ABSTRACT

High density housing in China is everywhere. As a result of unprecedented construction efforts to supply housing demand for a mass flux of population from rural areas to first tier cities (Shanghai, Tianjin, Guangzhou, Shenzhen, Chongqing, among others) at the turn of the twenty-first century. Huge apartment blocks and anonymous high-rise settlements bulldozing traditional housing communities are the characteristic features of today's urban and suburban landscapes in China.

The main question continues to investigate is how housing can absorb unavoidable outcomes of social, economic, material and human flows within Chinese cities.
We want to open new possibilities and alternatives to faceless or imported housing typologies in exchange for densification by way of re-interpreting, integrating and expanding the qualities of the traditional communities.

How can we construct meaningful models of contextualization on unstructured and unstable fabrics and communities?
Can new models for future housing be imagined leaving room for adaption to such unpredictable and fast changing environments?
Can architectural construction be more successful in keeping up with technological advances?
How can the inertia of the building industry that for the most part employs century-old technologies, a property market which avoids risk, and codes and building regulations, serve better current shifting patterns of living in fast urbanization cities?

We focus on Shanghai as one of the epicenters of a growing economy and a laboratory for urban transformation. We visited Shanghai and its rich and diverse housing typologies. We will show you the Shanghai's housing story – high population density and limited space and its several historic and cultural particularities.

POLITECNICO
MILANO 1863

BUILDING AND ARCHITECTURE ENGINEERING
MASTER'S THESIS
A.Y.2019-2020

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1.INTRODUCTION

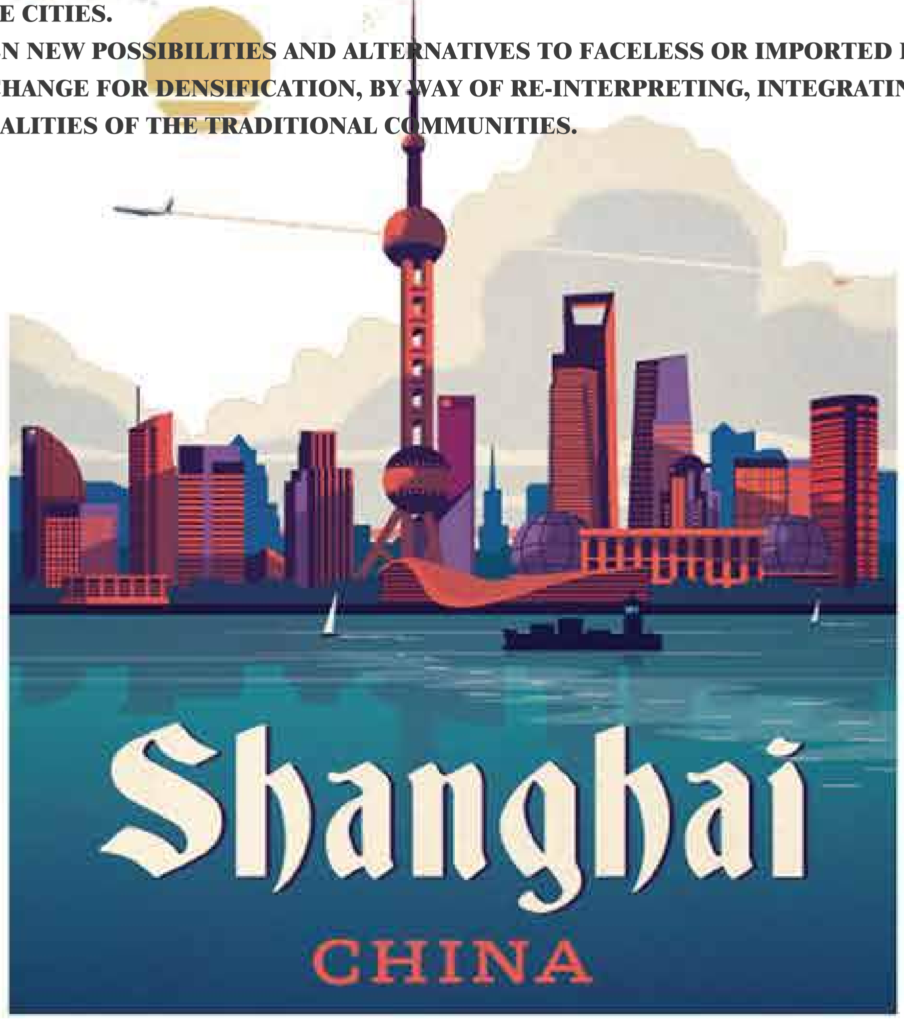
2 SITE ANALYSIS

3 ARCHITECTURE DESIGN

INTRODUCTION

INTRODUCTION

HIGH DENSITY HOUSING IN CHINA IS EVERYWHERE.
SINCE THE MID 1990'S UNPRECEDENTED CONSTRUCTION EFFORTS TOOK PLACE TO SUPPLY HOUSING DEMANDS FOR A MASS FLUX OF POPULATION FROM RURAL AREAS TO FIRST TIER CITIES. HUGE APARTMENT BLOCKS AND ANONYMOUS HIGHRISE SETTLEMENTS BULLDOZING TRADITIONAL HOUSING COMMUNITIES ARE THECHARACTERISTIC FEATURES OF TODAY'S URBAN AND SUBURBAN LANDSCAPES IN CHINA.
THE MAIN QUESTION OF OUR THESIS IS TO INVESTIGATE HOW HOUSING TYPOLOGIES CAN ABSORB THE UNAVOIDABLE PRESENT AND FUTURE OUTCOMES OF SOCIAL, ECONOMIC, MATERIAL AND HUMAN FLOWSWITHIN CHINESE CITIES.
WE WANT TO OPEN NEW POSSIBILITIES AND ALTERNATIVES TO FACELESS OR IMPORTED HOUSING TYPOLOGIES IN EXCHANGE FOR DENSIFICATION, BY WAY OF RE-INTERPRETING, INTEGRATING AND EXPANDING THE QUALITIES OF THE TRADITIONAL COMMUNITIES.



WHAT ARE TRADITIONAL COMMUNITIES IN CHINA TODAY?

COMMUNITY IN SHANGHAI

BEFORE 1840S

1860S

1930S

1980S

2000S

2019

DEMOLISION

"If the old doesn't go, the new never comes"

recites a teenager hanging out near a demolition site in the center of Chengdu.

DUN

蹲

1: Some one Residence in somewhere
2: Something Remain in somewhere

LOCATION: the Xiaonamen neighbourhood area
It is a dilapidated area, a compact labyrinth of low rise buildings with integrated small businesses.

High density housing in China is everywhere. As a result of unprecedented construction efforts to supply housing demand for a mass flux of population from rural areas to first tier cities (Shanghai, Tianjin, Guangzhou, Shenzhen, Chongqing, among others) at the turn of the twenty-first century. Huge apartment blocks and anonymous high-rise settlements bulldozing traditional housing communities are the characteristic features of today's urban and suburban landscapes in China.

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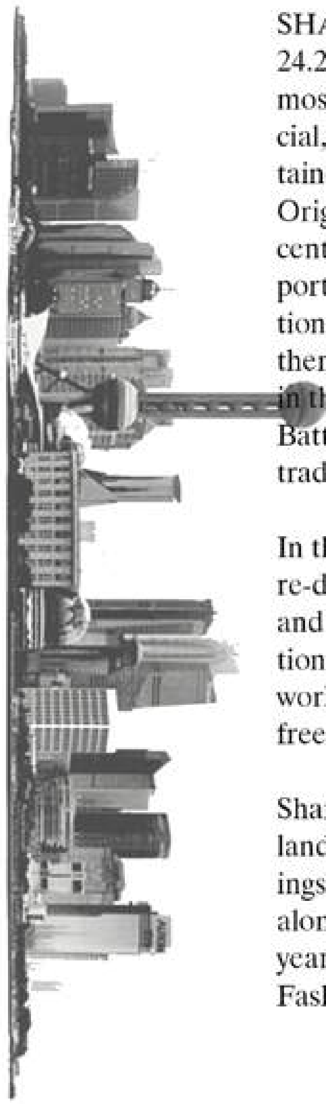
ALL ABOUT SHANGHAI



SHANGHAI located on the southern estuary of the Yangtze with a population of 24.2 million as of 2018,it is the most populous urban area in China, and the second most populous city proper in the world (after Chongqing). Shanghai is a global financial,innovation and technology, and transportation hub, with the world's busiest container port.
Originally a fishing village and market town, Shanghai grew in importance in the 19th century due to trade and its favorable port location. The city was one of five treaty ports forced open to foreign trade after the First Opium War. The Shanghai International Settlement and the French Concession was established subsequently. The city then flourished to a primary commercial and financial hub of the Asia-Pacific region in the 1930s.During the Second Sino-Japanese War, the city was the site of the major Battle of Shanghai. After the war, with the CPC takeover of mainland China in 1949, trade was limited to other socialist countries, and the city's global influence declined.

In the 1990s, economic reforms introduced by Deng Xiaoping resulted in an intense re-development of the city, especially the Pudong district, aiding the return of finance and foreign investment to the city. The city has since re-emerged as a hub for international trade and finance; it is the home of the Shanghai Stock Exchange, one of the world's largest by market capitalization,and the Shanghai Free-Trade Zone, the first free-trade zone in China.

Shanghai has been described as the "showpiece" of the booming economy of mainland China.The city is renowned for its Lujiazui skyline, museums, and historic buildings—including the City God Temple, the Yu Garden, the China pavilion, and those along the Bund—and for its sugary cuisine and unique dialect, Shanghainese. Every year, Shanghai hosts numerous national and international events, including Shanghai Fashion Week, the Chinese Grand Prix, and Chinajoy.

HISTORY OF SHANGHAI ARCHITURCTURE

Part 1. OPENING AS EARLY TREATY PORT

1.Shanghai Before Opening

-From Shanghai-Pu River to Shanghia Country/Township of Shanghai Country/Local Culture and Architecture

2.Beginning of settlements

-Land Regulation/Establishing the firste Settlement/The Earliest Western Buildings

Part 2. A NEW MODERN CITY IN FORMING 1850-1890

1.Explosion of Settlements

2.Early Building Industry

-Meeting of East and West/inter-influence

-Beginning of Real Estate an Earliest Lilong/Early Building Industry

3.Modern Municipality System

-Civic Construction/Civic Administration in Settlements/Civic Administration in Chinese Territory

Part 3.BUILDING INDUSTRY UPGRADE 1890-1919

1.Development of Building Types and Building Technologies

Part 4.GOLDEN ERA AND DECAY 1920-1949

1.Construction Boom

-Fast Economic Development/Booming of Real Estate/New Technologies/Growing-up of Constructors

2.Building Activities

-Rebuilding the Bund/High rise Building/Development of New Building Types

Shanghai Urban Plan in Qing Dynasty

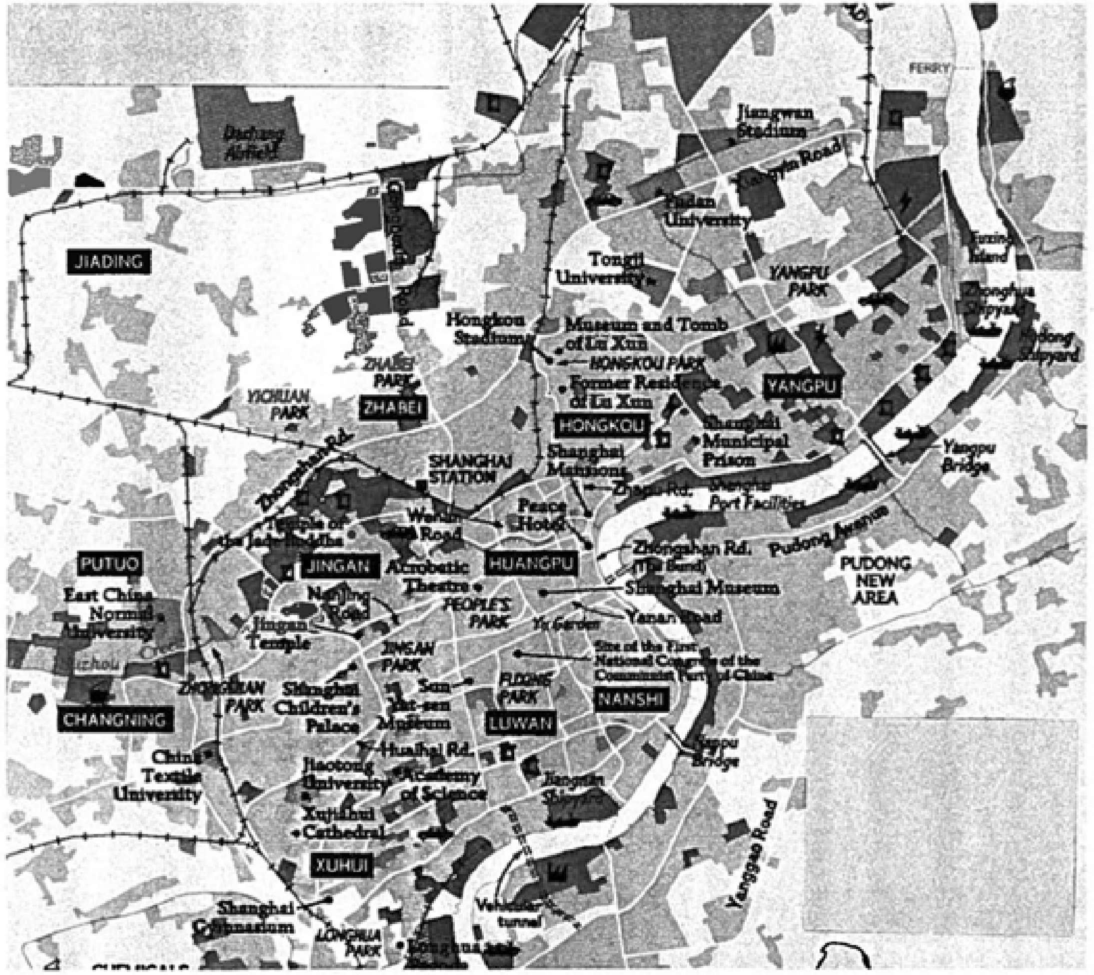
Huxinting in Shanghhai (Before Openning)

Settlements in Shanghhai in 1855

Map of Early Lilomg

HISTORY OF LILONG

Figure 1
Map of Greater Shanghai and Pudong Area.



Source: William S Ellis. "Shanghai: Where China's Past and Future Meet," National Geographic Magazine 185, No. 3 (March, 1994), p.11.

Longtang is what Shangahinese refer to as lilongs, lilong housing is longtang architecture. Longtang is a unique Shanghai product and belongs to Shanghai people."
Longtang (弄堂) is a colloquial term for lilong (里弄), a neighborhood of lanes populated by houses which had evolved since its creation from 1842 to about 1949, coinciding with the Western presence in this port city. They have evolved into five types: 1) the old shikumen (石库门) longtangs, the new shikumen longtangs, the new-type longtangs, the garden longtangs, and the apartment longtangs.
Completed in early 1920s, this lilong housed 2,700 families in 700 shikumen homes at its peak occupancy. The western compound was demolished years earlier to make way for the Shanghai Natural History Museum while the eastern part of the compound is a ghost town as the district government contemplates its fate.

LILONG ANALYSIS-DWELLER INVESTIGATION

Comparison of Various Indicators of Penglai 252 Project-Phase One.

Items	Pre-Construction	Post-Construction
Building Area Sq. M.	890	1506
Floor Area Sq. M.	730.6	1089.4
Increased % of Fl. Area		67.1
Loft Area Sq. M.	78.2	0
Loft Area %	8.7	0
Number of Households	21	34
Number of Residents	91	112
Full Facility %	0	100
Difficulty Household (<4.0 meters/person)	1	0
Average Usage Area/Person	8	13.4

Source: The Nanshi District Residential Property Office. Department of Old House Renovation.

Zhang Jia Zhai Project Summery

Items	Pre-Construction	Post-Construction
Total Project Area (hectares)	8.54	8.27
Total Floor Space (sq. meters)	115,001	187,535
Residential Building.	92,402	127,371
Old Li-long	43,911	18,267
New Terrace	46,654	39,749
Multi-Storey	1,837	34,483
High Rise	0	34,872
Factory	7,114	2,015
Public Building	15,485	58,149
Total No. of Households	3,126	2,817
Old Terrace	1,788	510
New Terrace	1,295	1,035
Multi-Storey	43	690
High Rise	0	582
Building Density	60.8%	52.1%
Persons/hectare	1,308	1,216
Sq. meters/person	8.28	12.67

Source: Zheng-tong Wu. "Report on Housing Renewal Project of Zhang Jia Zhai Neighbourhood in Shanghai Jing An District." Shanghai: Shanghai Housing Science Research Institute, 1988.

LIST OF PERSONS/HOUSEHOLD, UNIT AREAS, AREA/PERSON, DISTANCE TO WORK, AND LENGTH OF OCCUPANCY.

Interview Number	No. of Persons	Total Area of Unit (Sq. M.)	Area/ Person (Sq. M.)	Distance to Work Husband (hours)	Distance to Work Wife (hours)	Length of Occupancy (years)
Interview 1	3	22	7.3	-		41
Interview 4	5	30	6.0	3.0 Bus		19
Interview 7	1	5	5.0	Retired		24
Interview 8	5	30	6.0	Retired		46
Interview 9	5	48	9.6	.75 Bus		50
Interview 11	Private Residence					39
Interview 12	5	15	3.0	-		<3
Interview 13	5	10.5+21.5=32	6.4	.25 Bicycle	.25 Bicycle	45
Interview 14	5	15.8	3.1	.25 Bicycle	.25 Bicycle	26
Interview 15	3	12.3	4.1	.30 Bicycle		7
Interview 16	3 legal/ 6 illegal	9.4	3.1/1.6	.30 Bicycle		7
Interview 17	2	8.6	4.3	.50 Bicycle	.50 Bus	4
Interview 20	3	8.7	2.9	1.25 Bus	.75 Bus	3
Interview 30	Developer Project					2
Interview 31	3	26	8.6	.50 Bicycle	.50 Bicycle	60
Interview 32	3	14.7	4.9	.50 Bicycle	1.50 Bicycle	5
Interview 33	2	8	4.0	-	.75 Bus	20
Interview 34	4	23	5.7	.30 Bicycle	.20 Bicycle	68
Interview 44*	8	70	8.7	.50 Bus		Whole Life
Interview 45*	5	72	14.4			Whole Life
Average	3.5/3.7	19.3	5.2/5.1			26

*Data not used in calculations due to outside survey area

Firstly,iinherent social and economic conditions existed within the community framework of the Lilong neibourhoods and that tese conditiong were not only valued by the dwellers but were related to their survival in these old inner city nei-bourhooods.

Despite overcrowded conditions(the area per person among 12-13 squaremeters), lilong nei-bourhoods have maintained a high level of social stability, community ,cohesion and economic via-bility for the dweller.

Also, as a reslt of a shift from a centralized welfare housing delivery system to a market-oriented housing system, Lilong dwellers may experience greater disparities in housing access and alloca-tion.

Improving Lilong housing conditions in the ineer city is an enormous task of huge expense and tre-mendous scale.

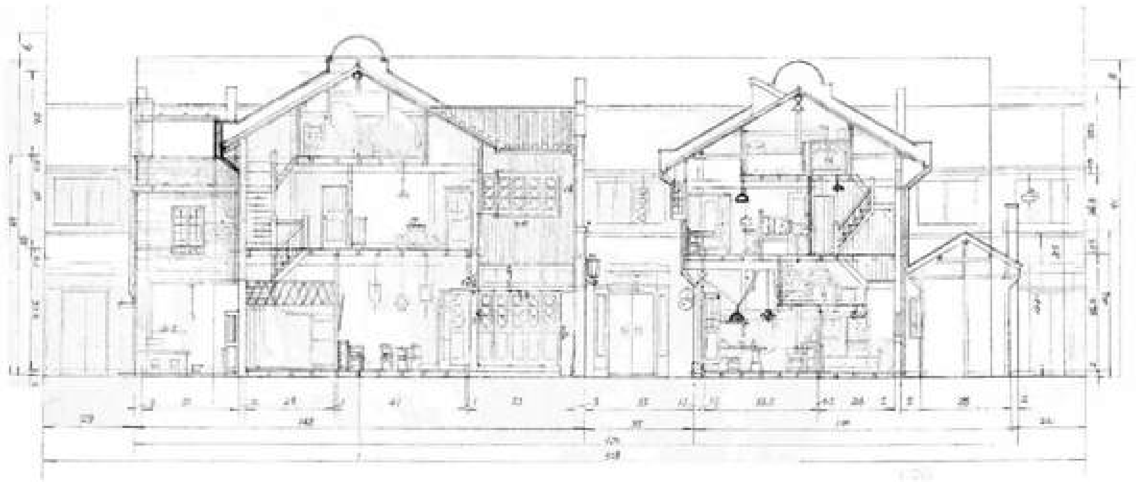
How will the designer solve the problem of Improv-ing living quality under high density condition and the relation between Lilong dwellers and one of the developed city-Shanghai?

HISTORY OF LILONG

The original construction of such supplies was rented out to the homes where the Chinese borrowed from the homes. They were all wooden houses, low in cost, simple in construction, and fast in construction.

From September 1853 to July 1854, less than one year, Guangdong Road and In the area of Fujian Road, more than 800 simple wooden houses with the purpose of renting profits were built. This kind of rented wooden house generally adopts the overall layout of the townhouse, and is named as “the XX”. It is the prototype of the house in Shanghai. By 1860, the number of houses under the name of "Li" had reached 8,740.

After 1870, this simple wooden house was banned by the renting authorities for reasons of flammability and insecurity, but the construction of rental housing began. In modern Shanghai, the real estate industry has become more and more prosperous and has become one of the most important industries in Shanghai at that time and the main source of tax revenue for the concession authorities. However, the wooden house has been completely replaced by the house in Shikumen. This early Shikumen Lane was called "old-fashioned Shikumen", which was distinguished from the later "new-style Shikumen". The overall layout of the “old-fashioned Shikumen” still uses a townhouse layout (this layout later became one of the main features of the house), but the unit plane is in the form of a traditional courtyard or quadrangle, and the structure also uses traditional Chinese brick and wood posts. formula. The shape is characterized by the fact that each façade has a stone door frame with a lacquered thick wood door and a gable wall or Guanyin pocket. Although the Shikumenli residential house is more expensive than the early wooden house, the construction is exquisite, but because of its cheap land, low maintenance costs and high rent, it quickly became popular in Shanghai and spread to the old city and other places.



plans and sections of early Shikumen architecture

SHIKUMEN RESIDENTIAL ARCHITECTURE FEATURES

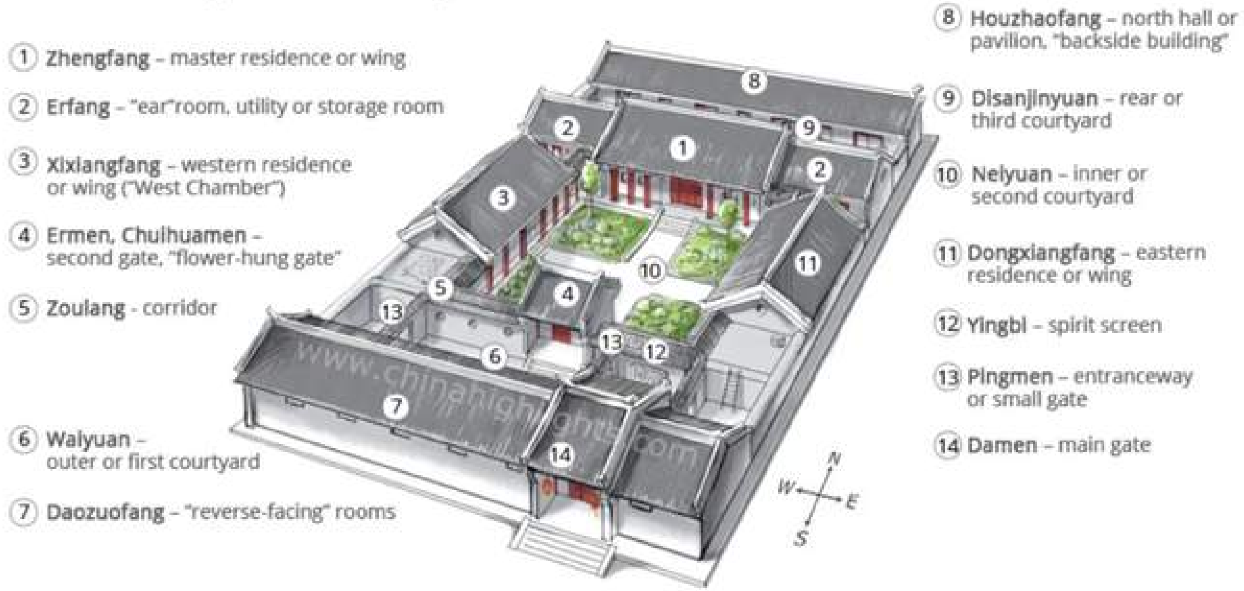
Context	Features
Section	-Symmetrical, regular, and the patio is centered -Outer wall is closed from outside -Entrance placed on the central axis
Elevation	-Threshold, become traditional brick carving blue tile top door style -Stone gate frame have more and various decorations.
Material	-Brick&wood vertical structure -Triple soil as foundation -Floor with square bricks and roof with butterfly-shaped mud tiles

TRADITIONAL JIANGNAN RESIDENTIAL BUILDING

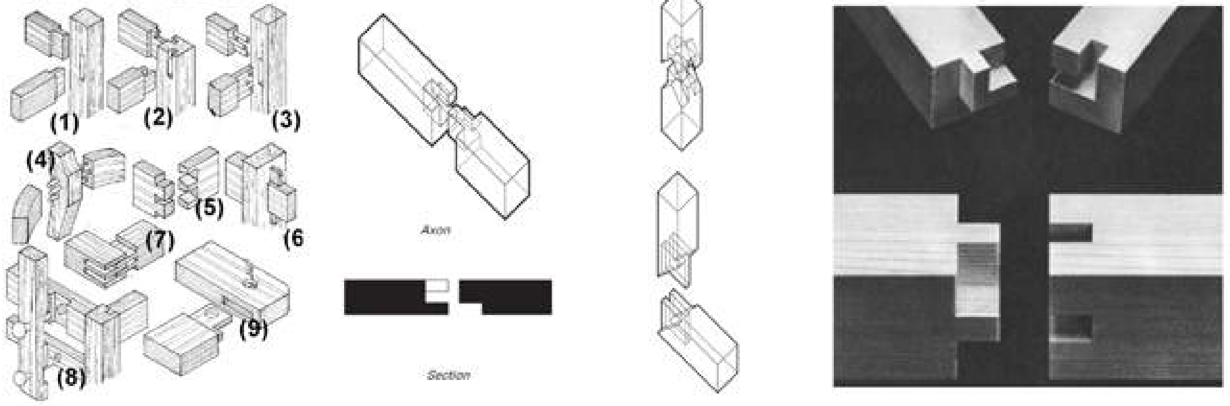
Relation analysis between formation of JIANGNAN residential and the geographical environment

Context	Features	Reasons
Shape	Double;sharp roof	Moisture proof; Ventilation
Color	White walls with black tiles	Environmental culture
Material	Brick;wood	Place of origin
Decoration	Carving in brick,wood,stone	Place of origin; Culture
Others	Water lane; Large windows	Water network; Ventilation

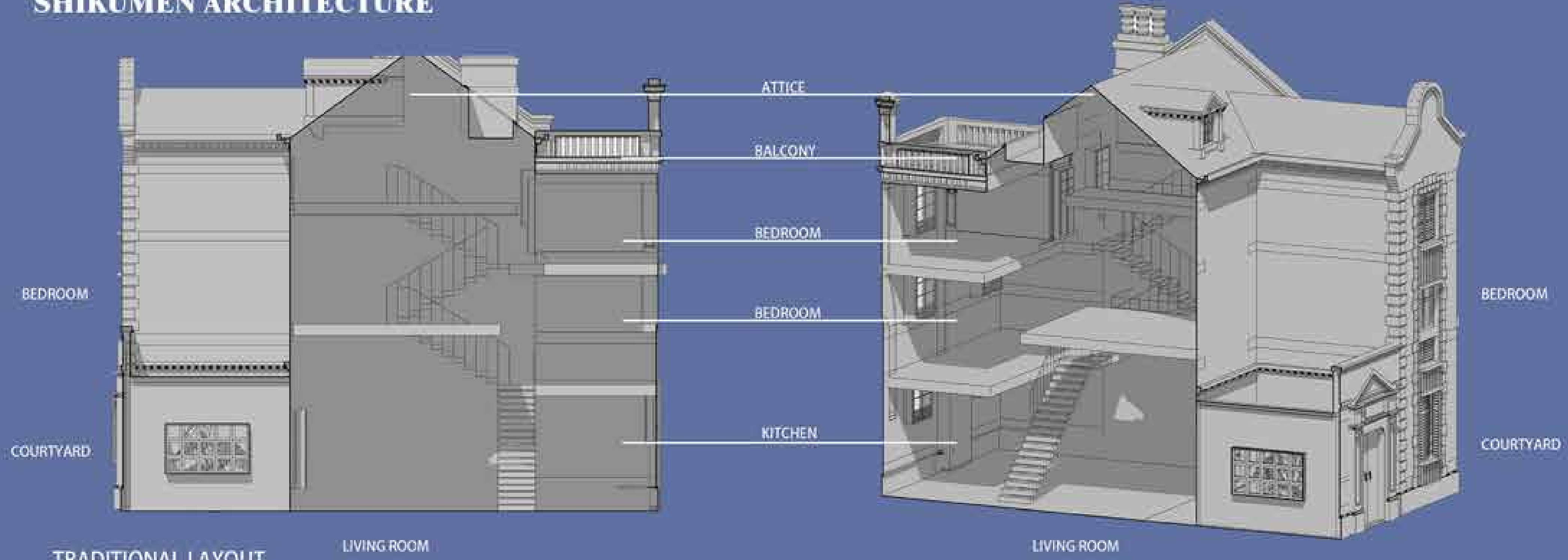
General Layout of Siheyuan



SUNMAO STURCTURE



SHIKUMEN ARCHITECTURE



TRADITIONAL LAYOUT

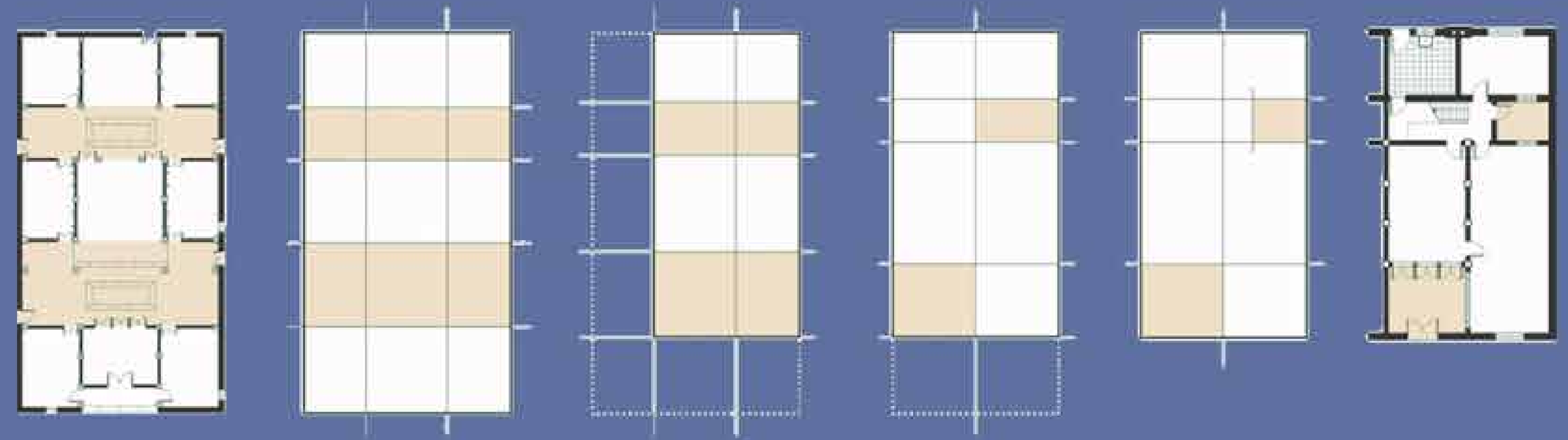
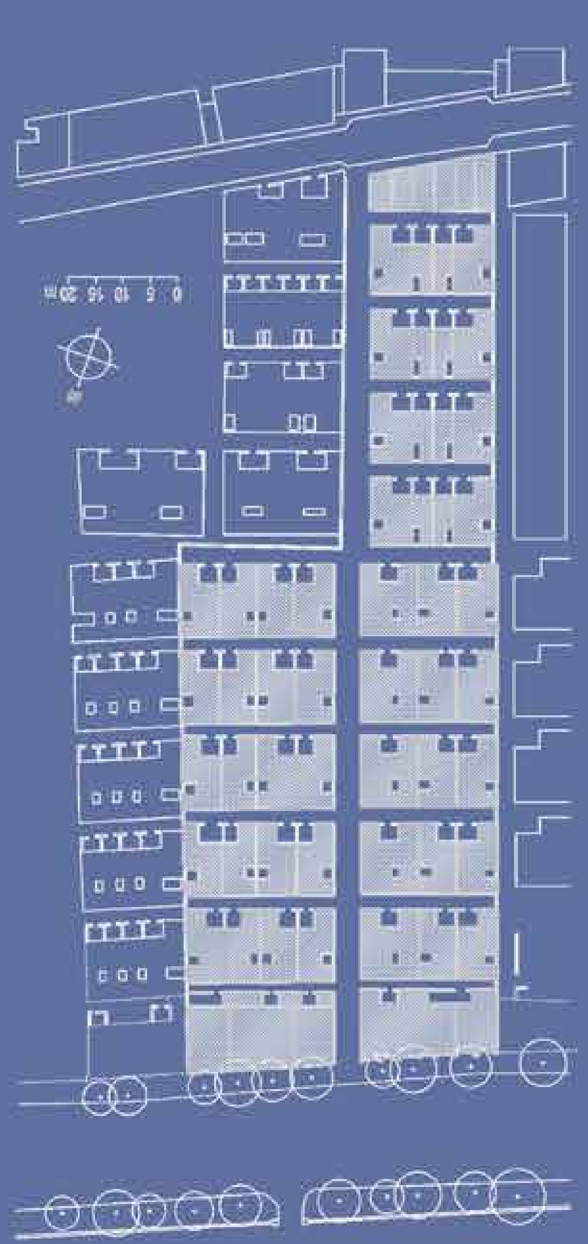
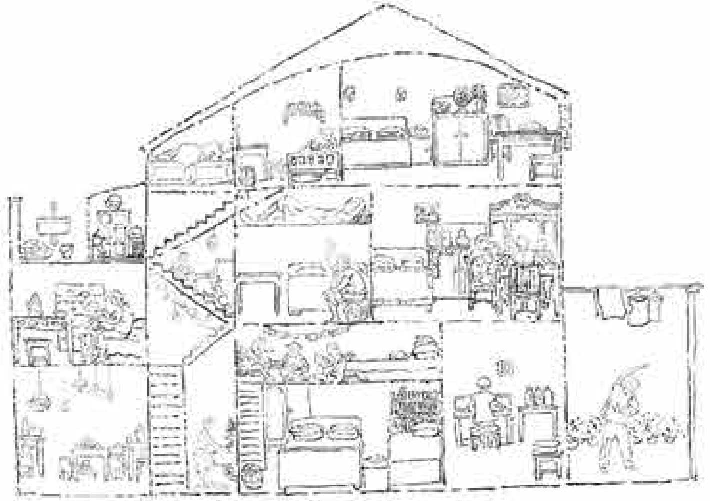


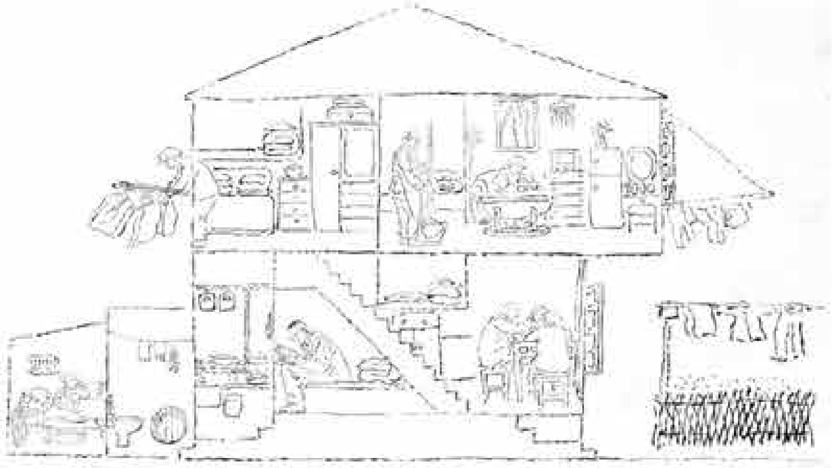
Diagram showing the transformational relationship between the courtyard space and morphology of the shikumen house (top) and the Anhui rural house. Author's drawing.

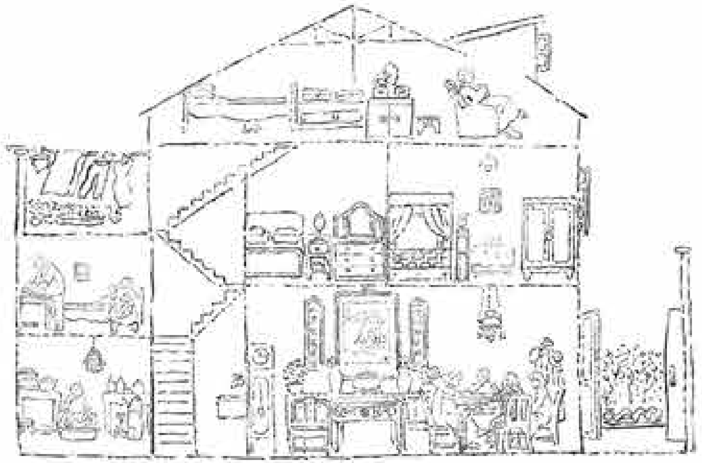


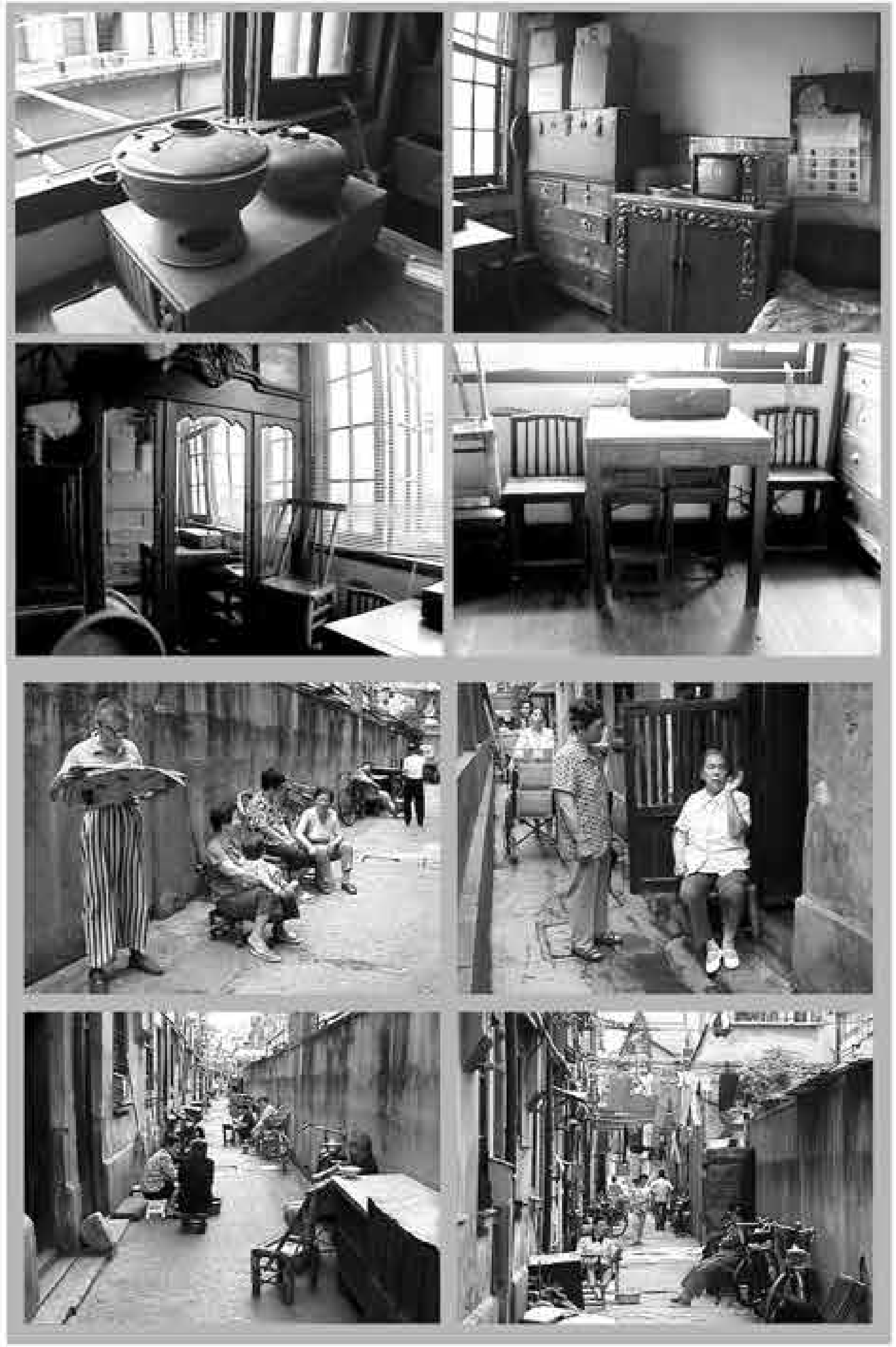
Typical Shanghai urban block in the International Settlement. The housing pattern depicts a late-shikumen cluster of houses. Author's

LIFE IN LILONG AND SHIKUMEN









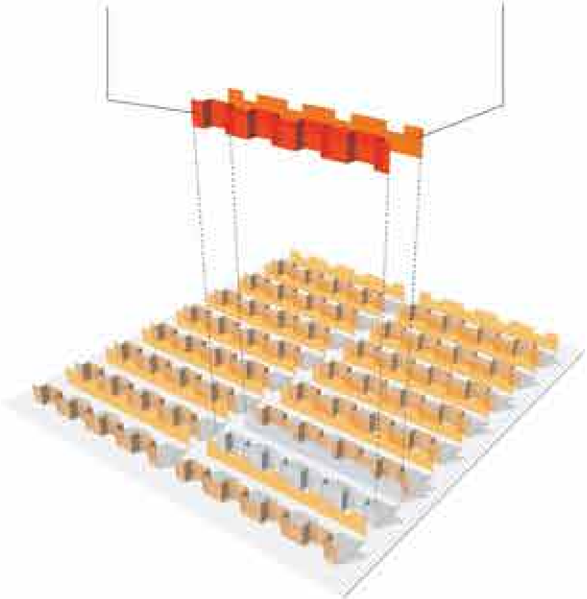
Views of No. 111 Alliance lane around the 1960s. In contrast to the unmodified unit in 1940s (see illustration above), five families lived in different rooms of the house from the mid-1950s to the mid-1990s.

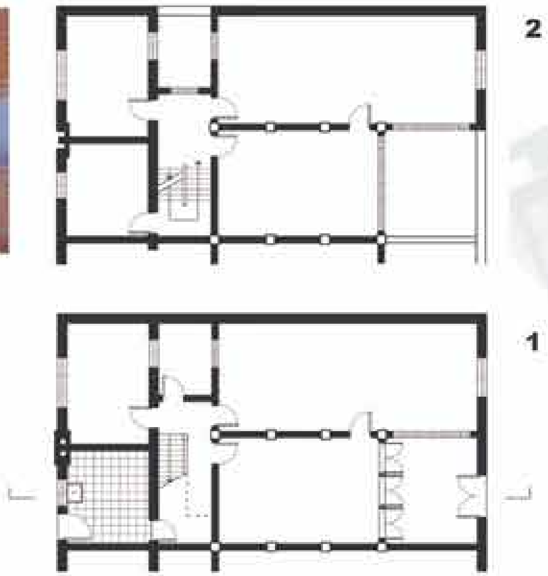
Because of overcrowding, Shanghainese have been obsessed about housing issues for decades. Tracing how private spaces were used and divided up over time can tell us a great deal about the city's political, social, economic, and cultural transformations. But homes are not just housing, but also filled with things that took on personal meanings and histories over time. Finally, their life narratives show how ordinary people made sense of twentieth century history, revealing private experiences, family relationships, and changing moral values.

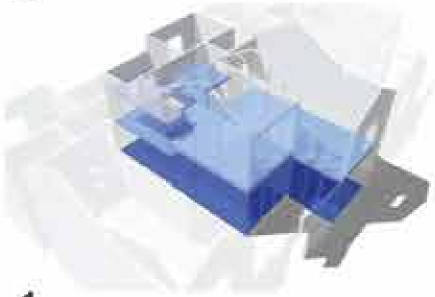
LATER SHIKUMEN ARCHITECTURE

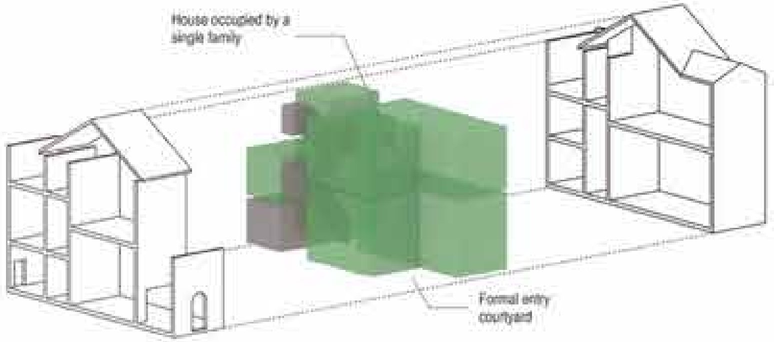
North Facing Service Wall

South Facing Public Stone Gate Facade



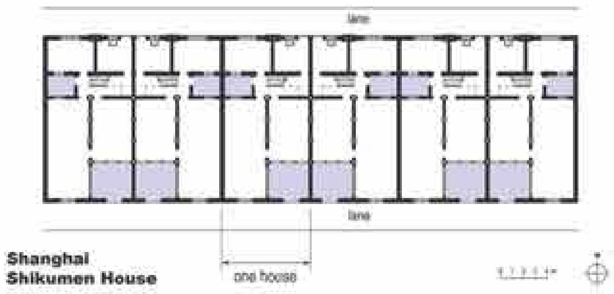


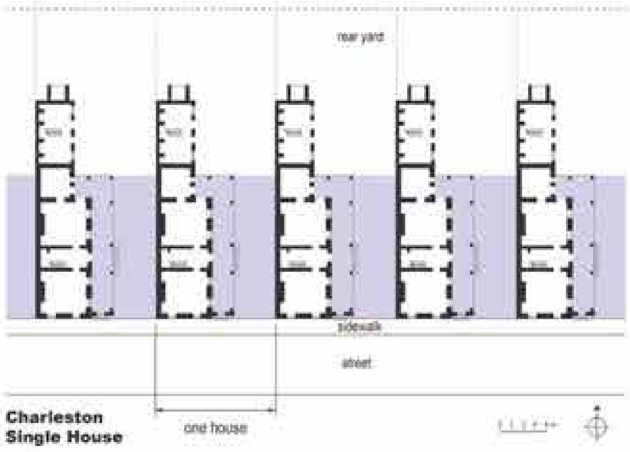


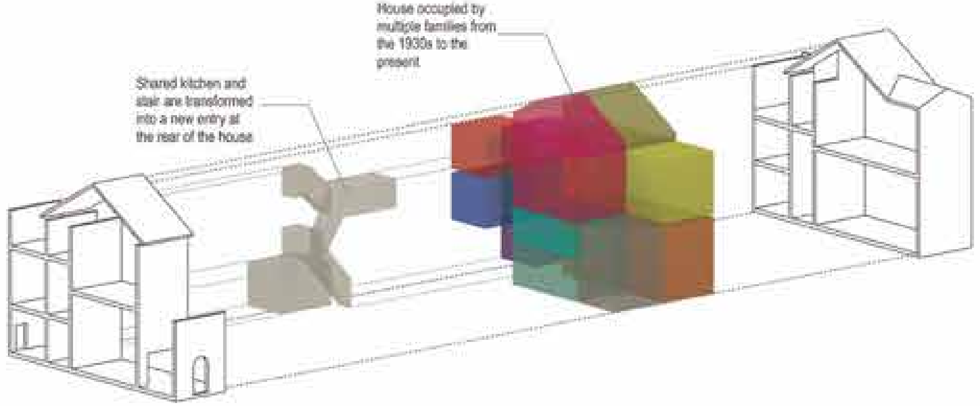


During this time, we also see three-story units that increased the population density of the concession districts.

The size of these houses would average between 1,800 and 2,500 square feet.

