

**An-Najah National University**  
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**Integrated redesign of a shopping mall in Jenin city**

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**Submitted as partial fulfillment of the requirements of BS degree in Building Engineering.**

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## **Dedication**

We dedicate our dissertation—our capstone project—to the engineering faculty of AnNajah University, in particular the building engineering department, for its dearth of educationally relevant information resources, lack of pleasant study spaces, and plenty of technological advancements. and tools that really aided us during the study process. This commitment also extends to our cherished medical professionals who took the time and care to train us and provide us the knowledge and information we needed to succeed in life. A particular thanks goes out to Dr. Haitham Sawalha, our graduation project's supervisor, who not only helped us with the project but also encouraged us to put our best efforts forward in order to reach the end result.

## **Acknowledgment**

Similar to any significant undertaking, such as a graduation project, which necessitates years of toil and Without the support and affection of those around us, devotion with the goal of achieving it would not be possible. Therefore, we would like to thank God for providing in the first place. Throughout our labor, you have given us wisdom and benefits. Second, we sincerely appreciate our parents and siblings for their unending love and support throughout the periods when such acts of faith and inspiration were required for us to overcome this challenging obstacle. Last but not least, we would want to thank our physicians for being sincere and honest in their work and educating us with the purpose that we students would excel in what we execute in our fields of employment. A special thank you goes out to Dr. Haitham Sawalha for being the best boss anybody could ask for.

## **Abstract**

This project is important because it helps the economy growth in Jenin. Jenin city lacks this type of malls, so this project encourages investors to buy shops in this mall. This shopping mall consists of 6 floors and one basement, the ground floor is a shopping center with an area of 960-meter square, the first floor up to the sixth floor is residential apartment for renting purposes. The main objective of the project will cover how the architectural plans will be examined and modified to meet the recommended standards, in addition to How the project will be environmentally be analyzed and treated from various perspectives, also how will a structural design plan be developed to be economically and operationally appropriate for the project, how will a electromechanical design will be done for the whole project, how will a cost estimate for the project be made, and the most crucial factor is how well all of these components will combine and cooperate.

Architecture redesign has been done by considering the size of the interior rooms, traffic flow, and the suitable function for each space. Environmental design involves calculating heating and cooling loads, calculating U-value for each component of the building, installing treatments to the elevations of the building, in addition to discussing the thermal, natural daylight, CFD, and energy consumption of the building. In this project a structural design is done by developing a thorough design for all of the building's current support structures, tests and values needed for various tests are gathered by using different soft wares. In addition to the proposed code used to satisfy structural requirements. A fully electromechanical design is done for the building including artificial lightning, HVAC, power, acoustical, firefighting system, water supply, drainage, and elevators. Created a cost estimation for the project. Last but not least, is establishing integration throughout the facility's engineering systems.

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## **CHAPTER 1 INTRODUCTORY**

**This chapter will outline the project, identify and address challenges, describe objectives, describe the process used to finish the project, and collect the literature required for the design.**

## **1.1. Introduction**

Jenin city is located at the north of Palestine, its area is about 37.3 km<sup>2</sup>, which makes a significant percentage of the total area of the west bank. Jenin's population is about 55,933 and 11,674 for Jenin's camp with a total of 67,607. Jenin's market is distinguished by its purchasing power due to the entry of Arabian people from the occupied cities inside the separation wall, who are reviving the city's economy.

Jenin lacks commercial complexes compared to its huge area and its big population, there are just three known commercial complexes like, City Center Mall, Taj Mall, and Clock Tower mall.

According to the official definition, a shopping mall is one or more buildings constituting a complex of shops representing merchandisers, with interconnected walkways enabling customers to stroll from unit to unit. Unofficially, they serve as the social haven for youths worldwide, the cornerstone of retail businesses, and the lifeblood of communities. The idea of the shopping mall, which originated in the United States and blossomed into a full-fledged modern retail trend there in the years following World War II, has recently spread around the world. Nowadays, Asia is home to the top five malls worldwide.

Malls' influence on people's lives is changing as a result of a confluence of concurrent global events. Their main purpose is no longer to shop. Consumers now search for experiences at malls that go much beyond simple retail therapy.

Some customers prefer mixed-use complexes where they can live, shop, and work all within walking distance rather than having to get in their car and travel to a busy suburban mall due to sustainability concerns.

## **1.2. Project problems**

Many subjects will be covered in this project, including:

1.2.1. How the architectural plans will be examined and modified to the recommended standards.

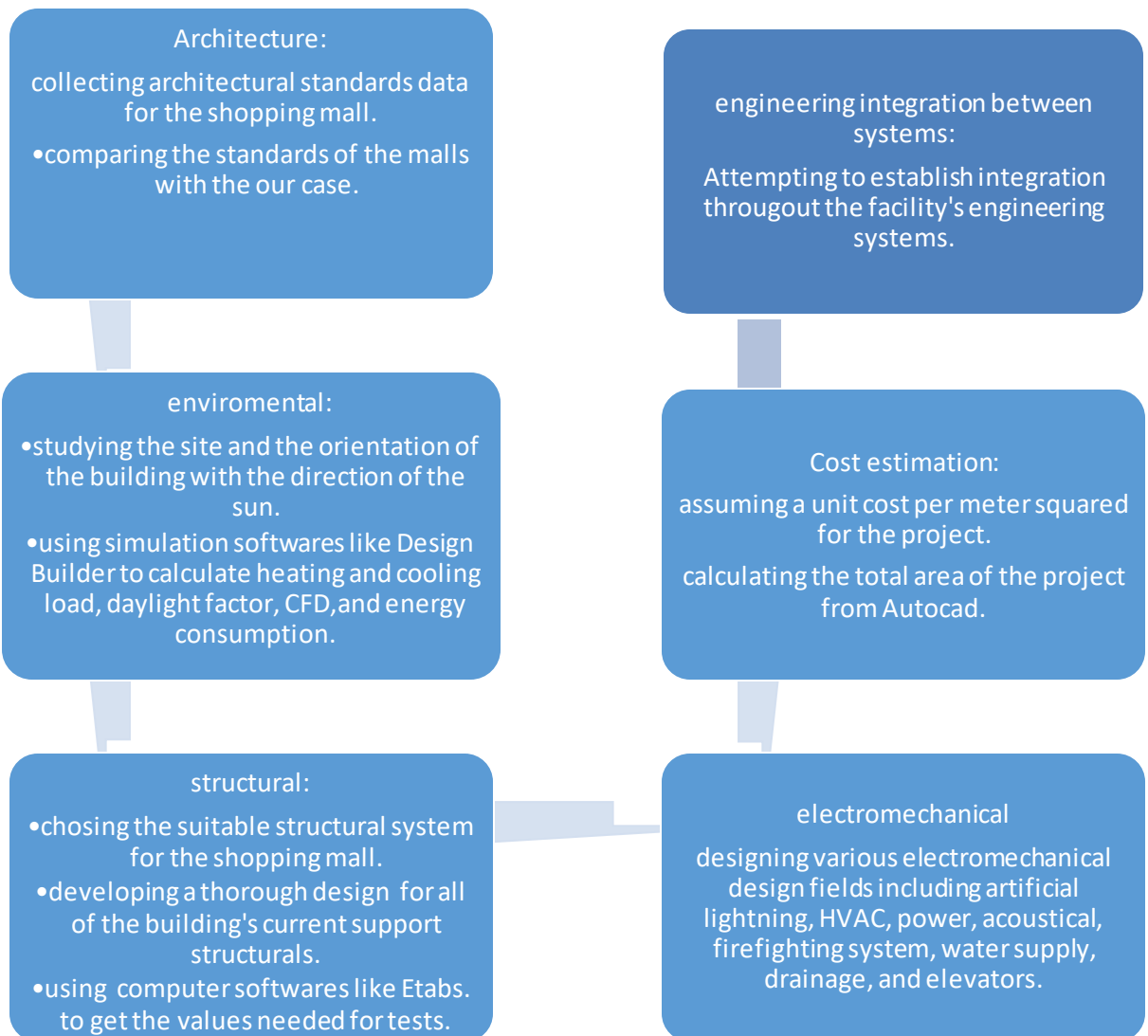
1.2.2. How the project will be environmentally assessed from various perspectives, including building orientation, illumination, acoustical studies, thermal comfort, and the use of computer applications to create a realistic simulation of the building, and how to improve all the mentioned topics to create the best internal environment in the building's spaces.

- 1.2.3. How will a structural design plan be developed to be economically and operationally appropriate for the project, and proposed solutions for the centers of columns so that they do not conflict with the architectural design, particularly with the parking garages in the facility's basements, and a design plan in accordance with seismic standards and codes.
- 1.2.4. And how will a cost estimate for the project be made, showing the methodology used and outlining the potential for expansion and improvement.
- 1.2.5. The most crucial factor is how well all of these components will combine and cooperate.

**1.3. Objectives:**

- 1.3.1. Architecture design to be done: considering the size of the interior rooms, traffic flow, and the suitable function for each space.
- 1.3.2. Environmental design involves calculating heating and cooling loads and calculating U-value by using the computer programs Revit and Design-Builder and making necessary adjustments to attain the proper daylight factor.
- 1.3.3. For doing structural design, develop a thorough design for all of the building's current support structures, and to get the values needed for various tests, computer software like ETABs will be employed.
- 1.3.4. The proposed code will be used to satisfy structural requirements.
- 1.3.5. Create a project's necessary cost estimate.
- 1.3.6. Attempting to establish integration throughout the facility's engineering systems.

## 1.4. Methodology:



## **1.5. Design constraints:**

- 1.5.1. Economy: how to benefit from every space in the project due to the high price of the land.
- 1.5.2. Environment: The project is located in the center of Jenin city, which leads to some environmental problems, such as the noise criteria, the natural lighting, moisture, shadow of nearby buildings, lack of sufficient information of materials and the design.
- 1.5.3. Politics: such as designs that promote gender and race equality, products that help national security, designs that help solve common international and national problems.
- 1.5.4. Health and Safety: such as public safety, safety of the consumers of the product, safety of workers.
- 1.5.5. Ethics: such as designs that do not violate safety and health issues, privacy issues, honesty, truthfulness.

## **1.6. Standards and Specifications (Codes):**

### **1.6.1. Architectural**

- 1.6.1.1. Ernt and peter Neufert “Third edition” used for the architectural standards.
- 1.6.1.2. Time saver for building types
- 1.6.1.3. Metric handbook planning and design data “Fifth edition”

### **1.6.2. Environmental**

- 1.6.2.1. Mechanical and Electrical Equipment for Building ‘MEEB’
- 1.6.2.2. Palestinian code for fire prevention and protection.
- 1.6.2.3. ASHRE

### **1.6.3. Structural**

- 1.6.3.1. The American concrete institute code (ACI 318-14)
- 1.6.3.2. ASCE/SEI 7-2016: Minimum Design Loads and Associated Criteria for Buildings and Other Structures

## **1.7. Earlier coursework:**

### 1.7.1. Architectural:

1.7.1.1. Architectural design principles, 10611260, this coursework helped in clarifying the means and standards of engineering drawings.

1.7.1.2. AutoCAD, 10611320, this coursework helped in drawing engineering 2D plans.

1.7.1.3. Revit, 10611320, this coursework helped in drawing engineering 3D plans.

### 1.7.2. Environmental:

1.7.2.1. Lighting design, 10611330, described and analyzed all lighting topics including (lux, intensity of light)

1.7.2.2. Solar design, 10611432, learned the orientation of the building with respect to solar insolation, and how to calculate and install PV systems.

1.7.2.3. HVAC design, 10611341, learned to calculate the heating and cooling loads, in addition to knowing all the heating ventilation air-conditioning systems available and what each system suits for.

### 1.7.3. Structural:

1.7.3.1. Concrete2, 10611416, learned to calculate the dead, live loads, in addition to check the equilibrium, more over learning how to design slabs columns and beams.

1.7.3.2. Building construction 2, 1061135, learned the layers of a standard building, the installation of construction works and how the construction activities are done.

1.7.3.3. Structural analysis, 10611310, learned to analyze the building and the loads and give a general understanding for how the construction design will be.

**CHAPTER 2 ENVIRONMENTAL -  
ARCHITECTURAL ASPECTS**

## **2.1. Introduction:**

Here this chapter is going to discuss the standards of the architectural aspects from different references...

Architecture is defined as the art and science of designing buildings and structures. Another definition in this scope is the design of any built environment, structure or object, from town planning, urban design, and landscape architecture to furniture and objects. In another words, it can be defined as the manipulation of shapes, and spaces to meet the standards of the architecture.

Spaces in this project varies and they are as the following, Place of worship, Stairs, Corridors, Parking, Ramp, Retail shops, bathrooms, and student housing.

## **2.2. Literature review:**

The spaces in this project vary according to their functions, and this project is considered a multi-functional building. In order to understand these spaces, they must be studied from several aspects of the required spaces, dimensions, and requirements, according to the previously mentioned standards. In the following, the spaces in the original design will be studied separately and then compared with the recommended standards.

### **2.2.1. Place of worship**

The size of the prayer hall is around 0.85-m<sup>2</sup> praying space per person. It is typically square or rectangular, frequently has a central dome, facing Mecca in the direction of prayer (kibla), and has the minbar right next to it. that always has an odd number of stairs. This is employed by the imam, who is the mosque's leader of prayer. Men and women are separated, occasionally only symbolically, and occasionally with the women in the hall. Down below figure1 shows the dimensions of a prayer.

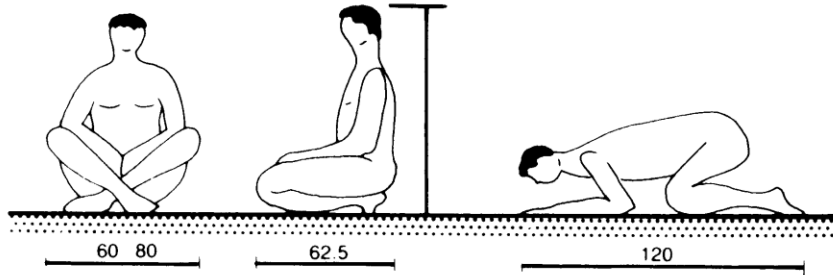


Figure 1 prayer dimensions

### 2.2.2. staircase, elevators, and escalators:

One of the most important topics to worry about in any building, is the design of the staircase. The staircase should be easily accessible to all occupants and wide enough. when a disaster takes place like a fire or an earthquake, the stairs should be an easy runaway route.

Normal staircase:

The stair in the commercial building needs a width that ranges between (1.20-1.40) m and be able to accommodate two people to pass easily according to the recommended specifications.

Emergency staircase:

The emergency stairway is known as the fastest way for occupants to escape from the building to the nearest safe place away from the danger zone. In this project the facility serves less than 2000 people in the very most cases, so these are the requirements of the international U.A.E standards. Down below figure 2 shows the required dimensions.

Emergency stair specification	
clause	Requirements
Minimum width without obstruction for less than 2000 persons	1200 mm
Minimum width without obstruction for more than 2000 persons	1420 mm
Maximum height of the step (riser)	180 mm
Minimum height of the step (riser)	100 mm
Minimum width of the horizontal part of step (run)	280 mm
Minimum vertical height of the stairs	2030 mm
Maximum vertical height between landings	3660 mm
Maximum slope of the horizontal part of the staircase and landing	21 mm (1 in 48)

Figure 2 emergency stair specification standards

**Elevators:**

Number of elevators in the mall depends on the population of the building. Here in this project we have both elevators and escalators. So we are going to have less elevators due to the help of escalators.

Elevator dimensions range due to its capacity to occupants. Some elevators are 1.8\*1.8m and up to 3\*2m. elevators.

Figure and table below shows the dimensions of different elevators and the capacity of each elevator's dimension. In addition to the shaft opening dimension, and mechanical room dimension.

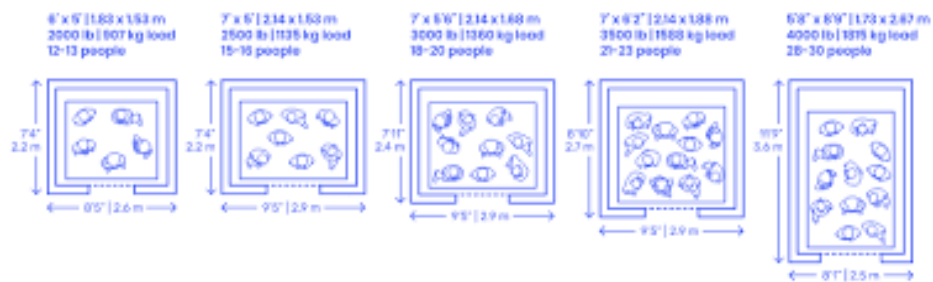


Figure 3 Different Elevator dimensions

Table 1 Different elevator specifications

Effective lift system design is a specialist design function but some basic assumptions can be made relating to car size, shaft dimensions and traffic flows.

	Car size C × D	Shaft size A × B	Machine room S × R	Load rating (Kg)	Rated Capacity (people)	Design Capacity (people)
Light traffic				320	4	3.6
	1100 × 950	1800 × 1600	3200 × 2500	400	5	
				450	6	5.0
	1100 × 1400	1800 × 2100	3700 × 2500	630	8	6.3
	1350 × 1400	1900 × 2300	3700 × 2500	800	10	7.6
	1100 × 2100	1800 × 2600	4200 × 2500	1000	13	9.1
General purpose lifts	1600 × 1400	2400 × 2300	4900 × 3200	1000	13	9.1
	1950 × 1400	2600 × 2300	4900 × 3200	1250	16	
				1275	16	11.0
	1950 × 1750	2600 × 2600	5500 × 3200	1600	21	13.5
	1600 × 2400	2400 × 3000	5800 × 3200	1800	24	14.9
	1500 × 2700	2400 × 3300	5800 × 3200	2000	26	16.0
	1800 × 2700	2700 × 3300	5800 × 3500	2500	33	19.0

#### Escalators:

It is important to recognize that lifts provide a different service to that of stairs and escalators discussed previously. Where escalators can carry large amounts of people relatively slowly, lifts carry much smaller amounts much more quickly.

#### 2.2.3. corridors:

Corridors are used to move between spaces, they need a width that can accommodate two people passing by each other, according to the recommended standards, their width should range between (1.20- 1.40) m. down below figure 4 shows the dimension and movement of two people passing by each other in a corridor.

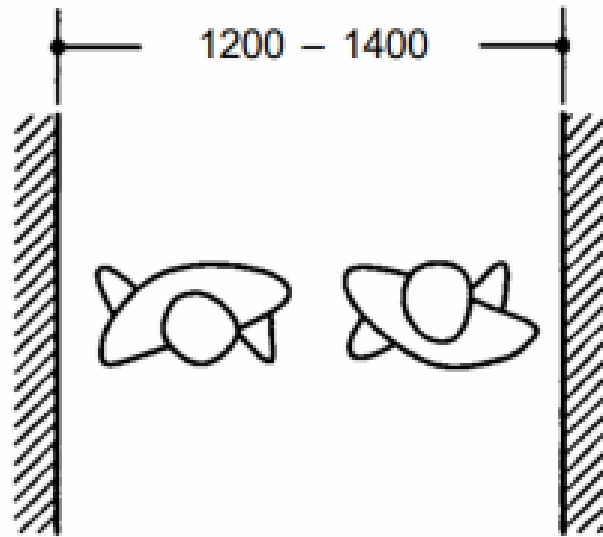


Figure 4 dimension of corridor when two people walking by each other

In the design of corridors also keep in mind handicapped people, here are the dimensions of wheelchairs occupied and unoccupied shown in figure 5 below.

Table 2 minimum width of door compared to wheelchairs

Chair type (excluding children)	Occupied		Unoccupied	
	Length (mm)	Width (mm)	Length (mm)	Width (mm)
Manual wheelchair	850-1250	560-800	700-1200	560-750
Attendant propelled	1200-1570	560-700	800-1350	550-660
Electric wheelchair	860-1520	560-800	700-1400	560-750
Electric scooter	1170-1600	630-700	1170-1500	620-640

In addition to the minimum door side opening to achieve the appropriate circulation for a wheelchair, and with a door width not less than 0.915m. It is shown in figure 6 below.

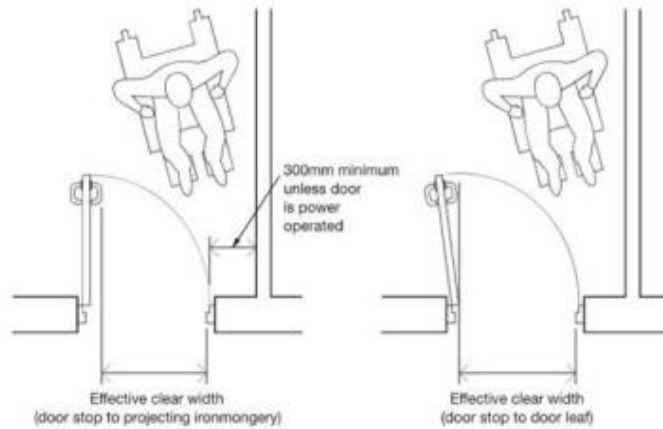


Figure 5 occupied wheelchair entering a door

fire safety and means of escape: Requirement for fire doors, fire separation, lobbies, emergency lighting, firefighting equipment and automatic fire detection systems. escape from bedrooms must not be through a higher risk area such as a kitchen.

#### 2.2.4. parking:

One of the most important things that must be taken into account during the design of the parking, is to allow the movement of cars without obstructing them either by columns misplaced, or movement contradict of other cars in the parking. There are standards for cars' dimension. From 2.5m-3.0m for single garage, and 5.0m-6.0m for double garage. Down below figure 7 shows those dimension.

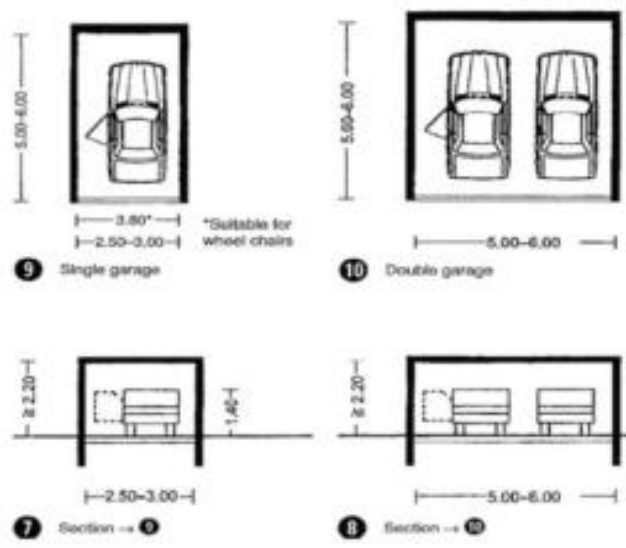


Figure 6 standard dimensions for parking lots

And this is the dimension that should be kept in mind when designing a parking for disabled people. Parking for disabled people should be wider than normal parking to allow movement and rotation of wheelchair easily. The dimensions are 3.3m wide which is 0.3-0.8m wider than the normal parking lot. Down below is figure8 that shows the dimensions of disabled people's parking.

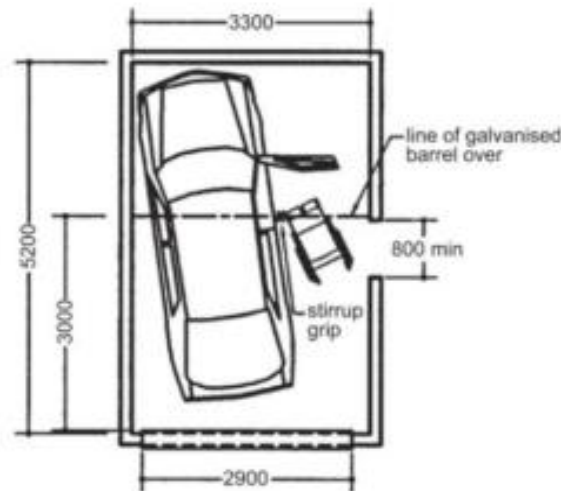


Figure 7 standard dimension of a normal car

Garage width depends also on the movement angle of the cars, as the angle becomes bigger the garage width needs to be wider. The dimensions of the garage compared to the different angles are shown in table1 below. As a standard requirement we need a minimum of 2.5m wide garage, as an example for a 90-degree rotation of a car it needs 5.5m to access the 2.5m parking lot. so we are going to focus on the third column in the table below.

Table 3 angles with minimum dimension for the circulation of cars

Arrangement of garage parking spaces to the access. At an angle of:	Required access width (in m) for a garage parking space width of:		
	2.30	2.40	2.50
90°	6.50	6.00	5.50
75°	5.50	5.25	5.00
60°	4.50	4.25	4.00
45°	3.50	3.25	3.00
up to 30°	3.00	3.00	3.00

For a better understanding of how the car moves, figure9 below shows

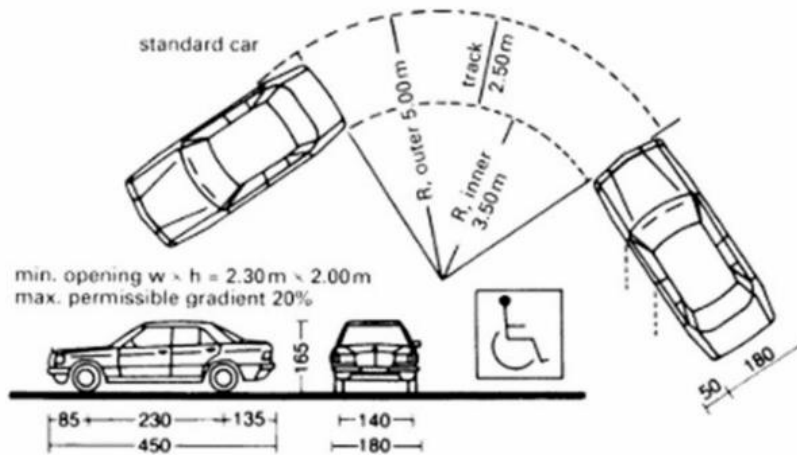


Figure 8 the circulation radius of a car

After the new interior design for the mall we have around 960 meter squared total area of ground floor, minus the corridors, the bathrooms, and hall, then divide the net area by 25 to get the number of needed cars in the building.

$$960 - 350 = 610$$

$610 / 25 = 24.4$  so 25 parking lot needed just for the ground floor.

### 2.2.5. Ramp:

The slope of the ramp should not exceed (20%). The ramp shall be connected to the internal surfaces and the external roads with sections of no more than (10%) slope. The width of the ramp shall not be less than following:

1. if the car parks did not exceed 30 cars shall be width 3.5 m.
2. if the car parks exceed 30 cars shall be width 5.25 m.

Figure 10 and 11 shows different slopes that can be used for ramps.

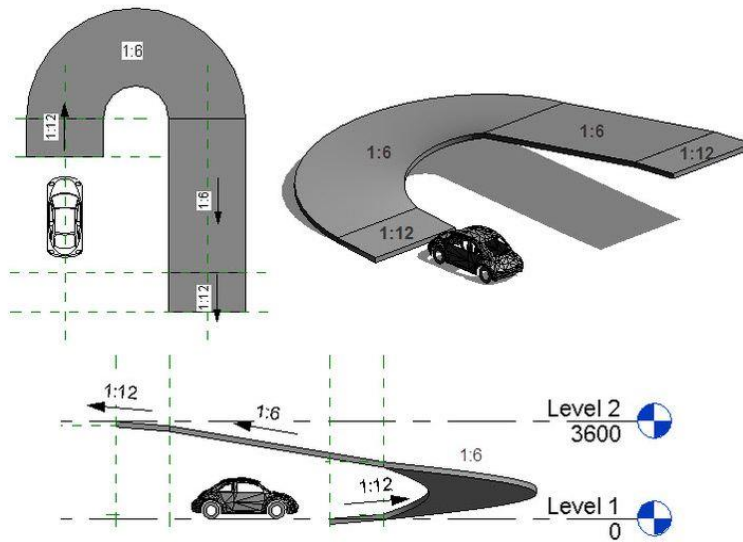


Figure 9 the elevations of a standard ramp

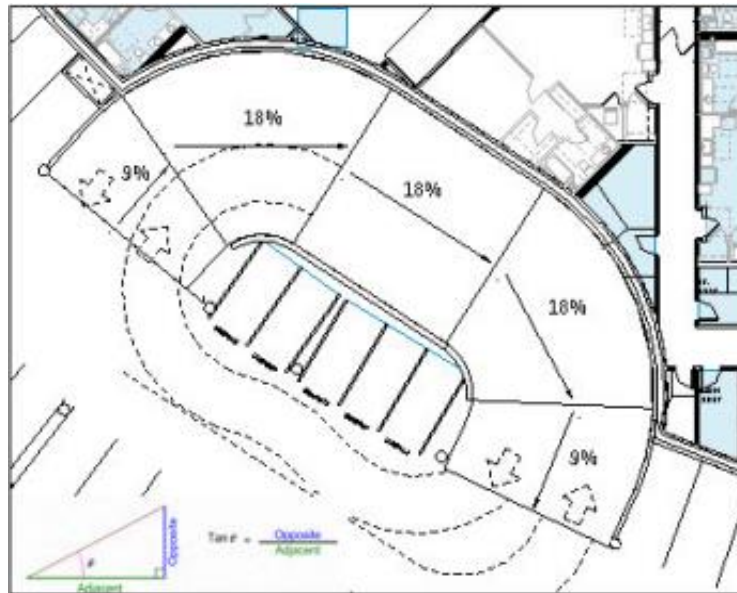


Figure 10: standard dimension of a ramp

### 2.2.6. Retail shops:

It is used to display and sell goods and often needs open spaces for better display. In this project retail shops are clothes shops, mobiles shops, Home accessories shops, and a supermarket.

### 2.2.7. Student Housing:

1- Ratio of toilets to number of occupants – typically a minimum of 1 toilet for 5 people. Provided in a separate room to the bathroom, if it serves more than 4 people.

2- Maximum distance of shared toilets from bedrooms – typically no more than 1 floor away.

3- Ratio of kitchen facilities to number of occupants – typically 1 set of facilities for 5 people comprising a sink and drainer, a food cupboard (500 mm wide base unit or 1000 mm wide wall unit), a fridge (130 liters), freezer space (60 liters), worktop (1000 mm min), 3 double power sockets in addition to those required for the appliances, a cooker with 4 burners, oven and grill.

4- The bathrooms in this project need fewer requirements than the normal (residential) bathroom because it is a Mall bathroom, where there is no bathtub or shower. According to the recommended specifications, a bathroom width of at least 1.10 M will be required.

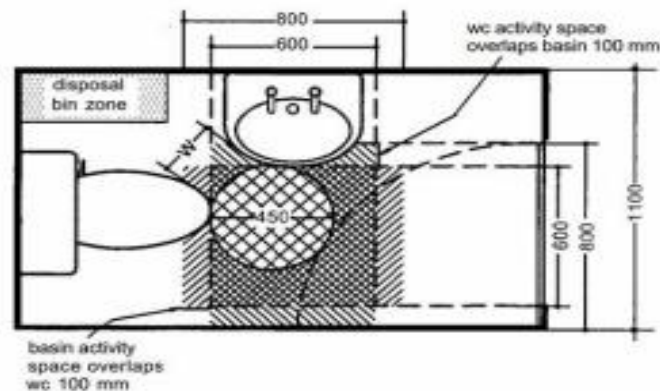


Figure 11 standard dimensions of a WC with a toilet

5- A study bedroom for one person (without en-suite bathroom) can be as small as 10 m<sup>2</sup>, but this is extremely tight and a more appropriate minimum area is 12 m<sup>2</sup>. A small sized room with en-suite bathroom is typically 15m<sup>2</sup>. In another words a bedroom can be 3.8m\*3.8m.

6- Also a small dirty kitchen it can be 6-7m<sup>2</sup>.

7- small living area with approximately 16 m<sup>2</sup>.

**2.3. Case Study:**  
**Building name: City Mall**

**Location: Nablus, Palestine**



*Figure 12City mall from the outside*



*Figure 13City mall interior*

**2.3.1 Introduction:**

This study focuses on building a comprehensive commercial complex in the city of Nablus. The project aims to meet the needs of the local community by providing an integrated shopping destination and a unique shopping experience for local residents and tourists.

### **2.3.2 Project overview:**

The City Mall complex consists of a main building that houses a variety of shops, restaurants, exhibition halls, and cinemas. The site enjoys a central location in the city of Nablus, and is considered a major destination for shopping and entertainment in the area.

### **2.3.3 Main challenges:**

- a.) Engineering Design: The design and implementation of a large and complex building that requires verification of structural, engineering, mechanical and electrical requirements to ensure safety and sustainability.
- b.) Technology and equipment: Providing advanced technical infrastructure that supports shops, restaurants, cinemas and public facilities, including sound systems, lighting and information technology.
- c.) Architectural Coordination: Coordinating the interior and exterior design of the complex to create a comfortable and distinctive experience for visitors and meet the diverse needs of different brands and tenants.
- d.) Legislation and Licensing: Comply with local legislation and regulations regarding construction, safety and environmental protection and obtain the necessary permits to start and complete a project.

### **2.3.4. Case study benefits**

This case study was used because it was like part of our project, The mall, or rather the shops. Also, this case in Nablus and the project in Jenin mean that the weather conditions are not the same. However, it should be noted that these differences are usually slight and depend on the geographical location and conditions surrounding each city. There may be fluctuations in the weather day by day and seasonal changes that may affect the weather conditions in each region. For more accurate information about the weather conditions in both Nablus and Jenin, it is recommended to consult local weather reports or approved data sources.

## 2.4. Site analysis

### 2.4.1. Introduction about Jenin city in Palestine

The Palestinian city of Jenin is located in the northern part of the West Bank, 77 km north of Jerusalem, with an area of about 37.3 km<sup>2</sup>, its city's population according to (Palestinian Statistics Center, 2023) is about 55,933 and 11,674 for Jenin's camp. And there is Al-Bayader neighborhood in which the project is located, as the neighborhood is one of the most vital areas in the city. Down below is the location of Jenin city on the map of Palestine.



Figure 14 Jenin city on the map of Palestine

### 2.4.2. Building Location

The next figure shows the location of the project and the land it is present on, and with the surroundings:



Figure 15 Project location from Geomolg

### 2.4.3. Land Analysis:

The level of the main road for the project present in Al-Bayader Street sidewalk is 250, and this level is considered the 0.00 as a reference level. The level of the land starting from the eastern north is below the reference level by one meter, and then towards the western north down the south where the level of the land stabilizes to the 0.00 level. Where the land is completely leveled and excavated to one piece. For excavation works the land itself where the project is built is excavated 3.3 meters below the street grade for the basement's parking, which is considered the -3.3. for this project two basement should be done, so the excavation works should two basements with 3.3 meters each, which gives a total excavation of 6.6meter below ground level. There is also a street whose level is also 0.00, where on its side there are shops and stores on the same level.

### 2.4.4. Climate and Average Weather Year-Round in Jenin

In Jenin, the summers are long, warm, arid, and clear and the winters are cold and mostly clear. Over the course of the year, the temperature typically varies from 7°C to 31°C and is rarely below 4°C or above 34°C.

### 2.4.5. Climate Summary

The next figure shows a summary of the climate in Jenin city:

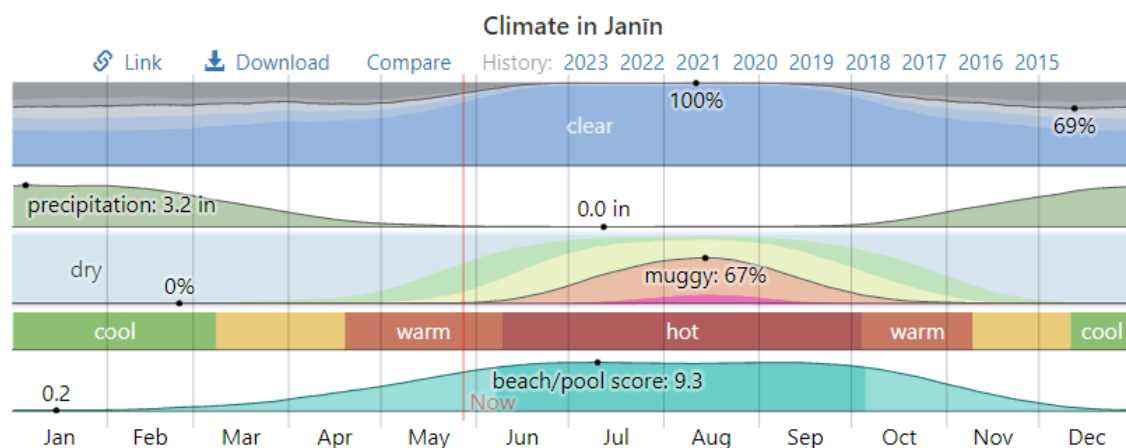


Figure 16 climate summary for Jenin throughout the year

### 2.4.6. Temperature in Jenin

The cold season where temperatures are cool and somehow moderate lasts for 3.1 months, from the 8<sup>th</sup> of December up to the 13<sup>th</sup> of March, with an average daily high temperature below 18°C. The coldest month of the year in Jenin is January, with an average low of 9.62°C and high of 15.71°C. The hot season where the high temperature are present lasts for 4.4 months, from May 30<sup>th</sup> to the 10<sup>th</sup> of October, with an average daily high temperature above 29.65°C. The hottest month of the year in Jenin is August, with an average high of 33°C and low of 24.5°C.

Table 4 Temperature records in Jenin

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Nov	Oct	Dec	Year
Record high °C (°F)	30.89 (87.6)	33.98 (93.16)	38.1 (100.58)	40.16 (104.29)	44.28 (111.7)	43.25 (109.85)	40.16 (104.29)	43.25 (109.85)	43.25 (109.85)	39.13 (102.43)	35.01 (95.02)	31.92 (89.46)	44.28 (111.7)
Average high °C (°F)	15.71 (60.28)	17.94 (64.29)	21.14 (70.05)	24.94 (76.89)	29.18 (84.52)	31.1 (87.98)	32.85 (91.13)	33.11 (91.6)	31.47 (88.65)	27.94 (82.29)	22.84 (73.11)	17.94 (64.29)	25.52 (77.94)
Daily mean °C (°F)	13.45 (56.21)	15.36 (59.65)	18.28 (64.9)	21.99 (71.58)	26.21 (79.18)	27.97 (82.35)	29.45 (85.01)	29.65 (85.37)	28.21 (82.78)	25.14 (77.25)	20.48 (68.86)	15.71 (60.28)	22.66 (72.79)
Average low °C (°F)	9.62 (49.32)	11.27 (52.29)	13.53 (56.35)	16.25 (61.25)	20.75 (69.35)	22.6 (72.68)	24.01 (75.22)	24.57 (76.23)	23.57 (74.43)	21.26 (70.27)	16.72 (62.1)	12.03 (53.65)	18.01 (64.42)
Record low °C (°F)	-1.03 (30.15)	0.0 (0)	2.06 (35.71)	8.24 (46.83)	10.3 (50.54)	14.42 (57.96)	17.51 (63.52)	18.54 (65.37)	15.45 (59.81)	13.39 (56.1)	8.24 (46.83)	1.03 (33.85)	-1.03 (30.15)
Average precipitation mm (inches)	43.0 (1.69)	33.18 (1.31)	24.83 (0.98)	8.99 (0.35)	10.32 (0.41)	1.43 (0.06)	0.15 (0.01)	0.18 (0.01)	1.82 (0.07)	12.43 (0.49)	21.04 (0.83)	30.6 (1.2)	15.66 (0.62)
Average precipitation days (≥ 1.0 mm)	7.67	6.55	4.49	2.43	1.69	0.37	0.0	0.0	0.57	3.84	5.81	5.9	3.27
Average relative humidity (%)	63.66	60.14	57.07	52.07	46.89	51.51	55.42	57.99	57.98	54.42	51.96	57.38	55.54
Mean monthly sunshine hours	8.11	8.35	10.74	13.26	14.21	14.52	14.42	13.69	12.04	11.68	9.12	8.44	11.54

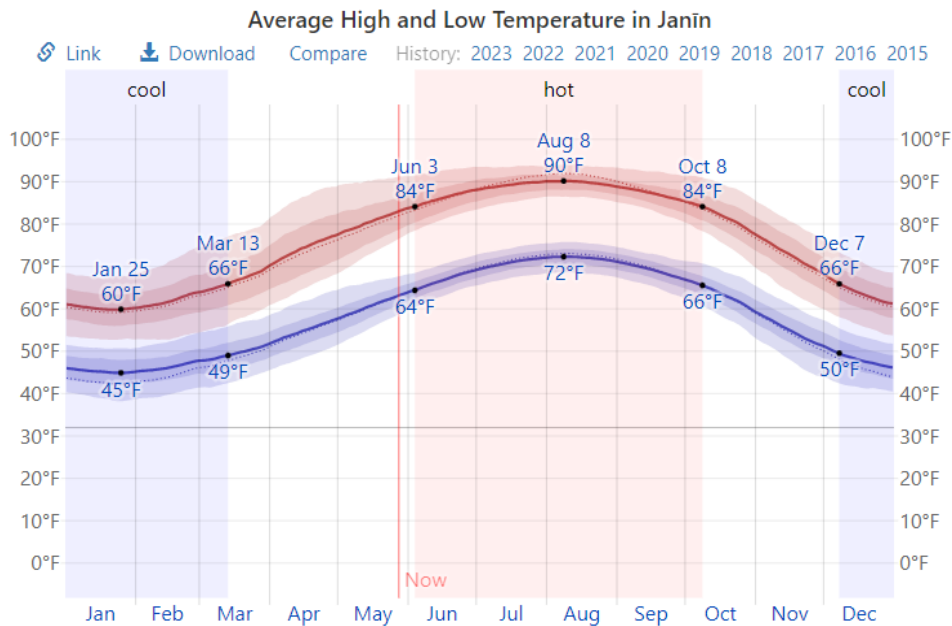


Figure 17 temperature in Jenin for a year

The daily average high (red line) and low (blue line) temperature, with 25th to 75th and 10th to 90th percentile bands. The thin dotted lines are the corresponding average perceived temperatures.

### 2.4.7. Clouds in Jenin

In Jenin City, the average percentage of the clouds covering the sky experiences a fluctuating seasonal variation over the year. So it is different for each month of the year. The cloudiest month of the year in Jenin is December, which has an overcast sky or mostly cloudy. On the other hand, the clearest month of the year in Jenin is August, which has a very clear sky, mostly clear 100% of the time.

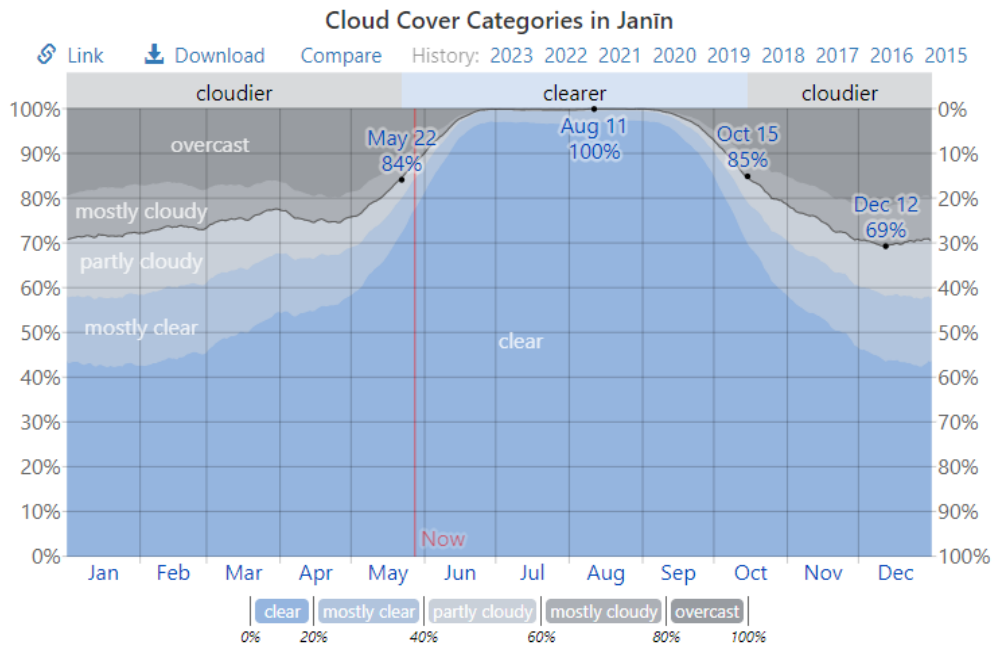


Figure 18 Clouds in Jenin for the past year

The percentage of time spent in each cloud cover band, categorized by the percentage of the sky covered by clouds.

Fraction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cloudier	28%	27%	24%	25%	17%	3%	0%	0%	2%	16%	26%	30%
Clearer	72%	73%	76%	75%	83%	97%	100%	100%	98%	84%	74%	70%

### 2.4.8. Sun visibility

The length of the days in Jenin varies a lot over the months of the year. So as an example in 2023, the shortest day is December 22, with 10 hours, 1 minute of daylight; the longest day is June 21, with 14 hours, 17 minutes of daylight. The figure below shows the sun hours throughout the months of the year:

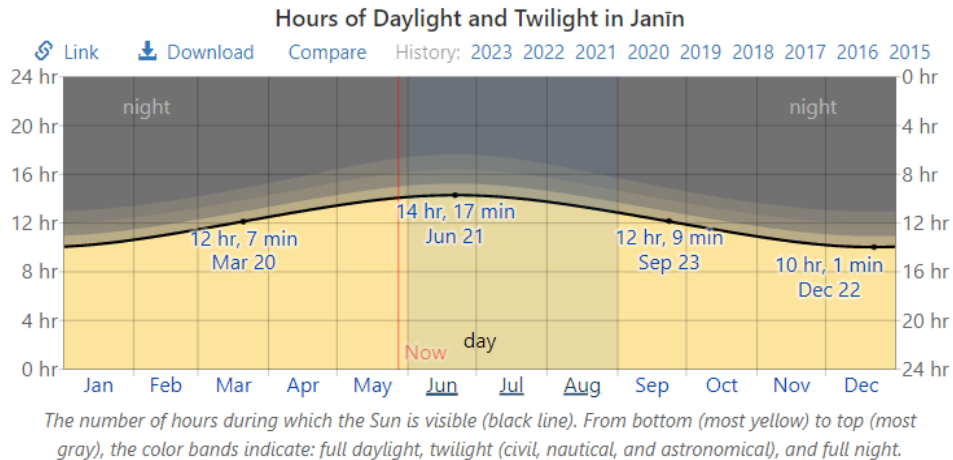


Figure 19 Sun visibility hours in Jenin

### 2.4.9. Ventilation:

Ventilation of building is a very important topic to talk about. The presence of ventilation is necessary to provide comfort within buildings, as ventilation helps in achieving comfort within a building, it helps to increase the productivity and the amount of good output of the occupants in the building. Ventilation is necessary due to the depletion of the unwanted odors and gases such as carbon dioxide, in addition to the location of the project and the pollutions in the surroundings. The height of the building and lack of coverage from other nearby buildings will help the natural ventilation to take place in the building easily.

Commercial buildings can have offices, shops, and even multipurpose rooms. Each space has a different need of ventilation to enter. For example, a commercial building that contains offices, needs a general ventilation rate around 1-2 (ach/h) times per hour, while on the other hand, commercial centers that has shops need ventilation with a little higher than the offices with around 2-3 times per hour.

## 2.5. Architecture drawings:

### 2.5.1. Plans before modification:

#### Basement 1:

The basement in the figure below lacks comfort for the circulation of the cars in the parking, due to the arrangement of the columns and the large number of columns present. The project needs another basement with more number of parking lots to meet the buildings' population requirements. The columns will be redistributed. The structural design criteria will be changed to get larger spans. Also redesign of the emergency staircase is needed.

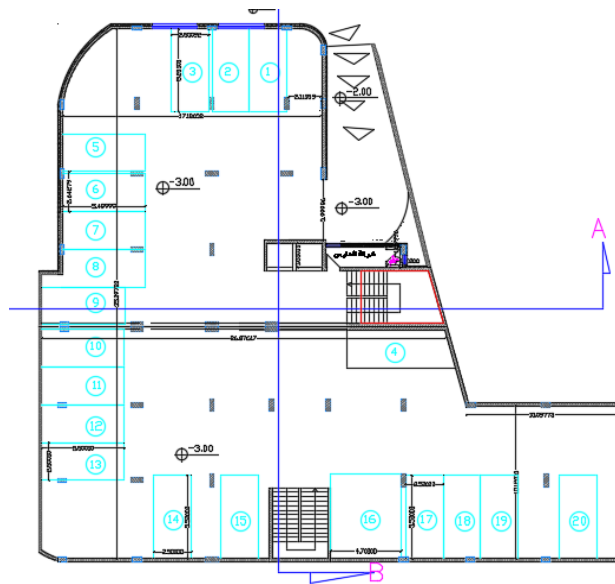


Figure 20 plan for basement 1 before modification

#### Ground floor:

The distribution of shops in the building is weak, a lot of space is not used wisely, it is a dull architectural design, in addition to the location of columns in the center of each shop. The ramp of wheelchair in the entrance should be extended to achieve the standard slope dimensions.

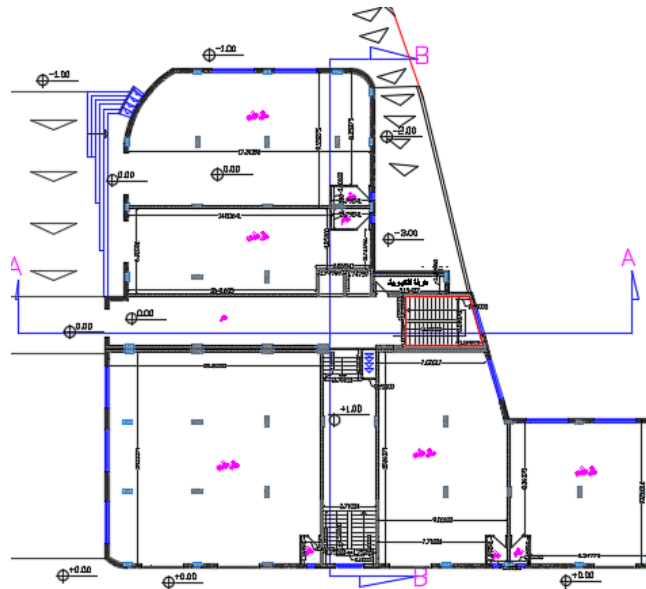


Figure 21 plan for Ground floor before modification

**First floor up to fifth floor same plans:**

The western end of the corridor must be exploited, by this move the guest room in the northern western apartment will be expanded to the standard's dimensions. In addition of redesigning the kitchen and make it larger to meet the specification and the standards' dimension. Kitchen plays a big role in the comfort of the house so it should meet the architectural standards. The emergency exit must be reviewed and mostly making it smaller to meet the standards, as a result of making it smaller, add a place for the electricity meters.

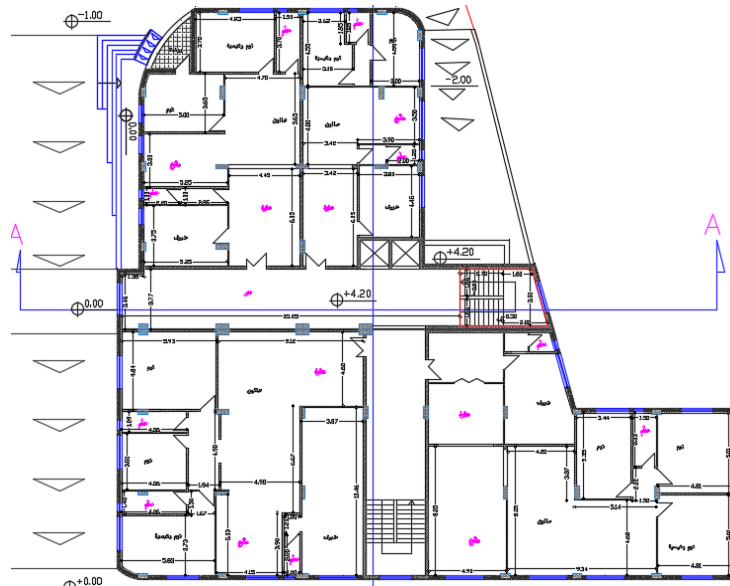


Figure 22 plan for first floor before modification

Roof:

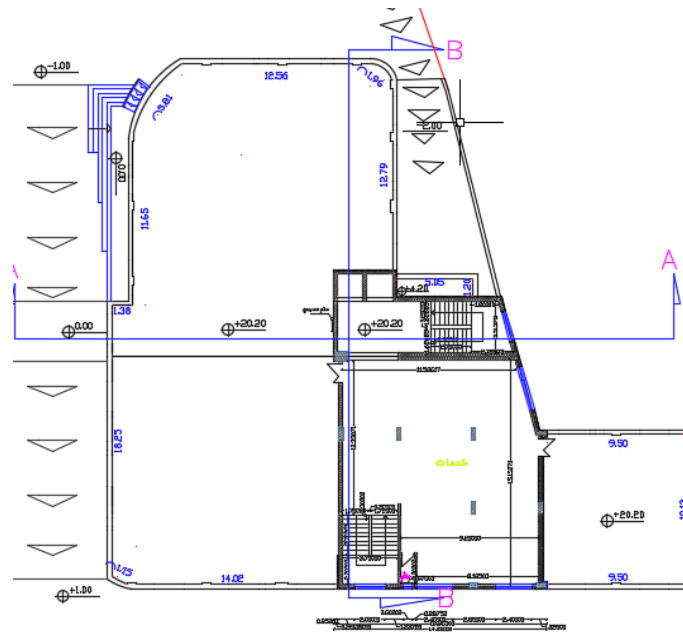


Figure 23 plan for roof before modification

### 2.5.2. Plans After modification:

#### Basement parking 2:

Here in the plan below, the project needs another basement due to the building's population and insufficient number of cars in the plans before modification. So as a result another basement for car's parking is added to meet the needs of the building population. The car's circulation problem is treated, the car's circulation now after modification is much easier and more comfortable. The redistribution of the columns helped a lot in the solution of circulation. In addition to creating a glass area like a loopy that separates the elevators from the parking, so the emissions and CO2 doesn't enter the elevators and travel the emissions and CO2 throughout the building as it is used and open in the above floors.

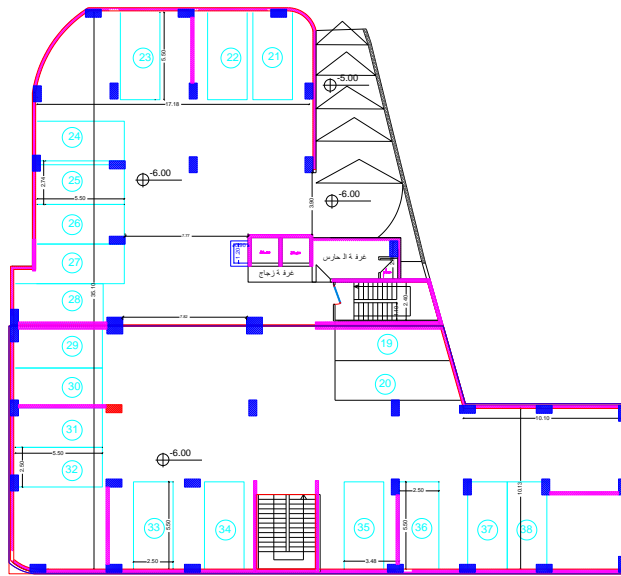


Figure 24 plan for basement 2 after modification

### Basement parking 1:

Same with basement number two, the circulation of the cars got better, with the addition of basement number 2 the project now can carry up to 38 cars in total which is much better. The elevators are separated with a glass area to avoid the polluted air from the cars' emissions to spread in the upper floors of the building through the elevator that makes a direct connection between all the floors in the project.

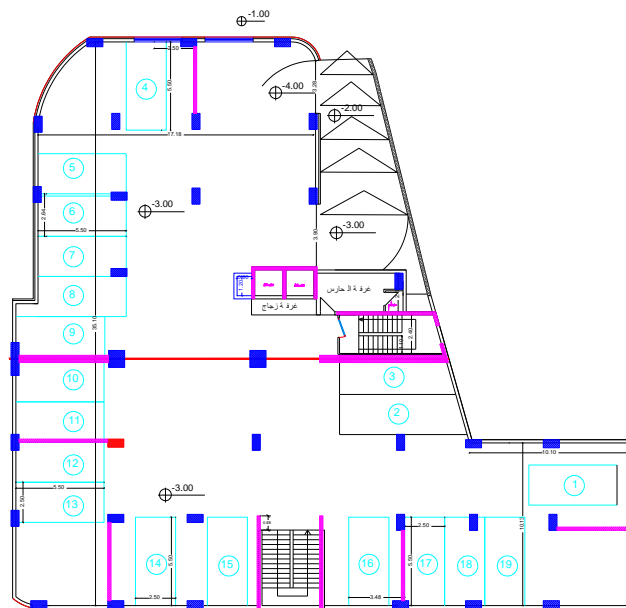


Figure 25 plan for basement 1 after modification

## Ground floor:

Down below in the next page is the modified plan for the ground floor, the idea of the large corridors was taken from design used in many shopping centers, one shopping center that is seen clearly using this type of corridors in city center mall present in Jenin. The partitions used between shops is made of glass that can be reused in different places if modification of the interior partitions will take place. In the ground floor before modification the division of shops were dull and boring, it had no corridors between them. There were 5 big shops with a lot of unused spaces, in addition to the columns that interacts the spaces in the center of the shop. Now in the plan below after modification the redistribution of the columns gave a free space to change the partitions of shops in the mall. 14 shop is now present every single space is exploited, a place for praying is added, a bathroom area is added, one for men use, and the other for women use. The emergency staircase is modified to the standard dimension and is closed and only for emergency use. The ramp at the entrance, the northern western ramp is modified and lengthened to meet the standard slope for ramps, so the handicapped people can use this ramp much easier.

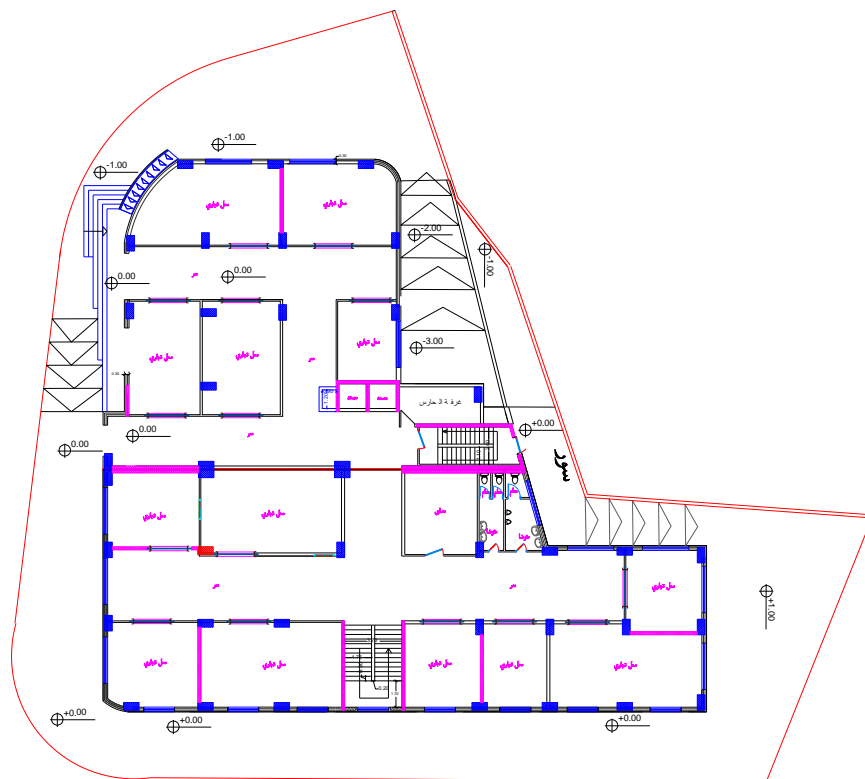


Figure 26 plan for Ground floor after modification

### First floor up to the fifth floor:

Down below is the modified plan of the first floor which continues up to the fifth floor, the emergency staircase is modified to meet the standards' dimension. The space in the northern western part of the building is exploited, apartment number one from the top left guest room is now bigger to meet the standard's dimensions, the kitchen is much wider. A place next to the emergency staircase is added for the use of electricity meters.

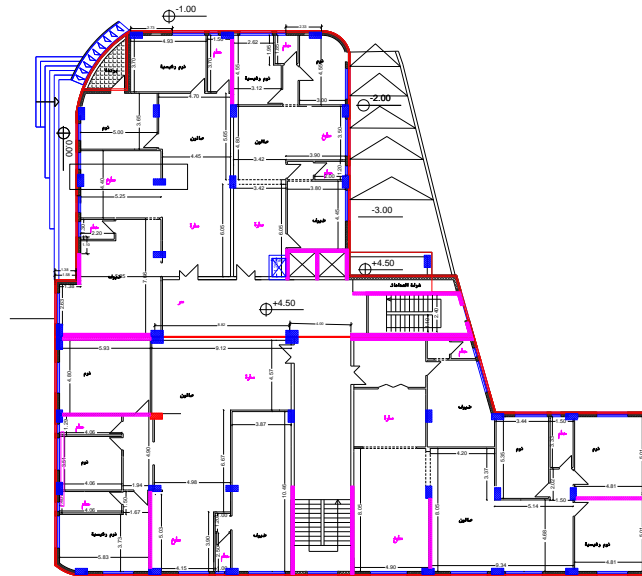


Figure 27 plan for First floor after modification

### Roof:

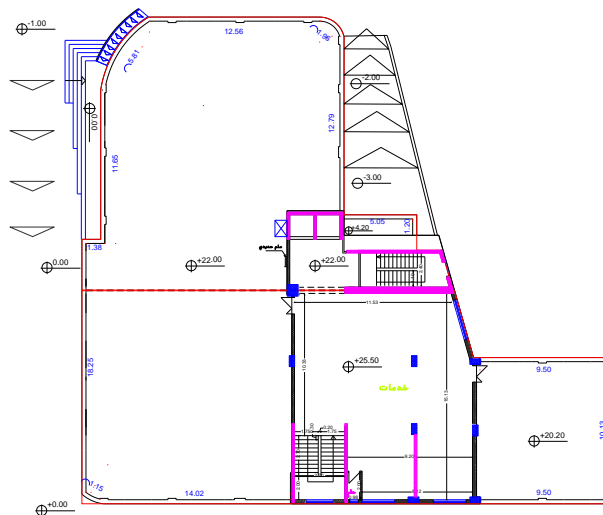


Figure 28 plan for roof after modification

# Elevations:



Figure 29 Northern Elevation



Figure 30 southern elevation



Figure 31 western elevation



Figure 32: Eastern elevation

**Sections:**

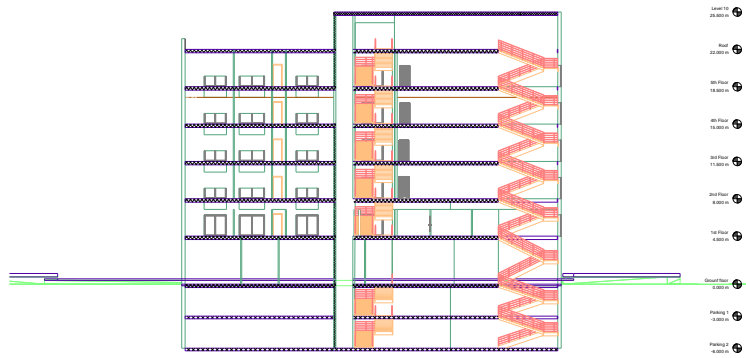


Figure 33 Section A-A

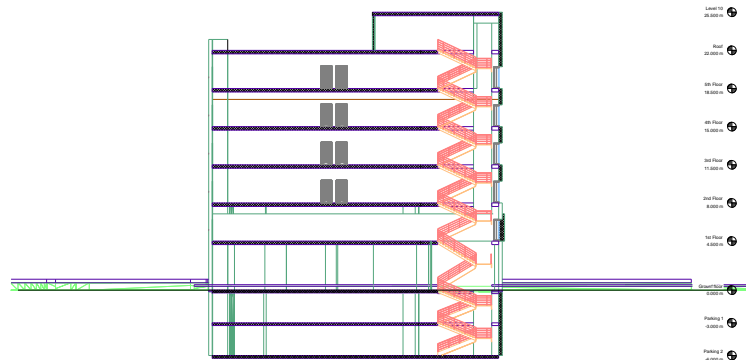


Figure 34 Section B-B

## 2.6. Environmental analysis using Design Builder and Revit:

### 2.6.1 Before modification

#### 2.6.1.1 Shadowing and overshadowing:

The following figures show the effect of overshadowing for the project to be designed at different times of the day. Analysis of the shadows were taken at 4 different months on the 21<sup>st</sup> of each month, March 21<sup>st</sup>, June 21<sup>st</sup>, September 21<sup>st</sup>, and December 21<sup>st</sup>. Three different times were taken for each month, at 8:00 AM, 12:00PM, and at 3:00PM. There are relatively small buildings surrounding the project but they have a slight effect on the building either in summer or winter.

#### In December:

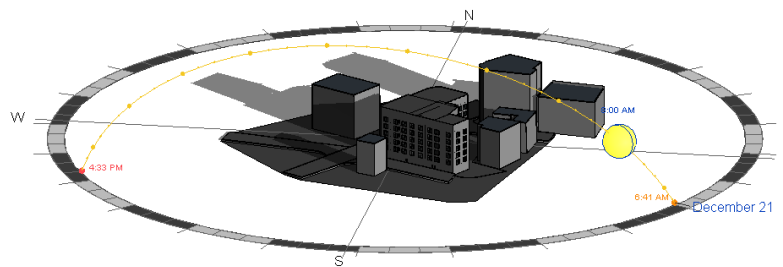


Figure 35 shading in December at 8:00AM

As we see in (figure 30) there is shading on the eastern façade of the building from neighboring buildings, and this will negatively affect the thermal requirement of the building in the winter, because the angle of the sun is less than in the summer, and this will lead to an increase in energy consumption.

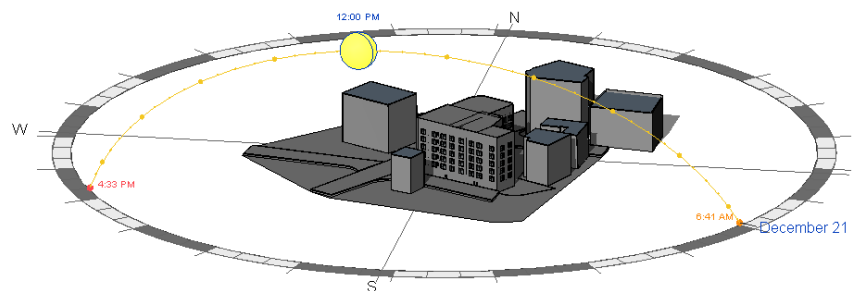


Figure 36 shading in December at 12:00PM

There is partial shading on the south façade of the building, due to the neighboring buildings. This will lead to a weakness in the efficiency of natural lighting in the rooms in this part of the building.

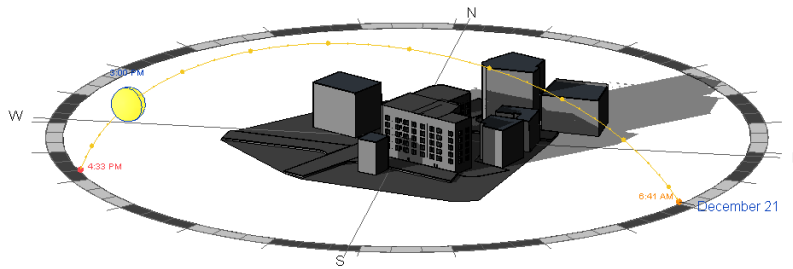


Figure 37 shading in December at 3:00PM

There is a partial shading on southern façade and partial shading on western façade due to neighboring buildings.

**In June:**

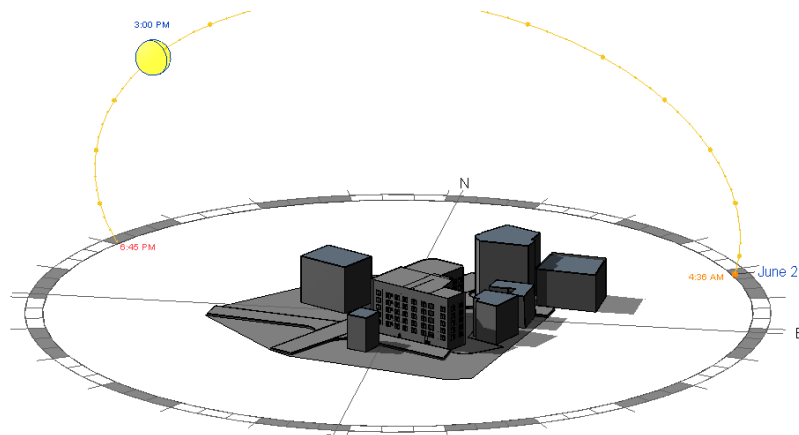


Figure 38 shading in June at 3:00PM

There is no shading on southern and western facades, because the angle of sun is high.

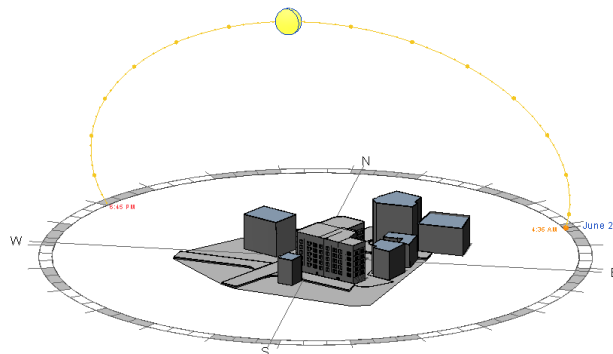


Figure 39 shading in June at 12:00PM

At this time of the day, the sun is almost perpendicular to the buildings, so the sun's rays are on the roofs of the houses and lead to an increase in the temperature of the building and thus lead to an increase in energy consumption in the buildings.

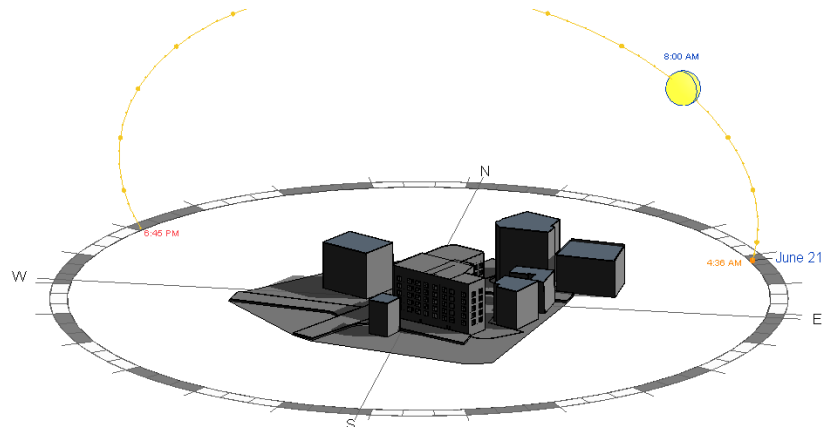


Figure 40 shading in June at 8:00AM

The northeastern façade receives direct sunlight with little shading due to the neighboring buildings, but the southern and western façades are almost completely shaded at this time due to the shade from the building itself.

