An-Najah National University

Faculty of Engineering & Information Technology

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Course: Graduation Project II

Design of Royal Suites Hotel

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"Presented in partial fulfillment of the requirements for Bachelor degree in Building Engineering"

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Dedication

This project was accomplished by the grace and guidance of Allah. We dedicate this achievement to everyone who played a role in its completion and success, and to those who served as sources of inspiration and support—starting with our beloved homeland, Palestine, and our resilient and powerful people. To the faculty members in the Building Engineering Department at An-Najah National University, thank you for your tremendous efforts in imparting knowledge and wisdom. To our project supervisor, Engineer Nermin Al-Barq, a heartfelt appreciation for you. To my dear family, my beloved mother, dear father, sisters, and brothers, your love and support made the journey easier. To our friends and colleagues in the building engineering department thank you for your encouragement and support, making the journey more beautiful despite its challenges.

Acknowledgment:

Deep appreciation and thanks to our beloved university, An-Najah National University, for providing a comfortable learning environment. A big thank you to all the faculty members in the Building Engineering department for their constant support and efforts in completing this project. Special thanks to our project supervisor, Engineer Nermin Al-Barq, for her tremendous efforts and unwavering support throughout, as she spared no effort in sharing her knowledge and experience with us.

Disclaimer:

This report was written by students in the Department of Building Engineering at An-Najah National University: Batool Dardook, Tahreer Atatri, Lama Thabaleh, and Tasbeeh Abu Yaqoub. All the information in the report was prepared by them, using their experience during the years of study, and the experience of teaching staff in the building engineering department, and based on information collected from approved books and references. The report may contain grammatical or linguistic errors; it has not been changed or corrected except for editorial corrections. An-Najah National University does not bear any responsibility if this report is used for any purpose other than its intended purpose.

Abstract:

The hotel is considered institutions that provide services to customers in exchange for a cash amount, and in this project the Royal Suites Hotel in Nablus, Rafidia Main Street, next to the Al-Rawda Mosque. The project land area is 968.69 m2, and the project area is 7097.06 m2 next to Al Rawda Mosque. It has been redesigned in all respects, to obtain an integrated building.

The multifunctional building has been redesigned and transformed into a hotel, achieving comprehensive design integration in all aspects: architectural, structural, environmental, acoustic, electrical, mechanical, and fire safety. From architectural design to attaining a comprehensive architectural design based on appropriate standards and references, research in hotel case studies, space studies, references to books, and hotel design standards. Then select the appropriate structural system, conduct the analysis using the ETABS program, and structurally design the building considering seismic and economic aspects. In our design, we emphasize ensuring comfort for individuals within the building by conducting an environmental analysis of the project and addressing all environmental issues. This includes analyzing sunlight, and the impact of nearby buildings, studying natural and artificial lighting, and ventilation, and providing acoustic comfort. Following that is the mechanical design, including plumbing and water supply systems, heating, and air conditioning. Then, moving on to fire safety, encompassing fire suppression systems, fire prevention, and other systems. Finally, calculate quantities and costs. Studying all aspects of the building achieves integrated design across different disciplines, reducing problems during implementation.

Nomenclature or list of symbols

Symbol	Meaning
m	Meter
m^2	Meter Squer
cm	Centimeter
cm^2	Ceniemeter Squer
mm	Millimeter
mm^2	Millimeter Squer
%	Percentage
KN	Kilonewton
KN/m	Kilonewton per meter
KN/m^2	Kilonewton per meter squer
Mpa	Mega pascal
C	Celsius degree
Km/h	Kilometer per hour
Kg/m^2	Kilogram per meter squer
m/s	Meter per second
ac/h	Air shading pet hour
$m^2.K/h$	Metet Squer.Kilven per hour
V	Velocity
db	Decibel
Ln	Clear length of the slab
h	Thickness of slab
E	Modulus of elasticity
Pu	The ultimate factored axial load
Fy	Yielding strength of steel
Qz	Static wind pressure
Kd	Wind directionality factor
Kzt	Topographic facto
Kwh/m^2	Kilowatt hour per meter square
U	Heat transfer coefficient
MWh	Megawatt hour

Chapter one

Introductory

Chapter one: Introductory

1.1: Introduction

The hotel is an establishment that provides customers with accommodation, food, and other services in exchange for a monetary amount. The concept of hotels dates back over 3000 years, when they were few and uncommon, primarily offering basic shelter and simple meals for travelers. Over time, hotels evolved and improved in quality, quantity, and popularity, becoming one of the fastest-growing sectors. The presence of a hotel in any area is considered a sign of success for that region and plays a significant role in developing the tourism sector.

The importance of hotels is highlighted in various areas, including providing diverse services to individuals such as accommodation, food, amenities like pools, markets, meeting rooms, clubs, restaurants, and other services. Additionally, the significance of hotels extends to creating job opportunities, both in the construction phase and during operations, catering to customers' needs. Another crucial aspect is the hotel sector's significant role in developing the tourism industry, with hotels being important facilities for tourists.

There are several types of hotels, including residential hotels, resembling residential buildings, where customers stay for extended periods with all necessities provided. Commercial hotels offer services and amenities for those seeking short-term stays. Resorts provide various services and comforts, focusing on leisure and entertainment, featuring multiple entertainment options.

1.2: Project problem

This project is implemented in several stages, starting with a literature review and a case study (Royal Suites Hotel) examining aspects such as location, environmental analysis, noise sources, and various other environmental factors. Subsequently, criteria and requirements necessary for hotel design are researched to ensure the implementation of required architectural modifications. The details of these modifications will be discussed later. Detailed analyses will then be conducted to address environmental aspects, including shadow analysis, leveraging natural lighting, and insulation procedures, and conducting simulations and analyses using the Revit software to achieve a comfortable, energy-efficient environment within the specified standards.

Following this, a structural study of the building will be carried out to select the optimal structural system, providing strength, durability, and the ability to withstand various conditions while adhering to architectural standards. Finally, a concise cost report will be generated based on the building type and systems used in its design.

1.3 Objectives

The main objective of this project is to redesign the Royal Suites Hotel, by studying the building and addressing problems from the architectural, structural, environmental, mechanical, and electrical aspects. For integration in the building, an energy-efficient and environmentally treated building.

The strategy for this purpose was to search, study, and analyze existing hotel projects as case studies. Hotel design references and standards have been used to obtain accurate and sufficient information to enable us to design the hotel correctly and perfectly.

- **Architectural objectives.**

The design of the plans implemented for the hotel with modifications such as changing rooms and adding space according to what is recommended in terms of functions and relationships. Along with Considering parking and site analysis.

- **Environmental objectives.**

Achieve appropriate levels of shading, daylight, and ventilation systems, along with good results in Heating and cooling loads from Revit and Design Builder.

- **Structural goals.**

Structural design of the structural elements of the hotel, software ETABs will be used for simulation and obtain values that will be used to fulfill the necessary checks.

- **Economical goals.**

Perform a cost estimation for the building to build a pre-known budget.

- **Mechanical goals,**

Provide an integrated design of water supply, HVAC, fire, and drainage systems.

- **Electrical goals,**

Providing hotel lighting system designs using DIAlux EVO software.

- **Acoustic goals.**

Provide hotel sound system designs using Ecotect2011, Insul, and Ease software.

1.4 Methodology

The stages of this project are as follows: first, the literature was reviewed by collecting data, standards, and specifications from books. Secondly, the architectural design of the hotel is based on data on the dimensions of hotel rooms and hotel design parameters. Standards for room dimensions were collected from books such as Neufert and Metric. Consider the design of elevators using the MIB book, and the design of emergency stairs using the Palestinian fire code. Next, make a comprehensive Revit model. After that, an environmental simulation was made using the Revit program, and the necessary adjustments were made by adding insulation and making adjustments to the architectural openings. After that, choose the appropriate structural system, perform a simulation using ETABs, and perform the necessary checks. Finally, some quantitative survey was done.

1.5 Limitations and Constraints:

The direction of the building has been changed, the building was redesigned. There was a need to increase the number of elevators according to the standards so two more elevators were added. There was also a need to add another emergency staircase. The solution was to change the location of the staircase to suit the architectural design.

1.6 Codes and Standards

Environmental standards are referenced to: the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

Structural standards are referenced by: the American Society of Civil Engineering ASCE for load combinations and, the American Concrete Institute Code ACI 319 for reinforced concrete design.

1.7 Earlier coursework

There is a range of courses studied in the Department of Construction Engineering, which greatly helped in the completion of this project. Some of these courses are as follows:

Foundations of Architectural Design: This course helped to understand the foundations of building design from an architectural perspective, and helped to understand spaces in terms of their areas, dimensions, distribution, and relationships between spaces, in addition to studying the foundations of environmental analysis of buildings.

Concrete Courses: We learned the basics of structural design.

Many courses have analysis using software, such as AutoCAD, Revit, SAP, and Design Builder.

Professional practices and technical writing: Learn from this course in writing this report.

Construction Economics and Quantity Surveying: Learn from this course how to calculate the quantities of building materials, and works and calculate costs

Basics of internal building systems, Heating and air conditioning systems, Environmental systems design 1- Lighting, Design of environmental systems 2- Thermal

1.8 Project organization

In this section, the project's division will be explained, and a simple discussion about what each section contains :

First Chapter: This is what was discussed above, and this section is considered part of it, which began with an introduction to the project and its introduction, then proceeded to talk about the project's problem and requirements, in addition to the construction codes used and architectural design standards.

Chapter Two: In this chapter, the architectural and environmental design standards for all spaces in the hotel were studied, to ensure that the design is not less than the minimum architectural design standards, in addition to a case study similar to the project function and attention to its design errors. Then move on to the study of the site, including solar radiation, wind, noise, and shadows. and main streets, entrances, etc. Then work on downloading the architectural plans produced on the Revit program to study some environmental aspects. Study the shadows generated by the building itself and neighboring buildings, use appropriate protection systems, study daylight for certain spaces, and adjust the size of windows based on the daylight factor.

Third chapter: structural aspects, in this chapter a full design for the structure of the project will be performed and simulated on ETABS software.

Fourth chapter: mechanical-electrical aspects, in this chapter mechanical and electrical parts of the project will be presented as fully designed.

Fifth chapter: Quantity surveying and cost estimate, where a full detailed cost estimation will be performed on this project to determine a budget.

Chapter Six: In this section, the references used in the project are presented as well as the percentage of similarity using the Turn it in program.

Chapter Two

Environmental – Architectural Aspects

Chapter Two: Architectural–Environmental Aspects

2.1 Introduction

In this section, spaces in the architectural design (hotel) will be discussed, in addition to studying and defining the architectural and environmental design criteria for hotels and comparing them with the design of the architectural project. Finally, we will present a case study of an existing hotel to avoid the problems that exist in this hotel and get distinctive ideas for their implementation in this project.

2.2 Architectural Literature Review

2.2.1 Spaces and functions of a hotel

1- **Entrance:** The appearance of the main entrances is important because it reflects the image of the hotel, and the entrances must be clear, wide, defined, and easy to access, in addition to automatic or revolving doors to facilitate movement, and it is preferable to have a separate door to carry bags, and it must be suitable for people with special needs.

2- **Reception:** It is the space where guests are received. It consists of a reception desk that contains a place to store letters, an inbox, and keys .The reservation office must also be easily accessible and must be surrounded by a multi-use hall.

3- **Multi-purpose hall:** This hall is used for multiple purposes, including a place to wait for visiting guests, a place for new guests to wait for the procedures to be completed, or for guests to sit to wait for taxis.

4- **Administration:** No building is without a place for management to organize the building, act decisively in the event of problems, plan activities, and distribute responsibilities to achieve the most efficient operating model and resolve conflicts.

5- **Breakfast Room:** Hotels cannot be without a place to serve breakfast, as some guests book bedrooms that include breakfast, so we need the presence of this place, which is mainly linked to the presence of a kitchen to prepare breakfast.

6- **Bedrooms:** Bedrooms are considered one of the most important places in hotels, as they are designated for accommodation for hotel guests, and their dimensions vary from one hotel to another depending on the class it holds, they are as follows:

- Single rooms: A single room is designed for one occupant and has one bed – generally a double or queen bed.
- Double rooms: A room for two people, sometimes with two full-size beds and sometimes with a king or queen bed. The size of this room is usually larger than a single room.
- Suite rooms: Connecting rooms under one room number, it could be for three or more people

7- **Services Department**: Hotels cannot be without a services department, as it consists of the following:

- **Bedroom**: Hotels operating on a 24-hour system must provide bedrooms for employees.
- **Dressing Room:** The locker rooms in the services department will be reserved for employees so that they can dress up and wear the work uniform.
- **Kitchen:** The service department in hotels is not without a small kitchen so that they can prepare drinks or light food during work.
- **Living room:** There must be a small living room so that workers can sit in it during break time.
- **Clean laundry area:** A place where employees can store clean linens and fabrics for hotel bedrooms
- **Dirty laundry area:** Where dirty clothes and sheets from hotel bedrooms are stored.
- **Ironing area:** A place where hotel bedroom bed linens are ironed.
- **Laundry sorting**: A designated place where white fabrics are separated from colored fabrics.
- **Laundry area:** A place where the hotel's washing machines are located in it.
- **Drying area:** A place where the hotel's Laundry drying machines are located in it.
- **Publishing area**: A place where laundry that needs natural ventilation is hung out and dried.

8- **<u>Gymnastic apparatus hall:</u>** The gym is considered one of the hotel's secondary facilities, but it is currently preferable for hotels to have gyms to encourage them to choose the hotel, as it gives the hotel a kind of entertainment.

9- **<u>Parking:</u>** Currently, the majority of users prefer places that provide parking, so hotels must be equipped with parking spaces to enable guests to find a safe place to park their cars.

10- **<u>Restaurant:</u>** Some hotels can provide their restaurants to make it easier for guests to find a place to eat, especially guests who do not know the city. This is considered a point that encourages customers to stay at the hotel.

2.2.2 Architectural Standards and Space Requirements

Entrance: The entrance is the most visible area in hotels and is often clearly defined, as it provides a good view for the visitor, and therefore it should be easy to identify and reach it directly and to the waiting area.

Ramp in the entrance: The ramp is a path that can be reached by the wheelchair with a regular ramping and width that allows safe and simple crossing, and the external door must have a ramping that does not exceed 6% and the minimum width is 0.9m as shown in the figure (Neufert, 2014):

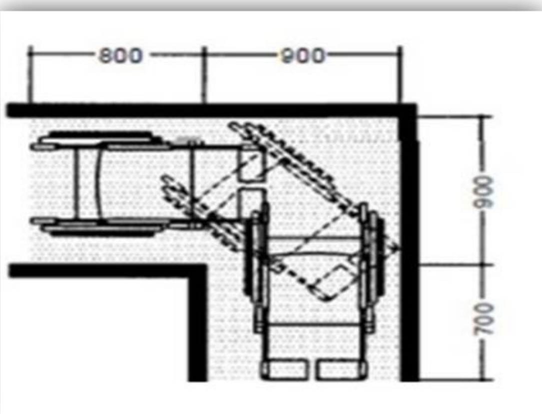


Figure 1: Ramp dimensions

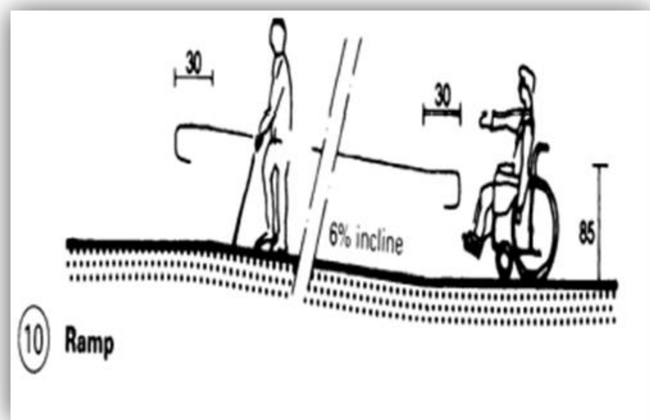


Figure 2:The entrance ramps.

Hotel lobby: The lobby is the heart of the hotel, which allows access to all elements and gives a beautiful view therefore must contain elevators and stairs, and there is also a reception counter with a length of 2.3-4 m, the main lobby includes the lobby / shared lounge area in the hotel with an area of (0.9 to 1.2) m2 per person, and the capacity of the hotel lobbies is 25% of the hotel guests. (Neufert, 2014).

Reception area: There is a place to receive hotel services and inquiries and be in a separate part therefore must contain sufficient lighting and be furnished with a sufficient number of waiting areas of the hotel lobby area for guests who need services such as registration, interview, and meetings.

In addition, it should be close to the entrance. The minimum standard area is 11m2. The main lobby includes reception (0.8 to 1.0) per room in the hotel. The dimensions of the desk reception (2592 ×700 ×1200) mm as shown in the figure. (Neufert, 2014).

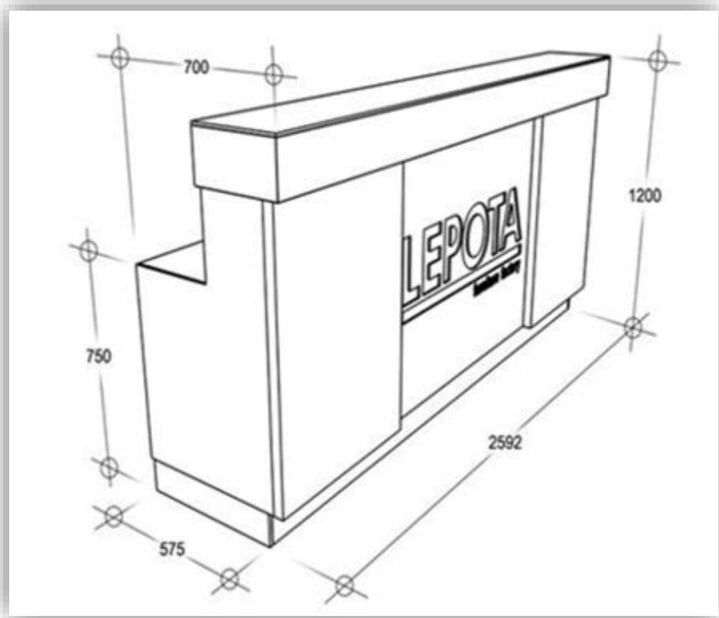


Figure 3:Typical dimensions of a reception counter.

Toilet: Bathrooms have separate bathrooms for men, women, and people with disabilities. There must be effective ventilation systems in addition to urinals, toilets, sinks, and mirrors.

People with special needs need more space to help them move where the necessary dimensions where the minimum diameter for the rotation of the vehicle is 1.5 m.

The number of bathrooms is determined by the number of consumers in the area, such as in a restaurant. The necessary dimensions for bathrooms and hand sinks are minimum (1.35 ×2.10) m and toilet dimensions (1.5×0.85) m (Neufert, 2014).

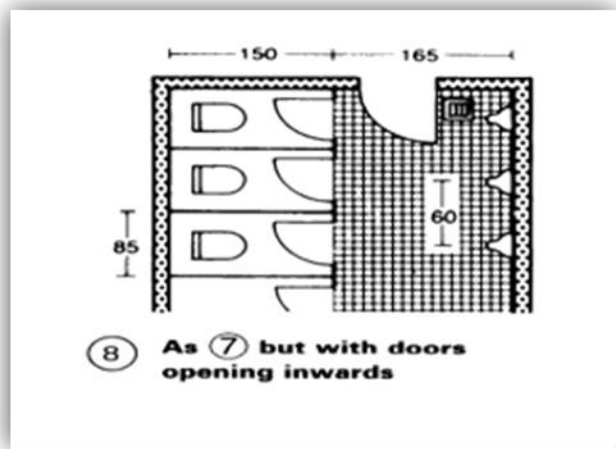


Figure 5:WC Dimensions

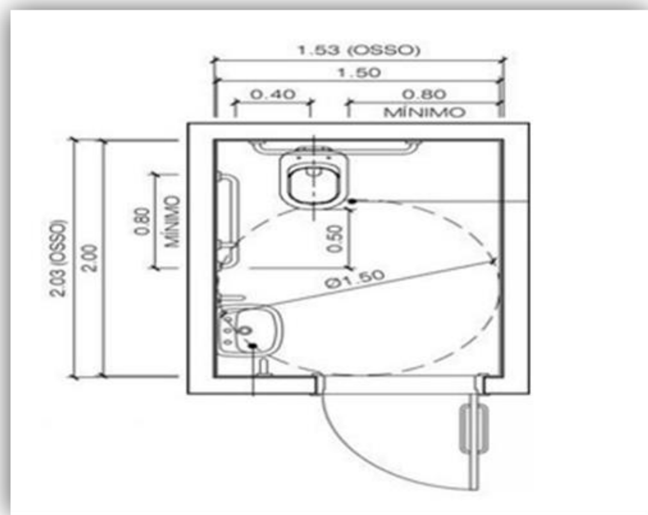


Figure 4:Toilet/WC standards

Number of customer places	Number of W.C
50	**1**
50-200	**2**
200-400	**3**

Figure 6: Number of public toilets.

Administration: It consists of a General Manager, a Secretariat, and an Area (0.25 - O.65) m2 for each room.

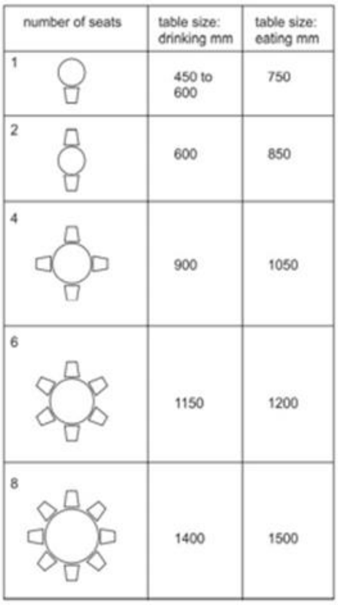
Restaurant: The hotel must have a café or restaurant to provide services to guests and customers, and in our project, we have a café and restaurant.

In addition, it must contain enough space for the dining area, a kitchen, a table, a storage area, a dishwashing area, and toilets with sufficient space and sizes, The required area is 1.5-2.2 m2. 60% for tenant service and 40% for guests.

__Dining area:__ The space required for the dining room varies according to the type of restaurant, in addition to the fact that the area contains dining tables based on the number of customers at one table

In addition to taking into account the ratio to determine the area about the number of customers and guests in the area.

Since the dining area is intended for people, each person needs space (1.1 - 1.3) m2 as shown in the figure (Neufert, 2014).



number of seats	table size: drinking mm	table size: eating mm
1	450 to 600	750
2	600	850
4	900	1050
6	1150	1200
8	1400	1500

Figure 7:Table dimensions

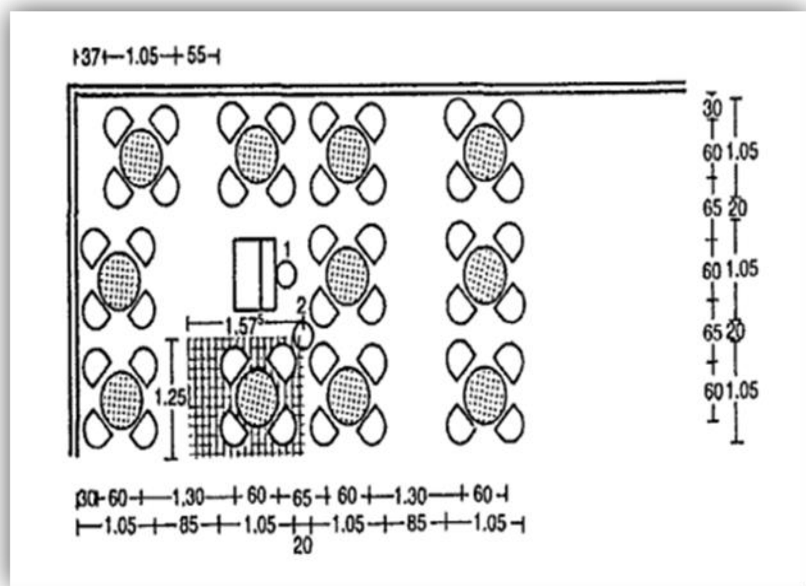


Figure 8:Table layout dimensions.

__Kitchen:__ The kitchen space is one of the inevitable spaces in the hotel and certain dimensions are required for its multifunctionality, which is divided into three sections: cooking, storage, cold storage, food preparation, dishwashing, and the servant's area, in addition to that safety requirements must be taken into account to prevent fires. The kitchen area should be 0.5-0.6 square meters per guest, with accessories of at least 80 square meters. The kitchen space should have minimum dimensions suitable for food preparation and cooking. (13.2-11.5 × 5.8-3.8 m) as shown in the figure**.**

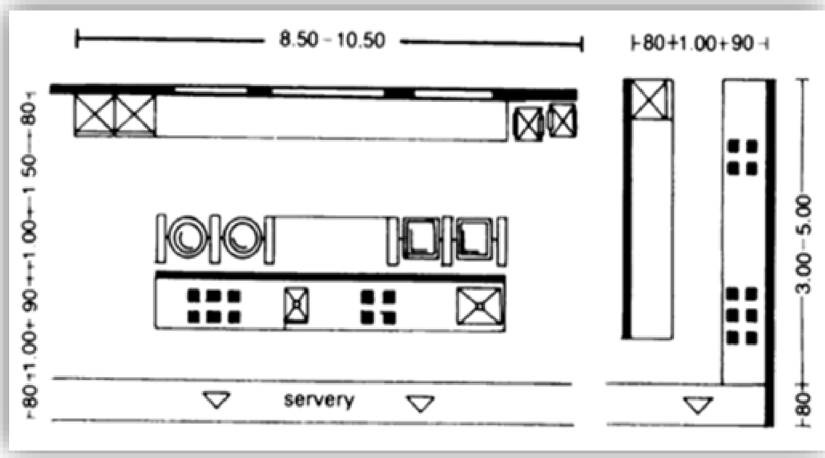


Figure 9:Typical kitchen configuration and dimensions.

<u>Laundry room:</u> The hotel should have a laundry room with washing machines to serve guests, the location should be carefully chosen to provide good lighting and ventilation, and it should be close to service rooms to facilitate work.

The number of washing machines depends on the number of guests and the restaurant's needs for washing tablecloths must be met.

Dimensions of laundry chamber (3×2.2) m, dirty laundry, washing machine/dryer, ironing machine, countertop, wall cabinet, and tall cabinet.

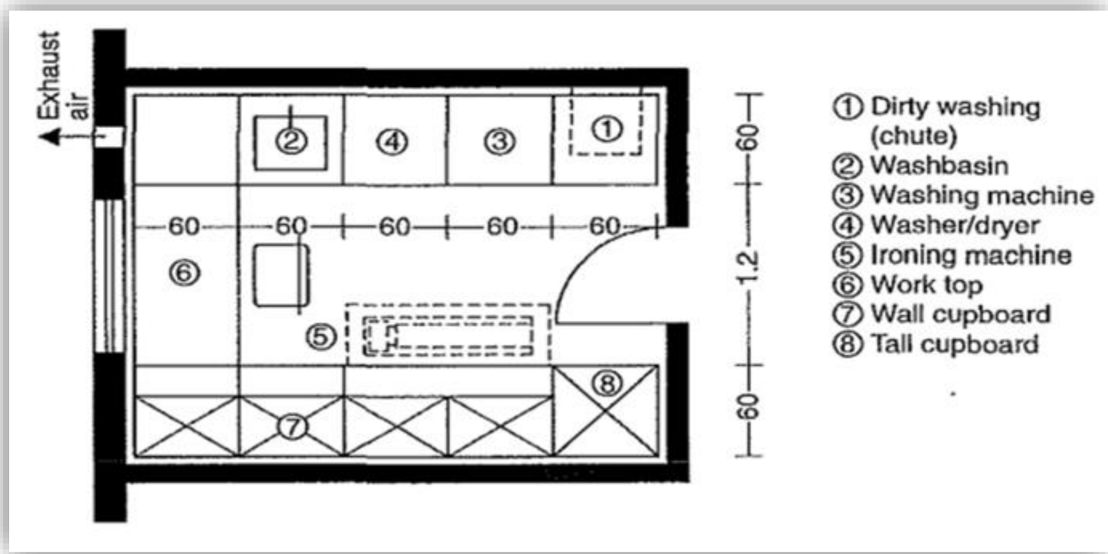


Figure 10:laundry room configuration.

Guest Room: These rooms occupy the majority of the space of the hotel, and the quality of these rooms is an important factor in the classification of guests, the best guest rooms face east, north, or south and have a window or balcony enjoying the scenery.

It is also important to achieve comfort and serenity in the bedrooms where there is a bed, table, chair, mirror, closet, TV, telephone, and bag table.

There are also two types of rooms for first-class guests, a single room with an area of 16 m2 and a double room with an area of 22 m2 as shown in the figure:

Grade	Basic	Budget	Mid-grade	High-grade	Luxury
Room area (net)[(a)]	17.5	21.7	25.2	30.0 (+5%)	36.0 (+5%)
Gross factor[(b)]	0.25	0.25	0.3	0.4	0.4
Gross residential area[(c)]	22	27	33	44	53
Public & support areas[(d)]	5.5	8	12	18	22
Residential % of total	80%	77%	73%	71%	71%

Figure 11: Bedroom standards.

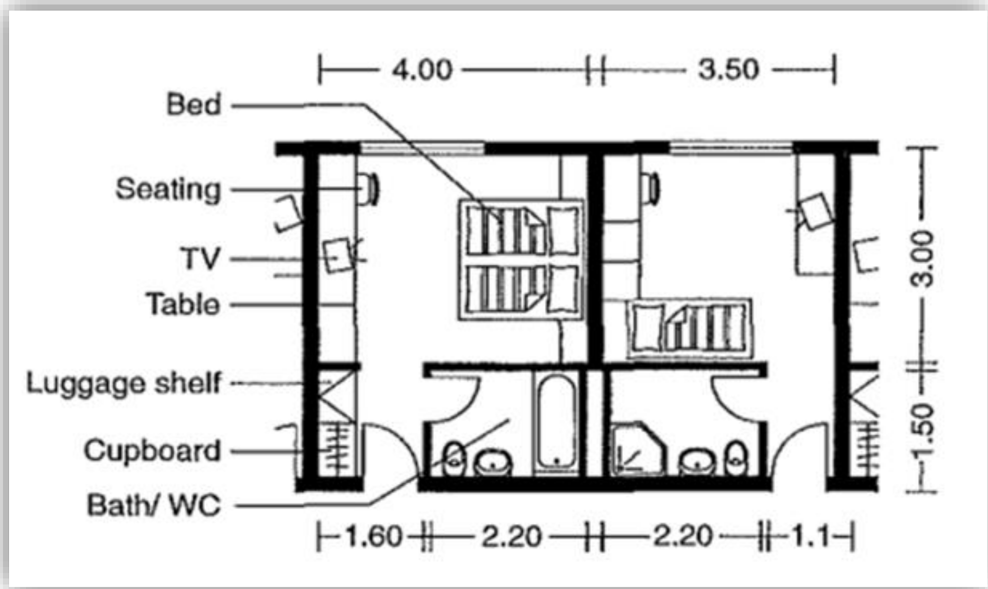


Figure 12: Guest room dimensions.

<u>suite room:</u> In addition, the hotel needs at least one private suite, a standard suite, and one junior suite, where the area of the junior is 25 square meters, consisting of a single, double, or twin bed, and a bathroom.

While the standard suite covers an area of 50 square meters, it consists of two separate rooms, including a bathroom, and each room consists of a single or double bed or two single beds. (Ministry, n.d.)

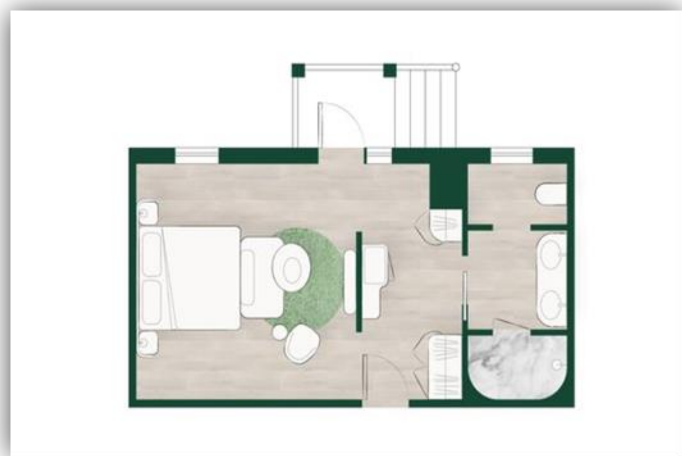


Figure 14:: Junior suite configuration

Figure 13:standard suite configuration.

Bathroom: The guest room and suite have a bathroom, consisting of a toilet, sink, and shower or bathtub to meet their needs. In addition, it must be close to the guest room, which ensures the appropriate distances and dimensions of movement (2.35 × 1.70) as shown in the figure.

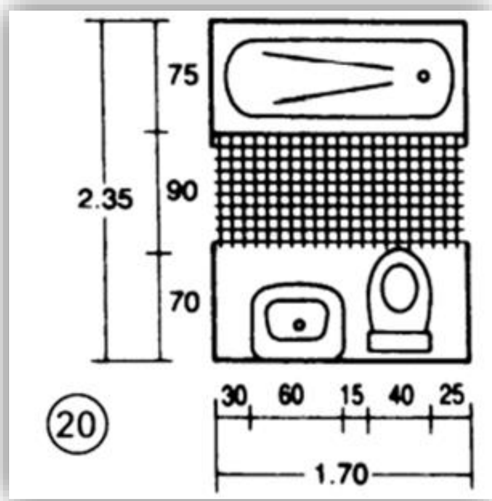


Figure 15: Bathroom standards.

Corridor: Corridors are a link between spaces and this requires spatially diverse and generous spread. Therefore, it is crazy that it contains openings and natural lighting. The width of the corridor is determined by the number of people passing through it. As shown in the table:

Corridor type	Little traffic	Heavy traffic
doors one side, opening into the rooms	0.90 m	1.30 m
doors both sides, opening into the rooms	1.60 m	
doors one side, opening into the corridor	1.40 m	1.80 m
doors both sides, opening into the corridor		2.20 m
doors both sides and opposite each other, opening into the corridor	2.40 m	2.60 m

Figure 16: Corridor standard dimensions.

The width of the corridor also depends on the number of people. One person needs 0.90 m or more, and for two people to pass, the width of the corridor is 1.3 m, and if it is for three people, the width of the corridor is 1.8 m or more as shown in the figure

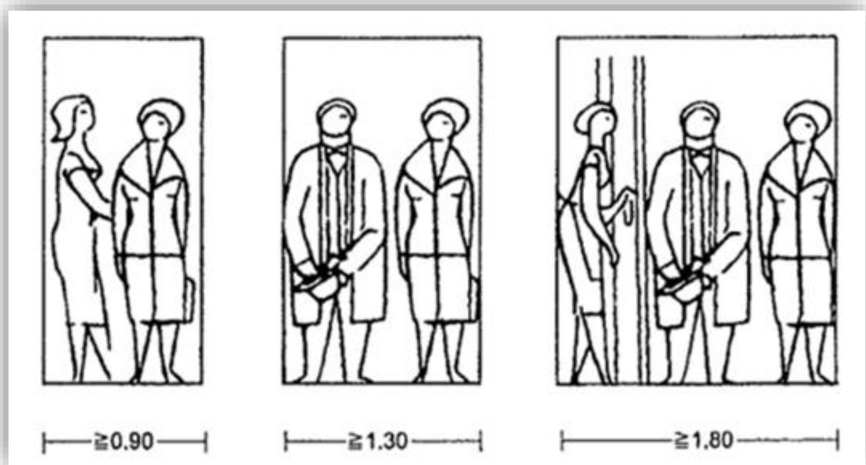
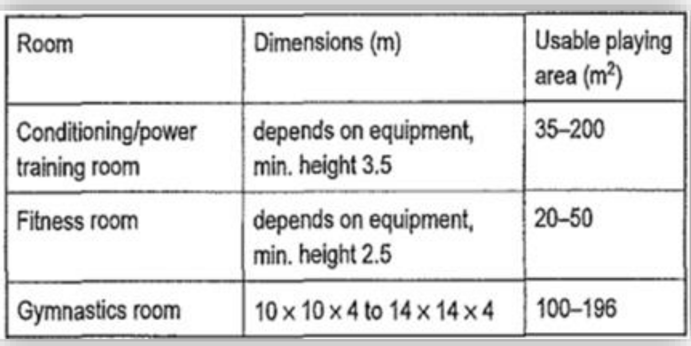


Figure 17: Corridor standard dimensions.

Gym: The gym is a recreational facility for the hotel with changing areas and a bathroom, which can accommodate 40-45 people with a height of 3 m.

The fitness room covers an area of 200 m2. The smallest room unit has an area of 40 m2 and can accommodate 12 people, with an equipment area per square meter of 0.12 m2.

In addition to the guardianship of upgrading air conditioning in it. The figure shows the dimensions of the gym for people.



Room	Dimensions (m)	Usable playing area (m^2)
Conditioning/power training room	depends on equipment, min. height 3.5	35–200
Fitness room	depends on equipment, min. height 2.5	20–50
Gymnastics room	10 × 10 × 4 to 14 × 14 × 4	100–196

Figure 18: Gym dimensions and areas.

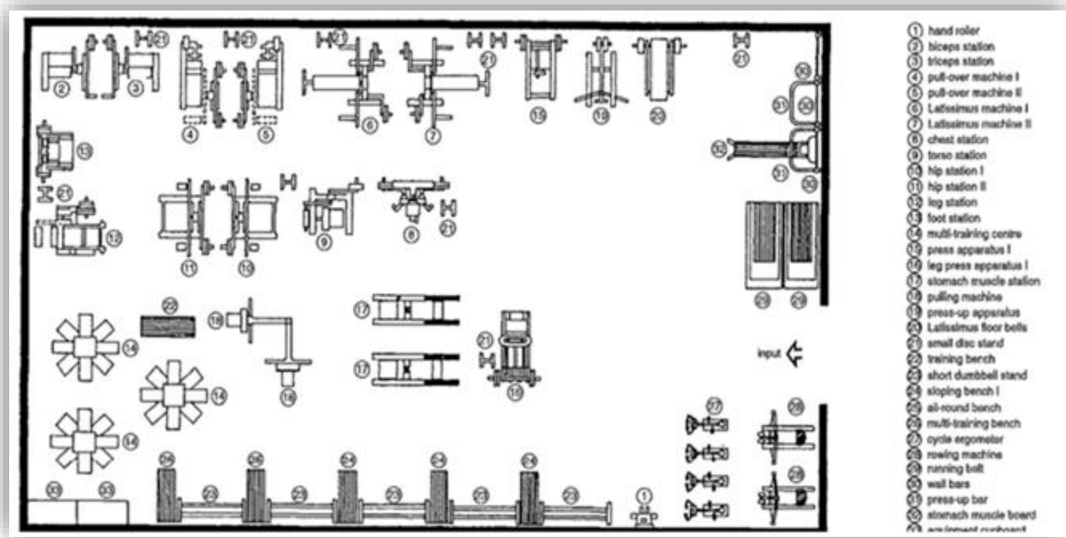


Figure 19: Gym equipment.

<u>Dressing room:</u> The gym needs a dressing room, where its area is according to the number of people the gym is designed to accommodate, one place per visitor per toilet (0.05-0.1) m2 (Neufert, 2014)

The dimensions of the room are (11.2×6.9) m, as shown in the figure.

No. people		Width a_p 1)
1	up to 5	0.88
2	up to 20	1.00
3	up to 100	1.25
4	up to 250	1.75
5	up to 400	2.25

Figure 21:Dressing room standards

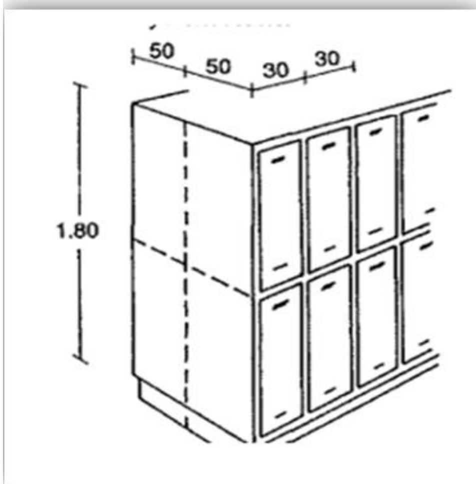


Figure 20:Dresser dimensions.

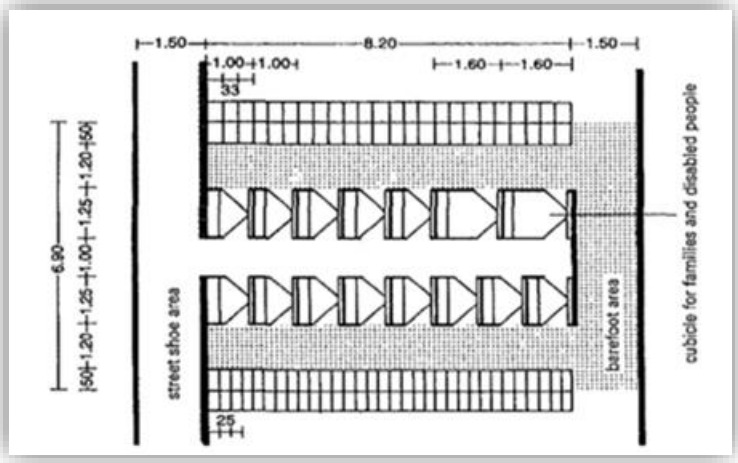


Figure 22: Dressing room standards

Washroom: The area and dimensions of the area to suffice the appropriate number of people and suit their movement, The ratio that takes from the area of the changing room is 40%, and as shown in the figure, the area of the rooms is 15 m2 with (3×5) m, and serves at least (11- 15) changing rooms.

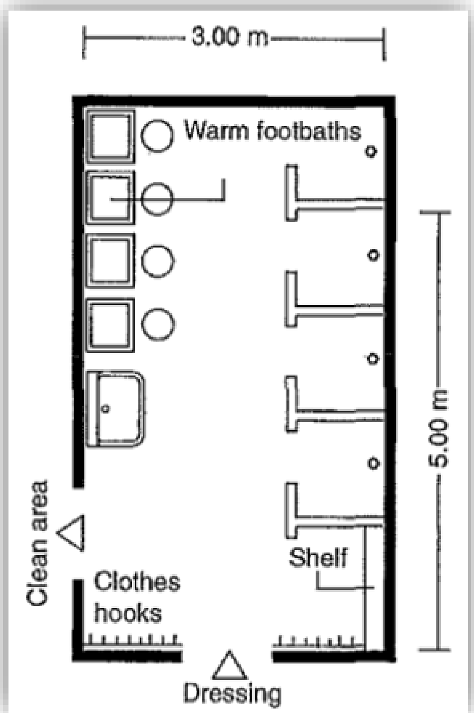


Figure 23: Washroom dimensions

Transformer Rooms: Each building must contain a room that contains at least one transformer and in large buildings, you need two transformers, so its area must not be less than 4 * 5 m.

The transformers may be on the ground floor or the level, and the transformer must be at least 60 cm above the ground.

The room should be away from water or if it is close, it is preferable to lay insulation and the grounding wires should be insulating.

Mechanical room: It is used to contain water pumps, water meters, and electrical objects, and its dimensions are according to the equipment inside it

Table 1:Transformer room standards

<table>
<tr><th rowspan="2">Operating Voltage</th><th rowspan="2">Adapter Type</th><th rowspan="2">No. of transformers in the room</th><th colspan="2">Transformer Capacity</th><th rowspan="2" colspan="3">Room Dimensions (Length*Width*Height)</th></tr>
<tr><th>From</th><th>To</th></tr>
<tr><td rowspan="5">12</td><td rowspan="5">Dry or Oily</td><td>One Adapter</td><td>500</td><td>1000</td><td colspan="3">(4*5*3) (It includes a transformer + a mmediumvoltage panel + a low voltage panel)</td></tr>
<tr><td>One Adapter</td><td>1500</td><td>2000</td><td colspan="3">(5*8*4) (It includes a transformer + a medium voltage panel + a low voltage panel)</td></tr>
<tr><td>Two Adapters</td><td>500</td><td>1000</td><td>(5*8*3)</td><td colspan="2">This is in the case that it is not possible to provide a room for each transformer</td></tr>
<tr><td rowspan="2">One Adapter</td><td rowspan="2">500</td><td rowspan="2">2000</td><td>(2*3*3)</td><td>Low Room</td><td rowspan="2">In the case that one room is not available for all tasks</td></tr>
<tr><td>(3*4*3)</td><td>Transformer Room + Intermediate plate</td></tr>
<tr><td rowspan="2">22</td><td rowspan="2">Dry or Oily</td><td>One Adapter</td><td rowspan="2">500</td><td rowspan="2">2000</td><td>(4*4*3)</td><td colspan="2">Dimensions of the transformer room (only a transformer can be installed in it)</td></tr>
<tr><td>One Adapter</td><td>(3*4*3)</td><td colspan="2">Dimensions of the room for medium and low voltage panels</td></tr>
</table>

Parking Spaces and ramping: specified parking regulations under the Building and Regulation System for Local Authorities in the city of Nablus, issued since 2011 and still in effect:

According to Article (30), page 186 of the system (Parking in Tourist Facilities):

- Point C: "Domestic hotels of second class (3) stars or less allocate one parking space for every four bedrooms, and for every 50 meters of shops you need one car, in addition to the needs of the restaurant every 20 meters need one car".

According to Article (31), page 187 of the system (Parking Specifications), points (7, 5, 2, 1):

"To determine the number of parking spaces required in any building, and to ensure the ease of entry and exit for each vehicle without any obstruction, the following conditions must be met:

1. The length of a parking space should not be less than (5.5 meters), and its width should not be less than (2.5 meters). The length of a bus parking space should not be less than (12 meters), and its width should not be less than (4 meters).
2. The slope of the external ramp should not exceed (20%).
3. The width of the external aisle should not be less than:

   a) (3.5 meters) for parking spaces with a capacity of up to (30) cars.

   b) (5.25 meters) for parking spaces with a capacity exceeding (30) cars. In case of providing separate entrance and exit, paragraph (a) of this clause applies to each.
4. The starting point of the external aisle should not exceed the front building line towards the street."

Stairs: Staircases serve as integral features in hotel architecture, requiring meticulous design for optimal shape and dimensions. In response to the considerable foot traffic within hotels, it's customary to encounter a grand staircase in the lobby, acting as a captivating centerpiece. Material selection, such as luxurious marble or exquisite hardwoods, is crucial for aligning with the hotel's style and conveying a sense of opulence. Equally important is the thoughtful integration of lighting, strategically employed to emphasize the staircase's architectural details, enhance its visual allure, and create a welcoming ambiance.

To achieve ideal placement, it is recommended to position the staircase near the main entrance for easy accessibility and in a central area where guests can conveniently access electric elevators. The choice of stairs should be tailored to accommodate the building's user capacity, emphasizing safety through the incorporation of a fixed handrail. This comprehensive approach ensures that the staircase not only complements the hotel's aesthetic but also prioritizes functionality, safety, and a pleasant guest experience. The following pictures show the appropriate stair width, taken from (Neufert, 2014) book.

- 0.55 m width allows 1 person to pass.
- 1.25 m width allows 2 people to pass.
- 1.875 m wide allowing 3 people to pass.

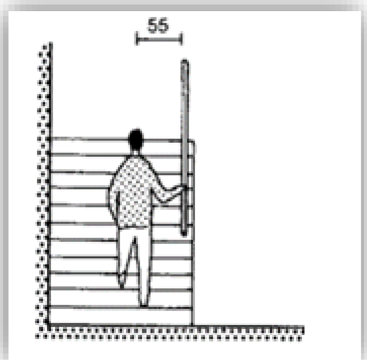


Figure 26: Width of stairs for one person to cross

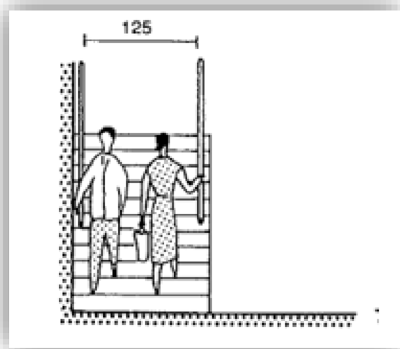


Figure 25: Width of stairs for two people to cross

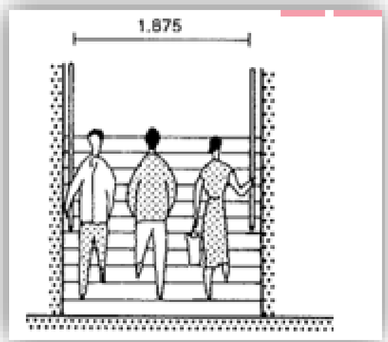
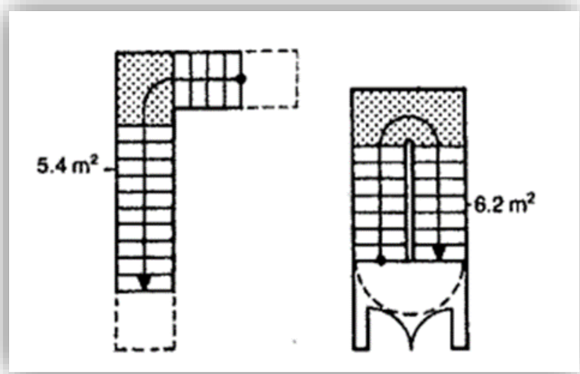


Figure 24: Width of stairs for three persons to cross.

Landing: Landing width ≥ stair width, to allow loads to be transported.(Neufert, 2014)



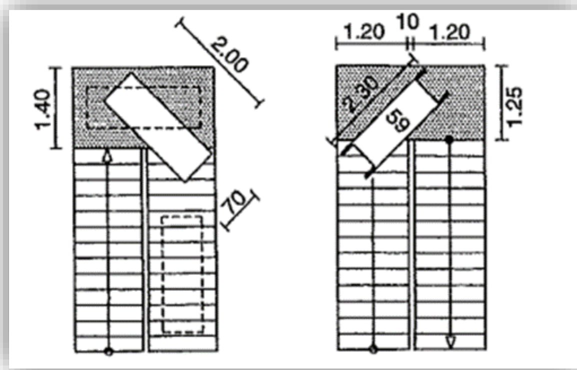


Figure 27: Dimensions of Landing.

Treads and Rise: Treads should be consistent throughout the flight with a rise of between 150 mm and 170mm and with a going of between 280 mm and 450 mm (reduced to between 75 mm and 150 mm rise with a minimum going of 280 mm in domestic situations). There should be no open risers. (Neufert, 2014)

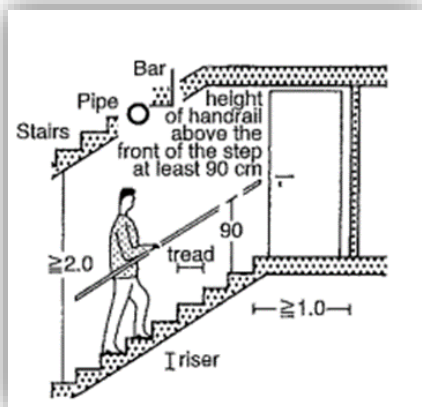


Figure 28: The standards for heights. between stairs

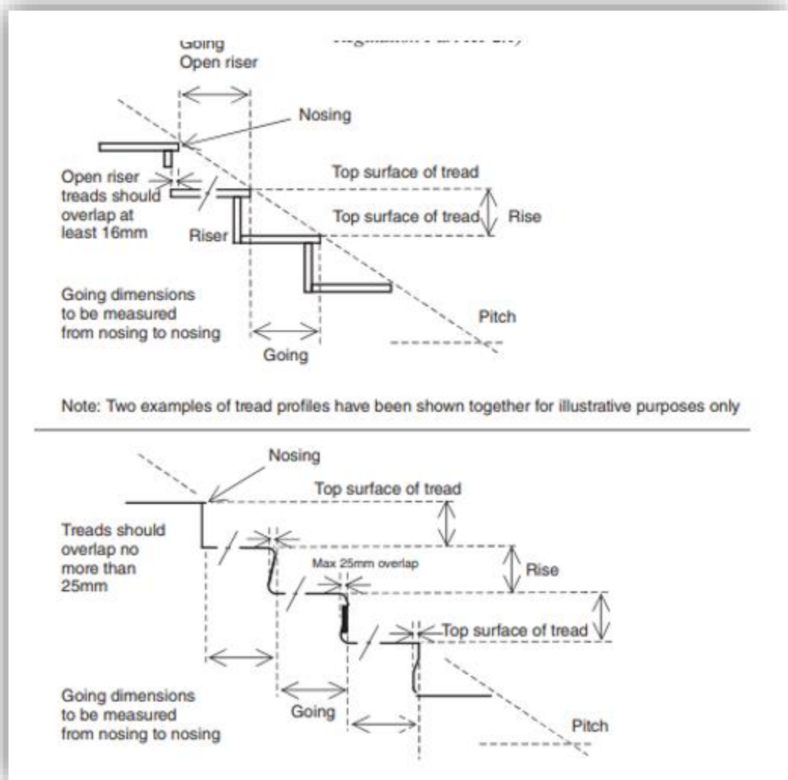


Figure 29: Stair parts.

stair nose: The primary function of a stair nose is to enhance stair safety. The extension of the stair edge increases the surface area slightly, thereby reducing the chances of missing a step or slipping while ascending or descending. It is crucial to avoid a circular design to minimize slipping risks. Additionally, the stair nose serves the purpose of safeguarding the rise from dirt accumulation.

Consider the following:

- Steps without a solid riser should have an overhang of 30 mm.
- If the tread is less than 260 mm, the step should overhang ≥ 30 mm.(Neufert, 2014)

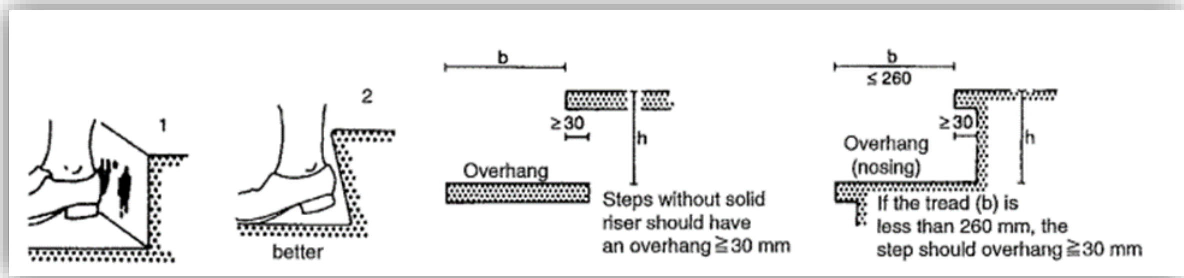


Figure 30:Standards for stair noses.

Handrails **:**Should be provided on both sides, Handrails to be terminated in a way that reduces the risk of clothing being caught, Closed end to the handrail at the top and bottom, and Handrail to be continuous across intermediate landings.(Neufert, 2014)

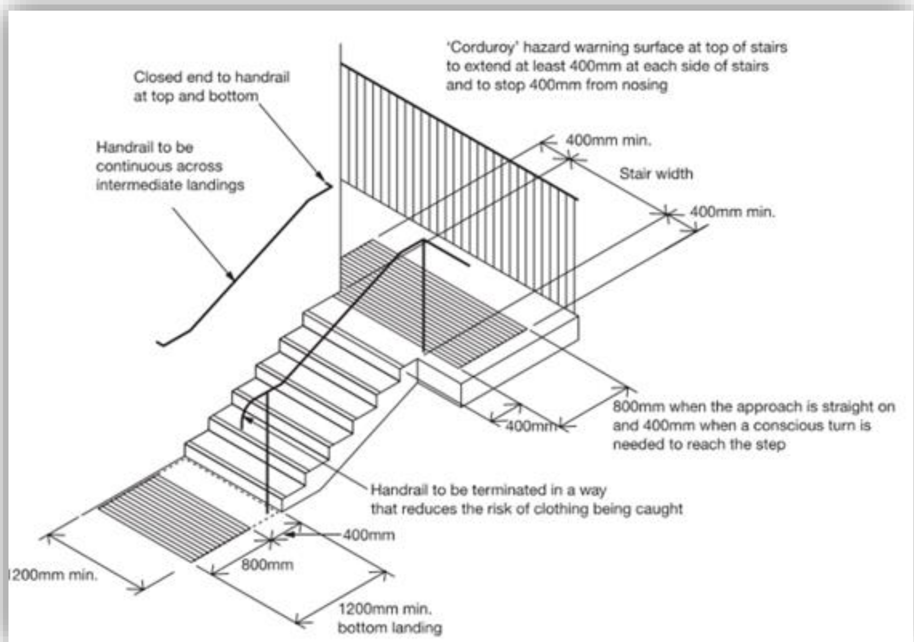


Figure 31:: Special conditions for handrails and stairs.

Headroom : A minimum of 2000 mm clear headroom should be provided at all landings and access points as well as above the pitch line. (Neufert, 2014)

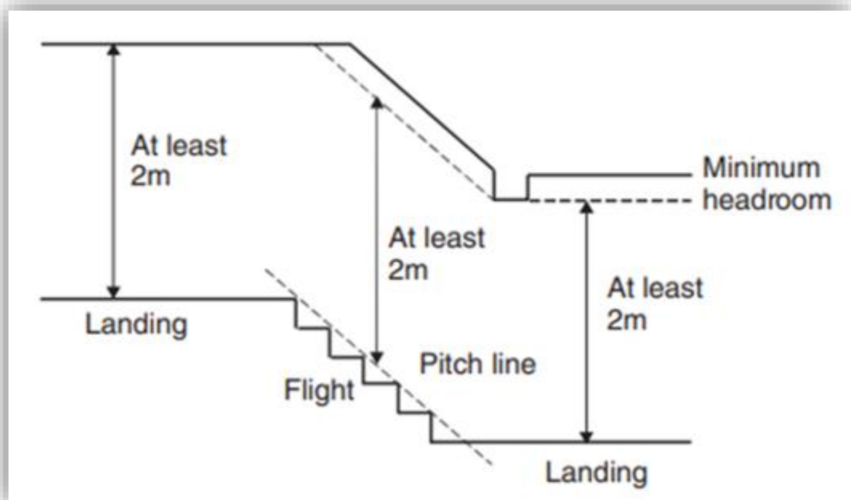


Figure 32: The minimum height allowed in the Headroom.

Access doors: Unless designing main (or alternative access) entrance doors it is important to consider all potential users. Wheelchair users will have certain requirements, as will the poorly sighted or those with limited strength. For example, a manually operated self-closing door set with sufficient power to close against normal wind speeds will probably be beyond the strength capacity of most wheelchair users or those with limited strength. (Neufert, 2014)

Revolving doors are not considered accessible because of the difficulties they create for a whole host of potential users. (Neufert, 2014)

Preferences:

- Glazed doors allow people to see potential obstacles and others approaching, but must also be made visually noticeable for the poorly sighted.
- Powered sliding doors do not waste the space associated with the arc of a door swing, and automatic opening sliding doors do not require access to a manual opening device.
- An opening and closing system operated by remote sensors requires no contact with the door. (Neufert, 2014)

Door width: To take account of different door styles and support systems, the 'effective clear width' is referred to as it states the total width of opening available that is devoid of any obstructions caused by such items as door handles, hinges, or limited turning capacity. Unpowered access doors should also have a minimum of 300 mm extra unobstructed space alongside the operating latch to allow for wheelchair approach.(Neufert, 2014)

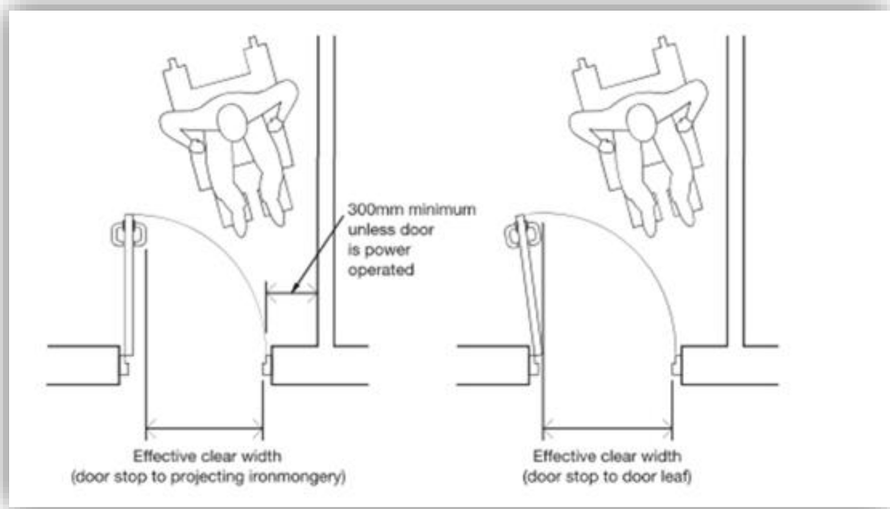


Figure 33: Staircase door standards to suit people with special needs.

Note: Designing stairs with a counterclockwise upward direction is preferred for various reasons, especially in high-traffic buildings like public spaces or commercial establishments. This design choice contributes to a well-organized and efficient flow of people, as users naturally follow a familiar path, minimizing congestion and enhancing overall circulation.

Much like the rationale behind drawer design, the counterclockwise upward direction aligns with the natural motion of the human body, especially for right-handed individuals. This ergonomic consideration enhances comfort and intuitiveness during the ascent of stairs.

Additionally, counterclockwise stair design is associated with improved safety. Users are accustomed to this direction, reducing the likelihood of missteps or accidents during the ascent. The familiar and expected pattern facilitates a safer experience for individuals navigating the stairs.

In summary, opting for a counterclockwise upward direction in stair design not only promotes efficiency and safety in high-traffic settings but also aligns with ergonomic principles, making the ascent more comfortable and intuitive for users.

Elevators: Among the myriad decisions faced by the designer of a multi-story building, perhaps none holds more significance than the choice of vertical transportation equipment. This encompasses passenger, service, and freight elevators. These elements not only constitute a substantial portion of the building's costs but also significantly impact the quality of elevator service. This, in turn, plays a crucial role in influencing a tenant's decision when selecting space in buildings that compete with one another.

Standard dimensions in elevators from (Neufert, 2014)

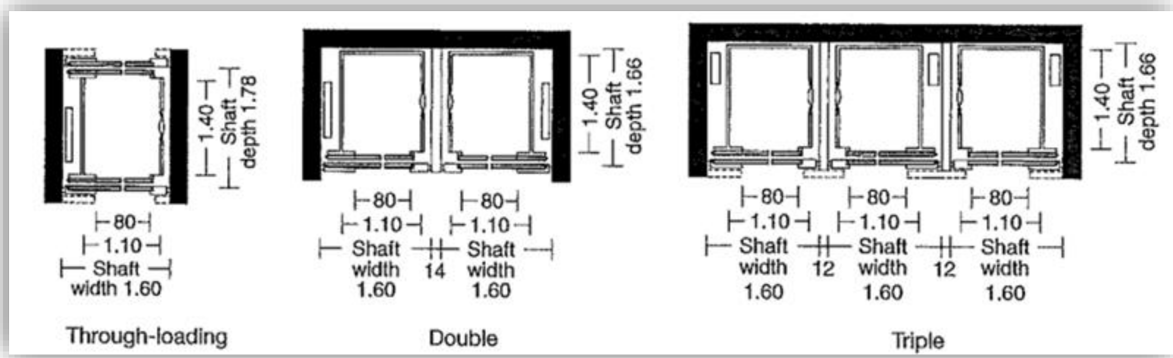


Figure 34: Dimensions of elevators.

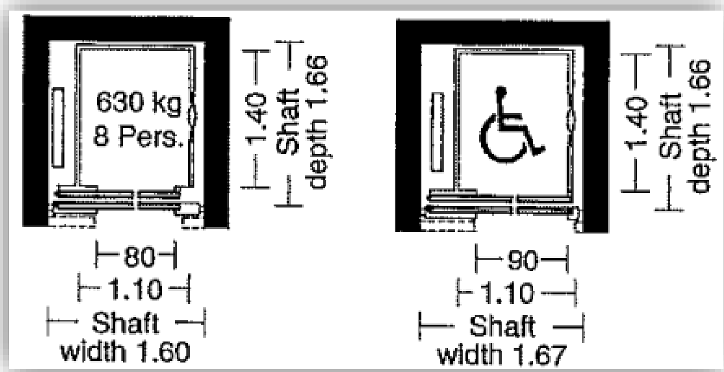


Figure 35: Dimensions of elevators suitable for people with special needs.

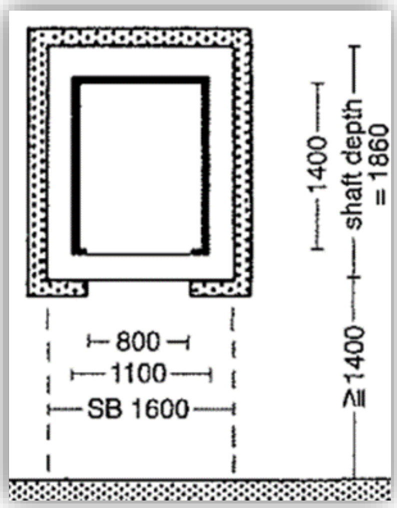


Figure 36: Dimensions of the waiting area in front of the elevator.

Dimensions of elevators based on capacity (Traction lifts)

load capacity	kg	800				1000 (1250)				1600			
nominal speed	m/s	0.63	1.0	1.6	2.5	0.63	1.0	1.6	2.5	0.63	1.0	1.6	2.5
min. shaft width	c	1900				2400 (2600)				2600			
min. shaft depth	d	2300				2300 (2600)				2600			
min. shaft pit depth	p	1400	1500	1700	2800	1400	1700		2800	1400	1900	2800	
min. shaft head height	q	3800		4000	5000	4200			5200	4400			5400
shaft door width	c_1	800; min. 900				1100				1100			
shaft door height	f_1	2000				2100				2100			
min. area of machine room	m^2	15			18	20				25			
min. width of machine room	r	2500			2800	3200				3200			
min. depth of machine room	s	3700			4900	4900				5500			
min. height of machine room	h	2200			2800	2400			2800	2800			
car width	a	1350				1500				1950			
car depth	b	1400				1400				1750			
car height	k	2200				2300				2300			
car door width	e_2	800; min. 900				1100				1100			
car door height	f_2	2000				2100				2100			
permissible no. passengers		10				13 (16)				21			

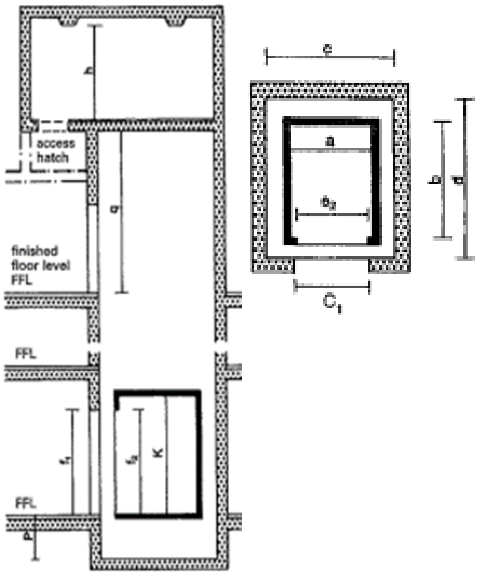


Figure 37: Dimensions of elevators based on capacity (Traction lifts). from (Neufert, 2014) Meaning of table symbols.

Dimensions of service elevators based on capacity (Traction lifts)

load capacity	kg	630	1000	1600	2000	2500	3200
nominal speed	m/s	← 0.40 — 0.63 — 1.00 →					
car dimensions	mm						
CW		1100	1300	1500	1500	1800	2000
CD		1570	1870	2470	2870	2870	3070
CH		2200	2200	2200	2200	2200	2200
door dimensions	mm						
DW		1100	1300	1500	1500	1800	2000
DH		2200	2200	2200	2200	2200	2200
shaft dimensions	mm						
SW		1800	2000	2200	2300	2600	2900
SD		1700	2000	2600	3000	3000	3200
SPH 0.4 and. 0.63	m/s	1200	1300	1300	1300	1300	1400
1.0	m/s	1300	1300	1600	1600	1800	1900
SHH 0.4 and 0.63	m/s	3700	3800	3900	4000	4100	4200
1.0	m/s	3800	3900	4200	4200	4400	4400
PHH		1900	1900	1900	2100	1900	1900

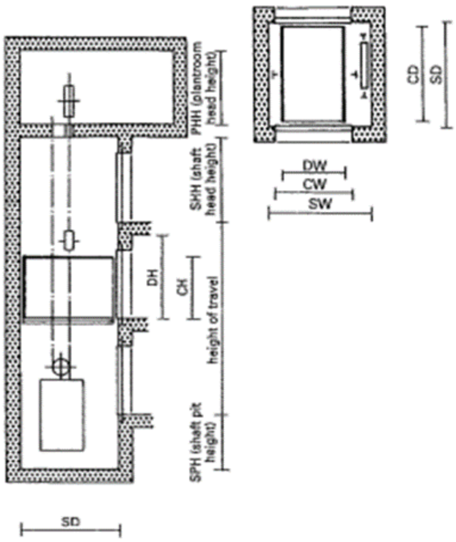


Figure 38: Dimensions of service elevators based on capacity) Traction lifts (from (Neufert, 2014) Meaning of table symbols.

