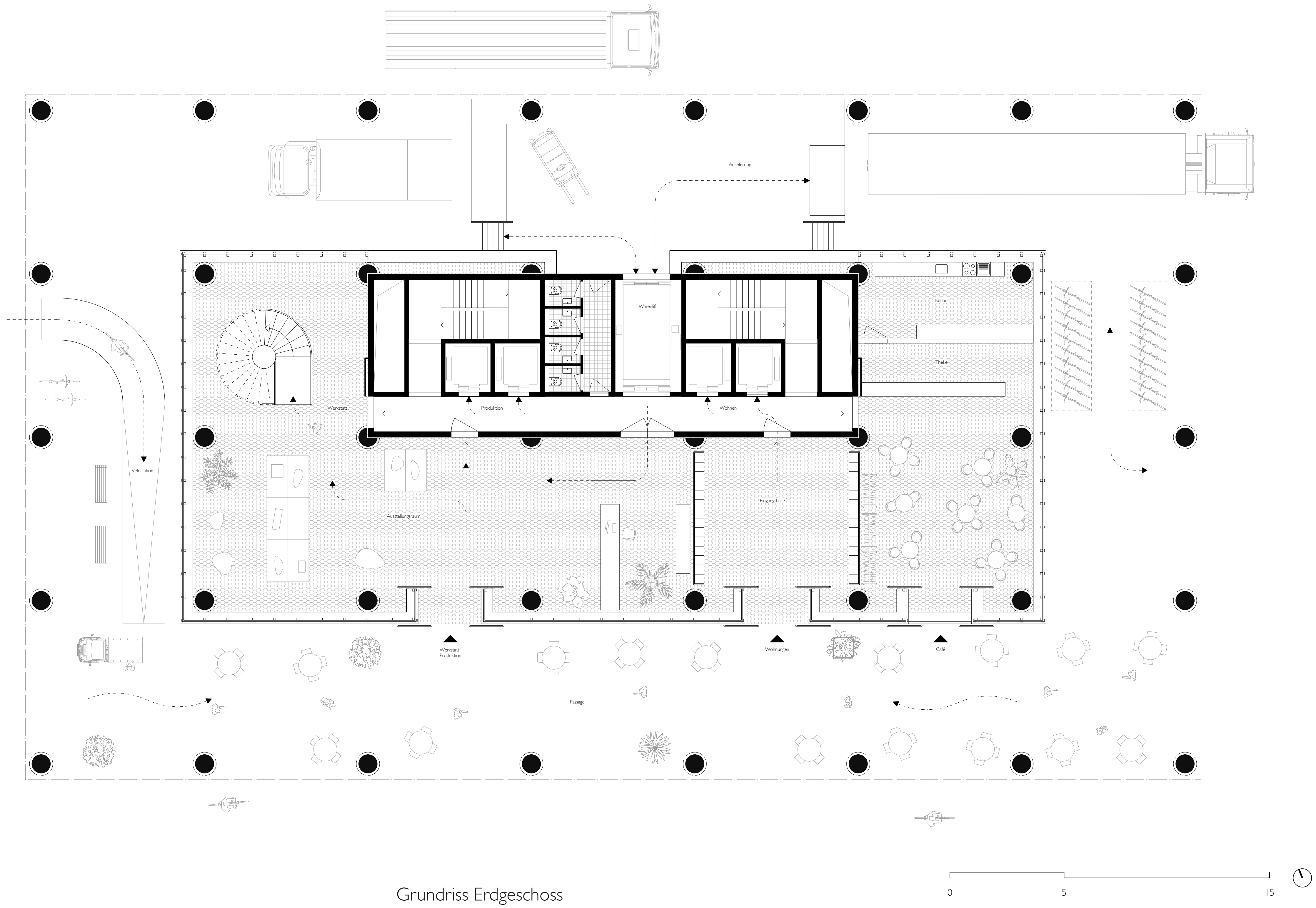
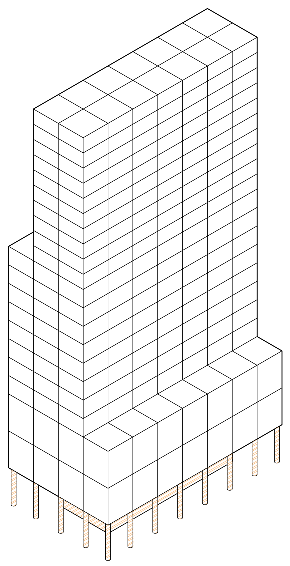


