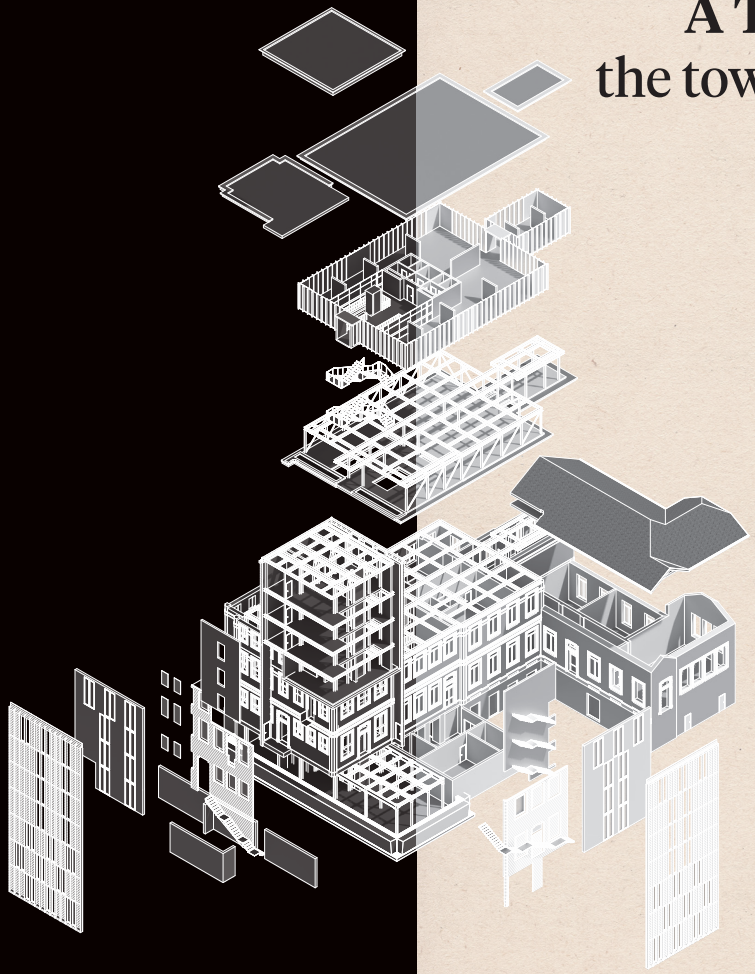
A Tall Archive
the tower for Apice



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Supervisor: Professor Giulio Massimo Barazzetta
Politecnico di Milano
School of Architecture Urban Planning
Construction Engineering
Master degree in 'Building Architecture'
A.Y. 2022-2023

All the drawings presented here are realised by the author of the thesis.

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Graduation session: July 2023

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MILANO 1863

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Index

Abstract

The project hereby presented concerns the addition of a new floor and relocation of the 'APICE' archive in its new hosting building, a construction that is part of a complex occupied by the Veterinary Medicine Department inside the University of Milano site of Via Celoria 10 in Città Studi district.
The existing building is owned by the University of Milano. The complex first appeared at the beginning of the twentieth century in a detailed masterplan for Città Studi, dated 1910. According to records, during the following decades, many drawings by architects Orlando Villa and Piergiulio Magistretti were submitted until the complete realisation of the complex in the late '50s. Nowadays the university intends to allocate, at this site, the center of the Department of Cultural Heritage with the addition of other strategic functions.
The building subject of the intervention is a former stable/kennel developed three floors above ground. Having a look at historical plans, there were originally two constructions connected by a porch but subsequently, they got unified into a unique building at an uncertain time leaving the final mass undoubtedly as the sum of three volumes. Furthermore, the second floor turned out to be an addition on its own due to structural and vertical circulation irregularities.
The archive of APICE (word, image and editorial communication archive), the University museum and offices as well as study spaces and reading rooms have to be addressed in the new building.
The project aimed at the removal and replacement of the latter floor, the reorganisation of rooms and vertical circulations within the building, and the addition of a vertical element growing above the southern volume of the construction. The aspect concerning preservation was fundamental and went in parallel with the development of the architectural design phases.
Regarding the functional distribution, the entirety of the APICE archive is expected to be uniquely hosted in the vertical element and its basement, except for a consultation room accessible directly from an exclusive staircase at ground level hidden behind the added façade. The museum space will be located in whole on the new second floor. All the institutional offices, personnel rooms and student spaces will be placed on the ground and first levels, while additional services like workshop areas, cafeteria and conference room will be located at the basement level with accesses to the outer lowered square.
The existing load-bearing structure is in masonry with four heads in solid bricks, while the new bearing structure will be in steel and as support for the existing one: steel columns in the vertical element will be flanking the existing masonry while for the second floor, they will be placed as a continuation of the load-bearing walls through the use of a slim-floor steel beam to distribute the new pointed loads.

The vertical element, like a bell tower emerging from the original volume, will be one of the tallest construction of the complex, as well as a new landmark for the entire site.

Chapter I

Analysis

Brief introduction

The project site is located in Città Studi area, a district northwest of Milano. Its first appearance is dated 1910 in a general masterplan for a new university site just outside the city centre. During the first post-war the municipality of Milano grew considerably, sprawling its centrality due to the enormous increase of citizens. Considered back then by Milanesi citizens as open countryside, the land from the second ring road towards the outside of the built environment has been the scenario for major interventions. In the late 20s, the construction of the new university district began in the so-called 'Città degli Studi', in between nowadays Piola and Lambrate districts. The university building had to host the polytechnic, medicine, agriculture and veterinary faculties. From an aerial view taken in the 30s, it is visible the entirety of the new university site, as well as the first image of the building subject of this project.

During the reconstruction period of the second post-war, new residential buildings started to appear around the university area combining their new language with the characteristic and distinct constructions already present in the district. Some interventions occurred at the site during the 50s, completing the original masterplan and modifying it where needed. In this context, even if not sure precisely when, the project building has been the subject of morphological interventions becoming a unique body and gaining a new floor.

Nowadays there is the willingness of the University of Milano institution to allocate in città Studi the centre of the Department of cultural heritage and other strategic functions. More precisely, in the project building it is designated to host the new campus exhibition and museum spaces for Apice and its collections, as well as its ancillary functions as reading rooms, offices and study spaces.

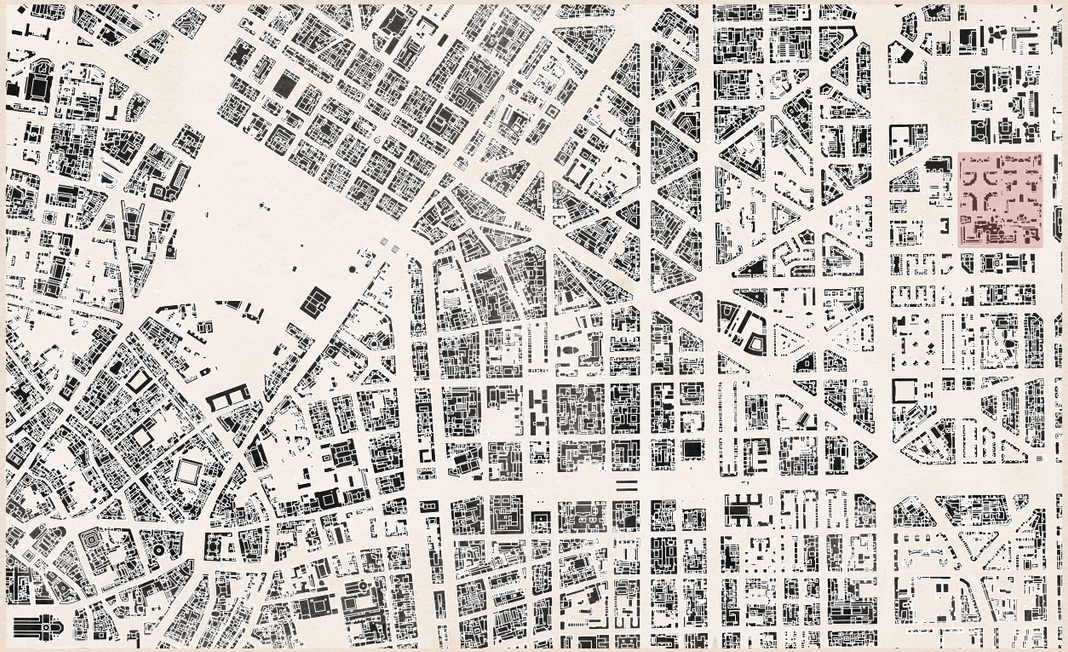
I.I

The project site

Milano scheme, 1:200’000

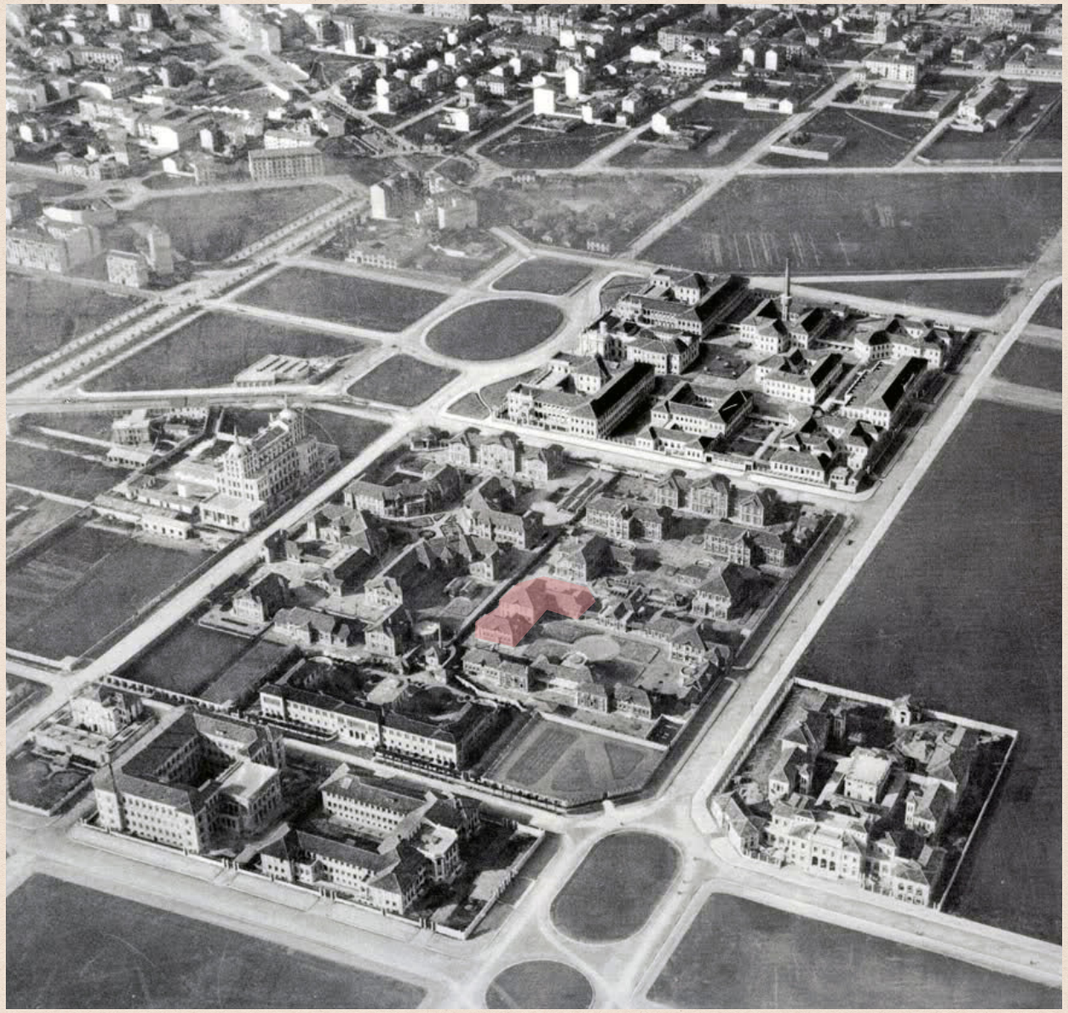
1600-1860
1860-1914
1914-1936
1936-1961
1961-1994
1994-2023
project site

Milano scheme, 1:20’000

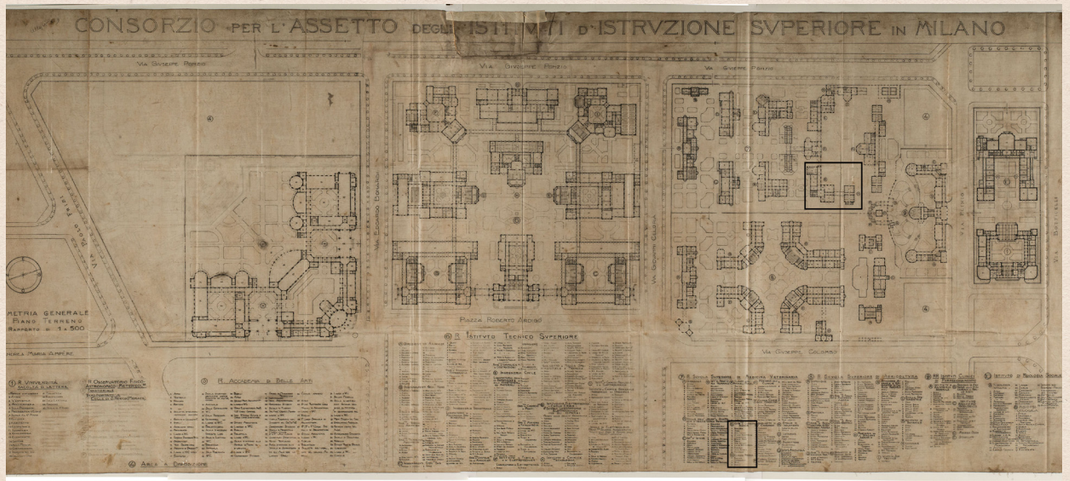


built
unbuilt
project site

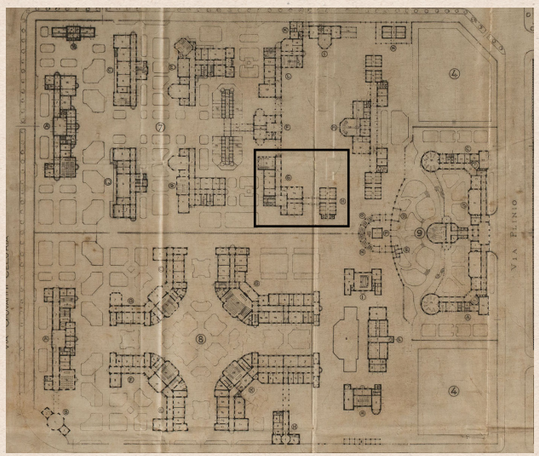
aerial view of ‘città degli studi ‘ area, dated 1930s



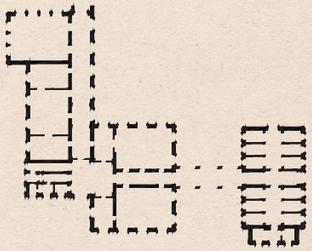
general masterplam of ‘città degli studi’, dated 1910



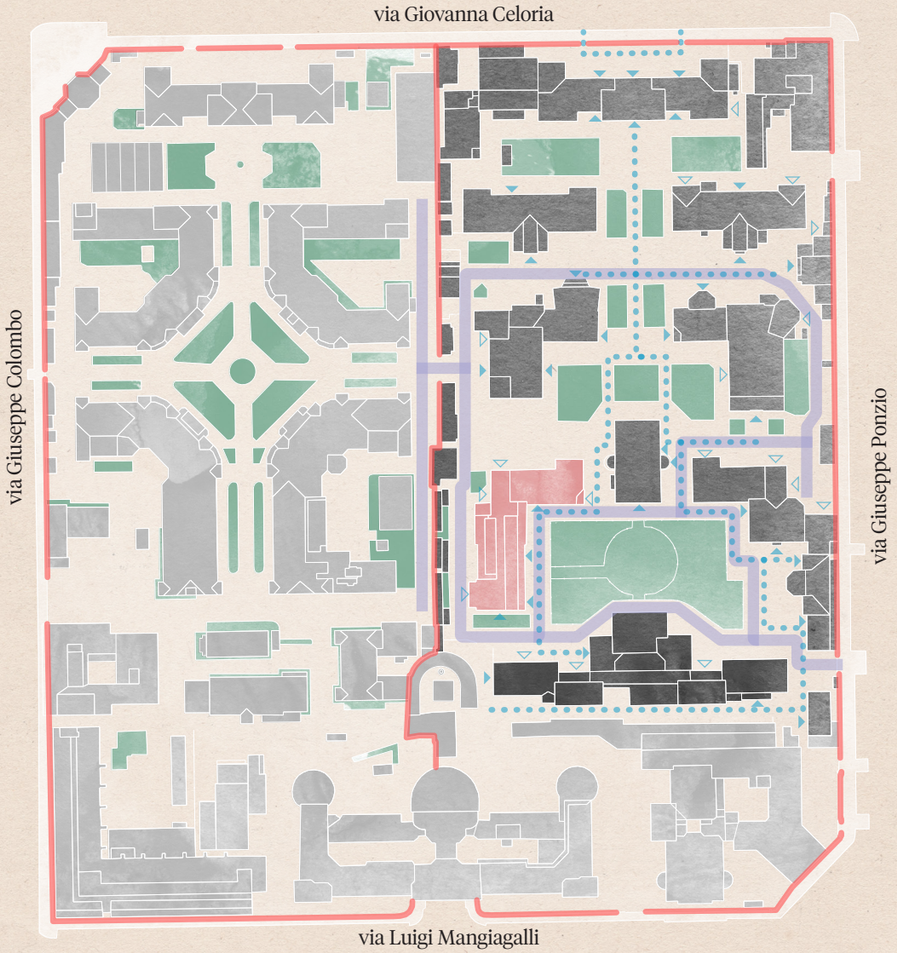
focus on project building



original plan, 1:1000



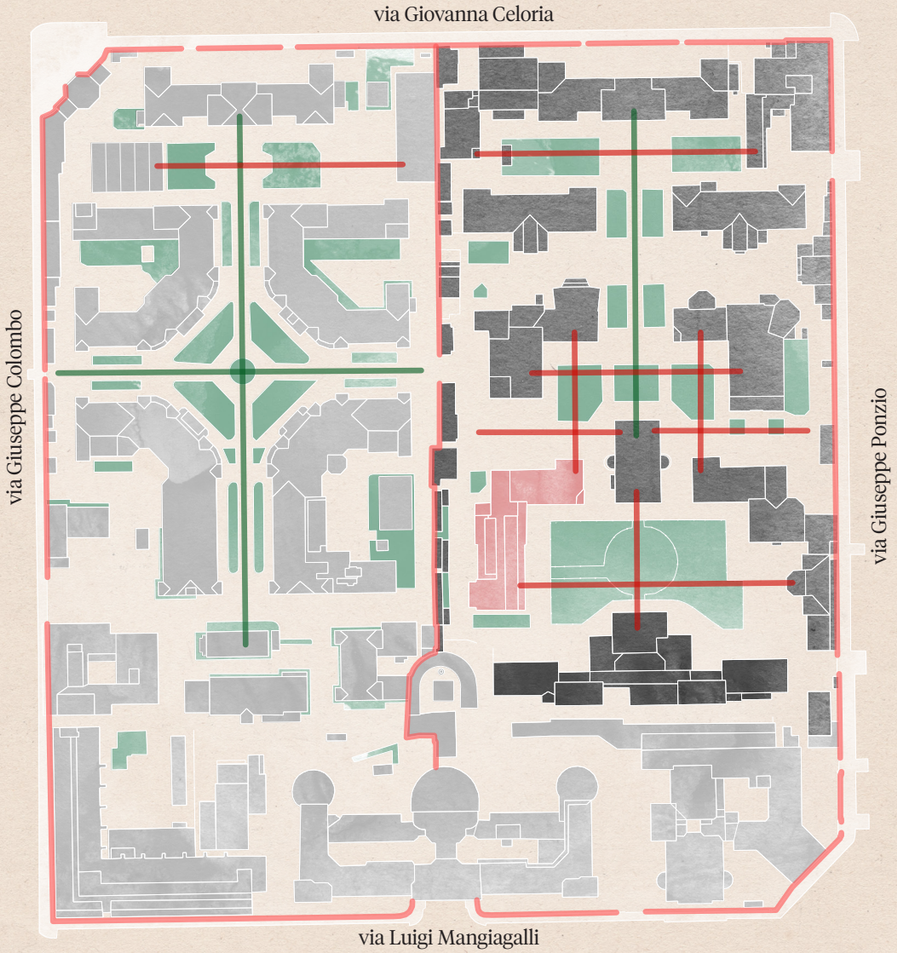
mobility scheme, 1:2000



legend

- pedestrian circulation
- vehicular circulation
- veterinaria buildings
- project building
- campus borders
- main accesses
- secondary accesses
- agraria buildings
- vegetation

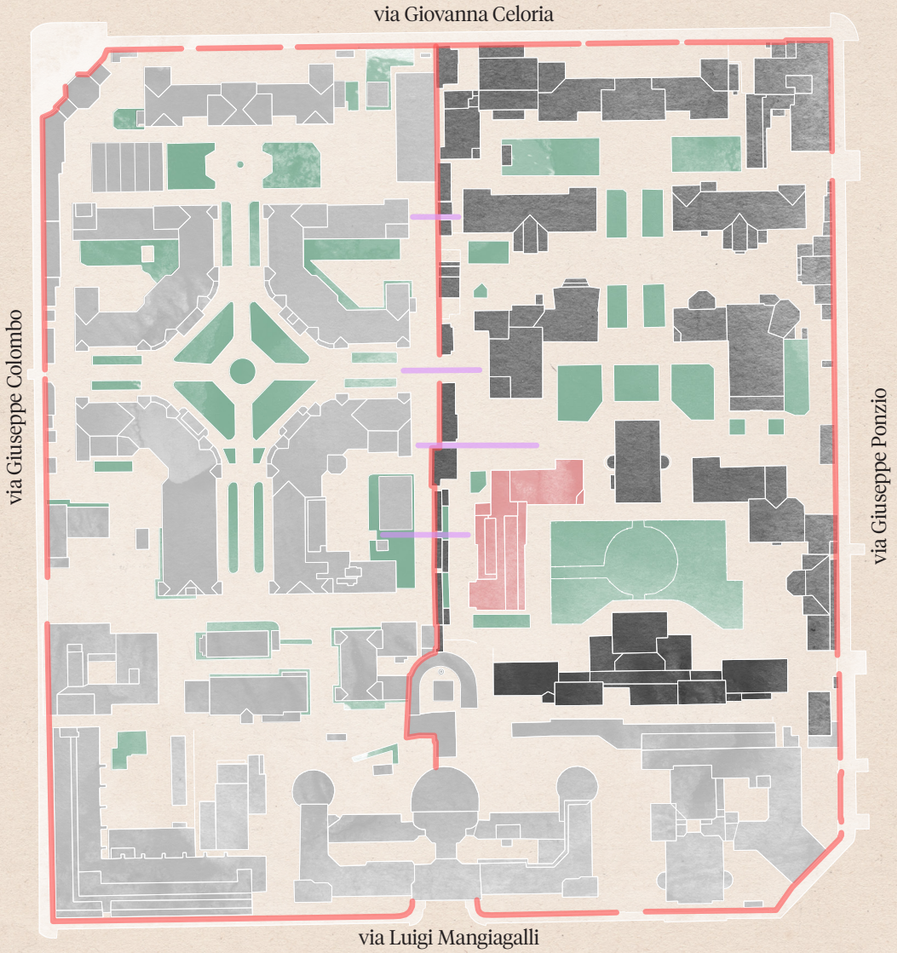
composition scheme, 1:2000



legend

- weak axes
- strong axes
- veterinaria buildings
- agraria buildings
- project building
- vegetation
- campus borders