**In March:**

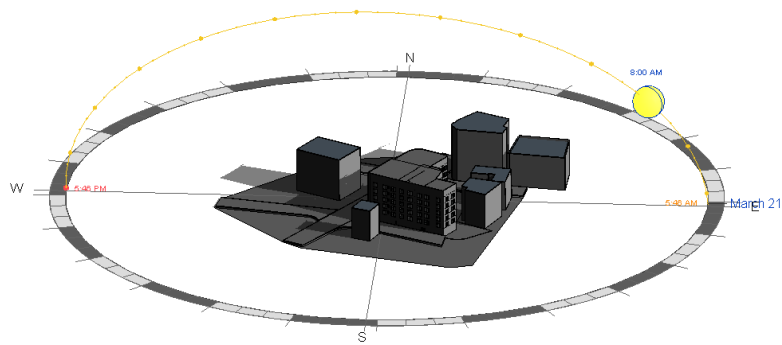


Figure 41 shading in March at 8:00AM

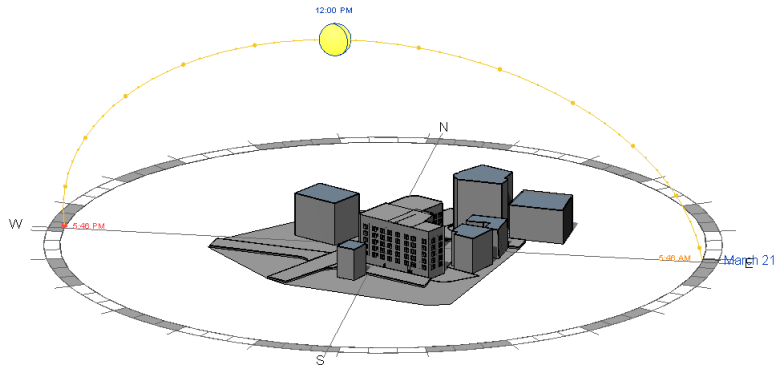


Figure 42 shading in March at 12:00PM

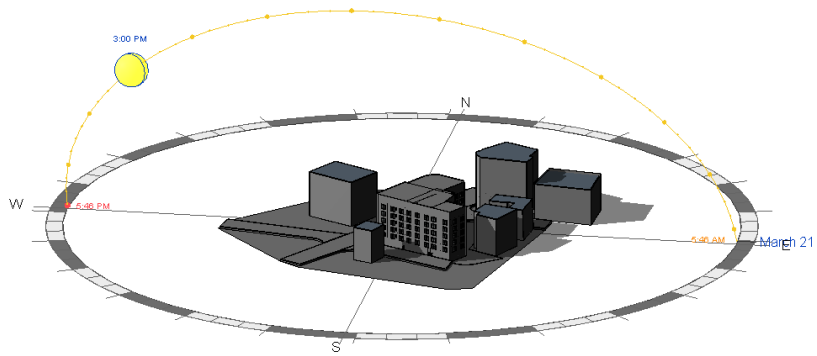


Figure 43 shading in March at 3:00PM

**In September:**

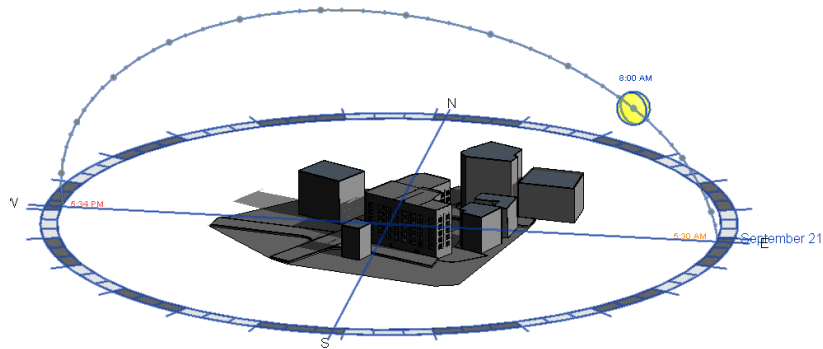


Figure 44 shading in September at 8:00AM

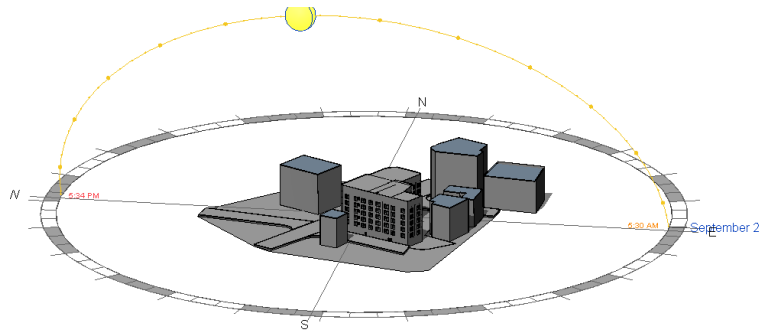


Figure 45 shading in September at 12:00PM

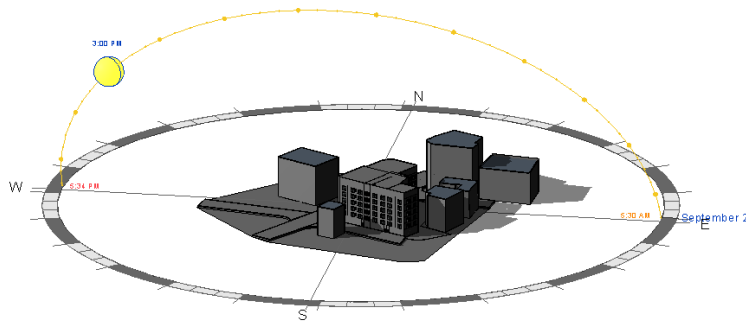


Figure 46 shading in September at 3:00PM

## 2.6.2. After modification

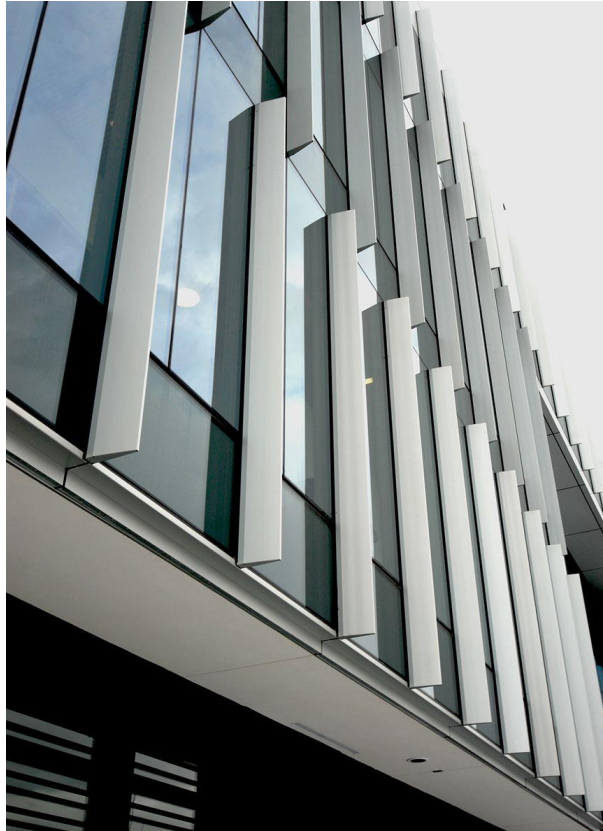
In this section, modification results are shown and the effect on the environment of the project:

### 2.6.2.1. Shading system of a building:

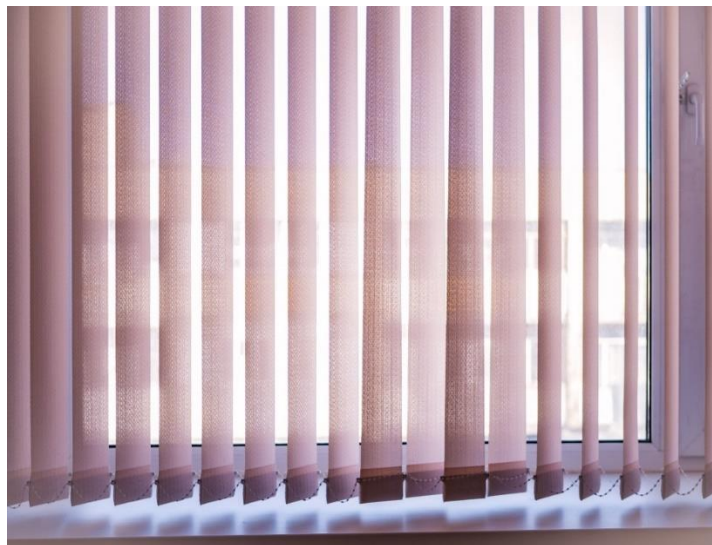
Shading is one of the most important elements that creates thermal and lighting comfort in the building. Shading improves the thermal and lighting performance in buildings, it improves the lighting performance using lighting coming from the solar insolation, it also improves thermal performance in the building by lowering the amount of heating load or cooling needed. There are many types of shading systems, shading systems vary according to their location and the nature of their use. Shading system for example, Side fins system, vertical louvers, vertical or horizontal shutters, also horizontal cantilevers.

In this project Side fins and horizontal cantilevers are going to be used as an external shading system, down below is a picture that defines the appearance and functionality of the systems to be used. Side fins made of metal will be installed on the eastern and western elevations of the building. In addition to horizontal cantilevers that will be used on the

southern elevation of the building. The system will be shown in detail in a picture taken from Design builder later on in this chapter. For glare treatment a suggested horizontal and vertical shatters will be installed based on their function inside the building acting as curtains. (vertical shatters for eastern and western elevations, horizontal shatters for south).



*Figure 47 Side Fins used on building's facade*



*Figure 48 Vertical window shatters*



*Figure 49 : horizontal window shutters*



*Figure 50 horizontal window shutters*

### **Dealing with the southern elevations:**

Horizontal cantilevers are the best choice to fix the southern elevations of the building, those cantilevers provide a good amount of solar insulation and prevent the high heat gain in the building in summers. Horizontal cantilevers are designed on two days in the year, which enables the sun to enter the building as much as possible in winters, and the least minimum in summers.

Design of the horizontal cantilever depends on the 21<sup>st</sup> of July at 11:00 AM, on the other hand in winter check the cantilever at the 21<sup>st</sup> of January at 12:00 PM. By this design thermal and lighting comfort will be achieved.

### **After modifications:**

The changes that were made, is installing horizontal cantilevers for the southern elevation of the building with a length of 0.5 meters along each southern window, the glass windows of the project were revealed 0.3meters to the inside, by revealing the windows we achieved less heating and cooling loads. In addition to installing side fins on the eastern and western elevations of the building. Those side fins are vertical components made of aluminum blade installed at the sides of the windows., they were installed at the outside of the eastern and western elevations. Not forgetting to enlarge the area of some windows in the facades, in order to take advantage of the sun's rays, especially in the winter seasons. Cantilevers are installed also at the far end of some facades that are exposed to direct sunlight, such as the southeastern facade, in order to mitigate the effect of sunlight reaching the building.

### **2.6.3. Heating and cooling loads:**

In building design and engineering, thermal comfort is a big concept to worry about. It's all about making sure people feel comfortable when it comes to temperature and air refreshing inside the building spaces. It is very important for creating spaces that keep people healthy, productive, and happy. Buildings undergo a lot of transformations, and there's a continual worry about saving energy. So insulating the building and using the right construction material will lead to thermal comfort in addition to saving energy that will be used directly for the HVAC system. However, striking the perfect balance between energy efficiency and ensuring people's comfort is a challenging problem.

Heating and cooling loads are calculated by taking into consideration a number of variables, including building size, insulation, orientation, occupancy, weather, and more

#### **1. Houses:**

Heating load: The heating load is the amount of energy needed to heat a house during colder periods. It is typically calculated based on factors such as the outdoor temperature, desired indoor temperature, insulation levels, and air leakage. Heating load requirements for houses can range widely depending on factors like climate and building efficiency but are commonly measured in British Thermal Units (BTUs) or kilowatts (kW).

2. Cooling load: The cooling load is the amount of energy required to cool a house during hotter periods. It is calculated based on factors such as the outdoor temperature, desired

indoor temperature, solar heat gain, insulation levels, and internal heat sources. Cooling load requirements for houses are also measured in BTUs or kilowatts.

### 3.Retail

- Cooling load: The cooling load for retail buildings is also calculated based on factors such as the building's size, insulation, outdoor temperature, solar heat gain, internal heat sources, and ventilation rates. It is typically measured in BTUs or kilowatts.

From ASHRE 55 or ISO 7730:

Maintain operative temperature between:

20.0 to 23.5o C in winter

22.5 to 26.0o C in summer

Maintaining Rh between 30 to 60%

AIR Speed between 0.1 to 0.35 m/s

#### **2.6.3.1. Design Builder Before modification:**

Here in this project the building was built and analyzed on “Design Builder” program. Two cases were taken into consideration, one before modification, and another one after modification.

Down below are some pictures of the project’s building before modification:

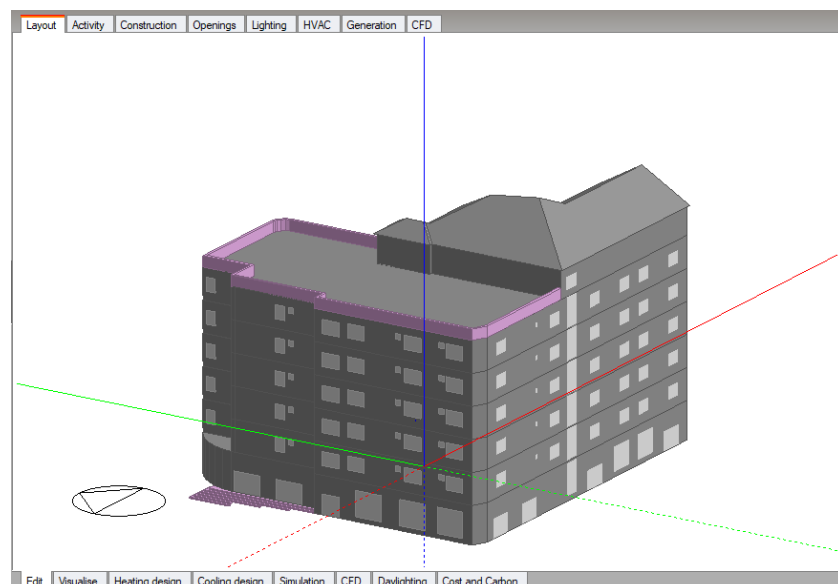


Figure 51 Building View 1

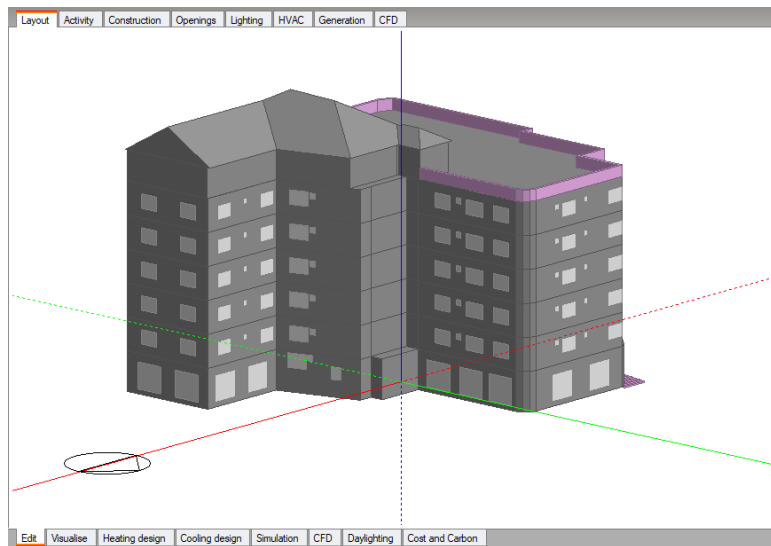


Figure 52: Building View 2

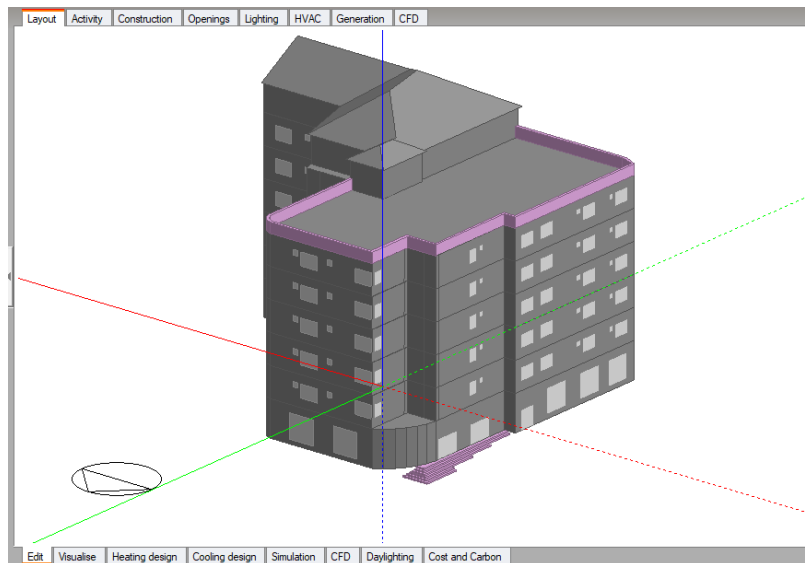
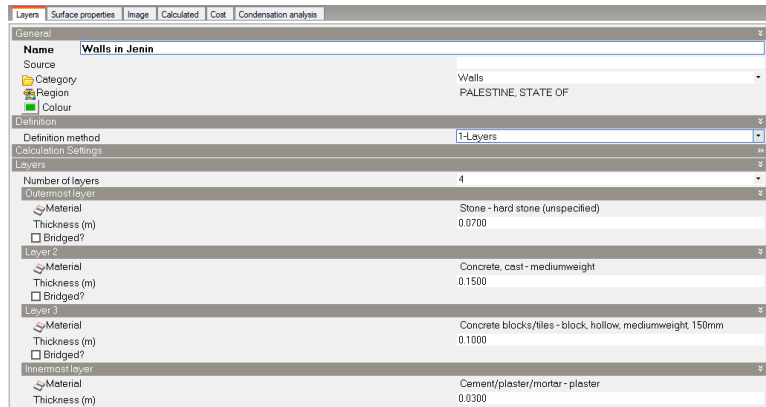


Figure 53: Building view 3

### 2.6.3.1.1. External Walls

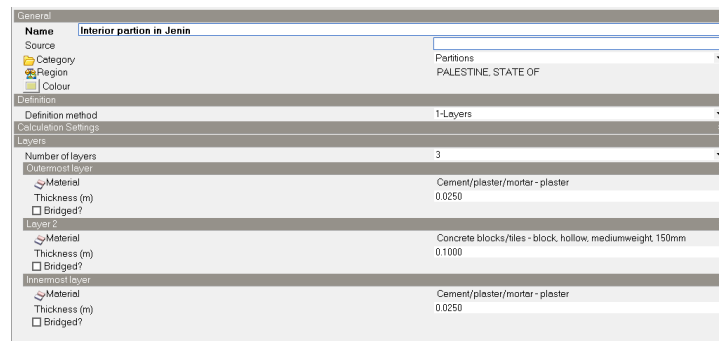
In the before case the external walls were composed of four layers, Hard stone, cast concrete, hollow block, plaster respectively, with the following thicknesses 7cm, 15cm, 10cm, 3cm respectively with an overall U-Value of the external wall 1.59.



### With Bridging (BS EN ISO 6946)

Thickness (m)	0.4600
Upper resistance limit (m...)	0.669
Lower resistance limit (m...)	0.656
U-Value surface to surfa...	2.222
R-Value (m <sup>2</sup> -K/W)	0.662
<b>U-Value (W/m<sup>2</sup>-K)</b>	<b>1.510</b>

**2.6.3.1.2. Internal partitions** were composed of three layers starting off with, plaster, hollow block, plaster, with the following thicknesses 2.5cm, 10cm, 2.5cm respectively. With a total U-Value of 1.77 as shown down below.

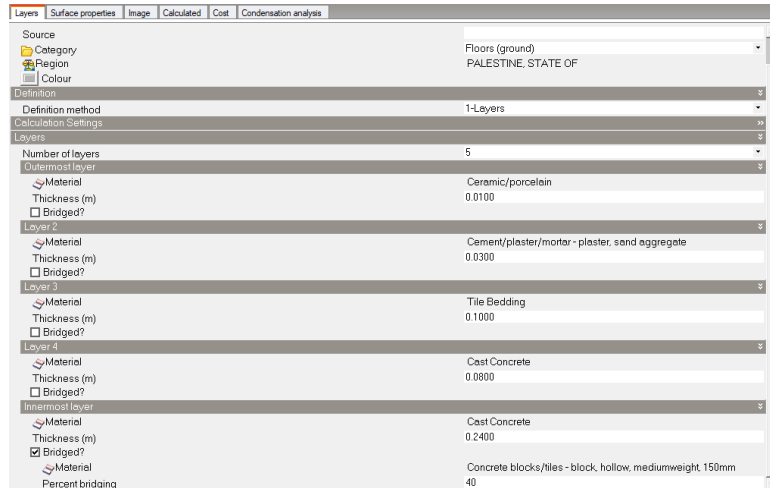


### With Bridging (BS EN ISO 6946)

Thickness (m)	0.1500
Upper resistance limit (m...)	0.564
Lower resistance limit (m...)	0.564
U-Value surface to surfa...	3.288
R-Value (m <sup>2</sup> -K/W)	0.564
<b>U-Value (W/m<sup>2</sup>-K)</b>	<b>1.773</b>

### 2.6.3.1.3. Ground floor slab and internal slabs:

are One-way slab, they are composed of 5 layers, starting with tiles, cement mortar, tile bedding, reinforced concrete, with the following thicknesses 1cm, 3cm, 10cm, 32cm respectively.



#### With Bridging (BS EN ISO 6946)

Thickness (m)	0.4600
Upper resistance limit (m...)	0.669
Lower resistance limit (m...)	0.656
U-Value surface to surfa...	2.222
R-Value (m <sup>2</sup> -K/W)	0.662
<b>U-Value (W/m<sup>2</sup>-K)</b>	<b>1.510</b>

### 2.6.3.1.4. Windows

used in the project were aluminum framed windows with thermal break with a clear glass 3mm and had a U-Value of 5.78.

Calculated Values	
Total solar transmission (SHGC)	0.819
Direct solar transmission	0.775
Light transmission	0.881
U-value (ISO 10292/ EN 673) (W/m <sup>2</sup> -K)	5.718
<b>U-Value (W/m<sup>2</sup>-K)</b>	<b>5.778</b>

### 2.6.3.2. Heating design capacity before modification:

As can be noticed down below the greatest heating load comes from the external walls in first place with a 90 KW load, and then the external windows with 50.5 KW load:

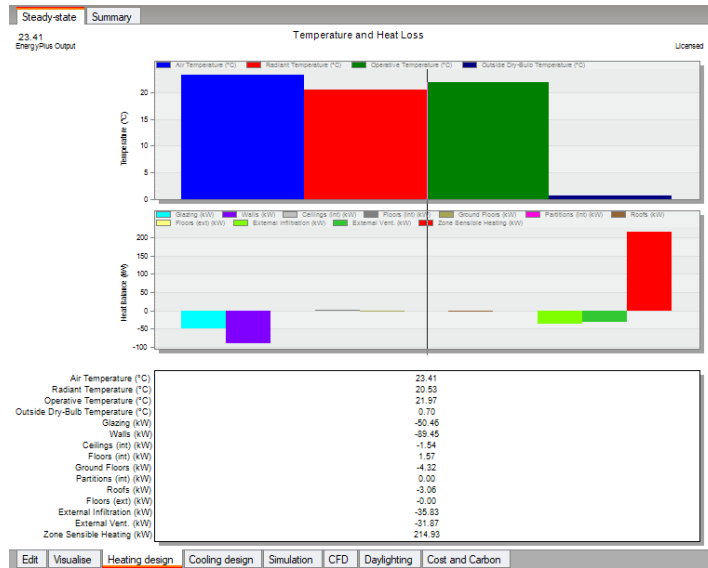


Figure 54 heating design analysis

Table 5 Ground floor and Roof heating capacity

Zone	Design Capacity (W/m2)	Comfort Tempe...	Steady-State ...	Design Capa...	Glazing ...	Wall Ga...	Floor G...	Floor an...	Ventilati...	Infiltratio...
<b>Building Total Design Heating Capacity = 268 650 (kW)</b>										
<b>Ground Floor Total Design Heating Capacity = 61 740 (kW)</b>										
shopping store 5	103.1171	22.00	3.72	<b>4.65</b>	-0.851	-1.617	-0.210	-0.092	-0.497	-0.451
shopping store 10	126.3336	22.00	3.86	<b>4.82</b>	-1.689	-1.201	-0.154	-0.004	-0.421	-0.392
Corridor 3	51.4947	22.00	5.29	<b>6.61</b>	-0.851	-1.023	-0.732	-0.019	-1.406	-1.201
Guard room	135.1176	22.00	1.26	<b>1.58</b>	0.000	-0.985	-0.065	-0.042	-0.053	-0.115
shopping store 8	116.8833	22.00	1.79	<b>2.24</b>	-0.862	-0.428	-0.094	-0.004	-0.211	-0.190
shopping store 6	77.9824	22.00	2.07	<b>2.59</b>	0.000	-1.193	-0.185	-0.006	-0.385	-0.320
shopping store 7	35.7695	22.00	1.10	<b>1.37</b>	0.000	-0.066	-0.264	0.004	-0.423	-0.350
Corridor 2	89.4525	22.00	1.98	<b>1.73</b>	0.000	-0.969	-0.113	-0.006	-0.212	-0.196
Corridor	59.9127	22.00	8.47	<b>10.59</b>	-2.377	-1.480	-0.997	0.000	1.935	1.685
shopping store 11	178.5222	22.00	3.10	<b>3.87</b>	-1.687	-0.854	-0.077	-0.013	-0.239	-0.228
Praying room	42.2514	22.00	0.87	<b>1.09</b>	0.000	-0.036	-0.185	0.008	-0.424	-0.234
shopping store 13	35.7295	22.00	1.44	<b>1.79</b>	0.000	-0.079	-0.342	-0.002	-0.553	-0.458
shopping store 12	85.9865	22.00	2.16	<b>2.70</b>	-0.860	-0.482	-0.167	-0.002	-0.347	-0.307
shopping store 3	103.4861	22.00	1.96	<b>2.46</b>	-0.803	-0.549	-0.120	0.002	-0.261	-0.234
shopping store 4	113.8524	22.00	4.93	<b>6.16</b>	-1.634	-1.908	-0.220	-0.021	-0.596	-0.552
shopping store 9	0.0000	16.25	0.00	<b>0.00</b>	0.000	-0.103	0.078	0.187	0.000	-0.162
shopping store 1	118.3004	22.00	3.37	<b>4.21</b>	-0.847	-1.600	-0.157	-0.013	-0.392	-0.360
shopping store 2	70.9382	22.00	2.62	<b>3.28</b>	-0.017	-1.418	-0.254	0.021	-0.509	-0.445
<b>Roof Total Design Heating Capacity = 15 620 (kW)</b>										
Service	39.0525	22.00	5.87	<b>7.34</b>	-0.311	-3.666	0.135	0.000	-0.852	-1.176
Closed Terrace	84.0442	22.00	6.62	<b>8.28</b>	0.000	-3.467	0.056	-0.003	-2.576	-0.632

Table 6 First floor heating capacity

Zone	Design Capacity (W/m2)	Comfort Tempe...	Steady-State ...	Design Capa...	Glazing ...	Wall Ga...	Floor G...	Floor an...	Ventilati...	Infiltratio...
<b>First Floor Total Design Heating Capacity = 37 720 (kW)</b>										
Kitchen 1	52.6438	22.00	0.91	<b>1.14</b>	-0.176	-0.477	0.008	-0.010	-0.109	-0.148
Guest room 1	46.8720	22.00	1.51	<b>1.88</b>	-0.322	-0.809	0.015	-0.021	-0.089	-0.275
Master bedroom 4	119.2314	22.00	1.58	<b>1.97</b>	-0.493	-0.930	0.025	-0.022	-0.036	-0.121
Guest room 2	71.7544	22.00	0.90	<b>1.12</b>	-0.329	-0.420	0.004	-0.011	-0.035	-0.109
Dining 1	46.4369	22.00	0.79	<b>0.99</b>	0.000	-0.039	-0.013	0.000	-0.604	-0.138
corridor 1	27.6218	22.00	0.05	<b>0.06</b>	0.000	-0.030	-0.003	0.000	0.000	-0.014
Master Bedroom 1	119.6053	22.00	1.24	<b>1.55</b>	-0.327	-0.793	0.013	-0.015	-0.028	-0.094
Bedroom 1	75.7636	22.00	0.80	<b>1.00</b>	-0.345	-0.219	-0.003	-0.007	-0.137	-0.091
kitchen and living	42.3951	22.00	0.96	<b>1.21</b>	-0.360	-0.295	0.006	-0.010	-0.113	-0.192
living and dining	14.3578	22.00	0.60	<b>0.76</b>	0.000	-0.098	-0.026	0.000	-0.140	-0.341
Master bedroom 2	80.1831	22.00	0.97	<b>1.22</b>	0.000	-0.865	0.017	-0.011	-0.033	-0.079
Bedroom 2	82.3478	22.00	0.88	<b>1.10</b>	-0.328	-0.324	0.010	-0.009	-0.139	-0.093
Master Bedroom 3	97.7456	22.00	1.74	<b>2.18</b>	-0.617	-0.915	0.018	-0.023	-0.048	-0.160
Bedroom's corridor	15.4007	22.00	0.10	<b>0.12</b>	0.000	-0.038	-0.007	0.000	0.000	-0.050
Bedroom 3	58.6250	22.00	1.34	<b>1.67</b>	-0.328	-0.506	0.003	-0.014	-0.295	-0.195
corridor 2	33.2762	22.00	1.45	<b>1.91</b>	0.000	-1.001	0.009	-0.017	-0.076	-0.365
Master bedroom	101.3653	22.00	1.90	<b>2.37</b>	-0.625	-1.050	0.026	-0.027	-0.051	-0.169
Dining	46.7988	22.00	0.67	<b>0.84</b>	0.000	-0.039	-0.009	0.000	-0.506	-0.116
Bedroom 4	113.5888	22.00	2.16	<b>2.69</b>	-0.648	-1.079	0.015	-0.027	-0.246	-0.172
Bedroom	67.4814	22.00	0.97	<b>1.22</b>	-0.327	-0.332	0.007	-0.010	-0.187	-0.124
living room	45.3374	22.00	2.20	<b>2.75</b>	-0.606	-0.983	-0.003	-0.029	-0.161	-0.417
Kitchen	46.5894	22.00	1.40	<b>1.74</b>	-0.301	-0.463	-0.181	-0.006	-0.188	-0.256
Guest room 3	32.6557	22.00	1.08	<b>1.35</b>	-0.303	-0.388	-0.007	-0.011	-0.091	-0.277
Guest room	48.4881	22.00	0.86	<b>1.08</b>	-0.337	-0.310	0.003	-0.010	-0.049	-0.158
Entrance	12.0555	22.00	0.14	<b>0.18</b>	0.000	-0.022	-0.005	0.000	-0.021	-0.096
corridor	29.7807	22.00	1.29	<b>1.61</b>	-0.597	-0.232	-0.007	-0.014	-0.075	-0.362
Kitchen and dining	22.8914	22.00	1.69	<b>2.11</b>	-0.003	-0.578	-0.026	-0.011	-0.463	-0.606

Table 7 Second floor heating capacity

Steady-state Summary		Design Capacity (W/m2)	Comfort Tempe...	Steady-State ...	Design Capa...	Glazing ...	Wall Ga...	Floor G...	Roof an...	Ventilati...	Infiltratio...
[-] Second Floor Total Design Heating Capacity = 37.360 (kW)											
Kitchen 1	52.7750	22.00	0.91	<b>1.14</b>	-0.178	-0.479	0.010	-0.010	-0.109	-0.148	
Guest room 1	46.8965	22.00	1.51	<b>1.88</b>	-0.330	-0.810	0.021	-0.021	-0.089	-0.276	
Master bedroom 4	120.2543	22.00	1.59	<b>1.99</b>	-0.500	-0.932	0.021	-0.022	-0.036	-0.121	
Guest room 2	71.6842	22.00	0.90	<b>1.12</b>	-0.334	-0.420	0.011	-0.011	-0.035	-0.109	
Dining 1	45.8065	22.00	0.78	<b>0.98</b>	0.000	-0.040	0.000	-0.001	-0.604	-0.138	
corridor 1	26.0094	22.00	0.05	<b>0.06</b>	0.000	-0.031	0.000	0.000	0.000	-0.014	
Master Bedroom 1	120.0656	22.00	1.25	<b>1.56</b>	-0.332	-0.794	0.015	-0.015	-0.028	-0.094	
Bedroom 1	75.3357	22.00	0.80	<b>1.00</b>	-0.351	-0.220	0.007	-0.008	-0.137	-0.091	
kitchen and living	42.4550	22.00	0.97	<b>1.21</b>	-0.366	-0.295	0.011	-0.011	-0.113	-0.192	
living and dining	13.8435	22.00	0.58	<b>0.73</b>	0.000	-0.101	0.001	-0.002	-0.140	-0.341	
Master bedroom 2	80.7315	22.00	0.98	<b>1.22</b>	0.000	-0.866	0.011	-0.011	-0.033	-0.080	
Bedroom 2	82.9351	22.00	0.89	<b>1.11</b>	-0.333	-0.324	0.009	-0.009	-0.139	-0.093	
Master Bedroom 3	98.0479	22.00	1.75	<b>2.19</b>	-0.625	-0.916	0.023	-0.023	-0.048	-0.160	
Bedroom's corridor	14.4626	22.00	0.09	<b>0.11</b>	0.000	-0.039	0.000	0.000	0.000	-0.050	
Bedroom 3	58.4114	22.00	1.33	<b>1.66</b>	-0.333	-0.507	0.014	-0.014	-0.295	-0.195	
corridor 2	33.1229	22.00	1.44	<b>1.80</b>	0.000	-1.001	0.017	-0.017	-0.076	-0.365	
Master bedroom	101.8809	22.00	1.91	<b>2.38</b>	-0.634	-1.051	0.027	-0.027	-0.051	-0.170	
Dining	46.0837	22.00	0.66	<b>0.82</b>	0.000	-0.038	0.000	-0.001	-0.506	-0.116	
Bedroom 4	113.7268	22.00	2.16	<b>2.70</b>	-0.657	-1.082	0.027	-0.028	-0.246	-0.173	
Bedroom	67.6980	22.00	0.98	<b>1.22</b>	-0.333	-0.333	0.010	-0.010	-0.187	-0.124	
living room	44.7986	22.00	2.18	<b>2.72</b>	-0.615	-0.981	0.030	-0.031	-0.161	-0.417	
Kitchen	41.1874	22.00	1.23	<b>1.54</b>	-0.305	-0.480	0.007	-0.014	-0.188	-0.254	
Guest room 3	32.3008	22.00	1.06	<b>1.33</b>	-0.307	-0.389	0.011	-0.012	-0.091	-0.277	
Guest room	48.1272	22.00	0.85	<b>1.07</b>	-0.342	-0.311	0.010	-0.010	-0.049	-0.152	
Entrance	11.6222	22.00	0.14	<b>0.17</b>	0.000	-0.022	0.000	0.000	-0.021	-0.096	
corridor	29.3469	22.00	1.27	<b>1.58</b>	-0.604	-0.226	0.014	-0.015	-0.075	-0.362	
Kitchen and dining	22.4306	22.00	1.65	<b>2.07</b>	-0.003	-0.581	0.012	-0.013	-0.463	-0.606	

Table 8 Third floor heating capacity

Steady-state Summary		Design Capacity (W/m2)	Comfort Tempe...	Steady-State ...	Design Capa...	Glazing ...	Wall Ga...	Floor G...	Roof an...	Ventilati...	Infiltratio...
[-] Third Floor Total Design Heating Capacity = 37.500 (kW)											
Kitchen 1	52.9269	22.00	0.92	<b>1.15</b>	-0.180	-0.480	0.011	-0.011	-0.109	-0.148	
Guest room 1	47.0410	22.00	1.51	<b>1.89</b>	-0.334	-0.812	0.022	-0.022	-0.089	-0.276	
Master bedroom 4	120.8041	22.00	1.60	<b>2.00</b>	-0.506	-0.934	0.021	-0.022	-0.036	-0.121	
Guest room 2	72.0219	22.00	0.90	<b>1.13</b>	-0.338	-0.421	0.011	-0.011	-0.035	-0.109	
Dining 1	45.8096	22.00	0.78	<b>0.98</b>	0.000	-0.040	0.001	-0.001	-0.604	-0.138	
corridor 1	26.0508	22.00	0.05	<b>0.06</b>	0.000	-0.031	0.000	0.000	0.000	-0.014	
Master Bedroom 1	120.5452	22.00	1.25	<b>1.57</b>	-0.335	-0.796	0.015	-0.015	-0.028	-0.094	
Bedroom 1	75.7035	22.00	0.80	<b>1.00</b>	-0.354	-0.220	0.008	-0.008	-0.137	-0.091	
kitchen and living	42.6492	22.00	0.97	<b>1.21</b>	-0.370	-0.295	0.011	-0.011	-0.113	-0.193	
living and dining	13.8529	22.00	0.58	<b>0.73</b>	0.000	-0.101	0.003	-0.004	-0.140	-0.341	
Master bedroom 2	80.8856	22.00	0.98	<b>1.23</b>	0.000	-0.868	0.011	-0.011	-0.033	-0.080	
Bedroom 2	83.3152	22.00	0.89	<b>1.12</b>	-0.336	-0.325	0.009	-0.009	-0.139	-0.093	
Master Bedroom 3	98.4752	22.00	1.76	<b>2.20</b>	-0.631	-0.918	0.023	-0.023	-0.048	-0.160	
Bedroom's corridor	14.4701	22.00	0.09	<b>0.11</b>	0.000	-0.039	0.001	-0.001	0.000	-0.050	
Bedroom 3	58.6056	22.00	1.33	<b>1.67</b>	-0.336	-0.508	0.014	-0.015	-0.295	-0.196	
corridor 2	33.1752	22.00	1.44	<b>1.81</b>	0.000	-1.003	0.018	-0.018	-0.076	-0.365	
Master bedroom	102.3076	22.00	1.91	<b>2.39</b>	-0.640	-1.053	0.027	-0.027	-0.051	-0.170	
Dining	46.0577	22.00	0.66	<b>0.82</b>	0.000	-0.038	0.001	-0.001	-0.506	-0.116	
Bedroom 4	114.1583	22.00	2.17	<b>2.71</b>	-0.664	-1.084	0.028	-0.028	-0.246	-0.173	
Bedroom	67.9678	22.00	0.98	<b>1.22</b>	-0.336	-0.333	0.010	-0.010	-0.187	-0.124	
living room	44.9121	22.00	2.18	<b>2.73</b>	-0.620	-0.983	0.031	-0.031	-0.161	-0.417	
Kitchen	41.1022	22.00	1.23	<b>1.54</b>	-0.308	-0.481	0.014	-0.014	-0.188	-0.254	
Guest room 3	32.3898	22.00	1.07	<b>1.33</b>	-0.309	-0.390	0.013	-0.013	-0.091	-0.277	
Guest room	48.3206	22.00	0.86	<b>1.07</b>	-0.346	-0.311	0.010	-0.010	-0.049	-0.152	
Entrance	11.6108	22.00	0.14	<b>0.17</b>	0.000	-0.022	0.001	0.000	-0.021	-0.096	
corridor	29.4459	22.00	1.27	<b>1.59</b>	-0.609	-0.226	0.015	-0.015	-0.075	-0.362	
Kitchen and dining	22.4529	22.00	1.66	<b>2.07</b>	-0.003	-0.582	0.015	-0.015	-0.463	-0.607	

Table 9 Fourth floor heating capacity

Steady-state Summary		Design Capacity (W/m2)	Comfort Tempe...	Steady-State ...	Design Capa...	Glazing ...	Wall Ga...	Floor G...	Roof an...	Ventilati...	Infiltratio...
[-] Fourth Floor Total Design Heating Capacity = 37.740 (kW)											
Kitchen 1	53.3493	22.00	0.92	<b>1.15</b>	-0.181	-0.481	0.011	-0.016	-0.109	-0.149	
Guest room 1	47.4368	22.00	1.52	<b>1.90</b>	-0.336	-0.813	0.022	-0.030	-0.089	-0.277	
Master bedroom 4	121.4373	22.00	1.61	<b>2.01</b>	-0.510	-0.936	0.021	-0.025	-0.036	-0.121	
Guest room 2	72.5497	22.00	0.91	<b>1.14</b>	-0.340	-0.422	0.011	-0.014	-0.035	-0.110	
Dining 1	46.2005	22.00	0.79	<b>0.99</b>	0.000	-0.040	0.002	-0.009	-0.604	-0.139	
corridor 1	26.3033	22.00	0.05	<b>0.06</b>	0.000	-0.031	0.000	-0.001	0.000	-0.014	
Master Bedroom 1	121.1220	22.00	1.26	<b>1.57</b>	-0.338	-0.797	0.015	-0.017	-0.028	-0.094	
Bedroom 1	76.2339	22.00	0.81	<b>1.01</b>	-0.357	-0.221	0.008	-0.010	-0.137	-0.091	
kitchen and living	43.1010	22.00	0.98	<b>1.23</b>	-0.372	-0.296	0.011	-0.018	-0.113	-0.193	
living and dining	14.2680	22.00	0.60	<b>0.75</b>	0.000	-0.099	0.005	-0.025	-0.140	-0.342	
Master bedroom 2	81.1889	22.00	0.98	<b>1.23</b>	0.000	-0.870	0.011	-0.013	-0.033	-0.080	
Bedroom 2	83.8473	22.00	0.90	<b>1.12</b>	-0.339	-0.326	0.009	-0.012	-0.139	-0.093	
Master Bedroom 3	99.0378	22.00	1.77	<b>2.21</b>	-0.636	-0.920	0.023	-0.027	-0.048	-0.161	
Bedroom's corridor	14.7834	22.00	0.09	<b>0.11</b>	0.000	-0.039	0.001	-0.002	0.000	-0.050	
Bedroom 3	59.0597	22.00	1.35	<b>1.68</b>	-0.339	-0.509	0.015	-0.022	-0.295	-0.196	
corridor 2	33.4287	22.00	1.46	<b>1.82</b>	0.000	-1.006	0.018	-0.026	-0.076	-0.366	
Master bedroom	102.6162	22.00	1.92	<b>2.40</b>	-0.644	-1.055	0.027	-0.026	-0.051	-0.170	
Dining	46.1510	22.00	0.66	<b>0.83</b>	0.000	-0.038	0.001	-0.002	-0.506	-0.116	
Bedroom 4	114.4989	22.00	2.17	<b>2.72</b>	-0.669	-1.086	0.028	-0.027	-0.246	-0.173	
Bedroom	68.1988	22.00	0.98	<b>1.23</b>	-0.339	-0.333	0.010	-0.010	-0.187	-0.124	
living room	45.9821	22.00	2.19	<b>2.74</b>	-0.624	-0.985	0.031	-0.032	-0.161	-0.418	
Kitchen	41.2107	22.00	1.23	<b>1.54</b>	-0.310	-0.482	0.014	-0.015	-0.188	-0.255	
Guest room 3	32.8045	22.00	1.08	<b>1.35</b>	-0.311	-0.390	0.013	-0.024	-0.091	-0.277	
Guest room	48.5104	22.00	0.86	<b>1.08</b>	-0.348	-0.312	0.010	-0.010	-0.049	-0.152	
Entrance	11.7127	22.00	0.14	<b>0.17</b>	0.000	-0.022	0.001	-0.002	-0.021	-0.096	
corridor	29.6121	22.00	1.28	<b>1.60</b>	-0.612	-0.227	0.016	-0.017	-0.075	-0.363	
Kitchen and dining	22.8271	22.00	1.68	<b>2.10</b>	-0.003	-0.581	0.017	-0.044	-0.463	-0.608	

Table 10 Fifth floor heating capacity

Zone	Design Capacity (W/m <sup>2</sup> )	Comfort Tempe...	Steady-State...	Design Capa...	Glazing	Wall Ga.	Floor G.	Roof an...	Verzikh...	Infiltratio...
- Fifth Floor Total Design Heating Capacity = 40.980 (kW)										
Kitchen 1	60.1172	22.00	1.04	1.30	-0.182	-0.482	0.016	-0.134	-0.109	-0.150
Guest room 1	54.0249	22.00	1.74	2.17	-0.358	-0.814	0.030	-0.245	-0.089	-0.279
Master bedroom 4	126.2369	22.00	1.70	2.12	-0.512	-0.938	0.023	-0.111	-0.036	-0.122
Guest room 2	79.9202	22.00	1.00	1.25	-0.242	-0.425	0.014	-0.099	-0.035	-0.110
Dining 1	52.5746	22.00	0.90	1.12	0.000	-0.034	0.009	-0.129	-0.604	-0.141
corridor 1	34.7695	22.00	0.06	0.08	0.000	-0.001	0.001	-0.015	0.000	-0.014
Master Bedroom 1	128.0684	22.00	1.33	1.66	-0.340	-0.799	0.017	-0.088	-0.028	-0.095
Bedroom 1	83.5285	22.00	0.89	1.11	-0.359	-0.222	0.010	-0.086	-0.137	-0.052
kitchen and living	49.9215	22.00	1.14	1.42	-0.374	-0.298	0.018	-0.174	-0.113	-0.195
living and dining	20.2139	22.00	0.85	1.06	0.000	-0.080	0.025	-0.309	-0.140	-0.348
Master bedroom 2	87.2180	22.00	1.06	1.32	0.000	-0.874	0.013	-0.083	-0.033	-0.080
Bedroom 2	91.0524	22.00	0.98	1.22	-0.340	-0.327	0.012	-0.088	-0.139	-0.094
Master Bedroom 3	105.8967	22.00	1.89	2.36	-0.639	-0.923	0.027	-0.146	-0.048	-0.162
Bedroom's corridor	22.8271	22.00	0.14	0.17	0.000	-0.039	0.002	-0.049	0.000	-0.051
Bedroom 3	85.0580	22.00	1.50	1.87	-0.340	-0.510	0.022	-0.174	-0.235	-0.198
corridor 2	37.9540	22.00	1.65	2.07	0.000	-1.014	0.027	-0.221	-0.076	-0.369
Master bedroom	101.9109	22.00	1.91	2.38	-0.648	-1.057	0.026	-0.065	-0.051	-0.170
Dining	47.3888	22.00	0.68	0.85	0.000	-0.035	0.002	-0.023	-0.506	-0.117
Bedroom 4	113.8034	22.00	2.16	2.70	-0.673	-1.088	0.027	-0.007	-0.246	-0.173
Bedroom	68.9341	22.00	0.99	1.24	-0.340	-0.334	0.010	-0.018	-0.187	-0.124
living room	45.3618	22.00	2.20	2.75	-0.628	-0.985	0.032	-0.042	-0.161	-0.418
Kitchen	41.5918	22.00	1.25	1.56	-0.312	-0.484	0.015	-0.022	-0.188	-0.255
Guest room 3	38.9965	22.00	1.28	1.61	-0.313	-0.385	0.025	-0.240	-0.091	-0.281
Guest room	48.7718	22.00	0.87	1.08	-0.350	-0.314	0.011	-0.011	-0.049	-0.152
Entrance	13.0041	22.00	0.15	0.19	0.000	-0.021	0.002	-0.018	-0.021	-0.096
corridor	38.5340	22.00	1.32	1.65	-0.615	-0.241	0.019	-0.042	-0.075	-0.364
Kitchen and dining	28.3781	22.00	2.14	2.67	-0.004	-0.562	0.045	-0.535	-0.463	-0.617

As shown in the results above heating capacity for the whole building is calculated to be 268.660 kw which is so high and need to be modified and decreased. Decreasing the heating capacity can be done by decreasing the U-Value for the building either by changing the material used or by adding an insulation.

### 2.6.3.3.cooling design capacity before modification:

Now as can be noticed down below the cooling load comes from the external glazing in first place which is represented in the yellow line in the second graph, in addition to external walls and a slight effect from the internal partitions:

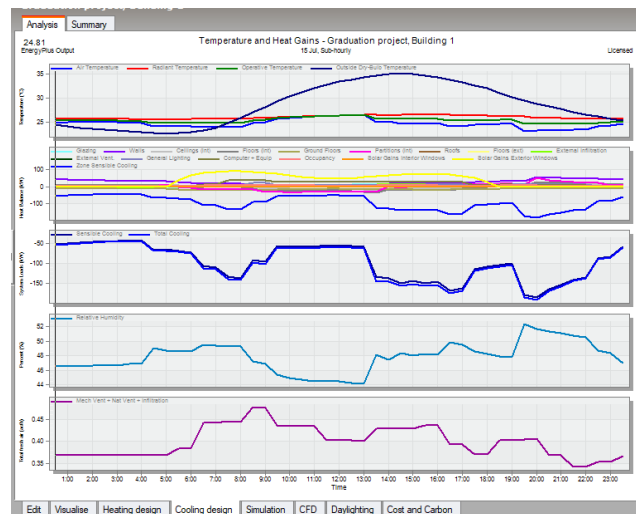


Figure 55 cooling design analysis

Table 11 Ground floor cooling capacity

Analysis Summary		Zone	Design Cooling Load Per Floor Area (W/m2)	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Sensible
<b>Building 1</b>							
	GroundFloor:ShoppingStore5	121.7	<b>5.49</b>	<b>0.4629</b>	4.77	4.50	
	GroundFloor:ShoppingStore10	171.6	<b>6.55</b>	<b>0.6709</b>	5.70	5.50	
	GroundFloor:Corridor3	38.1	<b>4.90</b>	<b>0.3113</b>	4.26	3.43	
	GroundFloor:GarageRoom	0.0	0.00	0	0.00	0.00	
	GroundFloor:ShoppingStore8	236.7	<b>4.53</b>	<b>0.5312</b>	3.94	3.87	
	GroundFloor:ShoppingStore6	115.5	<b>3.83</b>	<b>0.3080</b>	3.33	3.12	
	GroundFloor:ShoppingStore7	86.5	<b>3.32</b>	<b>0.2276</b>	2.89	2.56	
	GroundFloor:Corridor2	58.8	<b>1.14</b>	<b>0.0830</b>	0.99	0.87	
	GroundFloor:Corridor	48.7	<b>8.61</b>	<b>0.5913</b>	7.48	6.17	
	GroundFloor:ShoppingStore11	238.9	<b>5.18</b>	<b>0.6056</b>	4.50	4.40	
	GroundFloor:PrayingRoom	28.2	<b>0.72</b>	<b>0.0424</b>	0.63	0.50	
	GroundFloor:ShoppingStore13	87.4	<b>4.39</b>	<b>0.3038</b>	3.82	3.39	
	GroundFloor:ShoppingStore12	191.5	<b>6.03</b>	<b>0.6189</b>	5.24	4.99	
	GroundFloor:ShoppingStore3	193.7	<b>4.60</b>	<b>0.4980</b>	4.00	4.00	
	GroundFloor:ShoppingStore4	168.2	<b>9.11</b>	<b>0.9817</b>	7.92	7.92	
	GroundFloor:ShoppingStore9	0.0	0.00	0	0.00	0.00	
	GroundFloor:ShoppingStore1	200.9	<b>7.15</b>	<b>0.7634</b>	6.22	5.94	
	GroundFloor:ShoppingStore2	104.9	<b>4.84</b>	<b>0.3674</b>	4.21	3.82	

Table 12 First floor cooling capacity

Analysis Summary		Zone	Design Cooling Load Per Floor Area (W/m2)	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Sensible
	FirstFloor:Kitchen1	78.6	<b>1.70</b>	<b>0.1602</b>	1.48	1.45	
	FirstFloor:GuestRoom1	64.6	<b>2.59</b>	<b>0.2419</b>	2.26	2.23	
	FirstFloor:MasterBedroom4	131.2	<b>2.17</b>	<b>0.2289</b>	1.89	1.87	
	FirstFloor:GuestRoom2	155.7	<b>2.44</b>	<b>0.2784</b>	2.12	2.10	
	FirstFloor:Dining1	60.2	<b>1.29</b>	<b>0.0863</b>	1.12	0.93	
	FirstFloor:Corridor1	114.6	<b>0.25</b>	<b>0.0212</b>	0.22	0.21	
	FirstFloor:MasterBedroom1	158.4	<b>2.06</b>	<b>0.2278</b>	1.79	1.78	
	FirstFloor:Bedroom1	78.1	<b>1.04</b>	<b>0.0930</b>	0.90	0.88	
	FirstFloor:KitchenAndLiving	104.5	<b>2.97</b>	<b>0.2488</b>	2.58	2.09	
	FirstFloor:LivingAndDining	34.8	<b>1.83</b>	<b>0.1116</b>	1.59	1.17	
	FirstFloor:MasterBedroom2	75.3	<b>1.14</b>	<b>0.1038</b>	0.99	0.98	
	FirstFloor:Bedroom2	147.4	<b>1.98</b>	<b>0.2146</b>	1.72	1.70	
	FirstFloor:MasterBedroom3	151.3	<b>3.38</b>	<b>0.3926</b>	2.94	2.94	
	FirstFloor:Bedroom'sCorridor	53.6	<b>0.41</b>	<b>0.0316</b>	0.36	0.33	
	FirstFloor:Bedroom3	86.0	<b>2.45</b>	<b>0.2290</b>	2.13	1.89	
	FirstFloor:Corridor2	32.0	<b>1.74</b>	<b>0.1373</b>	1.51	1.43	
	FirstFloor:MasterBedroom	142.8	<b>3.34</b>	<b>0.3929</b>	2.90	2.90	
	FirstFloor:Dining	58.7	<b>1.05</b>	<b>0.0698</b>	0.91	0.75	
	FirstFloor:Bedroom4	128.0	<b>3.04</b>	<b>0.3343</b>	2.64	2.61	
	FirstFloor:Bedroom	53.9	<b>0.97</b>	<b>0.0856</b>	0.84	0.81	
	FirstFloor:LivingRoom	84.0	<b>5.10</b>	<b>0.5227</b>	4.44	4.44	
	FirstFloor:Kitchen	64.6	<b>2.42</b>	<b>0.2314</b>	2.11	2.11	
	FirstFloor:GuestRoom3	54.5	<b>2.24</b>	<b>0.2067</b>	1.95	1.95	
	FirstFloor:GuestRoom	87.6	<b>1.94</b>	<b>0.1885</b>	1.69	1.66	
	FirstFloor:Entrance	24.2	<b>0.36</b>	<b>0.0237</b>	0.31	0.26	
	FirstFloor:Corridor	61.1	<b>3.30</b>	<b>0.3281</b>	2.87	2.87	
	FirstFloor:KitchenAndDining	32.8	<b>3.02</b>	<b>0.2178</b>	2.63	2.34	

Table 13 Second floor cooling capacity

Analysis Summary		Zone	Design Cooling Load Per Floor Area (W/m2)	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Sensible
	SecondFloor:Kitchen1	82.1	<b>1.78</b>	<b>0.1689</b>	1.55	1.52	
	SecondFloor:GuestRoom1	69.4	<b>2.79</b>	<b>0.2611</b>	2.42	2.36	
	SecondFloor:MasterBedroom4	135.1	<b>2.23</b>	<b>0.2383</b>	1.94	1.92	
	SecondFloor:GuestRoom2	158.8	<b>2.49</b>	<b>0.2864</b>	2.16	2.14	
	SecondFloor:Dining1	61.6	<b>1.32</b>	<b>0.0889</b>	1.15	0.95	
	SecondFloor:Corridor1	109.4	<b>0.24</b>	<b>0.0202</b>	0.21	0.20	
	SecondFloor:MasterBedroom1	160.8	<b>2.09</b>	<b>0.2327</b>	1.82	1.80	
	SecondFloor:Bedroom1	74.4	<b>0.99</b>	<b>0.0878</b>	0.86	0.84	
	SecondFloor:KitchenAndLiving	109.2	<b>3.11</b>	<b>0.2668</b>	2.70	2.19	
	SecondFloor:LivingAndDining	36.3	<b>1.91</b>	<b>0.1174</b>	1.66	1.22	
	SecondFloor:MasterBedroom2	78.1	<b>1.18</b>	<b>0.1085</b>	1.03	1.01	
	SecondFloor:Bedroom2	156.4	<b>2.10</b>	<b>0.2334</b>	1.82	1.81	
	SecondFloor:MasterBedroom3	154.2	<b>3.44</b>	<b>0.4036</b>	2.99	2.99	
	SecondFloor:Bedroom'sCorridor	54.6	<b>0.42</b>	<b>0.0323</b>	0.37	0.33	
	SecondFloor:Bedroom3	86.2	<b>2.45</b>	<b>0.2297</b>	2.13	1.89	
	SecondFloor:Corridor2	32.2	<b>1.75</b>	<b>0.1382</b>	1.52	1.44	
	SecondFloor:MasterBedroom	145.7	<b>3.40</b>	<b>0.4048</b>	2.96	2.96	
	SecondFloor:Dining	60.4	<b>1.08</b>	<b>0.0723</b>	0.94	0.78	
	SecondFloor:Bedroom4	127.9	<b>3.04</b>	<b>0.3343</b>	2.64	2.61	
	SecondFloor:Bedroom	55.4	<b>1.00</b>	<b>0.0887</b>	0.87	0.83	
	SecondFloor:LivingRoom	83.9	<b>5.09</b>	<b>0.5218</b>	4.43	4.43	
	SecondFloor:Kitchen	61.9	<b>2.32</b>	<b>0.2330</b>	2.02	2.02	
	SecondFloor:GuestRoom3	57.2	<b>2.36</b>	<b>0.2189</b>	2.05	2.05	
	SecondFloor:GuestRoom	90.4	<b>2.01</b>	<b>0.1966</b>	1.74	1.71	
	SecondFloor:Entrance	27.0	<b>0.40</b>	<b>0.0271</b>	0.35	0.29	
	SecondFloor:Corridor	62.6	<b>3.38</b>	<b>0.3397</b>	2.94	2.94	
	SecondFloor:KitchenAndDining	33.4	<b>3.07</b>	<b>0.2227</b>	2.67	2.39	

Table 14 Third floor cooling capacity

Zone	Design Cooling Load Per Floor Area (W/m <sup>2</sup> )	Design Capacity (kW)	Design Flow Rate (m <sup>3</sup> /s)	Total Cooling Load (kW)	Sensible
ThirdFloor.Kitchen1	82.4	1.78	0.1638	1.55	1.52
ThirdFloor.GuestRoom1	70.0	2.81	0.2639	2.44	2.39
ThirdFloor.MasterBedroom4	135.6	2.24	0.2396	1.95	1.93
ThirdFloor.GuestRoom2	159.2	2.49	0.2875	2.17	2.15
ThirdFloor.Dining1	61.9	1.32	0.0894	1.15	0.96
ThirdFloor.Corridor1	109.3	0.24	0.0202	0.21	0.20
ThirdFloor.MasterBedroom1	169.9	2.09	0.2331	1.82	1.80
ThirdFloor.Bedroom1	74.3	0.98	0.0876	0.86	0.84
ThirdFloor.KitchenAndLiving	109.6	3.12	0.2686	2.71	2.20
ThirdFloor.LivingAndDining	36.6	1.93	0.1188	1.68	1.23
ThirdFloor.MasterBedroom2	78.3	1.19	0.1089	1.03	1.02
ThirdFloor.Bedroom2	157.1	2.11	0.2348	1.83	1.81
ThirdFloor.MasterBedroom3	154.4	3.45	0.4046	3.00	3.00
ThirdFloor.BedroomVsCorridor	54.8	0.42	0.0325	0.37	0.33
ThirdFloor.Bedroom3	86.3	2.46	0.2301	2.14	1.90
ThirdFloor.Corridor2	32.1	1.75	0.1382	1.52	1.44
ThirdFloor.MasterBedroom	145.7	3.41	0.4052	2.96	2.96
ThirdFloor.Dining	60.7	1.09	0.0728	0.94	0.78
ThirdFloor.Bedroom4	127.7	3.03	0.3335	2.63	2.61
ThirdFloor.Bedroom	55.5	1.00	0.0889	0.87	0.83
ThirdFloor.LivingRoom	83.9	5.09	0.5214	4.43	4.43
ThirdFloor.Kitchen	61.6	2.31	0.2317	2.01	2.01
ThirdFloor.GuestRoom3	57.5	2.37	0.2205	2.06	2.06
ThirdFloor.GuestRoom	92.4	2.05	0.2022	1.78	1.75
ThirdFloor.Entrance	27.4	0.41	0.0276	0.35	0.30
ThirdFloor.Corridor	62.7	3.39	0.3408	2.94	2.94
ThirdFloor.KitchenAndDining	33.5	3.09	0.2238	2.68	2.40

Table 15 Fourth floor cooling capacity

Zone	Design Cooling Load Per Floor Area (W/m <sup>2</sup> )	Design Capacity (kW)	Design Flow Rate (m <sup>3</sup> /s)	Total Cooling Load (kW)	Sensible
FourthFloor.Kitchen1	83.5	1.81	0.1726	1.57	1.54
FourthFloor.GuestRoom1	70.7	2.84	0.2673	2.47	2.41
FourthFloor.MasterBedroom4	137.2	2.27	0.2436	1.97	1.95
FourthFloor.GuestRoom2	159.2	2.49	0.2876	2.17	2.15
FourthFloor.Dining1	62.6	1.34	0.0908	1.16	0.97
FourthFloor.Corridor1	110.8	0.24	0.0205	0.21	0.21
FourthFloor.MasterBedroom1	162.1	2.11	0.2356	1.83	1.82
FourthFloor.Bedroom1	75.9	1.01	0.0898	0.87	0.86
FourthFloor.KitchenAndLiving	109.9	3.13	0.2698	2.72	2.21
FourthFloor.LivingAndDining	37.7	1.99	0.1230	1.73	1.27
FourthFloor.MasterBedroom2	79.8	1.21	0.1113	1.05	1.04
FourthFloor.Bedroom2	159.7	2.13	0.2383	1.85	1.83
FourthFloor.MasterBedroom3	155.7	3.47	0.4096	3.02	3.02
FourthFloor.BedroomVsCorridor	56.4	0.44	0.0336	0.38	0.34
FourthFloor.Bedroom3	87.5	2.49	0.2352	2.17	1.93
FourthFloor.Corridor2	32.5	1.77	0.1400	1.54	1.45
FourthFloor.MasterBedroom	145.2	3.39	0.4027	2.95	2.95
FourthFloor.Dining	62.2	1.11	0.0751	0.97	0.80
FourthFloor.Bedroom4	127.2	3.02	0.3315	2.62	2.60
FourthFloor.Bedroom	55.9	1.01	0.0896	0.87	0.84
FourthFloor.LivingRoom	84.6	5.13	0.5274	4.46	4.46
FourthFloor.Kitchen	62.6	2.34	0.2365	2.04	2.04
FourthFloor.GuestRoom3	57.9	2.38	0.2221	2.07	2.07
FourthFloor.GuestRoom	95.3	2.11	0.2105	1.84	1.81
FourthFloor.Entrance	28.8	0.43	0.0293	0.37	0.31
FourthFloor.Corridor	63.6	3.43	0.3473	2.99	2.99
FourthFloor.KitchenAndDining	34.2	3.15	0.2301	2.74	2.46

Table 16 Fifth floor cooling capacity

Zone	Design Cooling Load Per Floor Area (W/m <sup>2</sup> )	Design Capacity (kW)	Design Flow Rate (m <sup>3</sup> /s)	Total Cooling Load (kW)	Sensible
FifthFloor.Kitchen1	118.4	2.56	0.2765	2.23	2.20
FifthFloor.GuestRoom1	100.0	4.02	0.4263	3.49	3.44
FifthFloor.MasterBedroom4	170.5	2.82	0.3379	2.45	2.43
FifthFloor.GuestRoom2	191.8	3.00	0.3911	2.61	2.59
FifthFloor.Dining1	76.7	1.64	0.1189	1.43	1.22
FifthFloor.Corridor1	160.2	0.35	0.0316	0.30	0.30
FifthFloor.MasterBedroom1	192.4	2.50	0.3078	2.17	2.16
FifthFloor.KitchenAndDining	57.5	5.30	0.4564	4.61	4.00
FifthFloor.Bedroom1	107.8	1.43	0.1390	1.24	1.22
FifthFloor.KitchenAndLiving	135.6	3.86	0.4189	3.35	3.21
FifthFloor.LivingAndDining	62.1	3.27	0.2349	2.84	2.16
FifthFloor.MasterBedroom2	104.1	1.58	0.1556	1.37	1.36
FifthFloor.Bedroom2	197.9	2.65	0.3391	2.31	2.29
FifthFloor.MasterBedroom3	184.2	4.11	0.5416	3.57	3.57
FifthFloor.BedroomVsCorridor	96.4	0.74	0.0644	0.65	0.61
FifthFloor.Bedroom3	115.8	3.30	0.3633	2.87	2.83
FifthFloor.Corridor2	46.0	2.50	0.2126	2.18	2.07
FifthFloor.MasterBedroom	137.0	3.20	0.3689	2.79	2.79
FifthFloor.Dining	77.9	1.39	0.1012	1.21	1.03
FifthFloor.Bedroom4	121.9	2.89	0.3117	2.51	2.49
FifthFloor.Bedroom	59.6	1.07	0.0937	0.93	0.91
FifthFloor.LivingRoom	93.2	5.65	0.6007	4.92	4.92
FifthFloor.Kitchen	76.1	2.85	0.2849	2.48	2.48
FifthFloor.GuestRoom3	79.7	3.28	0.3327	2.86	2.86
FifthFloor.GuestRoom	111.8	2.48	0.2615	2.16	2.13
FifthFloor.Entrance	41.9	0.62	0.0470	0.54	0.47
FifthFloor.Corridor	75.9	4.10	0.4425	3.56	3.56

<b>Totals</b>	<b>78.8</b>
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As shown in the results above cooling capacity for the whole building is calculated to be 78.8 w/m<sup>2</sup> which is relatively high and need to be modified and decreased. Decreasing the cooling capacity can be done by decreasing the U-Value for the building either by changing the material used or by adding an insulation, or also adding cantilevers and louvers.

#### 2.6.4. Design Builder After modification:

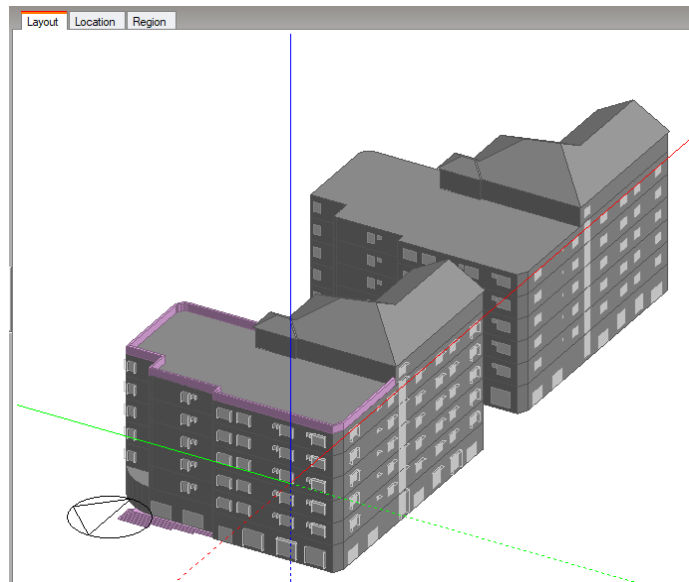


Figure 56 building view 1 after modification

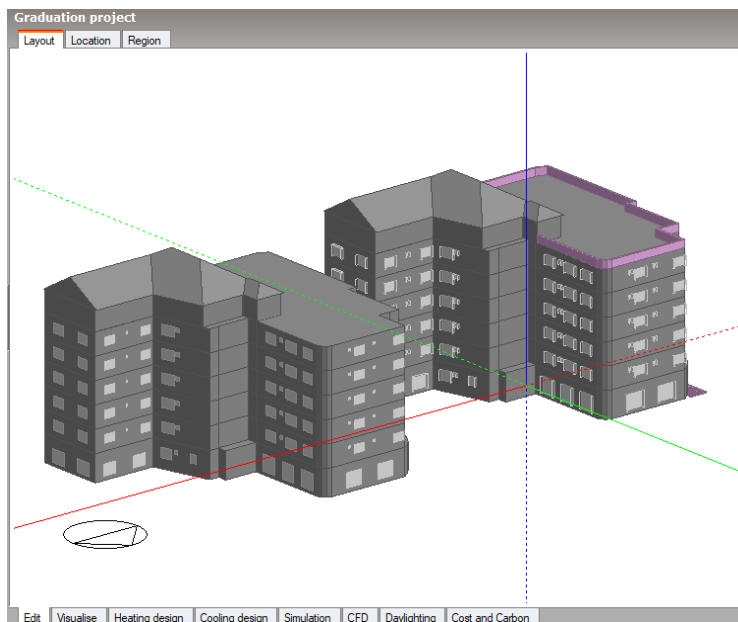
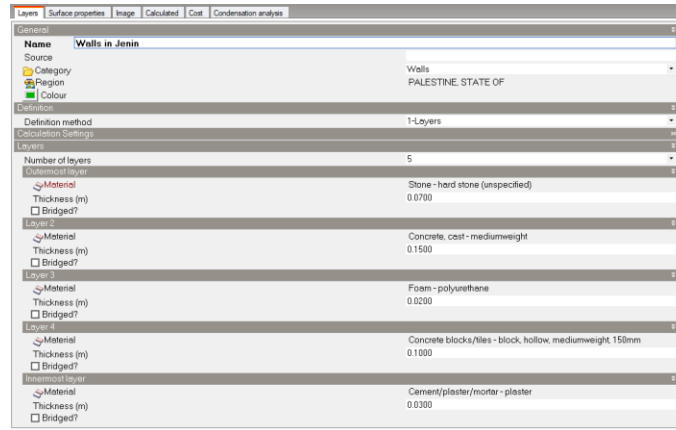


Figure 57 building view 2 after modification

### 2.6.4.1.External Walls

in the after case were composed of Five layers, Hard stone, cast concrete, foam polyurethane, hollow block, plaster respectively, with the following thicknesses 7cm, 15cm, 2cm, 10cm, 3cm respectively with and overall decreased U-Value of the external wall 0.745 as shown below.