Emergency stairs: An emergency stair, also known as an emergency exit stairwell or escape stair, is a designated and secure pathway within a building that is specifically designed for use during emergencies. The primary purpose of emergency stairs is to provide a safe and efficient means for occupants to evacuate the building quickly in the event of a fire, natural disaster, or other emergencies that may compromise the regular means of egress.

The dimensions of the rises and Threads are chosen so that they are not less than twice the height of the rise plus the size of the Thread (excluding the noses of the stairs) than 55 cm and not more than 70 cm, provided that the discrepancy in the measurements of the rise and Thread in one pitch of the stair does not exceed 5 mm. The number of rises in one pitch should not be less than 3 and not more than 12. Threads measuring less than 25 cm have a nose 25 mm long.

Table 2:Table Requirements for internal staircases in new buildings.

The minimum pure width for a staircase with an occupancy capacity of less than (50) people	(90) cm
The minimum pure width of a staircase with occupancy loads equal to or greater than (50) people	(110) cm
Maximum height of the hopper	(18) cm
The minimum size of the footwall, without taking into account the nose of the step or protrusion	(28) cm
Minimum distance between floor and ceiling	(2.10) cm
The maximum height between two consecutive stands	(3.7) cm
Minimum dimensions of the rack in the direction of movement	(110) cm
Note: The pure width of the stair rail is measured without deleting the thickness of the handrail within the width of the rail, whether from one side or both sides of this thickness does not exceed (90) mm	

2.2.3 Comparison of standards and areas in the new project

Basement floor 3:

Table 3: Basement floor comparisons with standards.

Basement Floor 3			
Space	***Area (m^2) / Dimensions (m)***	***Minimum Standard (minimum)***	***Suitable or not***
parking space for each space	***13.75 m2***	***13.75 m2***	***Suitable***
Ramp	***19 % slope***	***20 % slope (maximum)***	***Suitable***
Entrance	***5.41 m***	***5.25 m***	***Suitable***

Basement floor 2:

Table 4::Basement floor comparisons with standards.

Basement Floor 2			
Space	***Area (m^2) / Dimensions (m)***	***Minimum Standard (minimum)***	***Suitable or not***
parking space for each space	***13.75 m2***	***13.75 m2***	***Suitable***
Ramp	***19 % slope***	***20 % slope (maximum)***	***Suitable***
Entrance	***5 m***	***5.25 m***	***Not Suitable***
Electricity room	***20.0109 m2***	***20 m2***	***Suitable***
Transformer room	***20 m2***	***20 m2***	***Suitable***

Basement floor 1:

Table 5: Basement floor comparisons with standards.

Basement Floor 1			
Space	***Area (m^2) / Dimensions (m)***	***Minimum Standard (minimum)***	***Suitable or not***
GYM	***228.090 m2***	***200 m2***	***Suitable***
Shower area for GYM (The smallest sample was taken)	***1.6160 m2***	***1.35m2***	***Suitable***
Dressing area for GYM	***29.176 m2***	***20 m2***	***Suitable***
Wc for GYM (The smallest sample was taken)	***1.6612 m2***	***1.275 m2***	***Suitable***
Drying Area	***9.370 m2***	***6.6 m2***	***Suitable***
Laundry Area	***15.418 m2***	***6.6 m2***	***Suitable***
Publishing Area	***24.813 m2***	***6.6 m2***	***Suitable***
Dirty Laundry Area	***17.910 m2***	***6.6 m2***	***Suitable***
Prefabricated Bedding Area	***23.224 m2***	***6.6 m2***	***Suitable***
Laundry Room	***54.705***	***6.6 m2***	***Suitable***

Ground Floor:

Table 6:Ground floor space comparison with standards.

Ground Floor			
Space	**Area (m^2) / Dimensions (m)**	**Minimum Standard (minimum)**	**Suitable or not**
Shop 1(Based on shop width)	**4.27 m**	**4m**	**Suitable**
Wc 1 for shop 1	**5.2598 m2**	**4.32 m2**	**Suitable**
Shop 2(Based on shop width)	**4.28 m**	**4m**	**Suitable**
Wc 2 for shop 2	**5.2569 m2**	**4.32 m2**	**Suitable**
Reception	**46.3564 m2**	**40 m2**	**Suitable**
Rest Hall	**155.046 m2**	**78 m2**	**Suitable**
Emergency stair 1 (The minimum width of a stair)	**1.4 m**	**1.10 m**	**Suitable**
Emergency stair 2 (The minimum width of a stair)	**1.4 m**	**1.10 m**	**Suitable**
General stair (The minimum width of a stair)	**1.6 m**	**1.10 m**	**Suitable**
Elevator 1	**5.52 m2**	**5.52 m2**	**Suitable**
Elevator 2	**5.52 m2**	**5.52 m2**	**Suitable**
Elevator 3	**5.52 m2**	**5.52 m2**	**Suitable**
Service elevator	**5.52 m2**	**4 m2**	**Suitable**
The smallest sample of public bathrooms	**2.15 m2**	**1.275 m2**	**Suitable**
The smallest sample of bathrooms for people with special needs	**5.8962 m2**	**3.75 m2**	**Suitable**

Attics Floor:

Table 7:Attics floor space comparison with standards.

Attics Floor			
Space	***Area (m^2) / Dimensions (m)***	***Minimum Standard (minimum)***	***Suitable or not***
Breakfast room	***153.934 m2***	***43 m2***	***Suitable***
kitchen	***31.2160 m2***	***28 m2***	***Suitable***
Emergency stair 1 (The minimum width of a stair)	***1.4 m***	***1.10 m***	***Suitable***
Emergency stair 2 (The minimum width of a stair)	***1.4 m***	***1.10 m***	***Suitable***
General stair (The minimum width of a stair)	***1.6 m***	***1.10 m***	***Suitable***
Elevator 1	***5.52 m2***	***5.52 m2***	***Suitable***
Elevator 2	***5.52 m2***	***5.52 m2***	***Suitable***
Elevator 3	***5.52 m2***	***5.52 m2***	***Suitable***
Service elevator	***5.52 m2***	***4 m2***	***Suitable***
The smallest sample of public bathrooms	***2.15 m2***	***1.275 m2***	***Suitable***
The smallest sample of bathrooms for people with special needs	***5.8962 m2***	***3.75 m2***	***Suitable***

First Floor (Repeated floor) :

Table 8:Second-floor space comparison with standards.

First Floor			
Space	***Area (m^2) / Dimensions (m)***	***Minimum Standard (minimum)***	***Suitable or not***
Bedroom 1	***35.155 m2***	***25 m2***	***Suitable***
Bathroom 1	***5.4 m2***	***3.995m2***	***Suitable***
Bedroom 2	***31.330 m2***	***25 m2***	***Suitable***
Bathroom 2	***5.4 m2***	***3.995 m2***	***Suitable***
Bedroom 3	***25.0427 m2***	***25 m2***	***Suitable***
Bathroom 3	***5.274 m2***	***3.995 m2***	***Suitable***
Bedroom 4	***30.770 m2***	***25 m2***	***Suitable***
Bathroom 4	***5.4 m2***	***3.995 m2***	***Suitable***
Bedroom 5	***36.467 m2***	***25 m2***	***Suitable***
Bathroom 5	***5.07 m2***	***3.995 m2***	***Suitable***
Bedroom 6	***26.110 m2***	***25 m2***	***Suitable***
Bathroom 6	***5.4 m2***	***3.995 m2***	***Suitable***
Bedroom 7	***29.314 m2***	***25 m2***	***Suitable***
Bathroom 7	***7.138 m2***	***3.995 m2***	***Suitable***
Bedroom 8	***38.874 m2***	***25 m2***	***Suitable***
Bathroom 8	***5.4 m2***	***3.995 m2***	***Suitable***
Emergency stair 1 (The minimum width of a stair)	***1.4 m***	***1.10 m***	***Suitable***
Emergency stair 2 (The minimum width of a stair)	***1.4 m***	***1.10 m***	***Suitable***
General stair (The minimum width of a stair)	***1.6 m***	***1.10 m***	***Suitable***
Elevator 1	***5.52 m2***	***5.52 m2***	***Suitable***
Elevator 2	***5.52 m2***	***5.52 m2***	***Suitable***
Elevator 3	***5.52 m2***	***5.52 m2***	***Suitable***
Service elevator	***5.52 m2***	***4 m2***	***Suitable***

Roof Floor:

Table 9:Roof floor space comparison with standards.

Roof Floor			
Space	***Area (m²) / Dimensions (m)***	***Minimum Standard (minimum)***	***Suitable or not***
Kitchen	***55.3874 m2***	***43.7 m2***	***Suitable***
Restaurant	***328.3387 m2***	***71.4 m2***	***Suitable***
Emergency stair 1 (The minimum width of a stair)	***1.4 m***	***1.10 m***	***Suitable***
Emergency stair 2 (The minimum width of a stair)	***1.4 m***	***1.10 m***	***Suitable***
General stair (The minimum width of a stair)	***1.6 m***	***1.10 m***	***Suitable***
Elevator 1	***5.52 m2***	***5.52 m2***	***Suitable***
Elevator 2	***5.52 m2***	***5.52 m2***	***Suitable***
Elevator 3	***5.52 m2***	***5.52 m2***	***Suitable***
Service elevator	***5.52 m2***	***4 m2***	***Suitable***
The smallest sample of public bathrooms	***2.15 m2***	***1.275 m2***	***Suitable***
The smallest sample of bathrooms for people with special needs	***5.8962 m2***	***3.75 m2***	***Suitable***

2.3 Environmental Literature Review

2.3.1 Introduction

Environmental assessment is one of the crucial aspects in designing and implementing projects, indicating the success of any project. Environmental assessment tools are continually evolving, to achieve sustainability in construction and ensure comfort for users. This is accomplished through a study of the project concerning acoustic, lighting, and thermal aspects.

2.3.2 Case Study Analysis

Introduction

Golden Tree Hotel also known as Golden Old was chosen for its beautiful architectural design and a large number of different spaces inside, for example, it has separate swimming pools for men and women. It contains a restaurant and a special hall for events and also because it resembles the design of this project also through the presence of a restaurant, gym, and the use of glass facades. Finally, it was chosen as a case study to use the idea of double size in its design as one of the ideas used in the architectural design of this project.

Information about the case study

- **project name : Golden Tree Hotel**
- **Location :Beit Wezan,Nablus**
- **Engineering office :Arab experts**
- **Hotel Rating: Five stars**
- **Year of construction: 2015**
- **Construction area = 6000 m^2**
- **Number of floors: 7 floors above ground and underground floor**

(1) ***(2)***

(3)

Figure 39: 1-3 Exterior photos of Golden Tree Hotel.

(1)

(2)

(3)

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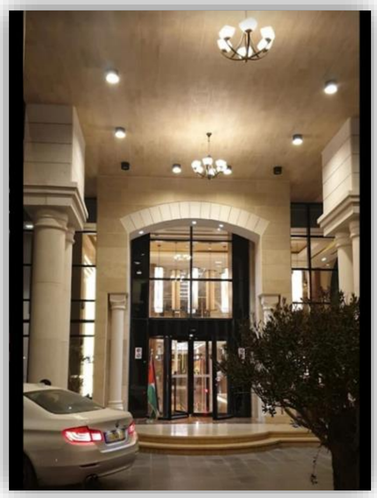


(5)

Figure 40: 1-5 Interior photos of Golden Tree Hotel.

Hotel location: Golden Tree Hotel is located in Nablus in Beit Wezan, the property is 41 km from Herzliya, located 30 km from Kakun Castle. Nearest airports : *Ben Gurion Airport* = 40.2 km*, Queen Alia International Airport* =92.6 km

Piece 6, basin 15

Figure 41: Location of Golden Tree Hotel from Geomolg.

Architectural plans

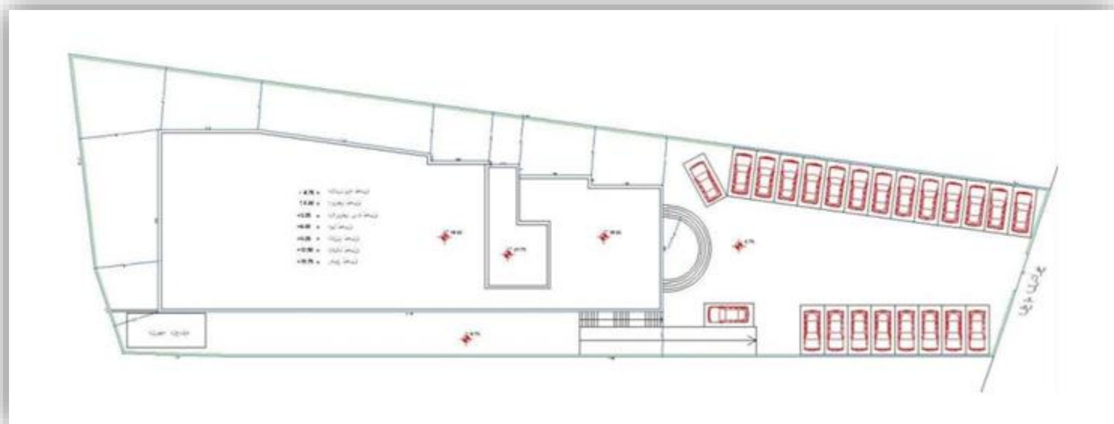


Figure 42:Site plan for Golden Tree Hotel.

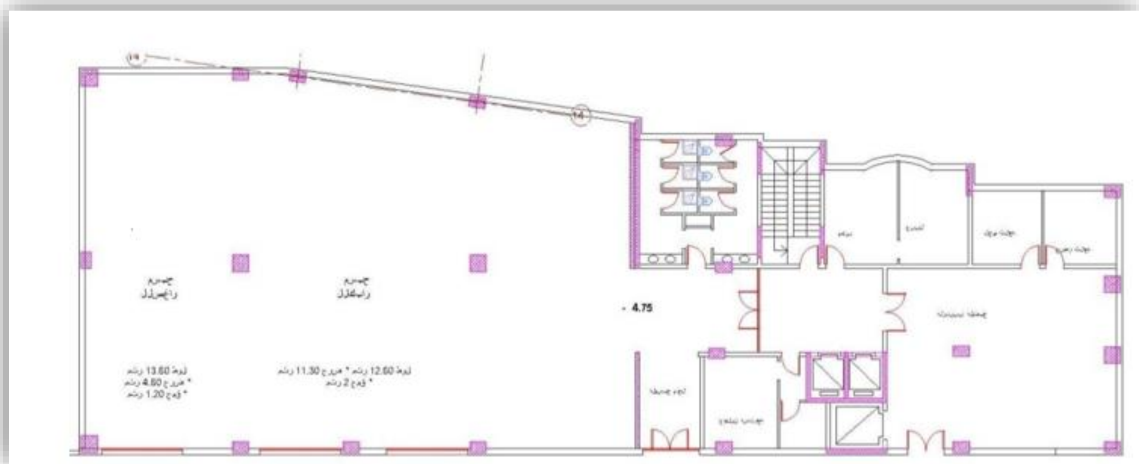


Figure 43: Basement plan for Golden Tree Hotel.

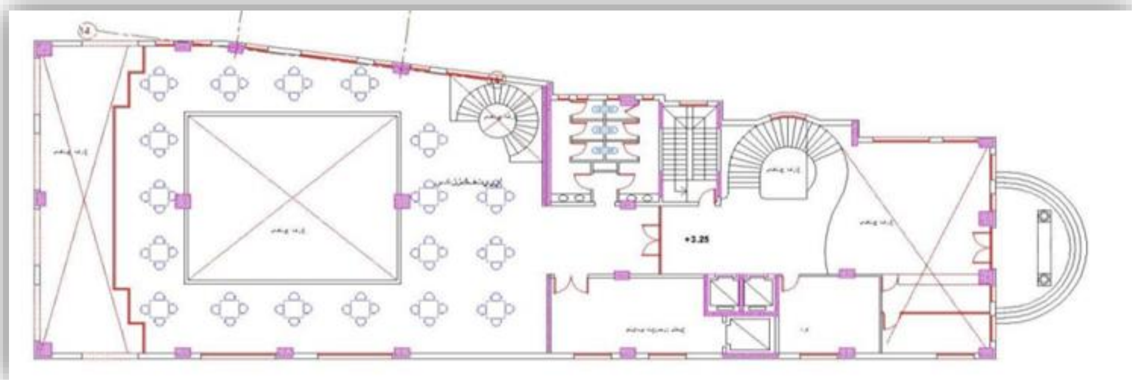


Figure 44: Ground floor plan for Golden Tree Hotel

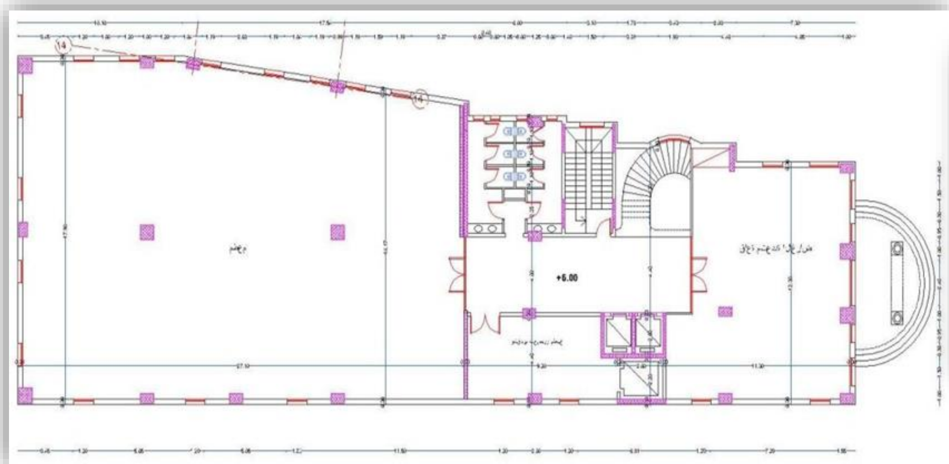


Figure 45:Clarifying the spaces of the first floor.

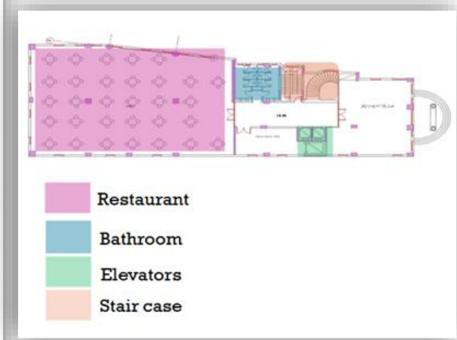


Figure 46:first floor plan for Golden Tree Hotel

Figure 47:The second, third, and fourth-floor plans for Golden Tree Hotel.

Figure 48:Clarifying the spaces of the second, third, and fourth floors.

Elevations

Figure 49:North elevation for Golden Tree Hotel

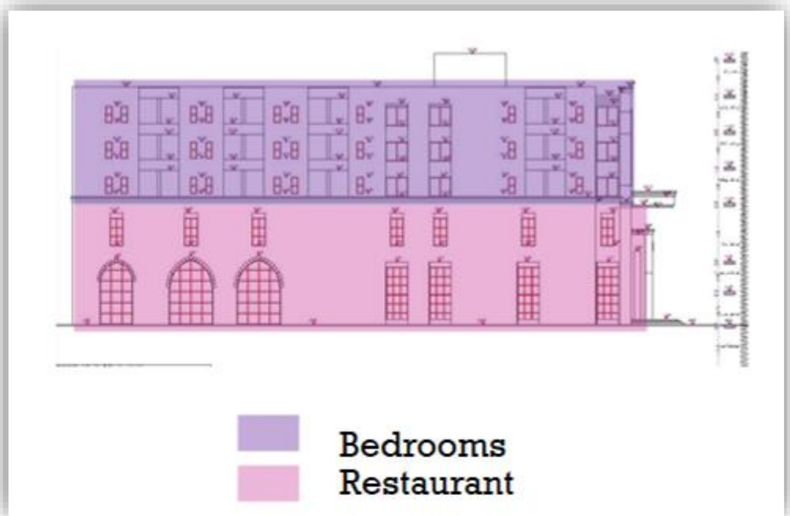


Figure 51:West elevation for Golden Tree Hotel.

Figure 50:South elevation for Golden Tree Hotel.

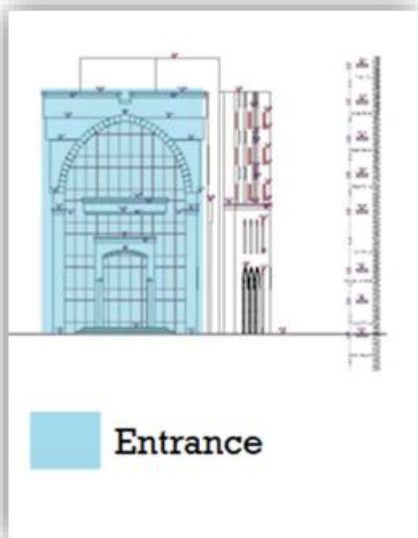


Figure 52:: East elevation for Golden Tree Hotel.

Advantages of this study

- It contains a sufficient number of elevators, as it includes 5 elevators, 2 for guests, one for services, one for the garage, and the last one connects the ground and second floors only.
- Its entrance is clear, wide, and easy to access.
- It consists of an isolated water drainage system that separates gray and black water.

Disadvantages of this study

- There is a shortage of escape stairs, as the building contains a main staircase for all floors and a staircase connecting the ground floor and the first floor, Recently, an iron escape staircase was designed to hang on the building. The civil defense requirements for escape stairs were not taken into consideration during the design, noting that one escape staircase is not enough.
- Difficulty in cleaning glass facades, especially the front façade
- There is no alternative source of energy such as solar cells to reduce the use of electricity, as it consumes large amounts of energy.

2.3.3 Site analysis and description of the project

Introduction

The site Analysis involves evaluating the location from various aspects, including the location, climate, and external environmental impacts. It is a crucial step before initiating the design process for any project. The agent monitors and records aspects such as the location's features, characteristics of the adjacent area, the nature of the region, activities taking place, noise levels, street studies, regulatory mechanisms, accessibility, and climate. Gathering data on these aspects is essential to achieve the project's goals and meet the requirements after the construction process. This also depends on the type and purpose of the project. Site study also holds significant importance for achieving and designing energy-efficient buildings and environmentally friendly structures.

Site Location

Site location analysis is a process of evaluating and determining the most suitable location for a specific purpose, such as a business, facility, or development. The goal of site location analysis is to choose a location that maximizes the chances of success and minimizes risks and costs for a specific project or business. It often involves data analysis, research, and sometimes geographic information systems (GIS) to make informed decisions.

Royal Suites Hotel is located in Nablus city, at a longitude of 35.24667 E, and a latitude of 32.22037 N.

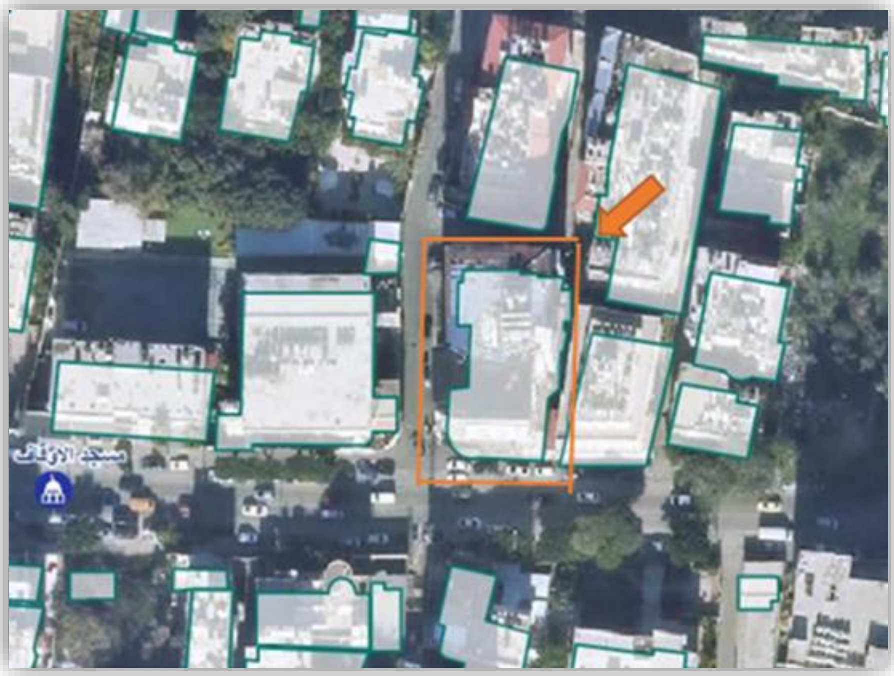


Figure 53: Royal Suits Hotel location.

The building is a commercial building. With sector number 24060, plot number of land 79. The building rebounds from the front direction by a distance of 3m, from the back direction by 4m, and from the side direction by a distance of 2m.

The constructed soil is a polar soil with a bearing capacity of 2.00 Kg/cm^2,

Figure 54: Site plan and demarcation from Nablus Municipality.

Site accessibility, roads, and entrances

The building is bounded from the west and south sides by two streets. The southern side contains the main street; its width is 20m. The western side contains the secondary street.

The figure below shows the streets, accessibility, and entrances to the building.

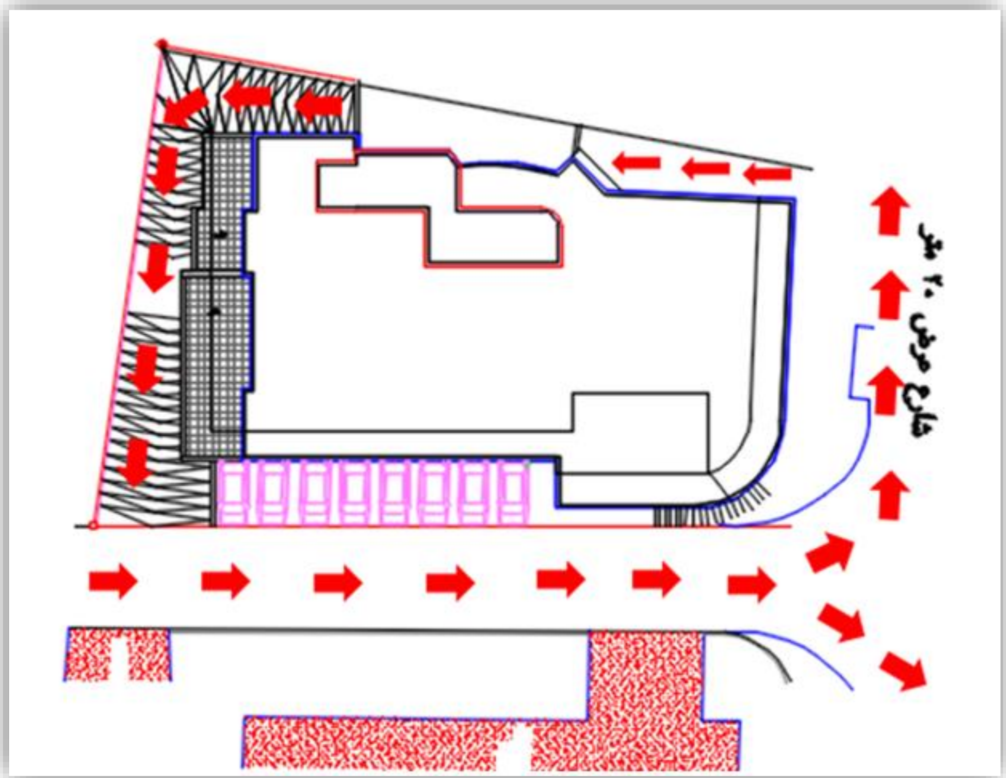


Figure 55: Site accessibility, roads, and entrances.

Contour lines

There a different levels of contour lines on the land, the highest level is 514m, and the lowest level is 510m.

Figure 56: Contour lines.

Site Climatic Analysis

Annual Temperature

In Nablus, the summers are long, warm, arid, and clear and the winters are cold and mostly clear. Over the year, the temperature typically varies from 5.56 °C to 29.44 °C and is rarely below 2.22 °C or above 32.22°C.

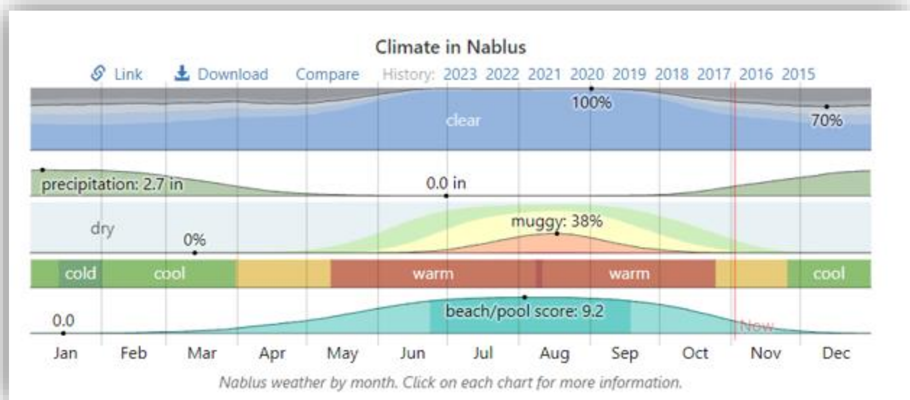


Figure 57: Nablus weather by month.

The *hot season* lasts for *4.4 months*, from *May 30* to *October 10*, with an average daily high temperature above 26.11 °C. The hottest month of the year in Nablus is *August*, with an average high of 29.44 °C and a low of 20°C.

The *cool season* lasts for *3.1 months*, from *December 8* to *March 13*, with an average daily high temperature below 16.11 °C. The coldest month of the year in Nablus is *January*, with an average low of 6.11 °C and a high of 12.78 °C.

In Figure 59, the red line indicates the daily average high temperature, the blue line indicates low temperatures and the dotted lines indicate the average corresponding perceived temperatures.

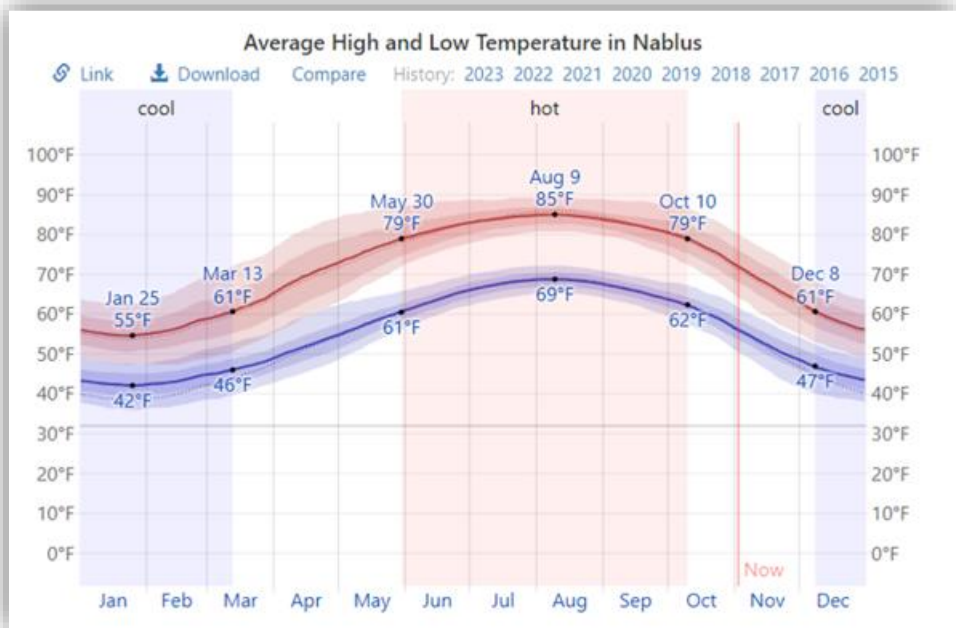


Figure 58: Average high and low temperatures in Nablus

Average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	55°F	57°F	62°F	70°F	76°F	81°F	84°F	85°F	82°F	77°F	67°F	59°F
Temp.	48°F	50°F	54°F	61°F	67°F	72°F	76°F	76°F	73°F	68°F	59°F	52°F
Low	43°F	43°F	47°F	52°F	58°F	64°F	68°F	68°F	66°F	60°F	52°F	45°F

Figure 59: Average annual temperature in Nablus

Figure 61, shows average hourly temperatures for the entire year, the horizontal axis represents a day of the year and the main axis is the hour of the day, and the colour expresses the average temperature for that hour and day.

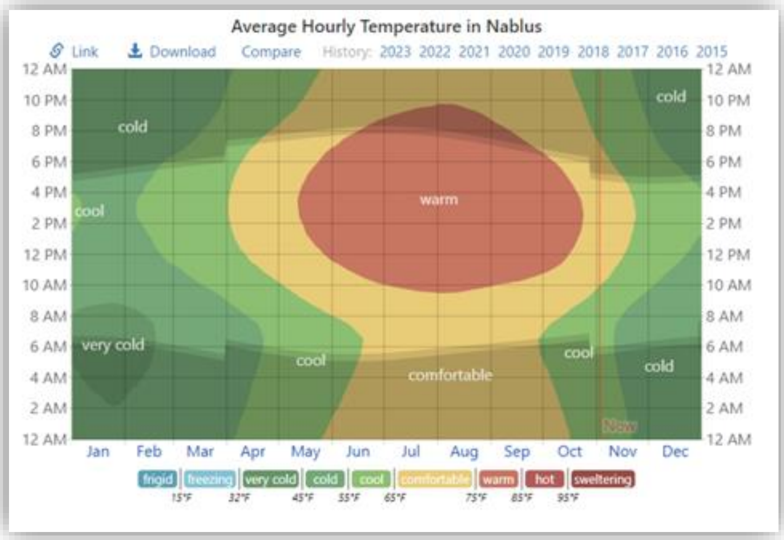


Figure 60: Average hourly temperature in Nablus.

Clouds

In Nablus, the average percentage of the sky covered by clouds experiences *significant* seasonal variation over the year.

The *clearer* part of the year in Nablus begins around *May 22* and lasts for *4.8 months*, ending around *October 15*.

The clearest month of the year in Nablus is *August*, during which on average the sky is *clear*, *mostly clear*, or *partly cloudy 100%* of the time.

The *cloudier* part of the year begins around *October 15* and lasts for *7.2 months*, ending around *May 22*.

The cloudiest month of the year in Nablus is *December*, during which on average the sky is *overcast* or *mostly cloudy 29%* of the time.

Figure 62 shows the percentage of the sky that is covered by clouds, and the time spent for each cloud cover.

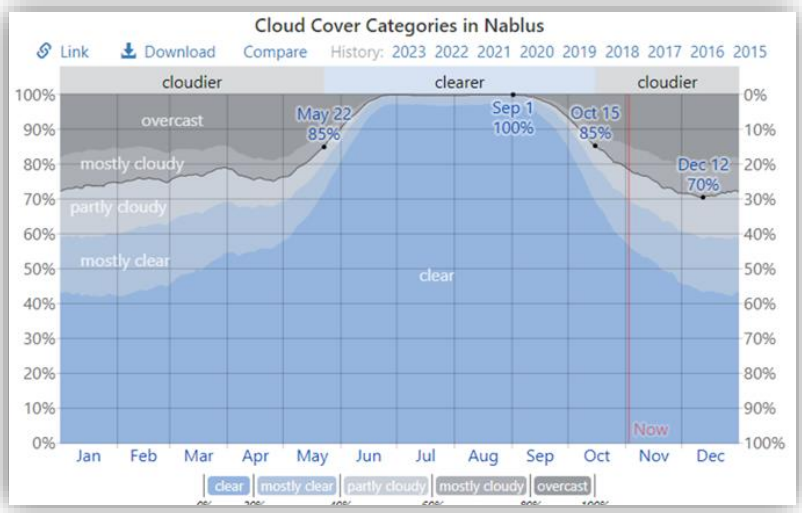


Figure 61: Cloud cover categories in Nablus.

Fraction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cloudier	26%	25%	23%	24%	17%	3%	0%	0%	2%	15%	25%	29%
Clearer	74%	75%	77%	76%	83%	97%	100%	100%	98%	85%	75%	71%

Figure 62: Cloud cover through months.

Rainfall

The rainy season begins in Nablus from October 19 to April 15 and continues for 5.9 months of the year. January is the month in which the most rain falls, with an average rainfall of 2.6 inches. From April 15 to October 19, it is considered a non-rainy period in Nablus, and it lasts for 6.1 months. July is the least rainy month in Nablus with an average rainfall of 0.0 inches.

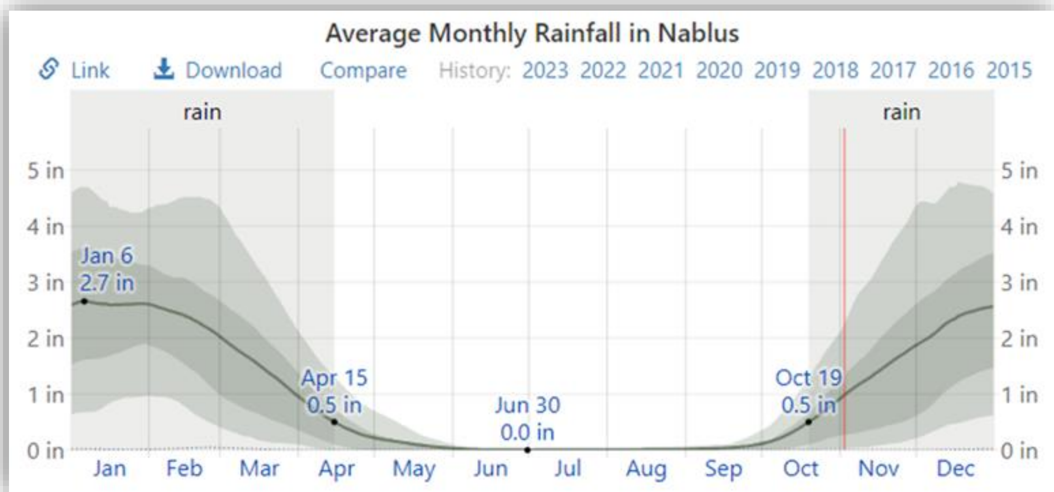


Figure 63: Average monthly rainfall.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	2.6"	2.4"	1.5"	0.5"	0.1"	0.0"	0.0"	0.0"	0.0"	0.4"	1.4"	2.3"

Figure 64: Rainfall through months.

Humidity analysis

Humidity is defined as the amount of water vapor present in the air, which is not visible. The probability of precipitation increases when moisture is present. High humidity negatively affects the human body by reducing the rate of evaporation of moisture from the skin.

Nablus experiences significant seasonal variation in the perceived humidity.

The muggier period of the year lasts for 2.6 months, from July 5 to September 23, during which time the comfort level is muggy, oppressive, or miserable at least 10%

of the time. The month with the muggiest days in Nablus is August, with 11.1 days that are muggy or worse.

Figure 66 The percentage of time spent at various humidity comfort levels, categorized by dew point.

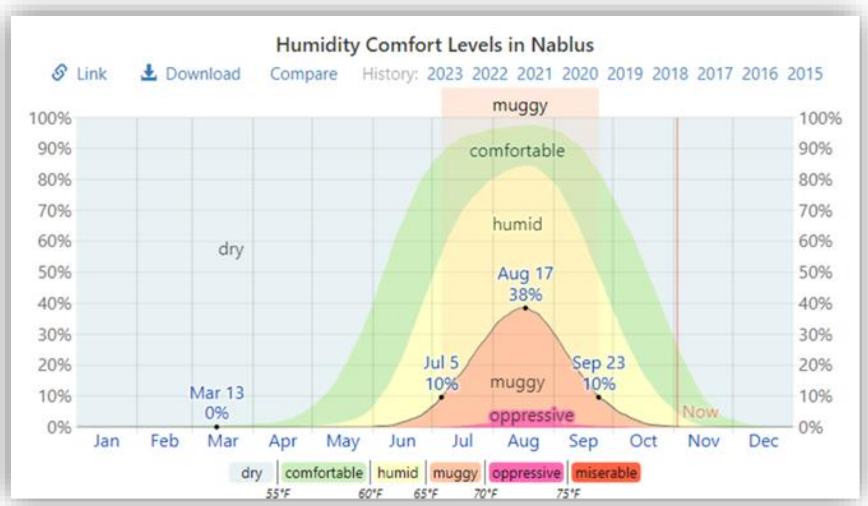


Figure 65: Humidity comfort levels in Nablus.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Muggy days	0.0d	0.0d	0.0d	0.0d	0.0d	0.7d	6.0d	11.1d	4.8d	0.6d	0.0d	0.0d

Figure 66: Muggy days through months.

The following figure shows the Thermal comfort range associated with air temperature and relative humidity (ASHRAE 55, 2010).

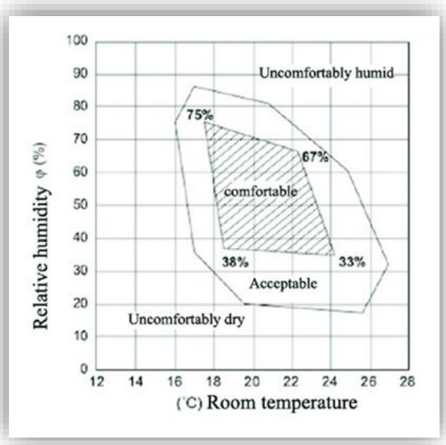


Figure 67: Thermal comfort range.

Wind analysis

This portion of the information focuses on the average speed and direction of the wind across a wide area, measured hourly at a height of 10 meters above the ground. The wind experienced in any specific location is greatly influenced by the local terrain and various other factors, leading to broader fluctuations in instantaneous wind speed and direction compared to the averages calculated over an hour.

The average hourly wind speed in Nablus does not vary significantly over the year, remaining within *0.5 miles per hour* of *6.5 miles per hour* throughout.

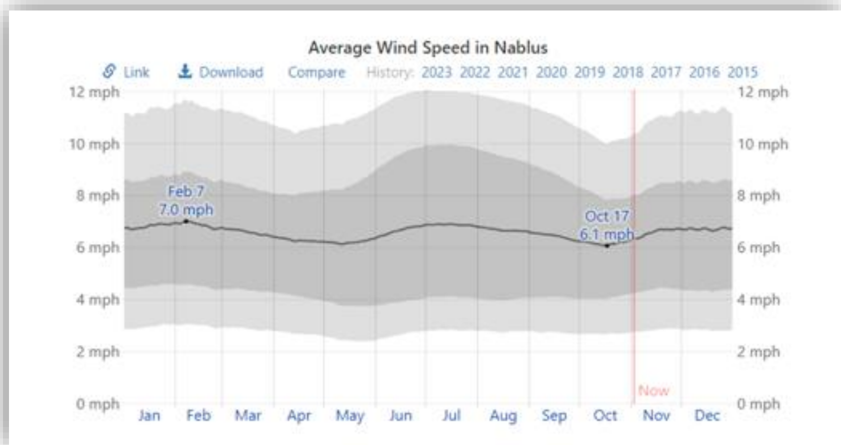


Figure 68: Average wind speed in Nablus.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wind Speed (mph)	6.8	6.9	6.6	6.3	6.2	6.7	6.9	6.7	6.4	6.2	6.6	6.7

Figure 69: Wind speed through months.

The predominant average hourly wind direction in Nablus varies throughout the year.

The wind is most often from the *north* for *1.0 months*, from *October 2* to *November 3*, with a peak percentage of *44%* on *October 11*. The wind is most often from the *west* for *1.1 weeks*, from *November 3* to *November 11*, and for *9.4 months*, from *December 22* to *October 2*, with a peak percentage of *33%* on *November 3*. The wind is most often from the *east* for *1.4 months*, from *November 11* to *December 22*, with a peak percentage of *38%* on *November 27*.

Figure70 shows the percentage of hours in which the wind direction is from the four main directions, excluding hours in which the mean wind speed is less than 1.0 mph, The lightly tinted areas at the boundaries are the percentage of hours spent in the implied intermediate directions (northeast, southeast, southwest, and northwest).

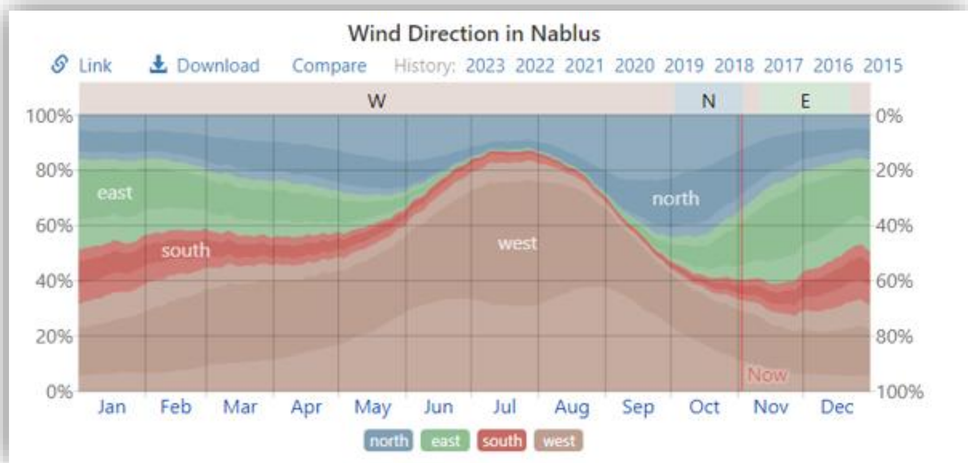


Figure 70: Wind direction in Nablus.

Sun path analysis

It has been observed that the solar path in summer is longer than in winter, with the sun rising in summer at 5:00 am, and setting at 6:00 pm, but in winter the sun rises at 7:00 am and sets at 4:00 pm.

The angle of incidence of the sun in the summer is almost perpendicular to 80.25 degrees from the surface, so the daytime period is greater than the night period, but in the winter the path of the sun is approximately 34.1 degrees below the surface, so the daylight period is short and the night light is long.

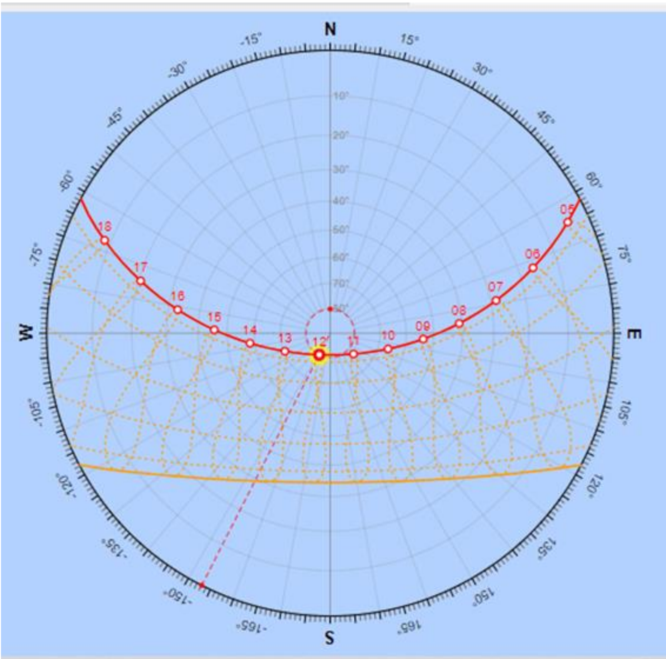


Figure 71:Sun path in summer

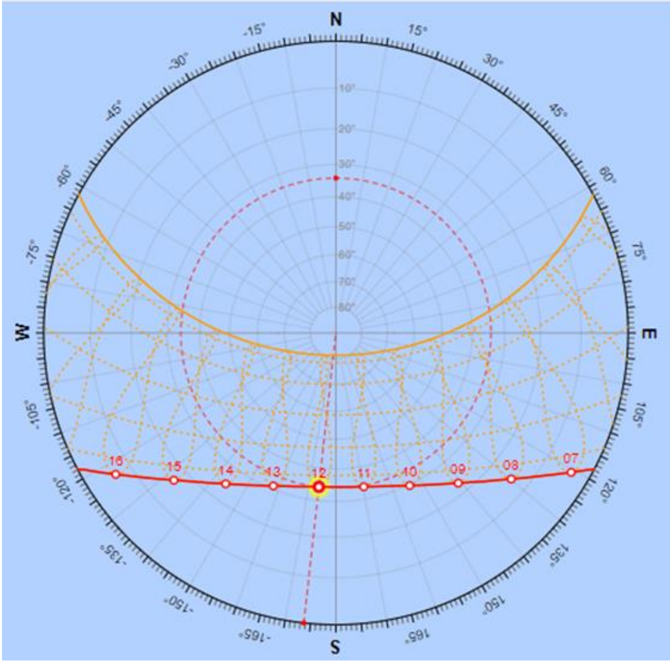


Figure 72: Figure 73: Sun path in winter

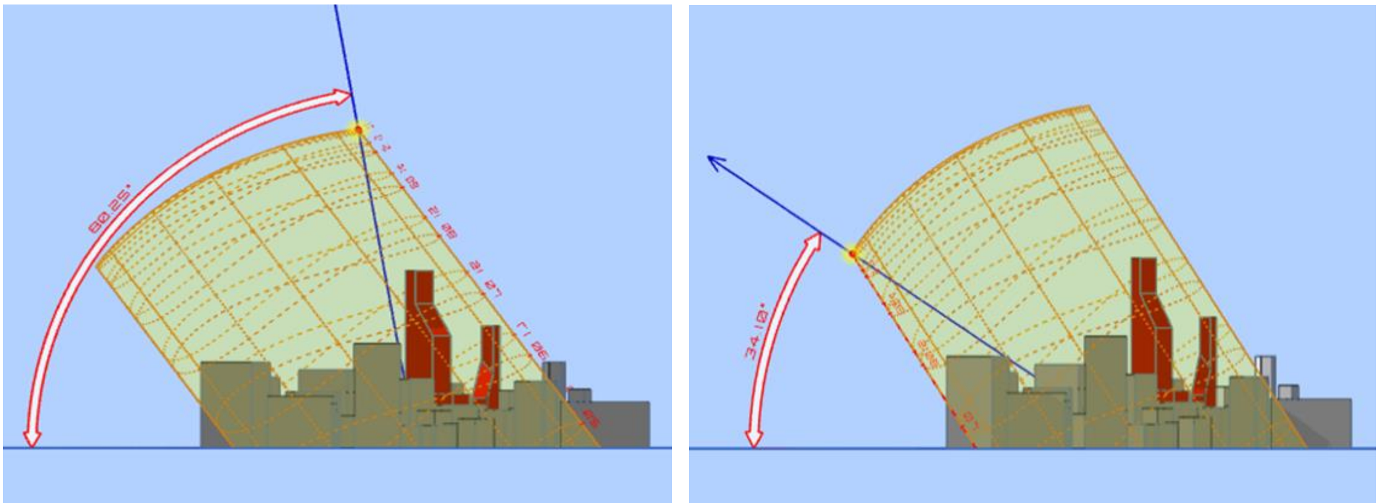


Figure 74: The angle of fall of the sun from the surface in the summer and winter.

Solar radiation analysis

Nablus experiences significant day length variations throughout the year, with the shortest day occurring on December 22 with 10 hours and 2 minutes, and the longest day occurring on June 21 with 14 hours and 16 minutes.

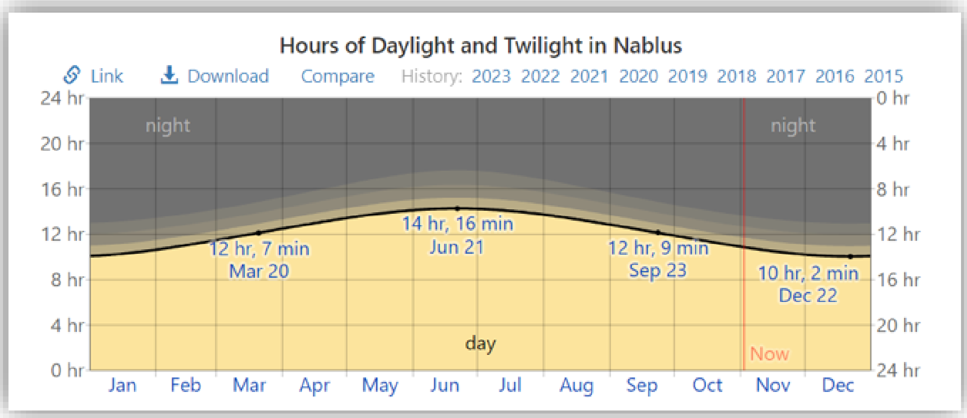


Figure 75: Day and night.

Hours of	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daylight	10.3h	11.1h	12.0h	13.0h	13.8h	14.2h	14.0h	13.3h	12.3h	11.4h	10.5h	10.1h

Figure 76: Daylight hours through months.

Solar Elevation and Azimuth

The figure shows the sun's elevation and azimuth for every hour of the day in the reporting period. The horizontal axis represents the day of the year and the vertical axis represents the hour. The background color indicates the sun's azimuth for that day and hour, while black isolines represent constant solar elevation contours.

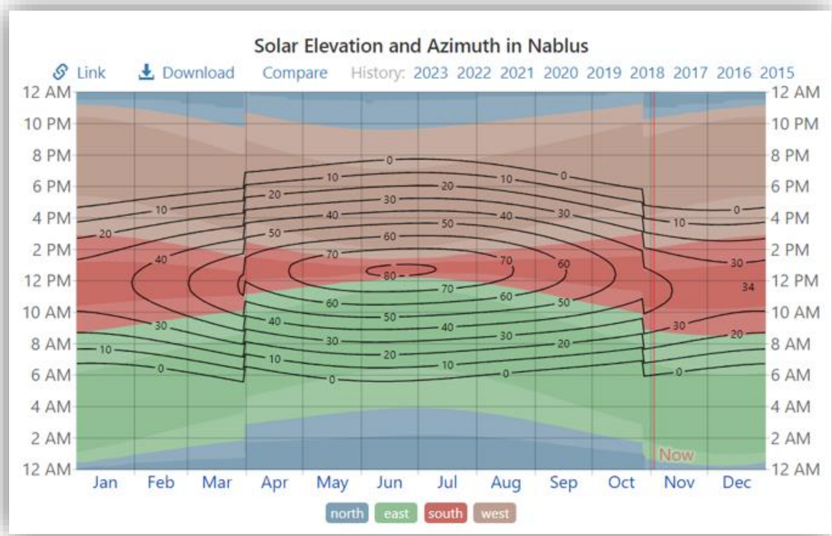


Figure 77: Solar elevation and azimuth in Nablus.

Solar energy

This section discusses the daily incident shortwave solar energy reaching the ground, considering seasonal variations in day length, Sun elevation, and absorption by clouds. The average daily incident shortwave solar energy experiences extreme seasonal variation. The brighter period lasts 3.6 months from May 5 to August 25, with an average daily incident shortwave energy per square meter above 7.4 kWh. The brightest month in Nablus is June, with an average of 8.5 kWh. The darker period lasts 3.2 months from November 5 to February 13, with an average daily incident shortwave energy per square meter below 4.1 kWh. The darkest month in Nablus is December, with an average of 3.0 kWh.

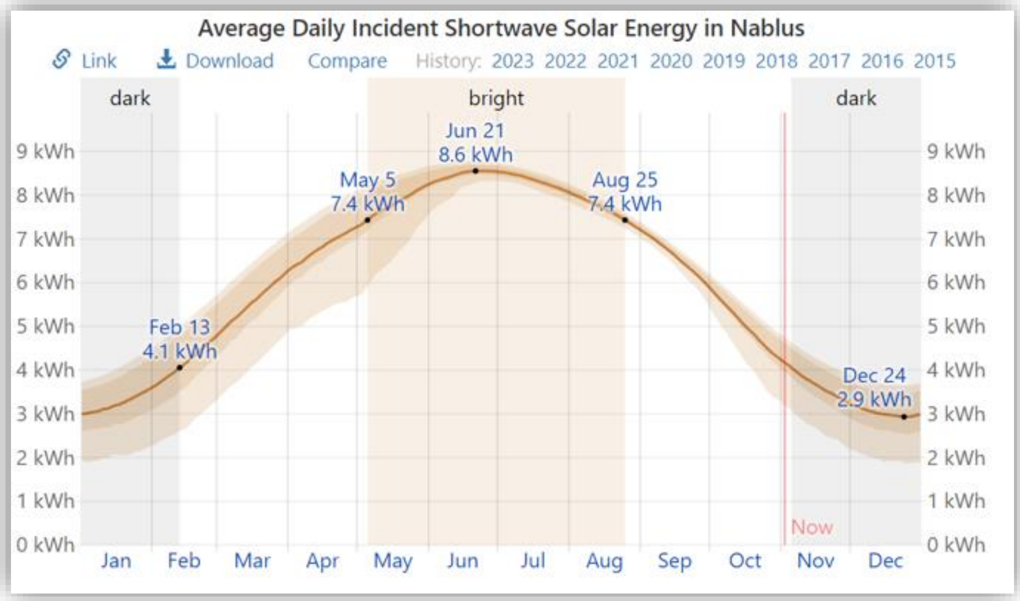


Figure 78: Average daily incident shortwave solar energy.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Solar Energy (kWh)	3.2	4.2	5.6	6.8	7.8	8.5	8.3	7.6	6.6	5.0	3.7	3.0

Figure 79: Solar energy through months.

Precipitation

Nablus experiences varying chances of wet days throughout the year, with the wetter season lasting 4.4 months from November 14 to March 25, with a greater than 15% chance of a given day being a wet day. January has the most wet days, with an average of 8.1 days with at least 0.04 inches of precipitation. The drier season lasts 7.6 months, from March 25 to November 14, with the fewest wet days in June. Wet days can be rain alone, snow alone, or a mixture of both. January has the most days of rain alone, with a peak probability of 29% on February 1.

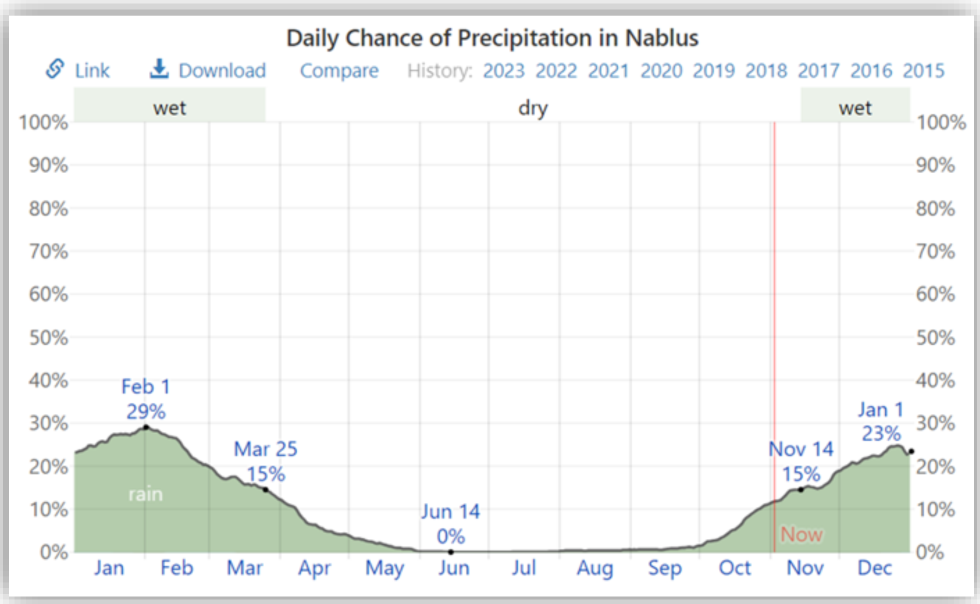


Figure 80: Average Precipitation in Nablus.

Days of	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rain	8.1d	6.9d	4.9d	2.0d	0.5d	0.0d	0.0d	0.1d	0.3d	2.0d	4.5d	6.9d

Figure 81: Precipitation through months.

Wind rose

The wind rose for Nablus indicates the number of hours per year the wind blows from the indicated direction, such as SW from South-West to North-East. Cape Horn, South America's southernmost land point, has a strong west wind, making crossings difficult.

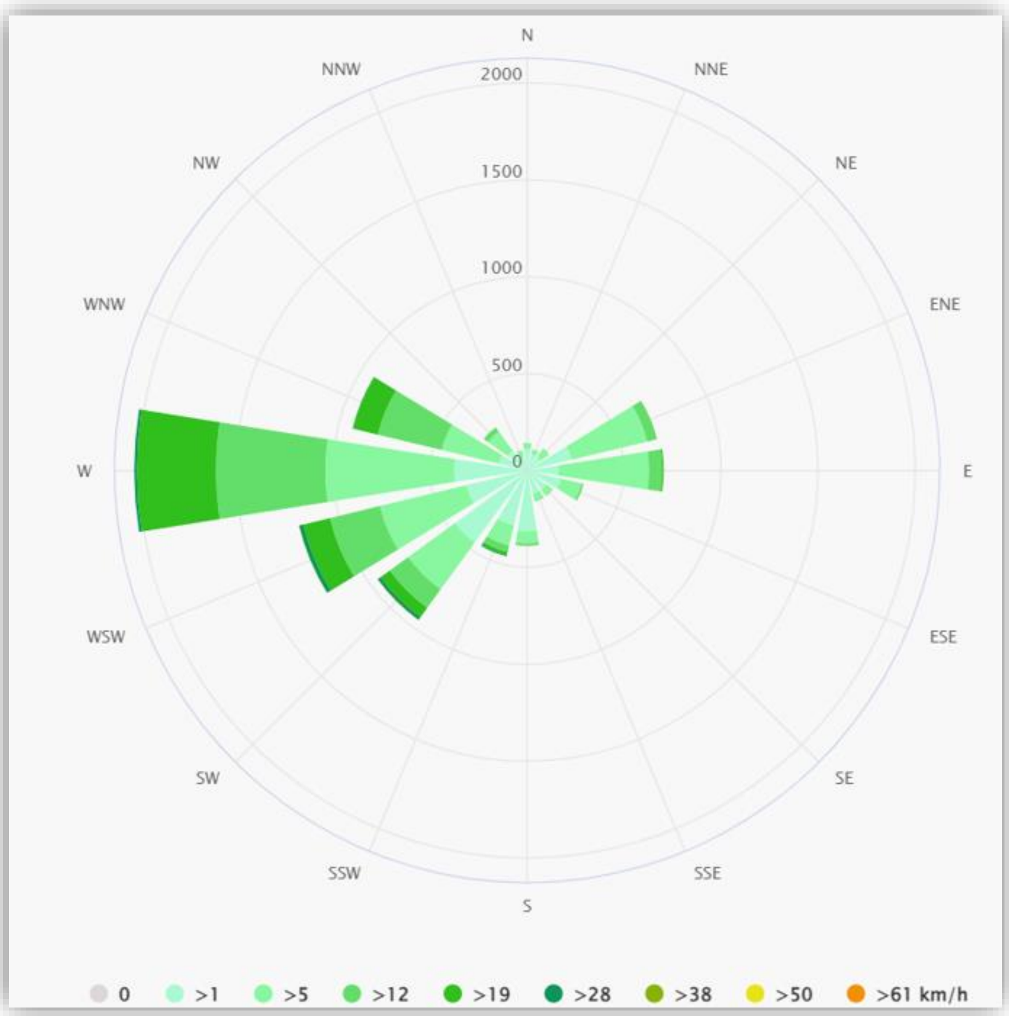


Figure 82: Average Wind rose in Nablus.

Ventilation

A comfortable indoor environment starts with the importance of the existence of proper ventilation. Ventilation requirements of buildings focus on maintaining levels of air quality, which means the number of air changes per hour (ACH). It focuses on the importance of bringing fresh air to buildings.

The table below illustrates the number of air changes per hour for various spaces from the ASHRAE code.

Table 10:Number of air changes per hour for different spaces according to ASHRAE.

Building/Room	Air Changes Rate -n- (1/h)
All spaces in general	4
Attic spacing for cooling	4-6
Kitchens	15-60
Assembly Rooms	4-8
Bathrooms	6-10
Cafes	10-12
Conference Rooms	8-12
Engine Rooms	15-30
Gymnasiums	6
Garages	6-8
Entrance Halls and Corridors	3-5
Changing Room and shower Area	15-20
Toilets	6-10
Shops and Supermarkets	8-15
Restaurants	8-12
Offices	6-10
Living Rooms	3-4
Laundries	30-10
Garages	20-30
Waiting Rooms	4
Building/Room	Air Changes Rate -n- (1/h)

Neighboring buildings

The picture below shows the neighboring buildings surrounding the project, which is the Royal Janja Hotel, there is a mosque in the west shown with the number 1 in the picture below, and on the rest of the eastern and northern sides, there are residential and commercial buildings, shown in the numbers 2, 3 and 4 in the picture below.

Figure 83: Illustration of the buildings adjacent to our project.

Noise analysis

Understanding the noise levels in the area of the project's residence is of paramount importance. The primary sources of noise are from the south and west, as the project overlooks two roads, one of which is a major thoroughfare, as illustrated. The area is vibrant, experiencing intense traffic flow during peak hours. The nearby commercial shops, both adjacent and within the building, add an extra layer of potential noise. These circumstances render the analysis and assessment of noise levels in this area exceedingly crucial, warranting sophisticated strategies to address this environmental challenge.

Figure 84: Location of streets of the building.

2.4 Environmental Analysis Aspects

2.4.1 Introduction

The environmental analysis study in the project aims to benefit from thermal insulation techniques, natural ventilation, and natural lighting, as well as from sunlight in winter, that is, from renewable energy sources, to save costs by exploiting renewable resources.

1. **Shadow analysis:** Study of neighboring buildings and their impact on Mina during the summer and winter several times. There are two types of shading on the building. The first is shading of the building itself and the second is shading resulting from shading of neighboring buildings, which will be studied at a later time.
2. **Daylight Factor Analysis:** Daylight must be taken advantage of naturally and in a limited quantity, because the large number of light entering negatively affects the building, especially in the summer, in hotels the percentage of natural light rays entering should be 2%-6%.
3. **Solar Radiation Analysis:** Sunlight entering the building can reduce cooling loads, which will include direct sunlight in summer and winter. As for the time according to the type of building, an example of this is the use of the municipality from morning to noon, so the following times will be considered for analysis (8 am 12 pm 2 pm).
4. **Heating and Cooling Load Analysis:** Cooling and heating can help reduce the use of mechanical ventilation and also include accumulating the heating and air conditioning loads needed to make this building thermally comfortable.

2.4.2 shading analysis

The study of the sun's movement around the building to be designed and the shadows generated by its neighboring buildings indicates how to benefit from natural lighting and the amount of heat gain of the building in winter. The shadows generated by neighboring buildings were studied on two different days of the year, which are as follows: July 21 in summer and January 21 in winter, and at different periods of the day, our study was conducted in the following hours of both days: 8:00 a.m., 12:00 p.m., and 3:00 p.m.

It is known in the city of Nablus that the project is located there, because in summer the sun follows a high path in the sky, extending the daylight hours, and on the contrary in winter, where the sun takes a shorter path, which leads to shorter days, meaning a shorter period of sunlight. It is preferable to enlarge the area of the windows on the southern side and reduce it on the western facades. And the eastern one, because the eastern and western facades are exposed to more sun in the summer, while the southern facade has greater solar gain in the winter.

***Shadows cast* in the summer on 21 - July**

1. **At 8:00 AM**

   In the photo below, the shade of the buildings on the east façade is very few, covering only the ground, first and second floors, while the upper floors are exposed to the sun in the morning from the east side. Therefore, it is preferable to treat it to reduce the entry of sunlight by using the Louvre Museum to prevent the entry of sunlight in the summer or choosing a suitable type of glass.

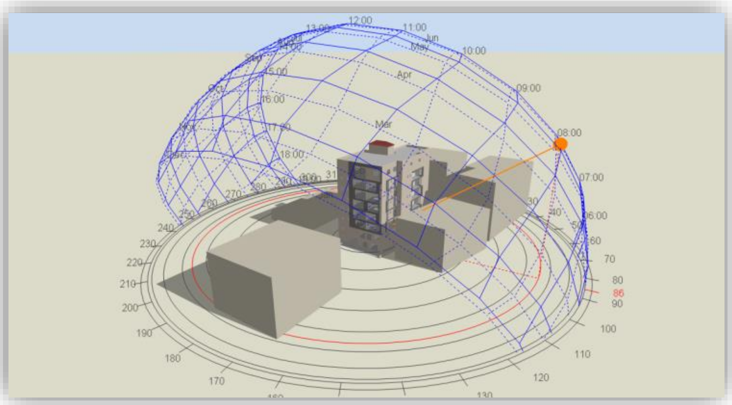


Figure 85: Summer overshadowing at 8:00 AM.

2. **At 12:00PM**

   The buildings on the south side of the hotel are low-rise, as well as there is a street 20 meters wide, so the resulting shades are negligible because they do not block the sun's rays from the south façade of the hotel at all. Therefore, the building needs a cantilever to protect the building from the summer sun of the entire façade or improve the type of glass.