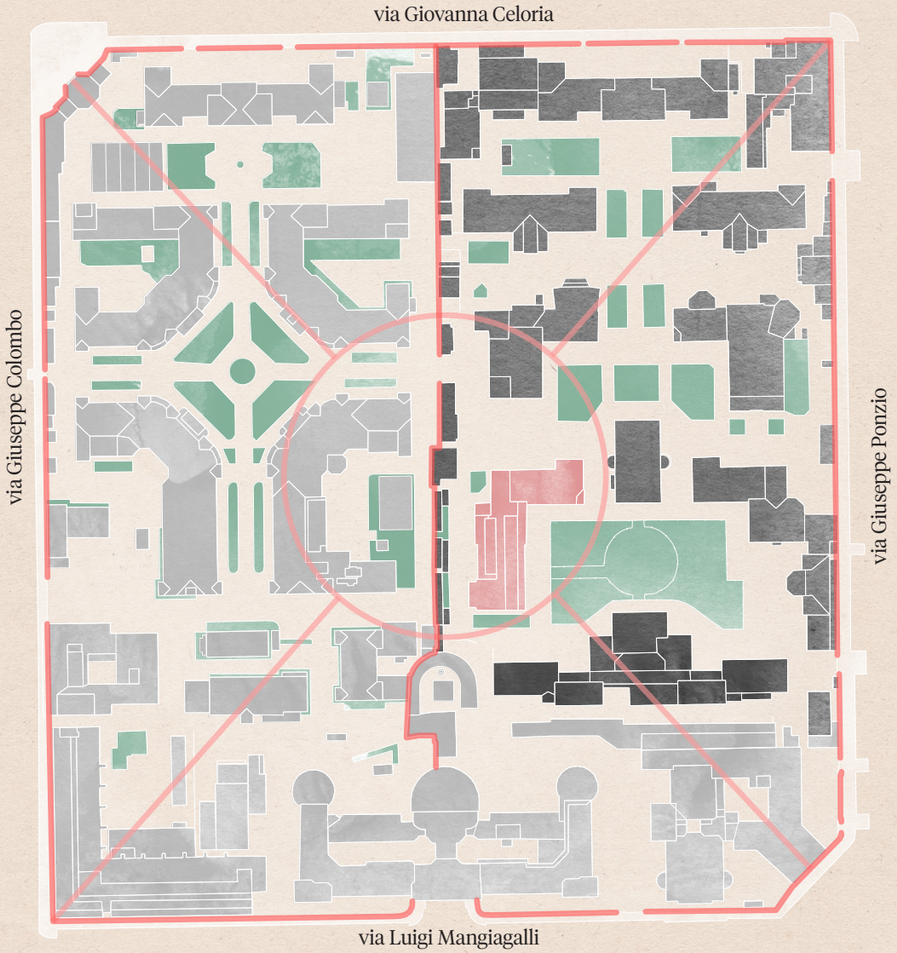
site internal division scheme, 1:2000



legend

- wall openess
- veterinaria buildings
- project building
- campus borders
- agraria buildings
- vegetation

centralisation scheme, 1:2000



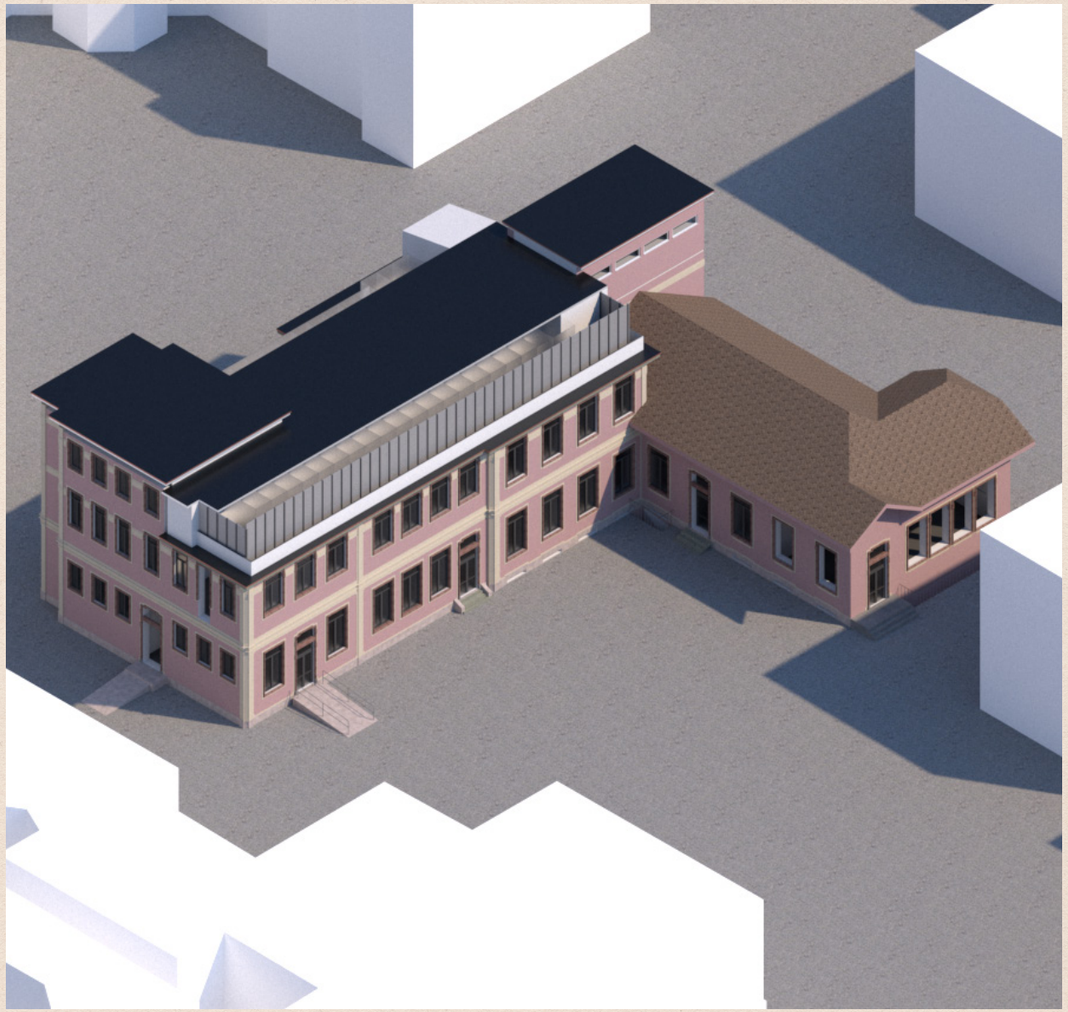
legend

- site center
- veterinaria buildings
- project building
- campus borders
- agraria buildings
- vegetation

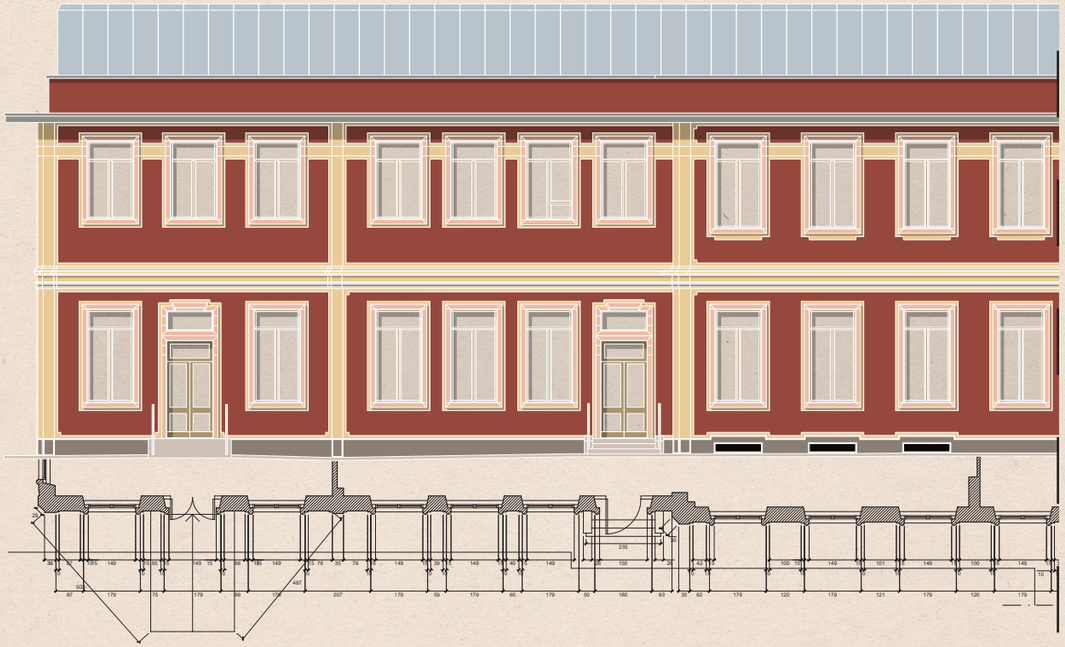
I.II

The building

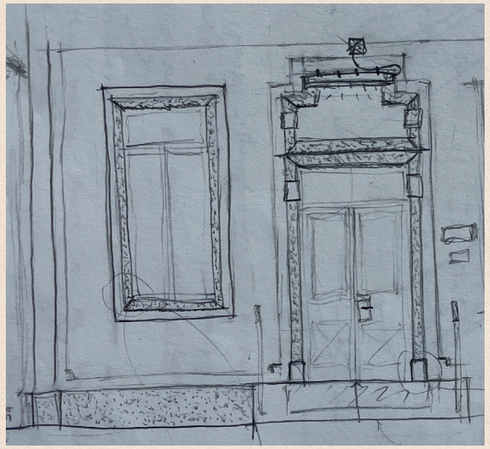
axonometric view of the building as found



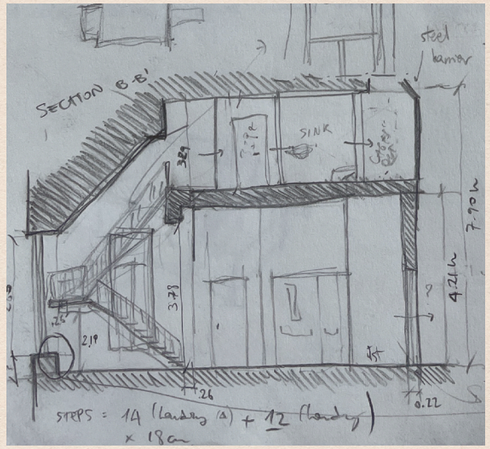
geometrical survey of the east facade, 1:200



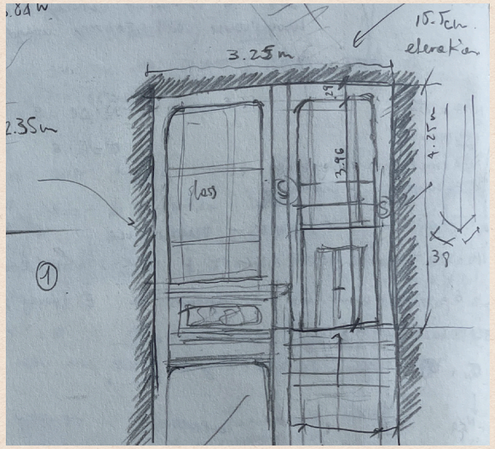
sketches produced on site diring surveys



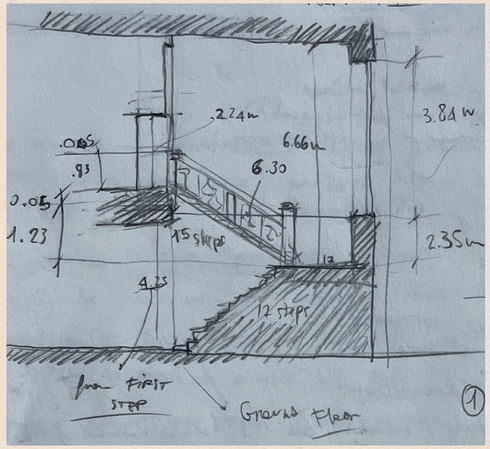
1. piece of the east facade



2. staircase at first level

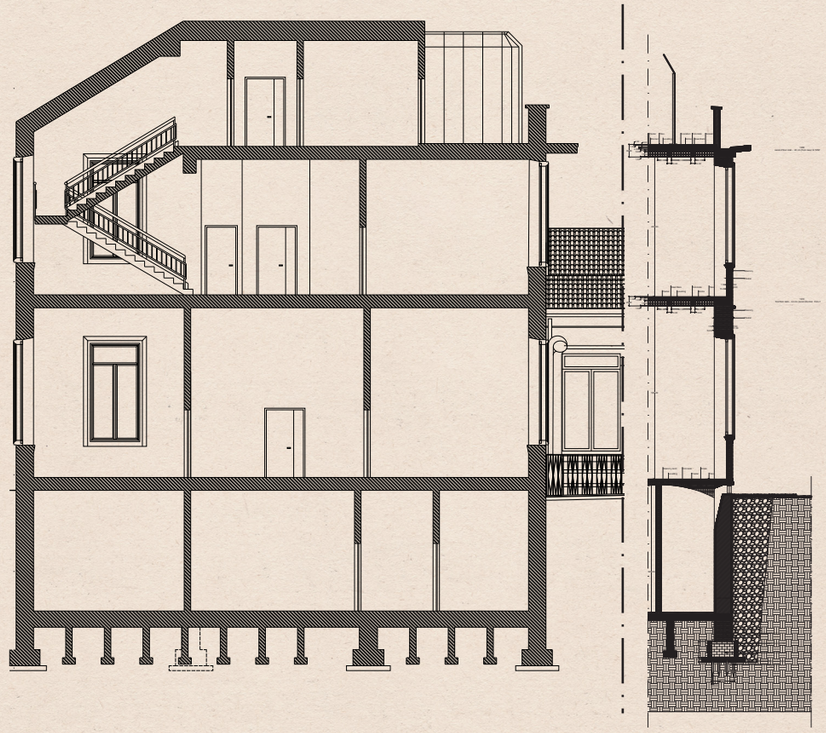


3. top of stone staircase (access to second level)



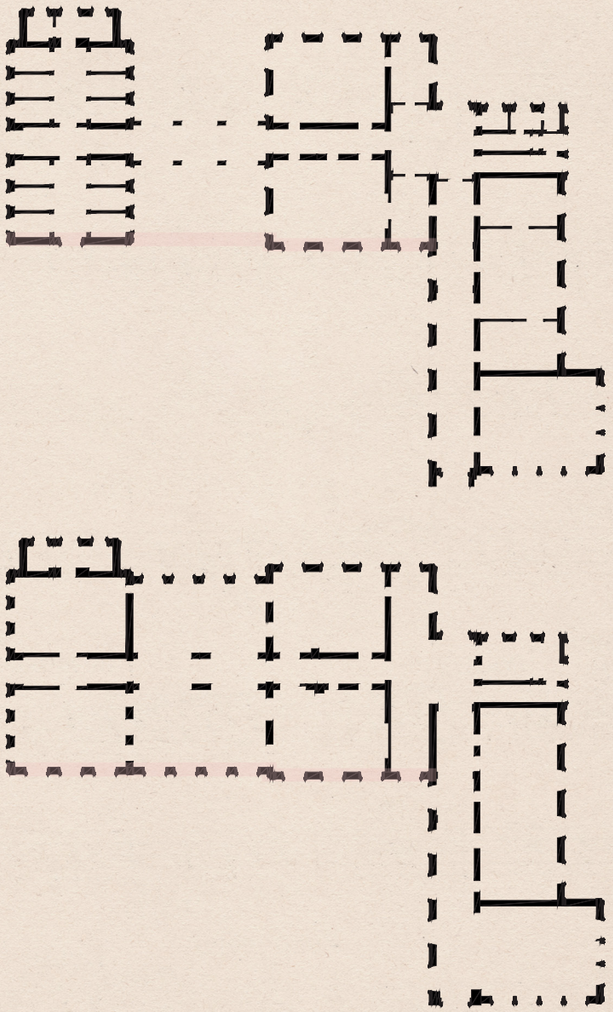
4. stone staircase at ground level

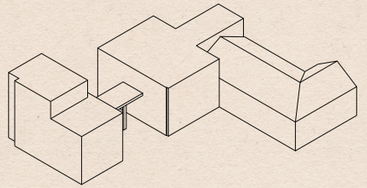
state of art detail reconstruction section, 1:200



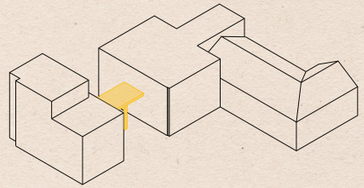
comparison ground floor plans, 1:500

↑from 1910 ↓as found

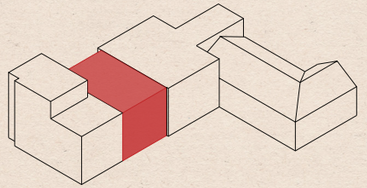




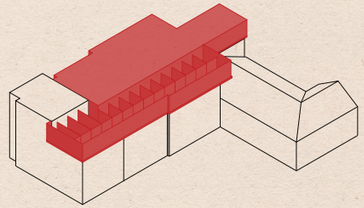
1. state of art - based on 1910 plan



2. connecting porch removal



3. adding new in-between volume



4. adding second floor with cages

Chapter II

Preservation & Conservation

II.I

Material survey and decay analysis

orthophoto

east facade, 1:200

rust staining

erosion

deposit

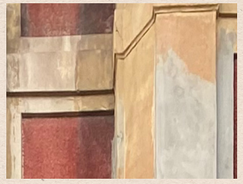
biological colonisation

efflorescence

cracks

missing parts

incoherent integrations

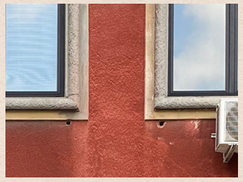


discolouration

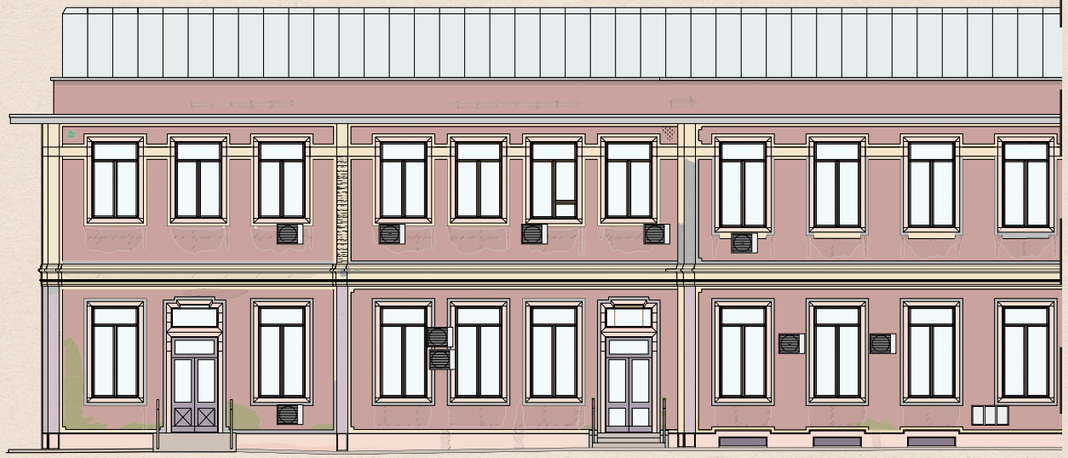
black deposit

incoherent integrations

mechanical damage



decay analysis



east facade, 1:200

materials

- plaster with red pigment
- plaster with ocher pigment
- aluminium
- wood
- decorative cement
- plaster with white pigment
- plaster with grey pigment
- glass
- metal (iron and steel)
- cement plaster
- artificial stone (conglomerate)

decays

- mechanical damage
- biological colonisation
- black deposit
- discolouration
- cracks
- detachment
- disintegration
- efflorescence
- erosion
- incoherent integration
- mising parts
- rust staining

II.II

Conservation and diagnostic project

phase 1

east facade, 1:200

Removal

It aims to remove incompatible materials on surfaces that require some interventions and treatments.

R01 Controlled removal of cement mortar for integration

Preconsolidation

It aims to give back stability to disintegrated surfaces which are required some interventions and treatments.

PCN01 Preconsolidation with ethyl silicate

Cleaning

This operation aims to eliminate the decay forms. It must be done in a very precise way starting with a careful analysis of the decay framework in order to maximise the preservation of the building. It is generally done by increasing the intensity of actions starting with the less aggressive ones.

PL01 Dry simple cleaning with small manual tools

PL02 Cleaning with biocida products

PL03 Cleaning with absorbent clays

phase 2a

east facade, 1:200

Cleaning

This operation aims to eliminate the decay forms. It must be done in a very precise way starting with a careful analysis of the decay framework in order to maximise the preservation of the building.

PL04 Wet cleaning with deionized and nebulised water at low pressure

Consolidation

It is used to restore the superficial or deep cohesion, to re-establish fallen pieces and to weld fissures but it doesn't prevent the decay phenomena from happening again.

CO01 Consolidation with ethyl silicate

CO02 Consolidation by filling the edges

phase 2b

east facade, 1:200

Consolidation

It is used to restore the superficial or deep cohesion, to re-establish fallen pieces and to weld fissures but it doesn't prevent the decay phenomena from happening again.

CO03 Integration of missing parts with compatible mortar

Protection

It is a necessary intervention aimed to avoid the aggression of the structure by atmospheric agents.

PR01 Lime mortar washing with adequate pigments

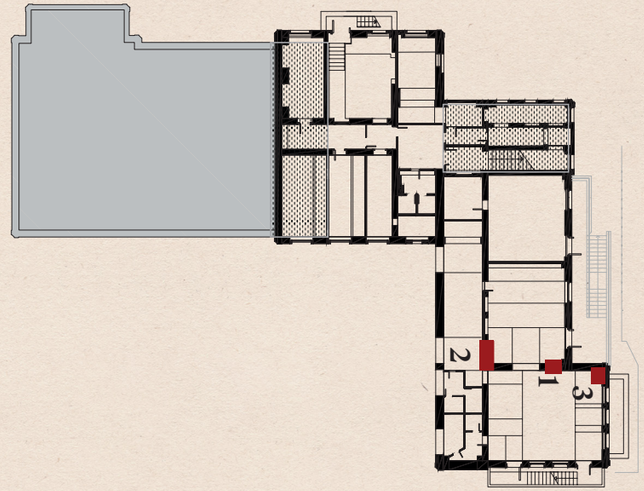
Special interventions

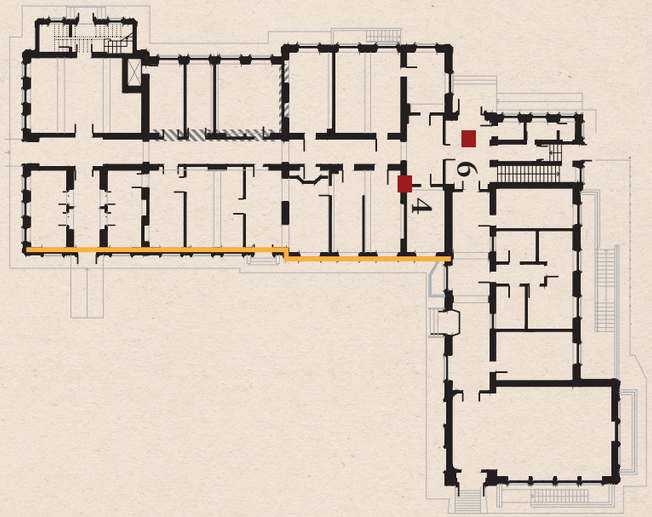
These type of interventions are aimed to re-establish the features of the original elements.

I01 Treatment of the metal

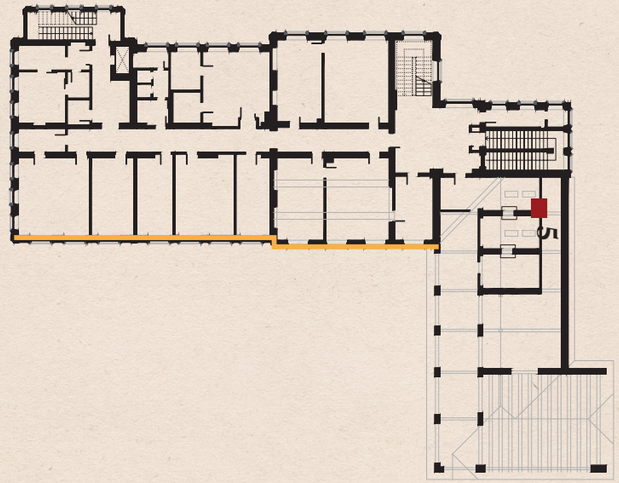
plans 1:500

↑ underground floor ↓ ground floor





first floor, 1:500



Thermography	Reading of the crack pattern Humidity mapping Define the decay of the finishing Understand the stratigraphy of the actual plaster
Double Flat Jacks Test	Understand the characters and the construction techniques
Core Drilling	Verification of the structure and consistency of a masonry
Georadar	Understand the foundation system Understanding evaluation of the homogenity of a structure

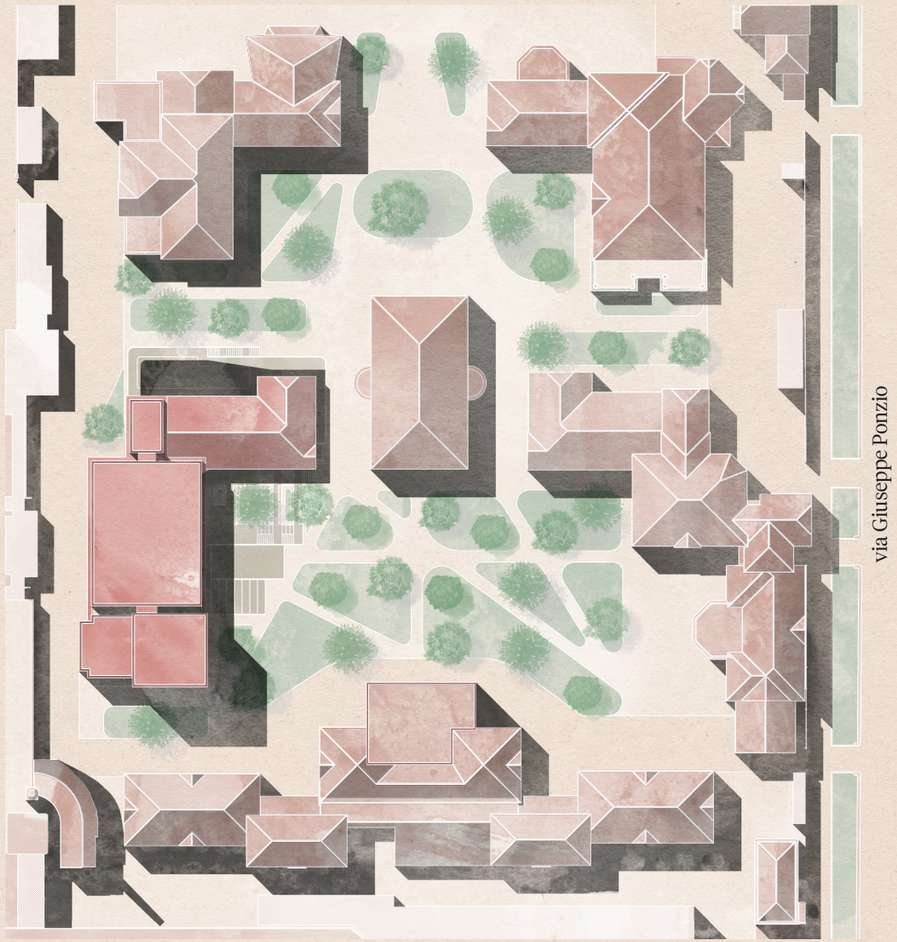
Chapter III

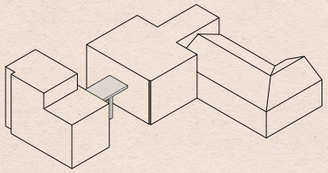
The project

III.I

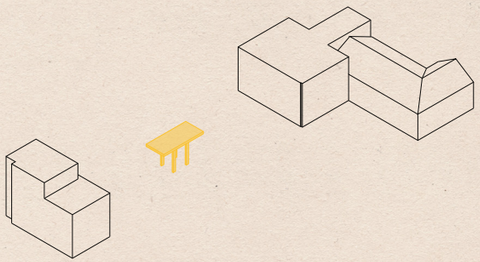
The strategy

masterplan, 1:1000

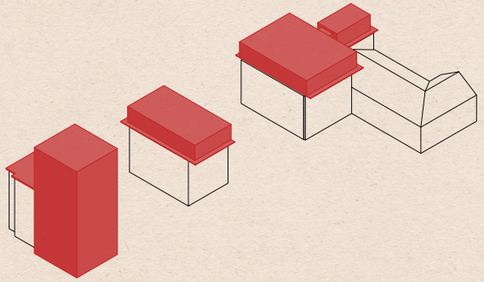




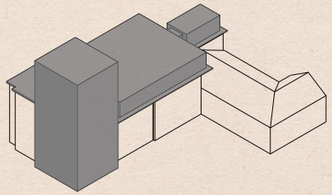
1. state of art (based on 1910 plan)



