

**hidden theatre**  
A THEATRE FOR NAUMBURG

Laura Oliveira Teixeira

# hidden theatre

## A THEATRE FOR NAUMBURG

**Master thesis in Building Architecture**

Politecnico di Milano

School of Architecture, Urban Planning and Construction Engineering

Author:

**Laura Oliveira Teixeira** | 883451

Advisor:

**Maria Grazia Folli** | Architectural Composition

**Corrado Pecora** | Structural Design

**Francesco Romano** | Building Services

**Giovanni Dotelli** | Technology of Materials

**Lavinia Chiara Tagliabue** | BIM Technology

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BUILDING SERVICES

BIM

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## ABSTRACT

*Il progetto visa a rivitalizzare l'area complessa della ex prigione di Naumburg, inserendo il nuovo teatro cittadino per fornire un equipaggiamento culturale e uno spazio pubblico all'aperto per la vita civile. Il progetto proposto esplora l'uso dello spazio sotterraneo come strategia per rispettare il paesaggio della città storica e del complesso edilizio, consentendo al contempo l'uso della superficie libera del suolo come spazio pubblico verde.*

*Il paesaggio medievale di Naumburg in Sassonia Anhalt, a Germania, è ben riconosciuto, avendo conquistato il patrimonio mondiale dell'UNESCO alla sua cattedrale nel 2018. La regione fa anche parte del paesaggio dell'Alto Medioevo dei fiumi Saale ed Unstrut, caratterizzato da una morfologia urbana unica e preservato paesaggio rurale.*

*Questa proposta è situata in un contesto complesso, con il suo contesto urbano, il suo patrimonio e la sua vitalità rappresentano un'opportunità di rigenerazione urbana per preservare la sua identità, valore e potenziale.*

The project aims to revitalize the complex area of the former prison of Naumburg, inserting the new town theatre to provide a cultural equipment and outdoor public space for the civil life. The proposed design explores the use of the underground space as a strategy to respect the landscape of the historical city and the building complex while allowing the use of the free ground surface as a green public space.

The medieval landscape of Naumburg in Saxony Anhalt, Germany is well recognized, having earned the UNESCO World Heritage Site to its cathedral in 2018. The region is also part of the High Medieval landscape of the rivers Saale and Unstrut, characterized by a unique urban morphology and preserved rural landscape.

This proposal is situated in a complex context, with an urban setting, heritage and social vitality that represents an opportunity of urban regeneration and to demonstrate its unique identity, value and potential.

THEME







The town of Naumburg holds since 2018, one of the Unesco World Heritage Sites, the Naumburg Cathedral, the cathedral is considered a testimony of medieval art and architecture, dating back to the 13th century.

The addition to Unesco list was allowed given the uniqueness and representativeness of the building. The medieval town is also the center of the regions of the rivers Saale and Unstrut, with a characteristic landscape that has also been proposed to join the list.

The High Medieval Cultural landscape of the rivers Saale and Unstrut is representative of particular urban morphology, vineyards, monuments and preserved rural landscape.

In 1855, a courthouse with pre-trial detainees building was built, which later, with new building additions, became a prison for about 150 cells, with the courthouse as the prison's central administration building. The prison was closed officially in 2012. The former prison buildings are located in a plot that today establishes an ending to the axi-ality present in between the bishop and civil towns and reinforced by the gates. This point also works as a stitch between three main roads in the south-west portion of Naumburg.



The prison plot represents a big interruption in the dynamic of the urban fabric. Located in the junction of the main roads and surrounded by 4m walls, the site divides two different zones of Naumburg, to the north, the civil and bishop town can be found, respectively to the west and east of Louisestrasse, and to the south, the residential zone.

This junction point has great potential of becoming a quality public space, giving continuity to the sequence of spaces and to the green areas along the city. With the proposed demolition of the late additions part of the complex, a large area gives opportunity to the implementation of a park, delimited by the site walls and the prison buildings, but allowing the free movement between north and south.

Naumburg has received performances on its first formal theatre, the Reichskrone, in Theatreplatz, since 1883. During the 90's the city theatre moved to the town council building, but the conditions are precarious to receive this use.

In the proposed design for the new theatre, the theatre foyer, auditorium and backstage activities are distributed in the underground spaces, below a park, and communicate to the existing buildings, with secondary access.

Although the underground spaces are still reminiscent of technical, secondary spaces, disprovided of environmental quality, the potential of these spaces can be explored with recognized architectural representation that can be traced as back as the 12th century, in Lalibela, exploring the underground as a mainly design choice.

This setting gives freedom to the community to occupy and define the character of the new public space, the cultural building doesn't aim to become a landmark but to operate as a urban process of requalification of public spaces while fostering the quality for the city life.





MASTERPLAN



Along the city green ring of public spaces, the main buildings of the municipality can be found, usually accompanied by a mineral square for public use and realization of events and street markets, this sequence of spaces enrich the urban fabric and social life. The proposal emphasizes the presence of the existing axis in the green ring aligned with the studied plot, giving continuity to the dynamic inside the plot, passing by the Royal Court and the two successive buildings, placed in sequence, that are part of the prison complex and are followed by the residential zone.

On the new proposed masterplan, the existing axuality remains while a new dynamic is developed to receive the Theatre for the city of Naumburg. The Royal Court building is kept as the main access and its position, scale and style are respected minimizing the contrast on the new volumes and enhancing its hierarchy with the landscape.

The maintained buildings are the ones that were originally built as part of the complex, and the posterior additions, from when the court and detainee house were extended into a proper prison, were removed.

The use of the underground as an inhabited space is proposed in order to house the auditorium, workspaces and all technical requirements without

interfering with the over ground landscape and to avoid greater contrast with the existing built.

To achieve a good relation between the existing and new, a second axis, in parallel, is defined to receive the additional volumes, having direct correspondence between their uses, in a gradient distribution of public and private and a specific balance between the over ground and underground.

The points of contact between these surfaces are explored using tunnels, vertical elements and visual connections. With the extensive use of the underground, the preserved buildings are sided by a large grass area, interrupted by the Fly Tower that erupts from the central portion as an extrusion that becomes the central piece of the collective of objects in the complex.

The centrality of the fly tower box is explored as an abstract element with reuse of the stones sourced on site to compose the facade, exploring the site materiality. The surface can be used for projections of open-air screen exhibition and/or advertise for the theatre activities. With almost the entire new building being underground, the existence of the sealed box, the Fly Tower, is empowered, attracting the community interest and provoking curiosity on the extension of the construction.

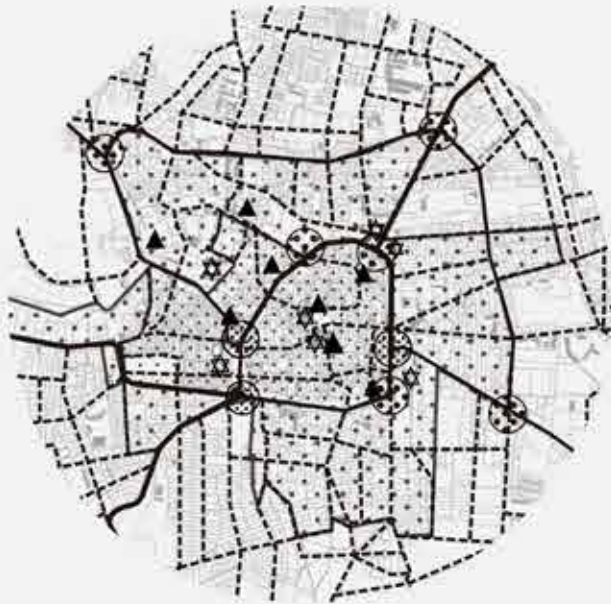


**NAUMBURG 1:5000**





## IMAGE OF THE CITY 1:10000



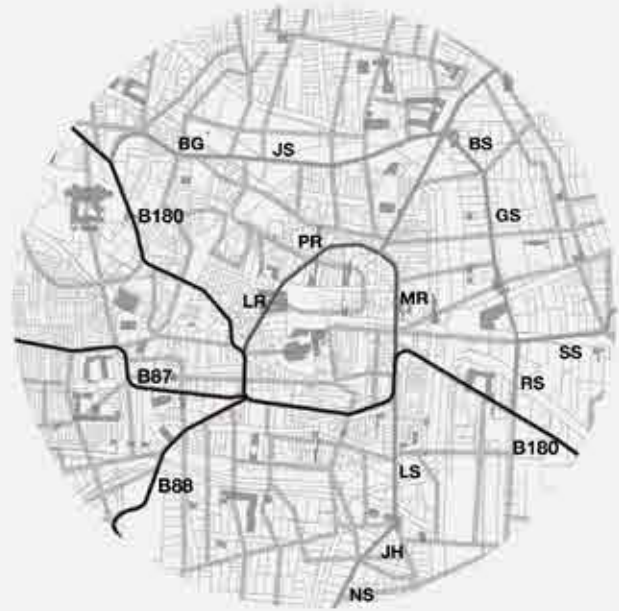
**Paths**  
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 - - -

**Districts**  
 • • • •  
 • • • •

**Floods**  
 ● ● ● ●  
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**Monuments**  
 ☆ ▲

## FRAMEWORK 1:10000

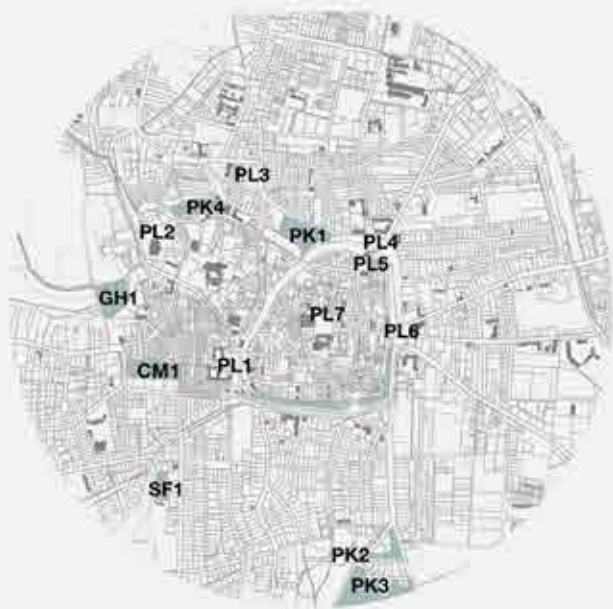


BG Biala Gostynia Bridge  
 B87 Białystok  
 B88 Białystok  
 LR Łódź  
 MR Mysłowice  
 B180 Białystok  
 LS Łódź  
 JH Jastrzębie  
 NS Nowy Sącz

RS Rybnik  
 GS Gostynin  
 PR Płock  
 SS Sosnowiec  
 RS Rybnik  
 B180 Białystok  
 LS Łódź  
 JH Jastrzębie  
 NS Nowy Sącz

HN Hłubka  
 JS Jastrzębie  
 BS Białystok  
 BS Białystok  
 BS Białystok  
 Wł. First-Class  
 Class

## GREEN BELT 1:10000

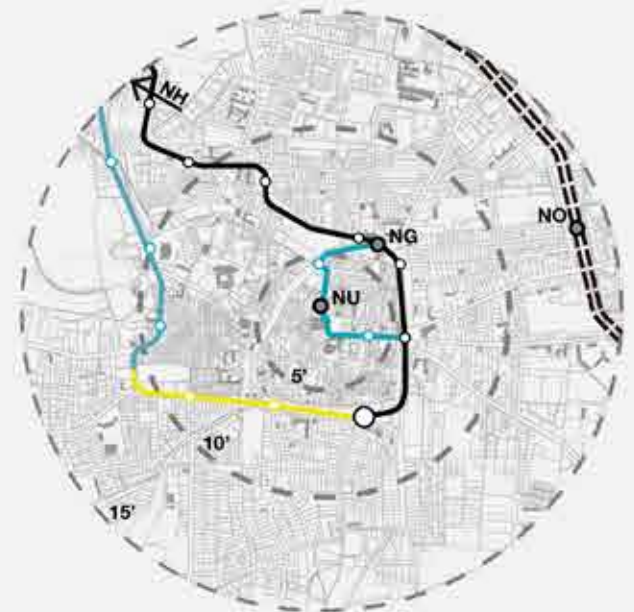


PK1 Gedung  
PK2 Gedung  
PK3 Gedung  
PK4 Gedung

PL1 Menengah  
PL2 Dikotak  
PL3 Lapangan  
PL4 Villa-Swirlan (Atr)  
PL5 Menengah  
PL6 Menengah  
PL7 Menengah