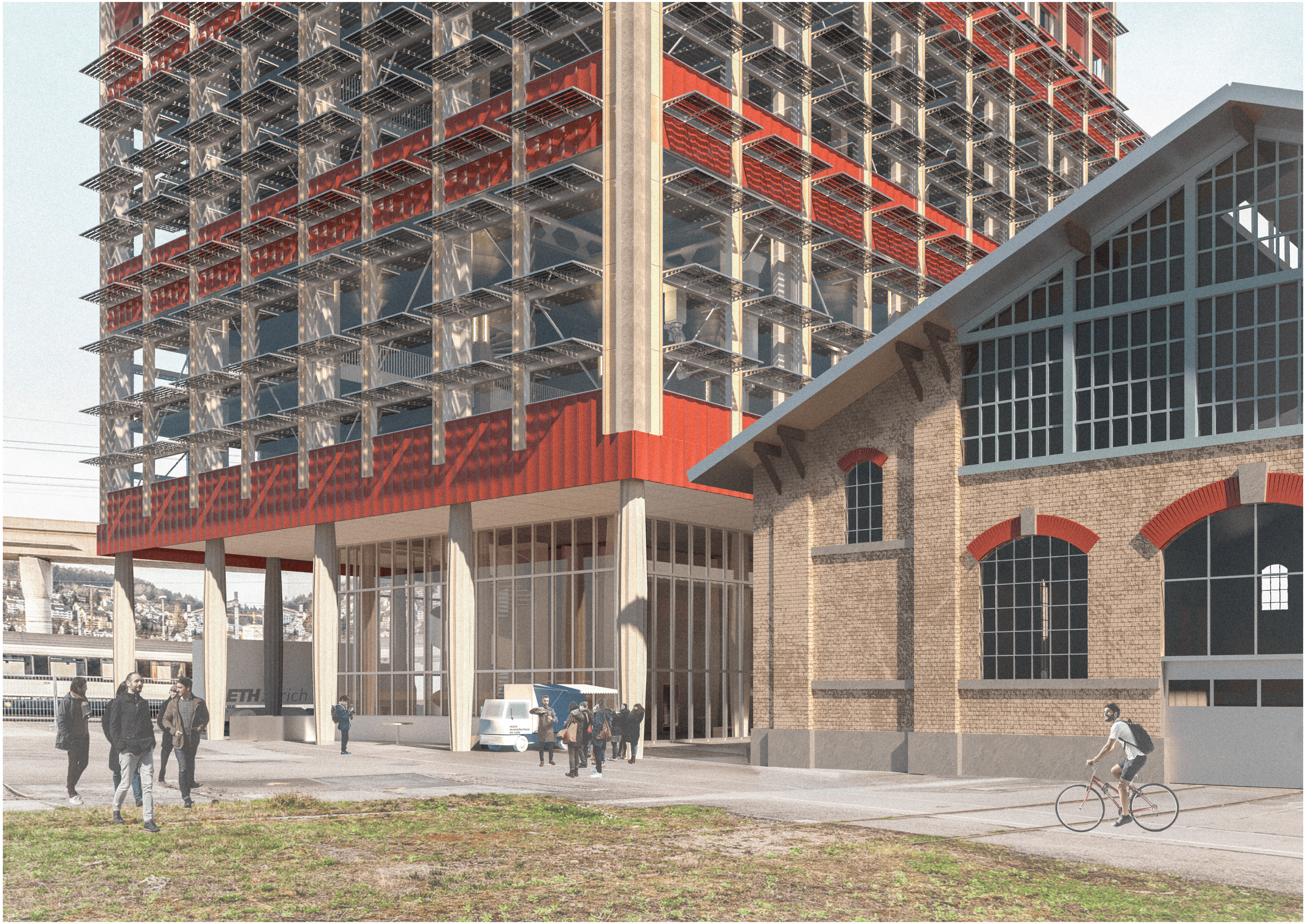
Situationsplan







Grundriss Erdgeschoss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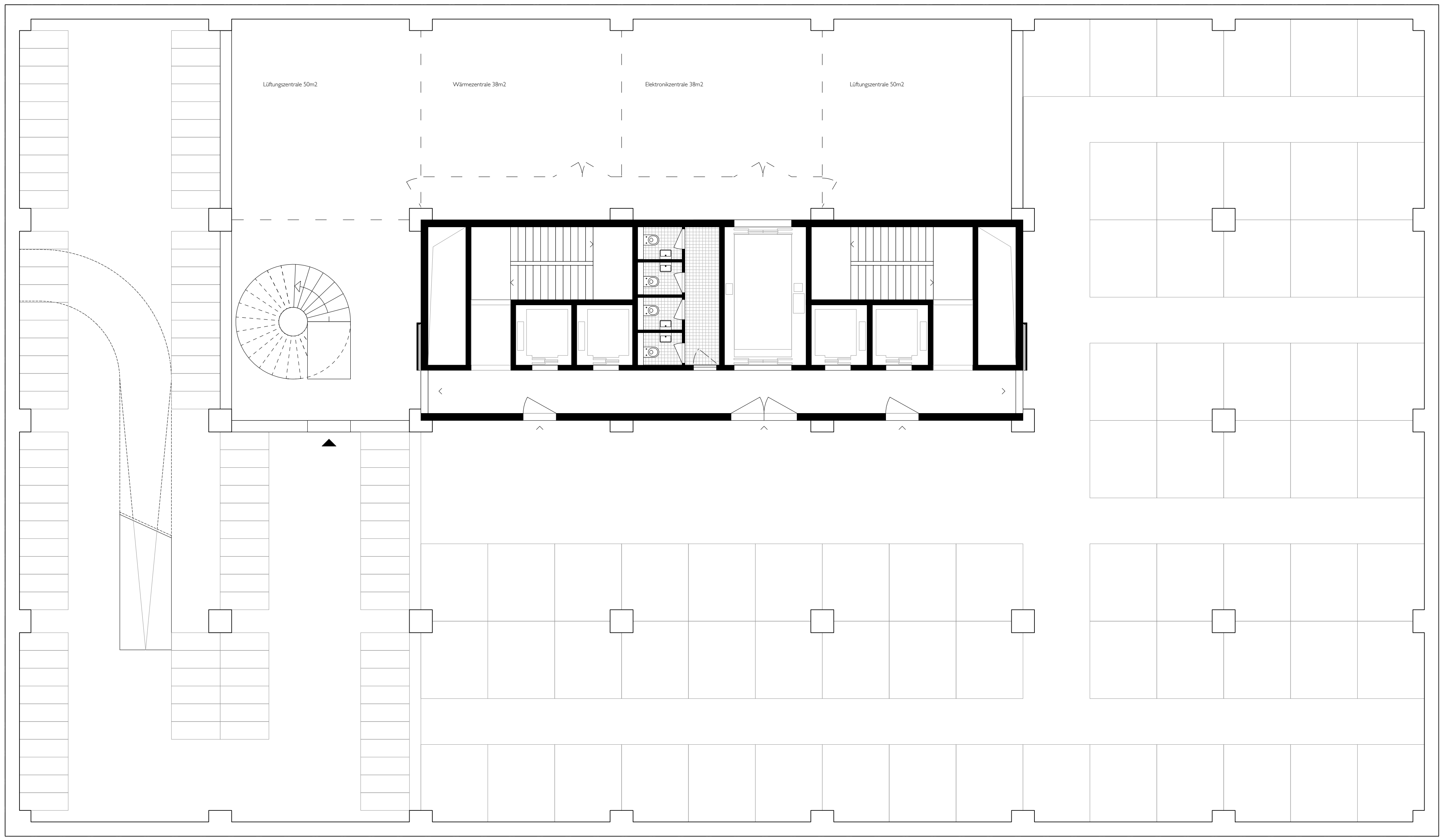
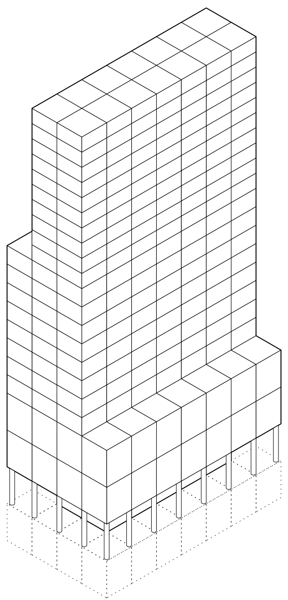
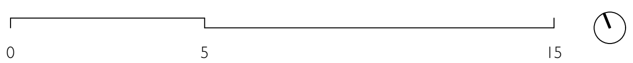
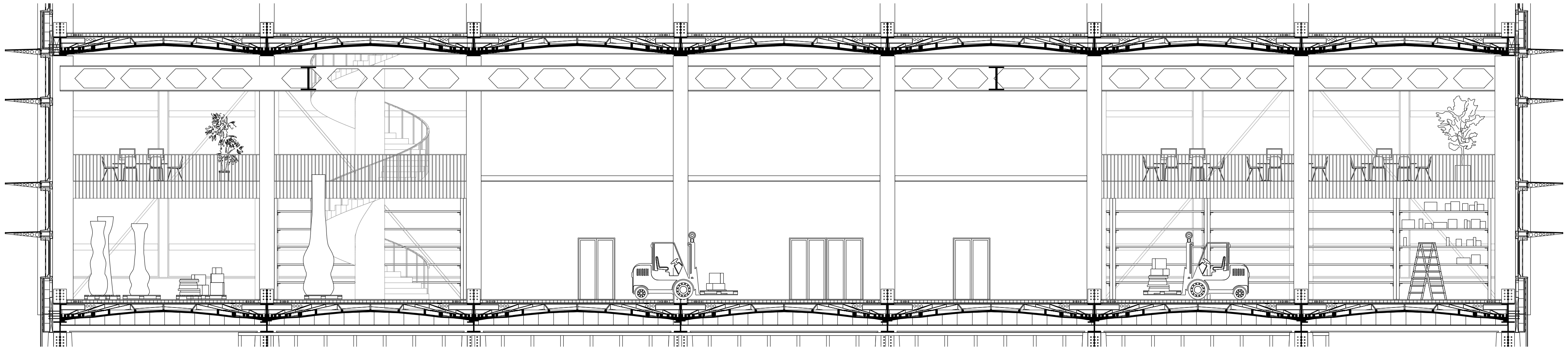
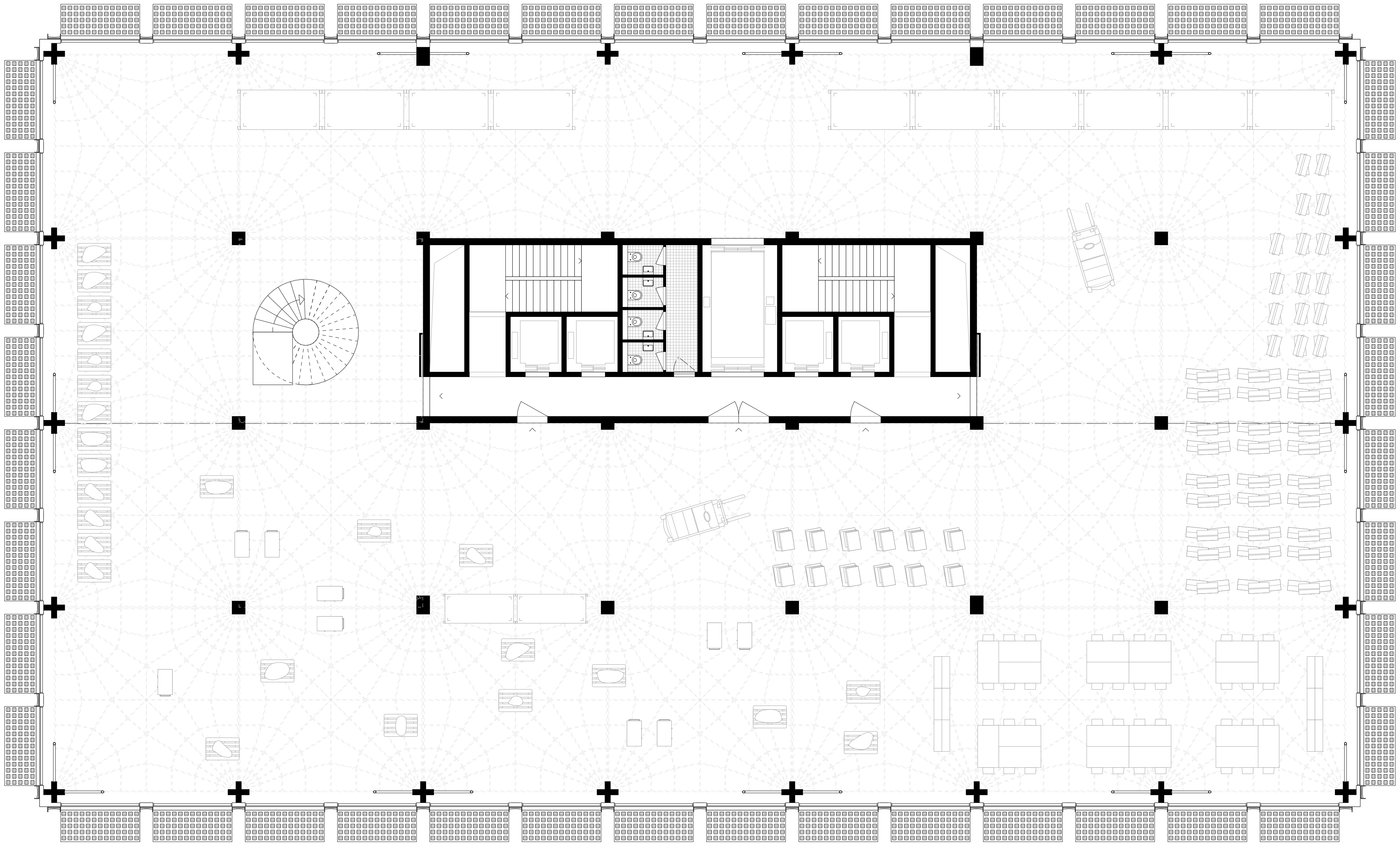