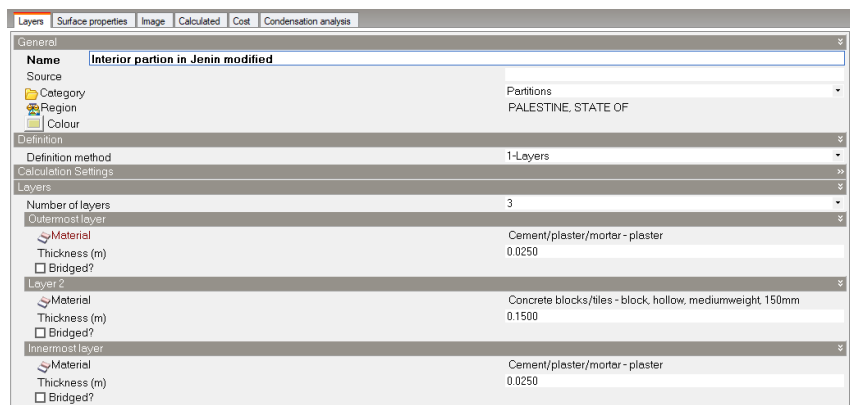


#### With Bridging (BS EN ISO 6946)

Thickness (m)	0.3700
Upper resistance limit (m...	1.343
Lower resistance limit (m...	1.343
U-Value surface to surfa...	0.853
R-Value (m <sup>2</sup> -K/W)	1.343
<b>U-Value (W/m<sup>2</sup>-K)</b>	<b>0.745</b>

### 2.6.4.2. Internal partitions

are now composed of three layers starting off with, plaster, hollow block, plaster, with the modified following thicknesses 2.5cm, 15cm, 2.5cm respectively. So the hollow blocks were increased 5cm. Internal partitions' U-Value is decreased to 1.55 as shown down below.



<b>With Bridging (BS EN ISO 6946)</b>	
Thickness (m)	0.2000
Upper resistance limit (m...)	0.645
Lower resistance limit (m...)	0.645
U-Value surface to surfa...	2.599
R-Value (m <sup>2</sup> -K/W)	0.645
<b>U-Value (W/m<sup>2</sup>-K)</b>	<b>1.551</b>

#### 2.6.4.3. Windows:

used in the project are aluminum framed windows with thermal break with clear glass, and revealed 30 cm to the inside of the building. The glass thickness' used is raised to 6mm and also used double glass with an air gap of 8mm. this treatment decreased the U-Value of the windows down to 2.9.

The image shows two screenshots from a software interface. The top screenshot is titled 'Glazing' and shows the 'Layers' tab. It displays the following properties for 'Jenin's Glazing':

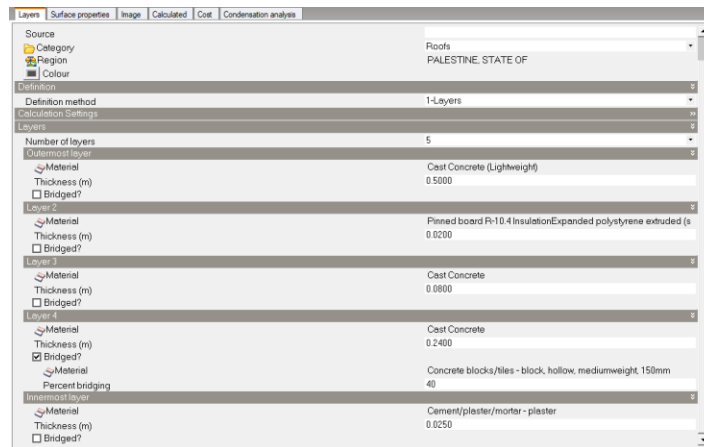
- Name: Jenin's Glazing
- Description: (empty)
- Source: (empty)
- Category: Project
- Region: PALESTINE, STATE OF
- Colour: (empty)
- Definition method: 1-Material layers
- Number layers: 2
- Outermost pane:
  - Pane type: Generic CLEAR 6MM
  - Flip layer: (unchecked)
- Window gas 1: (empty)
- Window gas type: AIR 8MM
- Innermost pane:
  - Pane type: Generic CLEAR 6MM
  - Flip layer: (unchecked)
- Radiance Daylighting: (empty)

The bottom screenshot is also titled 'Glazing' and shows the 'Calculated' tab. It displays the following calculated values:

- Total solar transmission (SHGC): 0.701
- Direct solar transmission: 0.604
- Light transmission: 0.781
- U-value (ISO 10292/ EN 673) (W/m<sup>2</sup>-K): 3.048
- U-Value (W/m<sup>2</sup>-K): 2.894**

#### 2.6.4.4. Ground floor slab, internal slabs, and flat roof slab:

both ground and internal slabs stayed the same as the before case, but the flat roof slab was treated to decrease the high U-Value in the before case. Flat roof slab is composed of four layers, sloped helicopter lightweight concrete, polystyrene pinned board, reinforced concrete slab, and plaster, with the following thicknesses 5cm, 2cm, 32cm, 2.5cm, respectively. Flat roof's U-Value is decreased to 0.38.



#### With Bridging (BS EN ISO 6946)

Thickness (m)	0.8650
Upper resistance limit (m...	2.647
Lower resistance limit (m...	2.626
U-Value surface to surfa...	0.401
R-Value (m <sup>2</sup> -K/W)	2.637
<b>U-Value (W/m<sup>2</sup>-K)</b>	<b>0.379</b>

#### 2.6.5. Heating design capacity after modification:

Now for the case after modification. After looking through the results of the heating and cooling loads, and noticing the critical points and weaknesses of the building to work on in the before case, the following treatments took place, starting off with adding an insulation between the concrete and between the hollow blocks of the external wall which decreased the heating load coming from the external walls from 90kw down to 43 kw. Also treating the windows by revealing the windows inside the building 30cm to avoid the abundant heat gain from the direct solar radiation, and adding double glass windows with an air gap instead of single glass. Windows treatment added a slight increase in the heat load of the building but on the other hand it decreased the cooling load a lot. White metaled blades were added as side fins to the window in the eastern and western elevations of the building, and cantilevers for the southern elevation of the building. On the other hand, the interior partitions were also modified using 15cm hollow blocks instead of 10cm hollow block.

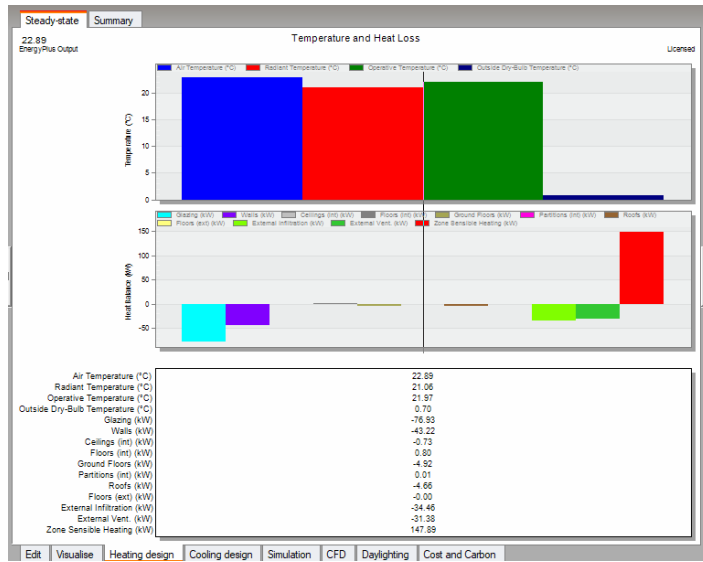


Figure 58: heating design analysis

Table 17 Ground floor heating capacity

Zone	Design Capacity (W/m2)	Comfort Te...	Steady-St...	Design Ca...	Glazi...	Wall...	Floor...	Roof...	Ventil...	Infiltra...
Building 1 Total Design Heating Capacity = 184 900 (kW)										
Ground Floor Total Design Heating Capacity = 44 850 (kW)										
shopping store 5	70 1287	22.00	2.49	3.12	-0.438	-0.758	-0.263	-0.118	-0.490	-0.427
shopping store 10	79 3108	22.00	2.39	2.98	-0.800	-0.601	-0.213	0.005	-0.415	-0.365
Corridor 3	44 0392	22.00	4.44	5.56	-0.328	-0.753	-0.830	0.012	-1.380	-1.165
Gaurd room	83 6366	22.00	0.76	0.95	0.000	-0.495	-0.080	-0.066	-0.052	-0.108
shopping store 8	73 9705	22.00	1.10	1.37	-0.367	-0.231	-0.119	0.000	-0.204	-0.176
shopping store 6	62 5138	22.00	1.63	2.04	0.000	-0.764	-0.204	0.004	-0.359	-0.308
shopping store 7	34 9890	22.00	1.05	1.32	0.000	-0.038	-0.266	0.009	-0.416	-0.343
Coridor 2	69 6852	22.00	1.05	1.32	0.000	-0.546	-0.124	0.001	-0.207	-0.178
Corridor	47 4693	22.00	6.63	8.28	-1.134	-0.891	-1.089	0.025	-1.910	-1.629
shopping store 11	97 5874	22.00	1.66	2.08	-0.584	-0.505	-0.124	-0.006	-0.234	-0.207
Praying room	41 6703	22.00	0.85	1.06	0.000	-0.021	-0.186	0.009	-0.420	-0.231
shopping store 13	34 7503	22.00	1.38	1.72	0.000	-0.043	-0.346	0.009	-0.545	-0.450
shopping store 12	60 6362	22.00	1.50	1.88	-0.441	-0.237	-0.195	0.005	-0.341	-0.292
shopping store 3	70 9807	22.00	1.32	1.65	-0.355	-0.352	-0.143	0.006	-0.256	-0.221
shopping store 4	75 5324	22.00	3.23	4.04	-0.644	-1.182	-0.297	0.000	-0.589	-0.518
shopping store 9	0 0000	16.93	0.00	0.00	0.000	-0.045	0.041	0.170	0.000	-0.166
shopping store 1	82 8962	22.00	2.33	2.91	-0.436	-0.965	-0.198	0.001	-0.386	-0.341
shopping store 2	56 5325	22.00	2.06	2.57	0.005	-0.873	-0.284	0.023	-0.502	-0.429

Table 18 First floor heating capacity

Zone	Design Capacity (W/m2)	Comfort Temper.	Steady-Stat...	Design Capacity (kW)	Glazing...	Wall G...	Floor G...	Roof a...	Ventilat...	Infiltra...
First Floor Total Design Heating Capacity = 25 400 (kW)										
Kitchen 1	34 9130	22.00	0.59	0.74	-0.428	-0.219	-0.001	-0.005	-0.107	-0.142
Guest room 1	30 0660	22.00	0.95	1.19	-0.850	-0.371	0.000	-0.010	-0.087	-0.264
Master bedroo...	67 1578	22.00	0.87	1.09	-0.638	-0.426	0.011	-0.013	-0.035	-0.113
Guest room 2	44 5260	22.00	0.55	0.69	-0.654	-0.190	0.000	-0.006	-0.034	-0.104
Dining 1	45 3898	22.00	0.76	0.95	0.000	-0.022	-0.011	0.001	-0.592	-0.135
coridor 1	20 7145	22.00	0.03	0.04	0.000	-0.018	-0.003	0.000	0.000	-0.013
Master Bedroo...	68 7245	22.00	0.70	0.87	-0.682	-0.363	0.005	-0.008	-0.028	-0.088
Bedroom 1	53 3454	22.00	0.56	0.70	-0.669	-0.098	-0.005	-0.004	-0.135	-0.087
kitchen and living	30 1001	22.00	0.67	0.84	-0.679	-0.135	-0.001	-0.005	-0.112	-0.185
living and dining	13 2868	22.00	0.55	0.69	0.000	-0.095	-0.025	0.002	-0.138	-0.335
Master bedroo...	41 5642	22.00	0.50	0.63	0.000	-0.399	0.007	-0.006	-0.033	-0.073
Bedroom 2	55 7285	22.00	0.59	0.74	-0.650	-0.147	0.004	-0.005	-0.137	-0.089
Master Bedroo...	59 5331	22.00	1.05	1.31	-1.310	-0.421	0.005	-0.012	-0.048	-0.151
Bedroom's cori...	12 7958	22.00	0.08	0.09	0.000	-0.022	-0.006	0.000	0.000	-0.048
Bedroom 3	41 6787	22.00	0.94	1.17	-0.643	-0.230	-0.004	-0.007	-0.291	-0.187
coridor 2	21 0438	22.00	0.90	1.13	0.000	-0.463	-0.005	-0.008	-0.074	-0.353
Master bedroom	61 1369	22.00	1.12	1.40	-1.336	-0.485	0.011	0.014	-0.050	-0.159
Dining	45 6654	22.00	0.64	0.80	0.000	-0.024	-0.008	0.001	-0.494	-0.113
Bedroom 4	71 7915	22.00	1.34	1.68	-1.372	-0.497	0.007	0.014	-0.242	-0.162
Bedroom	47 6389	22.00	0.67	0.84	-0.643	-0.153	0.001	-0.005	-0.183	-0.118
living room	30 6234	22.00	1.47	1.83	-1.222	-0.462	-0.014	-0.015	-0.159	-0.400
Kitchen	34 3061	22.00	1.01	1.26	-0.610	-0.209	-0.166	0.001	-0.185	-0.247
Guest room 3	23 3103	22.00	0.76	0.95	-0.590	-0.180	-0.012	-0.005	-0.090	-0.289
Guest room	32 4996	22.00	0.57	0.71	-0.654	-0.141	0.001	-0.005	-0.048	-0.151
Entrance	11 3412	22.00	0.13	0.17	0.000	-0.013	-0.006	0.000	-0.020	-0.094
coridor	22 2183	22.00	0.94	1.18	-0.926	-0.105	-0.011	-0.007	-0.074	-0.350
Kitchen and din...	18 7921	22.00	1.37	1.71	-0.001	-0.279	-0.035	-0.003	-0.458	-0.593

Table 19 Second floor heating capacity

Steady-state		Summary								
Zone	Design Capacity (W/m2)	Comfort Temper.	Steady-State	Design Capacity (kW)	Glazing	Wall G..	Floor G..	Roof a..	Ventilat.	Infiltrat.
[-] Second Floor Total Design Heating Capacity = 24,940 (kW)										
Kitchen 1	34.6954	22.00	0.59	<b>0.74</b>	-0.433	-0.219	0.005	-0.005	-0.107	-0.142
Guest room 1	29.6975	22.00	0.94	<b>1.18</b>	-0.650	-0.370	0.011	-0.011	-0.087	-0.264
Master bedroom...	67.3674	22.00	0.88	<b>1.09</b>	-0.645	-0.426	0.011	-0.013	-0.035	-0.113
Guest room 2	44.2412	22.00	0.55	<b>0.68</b>	-0.660	-0.190	0.006	-0.006	-0.034	-0.104
Dining 1	44.8266	22.00	0.75	<b>0.94</b>	0.000	-0.024	0.000	0.000	-0.592	-0.135
coridor 1	19.3276	22.00	0.03	<b>0.04</b>	0.000	-0.018	0.000	0.000	0.000	-0.013
Master Bedroo...	68.6231	22.00	0.70	<b>0.87</b>	-0.689	-0.363	0.008	-0.008	-0.028	-0.088
Bedroom 1	52.7298	22.00	0.55	<b>0.69</b>	-0.676	-0.098	0.004	-0.004	-0.135	-0.087
kitchen and living	29.8993	22.00	0.67	<b>0.84</b>	-0.687	-0.134	0.006	-0.006	-0.112	-0.186
living and dining	12.8001	22.00	0.53	<b>0.66</b>	0.000	-0.058	0.000	-0.001	-0.138	-0.335
Master bedroom...	41.6302	22.00	0.50	<b>0.63</b>	0.000	-0.398	0.006	-0.006	-0.033	-0.073
Bedroom 2	55.7920	22.00	0.59	<b>0.74</b>	-0.657	-0.147	0.005	-0.005	-0.137	-0.089
Master Bedroo...	59.2991	22.00	1.04	<b>1.30</b>	-1.321	-0.420	0.012	-0.013	-0.048	-0.151
Bedroom's corri...	11.9362	22.00	0.07	<b>0.09</b>	0.000	-0.023	0.000	0.000	0.000	-0.048
Bedroom 3	41.2810	22.00	0.93	<b>1.16</b>	-0.649	-0.230	0.007	-0.008	-0.291	-0.187
coridor 2	20.7175	22.00	0.89	<b>1.11</b>	0.000	-0.462	0.008	-0.008	-0.074	-0.353
Master bedroom	61.1226	22.00	1.12	<b>1.40</b>	-1.348	-0.485	0.014	-0.014	-0.050	-0.159
Dining	45.0080	22.00	0.63	<b>0.79</b>	0.000	-0.022	0.000	0.000	-0.494	-0.113
Bedroom 4	71.6693	22.00	1.34	<b>1.67</b>	-1.386	-0.497	0.014	-0.015	-0.242	-0.162
Bedroom	47.4919	22.00	0.67	<b>0.84</b>	-0.650	-0.152	0.005	-0.005	-0.183	-0.118
living room	30.0063	22.00	1.44	<b>1.79</b>	-1.226	-0.459	0.016	-0.017	-0.159	-0.400
Kitchen	29.3853	22.00	0.87	<b>1.08</b>	-0.602	-0.222	0.000	-0.007	-0.185	-0.245
Guest room 3	22.8476	22.00	0.74	<b>0.93</b>	-0.594	-0.180	0.006	-0.007	-0.090	-0.269
Guest room	32.0037	22.00	0.56	<b>0.70</b>	-0.661	-0.140	0.005	-0.006	-0.048	-0.145
Entrance	10.8930	22.00	0.13	<b>0.16</b>	0.000	-0.013	0.000	0.000	-0.020	-0.094
coridor	21.7347	22.00	0.92	<b>1.15</b>	-0.932	-0.099	0.008	-0.008	-0.074	-0.350
Kitchen and din...	18.2996	22.00	1.33	<b>1.67</b>	-0.001	-0.281	0.005	-0.006	-0.458	-0.593

Table 20 Third floor heating capacity

Steady-state		Summary								
Zone	Design Capacity (W/m2)	Comfort Temper.	Steady-State	Design Capacity (kW)	Glazing	Wall G..	Floor G..	Roof a..	Ventilat.	Infiltrat.
[-] Third Floor Total Design Heating Capacity = 25,020 (kW)										
Kitchen 1	34.7528	22.00	0.59	<b>0.74</b>	-0.437	-0.219	0.006	-0.006	-0.107	-0.142
Guest room 1	29.7600	22.00	0.94	<b>1.18</b>	-0.655	-0.371	0.012	-0.012	-0.087	-0.265
Master bedroom...	67.5580	22.00	0.88	<b>1.10</b>	-0.650	-0.426	0.011	-0.013	-0.035	-0.113
Guest room 2	44.3759	22.00	0.55	<b>0.69</b>	-0.666	-0.190	0.006	-0.006	-0.034	-0.104
Dining 1	44.8413	22.00	0.75	<b>0.94</b>	0.000	-0.024	0.001	-0.001	-0.592	-0.135
coridor 1	19.3406	22.00	0.03	<b>0.04</b>	0.000	-0.018	0.000	0.000	0.000	-0.013
Master Bedroo...	68.7967	22.00	0.70	<b>0.88</b>	-0.694	-0.363	0.009	-0.009	-0.028	-0.088
Bedroom 1	52.8750	22.00	0.55	<b>0.69</b>	-0.681	-0.099	0.004	-0.004	-0.135	-0.087
kitchen and living	29.9890	22.00	0.67	<b>0.84</b>	-0.692	-0.134	0.006	-0.006	-0.112	-0.186
living and dining	12.8232	22.00	0.53	<b>0.67</b>	0.000	-0.058	0.002	-0.004	-0.138	-0.335
Master bedroom...	41.6710	22.00	0.51	<b>0.63</b>	0.000	-0.398	0.006	-0.006	-0.033	-0.073
Bedroom 2	55.9477	22.00	0.59	<b>0.74</b>	-0.662	-0.147	0.005	-0.005	-0.137	-0.089
Master Bedroo...	59.4685	22.00	1.05	<b>1.31</b>	-1.330	-0.421	0.013	-0.013	-0.048	-0.151
Bedroom's corri...	11.9430	22.00	0.07	<b>0.09</b>	0.000	-0.023	0.000	0.000	0.000	-0.048
Bedroom 3	41.3639	22.00	0.93	<b>1.16</b>	-0.655	-0.230	0.008	-0.008	-0.291	-0.188
coridor 2	20.7371	22.00	0.89	<b>1.11</b>	0.000	-0.462	0.009	-0.009	-0.074	-0.353
Master bedroom	61.2760	22.00	1.12	<b>1.41</b>	-1.358	-0.485	0.015	-0.014	-0.050	-0.159
Dining	44.9726	22.00	0.63	<b>0.79</b>	0.000	-0.022	0.001	0.000	-0.494	-0.113
Bedroom 4	71.8180	22.00	1.34	<b>1.68</b>	-1.397	-0.498	0.015	-0.015	-0.242	-0.162
Bedroom	47.5880	22.00	0.67	<b>0.84</b>	-0.655	-0.153	0.005	-0.005	-0.183	-0.118
living room	30.0297	22.00	1.44	<b>1.80</b>	-1.234	-0.459	0.017	-0.017	-0.159	-0.400
Kitchen	29.1961	22.00	0.86	<b>1.08</b>	-0.605	-0.223	0.008	-0.008	-0.185	-0.245
Guest room 3	22.8915	22.00	0.75	<b>0.93</b>	-0.598	-0.180	0.007	-0.008	-0.090	-0.269
Guest room	32.0682	22.00	0.56	<b>0.70</b>	-0.666	-0.140	0.006	-0.006	-0.048	-0.145
Entrance	10.8715	22.00	0.13	<b>0.16</b>	0.000	-0.013	0.000	0.000	-0.020	-0.094
coridor	21.7618	22.00	0.92	<b>1.15</b>	-0.937	-0.099	0.009	-0.009	-0.074	-0.351
Kitchen and din...	18.3199	22.00	1.33	<b>1.67</b>	-0.001	-0.281	0.009	-0.010	-0.458	-0.593

Table 21 Fourth floor heating capacity

Steady-state		Summary								
Zone	Design Capacity (W/m2)	Comfort Temper.	Steady-State	Design Capacity (kW)	Glazing	Wall G..	Floor G..	Roof a..	Ventilat.	Infiltrat.
[-] Fourth Floor Total Design Heating Capacity = 25,300 (kW)										
Kitchen 1	35.3262	22.00	0.60	<b>0.75</b>	-0.440	-0.220	0.006	-0.015	-0.107	-0.142
Guest room 1	30.2952	22.00	0.96	<b>1.20</b>	-0.660	-0.371	0.012	-0.028	-0.087	-0.265
Master bedroom...	68.1242	22.00	0.89	<b>1.11</b>	-0.655	-0.427	0.011	-0.018	-0.035	-0.113
Guest room 2	44.9518	22.00	0.56	<b>0.70</b>	-0.671	-0.191	0.006	-0.012	-0.034	-0.105
Dining 1	45.4178	22.00	0.76	<b>0.95</b>	0.000	-0.023	0.002	-0.012	-0.592	-0.136
coridor 1	19.7434	22.00	0.03	<b>0.04</b>	0.000	-0.018	0.000	-0.001	0.000	-0.013
Master Bedroo...	69.2369	22.00	0.71	<b>0.88</b>	-0.699	-0.364	0.008	-0.012	-0.028	-0.088
Bedroom 1	53.4215	22.00	0.56	<b>0.70</b>	-0.686	-0.099	0.004	-0.009	-0.135	-0.088
kitchen and living	30.9559	22.00	0.68	<b>0.86</b>	-0.698	-0.135	0.007	-0.018	-0.112	-0.186
living and dining	13.4352	22.00	0.56	<b>0.70</b>	0.000	-0.055	0.006	-0.034	-0.138	-0.336
Master bedroom...	42.0342	22.00	0.51	<b>0.64</b>	0.000	-0.399	0.006	-0.010	-0.033	-0.073
Bedroom 2	56.9036	22.00	0.60	<b>0.75</b>	-0.667	-0.147	0.005	-0.010	-0.137	-0.090
Master Bedroo...	60.0398	22.00	1.06	<b>1.32</b>	-1.338	-0.421	0.013	-0.020	-0.048	-0.151
Bedroom's corri...	12.4351	22.00	0.07	<b>0.09</b>	0.000	-0.023	0.001	-0.003	0.000	-0.048
Bedroom 3	41.9627	22.00	0.94	<b>1.18</b>	-0.660	-0.230	0.009	-0.021	-0.291	-0.188
coridor 2	21.1107	22.00	0.91	<b>1.13</b>	0.000	-0.464	0.010	-0.024	-0.074	-0.354
Master bedroom	61.3800	22.00	1.13	<b>1.41</b>	-1.365	-0.485	0.015	-0.014	-0.050	-0.159
Dining	45.0385	22.00	0.63	<b>0.79</b>	0.000	-0.022	0.001	-0.001	-0.494	-0.113
Bedroom 4	71.8349	22.00	1.34	<b>1.68</b>	-1.406	-0.498	0.015	-0.014	-0.242	-0.162
Bedroom	47.5865	22.00	0.67	<b>0.84</b>	-0.659	-0.152	0.005	-0.005	-0.183	-0.119
living room	30.1022	22.00	1.44	<b>1.80</b>	-1.240	-0.460	0.017	-0.017	-0.159	-0.401
Kitchen	29.2417	22.00	0.86	<b>1.08</b>	-0.608	-0.223	0.008	-0.008	-0.185	-0.245
Guest room 3	23.4883	22.00	0.77	<b>0.96</b>	-0.603	-0.180	0.008	-0.027	-0.090	-0.270
Guest room	32.1477	22.00	0.56	<b>0.70</b>	-0.670	-0.140	0.006	-0.006	-0.048	-0.146
Entrance	10.9477	22.00	0.13	<b>0.16</b>	0.000	-0.013	0.001	-0.001	-0.020	-0.094
coridor	21.8831	22.00	0.93	<b>1.16</b>	-0.942	-0.100	0.010	-0.011	-0.074	-0.351
Kitchen and din...	18.8846	22.00	1.38	<b>1.72</b>	-0.001	-0.279	0.012	-0.056	-0.458	-0.595

Table 22 Fifth floor heating capacity

Zone	Design Capacity (W/m <sup>2</sup> )	Comfort Temper.	Steady-State	Design Capacity (kW)	Glazing	Wall G.	Floor G.	Roof	Ventilat.	Infiltrat.
Fifth Floor Total Design Heating Capacity = 30.270 (kW)										
Kitchen 1	46.2350	22.00	0.79	<b>0.98</b>	-0.458	-0.220	0.015	-0.206	-0.107	-0.145
Guest room 1	40.3233	22.00	1.30	<b>1.62</b>	-0.695	-0.371	0.028	-0.374	-0.067	-0.270
Master bedroo...	79.7615	22.00	1.04	<b>1.30</b>	-0.658	-0.428	0.017	-0.172	-0.035	-0.115
Guest room 2	56.2704	22.00	0.70	<b>0.87</b>	-0.632	-0.153	0.012	-0.153	-0.034	-0.106
Dining 1	55.5207	22.00	0.93	<b>1.16</b>	0.000	0.017	0.013	-0.195	-0.552	-0.138
corridor 1	34.0294	22.00	0.06	<b>0.07</b>	0.000	-0.019	0.001	-0.024	0.000	-0.013
Master Bedroo...	81.2987	22.00	0.83	<b>1.03</b>	-0.718	-0.364	0.012	-0.136	-0.028	-0.089
Bedroom 1	85.1286	22.00	0.68	<b>0.85</b>	-0.707	-0.100	0.009	-0.132	-0.135	-0.089
kitchen and living	41.3499	22.00	0.93	<b>1.16</b>	-0.724	-0.135	0.019	-0.266	-0.112	-0.189
living and dining	22.8404	22.00	0.95	<b>1.18</b>	0.000	-0.033	0.037	-0.469	-0.138	-0.344
Master bedroo...	51.8621	22.00	0.63	<b>0.79</b>	0.000	-0.404	0.009	-0.127	-0.033	-0.074
Bedroom 2	88.1883	22.00	0.72	<b>0.90</b>	-0.687	-0.147	0.010	-0.135	-0.137	-0.091
Master Bedroo...	71.0159	22.00	1.25	<b>1.57</b>	-1.379	-0.424	0.021	-0.224	-0.040	-0.153
Bedroom's com...	24.1880	22.00	0.14	<b>0.19</b>	0.000	-0.024	0.003	-0.075	0.000	-0.049
Bedroom 3	52.8020	22.00	1.18	<b>1.48</b>	-0.695	-0.231	0.021	-0.267	-0.291	-0.191
corridor 2	28.3238	22.00	1.22	<b>1.52</b>	0.000	-0.471	0.025	-0.337	-0.074	-0.359
Master bedroom	60.7960	22.00	1.12	<b>1.39</b>	-1.369	-0.486	0.014	0.000	-0.050	-0.159
Dining	45.8003	22.00	0.64	<b>0.80</b>	0.000	-0.021	0.002	-0.014	-0.494	-0.113
Bedroom 4	71.4218	22.00	1.34	<b>1.67</b>	-1.410	-0.459	0.014	-0.002	-0.242	-0.162
Bedroom	48.0804	22.00	0.68	<b>0.85</b>	-0.664	-0.152	0.006	-0.010	-0.183	-0.119
living room	30.2169	22.00	1.45	<b>1.81</b>	-1.245	-0.459	0.018	-0.021	-0.159	-0.401
Kitchen	29.4436	22.00	0.87	<b>1.08</b>	-0.611	-0.225	0.008	-0.012	-0.185	-0.245
Guest room 3	33.1307	22.00	1.08	<b>1.35</b>	-0.627	-0.170	0.028	-0.364	-0.090	-0.275
Guest room	32.2615	22.00	0.56	<b>0.70</b>	-0.674	-0.142	0.006	-0.005	-0.046	-0.145
Entrance	11.7704	22.00	0.14	<b>0.17</b>	0.000	-0.013	0.001	-0.011	-0.020	-0.094
corridor	22.6275	22.00	0.96	<b>1.20</b>	-0.948	-0.121	0.012	-0.021	-0.074	-0.352
Kitchen and din...	28.4521	22.00	2.07	<b>2.59</b>	-0.001	-0.253	0.059	-0.812	-0.458	-0.609

2.6.6. cooling design capacity after modification:

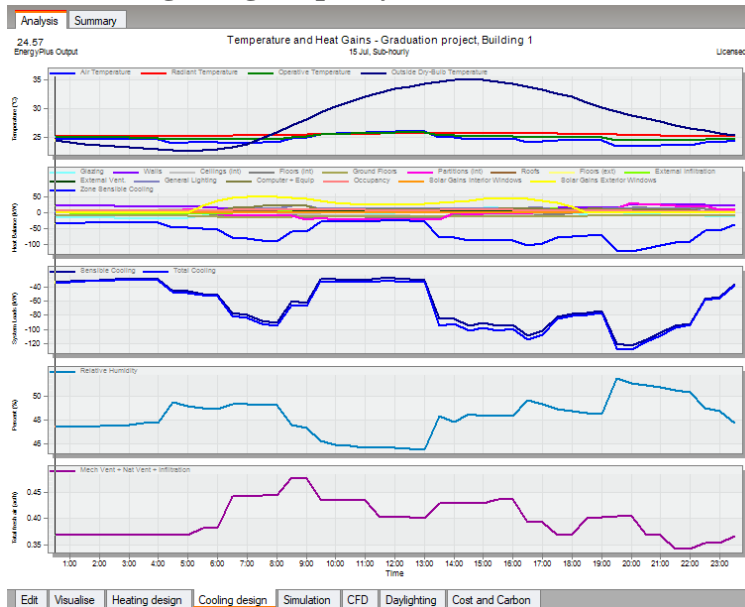


Figure 59 Cooling design analysis

Table 23 Ground floor and roof cooling capacity

Zone	Design Cooling Load Per Floor Area (W/m <sup>2</sup> )	Total Cooling Load (kW)	Design Capacity (kW)	Design Flow Rate (m <sup>3</sup> /s)	Sensal
Building 1					
GroundFloor Corridor	37.1	5.62	<b>6.47</b>	<b>0.3913</b>	4.42
GroundFloor ShoppingStore7	39.5	1.30	<b>1.49</b>	<b>0.0884</b>	1.04
GroundFloor ShoppingStore3	86.0	1.74	<b>2.00</b>	<b>0.1704</b>	1.74
GroundFloor Corridor3	28.4	3.11	<b>3.58</b>	<b>0.2110</b>	2.43
GroundFloor ShoppingStore10	96.2	3.15	<b>3.62</b>	<b>0.3009</b>	2.95
GroundFloor ShoppingStore13	40.1	1.72	<b>1.98</b>	<b>0.1180</b>	1.39
GroundFloor ShoppingStore6	62.5	1.77	<b>2.04</b>	<b>0.1392</b>	1.51
GroundFloor ShoppingStore5	60.3	2.33	<b>2.68</b>	<b>0.1931</b>	2.09
GroundFloor ShoppingStore2	51.9	2.06	<b>2.37</b>	<b>0.1542</b>	1.72
GroundFloor ShoppingStore4	76.4	3.55	<b>4.08</b>	<b>0.3523</b>	3.55
GroundFloor Corridor2	47.7	0.78	<b>0.90</b>	<b>0.0618</b>	0.67
GroundFloor ShoppingStore1	131.9	4.02	<b>4.62</b>	<b>0.4025</b>	3.73
GroundFloor ShoppingStore11	124.0	2.29	<b>2.64</b>	<b>0.2285</b>	2.18
GroundFloor GuardRoom	0.0	0.00	0.00	0	0.00
GroundFloor ShoppingStore9	0.0	0.00	0.00	0	0.00
GroundFloor PrayingRoom	21.0	0.47	<b>0.53</b>	<b>0.0343</b>	0.41
GroundFloor ShoppingStore8	142.4	2.30	<b>2.64</b>	<b>0.2415</b>	2.23
GroundFloor ShoppingStore12	126.9	3.41	<b>3.92</b>	<b>0.3310</b>	3.15
Roof Closed Terrace	76.1	6.46	<b>7.43</b>	<b>0.5705</b>	5.68

Table 24 First floor cooling capacity

Zone	Design Cooling Load Per Floor Area (w/m <sup>2</sup> )	Total Cooling Load (kW)	Design Capacity (kW)	Design Flow Rate (m <sup>3</sup> /s)	Sensl ^
FirstFloor Corridor1	69.0	0.12	<b>0.14</b>	<b>0.0112</b>	0.12
FirstFloor GuestRoom1	45.8	1.58	<b>1.81</b>	<b>0.1570</b>	1.55
FirstFloor KitchenAndLiving	79.3	1.93	<b>2.22</b>	<b>0.1615</b>	1.51
FirstFloor Kitchen1	57.4	1.06	<b>1.22</b>	<b>0.0967</b>	0.92
FirstFloor MasterBedroom2	40.3	0.53	<b>0.61</b>	<b>0.0502</b>	0.52
FirstFloor MasterBedroom	71.0	1.42	<b>1.63</b>	<b>0.1388</b>	1.24
FirstFloor Dining1	55.2	1.01	<b>1.16</b>	<b>0.0757</b>	0.83
FirstFloor MasterBedroom3	75.6	1.44	<b>1.66</b>	<b>0.1425</b>	1.34
FirstFloor Bedroom1	48.3	0.55	<b>0.63</b>	<b>0.0520</b>	0.53
FirstFloor Dining	52.8	0.80	<b>0.92</b>	<b>0.0596</b>	0.66
FirstFloor LivingRoom	47.6	2.47	<b>2.85</b>	<b>0.1881</b>	1.87
FirstFloor Bedroom4	76.8	1.56	<b>1.80</b>	<b>0.1670</b>	1.53
FirstFloor MasterBedroom4	76.7	1.08	<b>1.25</b>	<b>0.1127</b>	1.06
FirstFloor MasterBedroom1	96.2	1.05	<b>1.22</b>	<b>0.1146</b>	1.05
FirstFloor GuestRoom2	97.8	1.32	<b>1.51</b>	<b>0.1465</b>	1.23
FirstFloor Bedroom2	91.5	1.06	<b>1.21</b>	<b>0.1131</b>	1.04
FirstFloor GuestRoom	59.4	1.13	<b>1.29</b>	<b>0.1170</b>	1.07
FirstFloor GuestRoom3	28.3	1.00	<b>1.15</b>	<b>0.0777</b>	0.81
FirstFloor LivingAndDining	27.1	1.22	<b>1.41</b>	<b>0.0816</b>	0.88
FirstFloor KitchenAndDining	29.3	2.32	<b>2.67</b>	<b>0.1865</b>	2.04
FirstFloor Corridor2	24.4	1.14	<b>1.31</b>	<b>0.0867</b>	0.94
FirstFloor Bedroom	37.7	0.58	<b>0.67</b>	<b>0.0475</b>	0.48
FirstFloor Kitchen	38.3	1.23	<b>1.41</b>	<b>0.1046</b>	1.11
FirstFloor Corridor	38.6	1.78	<b>2.05</b>	<b>0.1797</b>	1.78
FirstFloor Entrance	19.7	0.25	<b>0.29</b>	<b>0.0183</b>	0.20
FirstFloor Bedroom3	58.7	1.43	<b>1.65</b>	<b>0.1322</b>	1.23
FirstFloor Bedroom'sCorridor	31.9	0.21	<b>0.24</b>	<b>0.0165</b>	0.18

Table 25 second floor cooling capacity

Zone	Design Cooling Load Per Floor Area (w/m <sup>2</sup> )	Total Cooling Load (kW)	Design Capacity (kW)	Design Flow Rate (m <sup>3</sup> /s)	Sensl ^
SecondFloor Kitchen1	60.8	1.12	<b>1.29</b>	<b>0.1043</b>	0.98
SecondFloor Bedroom3	60.3	1.47	<b>1.69</b>	<b>0.1373</b>	1.27
SecondFloor Dining	55.3	0.84	<b>0.97</b>	<b>0.0631</b>	0.69
SecondFloor Dining1	57.5	1.05	<b>1.20</b>	<b>0.0797</b>	0.86
SecondFloor GuestRoom3	30.9	1.09	<b>1.26</b>	<b>0.0861</b>	0.89
SecondFloor KitchenAndDining	30.9	2.45	<b>2.81</b>	<b>0.1991</b>	2.16
SecondFloor Bedroom'sCorridor	34.4	0.22	<b>0.26</b>	<b>0.0180</b>	0.19
SecondFloor Corridor2	25.7	1.20	<b>1.38</b>	<b>0.0925</b>	1.00
SecondFloor LivingAndDining	30.5	1.38	<b>1.58</b>	<b>0.0932</b>	1.00
SecondFloor Entrance	23.0	0.29	<b>0.33</b>	<b>0.0219</b>	0.24
SecondFloor Kitchen	37.7	1.21	<b>1.39</b>	<b>0.1025</b>	1.09
SecondFloor Bedroom1	48.3	0.65	<b>0.63</b>	<b>0.0520</b>	0.53
SecondFloor LivingRoom	49.3	2.95	<b>2.95</b>	<b>0.1868</b>	1.95
SecondFloor GuestRoom1	49.8	1.71	<b>1.97</b>	<b>0.1732</b>	1.69
SecondFloor Bedroom	40.2	0.62	<b>0.71</b>	<b>0.0512</b>	0.52
SecondFloor Corridor	40.6	1.87	<b>2.16</b>	<b>0.1910</b>	1.87
SecondFloor MasterBedroom2	43.5	0.57	<b>0.66</b>	<b>0.0547</b>	0.56
SecondFloor GuestRoom	61.8	1.17	<b>1.35</b>	<b>0.1199</b>	1.14
SecondFloor Corridor1	68.6	0.12	<b>0.14</b>	<b>0.0111</b>	0.12
SecondFloor MasterBedroom	75.1	1.50	<b>1.72</b>	<b>0.1498</b>	1.39
SecondFloor MasterBedroom1	100.4	1.11	<b>1.28</b>	<b>0.1208</b>	1.09
SecondFloor Bedroom4	79.8	1.62	<b>1.87</b>	<b>0.1751</b>	1.59
SecondFloor Bedroom2	99.6	1.15	<b>1.32</b>	<b>0.1256</b>	1.13
SecondFloor MasterBedroom4	82.3	1.16	<b>1.34</b>	<b>0.1227</b>	1.14
SecondFloor MasterBedroom3	77.8	1.49	<b>1.71</b>	<b>0.1476</b>	1.38
SecondFloor GuestRoom2	102.4	1.38	<b>1.59</b>	<b>0.1543</b>	1.35
SecondFloor KitchenAndLiving	84.7	2.05	<b>2.37</b>	<b>0.1775</b>	1.62

Table 26 Third floor cooling capacity

Zone	Design Cooling Load Per Floor Area (w/m <sup>2</sup> )	Total Cooling Load (kW)	Design Capacity (kW)	Design Flow Rate (m <sup>3</sup> /s)	Sensl ^
ThirdFloor MasterBedroom2	43.8	0.58	<b>0.66</b>	<b>0.0552</b>	0.56
ThirdFloor GuestRoom1	50.3	1.73	<b>1.99</b>	<b>0.1756</b>	1.71
ThirdFloor LivingAndDining	31.2	1.41	<b>1.62</b>	<b>0.0957</b>	1.02
ThirdFloor GuestRoom3	31.3	1.11	<b>1.28</b>	<b>0.0876</b>	0.91
ThirdFloor MasterBedroom3	78.0	1.49	<b>1.71</b>	<b>0.1481</b>	1.39
ThirdFloor Bedroom1	48.4	0.55	<b>0.63</b>	<b>0.0522</b>	0.53
ThirdFloor KitchenAndLiving	85.4	2.08	<b>2.39</b>	<b>0.1795</b>	1.64
ThirdFloor MasterBedroom	75.4	1.50	<b>1.73</b>	<b>0.1507</b>	1.40
ThirdFloor Kitchen	37.7	1.21	<b>1.39</b>	<b>0.1026</b>	1.09
ThirdFloor MasterBedroom4	82.9	1.17	<b>1.35</b>	<b>0.1238</b>	1.15
ThirdFloor LivingRoom	49.6	2.58	<b>2.97</b>	<b>0.1984</b>	1.96
ThirdFloor Bedroom'sCorridor	34.8	0.23	<b>0.26</b>	<b>0.0182</b>	0.19
ThirdFloor GuestRoom	63.0	1.20	<b>1.37</b>	<b>0.1228</b>	1.16
ThirdFloor Entrance	23.4	0.30	<b>0.34</b>	<b>0.0224</b>	0.24
ThirdFloor Corridor	40.9	1.89	<b>2.17</b>	<b>0.1925</b>	1.89
ThirdFloor Bedroom4	80.0	1.63	<b>1.87</b>	<b>0.1755</b>	1.59
ThirdFloor Kitchen1	61.2	1.13	<b>1.30</b>	<b>0.1052</b>	0.99
ThirdFloor Bedroom	40.4	0.62	<b>0.71</b>	<b>0.0516</b>	0.52
ThirdFloor Bedroom3	60.5	1.48	<b>1.70</b>	<b>0.1380</b>	1.27
ThirdFloor GuestRoom2	103.1	1.39	<b>1.60</b>	<b>0.1556</b>	1.36
ThirdFloor Corridor1	68.8	0.12	<b>0.14</b>	<b>0.0111</b>	0.12
ThirdFloor Bedroom2	100.2	1.16	<b>1.33</b>	<b>0.1266</b>	1.14
ThirdFloor KitchenAndDining	31.1	2.47	<b>2.84</b>	<b>0.2012</b>	2.18
ThirdFloor Dining	55.6	0.85	<b>0.97</b>	<b>0.0637</b>	0.70
ThirdFloor Corridor2	25.9	1.21	<b>1.39</b>	<b>0.0932</b>	1.01
ThirdFloor Dining1	57.9	1.05	<b>1.21</b>	<b>0.0804</b>	0.87
ThirdFloor MasterBedroom1	100.8	1.11	<b>1.28</b>	<b>0.1213</b>	1.10

Table 27 Fourth floor cooling capacity

Zone	Design Cooling Load Per Floor Area (W/m <sup>2</sup> )	Total Cooling Load (kW)	Design Capacity (kW)	Design Flow Rate (m <sup>3</sup> /s)	Sensl
FourthFloor.Kitchen	33.6	1.24	1.42	0.1059	1.12
FourthFloor.Bedroom2	101.1	1.17	1.34	0.1280	1.15
FourthFloor.Corridor2	26.5	1.24	1.42	0.0958	1.03
FourthFloor.Entrance	24.9	0.32	0.36	0.0240	0.26
FourthFloor.GuestRoom2	104.4	1.40	1.62	0.1501	1.30
FourthFloor.MasterBedroom1	101.6	1.12	1.29	0.1226	1.11
FourthFloor.KitchenAndDining	31.8	2.52	2.89	0.2067	2.23
FourthFloor.BedroomVsCorridor	35.9	0.23	0.27	0.0189	0.20
FourthFloor.MasterBedroom4	84.1	1.19	1.37	0.1260	1.16
FourthFloor.KitchenAndLiving	86.6	2.11	2.42	0.1830	1.66
FourthFloor.GuestRoom3	32.8	1.16	1.34	0.0924	0.95
FourthFloor.LivingAndDining	33.2	1.50	1.72	0.1028	1.09
FourthFloor.Bedroom4	79.7	1.62	1.86	0.1748	1.59
FourthFloor.Kitchen1	62.3	1.15	1.32	0.1076	1.01
FourthFloor.Bedroom1	49.6	0.56	0.65	0.0537	0.54
FourthFloor.MasterBedroom2	45.0	0.59	0.68	0.0568	0.58
FourthFloor.MasterBedroom	75.3	1.50	1.73	0.1505	1.40
FourthFloor.GuestRoom	65.4	1.24	1.43	0.1284	1.21
FourthFloor.Dining1	58.9	1.07	1.23	0.0822	0.89
FourthFloor.LivingRoom	51.0	2.65	3.05	0.2054	2.02
FourthFloor.Corridor	42.0	1.94	2.23	0.1985	1.94
FourthFloor.Bedroom	40.9	0.63	0.72	0.0524	0.53
FourthFloor.MasterBedroom3	78.8	1.50	1.73	0.1500	1.40
FourthFloor.Dining	57.1	0.87	1.00	0.0658	0.72
FourthFloor.GuestRoom1	51.5	1.77	2.04	0.1806	1.75
FourthFloor.Bedroom3	61.3	1.50	1.72	0.1404	1.29
FourthFloor.Corridor1	70.1	0.12	0.14	0.0114	0.12

Table 28 Fifth floor cooling capacity

Zone	Design Cooling Load Per Floor Area (W/m <sup>2</sup> )	Total Cooling Load (kW)	Design Capacity (kW)	Design Flow Rate (m <sup>3</sup> /s)	Sensl
FifthFloor.KitchenAndLiving	93.7	2.43	2.79	0.2252	1.94
FifthFloor.Corridor	53.5	2.47	2.84	0.2683	2.47
FifthFloor.GuestRoom1	62.2	2.14	2.46	0.2240	2.08
FifthFloor.MasterBedroom1	110.7	1.23	1.41	0.1368	1.21
FifthFloor.Bedroom2	111.4	1.28	1.48	0.1450	1.27
FifthFloor.LivingRoom	60.8	3.16	3.63	0.2593	2.43
FifthFloor.Dining1	68.7	1.25	1.44	0.1004	1.05
FifthFloor.MasterBedroom2	57.5	0.76	0.87	0.0755	0.74
FifthFloor.Bedroom1	65.0	0.74	0.85	0.0734	0.72
FifthFloor.MasterBedroom4	95.7	1.35	1.55	0.1480	1.33
FifthFloor.LivingAndDining	47.9	2.16	2.49	0.1602	1.60
FifthFloor.Bedroom4	77.2	1.57	1.80	0.1677	1.54
FifthFloor.Kitchen	49.0	1.57	1.81	0.1429	1.35
FifthFloor.Entrance	36.8	0.47	0.54	0.0388	0.40
FifthFloor.GuestRoom3	82.3	1.56	1.79	0.1708	1.53
FifthFloor.GuestRoom2	43.4	1.54	1.77	0.1308	1.28
FifthFloor.KitchenAndDining	38.3	3.03	3.49	0.2753	2.87
FifthFloor.Bedroom	44.3	0.68	0.78	0.0679	0.57
FifthFloor.GuestRoom2	114.9	1.54	1.78	0.1793	1.52
FifthFloor.MasterBedroom3	98.0	1.68	1.93	0.1826	1.65
FifthFloor.Corridor1	92.6	0.16	0.19	0.0155	0.16
FifthFloor.Dining	71.7	1.09	1.25	0.0885	0.92
FifthFloor.Corridor2	33.3	1.55	1.79	0.1420	1.47
FifthFloor.Kitchen1	74.6	1.38	1.59	0.1367	1.22
FifthFloor.BedroomVsCorridor	50.8	0.33	0.38	0.0281	0.29
FifthFloor.MasterBedroom	74.0	1.48	1.70	0.1472	1.37
<b>Totals</b>	<b>51.1</b>	<b>217.70</b>	<b>250.45</b>	<b>19.9057</b>	<b>194.1</b>

Finally, after taking the results of the heating and cooling load of the building after modification, the thermal comfort is reached in the building, and it is represented in the figure above for the temperatures inside the building all over the months of the year. Temperatures inside the building were between 19-26 Celsius in range. Down below is a figure that illustrates each month with its corresponding temperature inside the building:

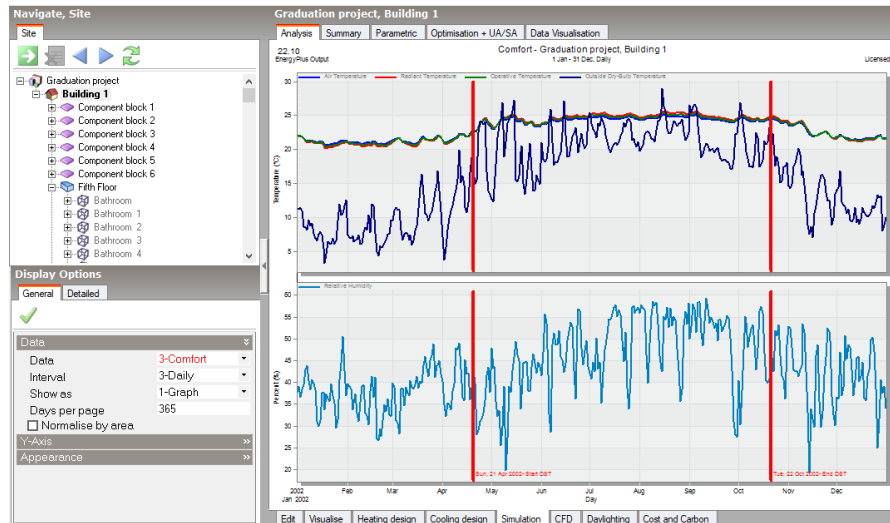


Figure 60 Thermal comfort inside the building

## 2.6.7. HVAC System Selection:

### 2.6.7.1. Introduction:

Heating, ventilation, and air conditioning (HVAC) is the use of various technologies to control the temperature, humidity, and purity of the air in an enclosed space. Its goal is to provide thermal comfort and acceptable indoor air quality. Ventilation (the "V" in HVAC) is the process of exchanging or replacing air in any space to provide high indoor air quality which involves temperature control, oxygen replenishment, and removal of moisture, odors, smoke, heat, dust, airborne bacteria, carbon dioxide, and other gases.

Two methods of ventilation are used to supply air to the building: natural ventilation, which uses the windows and doors that are scattered throughout the home, and industrial ventilation, which uses a variety of technologies and systems, including the VAV and VRF system and others. In modern buildings, the design, installation, and control systems of these functions are integrated into one or more HVAC systems. For very small buildings, contractors normally estimate the capacity and type of system needed and then design the system, selecting the appropriate refrigerant and various components needed. For larger buildings, building service designers, mechanical engineers, or building services engineers analyze, design, and specify the HVAC systems.

HVAC system keeps us warm in winter and cools in summer. It reduces humidity rise during the monsoon season. HVAC keeps the indoor and outdoor air clean in almost any season.

### 2.6.7.2. HVAC system selection:

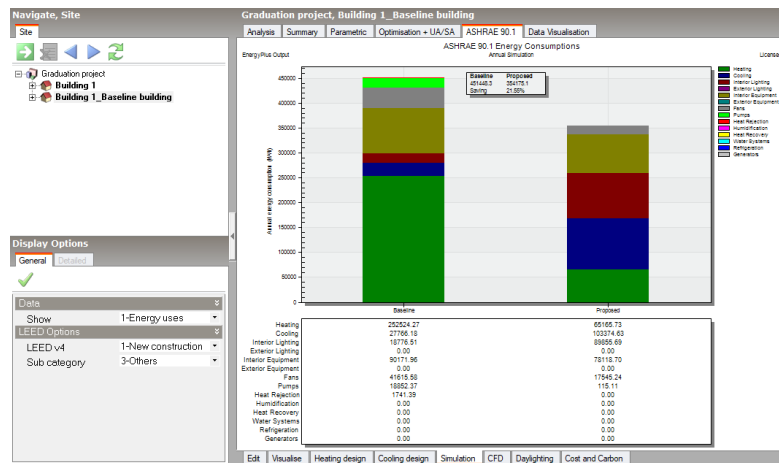
There are many types of HVAC systems available in the marketplace, but choosing the best suitable HVAC system will lead to the project's success. After research and multiple trials on Design Builder program, the best suitable HVAC system for our project will be VRF air cooled system.

### 2.6.7.3. HVAC system Sizing from Design builder calculations:

Based on the results taken from Design Builder, cooling loads in the buildings is much higher than heating loads. so the critical design to be worked on is the cooling loads because it is the worst case scenario for the design.

The sizing capacity for HVAC system for the building (including the ground floor and the first floor up to the fifth floor) will be discussed in details later on in **chapter 4**.

Table 29 Comparison between real case scenario and Baseline scenario



As can be seen above in the comparison, the building save energy up to 22% of energy used around 98000 kw annually compared to the baseline modeled building using the same HVAC system, this saving means that the passive design made the big difference on the building, and modifications of the shading system were critical and saved energy for the whole building. In addition to the nearly equal results for the modified scenario not like the high fluctuations in the results of the baseline scenario. Project's scenario has balanced results during all seasons so that the cooling load and heating loads are close to each other,

but in the baseline scenario the results were unbalanced during the four seasons so that the cooling load was much smaller than the heating load and this is an unwanted situation.

Table 30 total site and source energy

Site and Source Energy			
	Total Energy [kWh]	Energy Per Total Building Area [kWh/m2]	Energy Per Conditioned Building Area [kWh/m2]
Total Site Energy	354175.10	64.37	64.37
Net Site Energy	354175.10	64.37	64.37
Total Source Energy	985954.33	179.18	179.18
Net Source Energy	985954.33	179.18	179.18

The table above shows the total energy needed to run the whole project including the HVAC system, lighting, power, etc... in addition to the energy needed as an average for each squared meter in the building.

## 2.6.8. CFD analysis:

### 2.6.8.1. Introduction:

CFD refers to the use of applications by using numerical simulation methods to analyze and simulate the movement of air and heat flow within the building. It is also known as Internal Computational Fluid Dynamics (CFD) for buildings. It is a part of fluid dynamics, which employs mathematical equations to show the behavior of fluids like air and their interactions with solid surfaces inside the building.

Internal CFD analysis was done here for this project using Design Builder program:

### 2.6.8.2. Internal CFD analysis for ground floor (Simulation 500 iterations):

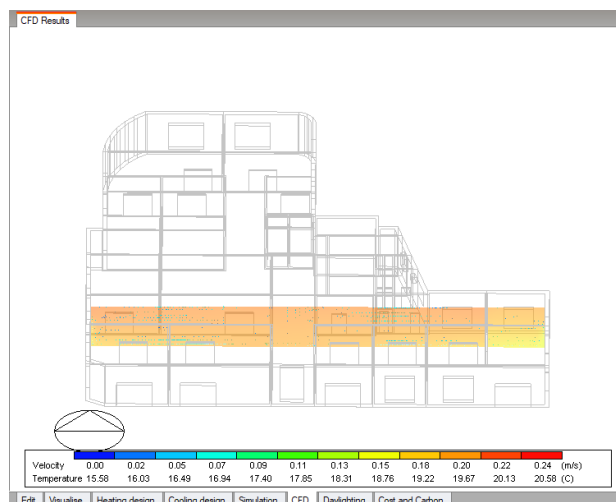


Figure 61 CFD slice in the ground's floor corridor 1

As shown above in the CFD analysis slice in the corridor number 1, the air flow or air velocity is around an average of 0.18 m/s which is illustrated in the yellowish orange color. The differentiation of the color shows how the air flow movement differs as we move away from the corridor's window and as we come closer to it. According to the ASHRE 55 or ISO 7730 air speed should be between 0.1 to 0.35 m/s, which is acceptable here.

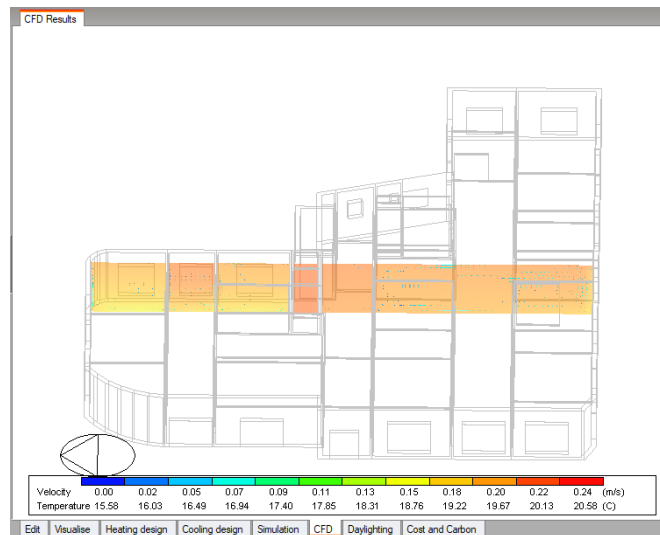


Figure 62 CFD slice in the ground's floor corridor 2

As shown above in the CFD analysis slice in the corridor number 2, the air velocity is around an average of 0.20 m/s which is illustrated in the orange color. The air velocity increases in the corridors as can be seen in the darker colors in the figure above, also a higher air velocity than the building represented in the red color with 0.21-0.22 m/s air velocity for the mechanical shaft because it is opened throughout the height of the building which creates a fast circulation of the air. In addition to an air velocity of 0.16-0.17 m/s inside the shopping stores which is critical to be less than the air circulation of the corridors and the mechanical shaft. According to the ASHRE 55 or ISO 7730 air speed should be between 0.1 to 0.35 m/s, which is acceptable here.

### 2.6.8.3. Internal CFD analysis for the First-Fifth floor (Simulation 300 iterations):

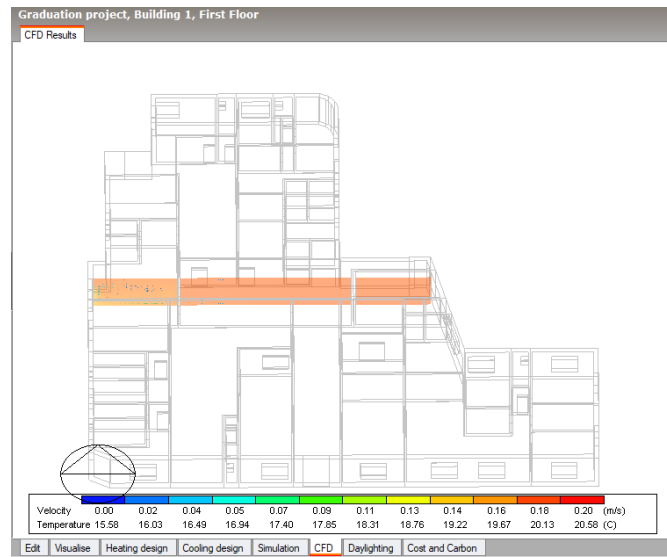


Figure 63 CFD slice in the First's floor main corridor between apartments

As shown above in the CFD analysis slice taken along the east and west part of the building in the main corridor between the residential apartments, the air flow or air velocity is around an average of 0.16 m/s which is illustrated in the orange color. The differentiation of the color shows how the air flow movement differs as we move away from the corridor's window and as we come closer to it. According to the ASHRE 55 or ISO 7730 air speed should be between 0.1 to 0.35 m/s, which is acceptable here.

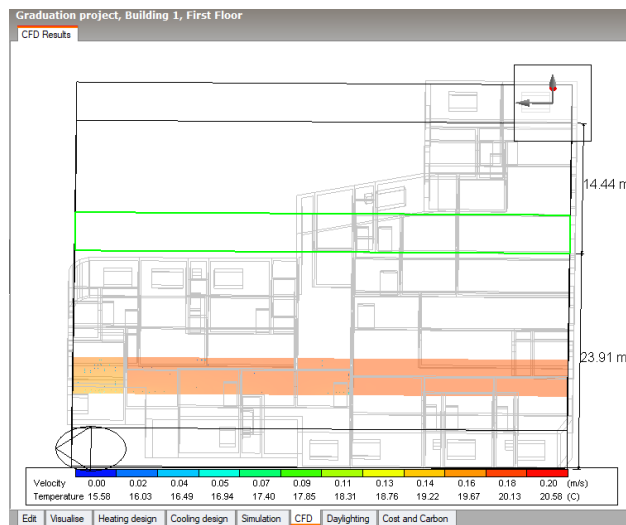


Figure 64 CFD slice in the First's floor apartments and multiple functional zones

As shown above in the CFD analysis slice taken along the north and south part of the building in two apartments and a part of the main corridor between residential apartments, the air velocity is around an average of 0.17 m/s which is illustrated in the orange color. The differentiation of the color shows how the air flow movement differs as we move through different spaces in the apartment and around the windows. According to the ASHRE 55 or ISO 7730 air speed should be between 0.1 to 0.35 m/s, which is acceptable here.

#### 2.6.8.4. Internal CFD analysis for the roof (Simulation 800 iterations):

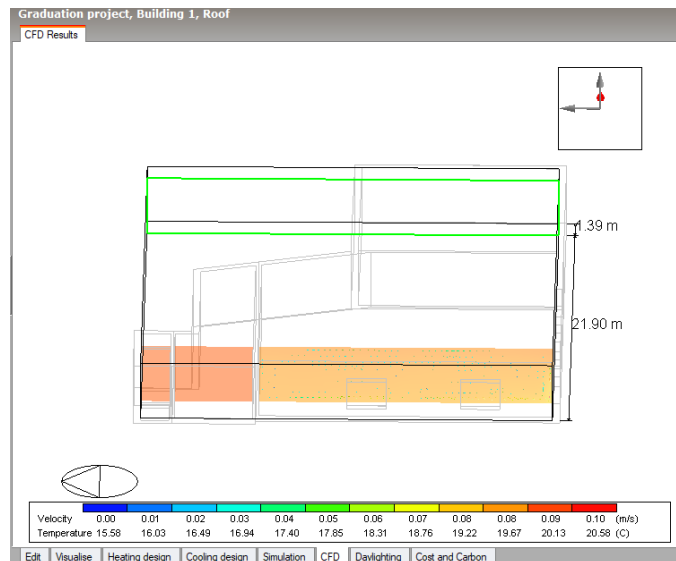


Figure 65 CFD slice in the Roof crossing through elevators

As shown in the CFD analysis slice above it is taken along the northern and southern part of the building throughout the roof containing the service room, the air velocity is around an average of 0.08 m/s which is illustrated in the orange color. The differentiation of the color shows how the air flow movement differs as we move away from the windows. According to the ASHRE 55 or ISO 7730 air speed should be between 0.1 to 0.35 m/s, which is not acceptable here. So we need to add more windows in the roof, but as known if somebody wants to use the roof for service needs, the roof door will be opened while service and will act like an additional window which adds for sure the slight air velocity to meet the standards.

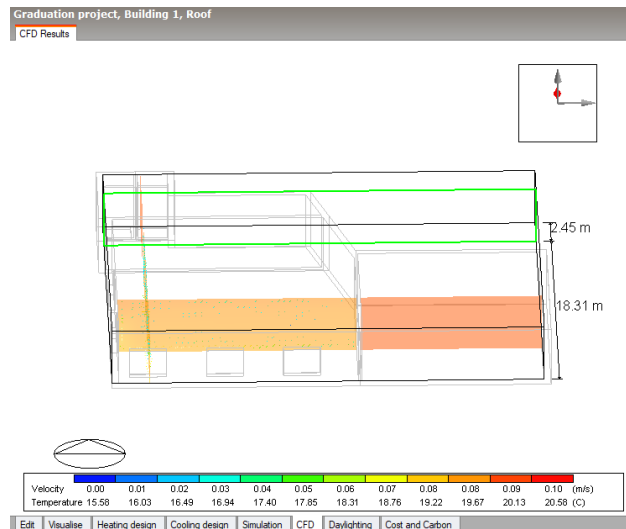


Figure 66 CFD slice in the Roof crossing through its windows

As shown in the CFD analysis slice above it is taken along the eastern and western part of the building throughout the roof containing the service room, the air velocity is around an average of 0.08 m/s which is illustrated in the orange color. The differentiation of the color shows how the air flow movement differs as we move away from the windows. According to the ASHRE 55 or ISO 7730 air speed should be between 0.1 to 0.35 m/s, which is not acceptable here. But it is a very slight difference which can be negligible. So we need to add more windows in the roof, and solution is like the case before.

## 2.6.9. Daylight in the building:

### 2.6.9.1. Introduction:

The daylight factor is a measure of the amount of natural light that enters a building's interior. It is typically expressed as a percentage and represents the ratio of the indoor illuminance (light level) to the outdoor illuminance.

The specific daylight factor requirements for houses and retails may vary depending on the country, region, and building codes or standards in place. However, I can provide you with some general guidelines that are often followed:

#### 1.) Houses:

Living areas and bedrooms: A minimum daylight factor of 2-5% is commonly recommended for these spaces.

Kitchens and bathrooms: A higher daylight factor of 3-8% may be required due to the need for brighter lighting in these functional areas.

## 2.) Retails:

Display areas: A higher daylight factor ranging from 3-10% is often desired to showcase products effectively.

Sales floors: A daylight factor of 2-5% is typically recommended to create a pleasant shopping environment.

Natural daylight is an important aspect of the building design. Natural daylight can significantly improve the lighting comfort in the building and therefore impact the productivity of occupants positively. Illuminance, measured in lux, it is the amount of light that comes on a surface. Both natural daylight and artificial lighting contribute to illuminance inside buildings.

Down below is a simulation for the natural daylight that enters the building, in an overcast day, using Design Builder program:

### 2.6.9.2. Natural Daylight distribution for the ground floor:

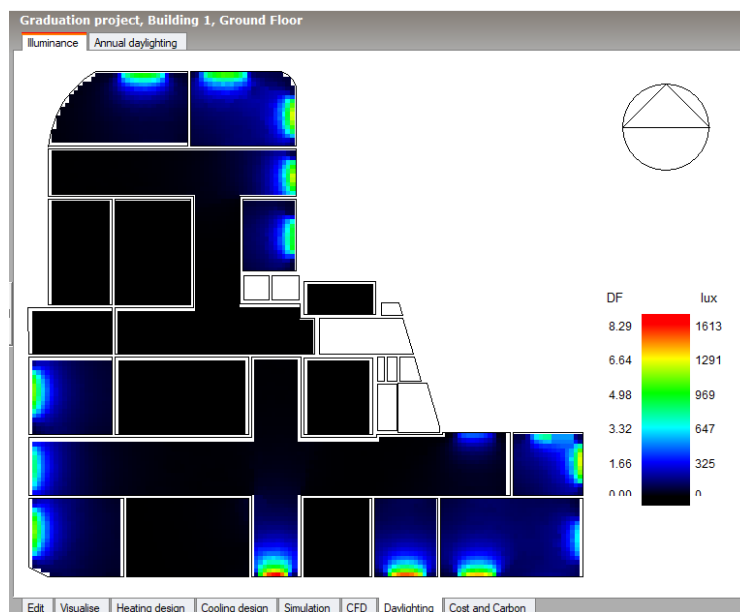


Figure 67 illuminance distribution map for the ground floor

As illustrated above in the figure, natural daylight does not enter the middle of the building due to the length of the building and the internal partitions' material. However, a good amount of illuminance still enters the building after treatments done to the windows and after adding the shading system for the building. Natural daylight adds up illuminance to the different spaces helping in reducing the illuminance needed from artificial lighting. Natural daylight is not a big deal here in the building because artificial lighting will take place in all cases. Big considerations and good achieved results were in the heating and cooling loads which makes the largest amount of net energy needed in almost every building. The entrances that contain external doors in the figure above, shows a dark space but it is not actually. Entrances are defined as glass external doors which transmits solar insolation, but as a door in the program it supposes that the door is closed and that's why it didn't show how the solar insolation enters.

### 2.6.9.3. Natural Daylight distribution for the First-Fifth floor:

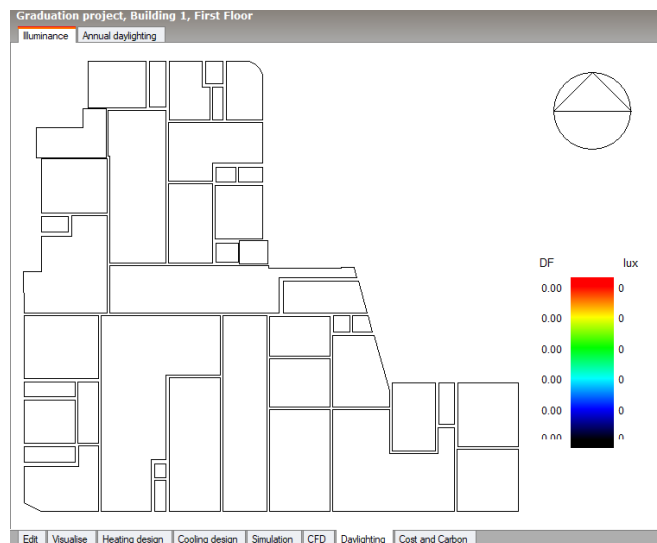


Figure 68 illuminance distribution map for the First floor

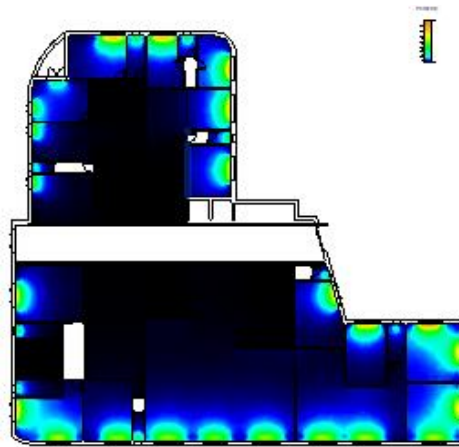


Figure 69 Daylight factor after modification from Revit

This picture is of the first floor after the modification, and it shows the effect of the daylight factor, as the rate for this floor ranges between 2-8%, and this rate is suitable for the apartments contained in this floor.