2. in-between element (based on 1910 plan)

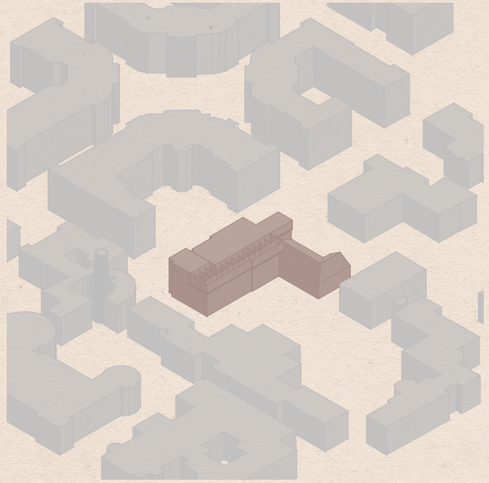


3. in-between existing volume and addiction



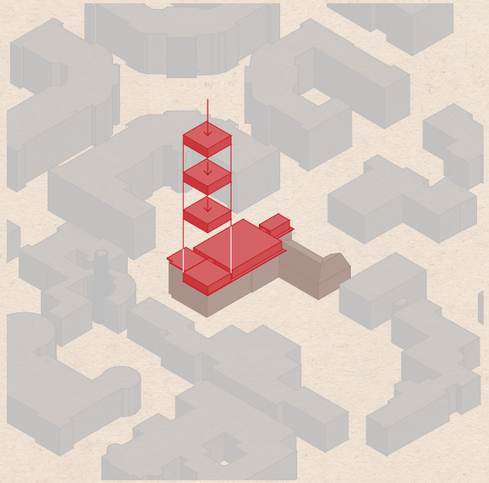
4. state of project

Considering the unification of the original two buildings connected by a porch in a unique volume, the project intends to keep as a medium the in-between body, using it as a hub for public vertical circulation. The entirety of the latter addition made at the second level will be demolished to leave space for the new intervention. The southern volume, always referring to the 1910 masterplan, will be functionally detached from the rest of the building: it will host the entirety of the Apice archive and its collections.
To achieve such an aim an underground level will be added as well as three more floors as well as the completion of the original portion at the second level. The new second level in the middle and northern body will host the exhibition area and it will be the new regular crown that closes the irregularities of the existing perimeter.
The tall archive is becoming one of the highest buildings on the site, aiming at the unification of the whole university campus as a common point of interest.
The new centralization of the project building, with respect to the entirety of the university site, will also point to the redesign of all the green areas across the campus with a focus on the east area right in front of the building where its new main entrance will be.



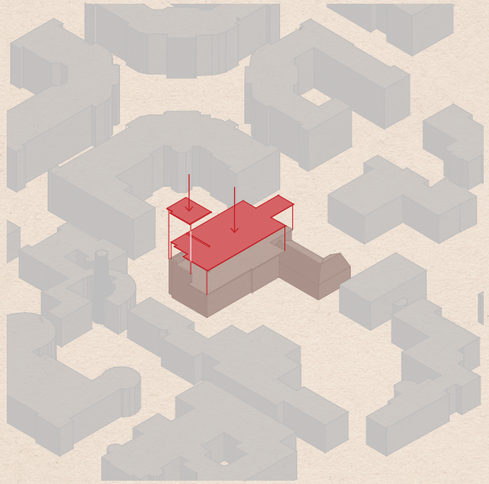
1. state of art

2. second floor removal

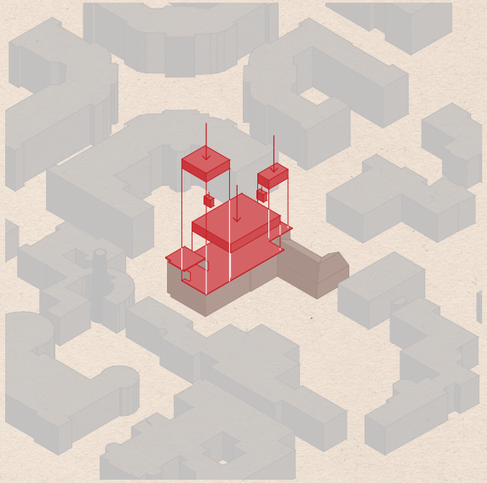


5. new additional floors (tower)

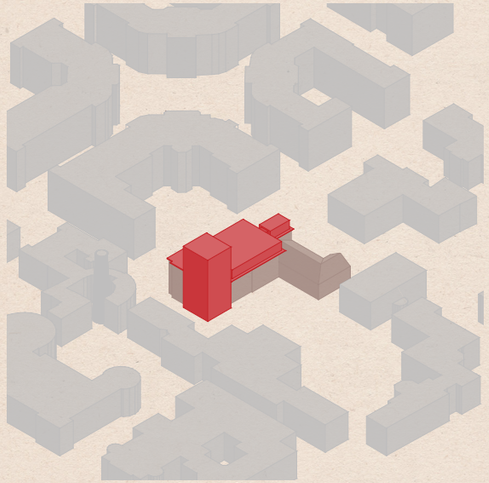
6. adding facade cladding and curtain wall



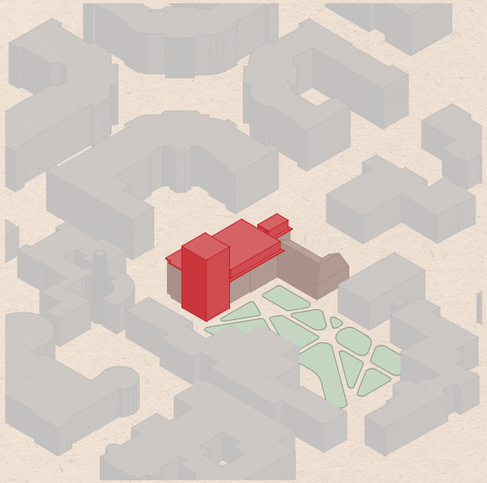
3. new structural pavimentation and roof



4. adding new second floor (exhibition level)



7. new tower and overlapping volumes

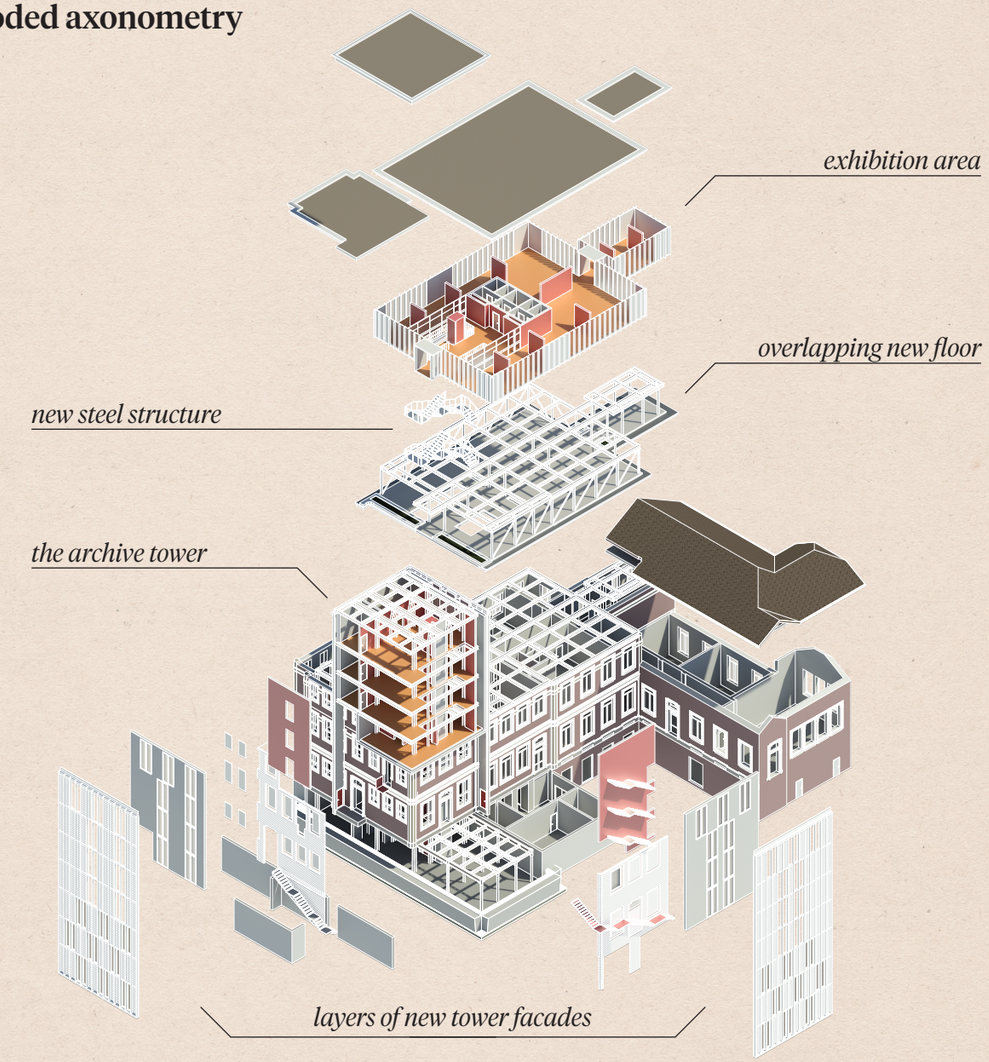


8. redesign of the front park

III.II

Overlapping: an overview

exploded axonometry



The building appears as a white vertical element that surrounds the southern area of the university campus.
The building opens to the east park both at ground and underground levels. Apart from most of the areas inside the tall archive, which is the only continuous function from the basement to the last floor, the other spaces around the building are accessible to the public. The presence of a system of staircases guides the visitor from the ground level to the lowered square where there are entrances to the underground level. The basement contains a workshop area which is intended to cooperate with archivists and show what are the tasks and the knowledge an archivist has. This workshop area is close to the repair room and the base of the archive tower. There is a cafeteria with a northern courtyard also accessible directly from ground level with a dedicated outer staircase. Adjacent to the cafeteria and directly connected both to the lowered squat at the east and the courtyard da at the north there is a conference room. Starting from here, the tower has a dedicated vertical circulation system compared with the public one present at the middle volume.
Through another system of steps and a ramp at ground level, there is the main access at the east which opens to the main atrium where the main public vertical circulation core is present. Here it is visible the removal of part of the slab at the first level, which generates a double-height space; also, the presence of a gallery that shows the workshop and repair rooms at the lower level as well as the entrances of the exhibition area at the second level helps in perceiving the open space of the entrance atrium. From this space, it is possible to reach offices and classrooms going to the northern part of the plan. One of the secondary entrances is present under the pitched roof volume; the previous classroom has been opened, removing window frames and reopening the ones that have been closed during past years, originating a study area semi-sheltered where the secondary entrance lies.
The only public staircase present in the archive volume is the one starting from ground level, outside the building and near the main entrance. This access, clearly visible in the façade, brings the visitor directly to the first level through a passage that flanks the covered existing façade and the curtain wall closing the perimeter of the upper floors tower. Once on top, there is a waiting room directly connected to the archive and a consultation room where it is possible to analyse specific documents only with the supervision of an archivist. In the other spaces on the first level, on the opposite side of the central hub, there are reading/studying rooms and meeting rooms.
The second floor hosts the entirety of the exhibition space, which is accessible from the main hub open to the underlying levels. The exhibition area is separated by the hub through glass partitions, and it is enclosed in a perimeter of U-glass and white opaque aluminium panels. At this level, the tower starts to emerge from the main volume requiring a new vertical circulation system apart from the freight elevator.
At top levels, only the archive personnel is allowed to go.
Recalling the staircase in the façade at ground level, new service staircases appeared in the front eastern façade. The southern and eastern facades of the tower are designed in such a way as not to have direct light on anything on its inside. The choice to have private staircases at upper levels visible in the façade helped to deal with direct light.

functions distribution

fifth floor

fourth floor

third floor

second floor

first floor

ground floor

underground floor

functions scheme

- archive
- consultation rooms
- workshop
- cafeteria
- exhibition area
- offices, ancillary rooms & management
- classrooms and reading rooms
- conference room

vertical distribution

fifth floor

fourth floor

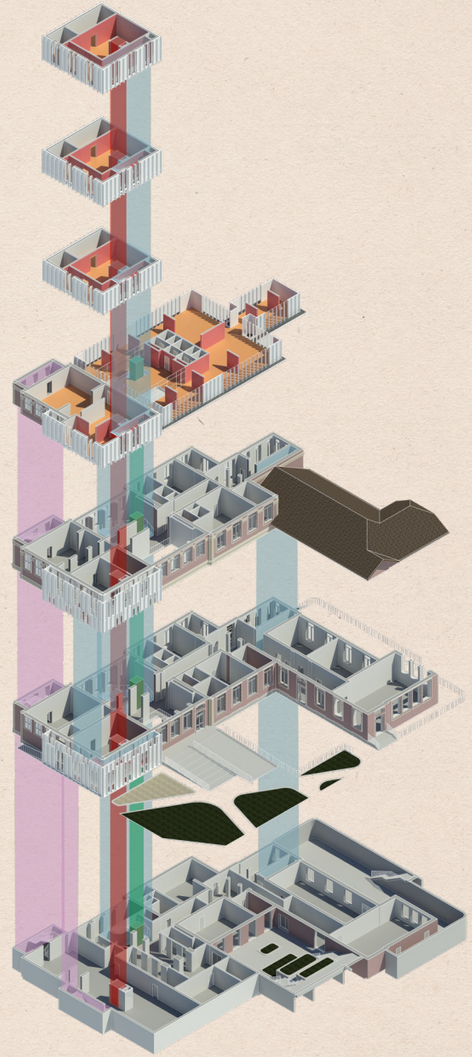
third floor

second floor

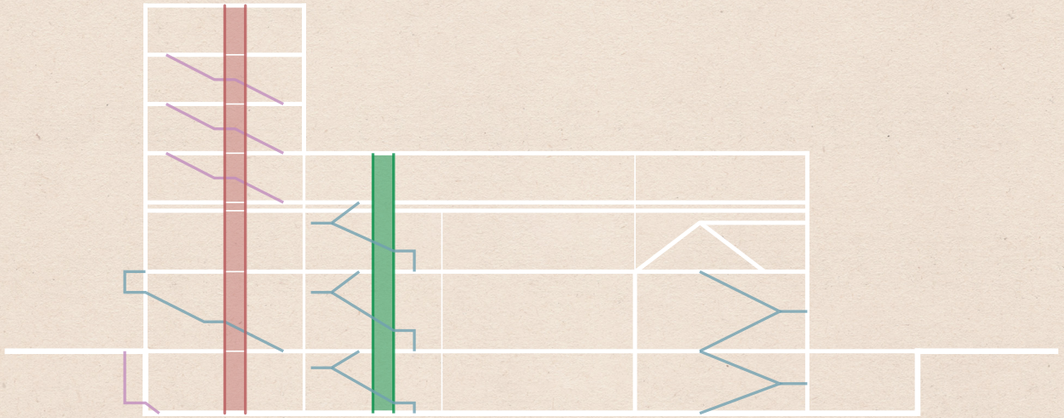
first floor

ground floor

underground floor



vertical scheme



private elevator

public elevator

private staircases

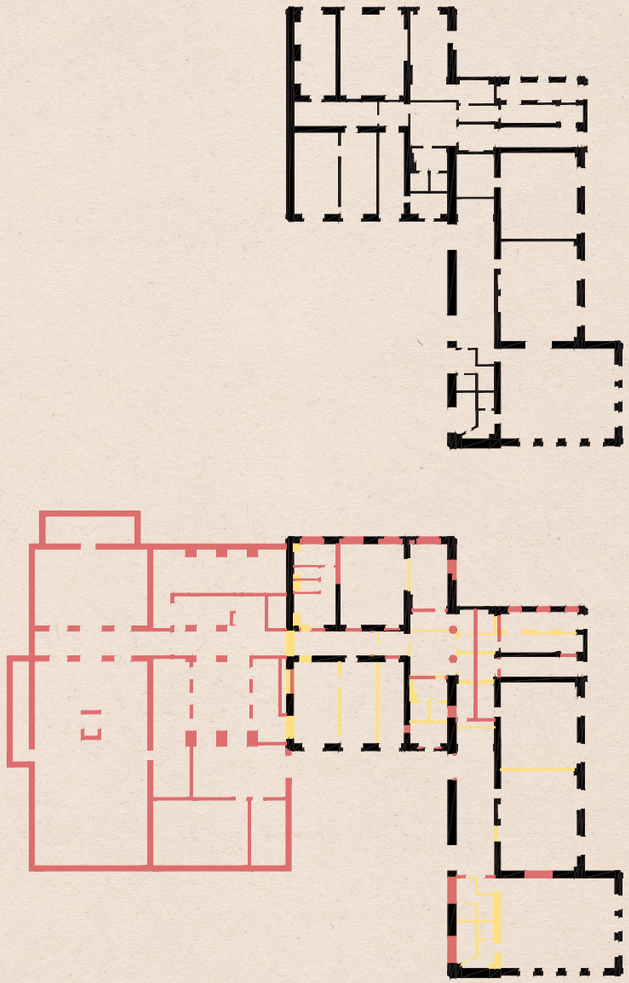
public staircases

III.III

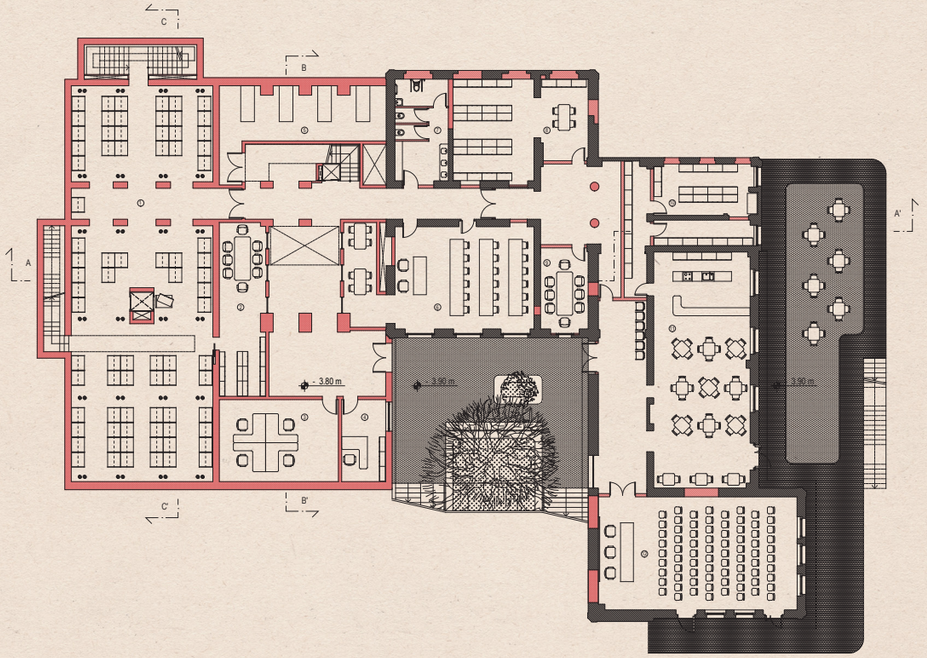
Plans

underground floor plan, 1:500

↑as found ↓demolition/addition



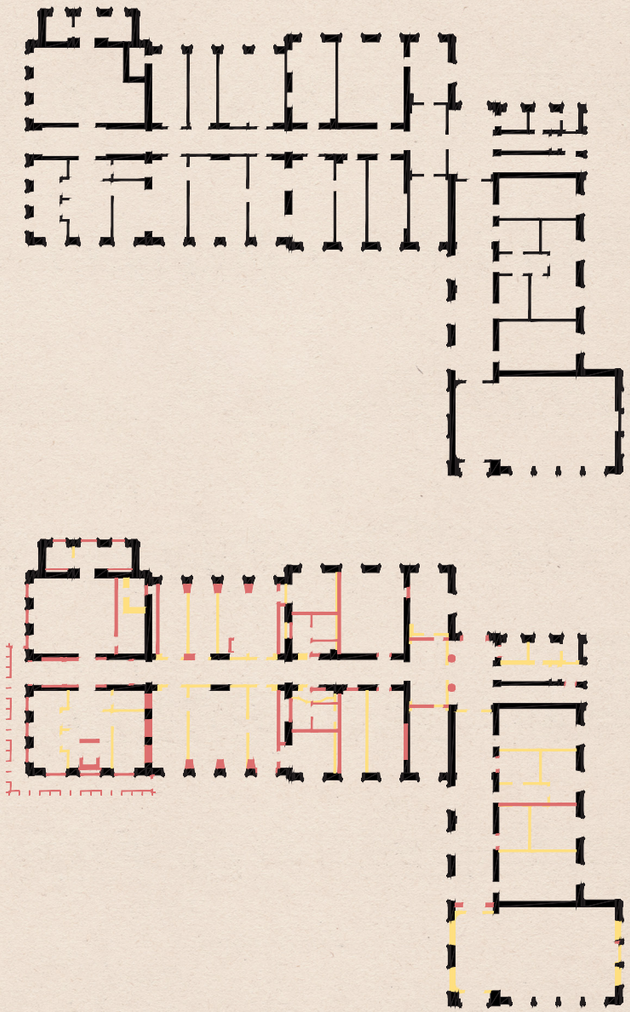
underground floor plan, 1:400



1. reparatory & archive
2. repair room
3. consulation room
4. office
5. technical room
6. workhop classroom
7. WCs
8. storage room
9. meeting room
10. cafeteria service rooms
11. cafeteria
12. conference room

ground floor plan, 1:500

↑as found ↓demolition/addition

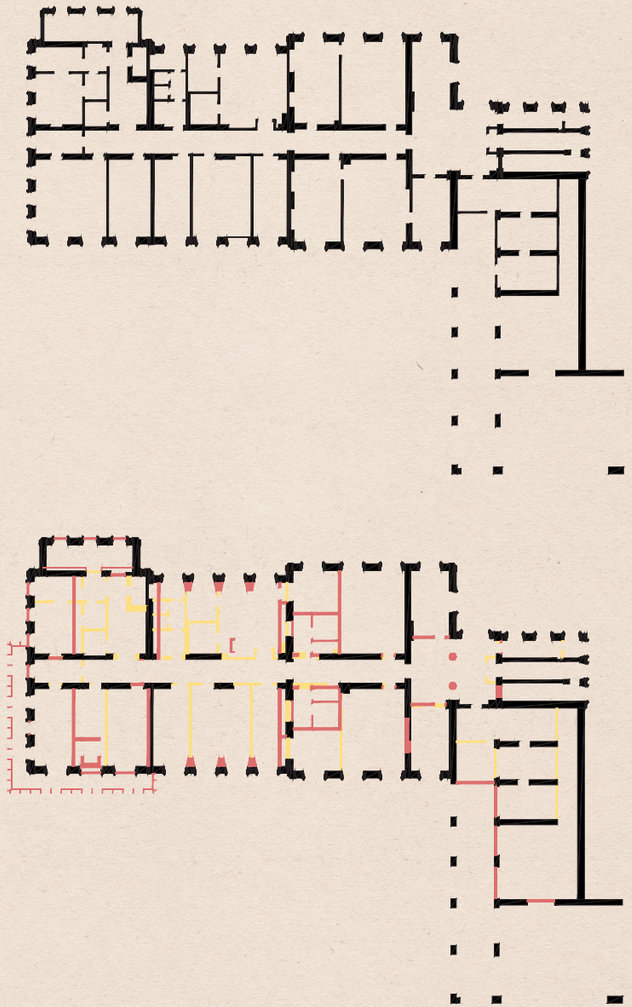


ground floor plan, 1:400

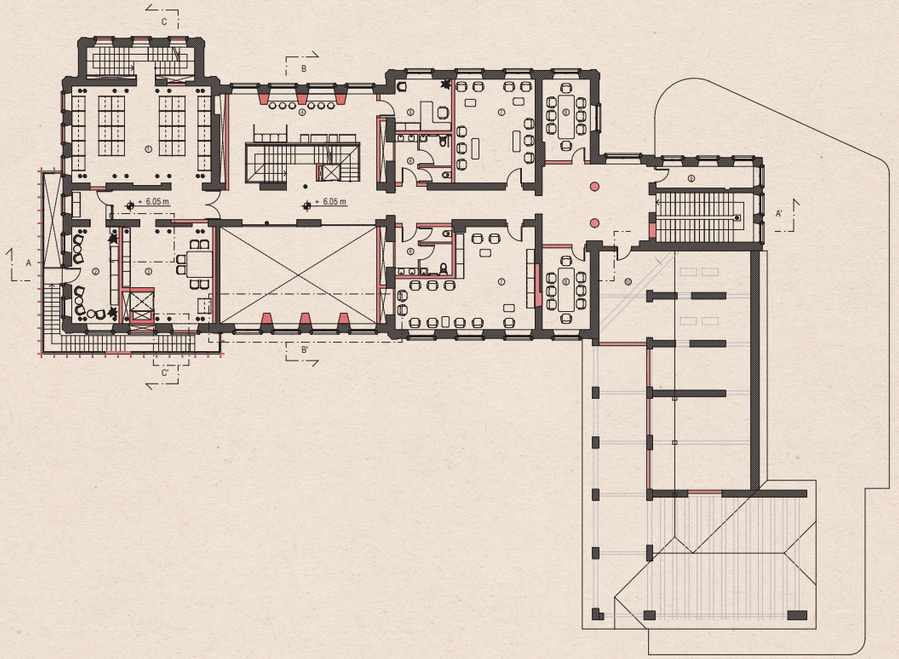
1. archive and packaging room
2. informal space
3. entrance atrium
4. reception
5. WCs
6. offices
7. break rooms
8. keeper room
9. classrooms
10. study area