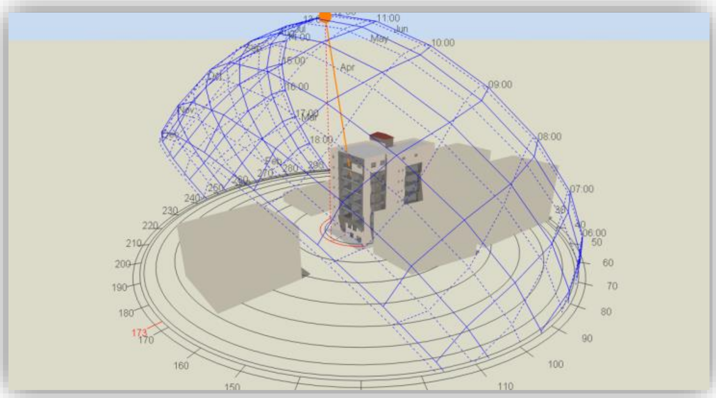


Figure 86: Summer overshadowing at noon.

3. **At 3:00 PM**

The same applies to the western façade. The hotel is bordered by a low-rise mosque, and the resulting shadows do not reach the hotel at all. Therefore, the building is exposed to sunlight in the summer, so it is preferable to design the Louvre Museum to prevent the entry of sunlight in the summer or improve the type of glass.

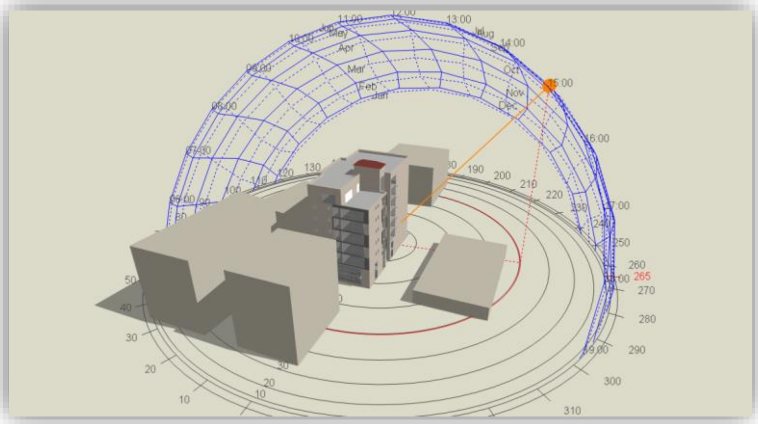


Figure 87: Summer overshadowing at 3:00 PM.

***Shadows cast* in the winter on 21 - January**

1. **At 8:00 AM**

From the photo below the neighboring buildings on the east side shade the lower floors of the hotel, while the three upper floors, in addition to the roof, are exposed to sunlight in winter. Therefore, when designing the Louvre Museum to prevent the entry of the summer sun, it must be taken into account to allow the winter sun to enter, in addition to the fact that the solar gain on the eastern façade is small compared to the southern façade.

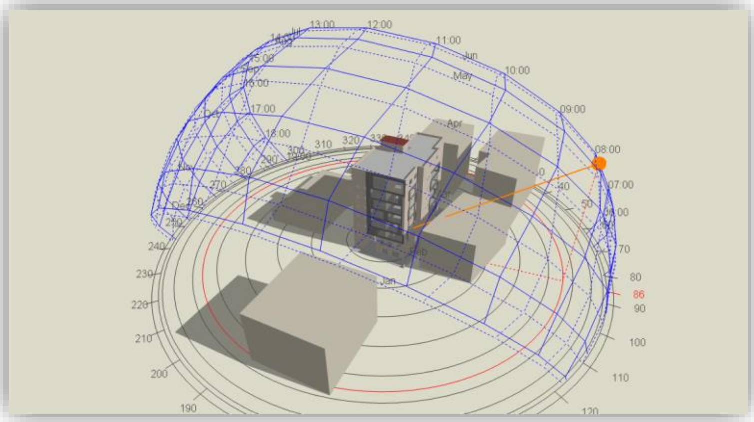


Figure 88: Winter overshadowing at 8:00 AM.

2. **At 12:00PM**

On the southern side, the buildings that border the hotel are of low height and are separated by a street 20 meters wide, so their shadows do not reach the hotel, this is good because the southern facade has high solar gain in winter, Therefore, when designing a cantilever to block the summer sun, it must be ensured that it allows the winter sun to enter.

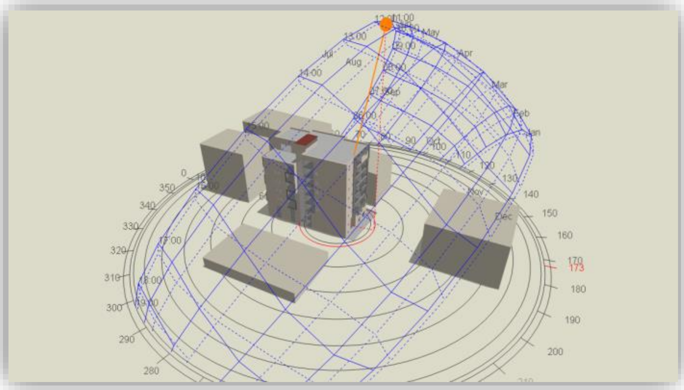


Figure 89: Winter overshadowing at noon.

3. **At 3:00 PM**

Since the mosque borders the hotel on the western facade, its shadows in winter reach only the first basement, while the floors from the ground and above are exposed to sunlight in winter, when designing the Louvre to prevent the summer sun from entering, it must be taken into account to allow the winter sun to enter, in addition, the solar gain on the western facade is small compared to the southern facade.

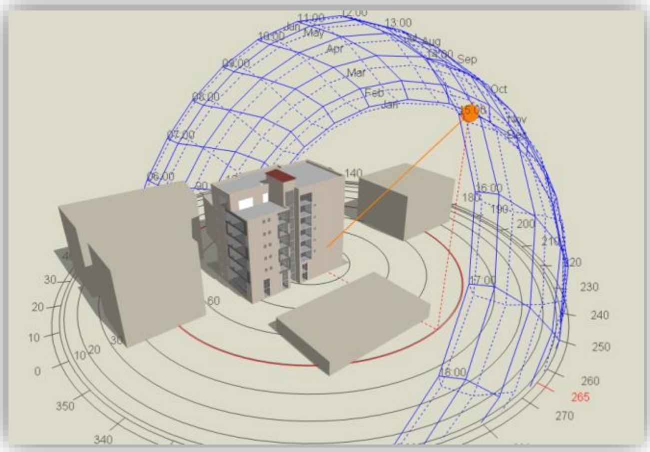


Figure 90: winter overshadowing AT 3:00 pm.

2.4.3 Daylight factor analysis

Daylight is considered one of the most important environmental factors through which we can save energy. Through daylight, we can dispense with artificial lighting at certain times of the day, but one of the things that many people do not know is that increasing daylight beyond the permissible limit may cause the presence of glaze in the area, and this is an abnormal situation. Comfortable for the eyes, in addition to making the building store large amounts of heat, and thus it relies heavily on heating and air conditioning systems in the summer. Therefore, the daylight should be between 2%-6% in the spaces, based on what has been studied in some environmental courses.

$DF = 100 * \frac{\text{Ein}}{\text{Eext}}$, where:

$Ein = inside\ illuminance\ at\ a\ fixed\ point$

$Eext = outside\ illuminance\ (horizontal) at\ overcast\ or\ uniform\ sky\ and$

$equal\ 9000\ luxin\ palatine.$

$DF = SC + ERC + IRC, where$:

SC: $Sky\ Component.$

ERC: $External\ Reflected\ component.$

IRC: $Internal\ Reflected\ component.$

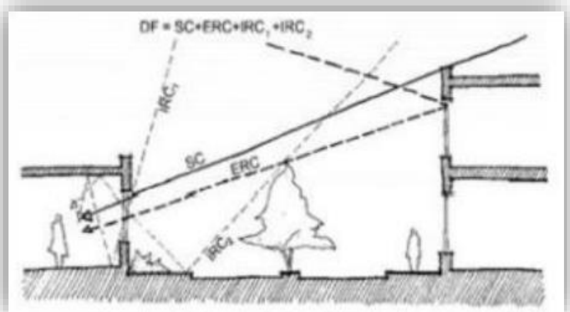


Figure 91:Component of daylight factor

Task	DF
Ordinary seeing tasks, such as reading, filing, and easy office work	1.5–2.5%
Moderately difficult tasks, such as prolonged reading, stenographic work, normal machine tool work	2.5–4.0%
Difficult, prolonged tasks, such as drafting, proofreading poor copy, fine machine work, and fine inspection	4.0–8.0%

Figure 92:Daylight factor standard

The daylight factor was studied through the Design Builder program and the results were as follows:

• Ground floor

The following figure shows the daylight factor before adjusting from a program Design Builder.

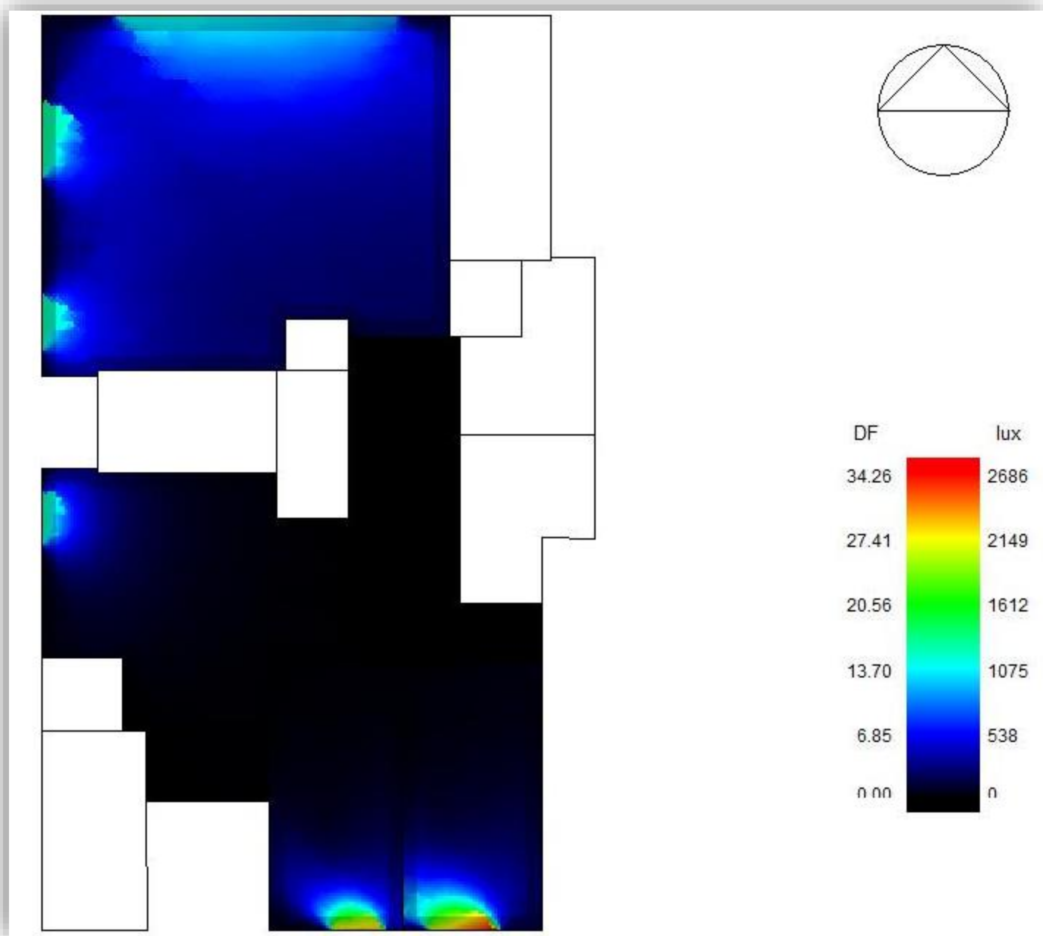


Figure 93: DF ground floor before daylight analysis.

The picture shows that the value of the daylight factor is average on the ground floor, so there is a decrease in natural light on this floor and a solution must be found, as there are dark areas that need artificial lighting.

- **First Floor**

The following figure shows the daylight factor before adjusting from a program Design Builder.

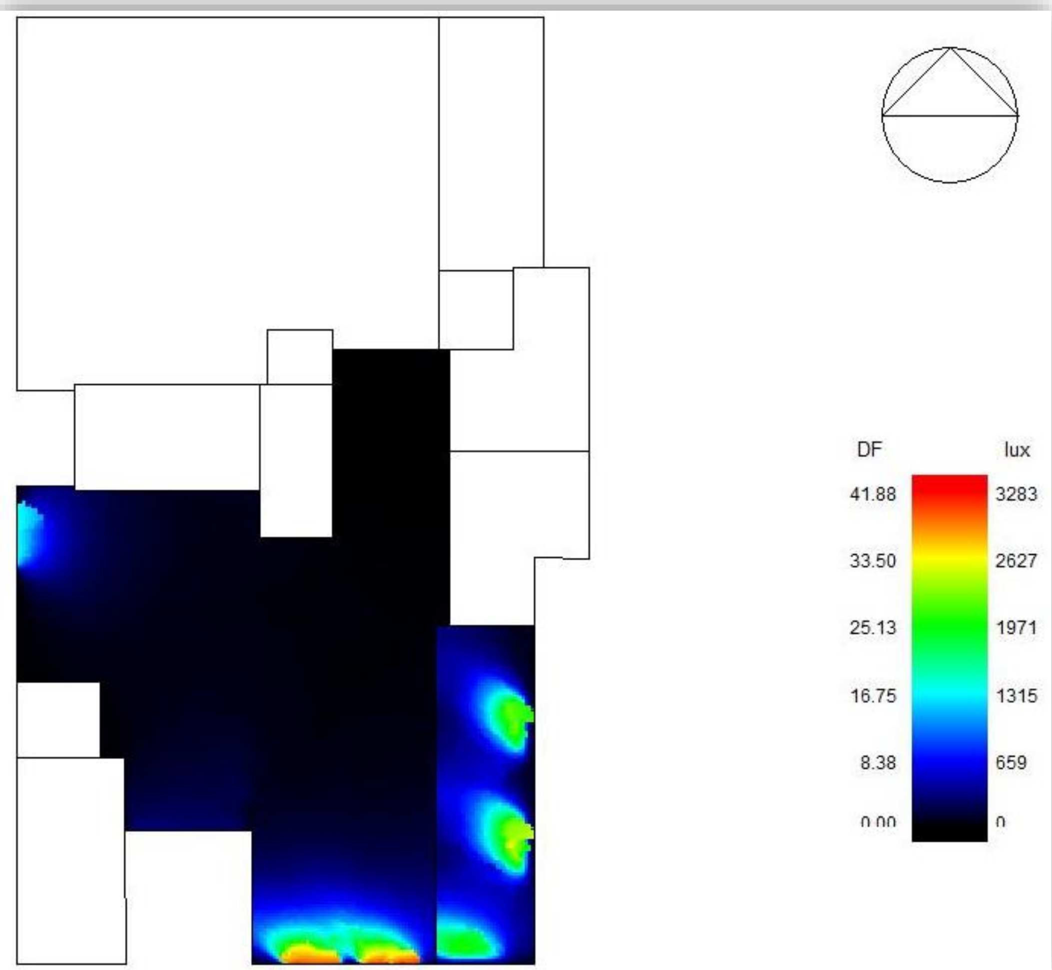


Figure 94: DF First floor before daylight analysis.

The picture shows that the value of the daylight factor is average on the first floor, so there is a decrease in natural light on this floor and a solution must be found, as there are high-light areas that need to be scared, and dark areas that need artificial lighting.

- **Second Floor (Repeated floor)**

The following figure shows the daylight factor before adjusting from a program Design Builder.

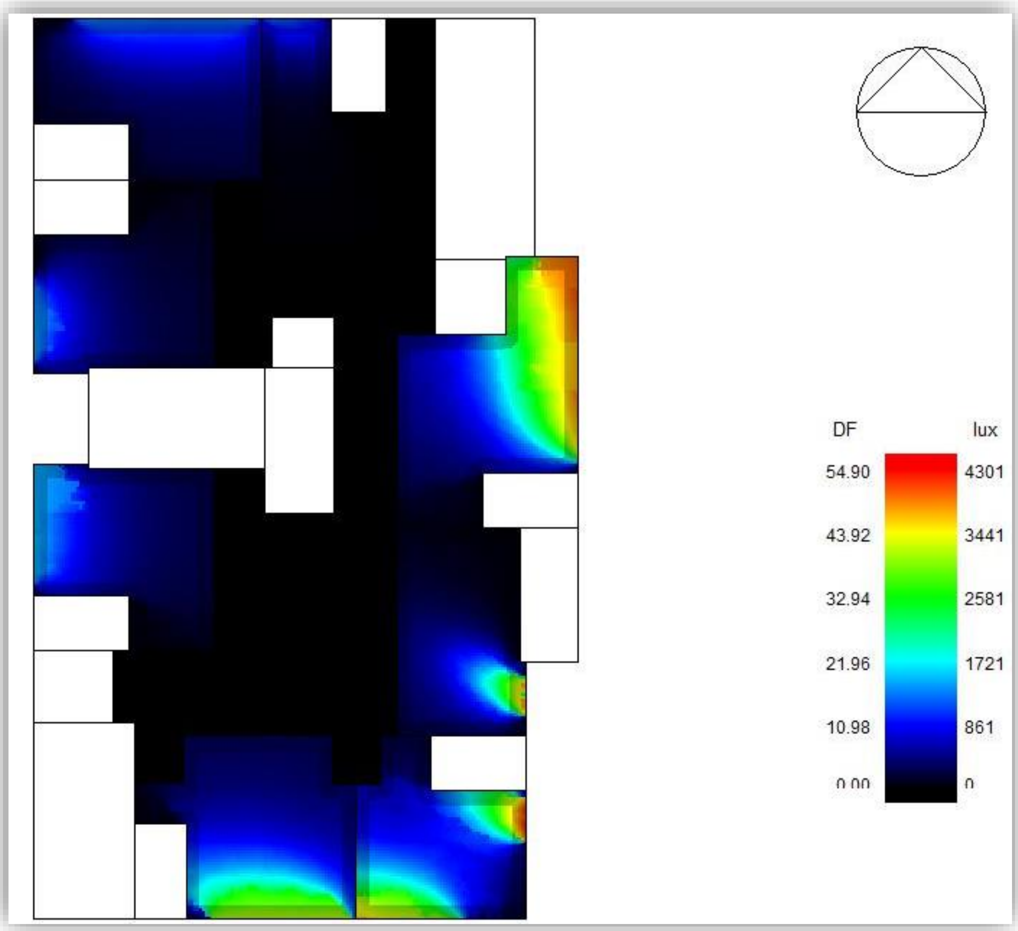


Figure 95: DF first floor before daylight analysis.

The picture shows that the value of the daylight factor is high on the eastern side and medium on the eastern and northern side on the repeated floors from the second to the sixth therefore, solutions must be found.

- **Roof Floor**

The following figure shows the daylight factor before adjusting from a program Design Builder.

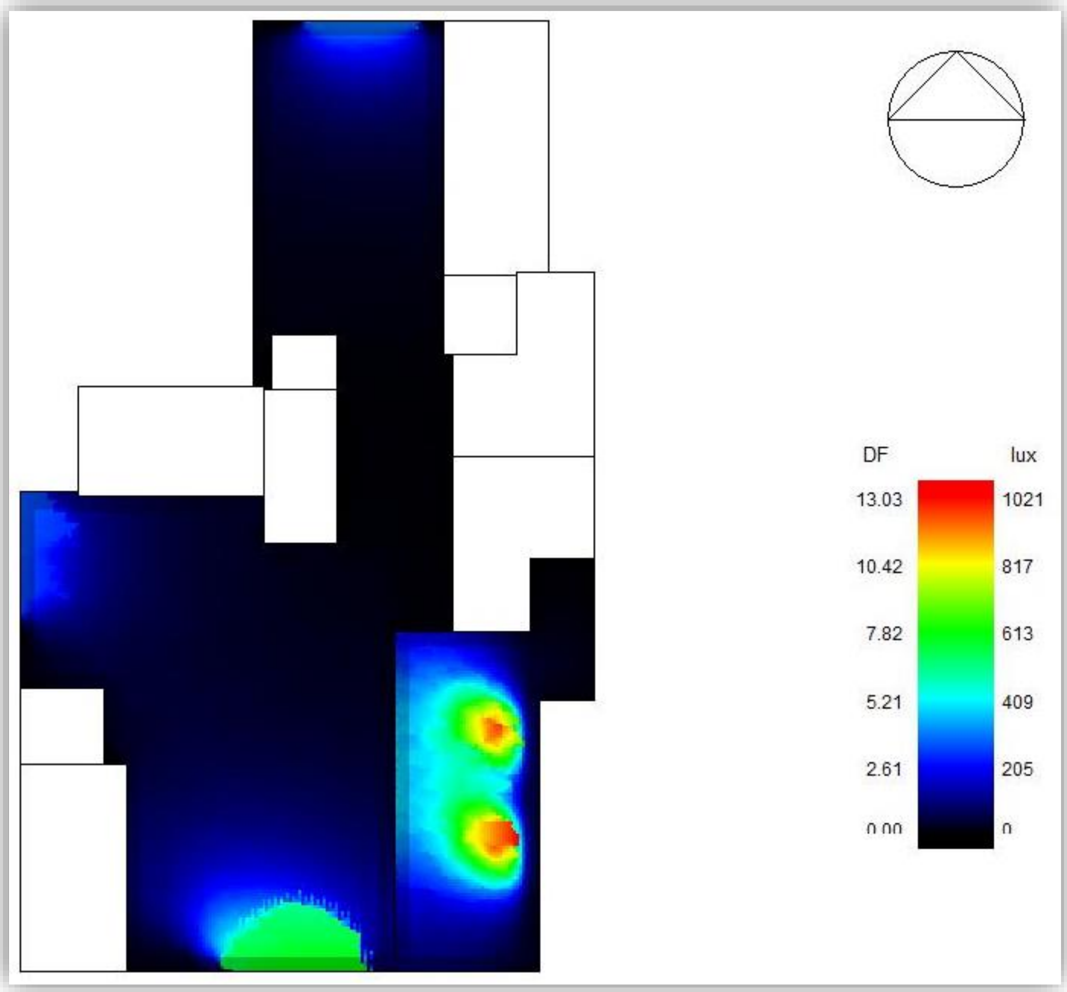


Figure 96: Roof floor before daylight analysis.

The picture shows that the value of the daylight factor is high from the east and south sides and medium on the eastern and northern sides on the seventh floor, so solutions must be found.

Several methods were used for this building:

Insulation of the floor and ceilings and the use of glass type SGG XT 60-28 6/16/4 of the good type of specifications (60% lighting, 26% solar energy, and good insulation).

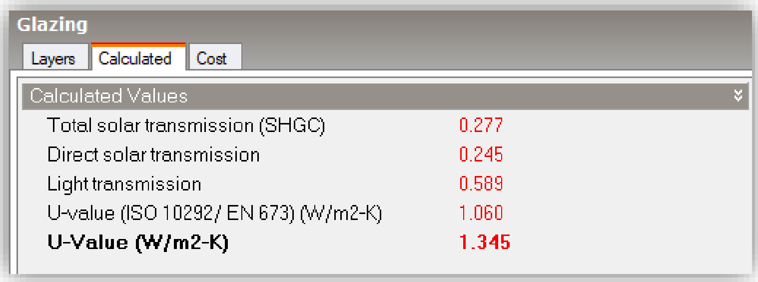


Figure 97:After making several modifications and improvements to the building, the percentage of daylight

• **Ground floor**

The figure shows the daylight factor from design builder software after design modification:

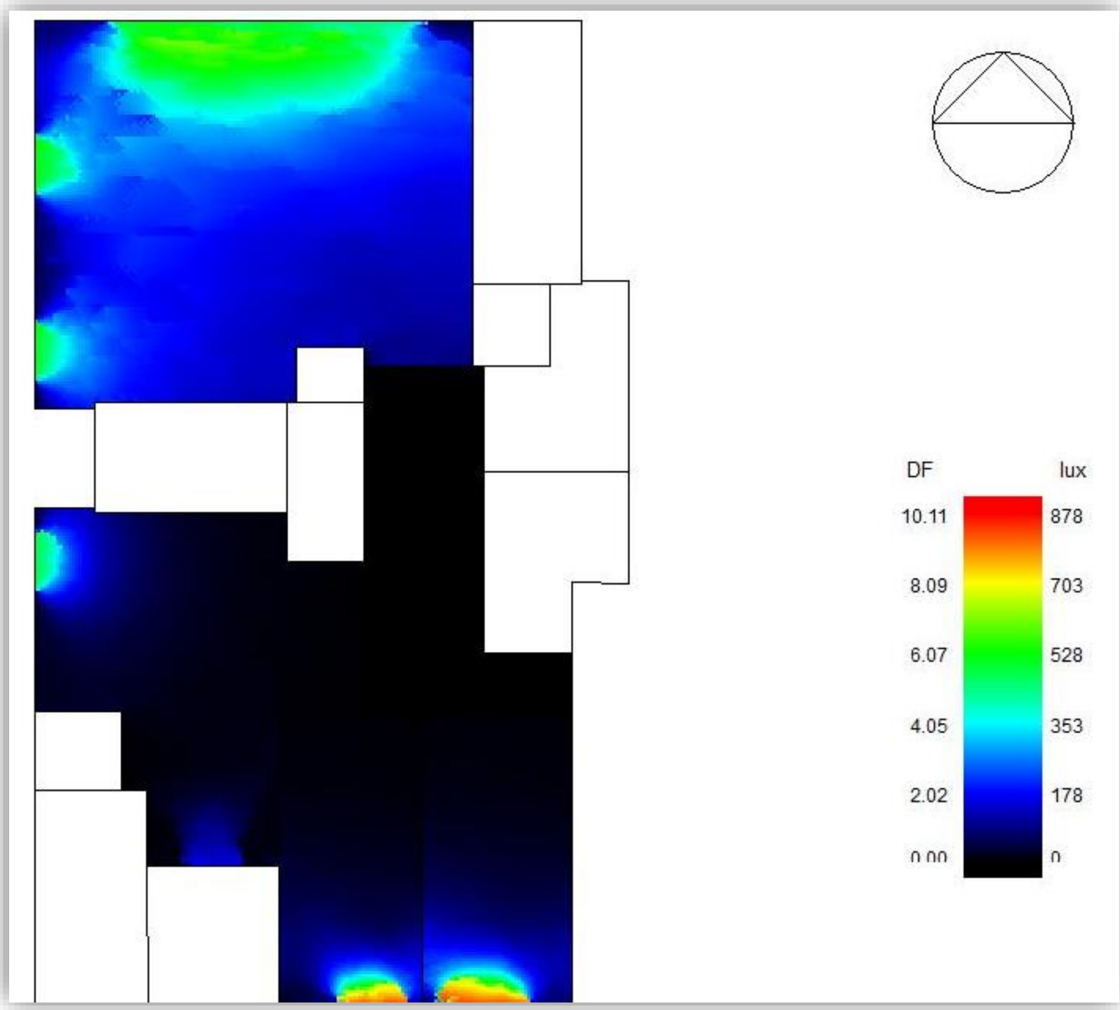


Figure 98: DF ground floor before daylight analysis.

In the adjacent picture, after making modifications and improvements to the building, it was found that some areas improved daylight, as it became within the required range or slightly higher, and therefore energy consumption was indicated, and the use of artificial lighting was reduced, and thus the energy consumption allocated to heating and cooling was reduced.

Note: The areas where the percentage of daylight coefficient remained high are commercial stores. We changed the type of glass to reduce the percentage, yet their value remained high.

- **First Floor**

The figure shows the daylight factor from design builder software after design modification:

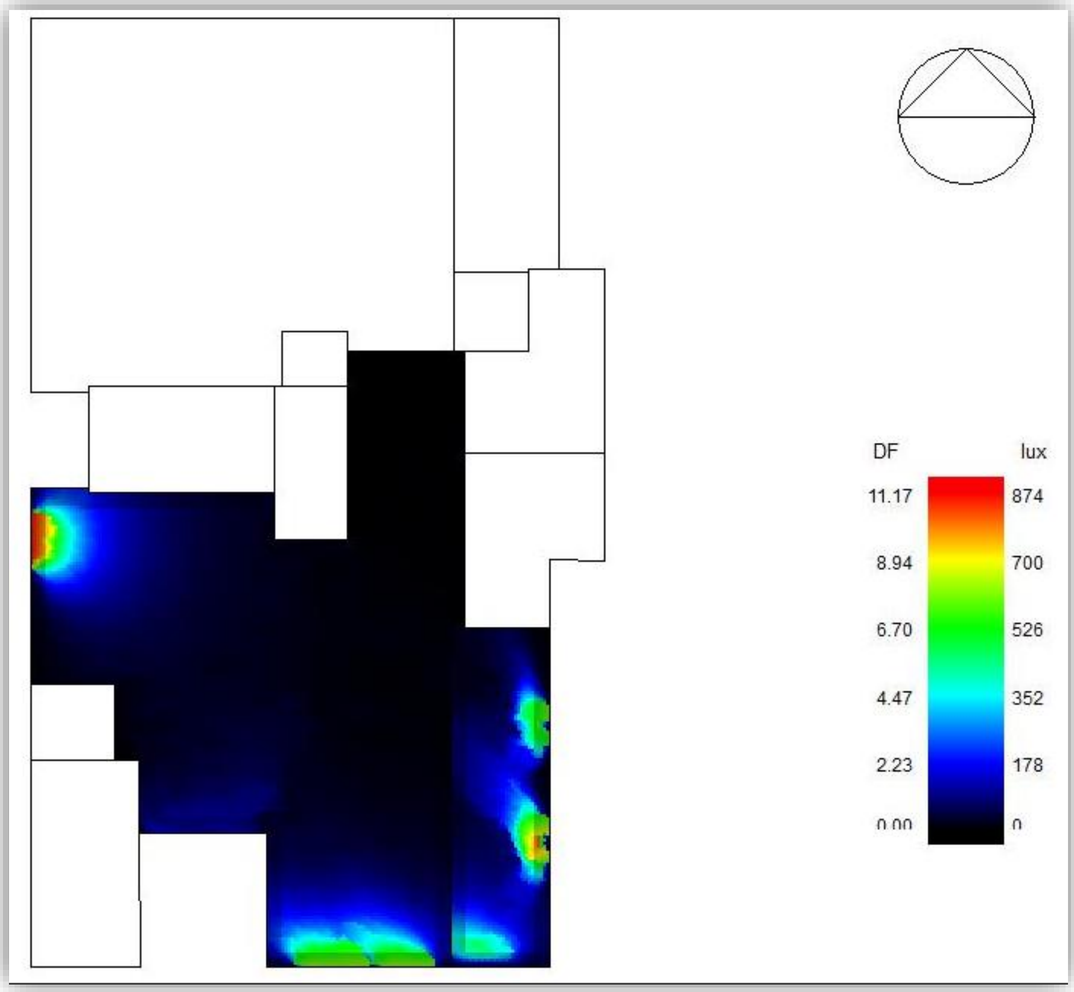


Figure 99: DF First floor before daylight analysis.

In the adjacent picture, after making modifications and improvements to the building, it was found that some areas improved daylight, as it became within the required range or slightly higher, and therefore energy consumption was guided and the use of artificial lighting was reduced, and thus the energy consumption allocated for heating and cooling was reduced.

Note in the corridor area near the bathrooms it is natural that it needs artificial lighting because there are no windows in the corridor.

- **Second Floor (Repeated floor)**

The figure shows the daylight factor from design builder software after design modification:

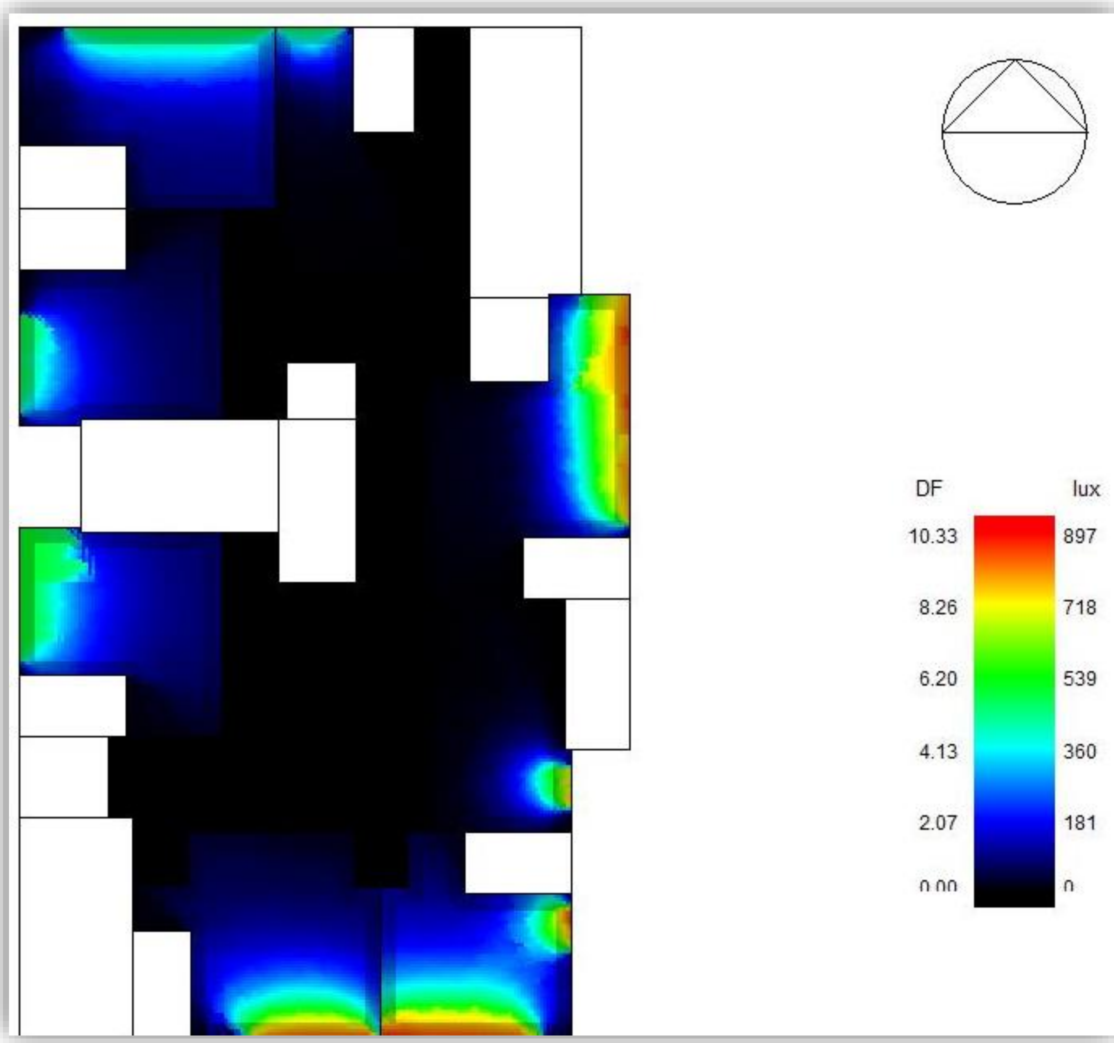


Figure 100: DF first floor before daylight analysis.

In the adjacent picture, after making modifications and improvements to the building, it was found that some areas improved daylight, as it became within the required range or slightly higher, and therefore energy consumption was guided and the use of artificial lighting was reduced, and thus the energy consumption allocated for heating and cooling was reduced.

Note in the corridor area between the rooms that it is normal for him to need artificial lighting because there are no windows in the corridor.

- **Roof Floor**

The figure shows the daylight factor from design builder software after design modification:

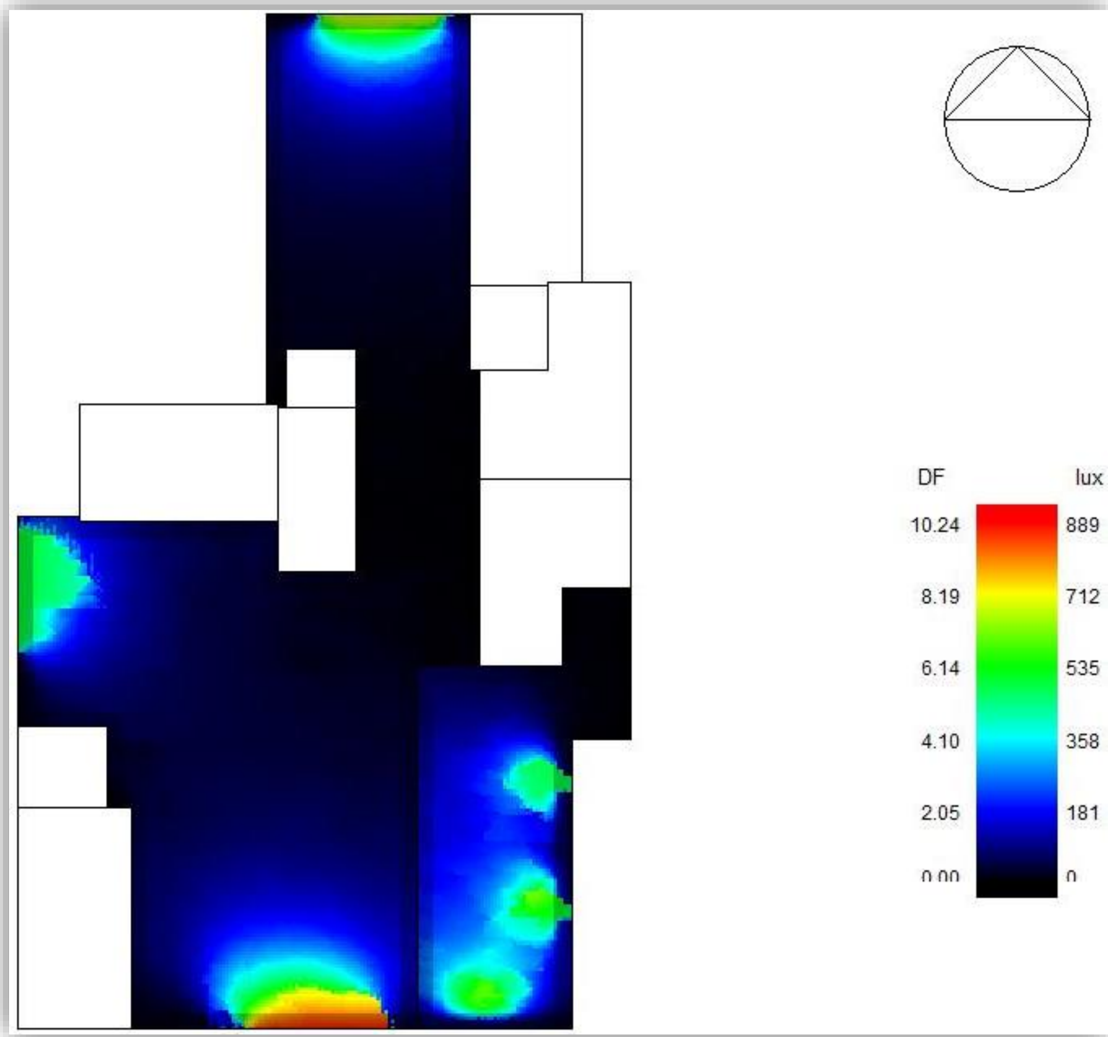


Figure 101: Roof floor before daylight analysis.

In the adjacent picture, after making modifications and improvements to the building, it was found that some areas improved daylight, as it became within the required range or slightly higher, and therefore energy consumption was guided and the use of artificial lighting was reduced, and thus the energy consumption allocated for heating and cooling was reduced.

Note in the corridor area near the bathrooms it is natural that it needs artificial lighting because there are no windows in the corridor.

Through the study, it was found that some areas do not receive natural light, such as the central areas of the building, and this is normal depending on the location of the windows. Some public bathrooms do not receive natural light, rely on artificial lighting, and rely on air conditioning and heating systems for ventilation. The percentage of daylight also exceeds the limit allowed in some areas. To avoid glare and high heat storage, the building was treated in several ways.

1. The type of glass has been changed and double and triple glass has been used.
2. Add an insulator.

2.4.4 Heating and Cooling Loads

This section contains the modifications obtained from the engineering office, where modifying the plans is vital for any project to suit changing developments and needs or to improve project efficiency. In this project, the project was completely changed from the plans we obtained, i.e. it was designed and not redesigned. The plans were for a multifunctional building with shops, apartments, and offices, while a hotel building was designed. For several reasons this was done, the main of which is that the building is a hotel. After the construction of the exoskeleton, it was converted into a hotel, and internal zonings were made on this basis. The building is currently called the Royal Suites Hotel, but the plans have not been obtained. It was also built in addition to the area's need for a hotel.

Before treatment

Values of Thermal Transmittance (U) for the elements in the building are as follows:

Table 11:U value standard for roof, floor, wall, and windows

Envelope Elements		U-value (W/m²K)	Specification
Windows	With frame	3.0143	Double Glazed – Clear float glass except bathrooms are translucent glass, 6-12-6mm thickness, aluminum frames, single side fixation.
	Only glass	2.8221	
External Wall		0.2118	External plaster layer, 250mm thick insulated block wall, internal plaster and paint.
Ground Floor		0.3704	Ceramic tiles, plaster, polypropylene separation and protection sheet, 50mm vapour insulation, 2 bitumen layers (water proof membrane), 30mm screed, 150 reinforced concrete, Sand.
Roof		0.5550	Flat Roof – Layers from outside to inside: concrete tiles, plaster, polypropylene separation and protection sheet, 50mm extracted polystyrene thermal insulation, 2 bitumen layers (water proof membrane), 30mm screed, 200mm reinforced concrete, and plaster.

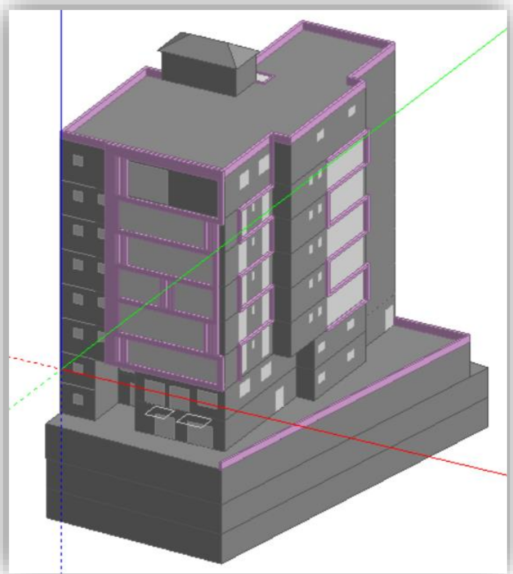
One of the common rules of the cooling loud standard for hotels is that 14-29 square meters of floor area per ton of cooling.

The following tables show heating and cooling loads for the building before making treatment by adding insulation:

Table 12:U values for building elements before treatment.

Element type	U value in $W/m^2.K$
Exterior Walls	2.066
Floor	2.742
Roof	2.101
Glass	5.915

3D model on design builder



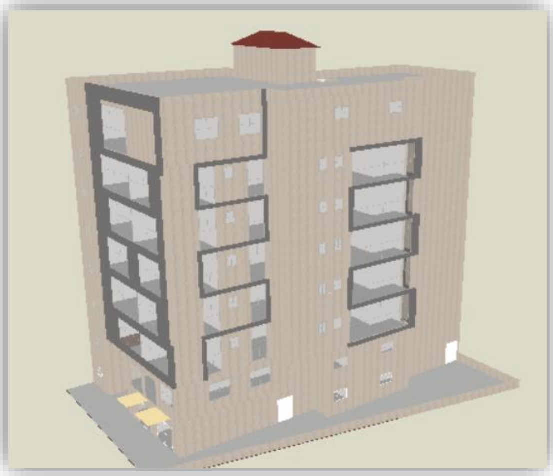


Figure 102:3D model of the building on design builder

Layers and U value for each element before insulation:

1. External wall:

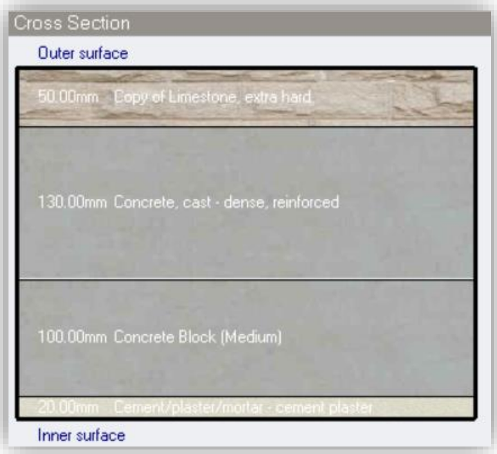


Figure 103:Layers and thickness of the outer wall before insulation

Thickness (m)	0.3000
Km - Internal heat capacity (KJ/m2-K)	141.5680
Upper resistance limit (m2-K/W)	0.484
Lower resistance limit (m2-K/W)	0.484
U-Value surface to surface (W/m2-K)	3.185
R-Value (m2-K/W)	0.484
U-Value (W/m2-K)	**2.066**

Figure 104:U-Value for the external wall before insulation

2. Interior partitions:

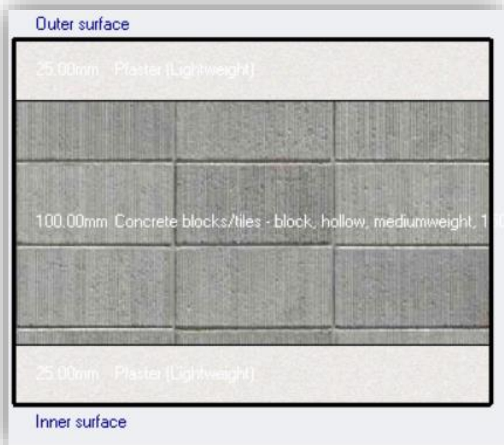


Figure 105:Layers and thickness for interior partitions before insulation

Thickness (m)	0.1500
Km - Internal heat capacity (KJ/m2-K)	80.5200
Upper resistance limit (m2-K/W)	0.614
Lower resistance limit (m2-K/W)	0.614
U-Value surface to surface (W/m2-K)	2.111
R-Value (m2-K/W)	0.614
U-Value (W/m2-K)	**1.629**

Figure 106 : U-Value for the interior partitions before insulation

3. Roof:

Figure 107:Layers and thickness for the roof before insulation

Thickness (m)	0.2600
Km - Internal heat capacity (KJ/m2-K)	89.3760
Upper resistance limit (m2-K/W)	0.476
Lower resistance limit (m2-K/W)	0.476
U-Value surface to surface (W/m2-K)	2.977
R-Value (m2-K/W)	0.476
U-Value (W/m2-K)	**2.101**

Figure 108:U-Value for the roof before insulation

4. Ground floor:

Figure 109: Layers and thickness for the ground floor before insulation

Thickness (m)	0.2150
Km - Internal heat capacity (KJ/m2-K)	156.1980
Upper resistance limit (m2-K/W)	0.365
Lower resistance limit (m2-K/W)	0.365
U-Value surface to surface (W/m2-K)	6.467
R-Value (m2-K/W)	0.365
U-Value (W/m2-K)	**2.742**

Figure 110:U-Value for the ground floor before insulation

5. Glass

Calculated Values	
Total solar transmission (SHGC)	0.883
Direct solar transmission	0.868
Light transmission	0.904
U-value (ISO 10292/ EN 673) (W/m2-K)	5.849
U-Value (W/m2-K)	**5.915**

Figure 111: U-Value for glass before insulation

Total Cooling Load for the hotel before treatment= 236.16 KW

Total Heating Load for the hotel before treatment= 144.13 KW

Cooling Load Density= 76 W/m^2

Heating Load Density= 56.02 W/m^2

Layers and U value for each element after insulation:

- External wall:

Figure 112:Layers and thickness of the outer wall after insulation

Thickness (m)	0.3200
Km - Internal heat capacity (KJ/m2-K)	141.5680
Upper resistance limit (m2-K/W)	1.072
Lower resistance limit (m2-K/W)	1.072
U-Value surface to surface (W/m2-K)	1.108
R-Value (m2-K/W)	1.072
U-Value (W/m2-K)	**0.933**

Figure 113:U-Value for the external wall after insulation

- Interior partitions:

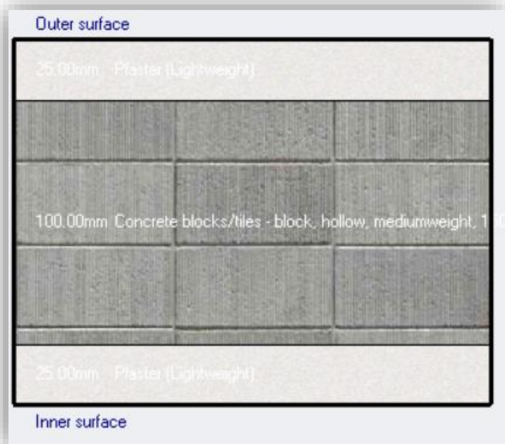


Figure 114:Layers and thickness for interior partitions after insulation

Thickness (m)	0.1500
Km - Internal heat capacity (KJ/m2-K)	80.5200
Upper resistance limit (m2-K/W)	0.614
Lower resistance limit (m2-K/W)	0.614
U-Value surface to surface (W/m2-K)	2.111
R-Value (m2-K/W)	0.614
U-Value (W/m2-K)	**1.629**

Figure 115: U-value for the interior partitions after insulation

- Roof:

A roof insulation was added to make the U section less than 0.5 $W/m^2.K$.

Figure 116:Layers and thickness for the roof after insulation

Thickness (m)	0.4960
Km - Internal heat capacity (KJ/m2-K)	75.1296
Upper resistance limit (m2-K/W)	2.003
Lower resistance limit (m2-K/W)	2.003
U-Value surface to surface (W/m2-K)	0.537
R-Value (m2-K/W)	2.003
U-Value (W/m2-K)	**0.499**

Figure 117:U-Value for the roof after insulation

As shown in the picture, the section of the roof U is equal to 0.499 $W/m^2.K$, which is less than 0.5 $W/m^2.K$, which means that the roof is energy-efficient.

- Ground floor:

Figure 118: Layers and thickness for ground floor after insulation

Thickness (m)	0.2550
Km - Internal heat capacity (KJ/m2-K)	89.8030
Upper resistance limit (m2-K/W)	1.514
Lower resistance limit (m2-K/W)	1.514
U-Value surface to surface (W/m2-K)	0.767
R-Value (m2-K/W)	1.514
U-Value (W/m2-K)	**0.660**

Figure 119:U-Value for the ground floor after insulation

- Glass

Glass spaces, ceilings, and walls have a great impact on heating and cooling loads because the building gains solar energy in most of the regions, so modification and treatment have been carried out to reduce the percentage of solar gain by using shading systems and a type of glass SGG XT 60-28 6/16/4 (60% lighting,26% solar, good insulation) suitable for glass facades.

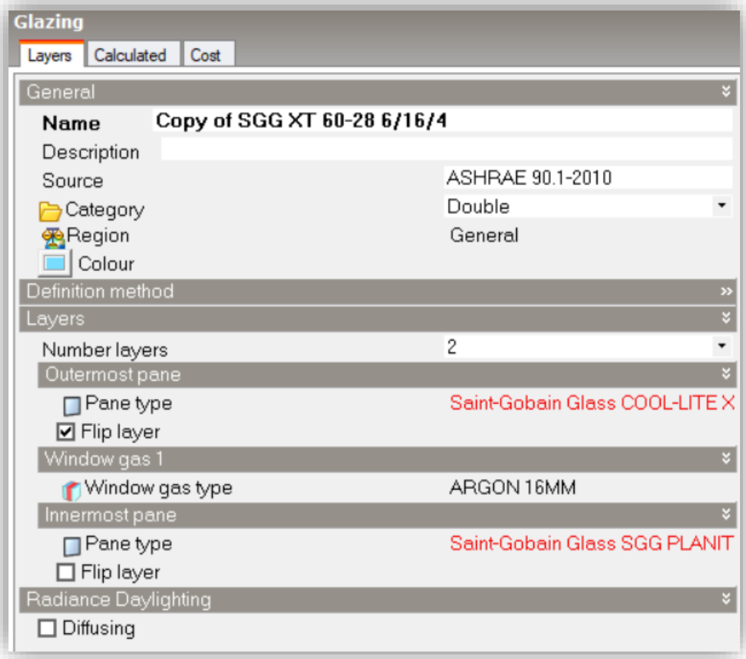


Figure 120:The layers of external glazing wall

The following figure shows the outer glass layers with the thickness of the layers:

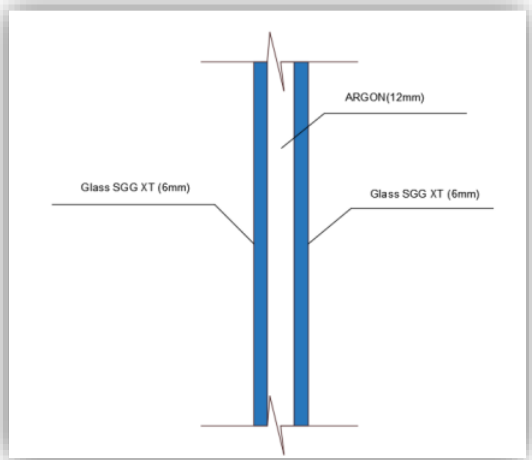


Figure 121:Layers and thickness for glass

The product is 6+12A+6mm Clear Argon insulated glazed Glass for Windows Facades Curtain Walls.

This type of glass was used in the building because it has many distinctions, including:

It is a good insulator for the building, with 60% lighting and 26% solar energy.

This glass consists of three layers, two layers of glass with a thickness of 12 mm and the middle layer of argon gas with a thickness of 6 mm.

There are many manufacturers of this type for example Qingdao Rich Glass Co., Ltd.

One of its most important characteristics:

- ✓ It looks flat
- ✓ Float glass type
- ✓ Build it hollow
- ✓ Glass thickness 3-19mm
- ✓ Warranty for more than five years
- ✓ Its uses for furniture, doors, buildings, and windows
- ✓ Qualified tempered float glass material
- ✓ The plywood case transfer package is strong
- ✓ Clear bottle colors or bronze or gray or blue or green
- ✓ Plate vibration tinted or clear glass
- ✓ Its production capacity is 1,600,000 meters per year
- ✓ Safety corners either sharp corners or round on request
- ✓ Its shapes are rectangular or square circle or oval

Table 13:Glazing Product description

Thickess of single glass	4mm 5mm 6mm 8mm 10mm
Size	Max:2500*4000mm, Min:180*350mm and customized size is available.
Colors	Clear, utral clear, grey, green,blue, bronze,etc.
Glass Type	Low E double glazed glass, reflective double glazed glass, clear double glazed glass, tinted double glazed glass etc.
Aluminum Spacer	6,9,12mm etc (1/4", 11/32", 1/2", 5/8")
Spacer filler	Dry air, noble gas like Argon,etc.
Application	External use of windows, doors, skylight, roof, curtain wall, etc.

After-sales Service:	Return and Replacement
Warranty:	More Than 5 Years
Type:	Float Glass
Shape:	Flat
Structure:	Hollow
Glass Thickness:	3-19mm

Usage	Furniture, Door, Building, Window
Material	Qualified Tempered Float Glass

Color	Clear, Blue, Green, Gray, Bronze, etc
Glass Color	Clear,Bronze,Grey,Blue,Green
Processing	Custom Designed
Sheet Glass	Tinted Glass , Clear Glass . Tempered Glass
Shapes	Rectangular, Square, Circle, Oval, Race-Track, or
Design Style	Industrial,Modern,Contemporary
Safety Corner	Blunted, Cutting and Round Corners as Your Request
Certificate	CE, ISO, SGS
Means of Transportation	Sea, Train, Air
Specification	Any size as your request
Origin	China
Production Capacity	1600000m2 Per Year

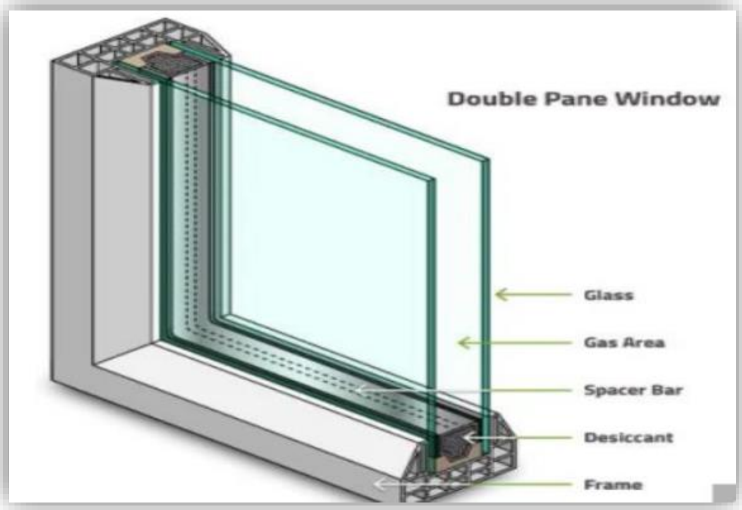


Figure 122:The shape of the product with the frame.

Double glazing:

It consists of two or more plates of glass and is separated from each other by aluminum residue and sealed at the edge Insulating atmospheric air is filled with dry air such as argon or krypton to slow heat exchange and reduce noise levels. The aluminum separator is separated by dried silica pellets to ensure that any moisture in the atmosphere is removed.

Low E glass (low emission):

In temperature and humidity season provides excellent performance. It is used to help meet energy requirements by blocking UV light and providing thermal insulation. This is done using an oxide coating that prevents the passage of solar energy and the small directed energy to the building and prevents the long directed energy that produces the amount of lighting and heating from escaping to the abscess or using a special thin metal layer.

Low-e insulated glass:

It comprises two or more floating glass dishes filled with an argon gas dryer with an aluminum frame.

Butyl seal (primary) between aluminum frame and glass, polysulfide seal or structure (secondary) where insulated glass will effectively protect radiation when coating Low-E film.

The glass will be taken care of to reach safely where:

First, steam is placed between each cup, paper, and cork so as not to harm each other, then corner protectors are placed on the edges. Glass is placed in a wooden shelling, and finally under the wooden cage forklift legs are placed to facilitate the loading and unloading process.

Argon glass is a wonderful material due to its low consumption, and this makes it easy to clean, environmentally friendly, and waterproof.

Installation method:

First, install the aluminum frame on the floor and ceiling using screws, then fix the glass panels on both sides of the frame using screws

The following picture shows the details:

Figure 123 : The installation detail in Revit

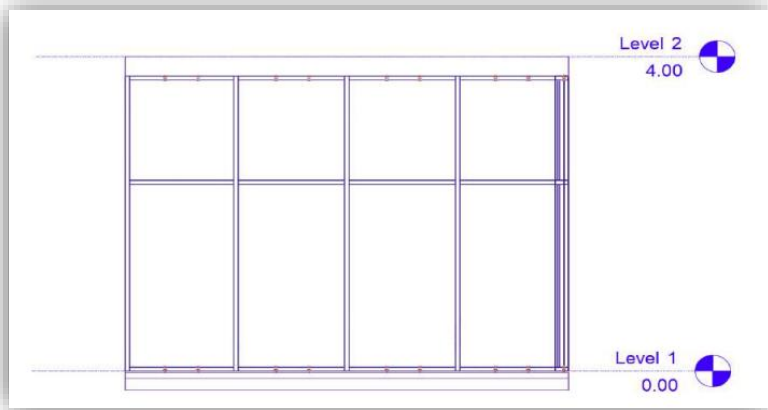


Figure 124: Installation detail in Autocad

Solar gain in the areas of glass facades well, and this is a good impression of the project because there is insulation in the ceiling and floor, in addition to the presence of a good glass type.

The figure below displays the solar gain for the floors.

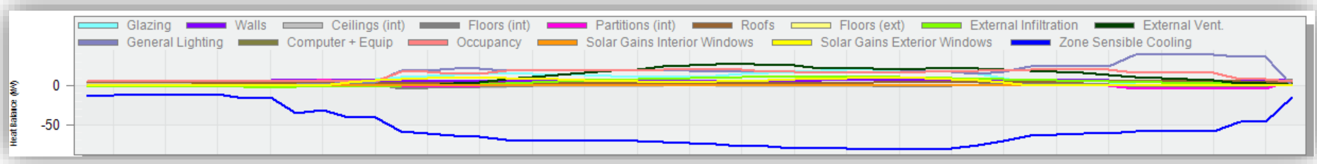


Figure 125:The solar gain for the floors

The figure below displays a sun path diagram during summer.

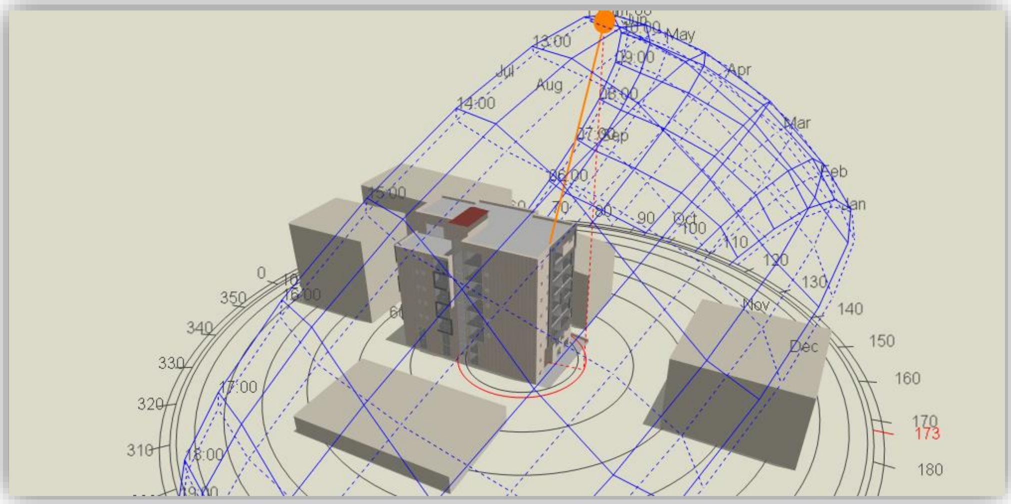


Figure 126:Sun path diagram in summer from Design Builder software

In the previous picture, it is clear that the sun does not fall directly on the northern façade And is direct on the rest of the facades of the building Therefore good glass type was used with low U values and features (60% lighting, 26% Solar, good insulation) and this helped to meet the solar gain of the building and this is good ownership of the building.

The figure displays the solar and thermal properties of the external layer of the glazing area. (SGG XT 60-28 6/16/4):

Thermal Properties	
Thickness (mm)	6.00000
Conductivity (W/m-K)	1.00000

Figure 127:Thermal properties for the external layer of the glazing area

Thermal Properties	
Thickness (mm)	6.00000
Conductivity (W/m-K)	1.00000

Figure 128:Solar properties for the external layer of the glazing area

The figure displays the solar properties of the inner layer of the glazing area. (SGG XT 60-28 6/16/4):

Solar Properties	
Solar transmittance	0.87100
Outside solar reflectance	0.07800
Inside solar reflectance	0.07700

Figure 129:Solar properties for the inner layer of the glazing area

Calculated Values	
Total solar transmission (SHGC)	0.278
Direct solar transmission	0.252
Light transmission	0.608
U-value (ISO 10292/ EN 673) (W/m2-K)	1.166
U-Value (W/m2-K)	**1.289**

Figure 130:3 U-Value for glass

The U value of the glazing area is equal to (1.289 W/m2-K) more than the U value of double glazing which is 1.2 W / m2-K, meaning that the building is energy-efficient.

The solar transmission (SHGC) is low, which reduces the cooling load of the building which means there is thermal comfort inside the building.

Cooling loads

The figure indicates that all components sheared in the cooling load are acceptable.

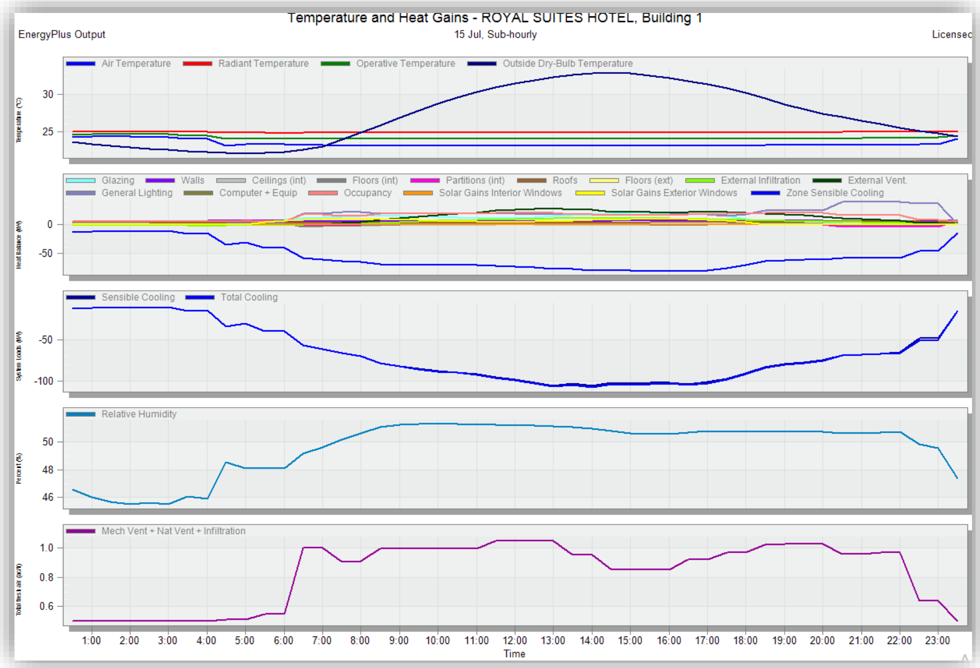


Figure 131:Results on cooling load after the modification

Solar gain has been reduced by using the previously mentioned solutions, especially glass facades.

The next tables show the cooling loads on the 1st Basement Floor:

Table 14:Cooling loads in 1st Basement Floor

Building	Block	Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Design Cooling Load Per Floor Area(W/m2)
Building 1	1st Basement Floor	WorkerBedRoom	0.62	0.0495	0.53	22.5
		WorkwearArea	1.58	0.1451	1.38	63.3
		Gym	9.49	0.7911	8.26	39
		Kitchen1	1.18	0.0955	1.03	47.4
		Living	1.25	0.101	1.09	44.3
		DirectorsRoom	1.64	0.1342	1.43	40.3
		IroningArea	1.72	0.1361	1.49	30.3
		Stair	1.45	0.1147	1.26	59.2
		PublishingArea	1.17	0.0945	1.02	43.1
		Entrance	1.49	0.1226	1.3	46.9
		Corridor	0.65	0.0533	0.56	86

In the previous table, the design cooling load values for each floor area (w/m2) between(22-86) which is older than (100 w/m2) and this means that the building is very energy-efficient.

The next tables show the cooling loads in the Ground Floor:

Table 15:Cooling loads on the Ground Floor

Building	Block	Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Design Cooling Load Per Floor Area(W/m2)
Building 1	Ground Floor	Reception	8.28	0.693	7.2	49.8
		Entrance	3.34	0.2722	2.91	38
		Shop2	1.03	0.0819	0.9	23.7
		Corridor	2.02	0.1661	1.76	40.9
		Shop1	1.18	0.0948	1.03	26.4

In the previous table, the design cooling load values for each floor area (w/m2) between(23-50) which is older than (100 w/m2) and this means that the building is very energy-efficient.

The next tables show the cooling loads on the 1st Floor:

Table 16:Cooling loads on the First Floor

Building	Block	Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Design Cooling Load Per Floor Area(W/m2)
Building 1	1st Floor	Kitchen	1.84	0.1491	49.5	32.4
		CoffeeShop	9.12	0.7474	48.4	32.4

In the previous table, the design cooling load values for each floor area (w/m2) between(32-32.5) which is older than (100 w/m2) and this means that the building is very energy-efficient.

The next tables show the cooling loads on the 2nd Floor (Repeated floor):

Table 17:Cooling loads in the 2nd Floor (Repeated floor)

Building	Block	Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Design Cooling Load Per Floor Area(W/m2)
Building 1	2nd Floor	BedRoom1	2.31	0.1908	52.4	24.8
		BedRoom2	0.58	0.0461	18	24.8
		BedRoom3	0.8	0.0647	26.3	26.9
		Corridor	4.18	0.3355	33.1	32.9
		BedRoom4	0.67	0.0527	16.8	32.4
		BedRoom5	1.68	0.1381	48.9	32.2
		BedRoom8	0.34	0.0266	11.8	24.7
		BedRoom7	0.72	0.0573	18.4	30.8
		BedRoom6	1.27	0.1022	35.6	31.8

In the previous table, the design cooling load values for each floor area (w/m2) between(24-33) which is older than (100 w/m2) and this means that the building is very energy-efficient.