SF1 South Facility/Perumahan  
GH1 Hill Mikros Dataran  
CM1 Cemetery St. Omer  
DND Cemetery luar Persekol

## TRANSPORTATION 1:10000



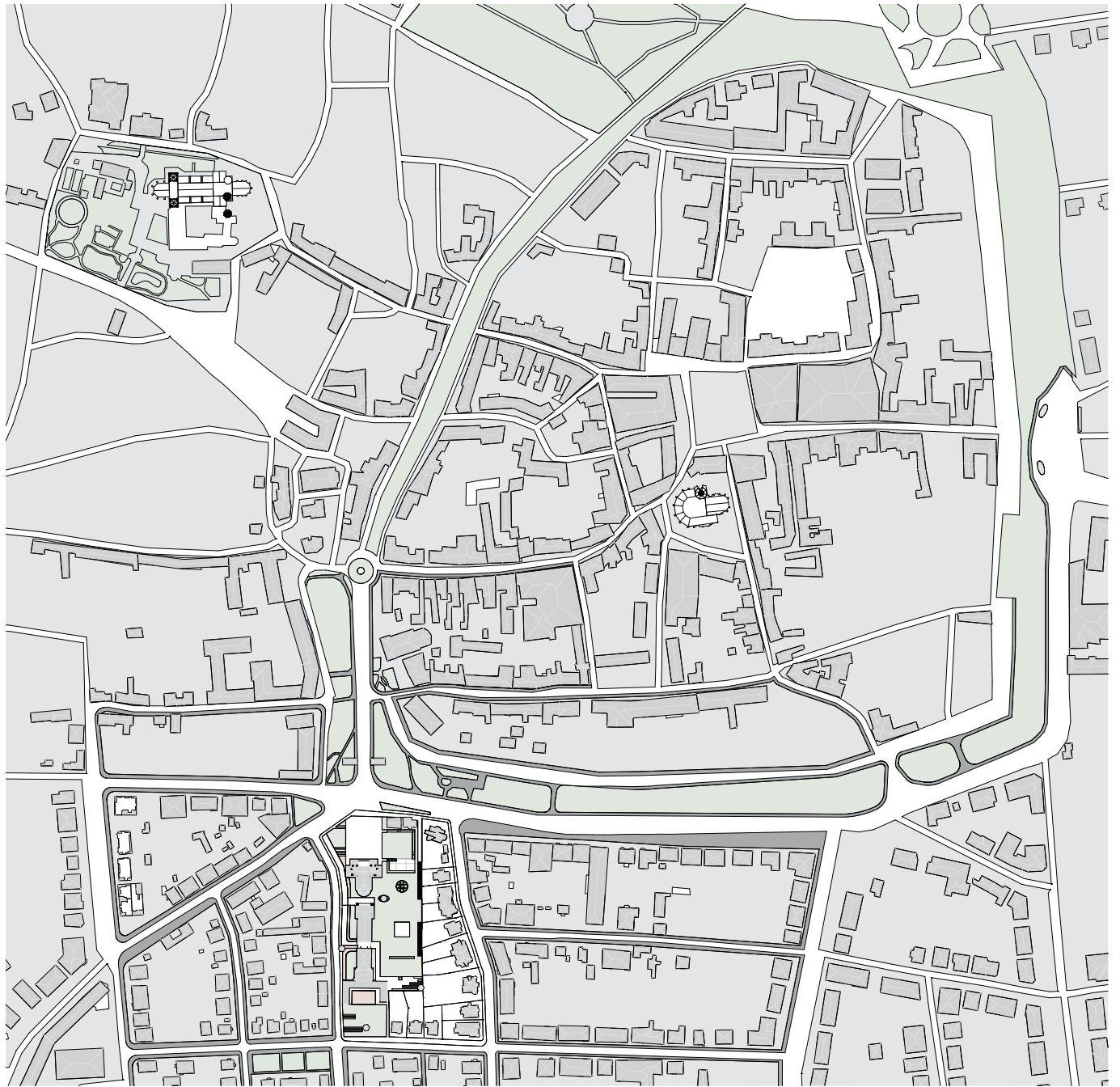
Stasiun

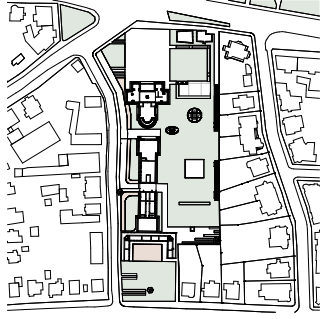
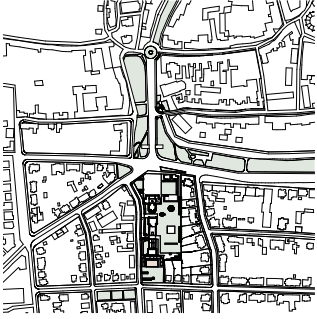
NH Stasiun Ng. Satrio (Atr)  
NH Stasiun Satrio (D)  
NU Stasiun Satrio (Atr) (A)  
NG Stasiun Satrio (Atr) (Atr)

Distrik

IC  
ICB  
IBB  
IB









THEATRE

The theatre components are design to bring the audience closer to the cast and production, creating awareness of the acting universe.

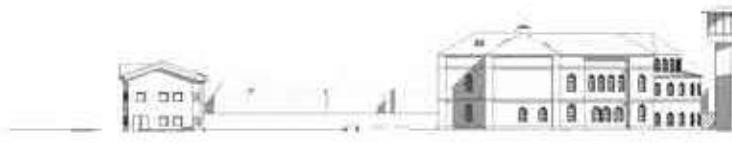
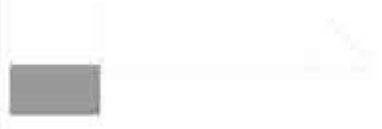
The main access starts from the Royal Court, followed by a tunnel that brings the audience to the gallery where a central spiral staircase leads to the theatre foyer, bcrowned by a large skylight that adds lightness and quality to this space.

The secondary access is from a ramp, with more public character, from where the gallery's visitors can access partially the building. From the foyer, a linear path arrives to the back of the auditorium, with the stage as the central viewpoint.

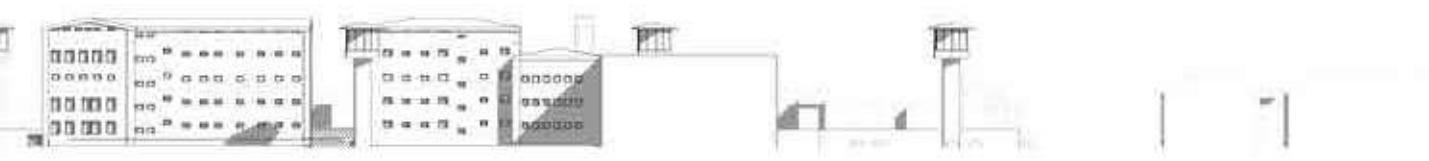
This volume is designed with shape and materials to provide an optimal acoustic condition to the plays and spectacles, as well as a better relationship between the audience and actors. The main elements of the stage, the apron and the proscenium, are shaped to be the defined focus point in contrast with the surroundings.

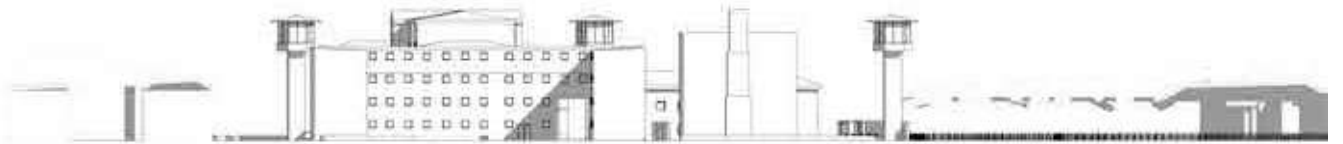


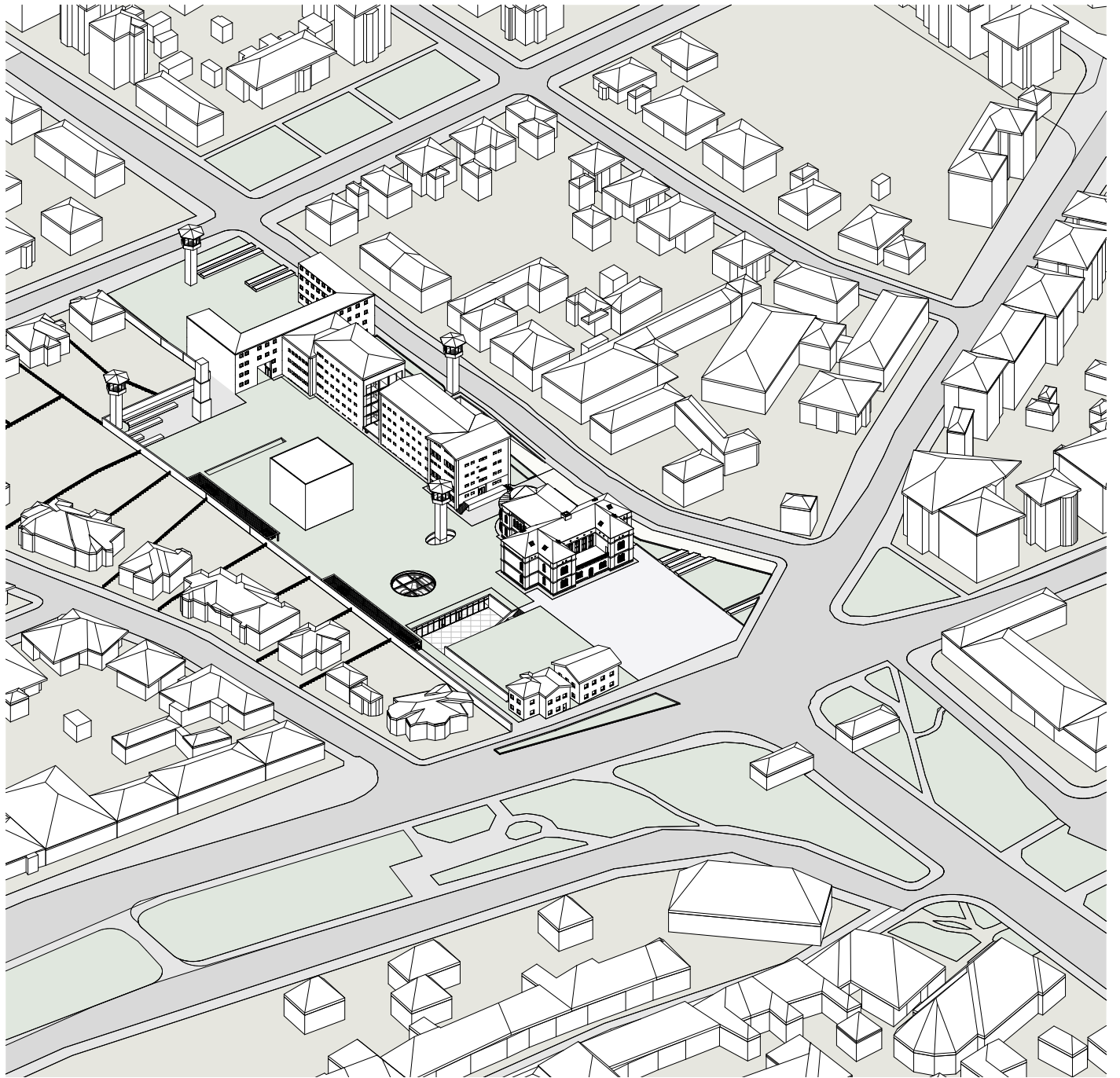


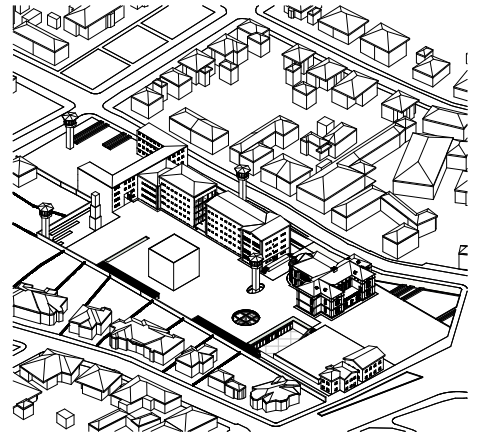
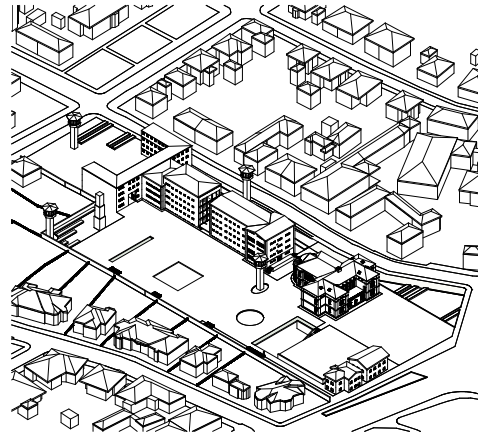
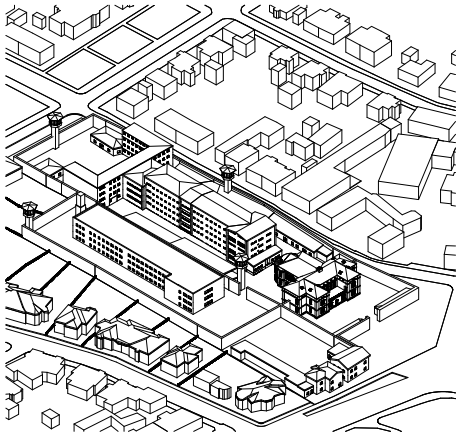