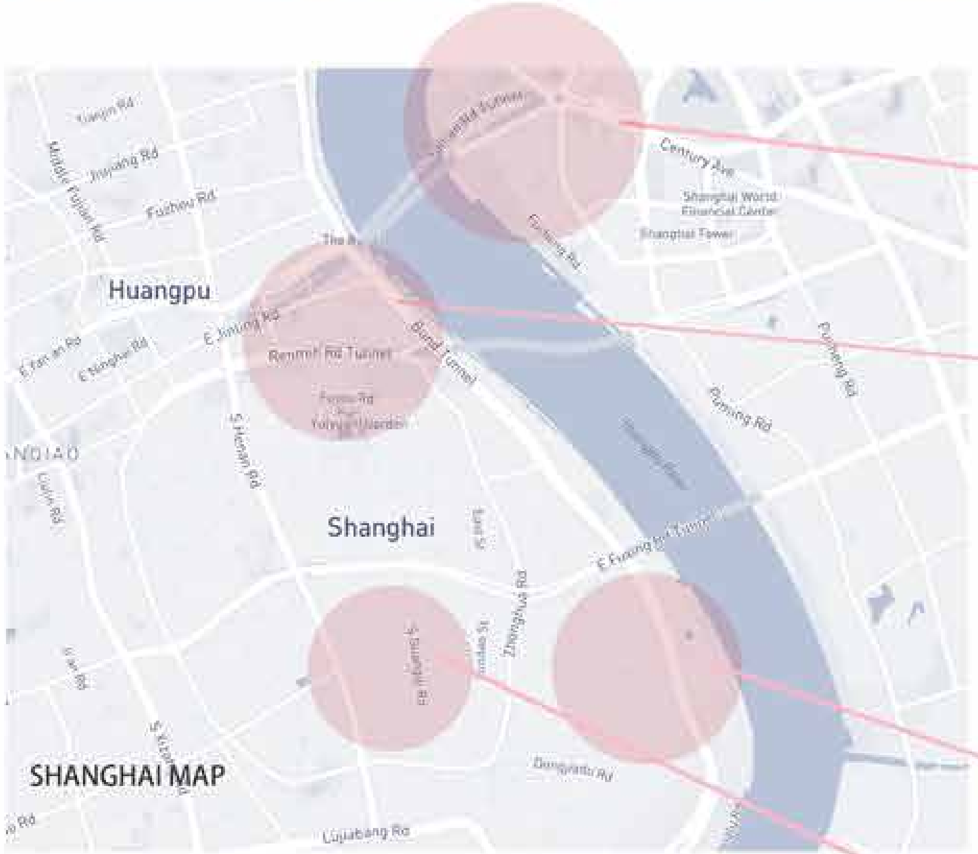


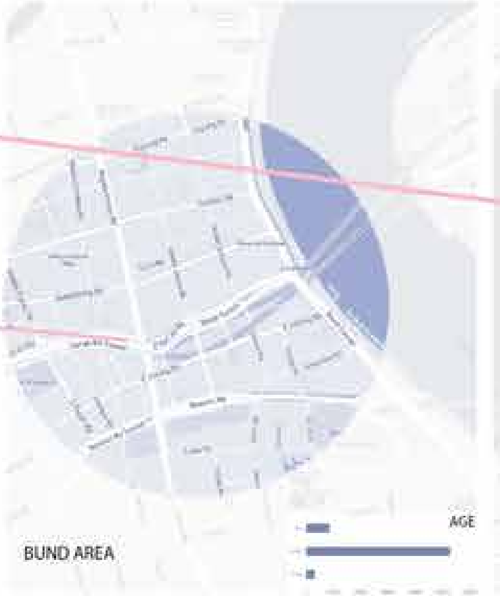




SITE ANALYSIS

POPULATION AND URBAN LANDUSE GROWTH OF SHANGHAI





COMPARATION BETWEEN 4 AREAS	AREA(m^2)	POPULATION	AREA/PERSON(m^2)
BUND AREA:	$2.18*10^6$	64896	34
LUJIAZUI AREA:	$6.89*10^6$	112507	61.2
LAOXIMEN STREET AREA(SITE):	$1.24*10^6$	72898	17
XIAODONGMEN STREET AREA:	$2.59*10^6$	74994	34.5

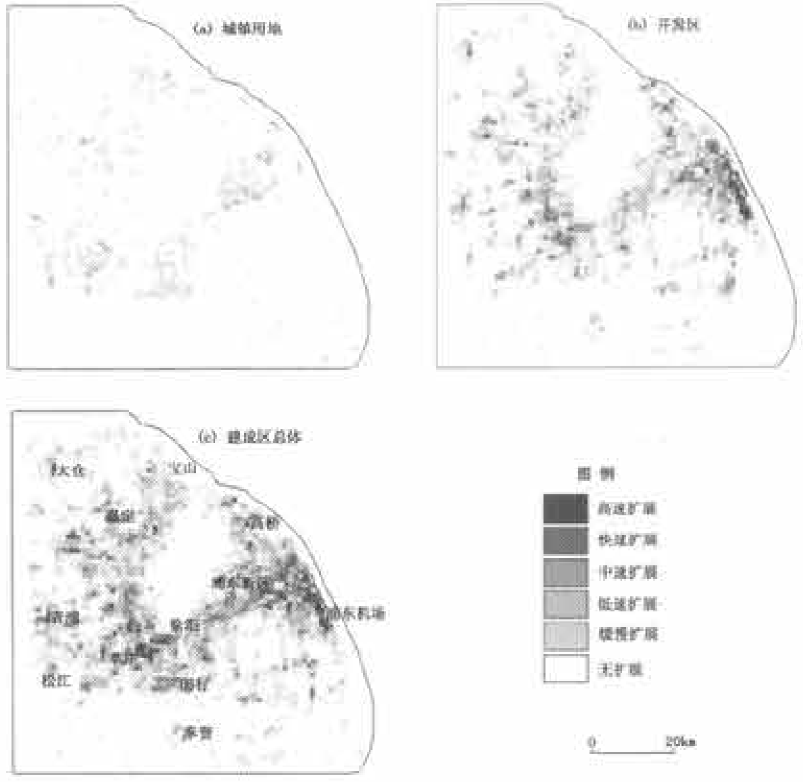
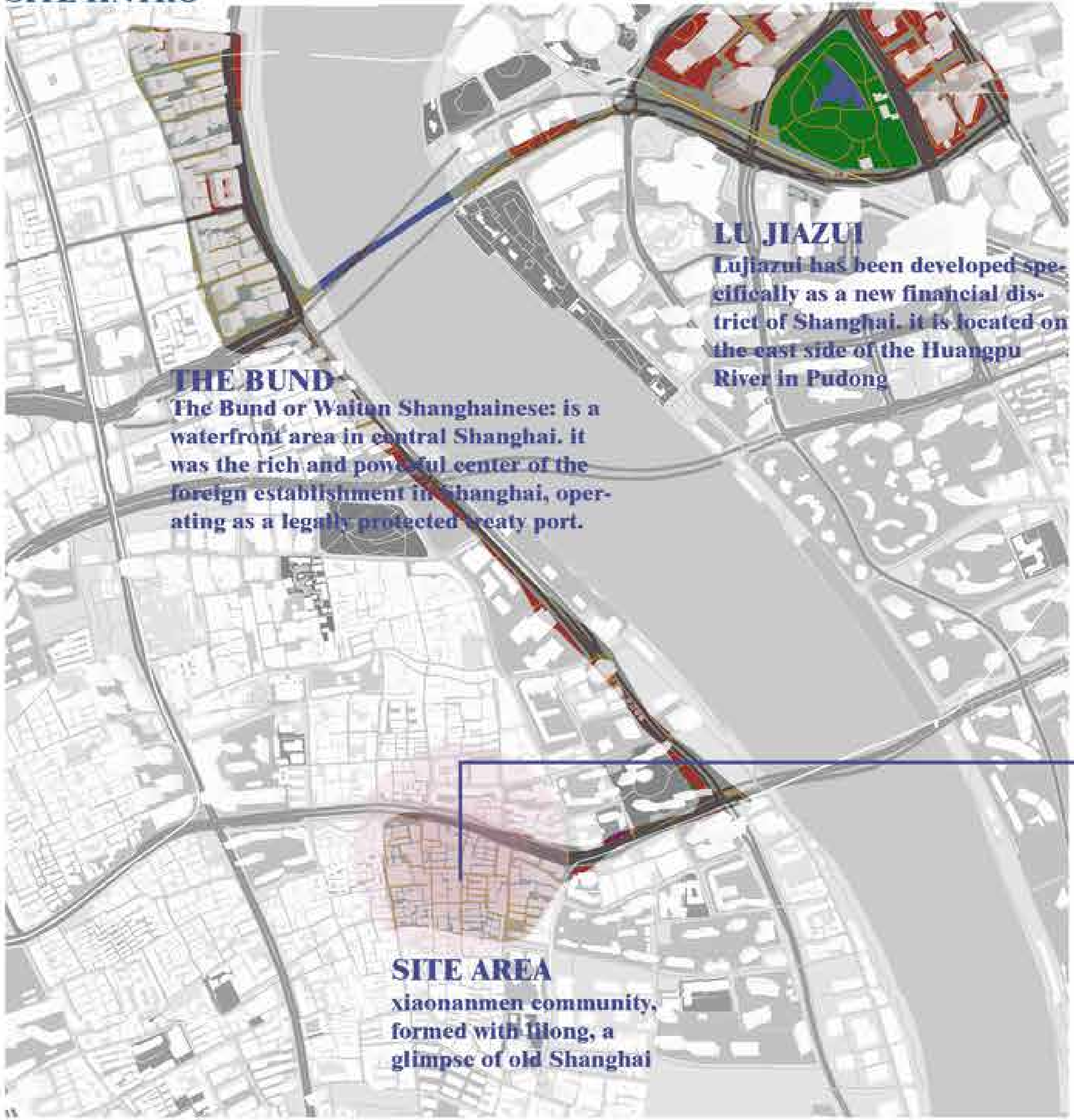
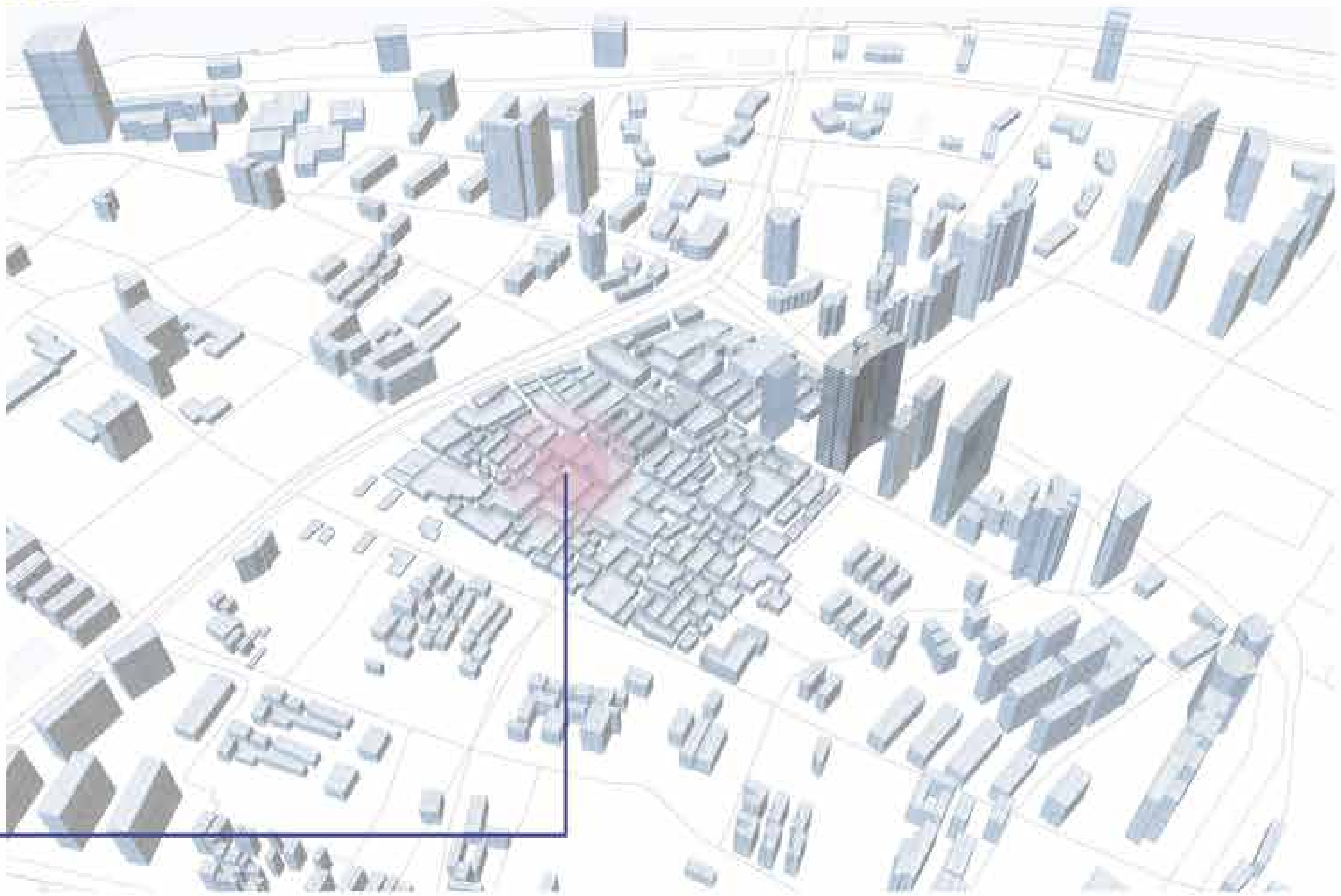


图 5 1995~2000 年上海地区城市扩展强度的空间分异
Fig.5 The spatial variation of urban landuse growth rate from 1995 to 2000 in Shanghai Region

SITE IINTRO

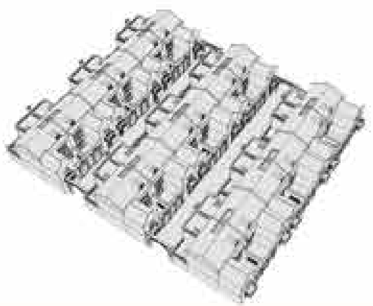


SITE



Our site is located in the old downtown of Shanghai - the Xiaonamen neighbourhood area. Surrounded by high level skyscrapers, buildings in Xiaonanmen neibourhood area are most three to six levels old architecture.
The Xiaonanmen area of Shanghai is an area of Shanghai's old city, and is currently a small South Gate station on Line 9 of Shanghai Metro. The Xiaonanmen area itself is a representative of Shang-hai's old city, and is also facing demolition and transformation.

ARCHITECTURE ANALYSIS

landscape		The oriental Pearl Radio & Television Tower 468 m high, it was the tallest structure in China from 1994–2007
skyscraper morden high level building (financial/residential)		more and more sky-crapers are under consruction Such as Shanghai Jinmao Tower
Western architecture style low level building		Most of the pure Western architec-ture are located in the old concession area. Buildings in The Bund
Chinese traditional building (shikumen;jiang-nan building)		Shikumen Build-ings mostly located in the old down-town of Shanghai. They are domolish-ing and replacing by high buildings

ARCHITECTURE ON SITE

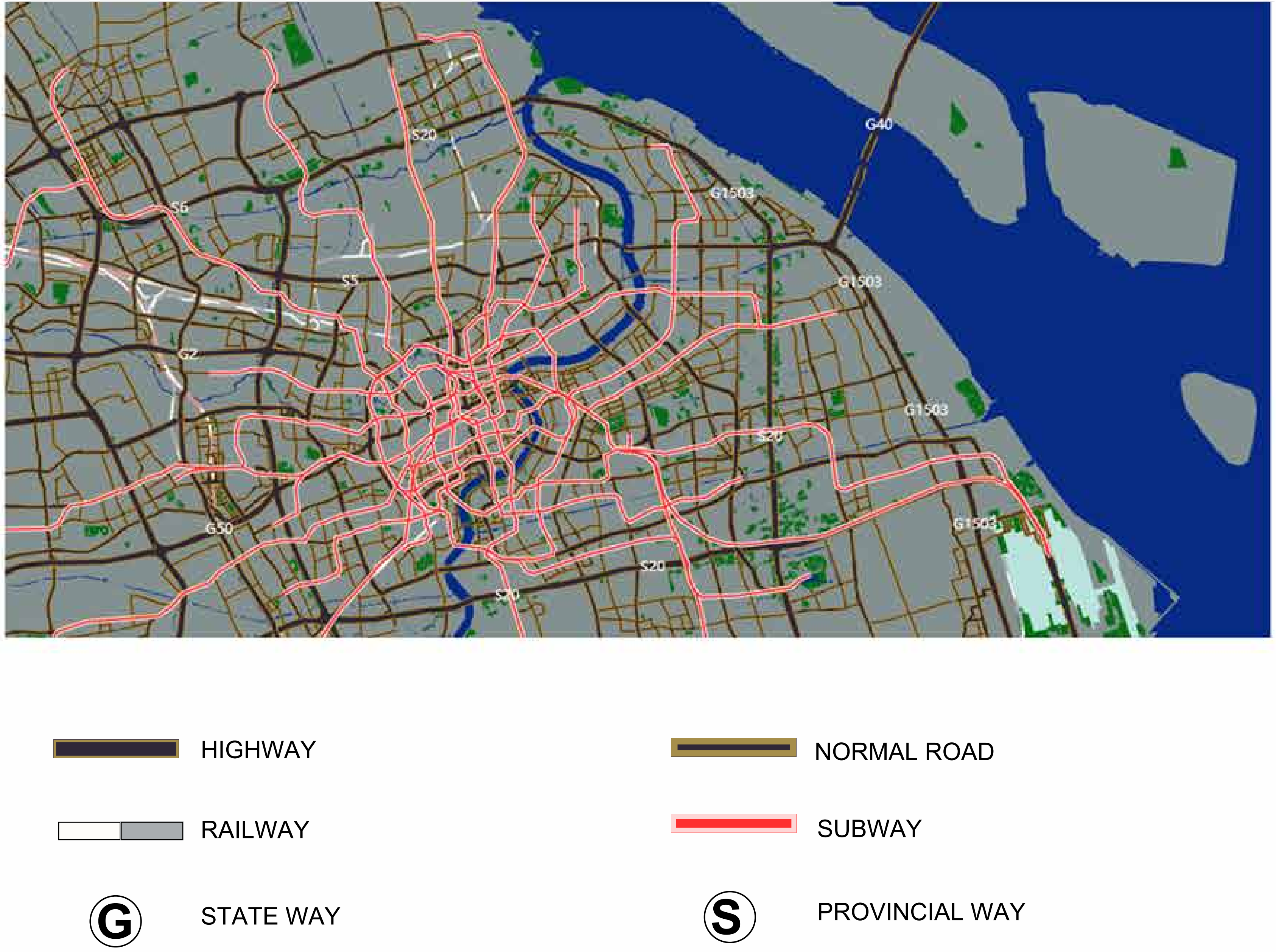
type1 shikumen buidling

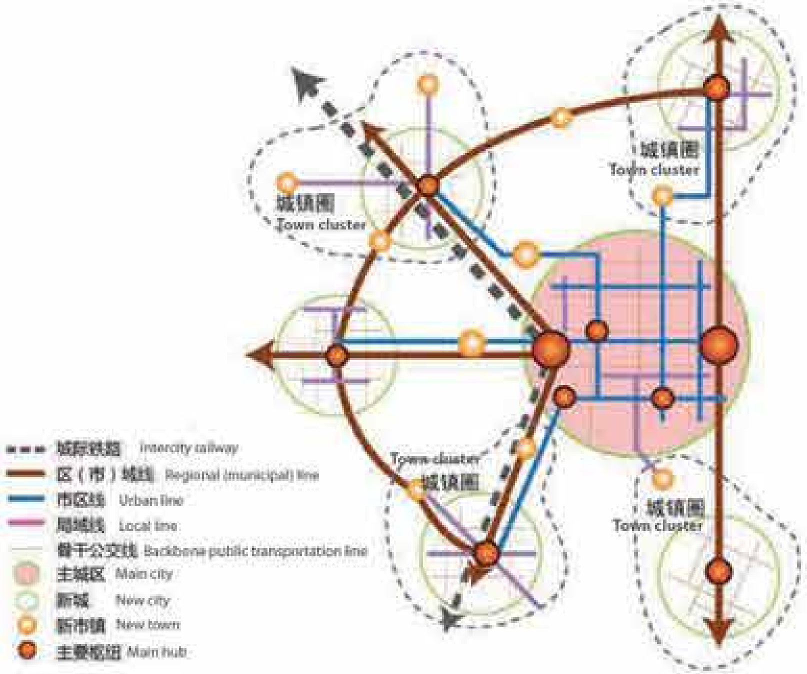
type2 self-build building
normally one level for cooking or as a toilet

type 3 traditional residence building
different from Shikumen buidling, they are constrctuted totally by wood

type4 bussiness building along the street
for the ground floor are some small shops, above are residential part

LOCAL TRANSPORTATION





	系统模式 System Model	功能定位 Functional Orientation	设计速度 Designed Speed	平均站距 Average Stop Spacing	规划里程 Planned Distance
城际线 Intercity lines	城际铁路 市域铁路 轨道快线 Intercity railway, municipal railway and express railway	服务于主城区与新城及近沪城镇、新城之间的快速、中长距离联系，并兼顾主要新市镇。 Serve fast connection and medium-and long-distance connection among the main city, new cities and towns near Shanghai and among new cities, and simultaneously support the major new towns	100-250	3-20	1000以上 Over 1,000
市区线 Municipal lines	地铁 Subway	服务高度密集发展的主城区，满足大运量、高频率和高可靠性的公交服务。 Serve intensively developed main city and meet the public transportation service requirement for large traffic volume, high frequency and high reliability	80	1-2	1000以上 Over 1,000
	轻轨 Light railway	服务于较高强度密集发展的主城区次级客流走廊，与地铁共同构成市区轨道网络。 Serve secondary passenger transportation corridors in the intensively developed main city, and form the municipal rail network with subways	60-80	0.6-1.2	
局域线 Local lines	现代有轨电车 胶轮系统等 Modern tramcar Rubber-tired transit system etc.	[illegible] Serve as the supplement and connection of high-capacity rapid rail transit, or serve the local passenger transportation corridors to improve service of local public transportation	-	0.5-0.8	1000以上 Over 1,000

SITE CONDITION

PEOPLE ON SITE

The triangle of land between Xiaonanmen metro station, the Lujiabang fabric market and the Cool Docks is a fascinating slice of old Shanghai that goes largely overlooked and is shrinking by the day as the cranes and bulldozers move in.
Residents in the area generally seem quite happy to be relocated to Minhang district, where they will be given new housing by the government, though they also acknowledge the fact that they have not been given much of a choice.

Chen Liangyu, 65, is the director of the neighbourhood committee in Xiaonanmen. He has only been staying here for around 10 years, and he says that he is still unsure when the government will issue the order for relocation. 'This place hasn't changed much since the day I moved in. The demolition process started in September 2007. As you can see, residents of the other neighbouring longtangs have been relocated already. I'm not sure when we can move out, but if the government says we have to move, we don't really have a choice. The government has the final say,' he says with a chuckle.
Mr Wang Shikai, 77, has been living in this area since he was born. His friend laughingly calls him the 'richest man in the district' because he owns a house – passed down by his parents – that is over 200 square metres in size. He sits in his rattan chair, one hand holding onto the leash of his Pomeranian, the other holding a cigarette, and is more than happy to speak to us. 'Yes, of course I'd like to move,' he says. 'This place is too cramped to live comfortably. Most of us don't even have a proper toilet to use because the government didn't create any sewers for the waste to be channelled into. We're still using a bucket to dispose human waste.'
He adds that their wooden homes have also become dangerous, as the structures inevitably become weaker over the years as rainwater dampens the wood and affects the durability. A small crowd gathers during our chat with him, all seemingly interested to hear what he says. Despite his apparent status in the community, he is refreshingly humble. 'My friend, that one,' he says, pointing to a semi-bald man in his 70s, 'He's sick. As much as I would love to move out of here, relocation to our new homes in Pujiang [in Minhang district] is going to be difficult for him - the nearest medical facilities are quite a distance away.'

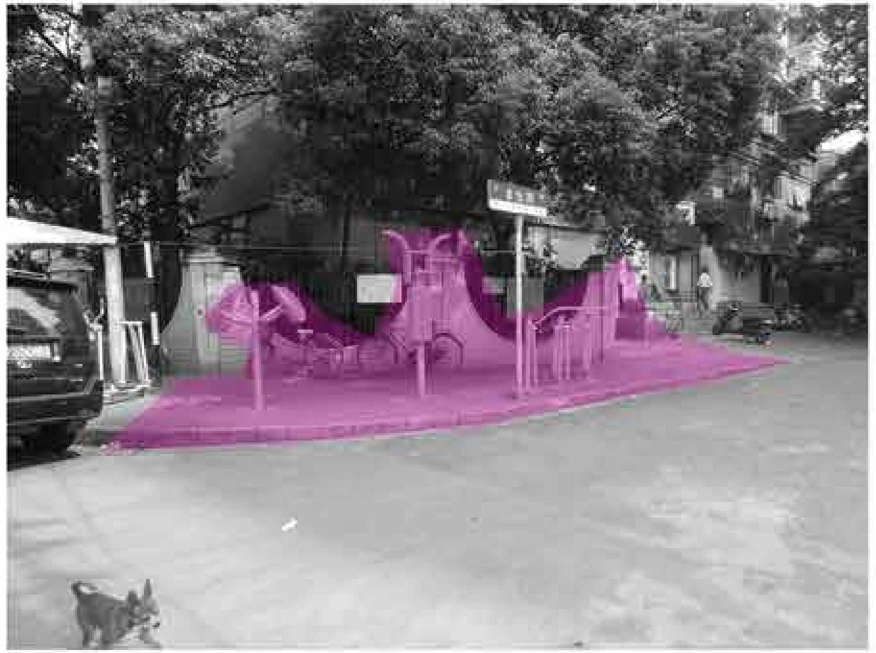
SITE CONSTRAINTS

Some existing building which are illegal present in our site but they also supply essential service and keep realy good relationship with the communities .

People living here tend to have really samll space also for nomal living and other aspects. Even the elders cannot enjoy their life.

SITE CONSTRAINTS

For our site they really do not have enough public space such as sports for the elders.

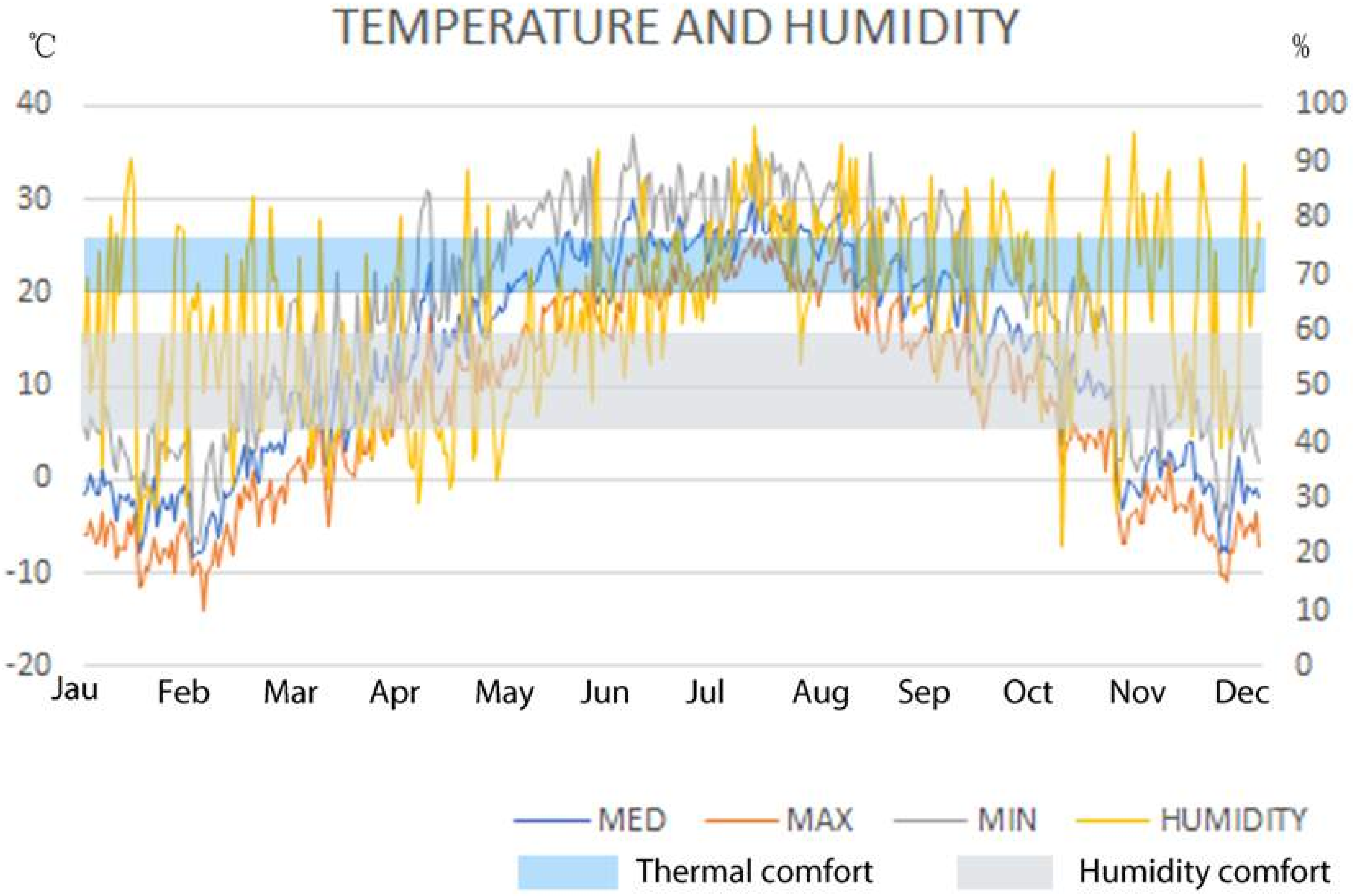


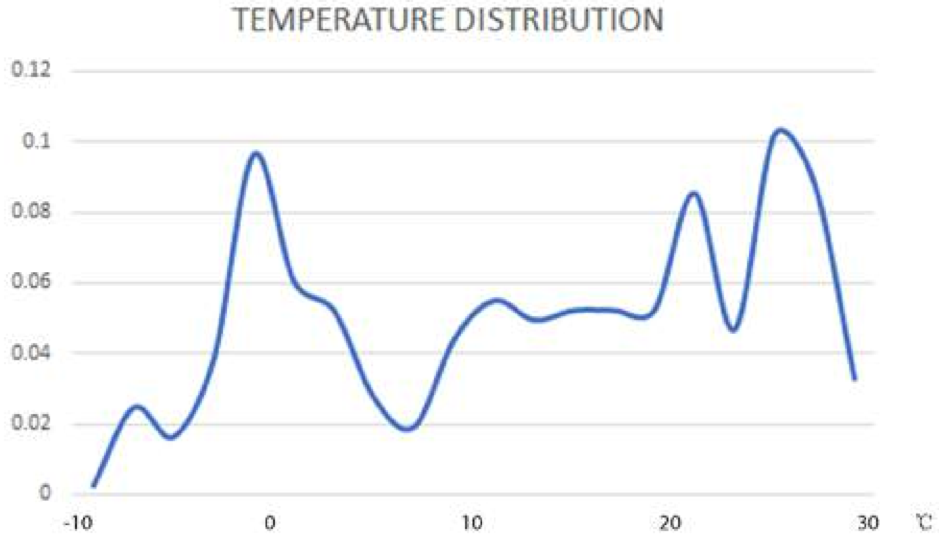
The walking way is so narrow also they are always occupied by stuffs whihc is so difficult for people to psaa.

COMFORT DISTRIBUTION

the right chat represent the trend during a year of temperature and humiduty,we can easily find T dif-ferentc is more than 40 degrees so maybe it will be a dificult for later.Also the humidity range is very big especially in winter compare to summer.We choose Tbetween 20 and 25 is thermal comfort zone humidity comfort zone is between 40 and 60,we realize most of them are not in these zones.

For the below chart,it represent the temperature dis-tribution and it is strange for the peak value happen at two point ,2 degrees and 26 degrees respectively.



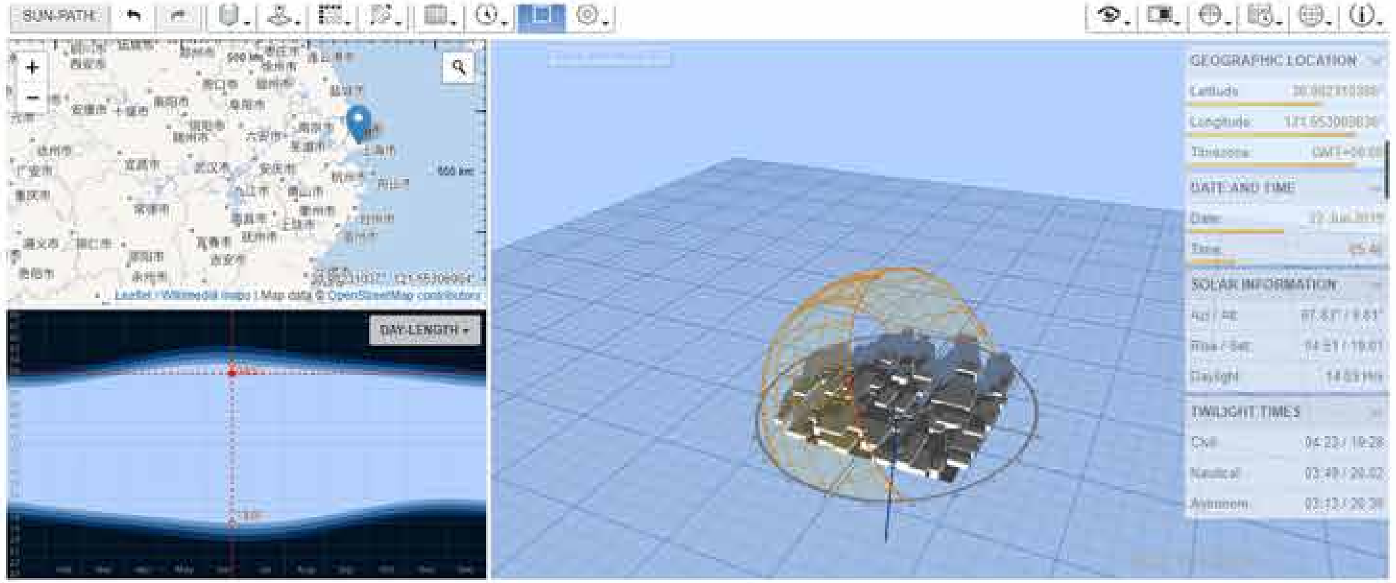


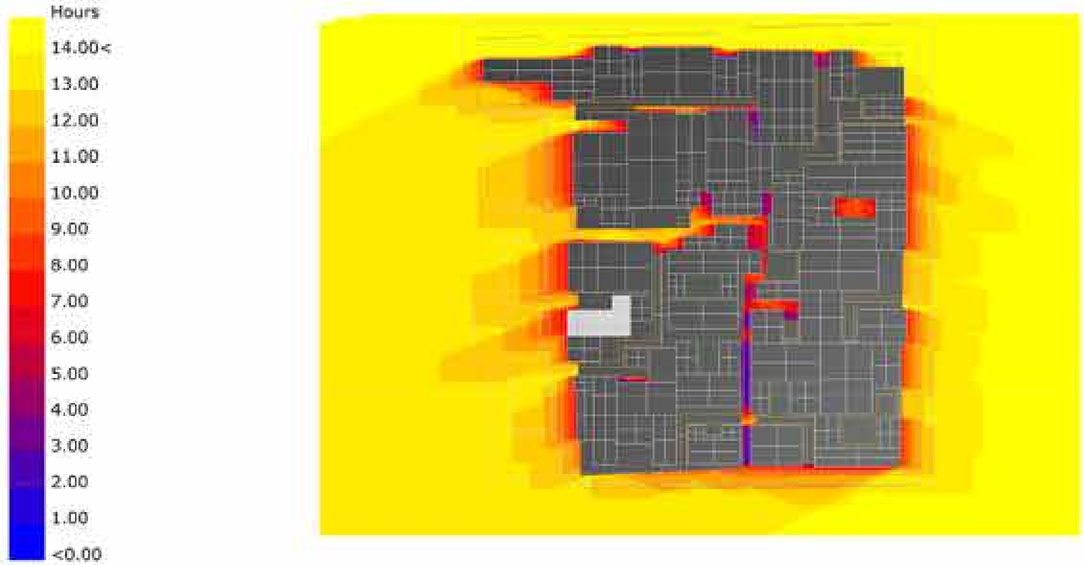
TEMPERATURE PERCENTILES

%	0	5	50	95	100
℃	-8.4	-3.2	13.8	28	30

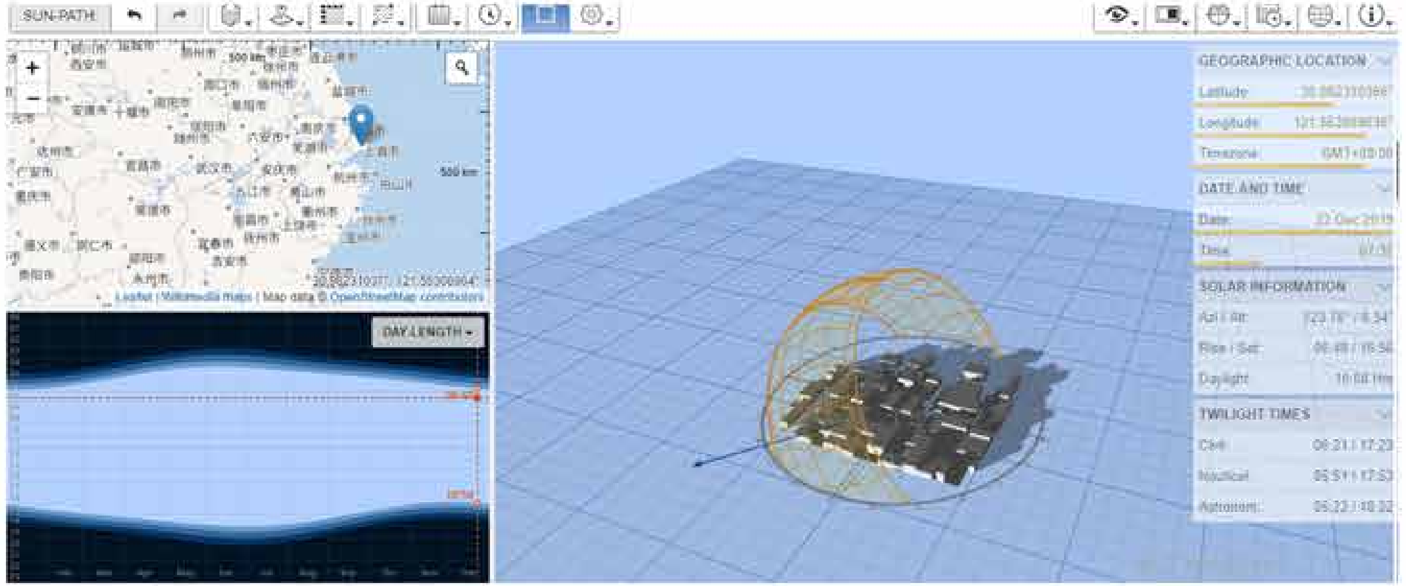
SHADOW RANGE ANALYSIS

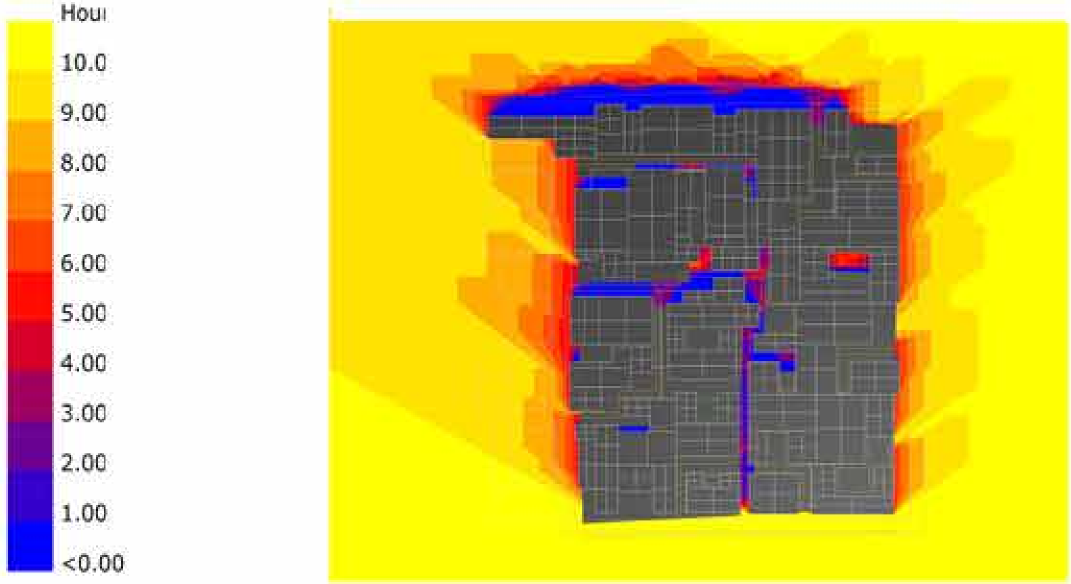
22/6





22/12



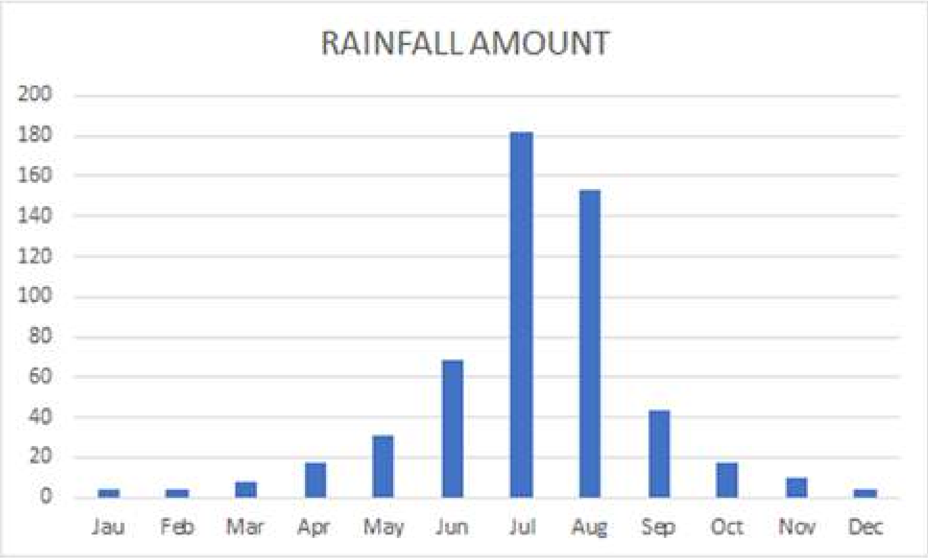


WIND AND RAINFALL

As the temperature climate is corresponding to the site in Shanghai , the monthly average rainfall calculated over several years is giving the peak in July with 182mm and the lowest one in January with 4mm.

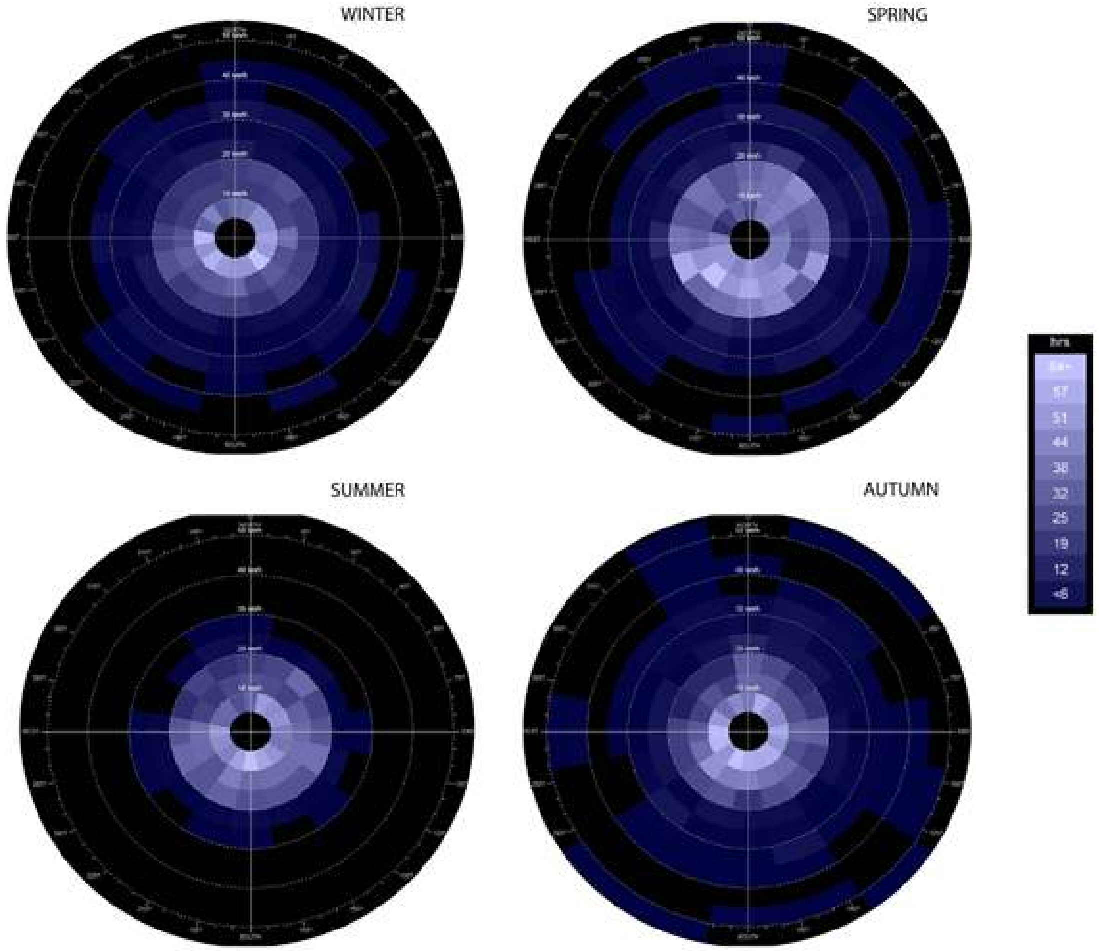
In orderr to understand the positive effect of natural ventilation, only data with a wind speed below 20km/h which we achieved from “Beaufort Scale” that set it as the speed of the wind that rise loose paper and dust have been considered.

The graphs show the frequencies in hrs and the direction of the wind owing on our site.
A global analysis has been performed according to the four seasons considering the prevailing directions for all kind of air flows.
The main direction of useful winds is SE-NW during all four seasons.
At the beginning of the building design, if it is conditional, the buildng should follow the best orientation also the win flow directions for improving the future performance.



Beaufort Scale

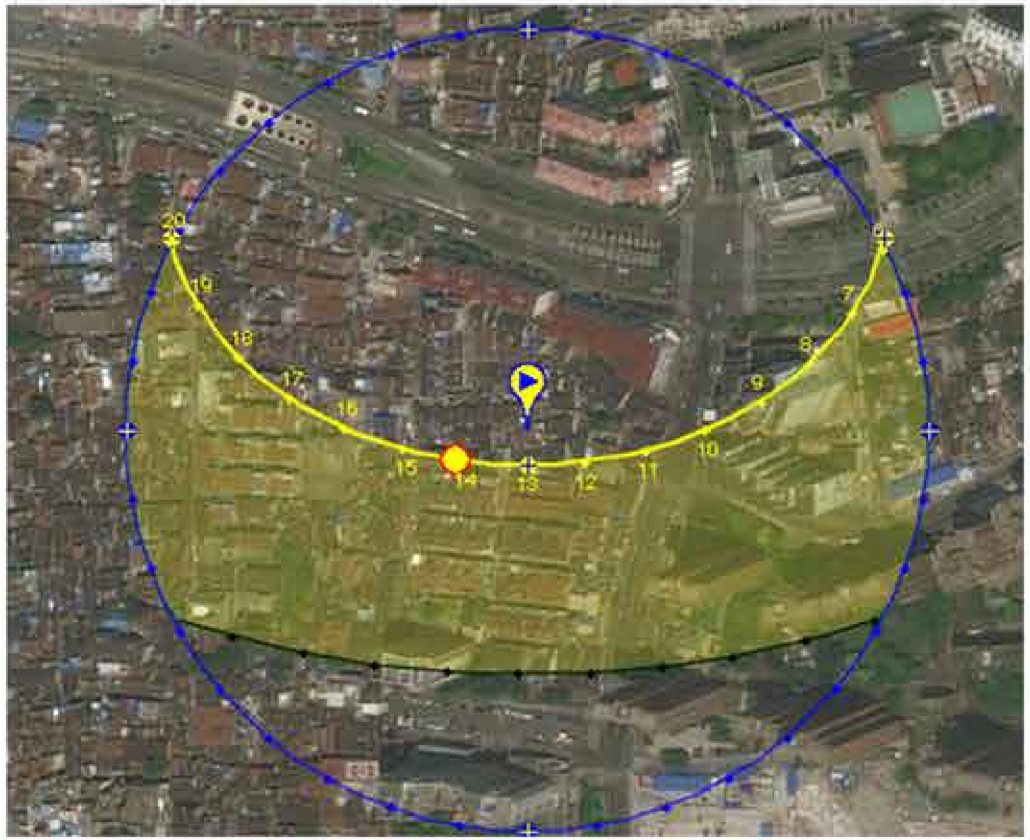
Beaufort number	Wind Speed (mph)	Seaman's term		Effects on Land
0	Under 1	Calm		Calm; smoke rises vertically.
1	1-3	Light Air		Smoke drift indicates wind direction; vanes do not move.
2	4-7	Light Breeze		Wind felt on face; leaves rustle; vanes begin to move.
3	8-12	Gentle Breeze		Leaves, small twigs in constant motion; light flags extended.
4	13-18	Moderate Breeze		Dust, leaves and loose paper raised up; small branches move.
5	19-24	Fresh Breeze		Small trees begin to sway.
6	25-31	Strong Breeze		Large branches of trees in motion; whistling heard in wires.
7	32-38	Moderate Gale		Whole trees in motion; resistance felt in walking against the wind.
8	39-46	Fresh Gale		Twigs and small branches broken off trees.
9	47-54	Strong Gale		Slight structural damage occurs; slate blown from roofs.
10	55-63	Whole Gale		Seldom experienced on land; trees broken; structural damage occurs.
11	64-72	Storm		Very rarely experienced on land; usually with widespread damage.
12	73 or higher	Hurricane Force		Violence and destruction.