The next tables show the cooling loads on the 7th Floor

Table 18:Cooling loads in 7th Floor

Building	Block	Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Design Cooling Load Per Floor Area(W/m2)
Building 1	7th Floor	Kitchen	3.87	0.328	3.36	60.1
		Restaurant	14.47	1.288	12.58	55.7

In the previous table, the design cooling load values for each floor area (w/m2) between(22-86) which is older than (100 w/m2) and this means that the building is very energy-efficient.

The next table shows the total cooling loads:

Table 19:The total cooling loads

Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Design Cooling Load Per Floor Area(W/m2)
Total	142.92	11.8727	124.28	40

After making all the modifications to the ceilings, walls, floors, and vibration, the result was (40 w/m2) which is less than (100 w/m2) and this means that the building is energy-saving.

Heating loads

The figure next illustrates the components involved in heating the origin.

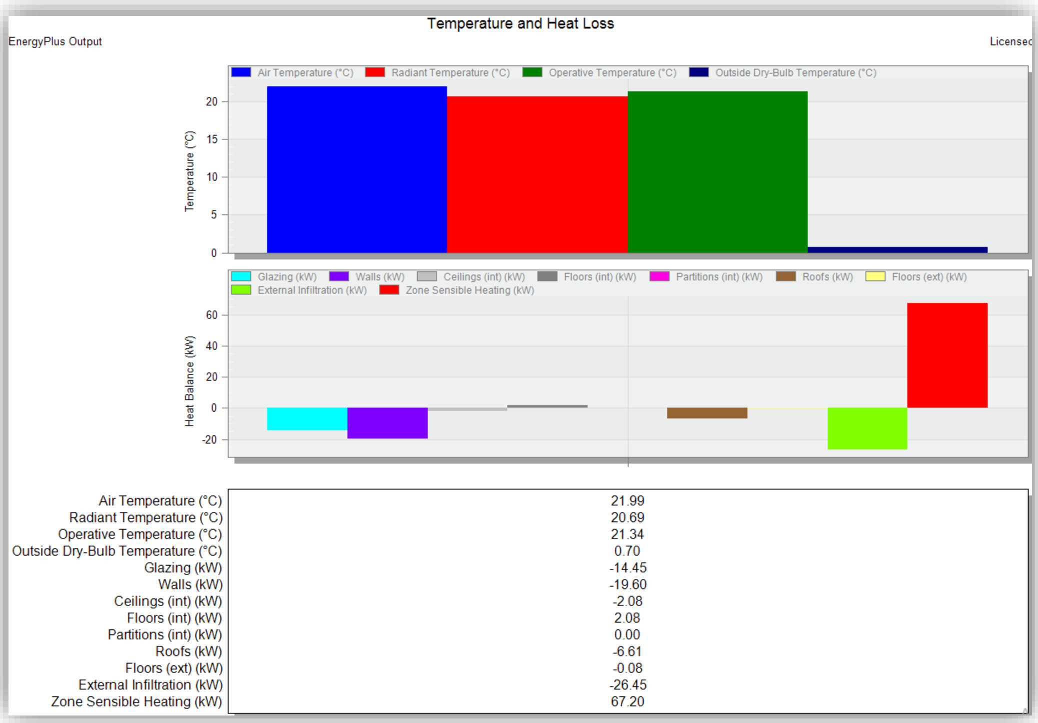


Figure 132:The components involved in the heating of origin

In the previous picture, it was found that all the components involved in the heating load were acceptable.

The solar gain that comes from glass destinations has been reduced by many of the solutions mentioned previously.

In addition, the difference between the air temperature and the operative temperature is less than 1, which means that the HVAC system will work with high efficiency.

The next tables show the heating loads on the 1st Basement Floor:

Table 20:Heating loads in 1st Basement Floor

Building	Block	Zone	Comfort Temperature (°C)	Steady-state heat Loss (kW)	Design Capacity (kW)	Design Capacity (W/m2)
Building 1	1st Basement Floor	Worker Bed Room	21.09	0.6	0.75	27.4285
		Workwear area	19.38	0.4	0.5	19.8758
		Gym	21.13	4.09	5.11	21.0007
		Kitchen 1	21.74	0.25	0.31	12.6043
		Living	21.58	0.34	0.43	15.286
		Directors room	21.69	0.42	0.53	12.9276
		Ironing area	21.61	0.65	0.81	14.2371
		Stair	21.54	0.44	0.55	22.535
		Publishing area	21.11	0.57	0.72	26.3426
		Entrance	21.12	0.68	0.85	26.6078
		Dressing	20.51	1.04	1.3	41.1299
		Corridor	21.51	0.14	0.17	22.5786
		Kitchen	20.99	0.26	0.33	39.9347

The previous table shows the heating load values for the floor, and these values are between (12-40 w/m2) so the facility is considered energy-saving.

The next tables show the cooling loads in the Ground Floor:

Table 21:Heating loads on Ground Floor

Building	Block	Zone	Comfort Temperature (°C)	Steady-state heat Loss (kW)	Design Capacity (kW)	Design Capacity (W/m2)
Building 1	Ground Floor	Reception	21.23	2.78	3.48	20.8966
		Entrance	21.26	1.38	1.72	19.5423
		Shop 2	21.22	0.77	0.96	22.0884
		Corridor	21.45	0.65	0.82	16.5525
		Shop 1	20.93	1.01	1.26	28.2875

The previous table shows the heating load values for the floor, and these values are between (16-29 w/m2) so the facility is considered energy-saving.

The next tables show the heating loads on the 1st Floor:

Table 22:Heating loads in 1st Floor

Building	Block	Zone	Comfort Temperature (°C)	Steady-state heat Loss (kW)	Design Capacity (kW)	Design Capacity (W/m2)
Building 1	1st Floor	Kitchen	20.9	0.99	1.23	33.1733
		Coffee Shop	21.39	2.61	3.26	17.299

The previous table shows the heating load values for the floor, and these values are between (17-34w/m2) so the facility is considered energy-saving.

The next tables show the heating loads on the 2nd Floor (Repeated floor):

Table 23:Heating loads in the 2nd Floor (Repeated floor)

Building	Block	Zone	Comfort Temperature (°C)	Steady-state heat Loss (kW)	Design Capacity (kW)	Design Capacity (W/m2)
Building 1	2nd Floor	Bed Room 1	21.6	0.91	1.13	25.7715
		Bed Room 2	21.6	0.45	0.56	17.4494
		Bed Room 3	21.21	0.88	1.1	36.0424
		Corridor	21.75	1.24	1.55	12.2649
		Bed Room 4	21.57	0.74	0.92	23.2306
		Bed Room 5	21.48	0.67	0.84	24.3115
		Bed Room 8	21.77	0.39	0.49	17.1524
		Bed Room 7	21.17	1.03	1.29	32.8006
		Bed Room 6	21.37	0.7	0.88	24.658

The previous table shows the heating load values for the floor, and these values are between (12-37 w/m2) so the facility is considered energy-saving.

The next tables show the heating loads on the 7th Floor

Table 24:Heating loads in 7th Floor

Building	Block	Zone	Comfort Temperature (°C)	Steady-state heat Loss (kW)	Design Capacity (kW)	Design Capacity (W/m2)
Building 1	7th Floor	Kitchen	20.25	2.69	3.36	52.196
		Restaurant	20.59	7.98	9.98	38.4509

The previous table shows the heating load values for the floor, and these values are between (38-59 w/m2) so the facility is considered energy-saving.

Table 25:The total heating loads

Zone	Comfort Temperature (°C)	Steady-state heat Loss (kW)	Design Capacity (kW)	Design Capacity (W/m2)
Total	1431.04	67.21	84	1662.2514

Thermal comfort

To get the best condition for the building, specifically the thermal condition, many modifications and solutions have been made, the most important of which are

1. The use of thermal insulation with an appropriate value, which helped to obtain energy-saving ceilings and walls, in addition to the use of aluminum frames around the windows.
2. The use of an appropriate type of glass with good specifications in terms of light and heat transfer to and from the building and solar energy (26% solar,60% lighting, good insulation).

After making modifications to the building from adding insulators to the walls and ceilings and the appropriate type of glass and after obtaining the results compared to the building after the modifications, this indicates that the building is energy-saving.

The following table shows the location power supply for the building after modification from the Design-Builder software:

Table 26:Site and source energy analysis

	Total Energy [kWh]	Energy Per Total Building Area [kWh/m2]	Energy Per Conditioned Building Area [kWh/m2]
Total Site Energy	81889.81	66.41	66.41
Net Site Energy	81889.81	66.41	66.41
Total Source Energy	259345.04	210.33	210.33
Net Source Energy	259345.04	210.33	210.33

The total site energy is 40.081 kWh/m2 which is less than the range (150-160) kWh/m2 and this is good.

In addition, the consumption of the building is about $66.41 KWh/m^2$

Thermal comfort:

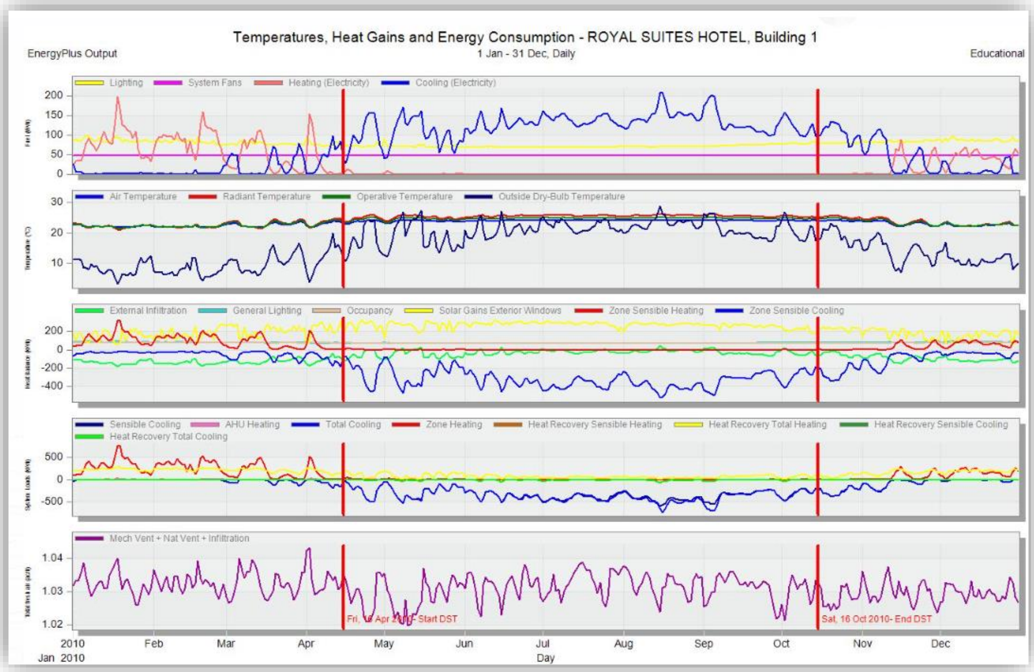


Figure 133 Thermal comfort:

One of the most important things to consider is the thermal comfort of people in the building. If thermal comfort is achieved inside the building, the modification procedures are feasible and useful, and therefore the building shouts energy reducer.

Within the building, there is a degree of thermal comfort obtained from the design constructor which is the PMV index (Predicated mean value).

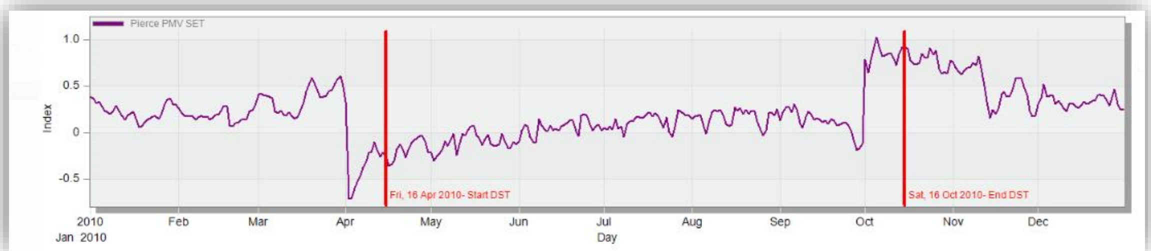


Figure 134:PMV index

The previous figure shows the PMV index for the project and it’s within the range (- 0.7 - 0.7) so that means that the thermal comfort is acceptable.

Baseline analysis:

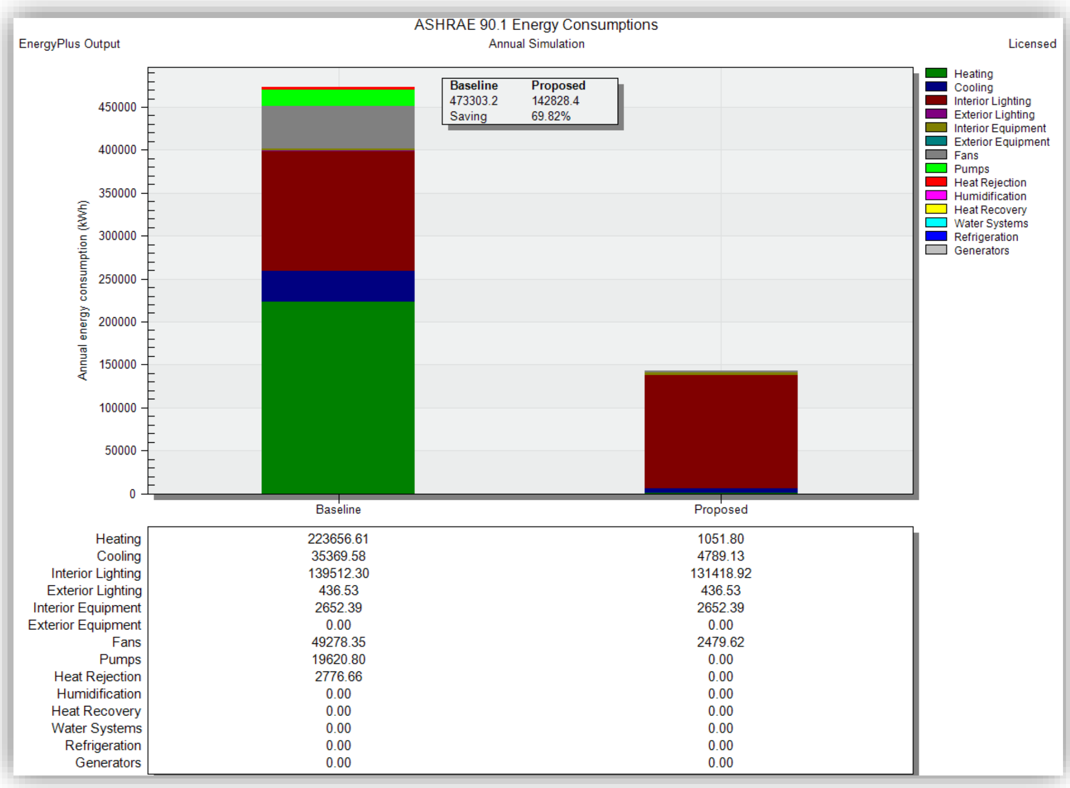


Figure 135:Baseline energy building analysis

In the previous picture, the baseline analysis shows that the energy conservation rate is 69.82%, which means that the building is energy-saving, in addition to the low value of the probability of cooling and heating.

Table 27:Total energy demand

	Area [m2]
Total Building Area	3572.70
Net Conditioned Building Area	3572.70
Unconditioned Building Area	0.00

In the previous table the total energy demand by the building after insulation

CFD anlysis:

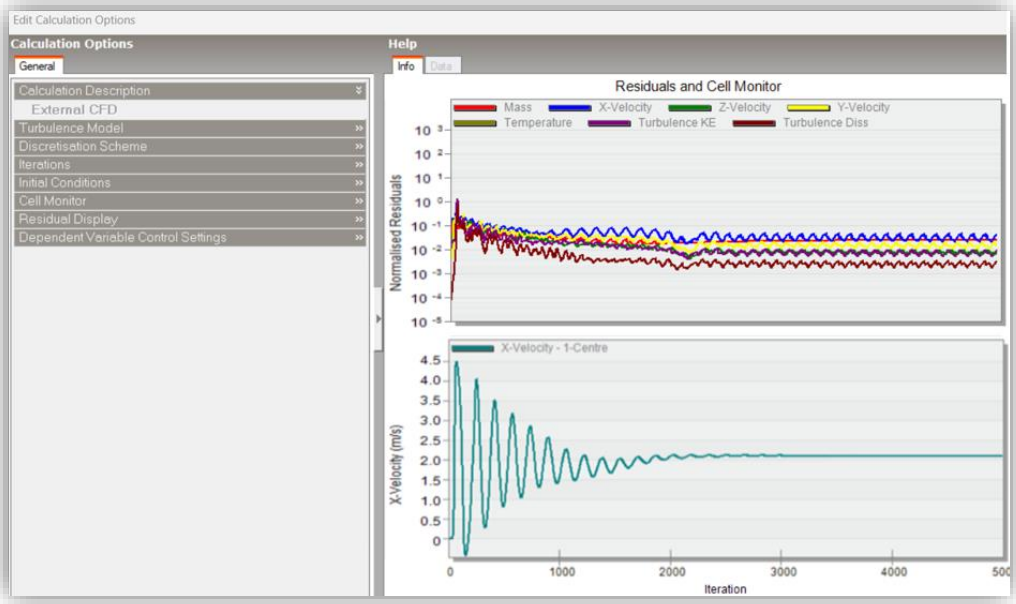


Figure 136: CFD chart

The following image shows the building's exterior analysis of CFD from the Design-Builder software.

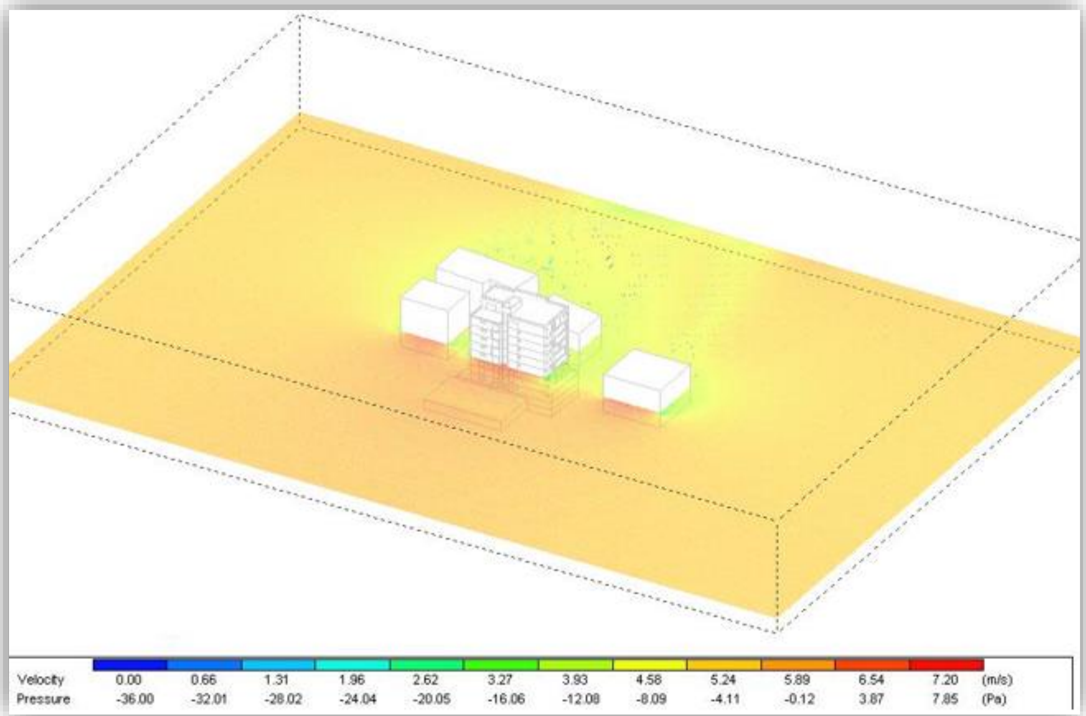


Figure 137:Building's exterior analyses is of CFD

Figure 139:Building's exterior analyses is of CFD

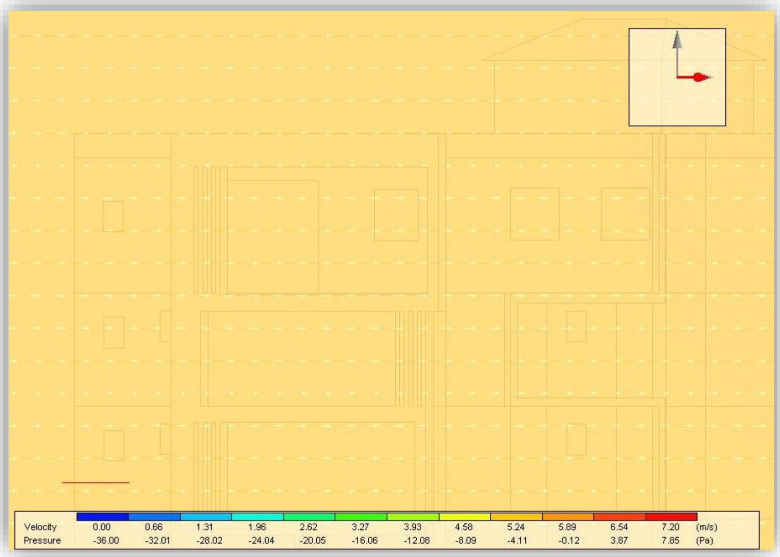


Figure 138:Building's exterior analyses is of CFD

The numbers show the smooth movement of the wind with the building, and this is evidence that there is no turbulent flow that the direction of its movement is regular and there are no obstacles to the arrival of air.

The following image shows the building's interior analysis of CFD from the Design-Builder software.

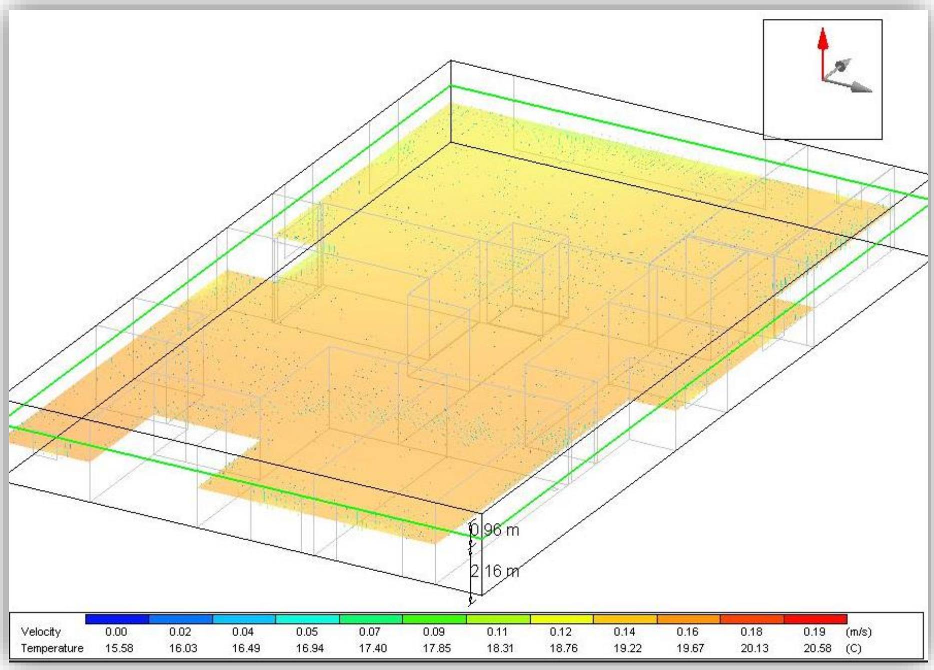


Figure 140:Building's interior analyses is of CFD

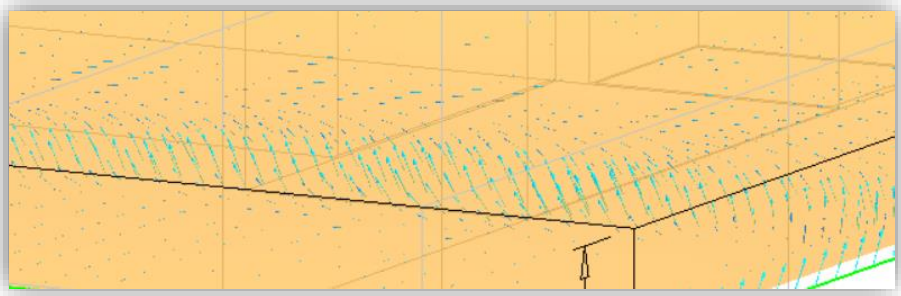


Figure 141:Building's interior analyses is of CFD

In the previous picture, it was noted that the internal spaces are the direction of wind movement from bottom to top and this is what it should be.

2.5 Photovoltaic design

2.5.1 Introduction

When designing the building, the location of the building and the direction of the sun and its movement it must be taken into account, which works to save energy consumption through solar cells on the roof of the building in the southern façade to save the electricity bill and provide environmentally friendly electric current.

A solar photovoltaic system is a renewable energy system that uses photovoltaic modules for electrical energy, in addition, it can be used directly, stored, returned to the grid line, or combined with one or more.

In addition, it is reliable and clean for electricity and is suitable for a wide range of applications.

The system includes different components that must be selected for the type of system, location, and applications.

Its main components of this system are inverter, solar charge controller, auxiliary power sources, and battery.

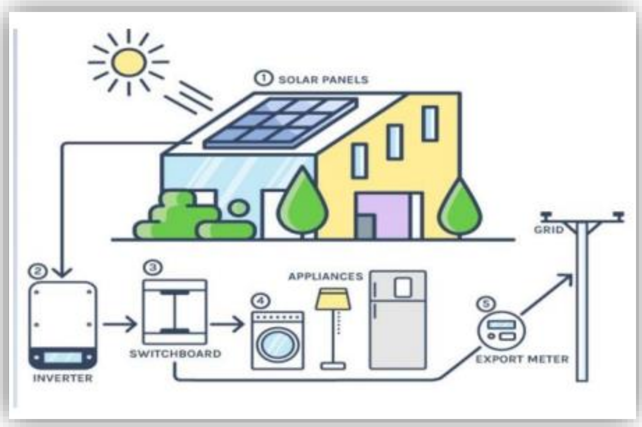


Figure 142: Solar PV system

2.5.2 Plan analysis:

It has been observed that the solar paths in Summer are longer than winter, as in summer the sun rises at 6:00 Am sets at 7:00 P.m., but in winter the sun rises at 7:00 Am and sets at 5:00 P.m.

In summer, the eastern and western elevations don't receive much sun, due to neighboring buildings that shade on both elevations. But in winter the greatest amount of solar radiation is in the southwestern elevation.

Northern elevation is not suitable for solar design, since the sun doesn't reach this elevation in summer or winter.

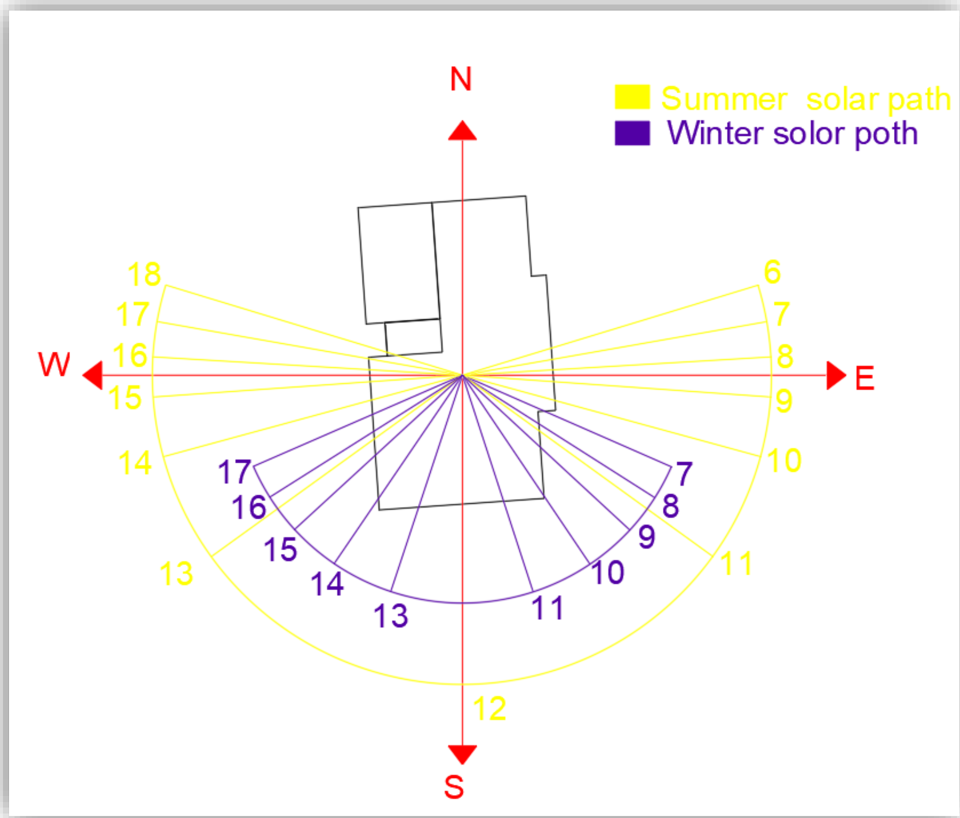


Figure 143:Solar Path in summer and winter

2.5.2 Photovoltaic modules:

First, choose the cell type

Table 28:Types of photovoltaic

Type	Construction	Cell Efficiency (%)	Module Efficiency (%)	Current stage of Development
Monocrystalline silicon	Uniform crystalline structure-single crystal	24	13-17	Industrial production
Ploycrystalline silicon	Multi-crystalline structure-different crystals visible	18	11-15	Industrial production
Amorphous silicon	Particles irregularly – arranged – thin film	11-12	4-7	Industrial production
Gallium-arsenide	Crystalline	25		Exclusive production
Gallium-arsenide, Gallium-antimony etc	Tandem (multi-junction), different layers sensitive to different light wavelengths	25-31		R&D
Copper-indium-diselenide	Thin-film	18	10-12	Industrial production
Cadmium-telluride	Thin-film	17	9-10	Ready for industrial production
Organic	Electrochemical principle based	5-8		R&D

Photovoltaic design:

The previous table shows the specifications of solar cells There are many companies including the Canadian company (Canadian Solar Company) that was selected to design this project.

Figure 144:The Canadian solar company

Specifications of the cells used

Table 29:Specifications of the cells.

ELECTRICAL DATA | STC*

		Nominal Max. Power (Pmax)	Opt. Operating Voltage (Vmp)	Opt. Operating Current (Imp)	Open Circuit Voltage (Voc)	Short Circuit Current (Isc)	Module Efficiency
CS6W-530MB-AG		530 W	40.9 V	12.96 A	48.8 V	13.80 A	20.5%
Bifacial Gain**	5%	557 W	40.9 V	13.62 A	48.8 V	14.49 A	21.5%
	10%	583 W	40.9 V	14.26 A	48.8 V	15.18 A	22.6%
	20%	636 W	40.9 V	15.55 A	48.8 V	16.56 A	24.6%
CS6W-535MB-AG		535 W	41.1 V	13.02 A	49.0 V	13.85 A	20.7%
Bifacial Gain**	5%	562 W	41.1 V	13.68 A	49.0 V	14.54 A	21.8%
	10%	589 W	41.1 V	14.34 A	49.0 V	15.24 A	22.8%
	20%	642 W	41.1 V	15.62 A	49.0 V	16.62 A	24.9%
CS6W-540MB-AG		540 W	41.3 V	13.08 A	49.2 V	13.90 A	20.9%
Bifacial Gain**	5%	567 W	41.3 V	13.73 A	49.2 V	14.60 A	21.9%
	10%	594 W	41.3 V	14.39 A	49.2 V	15.29 A	23.0%
	20%	648 W	41.3 V	15.70 A	49.2 V	16.68 A	25.1%
CS6W-545MB-AG		545 W	41.5 V	13.14 A	49.4 V	13.95 A	21.1%
Bifacial Gain**	5%	572 W	41.5 V	13.80 A	49.4 V	14.65 A	22.2%
	10%	600 W	41.5 V	14.46 A	49.4 V	15.35 A	23.2%
	20%	654 W	41.5 V	15.77 A	49.4 V	16.74 A	25.3%
CS6W-550MB-AG		550 W	41.7 V	13.20 A	49.6 V	14.00 A	21.3%
Bifacial Gain**	5%	578 W	41.7 V	13.87 A	49.6 V	14.70 A	22.4%
	10%	605 W	41.7 V	14.52 A	49.6 V	15.40 A	23.4%
	20%	660 W	41.7 V	15.84 A	49.6 V	16.80 A	25.5%
CS6W-555MB-AG		555 W	41.9 V	13.25 A	49.8 V	14.05 A	21.5%
Bifacial Gain**	5%	583 W	41.9 V	13.91 A	49.8 V	14.75 A	22.6%
	10%	611 W	41.9 V	14.58 A	49.8 V	15.46 A	23.6%
	20%	666 W	41.9 V	15.90 A	49.8 V	16.86 A	25.8%

* Under Standard Test Conditions (STC) of irradiance of 1000 W/m², spectrum AM 1.5 and cell temperature of 25°C.
** Bifacial Gain: The additional gain from the back side compared to the power of the front side at the standard test condition. It depends on mounting (structure, height, tilt angle etc.) and albedo of the ground.

ELECTRICAL DATA

Operating Temperature	-40°C ~ +85°C
Max. System Voltage	1500 V (IEC/UL) or 1000 V (IEC/UL)
Module Fire Performance	TYPE 29 (UL 61730) or CLASS C (IEC61730)
Max. Series Fuse Rating	30 A
Protection Class	Class II
Power Tolerance	0 ~ + 10 W
Power Bifaciality*	70 %

* Power Bifaciality = $Pmax_{rear}$ / $Pmax_{front}$, both $Pmax_{rear}$ and $Pmax_{front}$ are tested under STC, Bifaciality Tolerance: ± 5 %

ELECTRICAL DATA | NMOT*

	Nominal Max. Power (Pmax)	Opt. Operating Voltage (Vmp)	Opt. Operating Current (Imp)	Open Circuit Voltage (Voc)	Short Circuit Current (Isc)
CS6W-530MB-AG	397 W	38.3 V	10.38 A	46.1 V	11.13 A
CS6W-535MB-AG	401 W	38.5 V	10.42 A	46.3 V	11.17 A
CS6W-540MB-AG	405 W	38.7 V	10.47 A	46.5 V	11.21 A
CS6W-545MB-AG	409 W	38.9 V	10.52 A	46.7 V	11.25 A
CS6W-550MB-AG	412 W	39.1 V	10.55 A	46.9 V	11.29 A
CS6W-555MB-AG	416 W	39.3 V	10.60 A	47.1 V	11.33 A

* Under Nominal Module Operating Temperature (NMOT), irradiance of 800 W/m², spectrum AM 1.5, ambient temperature 20°C, wind speed 1 m/s.

MECHANICAL DATA

Specification	Data
Cell Type	Mono-crystalline
Cell Arrangement	144 [2 x (12 x 6)]
Dimensions	2278 × 1134 × 30 mm (89.7 × 44.6 × 1.18 in)
Weight	32.3 kg (71.2 lbs)
Front Glass	2.0 mm heat strengthened glass with anti-reflective coating
Back Glass	2.0 mm heat strengthened glass
Frame	Anodized aluminium alloy
J-Box	IP68, 3 bypass diodes
Cable	4.0 mm² (IEC), 12 AWG (UL)
Cable Length (Including Connector)	300 mm (11.8 in) (+) / 200 mm (7.9 in) (-) or customized length*
Connector	T6 or MC4-EVO2 or MC4-EVO2A
Per Pallet	35 pieces
Per Container (40' HQ)	700 pieces or 560 pieces (only for US & Canada)

* For detailed information, please contact your local Canadian Solar sales and technical representatives.

TEMPERATURE CHARACTERISTICS

Specification	Data
Temperature Coefficient (Pmax)	-0.34 % / °C
Temperature Coefficient (Voc)	-0.26 % / °C
Temperature Coefficient (Isc)	0.05 % / °C
Nominal Module Operating Temperature	41 ± 3°C

Inverters:

To convert the electricity generated from direct current to alternating current uses the inverter which is considered an expensive device it is changed every period and it is important to operate any device.

The following inverter type was used

Figure 145:The Canadian solar company

Table 30:Specification of the inverter.

SYSTEM/TECHNICAL DATA					
MODEL NAME	**CSI-15K-T4001A-E**	**CSI-17K-T4001A-E**	**CSI-20K-T4001A-E**	**CSI-23K-T4001A-E**	**CSI-25K-T4001A-E**
INPUT (DC)					
Max. Input Voltage	1100 V_{DC}				
Start-up DC Input Voltage	180 V_{DC}				
Rated Input Voltage	600 V_{DC}				
MPPT Voltage Range	160 - 1000 V_{DC}				
Max. String Input No.	4				
MPPT No.	2				
Max. Input Current	30 A / 30 A				
Max. DC short-circuit current	40 A / 40 A				
OUTPUT (AC)					
Rated AC Output Power	15 kW	17 kW	20 kW	23 kW	25 kW
Max. AC Output Power (Apparent)	15 kVA	17 kVA	20 kVA	23 kVA	25 kVA
Rated Output Voltage	380 V_{AC} / 400 V_{AC}				
Grid Connection Type	3 L / N / PE				
Max Output Current	22.8 A	25.8 A	30.4 A	34.9 A	37.9 A
Rated Output Frequency	50 / 60 Hz				
THDi	< 3 %				
Power Factor	0.8 leading ... 0.8 lagging				
Zero Export Solution	Support				
EFFICIENCY					
Max. Efficiency	98.5 %	98.5 %	98.6 %	98.6 %	98.6 %
EU Efficiency	98.0 %	98.0 %	98.0 %	98.0 %	98.0 %
ENVIRONMENT					
Protection Degree	IP66				
Cooling	Intelligent Air Cooling				
Operating Temperature Range	-30 °C to +60 °C				
Operating Humidity	0 - 100 %				
Operating Altitude	4000 m (> 3000 m derating)				

A suitable catalog was chosen so that the unit capacity is available in the simulation software, PVSyst, and RETscreen.

Software design and simulations:

- PVSyst:

The tilt angle:

where the Royal Suites Hotel is located in the city of Nablus on the longitude (35.24667 E) and latitude (32.22037 N). $\theta = (0.9 - 1)latitude \rightarrow (0.9 * 32.22 - 1 * 32.22) \rightarrow \theta = (28.99 - 32.22)\ \ use\ \theta = 30°$

Arrangement and dimensions:

How to install and arrange solar cells: Portraiture and landscapes, in this project will be arranged according to the vertical method, but due to the inclination of the angle by 30, the dimensions do not remain the same horizontally from the upper view, so the length of the cell will change.

$New\ Dimentsion = Old\ Dimentsion * \cos(tilt)$

$= 2.278 * \cos 30 = 1.972$

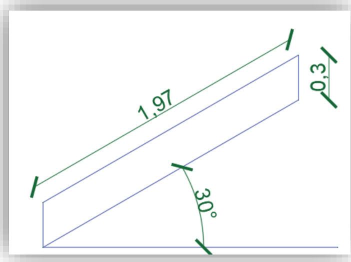


Figure 146: Dimensions of cells

So that the shadows of the cells do not meet on the neighboring cells comes putting a space d

$D \geq 3H \rightarrow 3 * 1.97 * \sin 30 = 2.95m$

Figure 147:Distance between cells

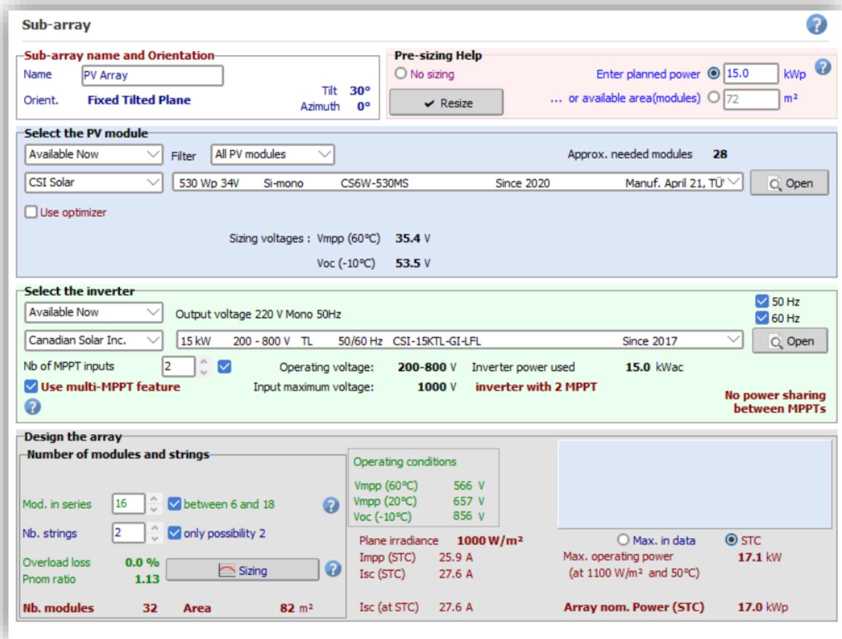


Figure 148:Sub-Array PVSyst

Global system summary

Nb. of modules	32
Module area	82 m²
Nb. of inverters	1
Nominal PV Power	17.0 kWp
Nominal AC Power	15.0 kWAC
Pnom ratio	1.131

Figure 149:Global system summary

System information

PV Array		Inverters	
Nb. of modules	32 units	Nb. of units	1 unit
Pnom total	16.96 kWp	Pnom total	15.00 kWac
		Pnom ratio	1.131

Figure 150:PV system report results

The project needs 32 units, with a total capacity = 16.96 kW.

Inverters selection: 15kw inverters were selected, operating voltage = 200-800V, universal power inverters = 15kW AC, we have 2 units in series, and we have 14 series.

$$\# \, modul = \frac{WPv \; system}{WPv \; modul}$$

$$WPv \; modul = 32 * 530 = 16960w$$

$= 16.960Kw$

$V_{min}\ at\ (85°) = V_{mmp}\ at\ 60° - (0.26 * (85 - 25))$

$= 56.6 - (0.26 * 60)$

$= 41\ V$

$V_{max}\ at\ (-40°) = V_{mmp}\ at\ 20° - (0.26 * (-40 - 25))$

$= 65.7 - (0.26 * -65)$

$= 82.6\ \ V$

$VOC\ at(-40°) = Voc\ at\ 10° + 0.26 * -65$

$= 85.6 + 16.9$

$= 102.5\ V$

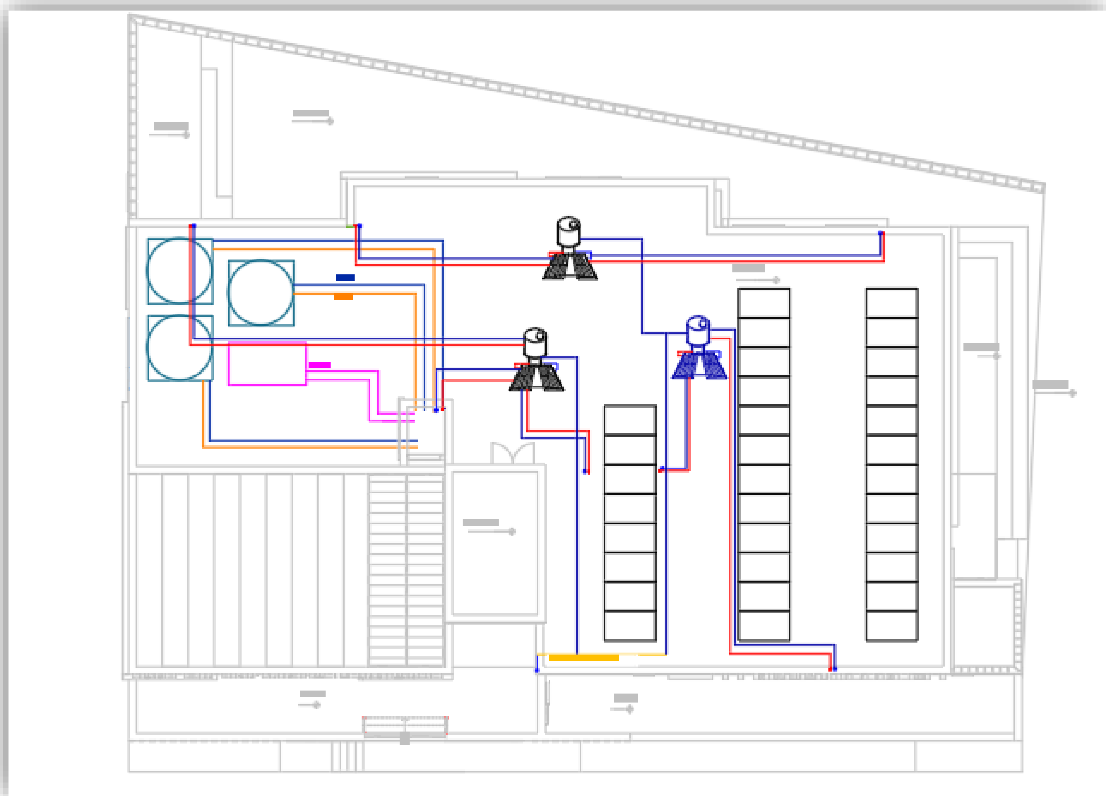


Figure 151:Destination of PV Modules in Roof

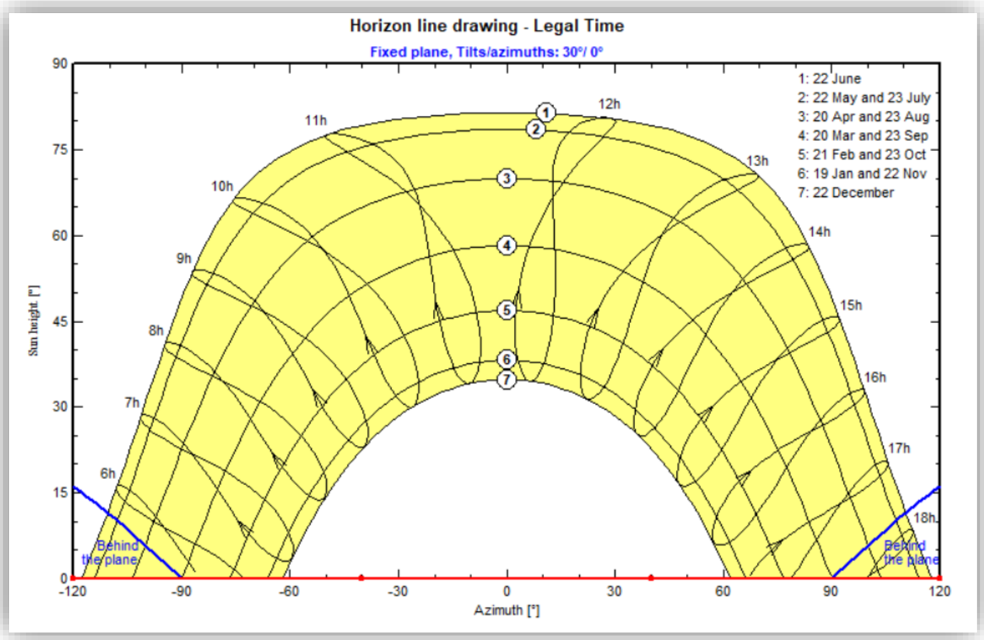


Figure 152:Horizon line drowing

- RETScreen:

The simulation was performed using RET Screen software

Location Nablus, Rafidia, Royal Suites Hotel

Monitoring Station: Jerusalem.

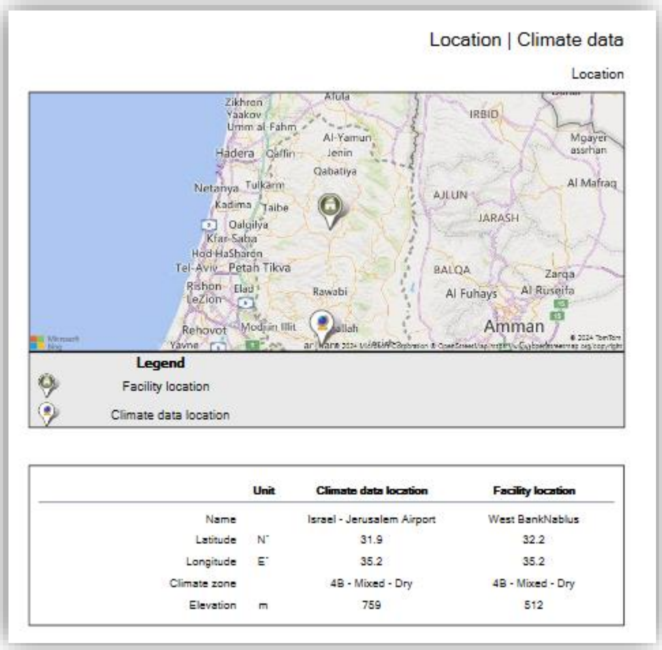


Figure 153:Location

Table 31:Climate data location.

Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days 18 °C	Cooling degree-days 10 °C
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	7.7	76.1%	56.42	3.37	98.8	3.2	10.6	319	0
February	8.2	73.4%	49.28	4.20	98.6	3.5	11.6	274	0
March	10.4	70.8%	32.86	5.30	98.5	3.7	14.6	236	12
April	15.1	58.6%	11.70	6.81	98.3	3.4	19.0	87	153
May	19.1	53.6%	2.79	7.83	98.2	3.6	24.0	0	282
June	21.4	56.0%	0.30	8.57	98.0	4.2	27.9	0	342
July	23.1	59.5%	0.00	8.40	97.8	4.5	29.9	0	406
August	23.1	64.4%	0.62	7.85	97.8	4.1	30.1	0	406
September	21.8	64.8%	0.90	6.73	98.2	3.6	27.9	0	354
October	19.1	63.5%	11.16	5.28	98.4	2.8	24.0	0	282
November	14.1	66.7%	29.70	3.74	98.6	2.8	17.6	117	123
December	9.7	73.5%	45.26	3.05	98.8	2.7	12.5	257	0
Annual	**16.1**	**65.0%**	**240.99**	**5.94**	**98.3**	**3.5**	**20.9**	**1,291**	**2,361**
Source	Ground	Ground	NASA	Ground	NASA	Ground	NASA	Ground	Ground
Measured at					m	10	0		

Results show air temperature, relative humidity, precipitation, daily radiation- horizontal, Atmospheric pressure, wind speed, earth temperature, heating degree days, and cooling degree days.

Environmental study (GHG emission analysis):

The project needs to burn fuel, diesel, gasoline, or kerosene to generate electric power. This combustion process produces gases harmful to the environment, such as carbon dioxide.

In this design, the generation of 1 MWh of electricity generates 0.330 tCO2 equivalent to 330 KCO2, thus harming the environment.

Transmission and distribution losses = 7%, so total losses = 0.530 tons of CO2 / MWh.

The project generates 53.5 MWh of electricity without harming the environment.

The program made a comparison with the base case and the proposed case, the base case = 19

TCO2 will be emitted. But in the proposed case, the amount of CO2

To emit = 2 tCO2. We reduce carbon dioxide emissions by 26.4 tons of carbon dioxide.

26.4 tCO2 is equivalent to 4.8 running light cars and trucks.

Money is saved for every ton of emissions that are reduced**.**

Table 32:The equivalent values of carbon dioxide gas.

Gross annual GHG emission reduction tCO2	Equivalent	Unit
26.4	4.8	cars & light trucks
26.4	11.49	litres of gasoline not consumed
26.4	61.4	Barrels of crude oil nit consumed
26.4	26.4	people reducing energy use by 20%
26.4	2.4	Hectares of forest absorbing carbon
26.4	9.1	Tonnes of waste recycled

This table illustrates the equivalent values of carbon dioxide gas whose emission was reduced as a result of using solar cells from different sources.

Financial Analysis:

Initial costs are paid = $ 48,301, the project will not make a profit until 7 years and will bring an increase in profits starting from the seventh year. Net profit in year 25 will be equivalent to $140,000.

There will be losses in both 8 and 16 years due to changing inverters.

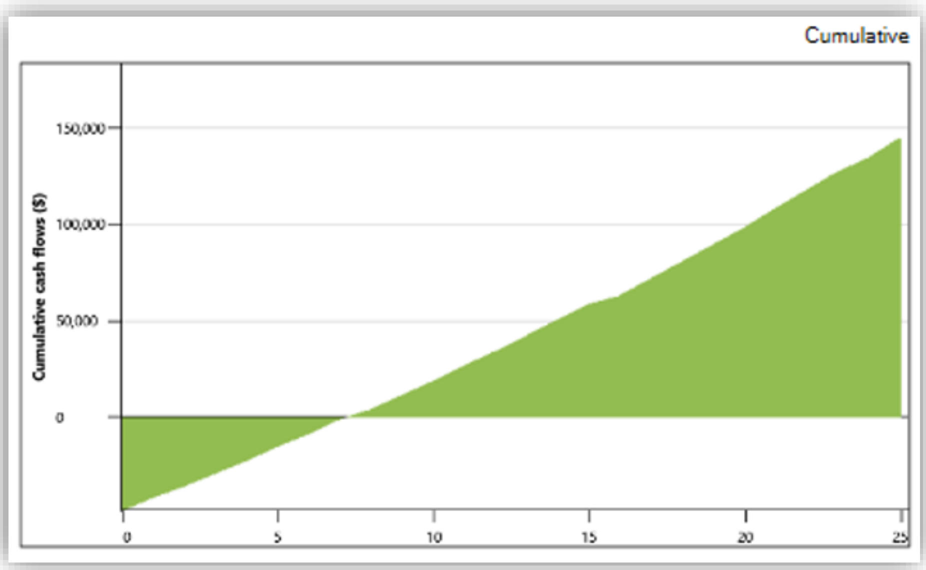


Figure 154:Financial Analysis

2.6 Architectural Modifications for the original plan

2.6.1 Introduction

This section contains modifications obtained from the engineering office, as modifying plans is vital for any project to suit changing developments and needs or to improve project efficiency. In this project, the project was completely changed from the plans obtained, that is, it was designed, not redesigned. The plans were for a multifunctional building with shops, apartments, and offices, while the design was for a hotel building. This has been done for several reasons, the most important of which is that the building is a hotel. After the construction of the exoskeleton, it was converted into a hotel, and the interior was divided on this basis. The building is currently called the Royal Suites Hotel, but plans have not been obtained as it was built as well as the area needs a hotel.

In this section, we talk about the contents of each diagram before and after the modification, and first, we talk about the criteria that were not taken into account in the first design but were taken into account in this design.

2.6.2 Modifications on plans

There are some common distances between the plans, which were noted that they were not subject to standards, whether architectural or safety requirements, as follows:

- **Safety requirements:** Both designs consist of 11 floors, and therefore, based on the `Palestinian Code for Fire Prevention and Protection, the design must contain two emergency stairs and they must be closed and used only in case of emergency, but the old design contains one staircase and is used to access residential apartments as a primary use, as shown in the following pictures.
  Note: The Palestinian code for fire prevention and protection was studied according to the type of building and the number of escape stairs was determined.

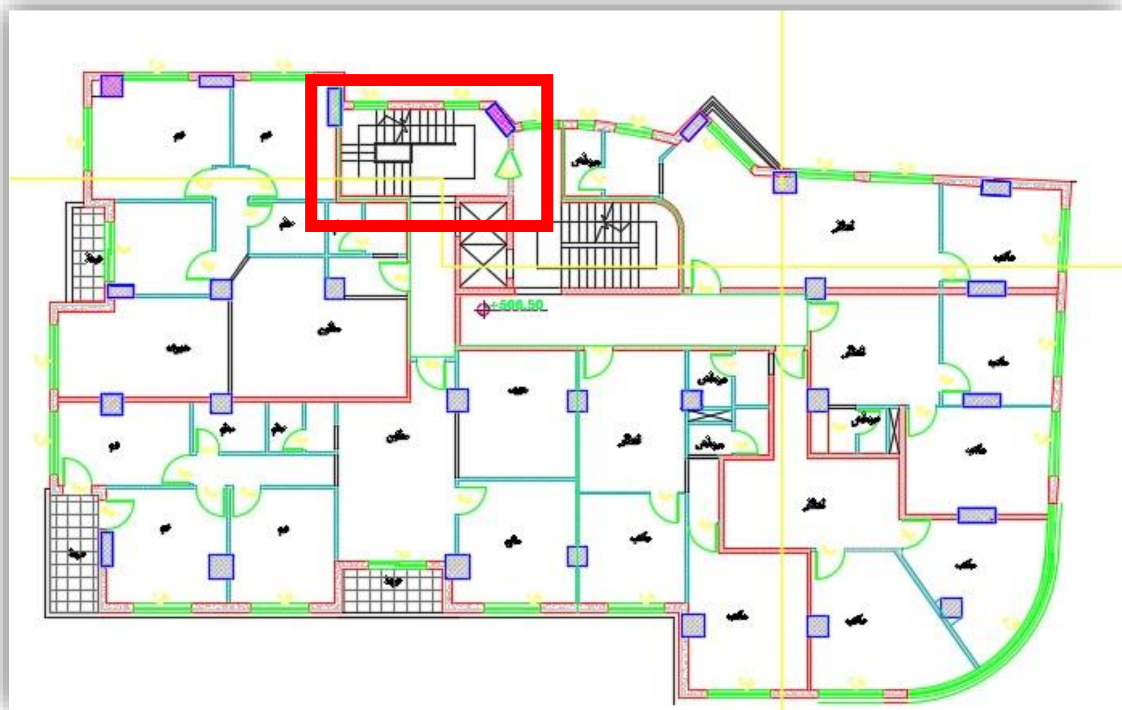


Figure 155: Emergency stair in the original design.

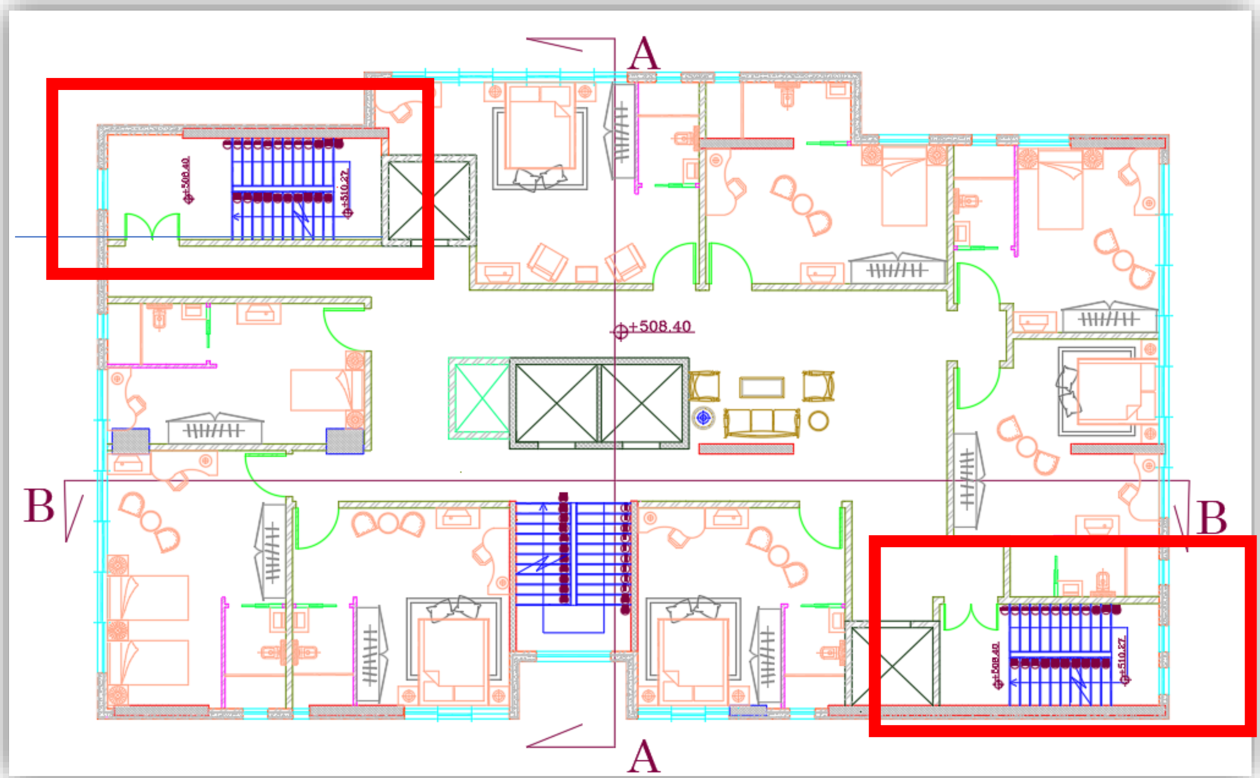


Figure 156: Emergency stair in our design.

- **Entrance ramps :** The old design did not take into account people with special needs and a ramp was not designed for the entrance as shown in the pictures.

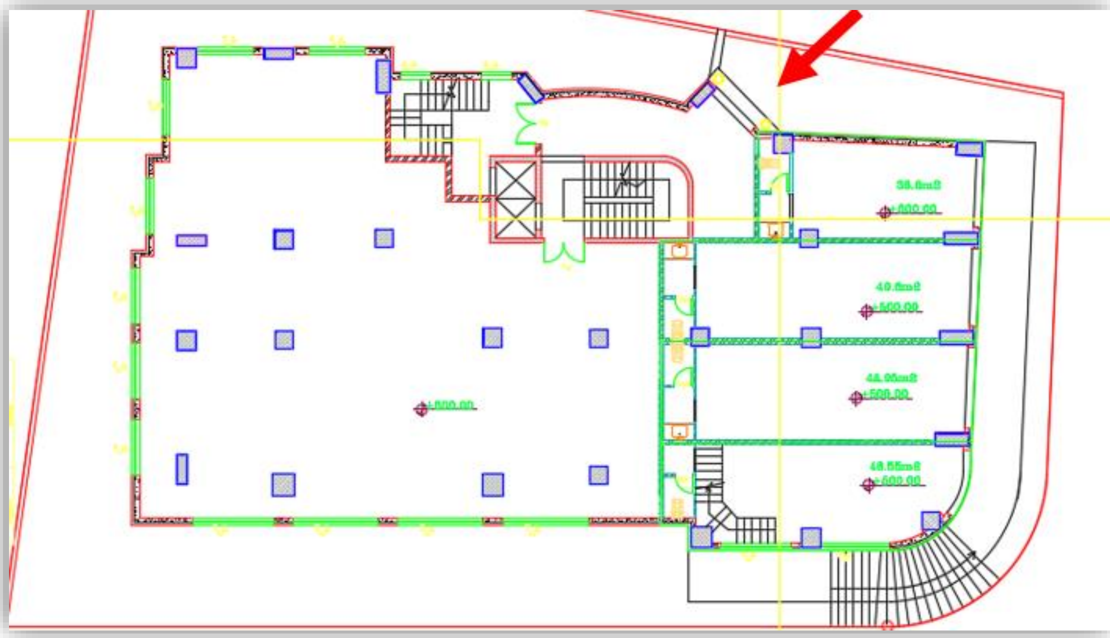


Figure 157: Entrance ramps in the original design.

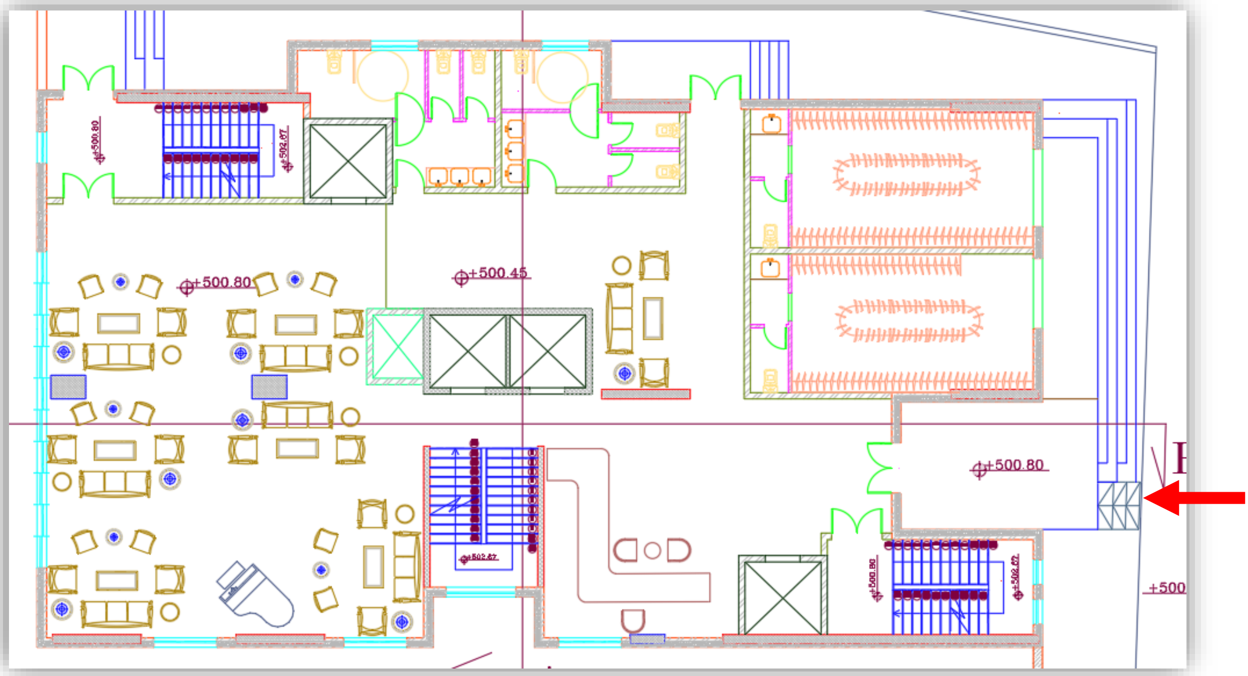


Figure 158: Entrance ramps in our design

Shafts are added for electrical and mechanical purposes, as the old design did not consider the columns, knowing that in the project's design, only one column was made, and the matter will be reviewed in mechanical and electrical designs.

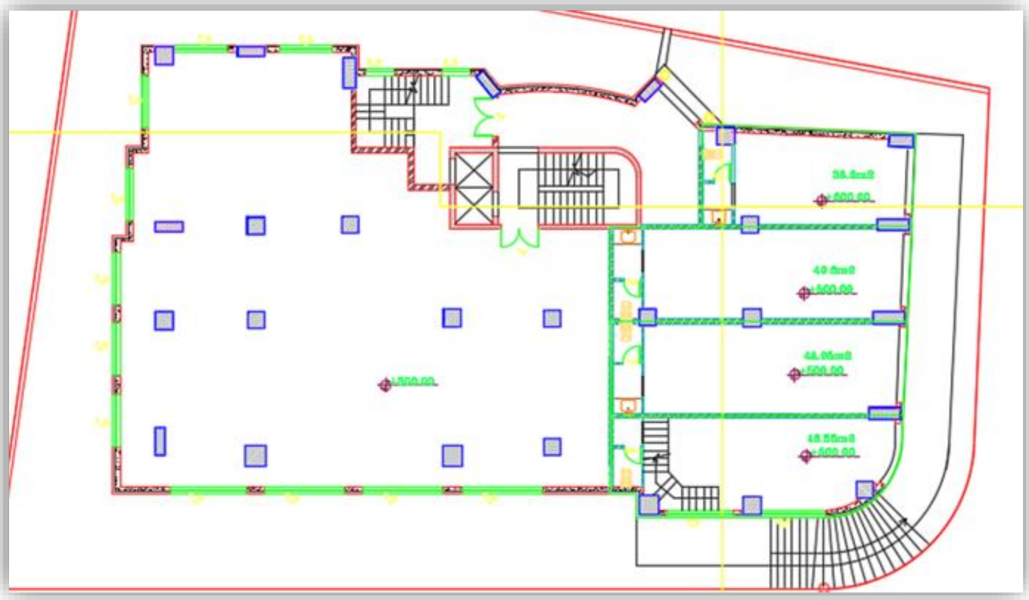


Figure 159: No shafts in the original design.