first floor plan, 1:500

↑as found ↓demolition/addition



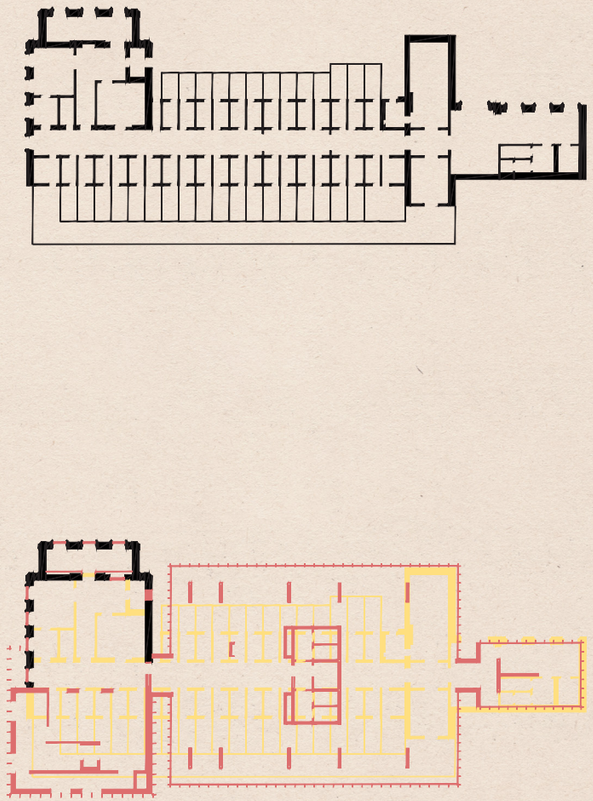
first floor plan, 1:400



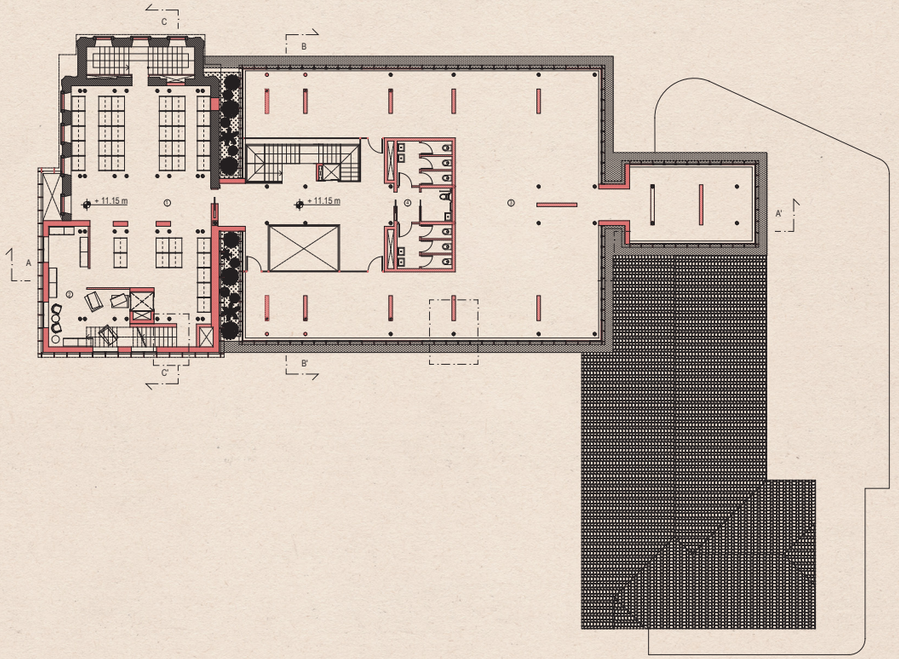
1. archive
2. waiting room
3. consultation room
4. informal space
5. office
6. WCs
7. reading/studying rooms
8. meeting rooms
9. rack room
10. storage room

second floor plan, 1:500

↑as found ↓demolition/addition

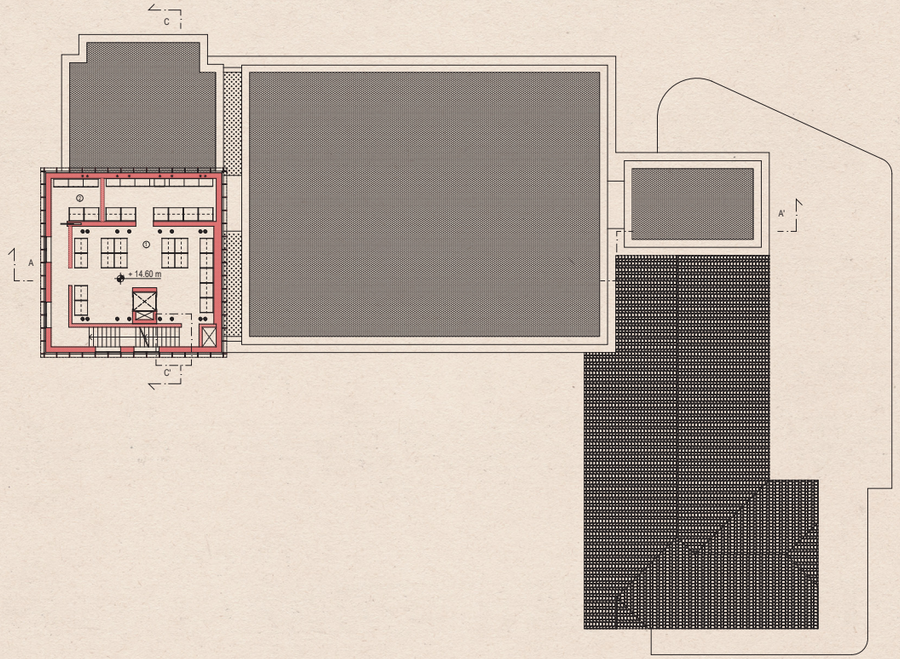


second floor plan, 1:400



1. archive
2. lobby area
3. exhibition area
4. WCs

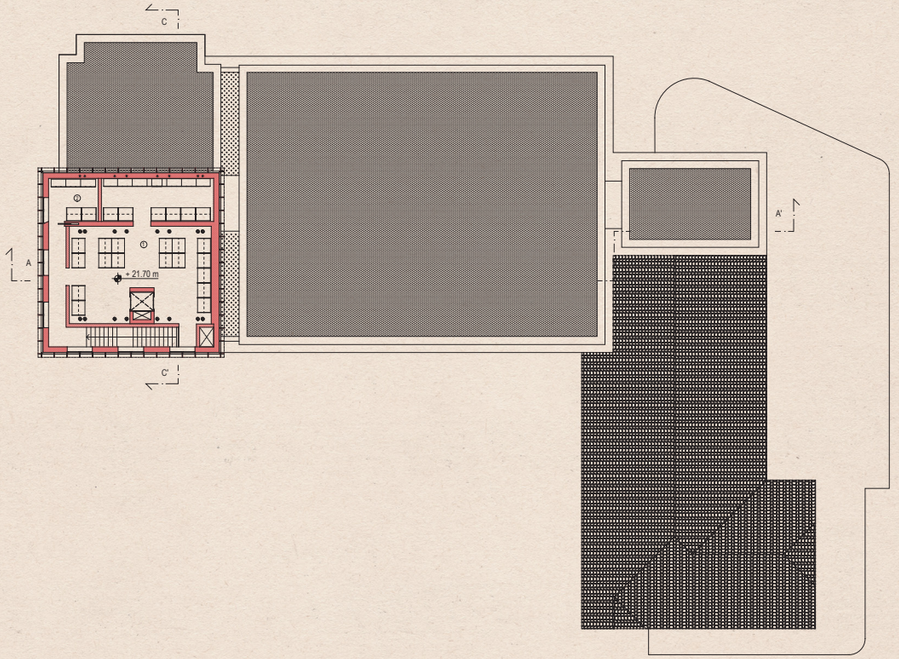
typical tower floor plan, 1:400



1. archive

2. safe room

fifth floor plan, 1:400



1. archive

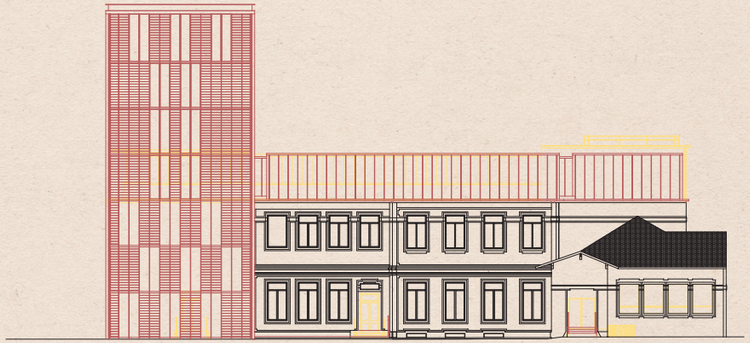
2. safe room

III.IV

Elevations

east facade, 1:500

↑as found ↓demolition/addition

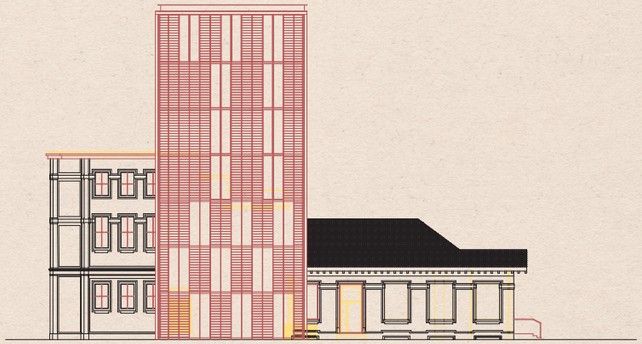


east facade, 1:400

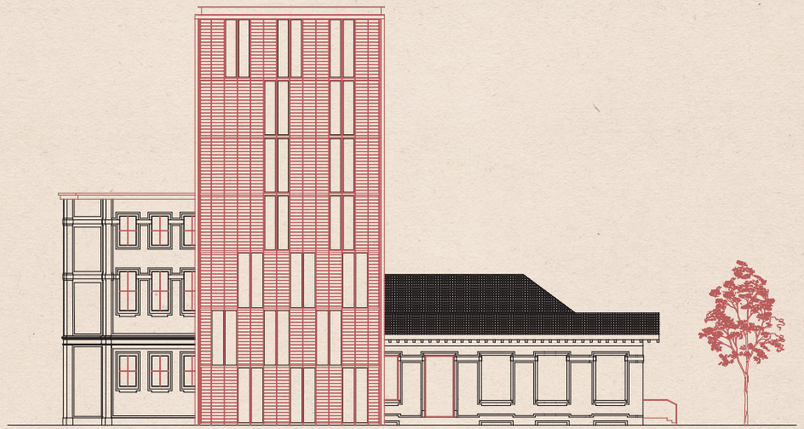
east facade, 1:200

south facade, 1:500

↑as found ↓demolition/addition



south facade, 1:400



south facade, 1:200

west facade, 1:500

↑as found ↓demolition/addition

west facade, 1:400

north facade, 1:500

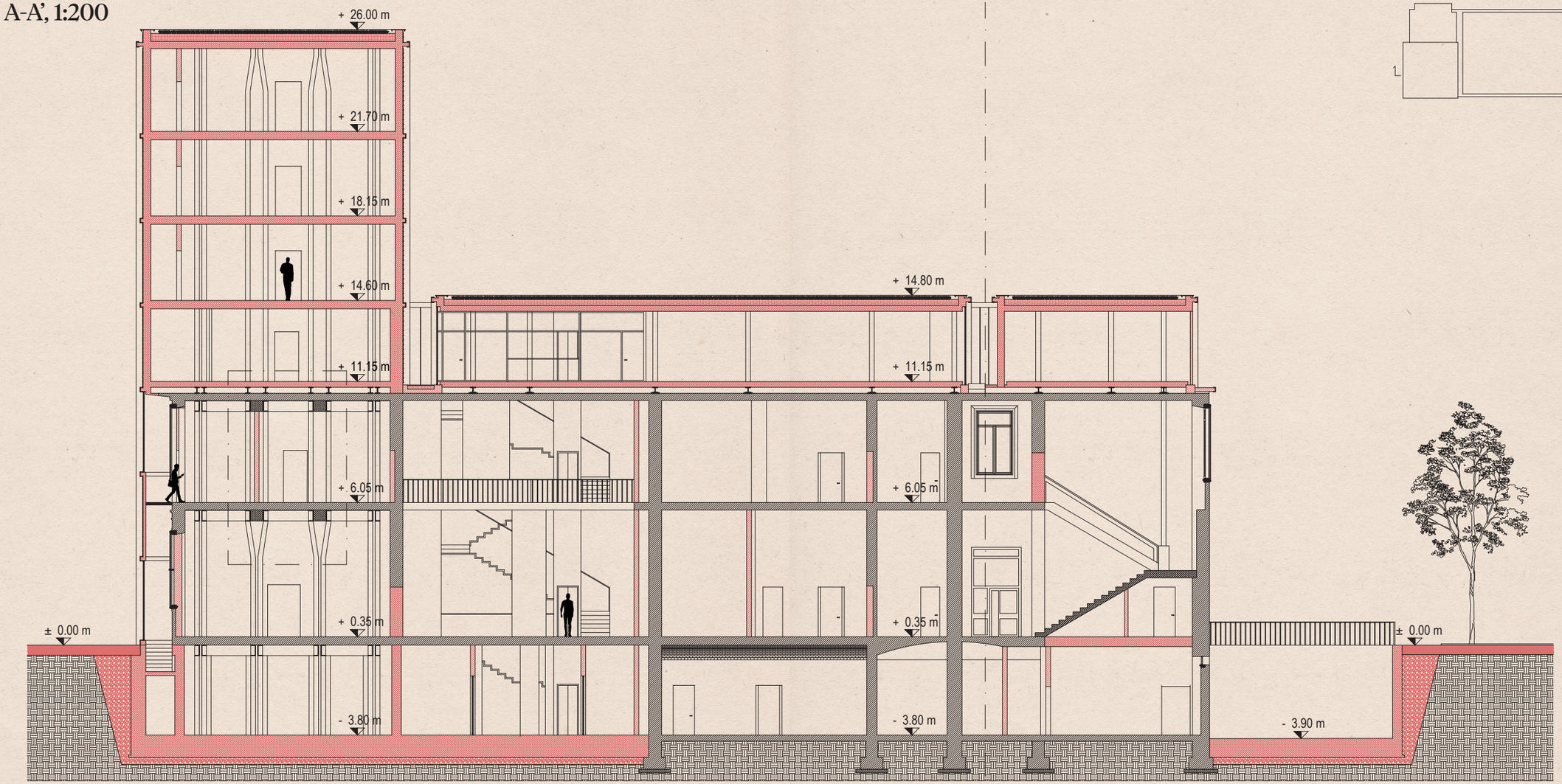
↑as found ↓demolition/addition

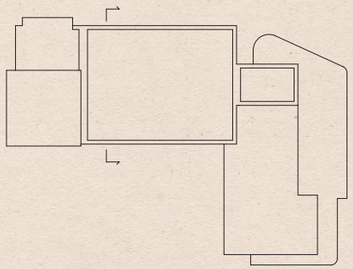
north facade, 1:400

III.V

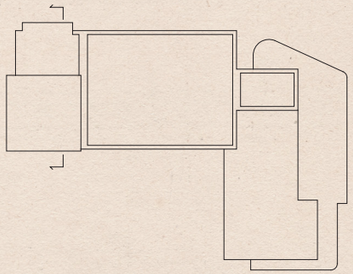
Sections

section A-A', 1:200





section B-B', 1:200

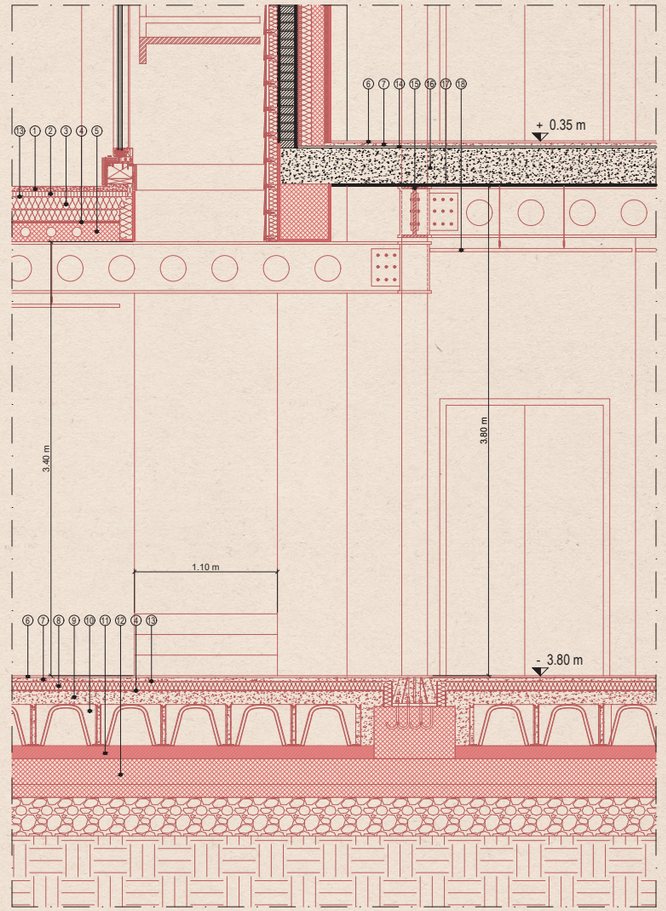


section C-C', 1:200

III.VI

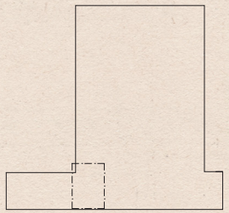
Construction details

detail section 1, 1 to 50

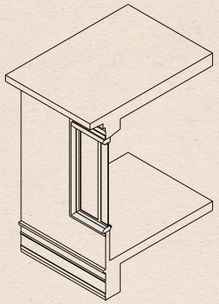


material legend

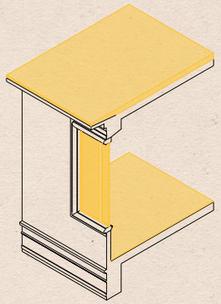
1. Outer concrete flooring
2. Structural screed
3. Rockwool roof rock 50 plus
4. Mapei mapeproof waterproof membrane
5. Prefabricated hollow concrete slab
6. Ceramic tiles finishing
7. Lightweight concrete screed
8. Rockwool hardrock
9. Concrete filling
10. Daliform group Iglu
11. RC footing
12. Magrone
13. Stego wrap 2 mil vapor barrier
14. Existing levelling
15. IPE 450
16. Existing concrete slab
17. Plaster finishing
18. Knauff acquapanel



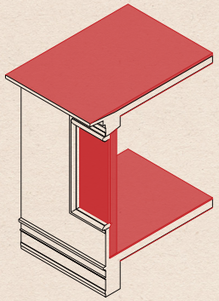
tower facade assembly, diagrams



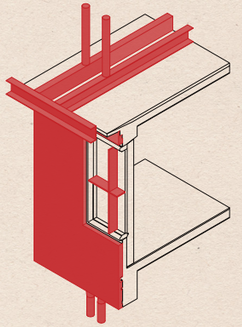
1. state of art



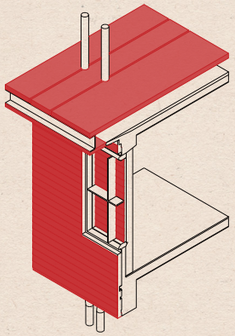
2. window, pavement and filler removal



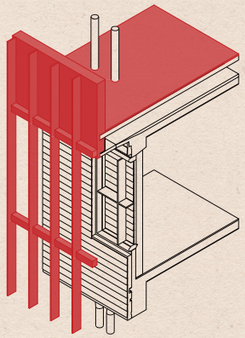
3. new pavimentation and window filler



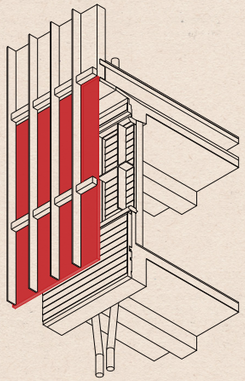
4. new steel structure and wall covering



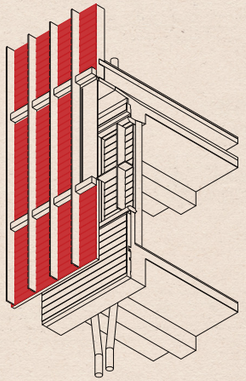
5. new slab and wall finishing



6. new pavement and curtain wall structure

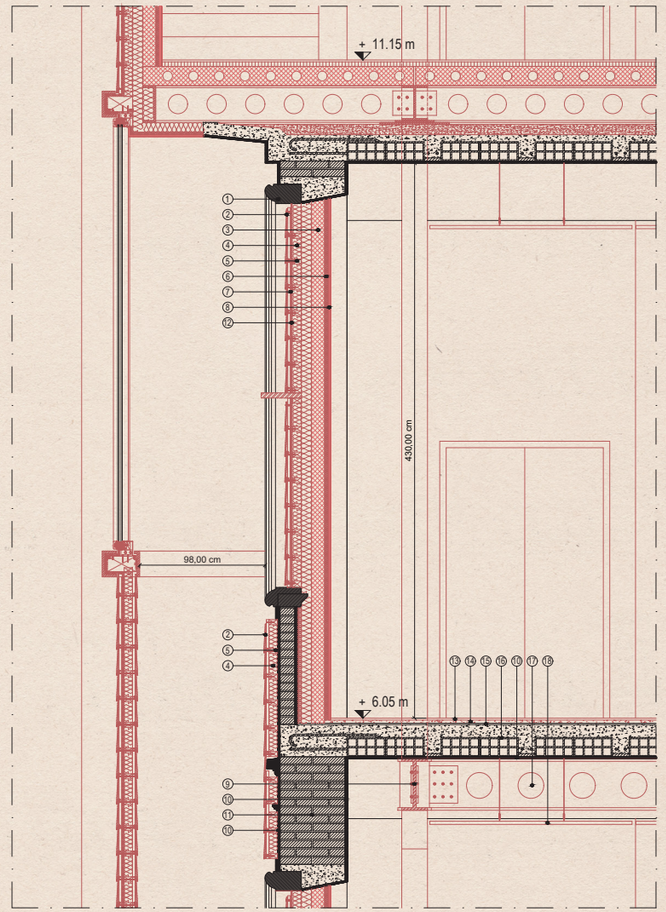


7. adding curtain wall panels and windows



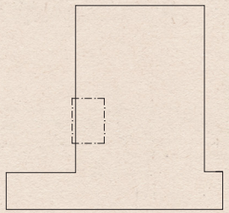
8. adding finishing on panels

detail section 2, 1 to 50



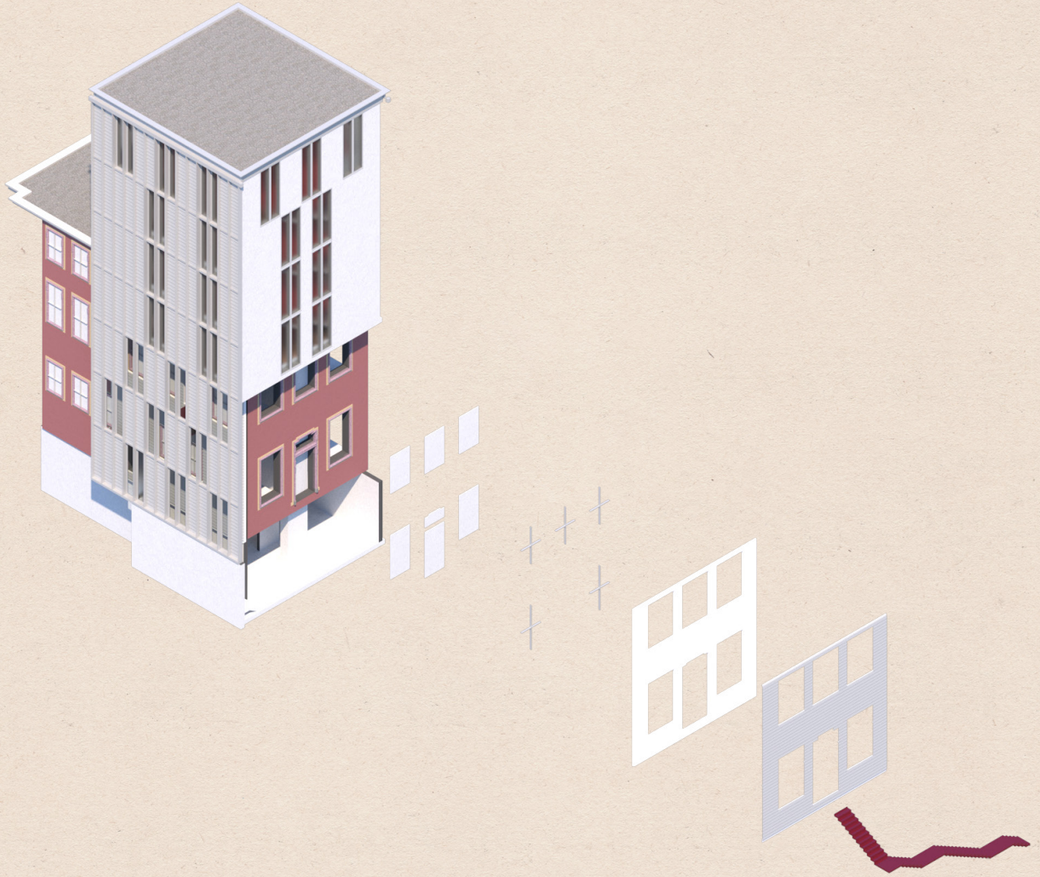
material legend

1. Decorative granite
2. White aluminium profiles finishing
3. Precast concrete wall
4. Rockwool frontrock
5. Wooden batten
6. Silenteco panel
7. Air chamber
8. Plaster finishing
9. HEA 500
10. Old plaster finishing
11. Existing masonry wall
12. Thermal insulation
13. Ceramic tiles finishing
14. Lightweight concrete screed
15. Getzner acoustic mat
16. Existing ferrocemento slab
17. ACB (HEA 450)
18. Knauff acquapanel