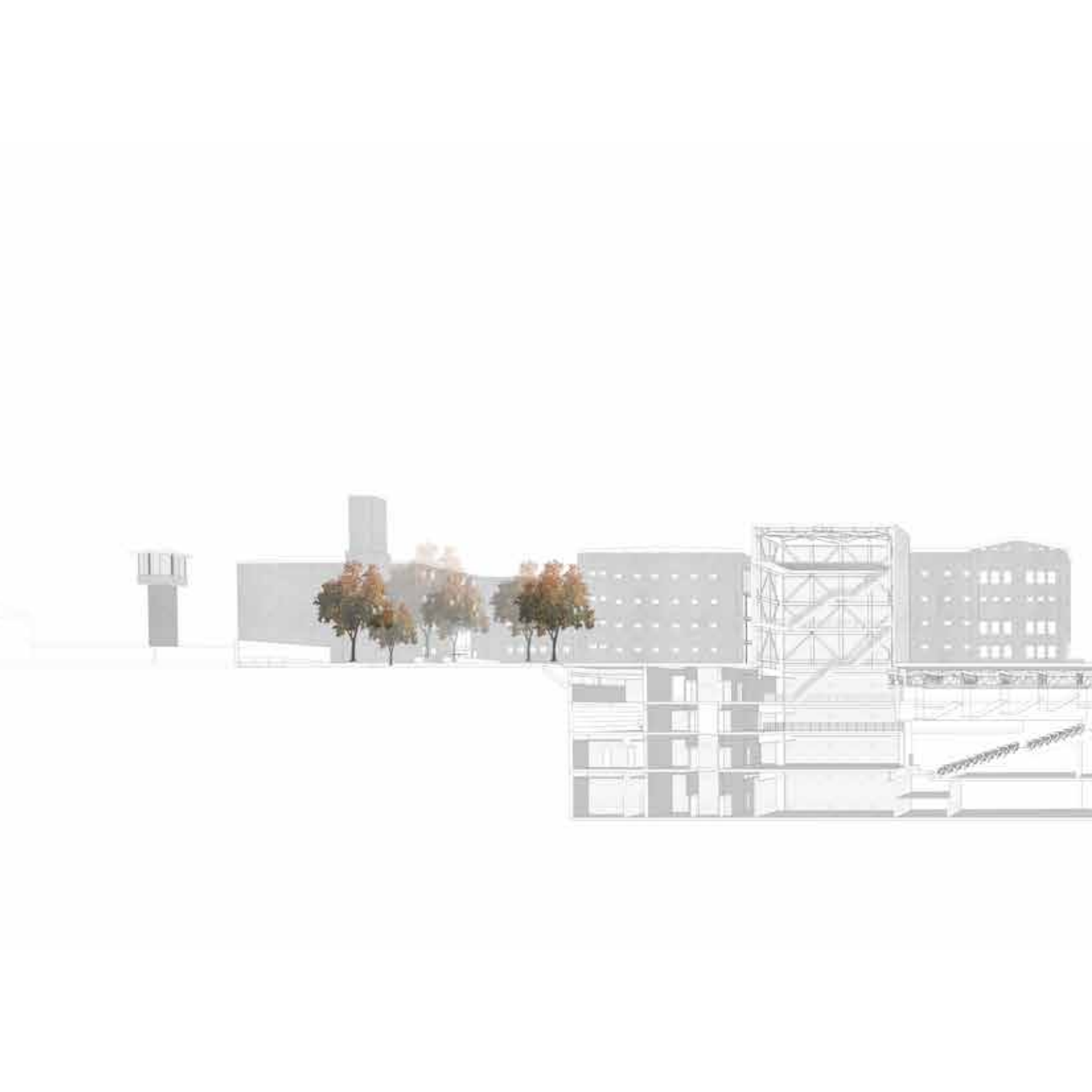


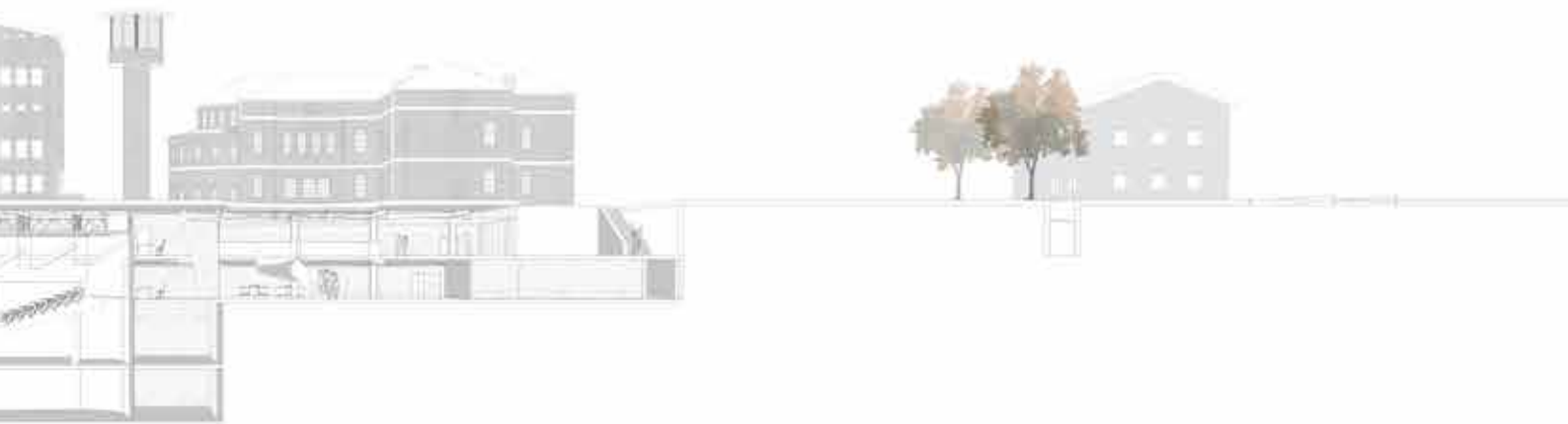


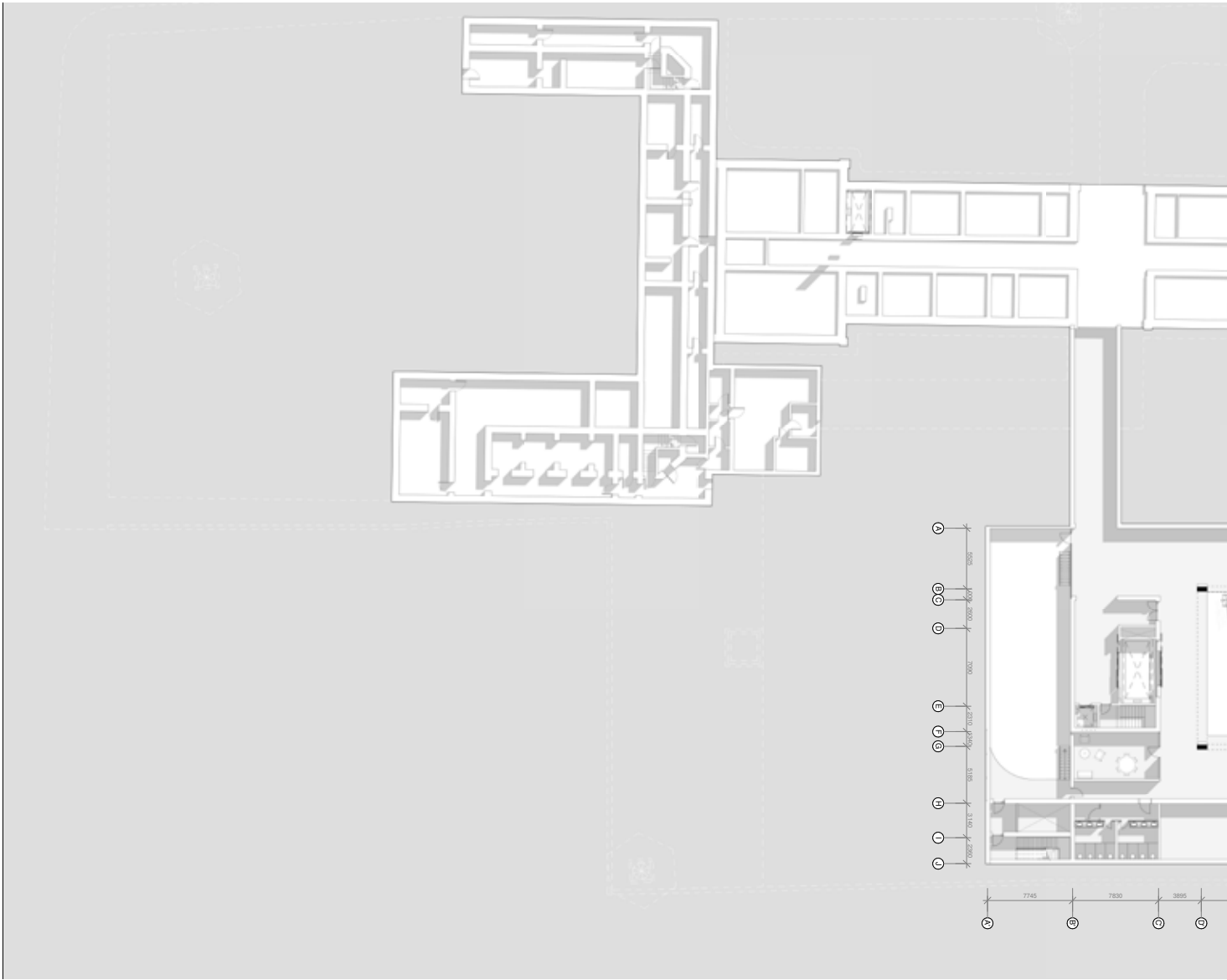


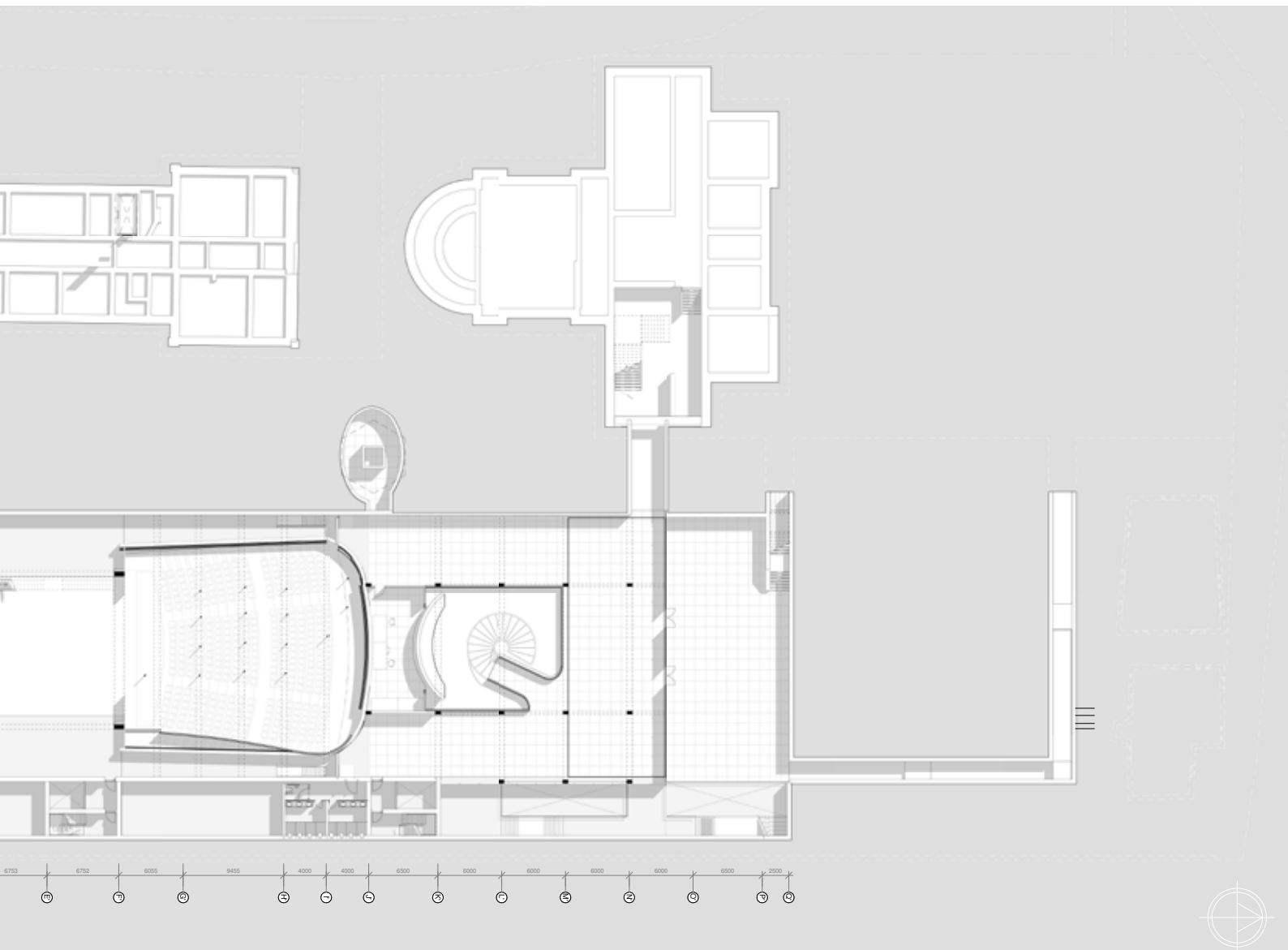




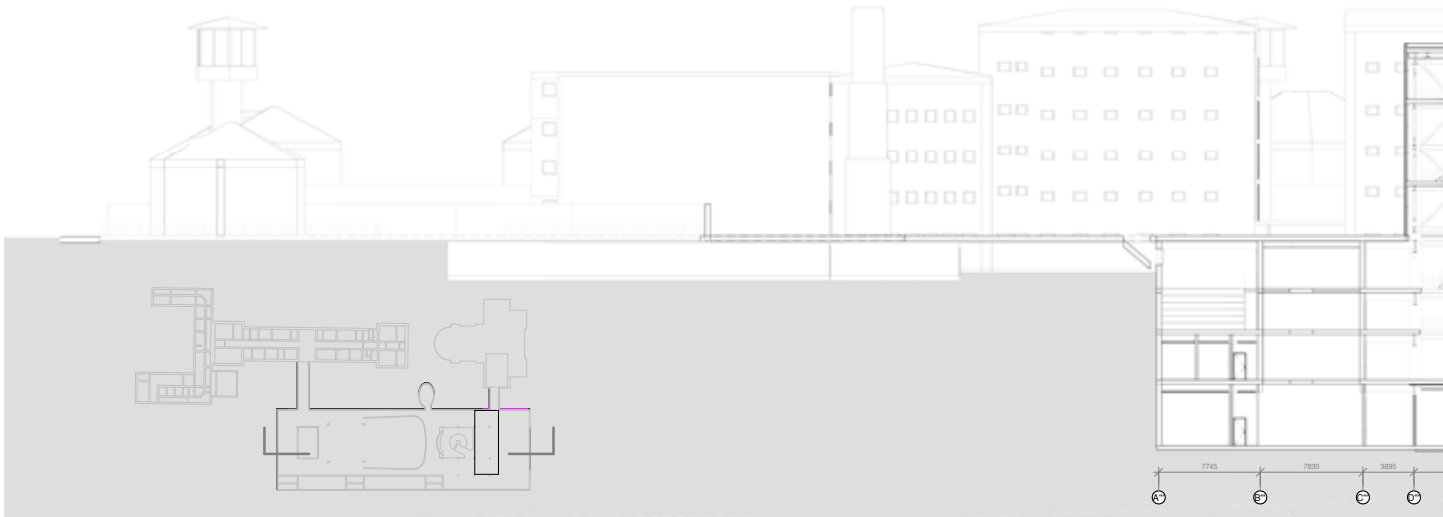


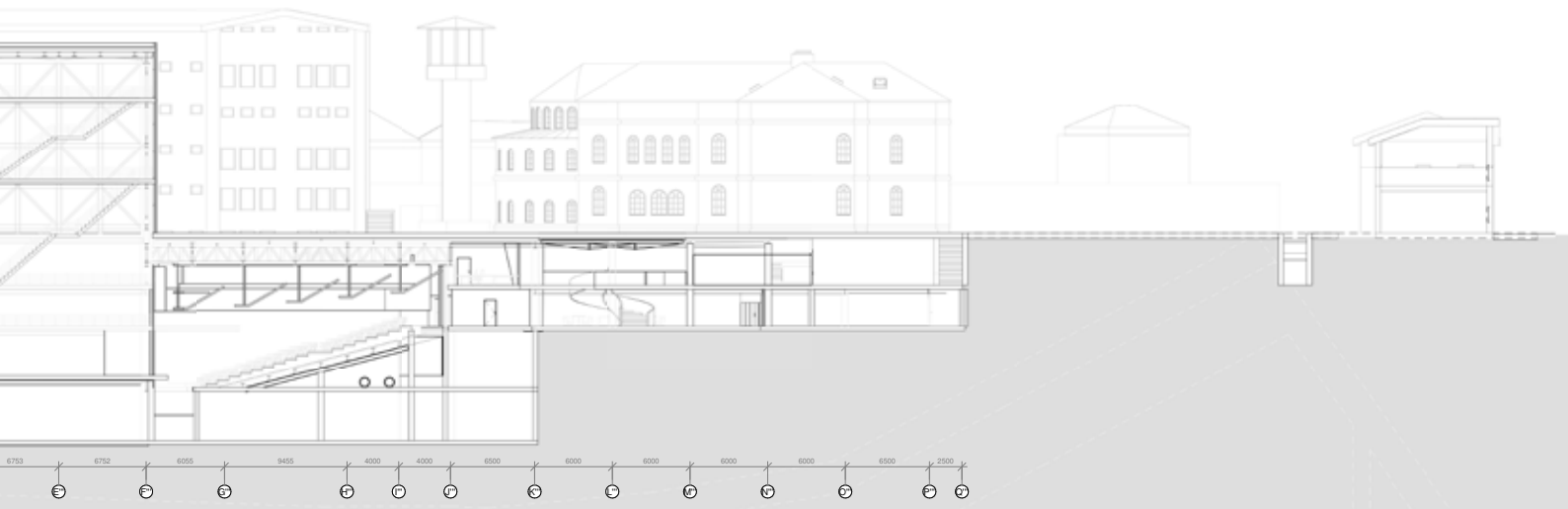


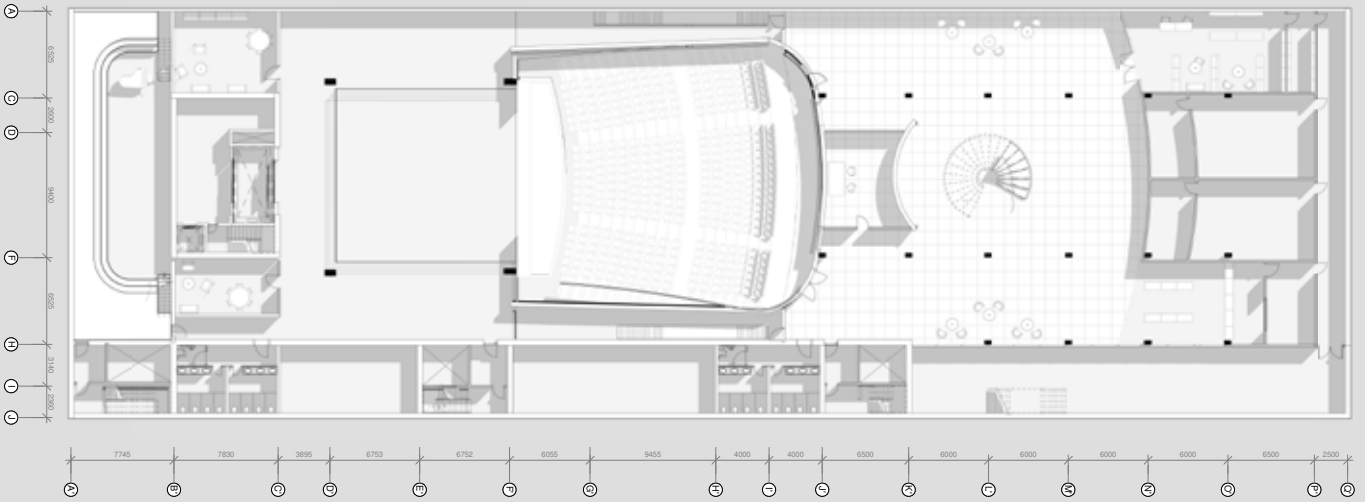


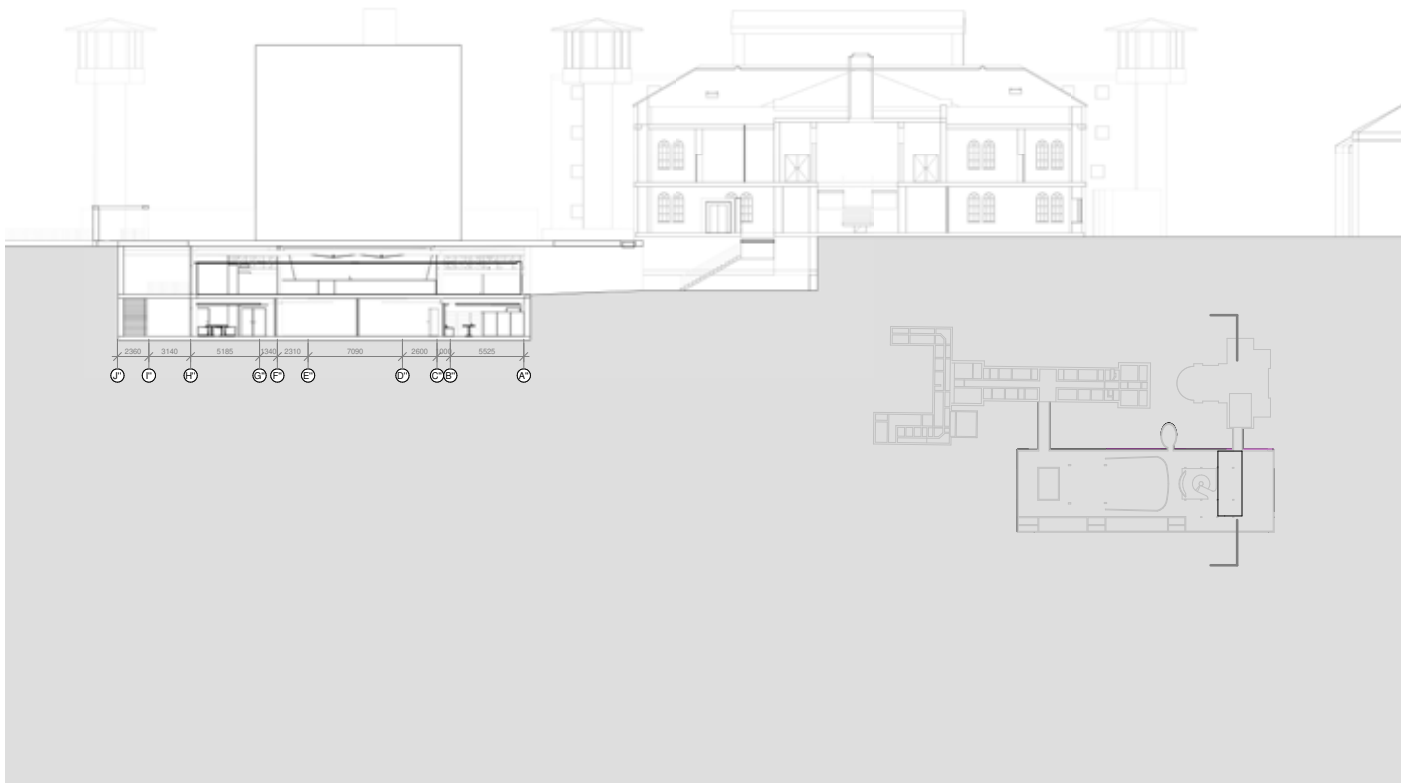


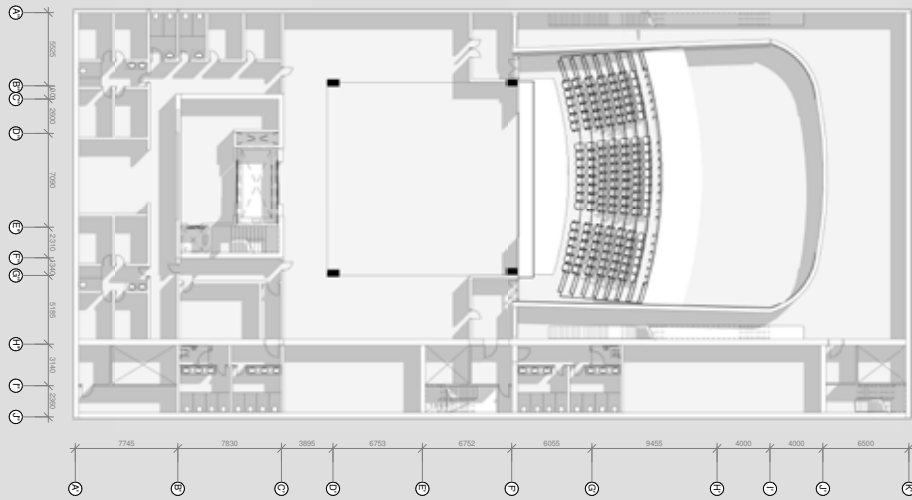


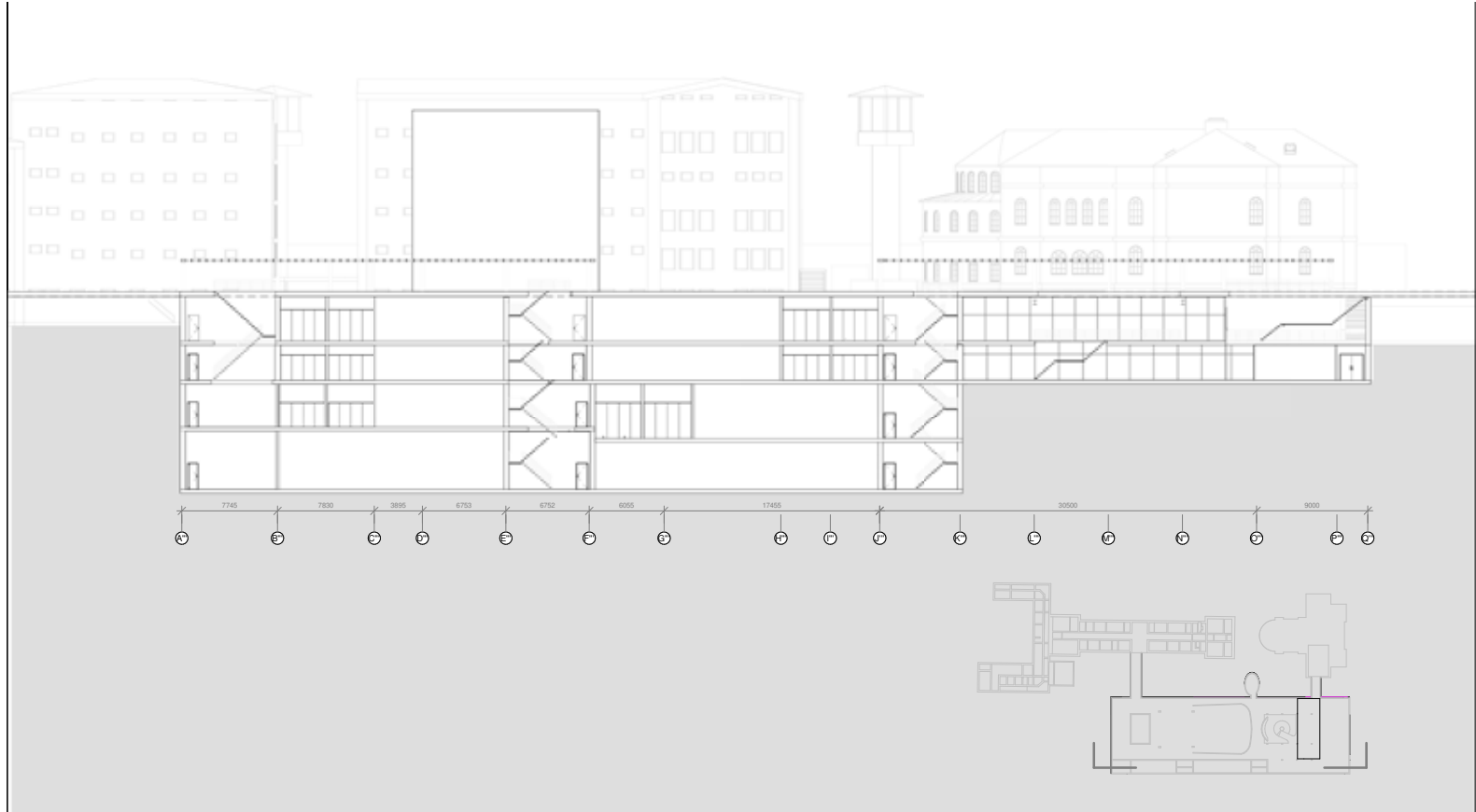


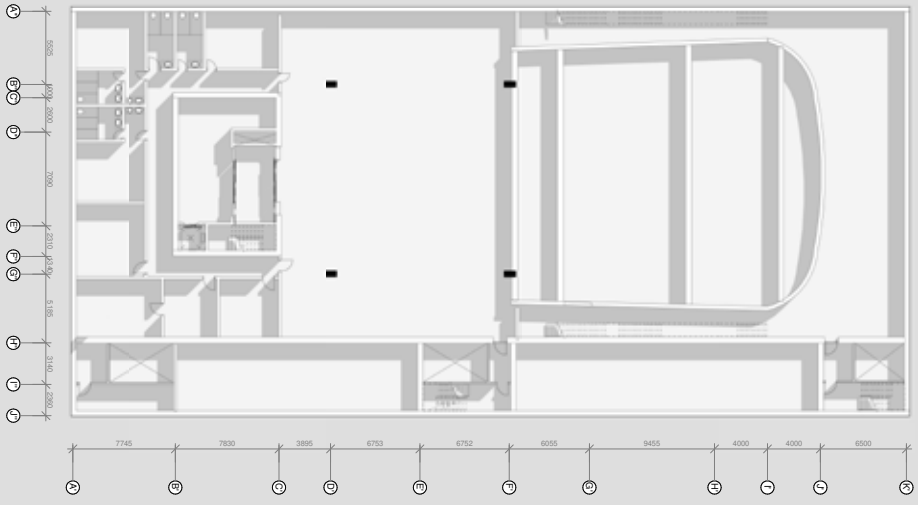


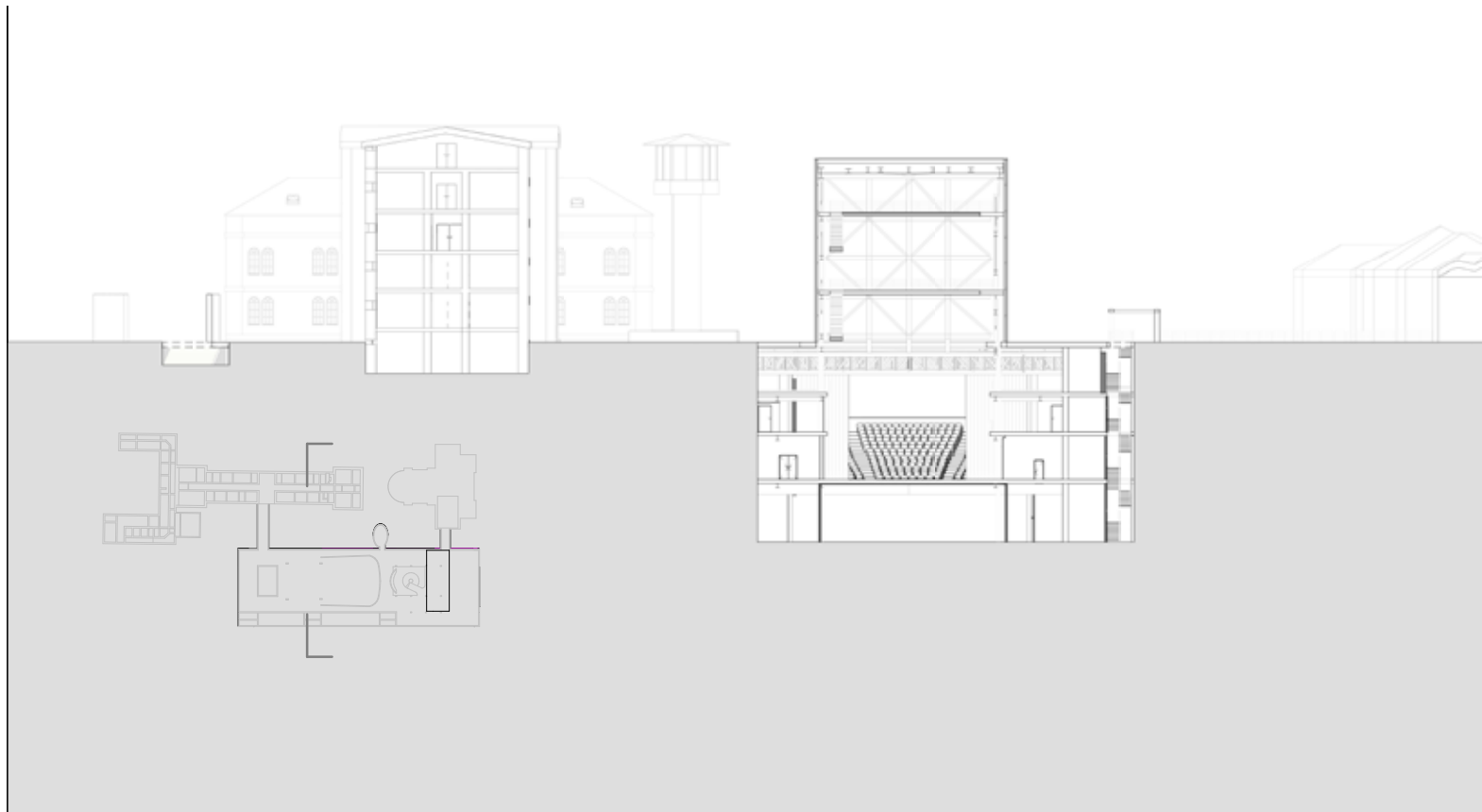








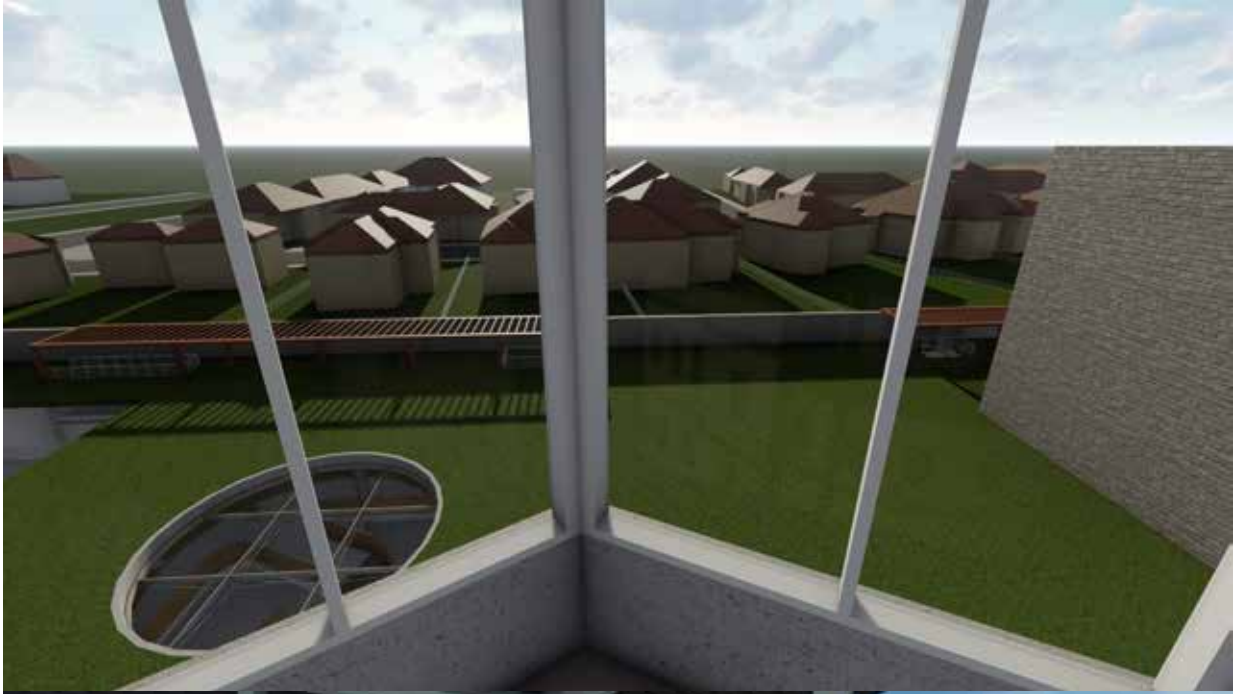








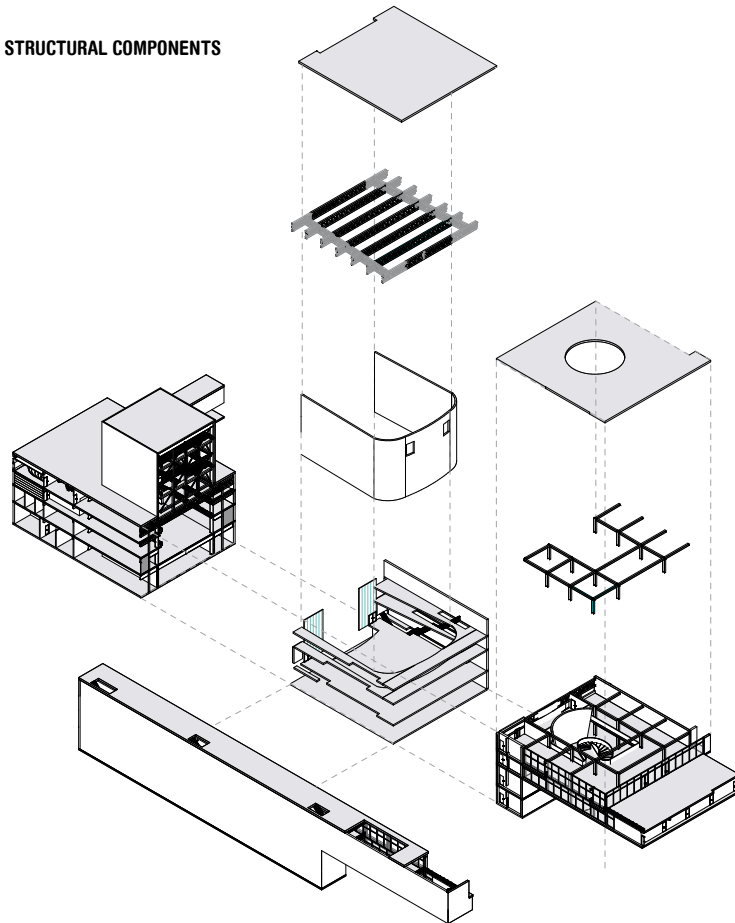




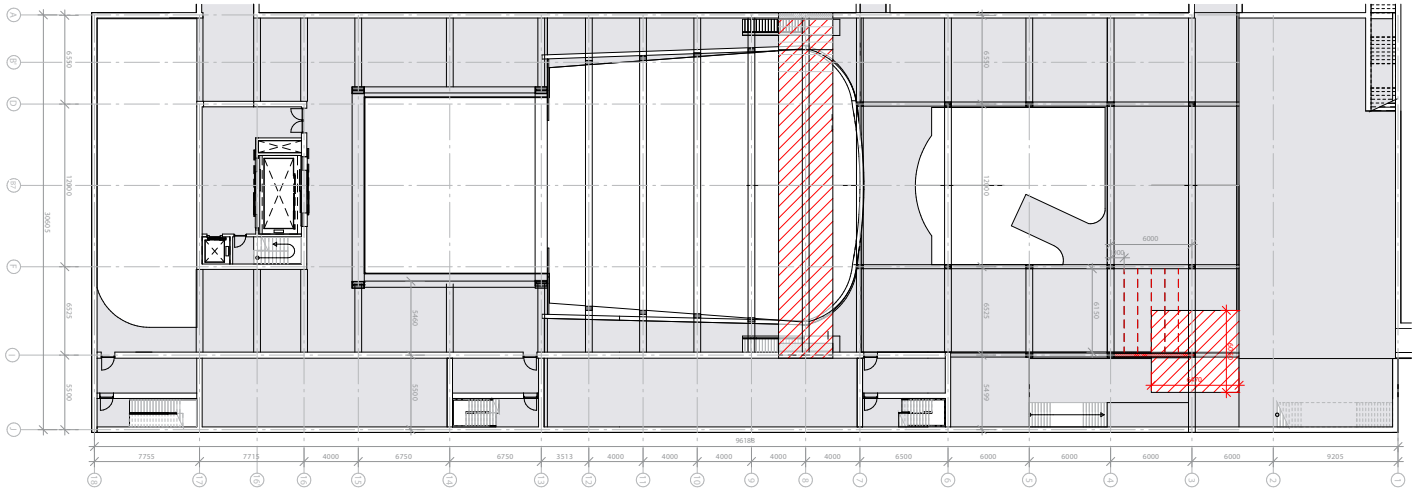


STRUCTURE

**STRUCTURAL COMPONENTS**



## STRUCTURAL PLAN UNDERGROUND -1:200



### BUILDING DATA

S275  
 Young's Modulus (E) 210000 N/mm<sup>2</sup>  
 Specific weight (γ) 78500 N/m<sup>3</sup>  
 Characteristic yield strength (f<sub>yk</sub>) 275 N/mm<sup>2</sup>  
 Ultimate tensile strength (f<sub>tk</sub>) 370 N/mm<sup>2</sup>