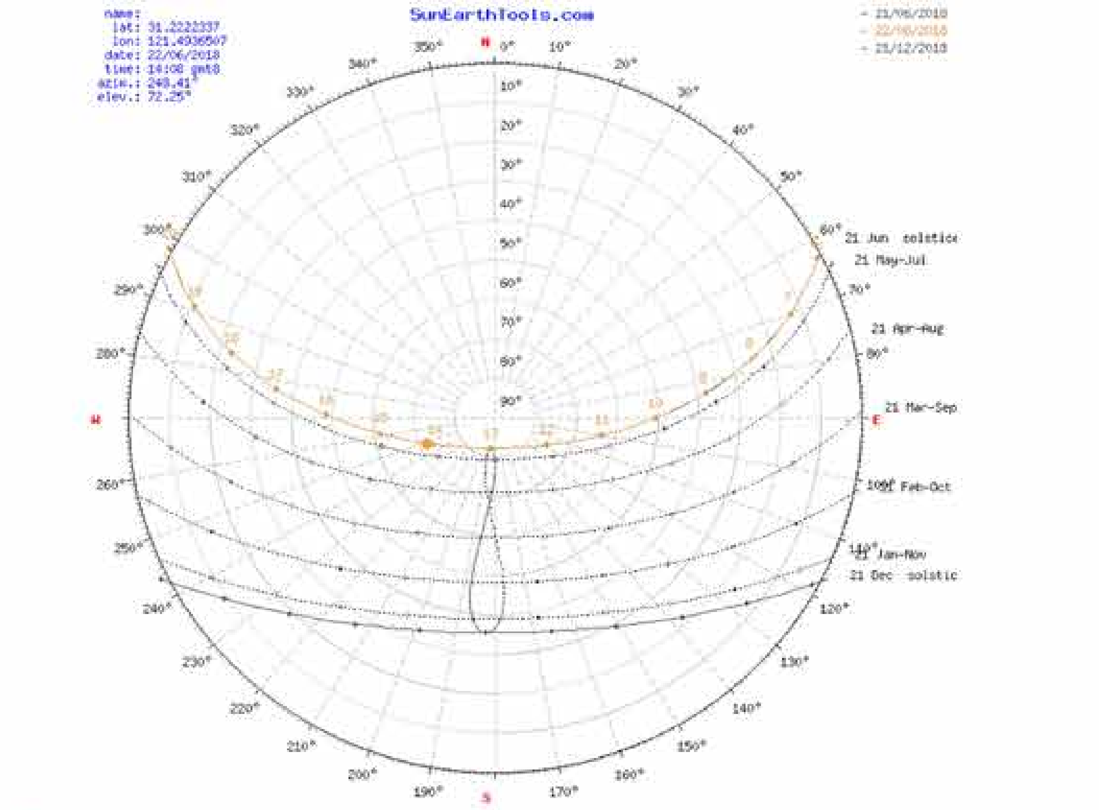
SUMMER SOLAR ANGLES

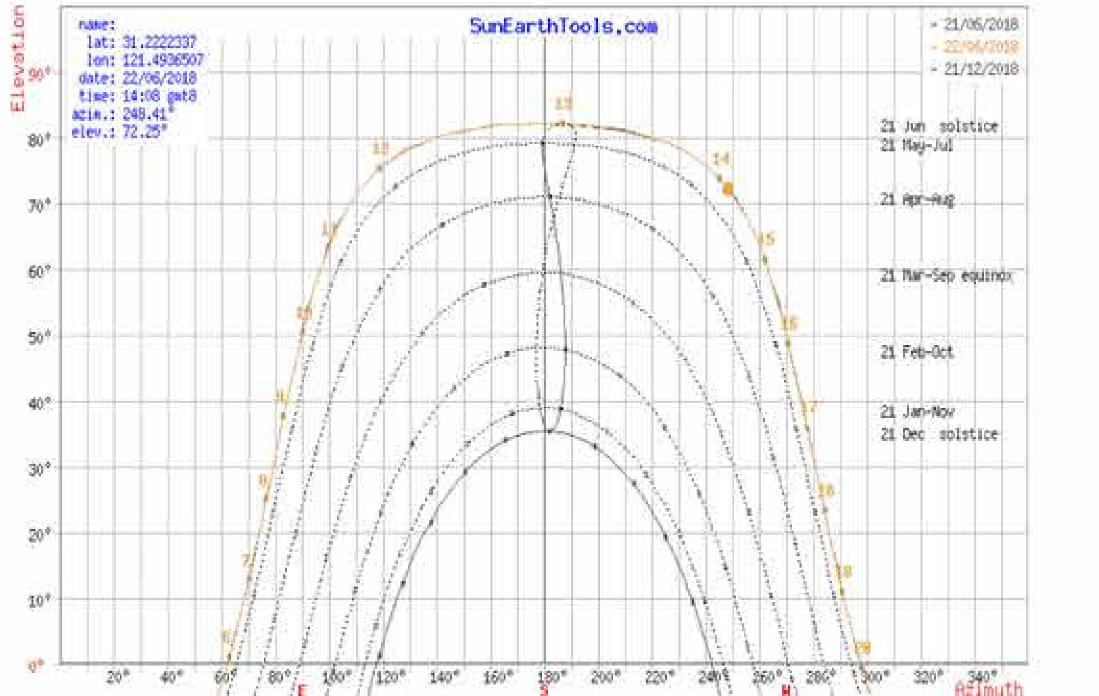
22/06

For the typical day during the summer when it is at 22th,Jun. From the graph we notice that in almost 13.00 the sun is exactly 180 which is south, and from below two charts ,we can realize the maximum solar angles changing process during the whole year,- closer to summer,bigger angles(almost 90 degrees)



Date	22/06/2018 | GMT8	
coordinates:	31.2222337, 121.4936507	
location:	Xundao Street, 斜桥, 上海市, 黄浦区, 上海市, 200010, 中国	
hour	Elevation	Azimuth
05:50:33	-0.833°	61.7°
6:00:00	0.95°	62.93°
7:00:00	12.71°	70.12°
8:00:00	25°	76.67°
9:00:00	37.62°	83.1°
10:00:00	50.41°	90.18°
11:00:00	63.18°	99.68°
12:00:00	75.35°	118.68°
13:00:00	82.16°	186.76°
14:00:00	73.82°	245.16°
15:00:00	61.49°	261.86°
16:00:00	48.7°	270.84°
17:00:00	35.92°	277.77°
18:00:00	23.33°	284.18°
19:00:00	11.1°	290.79°
20:00:00	-0.57°	298.11°
20:01:24	-0.833°	298.29°

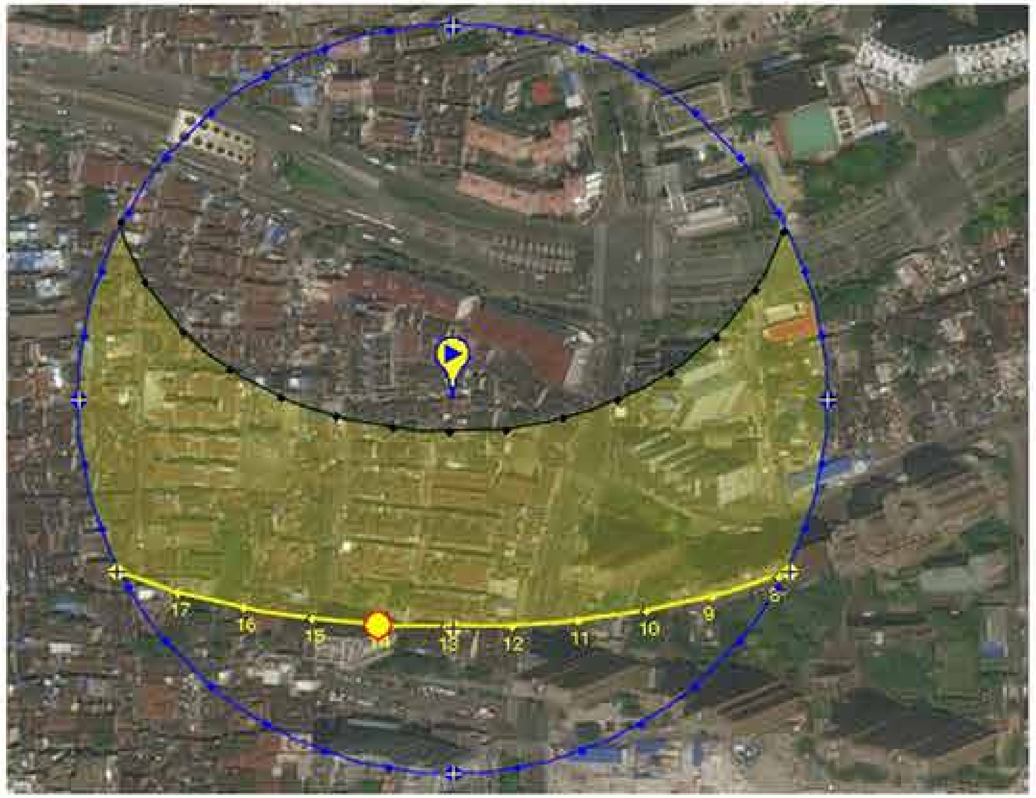




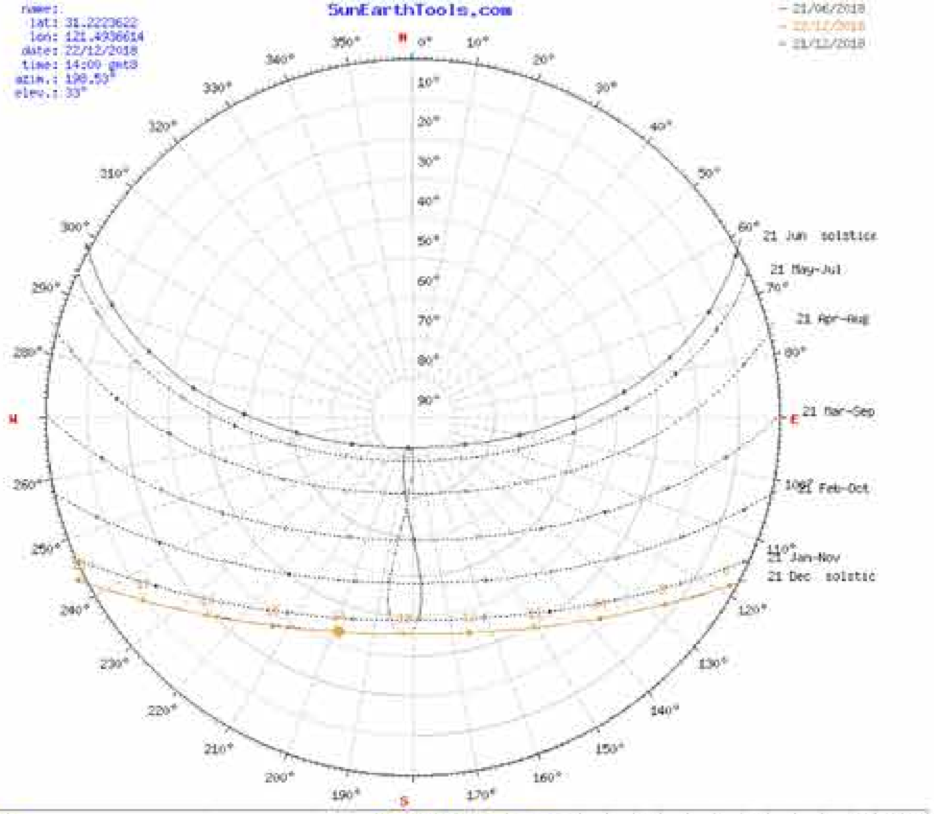
WINTER SOLAR ANGLES

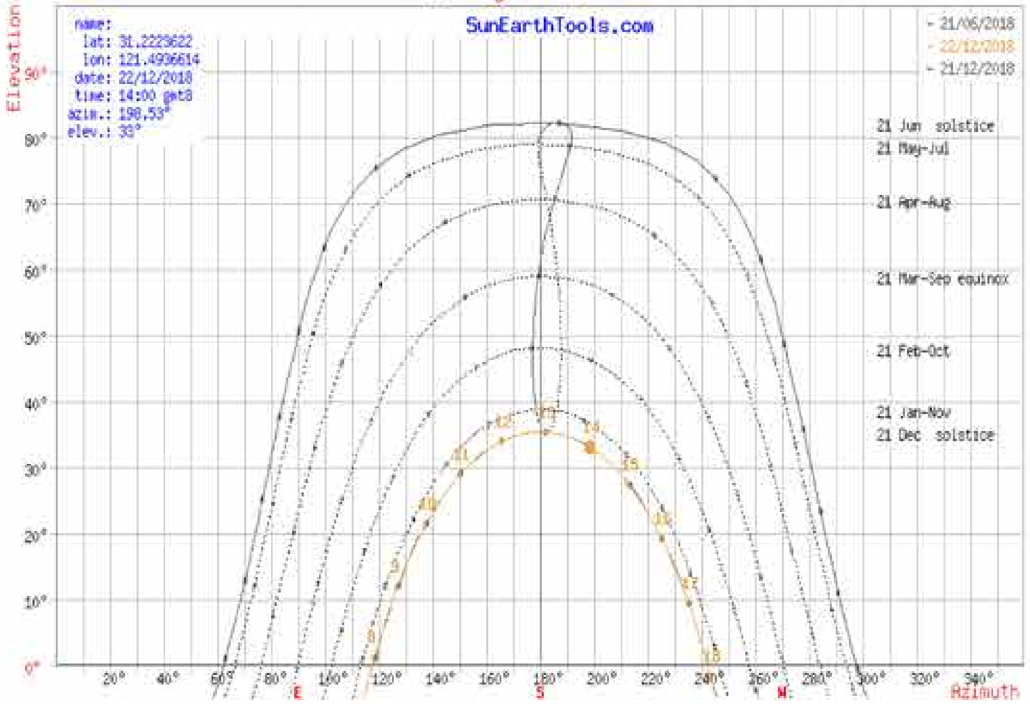
22/12

For the typical day during the summer when it is at 22th,Jun. From the graph we notice that in almost 13.00 the sun is exactly 180 which is south, and from below two charts ,we can realize the maximum solar angles changing process during the whole year,-closer to summer,bigger angles(almost 90 degrees)



日期:	22/12/2018 | GMT8	
坐标:	31.2223622, 121.4936614	
位置:	31.22236220,121.49366140	
小时	海拔	方位角
07:48:51	-0.833°	117.15°
8:00:00	1.27°	118.6°
9:00:00	12.04°	127.22°
10:00:00	21.52°	137.64°
11:00:00	29.08°	150.37°
12:00:00	33.92°	165.48°
13:00:00	35.31°	182.13°
14:00:00	33°	198.53°
15:00:00	27.39°	213.08°
16:00:00	19.28°	225.19°
17:00:00	9.42°	235.1°
17:55:59	-0.833°	242.85°





ARCHITECTURAL DESIGN

CASE STUDY

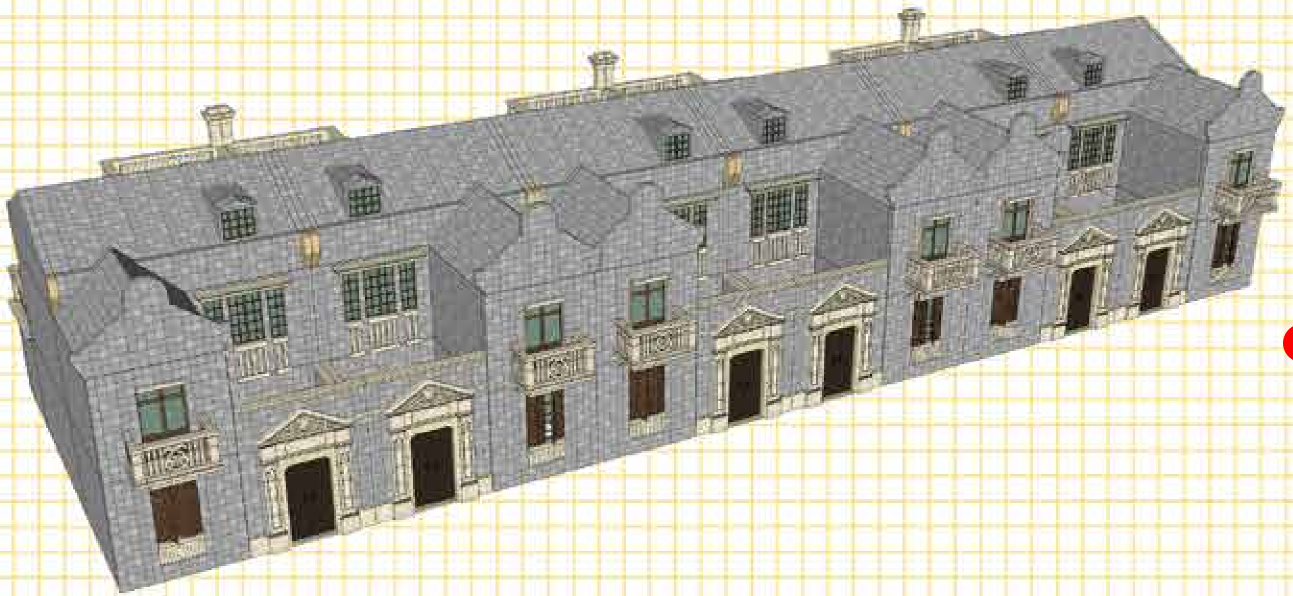
Optical Glass House / Hiroshi Nakamura & NAP

This house is sited among tall buildings in downtown Hiroshima, overlooking a street with many passing cars and trams. To obtain privacy and tranquility in these surroundings, we placed a garden and optical glass facade on the street side of the house. The garden is visible from all rooms, and the serene soundless scenery of the passing cars and trams imparts richness to life in the house. Sunlight from the east, refracting through the glass, creates beautiful light patterns. Rain striking the water-basin skylight manifests water patterns on the entrance floor. Filtered light through the garden trees flickers on the living room floor, and a super lightweight curtain of sputter-coated metal dances in the wind. Although located downtown in a city, the house enables residents to enjoy the changing light and city moods, as the day passes, and live in awareness of the changing seasons.

House NA / Sou Fujimoto Architects

Designed for a young couple in a quiet Tokyo neighborhood, the 914 square-foot transparent house contrasts the typical concrete block walls seen in most of Japan' s dense residential areas. Associated with the concept of living within a tree, the spacious interior is comprised of 21 individual floor plates, all situated at various heights, that satisfy the clients desire to live as nomads within their own home.

ENLARGE SPACE
1. SEMI-TRANSPARENT WALL
2. ROOF AND WINDOW
3. USING STAIRCASS
4.UNDERGROUND SPACE



DUN-KEEPING THE EXISTING TRADITIONAL PROFILES

Our idea is to keep the existing profile to memory the traditional and historical building but we still want to attract more people to live inside not only for the elders also for young people.So we need more space to satisify people's requirements.

BUD-INCREASE UPPER SPACE TO ATTRACT MORE PEOPLE

So what we did is do increase the upper space based on existing one to supply more space with people who lives here also on the roof we will have common space which attracts people come here.

BUILDING LAYOUT DESIGN

ROOF

FOURTH FLOOR
new facade

THIRD FLOOR
new facade

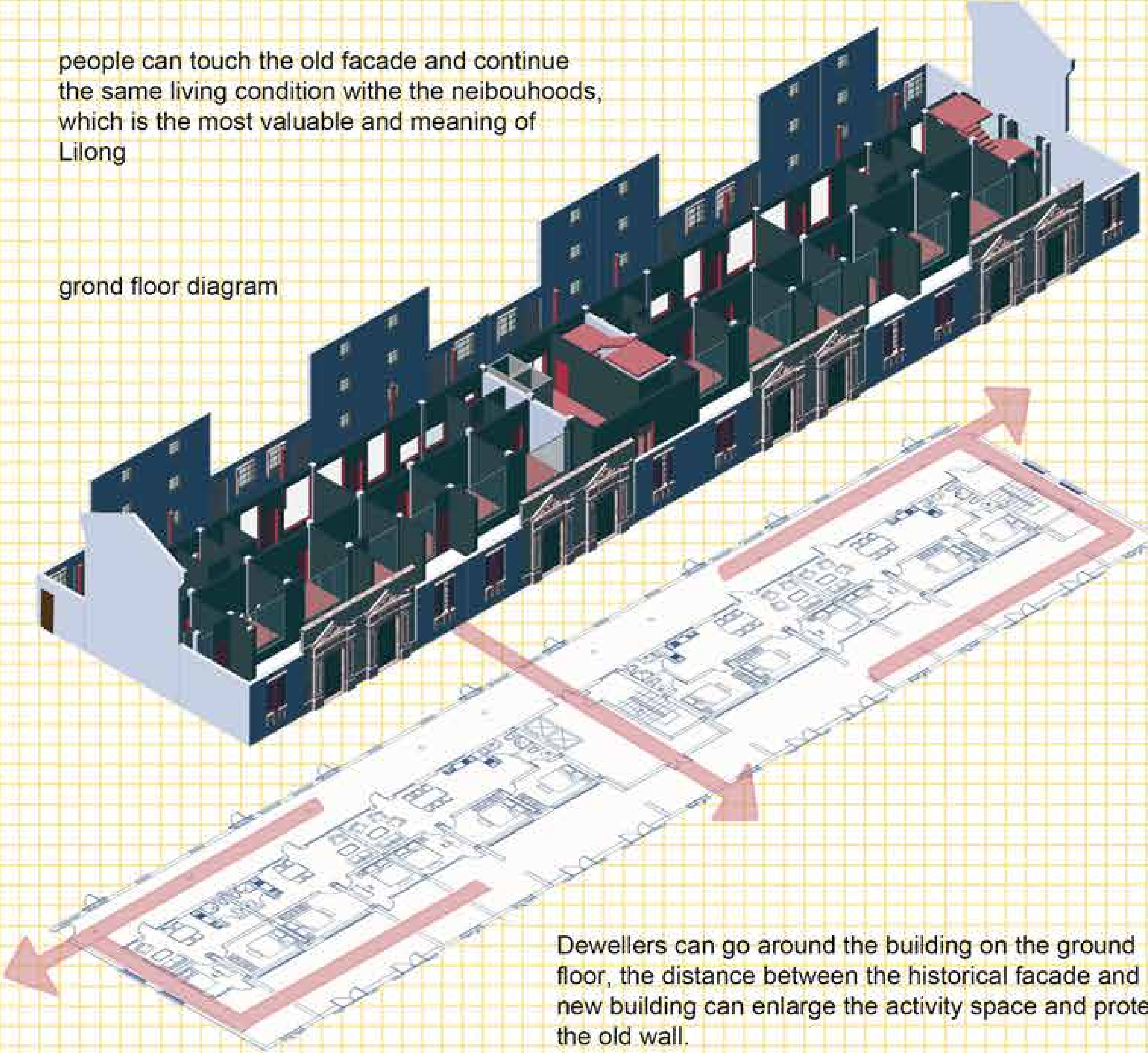
SECOND FLOOR
new facade

FIRST FLOOR
with old building facade

GROUND FLOOR
with old building
facade

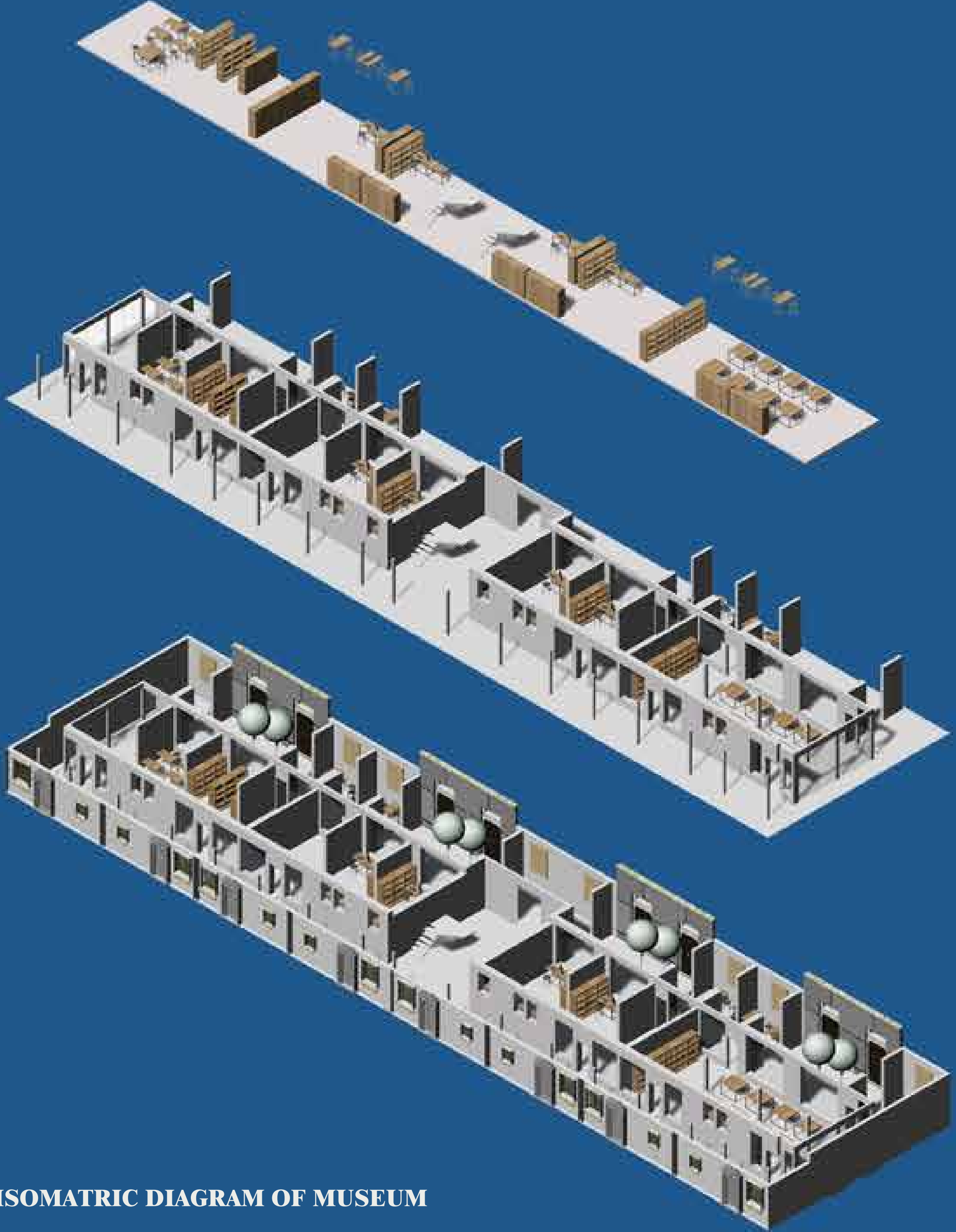
people can touch the old facade and continue the same living condition withe the neibouhoods, which is the most valuable and meaning of Lilong

grond floor diagram

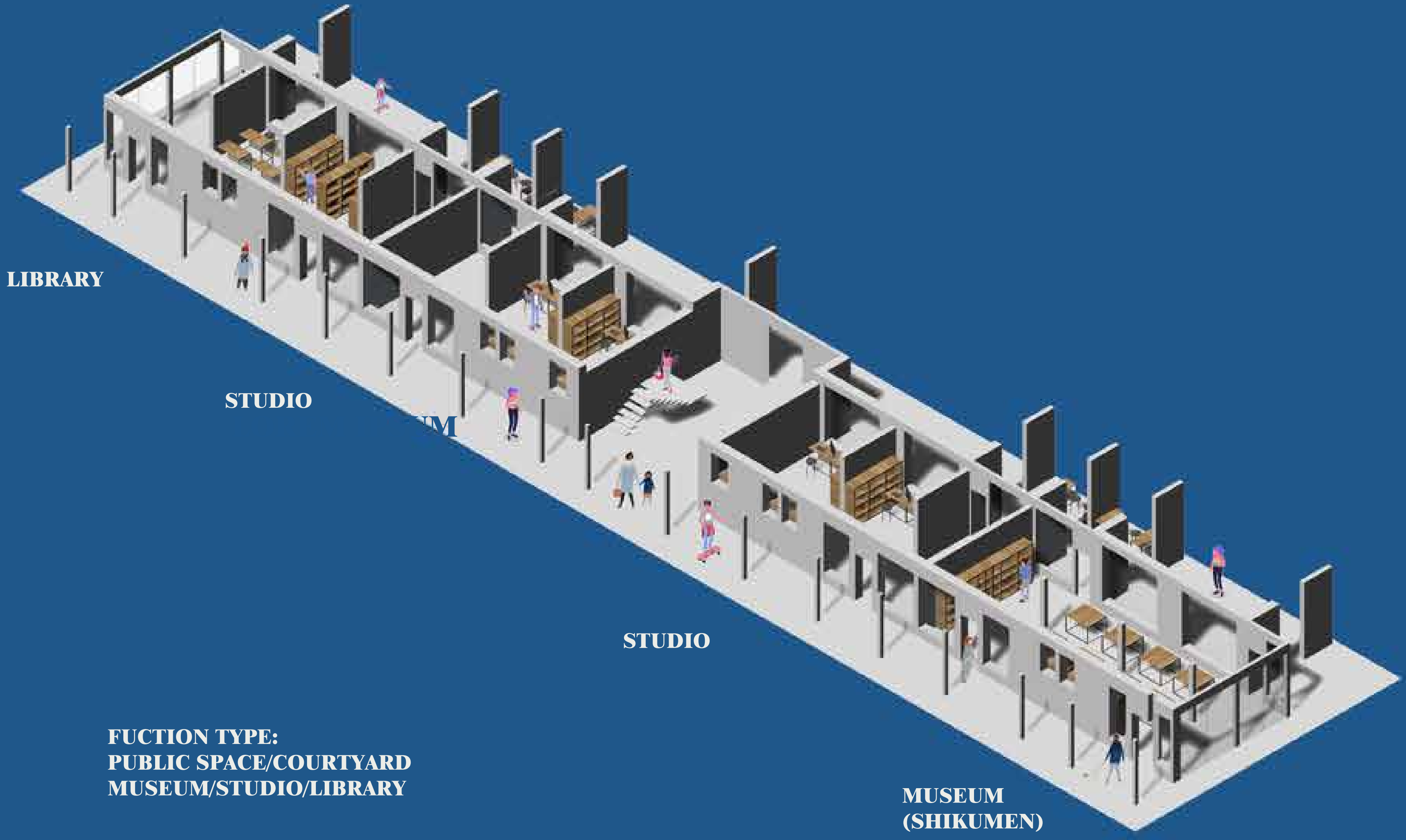


Dewellers can go around the building on the ground floor, the distance between the historical facade and new building can enlarge the activity space and protect the old wall.

MUSEUM FLOOR LAYOUT

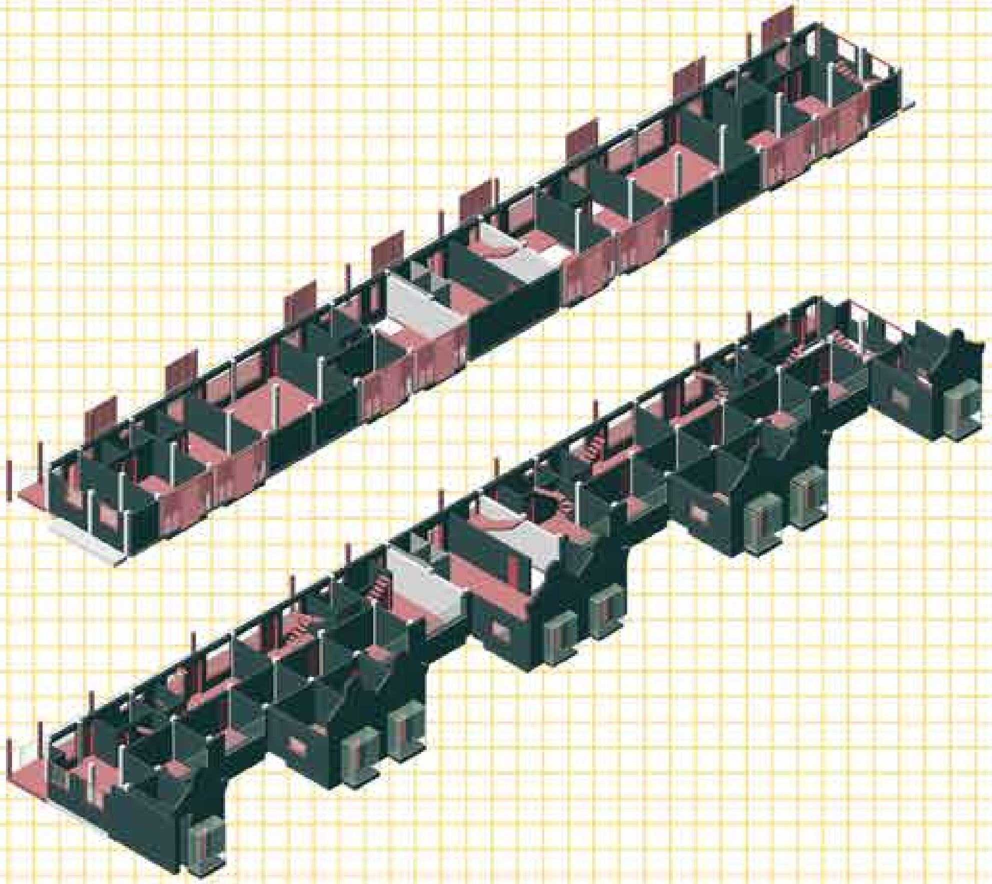


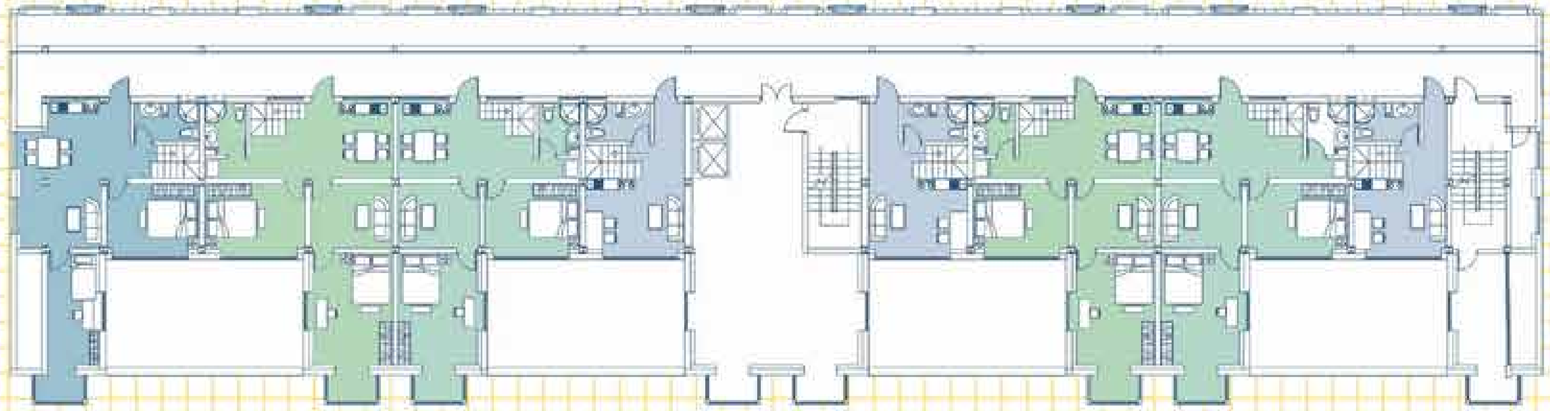
ISOMATRIC DIAGRAM OF MUSEUM

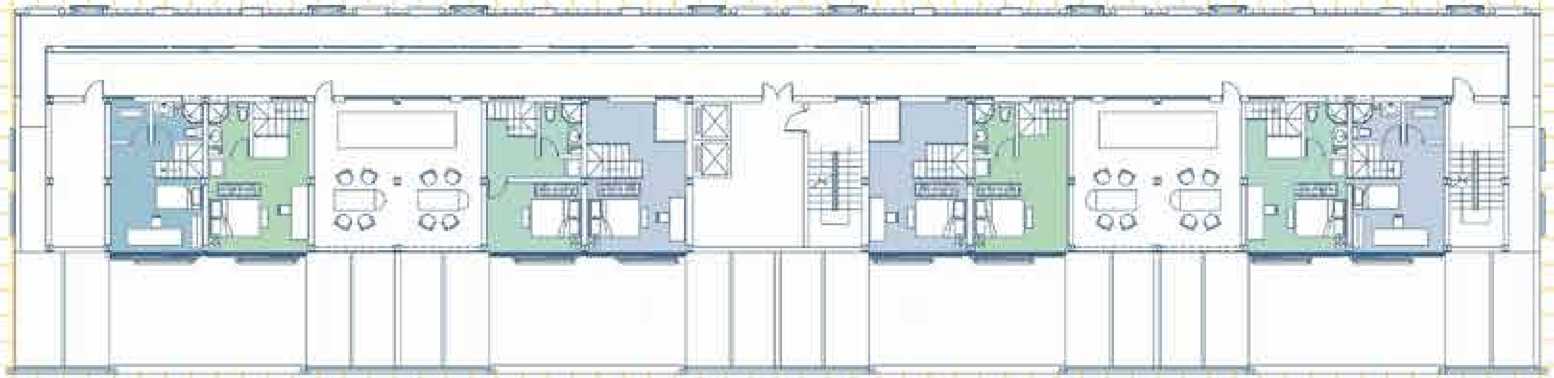


FUCTION TYPE:
PUBLIC SPACE/COURTYARD
MUSEUM/STUDIO/LIBRARY

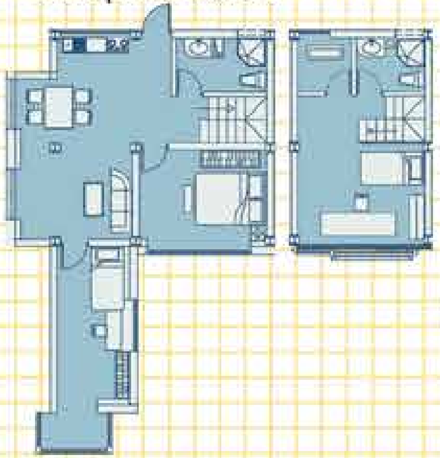
FIRST AND SECOND FLOOR LAYOUT



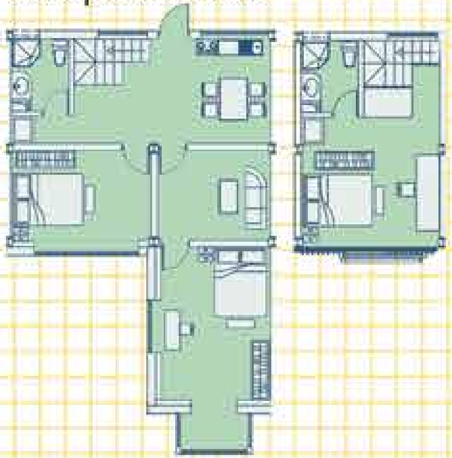




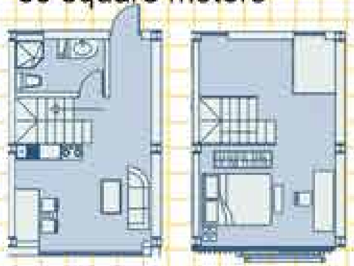
Type 1: for 6 people;
90 square meters



Type 2: for 6 people:
90 square meters

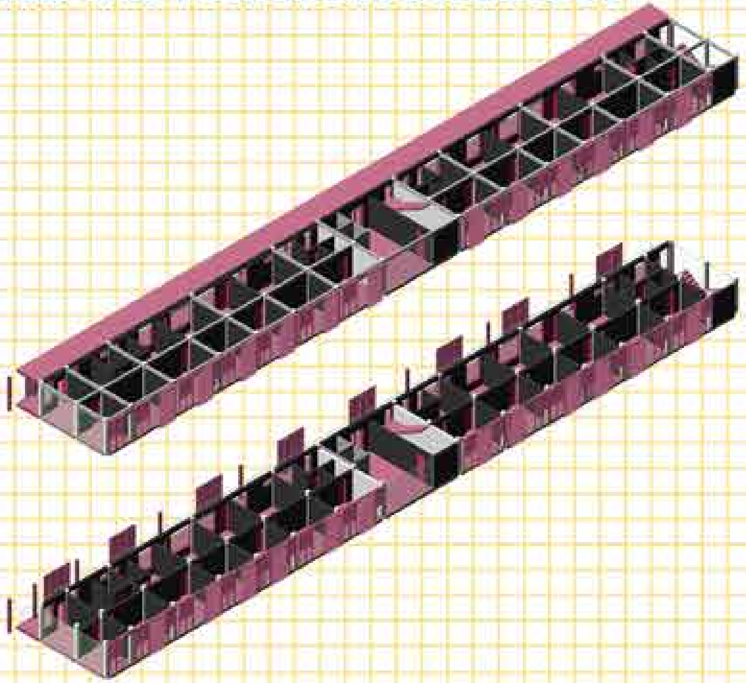


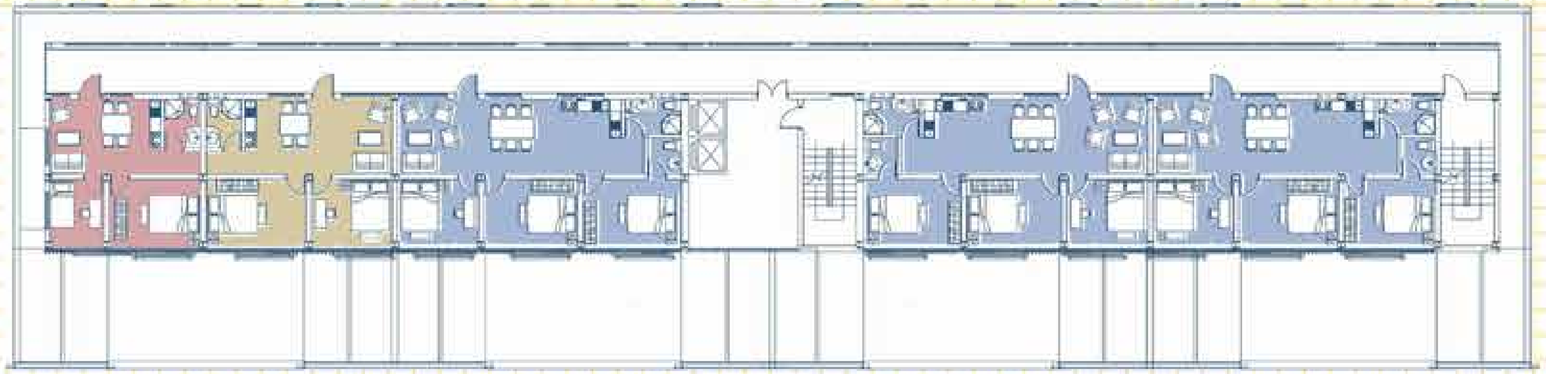
Type 3: for couple;
50 square meters



According to the original plan of Shikumen Building, there has a staircase linked the whole buidlins,and the first floor and second floor are the beadroom and study room in the attic. We hope people living inside could feel familiar with the previous layout, so we keep the height of each levels, and design lofts for first and second floor, so we can maintain part of the original layout of the building.
forthermore, we have a corridor in the north of the building which also from the balcony of the old building.
we also design two open space for activities of reading and playing to create interlocking patterns that governed community life in neighborhoods.

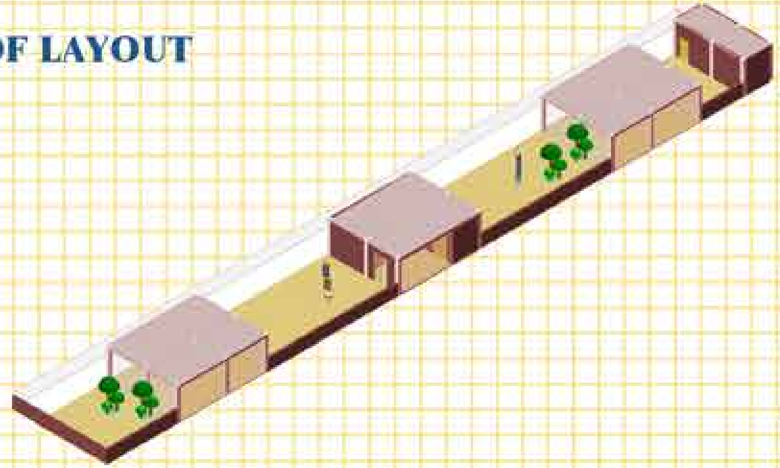
THIRD AND FORTH FLOOR LAYOUT

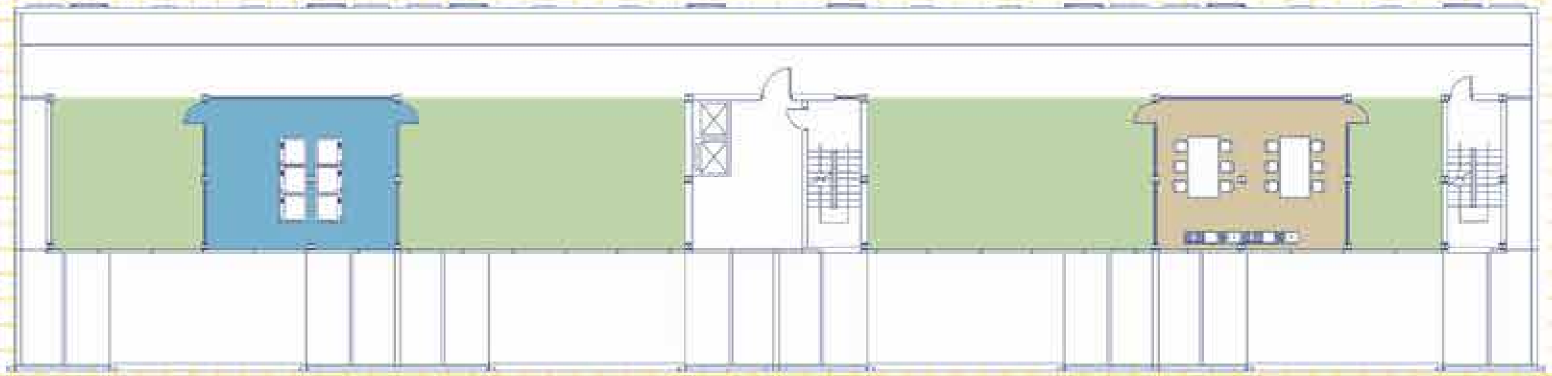




tTo satisfying the demands of increasing numbers of families, we designed more house-holds for big families.