In our project, from the first floor to the fifth floor, it contains apartments of the same nature, so we generalized the results on it from the first to the fifth.

**2.6.9.4. Natural Daylight distribution for the roof:**

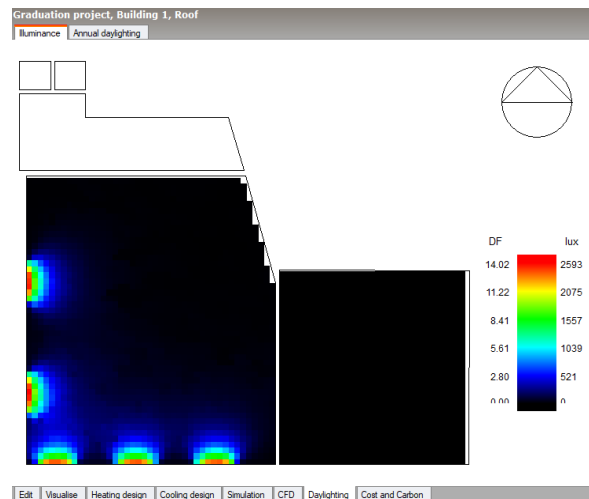


Figure 70 illuminance distribution map for the Roof

In the picture above of the roof after installing the shading system and the modifications, it shows the effect of the daylight factor distributed along the service room, as the rate for this floor ranges between 2-8%, and up to 13% next to the windows. The previous rates are suitable for the service room present in the roof.

## **CHAPTER 3 STRUCTURAL ASPECTS**

### 3.1 Introduction

The design of the structural system is an important stage in the design of any building, and it represents the sustainability and safety of the building and its users. Since, the structural aspect has a direct impact on the other aspects, especially the architectural aspect; a wise structural designer should use the best method to make the model as safe as possible while minimizing the impact on the main architectural designer idea. In this chapter, the structural system of the AL-Bayader shopping center and residential apartment has to be analyzed in terms of calculating the thickness of the slab, as well as the correct distribution and security of the columns so that it does not affect the architectural design, and evaluated using the structural modeling software ETABS 16, and that's showed with more detailing in this chapter.

### 3.2 Problem definition

The project is a 9-story AL-Bayader shopping center and residential apartment with a height of 3m for basement 1 &2 , 4.5m for ground floor and 3.5m for typical and roof floor each floor, the project location in Jenin, the project has many slab systems and different thicknesses, the building is not regular in elevations but it is regular in plan-view, after studying our building, we found that the length of the building exceeded 30 meters, which necessitated placing an expansion joint for the building, so that the building was divided into two separate parts as shown figure below.

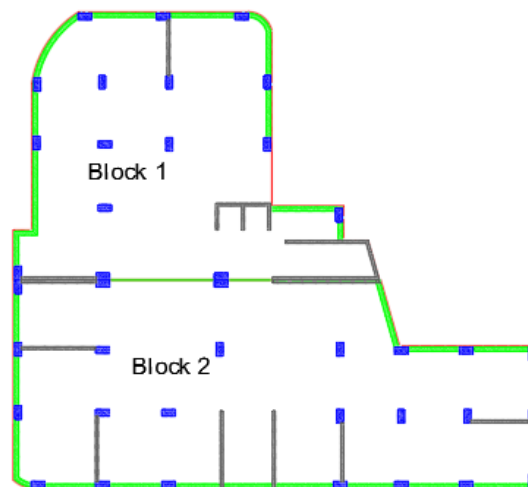


Figure 71 Building plan layout

### **3.3 Design code**

Structural designer will use the following codes of practice in loads-forces calculations, design and detailing of structural elements:

c. Building code requirement for reinforced concrete (ACI 318M-08)

d. Uniform building code (UBC-1997) for the calculation of equivalent static loads for earthquakes.

### **3.4 Material**

#### **1-Concrete**

The estimated specific weight of reinforced concrete is 25 kN/m<sup>3</sup> and for the plain concrete is 23 kN/m<sup>3</sup>.

$f_c'$ : compressive strength of concrete

$f_c' = 24$  MPa (used for slabs and beams).

$f_c' = 28$  MPa (used for columns, shear walls and footing).

#### **2-Steel**

The modulus of elasticity,  $E_s = 200$  GPa

$F_y$ : Yield Strength in Steel,  $F_y = 420$  MPa.

#### **3- Blocks**

Unit weight of blocks is considered as 12 kN/m<sup>3</sup>.

### **3.5 Load**

Loads and loads combinations were taken from ASCE7-10 standard as following:

#### **1- Dead load (DL)**

The buildings own weight is included in the dead load; these loads remain constant throughout the building's existence.

#### **2-Live load (LL)**

Live load is a load that is not constant, but changes over time. Live loads can be caused by anything adding, removing, or relocating weight on a structure. The minimum live load value varies according to space function. (ASCE7, 2010).

- ✓ Residential house =3.0KN/m<sup>2</sup>
- ✓ Shopping center= 5.0 KN/m<sup>2</sup>
- ✓ Parking= 6.0 KN/m<sup>2</sup>

### 3-Superimposed Dead Loads (SID)

Superimposed dead loads represent non-structural dead loads that remain permanently on the structure.

A- External wall

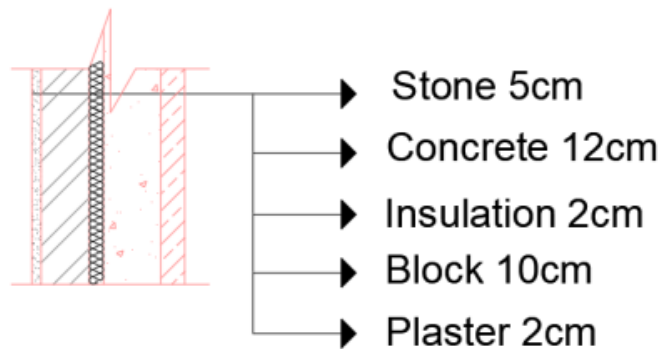


Figure 72 External walls layers used to calculate super dead loads

Table 31 The external walls and their loads

layers of the

**Total wall weight= 5.8\* height = 26 kn/m**

Layer name	Density (KN/m <sup>3</sup> )	Thickness (m)	Load (KN/m <sup>2</sup> )
Stone	26	0.05	1.3
Concrete	25	0.12	3
Insulation	0.27	0.02	0.0054
Block	12	0.1	1.2
Plaster	18.5	0.02	0.37

B-Weight of floor

$$3\text{cm Ceramic tiles} + 2\text{ cm mortar} + 7\text{cm sand} = 0.03 * 25 + 0.02*22 + 0.07*19$$

$$= 2.52 \text{ kN/m}^2$$

C-Weight of bricks in ribbed slab, it is considered as dead load

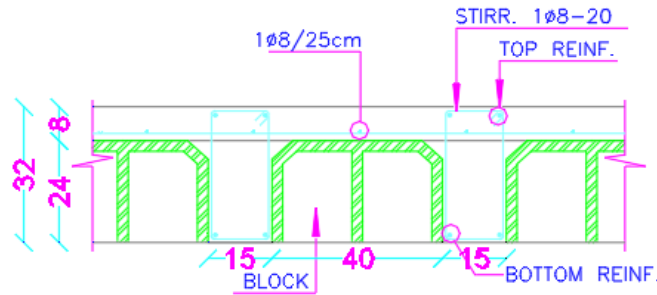


Figure 73 Typical section in slab

$$\begin{aligned} \text{- Weight of bricks} &= 0.4 * 0.24 * 12 = 1.152 \text{ kN/m}^2 / \text{ ribs} \\ &= 1.152 / 0.55 = 2.1 \text{ kN/m}^2 \end{aligned}$$

$$\begin{aligned} \text{Total SID} &= \text{weight of floor (2.52)} + \text{weight of partition (1)} + \text{weight of bricks (2.1)} \\ &= 5.62 \text{ kN/m}^2 \dots \text{ take it } 6 \text{ kN/m}^2 \end{aligned}$$

### 3.6 Seismic input data

UBC – 97, equivalent static method will be used after applying the required conditions and criteria's in the preliminary structural layout. UBC – 97 specifies the total seismic force or base shear acting on the structure by the formula ( $V = C_v I W / R T$ )

Where:

I: Important Factor

Z: seismic zone factor

Ca: Seismic Coefficient

Cv: Seismic Coefficient

W:  $DL + SID + 0.25L$

R: is a factor, which represents the ductility of the structural system.

T: fundamental period of the building.

hn: height, above the base to level n.

### 3.6.1 Important Factor

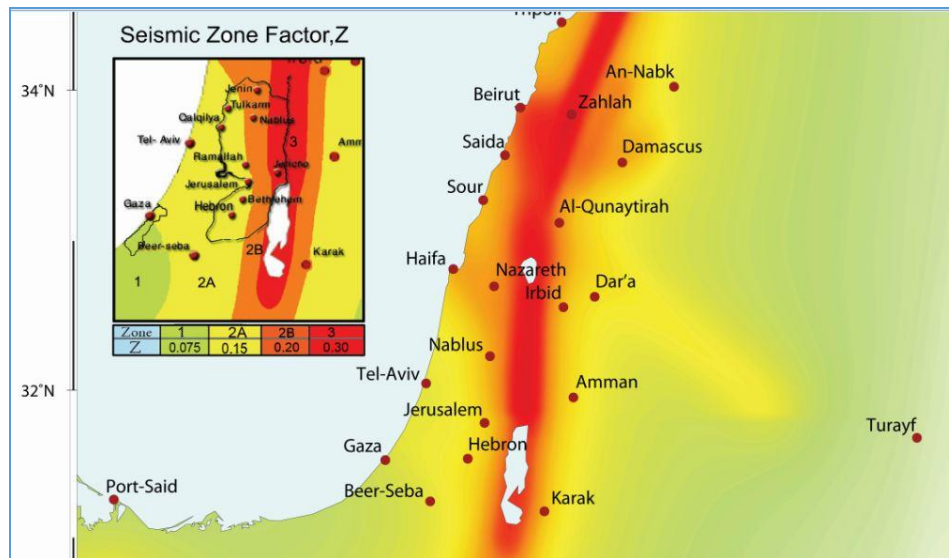
Table 32 Occupancy Importance Factors

Occupancy Category	Seismic Importance Factor, I
1-Essential facilities	1.25
2-Hazardous facilities	1.25
3-Special occupancy structures	1.00
4-Standard occupancy structures	1.00
5-Miscellaneous structures	1.00

The building is standard occupancy structure  $I = 1.00$

### 3.6.2 Seismic Zone

Zone factor was obtained from the following seismic map



The structure is located in Jenin zone 2B...  $Z=0.20$

Figure 74 seismic map

### 3.6.3 Soil profile

The type of soil that AL-Bayader shopping center stands on is very dense soil and soft rock that has a capacity of  $300\text{KN/m}^2$ . This is classified as **Sc** type according to UBC97 code.

### 3.6.4 Seismic Coefficient Ca, Cv

Table 33 Seismic Coefficient Ca

TABLE 16-Q—SEISMIC COEFFICIENT  $C_a$

SOIL PROFILE TYPE	SEISMIC ZONE FACTOR, Z				
	Z = 0.075	Z = 0.15	Z = 0.2	Z = 0.3	Z = 0.4
$S_A$	0.06	0.12	0.16	0.24	$0.32N_g$
$S_B$	0.08	0.15	0.20	0.30	$0.40N_g$
$S_C$	0.09	0.18	0.24	0.33	$0.40N_g$
$S_D$	0.12	0.22	0.28	0.36	$0.44N_g$
$S_E$	0.19	0.30	0.34	0.36	$0.36N_g$
$S_F$	See Footnote 1				

<sup>1</sup>Site-specific geotechnical investigation and dynamic site response analysis shall be performed to determine seismic coefficients for Soil Profile Type  $S_F$ .

Soil type C ..... Z=0.20.....Ca = 0.24

Table 34 Seismic Coefficient Cv

TABLE 16-R—SEISMIC COEFFICIENT  $C_v$

SOIL PROFILE TYPE	SEISMIC ZONE FACTOR, Z				
	Z = 0.075	Z = 0.15	Z = 0.2	Z = 0.3	Z = 0.4
$S_A$	0.06	0.12	0.16	0.24	$0.32N_v$
$S_B$	0.08	0.15	0.20	0.30	$0.40N_v$
$S_C$	0.13	0.25	0.32	0.45	$0.56N_v$
$S_D$	0.18	0.32	0.40	0.54	$0.64N_v$
$S_E$	0.26	0.50	0.64	0.84	$0.96N_v$
$S_F$	See Footnote 1				

<sup>1</sup>Site-specific geotechnical investigation and dynamic site response analysis shall be performed to determine seismic coefficients for Soil Profile Type  $S_F$ .

Soil type C ..... Z=0.20.....Cv = 0.33

### 3.6.5 Structural system (R – Coefficient of ductility of the lateral resisting)

TABLE 16-N—STRUCTURAL SYSTEMS<sup>1</sup>

BASIC STRUCTURAL SYSTEM <sup>2</sup>	LATERAL FORCE-RESISTING SYSTEM DESCRIPTION	R	$\rho_w$	HEIGHT 1,000 FEET (305 METERS) AND GREATER	
				MINIMUM PERCENT	MAXIMUM PERCENT
1. Bearing wall system	1. Light-framed walls with shear panels	5.5	2.8	65	—
	a. Wood structural panel walls for structures three stories or less	4.5	2.8	65	—
	b. All other light-framed walls	4.5	2.8	65	—
	2. Shear walls	4.5	2.8	160	—
	a. Concrete	4.5	2.8	160	—
	b. Masonry	4.5	2.8	160	—
	3. Light steel-braced bearing walls with tension-only bracing	2.8	2.2	65	—
	a. Braced frames where bracing carries gravity load	4.4	2.2	160	—
	b. Steel <sup>3</sup>	2.8	2.2	65	—
	c. Heavy timber	2.8	2.2	65	—
2. Building frame system	1. Steel concentrically braced frame (CBF)	7.0	2.8	240	—
	2. Light-framed walls with shear panels	4.5	2.8	65	—
	a. Wood structural panel walls for structures three stories or less	5.0	2.8	65	—
	b. All other light-framed walls	5.0	2.8	65	—
	3. Shear walls	5.5	2.8	240	—
	a. Concrete	5.5	2.8	240	—
	b. Masonry	5.5	2.8	160	—
	4. Ordinary braced frames	5.6	2.2	160	—
	a. Steel	5.6	2.2	65	—
	b. Concrete <sup>4</sup>	5.6	2.2	65	—
c. Heavy timber	5.6	2.2	65	—	
5. Special concentrically braced frames	6.4	2.2	240	—	
a. Steel	6.4	2.2	240	—	
3. Moment-resisting frame system	1. Special moment-resisting frame (SMRF)	8.5	2.8	N.L.	—
	a. Steel	8.5	2.8	N.L.	—
	b. Concrete <sup>5</sup>	8.5	2.8	160	—
	2. Masonry moment-resisting wall frame (MQRWF)	6.5	2.8	160	—
	3. Concrete intermediate moment-resisting frame (IMRF) <sup>6</sup>	5.5	2.8	—	—
	4. Ordinary moment-resisting frame (OMRF)	4.5	2.8	160	—
	a. Steel <sup>6</sup>	3.5	2.8	—	—
b. Concrete <sup>7</sup>	6.5	2.8	240	—	
5. Special truss moment frames of steel (STMF)	6.5	2.8	240	—	
4. Dual systems	1. Shear walls	8.5	2.8	N.L.	—
	a. Concrete with SMRF	4.5	2.8	160	—
	b. Concrete with steel CMRF	6.5	2.8	160	—
	c. Concrete with composite SMRF	4.5	2.8	160	—
	d. Masonry with SMRF	4.5	2.8	160	—
	e. Masonry with steel CMRF	4.5	2.8	160	—
	f. Masonry with concrete SMRF	4.5	2.8	160	—
	g. Masonry with masonry MQRWF	4.0	2.8	160	—
	2. Steel CBF	8.5	2.8	N.L.	—
	a. With steel SMRF	4.5	2.8	160	—
	b. With steel CMRF	4.5	2.8	160	—
	3. Ordinary braced frames	6.5	2.8	N.L.	—
	a. Steel with steel SMRF	4.5	2.8	160	—
	b. Steel with steel CMRF	4.5	2.8	160	—
	c. Concrete with concrete SMRF <sup>8</sup>	4.5	2.8	—	—
	d. Concrete with concrete CMRF <sup>8</sup>	4.5	2.8	—	—
4. Special concentrically braced frames	7.5	2.8	N.L.	—	
a. Steel with steel SMRF	4.5	2.8	160	—	
b. Steel with steel CMRF	4.5	2.8	160	—	
5. Cantilevered column building systems	1. Cantilevered column elements	2.2	2.0	35 <sup>9</sup>	—
	2. Shear wall-frame interaction systems	5.5	2.8	160	—
6. Shear wall-frame interaction systems	1. Concrete <sup>8</sup>	5.5	2.8	160	—

Structural system: Building frame system—shear wall concrete... R= 5.5

### 3.7 Load combinations

All reinforced concrete members/ elements of buildings/ structures as well as their supports and fixing points shall be analysed and designed for the load combinations in accordance with the Minimum Design Loads for Buildings (ACI- 9.2) requirements as follows:

A. Service load combinations were defined as follows:

$$\text{Combination (1)} = 1.0\text{DL} + 1.0 \text{SID} + 1.0 \text{LL}$$

$$\text{Combination (2)} = 0.9\text{DL} + 0.9\text{SID} + 0.71 \text{EQX}$$

$$\text{Combination (3)} = 0.9\text{DL} + 0.9\text{SID} + 0.71 \text{EQY}$$

$$\text{Combination (4)} = 0.9\text{DL} + 0.9\text{SID} + 0.75\text{LL} + 0.54 \text{EQX}$$

$$\text{Combination (5)} = 0.9\text{DL} + 0.9\text{SID} + 0.75\text{LL} + 0.54 \text{EQY}$$

B. Ultimate load combinations were defined as follows:

$$\text{Combination (1)} = 1.2\text{DL} + 1.2 \text{SID} + 1.6 \text{LL}$$

$$\text{Combination (2)} = 1.4\text{DL} + 1.4 \text{SID}$$

$$\text{Combination (3)} = 1.3\text{DL} + 1.3 \text{SID} + 1.0 \text{LL} \pm \text{EQX}$$

$$\text{Combination (5)} = 0.8 \text{DL} + 0.8 \text{SID} \pm 1.0 \text{EQX}$$

$$\text{Combination (6)} = 0.8 \text{DL} + 0.8 \text{SID} \pm 1.0 \text{EQY}$$

### 3.8 Design elements definitions

#### 3.8.1 Slab

The system that is used one way ribbed slab supported by dropped beams. And specify the minimum thickness according to -ASCI 318- code.

*Table 35 According ACI-318 use following table to calculate thickness of slab and beam*

Structure Element	Model			
	Simple	One-end continuous	Two-end continuous	Cantilever

One Way Solid Slab	L/20	L/24	L/28	L/10
Beams & Ribbed Slab	L/16	L/18.5	L/21	L/8

Maximum slab span in y direction about  $L=5.40$  one end continuous

Slab thickness  $h = 5.4/18.5=0.292$

Take it 32 cm

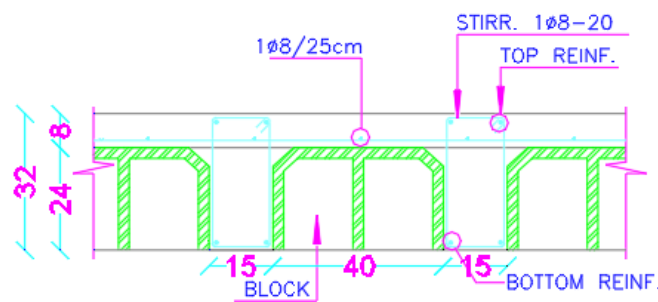


Figure 75 Typical section in slab

### 3.8.2 Beam

There are two types of beams that will be used in the construction system. Dropped beam in large distances and hidden beams in other distances. And specify the minimum thickness according to -ASCI 318- code.

A- Dropped beam

$$L = 8.80 \dots \text{ (One-end continuous)}$$

$$h_{\text{beam}} = 8.80/18.5 = 0.475 \text{ m increase 40\% for drop beam}$$

$$\text{Try } h_{\text{beam}} = 700 \text{ mm}$$

$$B = 500 \text{ mm}$$

B- Hidden beam

- Main beam with dimension 80cm\*32 cm
- Secondary beam dimension 60cm\*32 cm

### 3.8.3 Column

There are two types of column dimensions, 50cmx100 cm in (basement 1& and ground floor), and 40cm\*80 cm in (typical floor and roof floor). In order to count the cracks on

the column we had changed the used section modifiers, the modified modifiers shown at the following figure.

## Wall

There are two type of shear wall are used in building:

1. Basement wall with thickness 30 cm
2. Shear wall with thickness 20 cm

### 3.9 Response spectrum and mass source definition

#### 3.9.1 Response spectrum

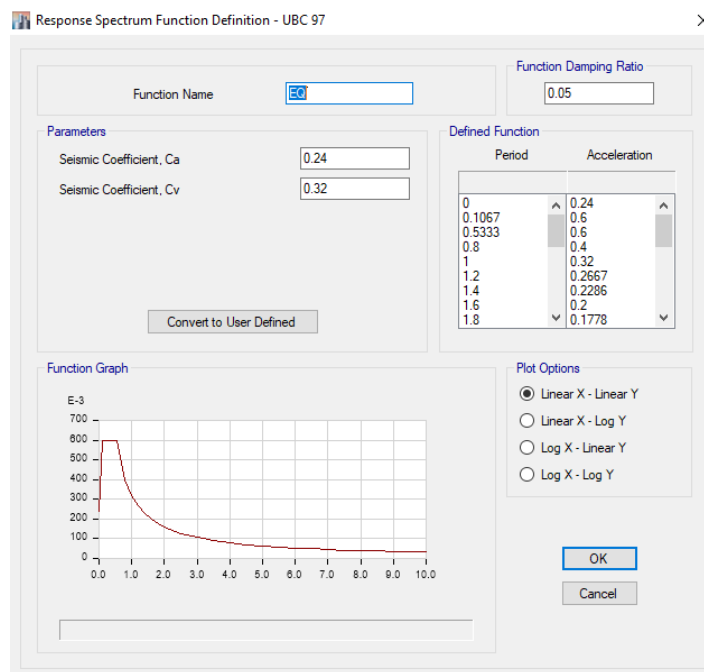
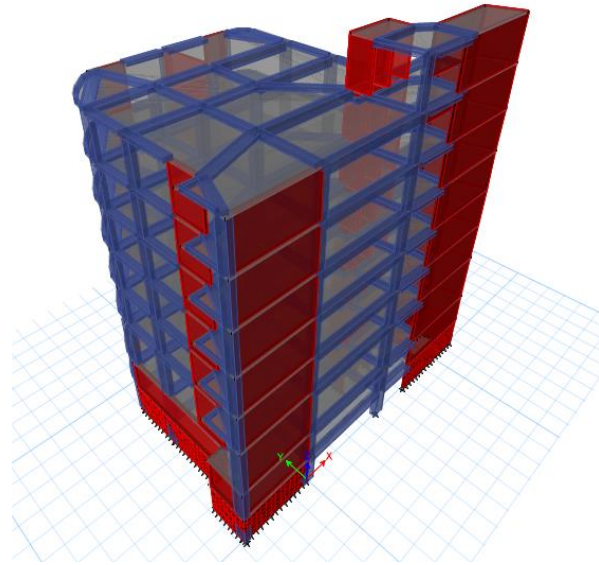


Figure 76 response spectrum functions

#### 3.9.2 Mass source

100% dead load and 25% live load take in consideration as a mass source.

### 3.10 Model analysis and check for Block 1



*Figure 77:3D mode of block 1*

The structural system it will be analyzed as a 3d model consists of frames and shear walls, in which columns and beams will be modeled as line elements having 3 degrees of freedom at each node, while the joints are considered to be fully rigid, Shear walls and floors will be modeled as area elements using (ETABS) structural analysis program.

The results were analyzed and verified by making the following checks:

- Compatibility
- Equilibrium
- Stress – strain relationship
- Deflection
- Seismic checks

### 3.10.1 Compatibility check (Block1)

Compatibility check, through this check it ensures that all building elements move together

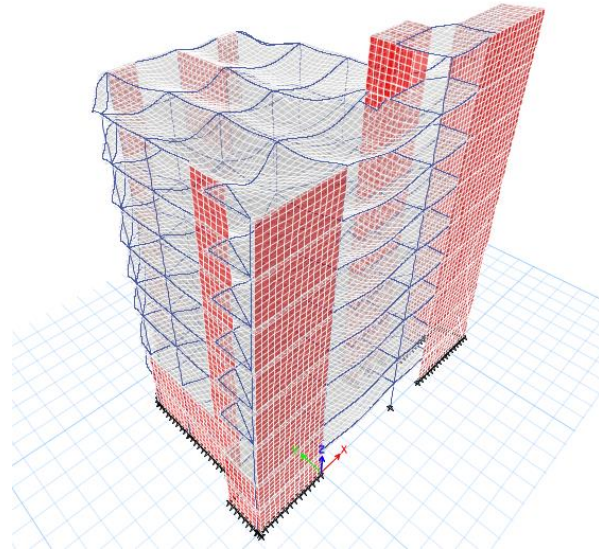


Figure 78: Compatibility check

### 3.10.2 Equilibrium check (Block 1)

In this check .It will be ensured through this examination that the loads resulting from the model representation are similar to the loads calculated manually with an error rate not exceeding 5%.

Table 36 Base reaction from ETABS block 1

Load Case/Combo	FX	FY	FZ
	kN	kN	kN
Dead	0.00002197	0.000008096	29879.4
Live	0.000013	0.000004298	10789.6675
SID	0.0000159	0.0000071	28513.6145

Live load check

Table 37 Live load check block 1

Stories	Area M <sup>2</sup>	Opining M <sup>2</sup>	Live load Kn/m <sup>2</sup>	Total load KN
<b>Basement2 slab</b>	392.7	24.95	6	2206.5
<b>Basement 1slab</b>	392.7	24.95	5	1838.75
<b>Ground to five slab</b>	392.7*6	24.95*6	3	6619.5
<b>Roof floor</b>	42.17	0	3	126.51
		Total		10791.3
		ETABS live base reaction		10789.6675
		%Error		0.014%

- Dead load check

Dead load = slab + beam +columns +walls

Own weight of slab = weight of slab +ribs

- Weight of slab = 0.08 \* 25= 2 kN/m<sup>2</sup>

- Weight of ribs = 0.15/0.55\* 0.24 \* 25 = 1.636 kN/m<sup>2</sup>

Own weight of slab= 3.64 kN/m<sup>2</sup>

Note: block weight in slab already included with SID

Table 38 Dead load check block 1

Slab					
Stories	Area	Opining	own weight	Total load	
	M2	M2	Kn/m2	KN	
Basement2 slab	392.7	24.95	3.64	1338.61	
Basement 1slab	392.7	24.95	3.64	1338.61	
Ground to five slab	392.7*6	24.95*6	3.64	8031.66	
Roof floor	42.17	0	3.64	153.4988	
			<b>total</b>	<b>10862.3788</b>	
dropped beam	length	B*H	own weight	Total load	
	m	m*m	Kn/m2	kn	
b50*70 in all floor	256.8	0.5*0.38	25	1219.8	

b80*32 in all floor	356.83	0.8*.32	25	2283.712	
b60*32 in all floor	470.04	0.6*.32	25	3008.256	
			<b>total</b>	<b>6511.768</b>	
<b>column</b>	<b>height</b>	<b>area of section</b>	<b>#of columns</b>	<b>own weight</b>	<b>Total load</b>
	m	M2	no	Kn/m2	kn
Basement2floor	3	0.5	16	25	600
Basement 1 floor	3	0.5	16	25	600
Ground floor	4.5	0.32	16	25	576
first to five slab	3.5	0.32	80	25	2240
Roof floor	3.5	0.32	1	25	28
				<b>total</b>	<b>4044</b>
<b>wall</b>	<b>wall area</b>	<b>wall thickness</b>	<b>own weight</b>	<b>Total load</b>	
	m2	M	Kn/m2	kn	
wall 30cm	314.26	0.3	25	2356.95	
wall 20 cm	1061.72	0.2	25	5308.6	
			total	7665.55	
			<b>total dead load</b>		<b>29083.7</b>
			<b>ETABS dead load</b>		<b>29879</b>
			<b>% Error</b>		<b>2.6</b>

- SID load check

Table 39 SID load check block 1

<b>Stories</b>	<b>Area M<sup>2</sup></b>	<b>Opining M<sup>2</sup></b>	<b>Live load Kn/m<sup>2</sup></b>	<b>Total load KN</b>
<b>Basement2 slab</b>	392.7	24.95	6	2206.5
<b>Basement 1slab</b>	392.7	24.95	6	2206.5
<b>Ground to five slab</b>	392.7*6	24.95*6	6	13239
<b>Roof floor</b>	42.17	0	6	253.02
		<b>Total</b>		<b>17905</b>

Wall In all floor	Length m	Wall load kn/m	Total kn
	402.36	26	10461.43
		Total	28366.4328
		ETABS SID base reaction	28513.6145
		%Error	0.52%

### 3.10.3 Stress strain check

Stress and strain testing is done through this test to ensure that the internal forces of the structural elements (bridges, ceilings, columns, walls), resulting from the structural analysis in the ETAB program are close to the manual calculations of these elements with an error rate not exceeding 10%.

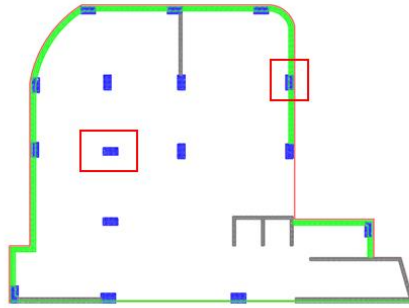


Figure 79: plan show columns that checked

- **Check of axial load on column (live load)**

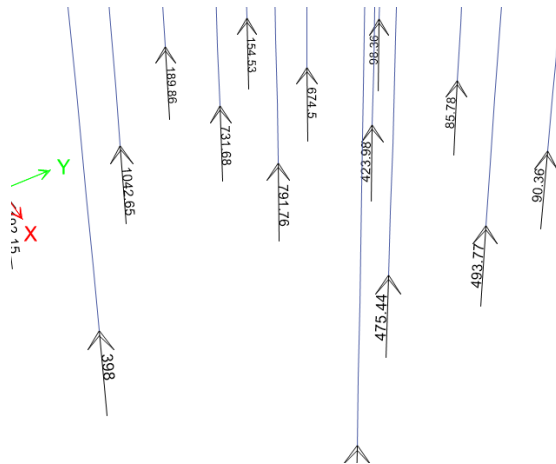


Figure 80: Axial load for selected column

Table 40 internal and edge col axial load check block 1

Column	Tributary Area	#of Floor	Live load	
internal column	mm2	no	kn/m2	kn
Basement2 slab	24.28	1	6	145.68
Basement 1slab	24.28	1	5	121.4
Ground to five slab	24.28	6	3	437.04
			total	704.12
			ETABS result	731.68
			error%	3.91
Column	Tributary Area	#of Floor	Live load	Total load
Edge column	mm2	no	kn/m2	kn
Basement2 slab	17.13	1	6	102.78
Basement 1slab	17.13	1	5	85.65
Ground to five slab	17.13	6	3	308.34
			total	496.77
			ETABS result	493.77
			error%	0.60

- Check of bending moment in beams (from live load)

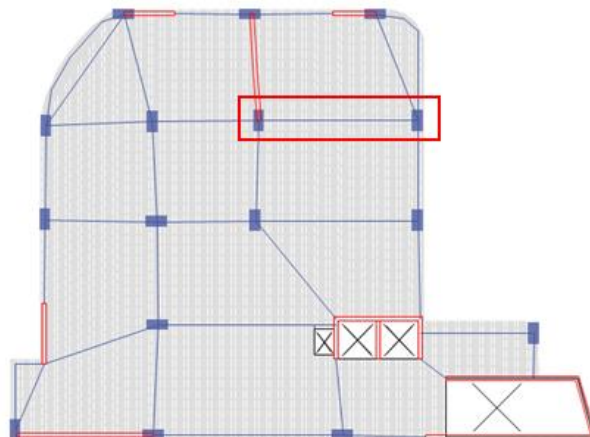


Figure 81 plan show beam that checked (first floor)

Live load = 3 kn/m<sup>2</sup>

Live load in selected beam = 3\*4.75=14.25 kn/m

Total moment in beam =  $W L_n^2/8$

Total moment in beam =  $14.25*6.90^2/8=84.8$  kn.m

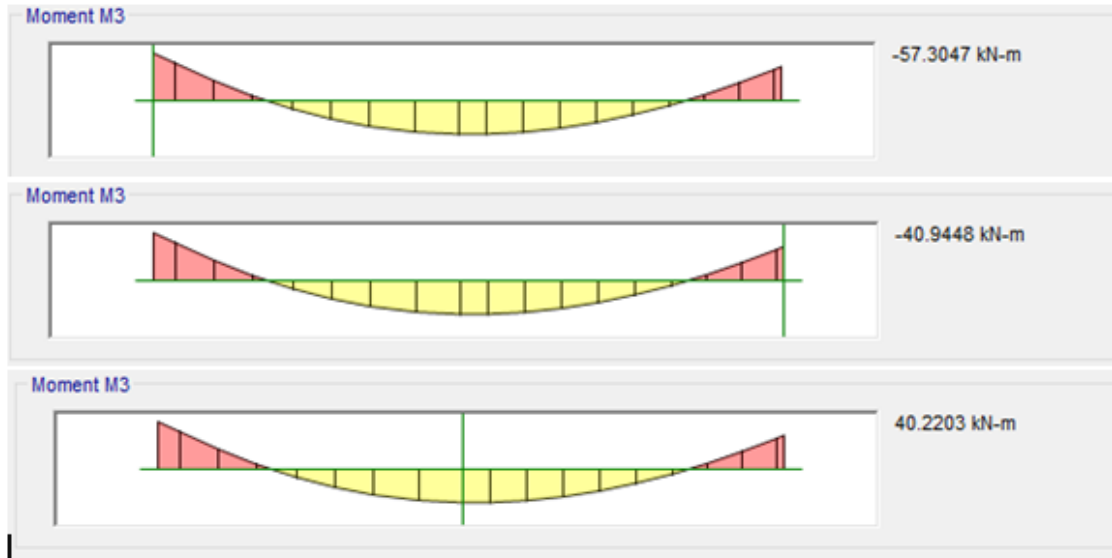


Figure 82 moment result for selected beam

Total moment from ETABS = Average for negative moment + positive moment

$$= 57.3 + 40.94/2 + 40.22 = 89.34 \text{ kn.m}$$

**% error = 4.90% < 10%... ok**

- **Check of bending moment in slab (from live load)**

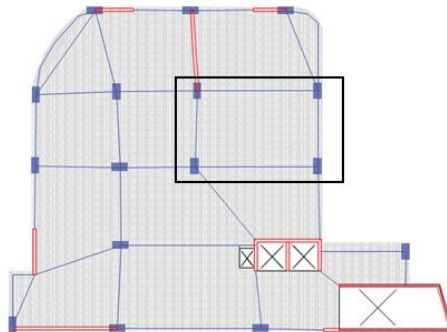


Figure 83: plan show slab span that checked (first floor)

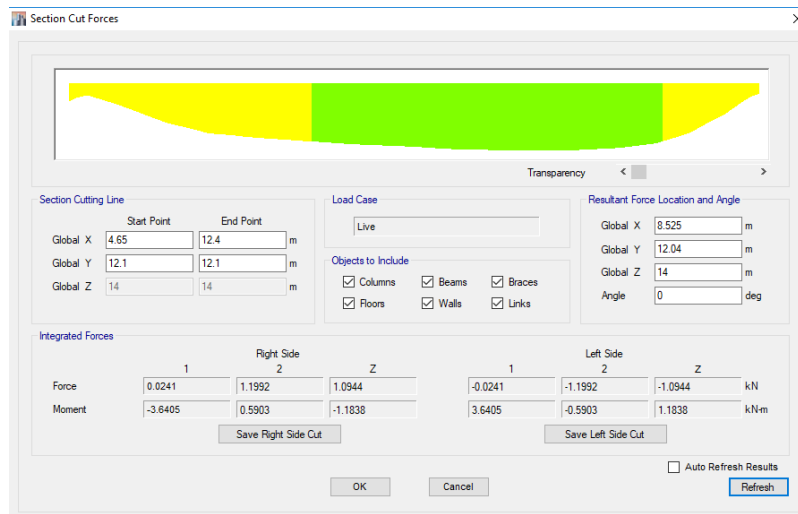
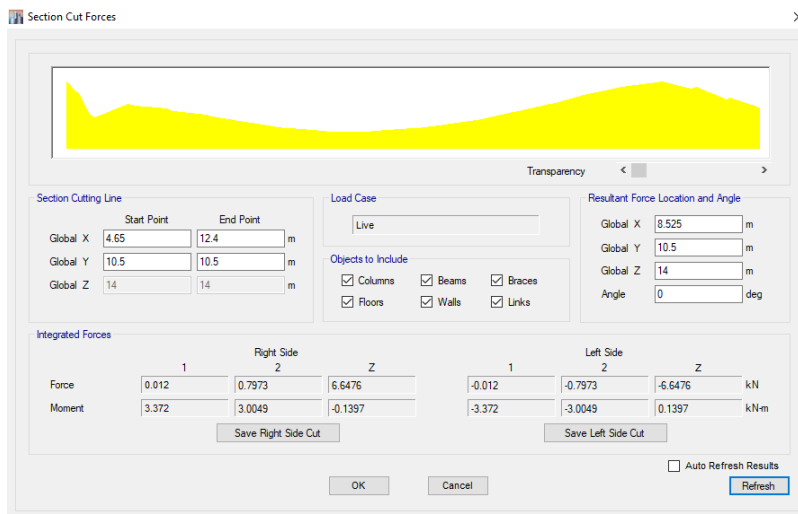
Live load = 3 kn/m<sup>2</sup>

Live load in selected span = 3\*0.55=1.65 kn/m.ribs

Total moment in beam =  $W L_n^2/8$

Where  $L_n$  =clear slab span = 4.15 m

Total moment in beam = 3.55 kn.m/ribs



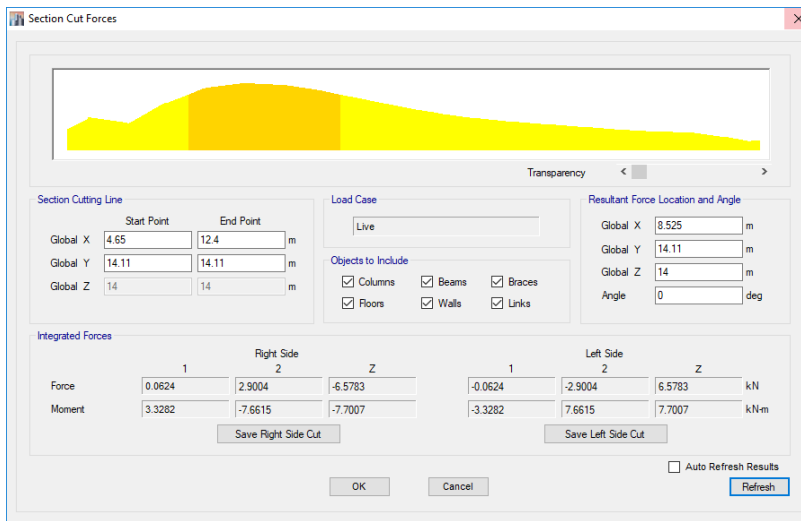


Figure 84 moment result for selected slab span

Total ETABS moment=  $6.99 \times 0.55 = 3.84$  kn.m/ribs.....%error = **8.2%** <10% ...ok

### 3.10.4 Long Term Deflection check

Long Term-Deflection in slabs/beams is the deflection or the deformation that occurs over time due to shrinkage and temperature. It is also influenced by the condition of the cracking before loading, then creeping, which depends on the time passed to the time of the first loading, the environment, and other factors.

$$\text{LTD combination} = \lambda D + \lambda \text{SID} + (1 + \lambda/2) L$$

$$\text{Where } \lambda = 2 / (1 + 50\rho)$$

$$\rho = 0.0033 \text{ in slab ...so } \lambda = 1.71$$

$$\text{LTD combination} = 1.71D + 1.71 \text{SID} + 1.86 L$$

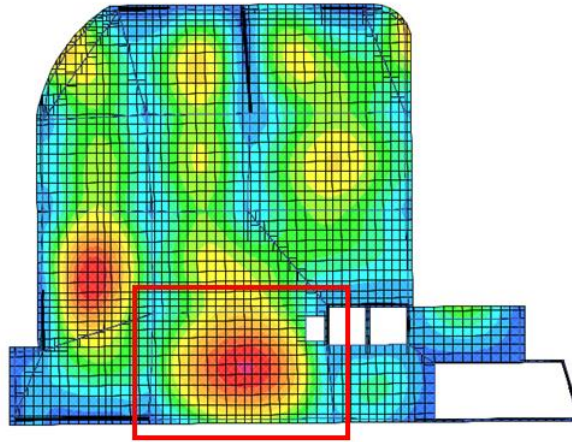


Figure 85 first floor long term deflection

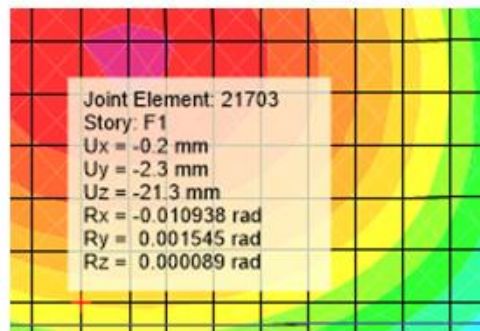
Allowable deflection in selected panel =  $L/240$

$$= 5.11/240 = 0.0213 \text{ m} = 21.29 \text{ mm}$$

Deflection from ETABS

Corner deflection 1

Corner deflection 2



Mid deflection



Figure 86 LTD deflection in selected panel

$$\Delta_{LT} = \Delta \text{ mid. span} - \Delta \text{ avg. corners}$$

$$= 36.4 - 23.3$$

$$= 13.1 \text{ mm} < 21.29 \text{ mm. ... Acceptable}$$

### 3.10.5 Seismic checks

#### 3.10.5.1 Period and mass ratio checks

$$T_a = C_t (h_n)^{3/4} \rightarrow T = 1.4 * T_a$$

WHERE: -

$C_t = 0.0853$  for steel moment-resisting frames.

$C_t = 0.0731$  for reinforced concrete moment-resisting frames and eccentrically

Braced frames.

-  **$C_t = 0.0488$  for all other build.**

$h_n =$  height above the base to level (n) = 31.5 m.

$$T_a = 0.0488 * (31.5)^{3/4} \rightarrow T = 1.4 * 0.65 \rightarrow T = 0.91 \text{ sec}$$

from ETABS = 1.194 sec

Table 41 Modal Participating Mass Ratios

Case	Mode	Period sec	UX	UY	UZ	Sum UX	Sum UY
Modal	1	1.194	0.1234	0.3476	0	0.1234	0.3476
Modal	2	0.842	0.2383	0.2486	0	0.3618	0.5962
Modal	3	0.541	0.2647	0.0033	0	0.6265	0.5995
Modal	4	0.271	0.0301	0.0929	0	0.6567	0.6924
Modal	5	0.214	0.0464	0.0738	0	0.7031	0.7662
Modal	6	0.127	0.1131	0.0025	0	0.8161	0.7687
Modal	7	0.118	2.811E-05	0.0332	0	0.8162	0.8019
Modal	8	0.107	4E-05	0.0153	0	0.8162	0.8172
Modal	9	0.091	0.0325	0.0053	0	0.8487	0.8224
Modal	10	0.068	0.0009	0.0854	0	0.8496	0.9078
Modal	11	0.057	0.1256	0.0039	0	0.9752	0.9117
Modal	12	0.044	0.0067	0.0776	0	0.982	0.9893

**Sum UX and Sum UY > 0.9 ----> ok**

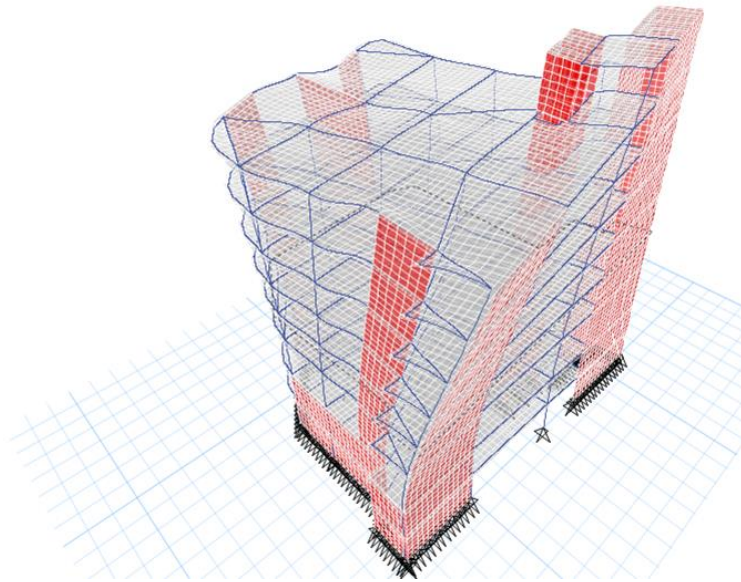


Figure 87 period from ETABS

### 3.10.5.2 Base-shear check

In base shear check it must be ensured that EQx and EQy in ETABS from response spectrum greater or equal to linear static earthquake load .

Table 42 Base Reaction for BLOCK 1

Load Case/Combo	FX	FY	FZ
	kN	kN	kN
Dead	0.00002197	0.000008096	29879.4
Live	0.000013	0.000004298	10789.6675
SID	0.0000159	0.0000071	28513.6145
EQX Max	2484.056	1288.4333	0.0001
EQY Max	1366.9495	1968.2056	0.0000325

$$V = C_v I W/R T$$

$$W: DL+ SID L + 0.25L.L = 29879.4+28513.6145+0.25*10789.6675=61090.43 \text{ kn}$$

$$V = 0.32 * 1 * 61090.43 / 5.5 * 0.91 = 3905.88 \text{ kn}$$

Table 43 Base-shear check block 1

	Vetabs	V code	Check V	New Factor	Vetabs	Check V
	Kn	Kn			Kn	
<b>X-dir</b>	2484.056	3905.8817	change factor	2804.5554	3907.51	ok
<b>Y-dir</b>	1968.2056	3905.8817	change factor	3539.60617	3954.75	ok

### 3.10.5.3 Drift check

- Drift (X or Y) = displacement at story n – displacement at story n-1

-  $\Delta X = \text{drift}(X) * 0.7 * R$ ,  $\Delta Y = \text{drift}(Y) * 0.7 * R$

- Delta limitation ( $\Delta_{\text{limit}}$ ) = 0.02 \* height of story

-  $\Delta X$  and  $\Delta Y$  should be  $\leq$  drift limitation

Table 44 Drifts Check In X Direction block 1

Floor	floor height	R	T Structure	$\Delta x$ elastic	Total $\Delta x$ inelastic	Max. $\Delta x$ inelastic	Result
	mm		sec	mm	mm	mm	
<b>9</b>	3500	5.5	1.194	16.9	-26.565	70	Safe
<b>8</b>	3500	5.5	1.194	23.8	15.015	70	Safe
<b>7</b>	3500	5.5	1.194	19.9	15.785	70	Safe
<b>6</b>	3500	5.5	1.194	15.8	16.555	70	Safe
<b>5</b>	3500	5.5	1.194	11.5	16.555	70	Safe
<b>4</b>	3500	5.5	1.194	7.2	13.86	70	Safe
<b>3</b>	4500	5.5	1.194	3.6	10.78	90	Safe
<b>2</b>	3000	5.5	1.194	0.8	2.31	60	Safe
<b>1</b>	3000	5.5	1.194	0.2	0.77	60	Safe

Floor	floor height	R	T Structure	$\Delta y$ elastic	Total $\Delta y$ inelastic	Max. $\Delta y$ inelastic	Result
	mm		sec	mm	mm	mm	
9	3500	5.5	1.351	43.3	31.185	70	Safe
8	3500	5.5	1.351	35.2	24.255	70	Safe
7	3500	5.5	1.351	28.9	24.255	70	Safe
6	3500	5.5	1.351	22.6	22.715	70	Safe
5	3500	5.5	1.351	16.7	20.79	70	Safe
4	3500	5.5	1.351	11.3	17.71	70	Safe
3	4500	5.5	1.351	6.7	16.555	90	Safe
2	3000	5.5	1.351	2.4	6.16	60	Safe
1	3000	5.5	1.351	0.8	3.08	60	Safe

### 3.11 Model analysis and check for Block 2

The structural system it will be analyzed as a 3d model consists of frames and shear walls, in which columns and beams will be modeled as line elements having 3 degrees of freedom at each node, while the joints are considered to be fully rigid, Shear walls and floors will be modeled as area elements using (ETABS) structural analysis program.

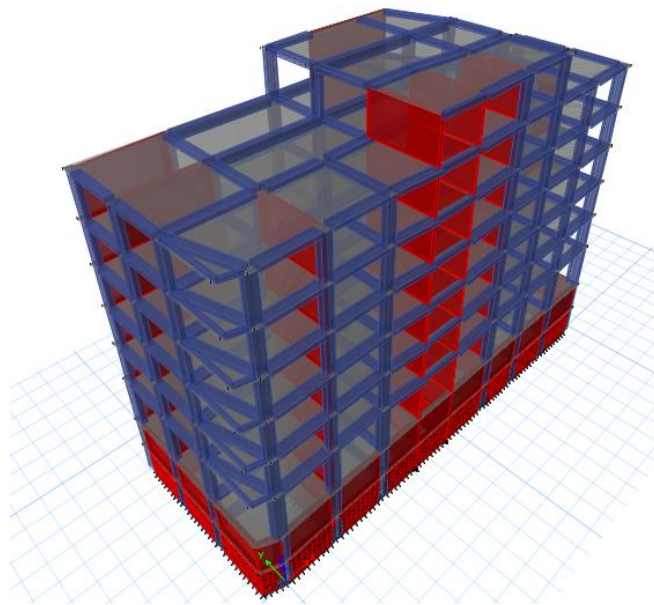


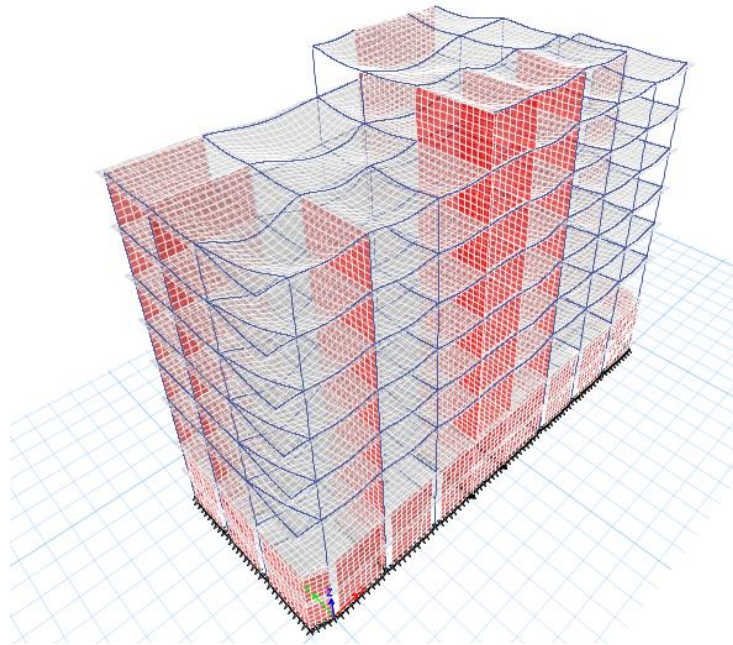
Figure 88 3D mode of block 2

The results were analyzed and verified by making the following checks:

- Compatibility
- Equilibrium
- Stress – strain relationship
- Deflection
- Seismic checks

### **3.11.1 Compatibility check (Block2)**

Compatibility check, through this check it ensures that all building elements move together



*Figure 89:Compatibility check*

### 3.11.2 Equilibrium check (Block 2)

In this check .It will be ensured through this examination that the loads resulting from the model representation are similar to the loads calculated manually with an error rate not exceeding 5%.

Table 46 Base reaction from ETABS

Load Case/Combo	FX	FY	FZ
	kN	kN	kN
<b>Dead</b>	-0.00001049	0.0037	40454.5411
<b>Live</b>	-0.000006046	0.0023	16187.2407
<b>SID</b>	0.000006797	-0.0008	37732.7552

- Live load check

Table 47 Live load check block 2

Stories	Area M <sup>2</sup>	Opining M <sup>2</sup>	Live load Kn/m <sup>2</sup>	Total load KN
<b>Basement2 slab</b>	556.68	20.28	6	3218.4
<b>Basement 1slab</b>	556.68	20.28	5	2682
<b>Ground to five slab</b>	556.68 *6	20.28*6	3	9655.2
<b>Roof floor</b>	210.48	0	3	631.44
		Total		16187.04
		ETABS live base reaction		16187.2407
		%Error		0.012%

- Dead load check

Table 48 Dead load check Block2

Slab					
Stories	Area	Opining	own weight	Total load	
	M2	M2	Kn/m2	KN	
Basement2 slab	556.68	20.28	3.64	1952.50	
Basement 1slab	556.68	20.28	3.64	1952.50	
Ground to five slab	3340.08	121.68	3.64	11714.98	
Roof floor	210.48	0.00	3.64	766.15	
			<b>total</b>	<b>16386.12</b>	
dropped beam	length	B*H	own weight	Total load	
	m	m*m	Kn/m2	kn	
b50*70 in all floor	293.31	0.5*0.38	25.00	1393.22	
b80*32 in all floor	544.49	0.8*.32	25.00	3484.74	
b60*32 in all floor	651.46	0.6*.32	25.00	3127.02	
			<b>total</b>	<b>8004.98</b>	
column	height	area of section	#of columns	own weight	Total load
	m	M2	no	Kn/m2	kn
Basement2floor	3.00	0.50	24.00	25.00	900.00
Basement 1floor	3.00	0.50	24.00	25.00	900.00
Ground floor	4.50	0.32	24.00	25.00	864.00
first to five slab	3.50	0.32	120.00	25.00	3360.00
Roof floor	3.50	0.32	8.00	25.00	224.00
				<b>total</b>	<b>6248.00</b>
wall	wall area	wall thickness	own weight	Total load	
	m2	M	Kn/m2	kn	
wall 30cm	388.68	0.30	25.00	2915.10	
wall 20 cm	1394.06	0.20	25.00	6970.30	
			total	9885.40	
			<b>total dead load</b>		<b>40524.50</b>
			<b>ETABS dead load</b>		<b>40454.54</b>
			<b>% Error</b>		<b>0.00</b>

- SID load check

Table 49 SID load check block2

Stories	Area	Opining	Live load	Total load
	M <sup>2</sup>	M <sup>2</sup>	Kn/m <sup>2</sup>	KN
<b>Basement2 slab</b>	556.68	20.28	6	3218.4
<b>Basement 1slab</b>	556.68	20.28	6	3218.4
<b>Ground to five slab</b>	3340.1	121.68	6	19310.4
<b>Roof floor</b>	210.48	0	6	1262.88
		<b>Total</b>		<b>27010.08</b>
<b>Wall In all floor</b>	<b>Length m</b>	<b>Wall load kn/m</b>		<b>Total kn</b>
	464.27	26		12071.02
		<b>Total</b>		<b>39081.1</b>
		<b>ETABS SID base reaction</b>		<b>37732.7552</b>
		<b>%Error</b>		<b>3.45%</b>

### 3.11.3 Stress strain check

Stress and strain testing is done through this test to ensure that the internal forces of the structural elements (bridges, ceilings, columns, walls), resulting from the structural analysis in the ETAB program are close to the manual calculations of these elements with an error rate not exceeding 10%.

- Check of axial load on column (live load )

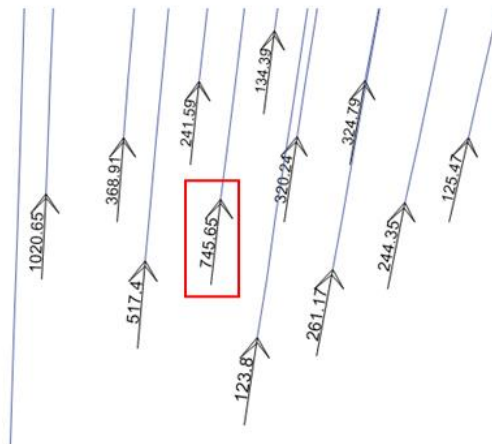
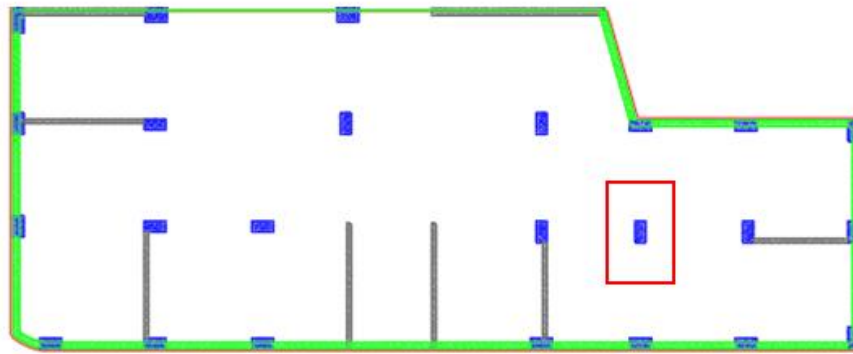


Figure 90: plan show columns that checked

Table 50 internal col axial load check

Column	Tributary Area	#of Floor	Live load	Total load
internal column	mm2	no	kn/m2	kn
Basement2 slab	25	1	6	150
Basement 1slab	25	1	5	125
Ground to five slab	25	6	3	450
			total	725
			ETABS result	745.65
			error%	2.84

- Check of bending moment in beams(from live load)

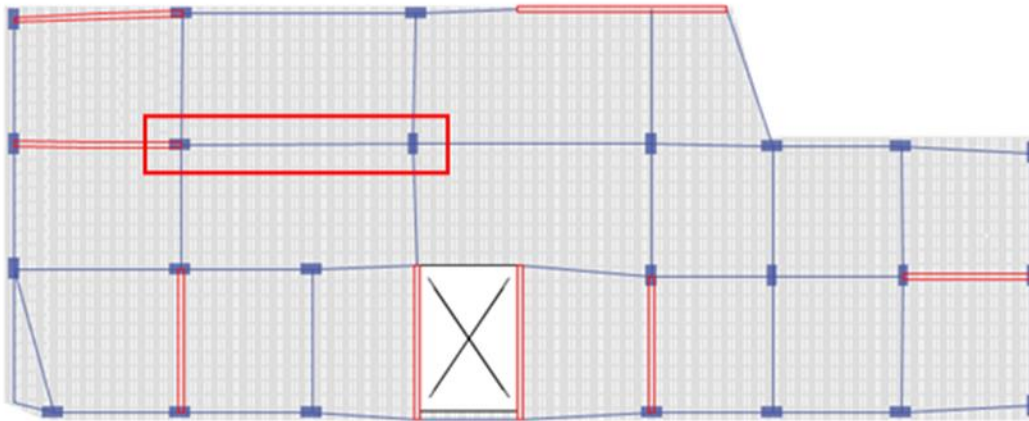


Figure 91 plan show beam that checked (first floor)

Live load = 3 kn/m<sup>2</sup>

Live load in selected beam = 3\*4.83=14.49 kn/m

Total moment in beam =  $W L_n^2/8$

Where  $L_n$  =clear beam span = 8.02 m

Total moment in beam =  $14.49*8.02^2/8=116.5$  kn.m

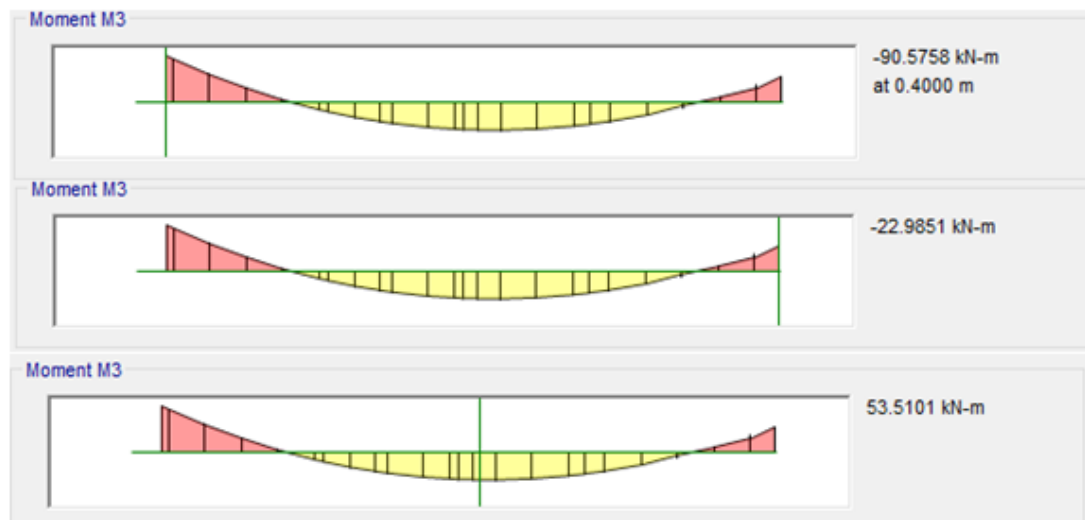


Figure 92 moment result for selected beam

Total moment from ETABS = Average for negative moment + positive moment

$$= 110.275 \text{ kn.m}$$

$$\% \text{ error} = 5.34\% < 10\% \dots \text{ok}$$

- **Check of bending moment in slab (from live load)**

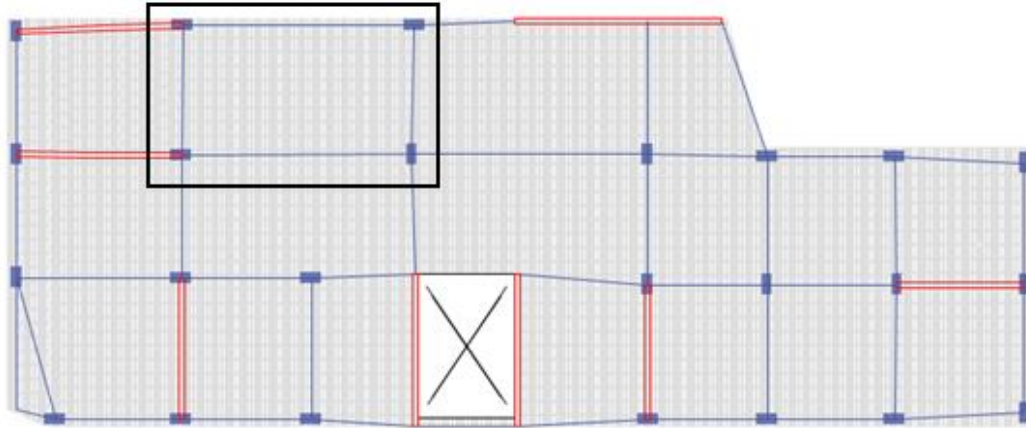


Figure 93 plan show slab span that checked (first floor)

$$\text{Live load} = 3 \text{ kn/m}^2$$

$$\text{Live load in selected span} = 3 * 0.55 = 1.65 \text{ kn/m.ribs}$$

$$\text{Total moment in beam} = W L_n^2 / 8$$

$$\text{Where } L_n = \text{clear slab span} = 4.47 \text{ m}$$

$$\text{Total moment in beam} = 4.12 \text{ kn.m/ribs}$$

$$\text{Total ETABS moment} = 6.99 * 0.55 = 3.84 \text{ kn.m/ribs}$$

$$\% \text{error} = 8.2\% < 10\% \dots \text{ok}$$

### 3.11.4 Long Term Deflection check

Long Term-Deflection in slabs/beams is the deflection or the deformation that occurs over time due to shrinkage and temperature. It is also influenced by the condition of the cracking before loading, then creeping, which depends on the time passed to the time of the first loading, the environment, and other factors.

$$\text{LTD combination} = \lambda D + \lambda \text{SID} + (1 + \lambda/2) L$$

Where  $\lambda = 2 / (1 + 50\rho)$

$\rho = 0.0033$  in slab ...so  $\lambda = 1.71$

LTD combination = 1.71D+ 1.71 SID+ 1.86 L

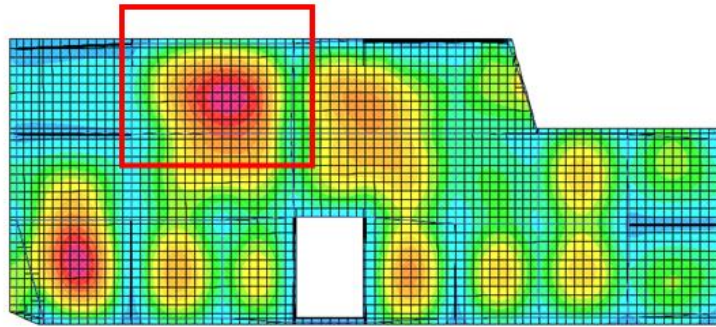


Figure 94 first floor long term deflection

Allowable deflection in selected panel =  $L/240$

$$= 4.97/240 = 0.0207 \text{ m} = 20.7 \text{ mm}$$

Deflection from ETABS

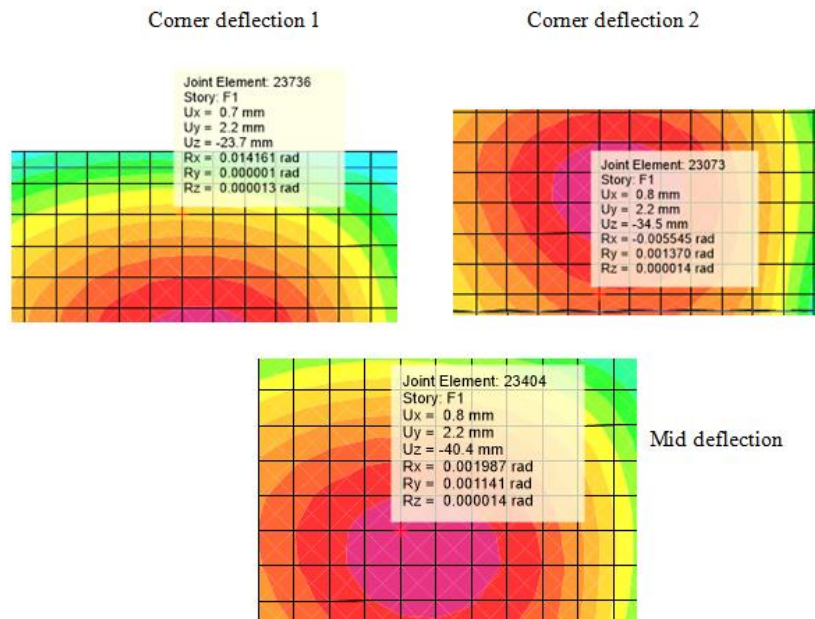


Figure 95 LTD deflection in selected panel

$$\begin{aligned}\Delta_{LT} &= \Delta \text{ mid. span} - \Delta \text{ avg. corners} \\ &= 29.1 - 40.4 \\ &= 11.3 \text{ mm} < 20.70 \text{ mm. ... Acceptable}\end{aligned}$$

### 3.11.5 Seismic checks

#### 3.11.5.1 Period and mass ratio checks

$$T_a = C_t (h_n)^{3/4} \rightarrow T = 1.4 * T_a$$

WHERE: -

$C_t = 0.0853$  for steel moment-resisting frames.

$C_t = 0.0731$  for reinforced concrete moment-resisting frames and eccentrically

Braced frames.

-  **$C_t = 0.0488$  for all other build.**

$h_n$  = height above the base to level (n) = 31.5 m.

$$T_a = 0.0488 * (31.5)^{3/4} \rightarrow T = 1.4 * 0.65 \rightarrow T = 0.91 \text{ sec}$$

from ETABS = 1.35sec

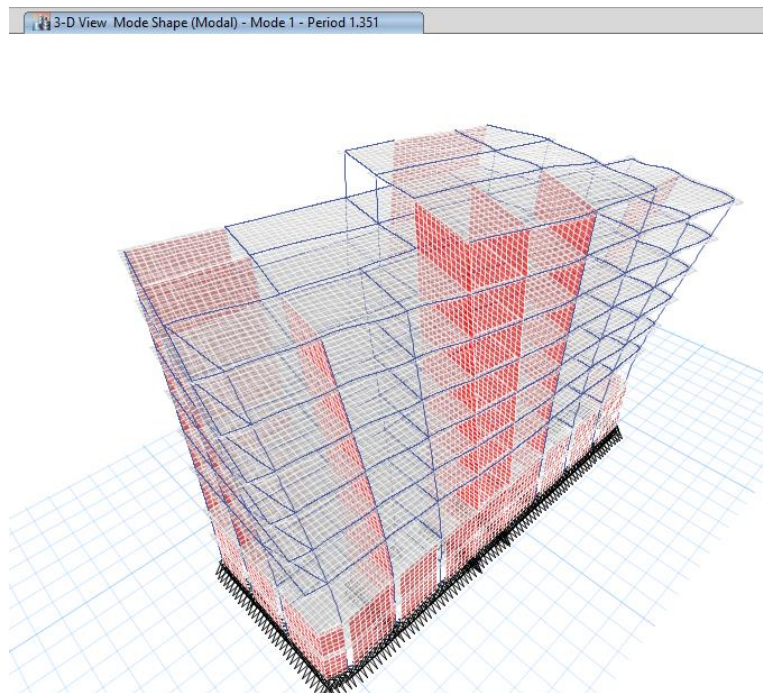


Figure 96: period from ETABS

Table 51 Modal Participating Mass Ratios

Case	Mode	Period sec	UX	UY	UZ	Sum UX	Sum UY
Modal	1	1.351	0.126	0.1266	0	0.126	0.1266
Modal	2	0.987	0.0806	0.4869	0	0.2066	0.6136
Modal	3	0.714	0.42	0.0127	0	0.6265	0.6262
Modal	4	0.317	0.0383	0.0292	0	0.6649	0.6554
Modal	5	0.217	0.0294	0.1486	0	0.6943	0.804
Modal	6	0.182	0.0198	0.0069	0	0.7141	0.811
Modal	7	0.153	0.1138	0.0103	0	0.8279	0.8212
Modal	8	0.129	0.0022	0.0078	0	0.8301	0.829
Modal	9	0.092	0.0088	0.0633	0	0.8389	0.8923
Modal	10	0.08	0.0389	0.0183	0	0.8778	0.9106
Modal	11	0.056	0.0331	0.0651	0	0.9108	0.9757
Modal	12	0.052	0.0752	0.0153	0	0.9861	0.991

**Sum UX and Sum UY > 0.9 ----> ok**

### 3.11.5.2 Base-shear check

In base shear check it must be ensured that EQx and EQy in ETABS from response spectrum greater or equal to linear static earthquake load .