Structural Component	Grade	Profile
Steel beams	S275	IPE 360, HE 700 A
Steel columns	S275	HE 180 A
Truss	S275	HEB 200, HEB 360, IPE 160
Slabs, retaining walls, foundations	C25	-

### LOADS

#### DEAD LOADS

Dead load total (DL) : 5,61 kN/m<sup>2</sup>  
 Roof Package:

#### LIVE LOADS

Maintenance load: 4,0 kN/m<sup>2</sup>  
 Since Neumburg is situated in Zone 2 and the altitude for the region is 130 m, we assume 0,66 kN/m<sup>2</sup> as the snow load.

$s_k = [(0,264 \times 2) - 0,002] [1 + (130/252)^2]$   
 $s_k = 0,526 \times 1,266 = 0,66 \text{ kN/m}^2$   
 Snow Load: 0,66 kN/m<sup>2</sup>  
 Live load total (LL): 4,0 kN/m<sup>2</sup>

### BEAMS - ULS AND SLS

Secondary beam  
 Beam span: L = 6,150 m  
 Competence distance = 1,0 m

1.  $q = 1,0 \times (1,3 \times DL + 1,5 \times LL + 0 \times s_k)$   
 $q = 1,0 \times (1,3 \times 5,61 + 1,5 \times 4,0)$   
 $q = 1,0 \times (7,293 + 6,0)$   
 $q = 13,293 \text{ kN/m}$

2.  $M_{max} = (q \times L^2)/8 = M_0$   