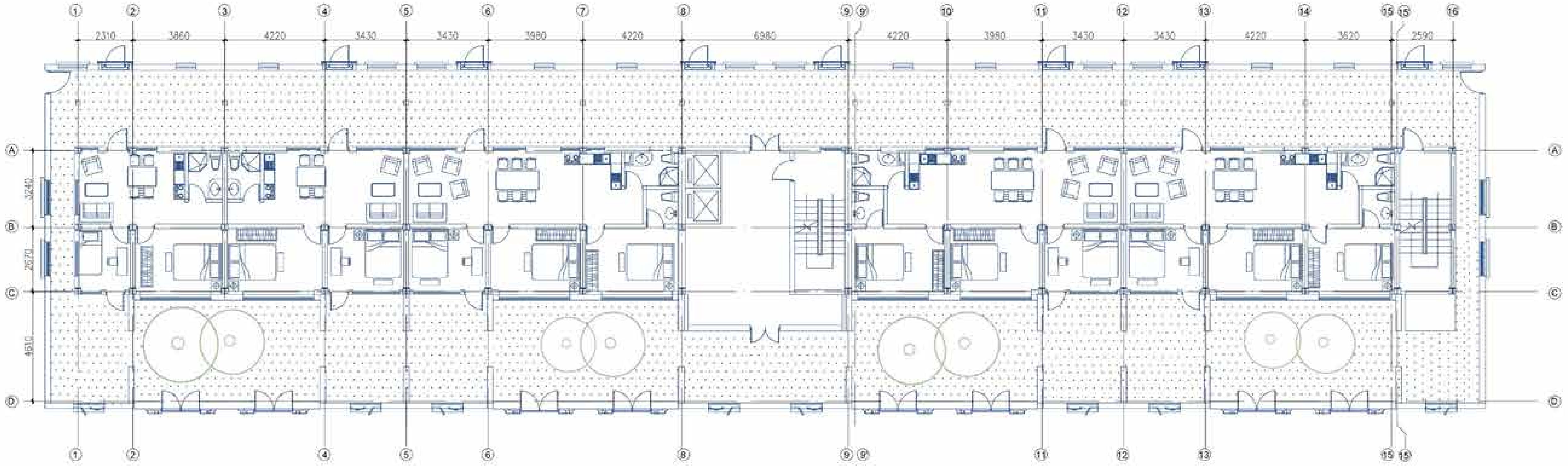
ROOF LAYOUT



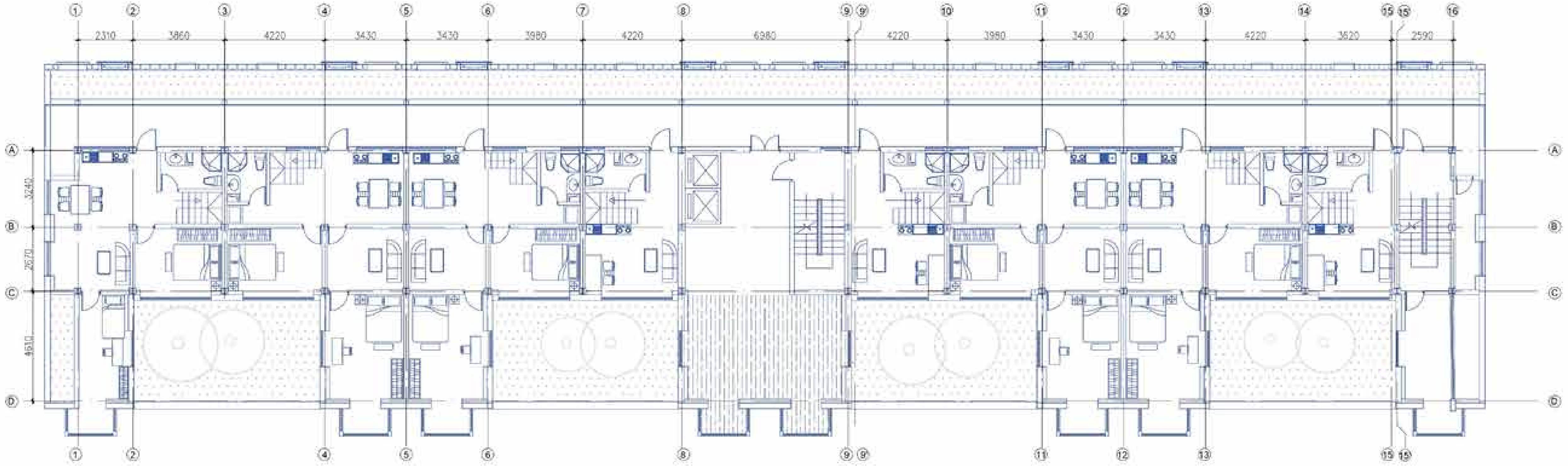


public activities can be hold on the roof floor, there has green roof for people walking freely. Also to respect the living habits of dewellers, we designed a public washing and drying space , this is also exists in Shikumen building.

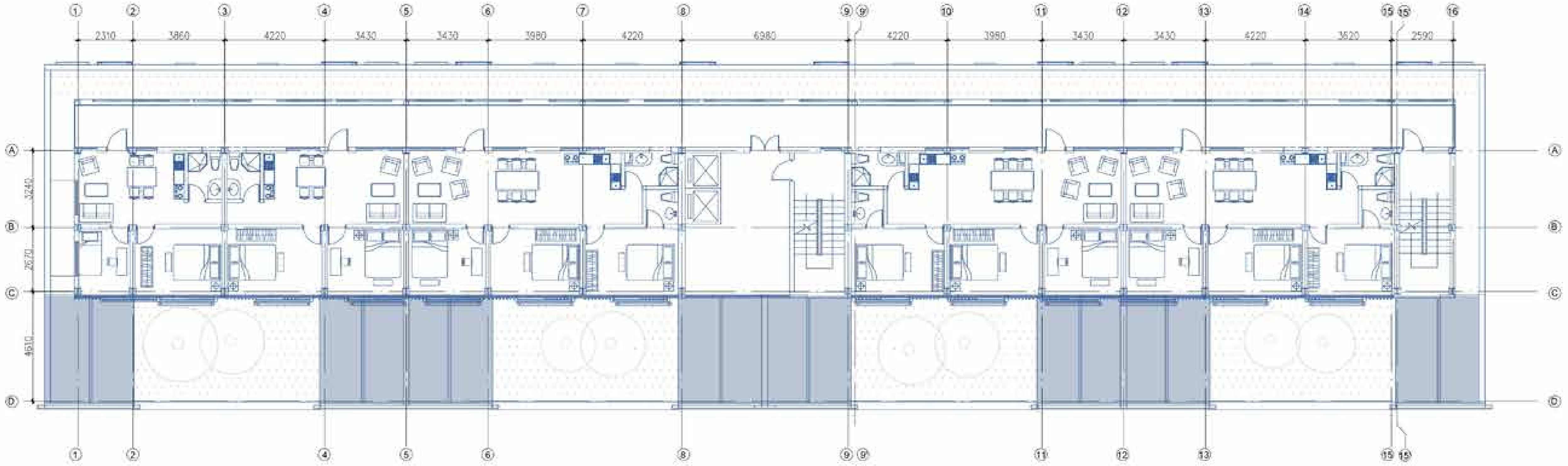
GROUND FLOOR PLAN
1:200



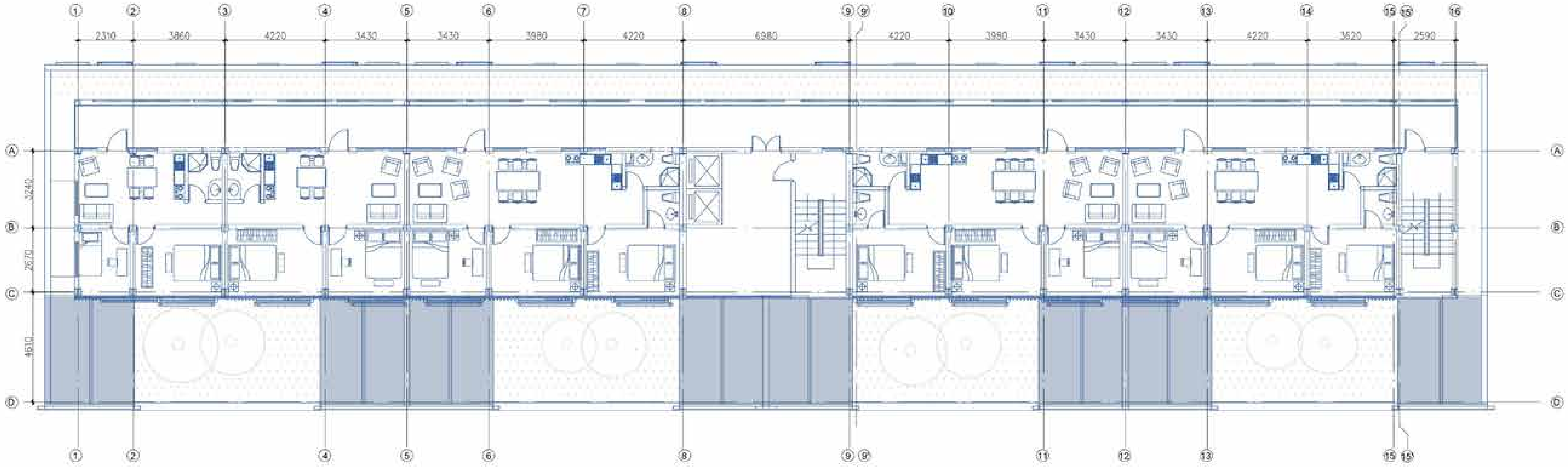
FIRST FLOOR PLAN
1:200



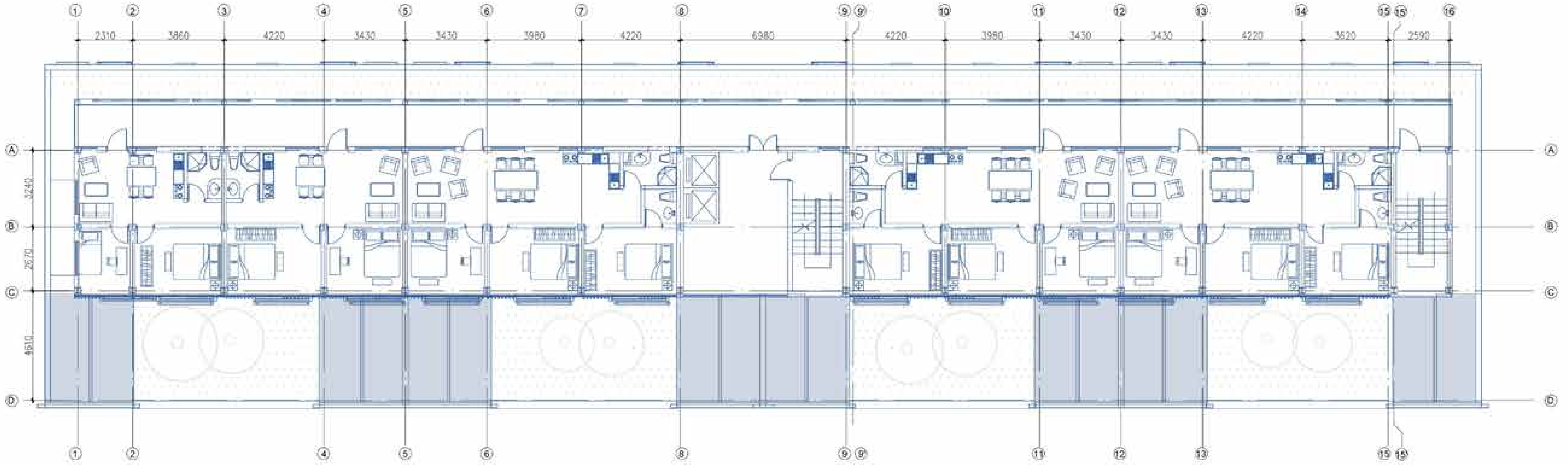
THIRD FLOOR PLAN
1:200



THIRD FLOOR PLAN
1:200



FOURTH FLOOR PLAN
1:200

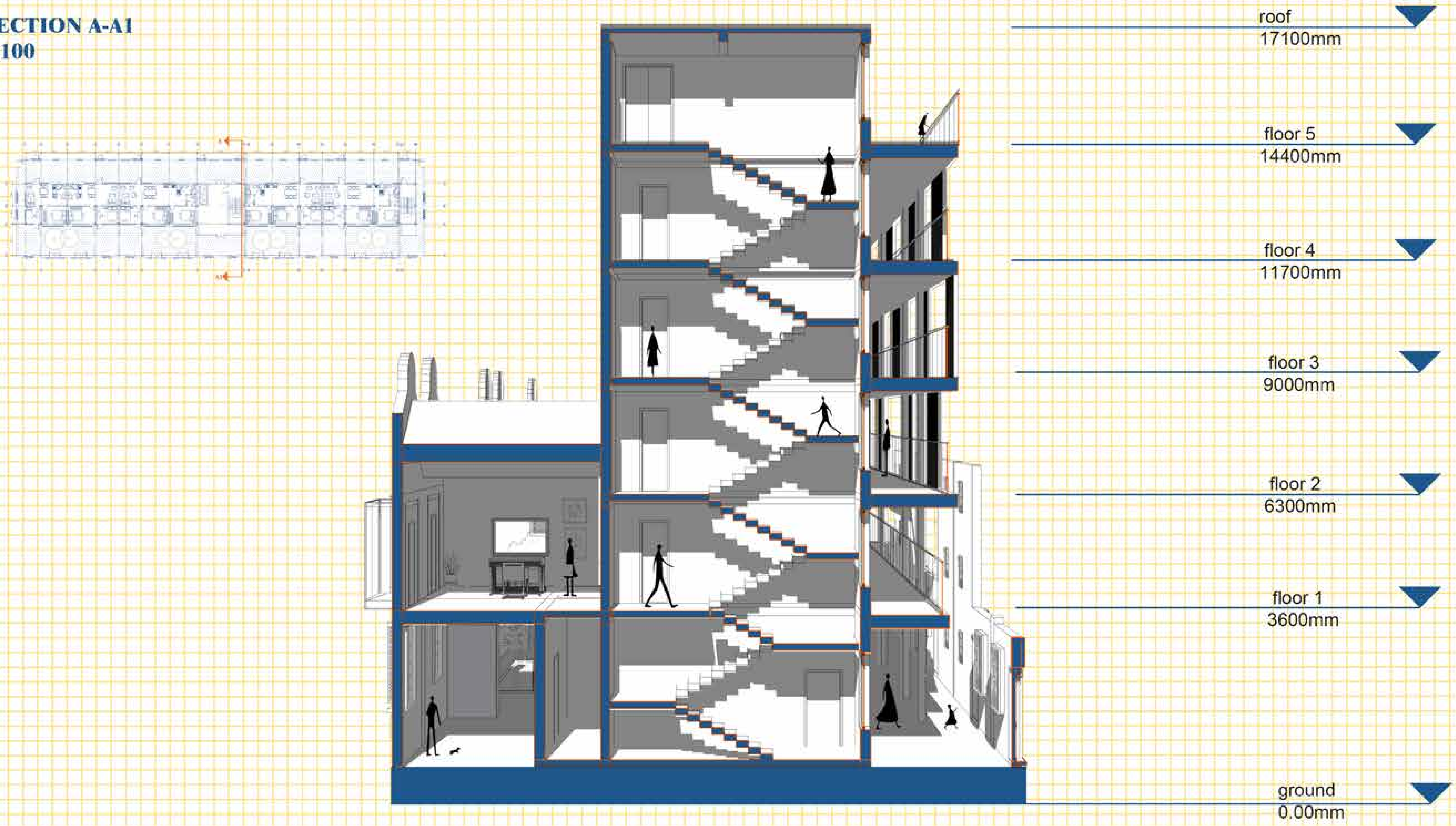


SOUTH FACADE ELEVATION
1:200

NORTH FACADE ELEVATION
1:200

WESTERN FACADE ELEVATION
1:200

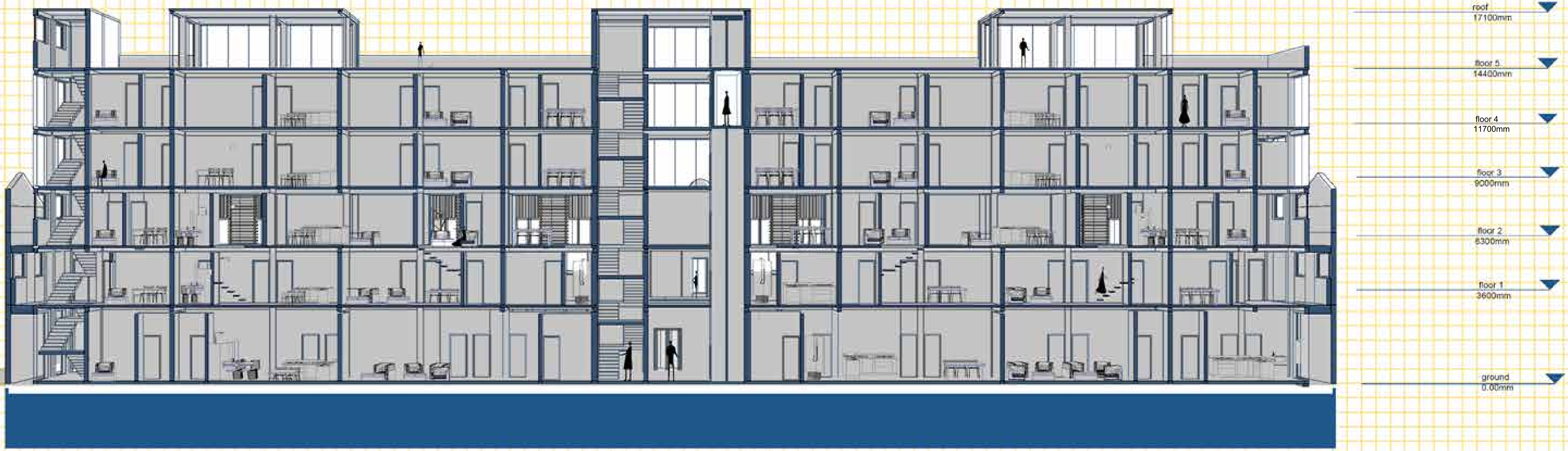
SECTION A-A1
1:100

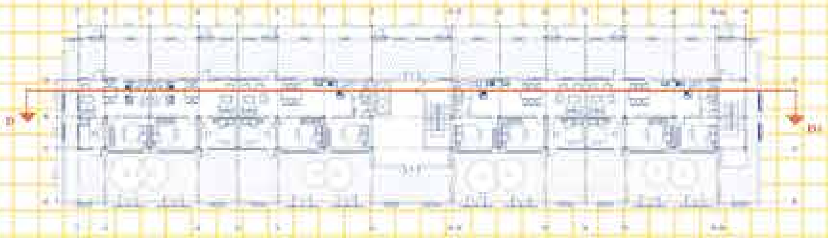


SECTION B-B1
1:100

SECTION C-C1
1:200

SECTION D-D1
1:200





MATERIAL

NEW OUTDOOR FINISHING

FIBER CEMENT PLASTER

THICKNESS 12.5mm
DENSITY 0.5-0.88 g/cm³

Material description:
It is a through-coloured facade material. Every panel is unique in its finish and its hue, characterized by a rough, slightly sanded surface that is superbly delicate to the touch. This finishing strongly emphasizes the raw texture of the core fibre cement material, creating a remarkable facade.

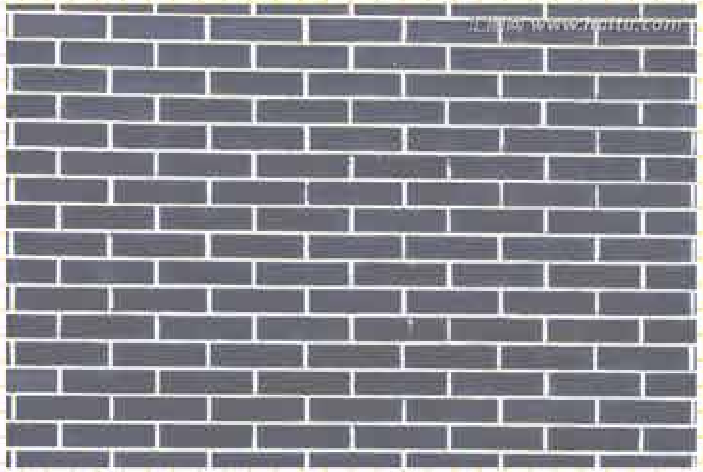
NEW INDOOR FINISHING

WOODEN PLASTER

THICKNESS 12.5mm
DENSITY 0.74 g/cm³

Material description:
- Anti-scratch
- 100% ressistant to moisture, which makes it easier to clean
-High resistance to noise

OLD OUTDOOR FINISHING

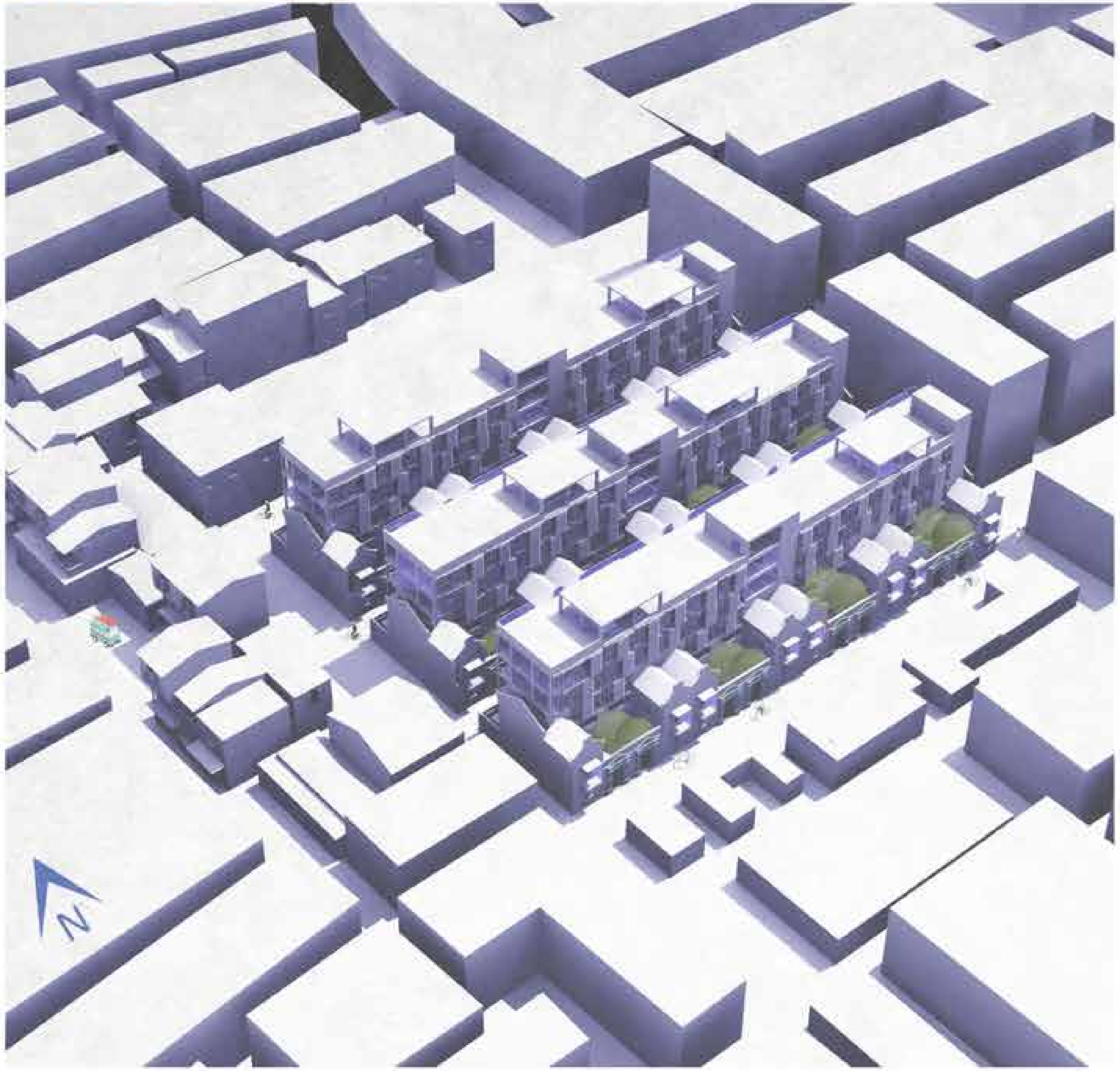


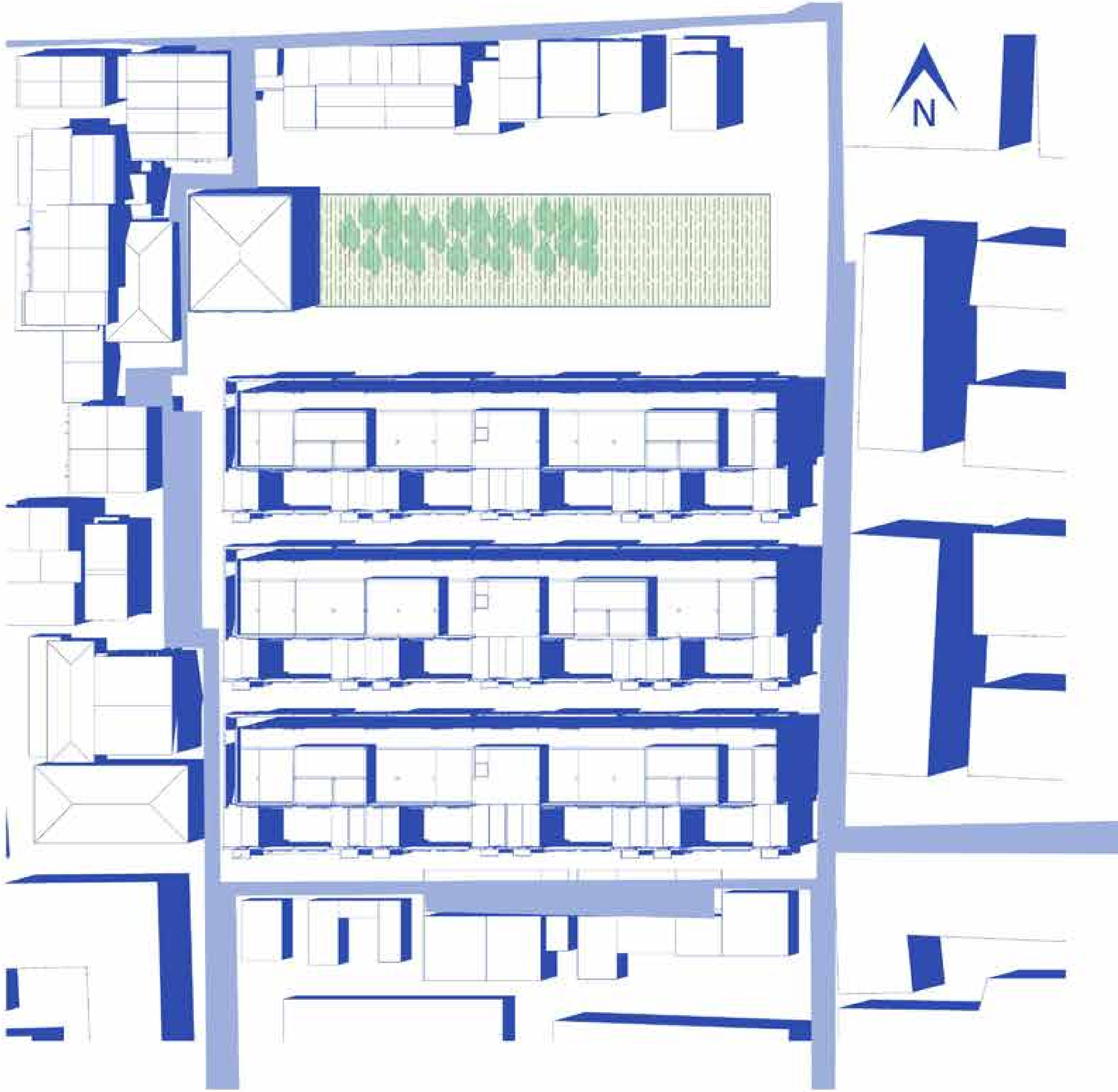
BLUE BRICKS

THICKNESS 240mm
DENSITY 2.5 g/cm³

Material description:
Blue bricks give people a sense of elegance, calmness, simplicity, and tranquility. Black and white gray green bricks launched a series of century-old green brick products, bas-relief, high-relief, and modern-style mechanism bricks. Mainly, exquisite patterns, allegorical meanings, novel design methods, blending with the essence of Chinese culture, can be tasted and collected, can be decorated and enjoyed, can carry the warmth and simplicity of life, not imported, not copied, it is the return of true civilization.

MASTER VIEW OF SITE



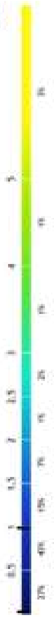


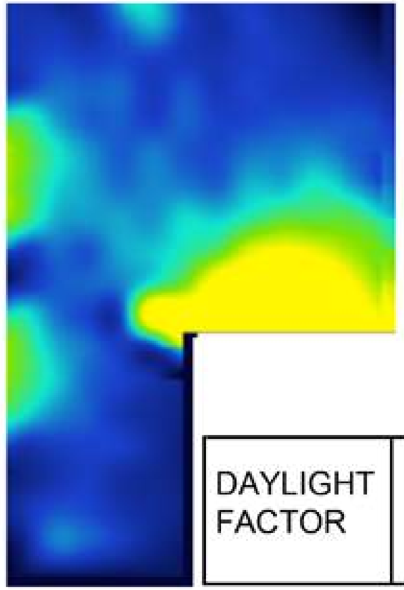
DAYLIGHT ANALYSIS

DUN SPACE GROUND FLOOR DURING SUMMER

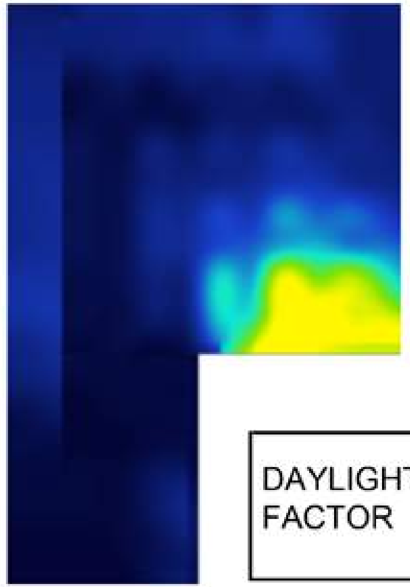
	OLD BUILDING	NEW BUILDING

DAYLIGHT FACTOR

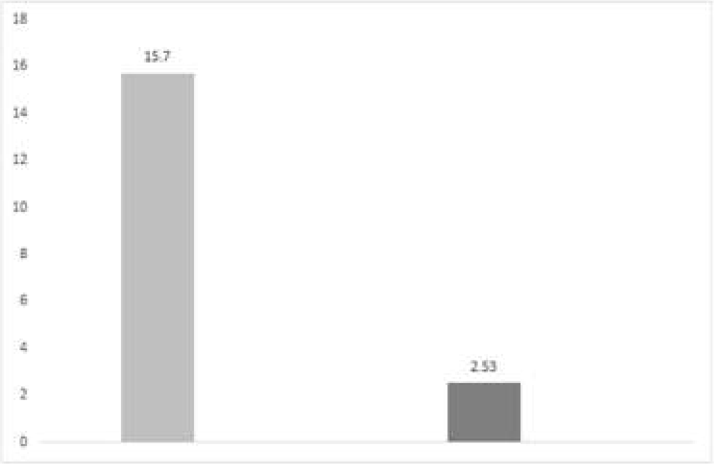




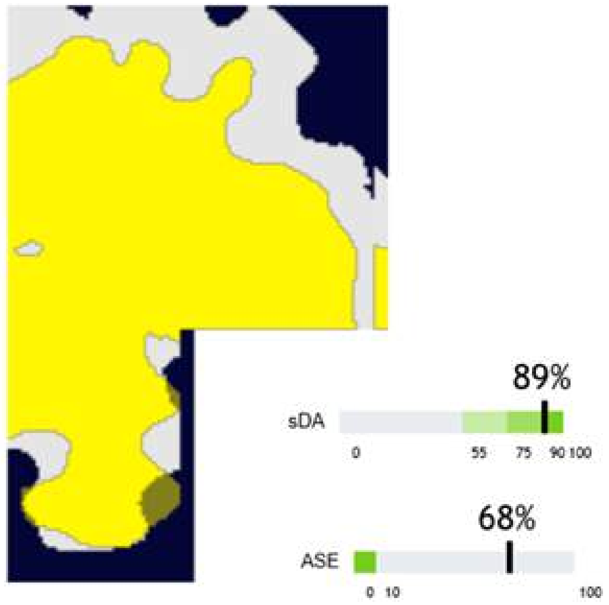
DAYLIGHT FACTOR	15.7

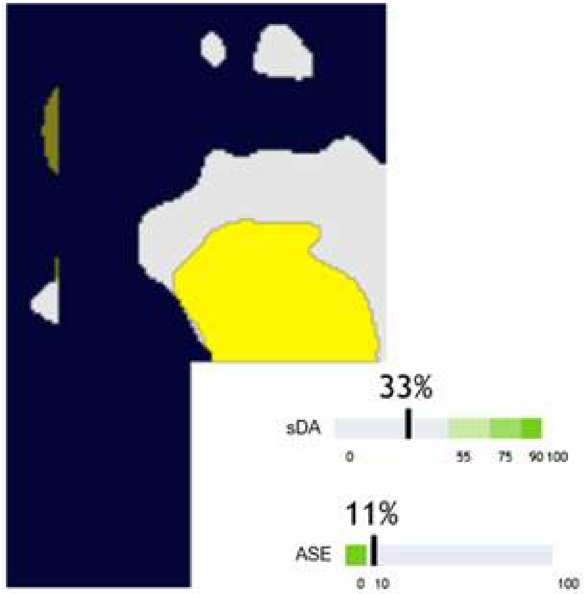


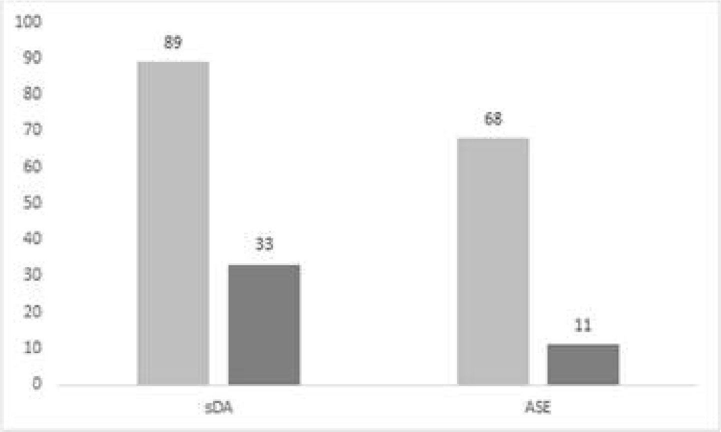
DAYLIGHT FACTOR	2.53



ASE&SDA



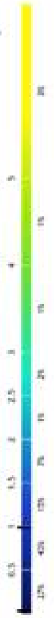


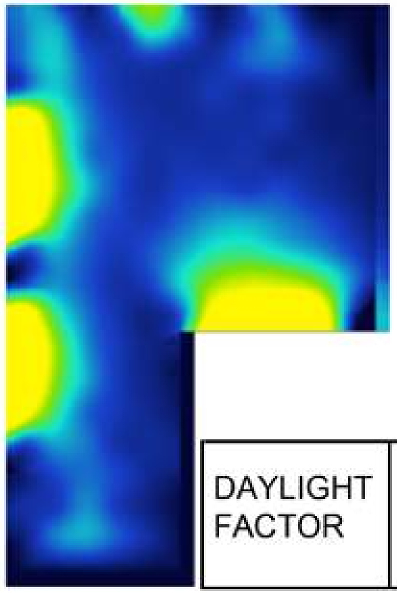


DUN SPACE GROUND FLOOR DURING WINTER

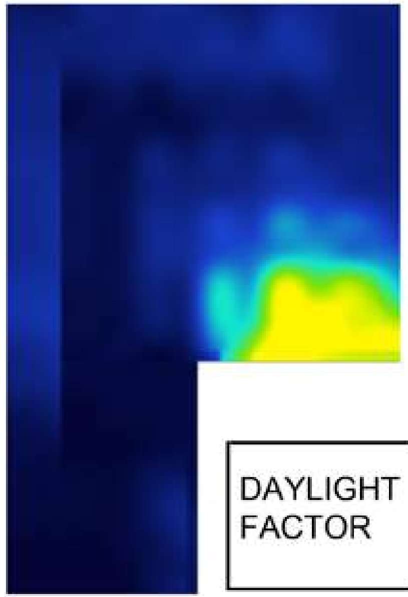
OLD BUILDING | NEW BUILDING

DAYLIGHT FACTOR

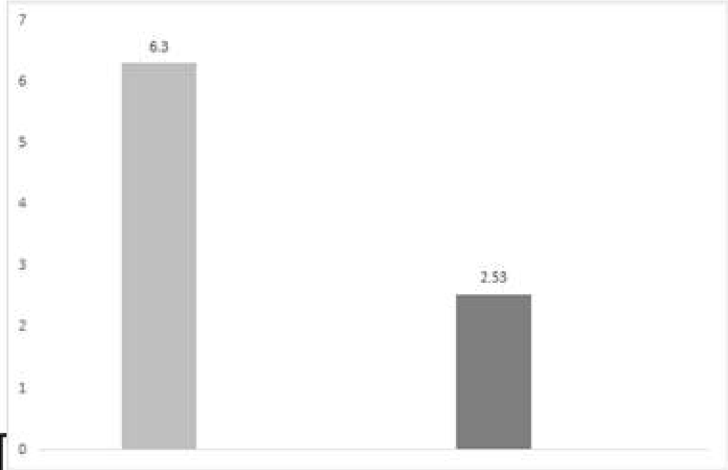




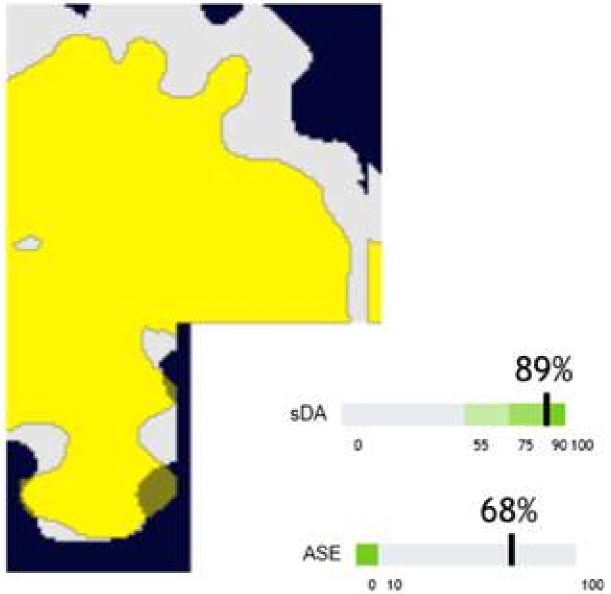
DAYLIGHT FACTOR	6.3

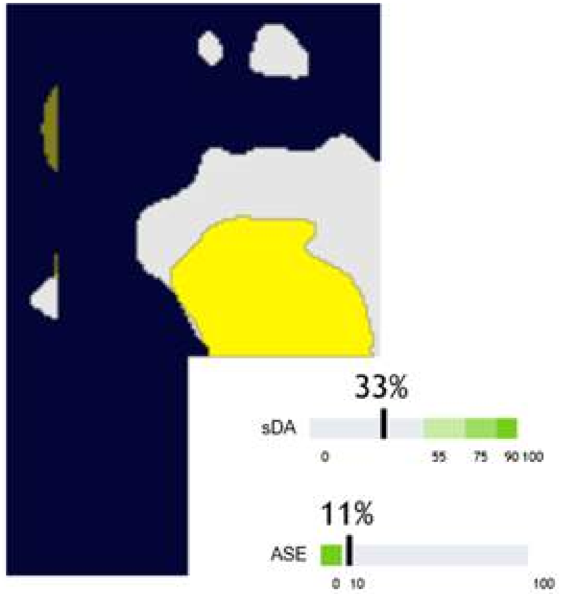


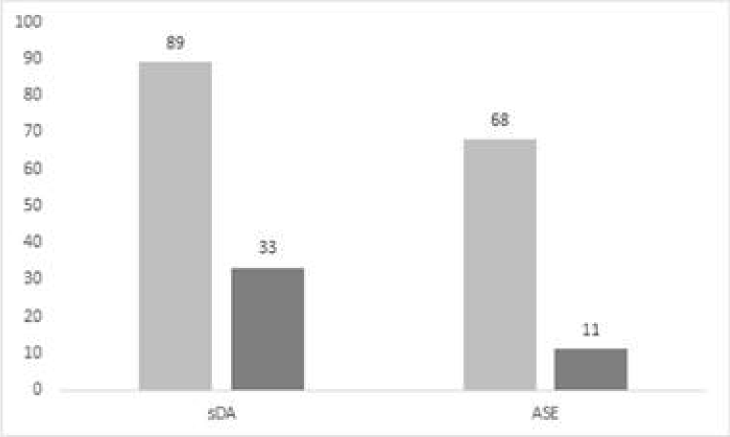
DAYLIGHT FACTOR	2.53



ASE&SDA







During winter on the ground floor,we compare 3 factors which are DF , ASE and sDA respetively.

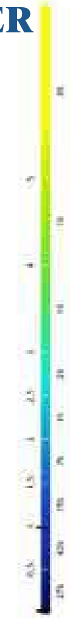
We find only old building DF change a little but ASE and sDA stay stll,also new building during both winter and summer.

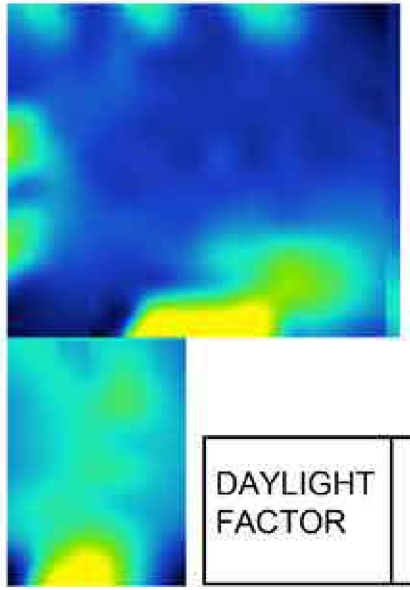
And we have a real high value of DF during summer of our old building.

DUN SPACE FIRST FLOOR DURING SUMMER

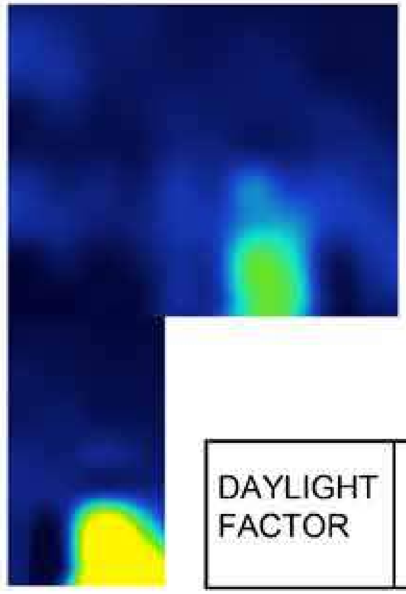
	OLD BUILDING	NEW BUILDING	

DAYLIGHT FACTOR

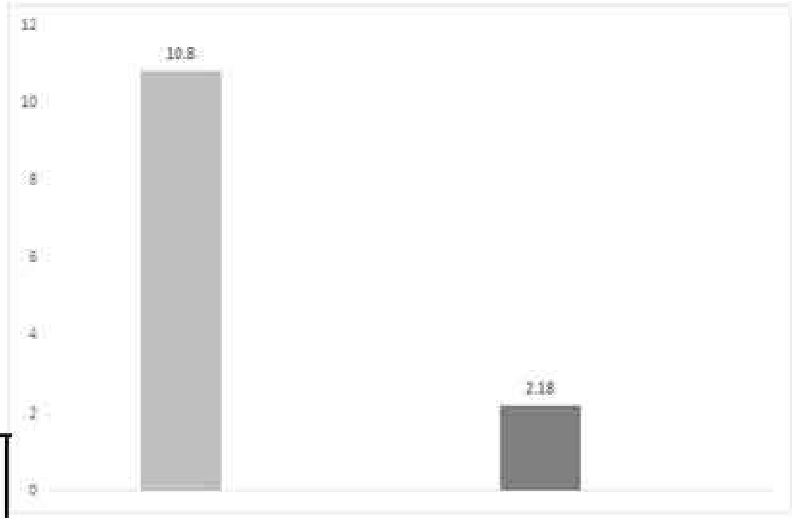




DAYLIGHT FACTOR	10.8



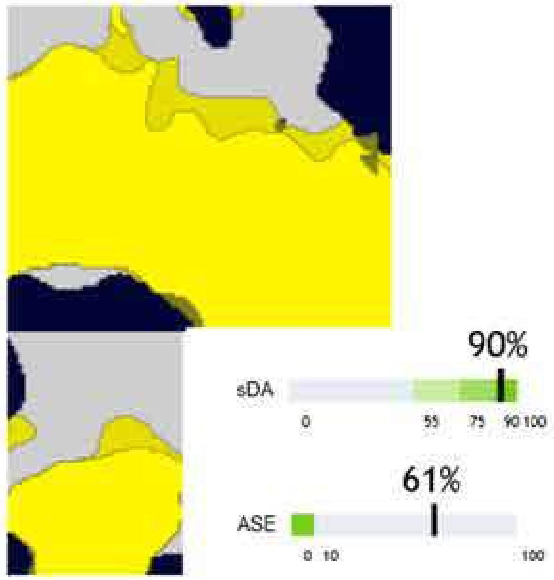
DAYLIGHT FACTOR	2.18

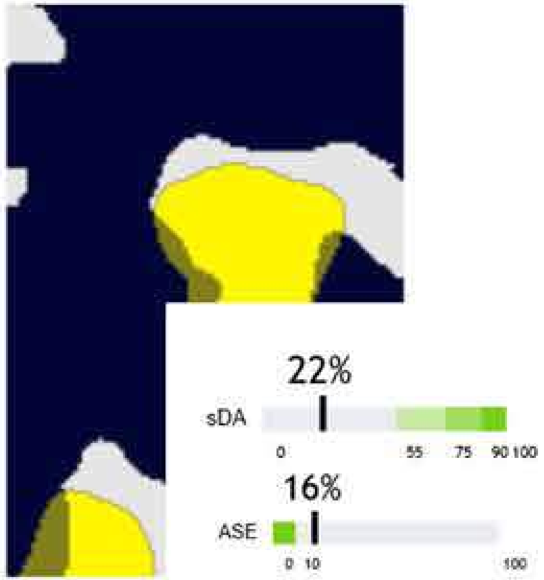


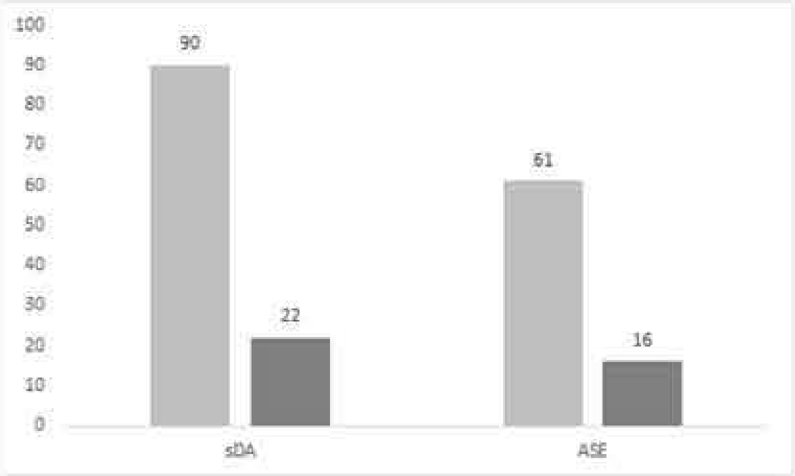
ASE&SDA

Overlit

Underlit



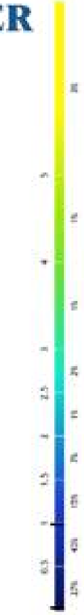


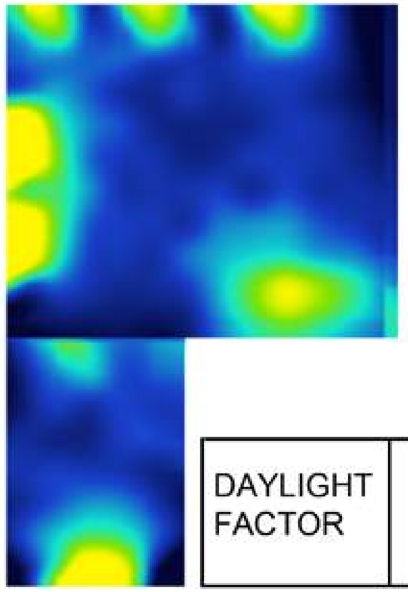


DUN SPACE
FIRST FLOOR
DURING WINTER

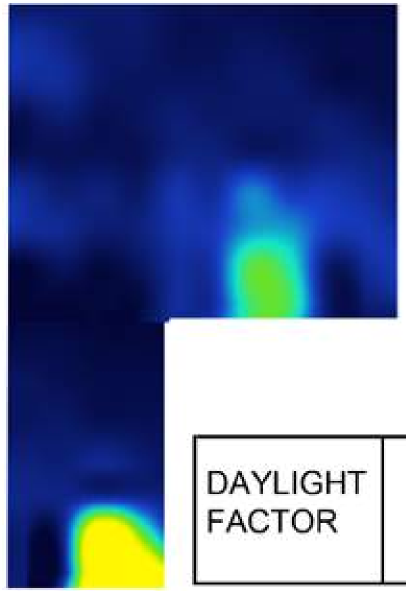
OLD BUILDING	NEW BUILDING

DAYLIGHT FACTOR

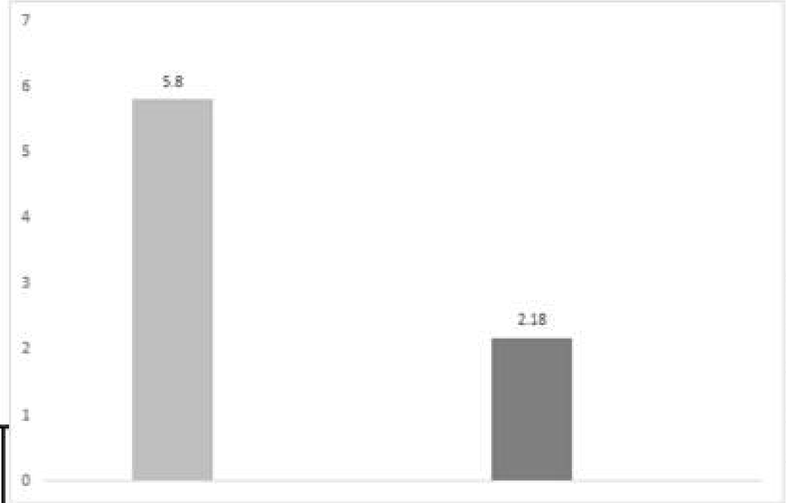




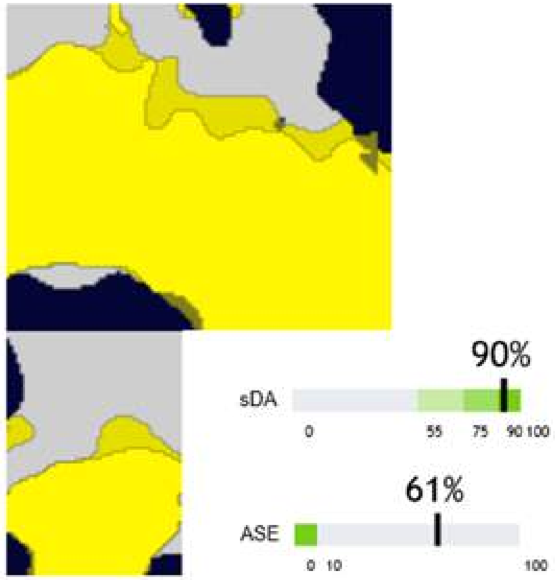
DAYLIGHT FACTOR	5.8

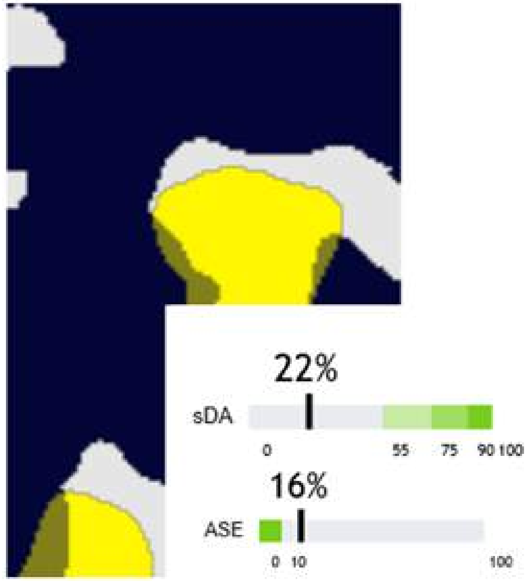


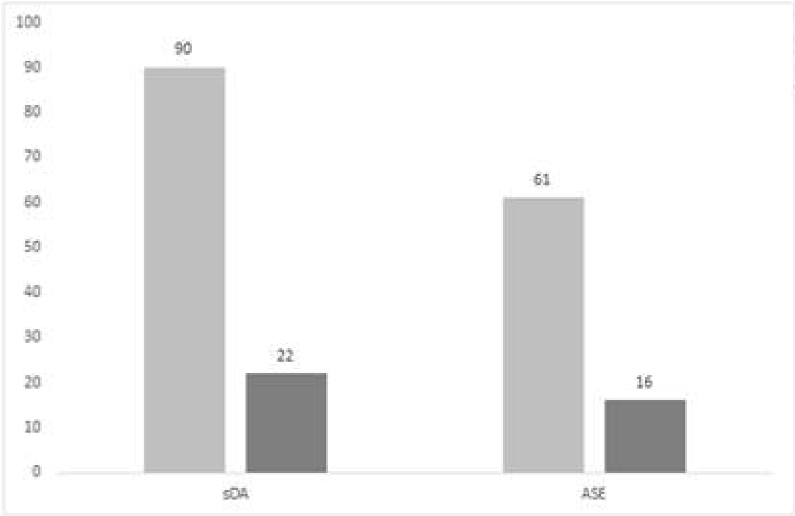
DAYLIGHT FACTOR	2.18



ASE&SDA



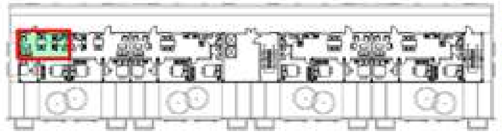




During winter on the first floor,we compare 3 factors which are DF , ASE and sDA respetively.