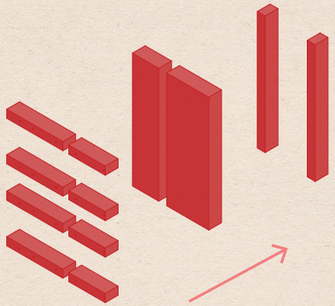


view of the gallery looking at basement level

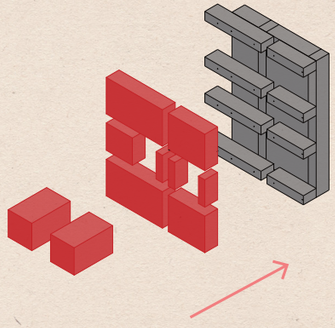
inner facade assembly scheme



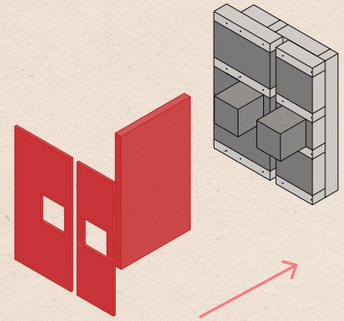
tower enclosure, assembly diagrams



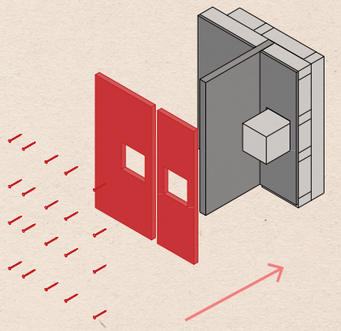
1. wood battens and rock wool



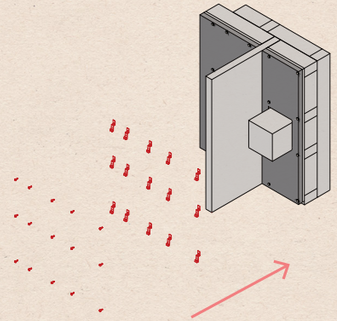
2. second layer of insulation and wood



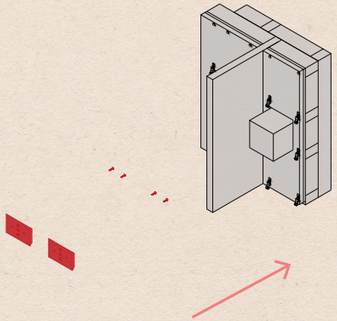
3. vertical mullion and thermal insulation



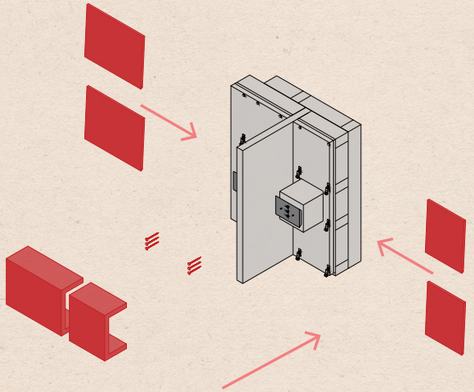
4. waterproof membrane and screws



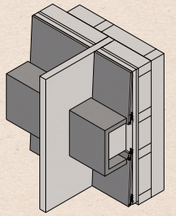
5. steel hooks and screws



6. connection steel plate and screws

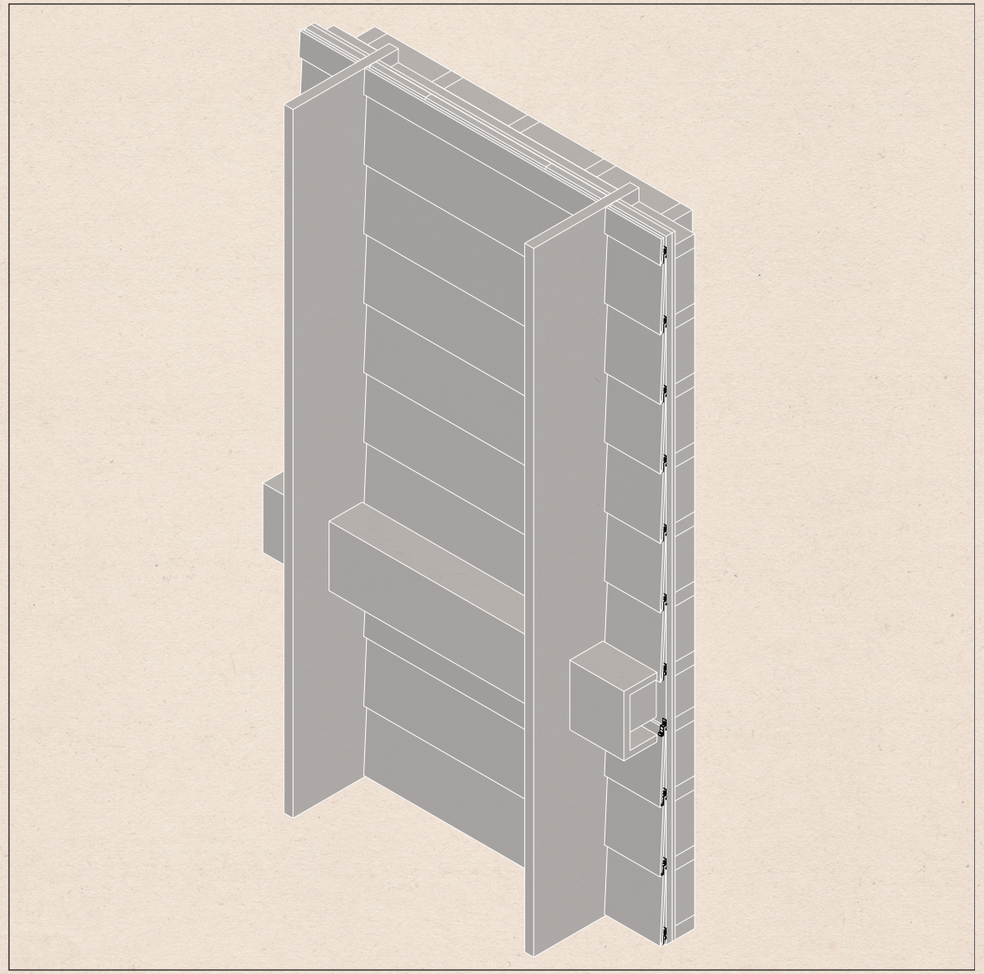


7. aluminium C profiles and inclined ones

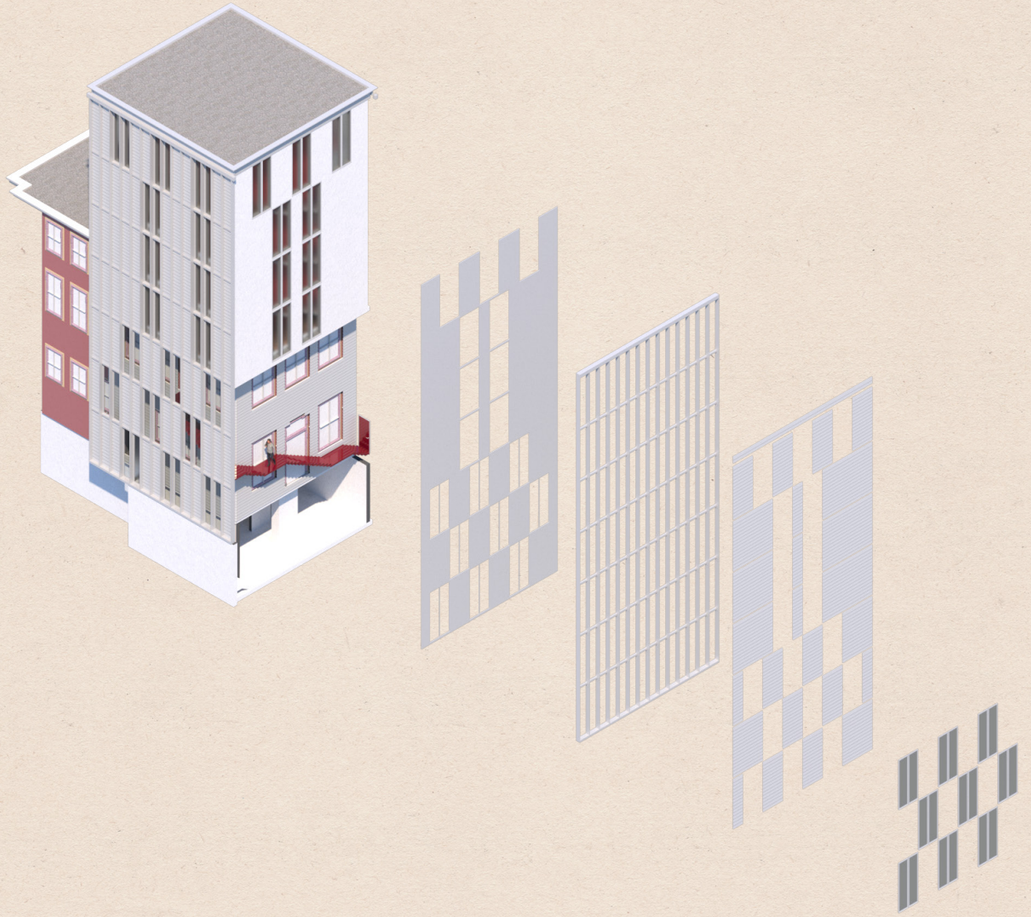


8. portion of tower finishing

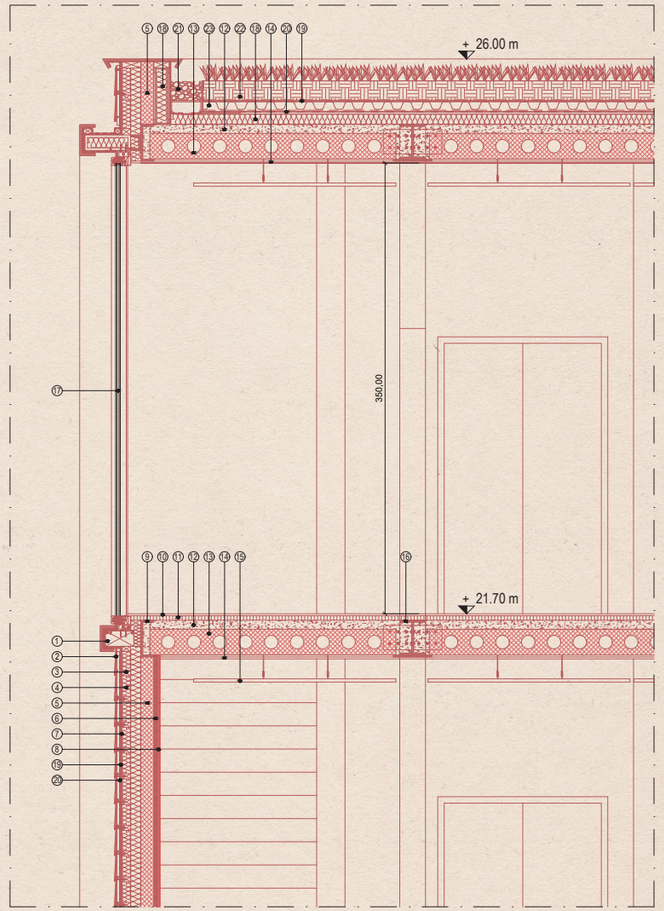
tower envelope axonometric slice



outer facade assembly scheme

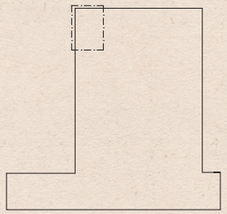


detail section 3, 1 to 50

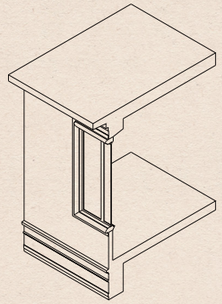


material legend

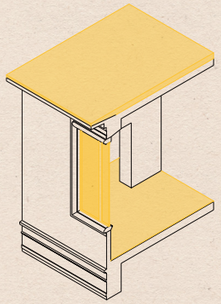
1. Wood joist
2. White aluminium profiles finishing
3. Wooden batten
4. Rockwool frontrock
5. Precast concrete wall
6. Silenteco panel
7. Air chamber
8. Plaster finishing
9. UPE 270
10. Ceramic tiles finishing
11. Beton wood screed
12. Concrete filling
13. Prefabricated hollow concrete slab
14. Drywall panel
15. Knauff acquapanel
16. SFB (HEM 240 + 450x30)
17. Secco sistemi 4FAF
18. Rockwool roof rock 50 plus
19. Thermal insulation
20. Mapei mapeproof waterproof membrane
21. Gravel
22. Growing medium
23. Drainage layer



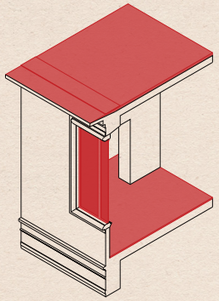
exhibition at the second level, assembly diagrams



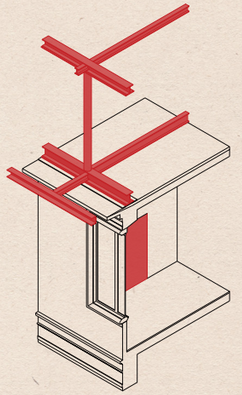
1. state of art



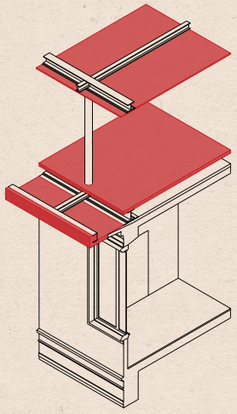
2. window, pavement and filler removal



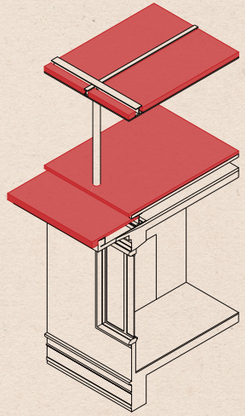
3. add flooring, window and steel plate



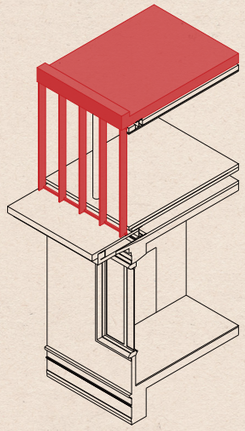
4. new steel structure lying on existing



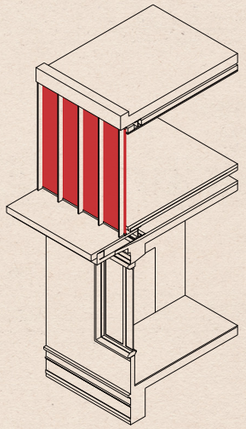
5. new slab, cantilever and ceiling



6. add roof slab and exhibition flooring

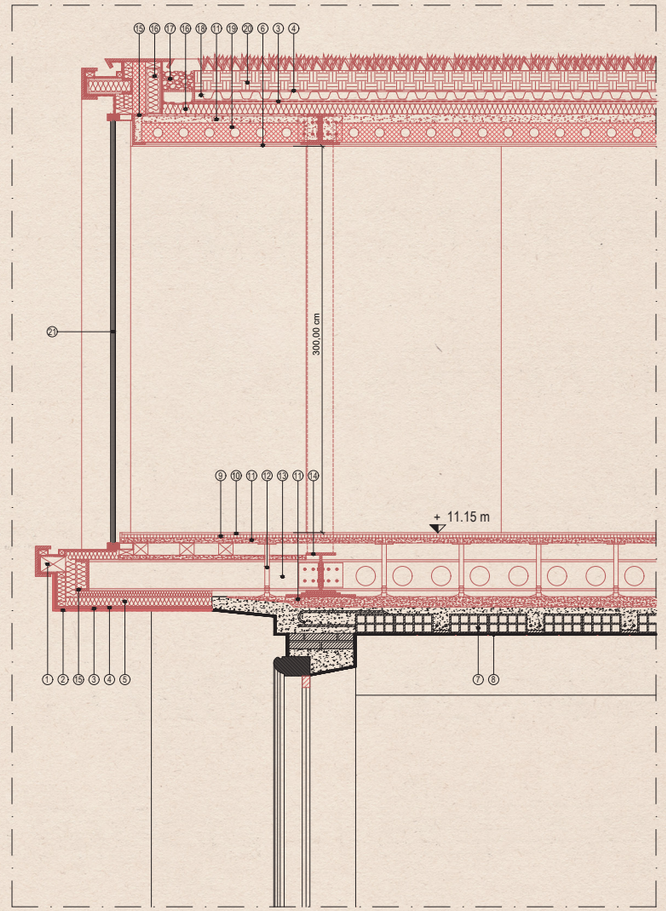


7. adding curtain wall and roof closing



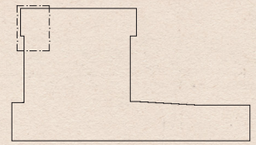
8. adding u-glass and aluminium panels

detail section 4, 1 to 50



material legend

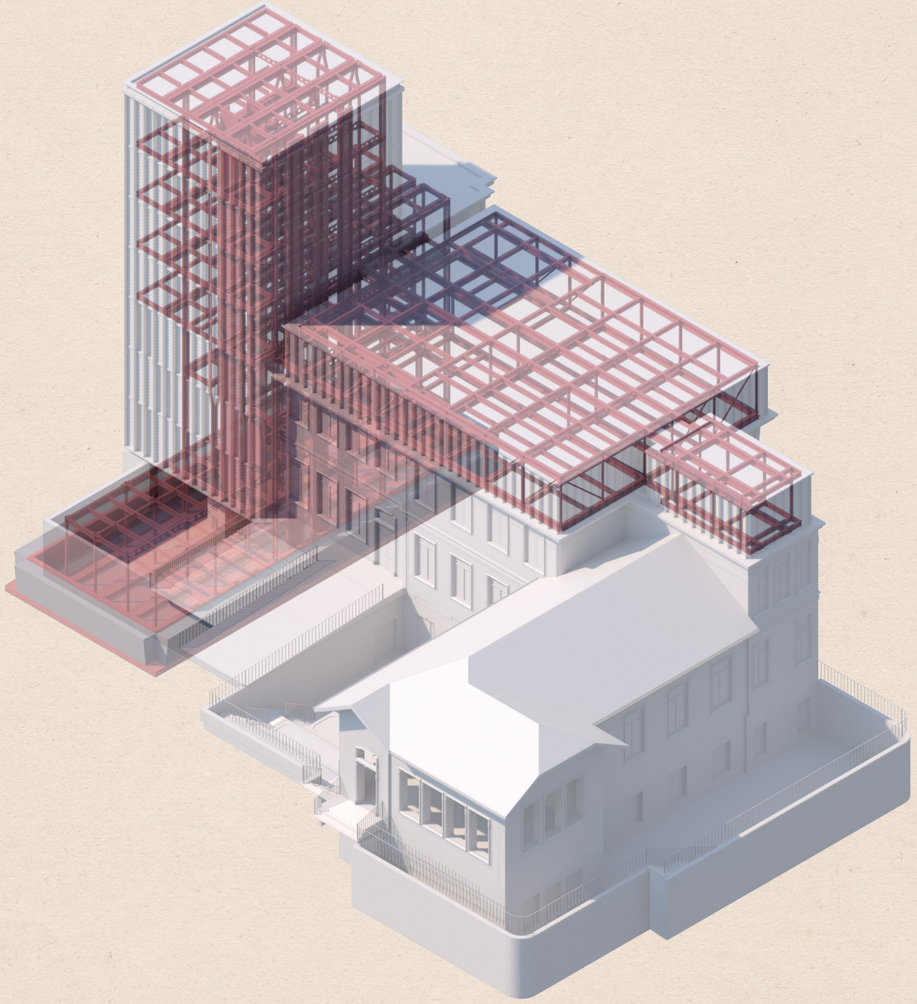
1. Wood joist
2. Plaster finishing
3. Mapei mapeproof waterproof membrane
4. Thermal insulation
5. Rockwool frontrock
6. Drywall panel
7. Existing ferrocemento slab
8. Existing plaster finishing
9. Beton wood screed
10. Ceramic tiles finishing
11. Structural concrete filling
12. Raised floor system
13. HEA 240
14. SFB (HEM 280 + 500x30)
15. UPE 240
16. Rockwool roof rock 50 plus
17. Gravel
18. Drainage layer
19. Prefabricated hollow concrete slab
20. Growing medium
21. Secco sistemi 4FAF



Chapter IV

The structure

new structural solution



The southern tall volume is supported by a steel structure which is independent from the existing masonry bearing walls, seeing the heavy furniture it is going to host. Referring to the other part of the new second level, since the loads are considerably lower than the ones expected in the tower, the new steel structure lies on top of the existing masonry walls. The idea is to keep all the existing ferrocemento slabs, also the ones at the second level, without stressing them with excessive loads.

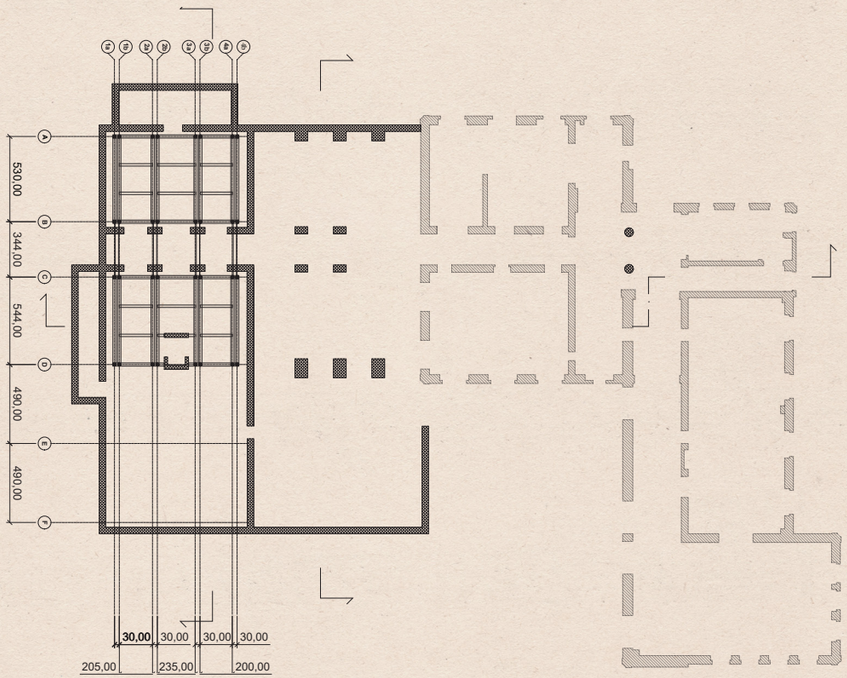
In the case of the tower, there are existing RC beams at the first and second levels. In order to bypass the issue, a system of twin columns starting from the basement to the roof has been studied together with steel plate reinforcements at the bottom of the slabs. In the proximity of the beams at the first level, these columns pull away from each other in order to flank the existing beam and cut through the slabs to proceed to the next floor. At the RC beams level, UPE and ACB profiles were placed both to give support to beams as well as the slabs. Regarding the second level, the steel UPE and ACB profiles are placed on top of the ferrocemento slab with the addition of a new prefabricated hollow core slab as the actual bearing floor. The gap between the existing and new slab serves to keep a clear division between old and new as well as being the space for system pipes and wires. On upper floors, the columns go on and there is the introduction of SFB profiles to support prefabricated slabs in order to save space in height. The freight elevator is surrounded by shear walls, from the basement up to the roof. Other shear walls are placed along the northern side of the tower, flanking the existing masonry wall at the ground and first levels.