 $M_{max} = (13,293 \times 6,15^2)/8$   
 $M_{max} = 62,847 \text{ kN m} = 62,847 \times 106 \text{ N mm}$

3.  $f_{y,d} = f_{yk}/1,05 = 275/1,05$   
 $f_{y,d} = 261,9 \text{ N/mm}^2$

4.  $M_{max}/f_{y,d} = 62847000/261,9 = 239965 \text{ mm}^3$   
 $M_{max}/f_{y,d} = 239 \text{ cm}^3$

5.  $W_{pl,x} > M_{max}/f_{y,d}$   
 $W_{pl,x} > 239 \text{ cm}^3$

6. IPE 500 beams are compatible  
 $W_{pe} = 336 \text{ mm}^3 \times 103$   
 $I = 48200 \text{ mm}^4 \times 104$

7. Deflection check:  
 $q = 1,0 \times (5,61 + 4,0) = 9,61 \text{ kN/m} = 9,61 \text{ N/mm}$   
 $E = 210000 \text{ N/mm}^2$   
 $L = 6150 \text{ mm}$   
 $q = (5/384) \times [(q \times L^4)/EJ] < L/200$   
 $q = < 30,75$   
 $q = 1,768 < 30,75 \text{ OK}$

Primary beam  
 Beam span: L = 6,0 m  
 Competence distance = 6,05 m

1.  $q = 6,05 \times (1,3 \times DL + 1,5 \times LL)$   
 $q = 6,05 \times (1,3 \times 5,61 + 1,5 \times 4,0)$   
 $q = 6,05 \times 13,293$   
 $q = 80,422 \text{ kN/m}$

2.  $M_{max} = (q \times L^2)/8 = M_0$   