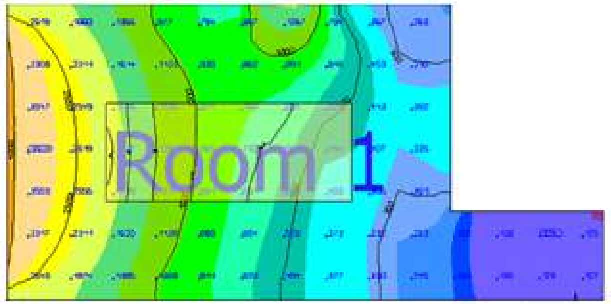
The first floor has a lower value in these 3 factors compared to ground floor.Also we find for the first floor the range of change of three factors is bigger compares new building with old building,

BUD SPACE DAYLIGH ANALYSIS UNDER SHADING (SITTING ROOM)

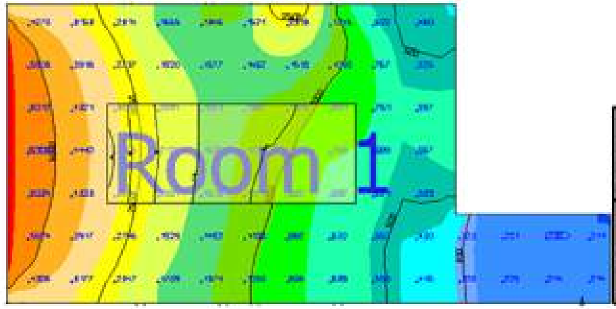


WINTER | SUMMER

NO SHADING



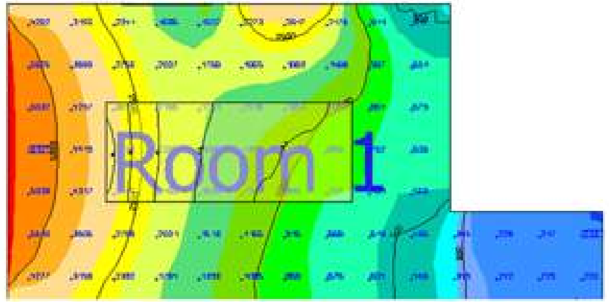
AVERAGE DF	7.401
AVERAGE ILLUMINANCE	1061 LX



AVERAGE DF	7.401
AVERAGE ILLUMINANCE	1798 LX

30% SHADING

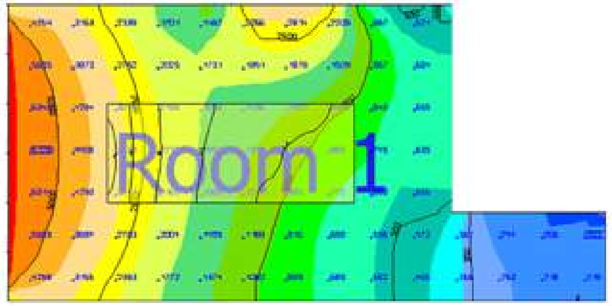
AVERAGE DF	7.795
AVERAGE ILLUMINANCE	1116 LX



AVERAGE DF	7.795
AVERAGE ILLUMINANCE	1892 LX

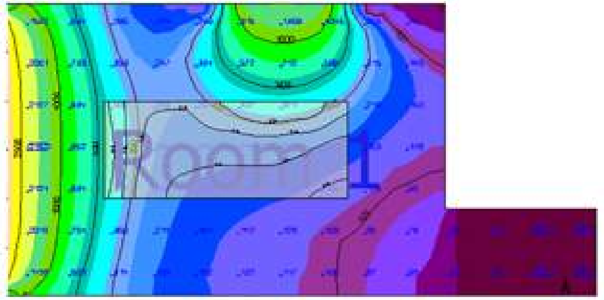
50% SHADING

AVERAGE DF	7.789
AVERAGE ILLUMINANCE	1114 LX

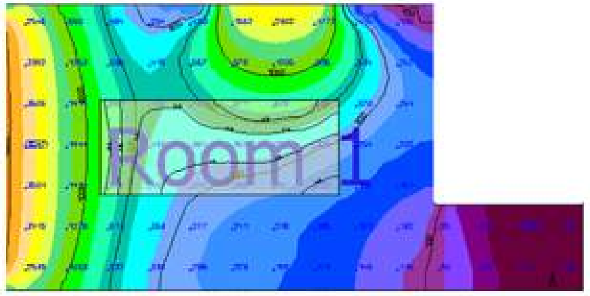


AVERAGE DF	7.789
AVERAGE ILLUMINANCE	1889 LX

70% SHADING

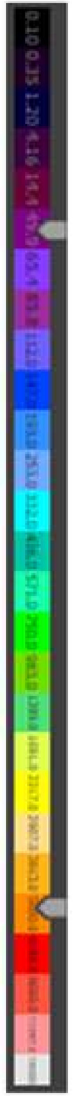


AVERAGE DF	1.941
AVERAGE ILLUMINANCE	444 LX



AVERAGE DF	1.941
AVERAGE ILLUMINANCE	753 LX

50 LUX



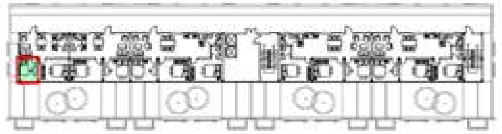
5000 LUX

We are analysing the daylightof upper floors over old building with curtain wall face south which we called BUD space.

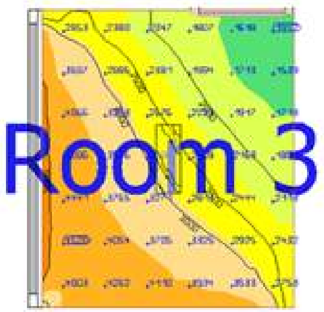
We choose one example as shown whose function is sitting room and we realize below 50% shading the factors we consider does not change a lot,and when shading reach 70% we will have a DF value 1.94 which did not satisfy our goal over 2 so our strategy in shading is lower than 70% shading.

BUD SPACE DAYLIGH ANALYSIS UNDER SHADING (FIRST BEDROOM)

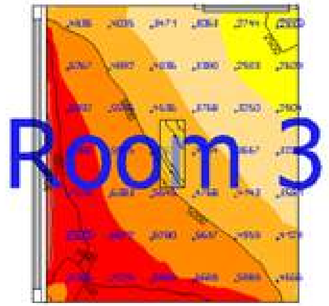
WINTER | **SUMMER**



NO SHADING

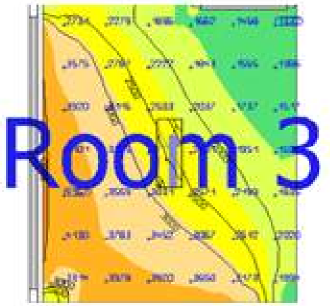


AVERAGE DF	21.485
AVERAGE ILLUMINANCE	2976 LX

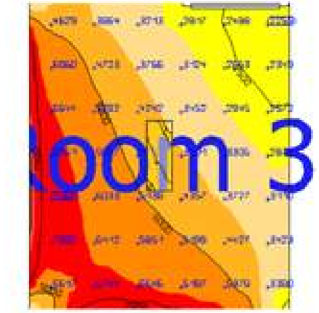


AVERAGE DF	7.401
AVERAGE ILLUMINANCE	1798 LX

30% SHADING

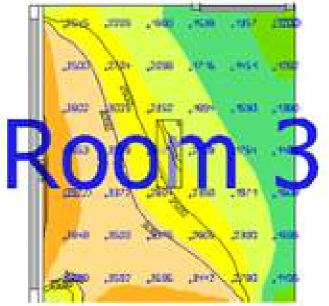


AVERAGE DF	19.786
AVERAGE ILLUMINANCE	2734 LX

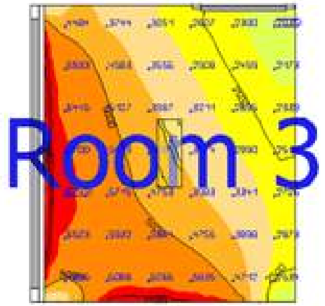


AVERAGE DF	19.786
AVERAGE ILLUMINANCE	4635 LX

50% SHADING

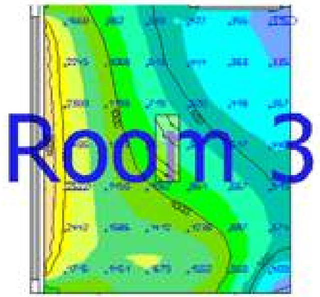


AVERAGE DF	18.422
AVERAGE ILLUMINANCE	2531 LX

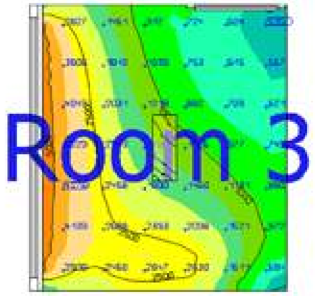


AVERAGE DF	18.422
AVERAGE ILLUMINANCE	4291 LX

70% SHADING

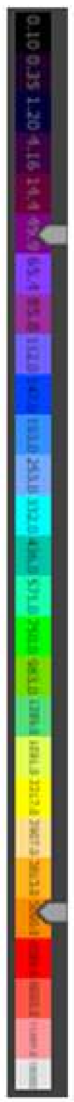


AVERAGE DF	5.553
AVERAGE ILLUMINANCE	1072 LX



AVERAGE DF	5.553
AVERAGE ILLUMINANCE	1817 LX

50 LUX

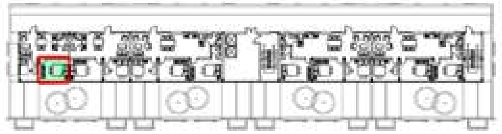


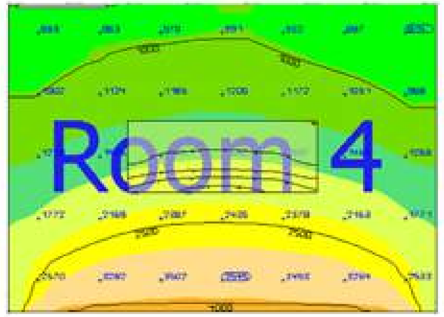
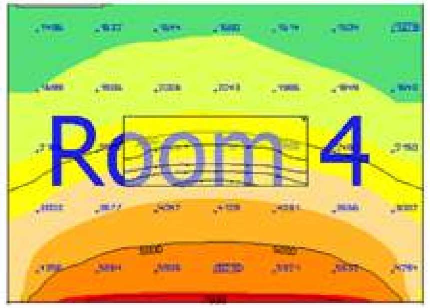
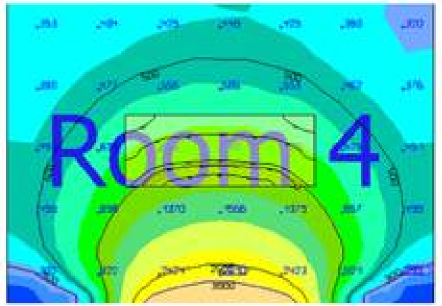
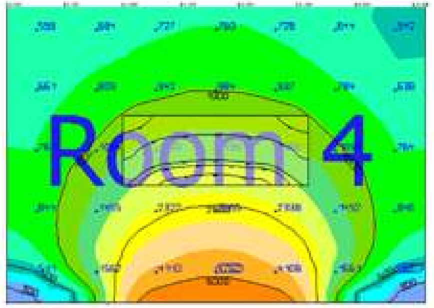
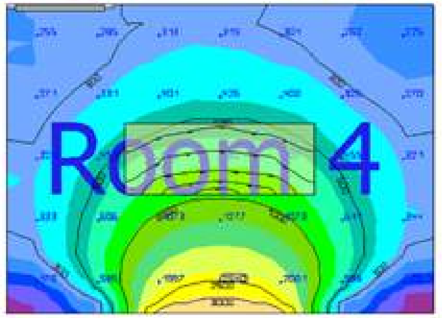
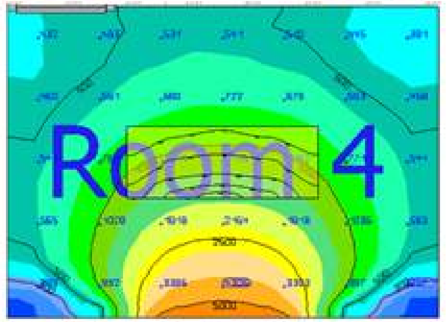
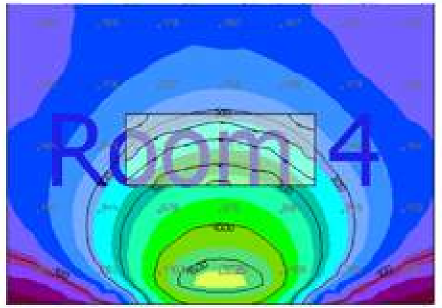
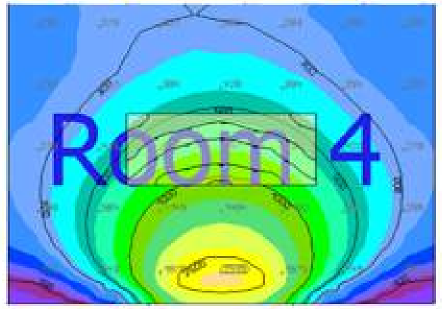
5000 LUX

We are analysing the daylightof upper floors over old building with curtain wall face south which we called BUD space.

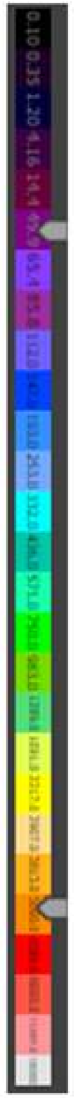
This time choose one bedroom and people usually have a high standard for living space so under 70% shading situation the DF reach 5.553 will satisfy the requirements.

BUD SPACE DAYLIGH ANALYSIS UNDER SHADING (SECOND BEDROOM)



	WINTER			SUMMER		
NO SHADING		AVERAGE DF: 12.075 AVERAGE ILLUMINANCE: 1776 LX			AVERAGE DF: 12.875 AVERAGE ILLUMINANCE: 3010 LX	
30% SHADING		AVERAGE DF: 6.67 AVERAGE ILLUMINANCE: 814 LX			AVERAGE DF: 6.67 AVERAGE ILLUMINANCE: 1379 LX	
50% SHADING		AVERAGE DF: 5.018 AVERAGE ILLUMINANCE: 615 LX			AVERAGE DF: 5.018 AVERAGE ILLUMINANCE: 1042 LX	
70% SHADING		AVERAGE DF: 2.999 AVERAGE ILLUMINANCE: 339 LX			AVERAGE DF: 2.999 AVERAGE ILLUMINANCE: 574 LX	

50 LUX



5000 LUX

We are analysing the daylightof upper floors over old building with curtain wall face south which we called BUD space.

This time choose one bedroom and people usually have a high standard for living space so under 70% shading situation the DF reach 2.999 will satisfy the requirements.

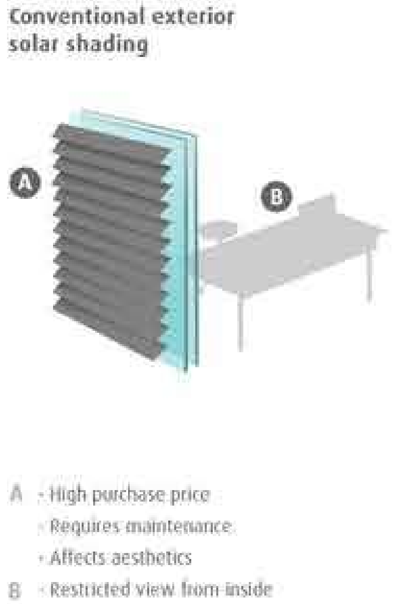
SHADING

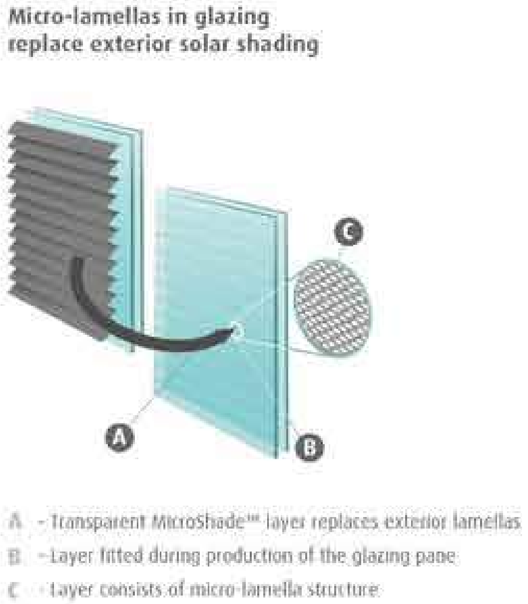
SUNSHADING DESCRIPTION	BENEFITS AND LIMITATIONS	
Integrated or 'built in' sunshading The sunshading is usually integrated into the design of the building such as an eave, overhang or balcony which cannot be easily removed and is considered within the overall design of the building.	• Moderately to very effective • South: Ideal if designed at 45% rule • East/West: Will have some impact but is not optimal	
Fixed horizontal projection The sunshading is commonly fixed above the glazing to the building's facade. It will effectively shade the glazing during summer and allow for the sun topenetrate through the building envelope in winter.	• Moderately to very effective • South: Ideal if designed to 45% rule • East/West: Will have some impact but is not sufficient	
Fixed horizontal battens Timber, aluminium or other material battens are placed at carefully considered spacings across the glazing and fixed to the façade. This can be very effective if designed to the 45% rule for the battens and spacing.	• Moderately to very effective • Can prevent overlooking • Reduce daylight penetration • South: Ideal if designed to 45% rule • East/West: Will have some impact but is not sufficient	
Adjustable devices Typically roller blinds, sliding screens or shutters which commonly are constructed in timber, aluminium or shading fabric and are either integrated into the building fabric or are fixed to the external façade. These can be manually operated or automated and allow for the occupant to easily control their thermal comfort.	• Effective • South: Closing shutters on summer days to reduce heat gains and having shutters open on winter days to capturewanted solar energy • East/West: As per north orientation, it relies on occupant awareness to function as intended	
Fixed vertical fins or battens Vertical elements cover the glazing and are fixed to the building's facade. These elements typically provide shading for one direction. Installed on west facing glazing, they block most western sun. However, spacings and angles are important as protection will be at its least when the sun is parallel to the device's angle.	• Moderately to very effective • Can prevent overlooking • South: Moderatly effective as is will not protect glazing at optimal times. Midday sun will strike the glass which is good in winter but undesirable in summer • East/West: Very effective	

Environmentally Sustainable Solar Shading in Facade Glazing

Freedom in Design

As standard, MicroShade comes in 140 mm wide strips for horizontal installation in the glazing pane, but specialised versions designed for vertical fitting can also be supplied. In this way, the MicroShade™ strip can be positioned as desired in the glazing pane. The strongest effect is achieved by completely covering the glazing pane, but MicroShade offers full flexibility and can be limited toone or more smaller areas in the same glazing unit if needed.





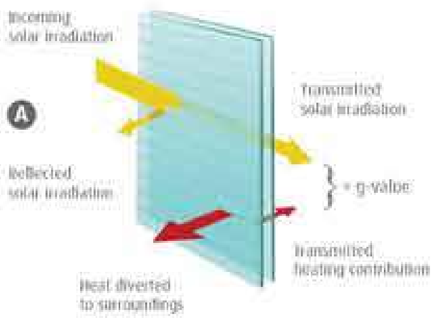
SHADING

Guideline values/ratings	MicroShade™ type MS-A	Sun-reducing glass **3)**
U-value rating (W/m²K)	1.1 / 1.1 **1)**	1.0 / 1.1 **4)**
Light transmittance **2)**	0.49	0.66
g-value (summer, average)	0.12	0.32
g-value (autumn, average)	0.27	0.36
g-value (winter, average)	0.33	0.37
g-value (spring, average)	0.18	0.34

1) Krypton/argon gas fills. **2)** Transmittance normally stipulated on surface, light source D65, cf. EN410.
3) Reference sun-reducing glass with g_0-value of 0.38, cf. EN410. **4)** Glazing unit selected as 6-15-4, including gas fill and energy glass.

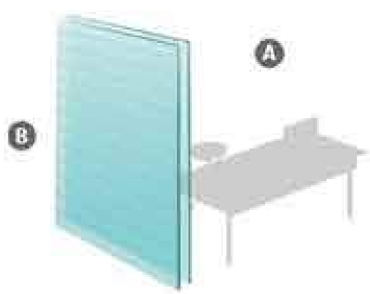
The shading principle in MicroShade has been designed accordingto the sun's pattern of movement during the day and year – the higher the sun, the better the shading effect.
The shading effect can be expressed as the g-value of the glazing pane. The lower the g-value, the stronger the shading effect. A standard low-energy glazing pane has a g-value of 0.76, while special sun-reducing panes can have values as low as 0.24. In comparison, the MicroShade g-value can be as low as 0.10, corresponding to maximum shading.
A significant benefit of MicroShade is that direct solar irradiation is heavily reduced or, in some cases, completely blocked. Compared to, for example, coated sun-reducing glass or solar film, this noticeably increases comfort near the facade.
With MicroShade a more even temperature distribution can be achieved throughout the room and extra cooling of areas near the windows can be avoided.

Provides effective shading when most needed



A - MicroShade™ reflects solar and heat irradiation
- Most shading when the sun is high in the sky (summer)
- Least shading when the sun is low – more heating contribution (winter)

Facade with MicroShade™



A - Comfortable temperature and daylight conditions indoors
- Unrestricted view

B - Aesthetic facade free of exterior solar shading
- No maintenance
- Easy cleaning of glass

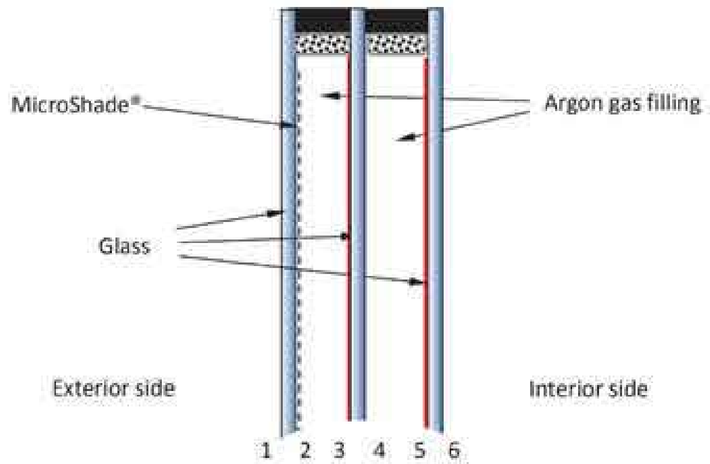
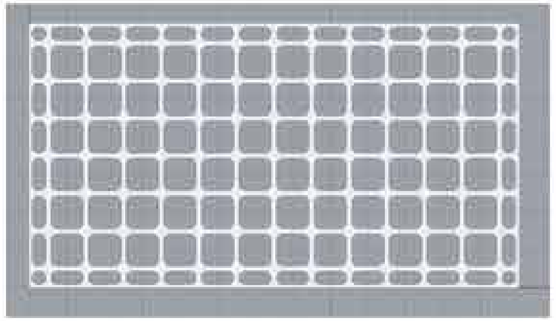
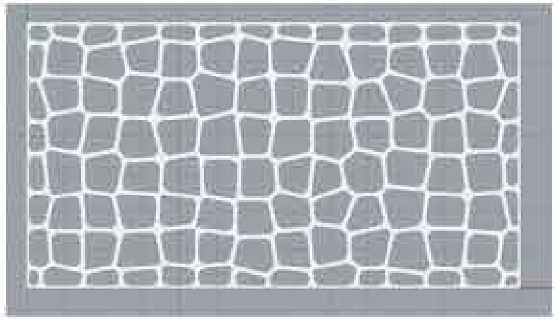
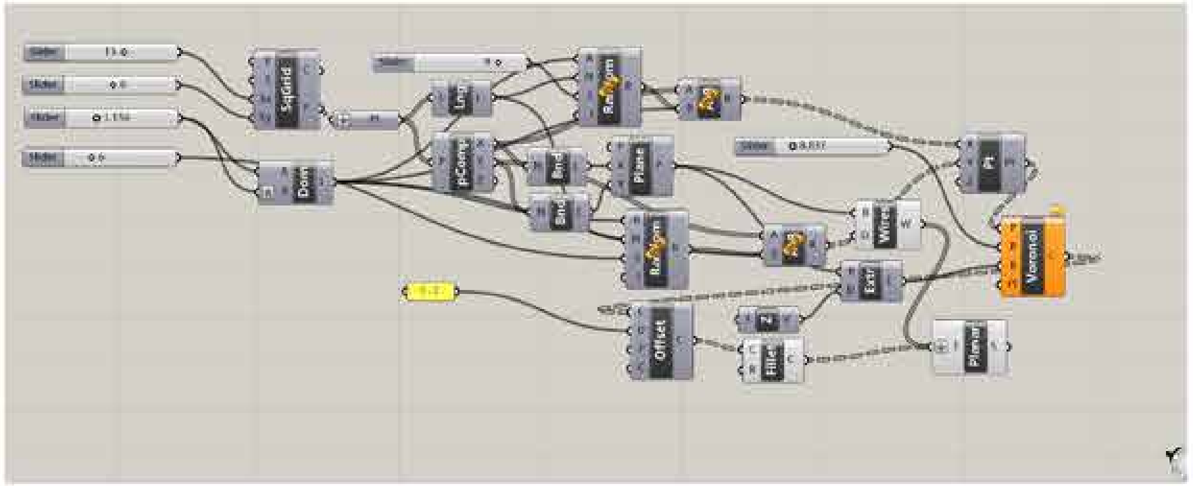


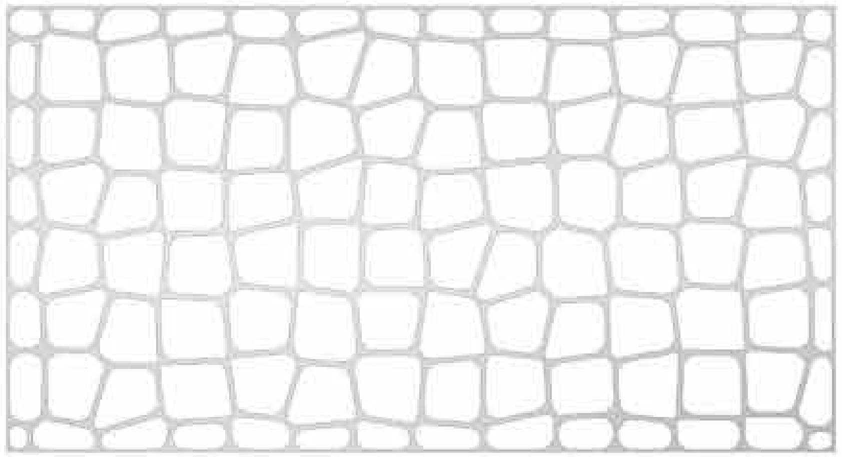
Figure 1. A glazing composition of a 3-layer LowE glazing with MicroShade®. The numbers indicate the indexing of the glazing surfaces.

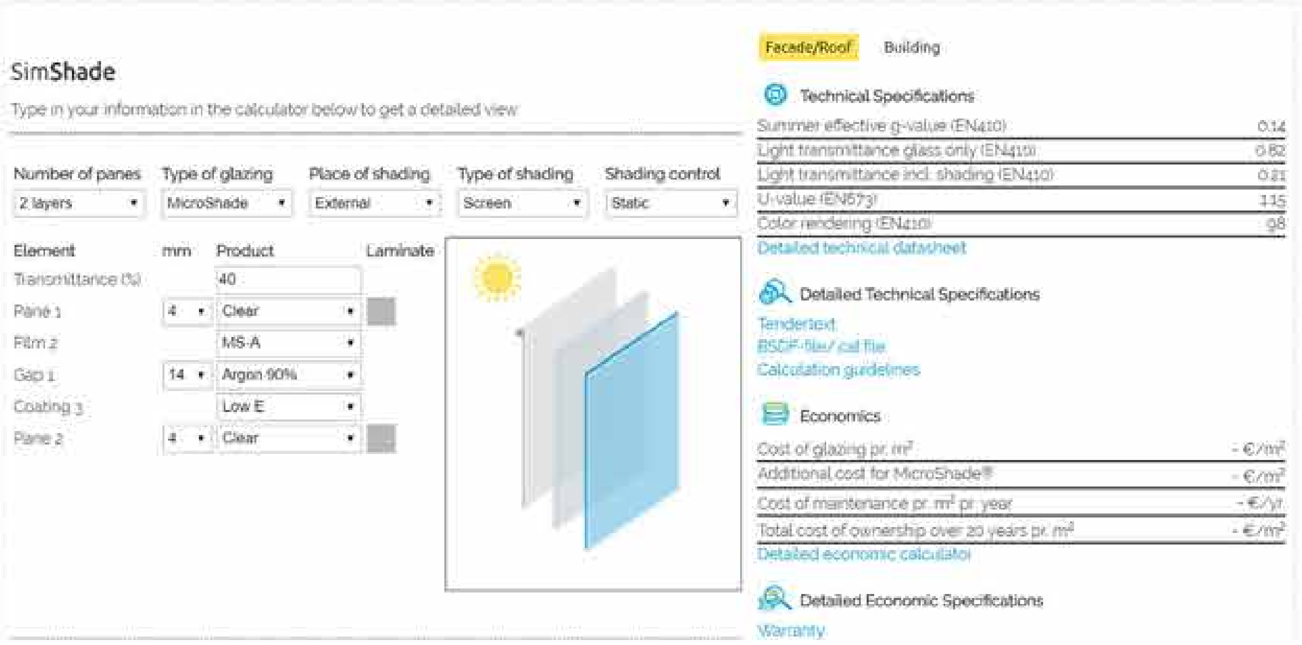
SHADING







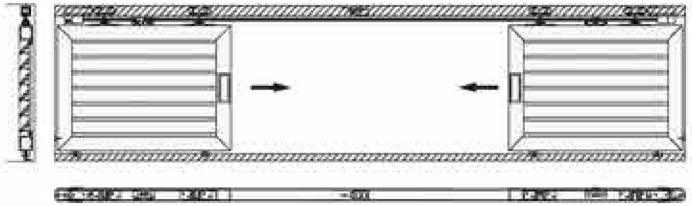



SimShade
Type in your information in the calculator below to get a detailed view
Number of panes
2 layers
Type of glazing
MicroShade
Place of shading
External
Type of shading
Screen
Shading control
Static
Element
mm
Product
Laminate
Transmittance (%)
40
Pane 1
4
Clear
Film 2
MS-A
Gap 1
14
Argon 90%
Coating 3
Low E
Pane 2
4
Clear
Facade/Roof
Building
Technical Specifications
Summer effective g-value (EN410) 0.14
Light transmittance glass only (EN410) 0.82
Light transmittance incl. shading (EN410) 0.21
U-value (EN673) 1.15
Color rendering (EN410) 98
Detailed technical datasheet
Detailed Technical Specifications
Tendertext
BSDF-file/ cal file
Calculation guidelines
Economics
Cost of glazing pr. m² - €/m²
Additional cost for MicroShade® - €/m²
Cost of maintenance pr. m² pr. year - €/yr
Total cost of ownership over 20 years pr. m² - €/m²
Detailed economic calculator
Detailed Economic Specifications
Warranty

COMBINED SHUTTERS

Sliding shutters

1. INNOWOOD Louvre Blade
2. Aluminium SHS Frame
3. Linkage Bar



SOL'ART OPERABLE LOUVRE - MOTORISED

SOL'ART Motorised Louvre Systems allow the blades to be adjusted automatically, either via: A simple flick of a switch, or The push of a button on remote control.
The blades can also be fully automated via integration into a building façade management system to maintain light and shade levels based on predetermined programs.

APPLICATIONS & BENEFITS

APPLICATIONS:

- Residential Applications
- Commercial Applications
- Health / Aged Care Facilities
- Educational Institutions
- Hospitality Sector
- Retail & Shopping Centres-

BENEFITS:

- Provide shade during the day while allowing cross breezes to flow through.
- Can be fully closed at night for privacy, comfort and security.
- SOL' ART operable Louvre Systems allow you to tilt the blades at the appropriate angle to regulate natural sunlight.
- SOL' ART Louvre Systems have been proven to be a sound investment as they reduce the need to use air-conditioning resulting in ongoing energy cost savings.
- SOL' ART Motorised Opening Roof Systems are so easy to operate – just the touch of a button will improve the functionality and comfort of your environment.

Fixed Shutters

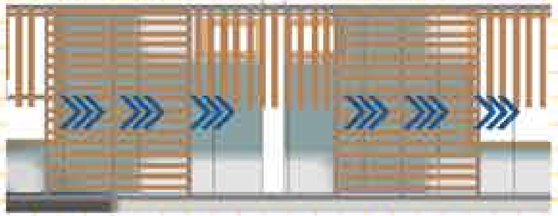
1. INNOWOOD Louvre Blade
2. Aluminium Flatbar
3. Aluminium SHS Frame

PROFILES			
PRODUCT CODES	LB09113	LB15535	LB30060
COVERAGE	91mm	150mm	300mm
HORIZONTAL SPAN	1200mm	1800mm	3000mm
VERTICAL SPAN	1800mm	2700mm	3850mm
INNOVATIVE COLOURS	Available	Available	Available
PREMIUM COLOURS	Not Available	Not Available	Available

PART OF SOUTHERN FACADE ELEVATION

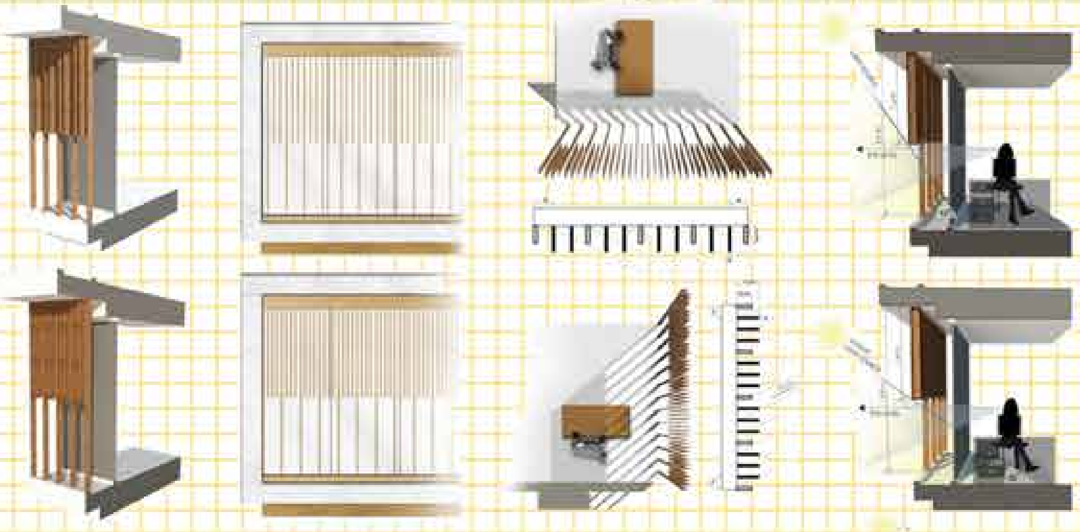
BEDROOM PART

sliding shading



LIVING ROOM PART

fixed shading



ENERGY ANALYSIS

BASELINE ANALYSIS

The table below show the climate zone number for a wide variety of international locations.Additional information on internal climatic zones can be found in ANSI/ASHAE/IESNA standard 90.1-2007 Normative Appendix B-Building Envelope Climate Criteria.The information below in from Tables B-2,B-3 and B-4 in that appendix.

International Climate Zone Definitions

Zone Number	Zone Name	Thermal Criteria (I-P Units)	Thermal Criteria (SI Units)
1A and 1B	Very Hot –Humid (1A) Dry (1B)	9000 < CDD50°F	5000 < CDD10°C
2A and 2B	Hot-Humid (2A) Dry (2B)	6300 < CDD50°F ≤ 9000	3500 < CDD10°C ≤ 5000
3A and 3B	Warm – Humid (3A) Dry (3B)	4500 < CDD50°F ≤ 6300	2500 < CDD10°C < 3500
3C	Warm – Marine (3C)	CDD50°F ≤ 4500 AND HDD65°F ≤ 3600	CDD10°C ≤ 2500 AND HDD18°C ≤ 2000
4A and 4B	Mixed-Humid (4A) Dry (4B)	CDD50°F ≤ 4500 AND 3600 < HDD65°F ≤ 5400	CDD10°C ≤ 2500 AND HDD18°C ≤ 3000
4C	Mixed – Marine (4C)	3600 < HDD65°F ≤ 5400	2000 < HDD18°C ≤ 3000
5A, 5B, and 5C	Cool-Humid (5A) Dry (5B) Marine (5C)	5400 < HDD65°F ≤ 7200	3000 < HDD18°C ≤ 4000
6A and 6B	Cold – Humid (6A) Dry (6B)	7200 < HDD65°F ≤ 9000	4000 < HDD18°C ≤ 5000
7	Very Cold	9000 < HDD65°F ≤ 12600	5000 < HDD18°C ≤ 7000
8	Subarctic	12600 < HDD65°F	7000 < HDD18°C

Marine (C) definition – Locations meeting all four of the following criteria:

1. Mean temperature of coldest month between 27°F (-3°C) and 65°F (18°C)
2. Warmest month mean < 72°F (22°C)
3. At least four months with mean temperatures over 50°F (10°C)
4. Dry season in summer. The month with the heaviest precipitation in the cold season has at least three times as much precipitation as the month with the least precipitation in the rest of the year. The cold season is October through March in the Northern Hemisphere and April through September in the Southern Hemisphere.

Dry (B) definition – Locations meeting the following criteria:

Not marine and

$P < 0.44 \times (T - 19.5)$ [I-P units]

$P < 2.0 \times (T + 7)$ [SI units]

Where:

P = annual precipitation in inches (cm) and

T = annual mean temperature in °F (°C).

Moist (A) definition – Locations that are not marine and not dry.

International Climate Zones

Country / City	Zone
Argentina	
Buenos Aires/Ezeiza	3
Cordoba	3
Tucuman/Pozo	2
Australia	
Adelaide (SA)	4
Alice Springs (NT)	2
Brisbane (AL)	2
Darwin Airport (NT)	1
Perth/Guildford (WA)	3
Sydney/KSmith (NSW)	3
Azores (Terceira)	
Lajes	3
Bahamas	
Nassau	1
Belgium	
Brussels Airport	5
Bermuda	
St George/Kindley	2
Bolivia	
La Paz/El Alto	5
Brazil	
Belem	1
Brasilia	2
Fortaleza	1
Porto Alegre	2
Recife/Curado	1
Rio de Janeiro	1
Salvador/Ondina	1
Sao Paulo	2
Bulgaria	
Sofia	5
Chili	
Concepcion	4
Punta Arenas/Chabunco	6
Santiago/Pedahuel	4
China	
Shanghai	3
Cuba	
Guantanamo Bay NAS (Ote)	1
Cyprus	
Akrotiri	3
Larnaca	3
Paphos	3

Country / City	Zone
Czech Republic	
Prague/Libus	
Dominican Republic	
Santo Domingo	
Egypt	
Cairo	
Luxor	
Finland	
Helinski/Seutula	
France	
Lyon/Satolas	4
Marseille	4
Nantes	4
Nice	4
Paris/Le Bourget	4
Strasbourg	5
Germany	
Berlin/Schoenfeld	5
Hamburg	5
Hannover	5
Mannheim	5
Greece	
Souda (Crete)	3
Thessalonika/Mikra	4
Greenland	
Narssarssuaq	7
Hungary	
Budapest/Lorinc	5
Iceland	
Reykjavik	7
India	
Ahmedabad	1
Bangalore	1
Bombay/Santa Bruz	1
Calcutta/Dum Dum	1
Madras	1
Nagpur Sonegaon	1
New Delhi/Safdarjung	1
Indonesia	
Djakarta/Halimperda (Java)	1
Kupang Penfui (Sunda Island)	1
Makassar (Celebes)	1
Medan (Sumatra)	1
Palembang (Sumatra)	1
Surabaga Perak (Java)	1

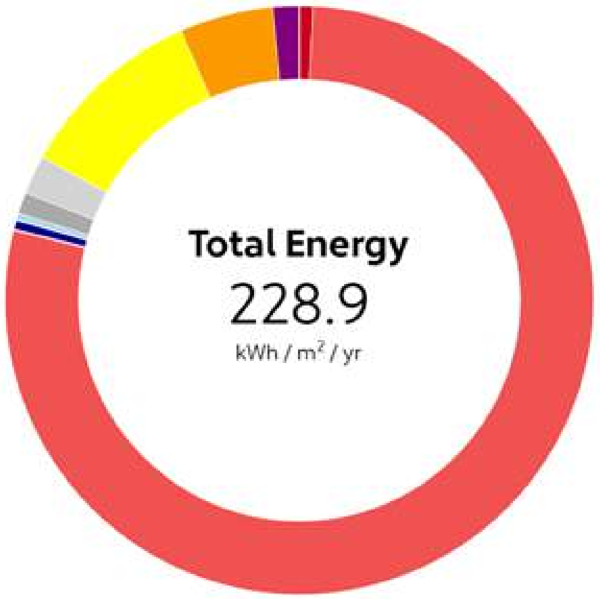
Country / City	Zone
Ireland	
Dublin Airport	5
Shannon Airport	4
Israel	
Jerusalem	3
Tel Aviv Port	2
Italy	
Milano/Linate	4
Napoli/Capodichino	4
Roma/Fiumicion	4
Jamaica	
Kingston/Manley	1
Montego Bay/Sangster	1
Japan	
Fukaura	5
Sapporo	5
Tokyo	3
Jordan	
Amman	3
Kenya	
Nairobi Airport	3
Korea	
Pyonggang	5
Seoul	4
Malaysia	
Kuala Lumpur	1
Penang/Bayan Lepas	1
Netherlands	
Amsterdam/Schiphol	5
New Zealand	
Auckland Airport	
Christchurch	
Wellington	
Norway	
Bergen/Florida	5
Oslo/Fornebu	6
Pakistan	
Karachi Airport	1
Papua New Guinea	
Port Moresby	1
Paraguay	
Asuncion/Stroessner	1

Since our site is located in shanghai and from the ASHAE book we denfine the shanghai is in Thermal Zone 3,so our following SBT analysis are all based on this situation.

What we want to do is to compare the difference or even improvement with the original building what we called “**Old building** ”.”**Old building**” is also our baseline to verify our following simulations make our building’s performance better in both energy and daylight.