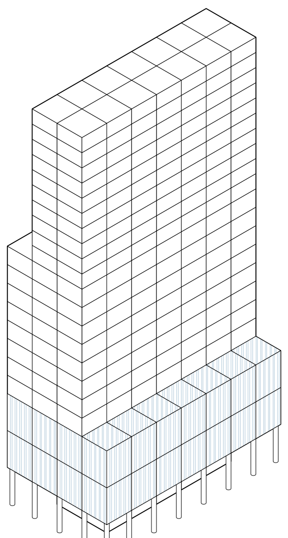




Grundriss Untergeschoss







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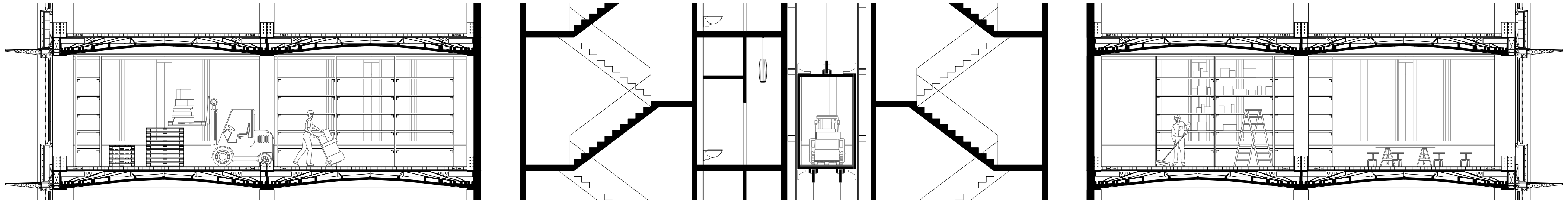
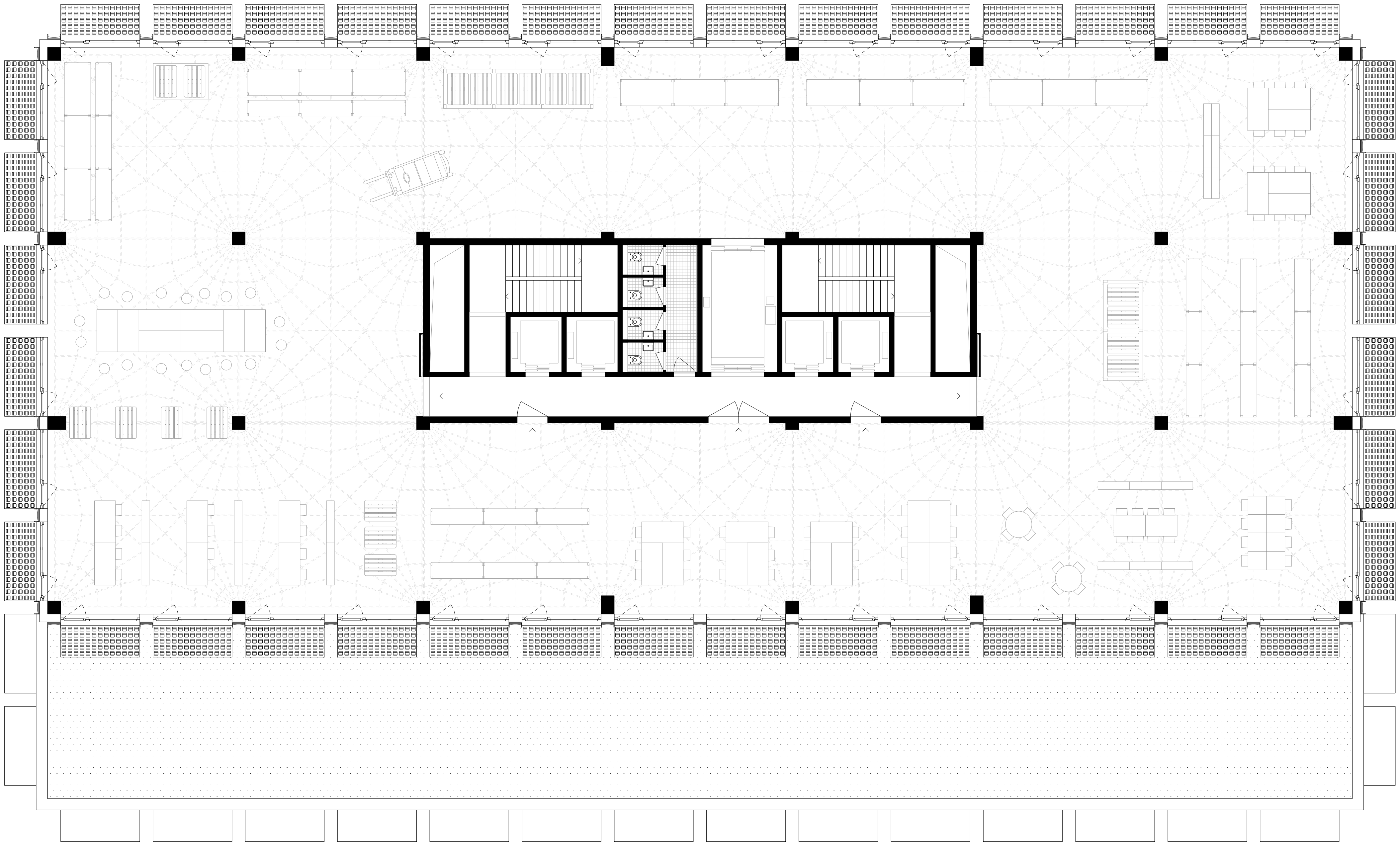
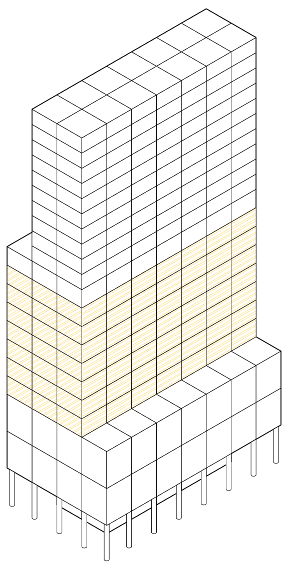
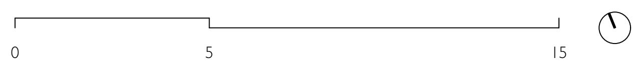
Grundriss Werkhallen