 $M_{max} = 80,422 \times 6^2 / 8$   
 $M_{max} = 361,901 \times 106 \text{ N mm}$

3.  $f_{y,d} = f_{yk}/1,05 = 275 / 1,05$   
 $f_{y,d} = 261,9 \text{ N/mm}^2$

4.  $M_{max}/f_{y,d} = 361901925 / 261,9$   
 $M_{max}/f_{y,d} = 1381832,5 \text{ mm}^3$   
 $M_{max}/f_{y,d} = 1382 \text{ cm}^3$

5.  $W_{pl,x} > M_{max}/f_{y,d}$   
 $W_{pl,x} > 1382 \text{ cm}^3$

6. HE 900 A beams are compatible  
 $W_{pe} = 1414 \text{ mm}^3 \times 103$   
 $I = 422100 \text{ mm}^4 \times 104$

7. Deflection check:  
 $q = 6,05 \times (5,61 + 4,0) = 58,14 \text{ kN/m} = 58,14 \text{ N/mm}$   
 $E = 210000 \text{ N/mm}^2$   
 $L = 6000 \text{ mm}$   
 $q = (5/384) \times [(q \times L^4)/EJ] < L/200$   
 $q = (5 \times q \times L^4) / (E \times J \times 384) < 6000/200$   
 $q = 1,10 < 30 \text{ OK}$

### COLUMN AND BUCKLING CHECK

L = 3,6m  
 Tributary floor area = 6,05 x 6,17 = 37,33 m<sup>2</sup>  
 Roof load  
 DL = 5,61 LL = 4,0  
 Floor load  
 DL = 3,47 LL = 5,0 (Foyer)