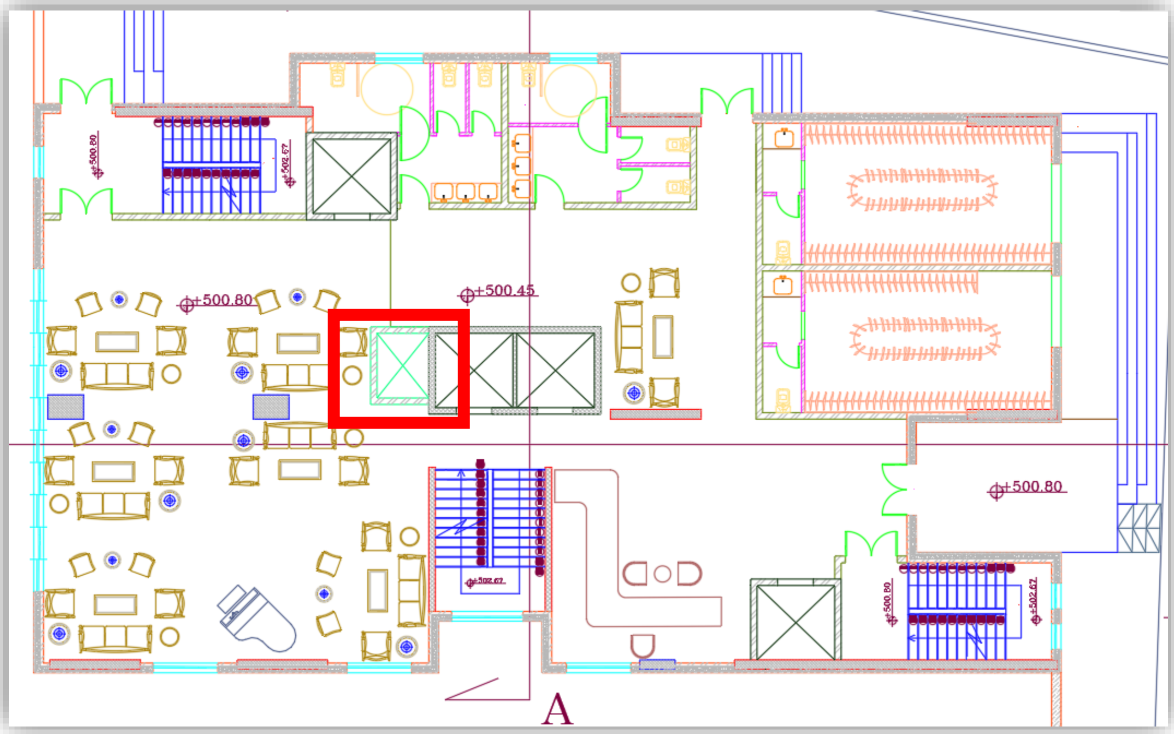


Figure 160: Shaft in our design.

- ***Basements***

The designated parking spaces outlined in the initial plans total 47, which proves insufficient. Furthermore, the existing layout poses challenges to the seamless movement of vehicles, particularly in terms of reversing and entering parking spaces. The dimensions of certain parking spaces restrict the ability of cars to maneuver freely, a condition that is deemed unacceptable. This issue is visually depicted in the accompanying figure.

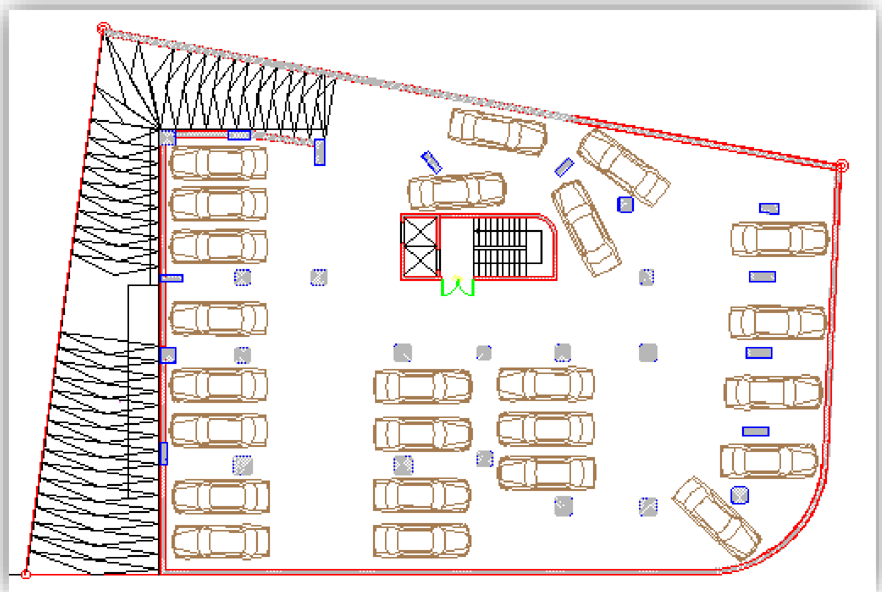


Figure 161: Basement 3 before the design of 24 car parking spaces.

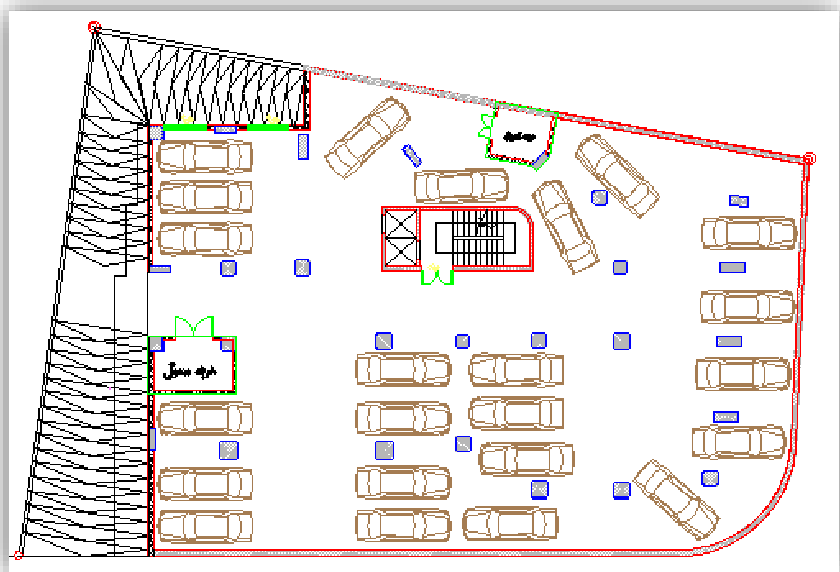


Figure 162: Basement 2 before the design of 23 car parking spaces.

Referring to the standard of building and regulation of local authorities, it was found that the number of parking spaces required for a 3-star hotel is one parking space for every four bedrooms, which means that the number of parking spaces must be at least 10. Taking advantage of the space available for a project, 36 parking spaces have been designed, including one parking space for disabled distributors on the second and third basements. The design is as follows:

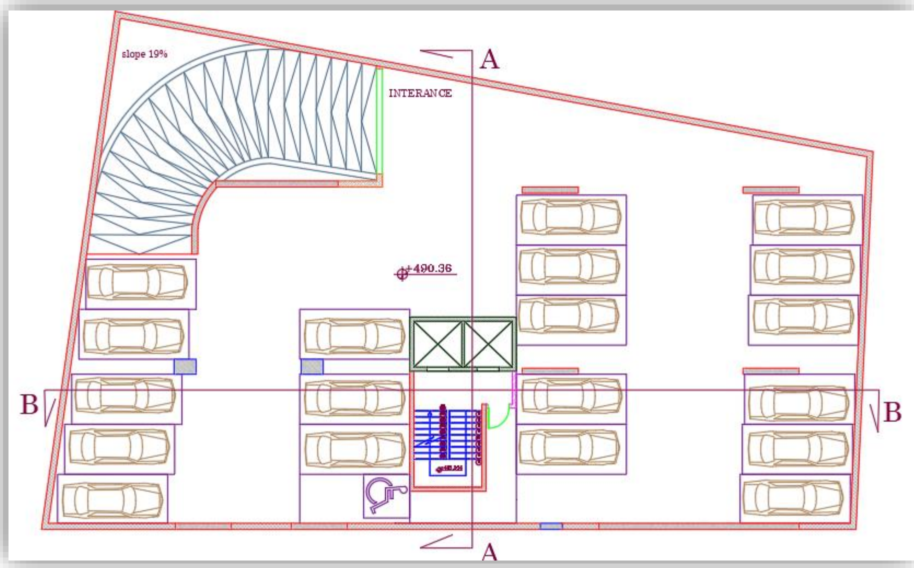


Figure 163:Basement 3 after the design of 20 car parking spaces.

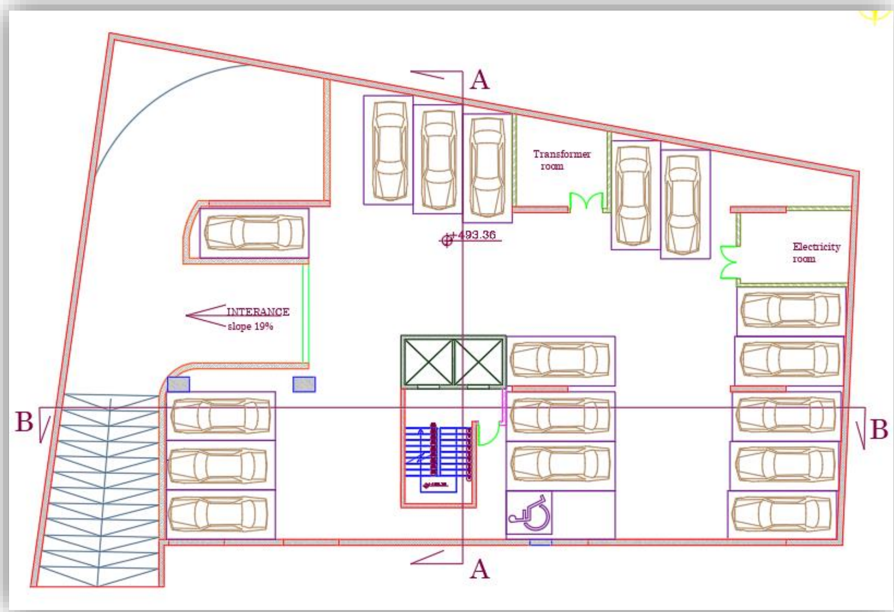


Figure 164: Basement 2 after design of 17 car parking spaces.

The basement ramp is designed with a slope of 19%, both as a parking entrance and exit with a width of 5.25 meters according to standards.

The parking space (2.5 m * 5.3 m) and free space to move and park smoothly.

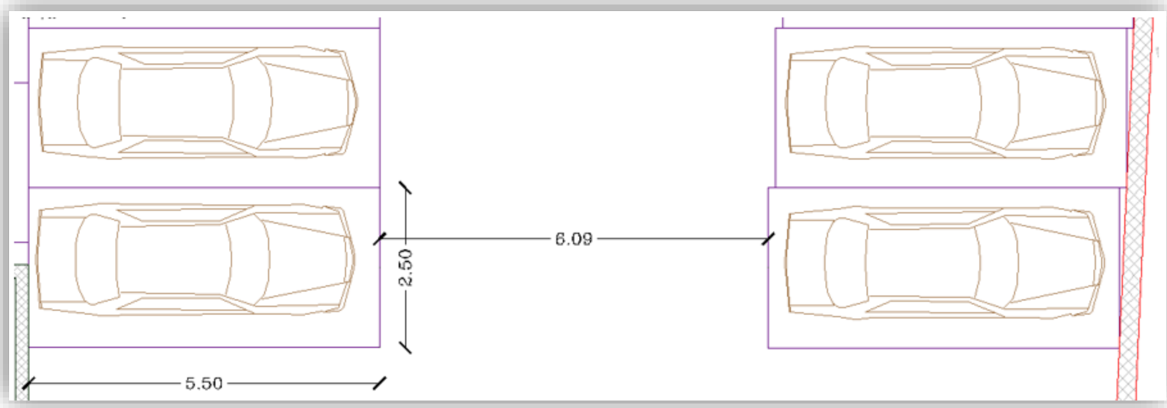
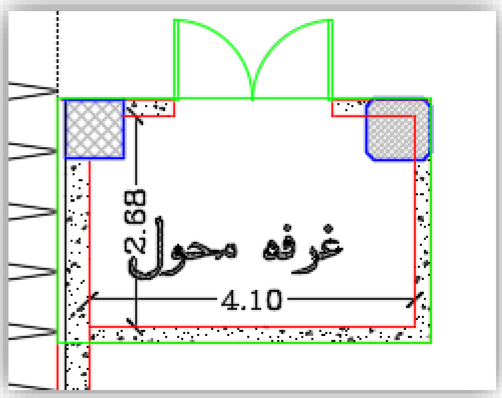


Figure 165: Parking dimensions.

- **Electricity room and Transformer room:** Neither of them met the architectural design criteria, as the minimum possible area was 20 square meters, but the area of the transformer room was 7.325 square meters, while the area of the electricity room was 7.0811, and in this design, the area of each was 20 square meters.



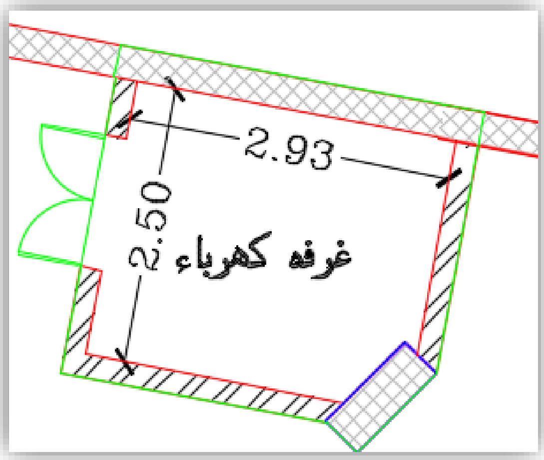


Figure 166:Transformer room in the original design.

Figure 167:Electricity room in the original design.

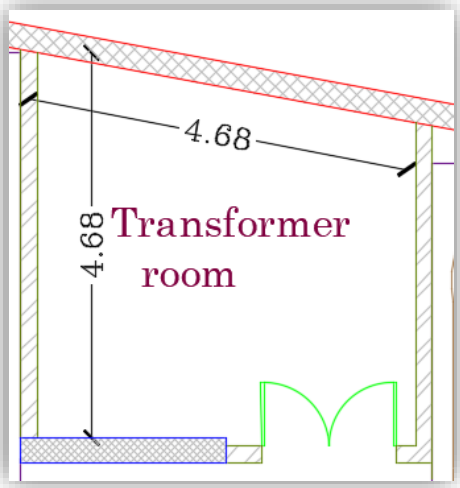


Figure 168:Transformer room in our design.

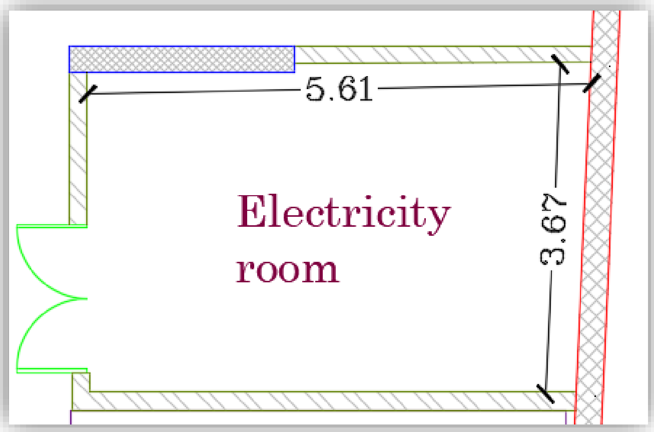


Figure 169:Electricity room in our design.

-Elevators

Elevators number: In the original design, there are only two elevators, and this is not enough to serve a multifunctional building, while in this design it turned out that the number of elevators that provide service is 3, and an elevator was added to the service as the building is a hotel. The following photos and calculations illustrate it**.**

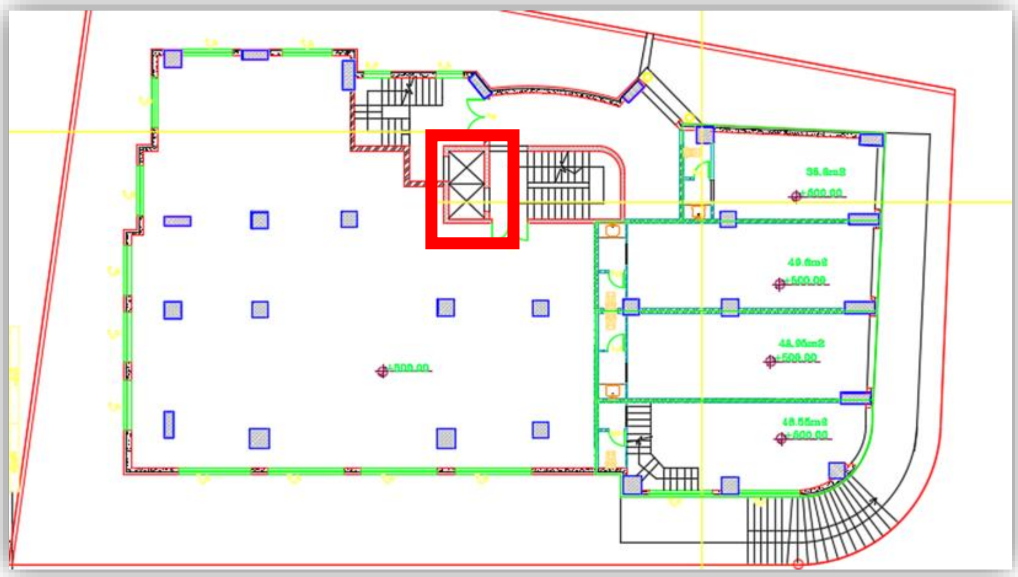


Figure 170: Elevators in the original design.

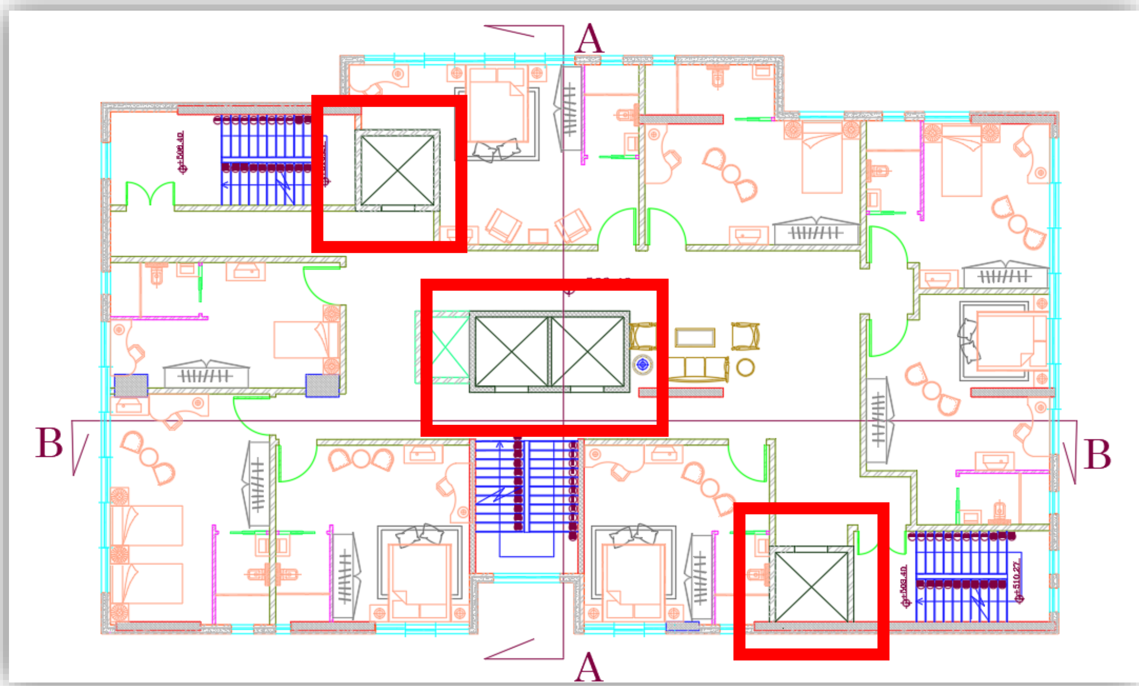


Figure 171: Elevators in our design.

Basement floor 1:

The original design consisted of shops, while the design consisted of a gym and a hotel service section consisting of a drying area, a laundry area, a sawing area, a dirty laundry area, a prefabricated bedding area, a laundry room, a manager's room, a workers' rest room, a workers' area, a kitchen, a living room, and an entrance.

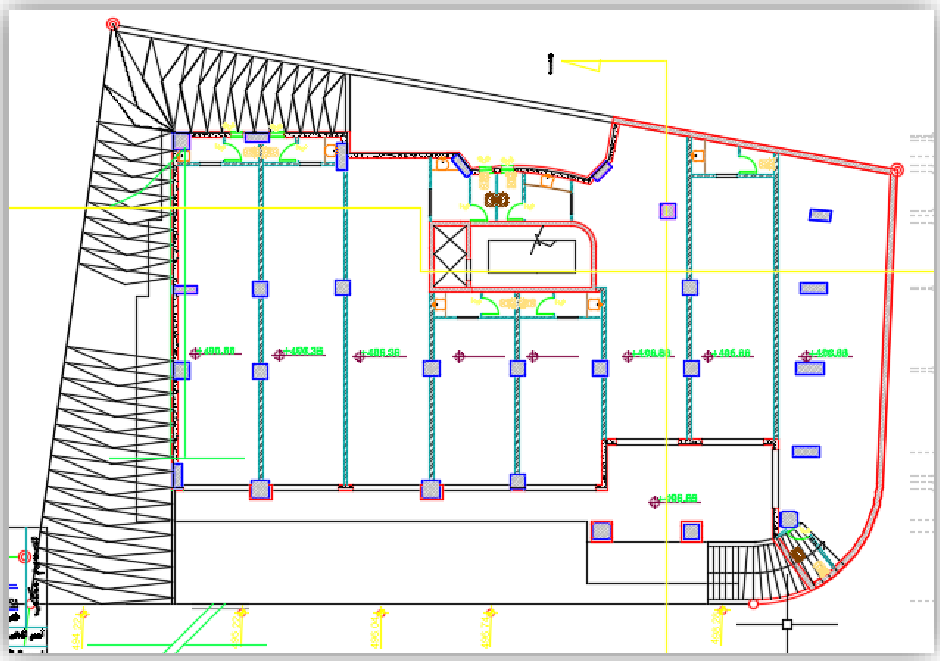


Figure 172: Basement floor plan 1 in the original design.

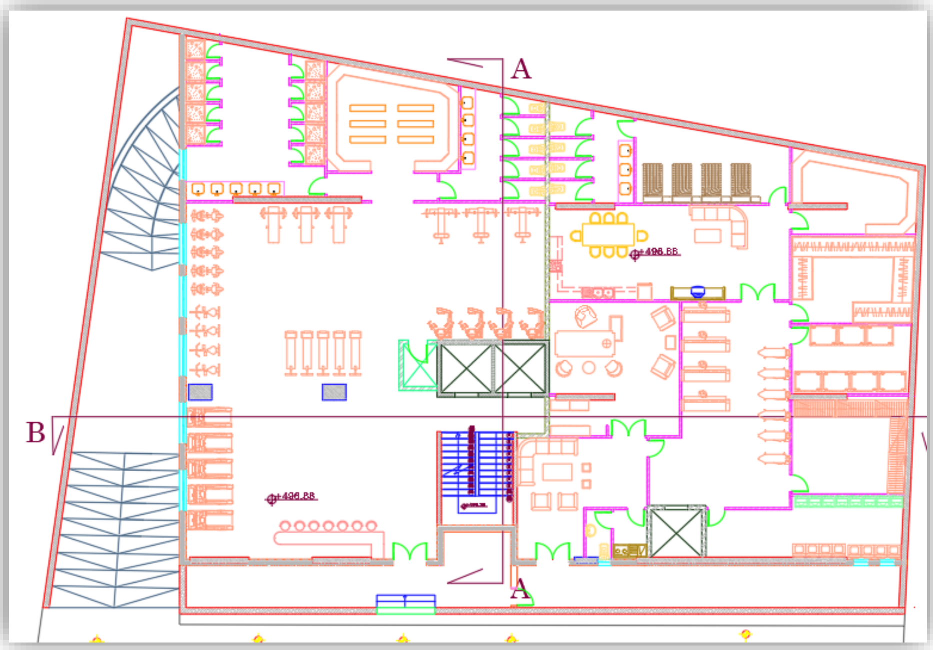


Figure 173: Basement floor plan 1 in our design.

Ground floor :

The original design, consists of four shops and a warehouse, while this design consists of a reception, a lounge, an entrance, public bathrooms, and two shops.

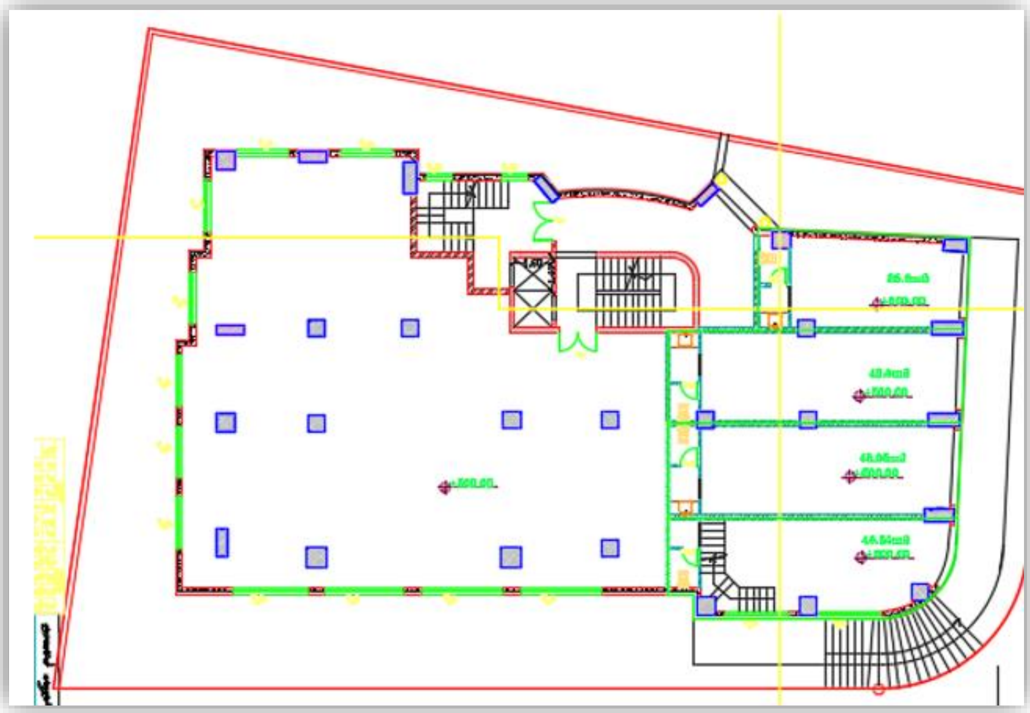


Figure 174: Ground floor plan in the original design.

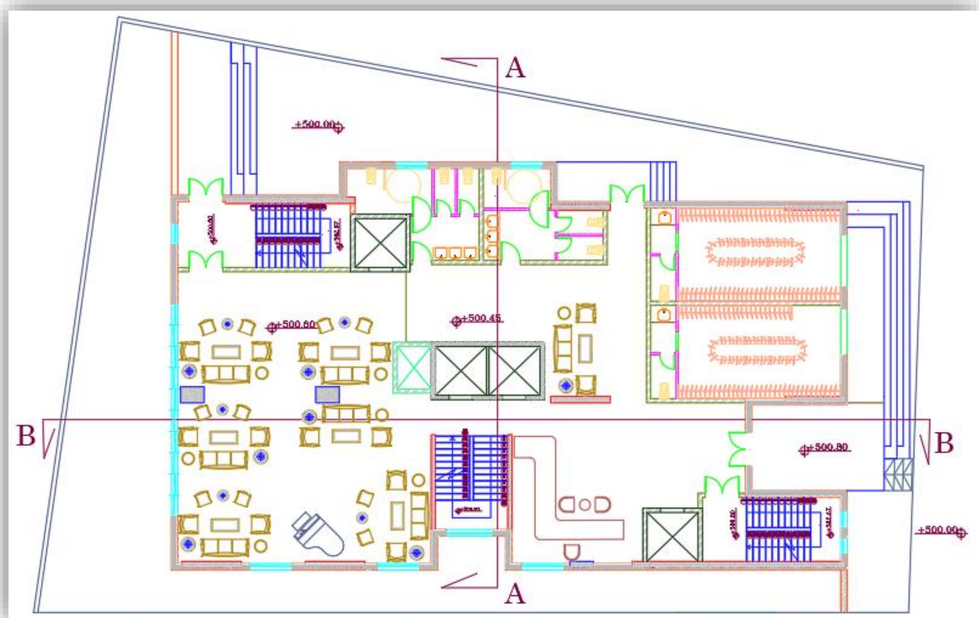


Figure 175: Ground floor plan in our design.

First floor:

In the original design, the floor was an attic for shops, while in this design it contained a kitchenette, breakfast room, and public bathrooms, and the floor overlooked the rest on the ground floor.

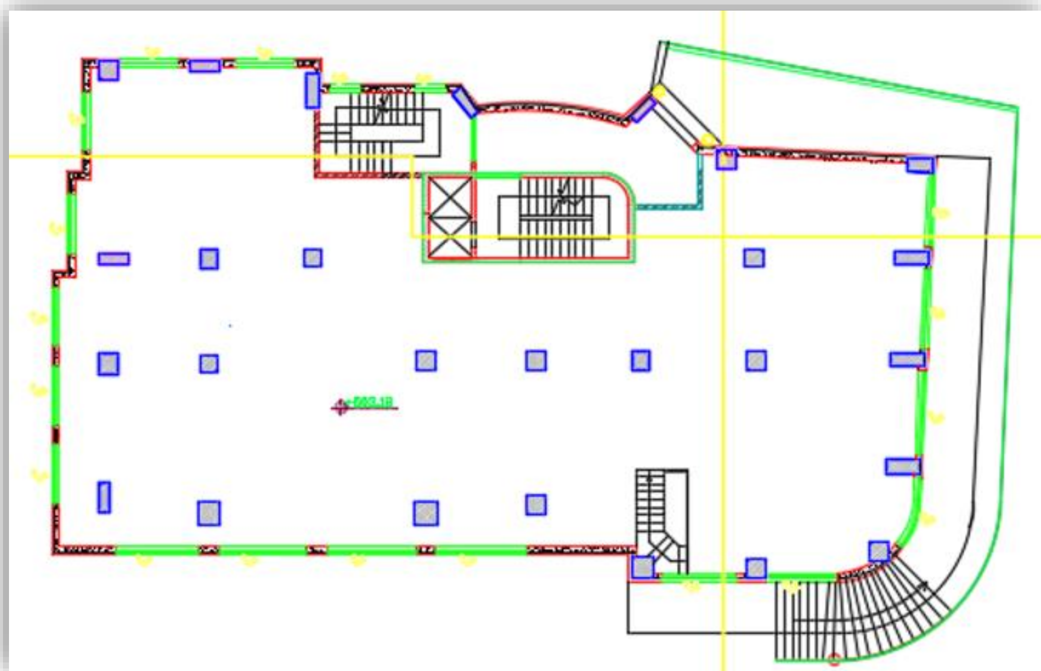


Figure 176: First floor plan in the original design.

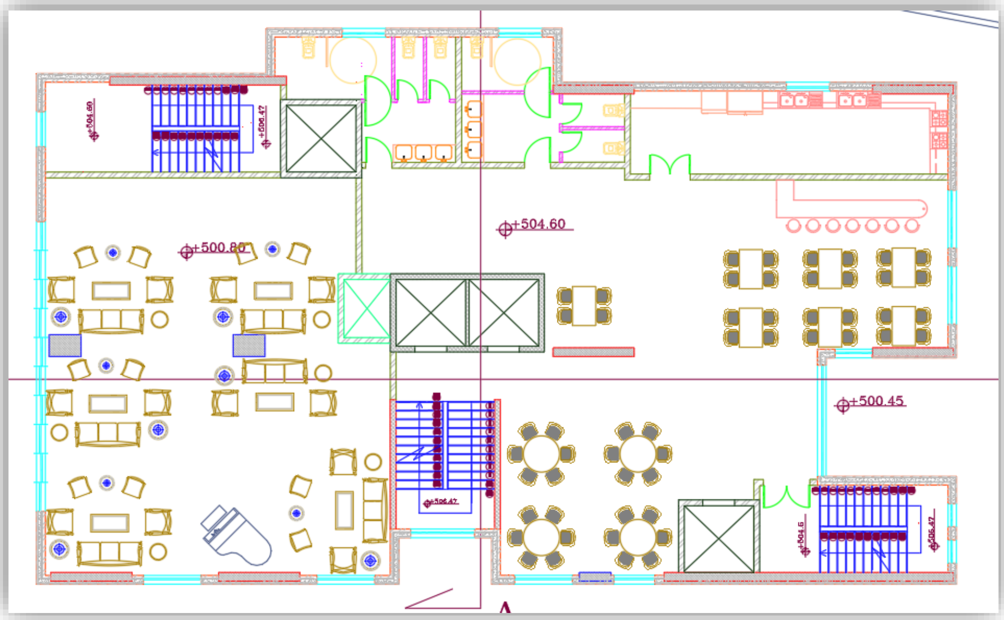


Figure 177: First floor plan in our design.

Second floor (Repeated floor in both designs):

In the original design, it consisted of two apartments with several offices adjacent to them, while in this design, the floor consisted of hotel bedrooms.

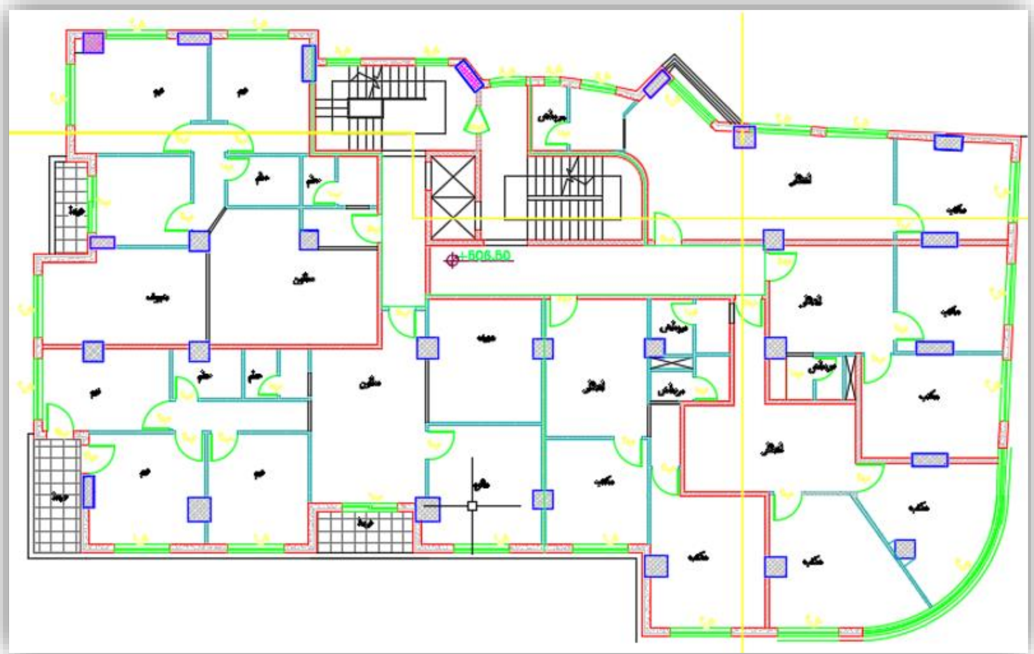


Figure 178: Second -floor plan in the original design.

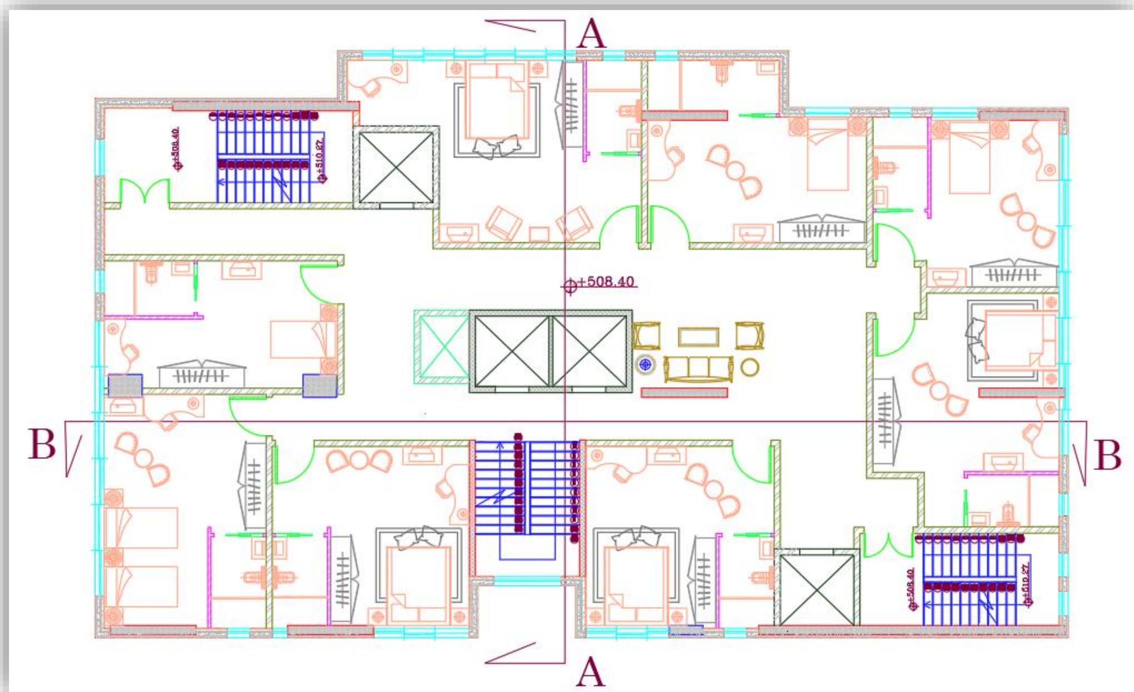


Figure 179: Second -floor plan in our design.

Roof floor:

In the original design, the roof was a residential apartment, while in this design it became a hotel restaurant with indoor and outdoor seating, a kitchen, and public bathrooms.

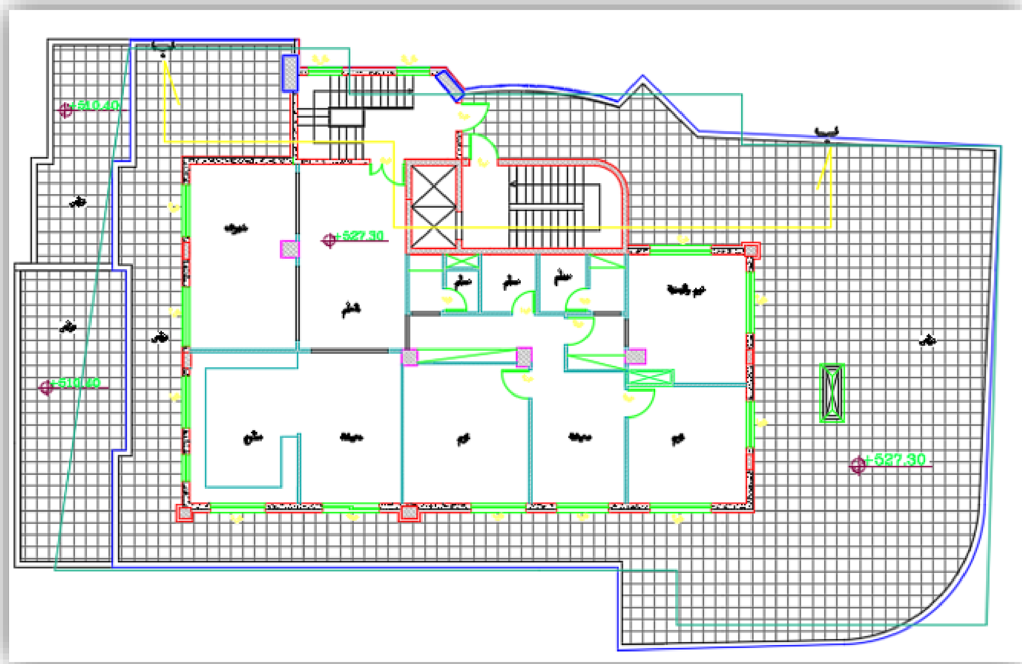


Figure 180: Roof floor in the original design.

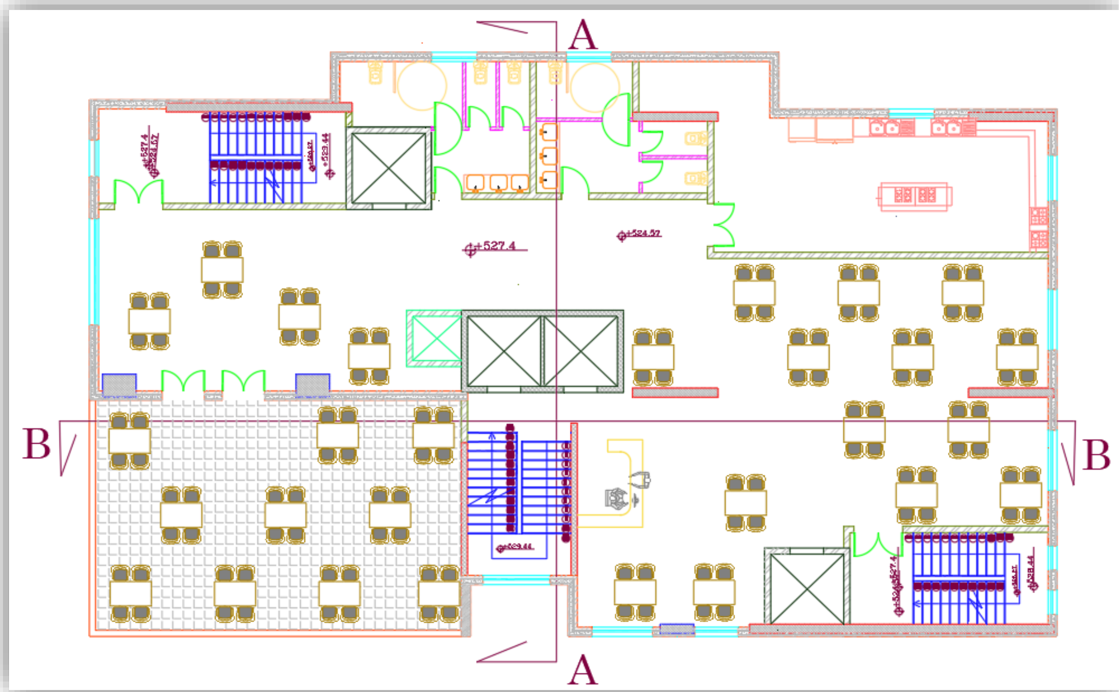


Figure 181: Roof floor in our design.

Site plans

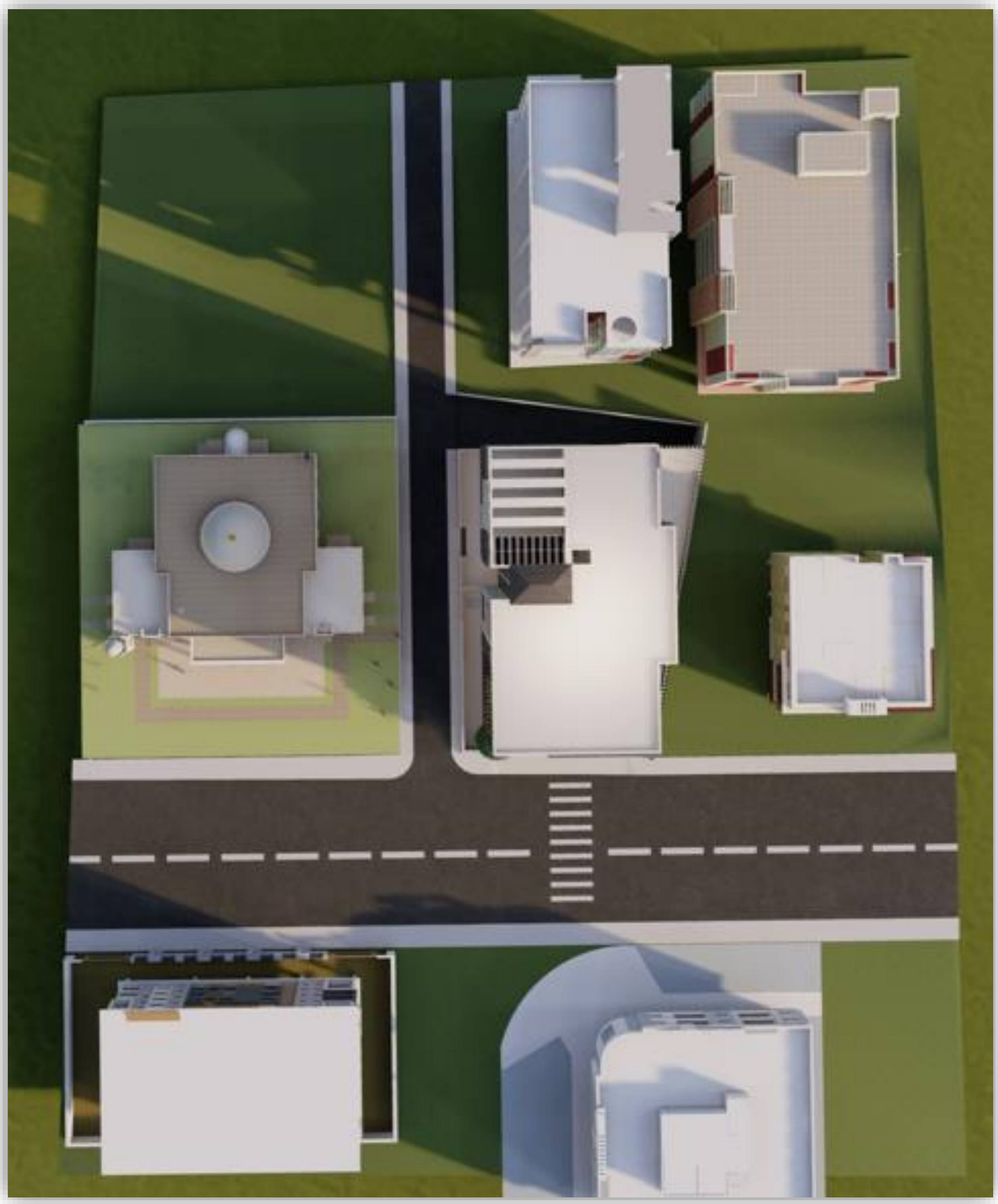


Figure 182: Site plan in our design.

Elevations

Figure 183: Northern elevation in our design.

Figure 184: Eastern elevation in our design.

Figure 185: Southern elevation in our design.

Figure 186: Western elevation in our design.

Sections

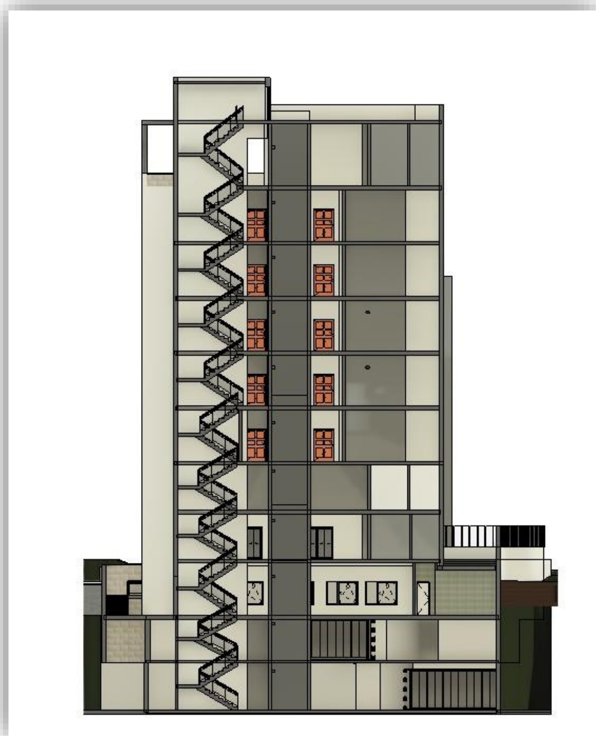


Figure 188: section A-A in our design.

Figure 187:Section B-B in our design.

Chapter Three

Structural Aspects

Chapter three: Structural aspects

3.1 Introduction

The production of an integrated design model is a fundamental objective when designing any project to ensure its implementation without issues. Therefore, it is essential to initiate consideration of the structural problems from the beginning of architectural design, ensuring there are no conflicts between various aspects of architectural, structural, and environmental design.

The structural design begins with determining the columns grid and orientation slab system and specifying the initial dimensions such as slab thickness, column dimensions, and beam dimensions, taking into account various design aspects to achieve an integrated prototype.

3.2 Objectives

The primary objectives of structural design encompass ensuring stability, strength, and serviceability, with considerations for economy and aesthetics. The design must fulfill three fundamental requirements:

1. **Stability**: This involves preventing the structure or its components from overturning, sliding, or buckling under applied loads.
2. **Strength**: “Buildings and other structures, and all parts thereof, shall be designed and constructed with adequate strength and stiffness to provide structural stability, and protect nonstructural components and systems from unacceptable damage”.(American Society of Civil Engineers., 2010).
3. **Serviceability**: “Structural systems, and members thereof, shall be designed to have adequate stiffness to limit deflections, lateral drift, vibration, or any other deformations that adversely affect the intended use and performance of buildings and other structures”.(American Society of Civil Engineers., 2010)
4. Beyond these fundamental requirements, a sensible designer should also consider **economy and aesthetics**. While it's possible to design an overly robust structure with ample stability, strength, and serviceability, the resulting cost may be excessive, and the aesthetic appeal compromised. According to Felix Candela, the designer bears the challenge and responsibility of creating a structure that not only aligns with architectural considerations but also strikes a balance between safety and cost-effectiveness. (Mishra).

3.3 Methodology

In this section, initial proposals for the structural components such as columns, slabs, and beams will be presented. The process begins with recommending optimal column placements in alignment with the architectural design. Subsequently, suggestions for slab thickness are made based on considerations including the dimensions between columns, potential loads, cost implications, and various other determining factors. This is followed by the formulation of appropriate dimensions for the beams. Then Constructing a 3D model for all blocks in the project. And making the required three checks to ensure the model is valid:

a. Compatibility check.
b. Equilibrium check.
c. Internal force checks.

3.4 Analysis and data collection

3.4.1 Slabs

There are several types of slabs, the most commonly used in Palestine are the following:

1. **Ribbed slab**, A ribbed slab is a reinforced concrete slab, the spacing of the concrete ribs is uniform, and the depth of the beams and ribs are usually the same.

a) **One-way ribbed slab**, are preferred in slabs that carry moderate loads. with spacing between columns not exceeding 6-7m. They are economical since the quantity of steel and concrete is relatively low.

b) **Two-way ribbed slabs**, are preferred in slabs that carry excessive loads. commonly use in long spans with spacing between columns more than 7m. They are economical since the quantity of steel and concrete is relatively low.

2. **Sloid slab,** it is preferable to use it if we have holes in the slabs or I have high loads, and it is one of the best options structurally, but it is considered bad in terms of insulation, so we prefer to use it in parking, and there are several types of it, such as:one-way solid slab, two-way solid slab with drop beams, flat plate, and flat plate with drop panel or column capitals.

3. **Voided slab**, voided panels have hollow parts inside the concrete block to reduce self-weight. This design reduces costs and the use of materials, especially for long distances, which are more than 10 meters. Types of Cobiax and U-bots.

4. **Waffle slab**, A waffle slab is a reinforced concrete slab with square grids running in two directions. It features deep sides. Upon concrete striking, a hollow hole is visible on the slab. A waffle slab is also known as a two-way joist slab. This type of slab is commonly used in large spans, commercial parking, malls, and hotel entrances due to its architectural appeal and is used when there is a limited requirement for a number of columns.

3.4.2 Beams

A beam is the horizontal structural element, it divides the building into spans and it supports the building's floors or slabs, and moves the loads into the vertical parts of the structural system.

there are two types of beams:

1. **Hidden beams**, is a type of beam that is incorporated into the depth of the floor system, making it not visible from the exterior. Hidden beams are often used when a more aesthetically pleasing and cleaner architectural finish is desired, as they allow for a seamless appearance in the ceiling or floor. Preferably used in residential and office buildings.
2. Dropped beams, are acknowledged as effective seismic solutions within structural engineering. However, architects often avoid their use due to their protrusion from the floors system, which compromises aesthetics, particularly in residential applications.

3.4.3 Columns:

Columns represent vertical structural elements primarily responsible for supporting loads through compression. They serve to transfer loads from various sources, including ceilings, floor slabs, roof slabs, or beams, to the underlying floors or foundations. Additionally, columns frequently bear bending moments along one or both cross-sectional axes.

3.4.4 Walls

1. **Retaining wall:**

A retaining wall is predominantly erected to counteract the lateral force exerted by the soil in response to alterations in ground elevation. Its purpose is to mitigate soil erosion or collapse, ensuring the containment and stability of the soil at its original location.

2. **Shear Wall:**

A shear wall is engineered to withstand horizontal forces applied to a structure, including wind loads, seismic forces, and other lateral forces. It serves to enhance stability and mitigate the lateral movement of the building, particularly in the context of seismic events.

3.4.5 Loads

"The loads subjected to the building structure are classified into static and dynamic. The normal static loads include the dead loads which are the weight of the structural elements, the superimposed dead loads which are the weight of the nonstructural elements and the live loads which are loads from occupants and furniture. Snow loads, rain loads, and soil surcharge shall be taken into account"(Arman, n.d.).

1. **Dead loads**, termed "permanent" or "static" loads, denote the intrinsic weight of a structure and the mass of all enduring constituents. These loads remain consistent and exhibit no temporal variation. They encompass the gravitational force exerted by structural members like columns, beams, walls, and slabs, along with the mass of the construction's inherent materials, surface coverings, and immobile equipment.) Superimposed dead load (SID)).
2. **Live loads**, Live loads, alternatively termed temporary or dynamic loads, exhibit variability that can fluctuate with time following factors such as occupancy and use. Instances of live loads encompass the mass of individuals, furniture, mobile equipment, and other transient loads. The incorporation of live loads is imperative in the structural design process to ensure that structures are adequately configured to withstand the diverse forces applied during various activities or events within the building.

3.4.6 Load combination

According to ASCE (American Society of Civil Engineers., 2010)The basic combinations used in any structural design, are the following combinations:

1) 1.4 D.L
2) 1.2 D.L +1.6 L.L
3) service (Dead+ Live)
4) Envelope, The composition of the envelope analyzes the worst case of (1.4 D.L), (1.2 D.L+1.6 L.L) This gathering gives the extreme result of forces and deformation. and is important when seismic examination.

3.5 Royal Suites hotel project's structural design requirements

3.5.1 Structure information

f'c concrete for (columns + footing + solid slab) =	B350 kg/cm^2 (28 MPa)
f'c concrete for (two-way ribbed slab) =	B300 kg/cm^2 (24 MPa)
fy steel =	420 MPa

3.5.2 Slabs

After distributing the columns and considering architectural aspects and the building's function, the lengths of our spans ranged from 7 to 9 meters. This led us to choose a two-way ribbed slab known for its distinctive features in terms of cost, insulation, and load-bearing capabilities. However, we opted for a two-way solid slab type with a drop beam in the third-basement slab, as it will bear vehicular loads and transportation. Additionally, there is no need for insulation, similar to the other slabs of the hotel.

3.5.2.1 Slab thickness:

Two-way solid slab with interior drop beam calculation:

$According\ to\ ACI\ 318-19,$

$Assume\ \alpha m\ > 2$

$$h = \frac{1.1 * (\ lnmax)}{36 + 9\beta} = \frac{1.1 * (\ 9.21)}{36 + 9(\frac{9.21}{8.662})} = 0.222\ m$$

$h\ of\ solid\ slab\ =\ 250\ mm$

$Drop\ beam\ dimension:$

$h\ beam\ =\ 1.5 * h\ slab\ = 1.5 * 250\ = 375 \approx 400mm$

$b\ beam\ =\ h\ beam\ * 0.5 =\ 200mm$

Two-way ribbed slab calculation:

$According\ to\ ACI\ 318-19,$

$Assume\ \alpha m\ > 2$

$$h = \frac{1.1 * (\ lnmax)}{36 + 9\beta} = \frac{1.1 * (\ 9.21)}{36 + 9(\frac{9.21}{8.662})} = 0.222\ m$$

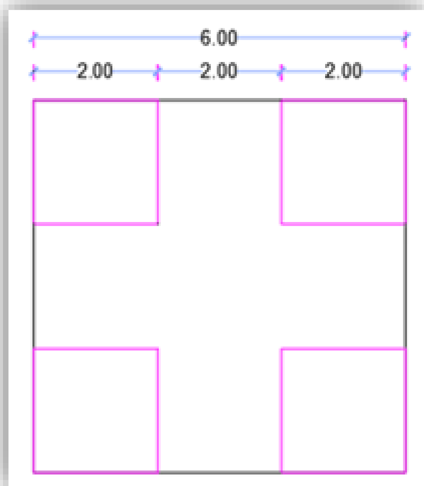


Figure 189:Top section on ribs.

$hreq.of\ solid\ slab\ =\ 250\ mm$

$try\ ribbed\ slab\ thickness\ =\ 320\ mm$

$I\ ribbed\ =\ 1.118\ x\ 109\ mm^4$

$bf\ =\ 600\ mm$

$I\ solid\ =\ I\ ribbed$

$$h\ equivalent\ = \sqrt{\frac{12Ir}{bf}} = \sqrt{\frac{12 * 8.704 * 10^8}{600}} =\ 259.17\ mm$$

$H\ equivalent\ >\ h\ required$

$Assume\ h\ = 320mm$

Hidden beam dimension:

$h_{beam} = h_{slab} = 320mm$

$b_{beam} = h_{beam} * 1.5 = 480 \approx 500mm$

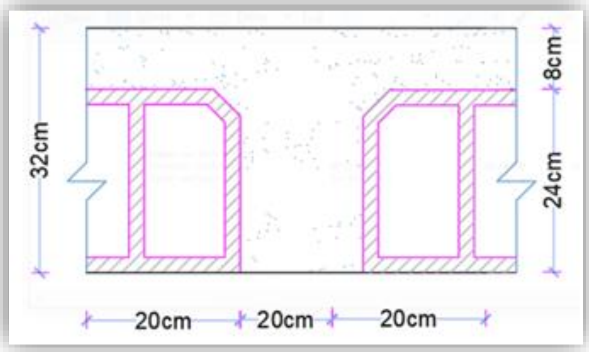


Figure 190: Cut section in ribs

3.5.3 Loads

According to Densities of materials (ASCE 7-16 Table C3.1-2) we can calculate the dead load as below and we can check our results from ETABS it has the ability to automatically calculate own weight of the building.

3.5.3.1 Dead load for slabs:

Dead load for solid slab h=250mm:

$$Concrete\ density = 25\ KN/m3$$

$$Weight = Density \times Thickness = 25 \times 0.25 = 6.25\ KN/m^2$$

Dead load for ribbed slab h=320:

$$Weight = ((volume\ of\ rib - volume\ of\ blocks) \times density) + (volume\ of\ blocks \times density)$$

$$W = \left[\left((0.6^2 \times 0.35) - (4 \times 0.2^2 \times 0.24)\right) \times 25\right] + (4 \times 0.2^2 \times 0.24 \times 12)$$

$$= 2.38KN/\ rib^2\ Weight = \frac{2.38}{0.6^2} = 6.61KN/m^2$$

Superimposed dead load on the slabs:

SID on the two-way ribbed slab:

Table 33:SID on the two-way ribbed slab:

SID material	Density (KN/m³)	Thickness (mm)
marble tiles	26	30
concrete mortar	23	20
fill material (gravel)	18	100

$$Weight\ of\ false\ ceiling = 0.20\ KN/m^2$$

$$Weight\ of\ partitions = 2\ KN/m^2$$

$$SID = (0.03 \times 26) + (0.02 \times 23) + (0.1 \times 18) + 0.2 + 2 = 5.25\ KN/m^2$$

3.5.3.2 Live loads used in building:

3.5.3.2.1 Live load used in hotels

Table 4.3-1. *(Continued)* Minimum Uniformly Distributed Live Loads, L_o, and Minimum Concentrated Live Loads

Occupancy or Use	Uniform, L_o psf (kN/m²)	Live Load Reduction Permitted? (Sec. No.)	Multiple-Story Live Load Reduction Permitted? (Sec. No.)	Concentrated lb (kN)	Also See Section
Penal institutions					
Cell blocks	40 (1.92)	Yes (4.7.2)	Yes (4.7.2)		
Corridors	100 (4.79)	Yes (4.7.2)	Yes (4.7.2)		
Recreational uses					
Bowling alleys, poolrooms, and similar uses	75 (3.59)	No (4.7.5)	No (4.7.5)		
Dance halls and ballrooms	100 (4.79)	No (4.7.5)	No (4.7.5)		
Gymnasiums	100 (4.79)	No (4.7.5)	No (4.7.5)		
Residential					
One- and two-family dwellings					
Uninhabitable attics without storage	10 (0.48)	Yes (4.7.2)	Yes (4.7.2)		4.12.1
Uninhabitable attics with storage	20 (0.96)	Yes (4.7.2)	Yes (4.7.2)		4.12.2
Habitable attics and sleeping areas	30 (1.44)	Yes (4.7.2)	Yes (4.7.2)		
All other areas except stairs	40 (1.92)	Yes (4.7.2)	Yes (4.7.2)		
All other residential occupancies					
Private rooms and corridors serving them	40 (1.92)	Yes (4.7.2)	Yes (4.7.2)		
Public rooms	100 (4.79)	No (4.7.5)	No (4.7.5)		
Corridors serving public rooms	100 (4.79)	Yes (4.7.2)	Yes (4.7.2)		

Figure 191:According to ASCE minimum live loads (ASCE 7-16 Table 4.3-1).

We observe that the critical value for live loads in hotels is the loads in public areas. Therefore, live load equals 4.8 kN/m^2.

3.5.3.2.1 Live load used in parking

$L.L = 2KN/m^2$.

Garages (See Section 4.10)				
Passenger vehicles only	40 (1.92)	No (4.7.4)	Yes (4.7.4)	See Sec. 4.10.1
Trucks and buses	See Sec. 4.10.2	—	—	See Sec. 4.10.2

Figure 192: According to ASCE minimum live loads (ASCE 7-16 Table 4.3-1).

3.5.3.3 Wall loads

3.5.3.3.1 External Stone wall weight

Table 34:External Stone wall weight.

Material	Density (KN/m³)	Thickness (mm)
Stone	26	70
Concrete mortar	23	80
Block	12	150

$$W = (0.07 \times 26) + (0.08 \times 23) + (0.15 \times 12) = 5.46 \text{ KN/m}^2$$

3.5.4 Columns

To calculate initial dimension,

- chose middle critical column.

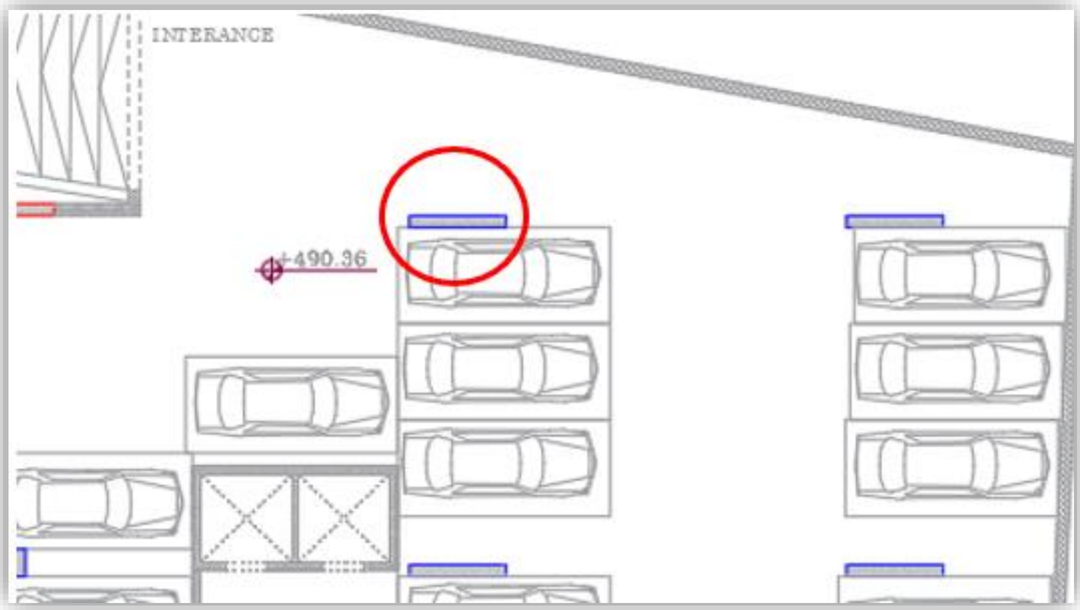


Figure 193:Middle critical column.

- **Calculate Wu:**

$$Wu\ parking = 1.2 * D.L + 1.6 * L.L = 1.2 * (5.61 + 5.25) + 1.6 * (4.8)$$
$$= 21.916\ KN/m^2$$

- $\boldsymbol{Tributary\ area\ on\ critical\ column = 50.112\ m2}$
- $\boldsymbol{Then\ we\ find\ Pu\ for\ 10\ story}$:

$\boldsymbol{Pu} = 21.916 \times 50.112 \times 10 = 10982.5\ KN$

$$\boldsymbol{Ag} = \frac{\boldsymbol{Pu * 10^3}}{\boldsymbol{0.65 * 0.8[(fy * \rho) + (0.85fc' * (1 - \rho))]}}$$

$$\boldsymbol{Ag} = \frac{\boldsymbol{10982.5 * 10^3}}{\boldsymbol{0.65 * 0.8[(420 * 0.01) + (0.85 * 28 * (1 - 0.01))]}}$$

$= 742741.4mm^2 = 7427cm^2$

$\boldsymbol{Critical\ columns\ dimension\ (0.3 * 2.5m), (1.1 * 0.7m)}$.

3.6 ETABS software for modeling and checks

3.6.1 3D modeling for Royal Suites hotel

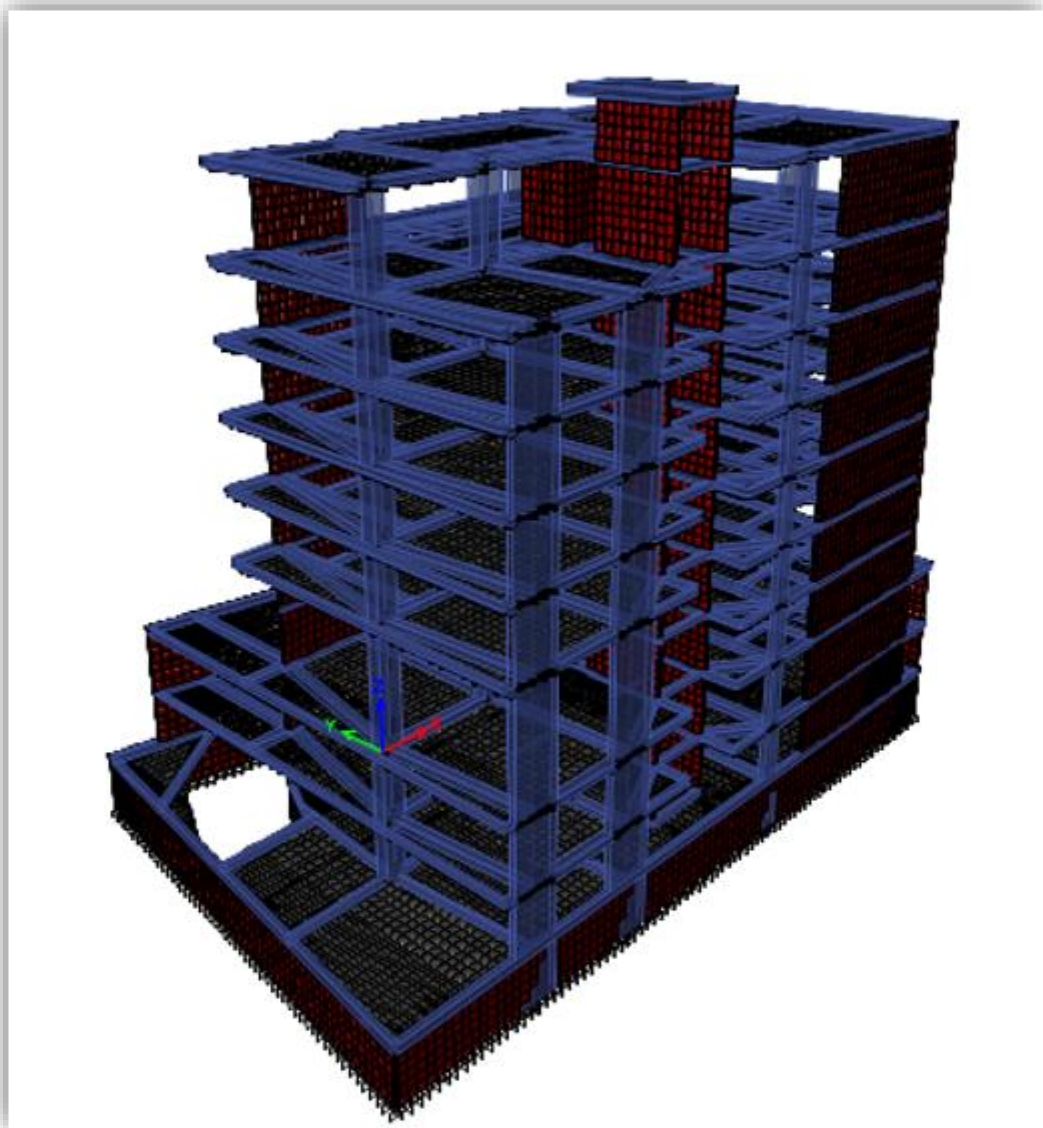


Figure 194:3D modeling structural for Royal Suites hotel

3.6.2 Checks

3.6.2.1 Compatibility check

“The compatibility check is achieved by default as structure moves as one unit in animation view in the program interface and no unconnected members or joints are found”(Arman, n.d.).