Table 52 Base Reaction for BLOCK 1

Load Case/Combo	FX	FY	FZ
	kN	kN	kN
Dead	-0.00001049	0.0037	40454.5411
Live	-0.000006046	0.0023	16187.2407
SID	0.000006797	-0.0008	37732.7552
EQX Max	3345.3762	1587.8327	0.0001
EQY Max	1652.1337	2930.7745	0.0001

$$V = C_v I W / R T$$

$$W: DL + SID L + 0.25L.L = 82234.10 \text{ kn}$$

$$V = 0.32 * 1 * 82234.10 / 5.5 * 0.91 = 5257.72 \text{ kn}$$

Table 53 Base-shear check

	Vetabs	V code	Check V	New Factor	Vetabs	Check V
	Kn	Kn			Kn	
<b>X-dir</b>	3345.3762	5257.7253	change factor	2803.23333	5266.39	ok
<b>Y-dir</b>	2930.7745	5257.7253	change factor	3199.79243	5270.47	ok

### 3.11.5.3 Drift check

- Drift (X or Y) = displacement at story n – displacement at story n-1

$$-\Delta X = \text{drift}(X) * 0.7 * R, \Delta Y = \text{drift}(Y) * 0.7 * R$$

- Delta limitation ( $\Delta_{\text{limit}}$ ) = 0.02 \* height of story

-  $\Delta X$  and  $\Delta Y$  should be  $\leq$  drift limitation

Table 54 Drifts Check In X Direction

Floor	floor height	R	T Structure	$\Delta x$ elastic	Total $\Delta x$ inelastic	Max. $\Delta x$ inelastic	Result
	mm		sec	mm	mm	mm	
<b>9</b>	3500	5.5	1.351	25.6	15.015	70	Safe
<b>8</b>	3500	5.5	1.351	21.7	15.015	70	Safe
<b>7</b>	3500	5.5	1.351	17.8	15.015	70	Safe
<b>6</b>	3500	5.5	1.351	13.9	14.245	70	Safe
<b>5</b>	3500	5.5	1.351	10.2	12.705	70	Safe
<b>4</b>	3500	5.5	1.351	6.9	11.55	70	Safe
<b>3</b>	4500	5.5	1.351	3.9	10.78	90	Safe
<b>2</b>	3000	5.5	1.351	1.1	2.695	60	Safe
<b>1</b>	3000	5.5	1.351	0.4	1.54	60	Safe

Table 55 Drifts Check In Y Direction

Floor	floor height	R	T Structure	$\Delta y_{\text{elastic}}$	Total $\Delta y_{\text{inelastic}}$	Max. $\Delta y_{\text{inelastic}}$	Result
-------	--------------	---	-------------	-----------------------------	-------------------------------------	------------------------------------	--------

	mm		sec	mm	mm	mm	
<b>9</b>	3500	5.5	1.351	43.3	31.185	70	Safe
<b>8</b>	3500	5.5	1.351	35.2	24.255	70	Safe
<b>7</b>	3500	5.5	1.351	28.9	24.255	70	Safe
<b>6</b>	3500	5.5	1.351	22.6	22.715	70	Safe
<b>5</b>	3500	5.5	1.351	16.7	20.79	70	Safe
<b>4</b>	3500	5.5	1.351	11.3	17.71	70	Safe
<b>3</b>	4500	5.5	1.351	6.7	16.555	90	Safe
<b>2</b>	3000	5.5	1.351	2.4	6.16	60	Safe
<b>1</b>	3000	5.5	1.351	0.8	3.08	60	Safe

### 3.12 Design and reinforcement for building (block 1&2)

#### 3.12.1 Slab design

##### 1- Block 1

Due to the use of the one way ribbed slab system in Y direction , M22 were found from ETABs.

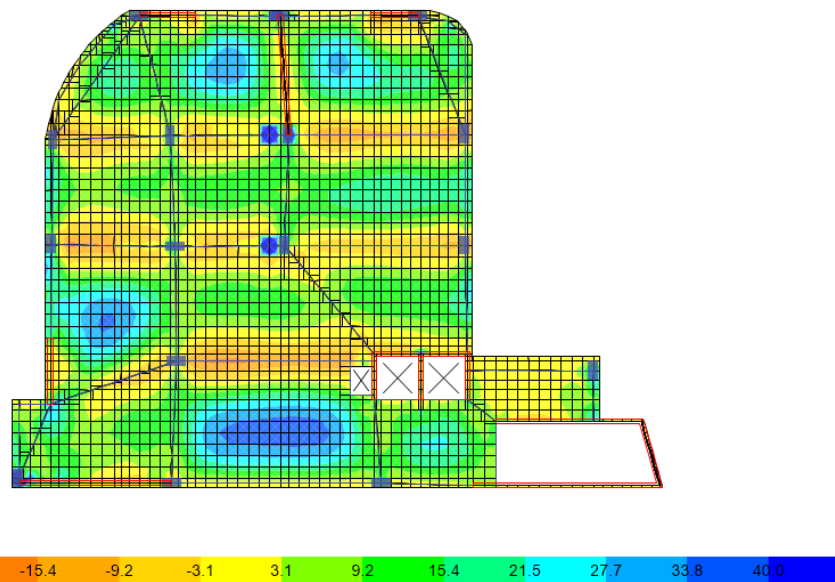


Figure 97 moment diagram M22 from envelop ultimate load for typical floor B1

Design of slabs for flexure:

h=320mm      cover = 30mm

D= 290mm      b= 150 mm

Max moment =37.86 Kn.m = 37.86\*.55= 20.724 kn.m / ribs

$\rho = 0.004493272 \dots AS = \rho b d = 195.45 \text{mm}^2$

$AS_{\min} = 0.0033 * 290 * 150 = 143.55 \text{mm}^2$

$AS > AS_{\min} \dots$  So use  $AS = 195.45 \text{mm}^2$

Use 2Ø12mm / ribs (top and bottom)

### Slab Shear check

$\phi V_c = 0.75 / 6 * \sqrt{f_c} * b * d = 0.75 / 6 * \sqrt{24} * 150 * 290 / 1000 = 26.63 \text{KN}$

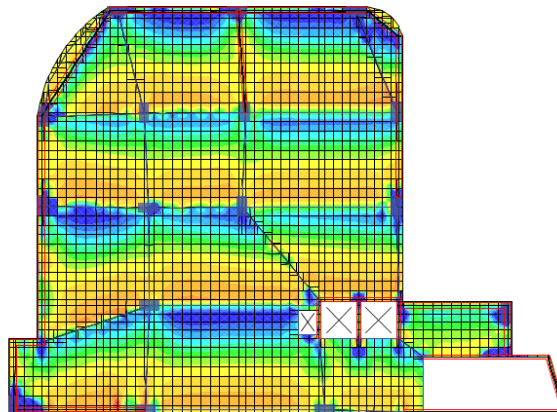


Figure 98 Shear diagram V23 from envelop ultimate load for typical floor B1

$V_{\max} = 42.5 \text{ kN/m} \dots$  for ribs =  $42.5 * .55 = 23.375 \text{ kN / ribs} < \phi V_c \dots$  **Ok**

### 2-Block 2

Due to the use of the one way ribbed slab system in Y direction , M22 were found from ETABS.

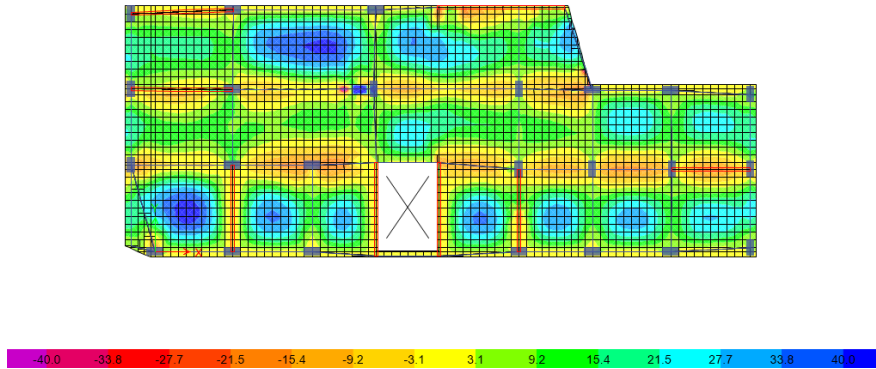


Figure 99 moment diagram M22 from envelop ultimate load for typical floor B2

-Design of slabs for flexure:

$h=320\text{mm}$        $\text{cover} = 30\text{mm}$

$D= 290\text{mm}$        $b= 150 \text{ mm}$

$\text{Max moment} = 43.63 \text{ Kn.m} = 37.86 * .55 = 23.99 \text{ kn.m / ribs}$

$\rho = 0.005291532 \dots AS = \rho b d = 230.2\text{mm}^2$

$AS_{\text{min}} = 0.0033 * 290 * 150 = 143.55 \text{ mm}^2$

$AS > AS_{\text{min}} \dots \text{So use } AS = 230.2\text{mm}^2$

Use  $2\text{Ø}14\text{mm}$  / ribs (top and bottom)

Other panel use  $2\text{Ø}12\text{mm}$  / ribs (top and bottom)

### Slab Shear check

$$\phi V_c = 0.75 / 6 * \sqrt{f_c} * b * d = 0.75 / 6 * \sqrt{24} * 150 * 290 / 1000 = 26.63 \text{KN}$$

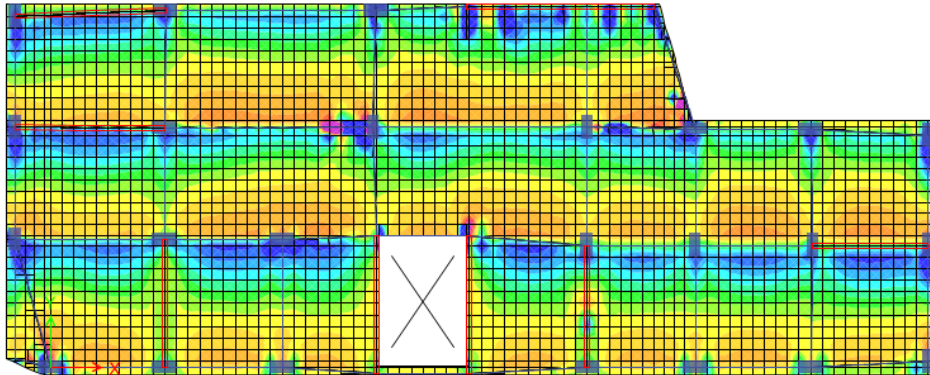


Figure 100 Shear diagram V23 from envelop ultimate load for typical floor B2

$$V_{\max} = 41.3 \text{ kn/m} \dots \text{for ribs} = 41.3 * .55 = 22.715 \text{ kn /ribs} < \phi V_c \dots \text{ok}$$

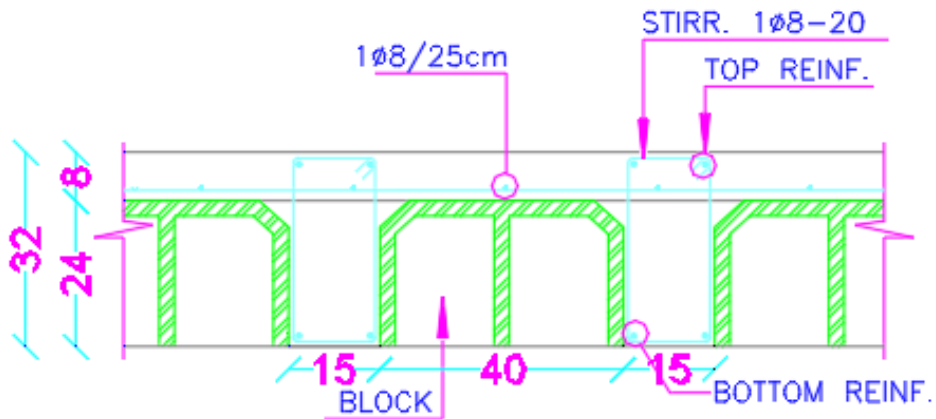


Figure 101 Slab section for block 1&2

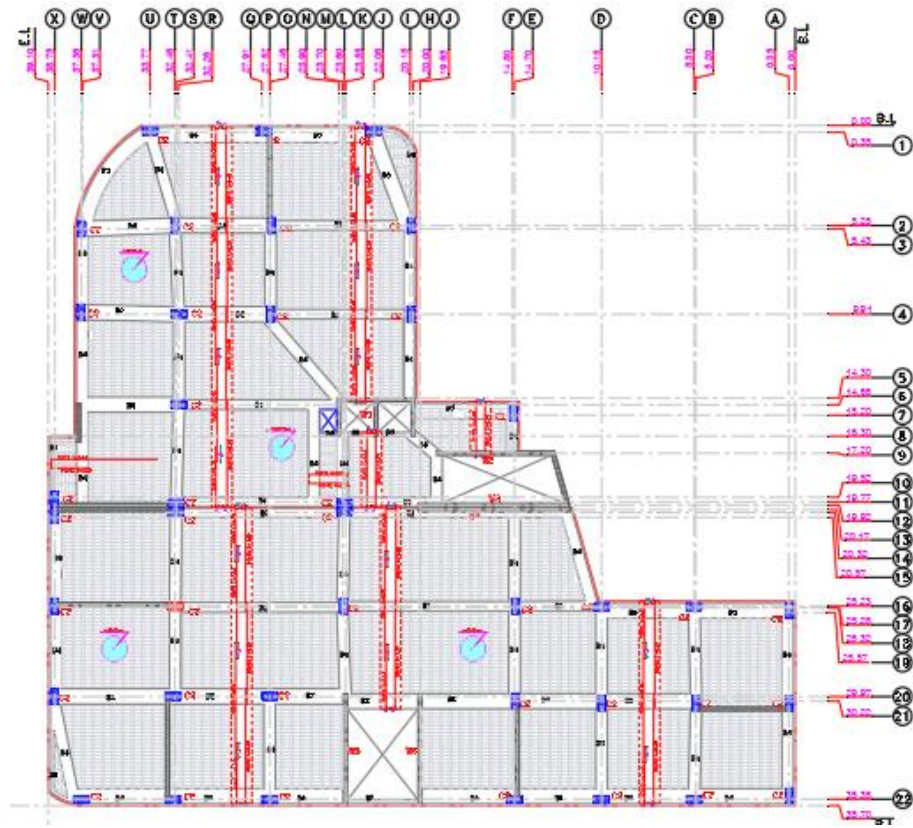


Figure 102 typical floor slab reinforcement and ribs

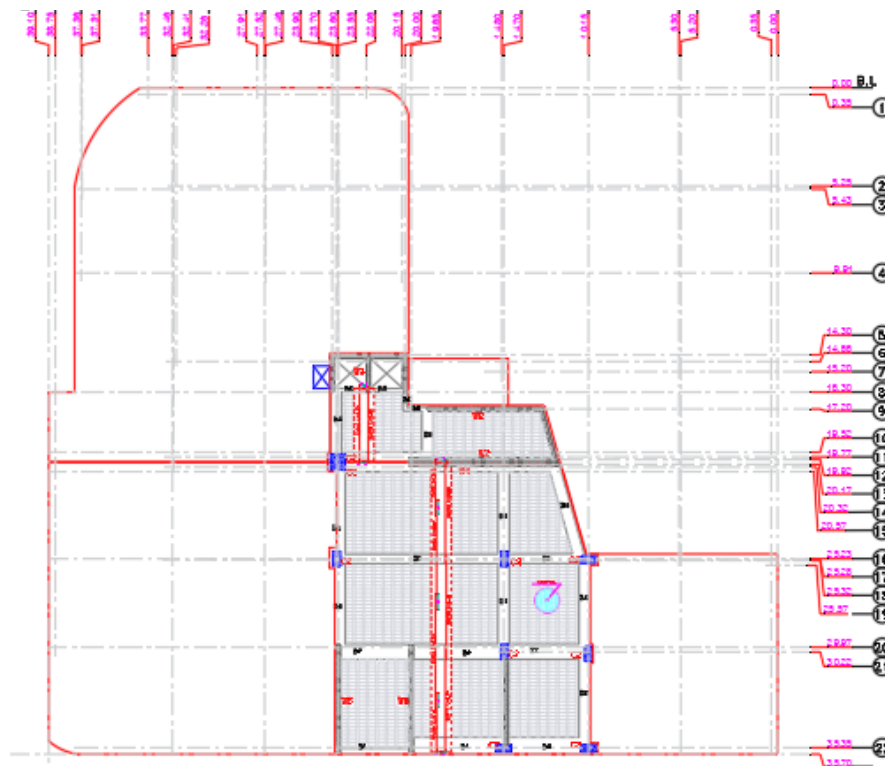


Figure 103 Roof floor slab reinforcement and ribs

### 3.12.2 Columns design

There are two types of columns according to dimensions. Columns 50\*100 cm are used in basement 1&2 and the ground floor. Columns 40\*80 cm are used in the other floors. Through design using the ETABS program, it must be ensured that the reinforcement ratio of these columns is 1%.

Figure 104 columns rebar

1

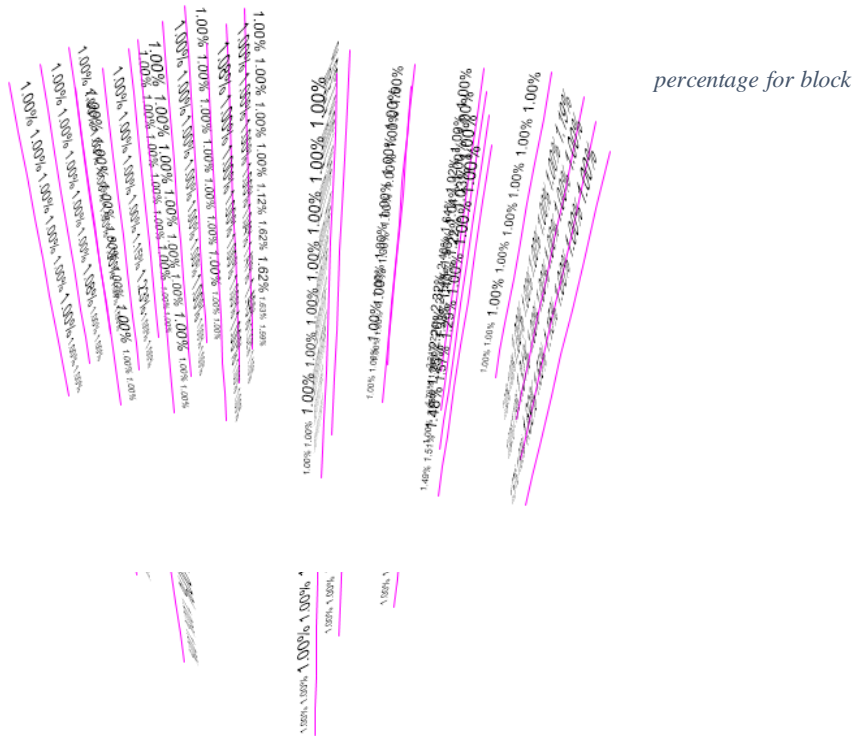


Figure 105 columns rebar percentage for block 2

Table 56 Column reinforcement

column	$\rho$ from ETABS	AS	#bar	stirrup
C 50*100	1.48%	7400	20 $\phi$ 22	3 $\phi$ 10/10-20-10cm
C40*80	1.23%	3936	16 $\phi$ 18	2 $\phi$ 10/10-20-10cm

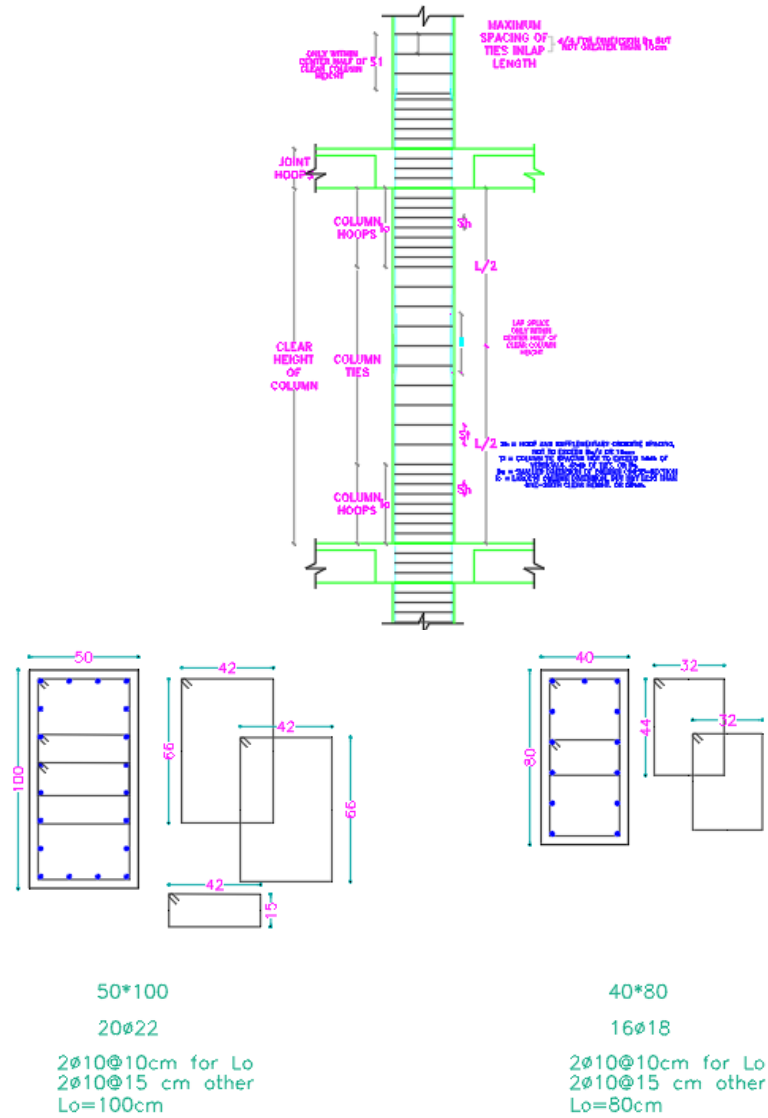


Figure 106 C1&C2 sections and reinforcement

### Check For spacing:

We use bar after bar in a stirrup corner

- For Column (500 X 100)

$$\text{Strip} = \begin{cases} \leq 24 \times d_s = 24 \times 10 = 240 \text{ mm} \\ \leq 8 \times d_b = 8 \times 22 = 176 \text{ mm} \\ \leq \text{Least} \frac{\text{Dimensions}}{2} = \frac{500}{2} = 250 \text{ mm} \end{cases}$$

Take Spacing =150 mm .

- For Column (400 X 800)

$$\text{Strip} = \begin{cases} \leq 24 \times d_s = 24 \times 10 = 240 \text{ mm} \\ \leq 8 \times d_b = 8 \times 18 = 144 \text{ mm} \\ \leq \text{Least} \frac{\text{Dimensions}}{2} = \frac{400}{2} = 200 \text{ mm} \end{cases}$$

Take Spacing = 150 mm .

**Check Distance Between bars if  $\leq 150$  :**

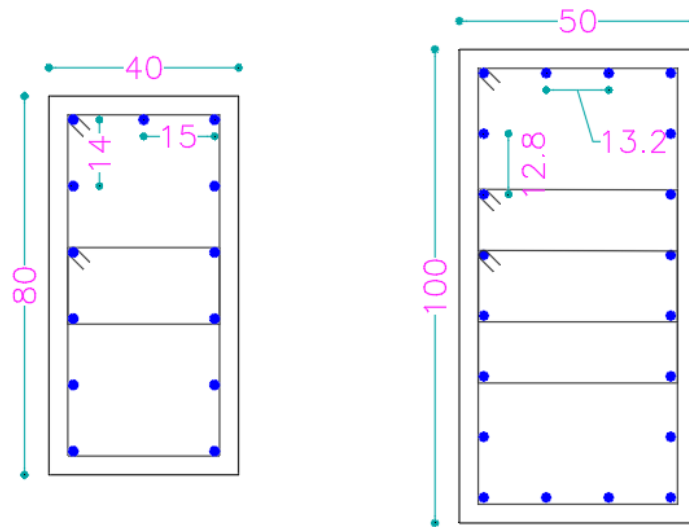


Figure 107 Details showing the distances between bar

### 3.12.3 Beam reinforcement

#### Block 1

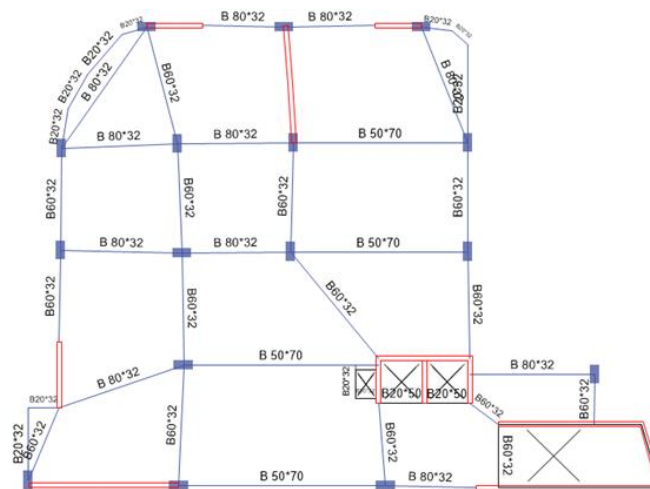


Figure 108 Typical floor beam sections -Block1

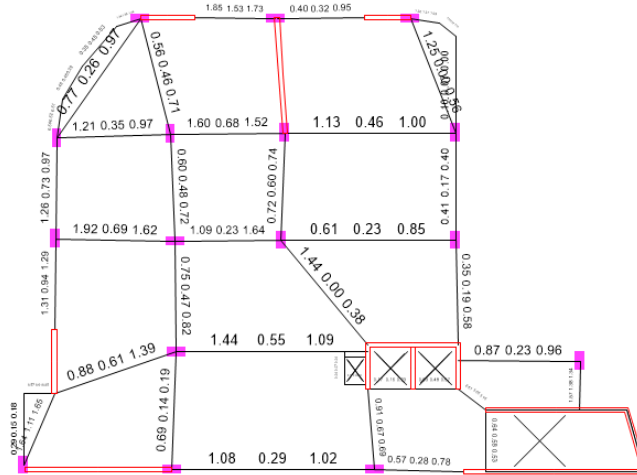


Figure 109 Typical floor beam shear reinforcing -Block1

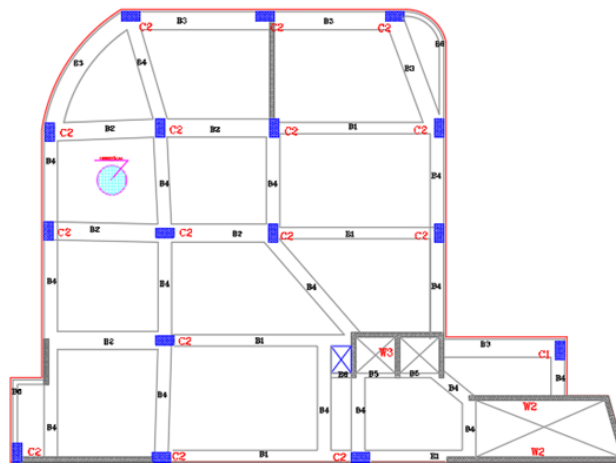


Figure 110 Beam layout for typical floor -Block1



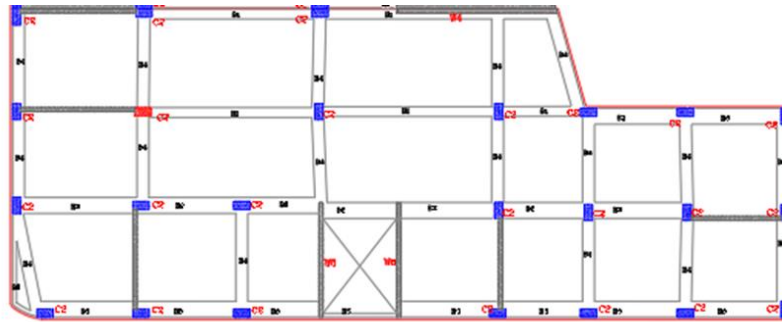


Figure 113 Beam layout for typical floor -Block2

Table 57 beam schedule reinforcement

Beam SCHEDULE					
Type	Dimension mm	Top Bar	Bottom Bar	Middel Bar	Stirrups
B1	500*700	10Ø18	5Ø20	4Ø14	Ø10@10cm
B2	800*320	7Ø18	5Ø18		2Ø10@10cm
B3	800*320	7Ø16	5Ø16		2Ø10@10cm
B4	600*320	5Ø16	5Ø14		Ø10@10cm
B5	200*500	3Ø16	3Ø16		Ø10@10cm
B6	200*320	2Ø12	2Ø12		1Ø10@10cm

Note: more details and sections in all beams attached in AUTOCAD drawing

### 3.12.4 Shear wall design

There are two types of walls according to dimensions. Wall 30 cm is used in basement 1&2. And wall 20 cm is used in the all floors.

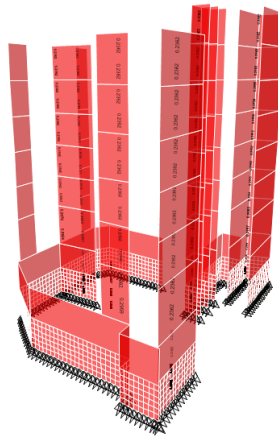


Figure 114: wall reinforcing ratio for Block1

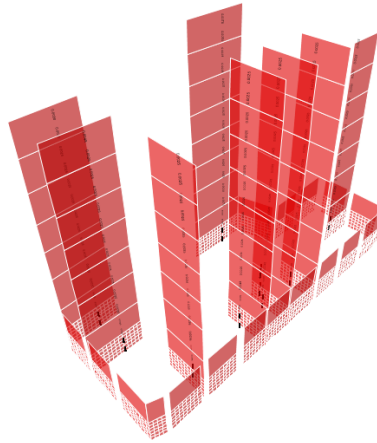


Figure 115: wall reinforcing ratio for Block1

### Shear wall 20 cm

Table 58 design shear wall 20cm

Flexural Design for $P_u$ , $M_{u2}$ and $M_{u3}$								
Station Location	Required Rebar Area (mm <sup>2</sup> )	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	$P_u$ kN	$M_{u2}$ kN-m	$M_{u3}$ kN-m	Pier $A_g$ mm <sup>2</sup>
Top	18287	0.0049	0.0079	DWal6	1271.0954	-7324.1851	5294.1717	3348481
Bottom	24418	0.0073	0.0079	DWal6	1505.4892	-10388.6652	8749.6875	3348481

Steel ratio in all shear wall in building =0.0073

Steel /1m in shear wall =0.0073\*200\*1000=1460 mm<sup>2</sup>

For one side =1460/2=730 mm<sup>2</sup> .....Use Ø14 /20cm.

Table 59 design shear wall 20cm for shear force

Shear Design								
Station Location	ID	Rebar mm <sup>2</sup> /mm	Shear Combo	$P_u$ kN	$M_u$ kN-mm	$V_u$ kN	$\Phi V_c$ kN	$\Phi V_n$ kN
Top	Leg 1	0.5	DWal3	-873.4717	4459227.21	1546.6886	1231.4474	2218.0976
Top	Leg 2	0.63	DWal4	-89.3975	292726.77	892.9067	446.2319	892.9067
Top	Leg 3	0.5	DWal4	-505.6093	1024861.89	1287.9962	983.9118	1751.3468
Bottom	Leg 1	0.5	DWal3	-1429.0964	7340844.66	1561.3107	1148.1037	2134.7538
Bottom	Leg 2	0.62	DWal6	-501.082	847812.78	855.7577	415.6928	855.7577
Bottom	Leg 3	0.5	DWal4	-1287.3007	2587279.74	1306.6791	866.6581	1634.093

$A_v/s = 0.63$

Assume use ø10 ...  $A_v = 2*78=156\text{mm}^2$

$S = 247$  mm ...so use Ø10 /20cm

## Shear wall 30 cm

Table 60 design shear wall 20cm

Flexural Design for $P_u$ , $M_{u2}$ and $M_{u3}$								
Station Location	Required Rebar Area (in <sup>2</sup> )	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	$P_u$ kip	$M_{u2}$ kip-ft	$M_{u3}$ kip-ft	Pier $A_g$ in <sup>2</sup>
Top	75.301	0.0025	0.0054	DWal6	1145.291	-3559.8924	-7262.2444	30120.3976
Bottom	75.301	0.0025	0.0054	DWal6	1484.482	-11718.9422	-19381.3086	30120.3976

Steel ratio in all shear wall in building =0.0025

Steel /1m in shear wall =0.0025\*300\*1000=750 mm<sup>2</sup> ...Use Ø12 /20cm.

Table 61 design shear wall 20cm for shear force

Shear Design (continued)								
Station Location	ID	Rebar mm <sup>2</sup> /mm	Shear Combo	$P_u$ kN	$M_u$ kN-mm	$V_u$ kN	$\Phi V_c$ kN	$\Phi V_n$ kN
Bottom	Leg 14	0.75	DWal3	343.3094	1418446.93	502.6252	1044.148	1782.9904
Bottom	Leg 15	0.75	DWal4	173.7209	1980343.04	809.31	982.9517	1675.8994
Bottom	Leg 16	0.75	DWal4	314.2549	1766290.5	700.5524	1021.1418	1726.48
Bottom	Leg 17	0.75	DWal4	96.208	1479956.86	1175.4985	1159.6477	1988.972

$A_v/s = 0.75$

Assume use ø10 ...  $A_v = 2*78=156\text{mm}^2$

$S = 208 \text{ mm}$  ...so use Ø10 /20cm.

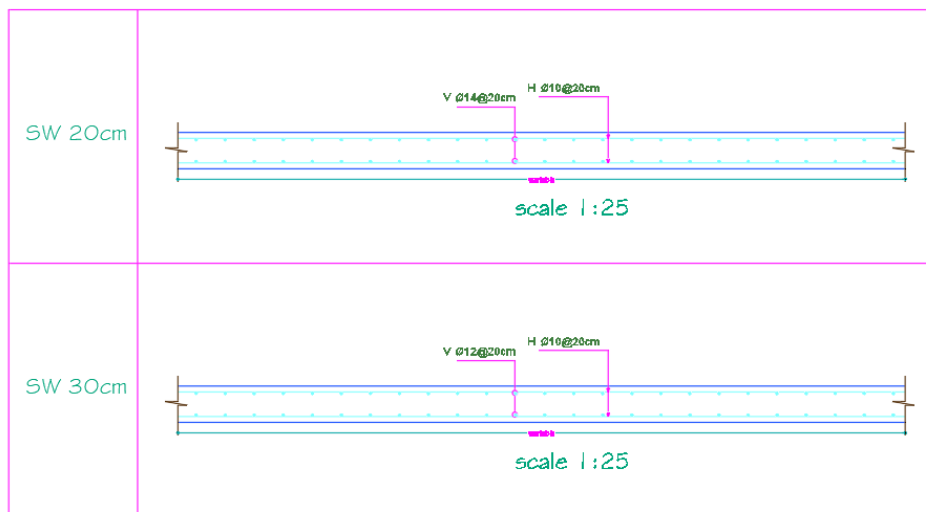


Figure 116 Typical section in shear walls

### 3.12.5 Manual column and beam design

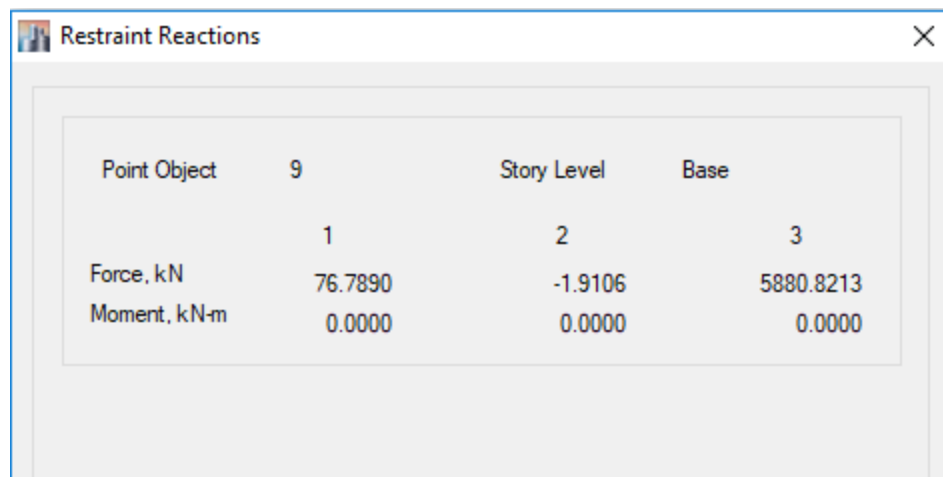
- **Column**

Column dimension:  $500\text{mm} \times 1000\text{mm} = 500000\text{mm}^2$ .

The area of steel (20 $\phi$ 22) is = 7599

Ratio of steel = 1.52%

Check for ratio of steel.



Point Object	9	Story Level	Base
	1	2	3
Force, kN	76.7890	-1.9106	5880.8213
Moment, kN-m	0.0000	0.0000	0.0000

Figure 117 The column with the largest reaction

Should be  $P_u \leq \Phi P_n$ .

Maximum  $P_u = 5880.82 \text{ KN}$

$\Phi = 0.65$  for tied columns.

$P_n = 0.80 \times (0.85 \times f_c' \times AC + f_y \times A_{st})$ .

$f_c' = 28 \text{ Mpa}$ .

$F_y = 420 \text{ Mpa}$ .

$AC = \text{Total area} - \text{Steel area} = 500000 - 7599 = 492401\text{mm}^2$

$A_s = 7599 \text{ mm}^2$

$P_n = 0.80 \times ((0.85 \times 28 \times 492401 + 420 \times 7599) \times 10^{-3})$

= 11928.5 KN.

--->  $\Phi P_n = 0.65 \times 11928.5 = 7753.57 \text{ KN} > P_u$  ----> Ok

- Beams (50\*70cm)

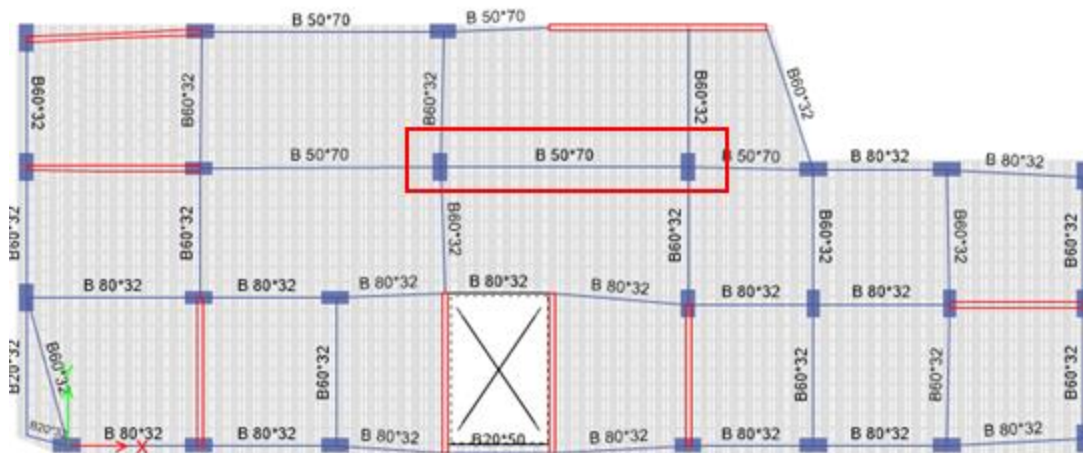


Figure 118 plan show beam that checked (first floor)

Live load in selected beam =  $3 \times 4.83 = 14.49$  kn/m

SID load in selected beam =  $6 \times 4.83 = 28.98$  kn/m

Own weight of beam =  $(0.5 \times .38) \times 25 = 4.75$  kn/m

Own weight slab =  $3.64 \times 4.83 = 17.60$  kn/m

$W_u = 1.2 \times (17.6 + 4.75 + 28.98) + 1.6 \times 14.49 = 75.75$  kn/m

$L_n = \text{clear beam span} = 8.50$  m

ACI coefficient for moment

$N_1 = W_u L_n^2 / 11 = 497.54$  Kn.m

$N_2 = W_u L_n^2 / 11 = 497.54$  kn.m

$P = W_u L_n^2 / 16 = 342.06$  kn.m

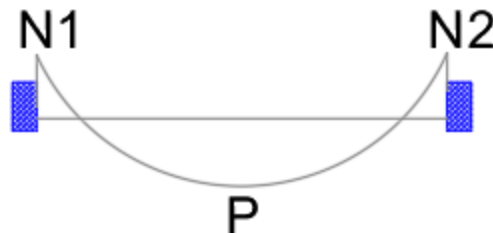


Table 62 steel cacluation for manually calculated moment

manual moment	d mm	bw mm	fy	fc	$\rho\%$	AS mm <sup>2</sup>	Asmin mm <sup>2</sup>	Asused mm <sup>2</sup>
497.54	660	500	420	24	0.0064366	2124.07915	1089	2124.1
342.06	660	500	420	24	0.00432448	1427.07982	1089	1427.1

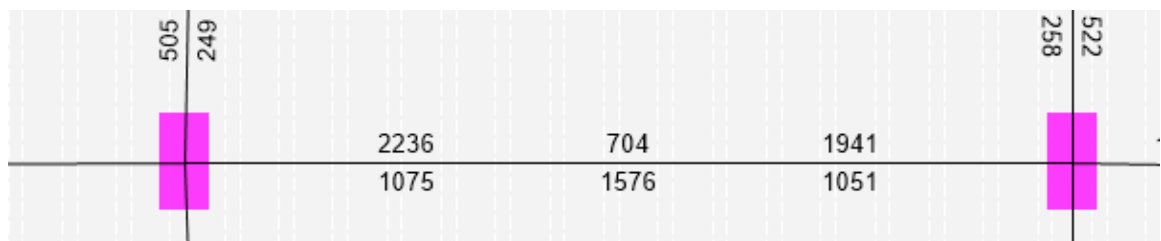


Figure 119 ETABS reinforcement for check beam



Figure 120 Manual reinforcement for check beam

**The values are acceptable.**

### 3.12.6 Footing design (SAFE software)

Mat foundation was used due to the isolated footing covered more than 50% of the building area, design parameters that adopted on SAFE2016, thickness of foundation = 800 mm. allowable bearing capacity for soil = 300KN/m<sup>2</sup>

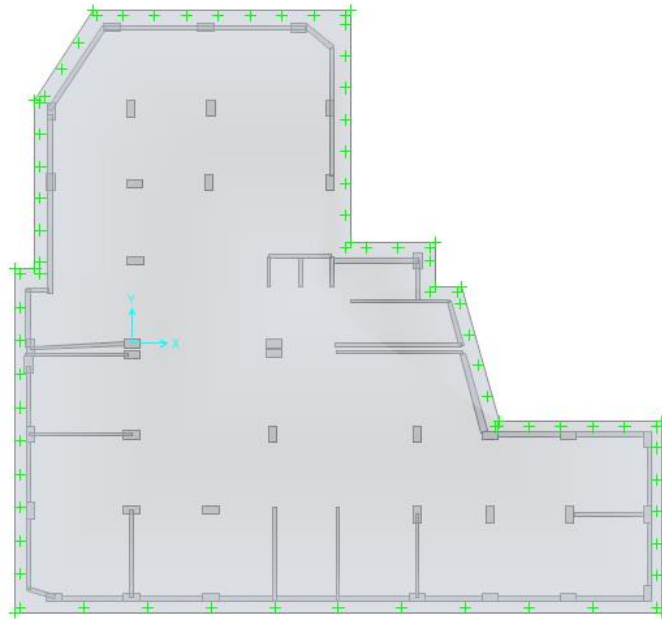


Figure 121 Layout of Mat foundation

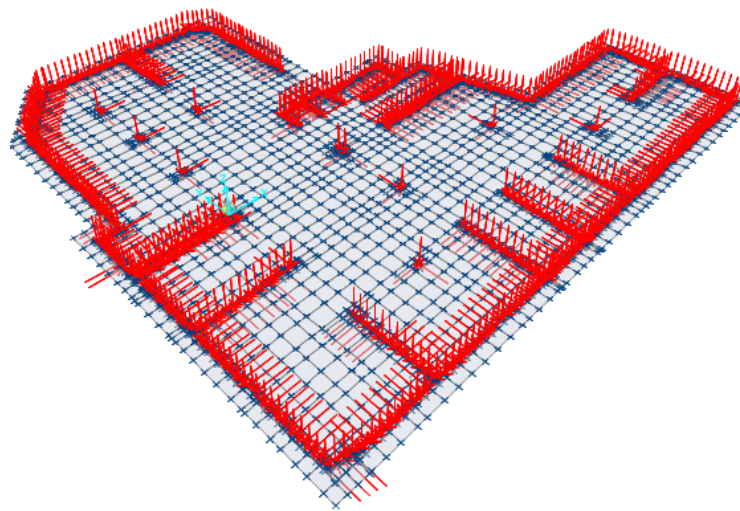
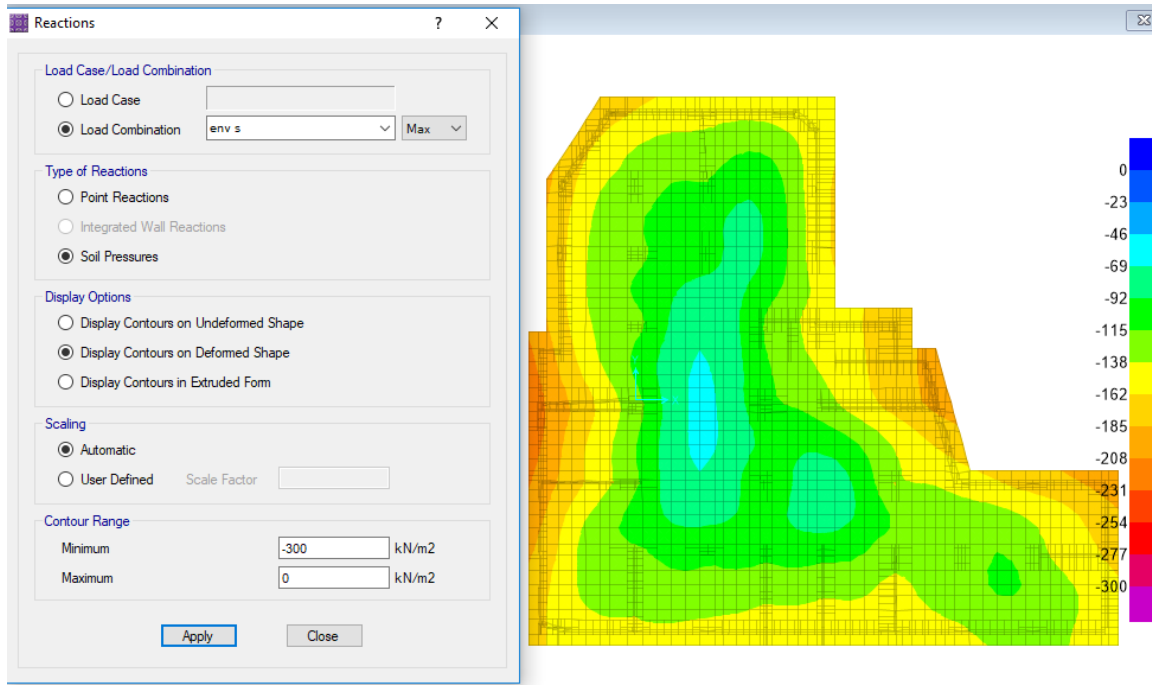


Figure 122 Analysis load

### **Bearing capacity check from service load**

Figure 123 Bearing capacity check from service load



Allowable bearing capacity from safe >footing stresses .....check is ok.

### Punishing shear check

Punching shear check was done on SAFE2016 software; all values for all columns should be less than 1

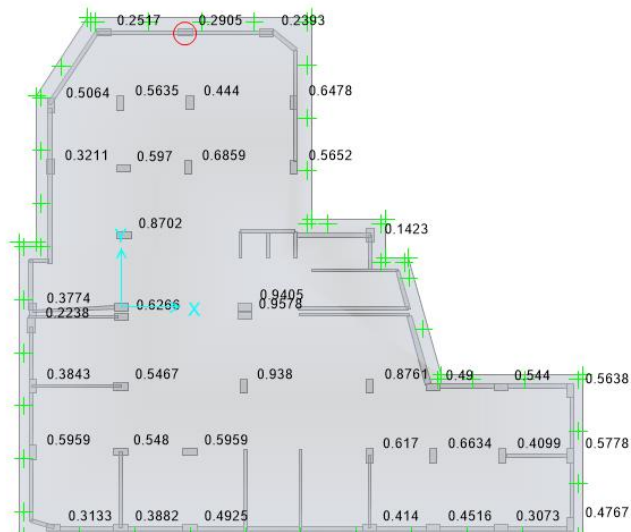


Figure 124: Punishing shear check for mat foundation

All result from safe modal less than 1 .....check is ok.

## Shear check

$$\Phi V_c = 0.75 / 6 * \sqrt{f_c} * b * d = 496.078 \text{KN}$$

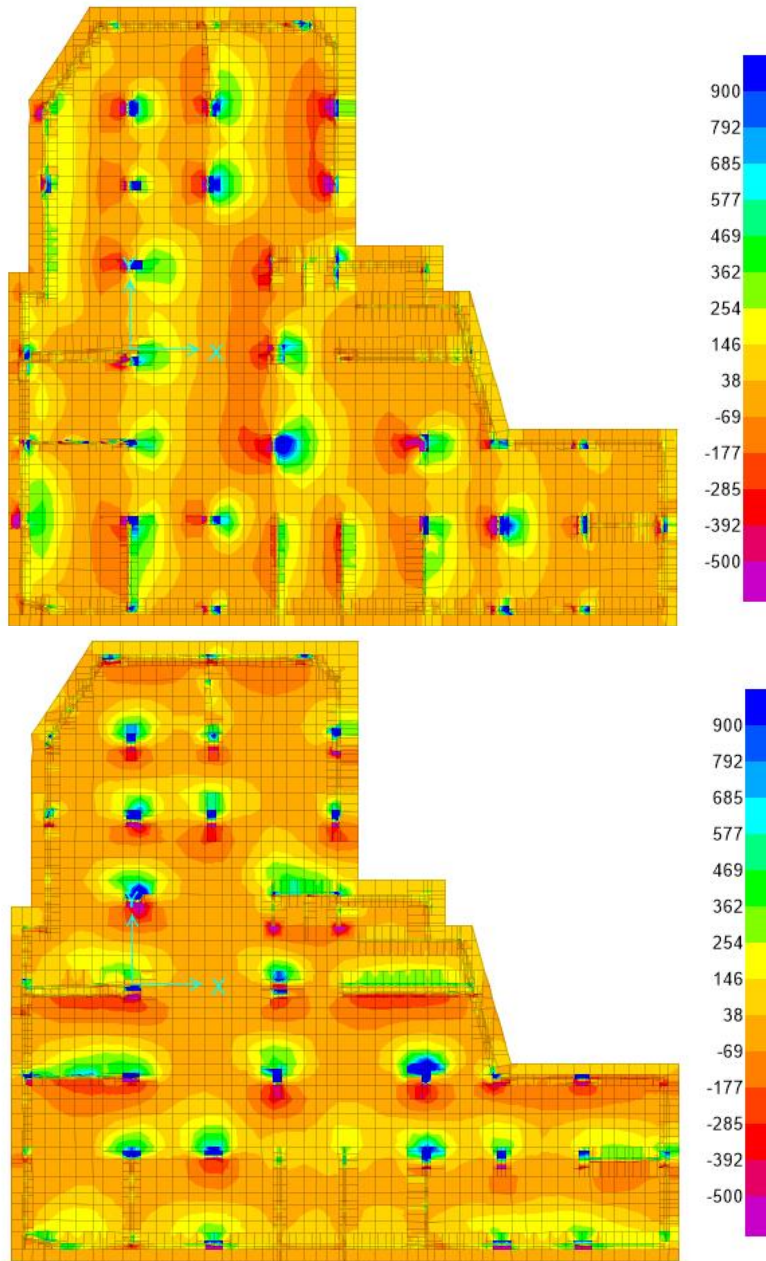


Figure 125 140 V12 & V23 For mat footing

All result

from safe modal less than  $\Phi V_c$  .....check is ok.

## Mat footing Reinforcement

Assumed use in  $\phi 20/10$  cm in top and bottom bar in two directions and checked in SAFE result.

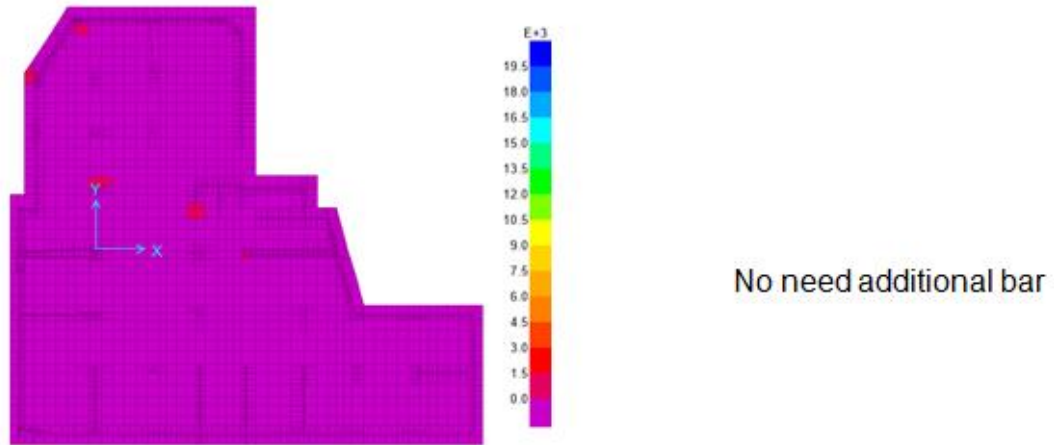


Figure 126 additional bar to  $\phi 20/10$  bottom in x dir

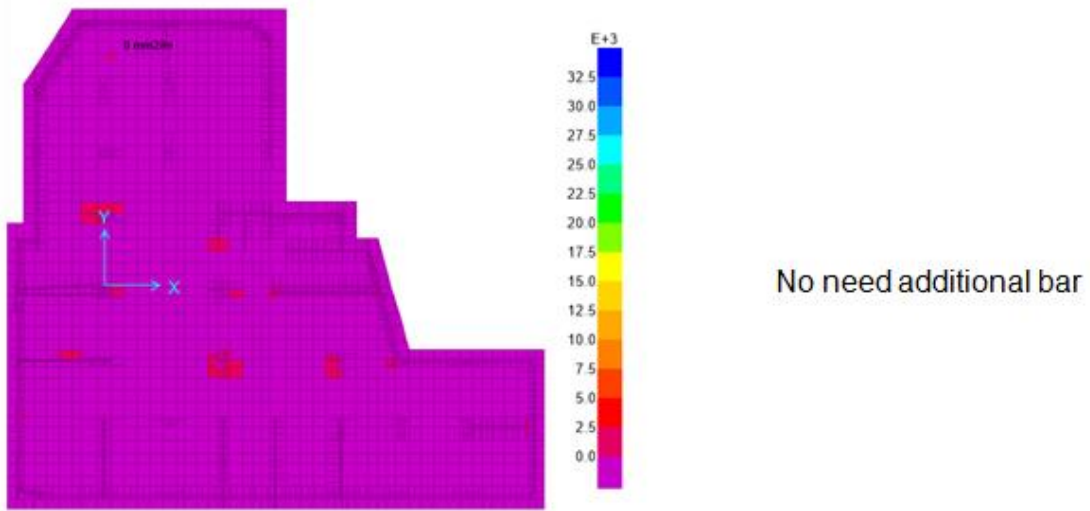


Figure 127 additional bar to  $\phi 20/10$  Top in x dir

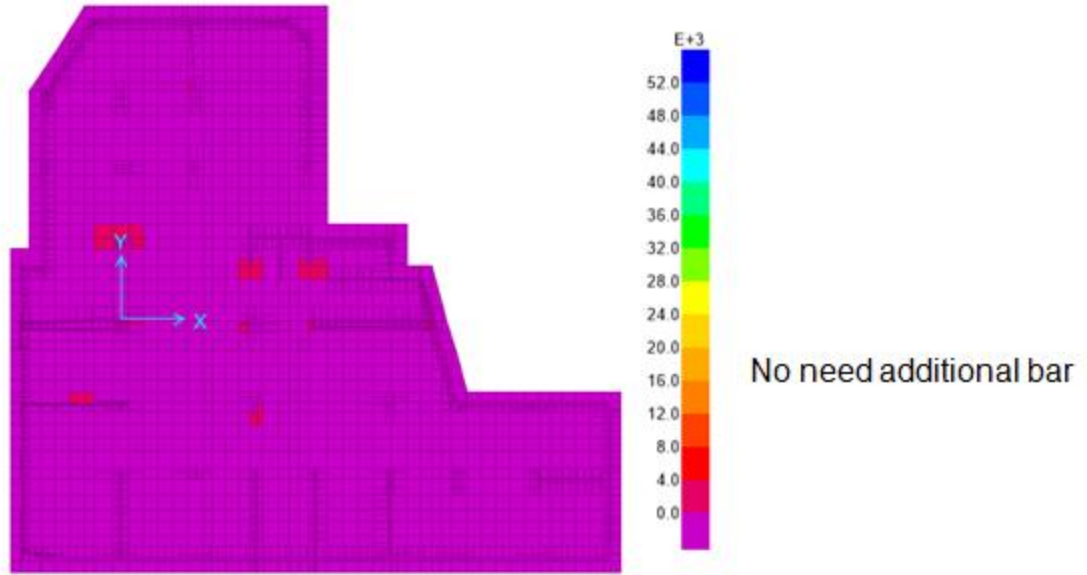


Figure 128 additional bar to  $\phi 20/10$  bottom in y dir

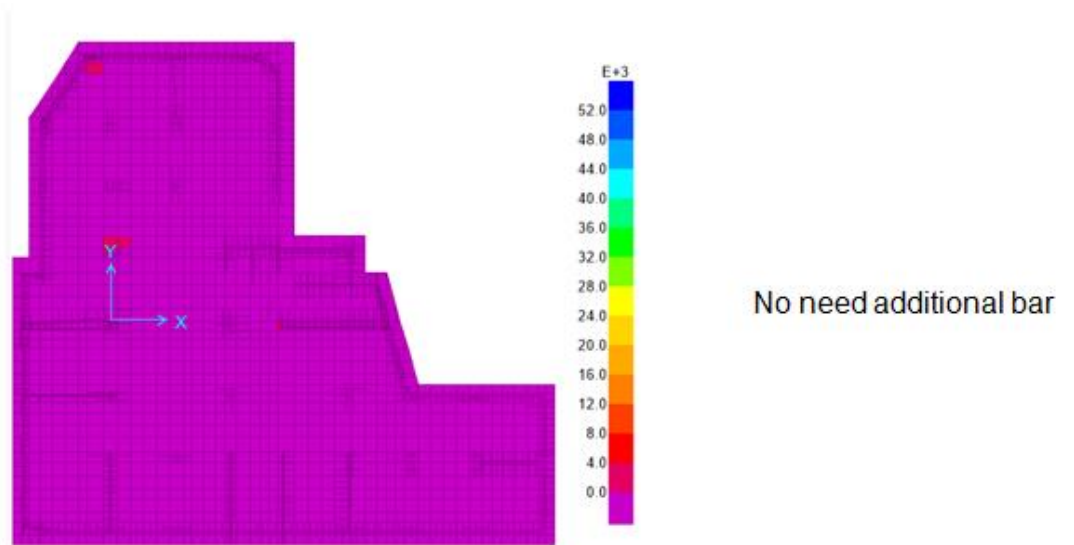


Figure 129 additional bar to  $\phi 20/10$  top in y dir

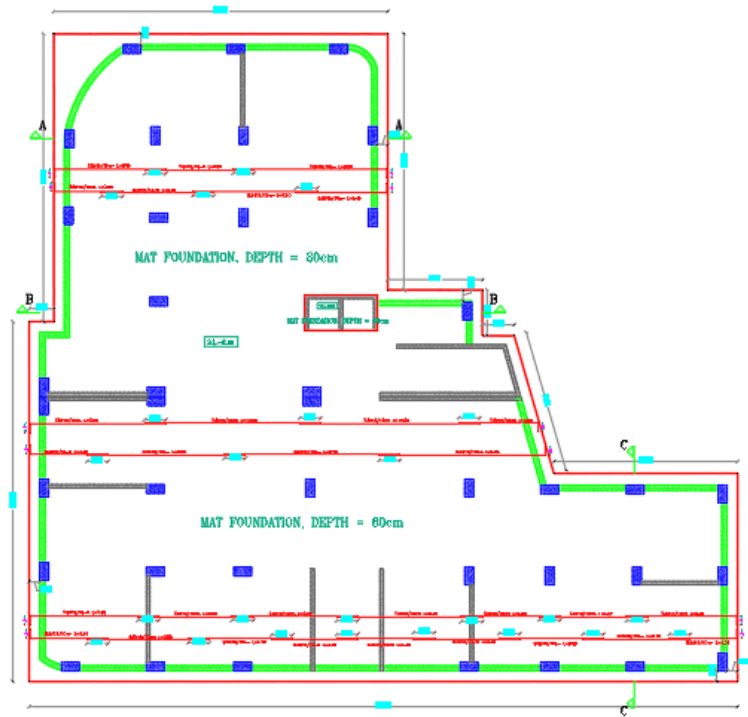


Figure 130 X DIR steel for mat footing

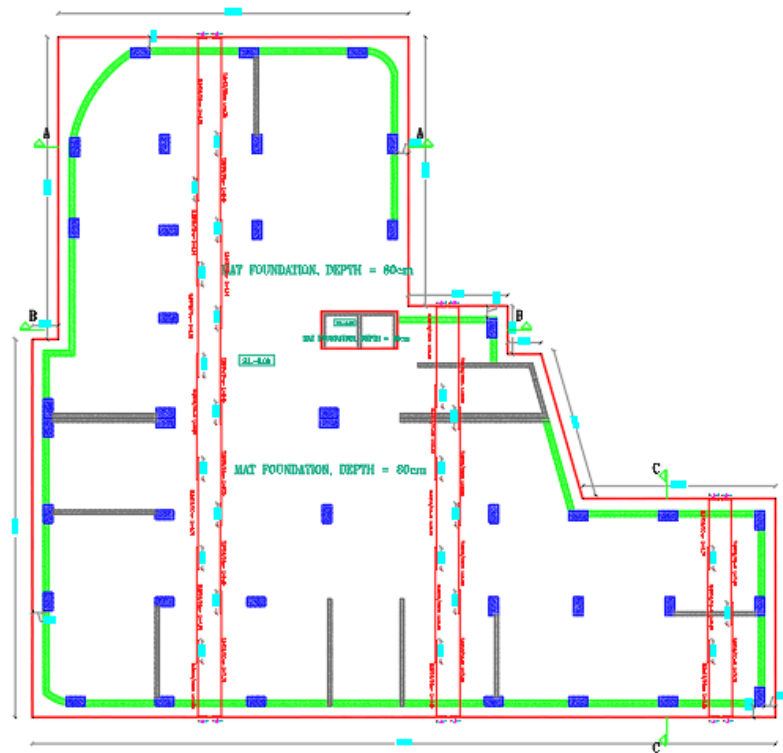
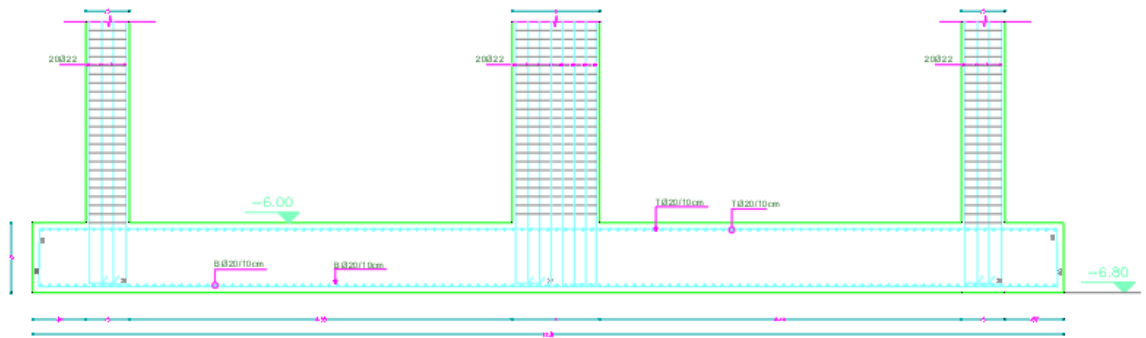


Figure 131 Y DIR steel for mat footing



SECTION(C-C)OF Mat Footing  
1:25

Figure 132 Footing detailing

Note: more details and sections attached in AUTOCAD drawing

### 3.13 Retaining wall design and reinforcement

The PROKON program was used to design the retaining wall adjacent to the ramp, and some input were imposed and entered into the program, including:

- Soil allowable bearing capacity = 300 KN/m<sup>2</sup>
- Friction angle of soil = 25°
- Height of wall = 5.5m
- Unit weight of concrete = 25 KN/m<sup>2</sup>
- Specific weight of soil = 18
- Yield Strength in Steel,  $F_y = 420$  MPa.
- Compressive strength of concrete = 28 MPa

Wall Dimensions				Unfactored Live Loads		General Parameters		Design Parameters	
H1 (m)	5.5	C (m)	0.5	W (kN/m <sup>2</sup> )		Soil frict $\phi$ (°)	25	SF Overt.	1.5
H2 (m)	0.5	F (m)		P (kN)		Fill slope $\beta$ (°)	0	SF Slip	1.2
H3 (m)	0	xf (m)		xp (m)		Wall frict $\delta$ (°)	0	ULS DL Factor	1.2
Hw (m)		At (m)	0.2	L (kN/m)		$\rho$ Conc kN/m <sup>3</sup>	25	ULS LL Factor	1.6
Hr (m)		Ab (m)	0.5	xl (m)		$\rho$ Soil kN/m <sup>3</sup>	18	Pmax (kPa)	300
B (m)	1	Cov wall mm	50	Lh (kN/m)		fc' (MPa)	19	Soil Poisson $\nu$	0.1
D (m)	2.2	Cov base mm	50	x (m)		fy (MPa)	450	DL Factor Dvt.	1

Title: \_\_\_\_\_

Seismic Analysis     User defined design values

Apply Active pressure on back of shear key for sliding

Design Values	
Hor Accel. (g)	
Vert Accel. (g)	Ka 0.429
Include LL's	Kp 2.464
<input checked="" type="checkbox"/> Allow Seepage	Ka incl. seismic effect 0.000
	Kp incl. seismic effect 0.000
Optimize	Base Friction constant 0.466
Select B    Select D	Tjiang/(U) uniform pressure T
Select F	Uniform pressure coefficient 0.65