OLD BUILDING ANALYSIS

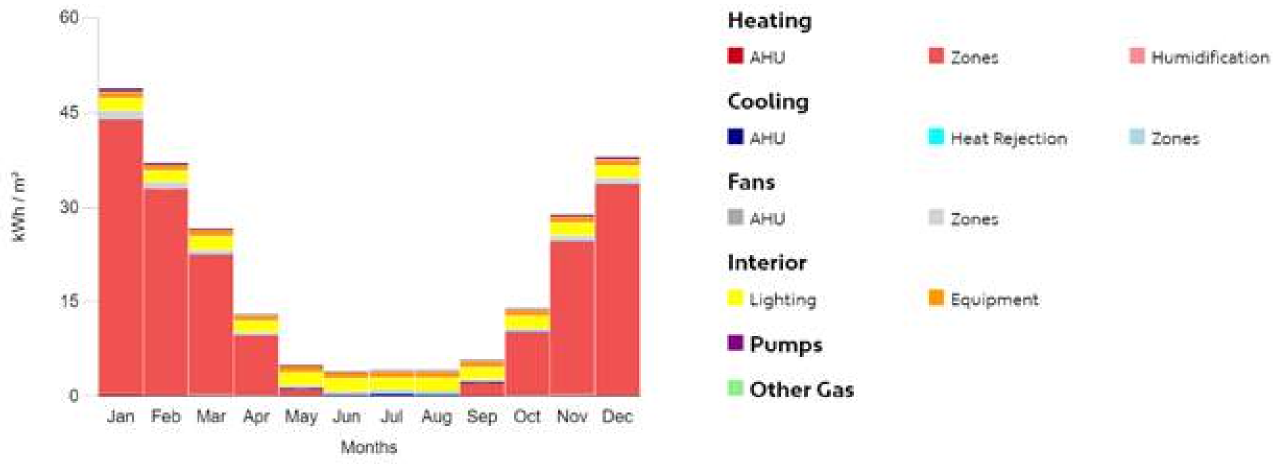
Annual Energy Use



Segment	kWh / m² / yr	% of total use
Heating	**180.6**	**79 %**
AHU	1.7	1 %
Zones	178.7	78 %
Humidification	0.2	0 %
Cooling	**2.0**	**1 %**
AHU	1.1	0 %
Heat Rejection	0.1	0 %
Zones	0.8	0 %
Fans	**7.6**	**3 %**
AHU	2.7	1 %
Zones	4.9	2 %
Interior	**35.4**	**15 %**
Lighting	23.6	10 %
Equipment	11.8	5 %
Pumps	**3.3**	**1 %**

thesis old building - Baseline Concept. Produced by undefined from Politecnico di Milano, 6 Nov 2019 @ 20:53:29

Monthly Energy Use

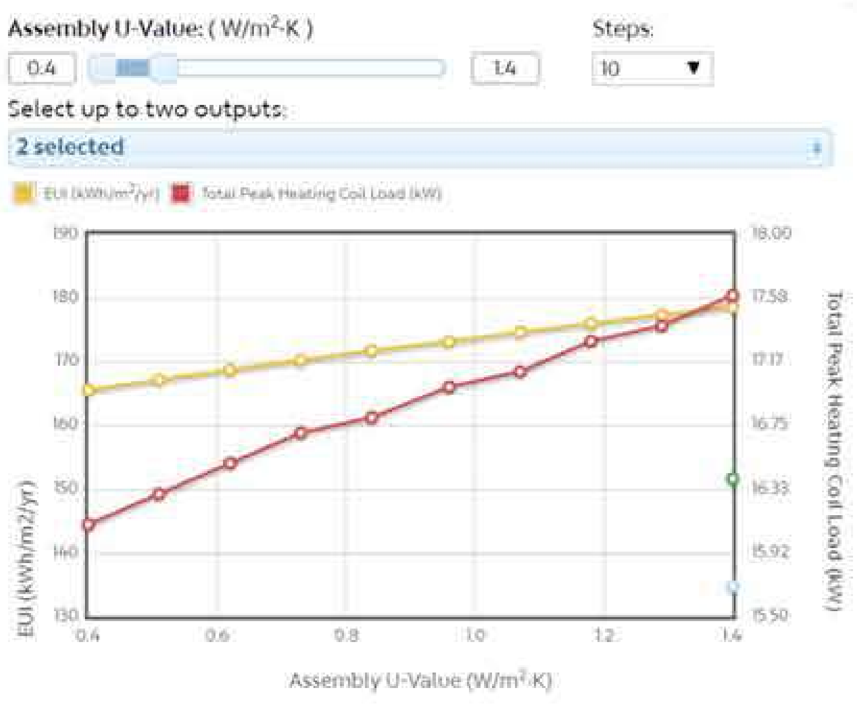


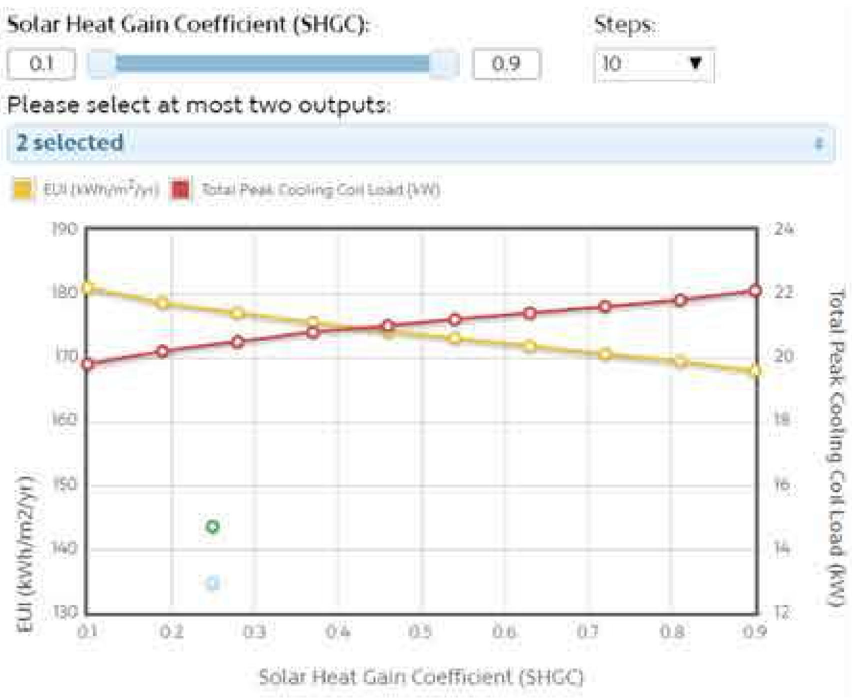
thesis old building - Baseline Concept. Produced by undefined from Politecnico di Milano, 6 Nov 2019 @ 20:50:21

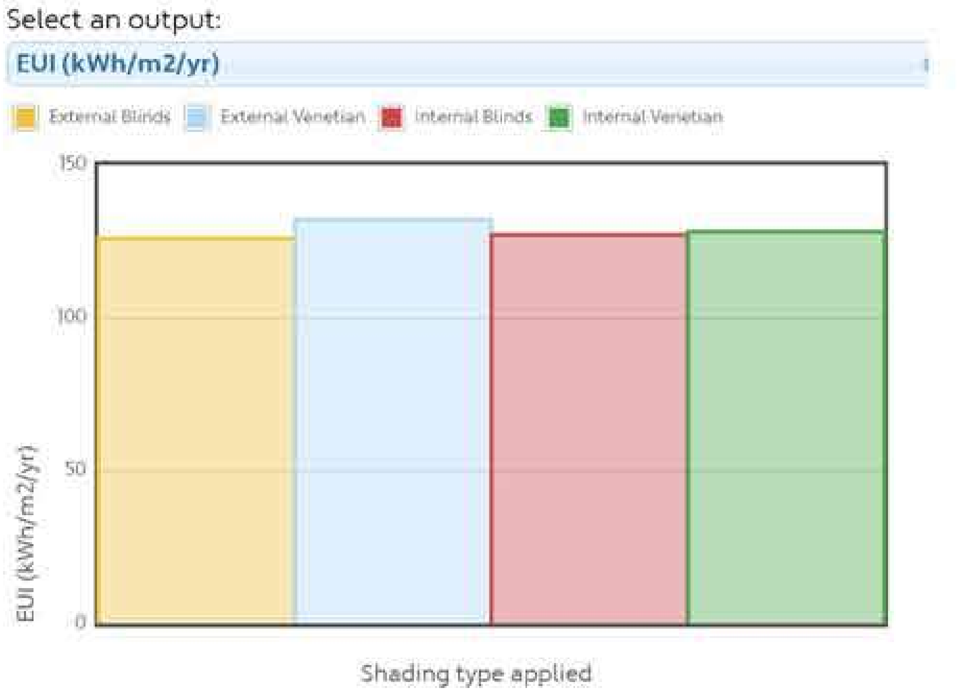
The above is shown the annual energy use for our OLD building which says that total energy is 228.9 kWh/m2/yr which is very high also form the chart shows that heating occupies 79% ,oppositely only 1% for cooling.
So what we can get is heating will always play an important role during our following energy analysis so our all strategies will focus more on heating season.

From the monthly energy use we realize for our building most time is during heating season,so what we want focus during our following energy simulation we will define heating season from January to April, from Novemeber to December; mid season including May,September and October;cooling season is composed of June,July and August.

RESPONSE CURVE FOR ENVELOPE







U-VALUE =1.35 W/m²K

From the response curve ,i choose two factor to verify the best point which is also the U-value for our envelope.We choose EUI which the most important factor for energy criteria per square meters and another factor we choose peak heating coil load which is important for our building energy performance. The upper limit is 1.4 W/m²K is coming from SHANGHAI city building energy performance criteria.

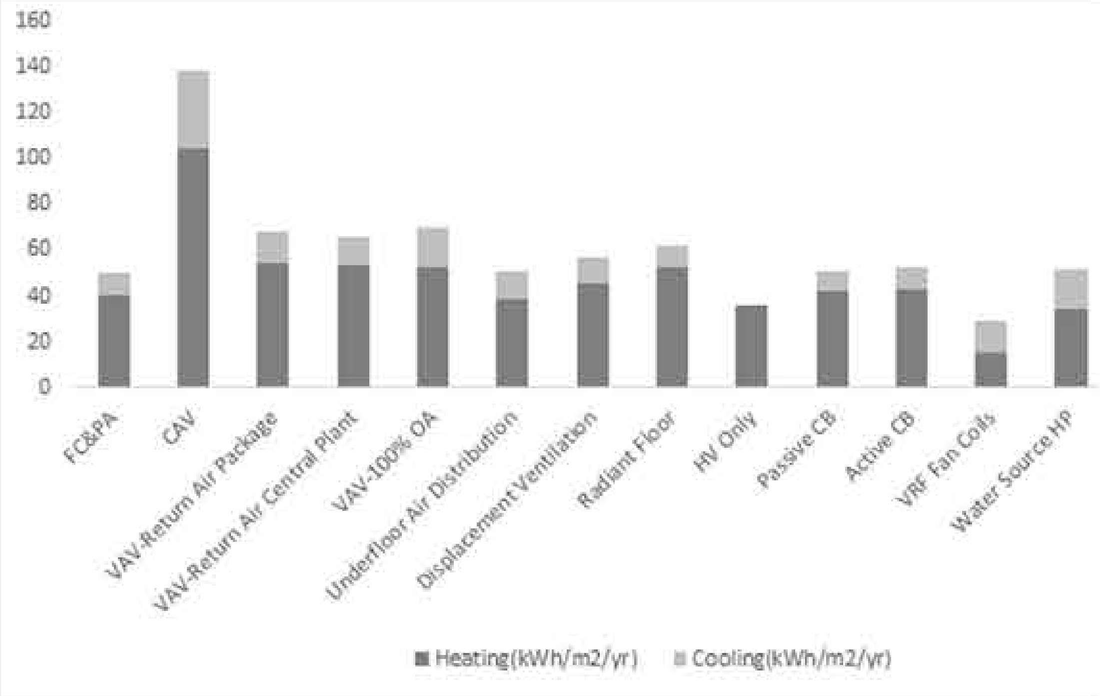
G-VALUE =0.45 W/m²K

The G-VALUE is also to find the best point of response curve

External shading&micro shading

Ather the analyse the EUI differences betwen various shading type aplied we get that external blinds has best performance.Also we have a big problem due to glazing of our “BUD” part so we decide to combine external blinds together with micro-shading to help our building daylight performance.

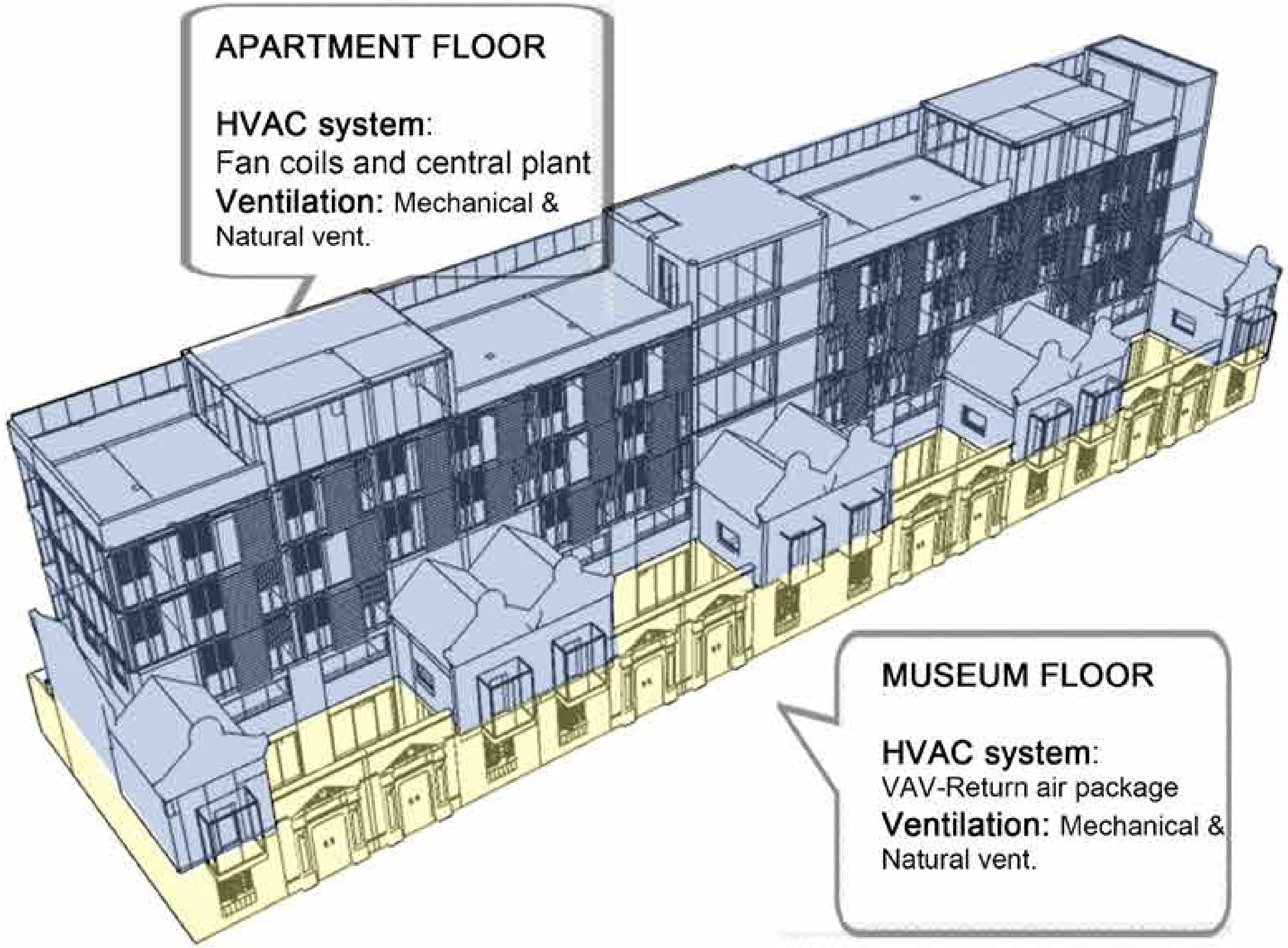
HVAC SYSTEM CHOOSE



The chart says the energy comparsion between different HVAC systems also the HVAC zones through functions. In our building,we only have museums ar apartment these two functions ,combined with energy comsumption we want apply the best HVAC systems to our following building energy simulation. From the right 3D model we can clearly distinguish HVAC zones.

ASHARE Handbook recommend HVAC system through functions

	CAV	VAV	FFS	FC&PA	Radiant F/C		
Hotel	■			■			
Apartment				■	■		
Museums	■	■					
Shops	■	■					
Office	■	■	■	■		■	■
Sports		■			■		
Schools					■		

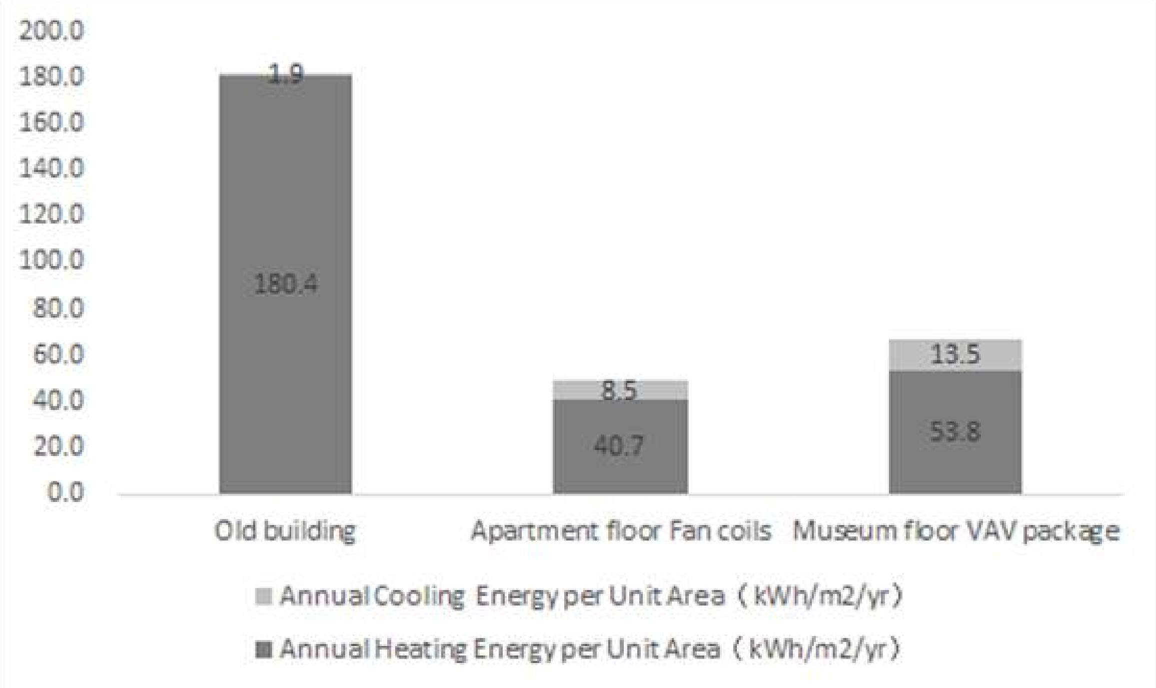


ENERGY PERFORMANCE COMPARSION

	Cooling Equipment Design Capacity(KW)	Heating Equipment Design Capacity (kW)	Heat Rejection Design Capacity (kW)	Annual Heating Energy per Unit Area (kWh/m2/yr)	Annual Cooling Energy per Unit Area (kWh/m2/yr)	EUI (kWh/m2/yr)
Old systems	11.4	31.7	15.2	180.43	1.88	229.12

	Cooling Equipment Design Capacity(KW)	Heating Equipment Design Capacity (kW)	Heat Rejection Design Capacity (kW)	Annual Heating Energy per Unit Area (kWh/m2/yr)	Annual Cooling Energy per Unit Area (kWh/m2/yr)	EUI (kWh/m2/yr
Apartment floor Fan coils	17.4	20.5	23.2	40.7	8.5	94.8

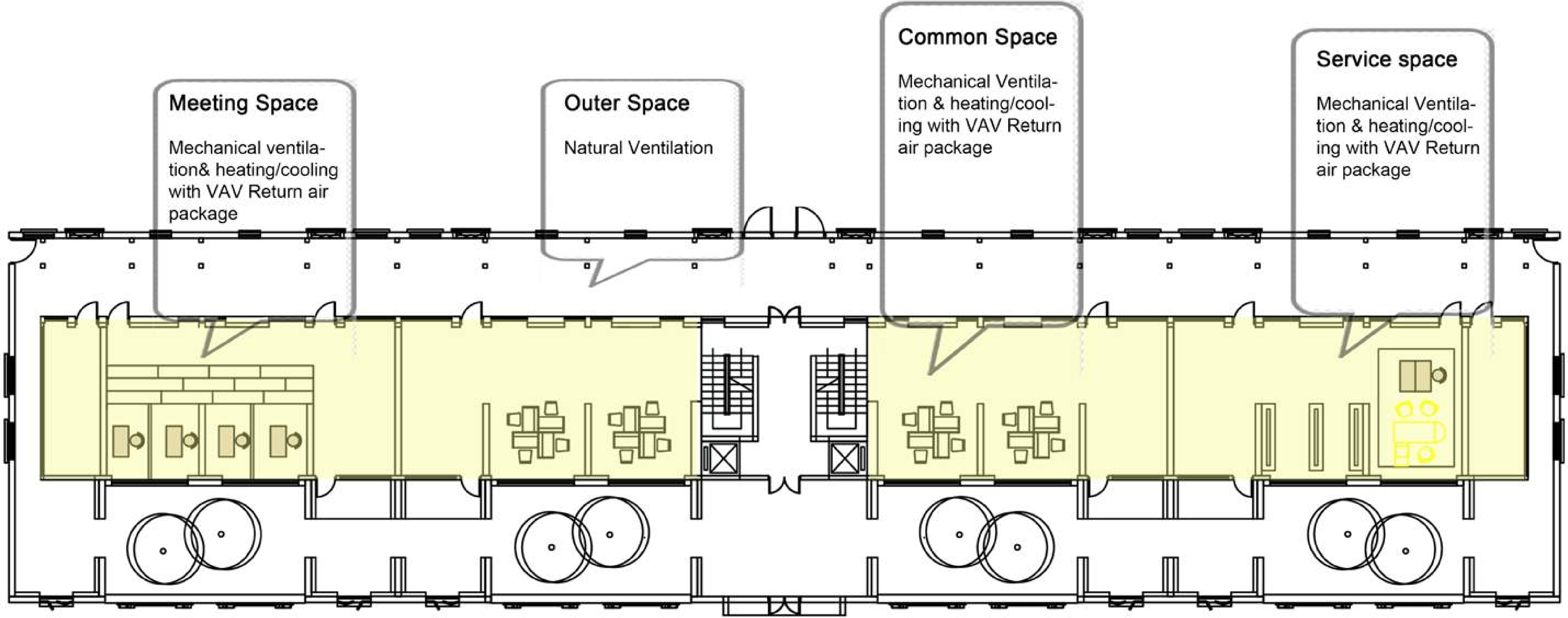
	Cooling Equipment Design Capacity(KW)	Heating Equipment Design Capacity (kW)	Heat Rejection Design Capacity (kW)	Annual Heating Energy per Unit Area (kWh/m2/yr)	Annual Cooling Energy per Unit Area (kWh/m2/yr)	EUI (kWh/m2/yr
Museum floor VAV package	21.8	35.5	0.0	53.8	13.5	112.9



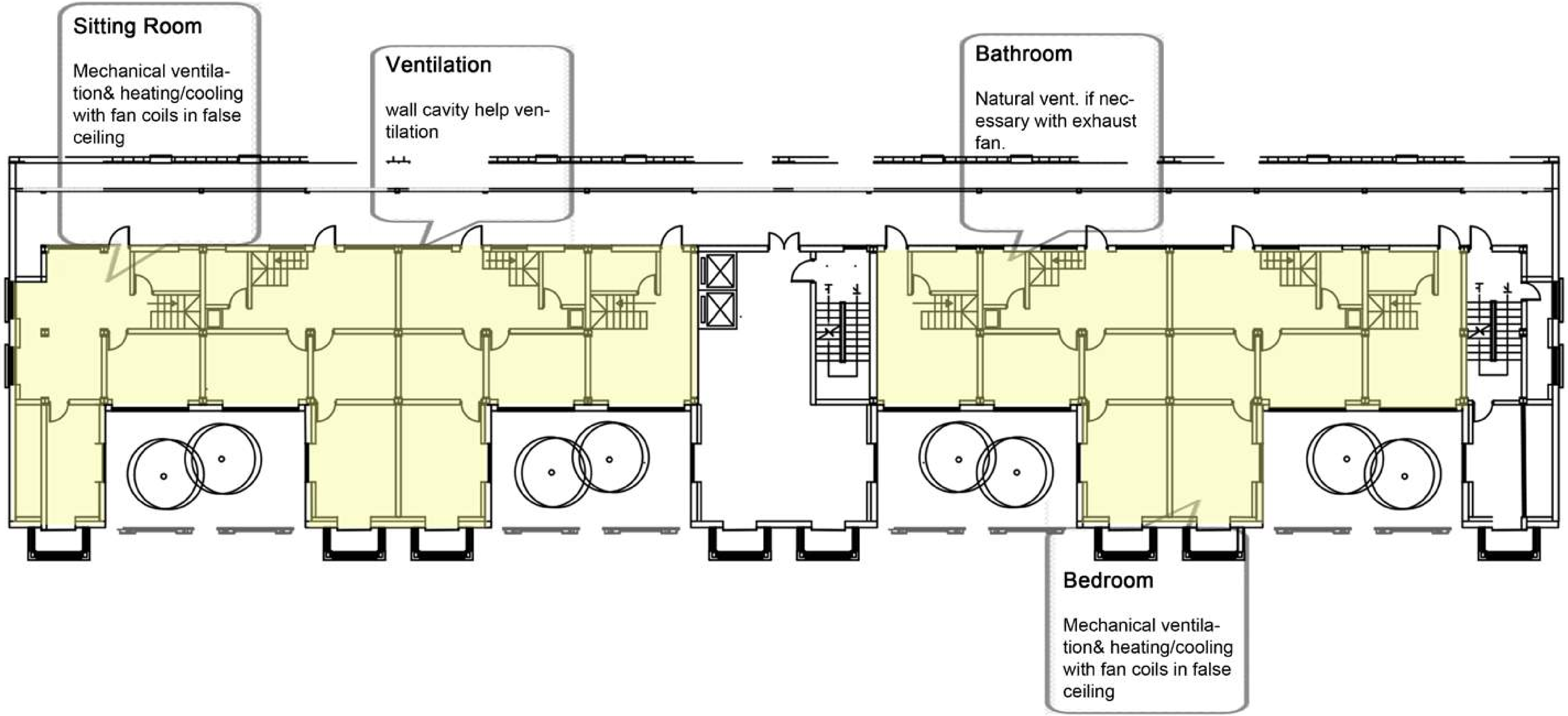
The above charts shows our old building energy performace, Fan coils for our apartment part and VAV package system for our museum ground floor part.

The left table says the exact improvement for our building after we apply our shading, envelope and HVAC system to different zones which is 49.2 kWh/m²/yr in apartment ,67.2 kWh/m²/yr in museum compared to 182.3 kWh/m²/yr of old building.

STRATEGY SCHEME OF MUSEUM FLOOR



STRATEGY SCHEME OF APPARTMENT FLOOR



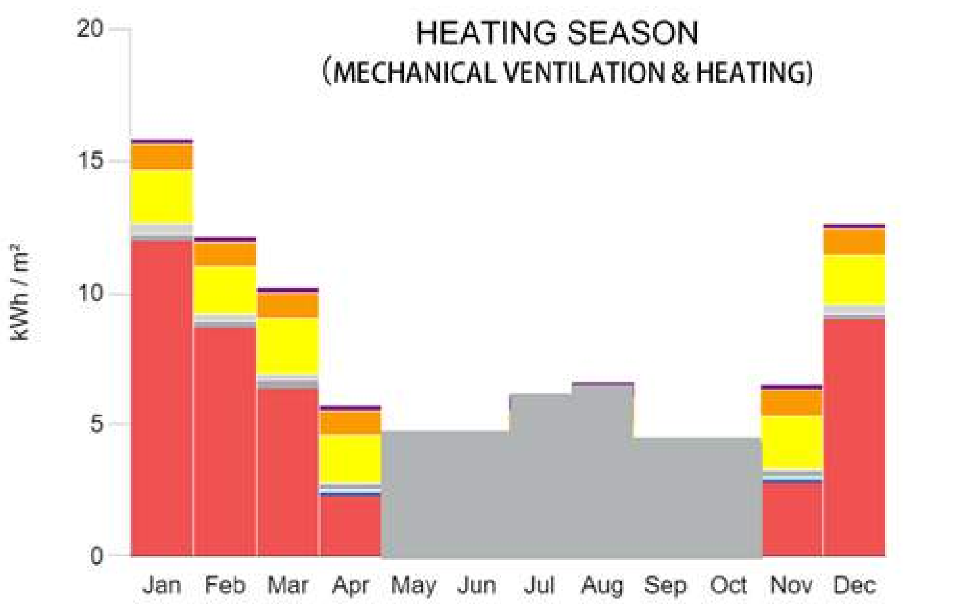
STRATEGY CHOOSE

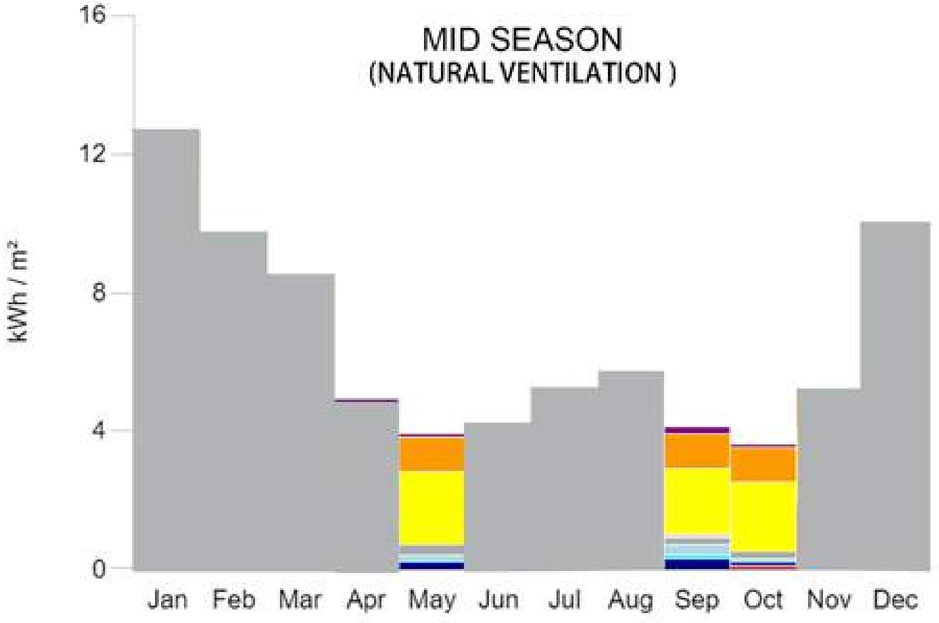
HEATING SEASON
NOV-APR
Mechanical ventilation & heating

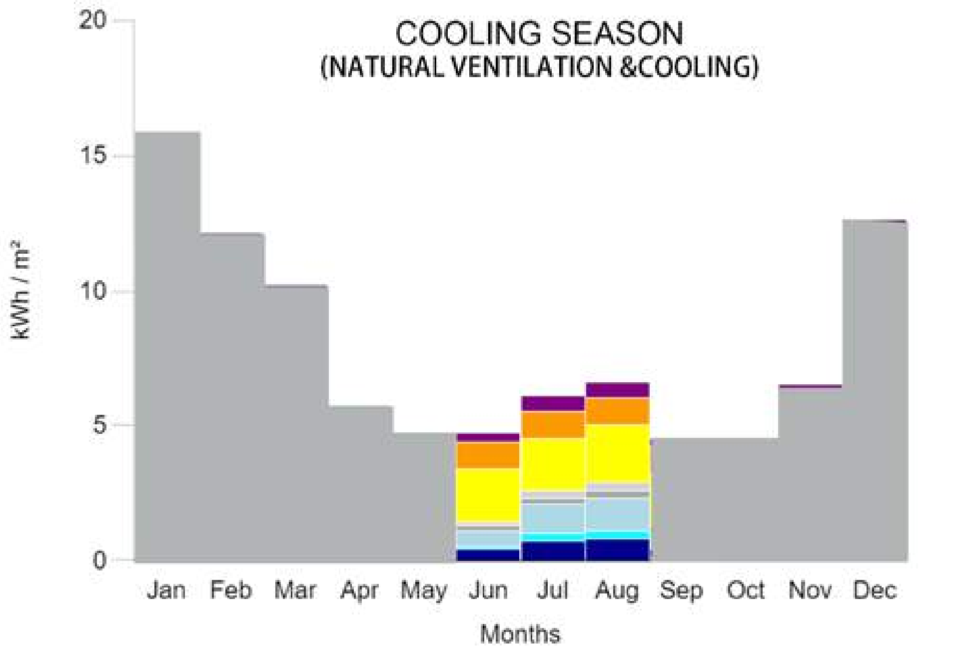
MID SEASON
MAY,SEP-OCT
Natural ventilation

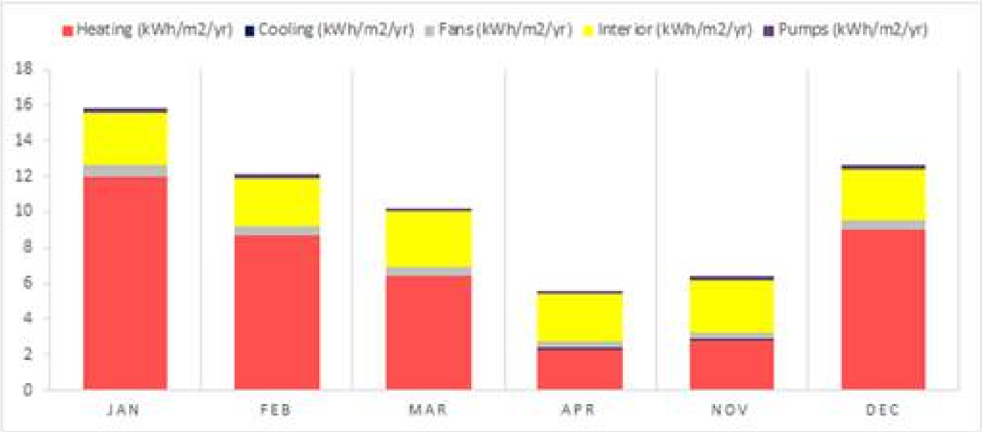
COOLING SEASON
JUN-AUG
Cooling & Natural ventilation

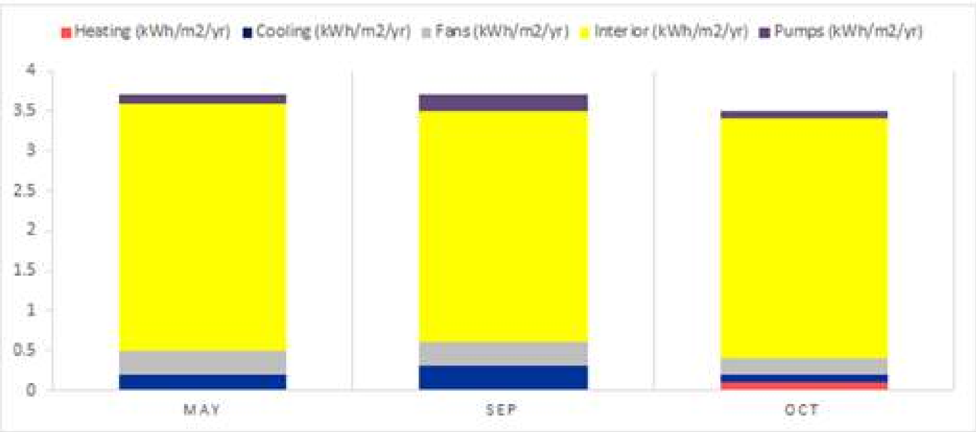
STRATEGY CHOOSE
MONTHLY ANALYSIS(APARTMENT FLOOR)



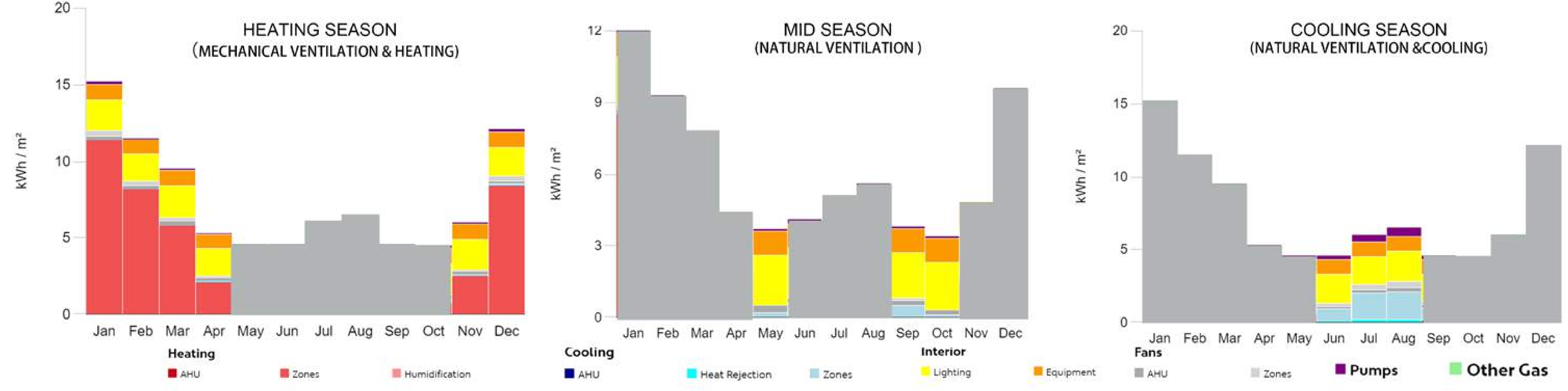


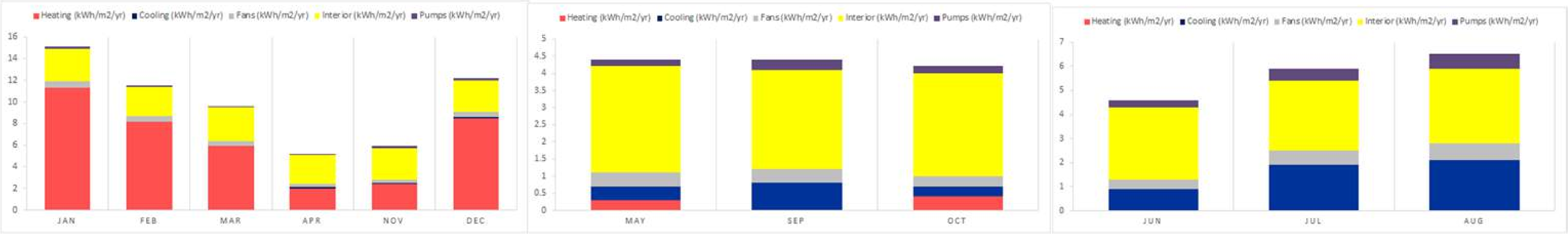






STRATEGY CHOOSE
MONTHLY ANALYSIS(MUSEUM FLOOR)



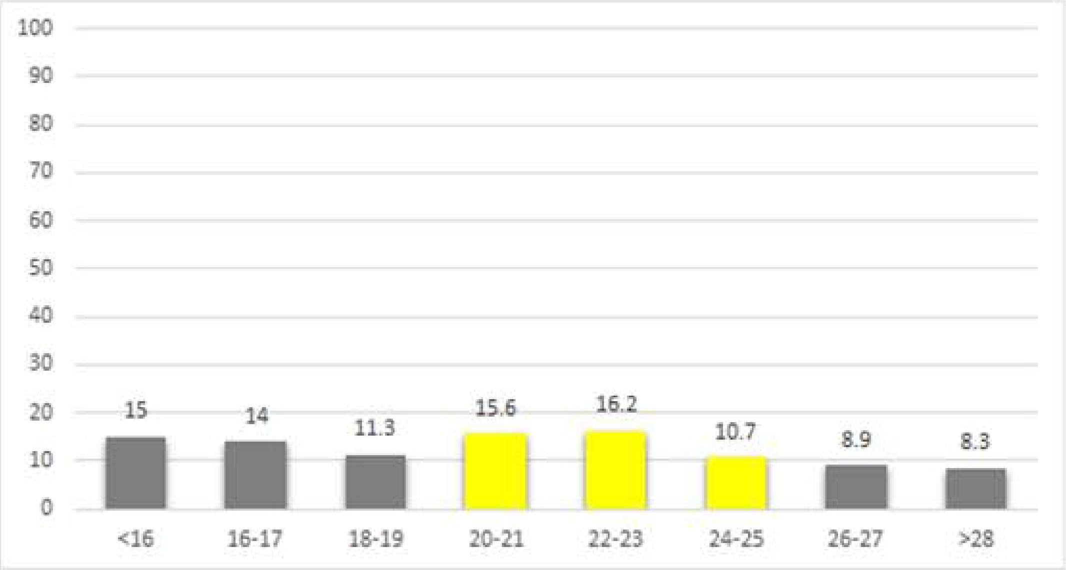


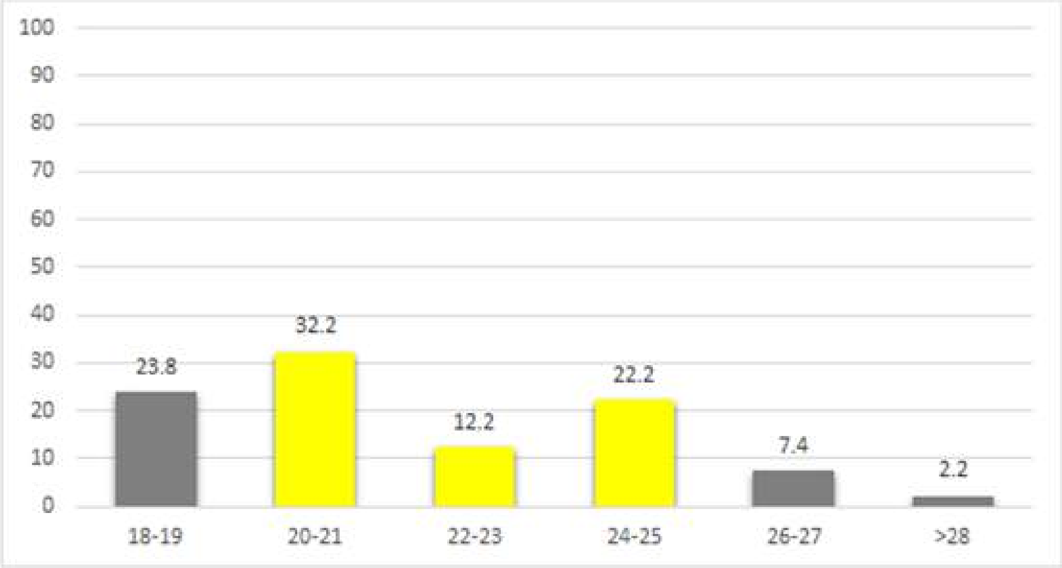
COMFORT ANALYSIS
WE APPLY COMFORT CEITERIA WHEN THE HOURLY TEMPERATURE VALUES WITHIN THE 0.2 DEGREES OF THE SETPOINT RANGE.

MID SEASON

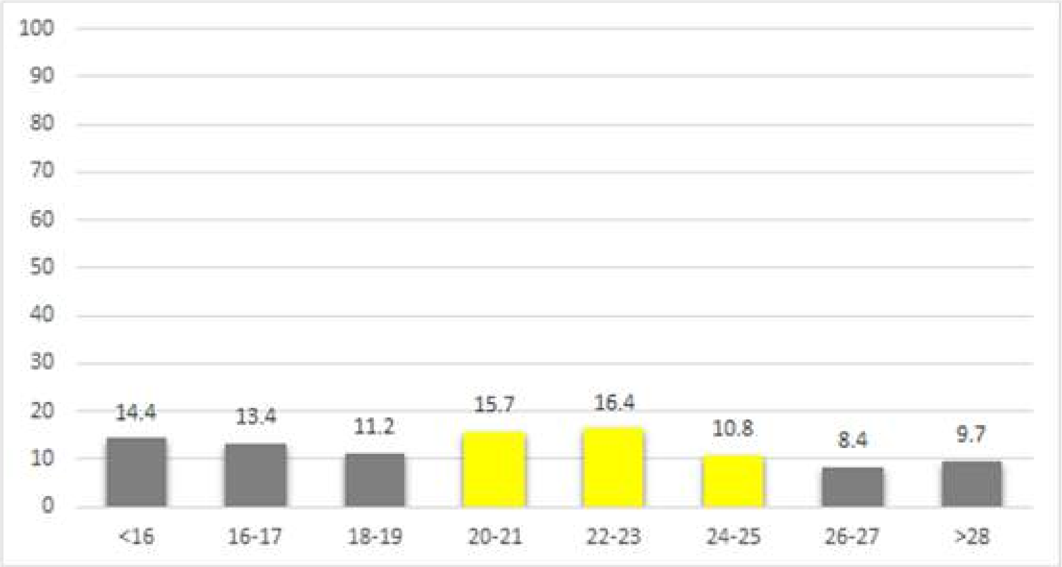
HEATING/COOLING SEASON

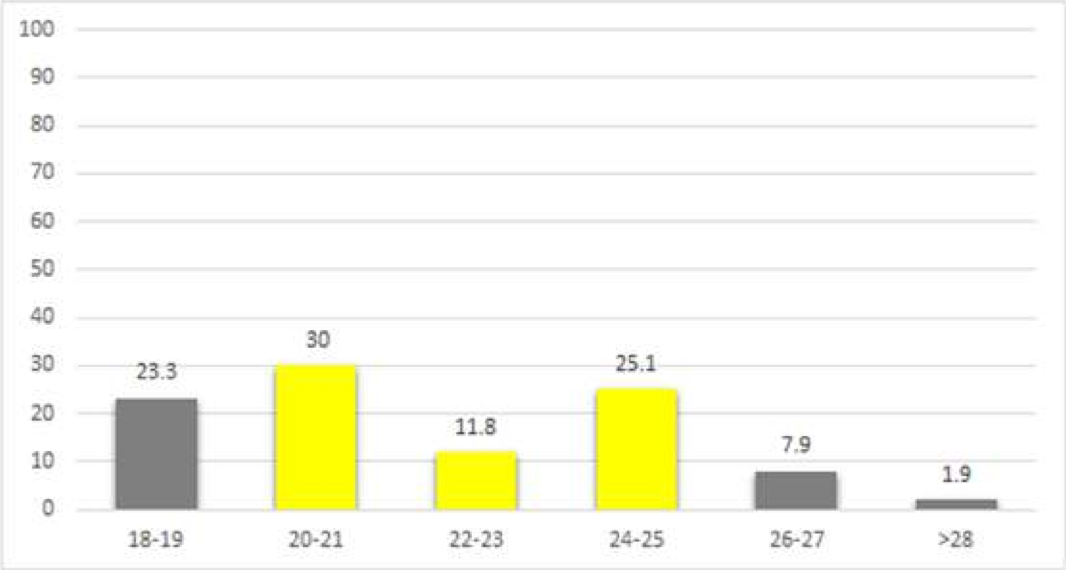
APARTMENT FLOOR





MUSEUM FLOOR

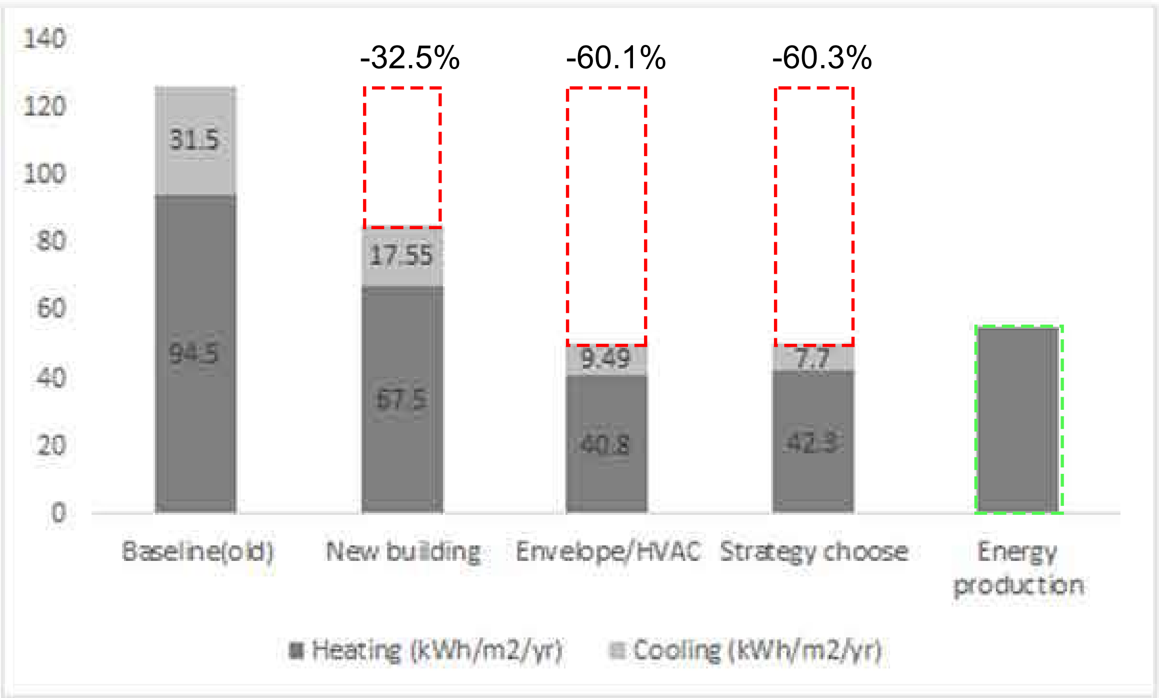


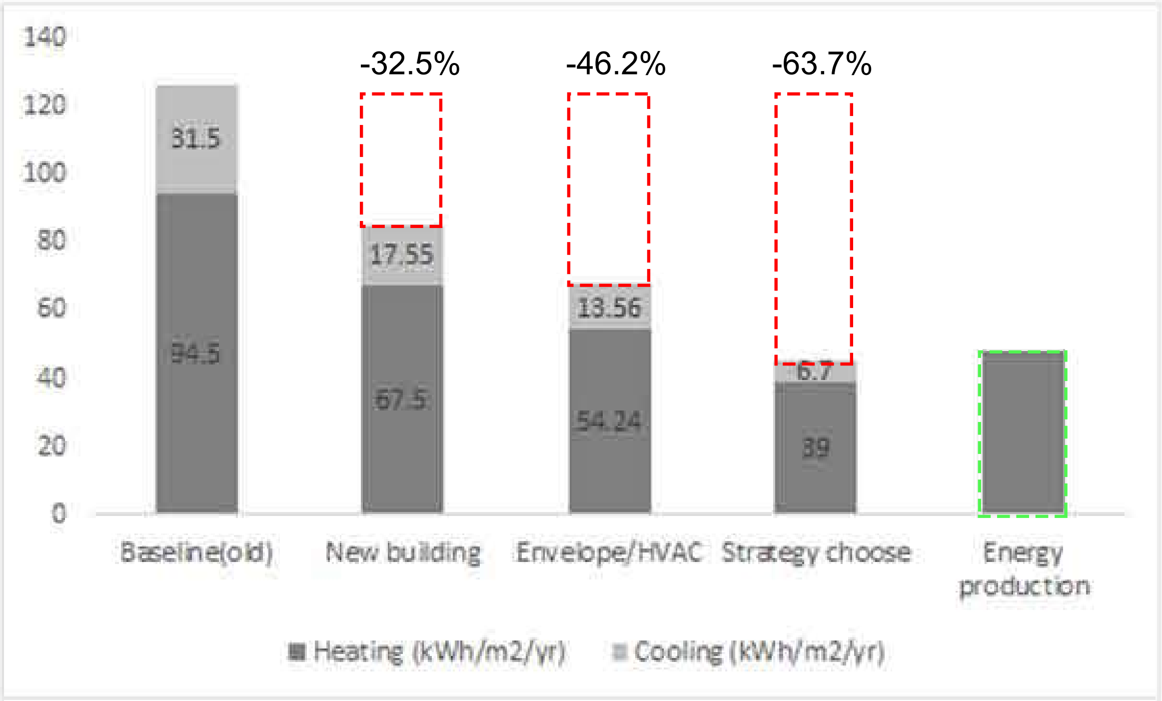


The charts show the temperature range is from 20-25 degrees which is also called comfort zones. When the temperatre is below 20 degree,it belongs to too cold zones and if the temperature is above 25 degree it belongs to too hot zones.

We can see form mid season,the temperature range is really average,the comfort zones occupied almost 40% hours during mid season. During heating and cooling season, we have 70% hours for comfort of both apartment floor and museum floor.