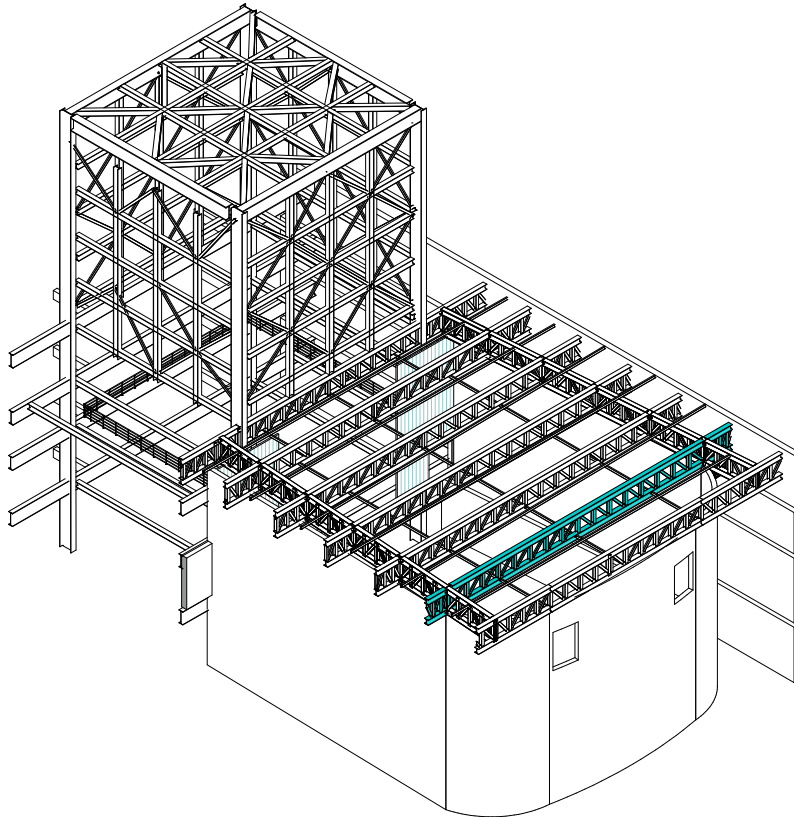
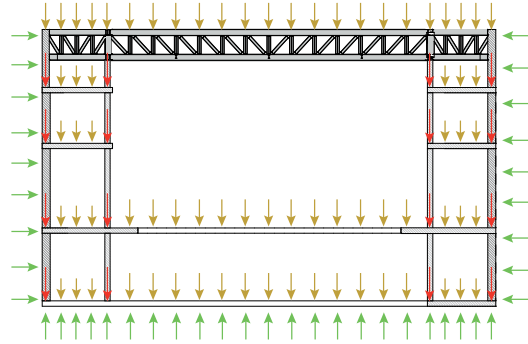
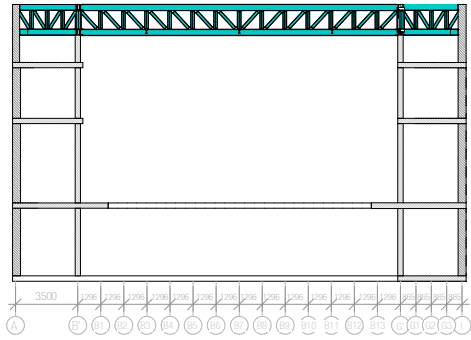
HE 160 A was chosen with  
 $W = (2,98 \times 3,6) \times 2 \text{ kN/m}$  and  $I = 615,6 \times 10^4 \text{ mm}^4$   
 $P = 944,60 + 21,45 = 966,05 \text{ kN/m}$

2. Buckling check  $P < P_{cr}$   
 $P_{cr} = (p^2 \times E \times I)/L^2$   
 $P_{cr,160} = (9,8 \times 210000 \times 615,6 \times 10^4)/3600^2$   
 $P_{cr,160} = 977,55 > 966,05 \text{ kN/m OK}$

For compatibility with the primary beam the column HE900 A is proposed

1.  $P = P_1 + P_2 + W$   
 $P_{1, \text{roof}} = (1,3 \times 5,61 + 1,5 \times 4,0) \times 37,33$   
 $P_{1, \text{roof}} = 496,23 \text{ kN/m}$   
 $P_{2, \text{slab}} = (1,3 \times 3,47 + 1,5 \times 5,0) \times 37,33$   
 $P_{2, \text{slab}} = 448,37 \text{ kN/m}$   
 $P = 496,23 + 448,37 + W$   
 $P = 944,60 + W$







## NODES, ELEMENTS AND SUPPORTS



### NODAL LOADS

DL1 = 5,61 kN/m<sup>2</sup> x 2,0 m<sup>2</sup>  
 DL1 = 11,22 kN  
 LL1 = 4,0 kN/m<sup>2</sup> x 2,0 m<sup>2</sup>  
 LL1 = 8,0 kN

DL2 = 5,61 kN/m<sup>2</sup> x 5,0 m<sup>2</sup>  
 DL2 = 28,0 kN

LL2 = 4,0 kN/m<sup>2</sup> x 5,0 m<sup>2</sup>  
 LL2 = 20,0 kN

## REACTION FORCES (Z)



Min. value: 6.6519e+001 (Node 6)  
 Max. value: 5.3771e+001 (Node 5)

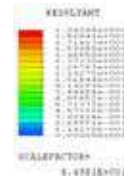
## DEFORMATION



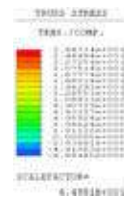
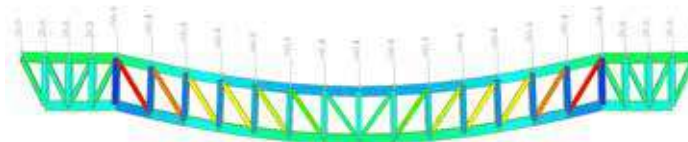
X-Dir = 0.000e+000 (Node 1)  
 Y-Dir = 6.990e-002 (Node 14)

Z-Dir = 1.943e+000 (Node 24)  
 Comb. = 1.943e+000 (Node 24)

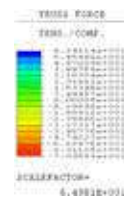
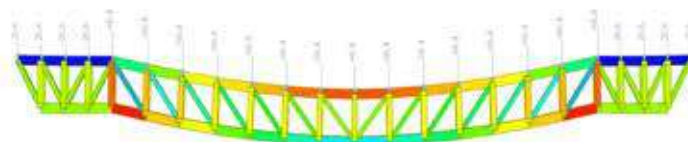
## DISPLACEMENT



## STRESS



## FORCES





# TECHNOLOGY OF MATERIALS

### 01 Roof package: Extensive green roof

Material	Thickness (m)	Weight (kN/m <sup>2</sup> )
01.1 Growing media Low density pumice substrate	0,080	0,05
01.2 Filter fabric Polypropylene sheet	0,040	1,50
01.3 Reservoir layer Expanded polystyrene drainage board	0,050	0,65
01.4 Moisture layer Recycled HDPE drainage and storage board	0,050	0,65
01.5 Insulation XPS Rigid	0,150	0,09
01.6 Drainage	0,0557	0,65
01.7 Protection mat	0,004	0,60
01.8 Cast concrete + Galvanized Iron sheet	0,080	1,42
		<b>5,61</b>

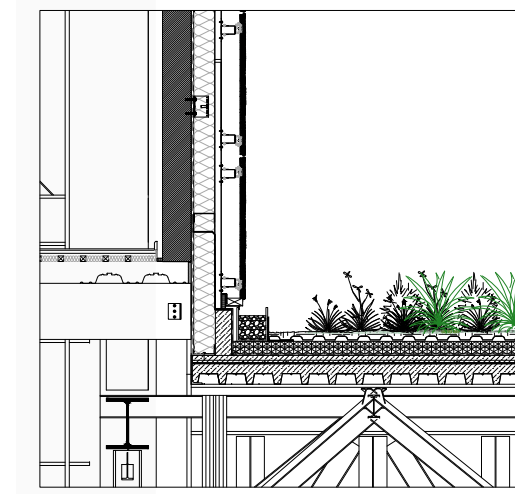
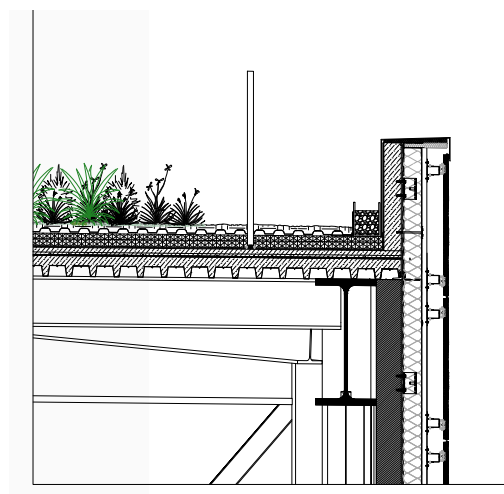
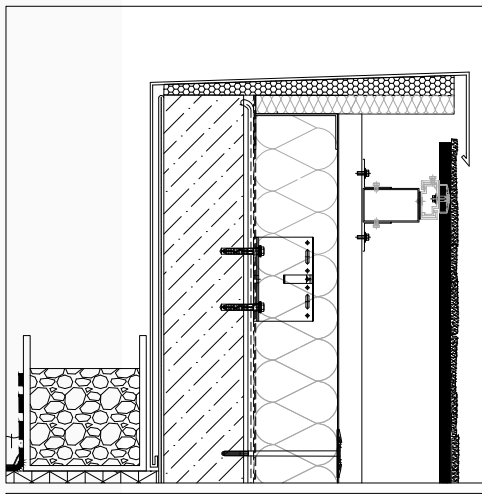
### 02 Wall package 1: Fly tower envelope

Material	Thickness (m)	Thermal Resistance (K m <sup>2</sup> /W)
02.1 Primer	0,005	0,13
02.2 Gypsum wall board	0,040	0,60
02.3 Solid wall	0,200	0,55
02.4 Vapour barrier	0,010	0,44
02.5 Sandwich panel	0,150	2,85
02.6 Air cavity	0,080	0,87
02.7 Lightweight concrete	0,019	2,20
02.8 Site sourced stone	0,013	0,08

### 03 Floor package

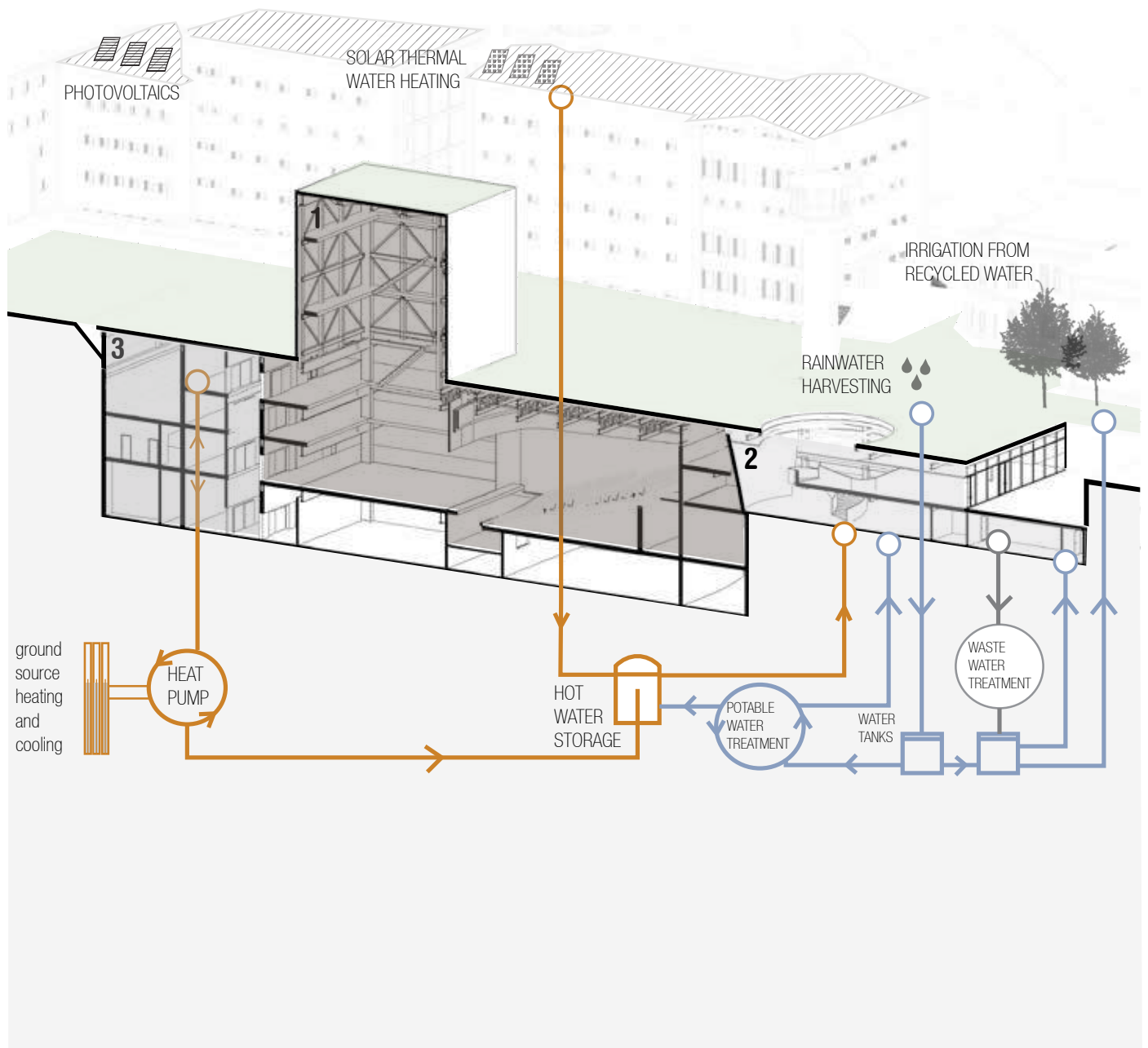
Material	Thickness (m)	Weight (kN/m <sup>2</sup> )
03.1 Porcelain Stoneware	0,12	0,24
03.2 Integrated heating system	0,16	0,03
03.3 Heating polystyrene insulation	0,45	0,01
03.4 Sub-floor acoustic insulation	0,003	0,00
03.5 Slab reinforcing mesh	0,06	0,02
03.6 Slab reinforcement steel bar	-	0,06
03.7 Cast concrete	1,23	2,89
03.8 Galvanized iron corrugated sheet	0,01	0,09
03.9 Glass mineral wool insulation	0,5	0,02
03.10 Ceiling Sub-structure	-	0,04
03.11 Ceiling plasterboard	0,125	0,07
		<b>3,47</b>