Theory: Coulomb (Recommended)    Symbols: \_\_\_\_\_

Wall Type: Cantilever    Input errors: \_\_\_\_\_

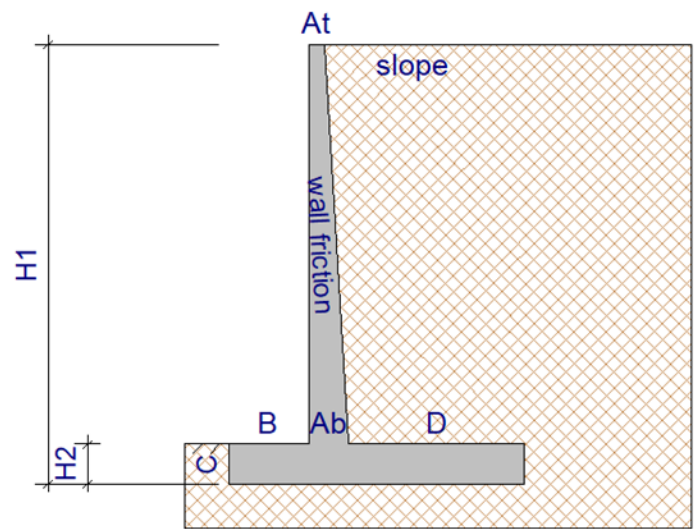


Figure 133 Output from PROKON

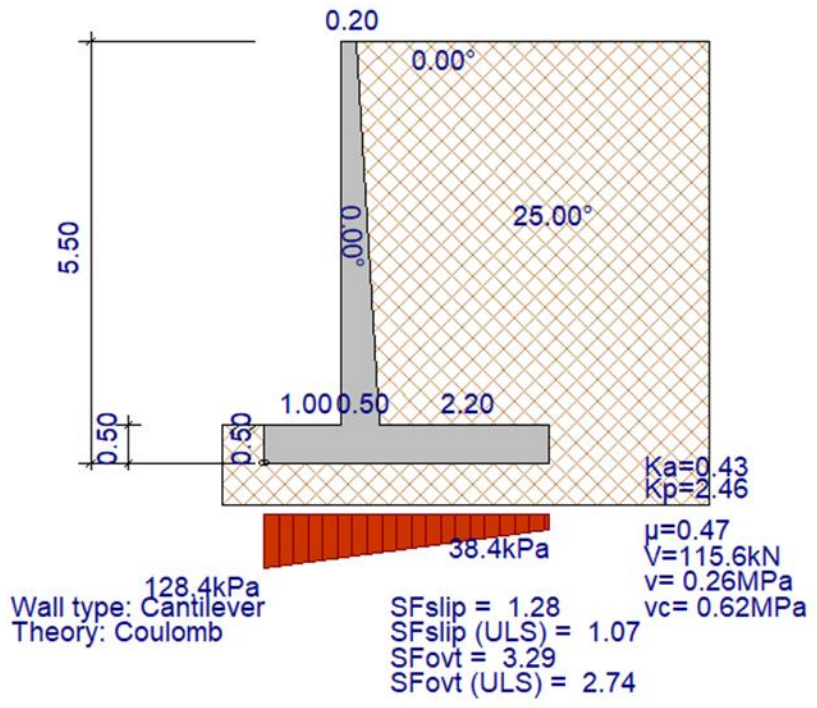


Figure 134 Retaining wall in PROKON

### 3.13.1 Modeling checks

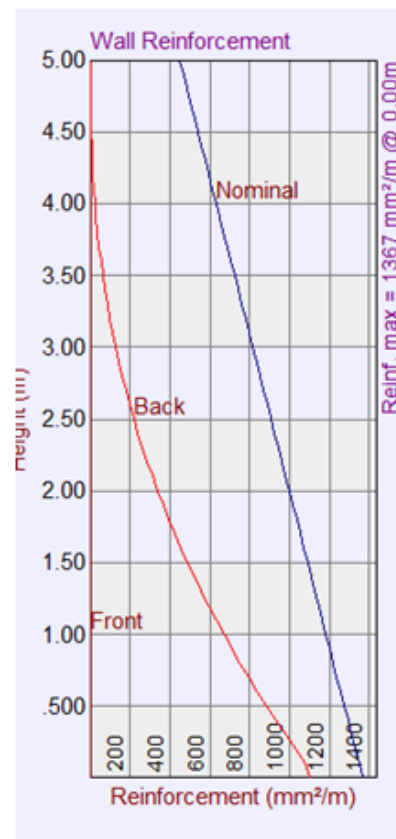
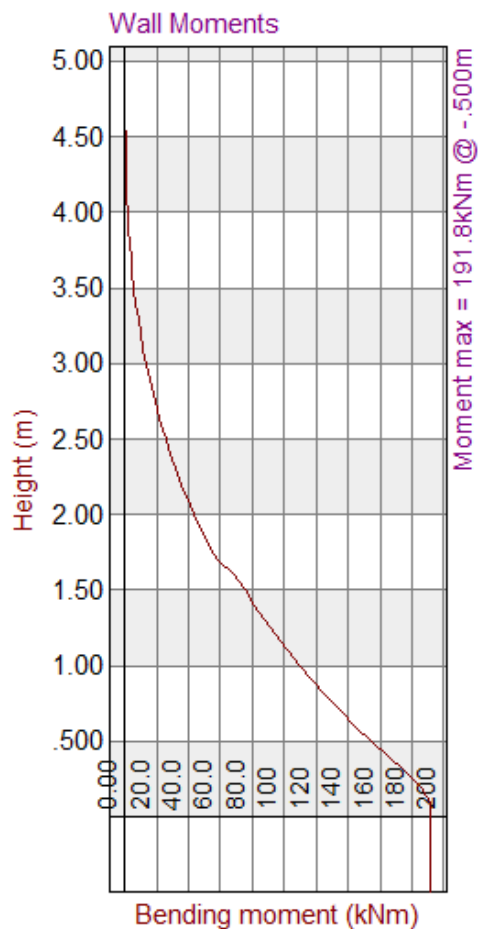
Model checks

- Factor of sliding = 1.2, < 1.28 ...ok
- Factor of turning = 1.5 < 3.29 .... Ok
- If  $\sigma_{max}$  and  $\sigma_{min}$  < q allowable, check is ok  
 $\sigma_{max} = 128.4$  Kpa,  $\sigma_{min} = 38.4$  Kpa < 300 Kpa → ok
- If  $\phi V_c > V_u$  check is ok  
 $\phi V_c = 0.75 / 6 \sqrt{f'_c} \times b d = 0.75 / 6 \sqrt{28} \times 1000 \times 450 / 1000 = 297.64$  KN  
 $V_u = 115.6$  KN <  $\phi V_c$  → ok

### 3.13.2 Reinforcement of retaining wall

#### 1- Stem (wall)

- Maximum bending moment in stem = 191.8 KN.m
- Maximum AS = 1367 mm<sup>2</sup> /m



Minimum Steel in walls (at bottom) is:

Horizontally  $A_{smin} = 0.0025bh = 0.0025 \times 1000 \times 500 = 1250 \text{ mm}^2/\text{m}$

Vertically  $A_{smin} = 0.0015bh = 0.0015 \times 1000 \times 500 = 750 \text{ mm}^2/\text{m}$

**Base (footing)**

- Maximum bending moment in stem = 157.9 KN.m
- Maximum AS = 715.5 mm<sup>2</sup> /m

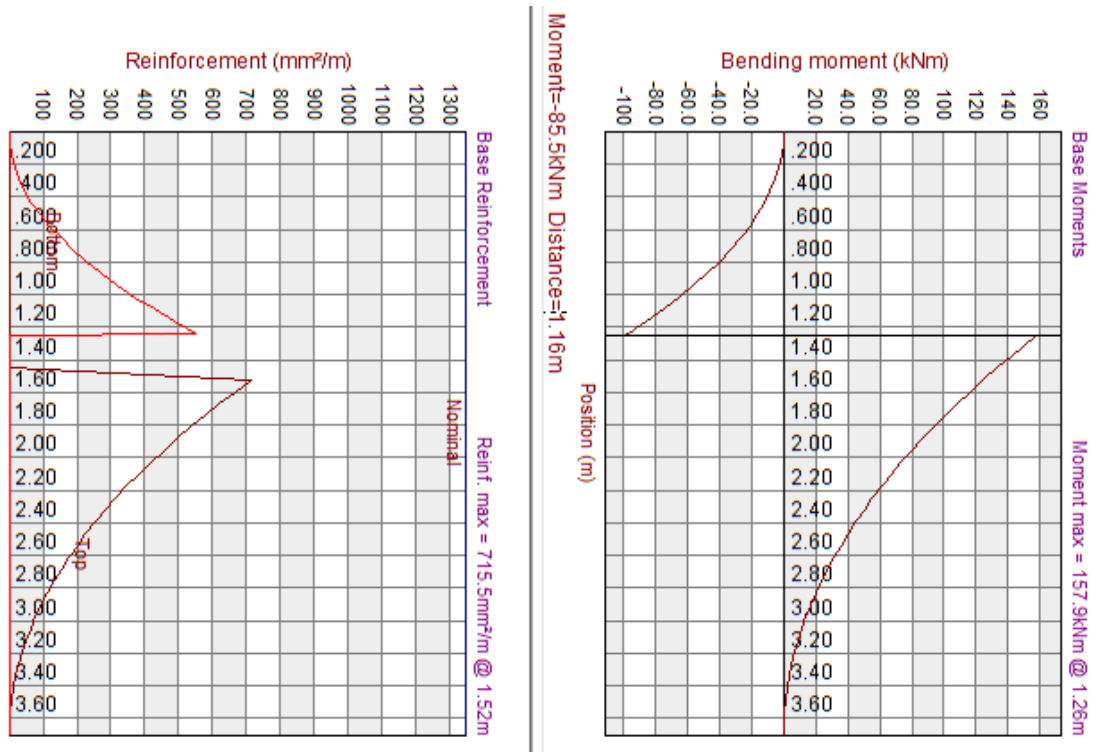


Figure 136 Bending moment and area of steel in Base

Minimum Steel in base is:

$A_{smin} = 0.0018bh = 0.0018 \times 1000 \times 500 = 900 \text{ mm}^2/\text{m} > AS$

We will use AS min in base

### 3.13.3 Reinforcement details of retaining wall

Bending Schedule Parameters		Rebar (mm <sup>2</sup> /m)		
Schedule file name:	WALLBS	Entered	Required	Nominal
Back vertical bars:	Y16@100	2011	1100	1379
Front vertical bars:	Y16@100	2011	0	1379
Back horizontal bars:	Y16@100	2011	1379	1379
Front horizontal bars:	Y16@100	2011	1379	1379
Back starter bars:	Y16@100	2011	1100	1379
Front starter bars:	Y16@100	2011	0	1379
Base top bars:	Y16@100	2011	716	1379
Base bottom bars:	Y16@100	2011	551	1379
Base top lacing bars:	Y16@100	2011	1379	1379
Base bot lacing bars:	Y16@100	2011	1379	1379
Shear key stirrups:	Y16@100	2011	1379	1379
Shear key lacings:	Y16@100	2011	1379	1379
Top clips:	1-R10/m2			
Bottom clips:	1-R10/m2			
Bond stress (MPa):	2.2			
Cover wall back (mm):	50			
Cover wall front (mm):	20			
Cover base top (mm):	50			
Cover base bot (mm):	50			
Length of wall (m):	6			
First bar mark:	01			
Language (A/E):	E			

Sketch Size	<input type="radio"/> A4
	<input checked="" type="radio"/> A5
<input type="checkbox"/> Store BS data with input	
Reset defaults	
Generate schedule	

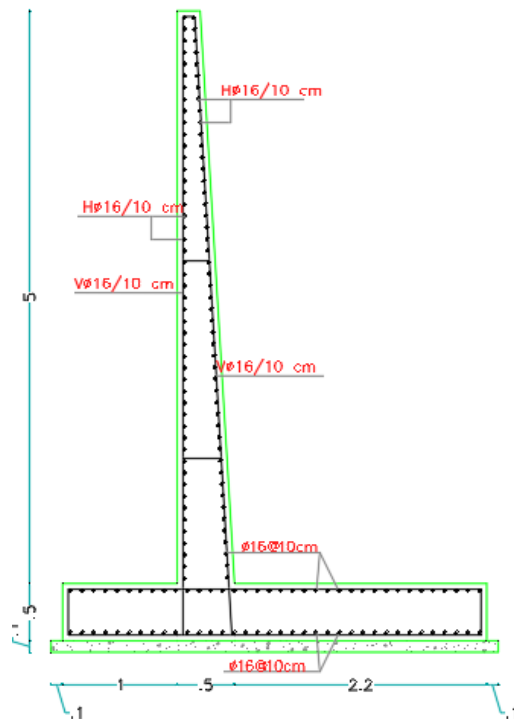
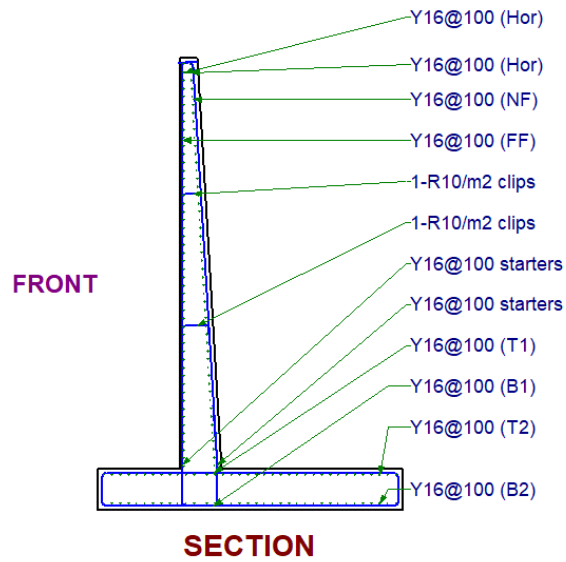


Figure 137 Reinforcement retaining wall

### 3.14 Ramp design

The ramp is used to reach cars and people to the lower floors, such as basements, garages, etc. In this project, it was used to reach the basement floors used as garages for cars.

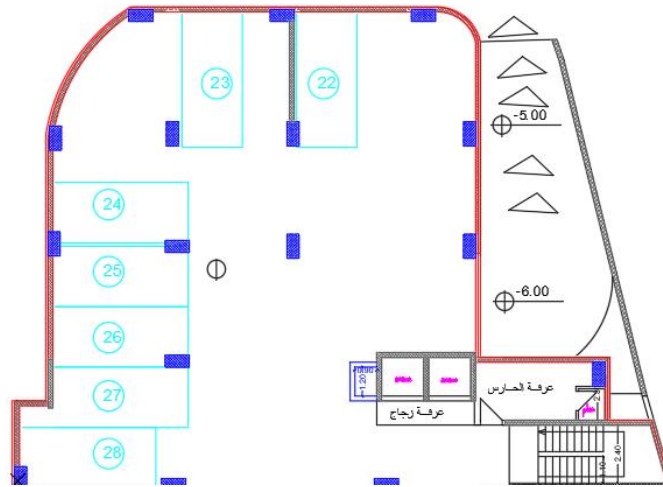


Figure 138 ramp for basement 2 floor

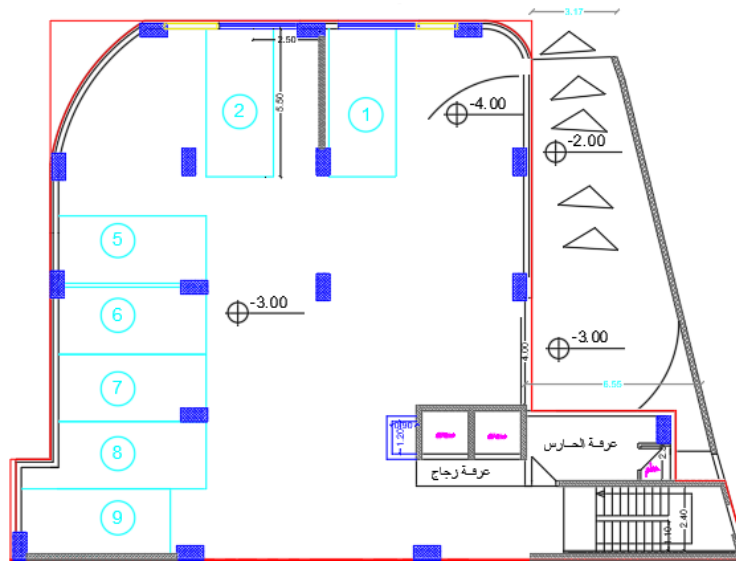


Figure 139 ramp for basement 1 floor

### 3.14.1 Ramp modeling in ETABS

We will use flat plate solid slab with slab thickness 250 mm based on ACI318 code

- Live load =  $6 \text{ kn/m}^2$   
SID =  $1 \text{ kn/m}^2$

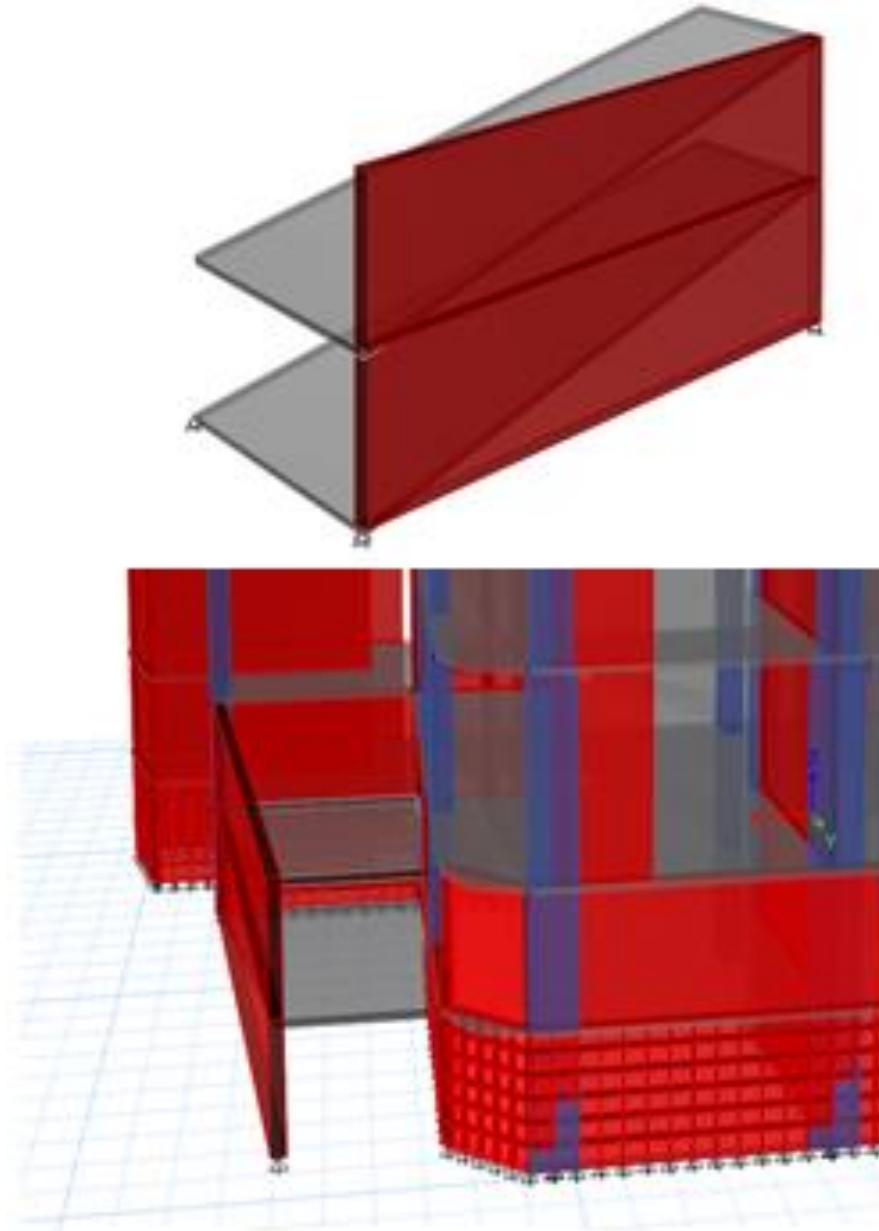


Figure 140 ramp modeling in ETABS (block 1)

### 3.14.2 Deflection check for ramp

From live load: Limit =  $5.20/360 = 14.44\text{mm}$ .

ETABS deflection less than 14.44 mm.....is ok

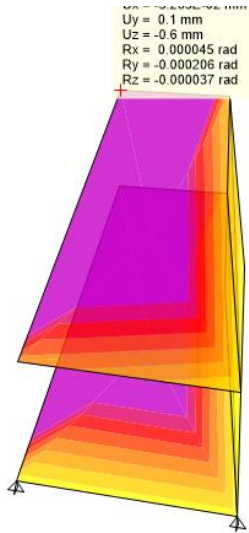
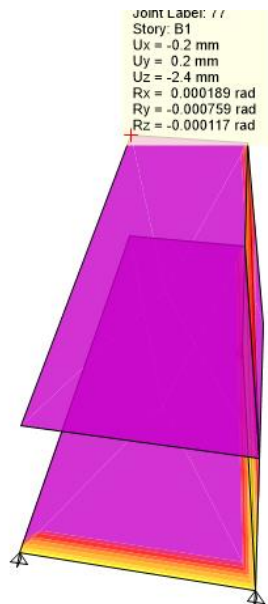


Figure 141 ramp deflection check (live load)

From LTD: Limit =  $5.20/240 = 12.40\text{mm}$ .

ETABS deflection less than 12.40 mm.....is ok



### 3.14.3 Ramp Shear check

$$\Phi V_c = 0.75 / 6 * \sqrt{f_c} * b * d = 0.75/6 * \sqrt{28} * 1000 * 210/1000 = 138.90 \text{KN}$$

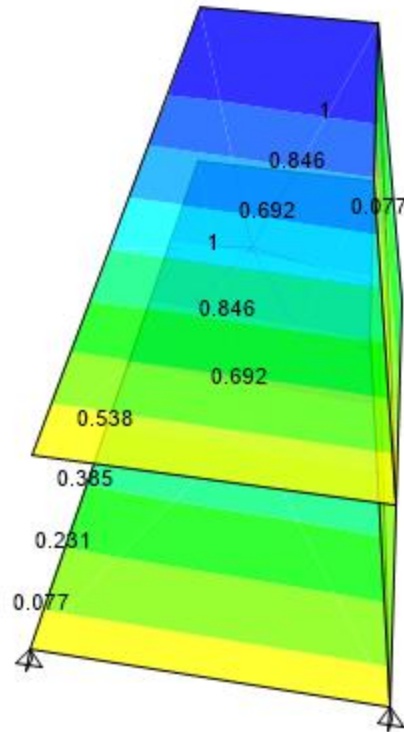


Figure 143 ramp shear diagram

$V_u < \Phi V$ ..... check it ok

### 3.14.4 Ramp design

Design of ramp for flexure:

$h = 250 \text{mm}$       cover = 40mm

$D = 210 \text{mm}$        $b = 1000 \text{mm}$

$F_y = 420 \text{MPa}$        $F_c = 28 \text{Mpa}$

$A_{smin} = 0.003 * 250 * 1000 = 750 \text{mm}^2$

$a = (750 * 420) / (0.85 * 28 * 1000) = 8 \text{mm}$

$\Phi M_n = 0.9 * 420 * 750 * (210 - 8/2) = 58.40 \text{KN.m}$

Any moment in the slab less than 58.40 KN.m, will be reinforced with Asmin

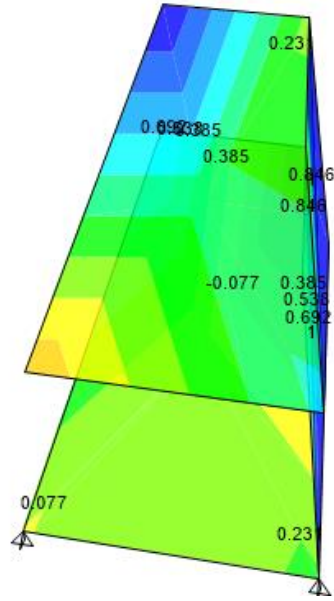
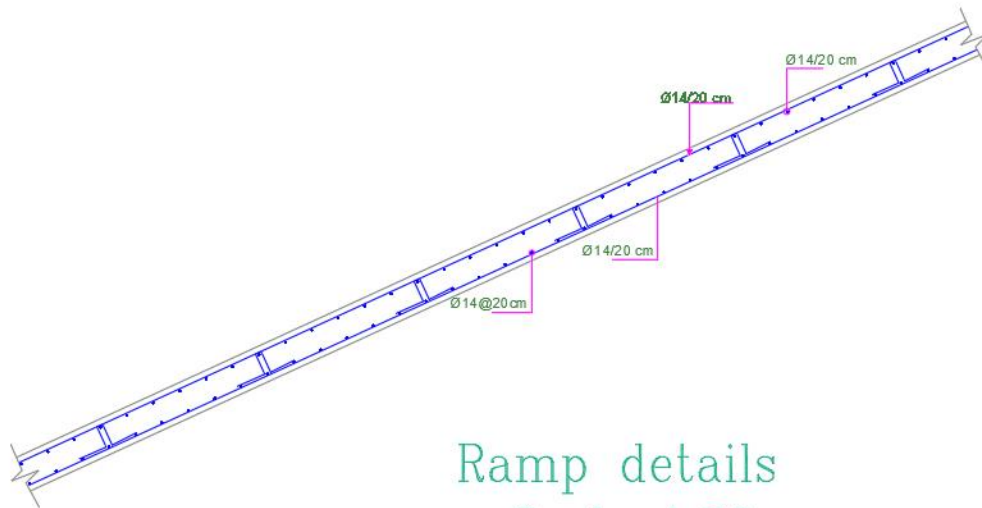


Figure 144 moment diagram for ramp

All moment  $< \phi M_n$  so use  $A_s$  min .... use  $\phi 14/20$ cm for bottom +Top steel in two direction



Ramp details  
Scale 1:20

Figure 145 Ramp detailing

# **CHAPTER 4 ELECTRO- MECHANICAL ASPECTS**

## Chapter 4 :Electro-mechanical Aspects

This chapter covers the distribution and design of lighting units, electrical circuits, the use of Design Builder to study the building's thermal loads, the distribution of HVAC units within the project, the mechanical and acoustic design of the buildings, and the project's firefighting system design.

### **Artificial lighting design. (Dialux software):**

Artificial lighting is one of the first and most noticeable elements in any area, no matter how big or little, since it's necessary to provide the eyes good, comfortable vision and because it greatly affects how the people using the space feel.

Since our project is a multi-use building, as there are commercial shops on the ground floor and there are residential apartments on the upper floors of the project, we have taken into account the provision of appropriate lighting for it in all places according to the use and requirements of each space and providing the highest possible productivity for the users of this place, whether they are residents of this place. Apartments or from buyers who frequent the shops, as we were keen to provide the best possible display of the products in the shops.

### **4.1 .Spaces design :**

This section contains the spaces for which we designed lighting. There is an explanation of the type and number of lighting units that were used, how they were distributed in the space, and the specifications of each lighting unit and its effect on the space.

#### **➤ Market (clothes shop) :**

We designed lighting for a commercial store, or especially a clothing store. This store is located on the ground floor and was chosen to make an example of it in the Dialuxe program because it is located almost in the center of the building, meaning it is somewhat far from the windows.

Where reflectance factor for ceiling, wall and floor = 80%, 80% and 45%

The luminaires we used in market

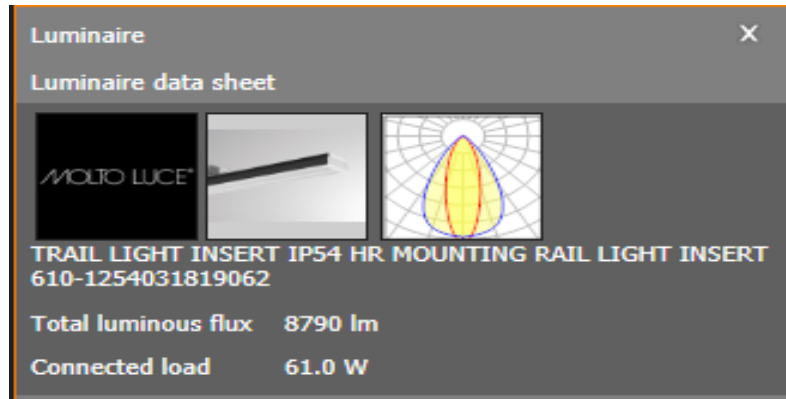


Figure 146 data sheet for luminaires used in market

➤ And now will show the results from Dialux to Market (clothes shop )

Table 63 Results from Dialux for Market

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Existe lux	Required Unifor.	Uniformity Existed
Market (clothes shop )	Trail Light insert	3000	61	2	300	500	2.5	2.5

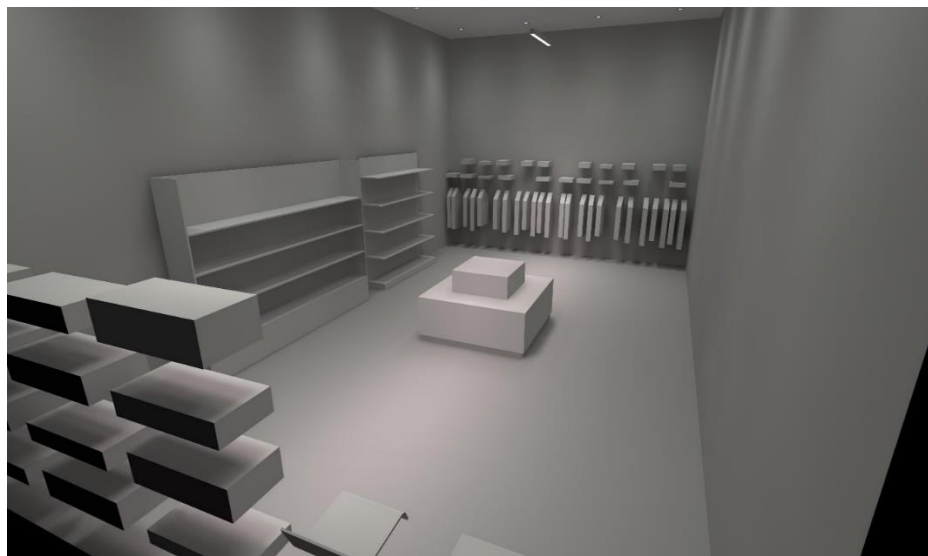


Figure 147 render for Market

- Now will show the illuminance level and uniformity

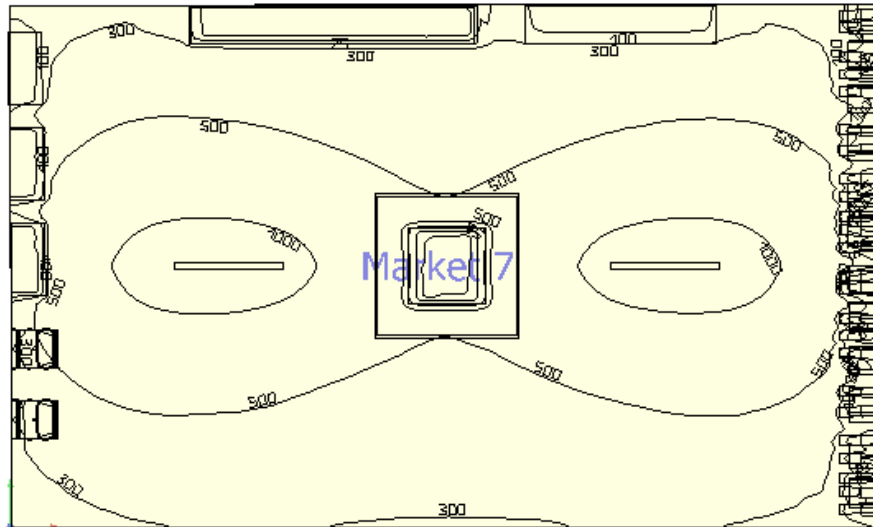


Figure 148 illuminance level and uniformity for market

- **Ablution:**

This place is used for washing and ablution to perform prayers, and we made sure that the lighting was appropriate to avoid minor accidents due to the presence of abundant water in this place.

Reflecting factor for ceiling, wall and floor = 70 % , 40% and 33%

The luminaires we used in Ablution

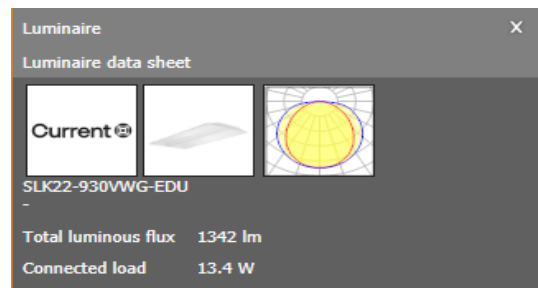


Figure 149 Data sheet for Ablution luminaires

- And now will show the results from Dialux to Ablution

Table 64 Results from Dialux for ablution

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Existe lux	Required Unifor.	Uniformity Existed
------------	----------------	------------------	--------------	----------------	--------------	------------	------------------	--------------------

ablution	SLK22 930VWG- EDU	3000	13.4	2	100	106	2	1.81
----------	-------------------------	------	------	---	-----	-----	---	------

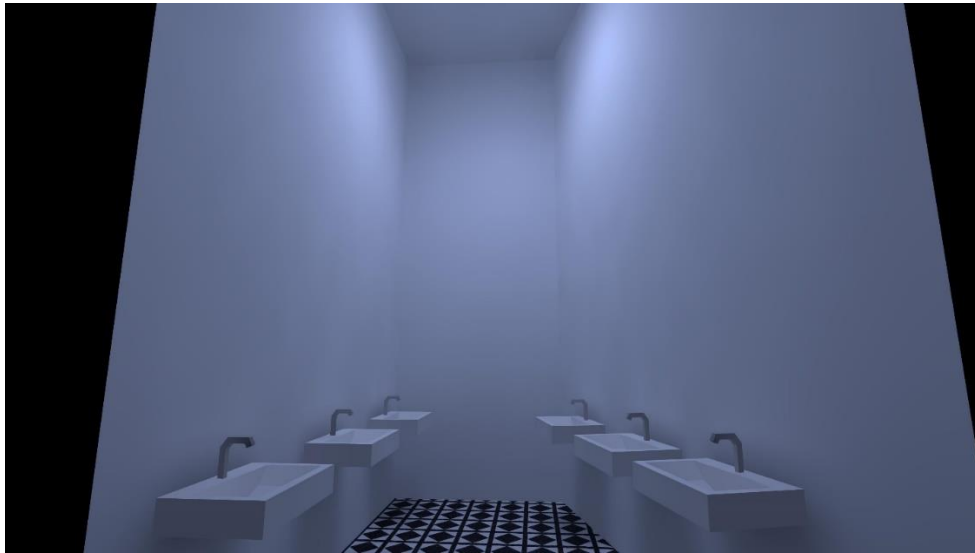


Figure 150 Render for Ablution

➤ Now will show the illuminance level and uniformity

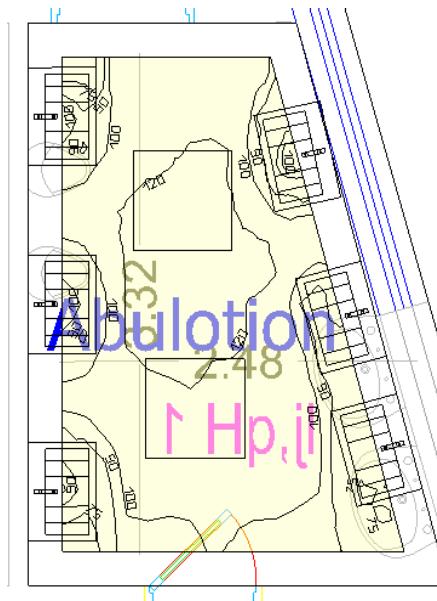


Figure 151 illuminance level and uniformity for ablution

➤ **Bathroom :**

A bathroom is a designated place inside the home or in public places that is used to perform normal human needs. The bathroom usually contains a toilet, and can also include a sink for washing hands.

Reflecting factor for ceiling ,wall and floor = 70 % , 40% and 33%

The luminaires we used in Bathroom

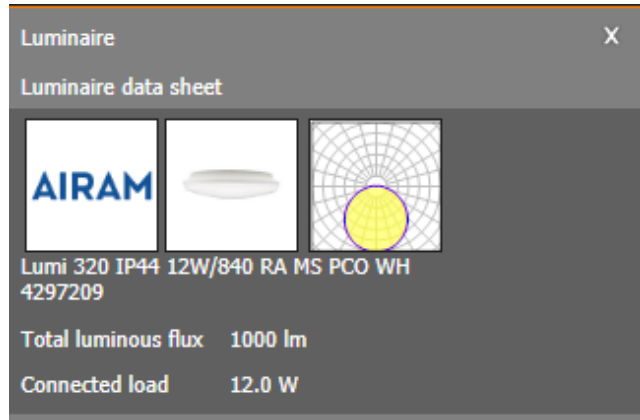


Figure 152 Data sheet for luminaires used in WC

➤ And now will show the results from Dialux to Ablution

Table 65 Results by Dialux for WC

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Existe lux	Required Unifor.	Uniformity Existed
Bathroom (WC)	Lumi320	3000	12	2	50	63	2	1.25



Figure 153 Render for bathroom

➤ Now will show the illuminance level and uniformity

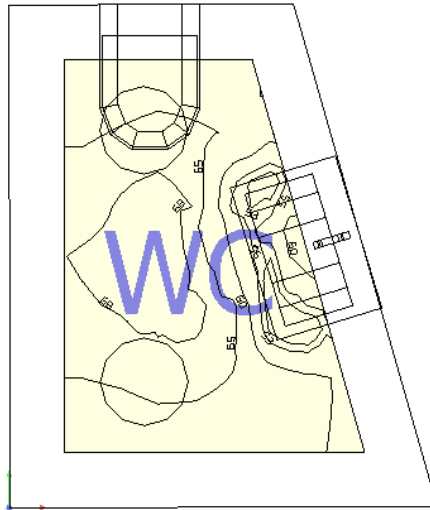


Figure 154 illuminance level and uniformity for WC

- **BEDROOM :**

A bedroom is the place where an individual rests after a long day, and it aims to provide a quiet and comfortable environment for rest and relaxation. Here's a simple description of the bedroom.

Reflecting factor for ceiling ,wall and floor = 80 % , 80% and 45%

The luminaires we used in Bedroom

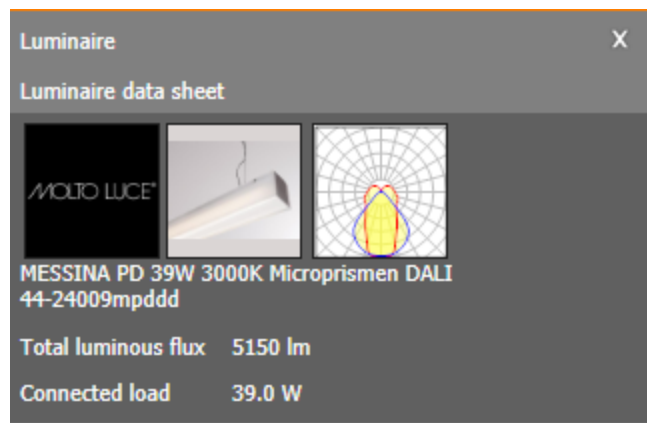


Figure 155 Data sheet for luminaires used in Bedroom

➤ And now will show the results from Dialux to Bedroom

Table 66 Results from Dialux for Bedroom

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Existe lux	Required Unifor.	Uniformity Existed
Bedroom	MESSINA PD	3000	39	2	300	436	3	2.32



Figure 156 Render for Bedroom

➤ This will show the lux level and uniformity

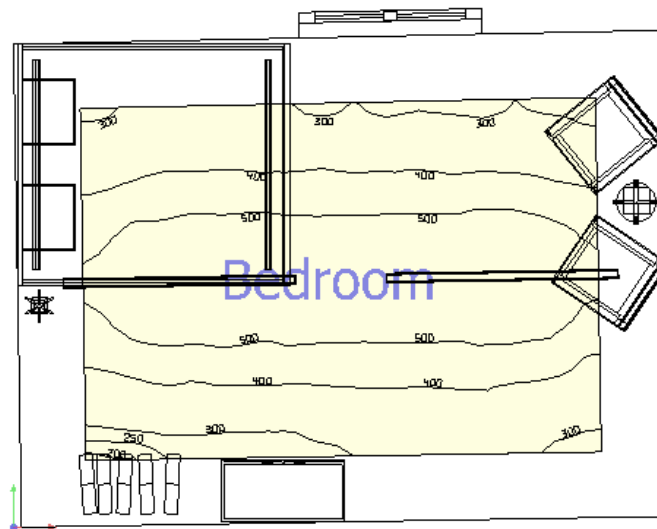


Figure 157 illuminance level and uniformity for Bedroom

- **Guest room :**

The guest room is a place that aims to welcome guests with comfort and warmth. It is carefully designed to ensure an enjoyable and comfortable stay experience.

Reflecting factor for ceiling ,wall and floor = 80 % , 80% and 45%

The luminaires we used in Guest room

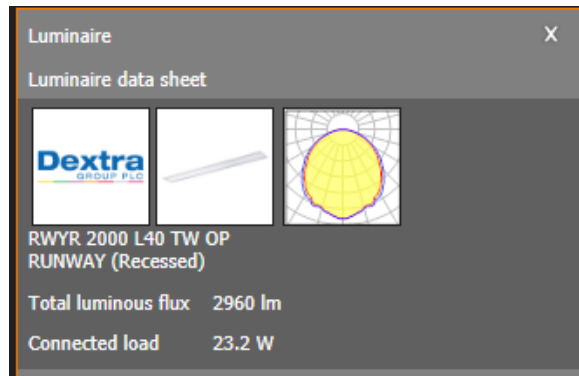


Figure 158 data sheet for luminaires used in guest room

➤ And now will show the results from Dialux to Bedroom

Table 67 Results by Dialux for guestroom,

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Existe lux	Required Unifor.	Uniformity Existed
Guestroom	RWYR2000	3000	23.2	6	200	283	5	3.35



Figure 159 Render for guestroom

➤ Now will show the illuminance level and uniformity

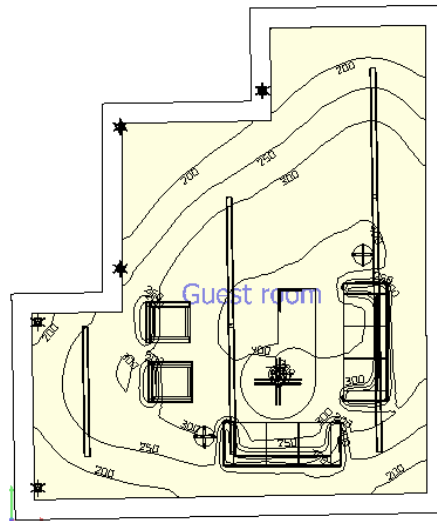


Figure 160 illuminance level and uniformity for Guestroom

- **Kitchen :**

The kitchen is the heart of the home, where family members gather to prepare and eat food together.

Overall, the kitchen is a warm and welcoming place, where family and friends come together to talk and laugh around the table.

Reflecting factor for ceiling ,wall and floor = 85 % , 80% and 45%

The luminaires we used in kitchen

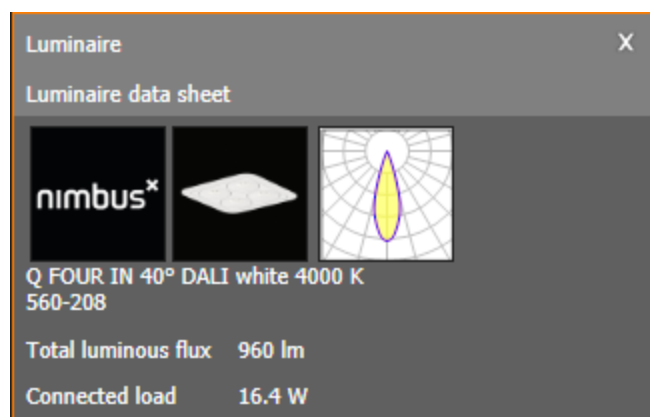


Figure 161 data sheet for luminaires used in kitchen

➤ And now this will show the results from Dialux to Bedroom

Table 68 Results by dialux for Kitchen

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Existe lux	Required Unifor.	Uniformity Existed
Kitchen	Nimbus Q four	4000	16.4	8	300	320	2	2



Figure 162 Render for Kitchen

➤ Now will show the illuminance level and uniformity

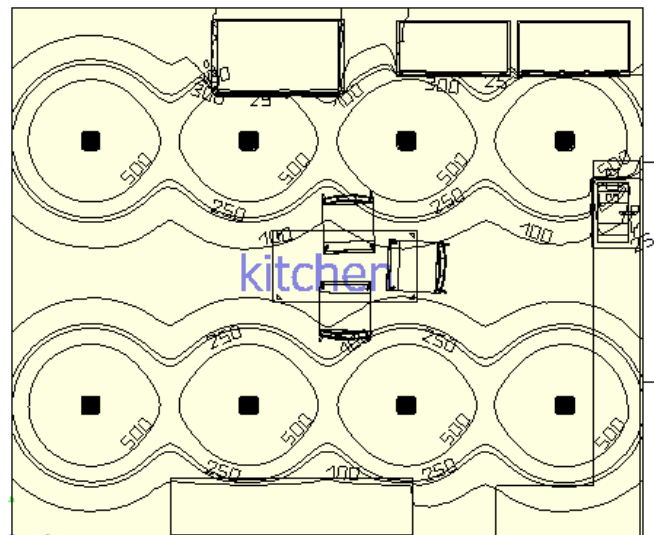


Figure 163 illuminance level and uniformity for kitchen

- **Living room :**

Family members and visitors congregate in the living room for relaxation and amusement.

Generally speaking, the living room is a lovely and pleasant area where friends and family may gather to spend quality time together.

Reflecting factor for ceiling ,wall and floor = 70 % , 40% and 70%

The luminaires we used in Living room

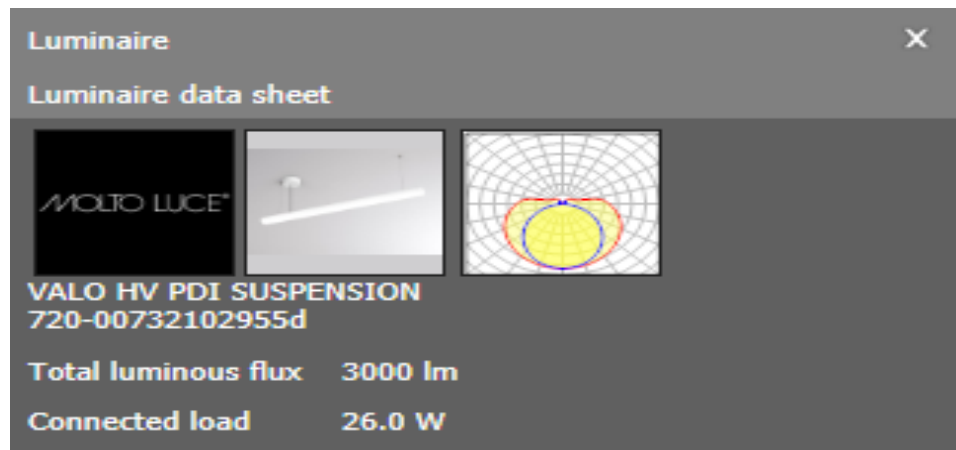


Figure 164 datasheet for luminaires used in livingroom

➤ And now will show the results from Dialux to Bedroom

Table 69 Results from dialux to Livingroom

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Existe lux	Required Unifor.	Uniformity Existed
Livingroom	Molto Luce VALO HV PDI	3000	26	6	300	342	5	4.23



Figure 165 Render for Livingroom

- Now this will show the illuminance level and uniformity

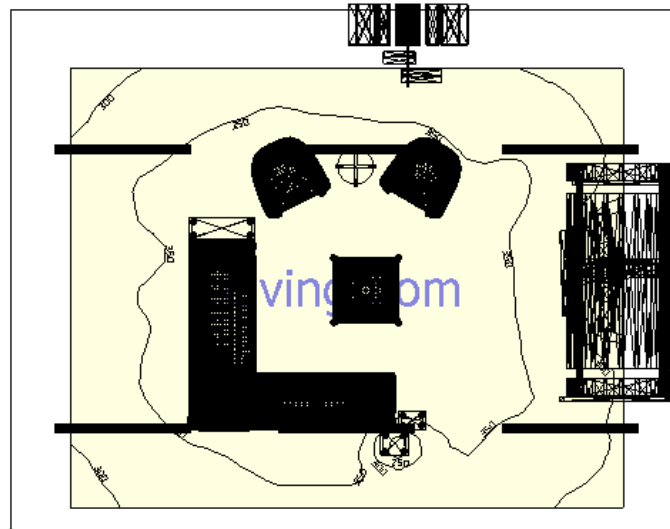


Figure 166 illuminance level and uniformity for livingroom

- **Corridor :**

Spaces are the long spaces inside buildings shown between different rooms or places. It can be spaces in homes or buildings, cooperation is important in achieving effective activities and connecting different things.

Corridors are not just paths for movement, they are also a part of the building design that can contribute to making the environment more attractive and functional.

Reflecting factor for ceiling, wall and floor = 70% , 40% and 70%

The luminaires we used in Corridor

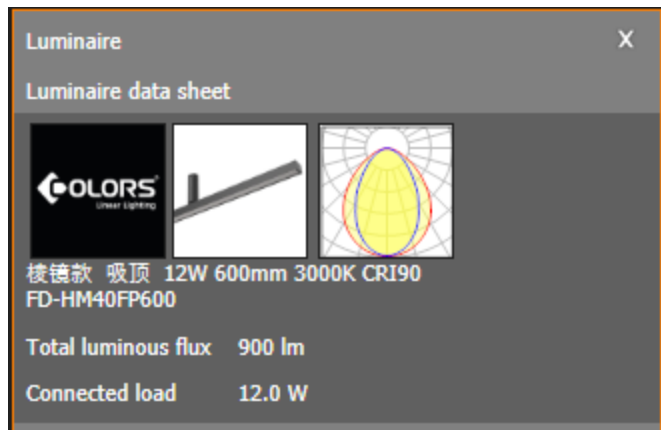


Figure 167 datasheet for luminaires used for Corridors

➤ And now this will show the results from Dialux to Bedroom

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Existe lux	Required Unifor.	Uniformity Existed
Corridor	COLORS	3000	12	16	100	113	2	1.87

Figure 168 Results from dialux for Corridor

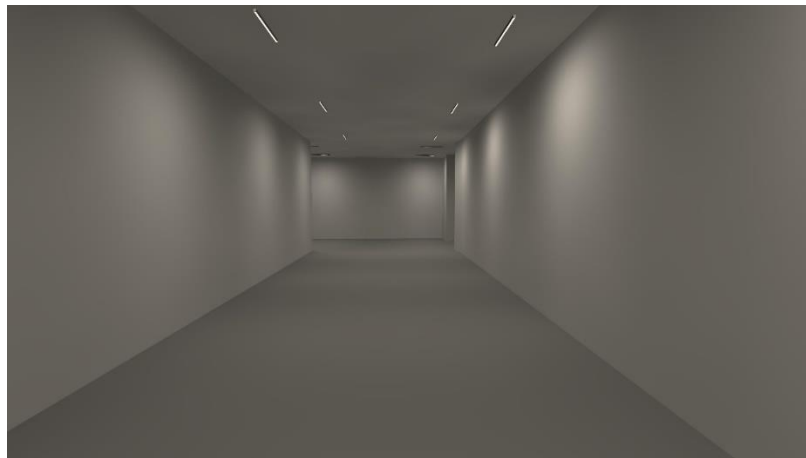


Figure 169: Render for Corridor

➤ Now will show the illuminance level and uniformity

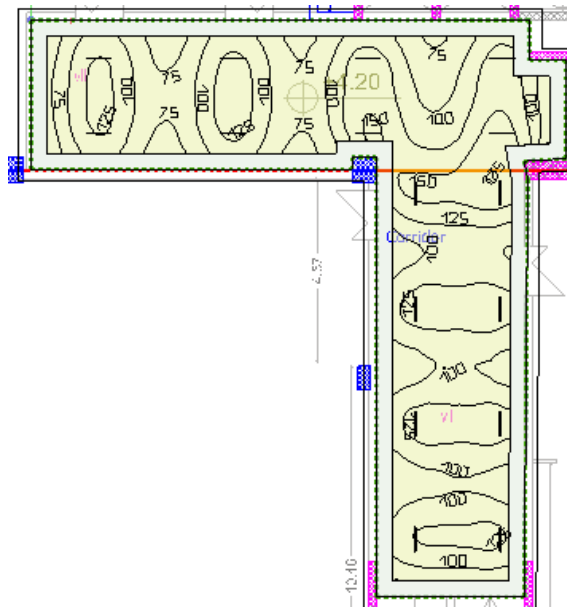


Figure 170: illuminance level and uniformity for Corridor

- **Parking :**

Garages are spaces designated for parking and securing vehicles. Garages are an essential part of residential and commercial buildings, providing a convenient and safe solution for vehicles. Garages can be attached to residential homes or part of corporate and institutional facilities.

Reflecting factor for ceiling ,wall and floor = 70 % , 40% and 70%

The luminaires we used in Corridor

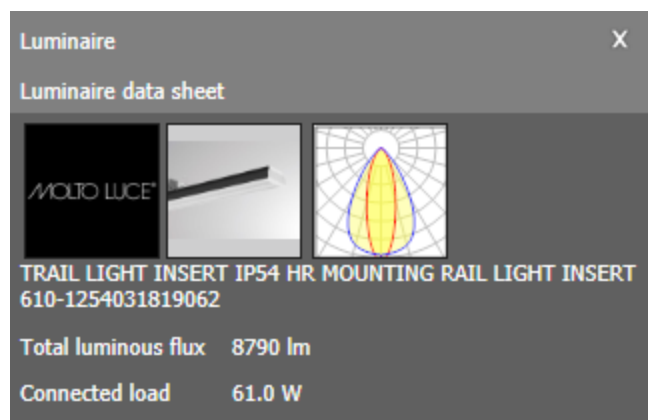


Figure 171 datasheet for luminaires used for parking

➤ And now will show the results from Dialux to Bedroom

Table 70 Results by dialux for parking

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Existe lux	Required Unifor.	Uniformity Existed
Parking	Molto Luce TRAIL LIGHT	3000	61	12	100	103	3	3



Figure 172 Render for Parking



Figure 173 Render for Parking

➤ Now will show the illuminance level and uniformity

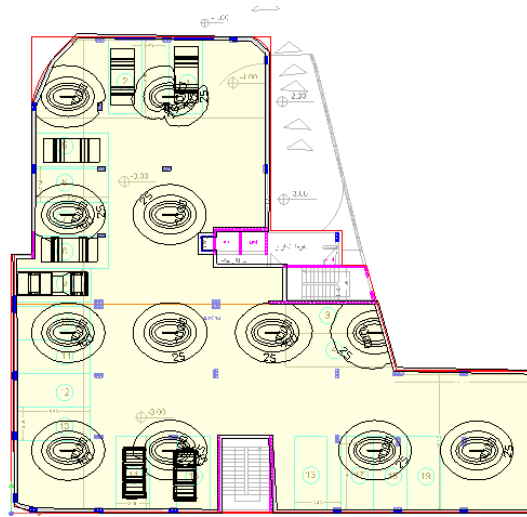


Figure 174 illuminance level and uniformity for Parking

#### 4.2 HVAC design :

Everyone desires a building with every comfort feature, including good interior air quality and thermal comfort. Buildings with access to thermal comfort are healthier and have a favorable impact on residents' attitudes about their employment, personal hygiene, and health.

A phrase that is frequently used is HVAC, which stands for heating, ventilation, and air conditioning. In addition to providing enough ventilation for the space, it strives to accomplish heating and suitable temperatures in both the summer and winter. In contrast to dwellings that experience poor ventilation, proper ventilation prevents difficulties with odors, humidity, and the subsequent effects it has on future building issues.

A key component of a building's construction is the HVAC system. It is a system that swaps out harmful indoor air for healthy outside air, guaranteeing high-quality indoor air while also regulating interior temperatures, reducing moisture, and getting rid of offensive smells.

Two methods of ventilation are used to supply air to the building: natural ventilation, which uses the windows and doors that are scattered throughout the home, and industrial

ventilation, which uses a variety of technologies and systems, including the VAV and VRF system and others.

In the event that natural ventilation is difficult to obtain or is insufficient due to the presence of obstacles that prevent this, such as the location of the building or the presence of nearby buildings that impede the arrival of air in the proper quantities, or the presence of other environmental obstacles, such as mountains, in this case, industrial ventilation is resorted to from In order to enhance the ventilation of the building.

➤ The next table shows the total loads for building from Design Builder :

*Table 71 Total heating and cooling loads for building*

<b>Total heating and cooling load in the building</b>	
<b>Cooling load</b>	<b>250.39 kw</b>
<b>Heating load</b>	<b>184.8 kw</b>

➤ And now I will show the cooling loads for each floor by tables :

❖ Ground floor :

*Table 72 Designing loads for Ground floor*

<b>Zone name</b>	<b>Zone</b>	<b>Design Flow Rate(m3/s)</b>	<b>Peak Cooling Load(kw)</b>
<b>ground floor</b>	<b>Groundfloor:SHOPPINGST ORE5</b>	<b>0.165</b>	<b>2.08</b>
<b>ground floor</b>	<b>Groundfloor:SHOPPINGST ORE10</b>	<b>0.283</b>	<b>3.23</b>
<b>ground floor</b>	<b>Groundfloor :CORRIDOR3</b>	<b>0.164</b>	<b>2.19</b>
<b>ground floor</b>	<b>Groundfloor:GAURDROOM</b>	<b>0.002</b>	<b>0.00</b>
<b>ground floor</b>	<b>Groundfloor :SHOPPINGSTORE8</b>	<b>0.231</b>	<b>2.49</b>
<b>ground floor</b>	<b>Groundfloor :SHOPPINGSTORE6</b>	<b>0.126</b>	<b>1.57</b>

ground floor	Groundfloor :SHOPPINGSTORE7	0.073	1.00
ground floor	Groundfloor :CORRIDOR2	0.05	0.63
ground floor	Groundfloor: CORRIDOR	0.322	4.23
ground floor	Groundfloor:SHOPPINGSTORE11	0.222	2.45
ground floor	Groundfloor:PRA YINGROOM	0.02	0.28
ground floor	Groundfloor:SHOPPINGSTORE13	0.097	1.33
ground floor	Groundfloor:SHOPPINGSTORE12	0.31	3.43
ground floor	Groundfloor:SHOPPINGSTORE3	0.153	1.83
ground floor	Groundfloor:SHOPPINGSTORE4	0.313	3.68
ground floor	Groundfloor:SHOPPINGSTORE1	0.384	4.12
ground floor	GROUND FLOOR:SHOPPINGSTORE2	0.146	1.87

❖ First floor :

Table 73 the designing loads for First floor

Zone name	Zone	Design Flow Rate(m <sup>3</sup> /s)	Peak Cooling Load(kw)
FIRST FLOOR	FIRSTFLOOR:KITCHEN1	0.089	1.06
FIRST FLOOR	FIRSTFLOOR:GUESTROOM1	0.151	1.74
FIRST FLOOR	FIRSTFLOOR:MASTERBEDROOM4	0.107	1.16
FIRST FLOOR	FIRSTFLOOR:GUESTROOM2	0.133	1.37
FIRST FLOOR	FIRSTFLOOR:DINING1	0.059	0.74
FIRST FLOOR	FIRSTFLOOR:CORRIDOR1	0.01	0.13
FIRST FLOOR	FIRSTFLOOR:MASTERBEDROOM1	0.107	1.15
FIRST FLOOR	FIRSTFLOOR:BEDROOM1	0.048	0.59

<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:KITCHEN AND LIVING</b>	<b>0.139</b>	<b>1.64</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:LIVING AND DINING</b>	<b>0.061</b>	<b>0.81</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:MASTER BEDROOM 2</b>	<b>0.048</b>	<b>0.57</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:BEDROOM 2</b>	<b>0.107</b>	<b>1.13</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:MASTER BEDROOM 3</b>	<b>0.138</b>	<b>1.50</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:BEDROOM X CORRIDOR</b>	<b>0.017</b>	<b>0.21</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:BEDROOM 3</b>	<b>0.127</b>	<b>1.50</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:CORRIDOR 2</b>	<b>0.079</b>	<b>1.03</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:MASTER BEDROOM</b>	<b>0.132</b>	<b>1.51</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:DINING</b>	<b>0.045</b>	<b>0.58</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:BEDROOM 4</b>	<b>0.152</b>	<b>1.69</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:BEDROOM</b>	<b>0.048</b>	<b>0.60</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:LIVING ROOM</b>	<b>0.157</b>	<b>1.95</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:KITCHEN</b>	<b>0.108</b>	<b>1.32</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:GUEST ROOM 3</b>	<b>0.076</b>	<b>0.98</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:GUEST ROOM</b>	<b>0.105</b>	<b>1.23</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:ENTRANCE</b>	<b>0.016</b>	<b>0.21</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:CORRIDOR</b>	<b>0.143</b>	<b>1.79</b>
<b>FIRST FLOOR</b>	<b>FIRSTFLOOR:KITCHEN AND DINING</b>	<b>0.177</b>	<b>2.26</b>

❖ Second floor :

Table 74 The design loads for second floor

<b>Zone name</b>	<b>Zone</b>	<b>Design Flow Rate(m<sup>3</sup>/s)</b>	<b>Peak Cooling Load(kw)</b>
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<b>SECOND FLOOR</b>	<b>SECONDFLOOR:KITCHEN1</b>	<b>0.096</b>	<b>1.13</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:GUESTROOM1</b>	<b>0.167</b>	<b>1.90</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:MASTER BEDROOM4</b>	<b>0.117</b>	<b>1.25</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:GUESTROOM2</b>	<b>0.141</b>	<b>1.44</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:DINING1</b>	<b>0.062</b>	<b>0.78</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:CORRIDOR1</b>	<b>0.01</b>	<b>0.13</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:MASTER BEDROOM1</b>	<b>0.114</b>	<b>1.19</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:BEDROOM1</b>	<b>0.048</b>	<b>0.59</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:KITCHENANDLIVING</b>	<b>0.154</b>	<b>1.79</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:LIVING ANDDINING</b>	<b>0.07</b>	<b>0.93</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:MASTER BEDROOM2</b>	<b>0.052</b>	<b>0.62</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:BEDROOM2</b>	<b>0.118</b>	<b>1.23</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:MASTER BEDROOM3</b>	<b>0.143</b>	<b>1.55</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:BEDROOMXSCORRIDOR</b>	<b>0.018</b>	<b>0.23</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:BEDROOM3</b>	<b>0.131</b>	<b>1.54</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:CORRIDOR2</b>	<b>0.083</b>	<b>1.09</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:MASTER BEDROOM</b>	<b>0.144</b>	<b>1.54</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:DINING</b>	<b>0.049</b>	<b>0.62</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:BEDROOM4</b>	<b>0.167</b>	<b>1.76</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:BEDROOM</b>	<b>0.052</b>	<b>0.65</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:LIVING ROOM</b>	<b>0.161</b>	<b>2.00</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:KITCHEN</b>	<b>0.105</b>	<b>1.29</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:GUESTROOM3</b>	<b>0.085</b>	<b>1.08</b>

<b>SECOND FLOOR</b>	<b>SECONDFLOOR:GUESTROOM</b>	<b>0.11</b>	<b>1.27</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:ENTRANCE</b>	<b>0.019</b>	<b>0.25</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:CORRIDOR</b>	<b>0.153</b>	<b>1.90</b>
<b>SECOND FLOOR</b>	<b>SECONDFLOOR:KITCHENANDDINING</b>	<b>0.19</b>	<b>2.40</b>

❖ Third floor :

Table 75 the designing loads for third floor

<b>Zone name</b>	<b>Zone</b>	<b>Design Flow Rate(m<sup>3</sup>/s)</b>	<b>Peak Cooling Load(kw)</b>
<b>THIRD FLOOR</b>	<b>THIRDFLOOR:KITCHEN1</b>	<b>0.097</b>	<b>1.14</b>
<b>THIRD FLOOR</b>	<b>THIRDFLOOR:GUESTROOM1</b>	<b>0.169</b>	<b>1.92</b>
<b>THIRD FLOOR</b>	<b>THIRDFLOOR:MASTERBEDROOM4</b>	<b>0.118</b>	<b>1.26</b>
<b>THIRD FLOOR</b>	<b>THIRDFLOOR:GUESTROOM2</b>	<b>0.142</b>	<b>1.45</b>
<b>THIRD FLOOR</b>	<b>THIRDFLOOR:DINING1</b>	<b>0.062</b>	<b>0.79</b>
<b>THIRD FLOOR</b>	<b>THIRDFLOOR:CORRIDOR1</b>	<b>0.01</b>	<b>0.13</b>
<b>THIRD FLOOR</b>	<b>THIRDFLOOR:MASTERBEDROOM1</b>	<b>0.115</b>	<b>1.20</b>
<b>THIRD FLOOR</b>	<b>THIRDFLOOR:BEDROOM1</b>	<b>0.048</b>	<b>0.59</b>
<b>THIRD FLOOR</b>	<b>THIRDFLOOR:KITCHENANDLIVING</b>	<b>0.156</b>	<b>1.81</b>
<b>THIRD FLOOR</b>	<b>THIRDFLOOR:LIVINGANDDINING</b>	<b>0.072</b>	<b>0.95</b>
<b>THIRD FLOOR</b>	<b>THIRDFLOOR:MASTERBEDROOM2</b>	<b>0.053</b>	<b>0.62</b>
<b>THIRD FLOOR</b>	<b>THIRDFLOOR:BEDROOM2</b>	<b>0.119</b>	<b>1.24</b>
<b>THIRD FLOOR</b>	<b>THIRDFLOOR:MASTERBEDROOM3</b>	<b>0.143</b>	<b>1.55</b>
<b>THIRD FLOOR</b>	<b>THIRDFLOOR:BEDROOMXSCORRIDOR</b>	<b>0.019</b>	<b>0.23</b>

THIRD FLOOR	THIRDFLOOR:BEDROOM3	0.132	1.55
THIRD FLOOR	THIRDFLOOR:CORRIDOR2	0.084	1.10
THIRD FLOOR	THIRDFLOOR:MASTERBEDROOM	0.144	1.55
THIRD FLOOR	THIRDFLOOR:DINING	0.049	0.63
THIRD FLOOR	THIRDFLOOR:BEDROOM4	0.168	1.76
THIRD FLOOR	THIRDFLOOR:BEDROOM	0.053	0.65
THIRD FLOOR	THIRDFLOOR:LIVINGROOM	0.162	2.01
THIRD FLOOR	THIRDFLOOR:KITCHEN	0.105	1.29
THIRD FLOOR	THIRDFLOOR:GUESTROOM3	0.086	1.09
THIRD FLOOR	THIRDFLOOR:GUESTROOM	0.112	1.30
THIRD FLOOR	THIRDFLOOR:ENTRANCE	0.02	0.26
THIRD FLOOR	THIRDFLOOR:CORRIDOR	0.155	1.92
THIRD FLOOR	THIRDFLOOR:KITCHEN AND DINING	0.192	2.42

❖ Fourth floor :

Table 76 the designing loads for 4th floor

Zone name	Zone	Design Flow Rate(m <sup>3</sup> /s)	Peak Cooling Load(kw)
FOURTH FLOOR	FOURTHFLOOR:KITCHEN1	0.099	1.16
FOURTH FLOOR	FOURTHFLOOR:GUESTROOM1	0.174	1.96
FOURTH FLOOR	FOURTHFLOOR:MASTERBEDROOM4	0.12	1.28
FOURTH FLOOR	FOURTHFLOOR:GUESTROOM2	0.144	1.46
FOURTH FLOOR	FOURTHFLOOR:DINING1	0.064	0.81

<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:CORRIDOR1</b>	<b>0.011</b>	<b>0.13</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:MASTERBEDROOM1</b>	<b>0.116</b>	<b>1.21</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:BEDROOM1</b>	<b>0.049</b>	<b>0.60</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:KITCHENANDLIVING</b>	<b>0.16</b>	<b>1.84</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:LIVINGANDDINING</b>	<b>0.079</b>	<b>1.03</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:MASTERBEDROOM2</b>	<b>0.054</b>	<b>0.64</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:BEDROOM2</b>	<b>0.121</b>	<b>1.25</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:MASTERBEDROOM3</b>	<b>0.146</b>	<b>1.57</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:BEDROOMXSCORRIDOR</b>	<b>0.019</b>	<b>0.24</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:BEDROOM3</b>	<b>0.135</b>	<b>1.58</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:CORRIDOR2</b>	<b>0.087</b>	<b>1.13</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:MASTERBEDROOM</b>	<b>0.144</b>	<b>1.55</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:DINING</b>	<b>0.051</b>	<b>0.65</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:BEDROOM4</b>	<b>0.167</b>	<b>1.75</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:BEDROOM</b>	<b>0.053</b>	<b>0.66</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:LIVINGROOM</b>	<b>0.168</b>	<b>2.09</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:KITCHEN</b>	<b>0.108</b>	<b>1.32</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:GUESTROOM3</b>	<b>0.089</b>	<b>1.13</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:GUESTROOM</b>	<b>0.117</b>	<b>1.34</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:ENTRANCE</b>	<b>0.021</b>	<b>0.28</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:CORRIDOR</b>	<b>0.16</b>	<b>1.98</b>
<b>FOURTH FLOOR</b>	<b>FOURTHFLOOR:KITCHENANDDINING</b>	<b>0.196</b>	<b>2.47</b>

❖ Fifth Floor :

Table 77 the designing loads for 5th floor

<b>Zone name</b>	<b>Zone</b>	<b>Design Flow Rate(m<sup>3</sup>/s)</b>	<b>Peak Cooling Load(kw)</b>
FIFTH FLOOR	FIFTHFLOOR:KITCHEN1	0.125	1.41
FIFTH FLOOR	FIFTHFLOOR:GUESTROOM1	0.217	2.36
FIFTH FLOOR	FIFTHFLOOR:MASTERBEDROOM4	0.141	1.46
FIFTH FLOOR	FIFTHFLOOR:GUESTROOM2	0.164	1.61
FIFTH FLOOR	FIFTHFLOOR:DINING1	0.083	1.01
FIFTH FLOOR	FIFTHFLOOR:CORRIDOR1	0.014	0.17
FIFTH FLOOR	FIFTHFLOOR:MASTERBEDROOM1	0.13	1.32
FIFTH FLOOR	FIFTHFLOOR:BEDROOM1	0.069	0.79
FIFTH FLOOR	FIFTHFLOOR:KITCHENANDLIVING	0.198	2.18
FIFTH FLOOR	FIFTHFLOOR:LIVINGANDDINING	0.132	1.66
FIFTH FLOOR	FIFTHFLOOR:MASTERBEDROOM2	0.072	0.81
FIFTH FLOOR	FIFTHFLOOR:BEDROOM2	0.137	1.38
FIFTH FLOOR	FIFTHFLOOR:MASTERBEDROOM3	0.174	1.82
FIFTH FLOOR	FIFTHFLOOR:BEDROOMXSCORRIDOR	0.029	0.35
FIFTH FLOOR	FIFTHFLOOR:BEDROOM3	0.165	1.86
FIFTH FLOOR	FIFTHFLOOR:CORRIDOR2	0.117	1.51
FIFTH FLOOR	FIFTHFLOOR:MASTERBEDROOM	0.141	1.52
FIFTH FLOOR	FIFTHFLOOR:DINING	0.072	0.87
FIFTH FLOOR	FIFTHFLOOR:BEDROOM4	0.16	1.70
FIFTH FLOOR	FIFTHFLOOR:BEDROOM	0.059	0.72

<b>FIFTH FLOOR</b>	<b>FIFTHFLOOR:LIVINGROOM</b>	<b>0.218</b>	<b>2.63</b>
<b>FIFTH FLOOR</b>	<b>FIFTHFLOOR:KITCHEN</b>	<b>0.143</b>	<b>1.68</b>
<b>FIFTH FLOOR</b>	<b>FIFTHFLOOR:GUESTROOM3</b>	<b>0.12</b>	<b>1.48</b>
<b>FIFTH FLOOR</b>	<b>FIFTHFLOOR:GUESTROOM</b>	<b>0.148</b>	<b>1.62</b>
<b>FIFTH FLOOR</b>	<b>FIFTHFLOOR:ENTRANCE</b>	<b>0.037</b>	<b>0.47</b>
<b>FIFTH FLOOR</b>	<b>FIFTHFLOOR:CORRIDOR</b>	<b>0.222</b>	<b>2.62</b>
<b>FIFTH FLOOR</b>	<b>FIFTHFLOOR:KITCHENANDDINING</b>	<b>0.257</b>	<b>3.12</b>

❖ Roof :








Table 78 the designing loads for roof

<b>Zone name</b>	<b>Zone</b>	<b>Design Flow Rate(m3/s)</b>	<b>Peak Cooling Load(kw)</b>
<b>ROOF</b>	<b>ROOF:CLOSETERRACE</b>	<b>0.431</b>	<b>4.98</b>

✚ **VRF outdoor unit:**

**We used VRF air cooled system**

The following table is the catalogue for various types of VRF unites from the Air stage company:

Energy Efficiency Combination			16	18	20	24	26	28	30
Rating Capacity range	HP								
Set Model name									
Unit 1		AJY144LALBH	AJY162LALBH	AJY180LALBH	AJY216LALBH	AJY234LALBH	AJY252LALBH	AJY270LALBH	
Unit 2		AJY072LALBH	AJY090LALBH	AJY108LALBH	AJY072LALBH	AJY090LALBH	AJY108LALBH	AJY126LALBH	AJY126LALBH
Unit 3		AJY072LALBH	AJY072LALBH	AJY072LALBH	AJY072LALBH	AJY072LALBH	AJY072LALBH	AJY072LALBH	AJY072LALBH
Maximum Connectable Indoor Unit*		34	39	43	52	56	60	64	
Indoor unit connectable capacity	kW	22.4-67.2	25.2-75.6	28.0-83.8	33.6-100.8	36.4-109.2	39.2-117.4	42.4-127.2	
Power source		3-phase 4 wire, 400 V, 50Hz							
Capacity	Cooling	kW	44.8	50.4	55.9	67.2	72.8	78.3	84.8
	Heating	kW	50.0	56.5	62.5	75.0	81.5	87.5	95.0
Input power	Cooling	kW	10.40	12.48	14.16	15.60	17.68	19.36	21.36
	Heating	kW	10.34	12.42	13.82	15.51	17.59	18.99	21.51
EER	Cooling	W/W	4.31	4.04	3.95	4.31	4.12	4.04	3.97
	Heating	W/W	4.84	4.55	4.52	4.84	4.63	4.61	4.42
CDP		m <sup>3</sup> /h	11,100-2	11,100-2	13,000-11,100	11,100-3	11,000-3	13,000-11,100-2	13,000-11,100-2
Airflow rate	High		11,100-2	11,100-2	13,000-11,100	11,100-3	11,000-3	13,000-11,100-2	13,000-11,100-2
Sound pressure level**)	Cooling	dB(A)	59 / 80	60 / 81	60 / 81	61 / 82	62 / 83	61 / 82	63 / 84
	Heating	dB(A)	61 / 83	62 / 84	62 / 85	63 / 85	63 / 85	64 / 86	65 / 87
Maximum external static pressure		Pa	82	82	82	82	82	82	82
Compressor motor output		kW	7.5-2	7.5-2	11.0-7.5	7.5-3	7.5-3	11.0-7.5-2	11.0-7.5-2
Minimum Recommended MCB		AMP	20 + 20	25 + 20	40 + 20	20 + 20 + 20	25 + 20 + 20	40 + 20 + 20	40 + 20 + 20
Net Dimensions	Height	mm	1,690	1,690	1,690	1,690	1,690	1,690	1,690
	Width	mm	930-2	930-2	1,240-930	930-3	930-3	1,240-930-2	1,240-930-2
	Depth	mm	765	765	765	765	765	765	765
Weight		kg	252-2	252-2	275+252	252+3	252+3	275+252-2	275+252-2
Refrigerant	Type		R410A	R410A	R410A	R410A	R410A	R410A	R410A
	Charge	kg	11.7-2	11.7-2	11.8+11.7	11.7+3	11.7-3	11.8+11.7-2	11.8+11.7-2
Connection pipe diameter	Liquid	inch	1/2	5/8	5/8	5/8	5/8	5/8	3/4
	Gas	inch	1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 3/8
Operation range	Cooling	°CDB	-5 to 46	-5 to 46	-5 to 46	-5 to 46	-5 to 46	-5 to 46	-5 to 46
	Heating	°CDB	-20 to 21	-20 to 21	-20 to 21	-20 to 21	-20 to 21	-20 to 21	-20 to 21

Note : Specifications are based on the following conditions.  
Cooling : Indoor temperature of 27°CDB / 19°CWB, and outdoor temperature of 35°CDB / 24°CWB.  
Heating : Indoor temperature of 20°CDB / 15°CWB, and outdoor temperature of 7°CDB / 6°CWB.  
Pipe length : 7.5 m; Height difference between outdoor unit and indoor unit : 0 m.  
When cooling operation will be conducted at outdoor air temperature below 5°C, the outdoor unit must be installed in a position that is higher than or equal to those of indoor units.