ENERGY OPTIMIZATION





APARTMENT FLOOR

ENERGY REDUCTION

ENERGY PRODUCTION

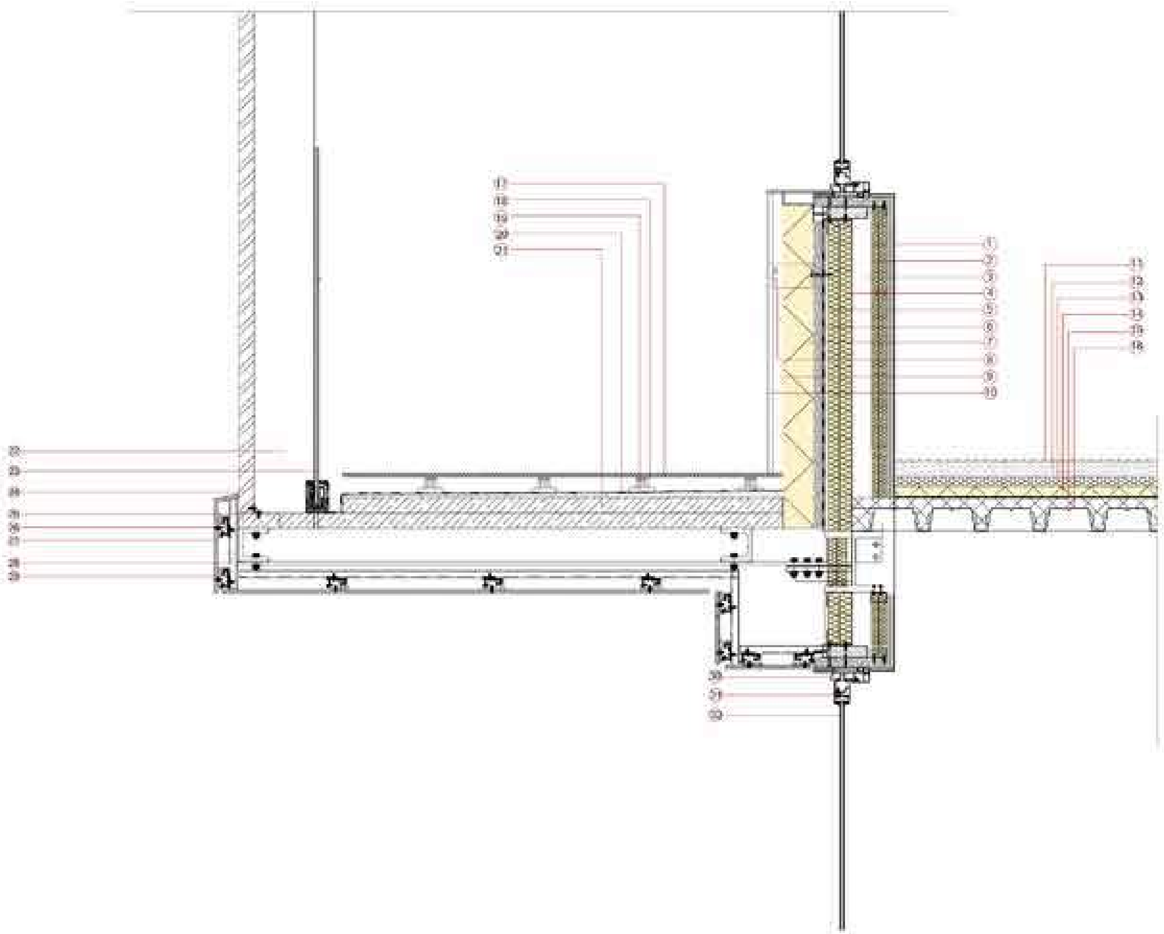
MUSEUM FLOOR

We analyse the reduction in annual energy consumption through various strategies and HVAC systems we apply to our new building compared to old building. What we need is to have enough energy productiob to cover energy consumption. Both apartment floor and museum floor will have 60% more energy reduction after we appling all our strategies to new building.

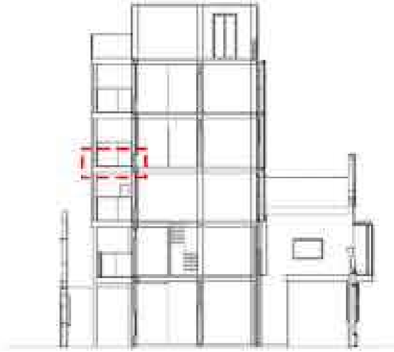
TECHNOLOGY

TECHNOLOGICAL DETAILS

SCALE 1：20



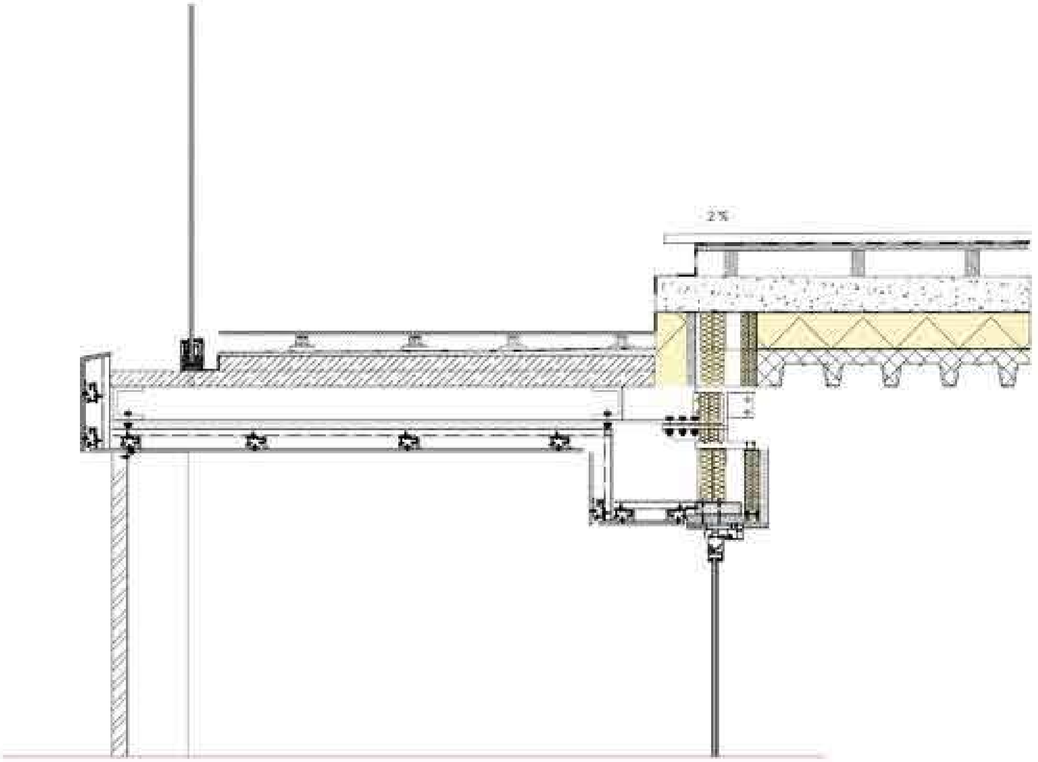
1. Double plasterboard panels 2x1,25 cm
2. Acoustic insulation in mineral wool;3 cm
3. Air cavity for installations; 4 cm
4. Thermal insulation in mineral wood; 5 cm
5. Air tightness layer; 0.3 cm
6. OSB wood board; thickness: 2 cm;
7. Thermal insulation in expanded polystyrene; 7 cm
8. Steel profile to fix the external panels
9. Air cavity; 2 cm;
10. Fiber cement panels(60*150) 1.25 cm;
11. Timber finishing 1cm;
12. Screed 5cm;
13. Acoustic insulation 3cm;
14. Thermal insulation 4cm;
15. Vapour barrier
16. Steel decking 18cm;
17. Outer floor tiles(150*150cm) 1cm
18. Support elements
19. Waterproofing
20. Light concrete with slope
21. Outdoor timber board
22. Outdoor Column 15.2x15.2x3
23. Glass parapet
24. Timber bar
25. C shape aluminum profile
26. Aluminum profile
27. Continues metal clamping system fixed to the outdoor slab
28. Steel beam cantilever
29. Hanging hook;
30. Aluminum tubular 15*4*2cm
31. Fixed frame
32. Double Glazing, U=0.43W/m²K

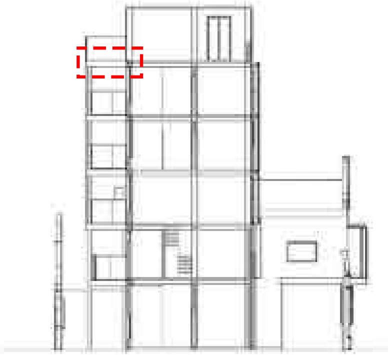


SECTION B-B1

TECHNOLOGICAL DETAILS

SCALE 1： 20

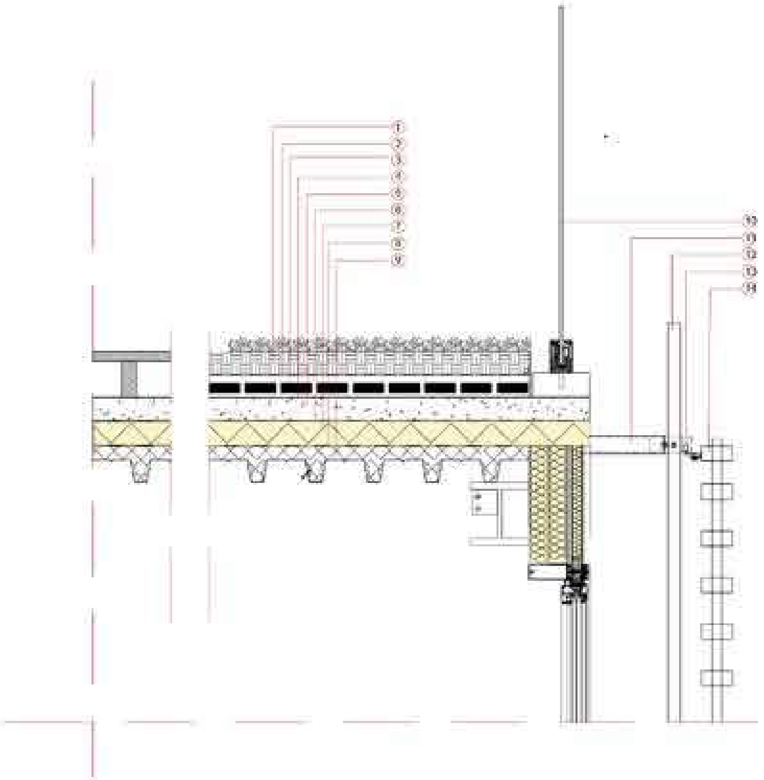




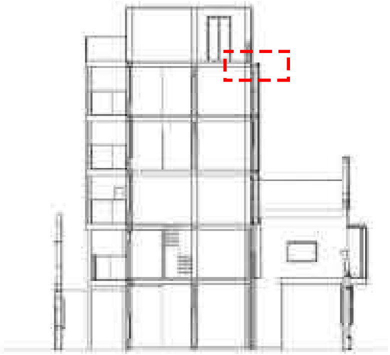
SECTION B-B1

TECHNOLOGICAL DETAILS

SCALE 1： 20



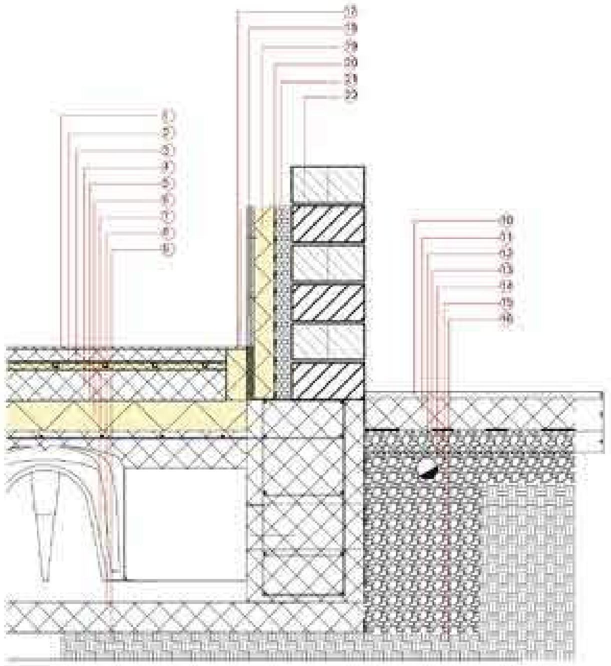
1 Soil
2 Geotextile 0.5cm;
3 Dimpled sheet 7cm;
4 Waterproofing
5 Screed 7.5cm;
6 Waterproofing
7 Thermal insulation 7.5cm;
8 Vapor barrier
9 Decking
10 Glass parapet
11 Fixed system for vertical shading
12 Vertical fixed shading
13 Roller system for sliding horizontal shading
14 Horizontal sliding shading



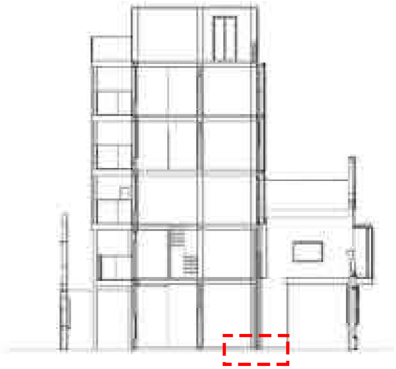
SECTION B-B1

TECHNOLOGICAL DETAILS

SCALE 1：20



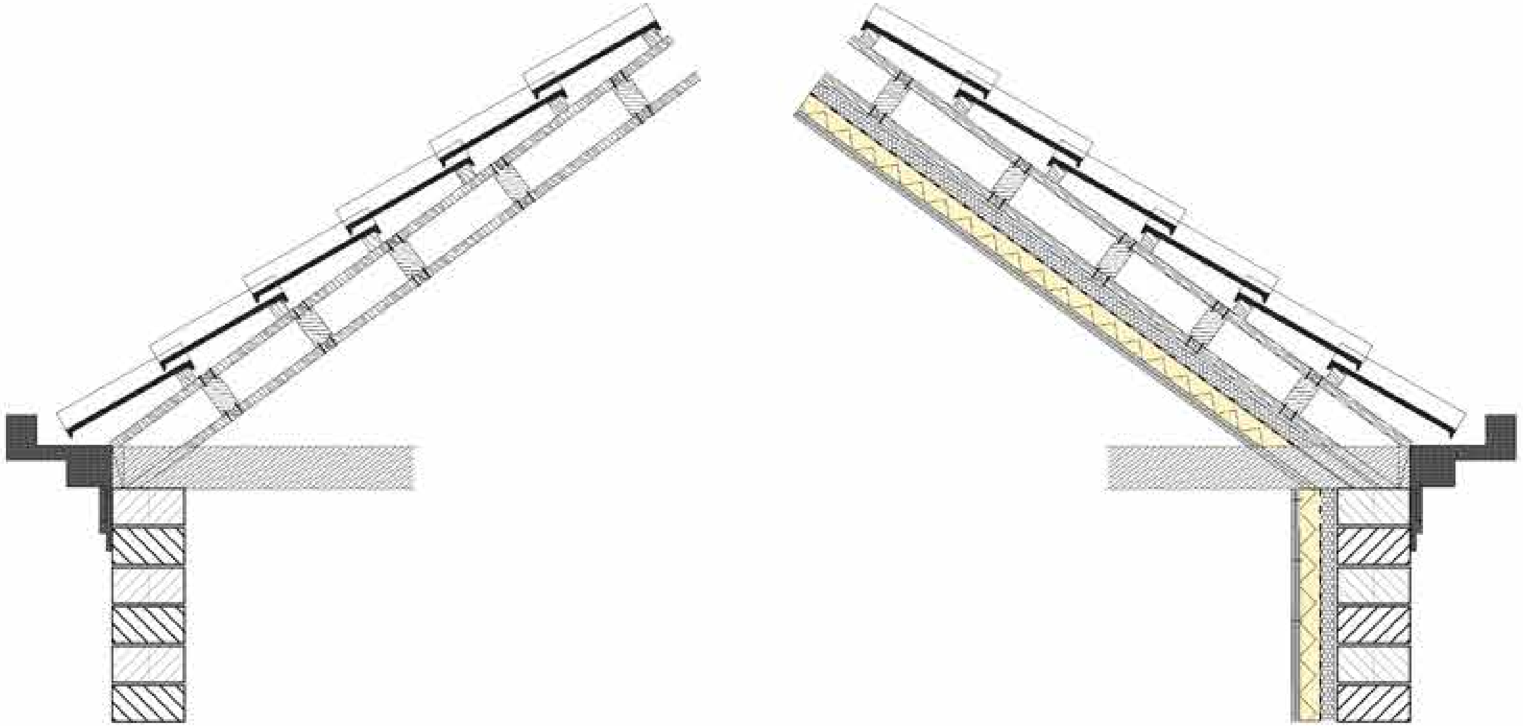
1 Timber finishing-1 cm
2 Leveling concrete-4 cm
3 Heating system-3 cm
4 Light concrete with pipes-10 cm
5 Thermal insulation
6 Vapor barrier
7 Ventilated foundation height 4.5 cm
8 Leveling concrete-10 cm
9 Soil
10 Granulate for slope 1.5%-4.5cm
11 Concrete-10 cm
12 Waterproof self-adhesive membrane
13 Course gravel-5 cm
14 Geotextile
15 Drainage pipe
16 Soil
17 Skirting
18 Finishing plasterboard 2*1.25 cm
19 Thermal insulation
20 Air tightness layer
21 Acoustic insulation
22 Existing brick wall

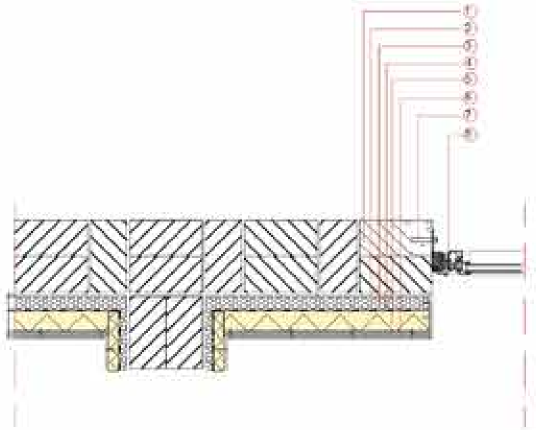


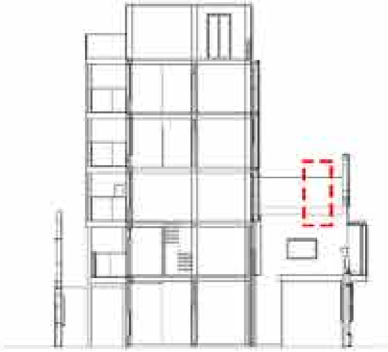
SECTION B-B1

TECHNOLOGICAL DETAILS

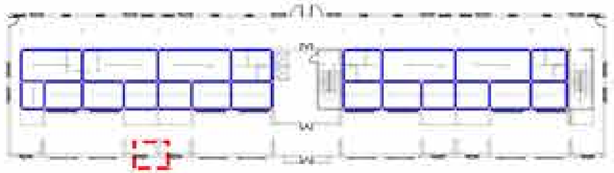
SCALE 1: 20







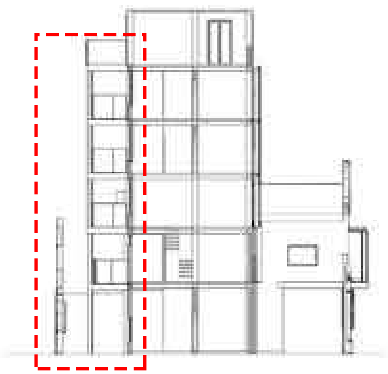
SECTION B-B1



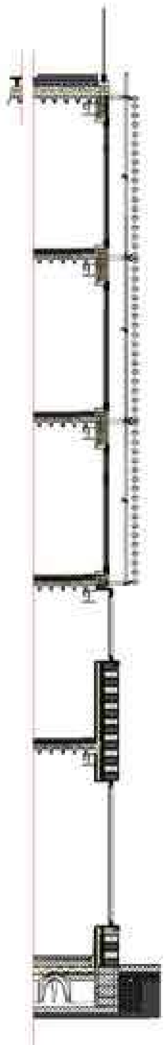
GROUND FLOOR PLAN

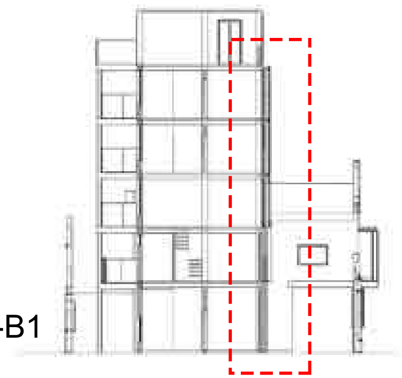
TECHNOLOGICAL DETAILS

SCALE 1：100



SECTION B-B1



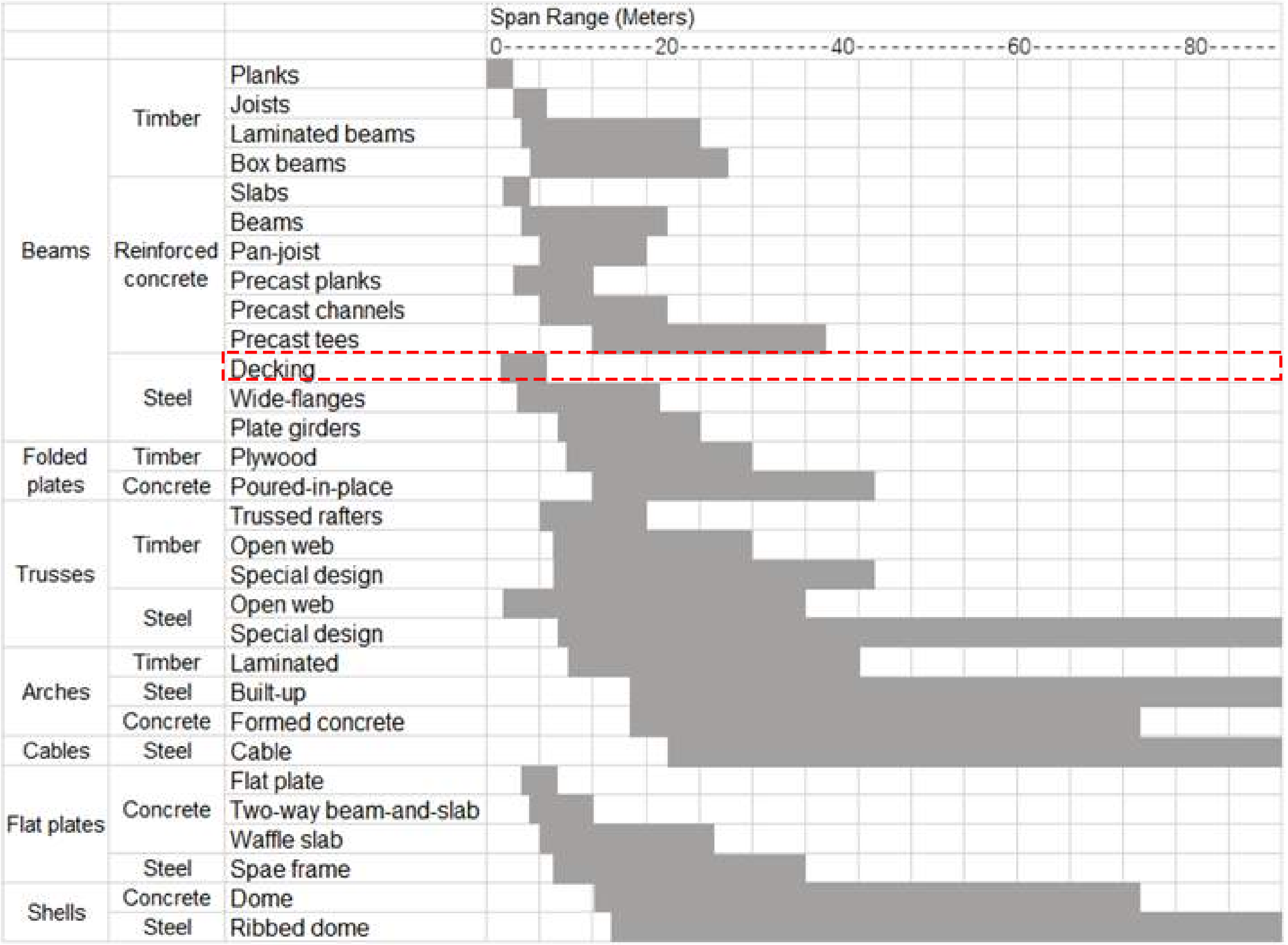


SECTION B-B1

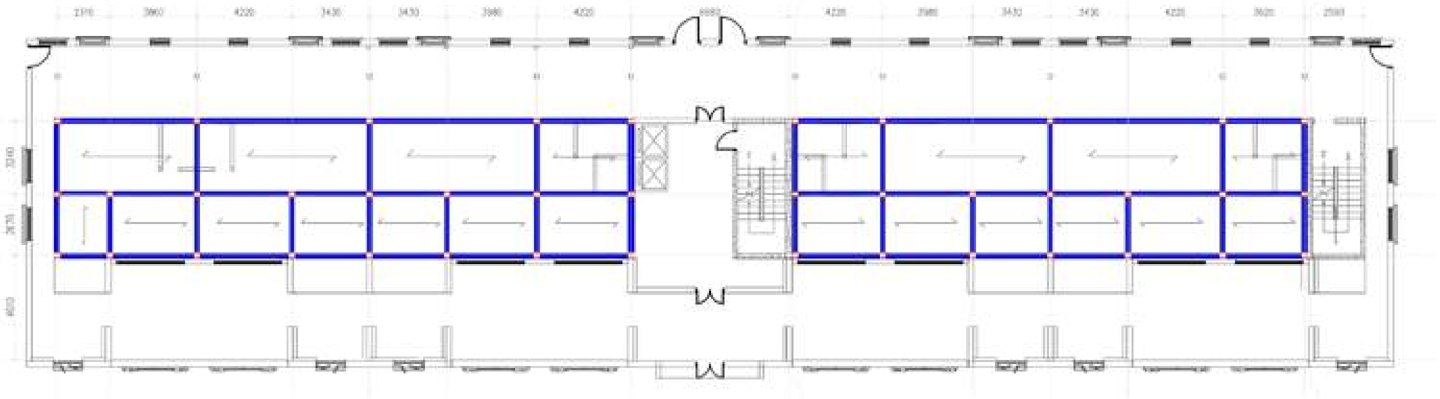
STRUCTURAL DESIGN

STRUCTURAL DESIGN

The building structural scheme should meet the requirements of reliable transmission and reasonable force.The project is located in Shanghai with only five floors and a height of 14.4 meter. We define our structural scheme according the below chart in which we can easily in different span range with different ways.Our beams span range usually from 3 meters t we want a relatively light way so we decide to choose Steel decking.



The size of the column net should first meet the requirements of the building function to the utmost extent, and then comprehensively consider the factors such as processing and installation conditions according to the principle of the most cost-effectiveness. According to the above conditions, the column network is determined as follows:



STRUCTURAL DESIGN

MATERIAL PROPERTIES

Concrete class: C30/37 – used for all concrete elements of the structure

(Table 3.1 – Eurocore 2)

$\gamma_c = 1.5$	Partial safety factor for concrete (2.4.2.4 Eurocode 2 and National Annex of Italy)
$f_{ck} = 30\ {}^{N}/_{mm^2}$	Characteristic compressive cylinder strength of concrete at 28 days
$f_{cd} = \frac{\alpha_{cc} * f_{ck}}{\gamma_c} = 17\ {}^{N}/_{mm^2}$	Design value of concrete compressive strength (3.1.6 Eurocode 2)
$\sigma_{c,adm} = k_1 * f_{ck} = 18\ {}^{N}/_{mm^2}$	Allowable compressive strength under characteristic combinations (EC2 – 7.2(2))
$f_{ctk,0.05} = 2.0\ {}^{N}/_{mm^2}$	Characteristic tensile strength
$f_{ctm} = 2.9\ {}^{N}/_{mm^2}$	Mean value of axial tensile strength of concrete
$\alpha_{cc} = 0.85$	Coefficient taking account of long term effects on the compressive strength and of unfavourable effects resulting from the way the load is applied (3.1.6 Eurocode 2 and National Annex of Italy)
$k_1 = 0{,}60$	k_1 – coefficient from National Annex of Italy

Structural steel: S235JR for beam and column

Structural steels grade at 16mm	Minimum yield strength at nominal thickness 16mm		Tensile strength MPa at nominal thickness between 3mm and 16mm
	psi	N/mm2(MPa)	
S235	33000	235 N/mm2	360-510 MPa

Here we choose the material including concrete and steel we will apply to our structure shceme including concrete C30/37 and Steel 235JR. The related data has been shown in the table.
The following we gonna to analyse the loads.

PERMANENT LOADS

Simple internal wall	#	Layer	Thickness	Specific weight	Load charact eristic value
	1	Plasterboard	0.025	9	0.225
	2	Mineral-wool thermal insulation	0.10	1.15	0.115
	3	plasterboard	0.025	9	0.225
		tot per unit area of wall	0.15		0.565

STRUCTURAL DESIGN

North external wall	#	Layer	Thcikness	Specific weight	Load charact eristic value
	1	Existing brick wall	0.12	6	0.72
	2	Rustic plaster	0.02	9	0.18
	3	isolation	0.06	18	1.08
	4	Tablet of perforated brick	0.08	6	0.48
	5	Finishing plaster	0.02	9	0.18
		tot per unit area of wall	0.3		2.64

South glazing wall	#	Layer	Thcikness	Specific weight	Load charact eristic value
	1	Toughened glass	0.006	25	0.15
	2	cavity	0.012	-	--
	3	Toughened glass	0.006	25	0.15
		tot per unit area of wall	0.024		0.3

Typical floor	#	Layer	Thcikness	Specific weight	Load charact eristic value
	1	Timber finishing	0.01	20	0.2
	2	Screed	0.05	10	0.5
	3	Insulation	0.07	0.3	0.021
	4	Structural concrete	0.18	20	3.6
	5	Steel sheet	0.06	-	-
	6	Ceiling plaster	0.025	20	0.5
		TOT			5.51

Above is different loads acting on the building which are used for the design of the structural elements will be evaluated.In the chapter,the action loads on the cmplete building including self-weight of different structural elements and envelopes of the building, live loads, snow loads and wind load according to the site zone and earthquake consideration will be summarized.

STRUCTURAL DESIGN

IMPOSED PROPERTIES

Category	Specific use	Examples
A	Areas for domestic and residential activities	Rooms in residential buildings and houses; bedrooms and wards in hospitals; bedrooms in hotels and hostels kitchens and toilets.
B	Office areas	Specific use
C	Areas where people may congrate (with the exception of areas defined under category A, B and D1))	**C1:** Areas with tables, etc e.g. areas in schools, cafes, restaurants, dining halls, reading rooms, receptions **C2:** Areas with fixed seats, e.g. areas in churches, theatres or cinemas, conference rooms, lecture halls, assembly halls, waiting rooms, railway waiting rooms. **C3:** Areas without obstacles for moving people, e.g. areas in museums, exhibition rooms, etc. and access areas in public and administration buildings, hotels, hospitals, railway station forecourts **C4:** Areas with possible physical activities, e.g. dance halls, gymnastic rooms, stages . **C5:**Areas susceptible to large crowds, e.g. in buildings for public events like concert halls, sports halls including stands, terraces and access areas and railway platforms.
D	Shopping areas	**D1:** Areas in general retail shops **D2:** Areas in department stores.

1) Attention is drawn to 6.3.1.1(2), in particular for C4 and C5. See EN 1990 when dynamic effects need to be considered. For Category E, see Table 6.3

NOTE 1. Depending on their anticipated uses, areas likely to be categorised as C2, C3, C4 may be categorised as C5 by decision of the client and/or National annex.
NOTE 2. The National annex may provide sub categories to A, B, C1 to C5, D1 and D2.
NOTE 3. See 6.3.2 for storage or industrial activity.

Here the tables which present characteristic values and design values of acrions corresponding to the live loads is given.The design values were obtained by multiplying the characteristic values with the corresponding safety coefficient.

Categories of loaded area	Specific use
H	Roofs not accessible except for normal maintenance and repair
I	Roofs accessible with occupancy according to categories A to G
K	Roofs accessible for special services, such as helicopter landing areas

Categories of loaded areas	q_k[kN/m2]	Q_k [kN]
Category A		
- Floors	1,5 to 2,0	2,0 to 3,0
- Stairs	2,0 to 4,0	2,0 to 4,0
- Balconies	2,5 to 4,0	2,0 to 3,0
Category B	2,0 to 4,0	2,0 to 4,0
Category C		
-C1	2,0 to 3,0	3,0 to 4,0
-C2	3,0 to 4,0	2,5 to 7,0 (4,0)
-C3	3,0 to 5,0	4,0 to 7,0
-C4	4,5 to 5,0	3,5 to 7,0
-C5	5,0 to 7,5	3,5 to 4,5
Category D		
-D1	4,0 to 5,0	3,5 to 7,0 (4,0)
-D2	4,0 to 5,0	3,5 to 7,0

STRUCTURAL DESIGN

SNOW LOADS

s	1.2 KN/ m²	$\mu_i . C_e . C_t . s_k$
s		Characteristic value of snow on the roof
μ_i	0.8	Snow load shape coefficient equal to 0.8 for an angle of the pitch of the roof less than 30°
C_e	1	Exposure coefficient function of the topography of the site. Ce=1.0 for normal topography that is "areas where there is no significant removal of snow by wind on construction work, because of terrain, other construction works, or trees".
C_t	1	Thermal coefficient that should be used to account for the reduction snow loads on the roof without high thermal transmittance Ct=1
S_k	1.5 KN/ m²	Characteristic value of the snow load on the ground. For provincial di Milano, for a design working life of the structure of 50 years in accordance with the initial design assumptions S_k=1.5KN/m2

WIND LOADS

Terrain category	z_0	z_{min}
0 Sea or coastal area exposed to the open sea	0,003	1
I Lakes or flat and horizontal area with negligible vegetation and without obstacles	0,01	1
II Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle heights	0,05	1
III Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest)	0,3	1
IV Area in which at least 15 % of the surface is covered with buildings and their average height exceeds 15 m	1	1

Shanghai belongs to category **IV** then we can have the following data:

Terrain factor depending on the roughtness length

$$k_r = 0.19 * z_0/z_{0,II}{}^{0.07}$$

z_0: roughless length 1m;

z_{min}: minimum height defined in GB50017-2003 10m;

z_{max}: default maximum height GB50017-2003 200m;

$z_{0,II}$: GB50017-2003 0.05m

$$k_r = 0.23$$

Orography coefficient.When orography changes within hills ;wind velocities increases by more than 5% and these increment should be taken into account

$$c_0(z) = 1$$

Roughness coefficient. This value varies according to the height above ground level and the ground roughness of the terrain upwind of the structure in the wind direction considered. The procedure of the determination of the roughness factor at height z is
based on a logarithmic velocity profile that is given by the following expression;

$$c_r = k_r * ln\frac{z}{z_0} \text{ for } z_{min} \leq z \leq z_{max} = 200m$$

$$c_r = c_r * z_{min} \text{ where } k_r = 0.19 * z_0/z_{0,\text{II}}{}^{0.07} \text{ with } z_{0,\text{II}} = 0.05m$$

$$c_r = 0.75$$

Wind speed

$$v_b = c_{dir} * c_{season} * v_{b,0}$$

$c_{dir} = 1$ directional factor;

c_{season}=1 seasonal influence factor;

$v_{b,0}$ basic wind velocity which corresponds to characteristic 10 minutes mean wind velocity that doesn't take into consideration the direction and time. According to National Annex, the respective value is

$v_{b,0} = v_{b,0} \; for \; a_s \leq a_0$

$v_{b,0} = v_{b,0} + ka(a_s - a_0) \; for \; a_0 \leq a_s \leq 1500$

$$v_b = 25m/s$$

Velocity pressure

$$q_b = 0.5\rho v_b^2$$

$\rho_{air} = 1.2 \; kg/m^3$ air density

$$q_b = 390.63 \; N/m^2$$

Turbulence intensity

$$l_v = \frac{k_l}{\left[c_0(z)\ln\left(\frac{z}{z_0}\right)\right]} \quad \text{for } z_{min} < z < z_{max}$$

$$l_v = l_v(z_{min}) \quad \text{for } z > z_{min}$$

$k_l = 1$ turbulence factor

$c_0(z)$: orography factor

$$l_v = 0.31$$

Peak pressure

$$q_p(z) = [1 + 7l_v(z)]0.5\rho c_r(z)^2 c_0(z)^2 v_m^2 = c_e(z) q_b$$

$$q_b = 0.5\rho v_b{}^2$$

$v_m(z) = c_r(z) * c_0(z) * v_b = 18.75m/s$ mean wind velocity which is calculated with the factors of terrain roughness and orography and basic velocity at a height z above the terrain

$c_e(z) = [1 + 7l_v(z)]0.5\rho c_r(z)^2 c_0(z)^2$=1.11 orography factor

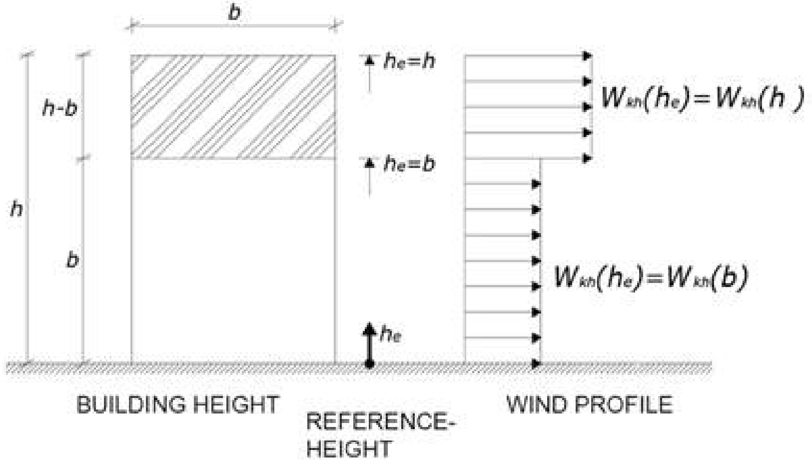
$$q_p(z) = 433.60N/m^2$$

$$q_b = 390.63N/m^2$$

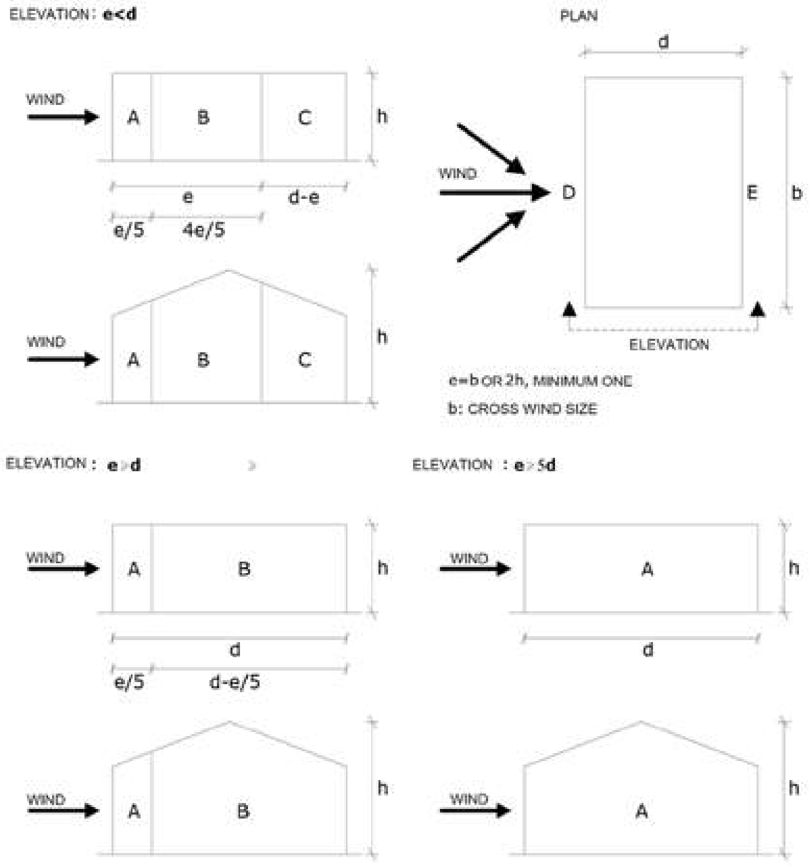
STRUCTURAL DESIGN

The following is the reference height of the rectangular plane building and the corresponding windward wall wind pressure profile

$b < h \leq 2b$



h: height of the building; h=17.25m
b: building dimension in the horizontal direction perpendicular to wind; b= 14.45m
d: dimension of building parallel to the wind direction; d=60.5m
h/d = 17.25/60.5 = 0.29
h_e: reference height which depends on the following parameters; $b < h < 2b$;
$h_e = b$
h_e = 14.45m; $h_e = h$, h_e = 17.25m
w_e= wind pressure acting on the external surfaces; $w_e = c_{pe}\, q_p\, (z_e)$
The external pressure coefficients c_{pe} for buildings and parts of buildings depend on the size of the loaded area of the structure, that produces the wind action in the section to be calculated. The external pressure coefficients are given for the loaded areas A of $1m^2$ and $10m^2$ in the tables for the appropriate building configurations as $c_{pe,1}$, for local coefficients and $c_{pe,10}$ for overall coefficients,respectively. In our calculation, the consideration of overall building is chosen and $c_{pe,10}$ value is respected.



FACADE PARTITION ON THE SIDE OF THE BUILDING

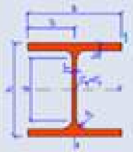
h/d was calculated as 0,29. Taking the following table into consideration the coefficients

Zones	A	B	C	D	E
h/d	$\delta_{pe,10}$				
5	-1.2	-0.8	-0.5	+0.8	-0.7
1	-1.2	-0.8	-0.5	+0.8	-0.5
≤ 0.25	-1.2	-0.8	-0.5	+0.8	-0.3

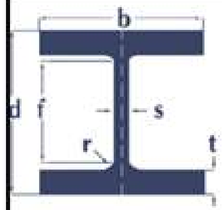
STRUCTURAL DESIGN

c_{pe}: pressure coefficients are calculated ; windward wall = 0,71 zone D
leeward wall = -0,32 zone E

$w_e = 0{,}71 * 433{,}60 = 307{,}86 \text{ N/m2}$; windward
$w_e = -0{,}32 * 433{,}60 = -138{,}75 \text{ N/m2}$; leeward
Since the h/d value is smaller than 1, obtained forced should be summed with 0,85.
A_i : influence area on wall; $A_i = 14.45m^2$
$c_s * c_d$: structural factor; $c_s * c_d = 1$
F_w : wind force; $F_w = c_s * c_d * \Sigma_i (w_{ei} * A_i)$
$F_w + 0{,}85 = 9{,}30\ kN$; windward
$F_w + 0{,}85 = -2.96kN$; leeward

HE200M			
Geometry		Section properties	
h = 220 mm		Axis y	Axis z
b = 206 mm		I_y = 1.06E+8 mm^4	I_z = 3.65E+7 mm^4
t_f = 25 mm		W_{y1} = 9.67E+5 mm^3	W_{z1} = 3.54E+5 mm^3
t_w = 15 mm		$W_{y,pl}$ = 1.14E+6 mm^3	$W_{z,pl}$ = 5.43E+5 mm^3
r_1 = 18 mm		i_y = 90.00 mm	i_z = 52.70 mm
y_s = 103 mm		S_y = 5.68E+5 mm^3	S_z = 2.72E+5 mm^3
d = 134 mm		Warping and buckling	
A = 13130 mm^2		I_w = 3.46E+11 mm^6	I_t = 2.59E+6 mm^4
A_L = 1.2 m^2 m^{-1}	G = 103 kg m^{-1}	i_w = 49.23 mm	i_{pc} = 104.3 mm

UC203X203X52



d	206.2	Depth d mm	b	203.9	Width b mm
s	8	Web s mm	t	12.5	Flange t mm
r	10.2	Root Radius r mm	f	160.8	Depth Between Fillets f mm
	52	Kg/m		19	Approx. Metres Per Tonne
	66.3	Area of Section cm²		1.2	Surface Area Per Metre m²
	23	Surface Area Per Tonne m²		0.013	Surface Area Two End Faces m²

DESIGN OF DECKING AND SLABS

Cellular secondary beams with composite slabs and steel decking are chosen for the slab design. It is composed of cellular beams that support composite slab that consist of steel deck profile and top concrete. The span of the beams ranges from 10m to 18m and openings are provided in close intervals. Secondary beams are normally placed at 3-4m spacing.
The system is highly advantageous, but it has also little disadvantages. One of the biggest advantages of the composite system is savings in steel weight of between 30 to 50% compared to non- composite ones. Advantages of this floor system are provision of large clear area without the need of columns, use lightweight utilized beams compared with other systems with the same span ranges and are cost effective. The only disadvantage is high cost of fabrication in comparison with plain section.Cellular beams are used as secondary beam structure to support the slab system.
Commonly, the shapes of openings of cellular beams are circular but other shapes are feasible to employ. It is recommended to omit openings at high shear locations such as regions close to supports. They are widely used where there is a need of piping and HVAC system installations passing through. Cellular beams are fabricated based on the exclusive use of hot rolled sections. A double cut-out is made in the web by flame cutting. The two obtained T-sections are shifted and rewelded leading to an increase in height.
The obtained structural product has an increased ratio of moment of inertia / weight. For a given section, the diameter and the spacing of openings are variable resulting in an extremely adjustable beam geometry and perfect suitability to project requirements. (The above is quoted from EN1994 Eurocode 4: Design of composite steel and concrete structures)

STRUCTURAL DESIGN

TYPES OF DECKING PROFILE

There are many types of profiled steel sheet used in composite slab. Mainly in two parts, open and closed. The following is most used profile types:

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	YX76-305-915	1220	0.75	105.00	23.28
			0.9	128.10	29.57
			1.0	148.45	36.50
			1.2	172.10	41.94
	YX130-300-600	1000	0.8	241.49	36.31
			0.9	275.99	41.50
			1.0	358.09	52.71
			1.2	441.34	63.95
	YX51-250-750	1000	0.8	44.23	14.59
			0.9	49.37	15.80
			1.0	56.21	18.28
			1.2	67.88	21.91
	YX35-125-750	1000	0.6	13.55	7.29
			0.8	18.13	9.69
			0.9	20.40	10.87
			1.0	22.67	12.05
	YX76-344-688	1000	0.8	117.63	29.53
			0.9	132.34	33.18
			1.0	147.06	36.84
			1.2	176.49	44.12
	YX51-305-915	1150	0.8	51.90	16.20
			0.9	57.40	19.70
			1.0	68.60	22.10
			1.2	76.50	28.10
	YX51-341-1025	1250	0.8	51.38	14.68
			0.9	57.80	16.52
			1.0	64.22	18.35
			1.2	77.06	22.02
	YX75-200-600	1000	0.8	89.9	21.95
			1.0	119.3	29.99
			1.2	151.84	39.39
	YX75-230-690 (1)	1100	0.8	121.93	31.53
			1.0	154.42	39.47
			1.2	[illegible]	47.52

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	YXB65-170-510	1000	0.8	98.60	22.41
			0.9	110.93	25.21
			1.0	123.35	28.01
			1.2	147.90	33.61
	YXB65-185-555	1085	0.8	93.80	17.05
			0.9	114.68	21.07
			1.0	123.35	23.27
			1.2	152.91	29.35
	YXB65-240-720	1210	0.75	83.50	21.30
			0.9	96.60	24.20
			1.0	104.30	25.90
			1.2	126.00	29.80
	YXB65-254-762	1250	0.8	71.21	39.89
			0.9	78.54	41.52
			1.0	85.86	43.15
			1.2	106.29	47.88
	YXB48-200-600	1000	0.8	43.24	12.35
			0.9	48.65	13.90
			1.0	54.05	15.44
			1.2	64.86	18.53
	YXB51-283-850	1250	0.8	12.35	43.24
			0.9	13.90	48.65
			1.0	15.44	54.05
			1.2	18.53	64.86
	YXB54-185-565	1000	0.8	52.72	15.34
			0.9	64.37	17.21
			1.0	71.52	19.07
			1.2	85.83	22.77
	YXB50-266.6-800	1200	0.8	52.72	15.34
			0.9	64.37	17.21
			1.0	71.52	19.07
			1.2	85.83	22.77

STRUCTURAL DESIGN

PROPERTIES OF TYPICAL DECKING

Thickness (mm)	Profiled plate weight (kg/m²)	Section moment of inertia (cm⁴/m)	Section resistance moment (cm³/m)	Effective width(mm)
0.8	10.45	89.9	21.95	600
1.0	13.08	119.3	29.99	
1.2	15.7	151.84	39.39	

YX75-200-600 composite slab properties with concrete C30/37 & S235

Composite slab thickness(mm)	Profiled plate thickness(mm)	Self-weight of composite slab (kg/m²)	Moment capacity(kNm)	Shear capacity(kN)
150	0.8	270	29.12	17.61
	1.0	273	35.01	21.17
	1.2	276	40.33	24.38
160	0.8	295	32.32	19.54
	1.0	298	39.01	23.59
	1.2	301	45.13	27.29
170	0.8	320	35.52	21.48
	1.0	323	43.01	26.00
	1.2	326	49.93	30.19
180	0.8	345	38.72	23.41
	1.0	348	47.04	28.44
	1.2	351	54.73	33.09

VERIFICATION OF COMPOSITE SLAB

Structural analysis

Structural analysis and dimensioning for the slab between the ground and the first floor.