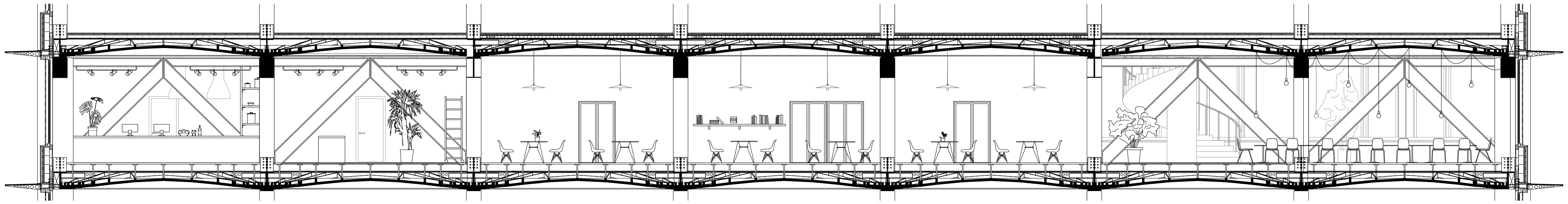


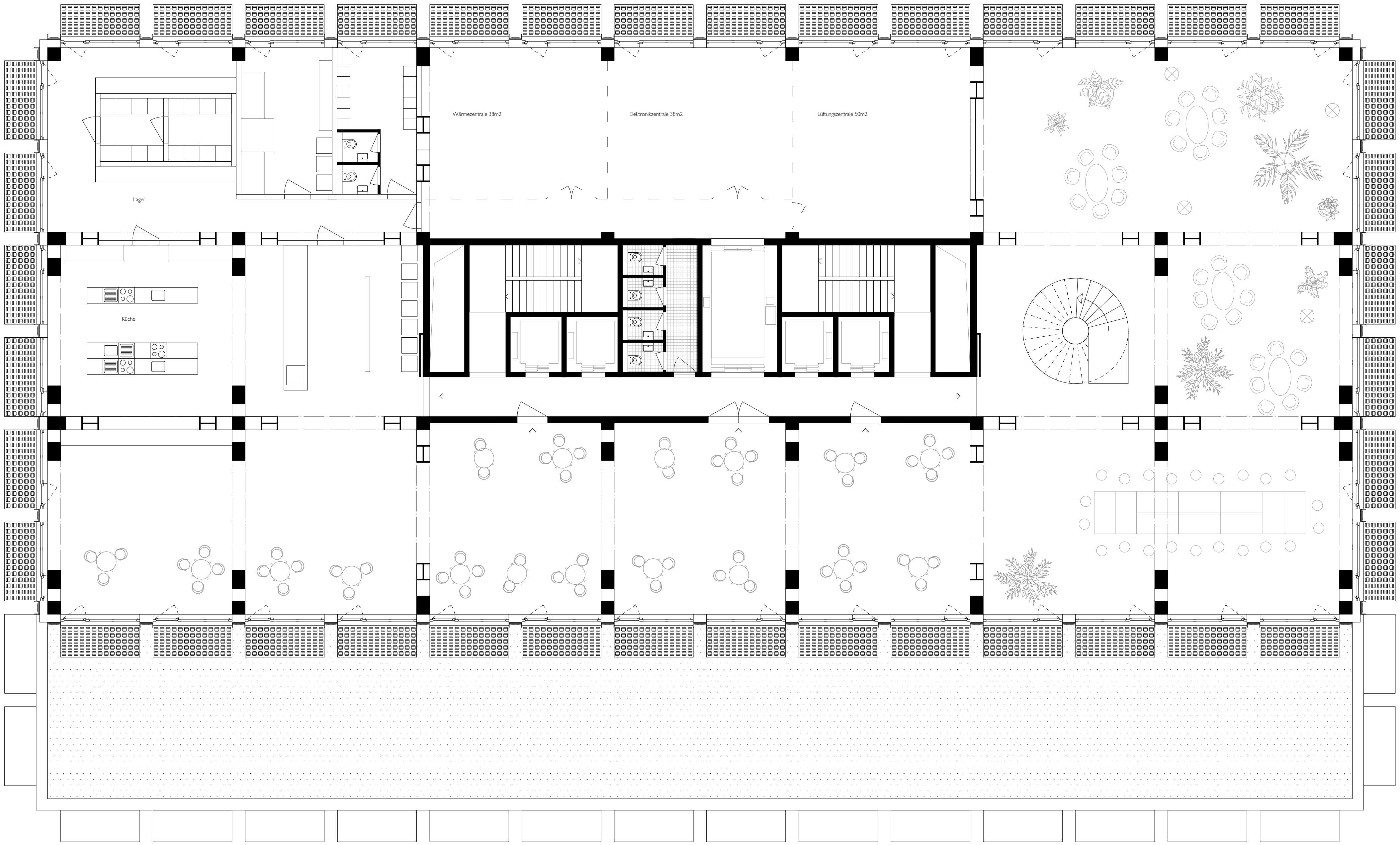


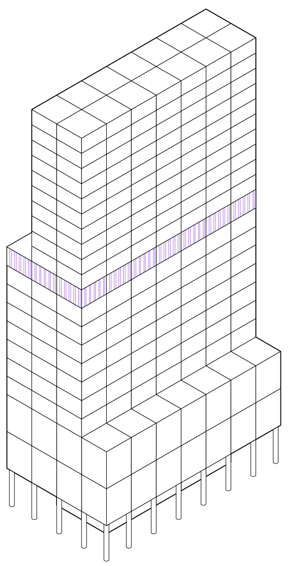


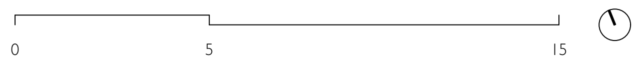


Grundriss Regelgeschoss Produktion

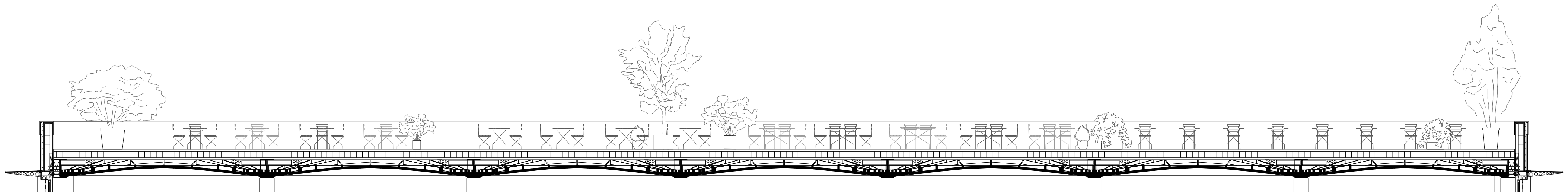


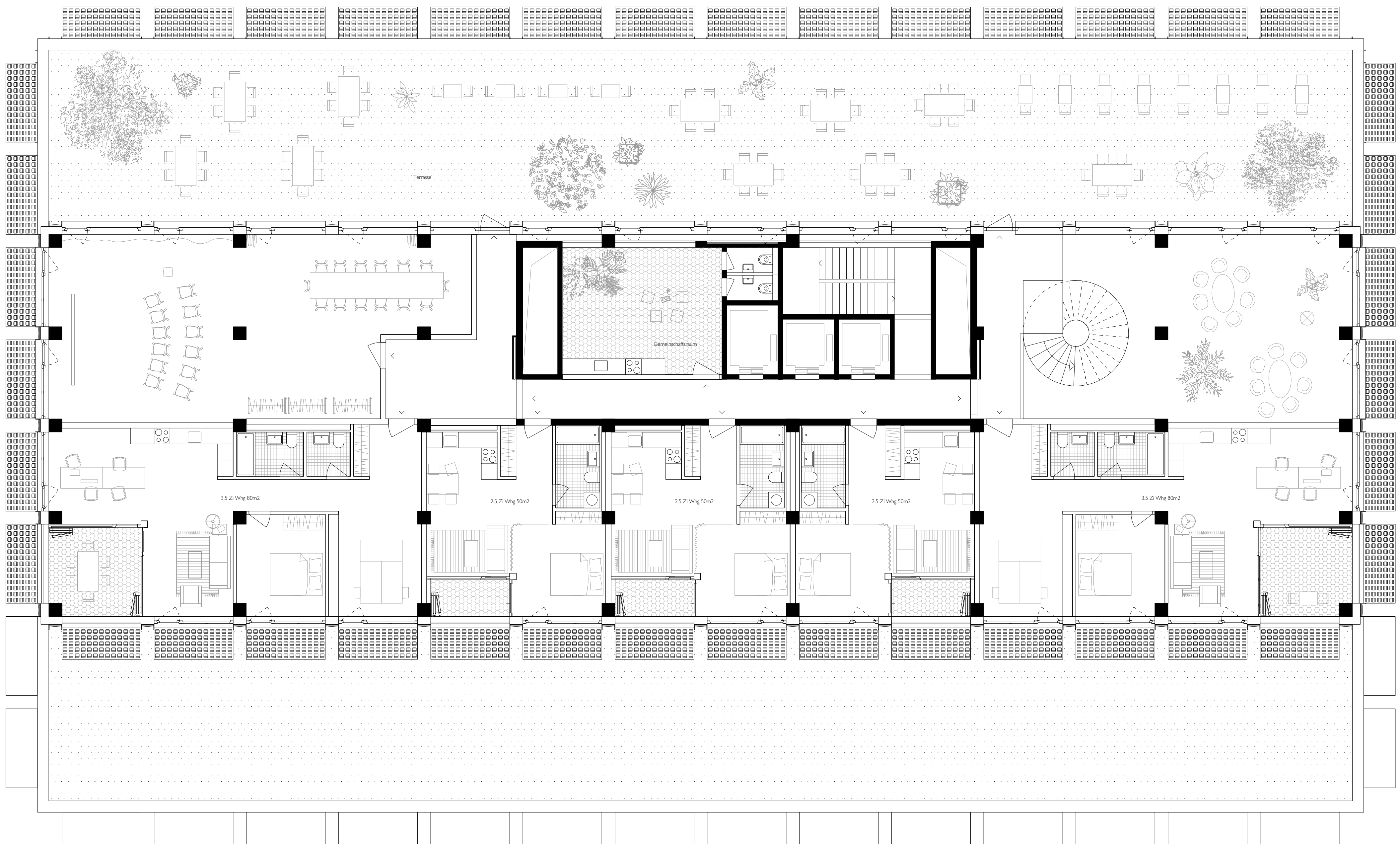


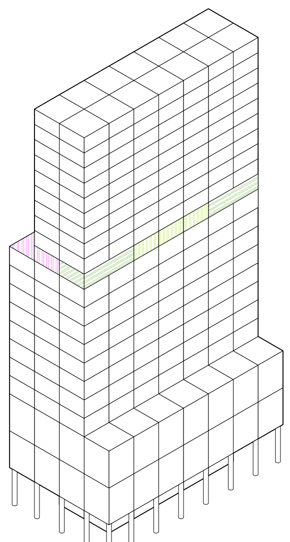


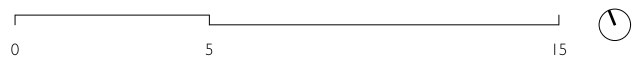


Grundriss Outrigger Geschoss

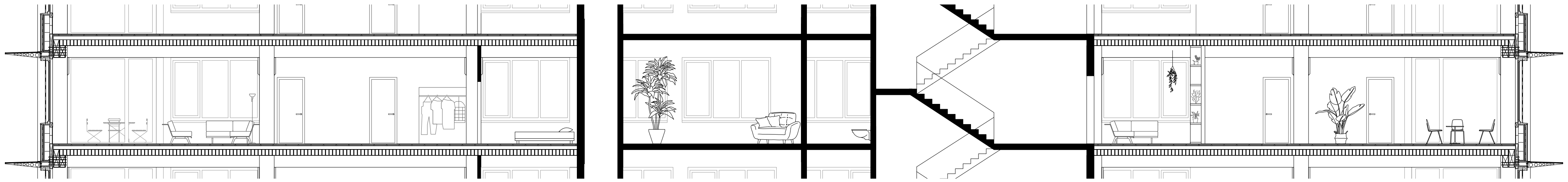


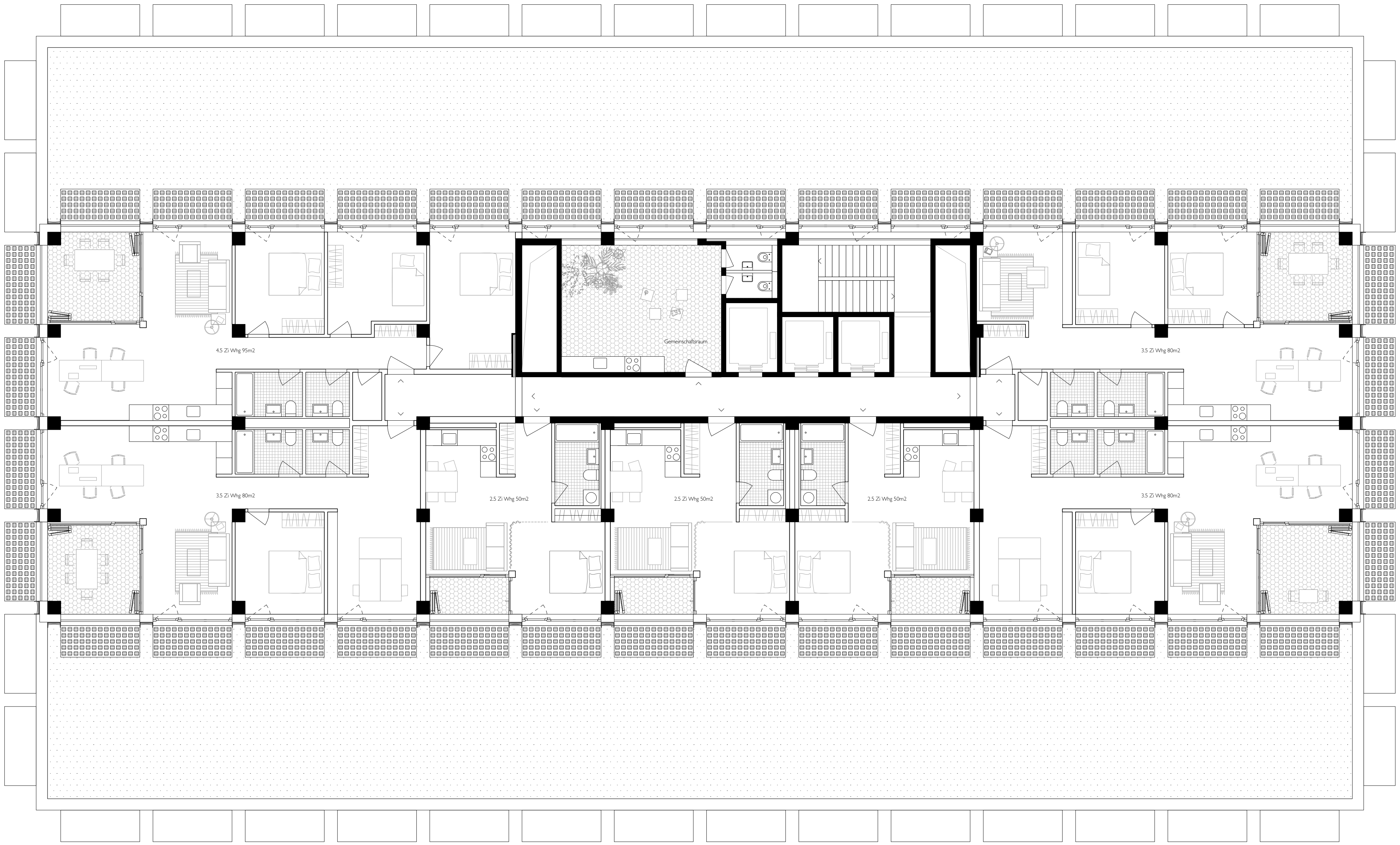