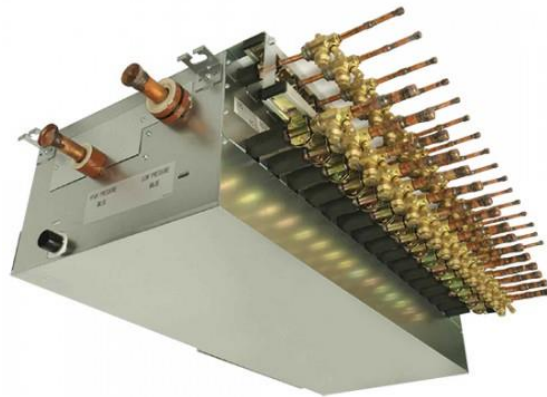
Figure 175 VRF catalogue

- The total Peak cooling load of outdoor unites need to cover all indoor unite = 250.39 KW
- The selected type is (AJY270LALBHH) with a total capacity of cooling load = 84.8 KW.
- The number of outdoor unites =  $\frac{\text{total peak ooling load}}{\text{capacity of unite}} = \frac{250.39}{84.4}$   
Number of outdoor unites = 2.967, **so we need to 3 outdoor unites**

#### ✚ Indoor unites :

In order to deliver the gas that is used in this system in order for the cooling and heating process to occur, there must be a link that works to deliver the gas in an orderly manner and without any problems, so we used the controller to perform this task.

The following picture shows the control used in the system:



*Figure 176 controller product*

We will use two types of indoor unites :

For ground floor (Market ) we use fan coil unites

And for the residential floors ( 1<sup>st</sup> floor – 5<sup>th</sup> floor ) we use the wall mounted split unite and the following pictures are for the catalogues for these unites:

Model : AUXB004GLEH / AUXB007GLEH / AUXB009GLEH  
 AUXB012GLEH / AUXB014GLEH / AUXB018GLEH  
 AUXB024GLEH

**Compact  
 Cassette**  
 Grid type



**Specifications**

Model name	AUXB004GLEH	AUXB007GLEH	AUXB009GLEH	AUXB012GLEH	AUXB014GLEH	AUXB018GLEH	AUXB024GLEH	
Power source	Single phase, ~230V, 50Hz							
Capacity	UK Total Cooling	0.80	1.60	2.10	2.70	3.30	4.20	
	UK Sensible Cooling	0.70	1.50	1.70	2.30	2.70	3.20	
	UK Heating	1.20	2.60	3.00	3.80	4.70	5.90	
	Nominal Cooling	1.10	2.20	2.80	3.60	4.50	5.60	
Input power	Nominal Heating	1.30	2.80	3.20	4.10	5.00	6.30	
	W	23	25	25	29	35	84	
Airflow rate	High	530/530	540	550	600	680	1,030	
	Med-H	490/480	500	520	560	620	910	
	Med	450/430	460	480	520	560	790	
	Med-L	420/380	420	440	480	500	680	
	Low	390/340	390	400	430	440	560	
	Quiet	350/300	350	350	390	390	400	
Sound pressure level	High	34/24	34	35	37	38	41	
	Med-H	32/23	32	33	34	37	39	
	Med	30/29	30	31	33	34	36	
	Med-L	28/26	28	29	31	32	33	
	Low	27/24	27	27	29	30	30	
	Quiet	25/21	25	25	27	27	27	
Net Dimensions (H x W x D)	mm	245 x 570 x 570	245 x 570 x 570	245 x 570 x 570	245 x 570 x 570	245 x 570 x 570	245 x 570 x 570	
Weight	kg(lbs)	14.5 (32)	15 (33)	15 (33)	15 (33)	15 (33)	17 (37)	
Connection pipe diameter	Liquid (Flare)	1/4					3/8	
	Gas (Flare)	1/2					5/8	
Cassette Grille	Model name	UTC-UPE-W						
	Net Dimensions (H x W x D)	50 x 620 x 620						
	Weight	2.3(5.1)						

Note : Specifications are based on the following conditions.  
 Cooling : Indoor temperature of 27°CDB / 19°CWB, and outdoor temperature of 35°CDB / 24°CWB.  
 Heating : Indoor temperature of 20°CDB / (15°CWB), and outdoor temperature of 7°CDB / 6°CWB.  
 Pipe length : 7.5 m; Height difference between outdoor unit and indoor unit : 0 m. Voltage : 230 [V].  
 \*1: This value is under cooling operation.

Figure 177: split unite cassette used in ground floor

**VRF**

Model : ASYA004GTEH / ASYA007GTEH / ASYA009GTEH  
 ASYE004GTEH / ASYE007GTEH / ASYE009GTEH

**Wall Mounted**



**Specifications**

Model name	ASVA004GTEH	ASVA007GTEH	ASVA009GTEH	ASVE004GTEH	ASVE007GTEH	ASVE009GTEH
Power source	Single phase, ~230V, 50Hz			Single phase, ~230V, 50Hz		
Capacity	UK Total Cooling	0.80	1.60	2.10	0.80	2.10
	UK Sensible Cooling	0.70	1.60	1.90	0.70	2.00
	UK Heating	1.20	2.60	3.00	1.20	2.60
	Nominal Cooling	1.10	2.20	2.80	1.10	2.20
Input power	Nominal Heating	1.30	2.80	3.20	1.30	2.80
	W	13	19	34	13	19
Airflow rate	High	430	550	720	430	720
	Med-H	420	460	570	420	460
	Med	390	420	500	390	420
	Med-L	380	390	410	380	390
	Low	360	360	360	360	360
	Quiet	330	330	330	330	330
Sound pressure level	High	31	35	43	31	35
	Med-H	30	32	38	30	38
	Med	28	30	34	28	30
	Med-L	26	27	29	26	27
	Low	24	24	24	24	24
	Quiet	22	22	22	22	22
Net Dimensions (H x W x D)	mm	262 x 820 x 206	262 x 820 x 206	262 x 820 x 206	262 x 820 x 206	262 x 820 x 206
Weight	kg(lbs)	7.5 (17)	7.5 (17)	7.5 (17)	7.0 (15)	7.0 (15)
Connection pipe diameter	Liquid (Flare)	1/4			3/8	
	Gas (Flare)	1/2			3/8	
EV Kit (option)	-			UTR-EV09XB		

Note : Specifications are based on the following conditions.  
 Cooling : Indoor temperature of 27°CDB / 19°CWB, and outdoor temperature of 35°CDB / 24°CWB.  
 Heating : Indoor temperature of 20°CDB / (15°CWB), and outdoor temperature of 7°CDB / 6°CWB.  
 Pipe length : 7.5 m; Height difference between outdoor unit and indoor unit : 0 m. Voltage : 230 [V].  
 When ASY\*004GTEH, ASY\*007GTEH, ASY\*009GTEH are connected to the outdoor unit other than J-IVL, gas pipe diameter should be Ø12.70.

Figure 178 wall mounted used in residential floors

- Calculations for number of indoor unites in each space in floors :

- Ground floor calculations :

We used in this floor a split unite cassette

Sample of calculations: ( for shopping store 5 )

The peak cooling load from design builder for this space = 2.08 KW

We choose (AUXB007GLEH) and it's capacity = 1.6 KW

$$\text{So, \#of unites} = \frac{2.08}{1.6} = 1.3 \text{ unite}$$

We need a **2 unites** of cassette AUXB007GLEH to cover this space

Now I will show you the calculations for all the spaces on the ground floor

using the following table :

Table 79 number of split unites on ground floor

ZONE NAME	ZONE	Design flow rate (m3/5)	peak cooling load(KW)	used HVAC system	UNITE capacity (KW)	number of split unites	number of split unite used
ground floor	Groundfloor:SHOPPINGSTORE5	0.165	2.08	AUXB007GLEH	1.6	1.30	2.0
ground floor	Groundfloor:SHOPPINGSTORE10	0.283	3.23	AUXB007GLEH	1.6	2.02	3
ground floor	Groundfloor:CORRIDOR3	0.164	2.19	AUXB007GLEH	1.6	1.37	2
ground floor	Groundfloor:GAURDROOM	0.002	0	AUXB007GLEH	1.6	0.00	0
ground floor	Groundfloor:SHOPPINGSTORE8	0.231	2.49	AUXB007GLEH	1.6	1.56	2

ground floor	Groundfloor :SHOPPINGSTORE6	0.126	1.57	AUXB007GLEH	1.6	0.98	1
ground floor	Groundfloor :SHOPPINGSTORE7	0.073	1	AUXB007GLEH	1.6	0.63	1
ground floor	Groundfloor :CORRIDOR2	0.05	0.63	AUXB007GLEH	1.6	0.39	1
ground floor	Groundfloor:CORRIDOR	0.322	4.23	AUXB007GLEH	1.6	2.64	3
ground floor	Groundfloor:SHOPPINGSTORE11	0.222	2.45	AUXB007GLEH	1.6	1.53	2
ground floor	Groundfloor:PRAYINGROOM	0.02	0.28	AUXB007GLEH	1.6	0.18	1
ground floor	Groundfloor:SHOPPINGSTORE13	0.097	1.33	AUXB007GLEH	1.6	0.83	1
ground floor	Groundfloor:SHOPPINGSTORE12	0.31	3.43	AUXB007GLEH	1.6	2.14	3
ground floor	Groundfloor:SHOPPINGSTORE3	0.153	1.83	AUXB007GLEH	1.6	1.14	2

ground floor	Groundfloor:S HOPPINGST ORE4	0.313	3.68	AUXB0 07GLE H	1.6	2.30	3
ground floor	Groundfloor:S HOPPINGST ORE1	0.384	4.12	AUXB0 07GLE H	1.6	2.58	3
ground floor	GROUND FLOOR:SHOPPING STORE2	0.146	1.87	AUXB0 07GLE H	1.6	1.17	2

- First floor calculations : (Residential floors )

Sample of calculations :

We used a wall mounted split unite in this floor

Sample of calculations (1<sup>st</sup> floor – 5<sup>th</sup> floor )

Sample of calculations: ( first floor Master bedroom 4 )

The peak cooling load from design builder for this space = 1.16 KW

We choose (ASYA004GTEH A ) and it's capacity = 0.8 KW

$$\text{So, \#of unites} = \frac{1.16}{0.8} = 1.45 \text{ unite}$$

We need **2 unites** of wall mounted ASYA004GTEHA to cover this space

Now I will show you the calculations for all the spaces on the ground floor using the following table:

**Note:** In the following table, I will calculate the number of units needed in the empty floors from the 1<sup>st</sup> floor to the 5<sup>th</sup> floor

- ✚ The number of the split units in the floors of the building will be shown in details and tables in the appendixes:

✚ The distribution of the split units on the floors of the building will be shown below in the AUTOCAD Drawings:

❖ Ground floor (Market ) :

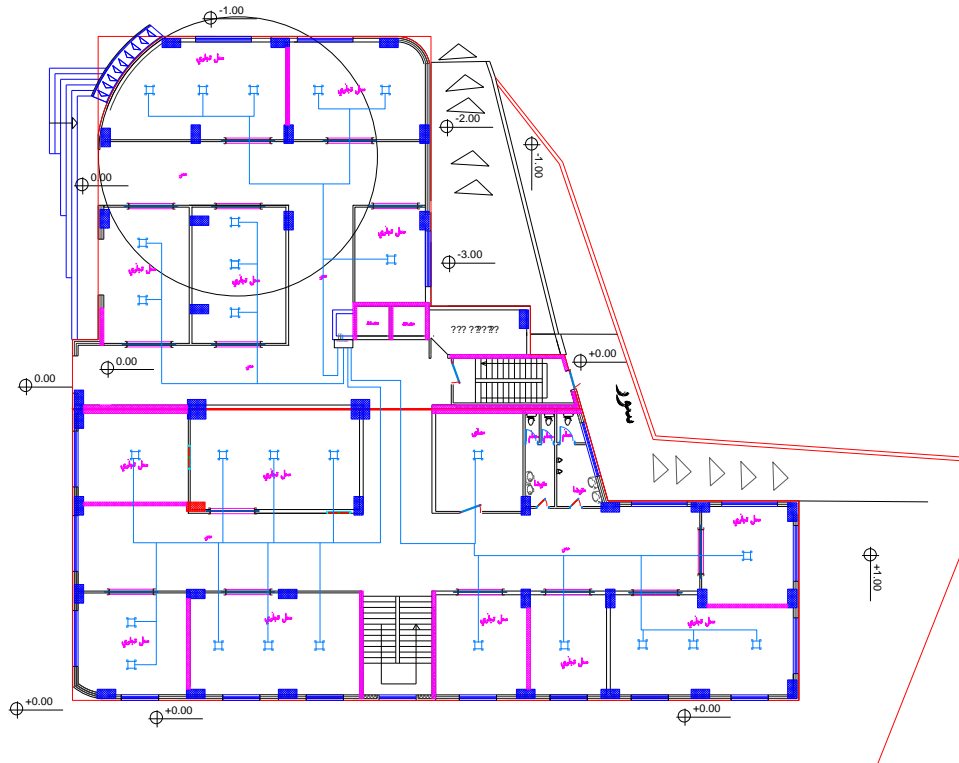


Figure 179:distribution of split units on GF

❖ First floor to Fifth floor :

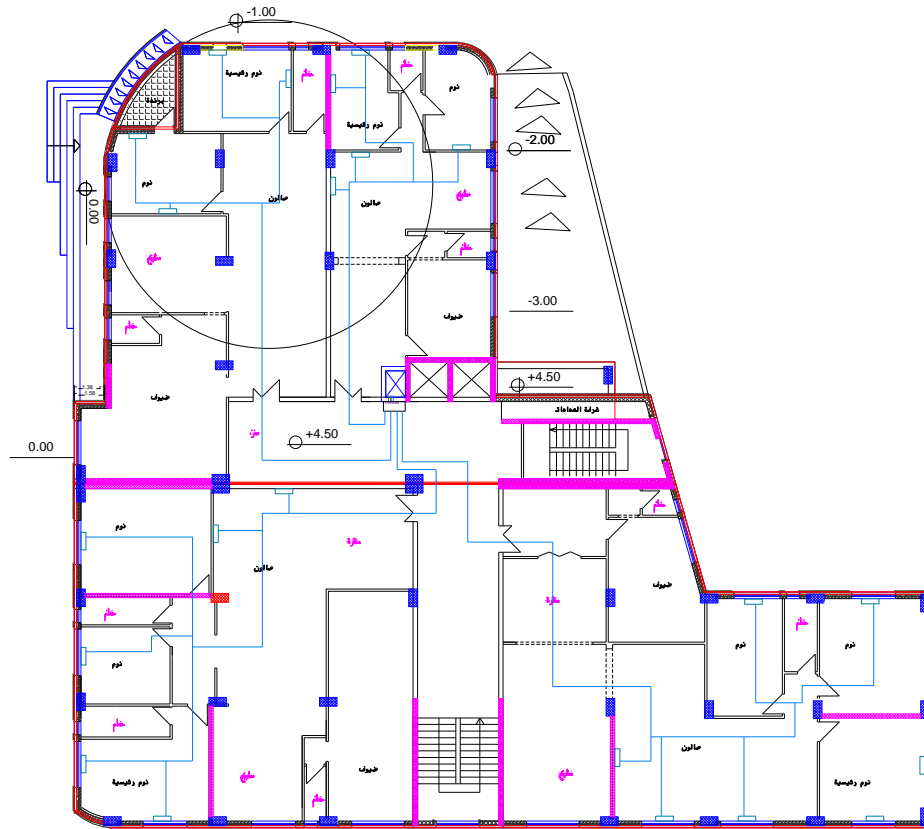


Figure 180: distribution of split units on First floor

### 4.3 Power design:

#### 4.3.1 electrical system:

Electrical networks, which consist of wires, transformers, and cables, are used by the electrical system to transport energy from the power generating source into the structure.

Different electrical connection types exist based on the needs of the building and the capacity needed in those connections—three phases for large loads and one phase for smaller loads. Meters are installed in each building and connected to the public electrical network in order to get power from municipalities or firms that distribute electricity.

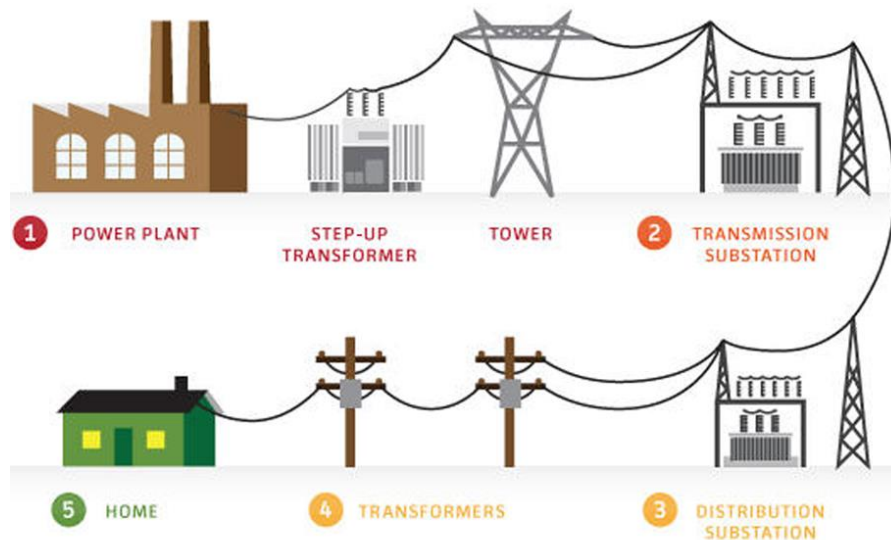


Figure 181 :Electrical system

#### 4.3.2 Electrical system elements:

##### ➤ Wires :

There are three types of copper wires used in electrical installations:

- Phase
- Neutral
- Earth

Function	Old Color Code القديم	New Color Code الجديد
Single Phase Line (L) خط كهرباء 1 فاز	Red	Brown
Three Phase Line 1 (L1) خط كهرباء الفاز الاول	Red	Brown
Three Phase Line 1 (L2) خط كهرباء الفاز الثاني	Yellow	Black
Three Phase Line 1 (L3) خط كهرباء الفاز الثالث	Blue	Gray
Neutral (N) خط النيوترال	Black	Blue
Protective Earth or Ground (PE) خط التأسيس	Green-and-Yellow	Green-and-Yellow

Figure 182 type of wires

##### ➤ Distribution board:

The electrical control panel serves as a connector between the building's internal electrical system and the network's power. There are several circuit breakers on the panel.

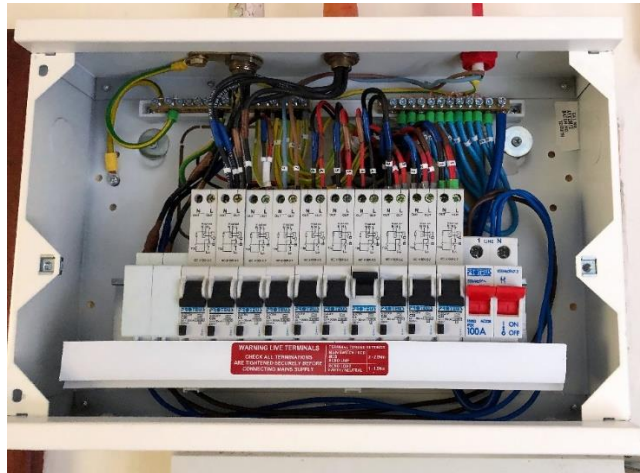


Figure 183 Distribution board

➤ **Circuit breakers:**

The purpose of the electrical circuit breaker is to safeguard the electrical network by immediately cutting off the current in the event of a network malfunction or an increase in current.



Figure 184 Circuit breaker

In order provide the power needed for the building's elevators, security systems, lighting, air conditioning, and other necessities, a three-phase system will be employed.

**4.3.1 Power calculations:**

➤ **Lighting calculations:**

⇒ **Market :**

Table 80 Lighting information of Market

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Exist lux	Required Unifor.	Uniformity Existed
Market (clothes shop )	Trail Light insert	3000	61	2	300	500	2.5	2.5

$$\text{Power} = I \times V \times P. \text{ Factor}$$

$$61 \times 2 = I \times 220 \times 0.8$$

$$I = 0.69 \text{ A}$$

⇒ Ablution :

Table 81 Information of lighting on ablution

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Existe lux	Required Unifor.	Uniformity Existed
ablution	SLK22 930VWG-EDU	3000	13.4	2	100	106	2	1.81

$$\text{Power} = I \times V \times P. \text{ Factor}$$

$$13.4 \times 2 = I \times 220 \times 0.8$$

$$I = 0.15 \text{ A}$$

⇒ Bathroom :

Table 82 lighting information of bathroom

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Existe lux	Required Unifor.	Uniformity Existed
Bathroom (WC)	Lumi320	3000	12	2	50	63	2	1.25

$$\text{Power} = I \times V \times P. \text{ Factor}$$

$$12 \times 2 = I \times 220 \times 0.8$$

$$I = 0.14 \text{ A}$$

⇒ **Bedroom:**

*Table 83 lighting information of bedroom*

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Existe lux	Required Unifor.	Uniformity Existed
Bedroom	MESSINA PD	3000	39	2	300	436	3	2.32

$$\text{Power} = I \times V \times P. \text{ Factor}$$

$$39 \times 2 = I \times 220 \times 0.8$$

$$I = 0.44 \text{ A}$$

⇒ **Guest room:**

*Table 84 lighting information of guestroom*

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Existe lux	Required Unifor.	Uniformity Existed
Guestroom	RWYR2000	3000	23.2	6	200	283	5	3.35

$$\text{Power} = I \times V \times P. \text{ Factor}$$

$$23.2 \times 6 = I \times 220 \times 0.8$$

$$I = 0.8 \text{ A}$$

⇒ **Kitchen:**

*Table 85 lighting information of kitchen*

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Existe lux	Required Unifor.	Uniformity Existed
Kitchen	Nimbus Q four	4000	16.4	8	300	320	2	2

$$\text{Power} = I \times V \times P. \text{ Factor}$$

$$16.4 \times 8 = I \times 220 \times 0.8$$

$$I = 0.75 \text{ A}$$

⇒ **Living room:**

*Table 86 lighting information for living room*

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Existe lux	Required Unifor.	Uniformity Existed
Livingroom	Molto Luce VALO HV PDI	3000	26	6	300	342	5	4.23

$$\text{Power} = I \times V \times P. \text{ Factor}$$

$$26 \times 6 = I \times 220 \times 0.8$$

$$I = 0.89 \text{ A}$$

⇒ **Corridor:**

*Table 87 lighting information for corridor*

Space type	Luminaire type	Luminaire CT (K)	Power (watt)	#of luminaires	Required lux	Existe lux	Required Unifor.	Uniformity Existed
Corridor	COLORS 棱镜款 吸顶	3000	12	16	100	113	2	1.87

$$\text{Power} = I \times V \times P. \text{ Factor}$$

$$12 \times 16 = I \times 220 \times 0.8$$

$$I = 1.1 \text{ A}$$

From the previous calculations, we found the amount of current that each room needs, and the next step is to know the number of lighting breakers that each of the previous spaces needs.

Each space need one circuit breaker for lighting.

➤ **Cable diameter:**

To find the area of cable we should find the  $I_{cb}$

Where  $I_{cb} = 1.25 * I$

$I_{cb} = 1.25 * 9.13$

$I_{cb} = 11.41 \text{ A}$

*Table 88 Cross sectional area by current rating*

Nominal cross-sectional area	Single phase current rating	Three phase current rating
mm <sup>2</sup>	Amp	Amp
1.5	10	14
2.5	16	18
4	28	24
6	36	31
10	50	44
16	66	59
25	88	77
35	109	97
50	131	117
70	167	149
95	202	180
120	234	208

From previous table we choose area of cable =  $1.5 \text{ mm}^2$

➤ **Power calculations:**

There are two cases in power calculation: normal loads and special loads.

Normal loads are power outlets with low power loads, as those found in chargers and other devices.

The other kind of power outlets has a specific load, such as equipment used in kitchens and HVAC systems indoors.

*Table 89 normal load and special loads*

Normal loads	Special loads
2 Amp.	(10,12,16,20,25,32) Amp.

➤ Normal load calculations:

Use the following formula to determine how many power sockets can fit inside of a single circuit breaker:

$$I_{cb} = 1.25 \times I_{load}$$

$$I_{cb} = 13.33 \text{ A}$$

A current of 13.33 Amperes can be placed into each circuit breaker. Additionally, as seen in the table above, a standard power socket's value is 2 A.

So, we can put more than one socket for each circuit breakers.

And to find the cable diameter for power :

$$I_{cable} = 1.15 \times I_{load}$$

$$I_{cable} = 1.15 \times 13.33$$

$I_{cable} = 15.4 \text{ A}$ , according to next table we choose area of cable =

**2.5 mm<sup>2</sup>**

*Table 90: Cross sectional area by current rating*

Nominal cross-sectional area	Single phase current rating	Three phase current rating
mm <sup>2</sup>	Amp	Amp
1.5	10	14
2.5	16	18
4	28	24
6	36	31
10	50	44
16	66	59
25	88	77
35	109	97
50	131	117
70	167	149
95	202	180
120	234	208

➤ Voltage drop check:

Max length of lighting wire from AutoCAD = 10.54 m

So,  $2L = 2 \times 10.54 = 21.08$  m

Where Resistivity ( $\rho$ ) for copper =  $1.72 \times 10^{-8} \Omega \cdot m$ .

And the max allowed voltage drop = 5 %

So,  $220 \times 5\% = 11$  v

To find the area needed we use the next formula

Voltage drop = I load x R

Voltage drop = I load x  $\frac{\rho * L}{A}$

So,  $A = 0.44 \text{ mm}^2$

So,  $2.5 \text{ mm}^2$  will be chosen.

➤ Special load calculations:

Use the following formula to determine how many power sockets can fit inside of a single circuit breaker:

Power = I x V x P. F

I load =  $\frac{\text{power}}{V * P f}$

I load =  $\frac{2000}{220 * 0.9} = 10.10$  A

Icb =  $1.15 * 10.10$

I cb = 11.6 A

A current of 11.6 Amperes can be placed into each circuit breaker

From previous table (Table 91) the area of cable =  $1.5 \text{ mm}^2$

➤ Voltage drop check :

Max length of power wire from AutoCAD = 5.32 m

So,  $2L = 2 * 5.32 = 10.64$  m

Where Resistivity ( $\rho$ ) for copper =  $1.72 \times 10^{-8} \Omega \cdot m$ .

And the max allowed voltage drop = 5 %

So,  $220 \times 5\% = 11$  v

To find the area needed we use the next formula

Voltage drop = I load x R

Voltage drop = I load x  $\frac{\rho * L}{A}$

So,  $A = 0.193 \text{ mm}^2$

➤ HVAC special load design:

✓ For ground floor :

Next figure show the indoor unite and their loads we used in ground floor:

Model : AUXB004GLEH / AUXB007GLEH / AUXB009GLEH  
 AUXB012GLEH / AUXB014GLEH / AUXB018GLEH  
 AUXB024GLEH

**Compact  
 Cassette**  
 Grid type



**Specifications**

Model name	AUXB004GLEH	AUXB007GLEH	AUXB009GLEH	AUXB012GLEH	AUXB014GLEH	AUXB018GLEH	AUXB024GLEH	
Power source	Single phase, ~230V, 50Hz							
Capacity	UK Total Cooling	0.80	1.60	2.10	2.70	3.30	5.30	
	UK Sensible Cooling	0.70	1.50	1.70	2.30	2.70	4.40	
	UK Heating	1.20	2.60	3.00	3.80	4.70	7.40	
	Nominal Cooling	1.10	2.20	2.80	3.60	4.50	7.10	
Input power	Nominal Heating	1.30	2.80	3.20	4.10	5.00	8.00	
		W	23	25	25	29	35	84
Airflow rate	High	530/530	540	550	600	680	1,030	
	Med-H	490/480	500	520	560	620	910	
	Med	450/430	460	480	520	560	790	
	Med-L	420/380	420	440	480	500	680	
	Low	390/340	390	400	430	440	560	
	Quiet	350/300	350	350	390	390	400	
Sound pressure level	High	34/26	34	35	37	38	41	
	Med-H	32/31	32	33	34	37	39	
	Med	30/29	30	31	33	34	36	
	Med-L	28/26	28	29	31	32	33	
	Low	27/24	27	27	29	30	30	
	Quiet	25/21	25	25	27	27	27	
Net Dimensions (H x W x D)	mm	245 x 570 x 570	245 x 570 x 570	245 x 570 x 570	245 x 570 x 570	245 x 570 x 570	245 x 570 x 570	
Weight	kg(lbs)	14.5 (32)	15 (33)	15 (33)	15 (33)	15 (33)	17 (37)	
Connection pipe diameter	Liquid (Flare)	1/4					3/8	
	Gas (Flare)	1/2					5/8	
Cassette Grille	Model name	UTE-UPYE-W						
	Net Dimensions (HxWxD)	50 x 620 x 620						
	Weight	2.3(5.1)						

Note : Specifications are based on the following conditions.  
 Cooling : Indoor temperature of 27°CDB / 19°CWB, and outdoor temperature of 35°CDB / 24°CWB.  
 Heating : Indoor temperature of 20°CDB / 15°CWB, and outdoor temperature of 7°CDB / 5°CWB.  
 Pipe length: 7.5 m; Height difference between outdoor unit and indoor unit: 0 m. Voltage : 230 [V].  
 \*1: This value is under cooling operation.

Figure 185:Indoor unite used on GF

We use the next formula for the I load calculations:

$$\text{Power} = I \times V \times P.F$$

Where power = 1600

So, I load = 8.08 A

$$I_{cb} = 1.25 \times 8.08$$

$$I_{cb} = 10.1 \text{ A}$$

And according to the ( Table 11 ) we choose area of cable =  $1.5 \text{ mm}^2$  and the current of circuit breaker = 14 A, for each indoor unite.

✓ Voltage drop check :

Max length of indoor unite wiring from AutoCAD = 10.12 m

$$\text{So, } 2L = 2 \times 10.12 = 20.24 \text{ m}$$

Where Resistivity ( $\rho$ ) for copper =  $1.72 \times 10^{-8} \Omega \cdot m$ .

And the max allowed voltage drop = 5 %

So,  $220 \times 5\% = 11 \text{ v}$

To find the area needed we use the next formula

Voltage drop = I load x R

Voltage drop = I load x  $\frac{\rho \cdot L}{A}$

So,  $A = 0.26 \text{ mm}^2$

So,  $1.5 \text{ mm}^2$  will be chosen.

✓ For 1<sup>st</sup> floor to 5<sup>th</sup> floor :

Next figure show the indoor unite and their loads we used in ground floor

VRF  
Model: ASYA004GTEH / ASYA007GTEH / ASYA009GTEH  
ASYE004GTEH / ASYE007GTEH / ASYE009GTEH

Wall Mounted



Specifications

Model / Range		ASYA004GTEH	ASYA007GTEH	ASYA009GTEH	ASYE004GTEH	ASYE007GTEH	ASYE009GTEH
Power source		Single phase, ~230V, 50Hz			Single phase, ~230V, 50Hz		
Capacity	UK Total Cooling	0.80	1.60	2.10	0.80	1.60	2.10
	UK Sensible Cooling	0.70	1.60	1.90	0.70	1.50	2.00
	UK Heating	1.20	2.60	3.00	1.20	2.60	3.00
	Nominal Cooling	1.10	2.20	2.80	1.10	2.20	2.8
	Nominal Heating	1.30	2.80	3.20	1.30	2.80	3.2
Input power	W	15	19	14	15	19	34
Airflow rate	High	430	550	720	430	550	720
	Med-H	420	460	570	420	460	570
	Med	390	420	500	390	420	500
	Med-L	380	390	410	380	390	410
	Low	360	360	360	360	360	360
Sound pressure level	Quiet	330	330	330	330	330	330
	High	31	35	43	31	35	43
	Med-H	30	32	38	30	32	38
	Med	28	30	34	28	30	34
	Med-L	26	27	29	26	27	29
Net Dimensions (H x W x D)	mm	262 x 820 x 206	262 x 820 x 206	262 x 820 x 206	262 x 820 x 206	262 x 820 x 206	262 x 820 x 206
	Weight	kg(lbs)	7.5 (17)	7.5 (17)	7.5 (17)	7.0 (15)	7.0 (15)
Connection pipe diameter	Liquid (Flare)				1/4		
	Gas (Flare)				3/8		
EV kit (option)					UTR-EV03XB		

Figure 186 Indoor unite used for residential floor

:

We use the next formula for the I load calculations :

Power = I x V x P. F

Where power = 800

So, I load = 4.04 A

I cb = 1.25 x 4.04

I cb = 5.05 A

And according to the ( Table 11 ) we choose area of cable =  $1.5 \text{ mm}^2$  and the current of circuit breaker = 14 A, for each indoor unite.

✓ Voltage drop check :

Max length of indoor unite wiring from AutoCAD = 10.12 m

So,  $2 L = 2 \times 10.12 = 20.24 \text{ m}$

Where Resistivity ( $\rho$ ) for copper =  $1.72 \times 10^{-8} \Omega \cdot \text{m}$ .

And the max allowed voltage drop = 5 %

So,  $220 \times 5\% = 11 \text{ v}$

To find the area needed we use the next formula

Voltage drop = I load x R

Voltage drop = I load x  $\frac{\rho * L}{A}$   $\rightarrow A = 0.26 \text{ mm}^2$  So,  **$1.5 \text{ mm}^2$**  will be chosen.

❖ Total power load calculations for DB:

○ Power of sockets:

- For ground floor:

We have a 28 normal sockets and 15 special sockets

So, the total power of sockets in GF = 42750 watt

Avg. power =  $\frac{42750}{15} = 2850 \text{ watt}$

Power = I x V x P. F

I load =  $\frac{2850}{220 * 0.9} = 14.4 \text{ A}$

Icb = 1.15 X I load

Icb = 1.15 X 14.4 = 16.56 A

According to the previous table, the used cable is  $2.5 \text{ mm}^2$  with a circuit breaker of 18 Amp .for the ground floor.

- For first floor :

We have a 56 normal sockets and 32 special load

So, the total power of sockets in 1<sup>st</sup> floor = 90360 watt

Note that we have similar floors from 1<sup>st</sup> floor to 5<sup>th</sup> floor

$$\text{Avg. power} = \frac{90360}{4} = 22590 \text{ watt}$$

$$\text{Power} = I \times V \times P. F$$

$$I \text{ load} = \frac{22590}{220 \times 0.9} = 114 \text{ A}$$

$$I_{cb} = 1.15 \times I \text{ load}$$

$$I_{cb} = 1.15 \times 114 = 131.1 \text{ A}$$

According to the previous table, the used cable is 70mm<sup>2</sup> with a circuit breaker of 149 Amp. for the residential floors.

❖ Total power of DB ground floor :

- Power = I X V X P. F

$$I \text{ load} = \frac{3298}{220 \times 0.9} = 16.66 \text{ A}$$

$$I_{cb} = 1.15 \times I \text{ load}$$

$$I_{cb} = 1.15 \times 16.66 = 19.15 \text{ A}$$

According to the previous table, the used cable is 4 mm<sup>2</sup> with circuit breakers of 24 Amp. for the shops floor.

- Power = I X V X P. F

$$I \text{ load} = \frac{23190.4}{220 \times 0.9} = 117.12 \text{ A}$$

$$I_{cb} = 1.15 \times I \text{ load}$$

$$I_{cb} = 1.15 \times 117.12 = 134.7 \text{ A}$$

According to the previous table, the used cable is 70 mm<sup>2</sup> with circuit breakers of 49 Amp. for the residential floors.

✓ Voltage drop check:

- Maximum Length of lighting wiring from CAD = 34+22=56m.
- $2L = 2 \times 56 = 112\text{m}$
- Resistivity ( $\rho$ ) for copper =  $1.72 \times 10^{-8} \Omega \cdot \text{m}$ .
- The area needed according to voltage drop =  $I \text{ load} \times (\rho * L) / A$
- $A = 23.58 \text{ mm}^2$  So, **25 mm<sup>2</sup>** will be chosen.

## **4.4 Acoustical Design:**

### **4.4.1 Introduction:**

Acoustical design has a significant role in enhancing the comfort of the facility to the end-users. Making buildings convenient involves looking at various factors during the early planning stages of a project. This is crucial to ensure smooth interaction, reduce conflicts, address overlaps, and achieve effective building performance. Architectural design is one of the most important parts of building a project it involves the selection of the material used in the building, choosing the different materials in the project and the combinations of the material in the building acts differently on the way acoustics run throughout the project.

Creating a well acoustical design improves the acoustical comfort in the building, by lowering the background noise coming from outside the site, and the background noise coming from different spaces in the same building. A good design also enhances the productivity rate in building due the clear sound when talking or when listening.

Creating a good acoustical design involves the right selection of the material and their arrangement, reducing the noise ratio, not exceeding the limit of the sound pressure level, and a good reverberation time for speech clearance.

### **4.4.2 Problem definition:**

The project is a shopping center and residential apartments, so this building contains different functions so it is necessary to ensure that the internal spaces are not affected negatively on each other or by the surrounding environment. Example of the requirements to be achieved are as the following: Sound pressure level (SPL), reverberation time, the intelligibility of the audience, the background noise, sound transmission class, and impact insulation class.

### 4.4.3 Recommendations and acoustical standards:

#### 4.4.3.1 Reverberation time:

Reverberation time is the time needed in seconds for the sound to decay by 60 (dB) after the sound generation stops from a source, down below in the following figure shows the reverberation time graph for different spaces. From the figure below the project reverberation time should somewhere around 1.4-2.0 second it is more like the use of general purpose auditorium for the ground floor due to the large areas of the shopping stores.

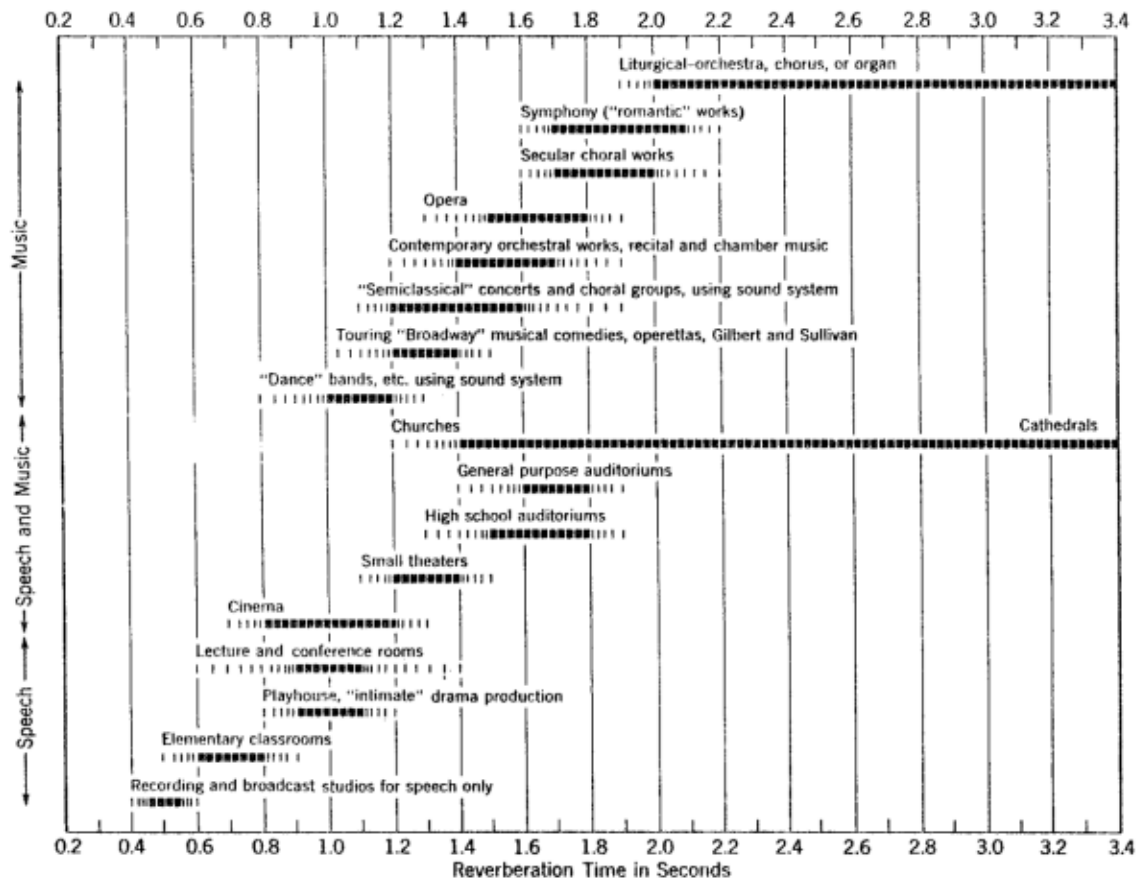


Figure 187 reverberation time in seconds

#### 4.4.3.2 Sound pressure level (SPL):

The sound pressure level is a logarithmic measure of the effective pressure of a sound relative to a reference value, it is defined in dB (decibel). From the table below it is shown that the shops and general usage areas need not less than 45-50 dB.

Permitted sound pressure levels according to type of place	dB(A)
Concert and opera halls, recording studios, theaters, cinemas, etc.	25-30
Bedrooms, TV and radio studios, conference rooms, classrooms, cameras, libraries, etc.	25-30
Living and living rooms, operating offices, hotel bedrooms, patient bedrooms	30-35
Lobby, private office areas, court buildings, fountains, hospitals, museums, etc.	40-45
Open spaces, Wet spaces, Reception areas, General usage areas, Shops, Shopping centers, Restaurants, etc.	45-50
Kitchen volumes, laundry, server rooms, cafeterias, market areas, fairgrounds, entertainment centers, schools, nightclubs, etc.	50-55

Figure 188 sound pressure level

#### 4.4.3.3 Noise reduction and background noise:

Noise in the building here comes from the chatter of people within the area, the noises generated by the HVAC system, and the sounds of cars and traffic from the street. From the figure below shops NC curve is not restricted to a specific number so it is assumed to be 50 dB.

Type of Space (and Acoustical Requirements)	NC Curve	Equivalent <sup>a</sup> dBA
Concert halls, opera houses, and recital halls (for listening to faint musical sounds).	10-20	20-30
Broadcast and recording studios (distant microphone pickup used).	15-20	25-30
Large auditoriums, large drama theatres, and houses of worship (for excellent listening conditions).	20-25	30-35
Broadcast, television, and recording studios (close microphone pickup only).	20-25	30-35
Small auditoriums, small theatres, small churches, music rehearsal rooms, large meeting and conference rooms (for good listening), or executive offices and conference rooms for 50 people (no amplification).	25-30	35-40
Bedrooms, sleeping quarters, hospitals, residences, apartments, hotels, motels, and so forth (for sleeping, resting, relaxing).	25-35	35-45
Private or semiprivate offices, small conference rooms, classrooms, libraries, and so forth (for good listening conditions).	30-35	40-45
Living rooms and similar spaces in dwellings (for conversing or listening to radio and TV).	35-45	45-55
Large offices, reception areas, retail shops and stores, cafeterias, restaurants, and so forth (for moderately good listening conditions).	35-50	45-60
Lobbies, laboratory work spaces, drafting and engineering rooms, general secretarial areas (for fair listening conditions).	40-45	50-55
Light maintenance shops, office and computer equipment rooms, kitchens, and laundries (for moderately fair listening conditions).	45-60	55-70
Shops, garages, power-plant control rooms, and so forth (for just acceptable speech and telephone communication). Levels above PNC-60 are not recommended for any office or communication situation.	—	—
For work spaces where speech or telephone communication is not required, but where there must be no risk of hearing damage.	—	—

Figure 189 Noise reduction in Db

#### 4.4.3.4 Sound transmission class (STC):

Sound transmission class (STC) it is a measure of how well the building partitions' isolate the sounds in the adjacent rooms. Here in this project, the sound transmission class (STC) of the internal and external walls will be calculated using the INSUL software. Down below is a figure that shows the standard STC for the partitions between different spaces, for the project STC should be 47-50 dB .

Type of Occupancy	Wall, Partition, or Panel Between		Sound Insulation Requirement: Background Level in Room Being Considered	
	Room Being Considered	and Adjacent Area	Quiet	Normal
	Normal school buildings without extraordinary or unusual activities or requirements	Classrooms	Adjacent classrooms Corridor or public areas Kitchen and dining areas Shops	STC 42 STC 40 STC 50 STC 50
		Recreation areas Music rooms Mechanical equipment rooms Toilet areas	STC 45 STC 55 STC 50 STC 45	STC 42 STC 50 STC 45 STC 42
	Music practice rooms	Adjacent practice rooms Corridor and public areas	STC 55 STC 45	STC 50 STC 42
Executive areas, doctors' suites; confidential privacy requirements	Office	Adjacent offices General office areas Corridor or lobby Washrooms and toilet areas	STC 50 STC 48 STC 45 STC 50	STC 45 STC 45 STC 42 STC 47
Normal office; normal privacy requirements; any occupancy using rooms for group meetings	Office	Adjacent offices Corridor, lobby, exterior Washrooms, kitchen, dining	STC 40 STC 40 STC 42	STC 38 STC 38 STC 40
	Conference rooms	Other conference rooms Adjacent offices Corridor or lobby Exterior of building Kitchen and dining areas	STC 45 STC 45 STC 42 STC 40 STC 45	STC 42 STC 42 STC 40 STC 38 STC 42
Large offices, drafting areas, banking floors, etc.	Large general office areas	Corridors, lobby, exterior Data-processing area Kitchen and dining areas	STC 38 STC 40 STC 40	STC 35 STC 38 STC 38
Motels and urban hotels Hospitals and dormitories	Bedrooms	Adjacent bedrooms <sup>a</sup> Bathroom <sup>a</sup> Living rooms <sup>a</sup> Dining areas Corridor, lobby, or public spaces	STC 52 STC 50 STC 45 STC 45 STC 45	STC 50 STC 45 STC 42 STC 42 STC 42

Figure 190 sound transmission standard

#### 4.4.3.5 Impact insulation class (IIC):

Impact Insulation Class (IIC) it is a classification of the ability of a floor or a ceiling in the building to block or impact the structure-borne noise from transmitting through it to the spaces below it. IIC for floor-ceiling should be between 45-50 dB

Assembly Function between Dwellings			Grade II	
Apt. A		Apt. B	STC	IIC
Bedroom	Above	Bedroom	52	52
Living room	Above	Bedroom <sup>a</sup>	54	57
Kitchen <sup>b</sup>	Above	Bedroom <sup>a,c</sup>	55	62
Family room	Above	Bedroom <sup>a,d</sup>	56	62
Corridor	Above	Bedroom <sup>a</sup>	52	62
Bedroom	Above	Living room <sup>e</sup>	54	52
Living room	Above	Living room	52	52
Kitchen	Above	Living room <sup>a,c</sup>	52	57
Family room	Above	Living room <sup>a,d</sup>	54	60
Corridor	Above	Living room <sup>a</sup>	52	57
Bedroom	Above	Kitchen <sup>c,e</sup>	55	50
Living room	Above	Kitchen <sup>c,e</sup>	52	52
Kitchen	Above	Kitchen <sup>c</sup>	50	52
Bathroom	Above	Kitchen <sup>a,c</sup>	52	52
Family room	Above	Kitchen <sup>a,c,d</sup>	52	58
Corridor	Above	Kitchen <sup>a,c</sup>	48	52
Bedroom	Above	Family room <sup>e</sup>	56	48
Living room	Above	Family room <sup>e</sup>	54	50
Kitchen	Above	Family room <sup>e</sup>	52	52
Bathroom	Above	Bathroom <sup>c</sup>	50	50
Corridor	Above	Corridor	48	48

Figure 191 Impact insulation class

#### 4.4.4 Results from Ease Software, INSUL software, and from ease address software respectively:

##### 4.4.4.1 Reverberation time using Ease 4.3:

Reverberation time for shopping store number 13 with dimensions of (9.1m \* 5.36m) located in the middle of the ground floor. Materials used with different absorption coefficient on different frequencies for shopping store number 13 as the following:

Table 92 absorption coefficient for materials used in shopping store 13

Building structure	Material used	250hz	500hz	1000hz	2000hz
Ceiling	Gypsum 12.5 MMB	0.29	0.2	0.1	0.04
Floor	Parquet con	0.05	0.18	0.1	0.09
Wall length	Wood paneling	0.9	0.8	0.5	0.4
Wall Width	Plaster/ LTHR	0.09	0.07	0.05	0.05
windows	Glass 6 mm	0.06	0.04	0.03	0.02

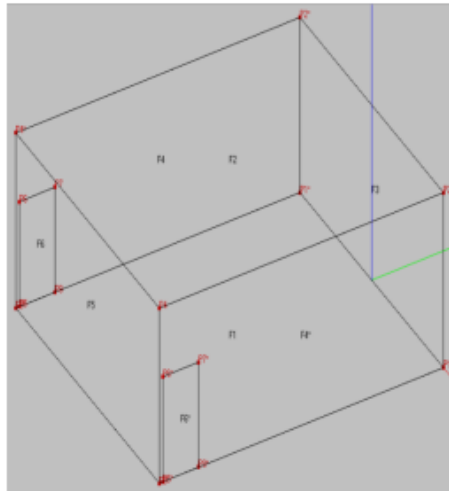


Figure 192 Ease layout for Shopping store number 13

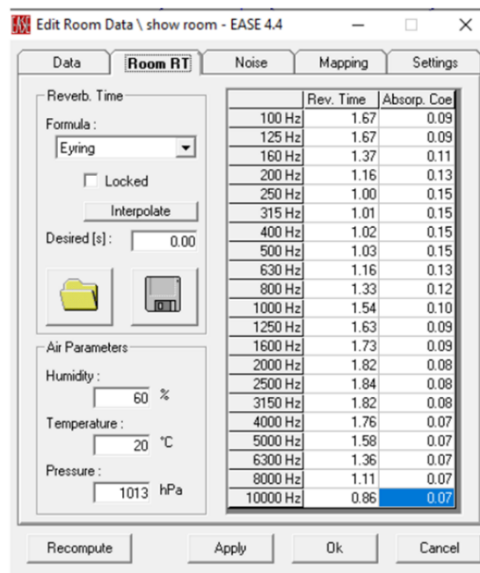


Figure 193 Ease results for reverberation time on different frequencies for shopping store number 13

Based on the results above RT60 on 1000hz is 1.54 which acceptable and within range (1.4-2.0).

#### 4.4.4.2 STC and IIC using INSUL software:

here in this project the STC should be between 47-50 dB as mentioned before FFOR the internal partitions, after calculations using INSUL software we achieved an internal partition with a STC 49 dB, which is in the range needed and illustrated in the picture below using 20cm thick blocks instead of 15cm blocks and with plaster 1.5cm instead of 2.5cm:

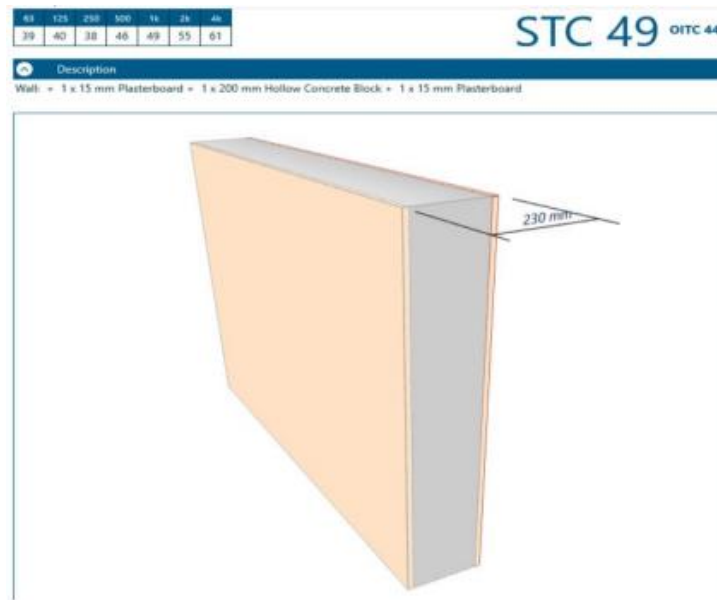


Figure 194 STC result for internal partitions in the ground floor

#### 4.4.4.3 Loud speaker's distribution using Ease Address:

Loud speakers' distribution for shopping store number 13:

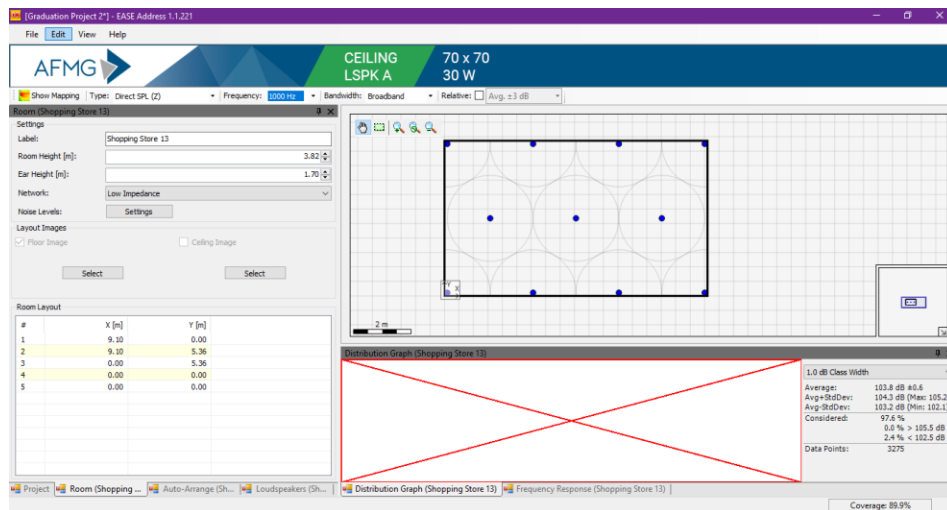


Figure 195 shopping store number 13 layout on EASE address

In this project a 30-watt speaker in the ceiling will be used with dimensions of 70cm\*70cm, also a hexagonal distribution of the speakers with minimum overlap:

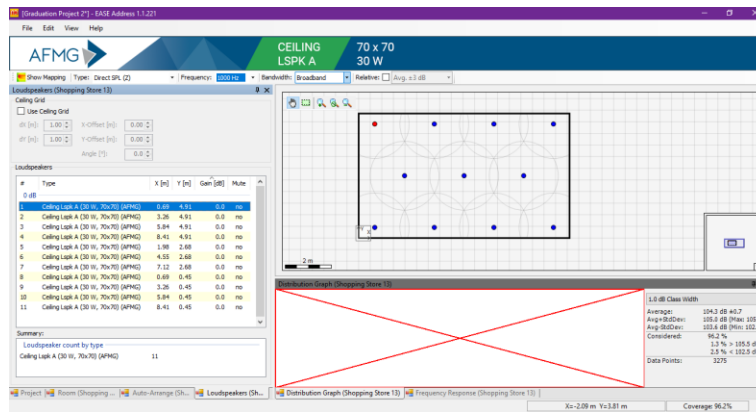


Figure 196 speakers selection and dimension

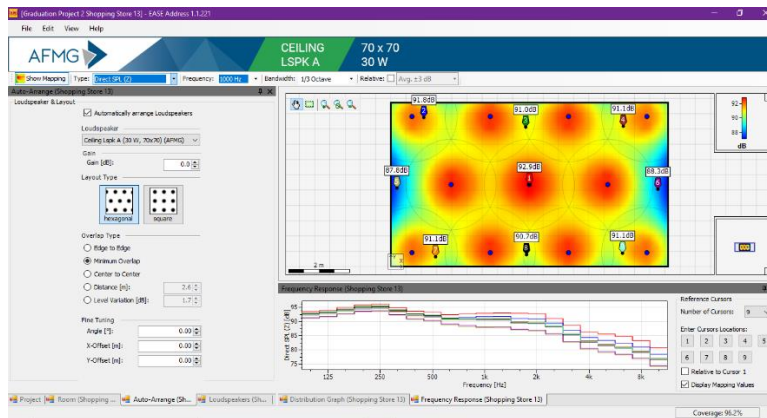


Figure 197 direct SPL in the shopping store (hexagonal distribution)

In the picture above the speakers can provide up to 92 dB, and can be dimmed down to meet the standards' SPL. Nothing less than 50 dB. So the articulation loss will be nearly zero.

Down below is a picture that shows the noise/sound ratio, it is around the standard which is 50 dB:

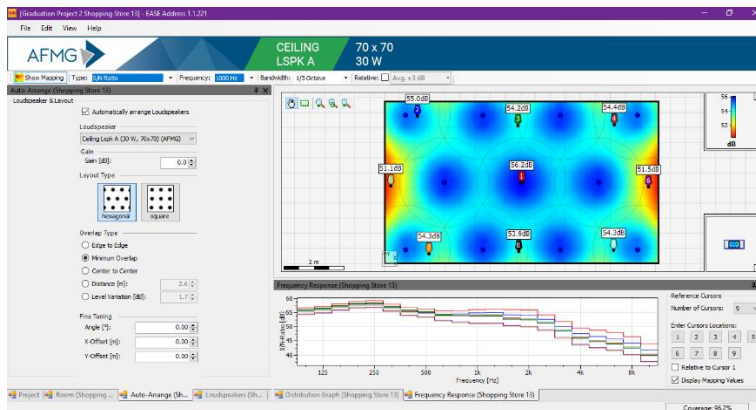


Figure 198 noise/sound ratio (hexagonal distribution)

Instead of using 11 speakers for this store which can be expensive, so another trial was done using just 3 speakers which covered almost all of the area needed and with a slight difference in the SPL. The critical scenario to design is the following, a rectangular distribution of the same speakers in the center of the room:

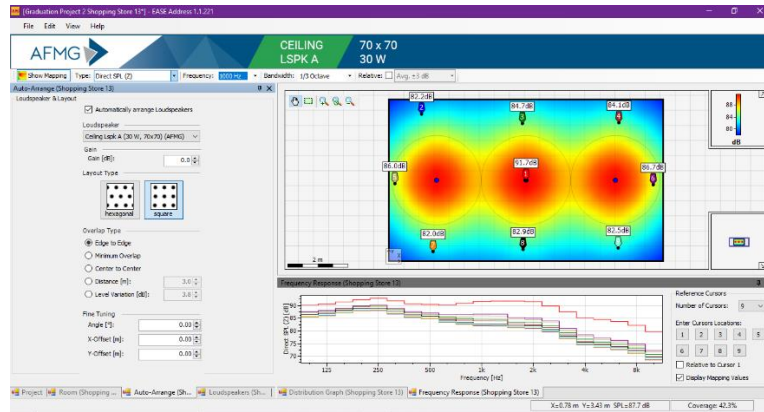


Figure 199 direct SPL in the shopping store (rectangular distribution)

As can be seen in the picture above, still having up to 82 SPL in the places the speakers do not cover directly.

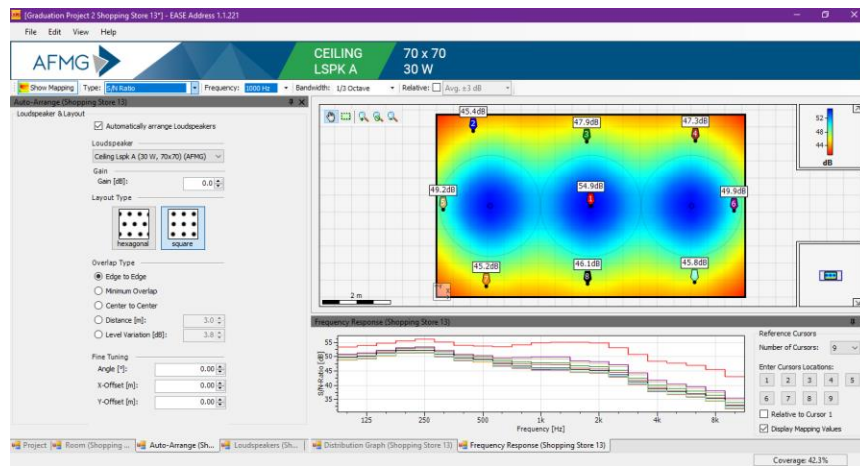


Figure 200 noise/sound ratio (rectangular distribution)

## 4.5 Fire alarm and Firefighting systems

### Introduction:

Fire is one of the most dangerous and phenomenal hazards that may face buildings, which significantly affect buildings in big way, the occupants inside them, and even the materials used in place. Therefore, in general, the occurrence of fire cannot be prevented, but rather they can be controlled, and this is what an engineer should work on to design and establish the fire suppression system in the buildings. This point is effective to a degree that enables lowering the danger and saving the occupants and the building in the first degree.

In this project, a fire suppression system will be designed for the 9-story shopping store and residential building where two floors of parking, 1 floor of shopping stores, 5 floors of residential and roof.

The nature of the spaces and rooms in the building varies widely and this is in good demand.

The building's rooms and spaces have a wide range of characteristics, so choosing the fire suppression system in each space.

### 4.5.1 Firefighting systems:

In this building, three different kinds of fire suppression systems will be employed:

- 1.) Sprinklers
- 2.) Host terminal system
- 3.) Fire Extinguisher

#### Fire Extinguisher :

It's a pressure vessel that is cylindrical in shape and has a dischargeable extinguishing chemical inside that puts out fires. It may be used to a minor fire without affecting the automated sprinkler system, should it start to spread. We utilized it in retail establishments, placing one device in each store.

	A	B	C	D	E	F
	Wood, paper, plastics, soft furnishings etc.	Flammable liquids, petrol, oil etc.	Flammable gases, propane, butane, methane etc.	Metals; aluminium, magnesium, titanium, swarf etc.	Electrical apparatus, computers, phone chargers etc.	Cooking oils & fats
AFF FOAM	✓	✓				
WATER	✓					
WET CHEMICAL	✓					✓
CO2		✓			✓	
DRY POWDER	✓	✓	✓		✓	
L2 & M28 POWDER				✓		

Figure 201:selection of type extinguisher

And to choose the type of extinguisher we use the figure below

From previous figure we choose L2 & M28 POWDER because we thought it was the most suitable because there are different materials in the shops.

And for more safety we put a one extinguisher each 10 meters of corridors.



Figure 202 Powder fire extinguisher

#### ✚ Hose terminal system :

It is a system for extinguishing fires using high-pressure water flow, and it is a large-scale system in corridors and is usually used in public buildings.

In our project, we placed it in the corridors in a place that allows shops to use it

The length of the hose is about 30 meters.



Figure 203 Hose terminal station

The following figure show the data sheet of hose station used in the building:

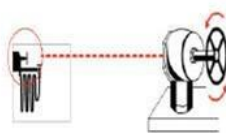
**Equipment**

1. Landing valve: Designed to B.S 2060 & B.S 5041  
Available in following sizes & types:-  
2" Thread x 2.5" INST 30° Landing valve bronze, Model 1711  
2" Thread x 2.5" 90° pin Rack landing valve Bronze Model 1713  
2.5" Flange x 2.5" INST. Landing valve (Bronze), Model 1718  
2.5" Flange x 2.5" INST. Landing valve with plastic cap & chain (Red finishing), Model 1719  
2.5" Flange x 2.5" INST Combined landing valve with pressure regulator (Bronze), Model EPR.V 1722  
2.5" Flange x 2.5" INST combined landing valve with pressure regulator (Red finishing) Model Standby P.R.V
2. Fire Hose: Synthetic rubber with textile reinforcement, Heavy duty Professional's fire hose to BS.6391 & 15636: 88 Standard length 100ft & 75 ft
3. Hose coupling: As standard hoses are normally equipped with light alloy aluminium male and female instantaneous couplings to BS.336 other couplings to customer requirements on request.
4. Fire Hose Nozzles: Available in two types:-  
Jet/spray/off Branch pipes, Model 1006 Diffuser type to BS 1490, Model DN
5. Hose Rack Assembly: Designed to BS. 5423. It is a pin type rack, red colour and usually furnished with stanely right angle valve. Model PRA

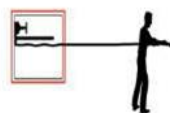
Figure 204 Hose station system we used in building

➤ In the following figure show you how to use hose terminal system

1. Open valve completely.



2. Pull hose entirely off rack (or else water will not flow).



3. Open nozzle. Water will flow when hose is entirely off rack and nozzle is open.



Figure 205 How we use hose station

## ✚ Sprinklers :

It is another way to put out fires, and there are several types of them, but we used the wet-pipe sprinkler in our project. This system was used mainly in residential floors and parking floors, and it was used on the ground floor (shopping stores) in the corridors only.

The following figure shows the type of sprinklers we used in building:

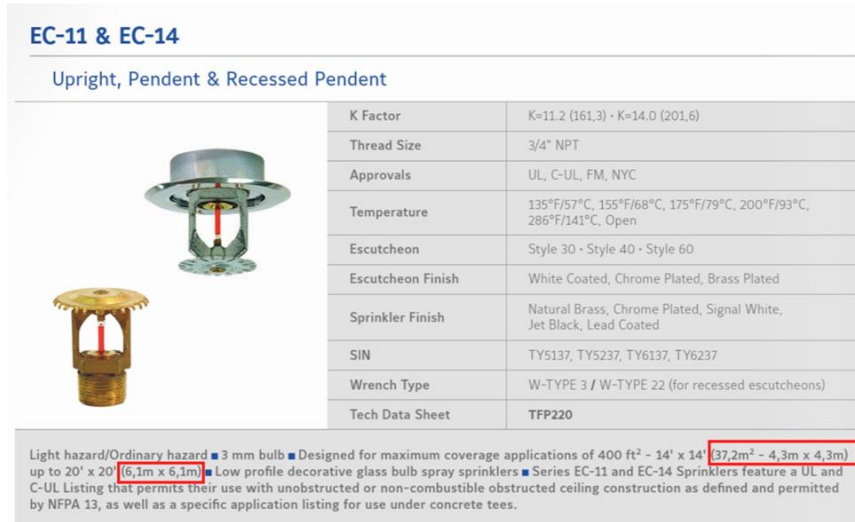


Figure 206 Catalogue of sprinklers

As we see in the previous figure the area covered by one unite about (37.2 m<sup>2</sup>)

- Show you the number of sprinklers on each floor in the building by the following table:

Table 93 number of sprinklers in each floor:

floor	The area in which the sprinkler is placed	Coverage area of sprinkler m <sup>2</sup>	Number of sprinkler
Basement 1	944	37.2	25
Basement2	944	37.2	25
Ground floor	315.6	37.2	9

<b>First floor</b>	<b>945</b>	<b>37.2</b>	<b>26</b>
<b>Second floor</b>	<b>945</b>	<b>37.2</b>	<b>26</b>
<b>Third floor</b>	<b>945</b>	<b>37.2</b>	<b>26</b>
<b>Fourth floor</b>	<b>945</b>	<b>37.2</b>	<b>26</b>
<b>Fifth floor</b>	<b>945</b>	<b>37.2</b>	<b>26</b>
<b>Roof</b>	<b>264</b>	<b>37.2</b>	<b>7</b>

➤ **Pipes:**

Steel pipes were used to connect sprinklers, tanks and individual floors in fire extinguishing networks

The pipe diameters required according to civil defense requirements are shown in the table below. 3.5-inch diameter pipes were used to connect the floors, while 2.5-inch diameter pipes were used to reach the sprinklers horizontally within floor

*Table 94 steel pipes diameter*

<b>Steel pipes</b>	
<b>Diameter</b>	<b>Number of sprinklers</b>
1 in.	2 sprinklers
1¼ in.	3 sprinklers
1½ in.	5 sprinklers
2 in.	10 sprinklers
2½ in.	30 sprinklers
3 in.	60 sprinklers
3½ in.	100 sprinklers
4 in.	See Section 8.2

➤ **Water tank:**

The building's roof was equipped with 2000-liter water tanks, which were used to supply water to the firefighting system. In case of a water shortage, the tanks were connected to the rainwater tank beneath the building, and a water hose was extended outside the building to allow water to be supplied to the system via fire trucks and Civil Defense.