From ETABS → start animation → Compatibility **OK**

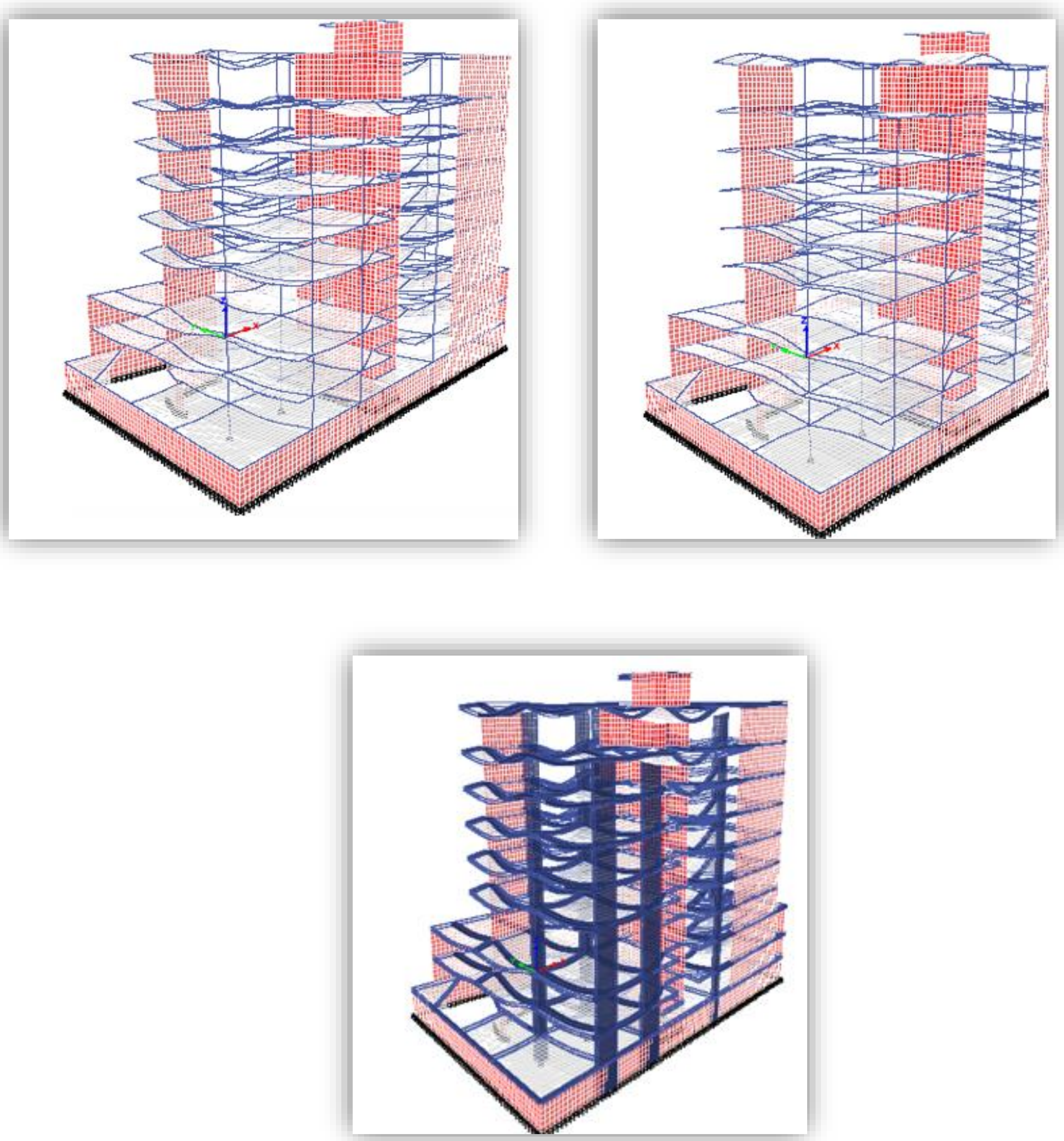


Figure 195:Animations for model

We note that all structural elements are working together then compatibility check is **OK.**

3.6.2.2 Equilibrium check

3.6.2.2.1 By ETABS the vertical loads are shown as bellow

Base Reactions

File Edit Format-Filter-Sort Select Options

Units: As Noted   Hidden Columns: No   Sort: None   Base Reactions

Filter: None

Output Case	Case Type	Step Type	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m	X m
Dead	LinStatic		0	0	56240.4263	121269.7794	-900216.8268	8.438E-07	0
Live	LinStatic		0	0	23051.9784	55509.0488	-370589.2709	8.181E-07	0
SID	LinStatic		0	0	35089.5227	82307.148	-563844.425	1.295E-06	0

Figure 196:The vertical loads by ETABS.

3.6.2.2.2 By hand the vertical loads are calculated as follow:

- $Dead\ load: structure\ self - weight.$

$Beams\ B - 400x200: Length = 161.4m. Weight\ = 0.4 * 0.2 * 161.4 * 25 = 322.8\ KN$

$Beams\ B - 500x320: Length = 1278m. Weight\ = 0.5 * 0.32 * 1278 * 25 = 5112\ KN$

$Beams\ B - 200x320: Length = 1734.1m. Weight\ = 0.2 * 0.32 * 1734.1 * 25 = 2774.54\ KN$

$Beams\ B - 700x320: Length = 21.8m. Weight\ = 0.7 * 0.32 * 21.8 * 25 = 122.1\ KN$

$Columns\ C - 300x2500: Weight\ = 0.3 * 2.5 * 25 * [(4 * 34.01) + (2 * 29.81)] = 3668.6\ KN$

$Columns\ C - 700x1100: Weight\ = 0.7 * 1.1 * 25 * 34.01 * 4 = 1309.4\ KN$

$Columns\ C - 300x600: Weight\ = 0.3 * 0.6 * 25 * 34.01 = 153\ KN$

$Slab\ S - 250: Area\ = 757.8\ m^2. Weight\ = 0.25 * 757.8 * 25 = 4736\ KN$

$Slab\ S - 320: Area\ = 3628.4\ m^2. Weight\ = 6.61 * 3628.4 = 23983.4\ KN$

$Slab\ S - 200: Area\ = 18.8\ m^2. Weight\ = 0.2 * 18.8 * 25 = 94\ KN$

3.6.2.3 Deflection check

Shear walls:

Shear wall weight			
Hight (m)	**Area (m)**	**Thickness (m)**	**Weight KN**
3	1236.75	0.3	9275.7
3.57	863.53	0.2	4317.6
3.12	86.93	0.12	260.8
Sum			13854.1

Figure 197:Shear wall weight calculations.

The Total weight of building = 56129.94 kN

$$Dead\ load\ =\ 56129.94\ kN \rightarrow \%error = \frac{|from\ ETABS - from\ hand|}{from\ hand} * 100\%$$

$$= \frac{|56240.43 - 56129.94|}{56129.94} * 100\% = 0.2\% < 5\% \rightarrow \boldsymbol{OK}$$

- $\boldsymbol{Superimposed\ dead\ load}$:

$Slab\ S - 250\ for\ basement2\ slab: Area\ =\ 757.8\ m^2. Weight\ = 1 * 757.8$
$= 757.8\ kN$

$Slab\ S - 320: Area\ =\ 4252.5\ m^2. Weight\ = 7.25 * 4252.5 = 30830.3\ KN$

$Slab\ S - 320: Area\ for\ restaurant\ slab\ =\ 438.7\ m^2. Weight\ = 4 * 438.7$
$= 1754.9\ KN$

$Slab\ S - 200: Area\ =\ 18.8\ m^2. Weight\ = 18.8 * 2.33 = 43.8\ KN$

Table 35:Stone wall weight calculations.

Stone wall weight			
Floor	**Length (m)**	**Weight (KN/m)**	**Weight KN**
Basement 2	53.71	2.33	125.1
Basement 1	53.71	2.33	125.1
GF	61.88	2.33	144.2
Duplicated 5 floor	529.30	2.33	1233.3
Restaurant floor	101.85	0.8	81.5
Sum			1709.2

$\boldsymbol{The\ Total\ SID\ of\ building\ =\ 35096\ KN}$

$$Superimposed\ load\ =\ 35096\ kN \rightarrow \%error = \frac{|from\ ETABS - from\ hand|}{from\ hand} * 100\%$$

$$= \frac{|35089.52 - 35096|}{35096} * 100\% = 0.02\% < 5\% \rightarrow \boldsymbol{OK}$$

- $Live\ load$:

$Slab\ S - 250\ for\ basement2\ slab: Area\ =\ 757.8\ m^2. Weight\ = 1.92 * 757.8$
$= 1454.9\ KN$

$Slab\ S - 320: Area\ =\ 4252.5\ m^2. Weight\ = 7.25 * 4252.5 = 20411.8\ KN$

$Slab\ S - 320: Area\ for\ restaurant\ slab\ =\ 438.7\ m^2. Weight\ = 2.5 * 438.7$
$= 1096.8\ KN$

$\boldsymbol{The\ Total\ Live\ load\ of\ building\ =\ 35096\ kN}$

$$Live\ load\ =\ 22963.45\ kN \rightarrow \%error = \frac{|from\ ETABS - from\ hand|}{from\ hand} * 100\%$$

$$= \frac{|23051.98 - 22963.45|}{22963.45} * 100\% = 0.4\% < 5\% \rightarrow \boldsymbol{OK}$$

3.6.2.3 Internal force check:

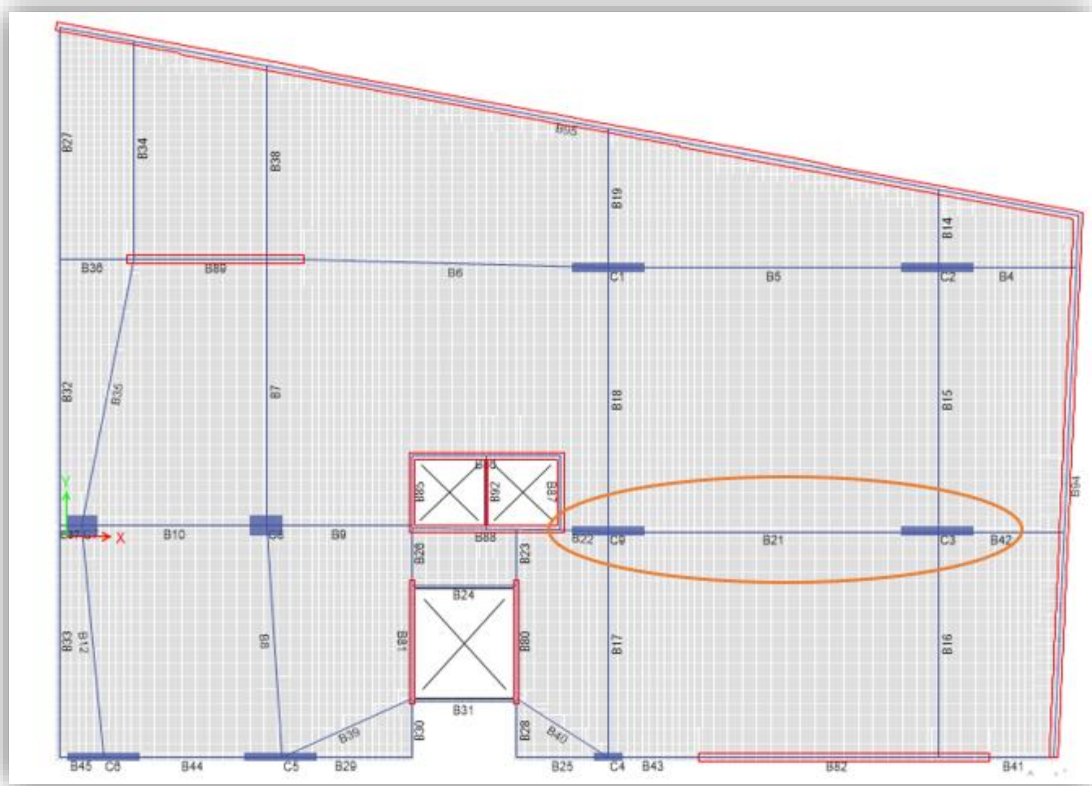


Figure 198:Internal span for check

3.6.2.3.1 By hand

The span between columns C9 and C3 is taken as sample for internal forces calculations. The span has a length of 11.32m and the tributary distance, L2, is 8.4m. The load for this span is:

$$Wu\ =\ (1.2*(5.25+6.61))\ +\ (1.6*4.8)\ =\ 21.91\ kN/m2$$

$$qu=\ Wu*L2\ =21.91*8.4\ =\ 184.04\ KN/m$$

$$The\ total\ statical\ moment, Mo\ is:$$

$$Mo=\frac{qu*l1^2}{8}=\frac{184.04\ *11.32^2}{8}=2947.92\ KN.m$$

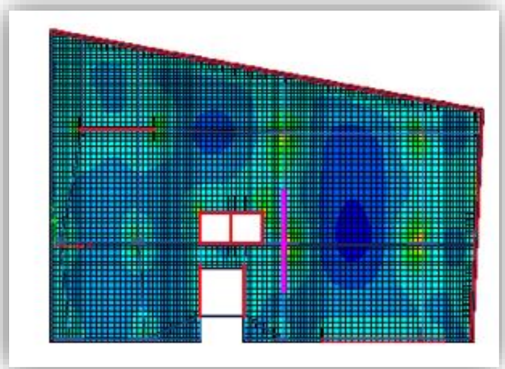
$$The\ moment\ from\ the\ beam\ self-weight, Mb, is:$$

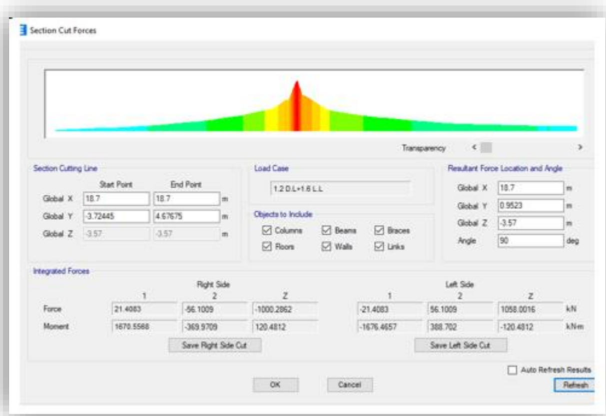
$$Mb=\frac{wu*l1^2}{8}=\frac{(0.5*0.32*25*1.2)*11.32^2}{8}=76.9\ KN.m$$

The total statical moment is equal to (2947.92+76.9) = 3024.8 KN.m

2.6.2.3.2 By ETABS

The bending moments in ETABS can be obtained by applying section cuts that are transverse to the span at its start point, middle point and end point. The width of the section cut is L_2=8.4m





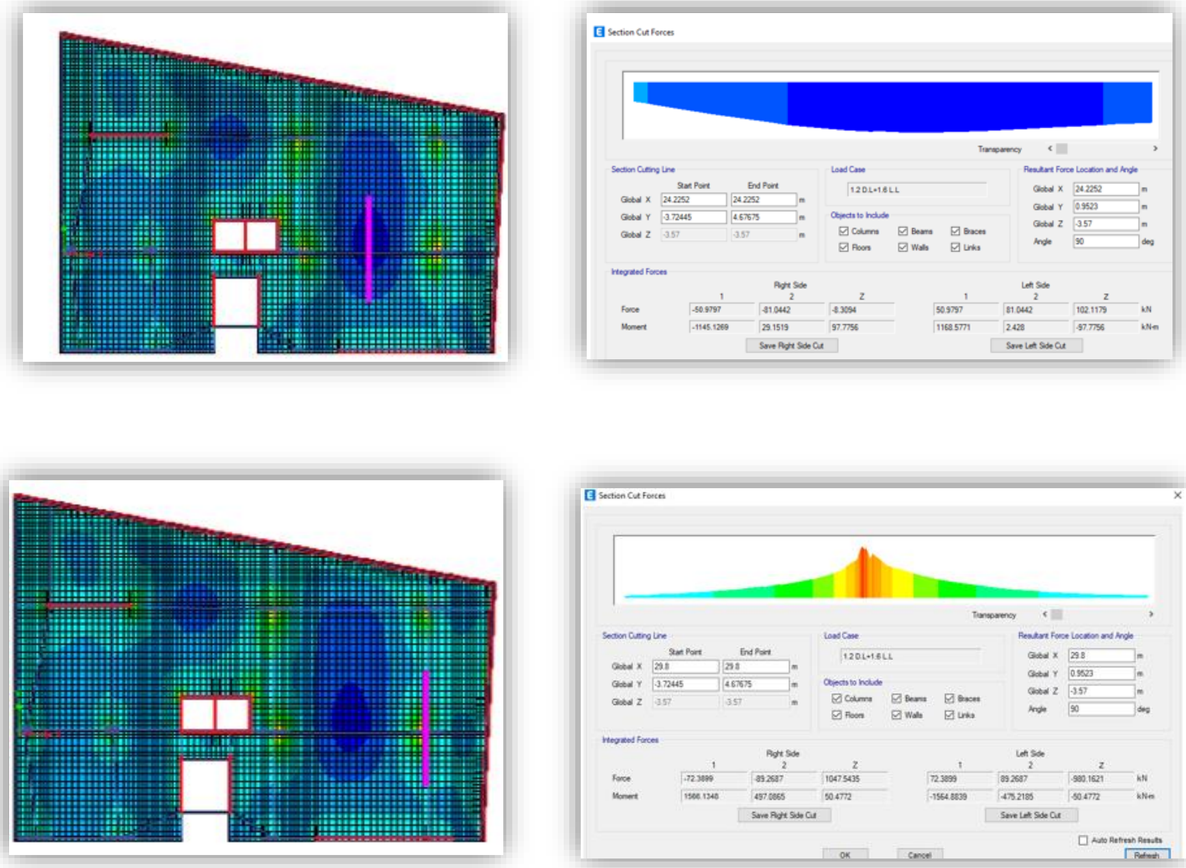


Figure 199:Moment values from ETABS section cuts.

From section cut:

$m1 = 1676.47$

$m3 = 1168.58$

$m2 = 1566.13$

$$Mo = \frac{m1 + m2}{2} + m3 = \frac{1676.47 + 1566.13}{2} + 1168.58 = 2789.88\ KN.m$$

$$\%\boldsymbol{Error} = \frac{|from\ ETABS - from\ hand|}{from\ hand} * 100\% = \frac{|2789.88 - 3024.8|}{3024.8} * 100\%$$

$= 7.7\% < 10\% \rightarrow OK$

The load at column

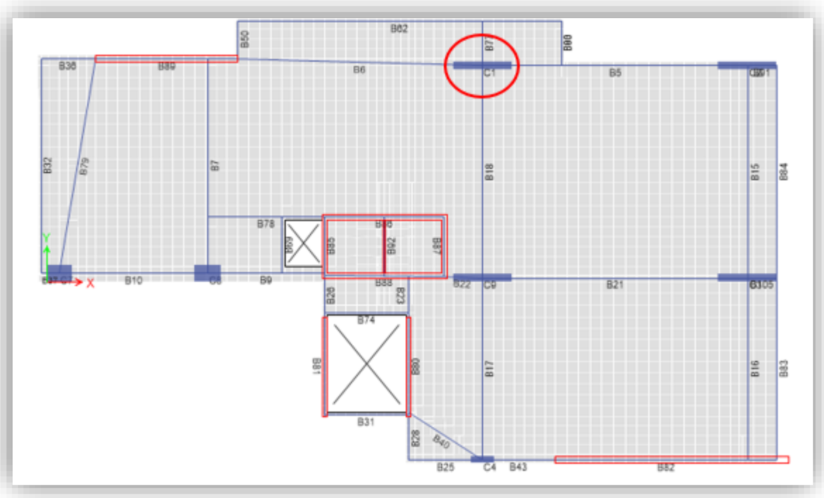


Figure 200:C1 column for check.

C1 is calculated as follows:

$Tributary\ area\ from\ S-320\ restaurant\ slab = 68.238m^2.$

$Wu\ =\ (1.2*(4+6.61))\ +\ (1.6*2.5)\ =\ 16.7\ KN/m2$

$Load = \ 16.7*68.2\ =\ 1138.9\ KN.$

C1 Load from ETABS

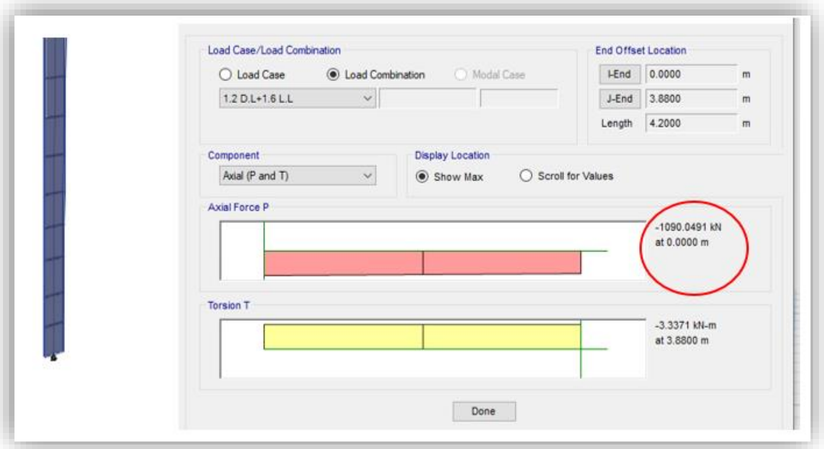


Figure 201:C1 load value from ETABS.

$$\%\boldsymbol{Error}\ =\frac{|from\ ETABS-from\ hand|}{from\ hand}*100\%=\frac{|1090-1138.9|}{1138.9}*100\%$$

$$=4.3\%<10\%\rightarrow \boldsymbol{OK}$$

Dynamic Analysis and design

The seismic load is designed according to UBC-97 code, response spectrum approachesused for design. Steps:

- Define Mass source
- Define response spectrum function and response spectrum cases

Define Mass source

100%from Dead load and 25%from live load must be used.

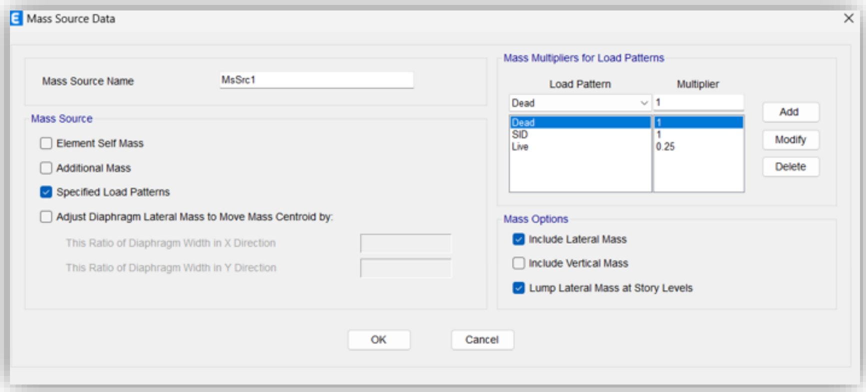


Figure 202:Mass source data

3.6.3 Earthquake design

Define Function

The project location is Nablus (2B) and Z= 0.2

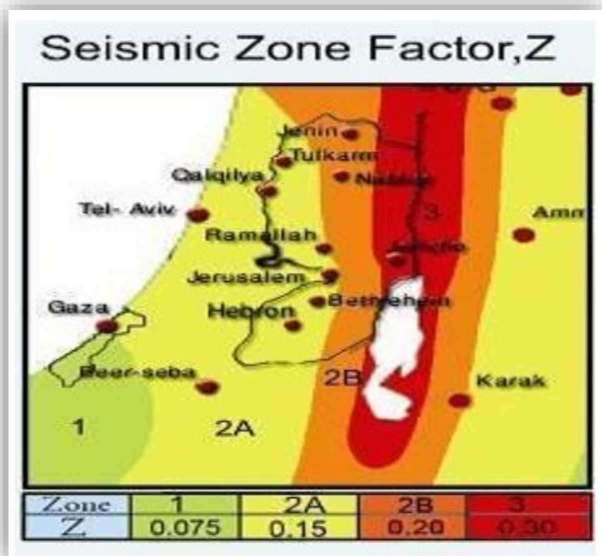


Figure 203:Seismic zone factor

Type of soil in the location is very dense soil and soft rock. Therefore, SD (according table for UBC 97)

$Bearing\ capacity\ = 200\ KN/m^2$

Table 36:Soil profile type

SOIL PROFILE TYPE	SOIL PROFILE NAME/GENERIC DESCRIPTION	AVERAGE SOIL PROPERTIES FOR TOP 100 FEET (30 480 mm) OF SOIL PROFILE		
		Shear Wave Velocity, $\bar{v}_s$ feet/second (m/s)	Standard Penetration Test, $\bar{N}$ [or $\bar{N}_{CH}$ for cohesionless soil layers] (blows/foot)	Undrained Shear Strength, $\bar{s}_u$ psf (kPa)
S_A	Hard Rock	> 5,000 (1,500)	—	—
S_B	Rock	2,500 to 5,000 (760 to 1,500)		
S_C	Very Dense Soil and Soft Rock	1,200 to 2,500 (360 to 760)	> 50	> 2,000 (100)
S_D	Stiff Soil Profile	600 to 1,200 (180 to 360)	15 to 50	1,000 to 2,000 (50 to 100)
S_E[1]	Soft Soil Profile	< 600 (180)	< 15	< 1,000 (50)
S_F	Soil Requiring Site-specific Evaluation. See Section 1629.3.1.			

[1]Soil Profile Type S_E also includes any soil profile with more than 10 feet (3048 mm) of soft clay defined as a soil with a plasticity index, $PI > 20$, $w_{mc} \geq 40$ percent and $s_u < 500$ psf (24 kPa). The Plasticity Index, PI, and the moisture content, w_{mc}, shall be determined in accordance with approved national standards.

Seismic Coefficient Cv = 0.4

Table 37:Seismic coefficient Cv

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				

[1]Site-specific geotechnical investigation and dynamic site response analysis shall be performed to determine seismic coefficients for Soil Profile Type S_F.

Seismic Coefficient Ca = 0.28

Table 38:Seismic coefficient Ca

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	$0.32N_a$
S_B	0.08	0.15	0.20	0.30	$0.40N_a$
S_C	0.09	0.18	0.24	0.33	$0.40N_a$
S_D	0.12	0.22	0.28	0.36	$0.44N_a$
S_E	0.19	0.30	0.34	0.36	$0.36N_a$
S_F	See Footnote 1				

[1]Site-specific geotechnical investigation and dynamic site response analysis shall be performed to determine seismic coefficients for Soil Profile Type S_F.

Defined response spectrum function

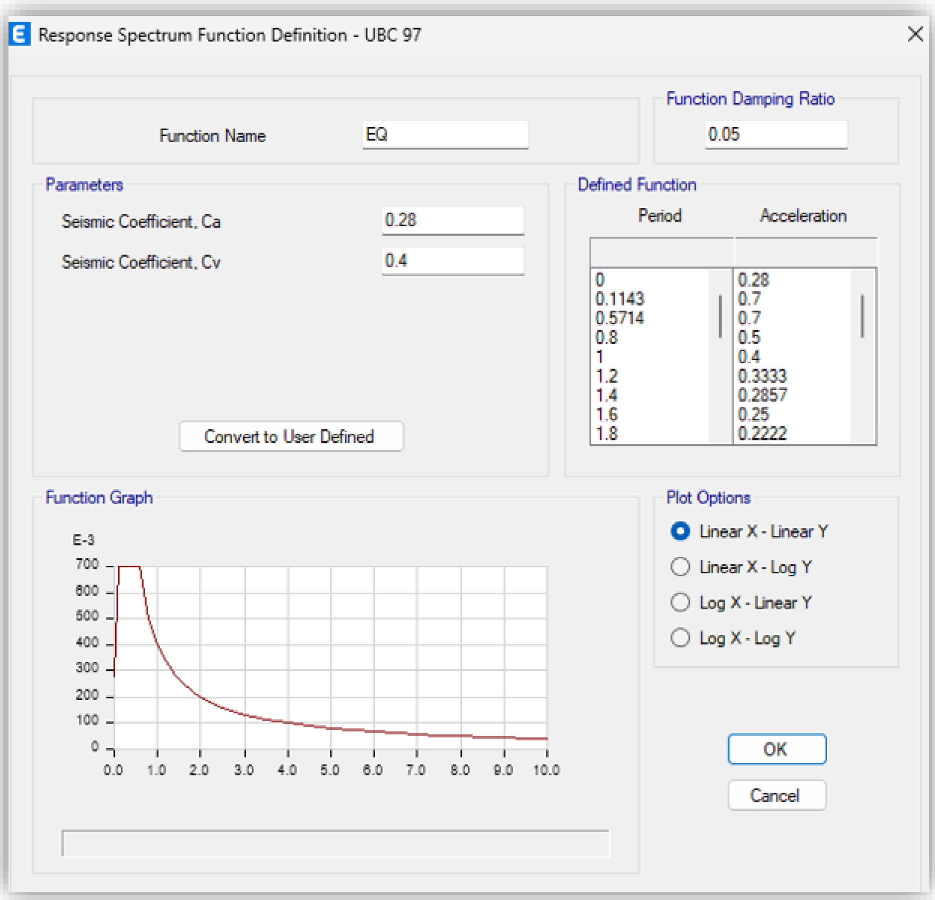


Figure 204:Function definition

3.6.4 Defined Load cases

$$Scale\ factor\ = \frac{g * I}{R}$$

$$G\ = 9810$$

$$I\ =\ importance\ factor\ = 1$$

$$R\ =\ 5.5\ (according\ to\ UBC97)$$

Table 39:Structural systema

BASIC STRUCTURAL SYSTEM[2]	LATERAL-FORCE-RESISTING SYSTEM DESCRIPTION	R	Ω_o	HEIGHT LIMIT FOR SEISMIC ZONES 3 AND 4 (feet) × 304.8 for mm
1. Bearing wall system	1. Light-framed walls with shear panels			
	a. Wood structural panel walls for structures three stories or less	5.5	2.8	65
	b. All other light-framed walls	4.5	2.8	65
	2. Shear walls			
	a. Concrete	4.5	2.8	160
	b. Masonry	4.5	2.8	160
	3. Light steel-framed bearing walls with tension-only bracing	2.8	2.2	65
	4. Braced frames where bracing carries gravity load			
	a. Steel	4.4	2.2	160
	b. Concrete[3]	2.8	2.2	—
	c. Heavy timber	2.8	2.2	65
2. Building frame system	1. Steel eccentrically braced frame (EBF)	7.0	2.8	240
	2. Light-framed walls with shear panels			
	a. Wood structural panel walls for structures three stories or less	6.5	2.8	65
	b. All other light-framed walls	5.0	2.8	65
	3. Shear walls			
	a. Concrete	5.5	2.8	240
	b. Masonry	5.5	2.8	160
	4. Ordinary braced frames			
	a. Steel	5.6	2.2	160
	b. Concrete[3]	5.6	2.2	—
	c. Heavy timber	5.6	2.2	65
	5. Special concentrically braced frames			
	a. Steel	6.4	2.2	240
3. Moment-resisting frame system	1. Special moment-resisting frame (SMRF)			
	a. Steel	8.5	2.8	N.L.
	b. Concrete[4]	8.5	2.8	N.L.
	2. Masonry moment-resisting wall frame (MMRWF)	6.5	2.8	160
	3. Concrete intermediate moment-resisting frame (IMRF)[5]	5.5	2.8	—
	4. Ordinary moment-resisting frame (OMRF)			
	a. Steel[6]	4.5	2.8	160
	b. Concrete[7]	3.5	2.8	—
	5. Special truss moment frames of steel (STMF)	6.5	2.8	240
4. Dual systems	1. Shear walls			
	a. Concrete with SMRF	8.5	2.8	N.L.
	b. Concrete with steel OMRF	4.2	2.8	160
	c. Concrete with concrete IMRF[5]	6.5	2.8	160
	d. Masonry with SMRF	5.5	2.8	160
	e. Masonry with steel OMRF	4.2	2.8	160
	f. Masonry with concrete IMRF[3]	4.2	2.8	—
	g. Masonry with masonry MMRWF	6.0	2.8	160
	2. Steel EBF			
	a. With steel SMRF	8.5	2.8	N.L.
	b. With steel OMRF	4.2	2.8	160
	3. Ordinary braced frames			
	a. Steel with steel SMRF	6.5	2.8	N.L.
	b. Steel with steel OMRF	4.2	2.8	160
	c. Concrete with concrete SMRF[3]	6.5	2.8	—
	d. Concrete with concrete IMRF[3]	4.2	2.8	—
	4. Special concentrically braced frames			
	a. Steel with steel SMRF	7.5	2.8	N.L.
	b. Steel with steel OMRF	4.2	2.8	160
5. Cantilevered column building systems	1. Cantilevered column elements	2.2	2.0	35[7]
6. Shear wall-frame interaction systems	1. Concrete[8]	5.5	2.8	160
7. Undefined systems	See Sections 1629.6.7 and 1629.9.2	—	—	—

3.6.4.1 Define EQx

$$\textit{Scale factor} = \frac{g * I}{R} = \frac{9810 * 1}{5.5} = 1783$$

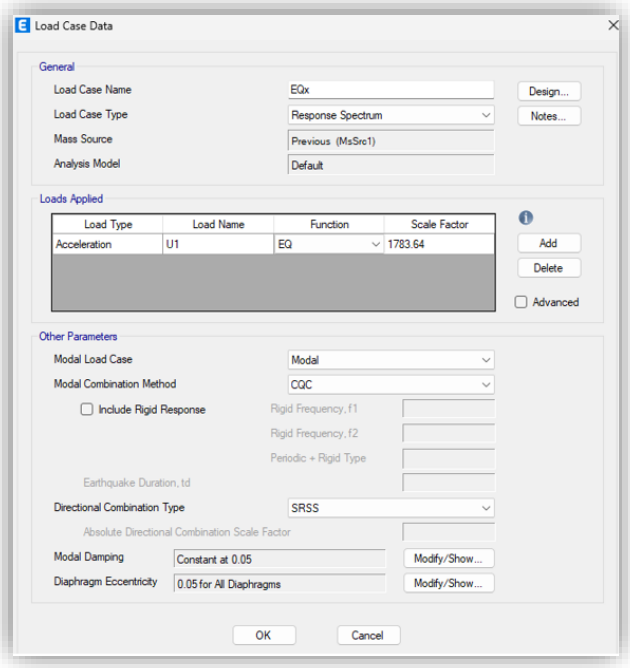


Figure 205:Load case data EQX

Define EQy

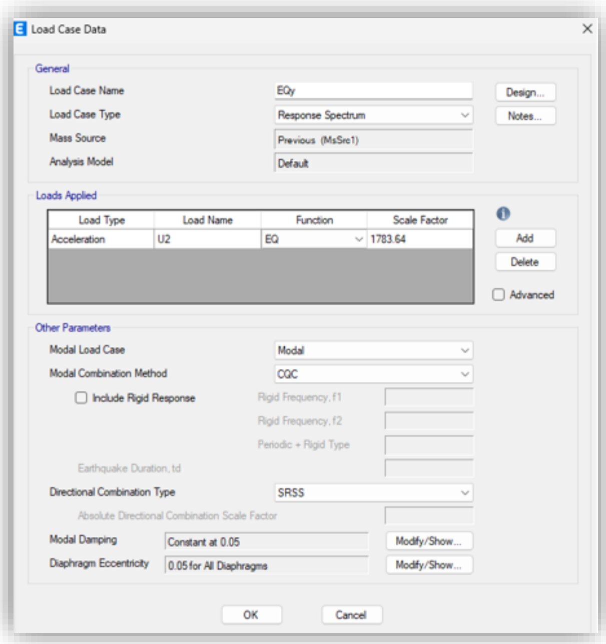


Figure 206:Load case data EQY

Load combinations on ETABS (according to UBC97)

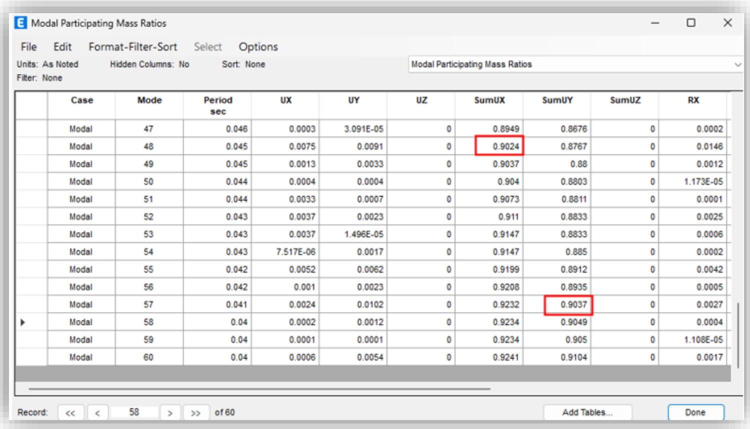
1. 1.4D	12-1
2. 1.2D+1.6L	12-2
3. 1.34D+1L+1EQx+0.3EQy	12-3
4. 1.34D+1L+1EQy+0.3EQx	12-4
5. 0.76D+1EQx+0.3EQy	12-5
6. 0.76D+1EQy+0.3EQx	12-6
7. 1D	12-7
8. 1D+1L	12-8
9. 1D+0.71EQx+0.21EQy	12-9a
10. 1D+0.71EQy+0.21EQx	12-9b
11. 0.9D+0.71EQx+0.21EQy	12-10 a
12. 0.9D+0.71EQy+0.21EQx	12-10b
13. 1D+0.54EQx+0.16EQy+0.75L	12-11a
14. 1D+0.54EQy+0.16EQx+0.75L	12-11b

3.6.4.2 Seismic load analysis

After the response spectrum is created on ETABs, checks are done to confirm that the ETABS analyses correctly, the checks needed:

- Modal Mass Participation ratio
- Period Check.
- Base Shear Check.
- Drift Check.

Modal Mass Participation ratio



Modal Participating Mass Ratios

File Edit Format-Filter-Sort Select Options

Units: As Noted Hidden Columns: No Sort: None Modal Participating Mass Ratios

Filter: None

Case	Mode	Period sec	UX	UY	UZ	SumUX	SumUY	SumUZ	RX
Modal	47	0.046	0.0003	3.091E-05	0	0.8949	0.8676	0	0.0002
Modal	48	0.045	0.0075	0.0091	0	0.9024	0.8767	0	0.0146
Modal	49	0.045	0.0013	0.0033	0	0.9037	0.88	0	0.0012
Modal	50	0.044	0.0004	0.0004	0	0.904	0.8803	0	1.173E-05
Modal	51	0.044	0.0033	0.0007	0	0.9073	0.8811	0	0.0001
Modal	52	0.043	0.0037	0.0023	0	0.911	0.8833	0	0.0025
Modal	53	0.043	0.0037	1.496E-05	0	0.9147	0.8833	0	0.0006
Modal	54	0.043	7.517E-06	0.0017	0	0.9147	0.885	0	0.0002
Modal	55	0.042	0.0052	0.0062	0	0.9199	0.8912	0	0.0042
Modal	56	0.042	0.001	0.0023	0	0.9208	0.8935	0	0.0005
Modal	57	0.041	0.0024	0.0102	0	0.9232	0.9037	0	0.0027
Modal	58	0.04	0.0002	0.0012	0	0.9234	0.9049	0	0.0004
Modal	59	0.04	0.0001	0.0001	0	0.9234	0.905	0	1.108E-05
Modal	60	0.04	0.0006	0.0054	0	0.9241	0.9104	0	0.0017

Record: << < 58 > >> of 60 Add Tables... Done

Figure 207:Modal Mass Participation ratio

60 modes are used to achieve 90% (sumUX & sumUX)

3.6.4.3 Period Check:

To ensure that the ETABS generation period is within the period limits from the manual calculation based on the UBC code formula, firstly, take the values of T from ETABS.

	Case	Mode	Period sec	UX	UY	UZ	SumUX	SumUY	SumUZ	RX
	Modal	1	1.355	0.0025	0.3817	0	0.0025	0.3817	0	0.5128
	Modal	2	1.089	0.0842	0.0379	0	0.0866	0.4196	0	0.0475
	Modal	3	0.76	0.3319	0.0022	0	0.4185	0.4218	0	0.0023

Figure 208:Period of mode of maximum model participation ratio

Period of mode of maximum model participation ratio in X ≤ 1.4T method A Period of mode of maximum model participation ratio in Y ≤ 1.4T method A From ETABS

Ty =1.355 sec Tx = 0.76 sec

T method A = Ct*(height of building) 3/4

(Ct =0.0488) According UBC 97 page 14

WHERE:

C_t = 0.035 (0.0853) for steel moment-resisting frames.

C_t = 0.030 (0.0731) for reinforced concrete moment-resisting frames and eccentrically braced frames.

C_t = 0.020 (0.0488) for all other buildings.

Height of building = 43 m

1.4*T method A =1.4*(0.0488(43)^3/4)=1.15 sec

Note the code allows an increase of up to 20-30% due to stiffness modifiers

Then the maximum allowed limit is (1.82* T method A =1.82*0.82=1.491sec)

$Ty\_ETABS = 1.355 < 1.42 \rightarrow ok$

$Tx\_ETABS = 0.76 < 1.42 \rightarrow ok$

3.6.4.4 Base shear Check:

In this check the base shear of EQx or EQy from response spectrum must be bigger than Base shear from the equivalent static.

$$V\ base\ (equivalent\ static) = \left(\min\left(\frac{Cv}{t}, 2.5Ca\right)\right) * W * \frac{I}{R}Cv$$

$$= 0.4, Ca = 0.28, R = 5.5, I = 1$$

$$W = DL + 0.25LL$$

$$W\ =\ SID\ +\ Dead\ load\ + Wall\ load\ + 0.25\ Live\ Load$$

Table 40:EQx and EQy

Output Case	Step Type	FX	FY	FZ
		kN	kN	kN
Dead		-5.9122	-9.3571	99908.5
Live		-0.9287	-4.1526	25114.87
SID		-5.6338	-7.9487	51016.51
EQx	Max	6686.031	1874.773	2.6107
EQy	Max	1933.465	5870.063	2.0744

W= 375287.7KN

Axsis	T	T_limit	T_used	V_manual	V_Etabs	Old scale Factor	New Scale Factor	V_Etabs after edit
X	0.76	1.49	0.76	35913	6686.031	1783	9577.0	35918
Y	1.355	1.49	1.355	20143	5870.063	1783	6118	20148

$$V\_manual\ EQx\ >\ equivalent\ static\ base\ shear\ from\ etabs\ \rightarrow\ ok$$

$$V\_manual\ \ EQy\ >\ equivalent\ static\ base\ shear\ from\ etabs\ \rightarrow ok$$

3.6.4.5 Story drift Check

According to UBC-97, the drift limitation should be more than the lateral displacement between the floors in the building.

According to the UBC-97, for structures having a period of 0.7 second or greater, the calculated story drift must not exceed 0.020 times the story height. Calculated story drift limit must not exceed 0.025 times the story height for structures having a fundamental period of less than 0.7 second.

$On\ this\ project\ T\ method\ A\ > 0.7\ sec$

$Limit\ = 0.20\ H$

Table 41:story drift

Story	Height	Dis_X	Dis_Y	Drift_X	Drift_Y	Delta_X	Delta_Y	Delta_limit
Base 3	0	0	0					
Base 2	3000	1.11	0.38	1.11	0.38	4.26	1.46	60
Base 1	3000	0.52	0.22	-0.59	-0.16	-2.28	-0.62	60
GF	3800	3.74	1.69	3.23	1.47	12.42	5.67	76
Attics	3800	11.49	15.30	7.75	13.61	29.82	52.40	76
Story 1	3800	22.56	23.67	11.08	8.37	42.64	32.22	76
Story 2	3800	34.02	36.30	11.46	12.63	44.11	48.61	76
Story 3	3800	46.10	49.03	12.08	12.74	46.50	49.03	76
Story 4	3800	58.34	61.31	12.24	12.28	47.13	47.28	76
Story 5	3800	70.42	72.88	12.08	11.56	46.51	44.52	76
Story 6	4200	83.43	89.62	13.01	16.75	50.09	64.48	84
Staircase	2700	95.97	89.31	12.54	-0.31	48.29	-1.21	54

$All\ (Delta\_X, Delta\_Y)\ <\ Delta\_limit\ \rightarrow\ drift\ check\ is\ OK$

3.6.4.6 Deflection check:

3.6.4.6.1 Deflection check for slabs service:

$\Delta Relative = \Delta slab\ abs - \Delta avg\ abs\ for\ the\ beams$

$$= 75.329 - \frac{36.314 + 34.323 + 56.397 + 46.371}{4}$$

$= 31.97mm = 0.0319m$

$L/240 = 11.3212/240 = 0.0472 > 0.0319 \rightarrow OK$

3.6.4.6.2 $\boldsymbol{Deflection\ check\ for\ beam\ service}$:

$\Delta Relative = \Delta beam\ abs - \Delta avg\ abs\ for\ the\ beams$

$= 36.314 - (21.651 + 8.014)/2 = 21.48mm = 0.0215$

$L/240 = 11.3212/240 = 0.0472 > 0.0215 \rightarrow OK$

Note: after conducting the necessary analyzes and modifications, some adjustments were made to the dimensions of the sections, slabs and beams

3.7 Design and reinforcement

3.7.1 Slab design

Type of slab is two way Solid slab with 25cm thickness.

The design was carried out using ETABS. Below is a model of the design process:

Slab design:

AS min = 0.0018*Ag=0.0018*250*1000=450

Use 4 Ø 12

in figure , shows the top reinforcement in the slab in X direction:

Figure 209:The top reinforcement in Basement 3 floor in x direction.

The slab needs 5 Ø 14 as minimum reinforcement.

In figure, shows the bottom reinforcement in the slab in X direction:

Figure 210:The bottom reinforcement in Basement 3 floor in x direction.

The slab needs 5 Ø 14 as minimum reinforcement.

In figure, shows the top reinforcement in the slab in y direction:

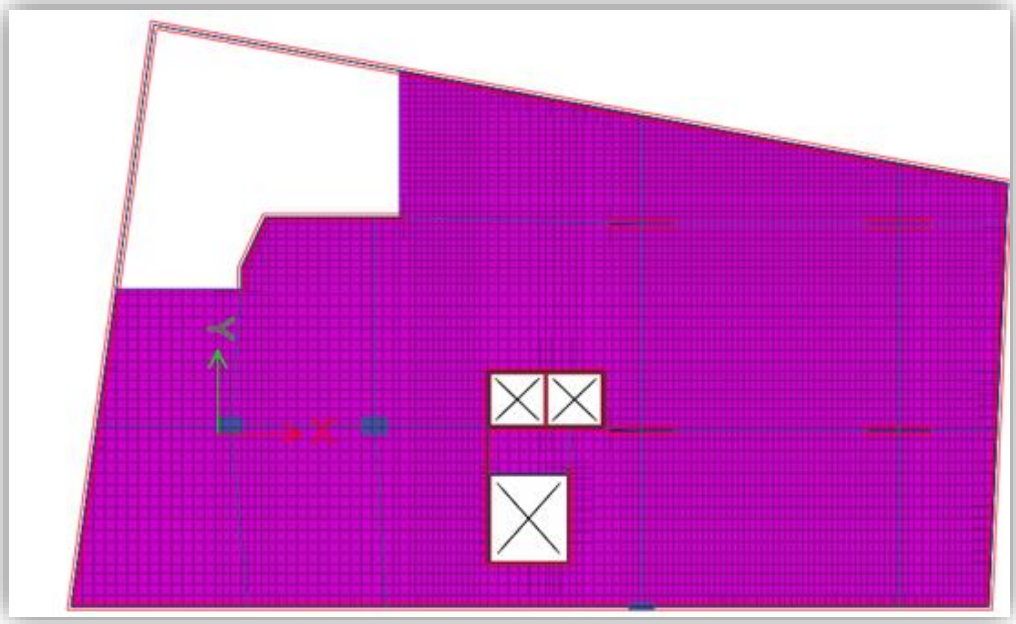


Figure 211:The top reinforcement in Basement 3 floor in x direction.

The slab needs 5 Ø 14 as minimum reinforcement.

In figure, shows the bottom reinforcement in the slab in y direction:

Figure 212:The bottom reinforcement in Basement 3 floor in y direction.

The slab needs 5 Ø 14 as minimum reinforcement.

3.7.2 Beam design

"A sample of calculation on beam is shown in figure 3-82.

Beam dimension = 800*400 mm. in first basement floor.

1- Longitudinal steel from ETABS for given beam is shown in figure.

Figure 213:Area of Steel (mm2) for Sample Beam in first basement floor"

$$As\ min = 0.0033 * 400 * 740$$
$$= 976.8\ mm2, use\ 5\ Ø16.$$

2- Design beam for shear.

For beam of dimensions 800*400 mm, its shear force diagram

Max shear (Vu max from ETABS) = 275.87 KN.

$$Vn = \frac{Vu}{\emptyset} = \frac{275.87}{0.75} = 367.83\ kN$$

$$Vc = \frac{1}{6} * \sqrt{f'c} * bw * d = \frac{1}{6} * \sqrt{24} * 400 * 740 * 10^{-3}$$

$$= 241.68\ KN$$

$$Vs = \frac{Vu}{\emptyset} - Vc = 367.83 - 241.68 = 126.15\ KN$$

$$Vs\ max. = 4\ Vc = 4 * 241.68 = 966.72\ KN$$

$$\frac{Av}{S} = \frac{Vs * 1000}{fy * d} = \frac{126.15 * 1000}{420 * 740} = 0.41$$

$$\frac{Av}{S} min = 0.35 \frac{bw}{fy} = 0.62$$

$$As\ \frac{Av}{S} < \frac{Av}{S} min$$

$Assume\ use\ 1\ \emptyset 10\ with\ 2\ legs$

$$Av = 2 * \frac{\pi}{4} 10^2 = 157mm^2 \rightarrow s = \frac{157}{0.62} = 253.2 \approx 250mm$$

$According\ to\ earthquake\ design\ S$

$$= min\ \{24\ ds\ or\ \frac{h}{4}\ or\ 8\ db\ or\ 300\}$$

$$= min\ \{240\ or\ 100\ or\ 80\ or\ 300\} 80\ mm$$

$Use\ 1\ \emptyset 10mm\ @80mm$

Table 42:Beam bar sizes

Beam No.	Beam Width	Beam Depth	Top Steel			Bottom Steel			Stirrups
B1 a	70	40	4	Ø	16	4	Ø	16	2Ø10@10 near column 2Ø10@15cm awayfrom column
B1 b	70	40	6	Ø	16	8	Ø	18	2Ø10@10 near column 2Ø10@15cm awayfrom column
B2 a	55	40	4	Ø	16	4	Ø	16	2Ø10@10 near column 2Ø10@15cm awayfrom column
B2 b	55	40	6	Ø	16	8	Ø	18	2Ø10@10 near column 2Ø10@15cm awayfrom column
B2 c	55	40	6	Ø	16	8	Ø	18	2Ø10@10 near column 2Ø10@15cm awayfrom column
B3 a	80	40	6	Ø	14	10	Ø	16	2Ø10@10 near column 2Ø10@15cm awayfrom column
B3 b	80	40	6	Ø	14	6	Ø	14	2Ø10@10 near column 2Ø10@15cm awayfrom column
B3 c	80	40	6	Ø	14	14	Ø	16	2Ø10@10 near column 2Ø10@15cm awayfrom column
B3 d	80	40	6	Ø	14	14	Ø	18	2Ø10@10 near column 2Ø10@15cm awayfrom column
B3 e	80	40	10	Ø	16	6	Ø	14	2Ø10@10 near column 2Ø10@15cm awayfrom column
B3 f	80	40	10	Ø	16	10	Ø	16	2Ø10@10 near column 2Ø10@15cm awayfrom column
B3 g	80	40	10	Ø	16	14	Ø	16	2Ø10@10 near column 2Ø10@15cm awayfrom column
B3 h	80	40	10	Ø	16	14	Ø	18	2Ø10@10 near column 2Ø10@15cm awayfrom column
B3 i	80	40	14	Ø	16	10	Ø	16	2Ø10@10 near column 2Ø10@15cm awayfrom column
B3 j	80	40	14	Ø	16	26	Ø	18	2Ø10@10 near column 2Ø10@15cm awayfrom column
B3 k	80	40	14	Ø	18	26	Ø	18	2Ø10@10 near column 2Ø10@15cm awayfrom column
B4 a	90	40	10	Ø	16	14	Ø	16	2Ø10@10 near column 2Ø10@15cm awayfrom column
B4 b	90	40	6	Ø	16	10	Ø	16	2Ø10@10 near column 2Ø10@15cm awayfrom column
B5 a	120	40	10	Ø	16	14	Ø	18	2Ø10@10 near column 2Ø10@15cm awayfrom column
B5 b	120	40	6	Ø	16	16	Ø	18	2Ø10@10 near column 2Ø10@15cm awayfrom column
B6 a	50	40	4	Ø	14	4	Ø	14	2Ø10@10 near column 2Ø10@15cm awayfrom column
B6 b	50	40	6	Ø	14	10	Ø	14	2Ø10@10 near column 2Ø10@15cm awayfrom column
B7 a	35	40	4	Ø	14	4	Ø	14	1Ø10@10 near column 1Ø10@15cm awayfrom column
B7 b	35	40	6	Ø	14	10	Ø	14	1Ø10@10 near column 1Ø10@15cm awayfrom column
B8	20	40	2	Ø	14	2	Ø	14	1Ø10@10 near column 1Ø10@15cm awayfrom column
B9	40	40	4	Ø	14	4	Ø	14	1Ø10@10 near column 1Ø10@15cm awayfrom column
B10	20	20	2	Ø	14	2	Ø	14	1Ø10@10 near column 1Ø10@15cm awayfrom column

3.7.3 Column Design

Column design manually as follows:

$The\ column\ with\ Pu\ = 11679.8\ KN$

$fy\ =\ 420\ MPA, fc\grave{}\ =\ 28\ Mpa, \%rebar\ = 0.01$

$Ag = 1138.9/(0.65 * 0.8 * (0.85 * 28 * (1 - 0.01) + 0.01 * 420)\ )\ \ = 809060$

$Dimension\ of\ column\ 1100 * 750\ = 825000\ mm2 > 809060mm2$

$ØPn = 0.65 * 0.8 * (0.85 * f'c * (Ag - As) + As * fy)$

$= 0.65 * 0.8 * (0.85 * 28 * (825000 - 825000 * 0.01) + (0.01 * 825000) * 420)$

$= 11909.9\ kN$

$11909.9\ KN > \ 11679.8\ KN\ ok.$

$AS\ =\ .01 * 825000\ =\ 8250\ mm2\ USE\ 24\ Ø20\ AS\ =\ 8831.25\ mm^2.$

Table 43:Schedule of columns

COL . NO.	DIMENSIONS		REINFORC.	STIRRUPS	NO.
	LENGTH	WIDTH			
C1	1100	30	20Ø20	2Ø10@15	2
C2	1100	30	24Ø20	2Ø10@15	1

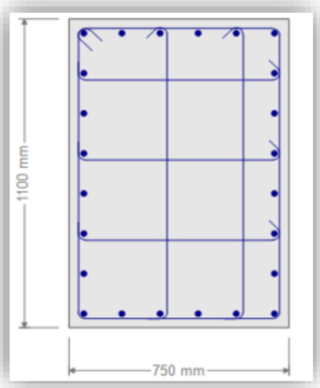


Figure 214:Column 1 design from ETABS

Seismic design requirement in longitudinal section in column:

$$S0 = min \begin{cases} \frac{Least\ column\ dimention}{2} \\ 8 * db \\ 24 * ds \\ 300mm \end{cases}$$

$$S1 = min \begin{cases} Least\ column\ dimention \\ 16 * db \\ 48 * ds \end{cases}$$

$$L0 = max \begin{cases} \frac{clear\ high\ of\ column}{6} \\ maximum\ column\ dimention \\ 450mm \end{cases}$$

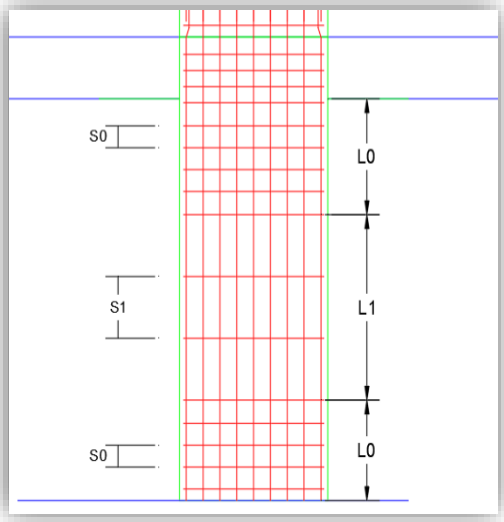


Figure 215:Seismic design requirement in longitudinal section in column

3.7.4 Shear wall design

In this project, firstly normal shear wall, secondly Basement wall. Figure shows the plan for shear wall in the building.

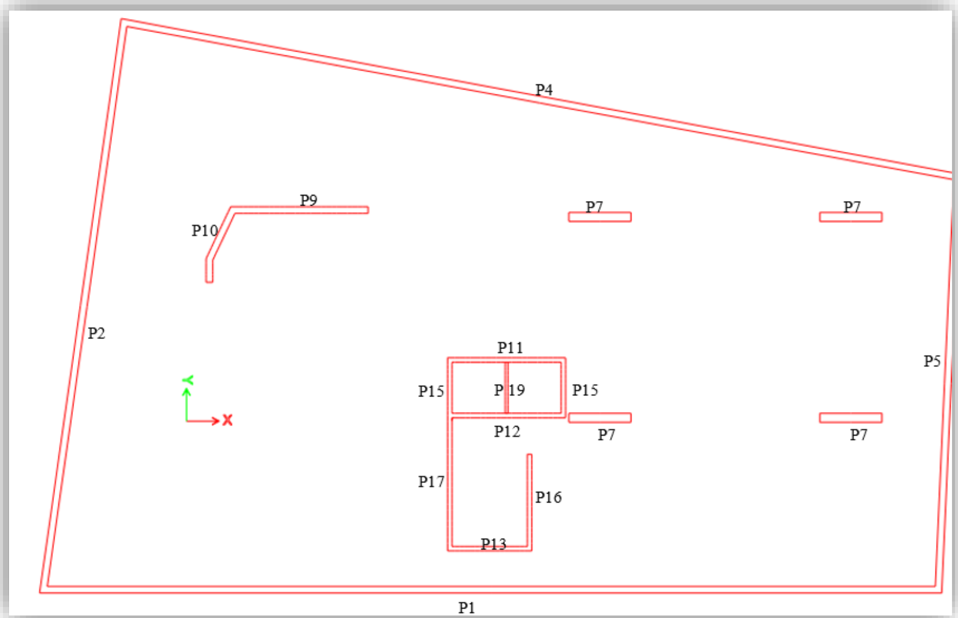


Figure 216:Shear walls in the project

Design done with Etabs, using uniform reinforcement method.

Sample of calculation P13

ACI 318-19 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
Base 2	P13	13675	-5747.2	3600	200	0.579

Material Properties

E_c (MPa)	f'_c (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
24870	28	1	420	420

Design Code Parameters

ϕ_T	ϕ_C	ϕ_V	ϕ_V (Seismic)	IP_{MAX}	IP_{MIN}	P_{MAX}
0.9	0.65	0.75	0.6	0.04	0.0025	0.8

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	11875	-5747.2	15475	-5747.2	3600	200
Bottom	Leg 1	11875	-5747.2	15475	-5747.2	3600	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A mm²
Top	2173	0.003	0.0107	ENV ULT	385.7902	84.8475	496.8798	720002
Bottom	1800	0.0025	0.0107	ENV ULT	3998.3665	-105.5471	155.6746	720002

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	ϕV_c kN	ϕV_n kN
Top	Leg 1	500	ENV ULT	385.7902	496.8798	569.7716	569.4358	1023.037
Bottom	Leg 1	500	ENV ULT	1247.5347	1080.3529	563.2906	569.4358	1023.037

Figure 217:Pier 13 details

Thickness =0.20 m, length =3.8 m total height =6 m, f`c =28 MPa

According to (ACI -310-14) the wall should be reinforced in two regions:

1-Boundaries. 2- Web.

Boundary width = Min (0.1 h or 4 b).

Where:

h: wall Length. b: wall thickness.

Boundary width= Min (0.38, 0.8), then boundary diminutions (0.4*0.2)

ACI requirement:

-- Minimum ρ in web in vertical and horizontal direction = 0.25 %.

-- ρ in boundary area = 1 %.

The steel reinforcement in boundary = 0.01* boundary diminutions

=0.01* 200 * 400 = 800 mm2 use 4 Ø 18 in boundaries. 2 Ø 18 on each face.

The steel reinforcement in web:

From ETABS ρ = 0.003 >> 0.0025

AS = 0.003 * 1000* 200 = 600 mm2 use 6Ø12/m

In vertical and horizontal 3 Ø 12 for each side.

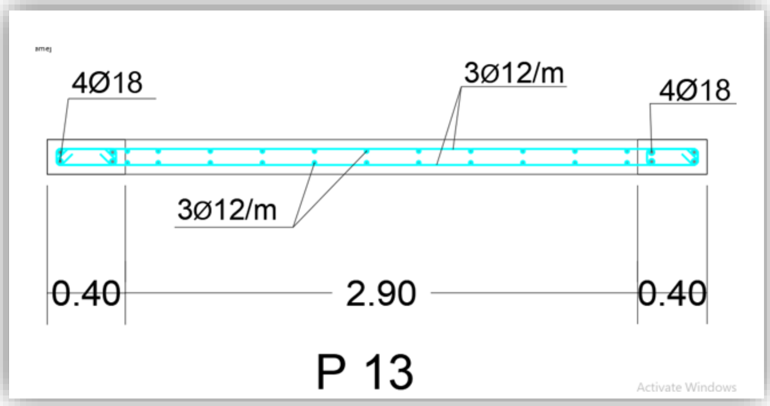


Figure 218:Shear wall reinforcement

Table 44:Shear wall reinforcement

Pier lable	Thickness	Boundary width	Boundary reinforcement for two side	Vertical web reinforcement	Horizontal web reinforcement	Boundary stirrup
P7	0.3	0.3	7ø18/Layer	12ø20/m	4ø12/m	1ø10/150mm
P7	0.3	0.3	8ø18/Layer	9ø20/m	4ø12/m	1ø10/150mm
P8	0.3	0.3	6ø18/Layer	15ø20/m	4ø12/m	1ø10/150mm
P9	0.3	0.6	4ø18/Layer	6 ø20/m	4ø12/m	1ø10/150mm
P10	0.3	0.3	3ø18/Layer	6ø20/m	4ø12/m	1ø10/150mm
P11	0.2	0.5	2ø18/Layer	3ø12/m	3ø12/m	1ø8/150mm
P12	0.2	0.5	2ø18/Layer	4ø12/m	3ø12/m	1ø8/150mm
P13	0.2	0.4	2ø18/Layer	3ø12/m	3ø12/m	1ø8/150mm
P15	0.2	0.2	2ø18/Layer	5ø12/m	3ø12/m	1ø8/150mm
P16	0.2	0.45	2ø18/Layer	5ø20/m	3ø12/m	1ø8/150mm
P17	0.2	0.2	2ø18/Layer	5ø12/m	3ø12/m	1ø8/150mm
P18	0.2	0.45	2ø18/Layer	5ø12/m	3ø12/m	1ø8/150mm
P19	0.12	________	________	2ø12/m	2ø12/m	1ø8/150mm

3.7.5 Basement wall

Etabs is used to design the basement wall. Non-Uniform load must be calculated:

Ɣ for soil =18 KN/m3 , Friction angle ᴓ = 30 for soil

F=K * H *Ɣ

When wall is at rest then K=(1-sinØ)/(1+sinØ)=0.33, H=9.8 F= 0.33 * 9.8 *18 = 58.2 KN/m

$P\ = C * Z + D\ = H\ , D = F\ Y(Z) = F\ at\ Z$

$when\ Z = 0\ \rightarrow P = D = 58.2 KN/m^2$

$when\ Z = 9.8$

$\rightarrow P = \ 0\ KN/m^2$

$0 = C * Z + D\ \rightarrow 0 = C * (9.8) + 58.2$

$\rightarrow C = \ -5.94\ kN/m3$

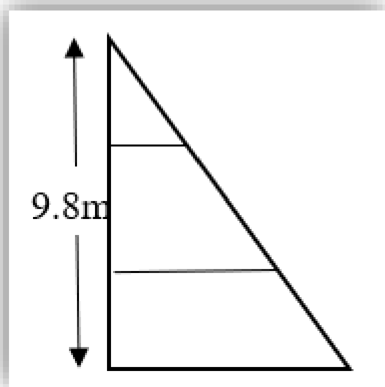


Figure 219:basement wal

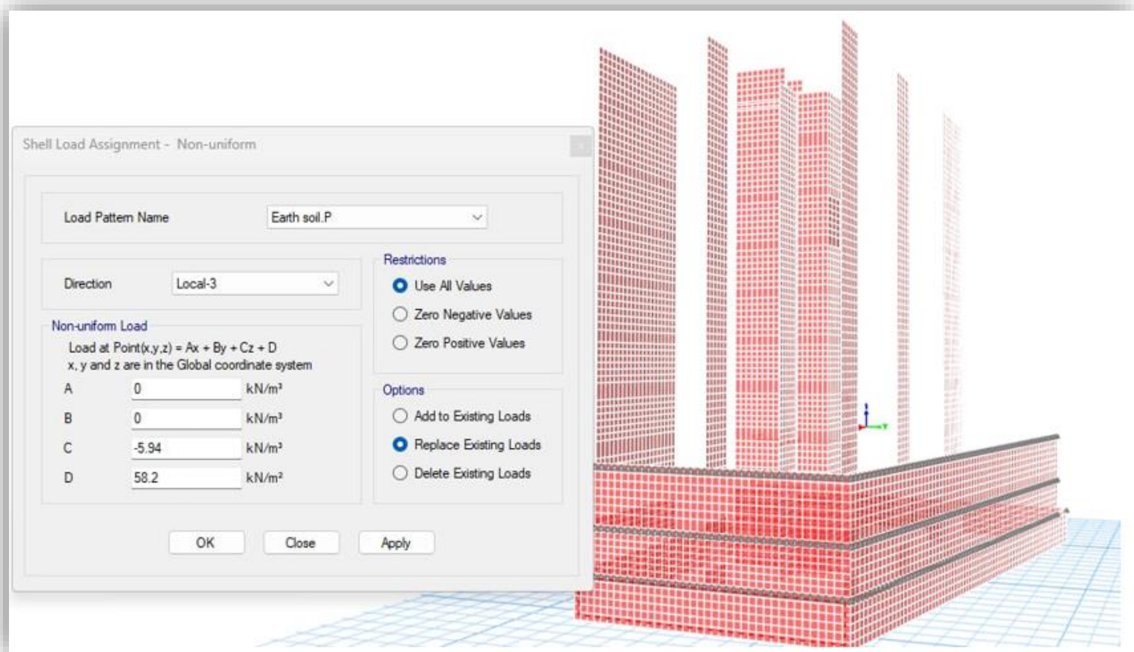


Figure 220:Non-uniform shell load

Design sample calculation for P1 (pire #1) (uniform reinforcement) and checked by Etabs.