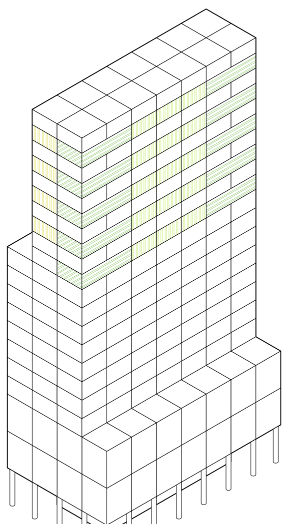




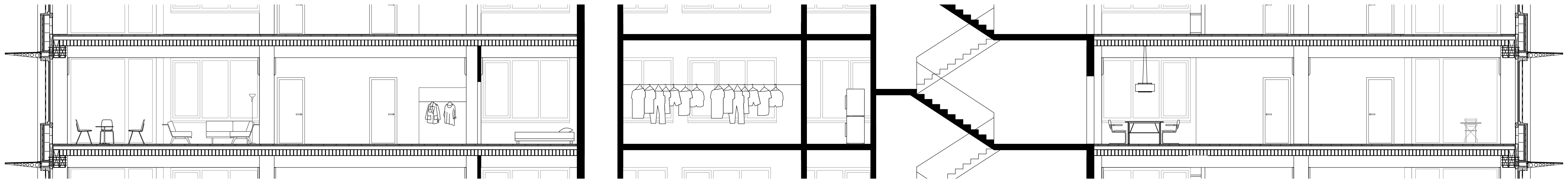
Grundriss Gemeinschaftsgeschoss

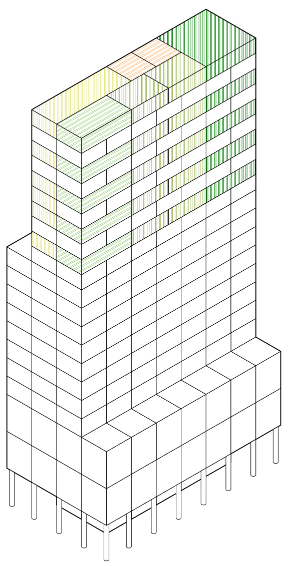


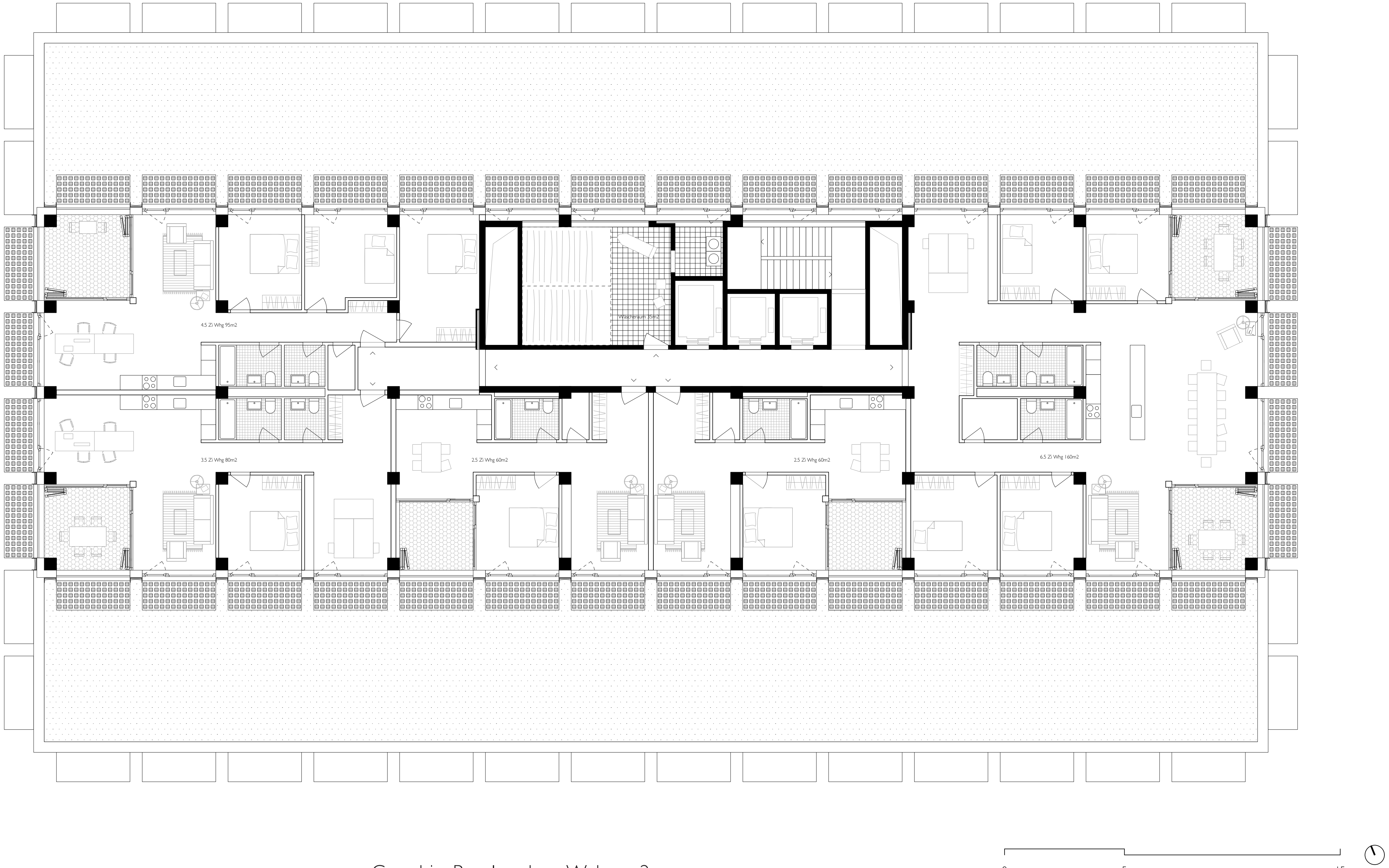




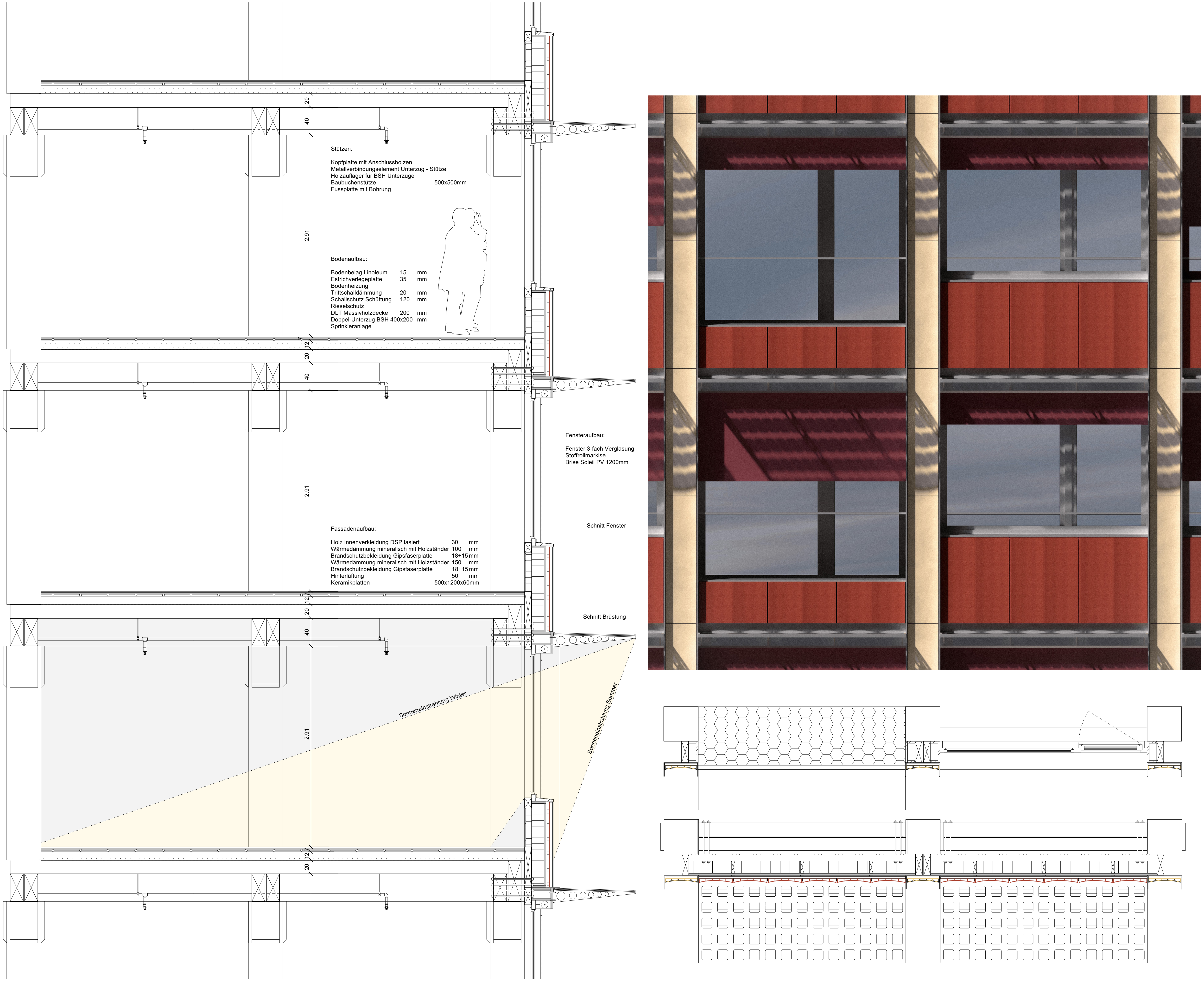
Grundriss Regelgeschoss Wohnen 1





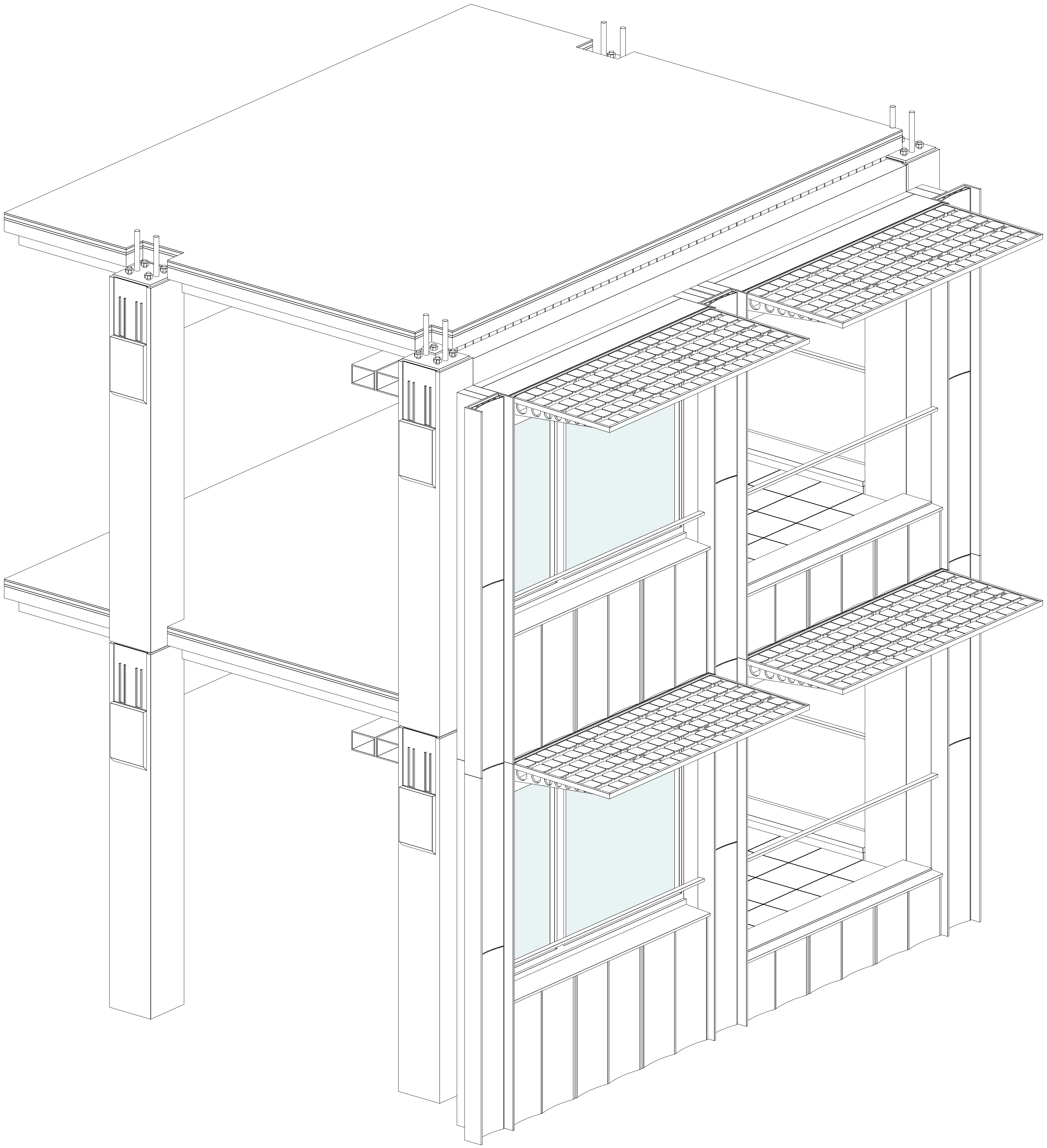


Grundriss Regelgeschoss Wohnen 2



Fassadenkonstruktion

Fassadenansicht Süd / West



Axonometrie Fassadenelement

Energiebezugsfläche

18502 m^2	90213 m^3