About the exhibition, SFB profiles with an additional plate at their bases have been anchored at the top of the existing masonry bearing walls. Taking into account the irregularity of the existing perimeter, an extension of the masonry walls (obtained through the flanking of the new RC portion of walls) allowed the new steel structure at the second level to find a safe load-bearing anchor point just inside the original perimeter. Also in this case the SFB profiles lie on top of the existing ferrocemento slab, leaving a gap between it and the raised flooring of the exhibition area suitable for the building' systems. The exhibition box is entirely enclosed in steel bracings.

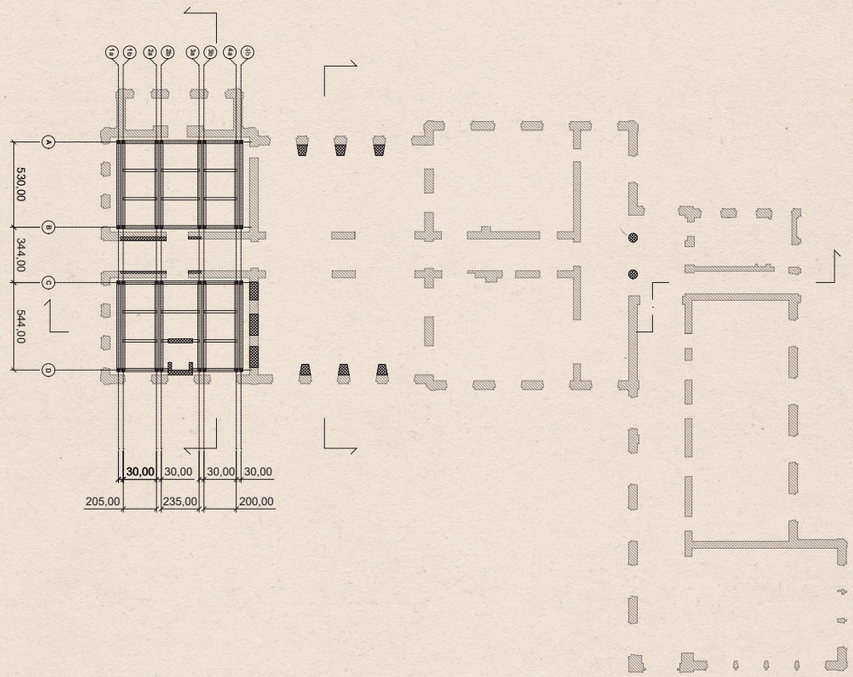
IV.I

Structural concept

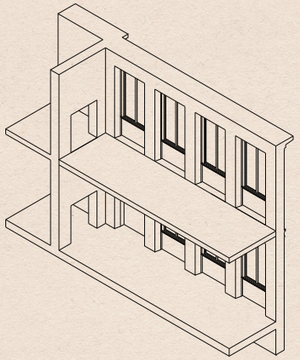
structural underground floor plan, 1:400



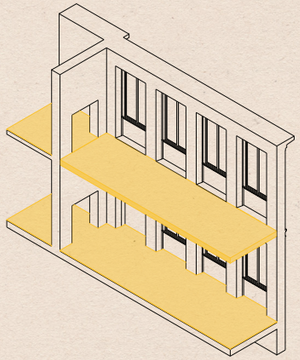
structural ground floor plan, 1:400



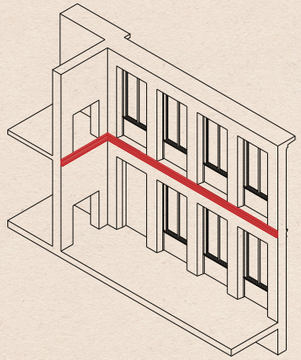
bearing pillars and atrium open space, assembly diagrams



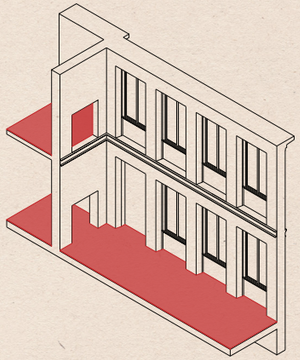
1. state of art



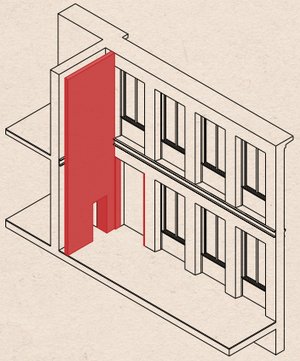
2. slab and pavement removal



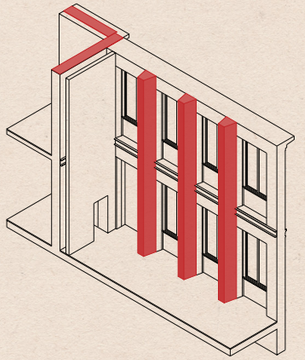
3. walls securing and reinforcement



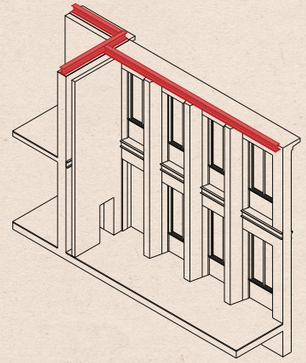
4. new pavement and closing door



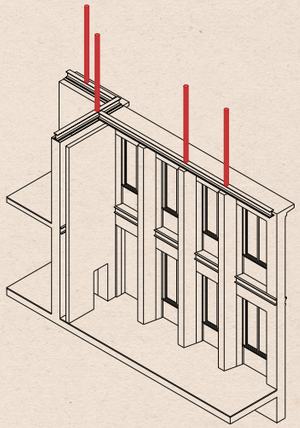
5. new door, shaft enclosure and entrance



6. adding pillars and steel plates

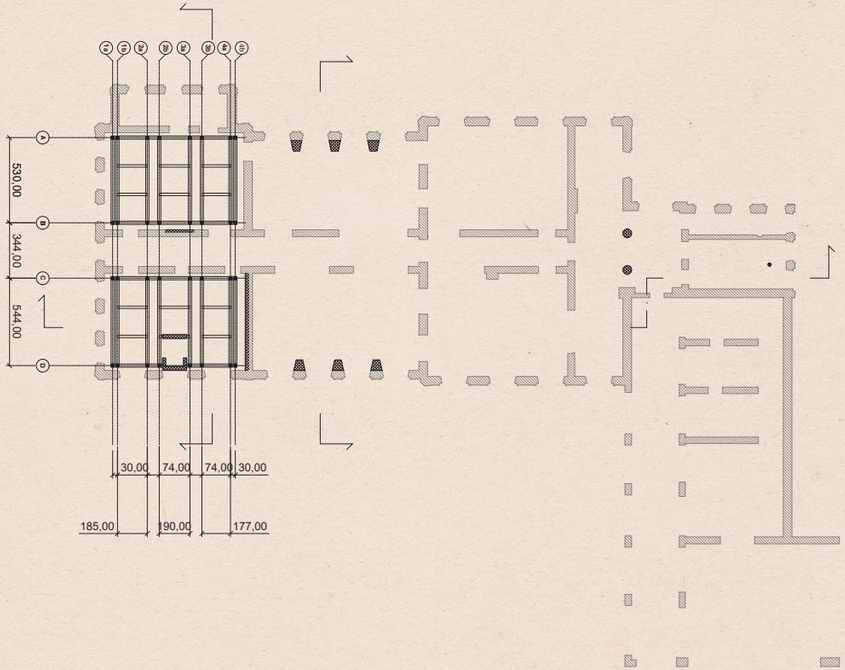


7. new steel beams on top of existing walls

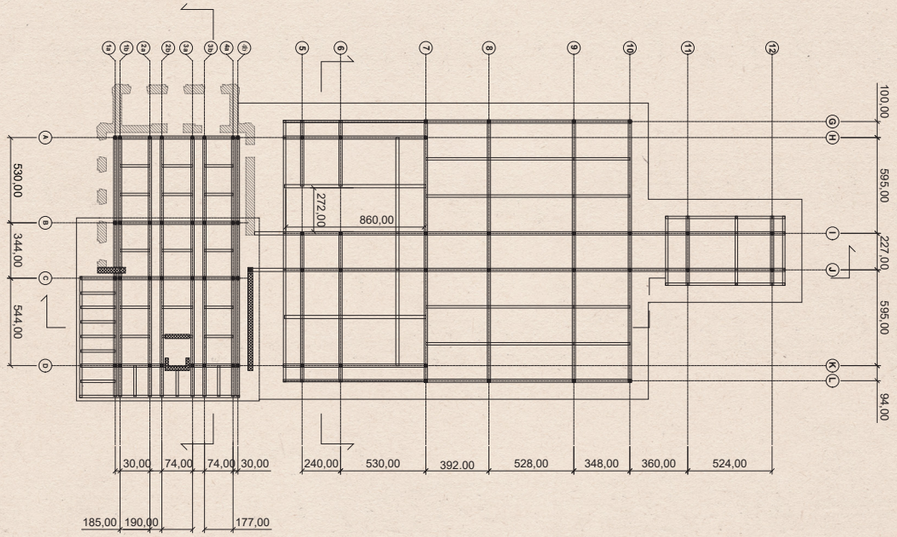


8. adding columns at exhibition level

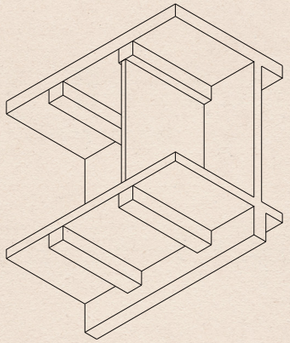
structural first floor plan, 1:400



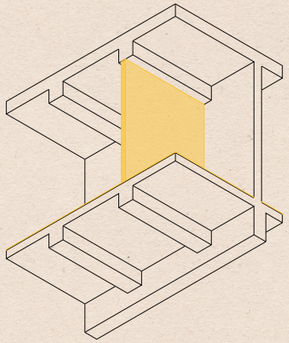
structural second floor plan, 1:400



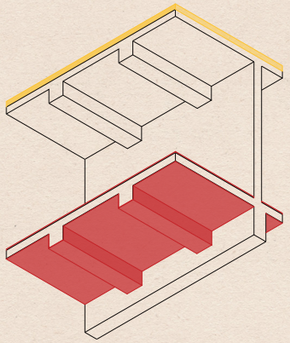
existing RC beams and new structure, assembly diagrams



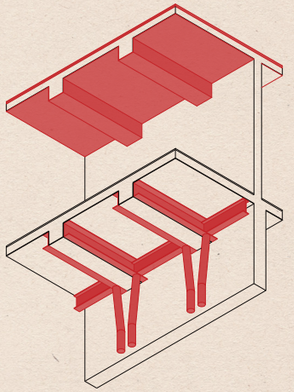
1. state of art



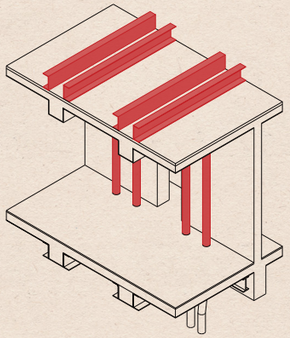
2. pavement removal and wall demolition



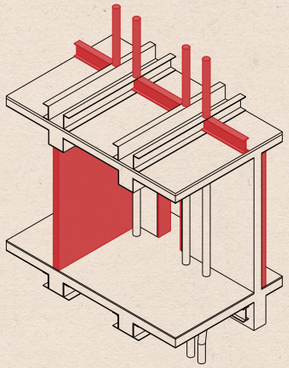
3. pavement removal and slab reinforcement



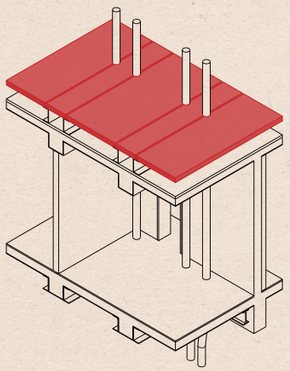
4. add steel structure and slab reinforcement



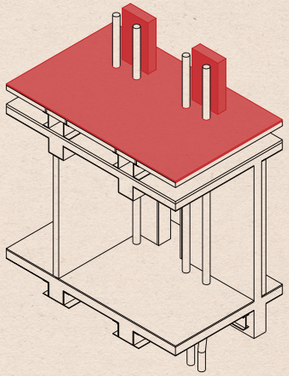
5. columns and C profiles flanking RC beams



6. new steel structure and new wall

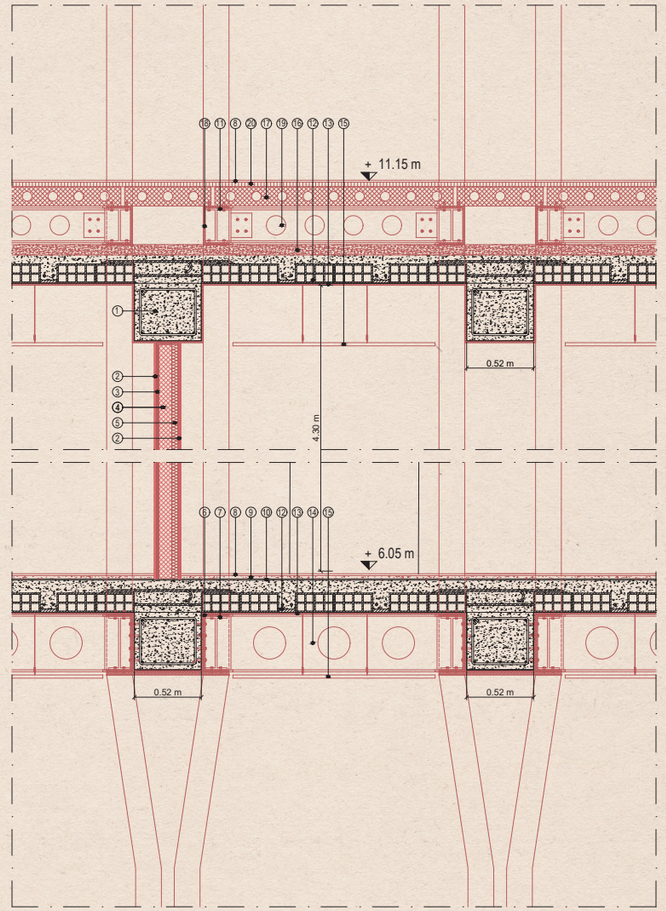


7. adding new slabs



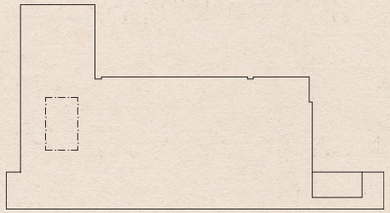
8. new flooring and tower interior walls

detail section 5, 1 to 50

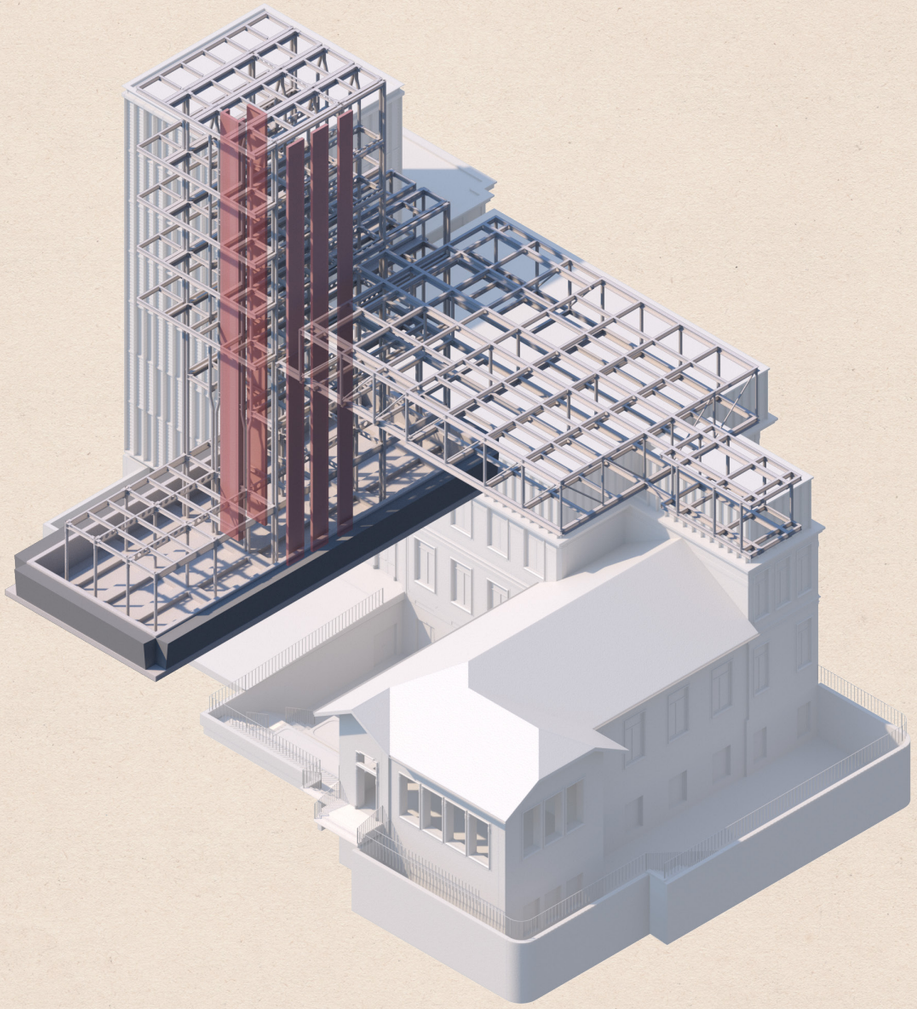


material legend

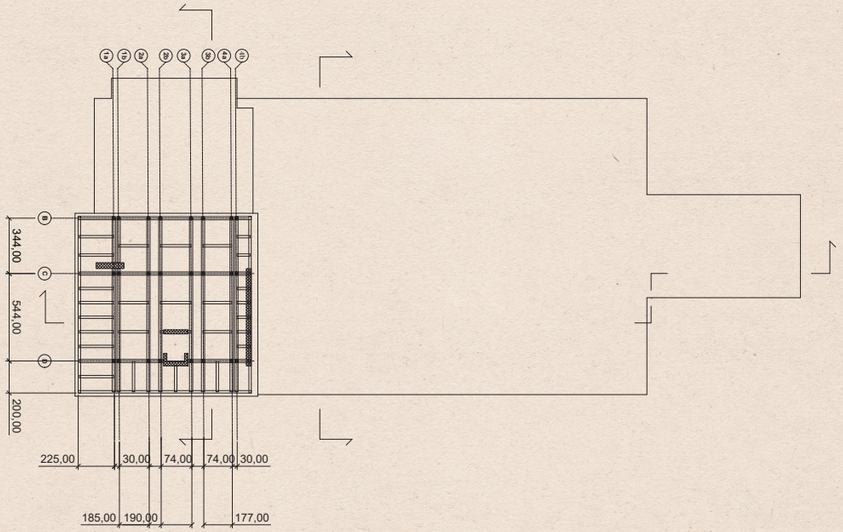
1. Existing RC beams
2. Plasterboard
3. Silenteco panel
4. Precast concrete wall
5. Rockwool frontrock
6. UPE 400
7. IPE 360
8. Ceramic tiles finishing
9. Lightweight concrete screed
10. Getzner acoustic mat
11. IPE 240
12. Existing ferrocemento slab
13. Steel plate as slab support
14. ACB (HEA 450)
15. Knauff acquapanel
16. Structural concrete filling
17. Prefabricated hollow concrete slab
18. UPE 270
19. ACB (HEA 260)
20. Beton wood screed



shear walls location



structural tower floor plan, 1:400



Chapter V

Systems and services

systems shafts distribution

fifth floor

fourth floor

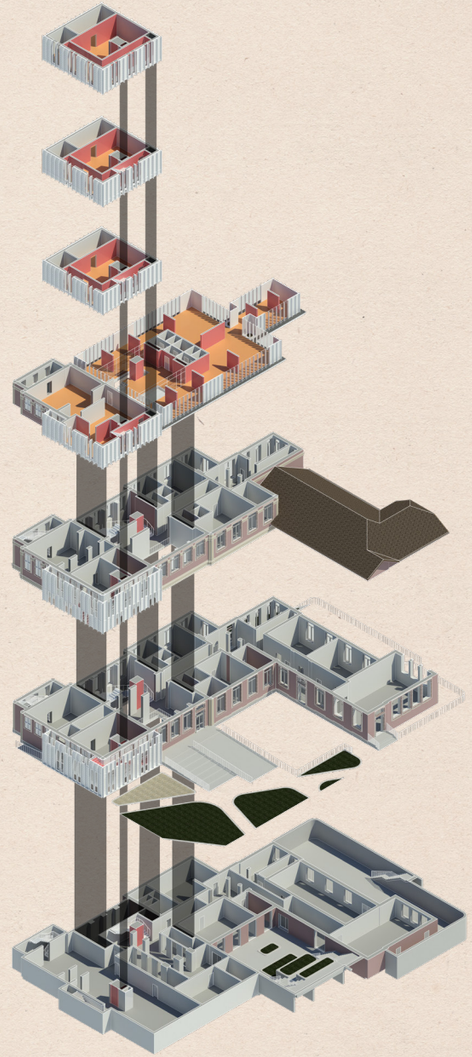
third floor

second floor

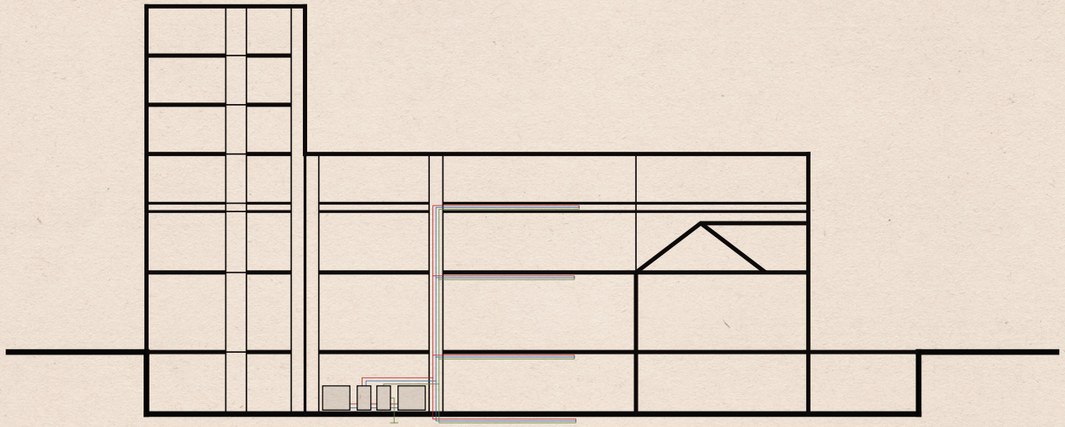
first floor

ground floor

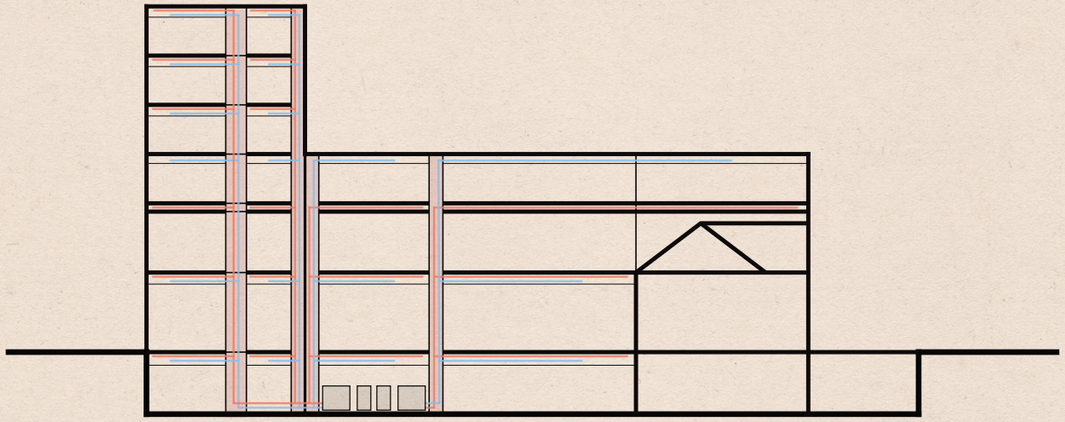
underground floor



water supply and waste distribution scheme



ventilation distribution scheme



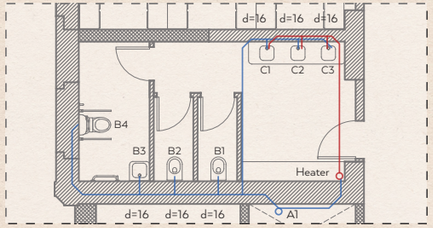
V.I

water supply and waste

supply systems

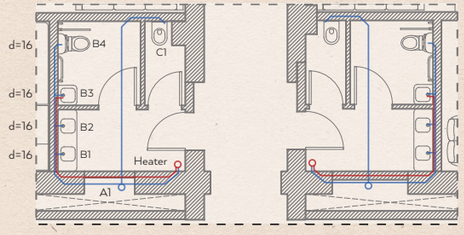
cold water and hot water supply

wc underground floor



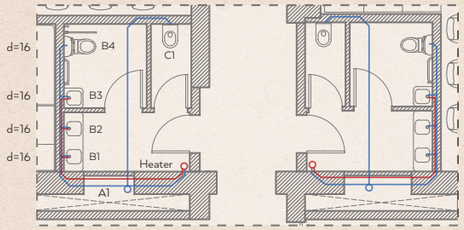
ΣLU = 25 + 11 = 36
d = 32

wc ground level



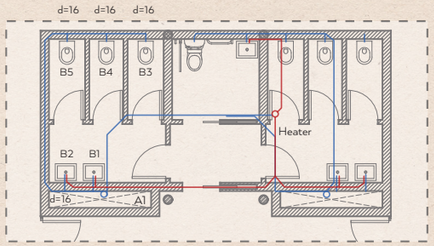
ΣLU = 8 + 17 = 25
d = 32

wc first floor



ΣLU = 8 + 9 = 17
d = 26

wc second floor



ΣLU = 9
d = 20

loading units and diameters

wc=1; washbasin=1

Table 5.1 Loading units for different points of use (EN 806-3).