**4.5.2 Fire alarm systems:**

✚ **Detectors:**

We use two types of detectors :

1.) Heat detectors :

We used heat detector type in parking lots instead of smoke detectors because the parking lots are filled with car smoke. We also placed it in corridors in ground floor and in the kitchens of residential floors.

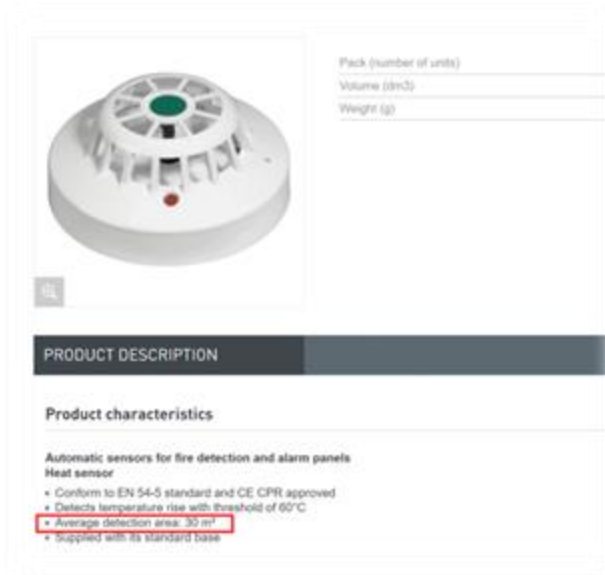


Figure 207 heat detector

2.) Smoke detectors:

We used smoke detectors in shopping stores on ground floor, in residential floors and roof because the percentage of smoke in these spaces is low.

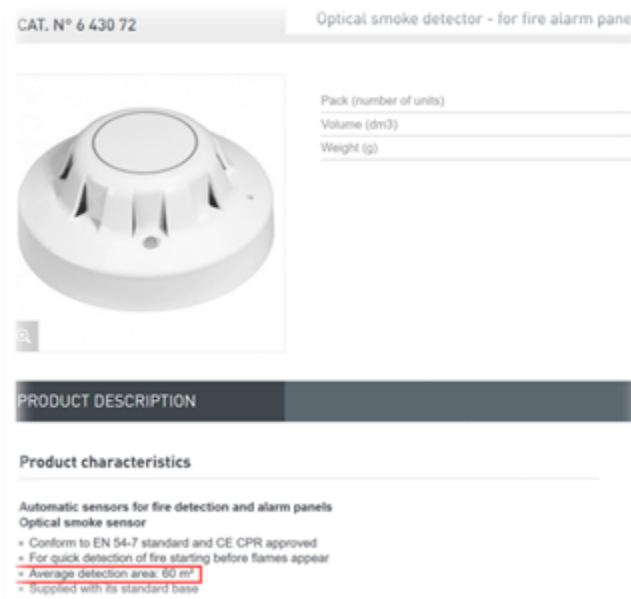


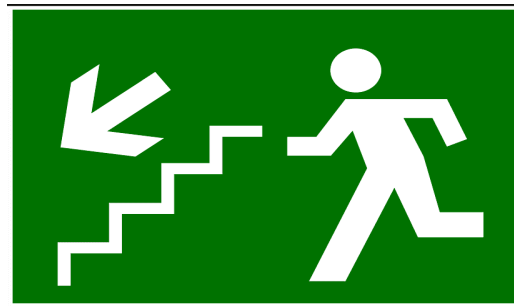
Figure 208 Smoke detector

### **✚ Signs and escape exits:**

Because visitors to the building may not be fully aware of the building's entrances and exits, signs, whether written or electronic, must be erected inside the structure to indicate how to get to the escape exits and how to evacuate the building in the case of a fire or any other risks.



*Figure 209 Exit sign*



*Figure 210 Exit sign for upper floors*



*Figure 211 Exit sign for basement floors*

- Down below are figures that shows the sprinkler system used in fires, and also will show the escape routes in the building:

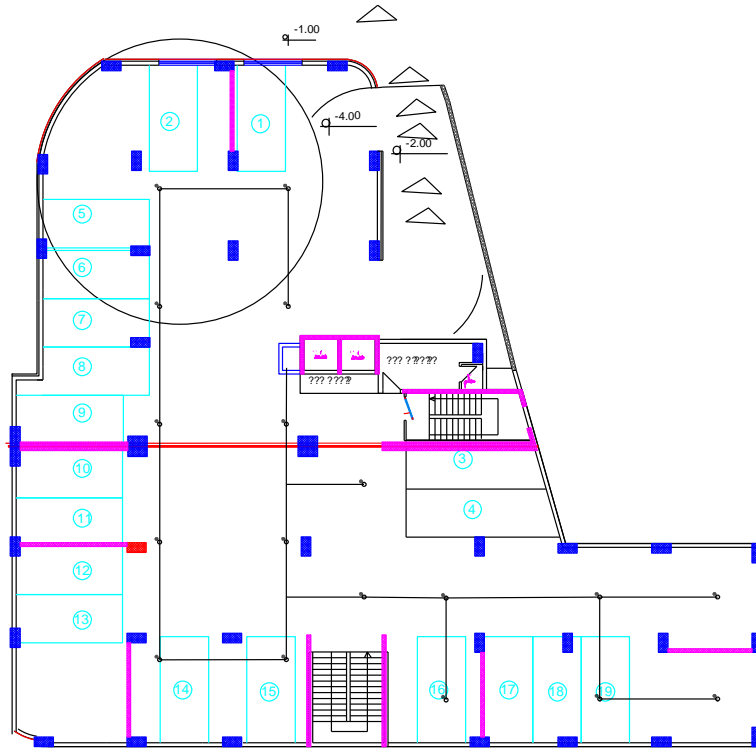


Figure 212: Fires system used in parking 1

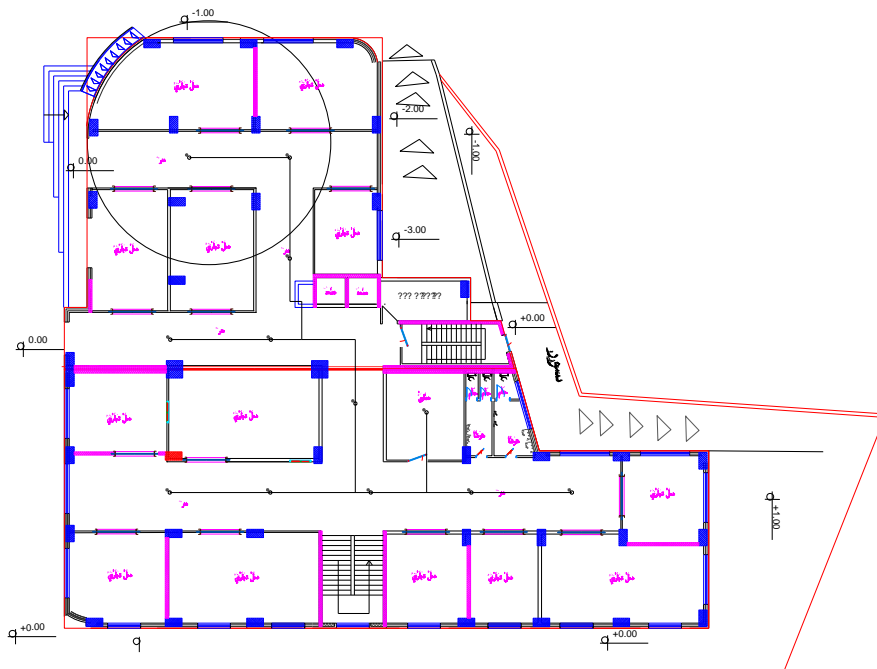


Figure 213 Fire system used in GF

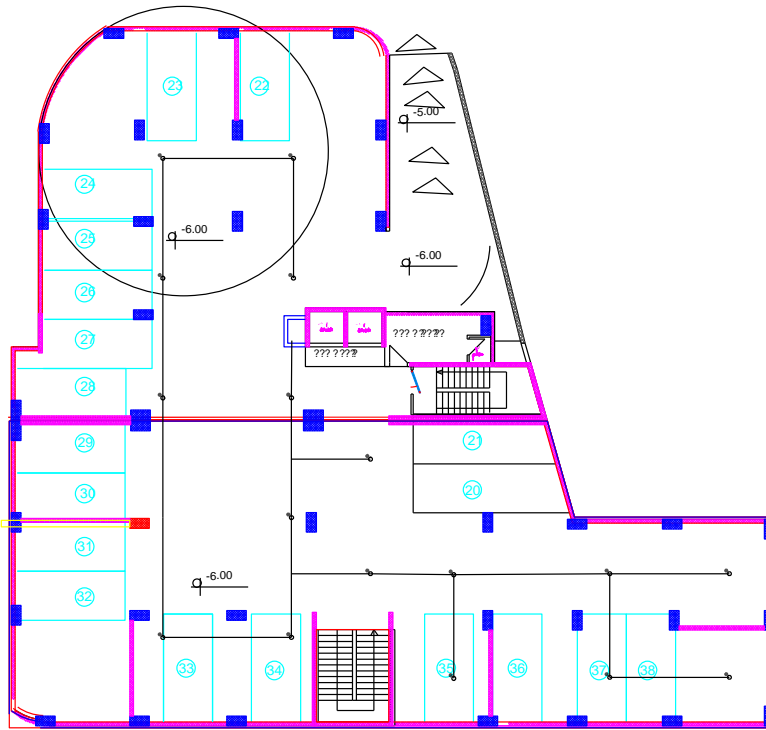


Figure 214: Fire system used in parking 2

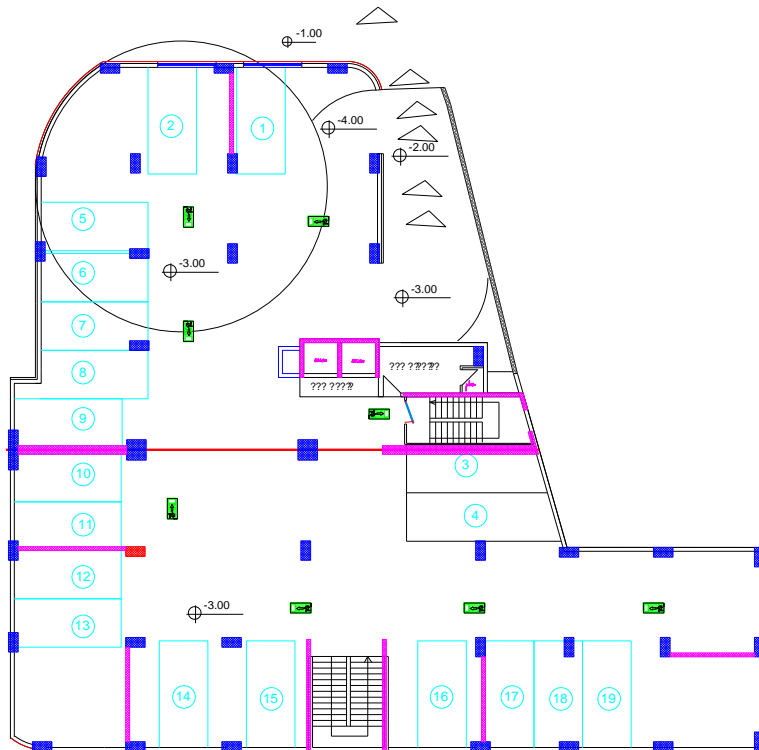


Figure 215 Escape routes for Parking

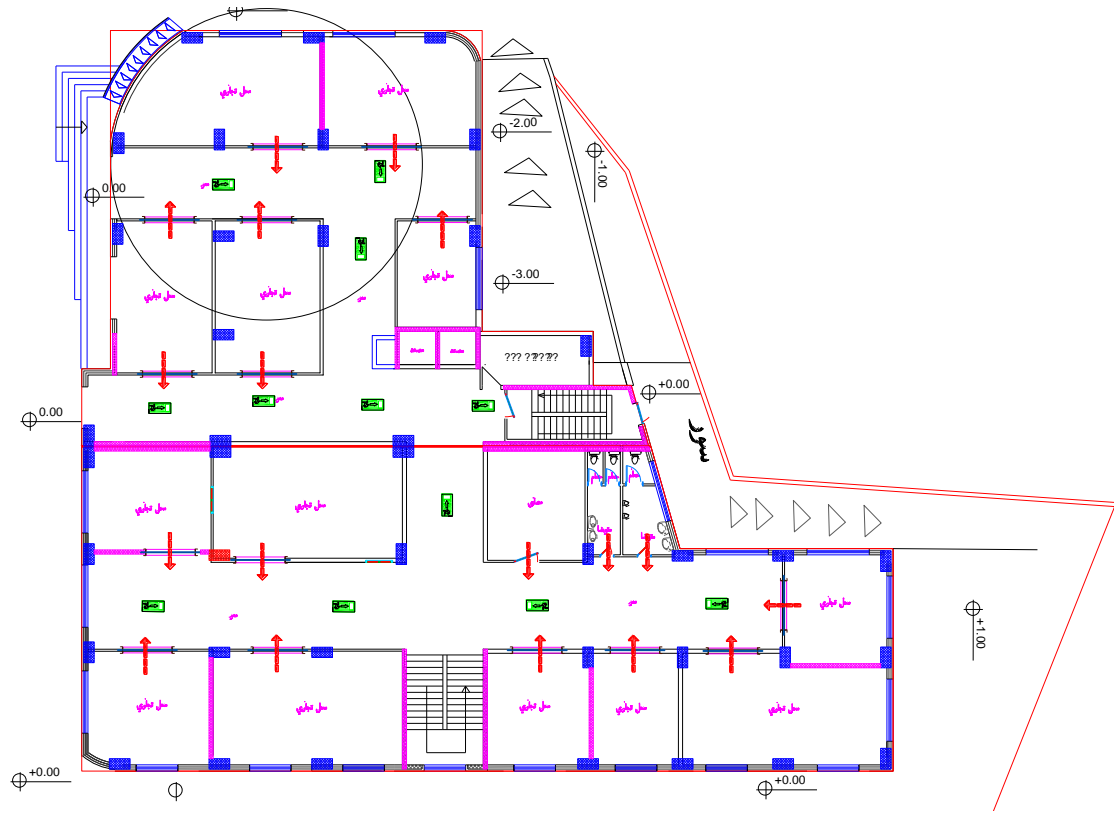


Figure 216 Escape routes in GF

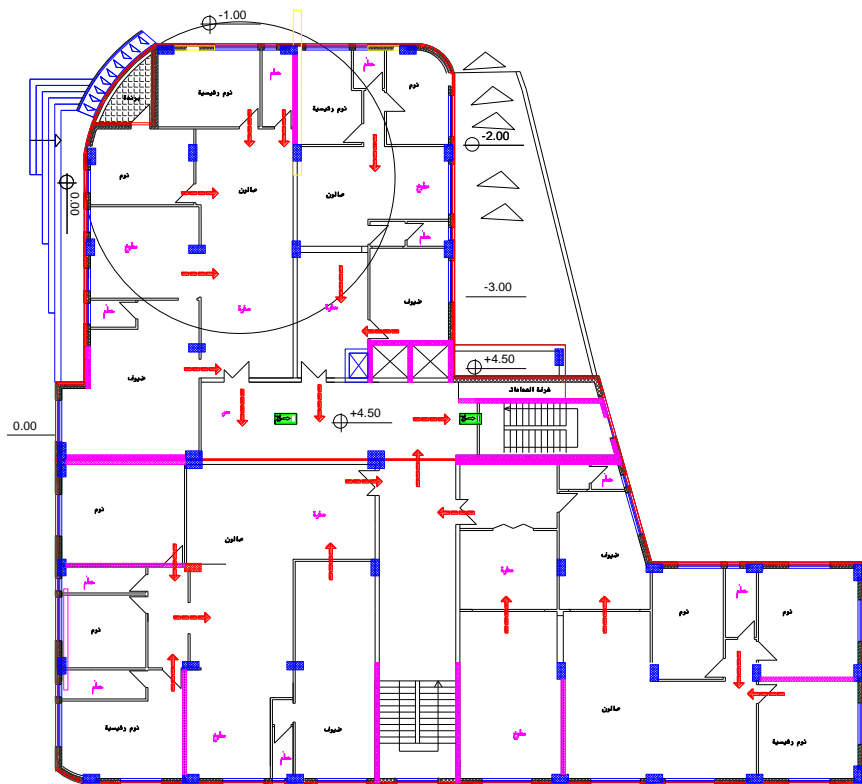


Figure 217 Escape routes in residential floors

## 4.6 Water supply

It is the system that supplies water to every part of the structure for applications like drinking, cleaning, and other purposes. Creating a system that is sufficient to meet all of these demands is crucial.

Table 95 estimation for water consumption

Estimation for the water consumption			
Type of user	Number of user	Consumption per person	Total consumption (liter)
resident person	240	80	19200
Market	36	80	2880
Visitors	50	5	250
<b>Total summation</b>			<b>22330</b>

- **The required number of roof tanks:**

A tank with a capacity of 3 m<sup>3</sup> will be taken.

$$\text{Number of roof tanks} = \frac{\text{total consumption}}{\text{tank capacity}} = \frac{22.330}{3} = 7.44$$

So, the number of tanks = 8 tanks

- **The location of the roof tanks :**

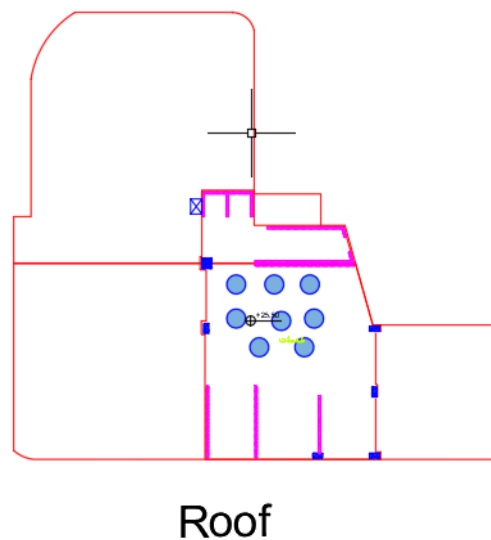


Figure 218 location of tanks (top view)



Figure 219 section of tank and floors

- Tank description:



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Figure 220 data sheet for tanks

Table 96 specifications of tanks

Code No.	Capacity (L)	Diameter (mm)	Height (mm)	Diameter of manhole (mm)
WSCC-0050-01-RENO-WHITE	500	900	875	400
WSCC-0070-01-RENO-WHITE	700	900	1195	400
WSCC-0100-01-RENO-WHITE	1000	1110	1170	406
WSCC-0150-01-RENO-WHITE	1500	1365	1155	400
WSCC-0200-01-RENO-WHITE	2000	1365	1515	407
WSCC-0250-01-RENO-WHITE	2500	1365	1875	400
WSCC-0300-01-RENO-WHITE	3000	1500	1875	400
WSCC-0500-01-RENO-WHITE	5000	1800	2175	510
WSCC-1000-01-RENO-WHITE	10000	2130	3155	510

- **Pipe diameter calculations :**

The numbers in the following table will be used to calculate the total number of fixture units that the vertical line should support:

Table 97 water supply fixture unites

Fixture	Occupancy	Type of Supply Control	Load Values in WSFU		
			Cold	Hot	Total
Bathroom group	Private	Flush tank	2.7	1.5	3.6
Bathroom group	Private	Flush valve	6	3	8
Bathub	Private	Faucet	1	1	1.4
Bathub	Public	Faucet	3	3	4
Bidet	Private	Faucet	1.5	1.5	2
Combination fixture	Private	Faucet	2.25	2.25	3
Dishwashing machine	Private	Automatic		1.4	1.4
Drinking fountain	Offices, etc.	¾ in. (9.5 mm) valve	0.25		0.25
Kitchen sink	Private	Faucet	1	1	1.4
Kitchen sink	Hotel, restaurant	Faucet	3	3	4
Laundry trays (1 to 3)	Private	Faucet	1	1	1.4
Lavatory	Private	Faucet	0.5	0.5	0.7
Lavatory	Public	Faucet	1.5	1.5	2
Service sink	Offices, etc.	Faucet	2.25	2.25	3
Shower head	Public	Mixing valve	3	3	4
Shower head	Private	Mixing valve	1	1	1.4
Urinal	Public	1 in. (25 mm) flush valve	10		10
Urinal	Public	¾ in. (19 mm) flush valve	5		5
Urinal	Public	Flush tank	3		3
Washing machine, 8 lb (3.6 kg)	Private	Automatic	1	1	1.4
Washing machine, 8 lb (3.6 kg)	Public	Automatic	2.25	2.25	3
Washing machine, 15 lb (6.8 kg)	Public	Automatic	3	3	4
Water closet	Private	Flush valve	6		6
Water closet	Private	Flush tank	2.2		2.2
Water closet	Public	Flush valve	10		10
Water closet	Public	Flush tank	5		5
Water closet	Public or private	Flushometer tank	2		2

Source: International Plumbing Code. © 1997, International Code Council, Falls Church, VA. Reprinted with permission. All rights reserved.

The next table describes the way the assumption for the number of fixture units in the main vertical line:

Table 98 number of fixtuers

Vertical main feeder	FU
GF ( markets)	27
1 <sup>st</sup> – 5 <sup>th</sup> floor (residential)	221
Parking	2.8
<b>Total</b>	<b>250.8</b>

- Water flow for the main vertical line calculated from the following by number of fixture unites :

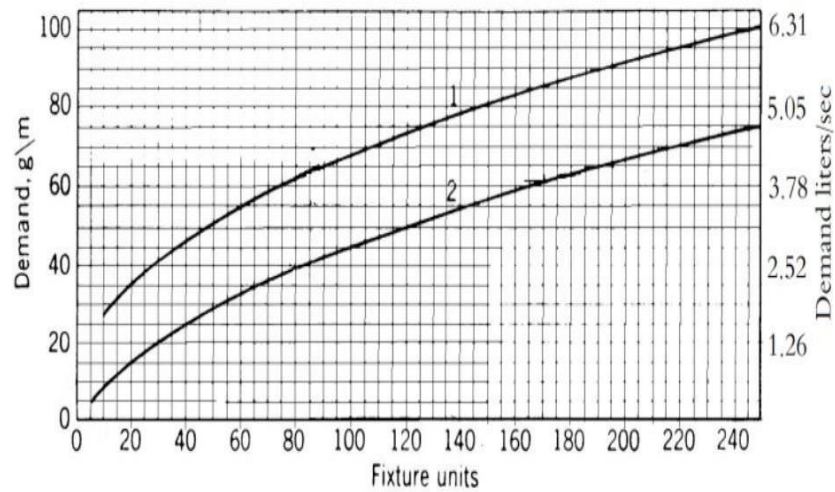


Figure 221 water flow chart

The number of FU is equal to **250.8 FU**

from the previous chart the water flow is **75g/m**

Table 99 Calculations of pressure

floor	h floor (ft)	Cumulative height of floors (ft)	Unite fixture
B2	9.84	103.32	1.4
	9.84	93.48	1.4
GF	14.76	83.64	27
	11.48	68.88	44.2

2nd floor	11.48	57.4	44.2
	11.48	45.92	44.2
4th floor	11.48	34.44	44.2
	11.48	22.96	44.5
roof	11.48	11.48	---

- **Design of vertical pipes :**

Total Type :steel pipes.

Total weigh in fixture unit = 250.8 UF

Flow = 75 gpm

Actual length = 103.32 ft

Equivalent length = 1.2 \* actual length

Equivalent length = 1.2 \* 103.32 = 123.98 ft

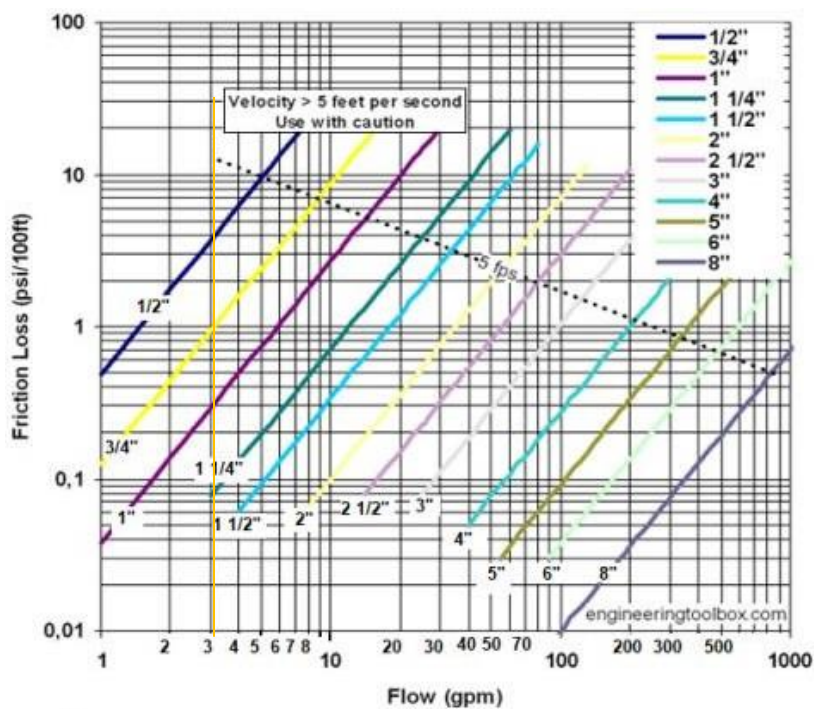


Figure 222 pipe diameter (flow & friction loss)

This table shows the pipe diameter and friction loss in each pipe

Table 100 diameter of the pipe and the friction loss in main vertical feeder

Diameter	5"	4"	3"	2.5"	2"	1.5"
Loss/100'	0.048	0.17	0.48	1.8	3.9	12
Loss/103.3'	0.0496	0.1756	0.496	1.8594	4.0287	12.396

- **Design of horizontal pipes :**

The critical length = 24.01 m so length in (ft) = 78.77 ft

Equivalent length = 1.2 \* 78.77 = 94.52 ft

Pipe sizing and friction loss calculation

Where unite flow in this part = 11

This table shows the pipe diameter and friction loss in each pipe:

Table 101 pipe diameter and friction loss for horizontal pipes

Diameter	2"	1.5"	1.25"	1"
Loss/100'	0.11	0.4	0.8	2.1
Loss/94.52'	0.104	0.378	0.756	1.985

- **Pressure design :**

$P = 0.433 * h$  (cumulative height of floors in feet)

H tank = 6.15 ft

Number of floor = 9 floor

Table 102 pressure calculations

floor	h floor (ft)	Cumulative height of floors (ft)	pressure
B2	9.84	103.32	44.74
	9.84	93.48	40.48
GF	14.76	83.64	36.22
	11.48	68.88	29.83
2nd floor	11.48	57.4	24.85
	11.48	45.92	19.88
4th floor	11.48	34.44	14.91
	11.48	22.96	9.94
roof	11.48	11.48	4.97

- The following figures show the water supply plans :

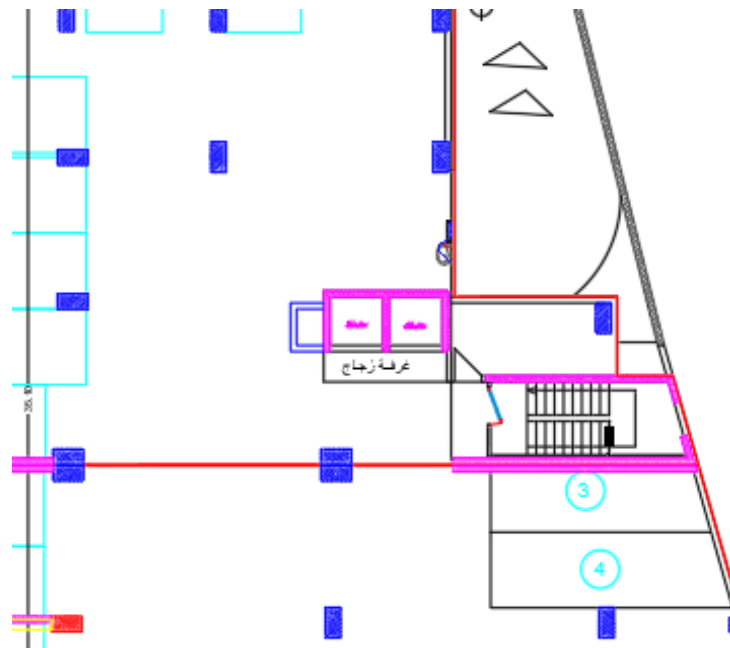


Figure 223 Parkings water supply plan

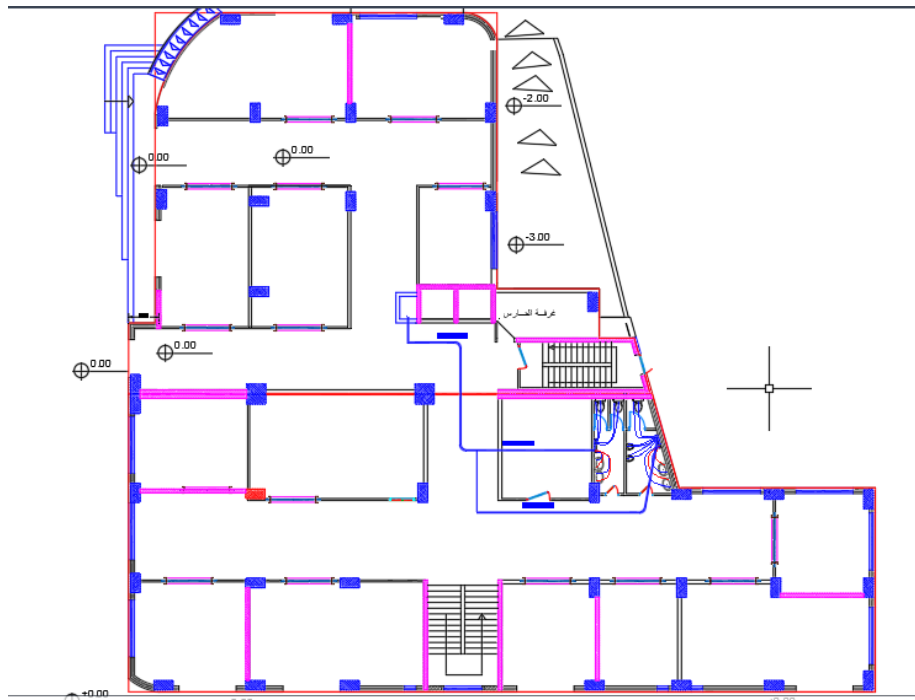


Figure 224 GF ( Market ) water supply plan

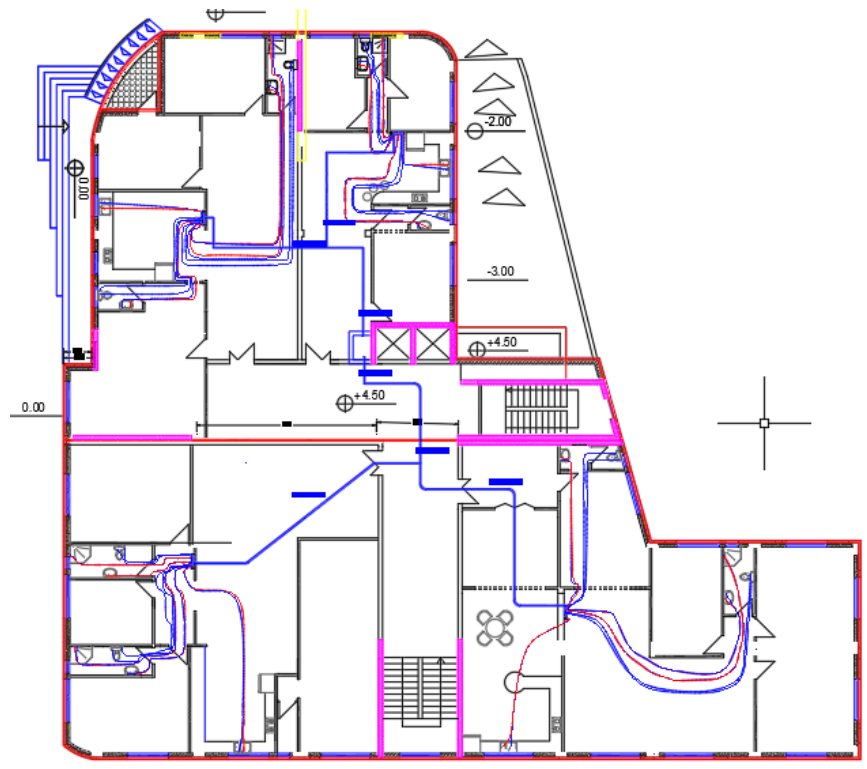


Figure 225 1st - 5th floor (residential) water supply plans

## 4.7 Drainage and Rain water

### 4.7.1 Drainage

One of the most crucial systems that must be planned for in each building is the sewage system, which uses specialized pipes to move liquid waste from the structure and correctly dispose of it in the public sewage lines.

The sewage system was created using the following guidelines and tables:

Table 103 Drainage fixture unites

Fixture(s)	Drainage Fixture Units (dfu)	Minimum Trap Size	
		in.	mm <sup>a</sup>
Automatic clothes washers: Commercial <sup>b</sup>	3	2	51
Residential	2	2	51
Bathroom group: Water closet (1.6 gpf [6 Lpf]), lavatory, and bathtub or shower, with or without a bidet and emergency floor drain	5	—	—
Bathroom group: Water closet (>1.6 gpf [6 Lpf]), lavatory, and bathtub or shower, with or without a bidet and emergency floor drain	6	—	—
Bathtub <sup>c</sup> (with or without overhead shower or whirlpool)	2	1½	38
Bidet	1	1¼	32
Combination sink and tray	2	1½	38
Dental lavatory	1	1¼	32
Dental unit or cuspidor	1	1¼	32
Dishwashing machine <sup>d</sup> , domestic	2	1½	38
Drinking fountain	0.5	1¼	32
Emergency floor drain	0	2	51
Floor drains	2	2	51
Kitchen sink, domestic	2	1½	38
Kitchen sink, domestic, with food waste grinder and/or dishwasher	2	1½	38
Laundry tray (1 or 2 compartments)	2	1½	38
Lavatory	1	1¼	32
Shower	2	1½	38
Service sink	2	1½	38
Sink	2	1½	38
Urinal	4	e	e
Urinal, 1 gal (3.8 L) per flush or less	2 <sup>f</sup>	e	e
Urinal, nonwater supplied	0.5	e	e
Wash sink (circular or multiple) each set of faucets	2	1½	38
Water closet, flushometer tank, public or private	4 <sup>f</sup>	e	e
Water closet, private (1.6 gpf [6 Lpf])	3 <sup>f</sup>	e	e
Water closet, private (>1.6 gpf [6 Lpf])	4 <sup>f</sup>	e	e
Water closet, public (1.6 gpf [6 Lpf])	4 <sup>f</sup>	e	e
Water closet, public (flushing >1.6 gpf [6 Lpf])	6 <sup>f</sup>	e	e

Table 104 Diameter of pipes

Diameter of Pipe		Maximum Number of dfu Connected to Any Portion of the Building Drain or Building Sewer, Including Branches of the Building Drain <sup>a</sup> Fall, in. per ft (% slope)			
in.	mm <sup>b</sup>	⅛ (0.5%)	¼ (1.04%)	⅓ (2.1%)	½ (4.2%)
2	51			21	26
2½	64			24	31
3	76		36	42	50
4	102		180	216	250
5	127		390	480	575
6	152		700	840	1000
8	203	1400	1600	1920	2300
10	254	2500	2900	3500	4200
12	305	3900	4600	5600	6700
15	381	7000	8300	10,000	12,000

Table 105 Diameter of horizontal pipes

Diameter of Pipe		Maximum Total Number of dfu Allowable			
		Horizontal Branch	Stacks <sup>b</sup>		
in.	mm <sup>c</sup>		One Branch Interval	Three Branch Intervals or Less	Greater than Three Branch Intervals
1½	38	3	2	4	8
2	51	6	6	10	24
2½	64	12	9	20	42
3	76	20	20	48	72
4	102	160	90	240	500
5	127	360	200	540	1100
6	152	620	350	960	1900
8	203	1400	600	2200	3600
10	254	2500	1000	3800	5600
12	305	3900	1500	6000	8400
15	381	7000	d	d	d

➤ As shown in the previous tables the fixture unites used are :

- ❖ Bathroom group : 6 dfu
- ❖ Floor drains : 2 dfu
- ❖ Kitchen sink : 2 dfu
- ❖ Urinal : 4 dfu
- ❖ Water closet public : 6 dfu
- ❖ Sink : 2 dfu

➤ And now I will show the distribution of fixture unites used on each floor :

- GF ( market ) :

Table 106 distribution of fixture unites in GF

DF Number of Gf	
Ablution 1	4 dfu
Ablution 2	12 dfu
WC 1	6 dfu
WC 2	6 dfu
WC 3	6 dfu

- 1<sup>st</sup> floor – 5<sup>th</sup> floor :

*Table 107 distribution of unite fixtures in 1st floor*

<b>DF Number of 1<sup>st</sup></b>	
<b>Kitchens</b>	16 dfu
<b>Baths</b>	48 dfu

- ✚ Note that our floors from the first floor to the fifth floor are similar residential floors and have the same distribution of unite fixtures .

- Parking :

*Table 108 distribution of unite fixture in parkings*

<b>DF Number of parkings</b>	
<b>Sinks</b>	4 dfu

- Drainage pipe used and the slope

This table shows the Diameter of the pipe used and the slope of each pipe:

*Table 109 diameter of pipes and it's slope*

<b>Type of pipe</b>	<b>Diameter</b>	<b>slope</b>
<b>Vertical vent</b>	4in	<b>0%</b>
<b>Vertical stack</b>	4in	<b>0%</b>
<b>Horizontal sewers</b>	4in , 2in	<b>0.15%</b>
<b>branches</b>	4in	<b>0.15%</b>
<b>Horizontal drain</b>	<b>4in</b>	<b>0.15%</b>

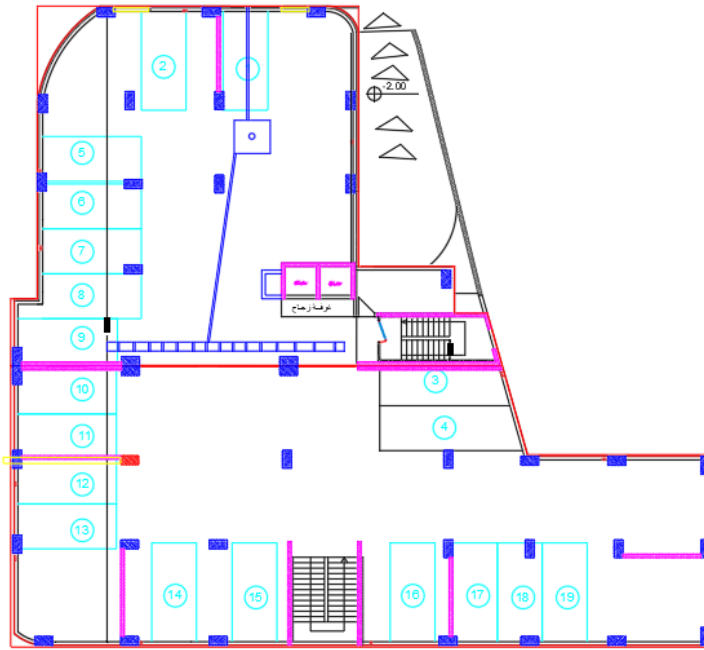


Figure 226: parking plan for drainage

➤ The following figures show the water drainage on floors :

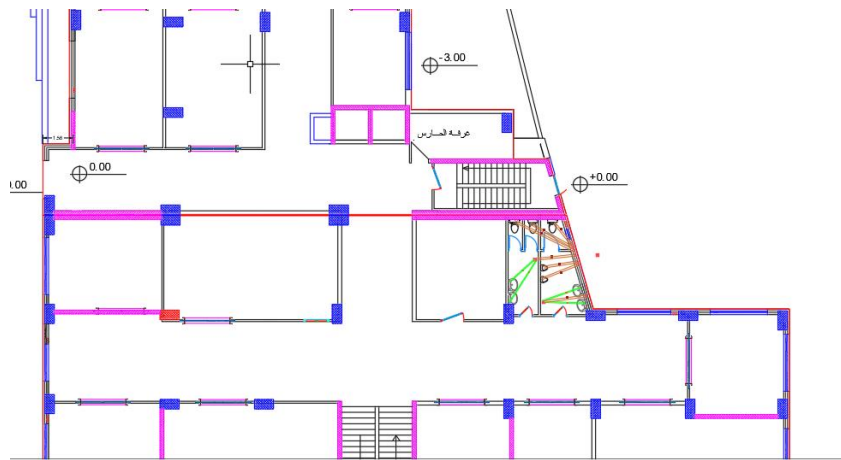


Figure 241: ground floor drainage plan

As we see in the figure above we have a drainage plan for the ground floor (Markets) including the tow ablutions and three of public baths. Note that our floors from the first floor to the fifth floor are similar residential floors.

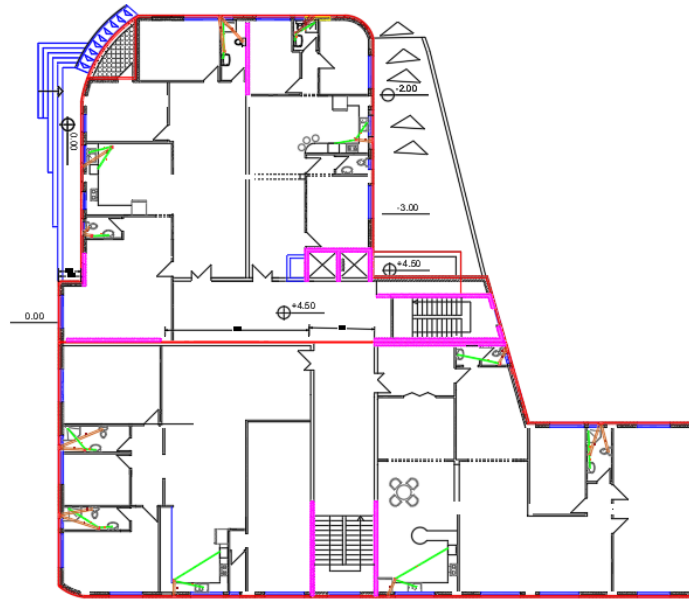


Figure 227 1st to 5th floor drainage floors

As shown in the picture above, there is a drainage plan for the first floor, which includes 4 residential apartments, each one containing a kitchen and two bathrooms, note that we have

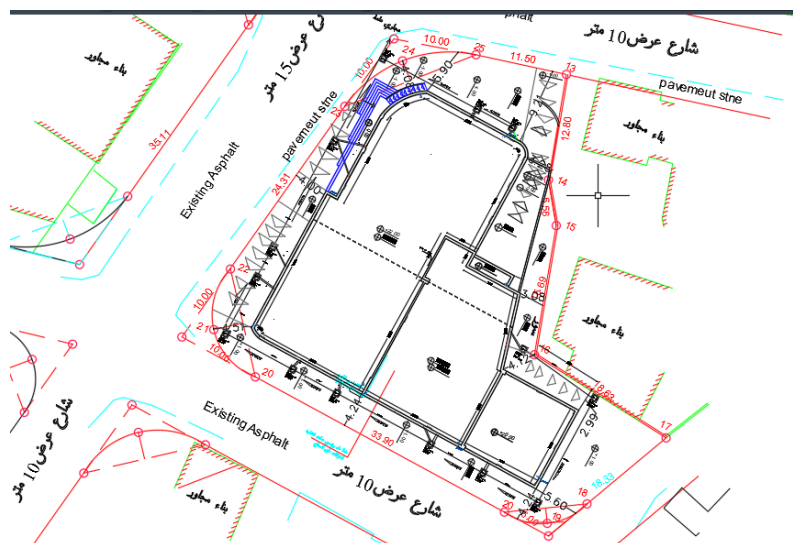


Figure 228 site plan and drainage of building

As you can see in the figure above, there is a site plan for the project, including the adjacent buildings, the streets surrounding it, their levels, and the municipality's drainage line to which we delivered the drained water from our building.

#### 4.7.2 Rain water drainage :

One of the most important aspects of building construction is rainwater drainage, which is intended to collect and divert rainfall away from the structure in order to prevent damage,

Below is a plan of rainwater drainage in our building:

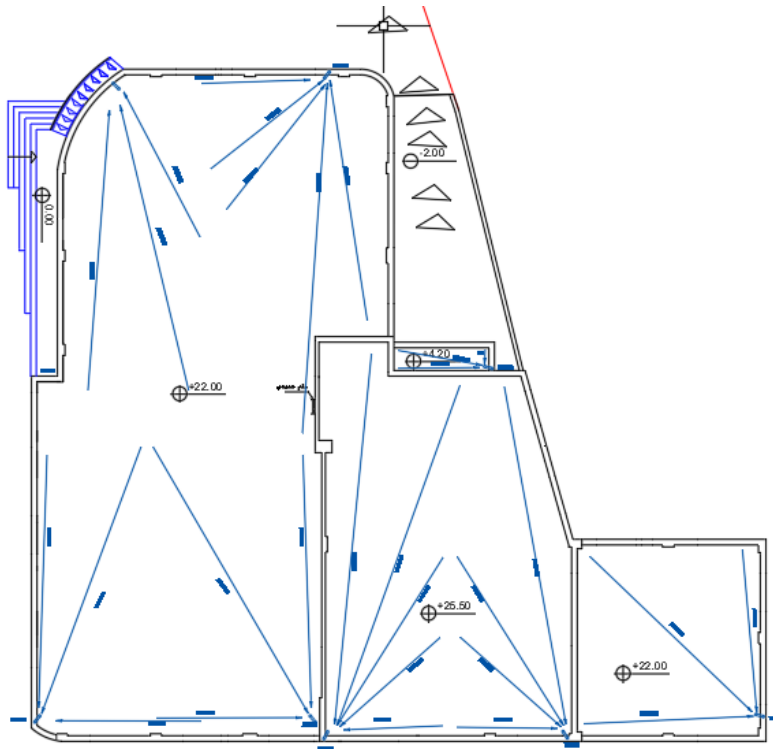


Figure 229 rain water plan

#### 4.8 Vertical and horizontal transportation:

One of the most popular forms of vertical mobility in Palestinian business and residential structures is the elevator, which fits the project's needs while also respecting the building's architectural style.

This building contains 9 floors, including 2 parking floors and the ground floor, which contains shops, in addition to 5 residential floors and the roof.

And the 5 floors of 9 that have the benefit of the existence of elevators

This building is considered to have a single tendency, and the service is to be good service.

- To estimate population of the building will be calculated as shown :

We calculate for the residential floors, so the population will depends on the number of beds in rooms: the population will equal

$2(\text{beds}) * 3 (\text{bedrooms}) * 4(\text{Residential apartments on one floor}) = 24$  persons/floor

$\text{POP} = 24 * 5(\text{floors}) = \mathbf{120 \text{ persons}}$

- The value of handling capacity of elevators system PHC and HC :

Table 110 PHC TABLE

**TABLE 31.6 Minimum Percent Handling Capacities (PHC)**

Facility	Percent of Population to Be Carried in 5 Minutes
OFFICE BUILDINGS	
Center city	12–14
Investment	11.5–13
Single-purpose	14–16
RESIDENTIAL	
Prestige	5–7
Other	6–8 <sup>a</sup>
Dormitories	10–11
Hotels—first quality	12–15
Hotels—second quality	10–12

From previous table choose **PHC = 8 %**

Then,  $\text{HC} = \text{PHC} * \text{POP}$

$\text{HC} = 8\% * 120$

**$\text{HC} = 9.6 \text{ person/5min}$**

- The rise of building = 31.5 m

Table 111 Elevators Recommendations

TABLE 32.9 Elevator Equipment Recommendations

Building Type	Car Capacity <sup>a</sup>		Rise		Minimum <sup>b</sup> Car Speed	
	lb	kg	ft	m	fpm	m/s
Office building	{ 2500 1250 } { 3000 1250 } { 3500 1600 }		0–125	0–40	350–400	2.0
			126–225	41–70	500–600	2.5
			226–275	71–85	700	3.15
			276–375	86–115	800	4.0
			Above 375	>115	1000	5.0
Hotel	{ 2500 1250 } { 3000 1250 }		As above		As above	
Hospital	{ 3500 1600 } { 4000 2000 }		0–60	0–20	150	0.63
			61–100	21–30	200–250	1.0
			101–125	31–40	250–300	1.6
			126–175	41–55	350–400	2.0
			176–250	56–75	500–600	3.15
>250	>75	700	4.0			
Apartments	{ 2000 1000 } { 2500 1250 }		0–75	0–25	100	0.63
			76–125	26–40	200	1.0
			126–200	41–60	250–300	1.6
			>200	>60	350–400	2.0
Stores	{ 3500 1600 } { 4000 2000 } { 5000 2500 }		0–100	0–30	200	1.0
			101–150	31–45	250–300	1.6
			151–200	46–60	350–400	2.0
			>200	>60	500	2.5

- From previous table the riser located between ( 26 – 40 )
- So, the minimum car speed = 200 fpm
- And the capacity ( 2000 , 2500 ) Ib
- So, the option we have it { 2000 / 200 } and { 2500 / 200 }

And now will show you the calculation to select the elevator :

Table 112 Calculations to select the elevator

	2000/200	2500/200
<b>p</b>	10	13
<b>RT</b>	100	110
<b>hc</b>	30	35.45
<b>HC</b>	9.6	9.6
<b>N</b>	0.32	0.27
<b>N1</b>	1	1
<b>Pop</b>	120	120
<b>PHC</b>	25%	29%
<b>Interval</b>	100	110
<b>N2</b>	2	2
<b>PHC</b>	50%	59%
<b>Interval</b>	50	55

- ✓ We have succeeded in both types of elevators as our interval located between (50-70)
- ✓ So, we need 2 elevators { 2500 Ib / 13 persons } and have a speed 200 fpm.

# **Chapter 5**

## **Quantity surveying and cost estimation**

### **5.1. Introduction:**

Estimating the quantities and costs of a construction project is one of the most important and vital topics to worry about when planning for a construction project. Accurate and precise estimations should be prepared before the implementation of any project, especially in construction projects, and it is usually one of the first things that is seen with interest, whether seen from an investor point of view or a contractor's perspective, as it helps both to determine their financial and investment resources for the investor, or to stay aware and be around the free space and margins of the project cost estimation and construction works costs, this allows the accurate and safe financing of the project. Also to determine the number and the quality of technical staff that will carry out the project for the contractor, and this estimate must be very accurate in order to reach the level of perfection as much as possible.

### **5.2. Methodology:**

After the work and the redesign for this project, with the present of adequate needed drawings, and the good understanding of the nature of the project. The next stage is the estimation cost of the project, the unit cost of a square meter is estimated by a specialist and a professional in this field Dr. Luay Dweikat, that estimated the work and the nature of the building, it was 900 dollars for each meter squared. The accurate and precise cost estimation of the project will be described in each small detail later on in Graduation project 2, with a bill of quantity of all materials used, and a work breakdown structure with the addition of the labor costs.

### **5.3. Budget development and tentative cost estimate:**

As an estimation of how the work that was done for this project in the Graduation project 1, and nature of the building after the redesign, an estimated cost of 700 dollars for each meter squared. An estimated total cost for the project was around 5600000\$, but now after making a table of unit prices and detailed prices and a detailed work breakdown structure the results were as the following:

❖ WBS:

The tables in the next pages shows the bill of quantity and costs:

Item No	Description	Unit	Quantity	Material Cost		Labor Cost		Total cost with waste factor
				Unit Cost	Total Cost	Unit Cost	Total Cost	
<b>1</b>	<b>GP 2</b>							
<b>1.1</b>	<b>Structural</b>							
<b>1.1.1</b>	<b>Sub-Structure</b>							
<b>1.1.1.1</b>	<b>Earth Works</b>							
<b>1.1.1.1.1</b>	<b>Excavation And Disposal</b>	<b>CM</b>	<b>5664</b>	<b>35</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>198240</b>
<b>1.1.1.1.2</b>	<b>Side walk Stone Pavement</b>	<b>M</b>	<b>492</b>	<b>70</b>				<b>34440</b>
<b>1.1.1.1.3</b>	<b>Pavement</b>	<b>SM</b>	<b>150</b>	<b>54</b>				<b>8100</b>
<b>1.1.1.2</b>	<b>Foundation</b>							
<b>1.1.1.2.2</b>	<b>Footing</b>							
<b>1.1.1.2.2.1</b>	<b>Matt</b>							
<b>1.1.1.2.2.1.1</b>	<b>Formwork</b>	<b>SM</b>	<b>147.8</b>	<b>3</b>	<b>443.4</b>	<b>10</b>	<b>1478</b>	<b>1921.4</b>
<b>1.1.1.2.2.1.2</b>	<b>Steel work</b>	<b>Ton</b>	<b>23.6</b>	<b>3500</b>	<b>82600</b>	<b>800</b>	<b>18880</b>	<b>101480</b>
<b>1.1.1.2.2.1.3</b>	<b>Concrete work</b>	<b>CM</b>	<b>760</b>	<b>320</b>	<b>243200</b>	<b>10</b>	<b>7600</b>	<b>250800</b>
<b>1.1.1.2.2.1.4</b>	<b>insulation footing or Proofing</b>	<b>SM</b>	<b>147.8</b>	<b>8</b>	<b>1182.4</b>	<b>6.4</b>	<b>945.92</b>	<b>2128.32</b>

1.1.2	Super-Structure				0		0	0
1.1.2.1	Structural Elements				0		0	0
1.1.2.1.1	Columns				0		0	0
1.1.2.1.1.1	Formwork	SM	861.6	3	2584.8	10	8616	11200.8
1.1.2.1.1.2	Steel	Ton	46.06	3500	161210	800	36848	198058
1.1.2.1.1.3	Concrete	CM	444.08	320	142105.6	10	4440.8	146546.4
1.1.2.1.2	Shear wall				0		0	0
1.1.2.1.2.1	Formwork	SM	13560	3	40680	9.6	130176	170856
1.1.2.1.2.2	Steel works	Ton	26.085	3500	91297.5	800	20868	112165.5
1.1.2.1.2.3	Concrete Works	CM	8695	320	2782400	10	86950	2869350
1.1.2.1.3	Beams				0		0	0
1.1.2.1.3.1	Steel work	Ton	214.24	3500	749840	800	171392	921232
1.1.2.1.4	Slab				0		0	0
1.1.2.1.4.1	Formwork	SM	8240	3	24720	9.6	79104	103824
1.1.2.1.4.2	Block work	Unit	36050	3.5	126175	0.23	8291.5	134466.5
1.1.2.1.4.3	Steel work	Ton	150.41	4100	616681	799.92	120315.9672	736996.9672

Item No	Description	Unit	Quantity	Material Cost	Labor Cost	Total cost with waste factor
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				Unit Cost	Total Cost	Unit Cost	Total Cost	
1.1.2.1.4.4	Concrete work	CM	2076.48	340	706003.2	14	29070.72	735073.92
1.1.2.1.5	Stairs				0		0	0
1.1.2.1.5.1	Formwork	SM	61.21	2.155	131.90755	9.6	587.616	719.52355
1.1.2.1.5.2	Steel work	Ton	2	4100	8200	799.9	1599.8	9799.8
1.1.2.1.5.3	Concrete work	CM	66	340	22440	14	924	23364
1.1.2.1.6	Ramp				0		0	0
1.1.2.1.6.1	Formwork	SM	317	2.6	824.2	9.6	3043.2	3867.4
1.1.2.1.6.2	Concrete	CM	63.4	340	21556	14	887.6	22443.6
1.1.2.1.6.3	Steel work	Ton	2.82	4100	11562	799.92	2255.7744	13817.7744
1.1.2.1.7	Retaining Walls				0		0	0
1.1.2.1.7.1	Formwork	SM	732.09	2.6	1903.434	9.6	7028.064	8931.498
1.1.2.1.7.2	Concrete	CM	732.09	340	248910.6	14	10249.26	259159.86
1.1.2.1.7.3	Steel work	Ton	15.05	4100	61705	799.92	12038.796	73743.796
1.1.2.2	Non- Structural Elements				0		0	0
1.1.2.2.1	External Walls				0		0	0
1.1.2.2.1.1	Blocks	SM	2421	18.75	45393.75	20	48420	93813.75
1.1.2.2.1.2	Concrete	CM	364	300	109200	20	7280	116480
1.1.2.2.1.3	Stone	SM	2421	120	290520	34.98	84686.58	375206.58
1.1.2.2.1.4	Sill	M	365	70	25550	10	3650	29200
1.1.2.2.1.5	Insulation	CM	145.26	350	50841	20	2905.2	53746.2
1.1.2.2.2	Internal Walls				0		0	0
1.1.2.2.2.1	Blocks	SM	5110	31.25	159687.5	20	102200	261887.5

1.1.2.2.2	Insulation	CM	306.6	350	107310	20	6132	113442
1.1.2.2.3	Lintel				0		0	0
1.1.2.2.3.1	Formworks	SM	704	3.45	2428.8	39.96	28131.84	30560.64
1.1.2.2.3.2	Steel	TON	3.13	4100	12833	799.2	2501.496	15334.496
1.1.2.2.3.3	Concrete	CM	70	300	21000	14	980	21980
1.1.3	Finishing				0		0	0
1.1.3.1	Plastering				0		0	0
1.1.3.1.1	All Floors	SM	13344	20	266880	20	266880	533760
1.1.3.2	Painting	SM			0		0	0
1.1.3.2.1	All Floors	SM	13344	15	200160	15	200160	400320
1.1.3.3	Kitchen marble	M	75	550	41250	50	3750	45000
1.1.3.4	False Ceiling	SM	7087.5	45	318937.5	35	248062.5	567000

								Total cost
Item No	Description	Unit	Quantity	Material Cost		Labor Cost		with waste factor
				Unit Cost	Total Cost	Unit Cost	Total Cost	
1.1.3.5	Tiles							
1.1.3.5.1	Regular + Bathrooms Floor Tiles+ Side Panels	SM	299.75	60	17985	35	10491.25	28476.25
1.1.3.5.2	Satires	M	285.7	120	34284	29.98	8565.286	42849.286
1.1.3.5.3	Wall tiles	SM	2163	66.25	143298.75	24.98	54031.74	197330.49
1.1.3.6	Doors				0		0	0
1.1.3.6.1	Wood	SM	268	250	67000	49.95	13386.6	80386.6

1.1.3.6.2	Steel	SM	42	800	33600	51	2142	35742
1.1.3.5	Windows	SM	452.88	750	339660	50	22644	362304
1.1.4	Mechanical						0	0
1.1.4.1	Drainage system						0	0
1.1.4.1.1	Tanks						0	0
1.1.4.1.1.1	TANKS 1.5 CM	Unit	16	400	6400	82.09	1313.44	7713.44
1.1.4.1.1.2	Tank support	Unit	16	300	4800	82.09	1313.44	6113.44
1.1.4.1.2	manholes				0		0	0
1.1.4.1.2.1	manholes	Unit	14	850	11900	82.09	1149.26	13049.26
1.1.4.1.3	drain water pipe	Unit	154	25	3850	82.09	12641.86	16491.86
	2 inch							
1.1.4.1.5	Tank Drains							
1.1.4.1.5.1	Floor drain	Unit	72	33	2376	82.09	5910.48	8286.48
1.1.4.1.5.2	Roof drain	Unit	7	25	175	82.09	574.63	749.63
1.1.4.2	Water System				0		0	0
1.1.4.2.1	Sinks				0		0	0
1.1.4.2.1.1	single sink	Unit	74	50	3700	82.09	6074.66	9774.66
					0		0	0
1.1.4.2.2	Valve Sink				0		0	0
1.1.4.2.2.1	valve sink single	Unit	74	200	14800	50	3700	18500
					0		0	0
1.1.4.2.3	Fire System				0		0	0
1.1.4.2.3.1	Fire Fitting	Unit	215	20	4300	15	3225	7525

1.1.4.2.3.2	Sprinklers	Unit	215	40	8600	30	6450	15050
1.1.4.2.3.3	Fire system pips	M	1870	15	28050	20	37400	65450
1.1.4.2.3.4	Hose Station	Unit	7	700	4900	150	1050	5950
1.1.4.2.4	WC				0		0	0
1.1.4.2.4.1	WC cabinet	Unit	53	600	31800	150	7950	39750
1.1.4.2.4.2	bidet spray	Unit	55	25	1375	82.09	4514.95	5889.95

								Total cost
Item No	Description	Unit	Quantity	Material Cost		Labor Cost		with waste factor
				Unit Cost	Total Cost	Unit Cost	Total Cost	
1.1.4.2.4.3	Stopcock water for wc	Unit	53	15	795	82.09	4350.77	5145.77
1.1.4.2.5	Elbow and valve						0	0
1.1.4.2.5.1	1/2 Inch valve	Unit	53	15	795	82.09	4350.77	5145.77
1.1.4.2.5.2	1 Inch valve	Unit	53	18	954	82.09	4350.77	5304.77
1.1.4.2.5.3	elbow 90 1/2-inch steel	Unit	133	6	798	82.09	10917.97	11715.97
1.1.4.2.5.4	elbow 90 1-inch steel	Unit	53	10	530	82.09	4350.77	4880.77

1.1.4.2.5.5	elbow 90 2- inch plastic	Unit	53	4	212	82.09	4350.77	4562.77
1.1.4.2.5.6	elbow T 4- inch plastic	Unit	87	8	696	82.09	7141.83	7837.83
1.1.4.2.5.7	elbow 90 4- inch plastic	Unit	111	4	444	82.09	9111.99	9555.99
1.1.4.2.5.8	elbow 45 4- inch plastic	Unit	111	4	444	82.09	9111.99	9555.99
1.1.4.2.6	solar mirrors							
1.1.4.2.6.1	Solar mirrors for tank	Unit	16	750	12000	82.09	1313.44	13313.44
1.1.4.2.7	meters				0		0	0
1.1.4.2.7.1	meters	Unit	68	150	10200	82.09	5582.12	15782.12
1.1.4.2.8	collectors	Unit	24	150	3600	82.09	1970.16	5570.16
					0		0	0
1.1.4.2.9	Water Pump	Unit	28	350	9800	50	1400	11200
1.1.4.3	HVAC				0		0	0
1.1.4.3.1	VRF outdoor unit	Unit	4	70000	280000	82.09	328.36	280328.36
1.1.4.3.2	Split unit	Unit	271	2000	542000	82.09	22246.39	564246.39
1.1.4.3.3	Cassette unit	Unit	32	4300	137600	82.09	2626.88	140226.88
1.1.4.3.4	Pipes	M	643	60	38580	1.07	688.01	39268.01

<b>1.1.4.4</b>	<b>Pipes</b>				<b>0</b>		<b>0</b>	<b>0</b>
<b>1.1.4.4.1</b>	<b>8-inch plastic</b>	<b>m</b>	<b>6.88</b>	<b>25</b>	<b>172</b>	<b>82.09</b>	<b>564.7792</b>	<b>736.7792</b>
<b>1.1.4.4.2</b>	<b>6-inch plastic</b>	<b>m</b>	<b>147.8</b>	<b>25</b>	<b>3695</b>	<b>82.09</b>	<b>12132.902</b>	<b>15827.902</b>
<b>1.1.4.4.3</b>	<b>4-inch plastic</b>	<b>m</b>	<b>600</b>	<b>4</b>	<b>2400</b>	<b>82.09</b>	<b>49254</b>	<b>51654</b>
<b>1.1.4.4.4</b>	<b>2-inch plastic</b>	<b>m</b>	<b>63.5</b>	<b>4</b>	<b>254</b>	<b>146.15</b>	<b>9280.525</b>	<b>9534.525</b>
<b>1.1.4.4.5</b>	<b>corrugated tube</b>	<b>m</b>	<b>1073</b>	<b>3.35</b>	<b>3594.55</b>	<b>82.09</b>	<b>88082.57</b>	<b>91677.12</b>

								Total cost
Item No	Description	Unit	Quantity	Material Cost		Labor Cost		with waste factor
				Unit Cost	Total Cost	Unit Cost	Total Cost	
<b>1.1.5</b>	<b>Electrical</b>							
<b>1.1.5.1</b>	<b>Lighting System</b>							
<b>1.1.5.1.1</b>	<b>rail light linear</b>	<b>unit</b>	<b>28</b>	<b>110</b>	<b>3080</b>	<b>17</b>	<b>476</b>	<b>3556</b>
<b>1.1.5.1.2</b>	<b>LED lamps residential</b>	<b>unit</b>	<b>184</b>	<b>200</b>	<b>36800</b>	<b>17</b>	<b>3128</b>	<b>39928</b>
<b>1.1.5.1.3</b>	<b>Downlight 40 w</b>	<b>unit</b>	<b>33</b>	<b>85</b>	<b>2805</b>	<b>17</b>	<b>561</b>	<b>3366</b>
<b>1.1.5.1.4</b>	<b>Downlight 12 w</b>	<b>unit</b>	<b>50</b>	<b>40</b>	<b>2000</b>	<b>17</b>	<b>850</b>	<b>2850</b>
<b>1.1.5.1.5</b>	<b>Track Light</b>	<b>unit</b>	<b>521</b>	<b>160</b>	<b>83360</b>	<b>17</b>	<b>8857</b>	<b>92217</b>
<b>1.1.5.1.6</b>	<b>Main Distribution Board</b>	<b>unit</b>	<b>34</b>	<b>200</b>	<b>6800</b>	<b>82.02</b>	<b>2788.68</b>	<b>9588.68</b>
<b>1.1.5.1.7</b>	<b>Switches</b>	<b>unit</b>	<b>510</b>	<b>15</b>	<b>7650</b>	<b>17</b>	<b>8670</b>	<b>16320</b>
<b>1.1.5.1.8</b>	<b>Light Wires</b>	<b>M</b>	<b>24366</b>	<b>1.2</b>	<b>29239.2</b>	<b>17</b>	<b>414222</b>	<b>443461.2</b>

1.1.5.2	<b>Power System</b>						<b>0</b>	<b>0</b>
1.1.5.2.1	<b>Power Socket outlet</b>	<b>unit</b>	<b>483</b>	<b>9</b>	<b>4347</b>	<b>17</b>	<b>8211</b>	<b>12558</b>
1.1.5.2.3	<b>Power Wires</b>	<b>M</b>	<b>9710</b>	<b>1.2</b>	<b>11652</b>	<b>17</b>	<b>165070</b>	<b>176722</b>
1.1.5.3	<b>Fire Alarm System</b>				<b>0</b>		<b>0</b>	<b>0</b>
1.1.5.3.1	<b>Fire Alarm Panel</b>	<b>unit</b>	<b>6</b>	<b>50</b>	<b>300</b>	<b>17</b>	<b>102</b>	<b>402</b>
							<b>0</b>	<b>0</b>
1.1.5.3.3	<b>Heat Detectors</b>	<b>unit</b>	<b>92</b>	<b>200</b>	<b>18400</b>	<b>17</b>	<b>1564</b>	<b>19964</b>
1.1.5.3.4	<b>Fire alarm red Flasher</b>	<b>unit</b>	<b>12</b>	<b>40</b>	<b>480</b>	<b>17</b>	<b>204</b>	<b>684</b>
1.1.5.3.5	<b>Fire system Wires</b>	<b>M</b>	<b>11360</b>	<b>1.2</b>	<b>13632</b>	<b>17</b>	<b>193120</b>	<b>206752</b>
1.1.5.4	<b>Circuit Breaker</b>				<b>0</b>		<b>0</b>	<b>0</b>
1.1.5.4.1	<b>Breaking Capacity_25KA</b>	<b>unit</b>	<b>1</b>	<b>300</b>	<b>300</b>	<b>17</b>	<b>17</b>	<b>317</b>
1.1.5.4.2	<b>MCB (40AM)</b>	<b>unit</b>	<b>58</b>	<b>90</b>	<b>5220</b>	<b>17</b>	<b>986</b>	<b>6206</b>
1.1.5.4.3	<b>16 AM</b>	<b>unit</b>	<b>415</b>	<b>11</b>	<b>4565</b>	<b>17</b>	<b>7055</b>	<b>11620</b>
1.1.5.4.4	<b>10AM</b>	<b>unit</b>	<b>400</b>	<b>7</b>	<b>2800</b>	<b>17</b>	<b>6800</b>	<b>9600</b>
1.1.5.5	<b>Earthing</b>				<b>0</b>		<b>0</b>	<b>0</b>
1.1.5.5.1	<b>Earthing Electrode</b>	<b>unit</b>	<b>10</b>	<b>100</b>	<b>1000</b>	<b>17</b>	<b>170</b>	<b>1170</b>
1.1.5.5.2	<b>Galvanized Steel Plates30*3 mm</b>	<b>SM</b>	<b>5</b>	<b>30</b>	<b>150</b>	<b>17</b>	<b>85</b>	<b>235</b>

#### 5.4. Summary:

After calculations and using the needed information for this project, the results were:

*Table 113 cost Summary*

Phase	Unit cost	Total cost of the project
GP1	700\$/M	Around 5,600,000\$
GP2	1532 NIS/M	12,107,000 NIS

# **Chapter 6**

## **Conclusion**

**Conclusion:**

In conclusion, the effective integration of architectural, environmental, structural, and electromechanical designs demonstrates the power of combining diverse expertise in creating a well-designed structure. This collaboration not only results in pleasing and comforting the occupants of the building, but also ensures their functionality, sustainability, and durability. This successful combination signifies the process in our approach to design, emphasizing the importance of dependency between different designs mentioned before, in addition to efficiency, and environmental responsibility. It points towards a future where the harmful emissions are decrease to the minimum and also the comfort of the users is up to the max, this teamwork not only makes structures look good but also makes them work well, be eco-friendly, and last a long time.

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Figure 230: Citation check sheet

**Appendix:**

There are PDF files including AutoCAD pictures that have specified details for the architectural plans and for the structural plans including the bars' quantities and lengths, also the electromechanical plans. In addition to the numbers of the split units for the first floor up to the fifth floor inserted in tables. Those mentioned files will be submitted with this Microsoft word file.