Thermischer Energiebedarf

Heizung	Jährlicher Bedarf	pro Tag
15 kWh/m^2	277530 kWh/a	760.4 kWh/d
Kühlung	**Jährlicher Bedarf**	**pro Tag**
6.5 kWh/m^2	120263 kWh/a	329.5 kWh/d
Wasser	**Jährlicher Bedarf**	**pro Tag**
19.8 kWh/m^2	366339.6 kWh/a	1003.7 kWh/d

Elektrischer Energiebedarf

Geräte	Jährlicher Bedarf	pro Tag
14 kWh/m^2	259028 kWh/a	709.7 kWh/d
Beleuchtung	**Jährlicher Bedarf**	**pro Tag**
4 kWh/m^2	74008 kWh/a	202.8 kWh/d
Lüftung	**Jährlicher Bedarf**	**pro Tag**
1.7 kWh/m^2	31453.4 kWh/a	86.2 kWh/d
WP Heizung	**Jährlicher Bedarf**	**pro Tag**
3.5 kWh/m^2	64541.86 kWh/a	176.8 kWh/d
4.3 JAZ		

Kältemaschine	Jährlicher Bedarf	pro Tag
1.4 kWh/m^2	26725.11 kWh/a	73.2 kWh/d
4.5 JAZ		

WP Wasser	Jährlicher Bedarf	pro Tag
5.2 kWh/m^2	96405.2 kWh/a	264.1 kWh/d
3.8 JAZ		

Energiebedarf

Thermisch	Gesamt Bedarf	pro Tag
41.3 kWh/m^2a	764132.6 kWh/m^2a	2093.5 kWh/d
Elektrisch	**Gesamt Bedarf**	**Gesamt Bedarf**
29.8 kWh/m^2a	525436.4 kWh/m^2a	1439.6 kWh/d