Point of use	Flow rate Q_A [l/s]	Loading unit (LU)
Washbasin, bidet, WC	0.1	1
Domestic sink, dishwasher, domestic washing machine, shower	0.2	2
Urinal with outlet valve	0.3	3
Domestic bathtub	0.4	4
Garden or garage taps	0.5	5
Non-domestic sinks and bathtubs DN20	0.8	8
DN20 outlet valve	1.5	15

Table 5.12 Diameters of the multilayer pipes in relation to the LUs in compliance with EN 806-3.

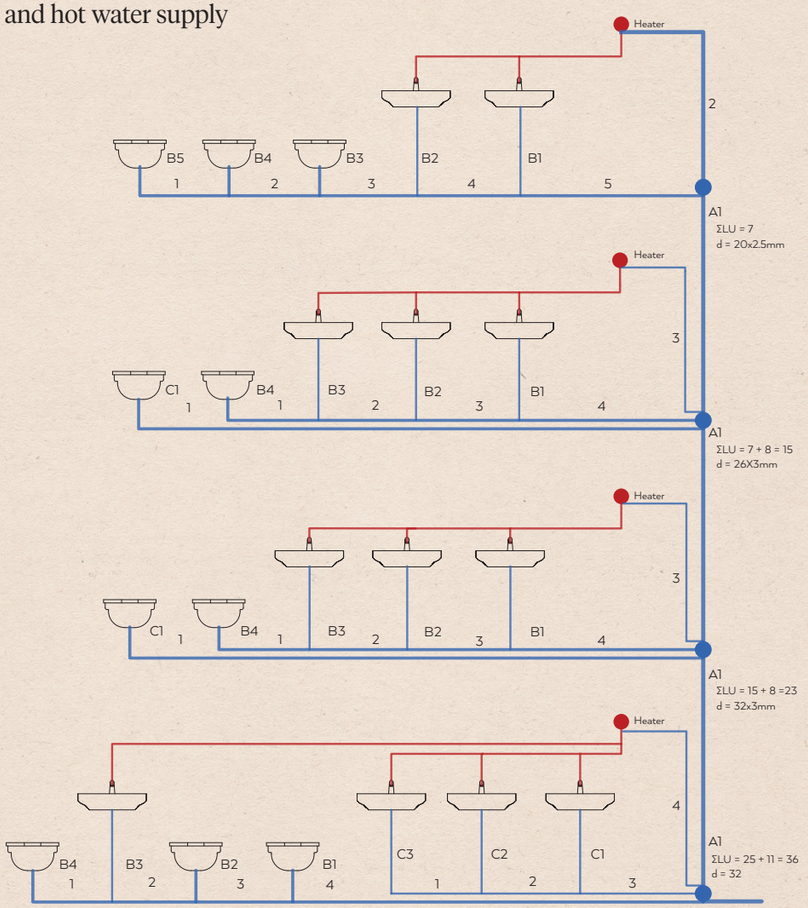
∑LU	LU	3	4	5	6	10	20	55	180	540	1300	2200*	3400*
LU_{max}	LU			4	5	5	8						
d_a x s	mm		16x2.25/16x2			18x2	20x2.5	26x3	32x3	40x3.5	50x4	63x4.5	75x5	90x7
d_i	mm		11.5/12			14	15	20	26	33	42	54	65	76
max pipe length	m	9	5	4										

*Values not indicated in EN 806 standard, obtained by interpolating.

Cold Water Supply Shaft A1			
Floor	**Branch**	**∑LU**	**Diameter (mm)**
Second Floor	B5-B4	1	16x2.25
	B4-B3	2	16x2.25
	B3-B2	3	16x2.25
	B2-B1	4	16x2.25
	B1-A1	5	16x2.25
	A1 - Heater	2	16x2.25
First & Ground Floors	B4-B3	1	16x2.25
	B3-B2	2	16x2.25
	B2-B1	3	16x2.25
	B1-A1	4	16x2.25
	C1-A1	1	16x2.25
	A1 - Heater	3	16x2.25
Underground	B4-B3	1	16x2.25
	B3-B2	2	16x2.25
	B2-B1	3	16x2.25
	B1-A1	4	16x2.25
	C3-C2	1	16x2.25
	C2-C1	2	16x2.25
	C1-A1	3	16x2.25
	A1 - Heater	4	16x2.25

supply systems

cold water and hot water supply

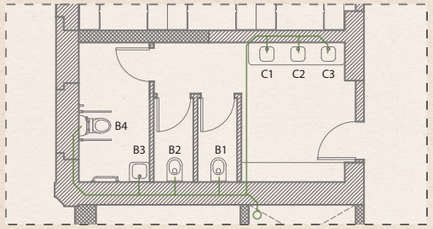


Hot Water Supply Electrical Heater			
Floor	**Branch**	**∑LU**	**Diameter (mm)**
Second Floor	B2-B1	1	16x2.25
	B1-Heater	2	16x2.25
First & Ground	B3-B2	1	16x2.25
	B2-B1	2	16x2.25
	B1-Heater	3	16x2.25
Underground	B3-Heater	1	16x2.25
	C3-C2	1	16x2.25
	C2-C1	2	16x2.25
	C1-Heater	3	16x2.25

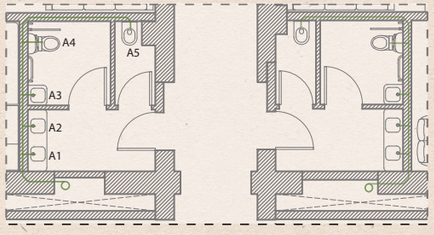
Cold Water Supply Shaft A1			
Floor	**LU**	**∑LU**	**Diameter (mm)**
Second	7	7	20x2.5
First	8	15	26x3
Ground	8	23	32x3
Underground	11	34	32x3

waste systems

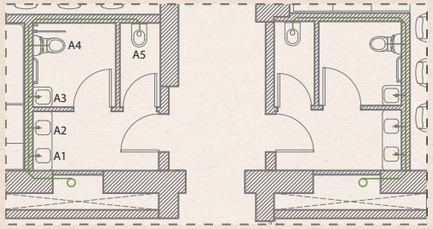
wc underground floor



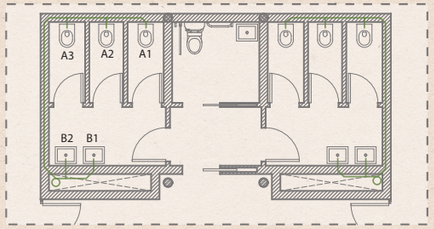
wc ground level



wc first floor



wc second floor



flow rate (DU)

wc with 9L cistern=2.5; washbasin=1.5

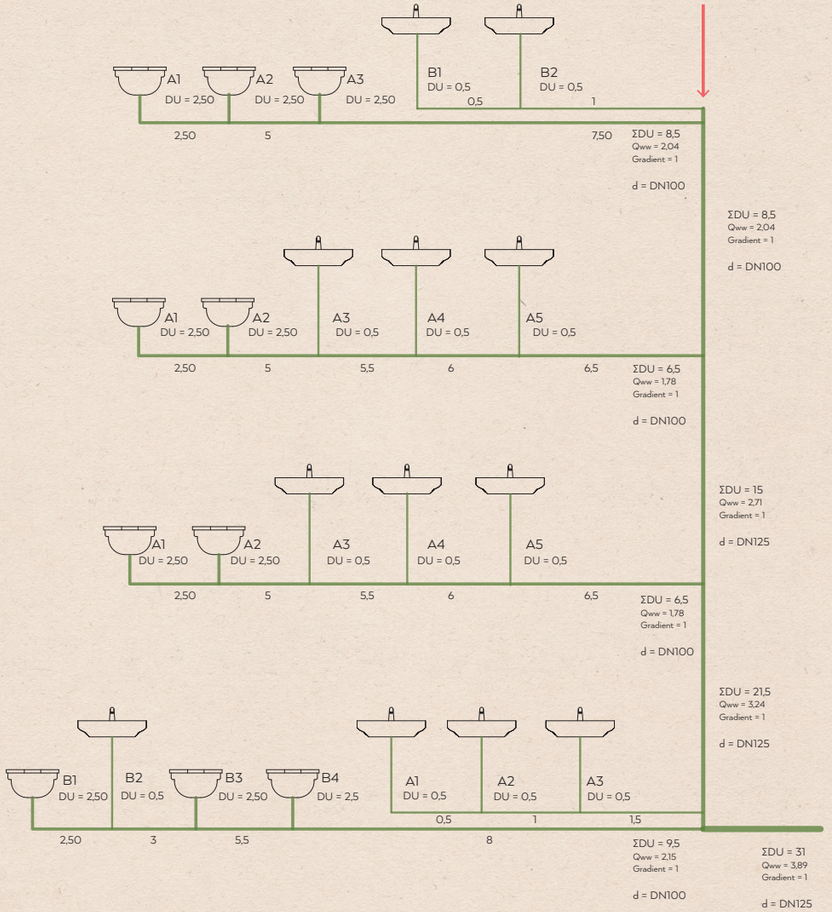
Table 4.4 Typical flow rates for various types of sanitary fixtures (domestic).

Sanitary fixture	DU [l/s]
Washbasin	0.5
Bidet	0.5
Shower without plug	0.6
Shower with plug	0.8
Urinal with cistern	0.8
Urinal with flush valve	0.5
Wall urinal	0.2
Bathtub	0.8
Kitchen sink	0.8
Dishwasher (domestic)	0.8
Washing machine, max. load 6 kg	0.8
Washing machine, max. load 12 kg	1.5
WC with 6 l cistern	2.0
WC with 7.5 l cistern	2.0
WC with 9 l cistern	2.5
Floor drain DN 50	0.8
Floor drain DN 70	1.5
Floor drain DN 100	2.0

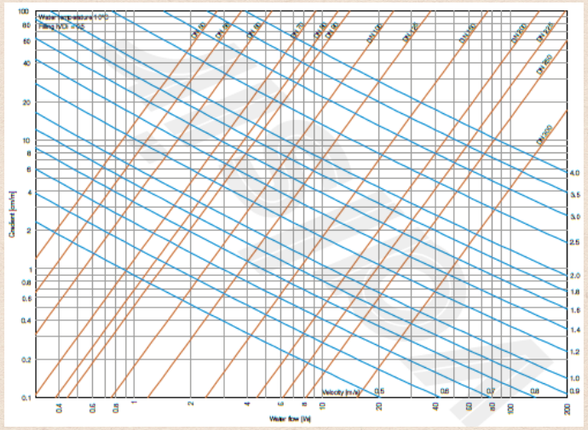
coefficient for building type K=0.7

Table 4.2 Coefficient of contemporary use as a function of use and type of building.

Use	Building type	Coefficient K
Intermittent	Homes and offices	0.5
Frequent	Hospitals, schools, restaurants, hotels	0.7
Very frequent	Public bathrooms and showers	1.0
Special	Laboratories	1.2



size of pipe, gradient: 1



Waste	Shaft A1	Waste Branches				
Floor	**Branch**	**Sanitary Fixture**	**Quantity**	**DU[l/s]**	**Branch DN**	**∑DU[l/s]**
Second	A	WC with 9lt cistern	3	2,50	100	8,5
	B	Washbasin	2	0,5	40	
First	A	WC with 9lt cistern Washbasin	2 3	2,50 0,5	100	6,5
Ground	A	WC with 9lt cistern Washbasin	2 3	2,50 0,5	100	6,5
Underground	A	WC with 9lt cistern Washbasin	3 1	2,50 0,5	100	9,5
	B	Washbasin	3	0,50	40	

Waste	Shaft A1	Vertical		
Floor	**DU[l/s]**	**∑DU[l/s]**	**Qww [K*√∑DU]**	**Branch DN**
Second	8,50	8,50	2,040833163	DN100
First	6,50	15,00	2,711088342	DN125
Ground	6,50	21,50	3,245766473	DN125
Underground	9,50	31,00	3,897435054	DN125

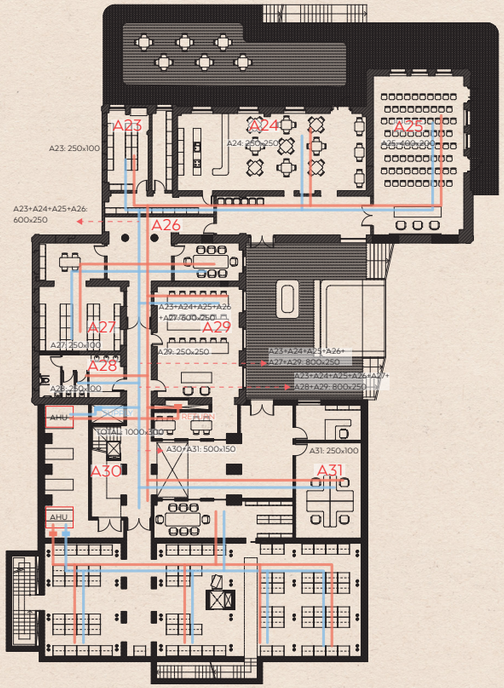
V.II

ventilation system

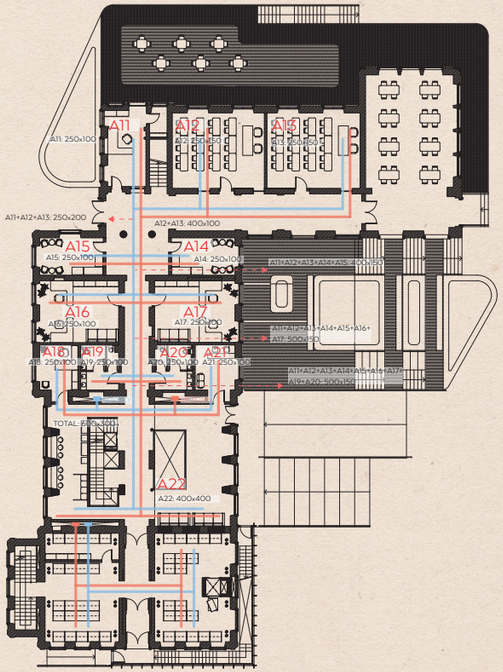
ventilation system

supply and return air

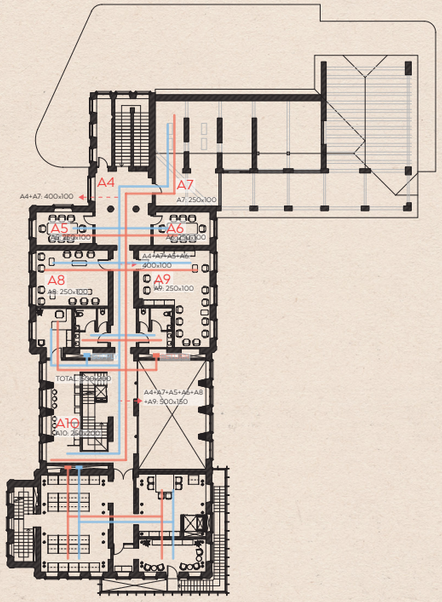
undergrounf floor



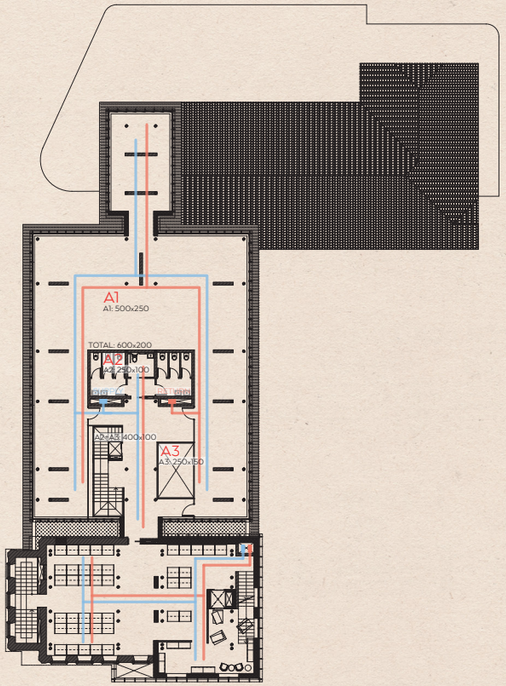
ground floor



first floor



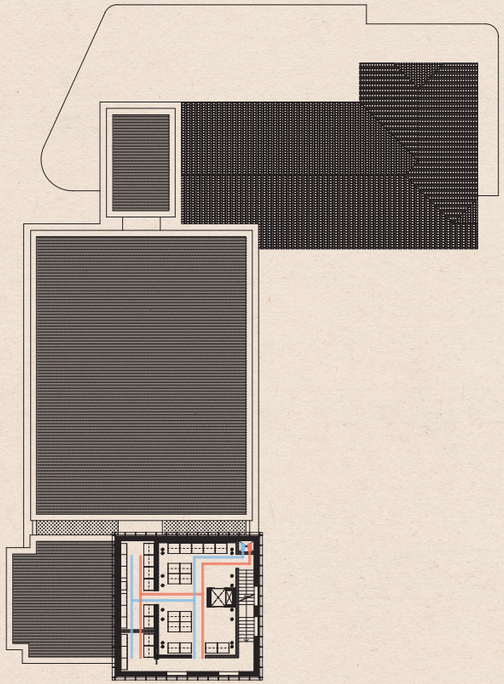
second floor



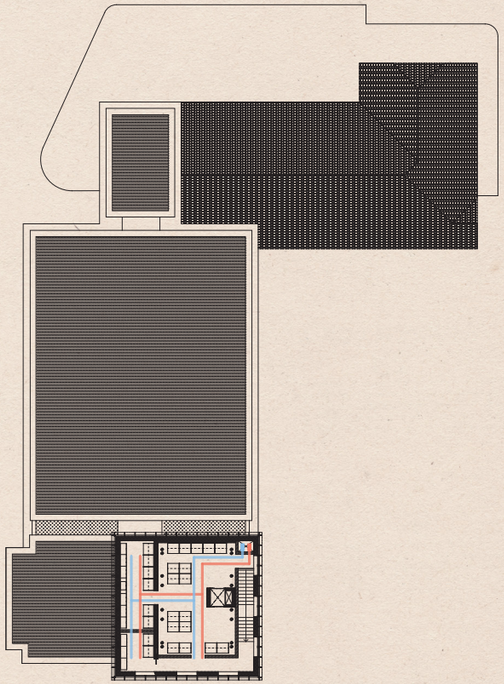
ventilation system

supply and return air

third & fourth floor



fifth floor



ventilation system

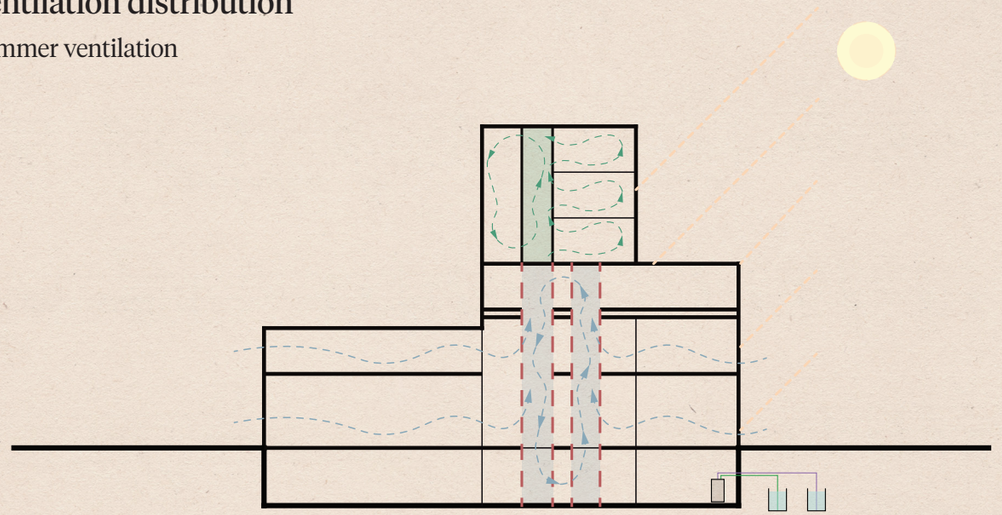
supply and return air

Floor	Room name	Room number	Qp (l/sp)	Nperson	Qs (l/sm²)	Surface (m²)	Conversion (s/l)	Total [m³/h]	Total m³/s	Ac (Q/V) V=4 (m²)	Duct size (mm) (axb)
2	Exhibition	A1	6	60	0,5	265	3,6	1773	0,49	0,123	500x250
	WC	A2	7	6	0,7	25,6	3,6	215,712	0,06	0,015	250x100
	Hall	A3	7	15	0,7	65	3,6	541,8	0,15	0,038	250x150
1	Corridor	A4	7	16	0,7	32,8	3,6	485,856	0,13	0,034	250x150
	Meeting room	A5	6	4	0,5	14,7	3,6	112,86	0,03	0,008	250x100
	Meeting room	A6	6	4	0,5	15,1	3,6	113,58	0,03	0,008	250x100
	Storage	A7	7	3	0,7	110	3,6	352,8	0,10	0,025	250x100
	Reading room	A8	5,5	8	0,5	32,2	3,6	216,36	0,06	0,015	250x100
	Reading room	A9	5,5	11	0,5	45	3,6	298,8	0,08	0,021	250x100
	Inf. Meeting	A10	6	20	0,5	78	3,6	572,4	0,16	0,040	250x200
0	Office	A11	6	2	0,5	18,5	3,6	76,5	0,02	0,005	250x100
	Classroom	A12	6	18	0,5	44,2	3,6	468,36	0,13	0,033	250x150
	Classroom	A13	6	18	0,5	44,6	3,6	469,08	0,13	0,033	250x150
	Staff room	A14	7	2	0,7	15	3,6	88,2	0,02	0,006	250x100
	Break room	A15	7	2	0,7	15	3,6	88,2	0,02	0,006	250x100
	Office	A16	6	3	0,5	31	3,6	120,6	0,03	0,008	250x100
	Office	A17	6	3	0,5	31	3,6	120,6	0,03	0,008	250x100
	Storage	A18	7	1	0,7	12,3	3,6	56,196	0,02	0,004	250x100
	WC	A19	7	2	0,7	10,6	3,6	77,112	0,02	0,005	250x100
	WC	A20	7	2	0,7	10,8	3,6	77,616	0,02	0,005	250x100
	Reception	A21	6	2	0,5	13	3,6	66,6	0,02	0,005	250x100
	Atrium	A22	7	65	0,7	139	3,6	1988,28	0,55	0,138	400x400
-1	Storage	A23	7	1	0,7	18,9	3,6	72,828	0,02	0,005	250x100
	Cafeteria	A24	6	35	0,5	86,7	3,6	912,06	0,25	0,063	250x250
	Conference room	A25	6	45	0,5	87	3,6	1128,6	0,31	0,078	400x200
	Corridor	A26	7	30	0,7	80	3,6	957,6	0,27	0,067	300x250
	Storage	A27	7	2	0,7	47,6	3,6	170,352	0,05	0,012	250x100
	WC	A28	7	4	0,7	20,9	3,6	153,468	0,04	0,011	250x100
	Workshop	A29	6	30	0,5	69	3,6	772,2	0,21	0,054	250x250
	Atrium	A30	7	45	0,7	96	3,6	1375,92	0,38	0,096	400x250
	Consultation	A31	6	4	0,5	37,4	3,6	153,72	0,04	0,011	250x100