- 04 Auditorium acoustic wall
- 05 Ceiling boards
- 06 Primary structure
- 07 Suspended ceiling
- 08 L Bracket
- 09 Steel flashing
- 10 Adjusting screw
- 11 Ceramic point
- 12 Fixing rail
- 13 Wall angle G
- 14 Substructure rivet
- 15 Termostop + fixing ref. to static
- 16 Mineral-wool insulation (TCG.032 and 035)
- 17 C-Channels
- 18 Laminated floor finishing
- 19 Gravel





**BUILDING SERVICES**





### AREA 1

- AUDITORIUM
- FLY TOWER
- LIGHT SYSTEMS
- ACOUSTIC SYSTEMS
- BAND
- CONTROL ROOM

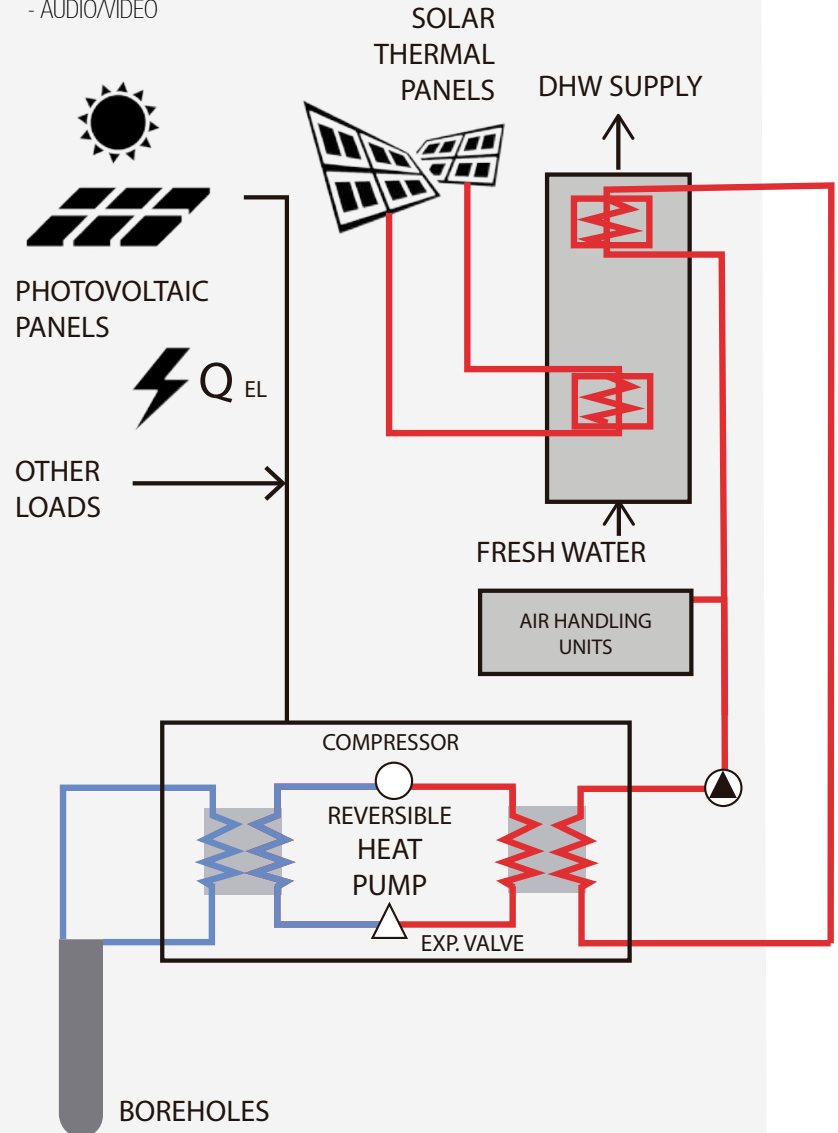
### AREA 2

- CAFE
- SERVICE: TOILETS
- GALLERY

### AREA 3

- DRESSING ROOMS
- VERTICAL CONNECTION
- STORAGE
- PREPS
- AUDIO/VIDEO

## energy systems



# ventilation rates

Occupancy	Area	Height	Volume	Occup./100 m <sup>2</sup>	Density	Rp	Ra	L/s	m <sup>3</sup> /h	n-1
<b>THEATRE</b>										
Main entry/Gallery	423	3.5	1480.5	634.5	150	2.5	0.3	1713.15	6167.34	4.17
Foyer	423	2.8	1184.4	634.5	150	2.5	0.3	1713.15	6167.34	5.21
Bookstore	42	2.8	117.6	6.3	15	3.8	0.6	49.14	176.90	1.50
<b>TOTAL AREA 1</b>								<b>3475.44</b>	<b>12511.58</b>	<b>10.88</b>
Auditorium	468	11.5	5382	702	150	2.5	0.3	1895.40	6823.44	1.27
Orchestra Pit	60	2.6	156	21	35	5	0.3	123.00	442.80	2.84
<b>TOTAL AREA 2</b>								<b>2018.40</b>	<b>7266.24</b>	<b>4.11</b>
Dressing Rooms	116	4.7	545.2	11.6	10	2.5	0.3	63.80	229.68	0.42
Technical Rooms	143	4.7	672.1	7.15	5	2.5	0.3	60.78	218.79	0.33
Break Rooms	63	4.7	296.1	15.75	25	2.5	0.3	58.28	209.79	0.71
Rehearsal Hall	185	6.3	1165.5	64.75	35	5	0.3	379.25	1365.30	1.17
Fly Tower	214	25	5350	42.8	20	2.5	0.3	171.20	616.32	0.12
<b>TOTAL AREA 3</b>								<b>733.30</b>	<b>2639.88</b>	<b>0.75</b>
	Airflow	Airflow	n-1	ROUND DUCT	RECTANG DUCT		SECTION AREA	VELOCITY	Vent. Type	
	L/s	m <sup>3</sup> /s			A (mm)	B (mm)	m <sup>2</sup>	m/s		
AREA 1	3475.44	<b>3.4754</b>	10.8771		800	1000	<b>0.8</b>	<b>4.3443</b>	Duct 1	
AREA 2	2018.4	<b>2.0184</b>	4.10629		600	800	<b>0.48</b>	<b>4.205</b>	Duct 2	
AREA 3	733.3	<b>0.7333</b>	0.74681		200	400	<b>0.08</b>	<b>9.16625</b>	Duct 3	

Rates based on ASHRAE: <https://www.ashrae.org/>

## FORMULA

$$V_{bz} = R_p * P + R_a * A_z$$

$V_{bz}$  = Volumetric airflow required in zone z

$A_z$  = zone floor area: the net floor area of the ventilation zone (z)

$P_z$  = zone population: the number of people in the ventilation zone (z) during typical usage

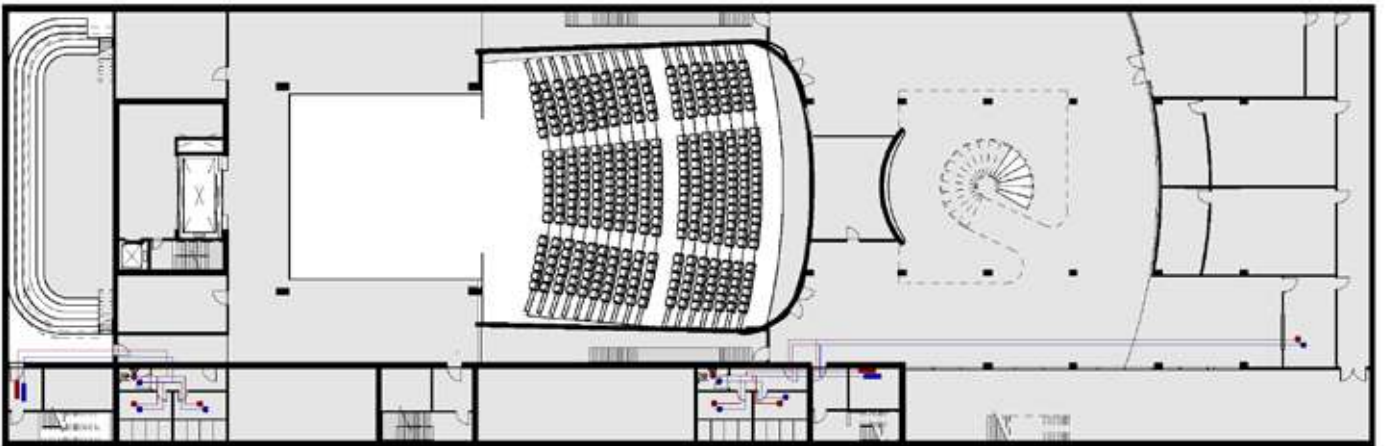
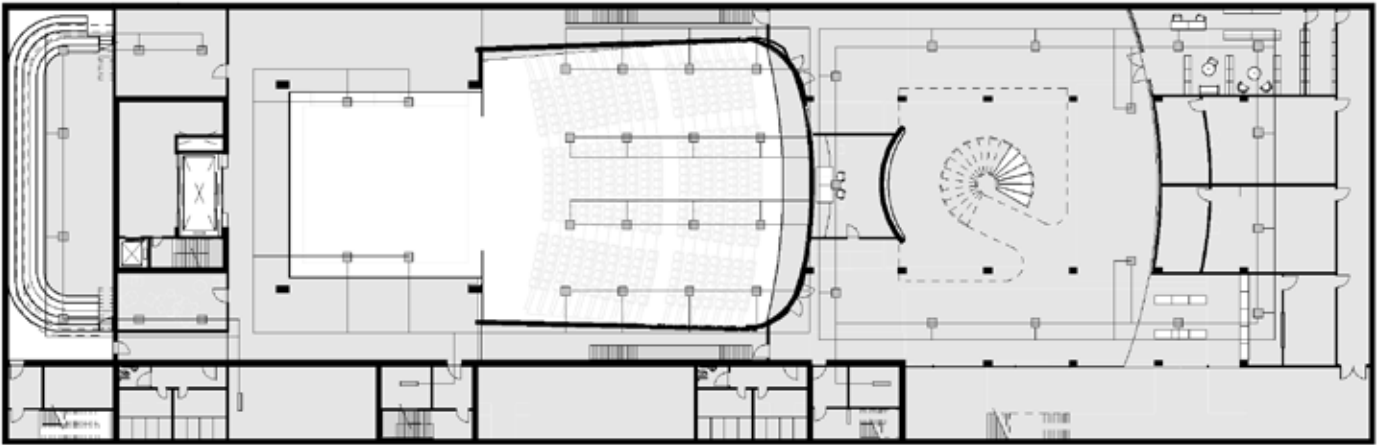
$R_p$  = outdoor airflow rate required per person (see table)

$R_a$  = outdoor airflow rate required per unit area

# building envelope | area 1

## 1. Transmittance loads (opaque walls)

Indicative values for Rsi and Rso		Rsi=0,13	Rso=0,04	
Calculation of $R_{\Lambda} = \sum_{n=1} \frac{d}{\lambda}$				
Layers	Density $\rho$ (kg/m <sup>3</sup> )	Thickness d (m)	Thermal conductivity $\lambda$ (W/mK)	Thermal resistance $d/\lambda$ (m <sup>2</sup> K/W)
Plaster	1800	0,02	0,87	0,023
Concrete	2400	0,45	1,0	0,450
Glasswool	32	0,15	0,04	3,750
Stone Cladding	1600	0,03	1,7	0,017
$\Sigma d$		0,7		
$R_{\Lambda} = \sum_{n=1} \frac{d}{\lambda}$				4,24
U-Value Calculation				
Rsi	(m <sup>2</sup> K)/W	0,13		
$R_{\Lambda}$	(m <sup>2</sup> K)/W	4,24		
Rso	(m <sup>2</sup> K)/W	0,04		
$1/U = (R_{si} + R_{\Lambda} + R_{so})$	(m <sup>2</sup> K)/W	4,41		
$U = \frac{1}{R_{si} + R_{\Lambda} + R_{so}} = \frac{1}{0,13 + 4,24 + 0,04}$	W/(m <sup>2</sup> K)	0,227		





BIM