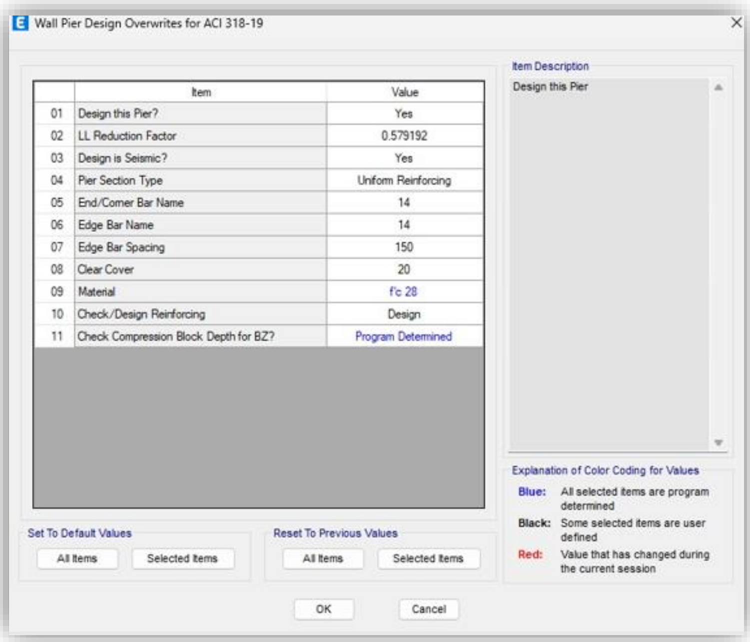


Figure 221:Pier design

Table 45:Flexural design

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	30277	0.0025	0.0069	ENV ULT	22092.1739	853.2987	-26941.7823	12110655
Bottom	61459	0.0051	0.0069	ENV ULT	6973.2219	3224.5287	-57747.1802	12110655

$Thickness\ of\ wall\ 30cm$

$Min\ ratio = 0.0025$

$required\ ratio\ from\ ETABS = 0.0051$

$As\ for\ W1 = 0.0051\ b\ h$

$= 1530\ mm^2/m \rightarrow Use\ 1\ Ø\ 12\ @150\ mm\ for\ vertical\ and\ horizontal\ in\ two\ layer.$

Table 46:Schedule of shear wall design

Pier lable	Thickness	Boundary width	Boundary reinforcement for two side	Vertical web reinforcement	Horizontal web reinforcement	Boundary stirrup
P1	0.3			7ø12/m	4ø12/m	
P2	0.3			4 ø20/m	4ø12/m	
P4	0.3			9ø20/m	4ø12/m	
P5	0.3			13ø20/m	4ø12/m	
P6	0.3			7ø20/m	4ø12/m	

3.7.6 Stair Design

The following figure shows the dimensions of the stair:

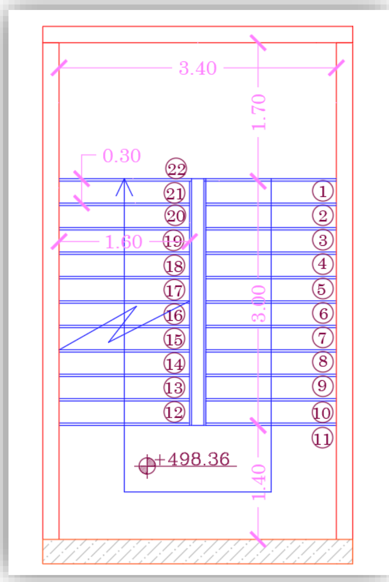


Figure 222:dimensions of the stair.

$Step\ Length = 140\ cm$

$Riser = 17cm$

$Landing\ length = 340$

$Landing\ width = 170\ cm$

Loude on stairs:

The design of stairs is based on several assumptions:

$Live\ loude = 5\ KN/m^2$

$SID\ loude = 4\ KN/m^2$

$Slab\ thikness\ = 20\ cm$

$Dead\ loude = 0.2 * 25 = 5\ KN/m^2$

$Wu\ =\ 1.2\ \times\ Wd\ +\ 1.6\ \times\ Wl$

$Wu\ =\ 1.2\ \times (5 + 4)\ +\ 1.6\ \times 5 = 18.8\ KN/m^2$

The slab is simply sapported, so $Mu = \frac{wu*L^2}{8}$

$$Mu = \frac{18.8 * 3.1^2}{8} = 22.6\ KN/m$$

Longitudinal reinforcement

$$\rho\ = \frac{0.85 * f'c}{Fy}\left(1 - \sqrt{1 - \left(\frac{2.61 * 10^6 * Mu}{fc * b * d^2}\right)}\right)$$

$$P = \frac{23.8}{420}\left(1 - \sqrt{1 - \left(\frac{2.61*10^6*22.6}{28*1000*170^2}\right)}\right) = 0.002$$

$As = \rho * b * d = 0.002 * 1000 * 170 = 340\ mm^2/m. use 4\emptyset 12/m$

$As\ shrinkage = 0.0018 * b * d = 0.0018 * 1000 * 200 = 360\ mm^2/m$.

in each direction.

Check Shear for the steps of the stairs:

$$Vu = \frac{wu * L}{2} = \frac{18.8 * 3.1}{2} = 29.14\ KN/m$$

$$\emptyset Vc\ =\ (\frac{0.75}{0.6} * \sqrt{f'c})bw\ d$$

$$\emptyset Vc\ =\ \left(\frac{0.75}{0.6} * \sqrt{28}\right)170 * 1000 = 112.4 > Vu\ \rightarrow Ok$$

Landing design:

$$Wu\ =\ 1.2\ \times (5 + 4)\ +\ 1.6\ \times 5 = 18.8\ KN/m^2$$

The slab is simply sapported, so $Mu = \frac{wu*L^2}{8}$

$$Mu = \frac{18.8 * 1.7^2}{8} = 6.8\ KN/m$$

Longitudinal reinforcement

$$\rho = \frac{0.85 * f'c}{Fy}\left(1 - \sqrt{1 - \left(\frac{2.61 * 10^6 * Mu}{fc * b * d^2}\right)}\right)$$

$$P = \frac{23.8}{420}\left(1 - \sqrt{1 - \left(\frac{2.61*10^6*6.8}{28*1000*170^2}\right)}\right) = 0.0006$$

$$As = \rho * b * d = 0.0006 * 1000 * 170 = 160\, mm^2/m. use3\emptyset10/m$$

$$As\ shrinkage = 0.0018 * b * d = 0.0018 * 1000 * 200 = 360\, mm^2/m\,.$$

$use4\emptyset12/m$

Check Shear for the steps of the stairs:

$$Vu = \frac{wu * L}{2} = \frac{18.8 * 1.7}{2} = 15.98KN/m$$

$$\emptyset Vc = (\frac{0.75}{0.6} * \sqrt{f'c})bw\ d$$

$$\emptyset Vc = \left(\frac{0.75}{0.6} * \sqrt{28}\right)170 * 1000 = 112.4 > Vu \rightarrow Ok$$

Detailind for staircase:

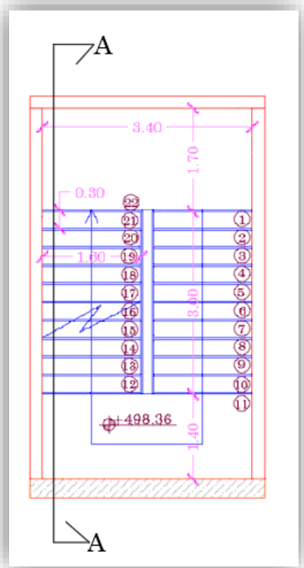


Figure 223:Section of the stair

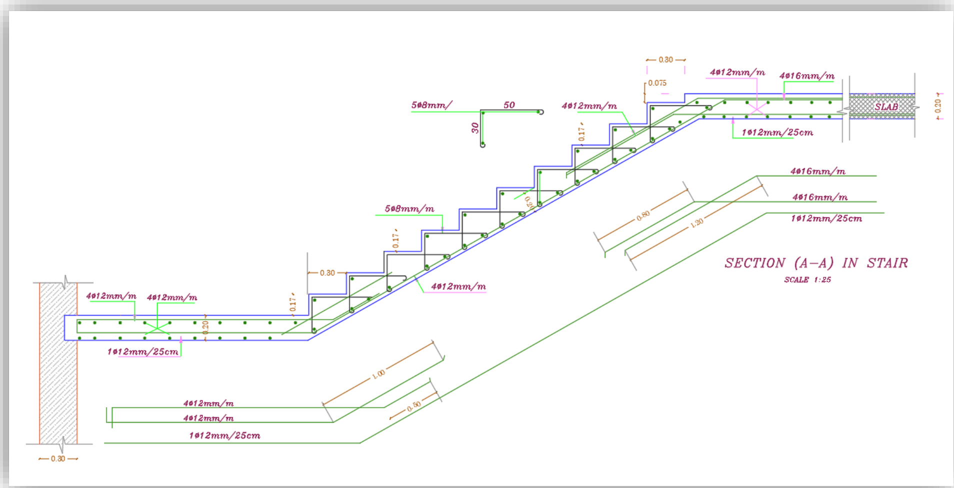


Figure 224:Detailing for staircase.

3.7.7 Foundation Design

Bearing capacity of soil =200 kN/m2, f`c=28 Mpa, fy =420Mpa

The project has a mat foundation with 1000mm thickness. ETABS 2021 software is used to design and check footings.

Soil pressure Check:

If all foundation has value less than 200KN/m2, the check is ok.

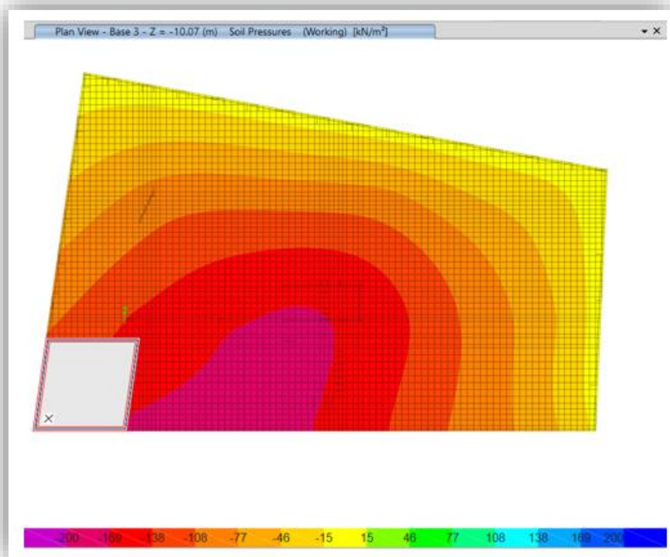


Figure 225:Foundation soil pressure check

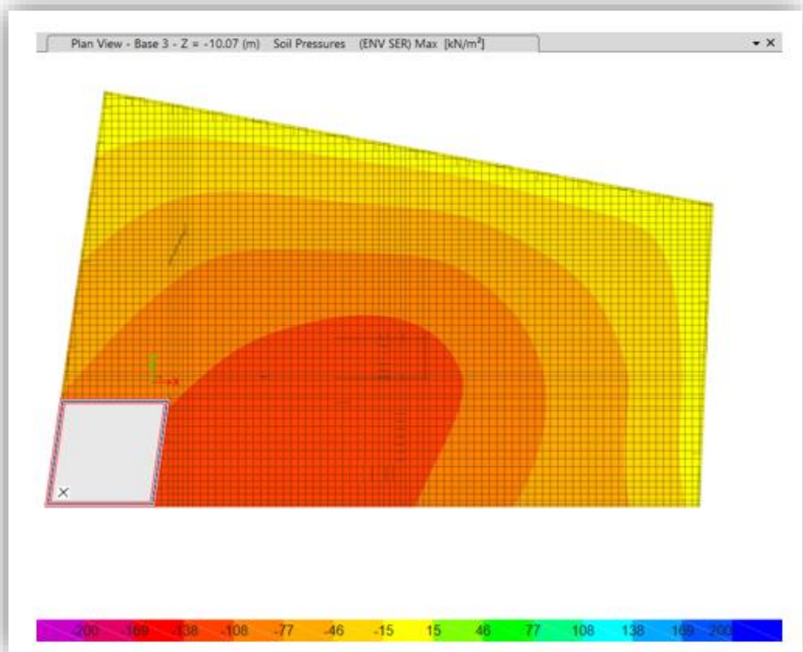


Figure 226:Foundation soil pressure check

Punching shear check:

The thickness of the footing is checked All values must be < 1

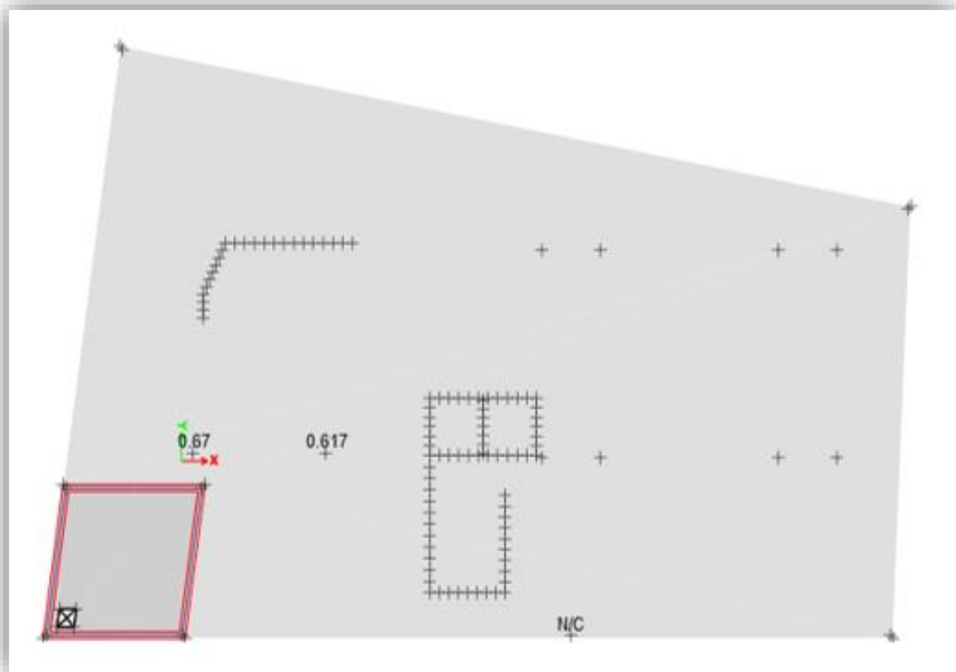


Figure 227:Punching shear check

Reinforcement for mat foundation

$$As\ min = 0.0018 * 1000 * 1000 = 1800\ mm2/m\ (4\ Ø25\ /m)$$

1) In top X direction

Use 1Ø25 /75mm

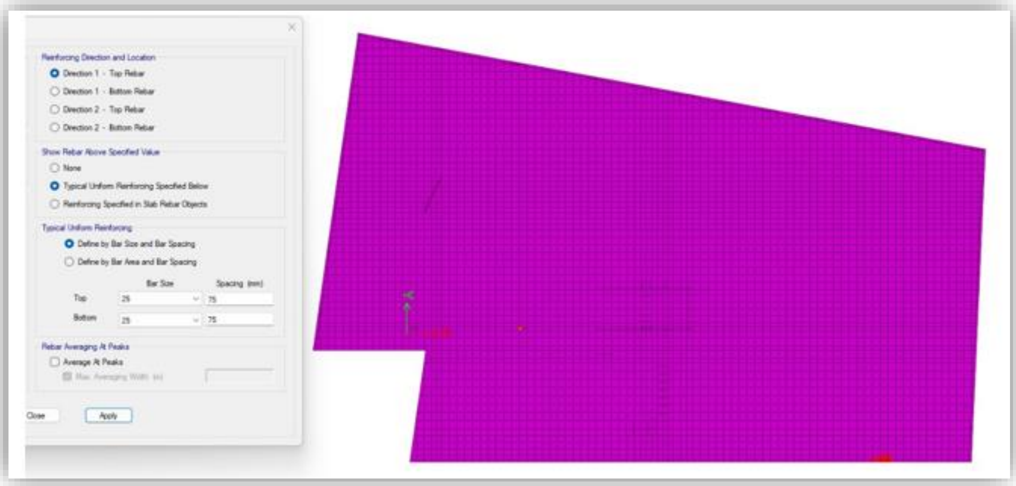


Figure 228:Foundation design

2) In bottom X direction

Use 1Ø25 /75mm

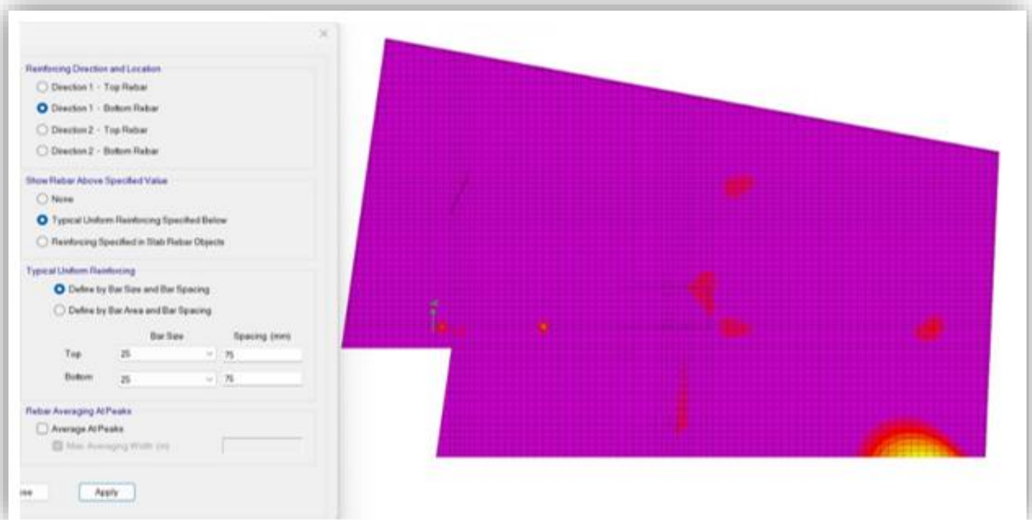


Figure 229:Foundation design

Additional reinforcement of 1Ø25/50cm were added to the red regions around column and shear walls.

3) In top Y direction

Use 1Ø25 /75mm

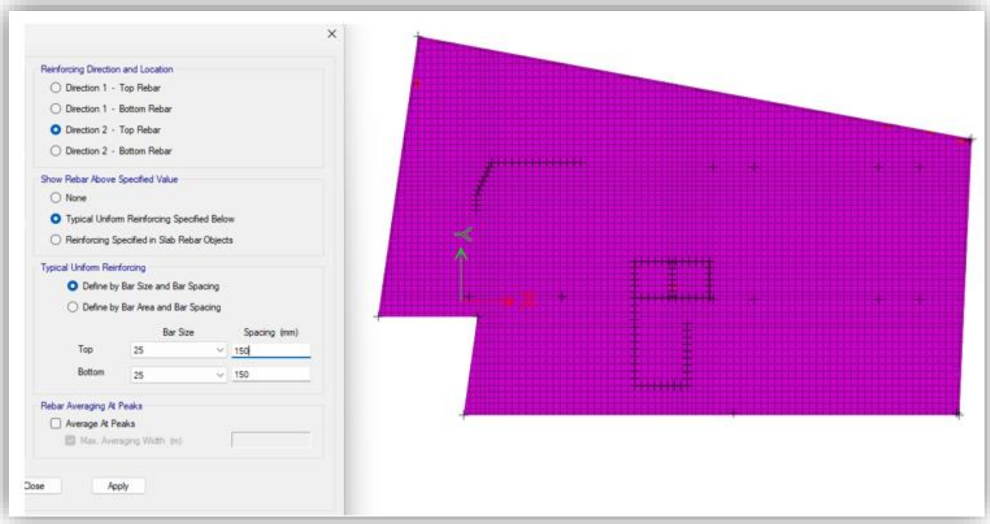


Figure 230:Foundation design

4) In bottom Y direction

Use 1Ø25 /75mm

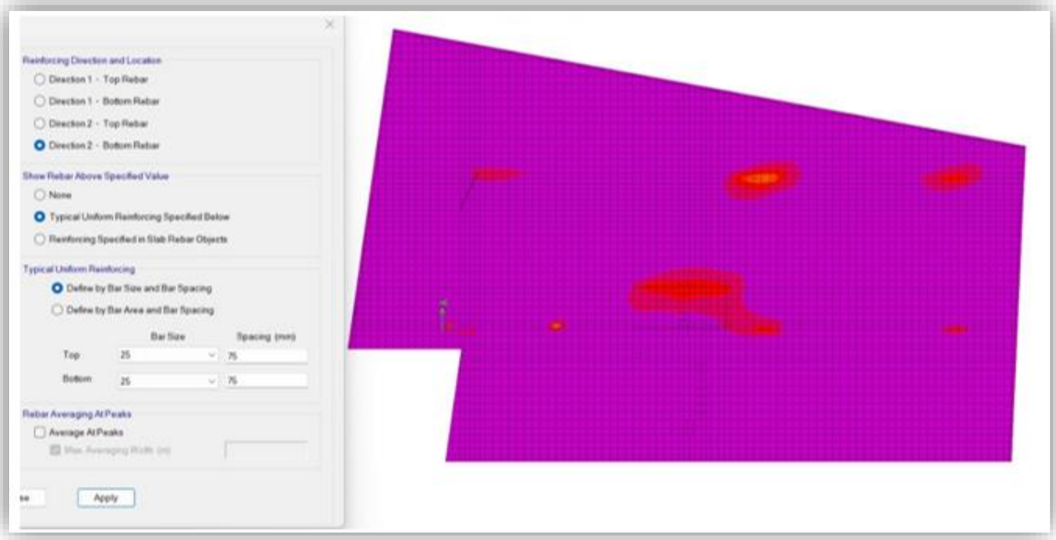


Figure 231:Foundation design

Additional reinforcement of 1Ø25/50cm were added to the red regions around column and shear walls.

Section in Mat:

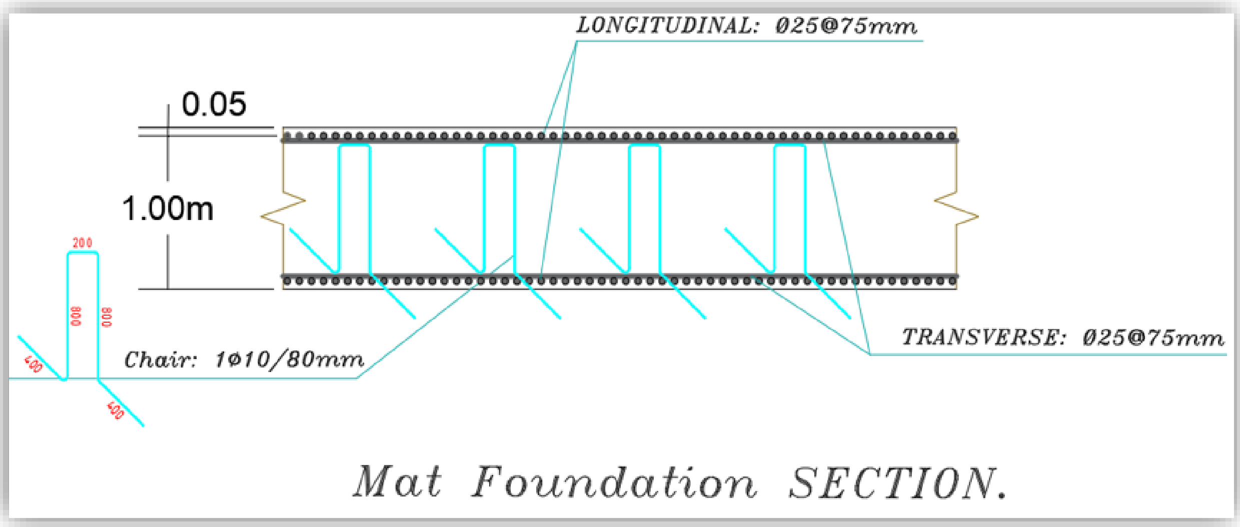


Figure 232:Mat foundation section and reinforcement

3.7.8 Ramp design:

$Ramp\ thicknes\ = 35\ cm$

$As\ min = \rho\ min * bw * d$

$\rho\ min = 0.0018$

$bw = 1000\ mm$

$H = 350\ mm$

$As\ min = 0.0018 * 1000 * 350 = 630\ mm^2$

$Mu\ From\ SAP = 67\ \ KN.m/m^2$

$\rho = 0.00176 < \rho\ min$

$As\ \ = 563.18\ mm^2/m$

$As\ min = 630\ mm^2/m\ \ \rightarrow 6\emptyset12/m$

$As < As\ min$

$Use\ As\ min = 6\emptyset12/m$

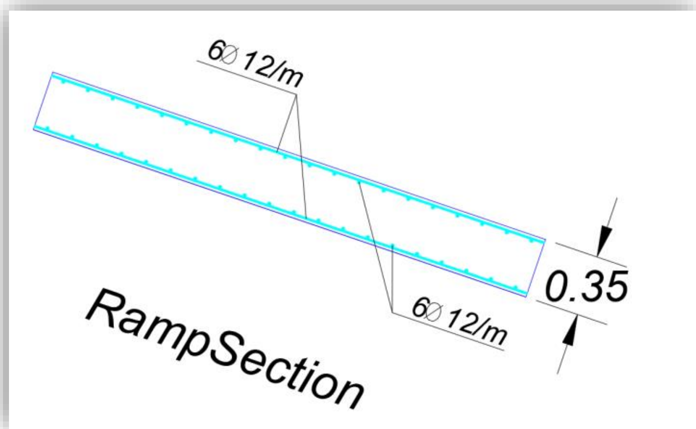


Figure 233:Ramp section

3.7.9 Water tank design

Definitions:

$water\ tank\ volume\ 120\ m2\ with\ diminution\ (6.5m\ x\ 6.5m\ x\ 3m).$

$ETABS\ 2021\ software\ is\ used\ to\ design\ and\ analysis\ water\ tank.$

$The\ material\ properties\ used:$

$Bearing\ capacity\ of\ soil\ (q)\ = 200\ kN/m2, f`c = 28\ MPa, fy = \ 420\ Mpa,$

$L.L(live\ load\ above\ water\ tank\ slab)\ =\ 5.5\ KN/m$

$Non - Uniform\ load\ must\ be\ calculated\ for\ two\ cases:$

$\boldsymbol{Case}\ \mathbf{1}: If\ the\ well\ is\ empty\ with\ lateral\ pressure\ from\ the\ surrounding\ soil.$

$\gamma\ for\ soil\ = 18\ kN/m3, Friction\ angle\ \phi\ =\ 30\ for\ soil$

$P = K * q\ +\ K\ *\ H\ * \gamma$

$$When\ wall\ is\ at\ rest\ then\ K = \frac{1 - sin\emptyset}{1 + sin\emptyset} = 0.33,$$

$H = 3, P =\ 0.33\ *\ 3\ * 18\ =\ 17.82\ KN/m^2$

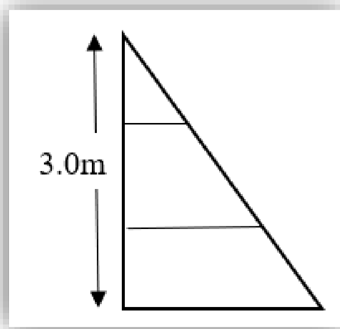


Figure 234:Well wall

$P = C * Z + D = H, D = F\ Y(Z) = F\ at\ Z$

$when\ Z = 0 \rightarrow P = D = 17.82\ KN/m^2$

$when\ Z = 3$

$\rightarrow P = 0\ KN/m^2$

$0 = C * Z + D \rightarrow 0 = C * (3) + 17.82 \rightarrow C = -5.94\ KN/m^3$

Case 2: If the well is full of water with no soil pressure.

$\gamma\ for\ water = 10\ kN/m3, P = K * q + K * H * \gamma$

$When\ wall\ is\ at\ rest\ then\ K = \dfrac{1 - sin\emptyset}{1 + sin\emptyset} = 0.33,$

$H = 3, P = 0.33 * 3 * 10 = 30\ KN/m^2$

$P = C * Z + D = H, D = F\ Y(Z) = F\ at\ Z$

$when\ Z = 0 \rightarrow P = D = 30\ KN/m^2$

$when\ Z = 3$

$\rightarrow P = 0\ KN/m^2$

$0 = C * Z + D \rightarrow 0 = C * (3) + 30 \rightarrow C = -10\ KN/m^3$

$The\ critical\ case\ is\ case\ two\ with\ P = 30\ KN/m^2$

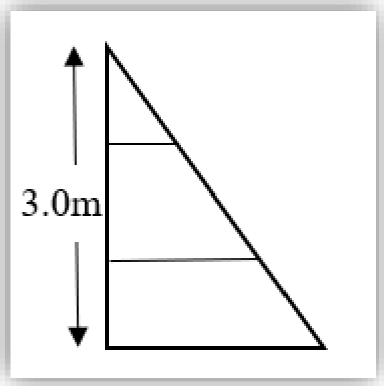


Figure 235:Well wall

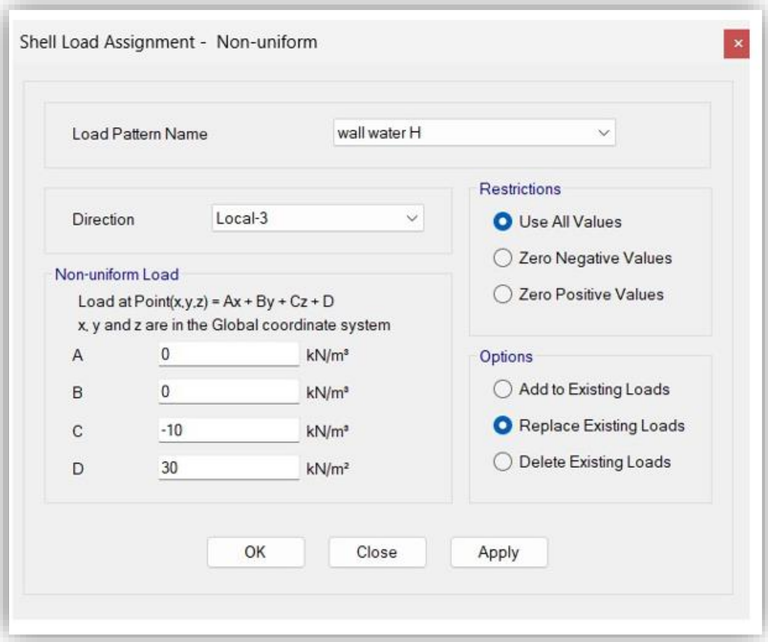


Figure 236:Shell Load

Soil pressure Check:

If all foundation has value less than 200KN/m^2, the check is ok.

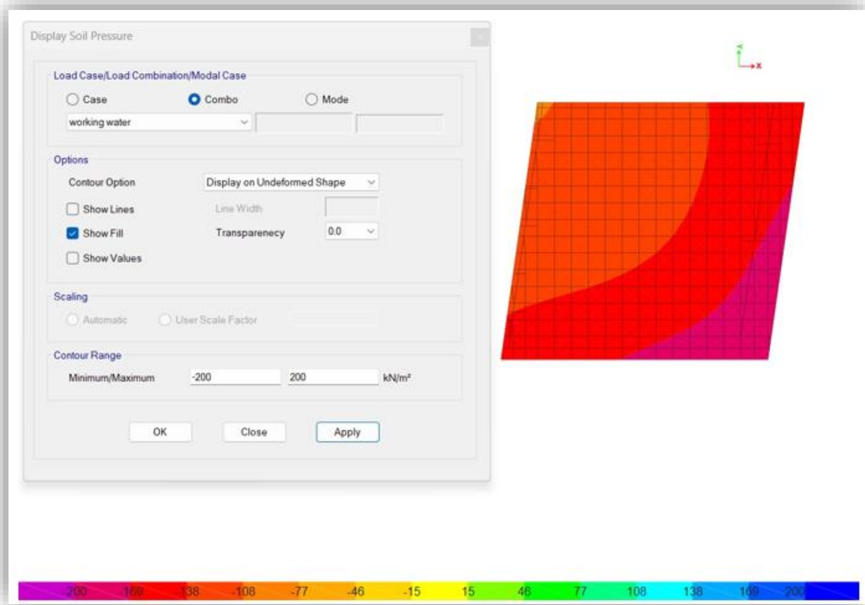


Figure 237:Foundation soil pressure check

Reinforcement for well mat foundation:

Mat foundation with 500 mm thickness

$As\ min\ =\ 0.0018\ *\ 1000\ *\ 500\ =\ 900\ mm^2/m\ (4\ Ø18/m)$

1- **In X direction:**

Use 1Ø18 /100mm for top rebar, 1Ø18 /150mm for bottom rebar

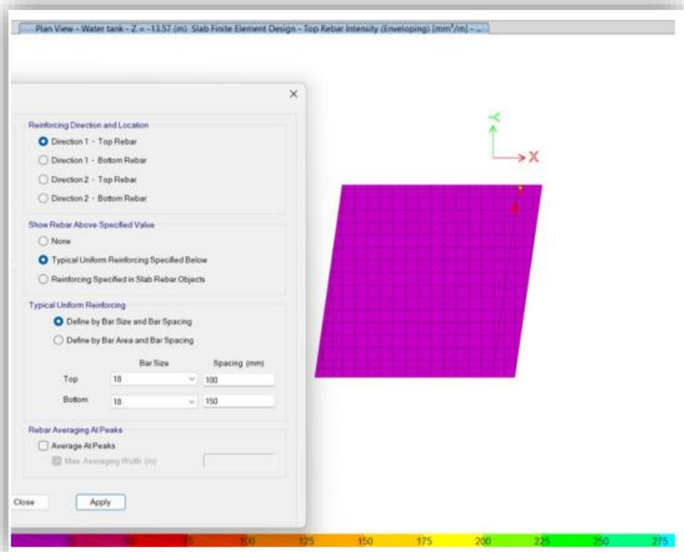


Figure 238: Well foundation design

2- **In Y direction**

Use 1Ø18 /100mm for top rebar, 1Ø18 /150mm for bottom rebar

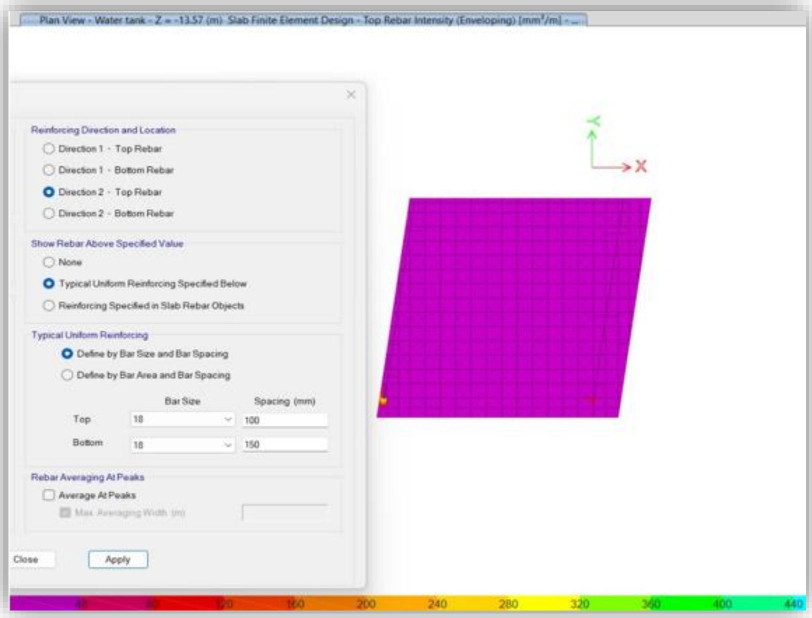


Figure 239:Well foundation design

Reinforcement for well Slab:

Slab with 200 mm thickness

1. **In X direction**

Use 1Ø12 /200mm for top rebar, 1Ø12 /200mm for bottom rebar

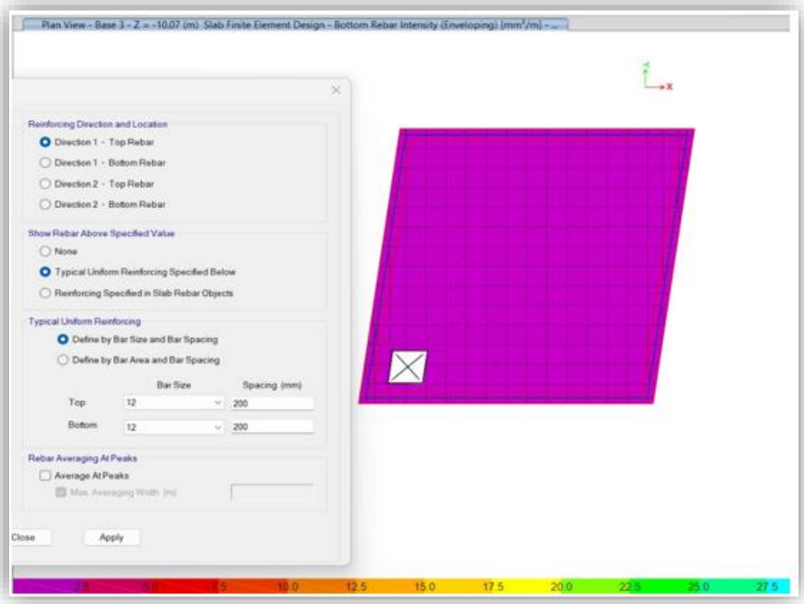


Figure 240:Well foundation design

2. In Y direction

Use 1Ø12 /200mm for top rebar, 1Ø12 /200mm for bottom rebar

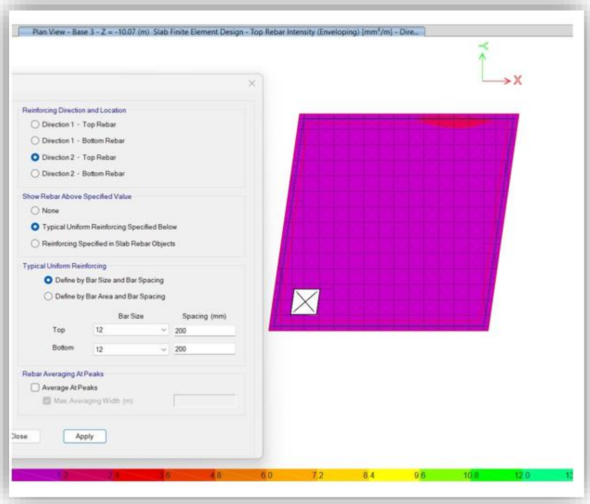


Figure 241:Well foundation design

Section in Well:

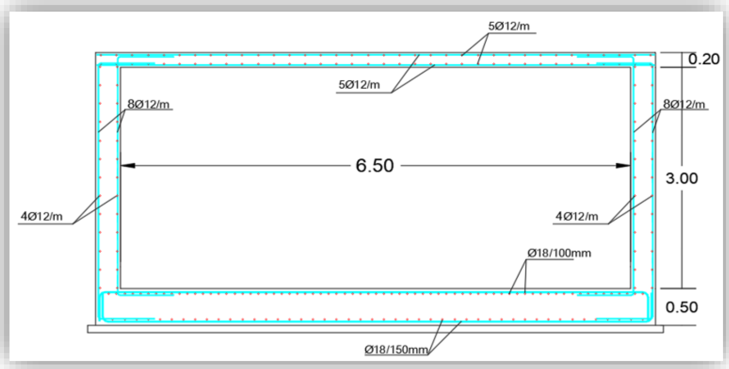


Figure 242:Well slab design

Table 47:Schedule for well (water tank) wall:

	Pier lable	Thickness	boundary width	boundary reinforcement for two side	vertical web reinforcement	Horizontal web reinforcement	boundary stirrup
Water Tank Wall	P water 1	0.3	0.3	4ø18/Layer	4ø12/m	4ø12/m	1ø10/150mm
	P water 2	0.3	0.3	4ø18/Layer	8ø12/m	4ø12/m	1ø10/150mm
	P water 3	0.3	0.3	4ø18/Layer	4ø12/m	4ø12/m	1ø10/150mm
	P water 4	0.3	0.3	4ø18/Layer	8ø12/m	4ø12/m	1ø10/150mm

Not : All the structural plans are attached in the conclusion-appendix section.

Chapter Four

Electro-mechanical Aspects

Chapter Four:Electro-mechanical Aspects

4.1 Artificial lighting design

Lighting plays a crucial role in enhancing both the visual appeal and functional effectiveness of any space, whether it be residential, commercial, or public. The right lighting design can significantly influence the atmosphere, mood, and productivity within an environment. In hotels, it is usually straightforward to adjust artificial lighting to achieve the desired effect. The choice of the artificial light source is determined by the specific space (such as the lobby, bedroom, gym, meeting room, restaurant, or kitchen), the quality and shape of the lighting needed, and the acceptable energy consumption. In summary, the thoughtful implementation of lighting design in hotels not only elevates the aesthetic and functional aspects of the space but also enhances the overall guest experience by catering to their emotional and physiological needs through carefully planned lighting scenarios.

Artificial lighting is meticulously designed for specific areas within the building using DIALUX software.

The table below illustrates the limits for Lux (illumination), UGR (Unified Glare Rating, CRI, CCT and Uniformity for each type of space:

Space	Illuminance (Lux)	UGR	Uniformity	CRI	CCT
Lobby hotel	300	22	0.6	80	2700-3000
Reception desk	300	22	0.6	80	2700-3000
Kitchen	500	22	0.6	80	4000
Halls	200	20	0.6	80	2700-3000
Bed rooms	200-500	22	0.6	90	2700-3000
Bathroom	150	19	0.6	80	3500-4000
Toilet	100	22	0.6	80	3500-4000
Gym	500	22	0.6	60	4000
Restaurant, Dining area	200-250	15	0.6	80	2700-3000
Laundry	200	22	0.6	80	4000
Corridors	100	25	0.4	80	2700-3000
Stairways	100	25	0.4	80	3000-4000
Elevators	150	17	0.6	90	3000-4000
Parking	75	25	0.6	80	4000-5000

Table 48:Standard Illuminance (Lux), Uniformity, and UGR for space

- Reflectivity

Many factors can affect the way light is reflected on other objects. These include the color of objects on which light is reflected, the type and texture of the material, and the angle and proximity of different objects compared to each other Here are some surfaces that are likely to be found in hotels:

• Glass: 8-80% (depends on type and thickness) .

• Concrete: 25-45% .

• Wood: 20-60% (depends on finish).

• Metal: varies greatly depending on the type and finish. For example, polished aluminum can reflect up to 80-90% of light, while oxidized or coarse metals may reflect much less.

• Mirror: reflects almost all incident light, usually about 90-95%.

Some approximate reflection values (as percentages) of colored surfaces under normal lighting conditions:

• Black: 1-10% (absorbs most light).

• Red: 10-30%.

• Blue: 10-30%.

• Green: 10-30%.

• Yellow: 30-50%.

• White: 70-90% (reflects most light).

• Grey: 50-70%.

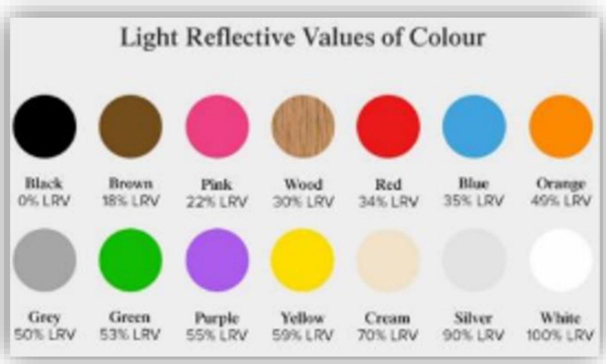


Figure 243: Light reflective values of colour

Some spaces were made on the Deluxe program and the rest of the spaces were circulated.

- Bedroom 7

The figure below shows the distribution of luminaires in Bedroom.

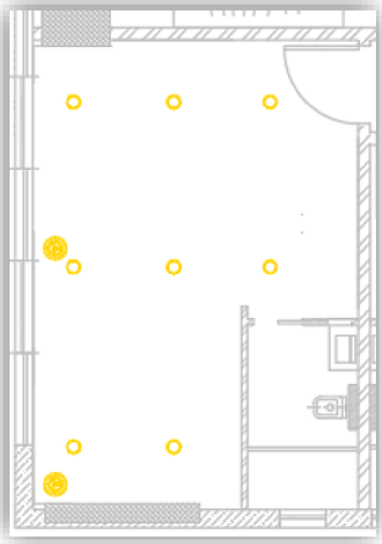
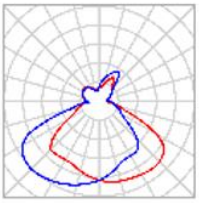


Figure 244:Distribution of luminaires in Bedroom

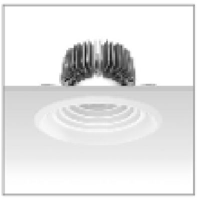
- The figure below shows the type of luminaire chosen for the Bedroom.

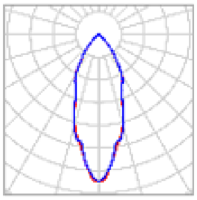
Artemide



Manufacturer	Artemide S.p.A.	P	52.0 W
Article No.	1128020A	$\Phi_{Luminaire}$	696 lm
Article name	Choose table Halo with diffuser that is covered by parchment paper		
Fitting	1x HSGSA (E27)		

Figure 245:The type of luminaire chosen to the Bedroom





Manufacturer	3F Filippi S.p.A.	P	37.0 W
Article No.	30583	$\Phi_{Luminaire}$	3315 lm
Article name	3F Reno 200 WH 3000/930 DALI SPOT		
Fitting	1x LED C COB Reno - 3000 - 930		

Figure 246:The type of luminaire chosen to the Bedroom

- Results from DIALUX

The average illuminance in the Bedroom is 510 Lux and the limit is 500 Lux, it is okay to design. The figure below shows the result for Bedroom.

	Symbol	Calculated	Target	Check	Index
Working plane	$E_{perpendicular}$	510 lx	≥ 500 lx	✓	WP4
	U_o (g_1)	0.62	≥ 0.60	✓	WP4
	Lighting power density	28.03 W/m²	-		
		5.49 W/m²/100 lx	-		
Glare valuation[1]	$R_{UG,max}$	22	≤ 22	✓	

Figure 247:Result for Bedroom

The figure below shows the number of luminaire and their types used in the space.

pcs.	Manufacturer	Article No.	Article name	P	Φ	Luminous efficacy
8	3F Filippi S.p.A.	30583	3F Reno 200 WH 3000/930 DALI SPOT	37.0 W	3315 lm	89.6 lm/W
2	Artemide S.p.A.	1128020A	Choose table Halo with diffuser that is covered by parchment paper	52.0 W	696 lm	13.4 lm/W

Figure 248:Luminaire list for bedroom

- The figures below show 3D views of Bedroom from the DIALUX program.

Figure 249:3D view for Bedroom

- Bathroom

The figure below shows the distribution of luminaires in the Bathroom.

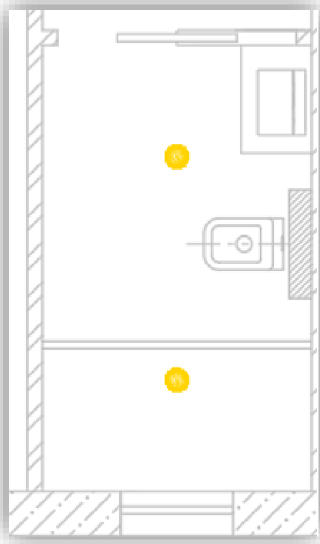


Figure 250:Distribution of luminaires in Bathroom

The figure below shows the type of luminaire chosen for the Bathroom.

Manufacturer	SLV	P	28.4 W
Article No.	1003681	$\Phi_{Luminaire}$	2322 lm
Article name	NUMINOS MOVE DL L		
Fitting	1x LED 4000K CRI>90		

Figure 251:the Type of luminaire chosen to the Bathroom

The figure below shows the number of luminaire and their types used in the space.

pcs.	Manufacturer	Article No.	Article name	P	Φ	Luminous efficacy
2	SLV	1003681	NUMINOS MOVE DL L	28.4 W	2322 lm	81.8 lm/W

Figure 252:Luminaire list for bathroom

- Results from DIALUX

The average illuminance in the Bathroom is 155 Lux and the limit is 150 Lux, it is okay to design.

The figure below shows the result for the Bathroom.

	Symbol	Calculated	Target	Check	Index
Working plane	$E_{perpendicular}$	155 lx	≥ 150 lx	✓	WP2
	U_o (g_1)	0.63	≥ 0.60	✓	WP2
	Lighting power density	12.66 W/m²	-		
		8.16 W/m²/100 lx	-		
Glare valuation[1]	$R_{UG,max}$	4	≤ 25	✓	
Energy estimation[2]	Consumption	[29.53 - 46.86] kWh/a	max. 200 kWh/a	✓	
Room	Lighting power density	10.51 W/m²	-		
		6.77 W/m²/100 lx	-		

Figure 253:Result for Bathroom

- The figures below show 3D views of the Bathroom from the DIALUX program.

Figure 254:3D view for Bathroom

- corridor

The figure below shows the distribution of luminaires in the corridor.

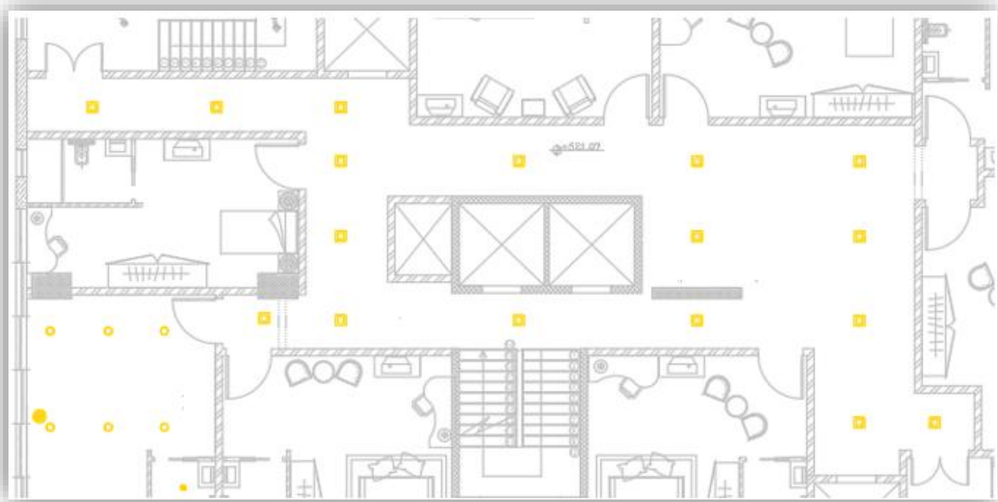
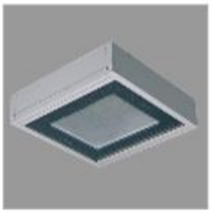
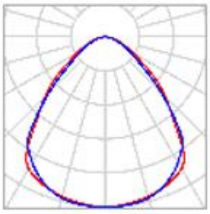


Figure 255: Distribution of luminaires in corridor

- The figure below shows the type of luminaire chosen to the corridor.

NORKA





Manufacturer	NORKA	P	29.0 W
Article No.	6851428349-H1	$\Phi_{Luminaire}$	3922 lm
Article name	TALON m1 - 4770lm, PC (fracture proof) clear, CDP-prism screen, 830/3000K, wide beam, silver		
Fitting	1x LED-Array		

Figure 256:Type of luminaire chosen to the corridor

The figure below shows the number of luminaire and their types used in the space.

pcs.	Manufacturer	Article No.	Article name	P	Φ	Luminous efficacy
17	NORKA	6851428349-H1	TALON m1 - 4770lm, PC (fracture proof) clear, CDP-prism screen, 830/3000K, wide beam, silver	29.0 W	3922 lm	135.2 lm/W

Figure 257:Luminaire list for corridor

- Results from DIALUX

The average illuminance in the corridor is 116 Lux and the limit is 100 Lux, it is okay to design.

The figure below shows the result for the corridor.

Figure 258:3D view for corridor

Figure 259:3D view for corridor

- Toilet

The figure below shows the distribution of luminaires in the Toilet.

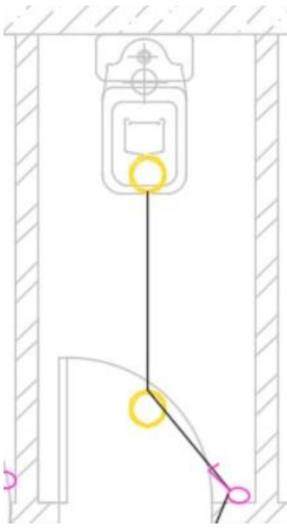
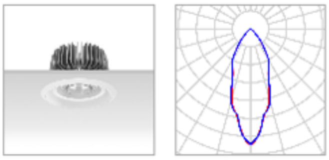


Figure 260:Distribution of luminaires in Toilet

The figure below shows the type of luminaire chosen to the Toilet.



Manufacturer	3F Filippi S.p.A.	P	29.0 W
Article No.	30298	$\Phi_{Luminaire}$	3319 lm
Article name	3F Reno 150 WH 3000/840 EP SPOT		
Fitting	1x LED C COB Reno - 3000 - 840		

Figure 261:The type of luminaire chosen to the Toilet

The figure below shows the number of luminaire and their types used in the space.

pcs.	Manufacturer	Article No.	Article name	R_{UG}	P	Φ	Luminous efficacy
2	3F Filippi S.p.A.	30298	3F Reno 150 WH 3000/840 EP SPOT	11	29.0 W	3319 lm	114.4 lm/W

Figure 262:Luminaire list for Toilet area

- Results from DIALUX

The average illuminance in the Toilet is 114 Lux and the limit is 100 Lux, it is okay to design.

The figure below shows the result for the Toilet.

	Symbol	Calculated	Target	Check	Index
Working plane	$E_{perpendicular}$	114 lx	≥ 100 lx	✓	WP29
	U_o (g_1)	0.70	≥ 0.60	✓	WP29
	Lighting power density	37.21 W/m²	-		
		32.61 W/m²/100 lx	-		
Glare valuation(1)	$R_{UG,max}$	11	≤ 25	✓	
Energy estimation(2)	Consumption	47.8 kWh/a	max. 100 kWh/a	✓	
Room	Lighting power density	27.00 W/m²	-		
		23.66 W/m²/100 lx	-		

Figure 263:Result for Toilet

- The figures below show 3D views for laundries area from DIALUX program.

Figure 264:3D view for Toilet

- Laundries area

The figure below shows the distribution of luminaires in laundries area.

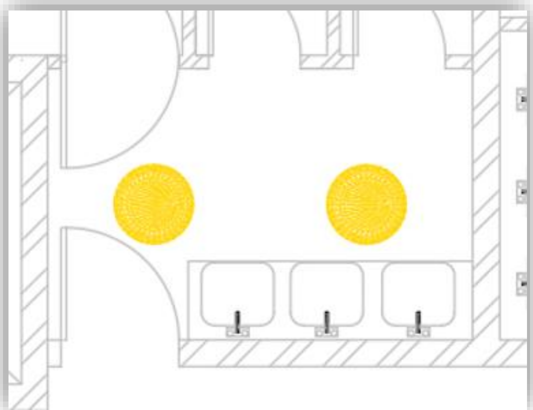


Figure 265:Distribution of luminaires in laundries area

The figure below shows the type of luminaire chosen to the laundries area.

Manufacturer	Philips	P	36.0 W
Article name	SM400C LED42S/840 OC PSU W60L60	$\Phi_{Luminaire}$	2915 lm
Fitting	1x		

Figure 266:The type of luminaire chosen to the laundries area

The figure below shows the number of luminaire and their types used in the space.

pcs.	Manufacturer	Article No.	Article name	P	Φ	Luminous efficacy
2	Philips		SM400C LED42S/840 OC PSU W60L60	36.0 W	4198 lm	116.6 lm/W

Figure 267:Luminaire list for laundries area

- Results from DIALUX

The average illuminance in the laundry area is 109 Lux and the limit is 100 Lux, it is okay to design.

The figure below shows the result for laundries area.

	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{perpendicular}$	109 lx	≥ 100 lx	✓	WP4
	U_o (g_1)	0.75	≥ 0.60	✓	WP4
Glare valuation(1)	$R_{UG,max}$	15	≤ 25	✓	
Energy estimation(2)	Consumption	59.4 kWh/a	max. 250 kWh/a	✓	
Room	Lighting power density	10.76 W/m²	-		
		9.85 W/m²/100 lx	-		

Figure 268:Result for laundries area

- The figures below show 3D views for laundries area from DIALUX program.

Figure 269:3D view for laundries area

- Entrance and reception

The figure below shows the distribution of luminaires in entrance and reception.

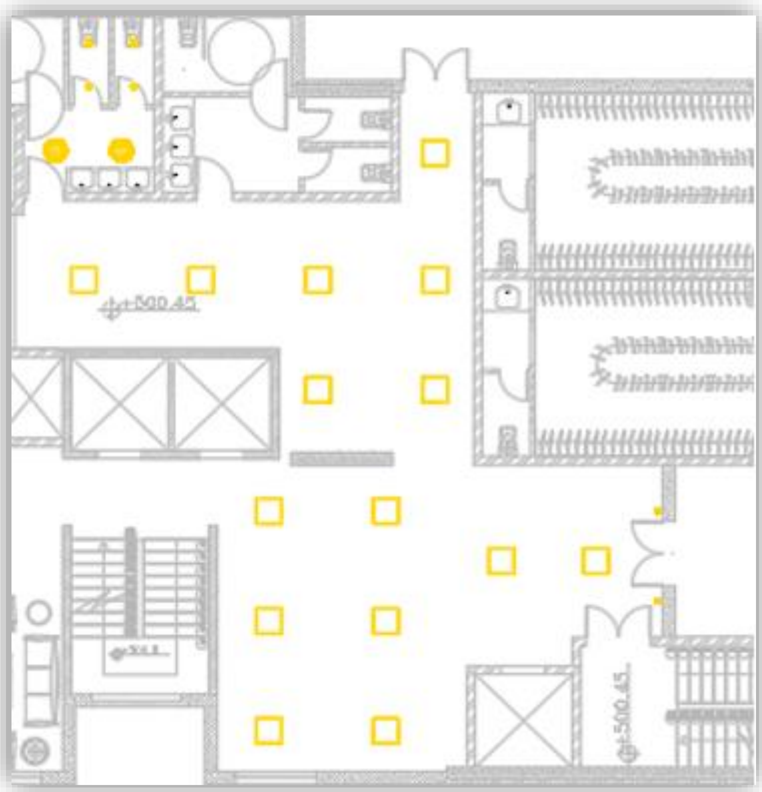
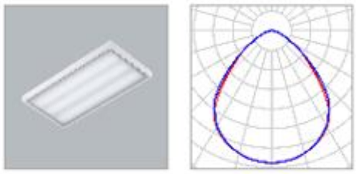


Figure 270:Distribution of luminaires in entrance and reception

The figure below shows the type of luminaire chosen to the entrance and reception.

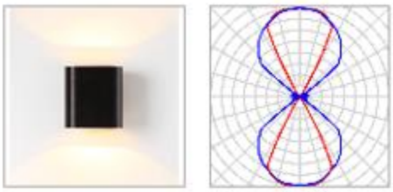
LUXIONA
Technical and Emergency Lighting



Manufacturer	LUXIONA	P	49.1 W
Article No.	19.4109.1411.34	$\Phi_{Luminaire}$	6343 lm
Article name	RUBIN CLEAN CLASS 5-6 LED 8800 MICRO-PRM SH E IP65 830 KRG3K / 600X600		
Fitting	4x LED 3000K 8811lm 46,8W		

Figure 271:The type of luminaire chosen to the entrance and reception

MODULAR LIGHTING — INSTRUMENTS



Manufacturer	Modular Lighting Instruments	P	12.0 W
Article No.	11074903	$\Phi_{Luminaire}$	535 lm
Article name	Duell wall LED 900lm 2700K GI ano black - black		
Fitting	2x V8 gen8 350mA 2700K		

Figure 272:The type of luminaire chosen to the entrance and reception

The figure below shows the number of luminaire and their types used in the space.

pcs.	Manufacturer	Article No.	Article name	P	Φ	Luminous efficacy
14	LUXIONA	19.4109.14 11.34	RUBIN CLEAN CLASS 5-6 LED 8800 MICRO-PRM SH E IP65 830 KRG3K / 600X600	49.1 W	6343 lm	129.2 lm/W
2	Modular Lighting Instruments	11074903	Duell wall LED 900lm 2700K GI ano black - black	12.0 W	535 lm	44.6 lm/W

Figure 273:Luminaire list for entrance and reception

- Results from DIALUX

The average illuminance in the reception is 314 Lux and the limit is 300 Lux, it is okay to design.

The figure below shows the result for entrance and reception.

	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{perpendicular}$	314 lx	≥ 300 lx	✓	WP32
	U_o (g_1)	0.62	≥ 0.60	✓	WP32
	Lighting power density	11.47 W/m²	–		
		3.66 W/m²/100 lx	–		
Glare valuation[(1)]	$R_{UG,max}$	20	≤ 22	✓	
Energy estimation[(2)]	Consumption	[1229.60 - 1369.45] kWh/a	max. 4400 kWh/a	✓	
Space	Lighting power density	5.67 W/m²	–		
		1.81 W/m²/100 lx	–		

Figure 274:Result for entrance and reception

- The figures below show 3D views for laundries area from DIALUX program.

Figure 275:3D view for entrance and reception

Figure 276:3D view for entrance and reception

- Hall

The figure below shows the distribution of luminaires in Hall.

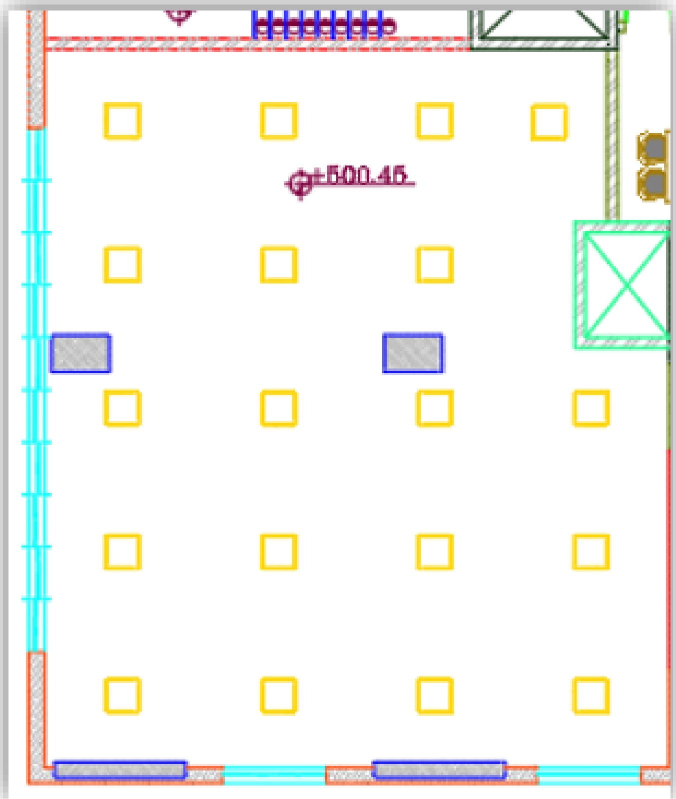
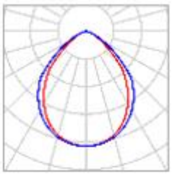


Figure 277:Distribution of luminaires in Hall

The figure below shows the type of luminaire chosen to the hall.



Manufacturer	LUXIONA	P	33.2 W
Article No.	19.4046.4511.34	$\Phi_{Luminaire}$	4329 lm
Article name	RUBIN CLEAN LED P SMOOTH 5400 MICRO-PRM SH E IP65 830 / 620X620		
Fitting	2x LED 3000K 5741lm 30,6W		

Figure 278:The type of luminaire chosen to the hall

The figure below shows the number of luminaire and their types used in the space.

pcs.	Manufacturer	Article No.	Article name	P	Φ	Luminous efficacy
19	LUXIONA	19.4046.45 11.34	RUBIN CLEAN LED P SMOOTH 5400 MICRO-PRM SH E IP65 830 / 620X620	33.2 W	4329 lm	130.4 lm/W

Figure 279:Luminaire list for hall

- Results from DIALUX

The average illuminance in the hall is 201 Lux and the limit is 200 Lux, it is okay to design.

The figure below shows the result for hall.

	Symbol	Calculated	Target	Check	Index
Working plane	$E_{perpendicular}$	201 lx	≥ 200 lx	✓	WP4
	U_o (g_1)	0.65	≥ 0.60	✓	WP4
	Lighting power density	5.96 W/m²	–		
		2.97 W/m²/100 lx	–		
Glare valuation(1)	$R_{UG,max}$	17	≤ 20	✓	
Energy estimation(2)	Consumption	[1853.54 - 2460.12] kWh/a	max. 5450 kWh/a	✓	
Room	Lighting power density	4.08 W/m²	–		
		2.04 W/m²/100 lx	–		

Figure 280:Result for hall

- The figures below show 3D views for laundries area from DIALUX program.

Figure 281:3D view for hall

Figure 282:3D view for hall

- Kitchen

The figure below shows the distribution of luminaires in the kitchen.

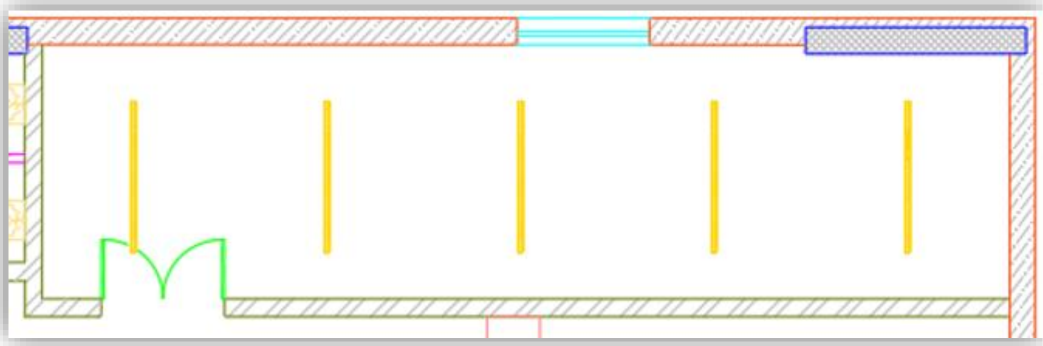
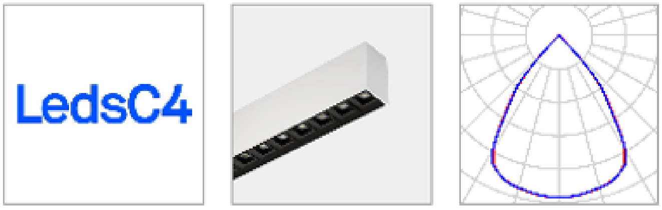


Figure 283:Distribution of luminaires in kitchen

The figure below shows the type of luminaire chosen to the kitchen.



Manufacturer	LEDS C4 S.A.	P	48.9 W
Article No.	AK18-48X9CLDS14	$\Phi_{Luminaire}$	6633 lm
Article name	Infinite Pro 1700mm Surface Opticell		
Fitting	1x LED neutral-white 4000K		

Figure 284:The type of luminaire chosen to the kitchen

The figure below shows the number of luminaire and their types used in the space.

pcs.	Manufacturer	Article No.	Article name	P	Φ	Luminous efficacy
5	LEDS C4 S.A.	AK18-48X9 CLDS14	Infinite Pro 1700mm Surface Opticell	48.9 W	6633 lm	135.6 lm/W

Figure 285:Luminaire list for kitchen

- Results from DIALUX

The average illuminance in the kitchen is 515 Lux and the limit is 500 Lux, it is okay to design.

The figure below shows the result for the kitchen.

	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{perpendicular}$	515 lx	≥ 500 lx	✓	WP9
	U_o (g_1)	0.67	≥ 0.60	✓	WP9
Glare valuation[1]	$R_{UG,max}$	19	≤ 19	✓	
Energy estimation[2]	Consumption	606 kWh/a	max. 1100 kWh/a	✓	
Room	Lighting power density	7.82 W/m²	–		
		1.52 W/m²/100 lx	–		

Figure 286:Result for kitchen

- The figures below show 3D views for kitchen from DIALUX program.

Figure 287:3D view for kitchen

- Restaurant

The figure below shows the distribution of luminaires in the restaurant.

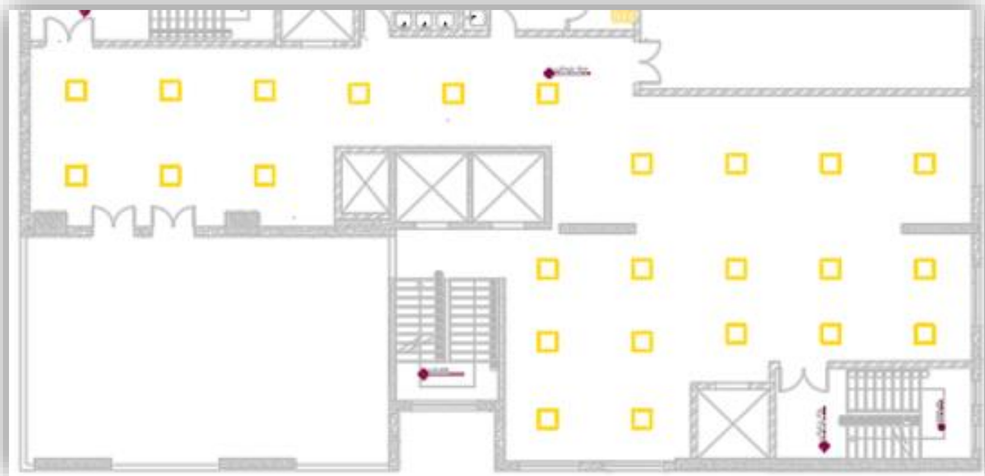
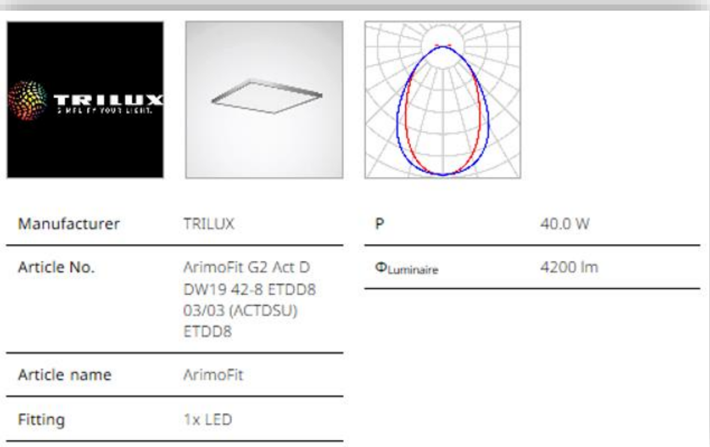


Figure 288:Distribution of luminaires in restaurant

The figure below shows the type of luminaire chosen to the restaurant.