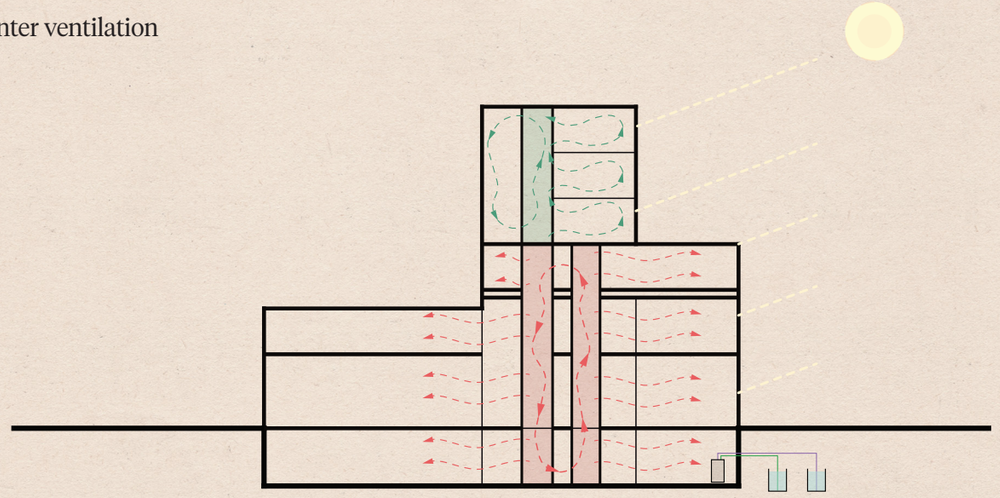
Air flow rate in ducts	Total [m³/h]	m³/s	Ac (m²) V=6	Duct size (mm) (axb)
A2 + A3	757,512	0,21	0,04	400x100
Second floor total	**2530,512**	0,70	0,12	**600x200**
A4 + A7	838,656	0,23	0,04	400x100
A4 + A5 + A6 + A7	1065,096	0,30	0,05	250x200
A4 + A5 + A6 + A7 + A8 + A9	1580,256	0,44	0,07	500x150
First floor total	**2152,656**	0,60	0,10	**500x200**
A12+A13	937,44	0,26	0,04	400x100
A11+A12+A13	1013,94	0,28	0,05	250x200
A11+A12+A13+A14+A15	1190,34	0,33	0,06	400x150
A11+A12+A13+A14+A15+A16+A17	1431,54	0,40	0,07	500X150
A11+A12+A13+A14+A15+A16+A17+A19+A20	1586,268	0,44	0,07	500X150
Ground floor total	**3697,344**	1,03	0,17	**600x300**
A23+A24+A25+A26	3071,088	0,85	0,14	600x250
A23+A24+A25+A26+A27	3241,44	0,90	0,15	600x250
A23+A24+A25+A26+A27+A29	4013,64	1,11	0,19	800x250
A23+A24+A25+A26+A27+A28+A29	4167,108	1,16	0,19	800x250
A30+A31	1529,64	0,42	0,07	500X150
Underground total	**5696,748**	1,58	0,26	**1000x300**
Building total	**14077,26**	3,91	0,65	**1400x500**

ventilation distribution

summer ventilation



winter ventilation



ventilation system

building occupancy dencities

Description	Rule of thumb	Comments	Ref
General offices	10 m^2 per workspace	Use this figure for calculating air conditioning loads, outdoor air requirements and small power loads	6
	6 m^2 per person	Use this figure for calculating means of escape	6, 7
	12 m^2 per person	Use this figure for calculating requirements for core elements, such as lifts and toilets and for calculating cold water storage requirements	6
	8 –13 m^2 per workspace	Use this figure for calculating workplace density	6
Standing spectator areas and bars	0.3 m^2 per person	Use this figure for calculating means of escape	7
Assembly halls, dance floors or concert venues without fixed seating	0.5 m^2 per person	Use this figure for calculating means of escape	7, 8, 9
	0.83 m^2 per person	Use this figure for calculating air conditioning loads and outdoor air requirements	
Concourses or queuing areas	0.7 m^2 per person	Use this figure for calculating means of escape	7, 10
	0.83 m^2 per person	Use this figure for calculating air conditioning loads and outdoor air requirements	
Restaurants	1 m^2 per person	Use this figure for calculating means of escape	7, 10
	3 m^2 per person	Use this figure for calculating air conditioning loads and outdoor air requirements	
Retail establishments	5 m^2 per person	Use this figure for calculating air conditioning loads and outdoor air requirements. Refer to *Approved Document B* for guidance about occupation densities for fire safety engineering	7, 11, 12, 13
Art galleries or museums	5 m^2 per person	Use this figure for calculating air conditioning loads, outdoor air requirements and means of escape	7
Bedrooms	8 m^2 per person	Use this figure for calculating means of escape	7

airflow per person

Building	Type of space	Airflow per non-adapted person l/(s pers.)		
		Category I	Category II	Category III
Offices	Small offices	8,5	7,5	5,5
	Landscaped offices, Conference rooms	8,5	7	5
	Call center	8,5	7	5
Hospitals[3]	Bedrooms, wards, diagnostic and examination rooms	11,5	10	8,7
	Treatment room	11,5	10	8,7
	Sitting rooms	11,5	10	8,7
Places of assembly	Auditoriums, cinemas, theaters, museums, exhibition's halls, churches	8,75	7	5,25
	Libraries, reading rooms	8,75	7	5,25
	games rooms, betting rooms	8,75	7	5,25
	dance halls, discos	18,75	15	11,25
Commercial	grocery stores, dry cleaning, pharmacies	8,75	7	5,25
	barbers and beauty salons	8,75	7	5,25
	All other retail stores, department stores, supermarkets	8,75	7	5,25
Restaurants	Cafeterias, Bars, Dining rooms	8,75	7	5,25
Educational	kindergartens and nursery schools	7,5	6	4,5
	Primary and high schools, university class rooms, labs and teachers' rooms	7,5	6	4,5
	libraries, reading rooms	6,9	5.5	4,1
	languages and music classrooms	6,9	5.5	4,1
Sport	Covered sport facilities: play fields	6,25	5	3,75
	Covered sport facilities: spectators areas	8,75	7	5,25
	Swimming Pools (water pool area)	8,75	7	5,25
	locker rooms	8,75	7	5,25
General	Service rooms, Corridors	10	7	4

ventilation system

airflow per area

Building	Type of space	Airflow per floor area l/(s m2)		
		Category I	Category II	Category III
Offices	Small offices	0,50	0,40	0,30
	Landscaped offices, Conference rooms	0,70	0,60	0,40
	Call center	0,80	0,70	0,50
Hospitals[3]	Bedrooms, wards, diagnostic and examination rooms	0,50	0,40	0,30
	Treatment room	1,00	0,80	0,60
	Sitting rooms	0,75	0,60	0,45
Places of assembly	Auditoriums, cinemas, theaters, museums, exhibition's halls, churches	0,50	0,40	0,30
	Libraries, reading rooms	0,63	0,50	0,30
	games rooms, betting rooms	0,75	0,60	0,45
	dance halls, discos	1,38	1,10	0,83
Commercial	grocery stores, dry cleaning, pharmacies	1,00	0,80	0,60
	barbers and beauty salons	0,60	0,50	0,40
	All other retail stores, department stores, supermarkets	0,50	0,40	0,30
Restaurants	Cafeterias, Bars, Dining rooms	1,25	1,00	0,75
Educational	kindergartens and nursery schools	1,25	1,00	0,75
	Primary and high schools, university class rooms, labs and teachers' rooms	0,63	0,50	0,38
	libraries, reading rooms	0,63	0,50	0,38
	languages and music classrooms	0,38	0,30	0,23
Sport	Covered sport facilities: play fields	0,75	0,60	0,45
	Covered sport facilities: spectators areas	0,50	0.40	0,30
	Swimming Pools (water pool area)	0,75	0,60	0,45
	locker rooms	0,38	0,30	0,23
General	Service rooms, Corridors	1,00	0,70	0,40

duct size

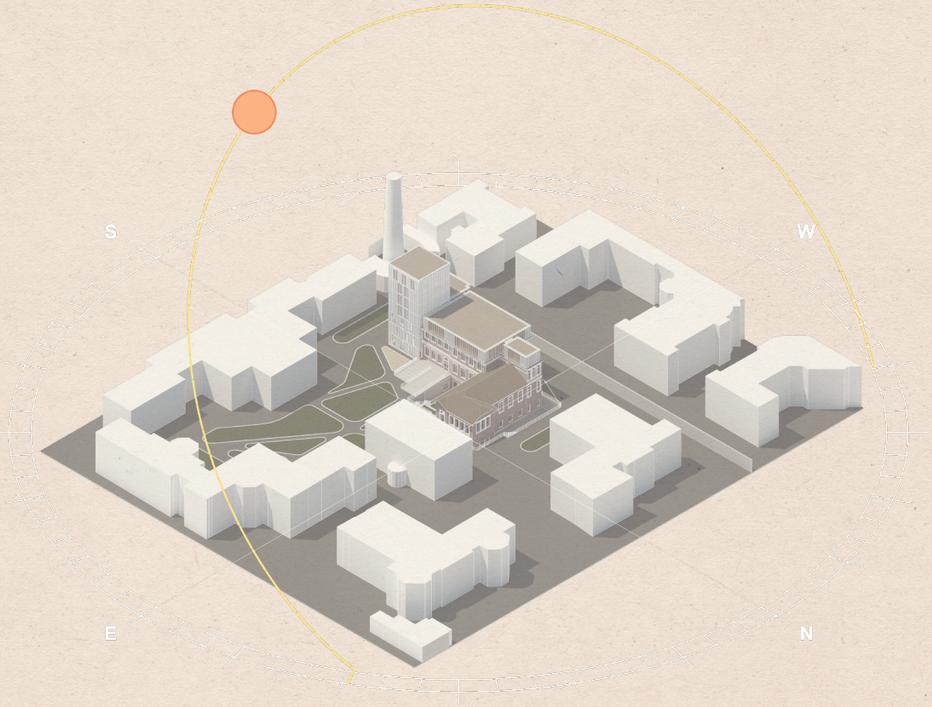
a [mm]	b [mm]											
	100	150	200	250	300	400	500	600	800	1000	1200	
250	0,025	0,038	0,050	0,063								A_c
	143	188	122	250								d_{eq}
	165	206	241	273								d_{ce}
	0,70	0,80	0,90	1,00								A_i
300	0,030	0,045	0,60	0,075	0,090							A_c
	150	200	240	273	300							d_{eq}
	180	224	262	296	327							d_{ce}
	0,80	0,090	1,00	1,10	1,20							A_i
400	0,040	0,060	0,080	0,10	0,12	0,16						A_c
	160	218	267	308	343	400						d_{eq}
	205	255	299	337	373	436						d_{ce}
	1,00	1,10	1,20	1,30	1,40	1,60						A_i
500		0,075	0,10	0,13	0,55	0,20	0,25					A_c
		231	286	333	375	444	500					d_{eq}
		283	331	374	413	483	545					d_{ce}
		1,30	1,40	1,50	1,60	1,80	2,00					A_i
600		0,090	0,12	0,15	0,18	0,24	0,30	0,36				A_c
		240	300	353	400	480	545	600				d_{eq}
		307	359	406	448	524	592	654				d_{ce}
		1,50	1,60	1,70	1,80	2,00	2,20	2,40				A_i
800			0,16	0,20	0,24	0,32	0,40	0,48	0,64			A_c
			320	381	436	533	615	686	800			d_{eq}
			410	463	511	598	675	745	872			d_{ce}
			2,00	2,10	2,20	2,40	2,60	2,80	3,20			A_i
1000				0,25	0,30	0,40	0,50	0,60	0,80	1,00		A_c
				400	462	571	667	750	889	1000		d_{eq}
				512	566	662	747	825	965	1090		d_{ce}

V.III

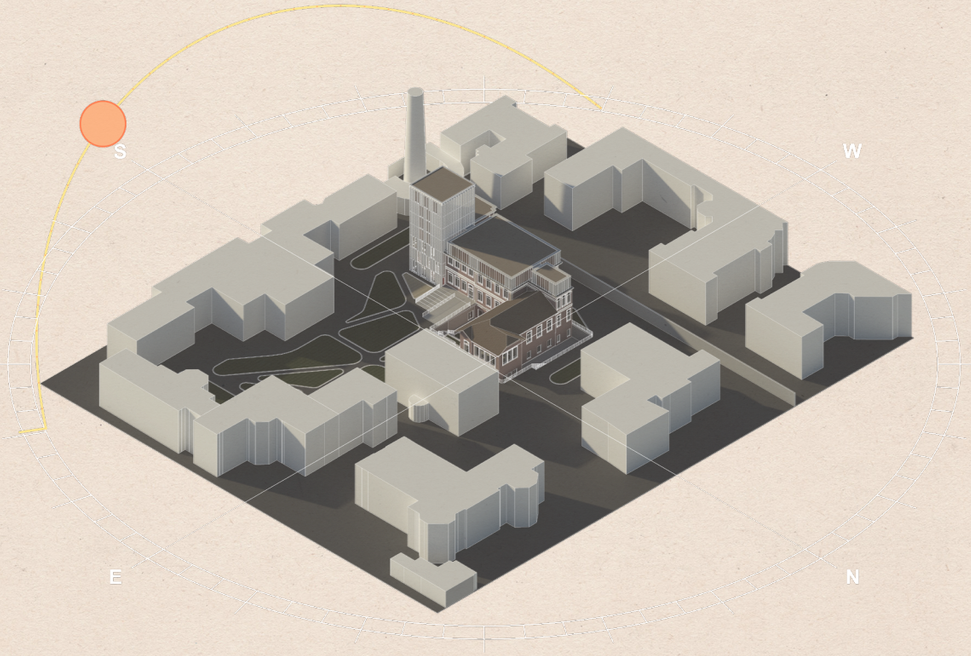
heat calculations

sun path analysis

18th July at 12:15



18th January at 12:15



heat load calculations

climate datas

Description	Symbol	Unit	Value
Design external temperature	θ_e	[°C]	-10
	$\theta_{m,e}$	[°C]	12

EXPOSURE COEFFICIENTS e_k AND e_i

Orientation	Value [p.u.]
N	1,2
E	1,15
W	1,1
S	1

DATA ON HEATED ROOMS

Room Name	Design Temeprature $\theta^{int,i}$ [°C]	Room area A_i [m^2]	Internal hight h_i [m]	Internal Volume V_i [m^3]
Exhitibition Hall	20	264,0	3,5	924
Corridor	20	43	3,5	150,5
WC	20	30	3,5	105
Total		**337,0**	**10,50**	**1179,5**

DATA ON UNHEATED ROOMS

Room name	B-value b_u p.u.	Temperature θ_u °C
there is no unheated adjacent room	-	-

conductivity of materials

Material Code	Description	λ (W/m×K)
1	Light bricks	0,8
2	Concrete	1,75
11	Gypsum	0,35
13	Cement plastering	1,15
21	Polystyrene	0,043
23	Rock wool	0,042
24	Extruded polystyrene	0,037
25	Mineral fiber panel DIN 18165	0,041
31	Gravel	0,7
32	Bitumen	0,23
41	Unventilated air layer s=40 mm	0
51	Wood	0,15
53	Metal composite	0,12

SURFACE RESISTANCES (BETWEEN AIR AND STRUCTURES)

Material Code	Description	Rsi OR Rse (m^2 X K/W)
41	Unventilated air layer	0,18
61	Internal surface resistance (horizontal heat flow)	0,13
62	External surface resistance (horizontal heat flow)	0,04
63	Internal surface resistance (heat flow upwards)	0,1
66	Internal surface resistance (heat flow downwards)	0,17

heat load calculations

U values

Element Code	Material Code	Description	d (m)	λ (W/mK)	R (m^2K/W)	Uk (W/m^2K)
Building element code	**Building element name**					
	Code	Internal laminar layer name			R_{si}	
	Code	Material name	d_1	λ_1	$R_1=d_1/\lambda_1$	
	...		...	...	...	
	Code	Material name	d_n	λ_n	$R_n=d_n/\lambda_n$	
	Code	External laminar layer name			R_{se}	
	Total thickness and U_k		**Σd_i**		**ΣR_i**	**$1/\Sigma R_i$**
2	**Insulated external door**					
	61	External surface resistance(horizontal heat flow)			0,13	
	53	Metal composite	0,100	0,12	0,83	
	61	External surface resistance(horizontal heat flow)			0,13	
	Total thickness and U_k		**0,100**		**1,09**	**0,915**
11	**Curtain wall facade**					
	11	Building Integrated Photovoltaic (BIPV) Insulated Glass Unit				
	Total thickness and U_k		**0,006**			**1,000**
13	**internal separations**					
	61	Internal surface resistance (horizontal heat flow)			0,13	
	11	Gypsum	0,010	0,35	0,03	
	21	Polystyrene	0,040	0,043	0,93	
	1	Light bricks	0,080	0,8	0,10	
	11	Gypsum	0,010	0,35	0,03	
	61	Internal surface resistance (horizontal heat flow)			0,13	
	Total thickness and U_k		**0,140**		**1,35**	**0,742**
15	**Internal Door**					
	61	Internal surface resistance (horizontal heat flow)			0,13	
	51	Wood	0,040	0,15	0,27	
	61	Internal surface resistance (horizontal heat flow)			0,13	
	Total thickness and U_k		**0,040**		**0,53**	**1,899**

Element Code	Material Code	Description	d (m)	λ (W/mK)	R (m^2K/W)	Uk (W/m^2K)
16	**Second Floor Celling**					
	63	Internal surface resistance (heat flow upwards)			0,1	
	11	Gypsum	0,010	0,35	0,03	
	23	Rock wool	0,080	0,042	1,90	
	63	Internal surface resistance (heat flow upwards)			0,1	
	Total thickness and U_k		**0,080**		**2,13**	**0,468**
17	**Second Floor Floor**					
	66	Internal surface resistance (heat flow downwards)			0,17	
	2	High density dry screed panel	0,020	1,75	0,01	
	41	Unventilated air layer	0,350	0	-	0,16
	2	Concrete	0,300	1,75	0,17	
	23	Thermal insulation	0,080	0,042	1,90	
	53	Metal composite facade cladding	0,002	0,12	0,02	
	66	Internal surface resistance (heat flow downwards)			0,17	
	Total thickness and U_k		**0,752**		**2,44**	**0,569**
18	**Extensive green roof**					
	63	Internal surface resistance (heat flow upwards)			0,1	
	0	Substrate(earth)	0,025	0,25	0,10	
	0	Filter Layer	0,001	0,22	0,00	
	0	Draining Layer	0,002	0,38	0,01	
	0	Waterproof membrane	0,002	0,16	0,01	
	23	Thermal insulation	0,080	0,042	1,90	
	0	Vapor barrier	0,001	0,38	0,00	
	0	Seperation Layer	0,001	0,38	0,00	
	53	Metal composite	0,300	0,12	2,50	
	63	Internal surface resistance (heat flow upwards)			0,1	
	Total thickness and U_k		**0,412**		**4,73**	**0,211**

heat load calculations

design transmission heat loss

HEAT LOSSES DIRECTLY TO THE EXTERIOR

Code	Building Element	L_1 [m]	L_2 [m]	A_k [m^2]	U_k [W/m^2K]	e_k [p.u]	$A_k x U_k x e_k$ [W/K]	
11	Curtain wall facade	17,2	3,50	0,00	1,00	1,2	0,00	N
11	Curtain wall facade	17,2	3,50	60,20	1,00	1	60,20	S
11	Curtain wall facade	22,5	3,50	0,00	1,00	1,15	0,00	E
11	Curtain wall facade	22,5	3,50	78,75	1,00	1,1	86,63	W
2	Insulated external door	1,8	2,5	4,50	0,91	1,2	4,94	N
13	Internal separations	7,6	3,5	26,60	0,74	1,2	23,69	N
13	Internal separations	4,57	3,5	16,00	0,74	1,15	13,65	E
13	Internal separations	4,57	3,5	16,00	0,74	1,1	13,06	W
15	Internal Door	0,9	2,5	2,25	1,90	1,2	5,13	N
17	Second Floor Floor	17,2	22,5	387,00	0,57	1	220,25	S
18	Extensive green roof	17,2	22,5	387,00	0,21	1	81,78	S
Total of buildings elements				**$\Sigma_k A_k x U_k x e_k$**		[W/K]	**367,340**	

Code	Thermal bridge	l_k [m]	ψ_k [W/m·K]	e_k [p.u]	$l_k x \psi_k x e_k$ [W/K]	
02B	External wall angle at neighbouring building, interior to neighbouring building	0,5	0,03	1,2	0,018	N
35B	Internal separation crossing, bridge through straight wall	7,6	0,03	1,2		N
35B	Cellar external wall angle, at basement, cellar to exterior	4,57	0,03	1,15		E
65A	Internal door base	0,9	0,13	1,12	0,131	N
65B	Internal door top	0,9	0,12	1,12	0,121	N
65C	Internal door side	5	0,12	1,12	0,672	N
62A	Window base	17,2	0,12	1	2,064	S
62B	Window top	17,2	0,12	1	2,064	S
63A	Window base	22,5	0,13	1,15	3,364	E
63B	Window top	22,5	0,12	1,15	3,105	E
62C	Window side	3,50	0,12	1,15	0,483	E
Total of Thermal bridges		**$\Sigma_k l_k x \psi_k x e_k$**		[W/K]	**12,022**	
Total heat loss coefficient directly to the exterior		**$H_{t,ie} = \Sigma_k A_k x U_k x e_k + \Sigma_k l_k x \psi_k x e_k$**			**379,36**	

HEAT LOSSES TO SPACE HEATED AT DIFFERENT TEMPERATURES

Code	Building Element	L_1 [m]	L_2 [m]	A_k [m^2]	U_k [W/m^2K]	f_{ij} [p.u]	$A_k x U_k x f_{ij}$ [W/K]
-	None			0,00			0,000
				0,00			0,000
				0,00			0,000
				0,00			0,000
				0,00			0,000
Total heat loss coefficient directly to the exterior				**$H_{t,ij} = \Sigma_k A_k x U_k x f_{ij}$**			**0,00**

TOTAL TRANSMISSION HEAT LOSS COEFFICIENT	**$H_{T,i} = H_{T,ie} + H_{T,iue} + H_{T,ig} + H_{T,ij}$**	**[W/K]**	**382,24**

TEMPERATURE DATA

Design external temperature	θ_e	[°C]	-10
Designa internal temperature	θ_{int}	[°C]	20
Design temperature difference	$\theta_{int} - \theta_e$	[°C]	30

DESIGN TRANSMISSION HEAT LOSS	**$\Phi_{T,i} = H_{T,i} x (\theta_{int} - \theta_e)$**	[W]	**11467**

heat load calculations

airing

ROOM NAME				Exhitibition Hall	Corridor	WC	Total
Room internal volume		V_i	[m^3]	924	150,5	105	**1180**
External Temperature		θ_e	[°C]	-10			
internal Temperature		$\theta_{int,i}$	[°C]	20	20	20	
Minimum hygenic needs	Minimum hygenic air exchange rate	$n^{min,i}$	[h^{-1}]	0,5	0,5	1,5	
	Minimum hygenic air flow rate	$V'_{min,i}$	[m^3/h]	462	75,25	157,5	
Infiltration flow rate	Exposed openings	-	[p.u.]	1	0	0	
	Air exchenge rate at 50 Pa	n_{50}	[h^{-1}]	6,0			
	Shielding Coefficient	*e*	[p.u.]	0,02	0,00	0,00	
	Height correction factor	ε	[p.u.]	1,0	1,0	1,0	
	Infiltration air flow rate $V'_{inf,i}=2\times Vi\times n50\times e\times\varepsilon$	$V'_{inf,i}$	[m^3/h]	221,8	0,0	0,0	
Ventilation heat loss calculation	Selected value for calculation $V'i=max(V'_{inf,i}\ ;\ V'_{min,i})$	V'i	[m^3/h]	462,0	75,3	157,5	
	Design ventilation heat loss coefficient	HV,i	[W/K]	157,1	25,6	53,6	
	Temperature Difference	θint,i-θe	[°C]	30	30	30	
	Design ventilation heat loss	**ΦV,i**	**[W]**	**4712**	**768**	**1607**	**7086**

mechanical ventilation with HR

ROOM NAME				Exhitibition Hall	Corridor	WC	Total
Room internal volume		V_i	[m^3]	264,0	43,0	30,0	**337,0**
External Temperature		θ_e	[°C]	-10			
internal Temperature		$\theta_{int,i}$	[°C]	20	20	20	
Infiltration flow rate	Exposed openings	-	[p.u.]	5	0	0	
	Air exchenge rate at 50 Pa	n_{50}	[h^{-1}]	2,0			
	Shielding Coefficient	*e*	[p.u.]	0,01	0,00	0,00	
	Height correction factor	ε	[p.u.]	1,0	1,0	1,0	
	Infiltration air flow rate $V'_{inf,i}=2\times Vi\times n50\times e\times\varepsilon$	$V'_{inf,i}$	[m^3/h]	10,6	0,0	0,0	**10,6**
Ventilation System: air flow rate, termperature and recution factors	Exhaust air volume flow	$V'_{ex,i}$	[m^3/h]	924	150,5	105	**1179,5**
	Supply air volume flow	$V'_{SU,i}$	[m^3/h]	924	150,5	105	**1179,5**
	Supply air temperature	θ_{SU}	[°C]	12,0			
	Reduction factor	$f_{V,i}$	[p.u.]	0,27	0,27	0,27	
	Transfert air volume flow	$V'_{ex,i}$-$V'_{SU,i}$	[m^3/h]	0,0	0,0	0,0	
	Reduction factor	$f_{V,i}$	[p.u.]	0,00	0,00	0,00	
	Excess exhaust air whole building $V'_{mech,\ inf}=\Sigma V'_{ex,i}-\Sigma V'_{SU,i}$	$V'_{mech,inf}$	[m^3/h]	0,00			
	Excess exhaust air room by room	$V'_{mech,inf,i}$	[m^3/h]	0,0	0,0	0,0	**0,0**
Ventilation heat loss calculation	Total air flow rate $V'_i = V'_{inf,i} + V'_{SU,i} \times f_{V,i} + V'_{mech,inf,i}$	V'_i	[m^3/h]	257,0	40,1	0,0	
	Design ventilation heat loss coefficient	HV,i	[W/K]	87,4	13,6	0,0	
	Temperature Difference	θint,i-θe	[°C]	30	30	30	
	Design ventilation heat loss	**ΦV,i**	**[W]**	**2621**	**409**	**0**	**3030**

heat load calculations

heating up capacity

ADDITIONAL HEATING UP POWER IN INTERMITTEDNTLY HEATED SPACES

Room Name	**Heating UP factor** f_{RH} [W/m^2]	**Room area** A_i [m^2]	**Heating Up Capacity** $\Phi_{RH,i}=f_{RH}xA_{,i}$ [W]
Exhitibition Hall	13	264	3432
Corridor		43	559
WC		30	390
Total		**337**	**4381**

total heating load

Room Name	**Design Transmission Heat Loss** $\Phi_{T,i}$ [W]	**Design Ventilazion Heat Loss** $\Phi_{V,i}$ [W]	**Design Heating UP** $\Phi_{RH,i}$ [W]	**Design Heating load** $\Phi_{HL,i}$ [W]
Exhitibition Hall	11467	4712	3432	19611
Total	**11467**	**4712**	**3432**	**19611**

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