The structural analysis will be carried out using liner analysis based on the theory of elasticity, considering the combination of actions for Ultimate Limit States. [EC2 –5.1.3(1)P] that is [EC0 – Expression 6.10] and [National Annex of Italy]

$$\Sigma_{j\geq 1}\gamma_{Gj}G_{kj} + \gamma_{Q1}Q_{k1} + \Sigma_{i>1}\gamma_{Qi}\Psi_{0i}Q_{ki}$$

Loads

Permanent actions: floor weight with finishes

- floor self-weight: $G_1 = 3.51\frac{kN}{m2}$; $\gamma_G = 1.35$

- Other permanent loads: $G_2 = 2\ \frac{kN}{m2}$; $\gamma_G =$ 1.35

(floor finishes, etc.)

Variable actions:

- Live loads: $Q_1 = 2\ \frac{kN}{m2}$; $\gamma_Q = 1.5$

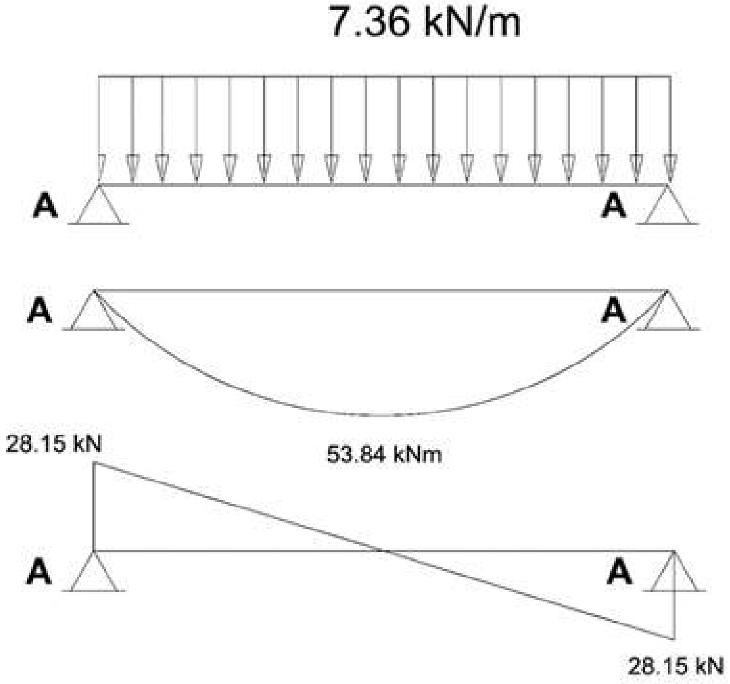
- Internal walls self-weight: $Q_2 = 0.565\ \frac{kN}{m2}$; $\gamma_Q = 1.5$; $\Psi_Q =$ 0.3

Ultimate Limit State= permanent load+ variable load=5.51*1.35+2.565*1.5=7.36kN/m

STRUCTURAL DESIGN

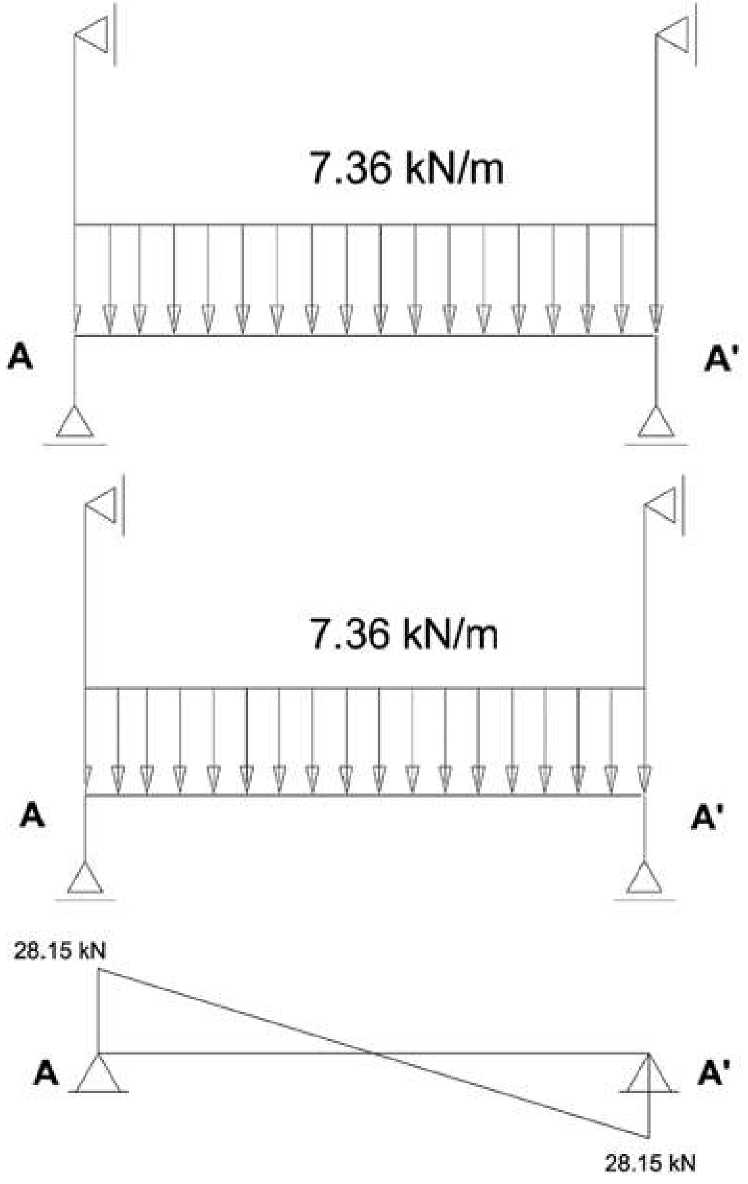
MATERIAL PROPERTIES

Combination 1



Reactions:	Max. moment in the middle
$R_1 = 28.15\ kN$ $R_2 = 28.15\ kN$	$M_{max} = 53.84\ kNm$

Combination 2



Reactions:	Max. moment in the middle
$R_1 = 28.15\ kN$ $R_2 = 28.15\ kN$	$M_{max} = 35.89\ kNm$ $M_1 = 17.94\ kNm$ $M_2 = 17.94\ kNm$

Flexture ULS verification

$$M_{Ed} = ql^2/8 = 53.84kNm < M_{Rd} = 54.73kNm$$

Shear ULS verification

$$V_{ed} = \frac{ql}{2} = 28.15kN \qquad V_{rd} = 33.09kN$$

DESIGN OF BEAM

This area is designed with steel elements (S235 JR), fy=235MPa.

Load Analysis

Permanent loads:

- Self-weight of the slab G1 (reaction in the continuity support from G=3.51kN/m2):

$$G_{1beam} = 8.736\frac{kN}{m}$$

- Other permanent loads G2 (reaction in the continuity support from G=2kN/m)

$$G_{2beam} = 6.72\frac{kN}{m}$$

Variable loads:

- Live load Q1 (reaction in the continuity support from Q=2kN/m)

$$Q_{1beam} = 6.72\frac{kN}{m}$$

- Inside partition self-weight Q2 (reaction in the continuity support from Q=0.565kN/m2)

$$Q_{2beam} = 1.90\frac{kN}{m}$$

In total:

total SLS load = 24.076kN/m2
total ULS load = 33.80 kN/m2

Beam SLS verification

Checking the beam of deflection:

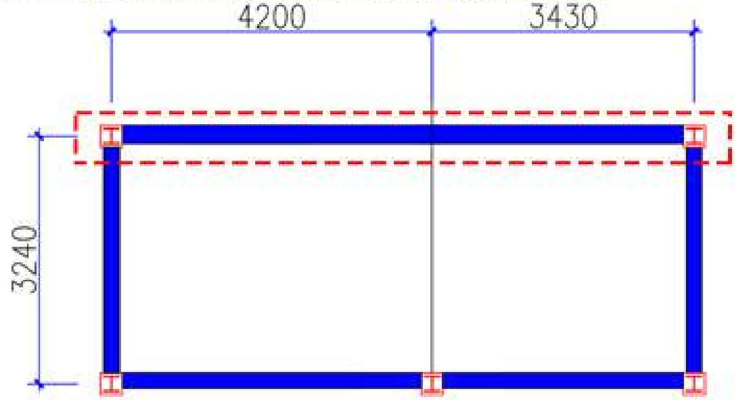
$$\delta \leq \frac{L}{500}$$

according to calculations:

$$\delta = \frac{5}{384} * \frac{p * L^4}{E * I} \rightarrow I = \frac{5}{384} * \frac{p * L^4}{E * \delta} = \frac{5}{384} * \frac{40440 * 7650^4}{210 * 10^9 * \frac{7650}{500}} = 18952cm^4$$

where p= 24.076kN/m * 3.22/2 = 40.44kN and L = 7.65 (biggest span) and E = 210 GPa

The beams considered for the metallic floor structure were:



Then, we can search for a **steel profile** according to the needed moment of inertia in order to overcome the deflection limitation:

HE 200M

Weight=103 kg/m

$I_y = 10640\ cm^4 = 10640 * 10^4 mm^4$

A=$131cm^2 = 13100mm^2$

Checking the profile for deflection:

$\delta = \frac{5}{384} * \frac{40440*7650^4}{210*10^9*10640*10^4} = 6.63mm \leq 6.72$ (ok)

Beam ULS verification

Classification of the section

S235 – HE 200M

Where $f_{yk} = 235MPa$ and $f_{yd} = \frac{235}{1.15} = 204MPa$

Resistance check of the section:

Bending check:

$\frac{M_{Ed}}{M_{Rd}} \leq 1.0$

$M_{Ed} = M_{max} = \frac{p * L^2}{8} = \frac{33.08\frac{kN}{m} * (7.65m)^2}{8} = 106.68kN * m$

$M_{Rd} = \frac{W_{plz} * f_{yd}}{\gamma_{M0}} = \frac{543*10^3mm^3*204\frac{N}{mm^2}}{1} = 110.77\text{kN} * \text{m}$ (ok)

Shear check for the section

$\frac{V_{Ed}}{V_{Rd}} \leq 1.0$

$V_{Ed} = M_{max} = \frac{p * L}{2} = \frac{33.08\frac{kN}{m} * 7.65m}{2} = 126.5kN$

$V_{Rd} = V_{pl,Rd} = \frac{A_v * \frac{f_{yd}}{\sqrt{3}}}{\gamma_{M0}} = \frac{2520mm^2 * \frac{204MPa}{\sqrt{3}}}{1} = 296.8\text{kN}$ (ok)

Where $A_v = n * R * t_w = 1 * 220 * 15 = 2520mm^2$ HE deep*thickness

$\frac{V_{Ed}}{V_{Rd}} = \frac{126.5}{296.8} = 0.42 < 0.5$ which means we do not need to check the relation between bending and shear.

Lateral-Torsional Buckling check:

$\frac{M_{Ed}}{M_{b,Rd}} \leq 1.0$

$M_{Ed} = M_{max} = \frac{p * L^2}{8} = \frac{33.08\frac{kN}{m} * (7.65m)^2}{8} = 106.68kN * m$

$= 106.68 * 10^6 N * mm$

$$M_{cr} = C_1 \frac{\pi^2 * E * I_z}{(k_z * L)^2} * \sqrt{\left(\frac{k_z}{k_w}\right)^2 * \frac{I_w}{I_z} + \frac{(k_z * L)^2 * G * I_T}{\pi^2 * E * I_z} + (C_2 * z_g)^2} - (C_2 * z_g)$$

$$= 1.12 * \frac{\pi^2 * 210 * 10^3 * 36510000}{(1 * 7650)^2}$$

$$* \sqrt{\left(\frac{1}{1}\right)^2 * \frac{347000}{3651 * 10^4} + \frac{(1 * 7650)^2 * 81 * 10^3 * 2580000}{\pi^2 * 210 * 10^3 * 3651 * 10^4} + (0.45 * 110)^2}$$

$$- (0.45 * 110)$$

$\boldsymbol{M_{cr} = 1376.65 * 10^6 N * mm}$

Where zg=za-zs=h/2-zs=220/2-0=110mm.

$\overline{\lambda_{LT}} = \sqrt{\frac{w_{el,y} * f_y}{M_{cr}}} = \sqrt{\frac{967000*204\frac{N}{mm2}}{1376.65*10^6}}$=0.38

h/b=220/206=1.068<2

→we should take buckling curve a(since h/b<2)

→ $\alpha_{LT} = 0.21$(buckling curve factor for curve a)

$$\Phi = 0.5 * \left(1 + \alpha_{LT} * \left(\overline{\lambda_{LT}} - 0.2\right) + \overline{\lambda_{LT}}^2\right)$$

$$= 0.5 * (1 + 0.21 * (0.38 - 0.2) + 0.38^2)$$

$\Phi = 0.59$

$$\chi_{LT} = \frac{1}{\Phi + \sqrt{\Phi^2 - \overline{\lambda_{LT}}^2}} = \frac{1}{0.59 + \sqrt{0.59^2 - 0.38^2}} = 0.96$$

$$M_{b,Rd} = \chi_{LT} * W_y * \frac{f_y}{\gamma_{M1}} = 0.96 * 967000mm^3 * \frac{204}{1} = 189.38 * 10^6 N * mm$$

$\frac{M_{Ed}}{M_{b,Rd}} = \frac{46.68}{189.38} = 0.25 \leq 1.0$ (ok)

DESIGN OF COLUMN

The area of load for 1 column is A=$\frac{3.22+2.76}{2} * \frac{7.65}{2} = 11.7m^2$

-Dead loads:

-roof aluminum sandwich panel

G1=0.6 kN/m2

$Y_Q = 1.35$

-beam HE 200M

103*9.81=1.01kN/m 1.01kN/m*3.825m=3.09KN

G1=3.09kN/11.7m2=0.26kN/m2

$Y_Q = 1.35$

Total dead loads: G1=0.86kN/m2 & $Y_Q = 1.35$

-Imposed loads: for a category 2 roof

Q1=1kN/m2

$Y_G = 1.5$

-Snow loads

Q1=1.2kN/m2

$Y_G = 1.5$

STRUCTURAL DESIGN

Roof

- Permanent loads

$0.86\text{kN}/m^2 \times 11.7\ m^2 = 10.06\ kN$

- Variable loads

$2.2\text{kN}/m^2 \times 11.7m^2 = 25.74\ kN$

Residential floors

- Permanent loads

$5.51\text{kN}/m^2 \times 11.7\ m^2 = 64.467\ kN$

- Variable loads

$2.565\text{kN}/m^2 \times 11.7m^2 = 30.01\ kN$

LOFT

- Permanent loads

$5.51\frac{\text{kN}}{m^2} \times 11.7\ m^2 * 1.5 = 96.7\ kN$

- Variable loads

$2.565\text{kN}/m^2 \times 11.7m^2 = 30.01\ kN$

Roof	Permanent 10.06kN Variable 25.74kN
Floor 3(Residential)	Permanent 96.7 kN Variable 30.01 kN
Floor 2(Residential)	Permanent 64.467 kN Variable 30.01 kN
Floor 1(Residential)	Permanent 96.7 kN Variable 30.01 kN

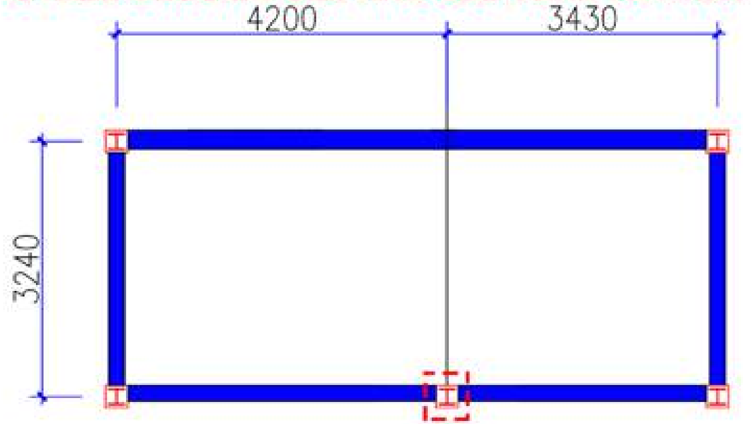
Total SLS load:

(10.06+96.7+64.467+96.7)+(25.74+30.01+30.01+30.01)= 383.697kN/m2

Total ULS load:

1.35*(10.06+96.7+64.467+96.7)+1.5*(25.74+30.01+30.01+30.01)= 535.36kN/m2

STEEL COLUMN ULS AND SLS VERIFICATION



Compression in ULS:

$$N_{c,Rd} = \frac{A \cdot (f_y)}{\gamma_{M_0}}$$

$N_{c,Rd}$=535.36

$$A = \frac{N_{c,Rd} \cdot \gamma_{M_0}}{fy} = \frac{535.36 \times 1000\text{N} \times 1}{204\ N/mm2} = 2624.3\ \text{mm2}$$

We choose profile **UC203x203x52** (A=6680mm2)

Compression in ULS:

Lets consider a slenderness $\lambda = 100$,then no-dimensional slenderness $\bar{\lambda} = \frac{100}{87} = 1.15$

According to this data, we can obtain a reduction factor of $\chi = 0.4$

$$N_{c,Rd} \leq \frac{\chi * A \cdot (f_y)}{\gamma_{M_0}} = 558.448kN$$

$\frac{\mathbf{N_{Ed}}}{\mathbf{N_{Rd}}} \leq \mathbf{1.0}$ OK!

STRUCTURAL DESIGN

COLUMN BASE

Ground Floor(Residential)	Permanent 64.467 kN Variable 30.01 kN

Total SLS load: $64.467 + 30.01 = 94.477 kN/m^2$

Total ULS load: $1.35 * 64.467 + 1.5 * 30.01 = 132.045 kN/m^2$

Columns are assumed to be pin-ended 200mm*200mm base plate is considered in the beginning

Basic requirement: $A_p \geq A_{req}$

A_p: Area of base plate ; $A_p = 300 * 300 = 90000\ mm^2$

For the concrete capacity of foundation

$$f_{cd} = \frac{f_{ck} * \alpha_{cc}}{\gamma_c} = \frac{0.85 * 30}{1.5} = 17 N/mm^2$$

$f_{id} = \alpha * \beta_i * f_{cd}$ where $\alpha = 1.5; \beta_i = 2/3$

$$f_{id} = 1.5 * \frac{2}{3} * 17 = 17 N/mm^2$$

A_{req}: Area required ; $A_{req} = N_{ed}/f_{id}$

$N_{ed} = 621.44N$

$$A_{req} = \frac{621.44 * 10^3}{17} = 36555.3\ mm^2$$

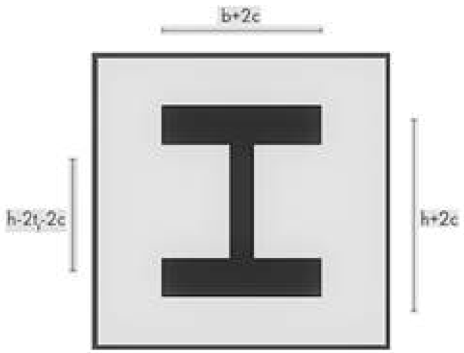
$A_p = 90000mm^2 > 36555.3\ mm^2$

Effective area check

Basic requirement $A_{eff} = A_{req}$

A_{eff}: effective area $A_{eff} = 4 * c^2 + section\ perimeter * c + section\ area$

c : projection width



Section perimeter of UC203x203x52 =821 mm

Section area 6680 mm2

$36555.3 = 4 * c^2 + 821c + 6680$

c=31mm ; also $c < \frac{h-2t_f}{2} = \frac{206.2-2*7.9}{2} = 95mm$

Even though 'c value' is satisfying the requirement, it is occurred being too small. Recalculation of 'c value' will be done. 'c value' will be verified with base plate dimensions

$$h + 2c < h_p ; c < \frac{300 - 206.2}{2} = 46.9mm$$

$$b + 2c < b_p ; c < \frac{300 - 204.3}{2} = 47.85mm$$

As a result, c value is decided to be taken as 40mm.

FOUNDATION

A simple calculation of the plinth under the inside column P4 is presented

Bearing capacity

The foundation of the 300*300mm column is 1500*1500mm footing foundation with a depth of 800mm

$$G_{plinth} = (1.5 * 1.5 * 0.8)m^3 * \frac{25kN}{m^3} = 32.625kN$$

Assuming a gravel soil with internal friction angle to $\varphi = 35$ and density $\gamma = 18$ kN/m3, the bearing capacity of the soil is given by the Terzaghi formula, where the pressure due to the lateral soil is not considered:

$$\sigma_{Rd,terreno} = s_\gamma N_\gamma \gamma b/2$$

where $s_\gamma = 1 - \frac{0.4b}{a}$ $\qquad N_\gamma = 2 < e^{\pi tg\emptyset} tg^2\left(\frac{\pi}{4} + \frac{\emptyset}{2}\right) + 1 > tg\emptyset$

The verification implies that $\sigma_{Rd,terreno,d} > \sigma_{Ed}$ where σ_{Ed} is the design pressure on the soil due to loads and foundation self-weight.

According to Eurocode 7 [EC7 – 2.4.7.3.4] and Eurocode 0 [EC0 – A1.3(5)] the following values for combination coefficients apply, where γ_F refers to actions, γ_M refers to geotechnical parameters and γ_R refers to the soil resistance after the previous calculations.

$\gamma_F = \gamma_G = 1.0$ **for permanent loads** [EC7 – Table A.3]
$\gamma_F = \gamma_G = 1.3$ **for variable loads** [EC7 – Table A.3]

A single value can be used averaging the previous coefficients: $\gamma_F = 1.13$

$\gamma_M = 1.25$ for the internal friction angle [EC7–Table A4] and to be applied to the tangent of the angle ϕ

$\gamma_M = 1.0$ for the soil density [EC7 – Table A4]

$\gamma_R = 1.4$ [EC7 – Table A5]

Table A.3 - Partial factors on actions (γ_F) or the effects of actions (γ_E)

Action		Symbol	Set	
			A1	*A2*
Permanent	Unfavourable	γ_G	1,35	1,0
	Favourable		1,0	1,0
Variable	Unfavourable	γ_Q	1,5	1,3
	Favourable		0	0

Table A.4 - Partial factors for soil parameters (γ_M)

Soil parameter	Symbol	Set	
		M1	*M2*
Angle of shearing resistance[a]	$\gamma_{\varphi'}$	1,0	1,25
Effective cohesion	$\gamma_{c'}$	1,0	1,25
Undrained shear strength	γ_{cu}	1,0	1,4
Unconfined strength	γ_{qu}	1,0	1,4
Weight density	γ_γ	1,0	1,0
[a] This factor is applied to tan φ'			

Table A.5 - Partial resistance factors (γ_R) for spread foundations

Resistance	Symbol	Set		
		R1	*R2*	*R3*
Bearing	$\gamma_{R;v}$	1,0	1,4	1,0
Sliding	$\gamma_{R;h}$	1,0	1,1	1,0

Column Dimensioning	Ned(kN)
Floor 3	52.19
Floor 2	227.75
Floor 1	359.80
Ground Floor	535.36
Basement	667.41

$$N_{Ed} = 1.13 * N + 1.0 * G_{plinto} = 1.13 * 667.41 + 1.0 * 32.625 = 786.80kN$$

$$\sigma_{Ed,terreno,d} = \frac{N_{Ed}}{a * b} = \frac{786.80}{1500 * 1500} = 0.035\text{MPa}$$

$$S_y = (1 - 0.4) * \frac{1500}{1500} = 0.6$$

$$\text{tg}\varphi = \frac{\text{tg}35}{1.25} = 0.56$$

$$N_\gamma = 20.06kN$$

$$\sigma_{Rd,terreno,d} = (\frac{0.56 * 20.06 * \frac{18kN}{m3} * 1500mm}{2})/1.4 = 0.11\text{MPa}$$

PLINTH VERIFICATION

Direction of A

a =1500mm, a'=300mm, d_a=375mm

$$c_a = \min\left(0.2d_a, \frac{a'}{4}\right) \quad then \quad c_a = 75mm$$

$$l_a = \frac{a - a'}{4} + c_a \qquad \lambda_a = \frac{l_a}{d_a}$$

$$l_a = \frac{1500 - 300}{4} + 75 = 375\text{mm} \qquad \lambda_a = \frac{l_a}{d_a} = \frac{375}{375} = 1$$

$$P_{Ed,sa} = \frac{1500 - 300}{1500} * 667.41 * 1.4 = 747.50kNm$$

$$A_{sa} = \frac{2P_{Ed,sa} * \lambda_a}{2 * fyd} * \gamma_F * 1.1 = 1470.7mm^2$$

we pick the 5Ø20, Asa=1570.80 mm^2

Direction of B

b =1500mm, b'=200mm, $d_b = 375mm$

$$c_b = \min\left(0.2d_b, \frac{b'}{4}\right) \quad then \quad c_b = 75mm$$

$$l_b = \frac{a - a'}{4} + c_b \qquad \lambda_b = \frac{l_b}{d_b}$$

$$l_b = \frac{1500 - 300}{4} + 75 = 375\text{mm} \qquad \lambda_b = \frac{l_b}{d_b} = 1$$

$$P_{Ed,sb} = \frac{1500 - 300}{1500} * 667.41 * 1.4 = 747.50kNm$$

$$A_{sb} = \frac{2P_{Ed,sb} * \lambda_b}{2 * fyd} * \gamma_F * 1.1 = 1470.7mm^2$$

we pick the 5∅20, Asa=$1570.80\ mm^2$

CONCRETE CAPACITY

It is to be noted that the self-weight of the footing is not considered in its verifications since, balance at each point by the corresponding soil reaction, it does not generate internal forces.

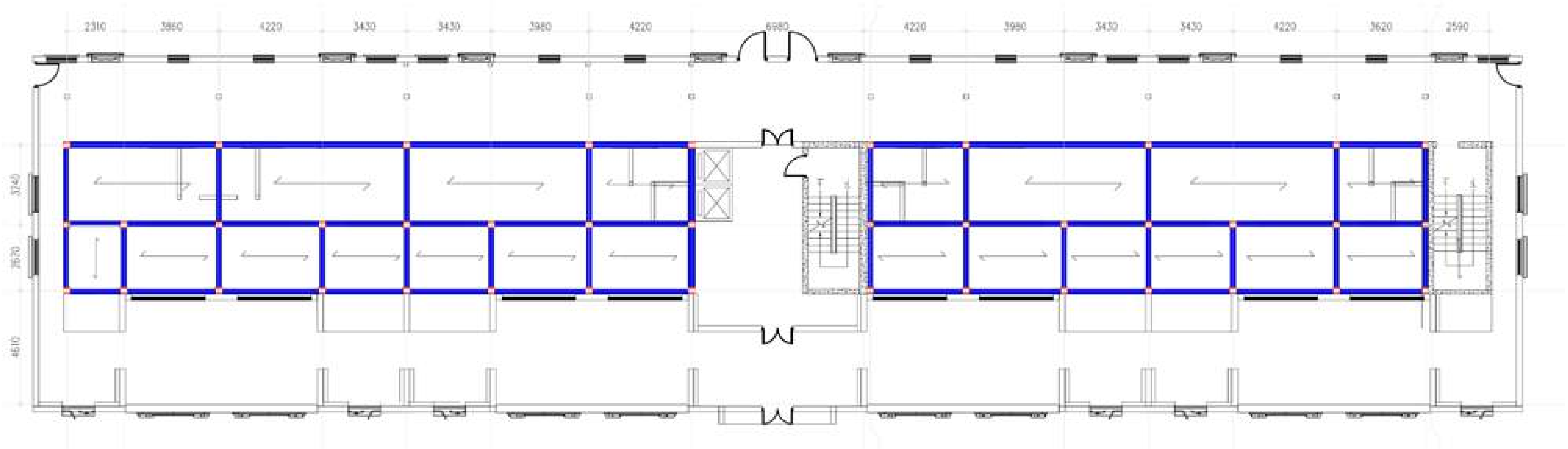
$$P_{Ed,c} = N_{Ed}\left(1 - \frac{a'b'}{ab}\right) = 1.4 * 667.41kN * (1 - \frac{300 * 300}{1500 * 1500}) = 897.0kNm$$

$$P_{Rd,c} = 2 * 0.4\left(\frac{d_a}{1 + \lambda a^2} + \frac{d_b}{1 + \lambda b^2}\right) f_{cd} = 13.6 * \left(\frac{375 * 200}{1 + 1} + \frac{375 * 200}{1 + 1}\right)$$
$$= 1274.9\text{kNm}$$

$P_{Rd,c} > P_{Ed,c}$ OK

STRUCTURAL DESIGN

Ground Floor

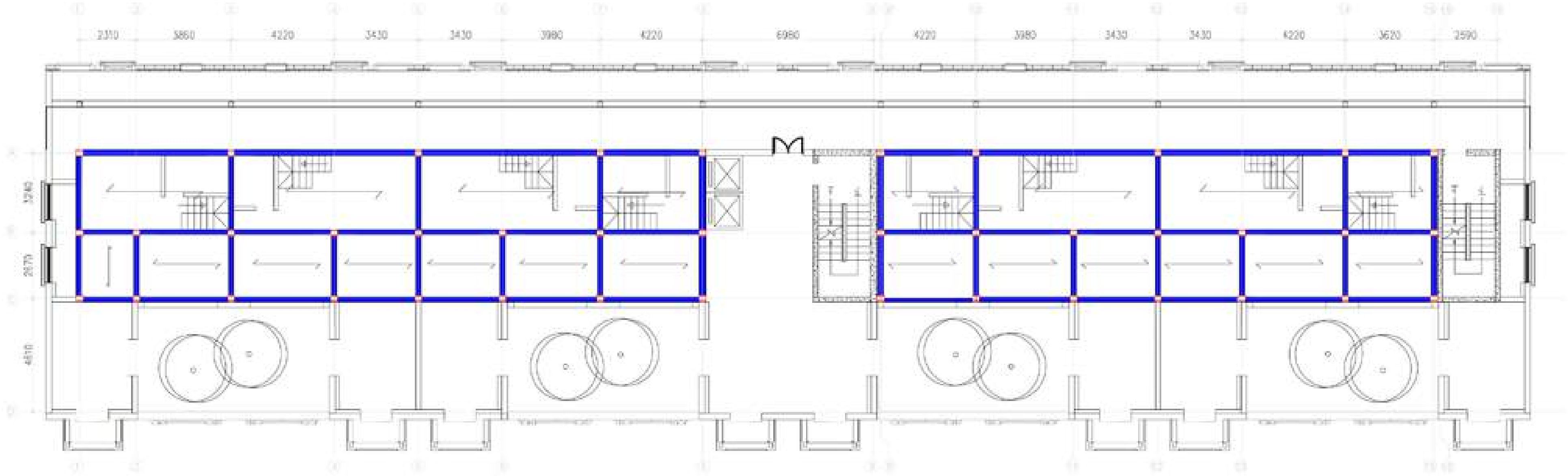


Scale 1:200

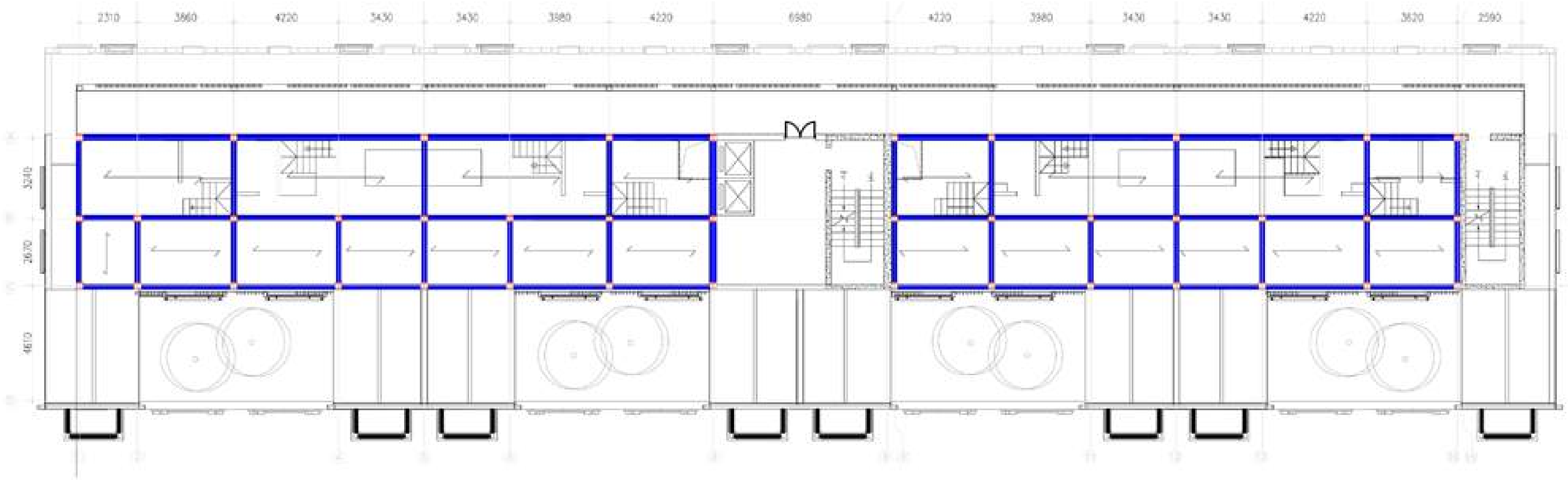
LEGEND (STRUCTURAL TYPE)	
UC203*203*52 COLUMN	HE200M BEAM
COMPOSITE SLAB	VOID
SHEAR WALL	

STRUCTURAL DESIGN

First Floor



Second Floor



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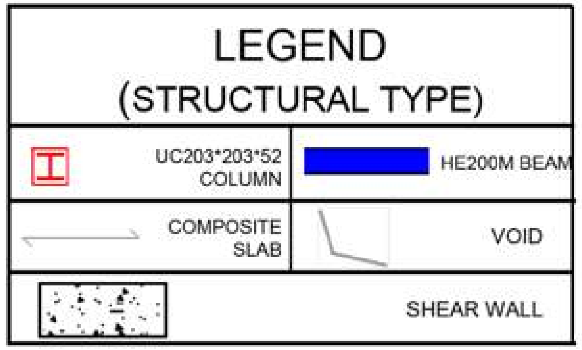
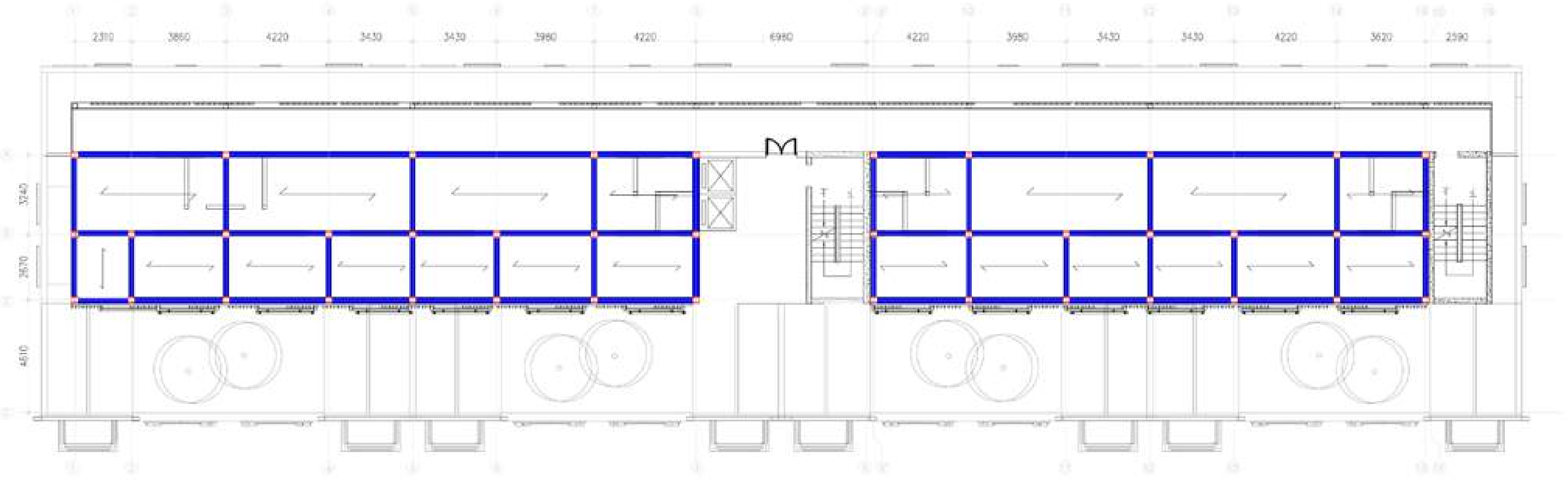
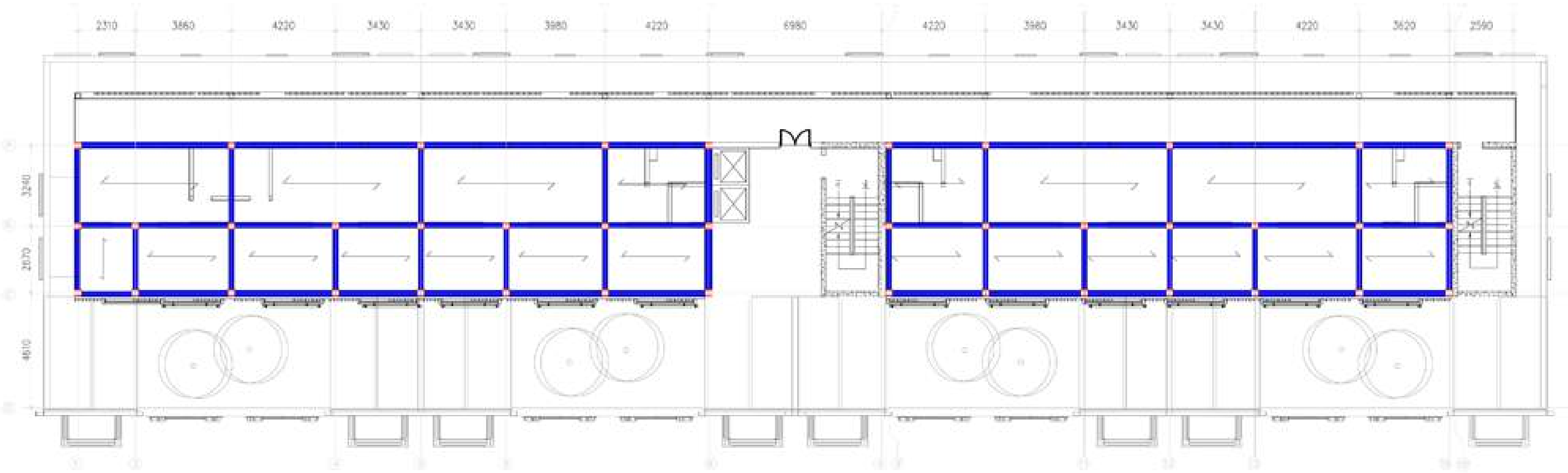


STRUCTURAL DESIGN

Third Floor



Fourth Floor



Scale 1:200

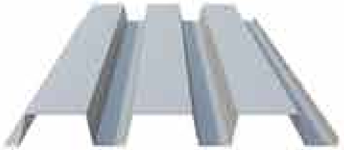
LEGEND
(STRUCTURAL TYPE)

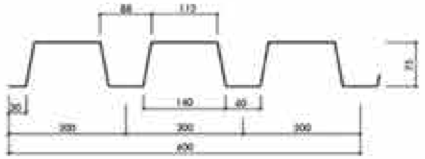
UC203*203*52 COLUMN	HE200M BEAM
COMPOSITE SLAB	VOID
SHEAR WALL	

STRUCTURAL FRAME

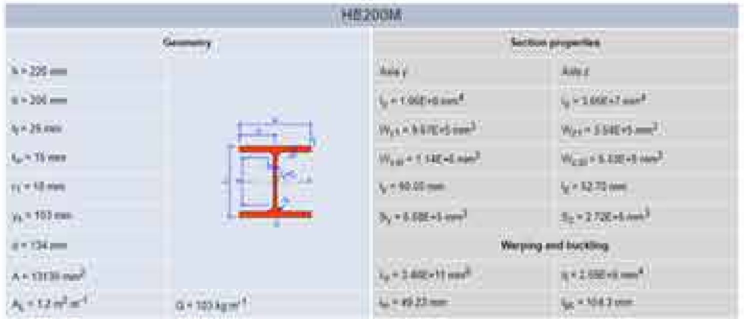
Our final steel frame is shown on the right. Following is the type we used during our structural design.

STEEL DECKING PROFILE :YX75-200-600 composite slab with concrete 180mm thickness (produced by waskind compny)





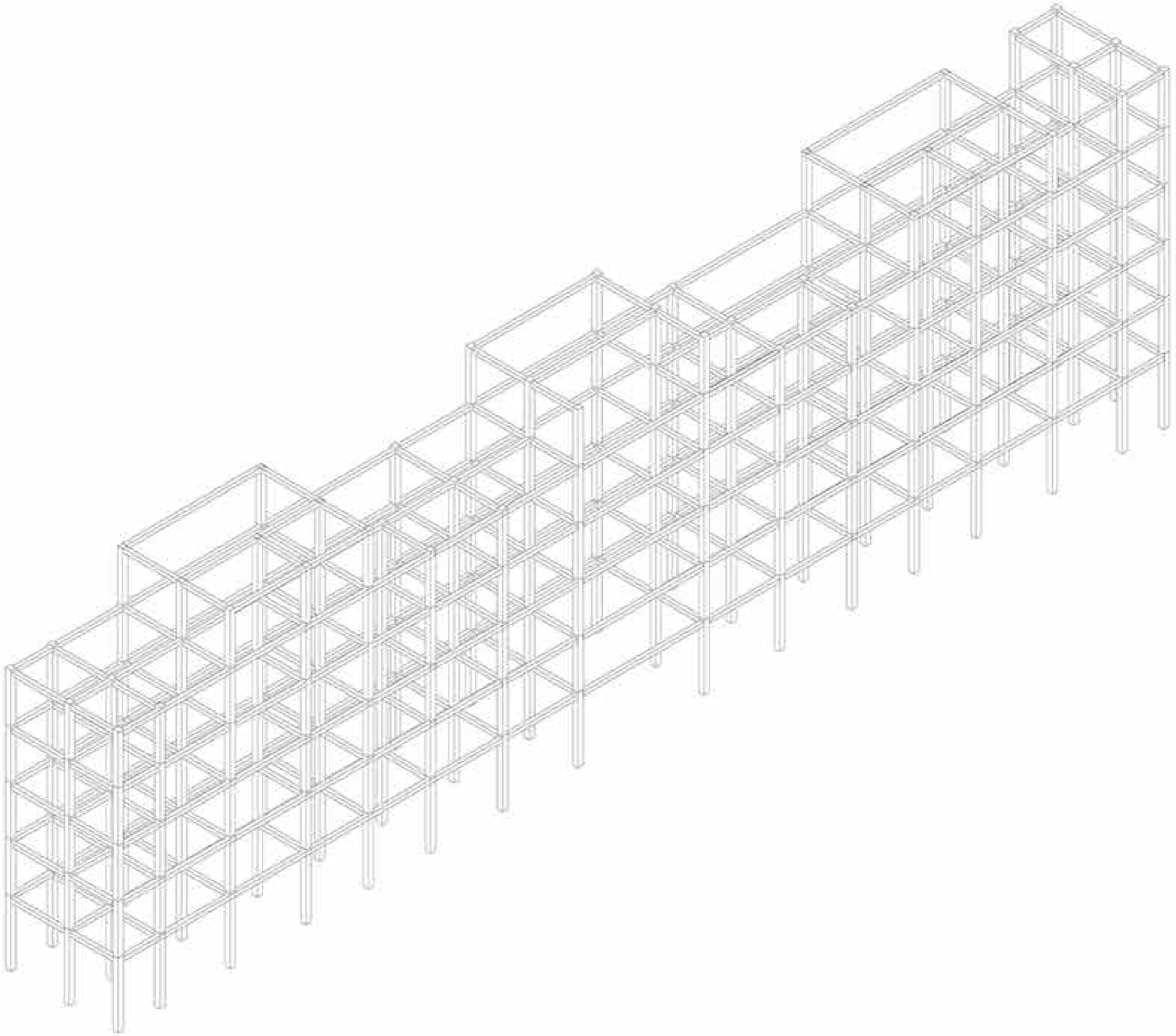
STEEL BEAM TYPE: S235-HE 200M



HE200M			
Geometry		Section properties	
h = 220 mm		Axis y	Axis z
b = 206 mm		I_y = 1.06E+8 mm^4	I_z = 3.66E+7 mm^4
t_f = 25 mm		$W_{el,y}$ = 9.67E+5 mm^3	$W_{el,z}$ = 3.54E+5 mm^3
t_w = 15 mm		$W_{pl,y}$ = 1.14E+6 mm^3	$W_{pl,z}$ = 5.43E+5 mm^3
r_1 = 18 mm		i_y = 90.00 mm	i_z = 52.70 mm
y_s = 103 mm		S_y = 5.68E+5 mm^3	S_z = 2.72E+5 mm^3
d = 134 mm		Warping and buckling	
A = 13130 mm^2		I_w = 3.46E+11 mm^6	I_t = 2.59E+6 mm^4
A_L = 1.2 m^2 m^{-1}	G = 103 kg m^{-1}	i_{lt} = 49.23 mm	i_{pc} = 104.3 mm

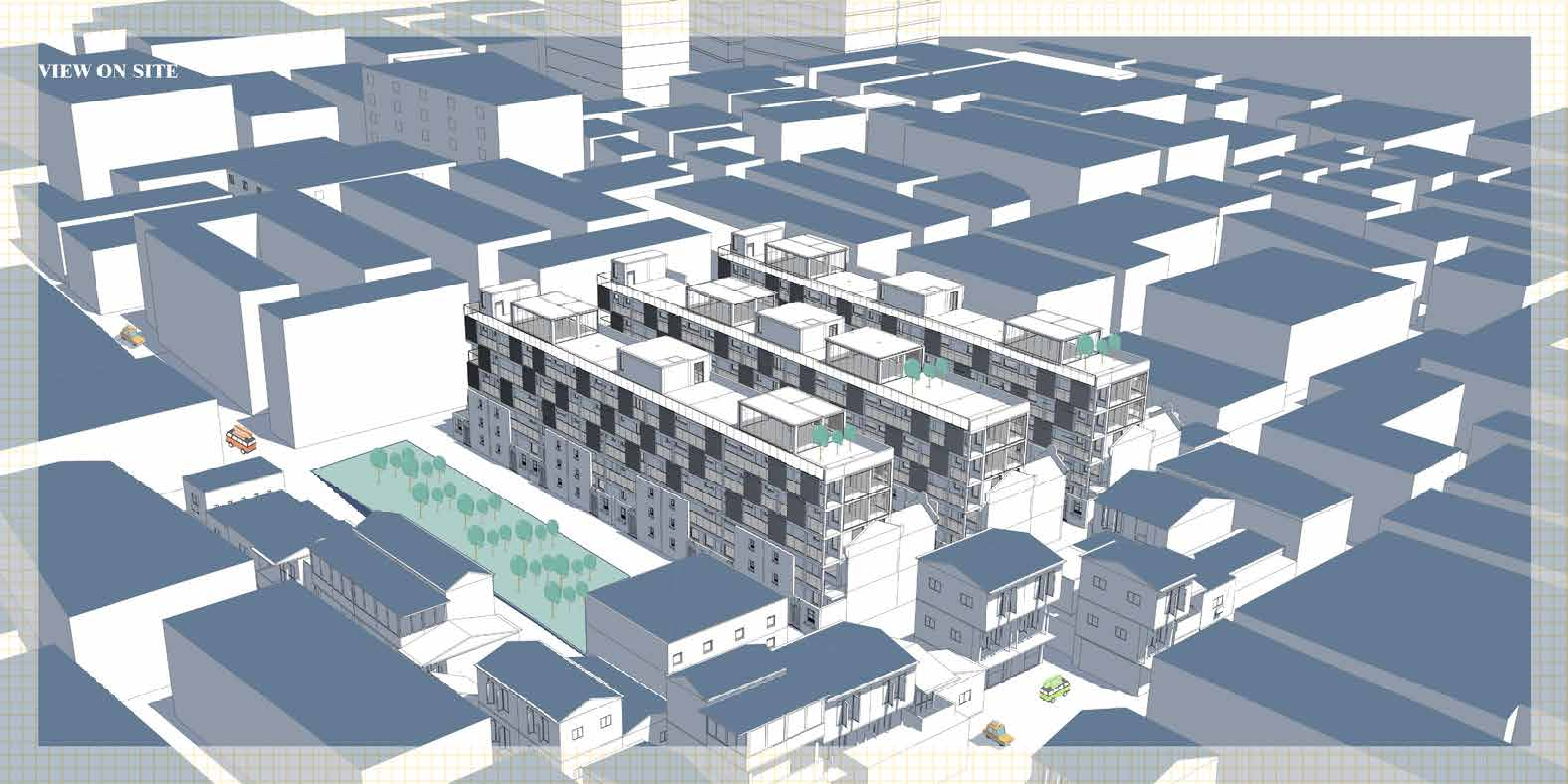
STEEL COLUMN TYPE:UC203X203X52(6680 mm^2)

Dimensions	Specifications	Description			
Measurements from diagram					
d	206.2	Depth d mm	b	203.9	Width b mm
s	8	Web s mm	t	12.5	Flange t mm
r	10.2	Root Radius r mm	[illegible]	160.8	Depth Between Fillets f mm
	52	Kg/m		19	Approx. Metres Per Tonne
	66.3	Area of Section cm²		1.2	Surface Area Per Metre m²
	23	Surface Area Per Tonne m²		0.013	Surface Area Two End Faces m²



VIEW

VIEW ON SITE



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