Ausrichtung (Abweichung von Süden) / Neigungswinkel	0°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°	90°
0°	86,5	90,0	92,9	95,3	97,3	98,7	99,6	**100,0**	99,8	99,0	97,8	96,0	93,7	90,9	87,6	83,9	79,9	75,3	70,6
5°	86,5	90,0	92,9	95,3	97,3	98,7	99,6	**100,0**	99,8	99,0	97,7	96,0	93,7	91,0	87,7	84,0	79,9	75,5	70,7
10°	86,5	89,9	92,8	95,3	97,2	98,6	99,5	**99,8**	99,6	98,9	97,6	95,9	93,6	90,8	87,6	83,9	79,9	75,5	70,7
15°	86,5	89,9	92,7	95,1	97,0	98,4	99,2	**99,5**	99,3	98,7	97,4	95,6	93,3	90,5	87,3	83,7	79,7	75,3	70,7
20°	86,5	89,8	92,6	94,9	96,7	98,0	98,8	**99,1**	98,9	98,1	96,9	95,0	92,8	90,1	87,0	83,5	79,5	75,2	70,6
25°	86,5	89,7	92,4	94,6	96,3	97,6	98,3	**98,6**	98,3	97,5	96,1	94,4	92,3	89,6	86,5	83,0	79,1	74,9	70,4
30°	86,5	89,6	92,1	94,1	95,8	97,0	97,6	**97,9**	97,5	96,7	95,5	93,8	91,6	88,9	85,8	82,4	78,6	74,4	70,1
35°	86,5	89,4	91,8	93,7	95,3	96,2	96,9	**97,0**	96,6	95,8	94,6	92,8	90,6	87,9	85,0	81,6	77,9	73,9	69,6
40°	86,5	89,2	91,4	93,2	94,5	95,5	96,0	**96,0**	95,5	94,7	93,5	91,6	89,4	87,0	84,0	80,7	77,0	73,1	69,0
45°	86,5	89,0	91,0	92,6	93,8	94,6	**95,0**	94,9	94,4	93,6	92,1	90,4	88,3	85,8	82,8	79,6	76,1	72,2	68,1
50°	86,5	88,7	90,5	92,0	93,0	93,6	**93,9**	93,7	93,2	92,1	90,7	89,0	87,0	84,4	81,4	78,4	74,9	71,2	67,3
55°	86,5	88,5	90,1	91,3	92,1	92,6	**92,7**	92,4	91,7	90,7	89,3	87,6	85,3	82,7	80,1	77,0	73,6	69,9	66,2
60°	86,5	88,3	89,6	90,5	91,1	**91,4**	91,3	91,0	90,7	89,0	87,6	85,9	83,6	81,2	78,5	75,5	72,1	68,7	65,0
65°	86,5	88,0	89,0	89,7	90,1	**90,2**	89,9	89,4	88,5	87,3	85,9	84,0	81,9	79,6	76,8	73,7	70,6	67,3	63,6
70°	86,5	87,7	88,4	88,9	**89,0**	88,9	88,4	87,9	86,8	85,6	84,0	82,1	80,0	77,6	74,9	72,0	69,0	65,7	62,1
75°	86,5	87,4	87,9	**88,0**	87,9	87,6	87,0	86,1	85,0	83,7	82,0	80,1	78,0	75,6	72,9	70,2	67,3	63,9	60,6
80°	86,5	87,1	**87,3**	87,1	86,7	86,2	85,4	84,4	83,1	81,7	79,9	78,1	75,9	73,5	71,0	68,2	65,3	62,1	59,0
85°	86,5	**86,7**	86,6	86,2	85,6	84,7	83,8	82,6	81,2	79,6	77,9	75,9	73,7	71,3	68,8	66,1	63,2	60,3	57,3
90°	**86,5**	86,4	86,0	85,3	84,4	83,3	82,1	80,7	79,2	77,5	75,6	73,6	71,4	69,0	66,6	63,9	61,2	58,4	55,3
95°	**86,5**	86,1	85,3	84,4	83,1	81,9	80,4	78,8	77,1	75,3	73,3	71,3	69,0	66,7	64,3	61,6	59,0	56,2	53,3
100°	**86,5**	85,9	84,7	83,4	81,9	80,3	78,6	76,8	75,0	73,0	71,0	68,9	66,7	64,4	61,9	59,3	56,8	54,1	51,3
105°	**86,5**	85,5	84,1	82,4	80,7	78,8	76,9	74,9	72,8	70,8	68,7	66,5	64,2	61,9	59,5	57,0	54,5	51,9	49,3
110°	**86,5**	85,2	83,5	81,6	79,5	77,3	75,1	72,9	70,7	68,5	66,3	64,0	61,8	59,5	57,0	54,7	52,1	49,7	47,3
115°	**86,5**	84,9	82,9	80,7	78,3	75,9	73,3	71,0	68,5	66,2	63,9	61,6	59,3	57,0	54,6	52,3	49,9	47,6	45,2
120°	**86,5**	84,6	82,3	79,8	77,1	74,4	71,6	69,0	66,4	63,9	61,5	59,1	56,8	54,5	52,2	50,0	47,7	45,5	43,1
125°	**86,5**	84,4	81,8	79,0	76,0	73,0	70,0	67,0	64,3	61,6	59,1	56,7	54,4	52,1	49,9	47,7	45,5	43,3	41,3
130°	**86,5**	84,1	81,2	78,1	74,9	71,6	68,4	65,3	62,2	59,5	56,8	54,4	52,0	49,8	47,6	45,5	43,5	41,4	39,4
135°	**86,5**	83,9	80,7	77,4	73,9	70,4	66,9	63,5	60,3	57,3	54,6	52,1	49,8	47,6	45,5	43,4	41,4	39,5	37,6
140°	**86,5**	83,6	80,3	76,7	73,0	69,2	65,5	61,9	58,5	55,3	52,5	49,9	47,6	45,4	43,4	41,5	39,6	37,8	36,0
145°	**86,5**	83,4	79,9	76,1	72,0	68,1	64,2	60,5	56,9	53,6	50,6	47,9	45,6	43,4	41,5	39,6	37,9	36,1	34,5
150°	**86,5**	83,3	79,5	75,5	71,4	67,3	63,3	59,3	55,6	52,1	48,8	46,1	43,6	41,6	39,6	37,9	36,3	34,7	33,1
155°	**86,5**	83,0	79,2	75,0	70,4	66,4	62,4	58,4	54,5	50,8	47,4	44,4	41,9	39,9	38,0	36,4	34,8	33,3	31,9
160°	**86,5**	83,0	78,9	74,6	70,1	65,9	61,7	57,6	53,6	49,9	46,3	43,1	40,4	38,3	36,5	35,0	33,5	32,1	30,8
165°	**86,5**	82,8	78,7	74,3	69,7	65,4	61,2	57,0	53,0	49,1	45,5	42,1	39,3	37,0	35,3	33,9	32,4	31,2	29,9
170°	**86,5**	82,7	78,5	74,0	69,4	65,0	60,8	56,6	52,5	48,6	44,9	41,5	38,5	36,1	34,4	33,0	31,6	30,4	29,3
175°	**86,5**	82,7	78,4	73,9	69,3	64,9	60,6	56,4	52,2	48,3	44,5	41,1	38,1	35,6	33,9	32,4	31,2	29,9	28,8
180°	**86,5**	82,7	78,4	73,8	69,2	64,8	60,5	56,3	52,1	48,1	44,4	41,0	37,9	35,5	33,7	32,3	31,0	29,8	28,7

Ertrag PV Dach Ost/West

Global Radiation	Irrad. Area	Module Surf.	Module Effi.	Perf. Ratio	Jährlicher Ertrag	Flächen Ertrag
1200 kWh/m^2a	0.86 %	550 m^2	0.21 %	0.7 %	83437.2 kWh/a	151.704 kWh/m^2a

Ertrag Fassade PV Süd

Global Radiation	Irrad. Area	Module Surf.	Module Effi.	Perf. Ratio	Jährlicher Ertrag	Flächen Ertrag
1200 kWh/m^2a	0.97 %	1310 m^2	0.21 %	0.65 %	208140.7 kWh/a	158.886 kWh/m^2a

Ertrag Fassade PV Ost/West

Global Radiation	Irrad. Area	Module Surf.	Module Effi.	Perf. Ratio	Jährlicher Ertrag	Flächen Ertrag
1200 kWh/m^2a	0.84 %	1094 m^2	0.21 %	0.65 %	150525.6 kWh/a	137.592 kWh/m^2a

Ertrag Fassade PV Nord

Global Radiation	Irrad. Area	Module Surf.	Module Effi.	Perf. Ratio	Jährlicher Ertrag	Flächen Ertrag
1200 kWh/m^2a	0.69 %	1310 m^2	0.21 %	0.65 %	148058.8 kWh/a	113.022 kWh/m^2a

Ertrag PV-Thermie Dach

Global Radiation	Irrad. Area	Module Surf.	Module Effi.	Perf. Ratio	Jährlicher Ertrag	Flächen Ertrag
1200 kWh/a	0.8 %	2615 m^2	0.6 %	0.65 %	979056 kWh/a	374.4 kWh/m^2a

Energiebilanz

Elektrizitätsbedarf	Ertrag PV	Eigenenergieversorgung
525436.4 kWh/a	590162.3 kWh/a	112.32 %

Termische Energiebilanz

Elektrizitätsbedarf	Ertrag PV-Thermie	Eigenenergieversorgung
764132.6 kWh/a	979056 kWh/a	128 %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