Manufacturer	TRILUX	P	40.0 W
Article No.	ArimoFit G2 Act D DW19 42-8 ETDD8 03/03 (ACTDSU) ETDD8	$\Phi_{Luminaire}$	4200 lm
Article name	ArimoFit		
Fitting	1x LED		

Figure 289:The type of luminaire chosen to the restaurant

The figure below shows the number of luminaire and their types used in the space.

25	TRILUX	ArimoFit G2 Act D DW19 42-8 ETDD8 03/03 (ACTDSU) ETDD8	ArimoFit	40.0 W	4200 lm	105.0 lm/W

Figure 290:Luminaire list for restaurant

- Results from DIALUX

The average illuminance in the restaurant is 215 Lux and the limit is 200-250 Lux, it is okay to design.

The figure below shows the result for the restaurant.

	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{perpendicular}$	215 lx	≥ 200 lx	✓	WP1
	U_o (g_1)	0.60	≥ 0.60	✓	WP1
	Lighting power density	8.12 W/m²	-		
		3.77 W/m²/100 lx	-		
Glare valuation[1]	$R_{UG,max}$	19	≤ 19	✓	
Energy estimation[2]	Consumption	[3099.89 - 4105.92] kWh/a	max. 8500 kWh/a	✓	
Room	Lighting power density	4.35 W/m²	-		
		2.02 W/m²/100 lx	-		

Figure 291:Result for restaurant

- The figures below show 3D views for restaurant from DIALUX program.

Figure 292:3D view for restaurant

Figure 293:3D view for restaurant

GYM

The figure below shows the distribution of luminaires in the GYM.

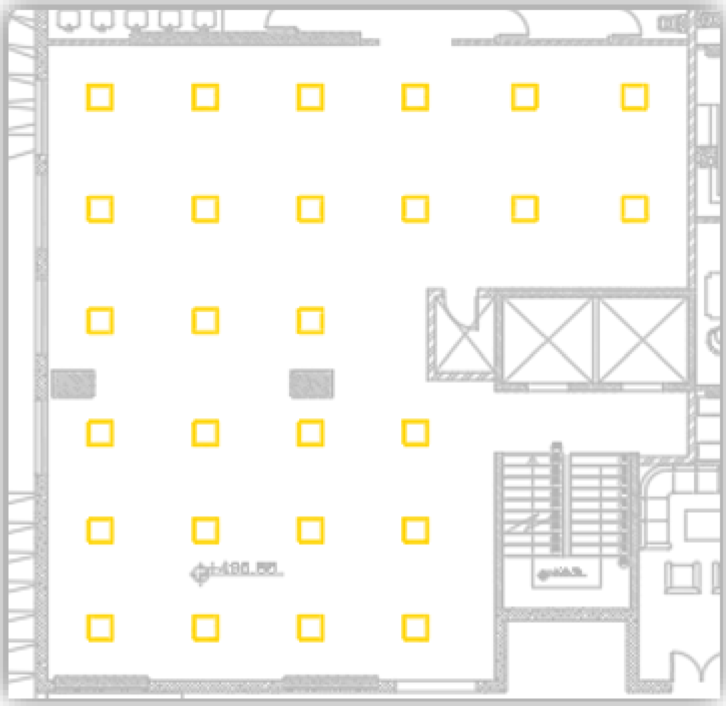
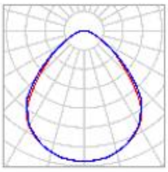


Figure 294:Distribution of luminaires GYM

The figure below shows the type of luminaire chosen to the GYM.

Manufacturer	LUXIONA	P	49.1 W
Article No.	19.4109.1411.34	$\Phi_{Luminaire}$	6343 lm
Article name	RUBIN CLEAN CLASS 5-6 LED 8800 MICRO-PRM SH E IP65 830 KRG3K / 600X600		
Fitting	4x LED 3000K 8811lm 46,8W		

Figure 295:The type of luminaire chosen to the GYM

The figure below shows the number of luminaire and their types used in the space.

pcs.	Manufacturer	Article No.	Article name	P	Φ	Luminous efficacy
27	LUXIONA	19.4109.14 11.34	RUBIN CLEAN CLASS 5-6 LED 8800 MICRO-PRM SH E IP65 830 KRG3K / 600X600	49.1 W	6343 lm	129.2 lm/W

Figure 296:Luminaire list for GYM

- Results from DIALUX

The average illuminance in the GYM is 502 Lux and the limit is 500 Lux, it is okay to design.

The figure below shows the result for the GYM.

	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{perpendicular}$	502 lx	≥ 500 lx	✓	WP1
	U_o (g_1)	0.60	≥ 0.60	✓	WP1
Glare valuation[(1)]	$R_{UG,max}$	19	≤ 22	✓	
Energy estimation[(2)]	Consumption	[4479.65 - 5531.09] kWh/a	max. 8100 kWh/a	✓	
Space	Lighting power density	5.94 W/m²	–		
		1.22 W/m²/100 lx	–		

Figure 297: Result for GYM

- The figures below show 3D views for GYM from DIALUX program.

Figure 298:3D view for GYM

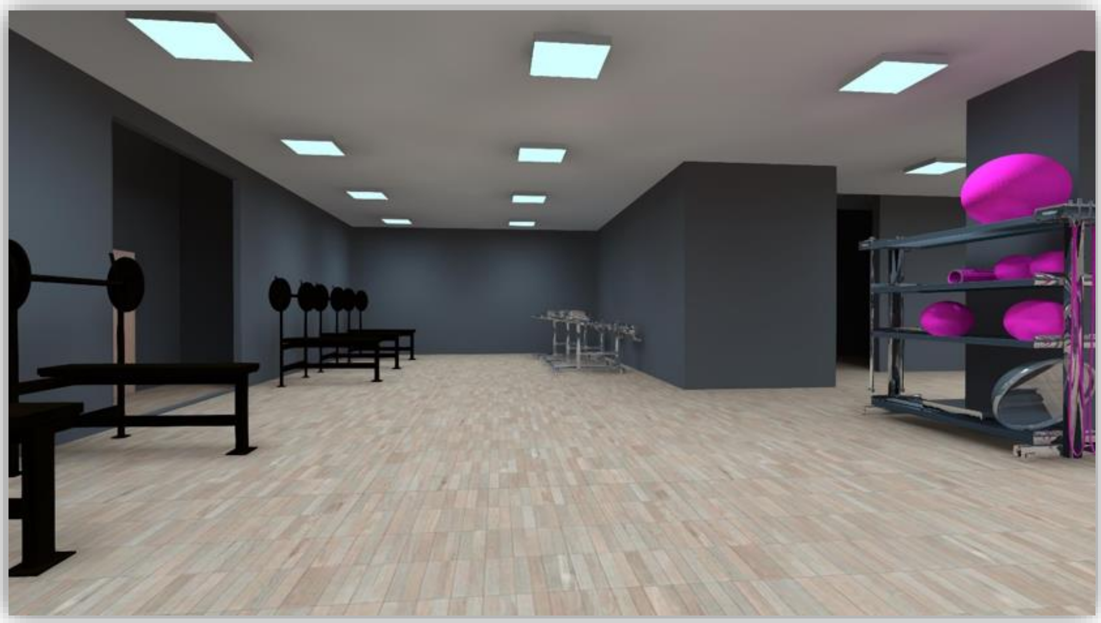


Figure 299:3D view for GYM

Laundry

The figure below shows the distribution of luminaires in the laundry.

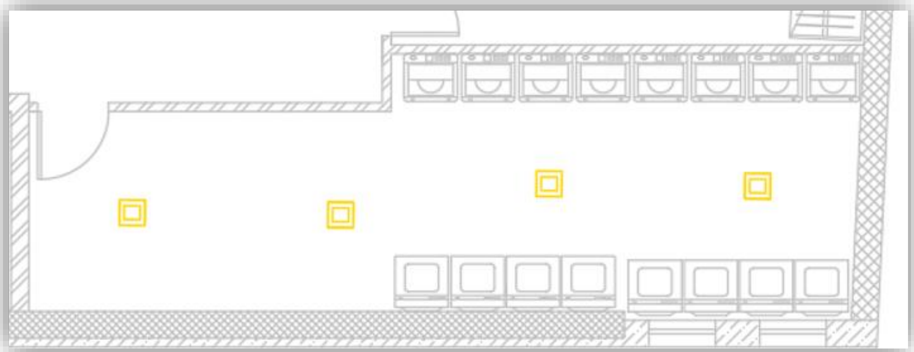
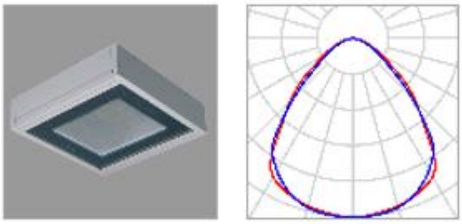


Figure 300:Distribution of luminaires laundry

The figure below shows the type of luminaire chosen to the laundry.

NORKA



Manufacturer	NORKA	P	29.0 W
Article No.	6851428349-H1	$\Phi_{Luminaire}$	3922 lm
Article name	TALON m1 - 4770lm, PC (fracture proof) clear, CDP-prism screen, 830/3000K, wide beam, silver		
Fitting	1x LED-Array		

Figure 301:The type of luminaire chosen to the laundry

The figure below shows the number of luminaire and their types used in the space.

pcs.	Manufacturer	Article No.	Article name	P	Φ	Luminous efficacy
4	NORKA	6851428349-H1	TALON m1 - 4770lm, PC (fracture proof) clear, CDP-prism screen, 830/3000K, wide beam, silver	29.0 W	3922 lm	135.2 lm/W

Figure 302:Luminaire list for laundry

- Results from DIALUX

The average illuminance in the laundry is 209 Lux and the limit is 200Lux, it is okay to design.

The figure below shows the result for the laundry.

Properties	$\bar{E}$ (Target)	E_{min}	E_{max}	U_o (g_1) (Target)	g_2	Index
Working plane (Room 4) Perpendicular illuminance (adaptive) Height: 0.915 m, Wall zone: 0.500 m	209 lx (≥ 200 lx) ✓	155 lx	239 lx	0.74 (≥ 0.60) ✓	0.65	WP4

Figure 303:Result for laundry

- The figures below show 3D views for laundry from DIALUX program.

Figure 304: 3D view for laundry

Figure 305:3D view for laundry

- Parking

The figure below shows the distribution of luminaires in parking.

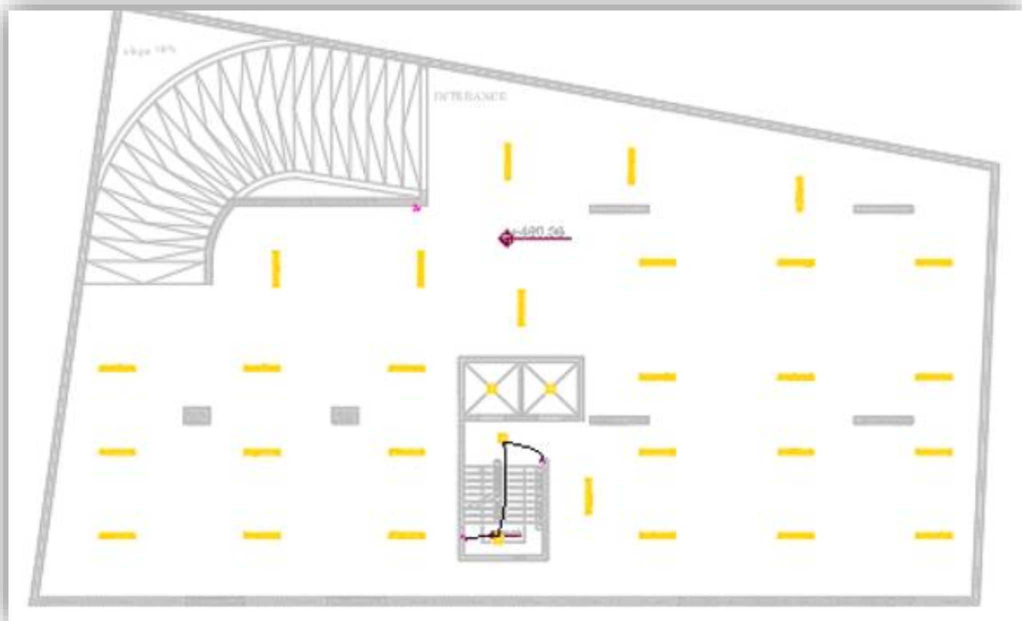
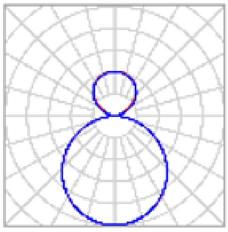


Figure 306:Distribution of luminaires parking

The figure below shows the type of luminaire chosen to the parking.

PHILIPS



Manufacturer	Philips	P	52.0 W
Article name	SP342P LED60S/930 O SRD L1500	$\Phi_{Luminaire}$	5999 lm
Fitting	1x		

Figure 307:The type of luminaire chosen to the parking

The figure below shows the number of luminaire and their types used in the space.

pcs.	Manufacturer	Article No.	Article name	P	Φ	Luminous efficacy
27	Philips		SP342P LED60S/930 O SRD L1500	52.0 W	5999 lm	115.4 lm/W

Figure 308:Luminaire list for parking

- Results from DIALUX

The average illuminance in the parking is 79.1 Lux and the limit is 75Lux, it is okay to design.

The figure below shows the result for the parking.

	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{perpendicular}$	79.9 lx	≥ 75.0 lx	✓	WP4
	U_o (g_1)	0.53	≥ 0.40	✓	WP4
	Lighting power density	0.00 W/m²	-		
		0.00 W/m²/100 lx	-		
Energy estimation[2]	Consumption	0.00 kWh/a	max. 23700 kWh/a	✓	
Room	Lighting power density	0.00 W/m²	-		
		0.00 W/m²/100 lx	-		

Figure 309:Result for parking

- The figures below show 3D views for parking from DIALUX program

Figure 310:: 3D view for parking

Figure 311:3D view for parking

4.2 HVAC design

4.2.1 Introduction

The building must be equipped with a suitable HVAC system that achieves thermal comfort for individuals and users, which depends on temperature and humidity. In this project, the Variable Refrigerant Flow (VRF) system was used. This system provides ease of installation and reduces the number of outdoor units needed. This system consists of:

- Outdoor unit
- Indoor unit
- Controller

The Design builder software was used to obtain the heating and cooling loads values:

Design capacity = 142.92 KW.

Tin (winter) = 22 ℃.

Tin (summer) = 25 ℃.

Relative humidity = 30%-70%.

4.2.2 Selecting VRF units

➢ Outdoor unit

An external VRV unit from DAIKIN company was selected which has capacity = 56 KW,

We need 3 units from this type to reach the demand, 142.92/56 = 2.6 = 3 units.

OUTDOOR SYSTEM				RYYQ8T	RXYQ8T	RYYQ10T	RXYQ10T	RYYQ12T	RXYQ12T	RYYQ14T	RXYQ14T	RYYQ16T	RXYQ16T	RYYQ18T	RXYQ18T	RYYQ20T	RXYQ20T
Capacity range			HP	8		10		12		14		16		18		20	
Cooling capacity	Nom.		kW	22.4		28.0		33.5		40.0		45.0		50.0		56.0	
Heating capacity	Nom.		kW	25.0		31.5		37.5		45.0		50.0		56.0		63.0	
Power input - 50Hz	Cooling	Nom.	kW	5.2		7.29		8.98		11.0		13.0		14.7		18.5	
	Heating	Nom.	kW	5.5		7.38		9.10		11.2		12.8		14.4		17.0	

Figure 312:The external VRV unit that used in the project from Daikin company.

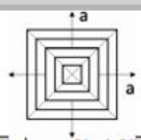
➢ Selecting diffusers

Diffusers are essential components in HVAC system, they distribute air in the spaces. Many types of diffusers have been used in the project from Andalosia, and DAIKIN companies. These types are:

- Linear slot diffusers: Type: straight linear slot.

Figure 313:Linear slot diffuser used in the project.

- Square diffuser: Four-way throw.



MODEL 4SCD FOUR-WAY THROW SQUARE DIFFUSER

NECKSIZE AK	Neck VELOCIY FPM	200	300	400	500	600	700	800	900
	TOTAL PRESSURE	.019	.039	.067	.10	.14	.19	.24	.30
6"x6"	TOTAL CFM	50	75	100	125	150	175	200	225
	CFM each side – a	13	19	25	32	38	44	50	57
AK= 0.13	Throw each side – a	2-3	3-5	4-7	5-9	6-11	7-13	8-15	9-17
9"x9"	TOTAL CFM	112	168	224	280	336	392	448	504
	CFM each side – a	28	42	56	70	84	98	112	126
AK= 0.28	Throw each side – a	2-3	3-5	4-8	5-10	6-12	7-14	9-17	9-18
12"x12"	TOTAL CFM	200	300	400	500	600	700	800	900
	CFM each side – a	50	75	100	125	150	175	200	225
AK= 0.5	Throw each side – a	2-4	4-7	5-9	6-11	7-14	8-16	10-19	11-21
15"x15"	TOTAL CFM	312	468	624	780	936	1092	1248	1404
	CFM each side – a	78	117	156	159	235	273	312	351
AK= 0.79	Throw each side – a	3-5	4-8	5-10	7-13	8-16	10-19	11	12-24
18"x18"	TOTAL CFM	450	675	900	1125	1350	1575	1800	2025
	CFM each side – a	113	169	225	281	338	394	450	507
AK= 0.13	Throw each side – a	3-5	4-8	5-10	7-13	9-17	10-20	12-24	13-26
21"x21"	TOTAL CFM	612	918	1224	1530	1836	2142	2448	275
	CFM each side – a	153	229	306	382	459	535	612	689
AK= 1.54	Throw each side – a	3-5	4-8	6-11	7-13	9-18	11-21	13-25	14-28
24"x24"	TOTAL CFM	800	1200	1600	2000	2400	2800	3200	3600
	CFM each side – a	200	300	400	500	600	700	800	900
AK= 2	Throw each side – a	3-6	5-9	6-12	7-14	10-19	11-22	13-26	15-30

Figure 314:Square diffuser used in the project.

This type of diffusers depends on the noise criteria (NC), of the space, depending on the type of the space.

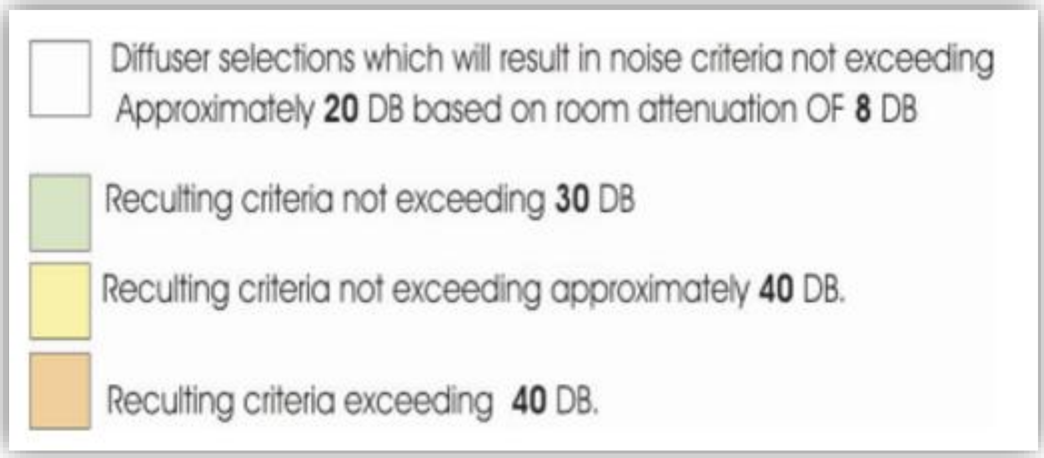


Figure 315:Explaining the meaning of each color in the catalogue selected in terms of NC.

In Hotels, NC values are:

NC: 30-40 in individual's rooms or suits, bell rooms, banquet rooms.

NC: 35-45 in halls, corridors, and lobbies.

Diffusers were selected based on their flow rate values so that they match and cover the flow rate value of the space. Based on this, the number of diffusers needed for each space was calculated.

The tables below show the types and quantities of diffusers that used in the project.

Table 49:Types and quantities of diffusers used in basement1.

Basement1							
Zone	Design flow rate (m^3/s)	Design flow (CFM)	Design Capacity (KW)	Diffuser used	Air flow of diffuser used (CFM)	Size of diffuser used (In)	No. of diffusers
Worker bedroom	0.0495	104.88	0.62	Square diffuser	175	6" * 6"	1
Workwear area	0.1451	307.45	1.58	Square diffuser	336	9" * 9"	1
Kitchen1	0.1491	315.9	1.18	Square diffuser	336	9" * 9"	1
Living room	0.101	214	1.25	Square diffuser	336	9" * 9"	1
Director's room	0.1342	274.35	1.64	Square diffuser	336	9" * 9"	1
Ironing area	0.1361	288.38	1.72	Square diffuser	336	9" * 9"	1
Publishing area	0.0945	200.23	1.17	Square diffuser	336	9" * 9"	1
Entrance	0.1226	259.77	1.49	Square diffuser	336	9" * 9"	1
Dressing room	0.9855	2088	10.92	Square diffuser	2142	21" * 21"	1
Corridor	0.0533	112.94	0.65	Square diffuser	175	6" * 6"	1

Zone	Design flow rate (m^3/s)	Design flow rate (CFM)	Design Capacity (KW)	Diffuser used	Flow rate of the selected diffuser (CFM)	No. of diffusers
Gym	0.7911	1676.25	10.49	Linear slot diffuser	400	5

Table 50:Types and quantities of diffusers used in ground floor.

Ground floor							
Zone	Design flow rate (m^3/s)	Design flow rate (CFM)	Design Capacity (KW)	Diffuser used	Air flow of diffuser used (CFM)	Size of diffuser used (In)	No. of diffusers
Shop1	0.0948	200.87	1.18	Square diffuser	225	6" * 6"	1
Shop2	0.0819	173.54	1.03	Square diffuser	225	6" * 6"	1
Corridor	0.1661	351.95	2.02	Square diffuser	225	6" * 6"	2
Entrance	0.2722	576.76	3.34	Square diffuser	225	6" * 6"	3

Zone	Design flow rate (m^3/s)	Design flow rate (CFM)	Design Capacity (KW)	Diffuser used	Flow rate of the selected diffuser (CFM)	No. of diffusers
Reception	0.693	1468.4	8.28	Linear slot diffuser	400	4

Table 51: Types and quantities of diffusers used in Attic floor.

Attic floor							
Zone	Design flow rate (m^3/s)	Design flow rate (CFM)	Design Capacity (KW)	Diffuser used	Air flow of diffuser used (CFM)	Size of diffuser used (In)	No. of diffusers
Coffee shop	0.7474	1583	9.12	Square diffuser	336	9" * 9"	5
Kitchen	0.1491	315.92	1.84	Square diffuser	225	6" * 6"	2

Table 52:Types and quantities of diffusers used in first floor.

First floor							
Zone	Design flow rate (m^3/s)	Design flow rate (CFM)	Design Capacity (KW)	Diffuser used	Air flow of diffuser used (CFM)	Size of diffuser used	No. of diffusers
Bedroom1	0.1908	404.28	2.31	Linear slot diffuser	400	2m, 2slot	1
Bedroom2	0.0461	97.68	0.58	Linear slot diffuser	200	1m, 2slot	1
Bedroom3	0.0647	137.09	0.8	Linear slot diffuser	200	1m, 2slot	1
Bedroom4	0.0527	111.66	0.67	Linear slot diffuser	200	1m, 2slot	1
Bedroom5	0.1381	292.61	1.68	Linear slot diffuser	400	2m, 2slot	1
Bedroom6	0.1022	216.55	1.27	Linear slot diffuser	400	2m, 2slot	1
Bedroom7	0.0573	121.41	0.72	Linear slot diffuser	200	1m, 2slot	1
Bedroom8	0.0266	56.36	0.34	Linear slot diffuser	200	2m, 2slot	1
Corridor	0.3355	710.88	4.18	Square diffuser	336	9” * 9”	3

Table 53: Types and quantities of diffusers used in second floor.

Second floor							
Zone	Design flow rate (m^3/s)	Design flow (CFM)	Design Capacity (KW)	Diffuser used	Air flow of diffuser used (CFM)	Size of diffuser used	No. of diffusers
Bedroom9	0.1923	407.46	2.33	Linear slot diffuser	400	2m, 2slot	1
Bedroom10	0.0433	91.74	0.55	Linear slot diffuser	200	1m, 2slot	1
Bedroom11	0.0619	131.16	0.77	Linear slot diffuser	200	1m, 2slot	1
Bedroom12	0.0515	109.12	0.66	Linear slot diffuser	200	1m, 2slot	1
Bedroom13	0.1422	301.38	1.74	Linear slot diffuser	400	2m, 2slot	1
Bedroom14	0.1045	221.24	1.3	Linear slot diffuser	400	2m, 2slot	1
Bedroom15	0.0628	133.07	0.79	Linear slot diffuser	200	1m, 2slot	1
Bedroom16	0.0269	56.99	0.34	Linear slot diffuser	200	1m, 2slot	1
Corridor	0.3267	692.24	4.07	Square diffuser	336	9” * 9”	3

Table 54: Types and quantities of diffusers used in third floor.

Third floor							
Zone	Design flow rate (m^3/s)	Design flow (CFM)	Design Capacity (KW)	Diffuser used	Air flow of selected diffuser (CFM)	Size of diffuser used	No. of diffusers
Bedroom17	0.1942	411.48	2.35	Linear slot diffuser	400	2m, 2slot	1
Bedroom18	0.044	93.23	0.56	Linear slot diffuser	200	1m, 2slot	1
Bedroom19	0.0638	135.18	0.79	Linear slot diffuser	200	1m, 2slot	1
Bedroom20	0.0499	105.73	0.64	Linear slot diffuser	200	1m, 2slot	1
Bedroom21	0.1434	303.84	1.75	Linear slot diffuser	400	2m, 2slot	1
Bedroom22	0.1066	225.78	1.32	Linear slot diffuser	400	2m, 2slot	1
Bedroom23	0.059	125.01	0.74	Linear slot diffuser	200	1m, 2slot	1
Bedroom24	0.0267	56.57	0.34	Linear slot diffuser	200	1m, 2slot	1
Corridor	0.3258	690.33	4.06	Square diffuser	336	9” * 9”	3

Table 55: Types and quantities of diffusers used in fourth floor.

Fourth floor							
Zone	Design flow rate (m^3/s)	Design flow rate (CFM)	Design Capacity (KW)	Diffuser used	Air flow of selected diffuser (CFM)	Size of diffuser used	No. of diffusers
Bedroom25	0.1952	413.6	2.36	Linear slot diffuser	400	2m, 2slot	1
Bedroom26	0.0446	94.5	0.57	Linear slot diffuser	200	1m, 2slot	1
Bedroom27	0.0652	138.15	0.81	Linear slot diffuser	200	1m, 2slot	1
Bedroom28	0.0481	101.92	0.61	Lineaslot diffuser	200	1m, 2slot	1
Bedroom29	0.1447	306.6	1.77	Linear slot diffuser	400	2m, 2slot	1
Bedroom30	0.1076	228	1.33	Linear slot diffuser	400	2m, 2slot	1
Bedroom31	0.0635	134.55	0.8	Linear slot diffuser	200	1m, 2slot	1
Bedroom32	0.027	57.2	0.34	Linear slot diffuser	200	1m, 2slot	1
Corridor	0.3271	693.08	4.08	Square diffuser	336	9” * 9”	3

Table 56:: Types and quantities of diffusers used in fifth floor.

Fifth floor							
Zone	Design flow rate (m^3/s)	Design flow rate (CFM)	Design Capacity (KW)	Diffuser used	Air flow of diffuser used (CFM)	Size of diffuser used	No. of diffusers
Bedroom33	0.1793	379.91	2.18	Linear slot diffuser	400	2m, 2slot	1
Bedroom34	0.0488	103.4	0.61	.Linear slot diffuser	200	1m, 2slot	1
Bedroom35	0.0679	143.87	0.83	Linear slot diffuser	200	1m, 2slot	1
Bedroom36	0.0567	120.14	0.72	Linear slot diffuser	200	1m, 2slsot	1
Bedroom37	0.1444	305.97	1.76	Linear slot diffuser	400	2m, 2slot	1
Bedroom38	0.1199	254.054	1.45	Linear slot diffuser	400	2m, 2slot	1
Bedroom39	0.0964	204.26	1.12	Linear slot diffuse	400	2m, 2slot	1
Bedroom40	0.0326	69.07	0.41	Linear slot diffuser	200	1m, 2slot	1
Corridor	0.3392	718.72	4.22	Square diffuser	336	9” * 9”	3

Table 57: Types and quantities of diffusers used Sixth floor.

Sixth floor							
Zone	Design flow rate (m^3/s)	Design flow (CFM)	Design Capacity (KW)	Diffuser used	Air flow of diffuser used (CFM)	Size of diffuser used	No. of indoor units
Kitchen	0.328	694.99	3.87	Square diffuser	366	9” * 9”	2
Restaurant	1.288	2729	14.47	Square diffuser	600	12” * 12”	5

➢ Fan coil units

A fan coil unit of type FWB – BT was selected from Daikin company.

Figure 316:Fan coil unit used in the project.

The number of fan coil units required on each floor has been calculated, and the types of fan coil units have been selected from the DAIKIN company.

Table 58:Types and quantities of fan coil units used in each floor from DAIKIN company.

The floor	No. of Fan coil unit	Air flow (m^3/s)	Capacity (KW)	Type of fan coil unit used	Capacity of the type used (KW)
Basement1	Fan coil No.1	1.8299	10.49	FWB-BT	10.34
	Fan coil No.2	0.4447	3.38	FWB-BT	3.49
	Fan coil No.3	0.4874	5.92	FWB-BT	6.47
Ground floor	Fan coil No.4	0.4383	5.36	FWB-BT	6.47
	Fan coil No.5	0.1767	2.21	FWB-BT	2.61
Attic floor	Fan coil No.6	0.693	8.24	FWB-BT	8.67
	Fan coil No.7	0.8965	10.96	FWB-BT	10.34
First floor	Fan coil No.8	0.716	8.83	FWB-BT	8.67
	Fan coil No.9	0.298	3.72	FWB-BT	5.08
Second floor	Fan coil No.10	0.3031	3.787	FWB-BT	5.08
	Fan coil No.11	0.709	8.76	FWB-BT	8.67
Third floor	Fan coil No.12	0.205	3.75	FWB-BT	5.08
	Fan coil No.13	0.7125	6.58	FWB-BT	7.57
Fourth floor	Fan coil No.14	0.307	3.83	FWB-BT	3.49
	Fan coil No.15	0.716	8.84	FWB-BT	8.67
Fifth floor	Fan coil No.16	0.362	4.287	FWB-BT	5.08
	Fan coil No.17	0.544	8.9	FWB-BT	8.67
Sixth floor	Fan coil No.18	0.515	5.788	FWB-BT	6.47
	Fan coil No.19	1.1008	12.552	FWB-BT	10.34

4.2.3 Ventilation design for car parking in basement2, and basement3.

Basement2

$$CFMexhaust \ = \frac{V * ACH}{1.7}$$

$V: space\ volume\ in\ m^3.$

$ACH: Air\ change\ per\ volume.$

$Parking\ volume = \ 1474.364\ m^3.$

$The\ recommended\ air\ change\ per\ volume\ is\ 8\ in\ garages\ from\ ASHRAE.$

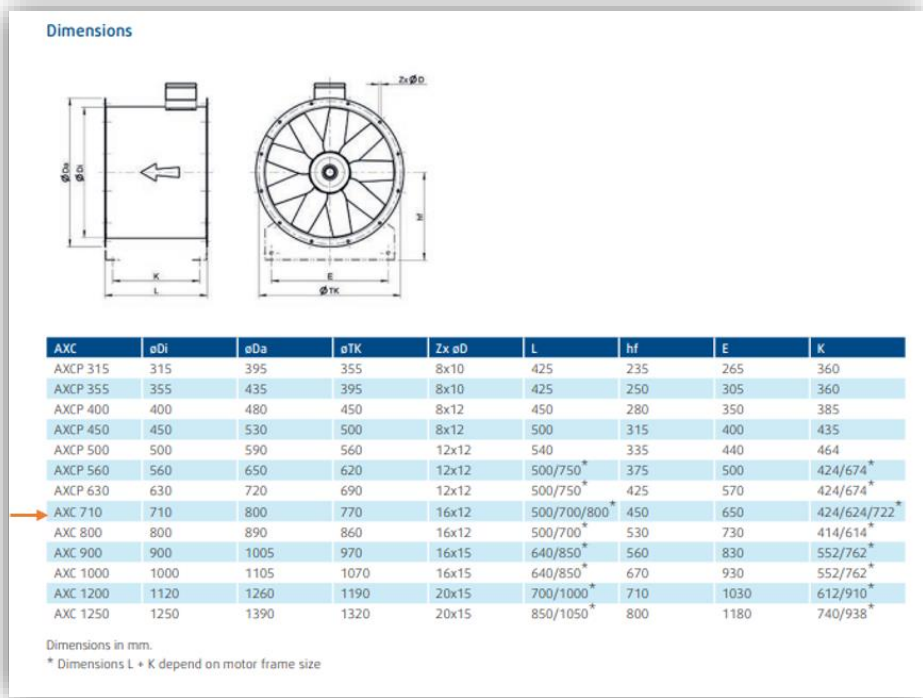
$$CFMexhaust \ = \frac{1474.364 * 8}{1.7} \ = \ 6938.18\ cfm \ \rightarrow \ 11788.043\ m^3/h.$$

$$CFMfresh \ = \ (0.85 - 0.9) * CFMexhaust \ = \ 0.85 * 6938.18$$

$$= \ 5897.45\ cfm \ \rightarrow \ 10019.83\ m^3/h.$$

There is a need to use an exhaust fan with 6938.18 cfm capacity, and a fresh fan with 5897.45 cfm capacity.

- **Exhaust fan**


Dimensions

AXC	øDi	øDa	øTK	Zx øD	L	hf	E	K
AXCP 315	315	395	355	8x10	425	235	265	360
AXCP 355	355	435	395	8x10	425	250	305	360
AXCP 400	400	480	450	8x12	450	280	350	385
AXCP 450	450	530	500	8x12	500	315	400	435
AXCP 500	500	590	560	12x12	540	335	440	464
AXCP 560	560	650	620	12x12	500/750*	375	500	424/674*
AXCP 630	630	720	690	12x12	500/750*	425	570	424/674*
AXC 710	710	800	770	16x12	500/700/800*	450	650	424/624/722*
AXC 800	800	890	860	16x12	500/700*	530	730	414/614*
AXC 900	900	1005	970	16x15	640/850*	560	830	552/762*
AXC 1000	1000	1105	1070	16x15	640/850*	670	930	552/762*
AXC 1200	1120	1260	1190	20x15	700/1000*	710	1030	612/910*
AXC 1250	1250	1390	1320	20x15	850/1050*	800	1180	740/938*

Dimensions in mm.
* Dimensions L + K depend on motor frame size

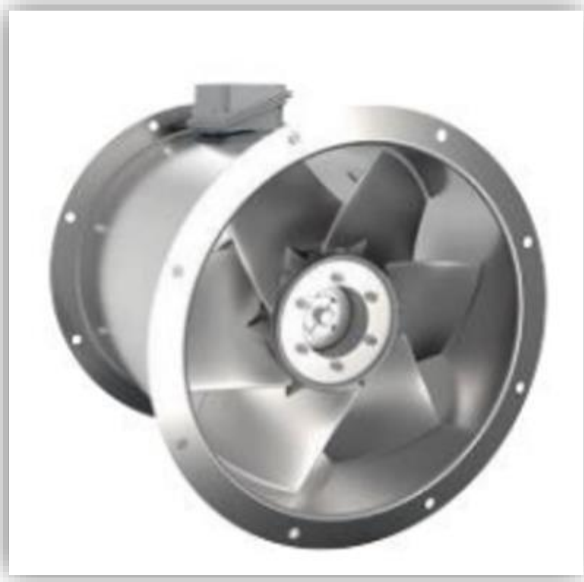


Figure 317: Exhaust fan that used in basement2.

Type AXC 710 was used, D = 710.

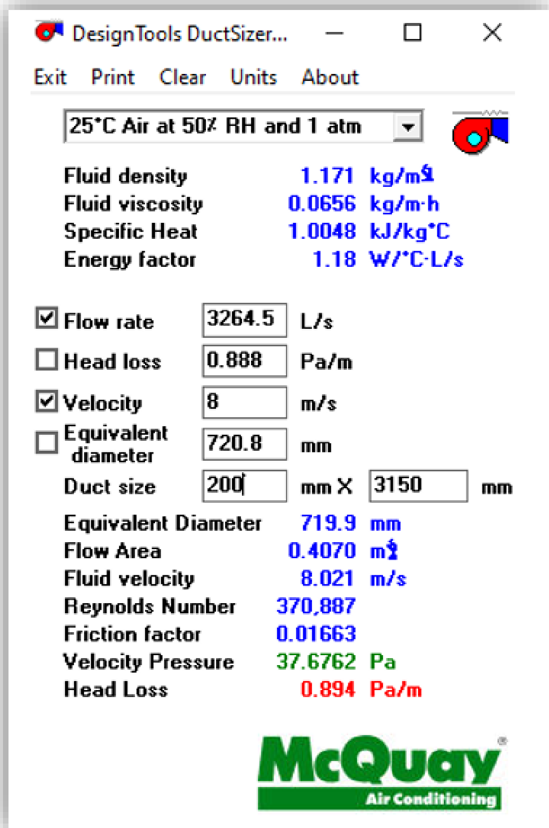


Figure 318: Duct sizing for duct used in basement2 for exhaust air.

From duct sizer calculator, main exhaust duct size is 200*3150, with diameter 720.8mm.

Diffuser selection

There is a need for 4 diffusers with each capacity = 1597 cfm, with size 600*200mm.

They were selected from: (Ventilation air grille diffuser air vent manufacturer since 2002) catalog.

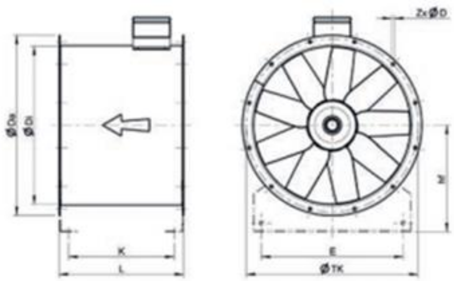
Standard size :

Item Code	Neck Size(mm)	Face Size(mm)
DG-A	300×150	325×175
DG-A	300×300	325×325
DG-A	400×200	425×225
DG-A	600×150	625×175
DG-A	600×200	625×225
DG-A	600×300	625×325

Figure 319: diffuser selection for basement2 for exhaust air.

- **Fresh fan**

Dimensions



AXC	øDi	øDa	øTK	Zx øD	L	hf	E	K
AXCP 315	315	395	355	8x10	425	235	265	360
AXCP 355	355	435	395	8x10	425	250	305	360
AXCP 400	400	480	450	8x12	450	280	350	385
AXCP 450	450	530	500	8x12	500	315	400	435
AXCP 500	500	590	560	12x12	540	335	440	464
AXCP 560	560	650	620	12x12	500/750*	375	500	424/674*
AXCP 630	630	720	690	12x12	500/750*	425	570	424/674*
AXC 710	710	800	770	16x12	500/700/800*	450	650	424/624/722*
AXC 800	800	890	860	16x12	500/700*	530	730	414/614*
AXC 900	900	1005	970	16x15	640/850*	560	830	552/762*
AXC 1000	1000	1105	1070	16x15	640/850*	670	930	552/762*
AXC 1200	1120	1260	1190	20x15	700/1000*	710	1030	612/910*
AXC 1250	1250	1390	1320	20x15	850/1050*	800	1180	740/938*

Dimensions in mm.

* Dimensions L + K depend on motor frame size

Figure 320:Fresh fan that used in basement2.

Type AXC 710 was used, D = 710.

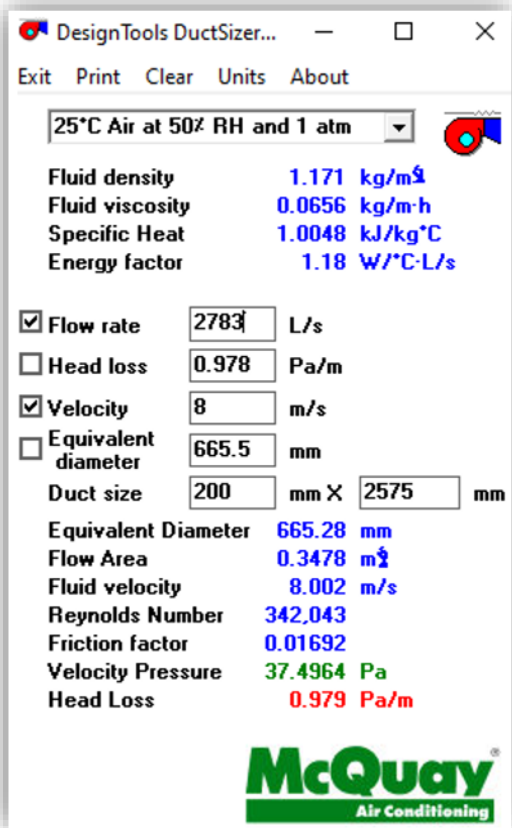


Figure 321: Duct sizing for duct used in basement2 for fresh air.

From duct sizer calculator, main fresh duct size is 200mm*2575mm, with diameter = 665.5.

Diffuser selection

There is a need for 4 diffusers with each capacity = 1474 cfm, with size 600*200mm.

They were selected from: (Ventilation air grille diffuser air vent manufacturer since 2002) catalog.

Standard size :

Item Code	Neck Size(mm)	Face Size(mm)
DG-A	300×150	325×175
DG-A	300×300	325×325
DG-A	400×200	425×225
DG-A	600×150	625×175
→ DG-A	600×200	625×225
DG-A	600×300	625×325

Product Specification:

Materail : Aluminum

Material Thickness : 0.8/1.0/1.2mm or upon your request

Surface finish : Original

Standard Color : RAL9019,9010, anodized

Size : Any Size Available

feature : Fixed blade

Place to install : Instal

Figure 322: Diffuser selection for basement2 for fresh air.

Basement3

$$CFMexhaust = \frac{V * ACH}{1.7}$$

$V: space\ volume\ in\ m^3.$

$ACH: Air\ change\ per\ volume.$

$Parking\ volume = 2151.431\ m^3.$

$The\ recommended\ air\ change\ per\ volume\ is\ 8\ in\ garages\ from\ ASHRAE.$

$$CFMexhaust = \frac{2151.43 * 8}{1.7} = 10124.38cfm \rightarrow 17201.43\ m^3/h.$$

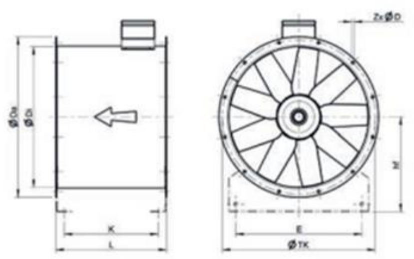
$$CFMfresh = (0.85 - 0.9) * CFMexhaust = 0.85 * 10124.38$$

$$= 8605.723cfm = 14621.2m^3/h.$$

There is a need to use an exhaust fan with 10124.38 cfm capacity, and a fresh fan with 8605.723 cfm capacity.

- **Exhaust fan**

Dimensions



AXC	øDi	øDa	øTK	Zx øD	L	hf	E	K
AXCP 315	315	395	355	8x10	425	235	265	360
AXCP 355	355	435	395	8x10	425	250	305	360
AXCP 400	400	480	450	8x12	450	280	350	385
AXCP 450	450	530	500	8x12	500	315	400	435
AXCP 500	500	590	560	12x12	540	335	440	464
AXCP 560	560	650	620	12x12	500/750*	375	500	424/674*
AXCP 630	630	720	690	12x12	500/750*	425	570	424/674*
→ AXC 710	710	800	770	16x12	500/700/800*	450	650	424/624/722*
AXC 800	800	890	860	16x12	500/700*	530	730	414/614*
AXC 900	900	1005	970	16x15	640/850*	560	830	552/762*
AXC 1000	1000	1105	1070	16x15	640/850*	670	930	552/762*
AXC 1200	1120	1260	1190	20x15	700/1000*	710	1030	612/910*
AXC 1250	1250	1390	1320	20x15	850/1050*	800	1180	740/938*

Dimensions in mm.

* Dimensions L + K depend on motor frame size

Figure 323: Exhaust fan that used in basement3.

Type AXC 710 was used, D = 710.

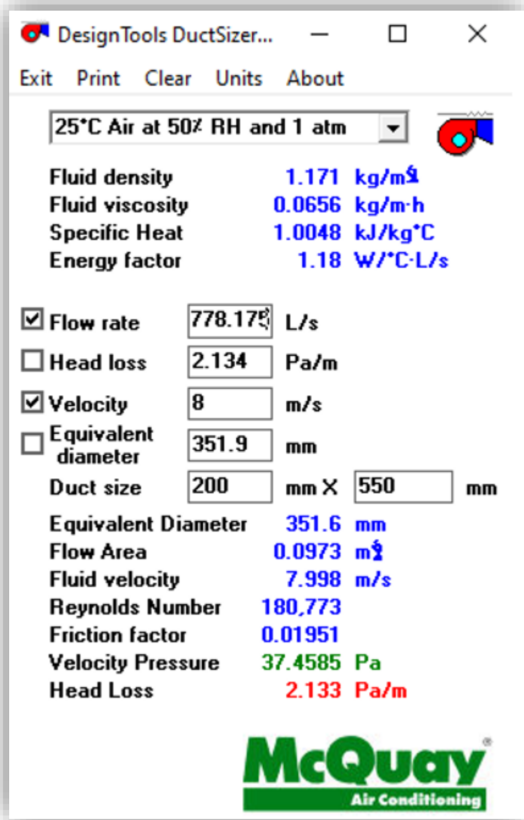


Figure 324: Duct sizing for duct used in basement3 for exhaust air.

From duct sizer calculator, main exhaust duct size is 200mm*550mm. with diameter equal 351.9.

Diffuser selection

There is a need for 4 diffusers with each capacity = 2531.095cfm, with size 600*200mm.

They were selected from: (Ventilation air grille diffuser air vent manufacturer since 2002) catalog.

Standard size :

Item Code	Neck Size(mm)	Face Size(mm)
DG-A	300×150	325×175
DG-A	300×300	325×325
DG-A	400×200	425×225
DG-A	600×150	625×175
→ DG-A	600×200	625×225
DG-A	600×300	625×325

Product Specification:

Materail : Aluminum

Material Thickness : 0.8/1.0/1.2mm or upon your request

Surface finish : Original

Standard Color : RAL9019,9010, anodized

Size : Any Size Available

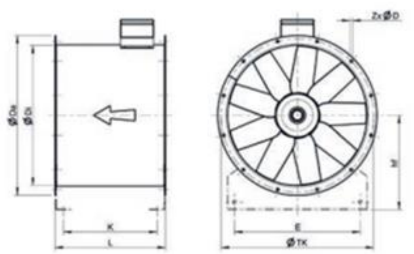
feature : Fixed blade

Place to install : Instal

Figure 325:Diffuser selection for basement3 for exhaust air.

Fresh fan

Dimensions



AXC	øDi	øDa	øTK	Zx øD	L	hf	E	K
AXCP 315	315	395	355	8x10	425	235	265	360
AXCP 355	355	435	395	8x10	425	250	305	360
AXCP 400	400	480	450	8x12	450	280	350	385
AXCP 450	450	530	500	8x12	500	315	400	435
AXCP 500	500	590	560	12x12	540	335	440	464
AXCP 560	560	650	620	12x12	500/750*	375	500	424/674*
AXCP 630	630	720	690	12x12	500/750*	425	570	424/674*
AXC 710	710	800	770	16x12	500/700/800*	450	650	424/624/722*
AXC 800	800	890	860	16x12	500/700*	530	730	414/614*
AXC 900	900	1005	970	16x15	640/850*	560	830	552/762*
AXC 1000	1000	1105	1070	16x15	640/850*	670	930	552/762*
AXC 1200	1120	1260	1190	20x15	700/1000*	710	1030	612/910*
AXC 1250	1250	1390	1320	20x15	850/1050*	800	1180	740/938*

Dimensions in mm.

* Dimensions L + K depend on motor frame size

Figure 326: Fresh fan that used in basement3.

Type AXC 710 was used, D = 710.

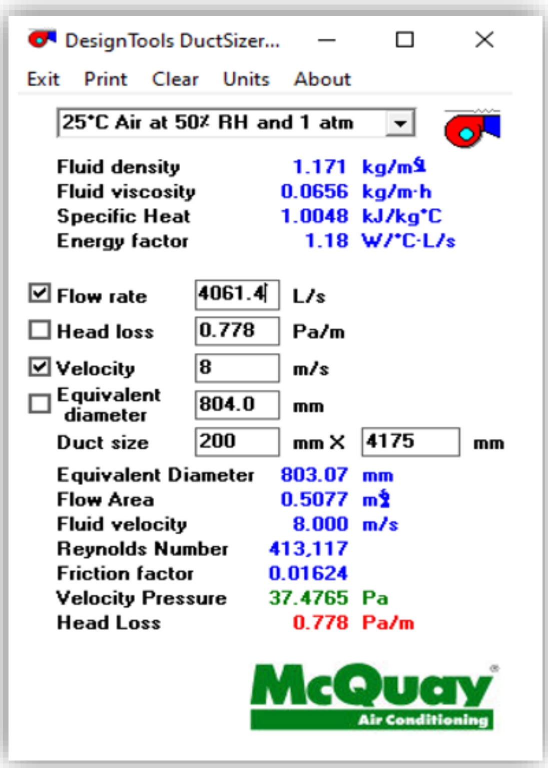


Figure 327: Duct sizing for duct used in basement3 for fresh air.

From duct sizer calculator, main fresh duct size is 200mm*4175mm. with diameter equal to 804.0.

Diffuser selection

There is a need for 4 diffusers with each capacity = 2151.43 cfm, with size 600*200mm.

They were selected from: (Ventilation air grille diffuser air vent manufacturer since 2002) catalog.

Standard size :

Item Code	Neck Size(mm)	Face Size(mm)
DG-A	300×150	325×175
DG-A	300×300	325×325
DG-A	400×200	425×225
DG-A	600×150	625×175
DG-A	600×200	625×225
DG-A	600×300	625×325

Product Specification:

Materail : Aluminum

Material Thickness : 0.8/1.0/1.2mm or upon your request

Surface finish : Original

Standard Color : RAL9019,9010, anodized

Size : Any Size Available

feature : Fixed blade

Place to install : Instal

Figure 328: Diffuser selection for basement3 for fresh air.

Duct sizing

The dimensions of the ducts were calculated using duct sizer software. Assume using duct depth 400mm, and assume velocity for main duct = 5m/s (984.25 FPM). From ASHRAE.

Description	Recommended Velocity, m/s		
	Residence Buildings	Public Buildings	Industrial Buildings
Outside air intake	2.5	2.5	2.5
Heating coils	2.3	2.5	3.0
Cooling coils	2.3	2.5	3.0
Fan suction	3.5	4.0	5.0
Fan outlet	5.0-8.0	6.5-10.0	8.0-12.0
Main duct	4.0-4.5	5.0-6.5	6.0-9.0
Branch ducts	3.0	3.0-4.5	4.0-5.0
Branch risers	2.5	3.0-3.5	4.0

Figure 329: Velocity of the main duct in the project from ASHRAE.

Tables below show duct sizing for all ducts in the project.

Table 59: Duct sizing for ducts in basement1

No. of fan coil	Duct name	Duct air flow (m3/s)	Duct depth (mm)	Duct diameter (mm)	Duct width (mm)
Fan coil No.1	AB	1.83	400	682.6	1025
	BC	0.16	400	283.2	175
	BD	1.51	400	635.1	875
	DG	1.04	400	551.7	650
	GH	0.99	400	541.5	625
	DI	0.47	400	409.1	350
	EF	0.16	400	273.1	175
	EI	0.47	400	409.1	350
	IJ	0.16	400	273.1	175
	IK	0.32	400	354.1	275
	KL	0.16	400	273.1	175
	MN	0.16	400	273.1	175
Fan coil No.2	AB	0.45	400	338.5	200
	BC	0.15	400	224.3	100
	CD	0.15	400	224.3	100
	BG	0.25	400	271.6	125
	GH	0.1	400	192.7	75
	GI	0.15	400	224.3	100
	IJ	0.15	400	224.3	100
	BE	0.05	400	148.8	50
	EF	0.05	400	148.8	50
Fan coil No.3	AB	0.49	400	353.2	275
	BC	0.12	400	208.5	100
	BD	0.37	400	266	225
	DE	0.13	400	214.8	100
	EF	0.13	400	214.8	100
	DG	0.23	400	266	150
	GH	0.14	400	220.9	100
	IJ	0.09	400	187.2	75
	GI	0.09	400	187.2	75

Table 60: Duct sizing for ducts in ground floor.

No. of fan coil	Duct name	Duct air flow (m3/s)	Duct depth (mm)	Duct diameter (mm)	Duct width (mm)
Fan coil No.4	AB	0.44	400	334.7	200
	BC	0.09	400	184.8	75
	BD	0.09	400	184.8	75
	BG	0.26	400	274.9	150
	GE	0.09	400	184.8	75
	EF	0.09	400	184.8	75
	GH	0.18	400	239.5	100
	HI	0.09	400	184.8	75
	HJ	0.09	400	184.8	75
	JK	0.09	400	184.8	75
Fan coil No.5	AB	0.18	400	214.1	100
	BC	0.1	400	172	75

Table 61:Duct sizing for ducts in Attic floor.

No. of fan coil	Duct name	Duct air flow (m3/s)	Duct depth (mm)	Duct diameter (mm)	Duct width (mm)
Fan coil No.6	AB	0.693	400	420.1	375
	BC	0.17	400	247.9	225
	BD	0.35	400	325	175
	DE	0.17	400	247.9	225
	DF	0.17	400	247.9	225
	FG	0.17	400	247.9	225
	BH	0.17	400	247.9	225
	HI	0.17	400	247.9	225
	IJ	0.17	400	247.9	225
Fan coil No.7	AB	0.9	400	478.7	475
	BC	0.15	400	244.3	125
	CD	0.15	400	244.3	125
	DE	0.15	400	244.3	125
	BF	0.75	400	447.5	425
	FG	0.15	400	244.3	125
	FH	0.15	400	244.3	125
	HI	0.15	400	244.3	125
	JM	0.075	400	188.6	75
	JK	0.15	400	244.3	125
	KL	0.15	400	244.3	125
	KN	0.22	400	282	175
	NO	0.075	400	188.6	75
	OP	0.075	400	188.6	75
	NQ	0.15	400	244.3	125
	QR	0.15	400	244.3	125
	FJ	0.3	400	316.7	225

Table 62:Duct sizing for ducts in First floor which is repeated floor to fifth floor.

No. of fan coil	Duct name	Duct air flow (m3/s)	Duct depth (mm)	Duct diameter (mm)	Duct width (mm)
Fan coil No.9	AB	0.35	400	298.5	200
	BC	0.17	400	227.9	125
	CD	0.17	400	227.9	100
	AH	0.1	400	186.8	75
	HI	0.1	400	186.8	75
	IJ	0.1	400	186.8	75
	AG	0.06	400	154.4	50
	GK	0.06	400	154.4	50
	BE	0.03	400	119.3	25
	EF	0.03	400	119.3	25
	KZ	0.06	400	154.4	50
Fan coil No.8	AB	0.66	400	410	350
	BL	0.11	400	209.4	100
	BH	0.25	400	284.8	175
	HM	0.11	400	209.4	100
	MN	0.11	400	209.4	100
	HI	0.1381	400	227.9	125
	IJ	0.1381	400	227.9	125
	JK	0.1381	400	227.9	125
	CD	0.12	400	216.3	100
	DQ	0.52	400	375	300
	QY	0.52	400	375	300
	DP	0.065	400	172.1	75
	CZ	0.24	400	280.4	175
	ZE	0.24	400	280.4	175
	EO	0.05	400	156.1	50
	EF	0.19	400	256.9	150
	FG	0.19	400	256.9	150

Table 63:Duct sizing for ducts in sixth floor.

No. of fan coil	Duct name	Duct air flow (m3/s)	Duct depth (mm)	Duct diameter (mm)	Duct width (mm)
Fan coil No.18	AB	0.65	400	406.8	350
	BC	0.32	400	311.8	200
	BD	0.32	400	311.8	200
	CE	0.32	400	311.8	200
Fan coil No.19	AB	0.972	400	497.5	525
	BC	0.26	400	303.1	200
	BD	0.59	400	412.4	350
	DE	0.52	400	393.3	325
	EF	0.26	400	303.1	200
	EJ	0.26	400	303.1	200
	JK	0.26	400	303.1	200
	KM	0.26	400	303.1	200
	DG	0.33	400	331.5	224
	GH	0.16	400	252.7	150
	GI	0.16	400	252.7	150

Plans for HVAC design for some floors in the project.

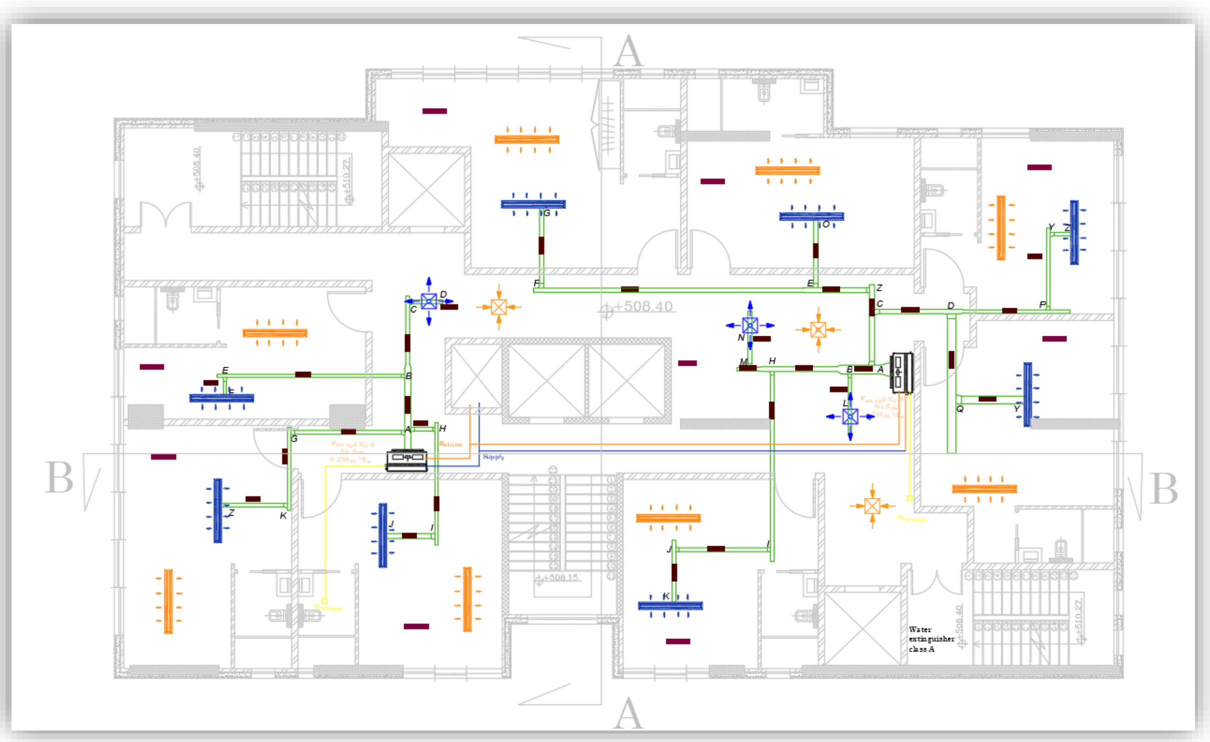


Figure 330:HVAC design for first floor

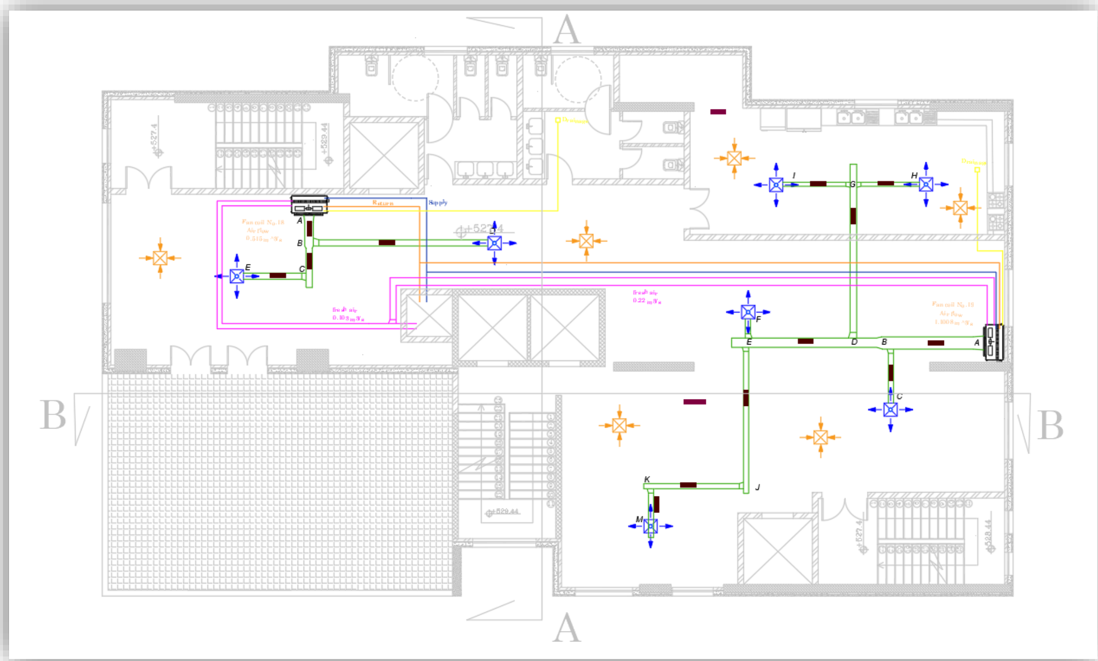


Figure 331:HVAC system for sixth floor.

4.3 Power

4.3.1 Introduction:

In this section of the project, we focus on designing the electrical wiring for the building. We have strategically placed the necessary exits and switches and planned the breaker board for the building. Since all electrical devices in the building rely on the primary energy feeder, electrical energy is crucial and significantly influences our daily lives. To meet the building's electrical energy requirements, the primary cable must be meticulously designed.

4.3.2 Lighting power calculations: -

Sample of calculation:

Gust room (Hall)

$Total\ number\ luminaries\ =\ 19\ Power\ =\ 19 * 33.2\ =\ 630.8\ watt$

$, I\ Load\ =\ Power/V * Power\ factor\ =\ 630.8/220 * 0.9\ =\ 3.19\ Amp.$

$3.19\ *\ Demand\ factor\ =\ 3.19 * 0.8 =\ 2.55\ Amp.$

$I\ CB\ =\ 2.55\ *\ 1.15\ =\ 2.93\ Amp.$

$I\ Cabel\ =\ 2.93\ *\ 1.15\ =\ 3.37\ Amp.$

$Area\ of\ section\ to\ Cable\ =\ 1\ mm^2$

$Use\ Area\ of\ section\ to\ Cable\ =\ 1.5\ mm^2$

- **Calculation of voltage drop:**

$I\ Load\ =\ 3.19\ Amp.$

$R\ Wire\ =\ (1.77 * 10 - 8) * (2 *\ 24.02)/1.5 * 10 - 6\ =\ 0.566872$

$V\ Drop\ =\ I\ Load\ *\ R\ Wire\ \rightarrow V\ Drop\ =\ 3.19 *\ 0.57\ =\ 1.81$

$volt\ Percentage\ Voltage\ =\ (1.81/220)\ * 100\%\ =\ 0.008\ \%\ <\ 5\%. \rightarrow\ ok.$

- **Number of circuit breaker**

The circuit breaker load is usually 10 amperes, for lighting so to find the maximum load 10- ampere circuit breaker has the following calculations:

$Icb = 1.2 * I\ load$

$10\ amperes = 1.2 * I\ load$

$I\ load = 8.333\ ampere$

To find how many circuit breakers we need in each space on all floors will be taken as a sample of calculation as the following calculations:

In Gust room (Hall) we have power equal 630.8

$Power\ (Watt) = I\ load\ (Ampere) * Volt\ (V) * Power\ factor$

$630.8\ watt = I\ load * 220 * 0.9$

$I\ load = 3.19\ ampere.$

Number of circuit breaker for Gust room (Hall)= 3.19/8.33 =1 circuit breaker.

- **Cable size**

To find the electricity cable diameter for lighting switches the following formula is used:

$I\ Cabel = 10 * 1.15 = 12\ Amp.$

$According\ to\ Table\ I\ cable = 1.5\ mm^2$

Table 64:Cross-Sectional table

Single phase Current rating ((Amp	Nominal cross (sectional area (mm2
11	1.0
13	**1.5**
18	2.5
24	4.0
31	6.0
42	10
56	16
73	25
90	35

Number of lighting breakers, current calculations, wire cross-sectional area, and low voltage for each space in the building.

For the Lighting, wire cross-sectional area 1.5 mm2 and current 10 A are used.

- ❖ Basement 1

Table 65:Number of lighting breakers, current calculations, wire cross-sectional area, and low voltage for Basement 1

Space	power lamps	N	power	D.F	Iload	I CB	I Cable	Area of cable (mm2)	ρ	L	A (Use)	R	% Voltag drop	# CB
Parking	52	28	1456	0.8	5.883	6.765	7.780	1	1.77	39.14	1.5	0.9237	0.0247	1
Main stair	29	2	58	0.8	0.234	0.269	0.310	1	1.77	30.53	1.5	0.7205	0.0008	1

- ❖ Basement 2

Table 66:Number of lighting breakers, current calculations, wire cross-sectional area, and low voltage for Basement 2

Space	power lamps	N	power	D.F	I_{load}	I_{CB}	I_{Cable}	Area of cable (mm^2)	ρ	L	A (Use)	R	% Voltag drop
Parking	52	28	1456	0.8	5.883	6.765	7.780	1	1.77	30.8	1.5	0.727	0.019
Main stair	29	2	58	0.8	0.234	0.269	0.310	1	1.77	26.55	1.5	0.627	0.001
Transformer room	29	2	58	0.8	0.234	0.269	0.310	1	1.77	12.08	1.5	0.285	0.000
Electricity room	29	2	58	0.8	0.234	0.269	0.310	1	1.77	18.73	1.5	0.442	0.000

❖ Basement 3

Table 67:Number of lighting breakers, current calculations, wire cross-sectional area, and low voltage for Basement 3

Space	power lamps	N	power	D.F	I_{load}	I_{CB}	I_{Cable}	Area of cable (mm^2)	ρ	L	A (Use)	R	% Voltag drop	# CB
Worker Bed Room	37	6	222	0.8	0.897	1.032	1.186	1	1.77	33.54	1.5	0.7915	0.0032	1
Workwear area	29	3	87	0.8	0.352	0.404	0.465	1	1.77	28.71	1.5	0.6776	0.0011	1
Prefabricated bedding area	29	2	58	0.8	0.234	0.269	0.310	1	1.77	24.02	1.5	0.5669	0.0006	1
Dirty laundry area	29	3	87	0.8	0.352	0.404	0.465	1	1.77	22.24	1.5	0.5249	0.0008	1
Publishing area	29	4	116	0.8	0.469	0.539	0.620	1	1.77	19.01	1.5	0.4486	0.0010	1
Laundry area &Drying area	29	4	116	0.8	0.469	0.539	0.620	1	1.77	24.5	1.5	0.5782	0.0012	1
Laundry sorting &Ironing area	29	9	261	0.8	1.055	1.213	1.395	1	1.77	17.01	1.5	0.4014	0.0019	1
Living room	33.2	4	132.8	0.8	0.537	0.617	0.710	1	1.77	24.68	1.5	0.5824	0.0014	1
Kitchen 1	48.9	4	195.6	0.8	0.790	0.909	1.045	1	1.77	30.62	1.5	0.7226	0.0026	1
Kitchen 2	48.9	1	48.9	0.8	0.198	0.227	0.261	1	1.77	10.9	1.5	0.2572	0.0002	1
Entrance	49.1	3	147.3	0.8	0.595	0.684	0.787	1	1.77	6.4	1.5	0.1510	0.0004	1
Toilet 1	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	45.91	1.5	1.0835	0.0011	1
Toilet 2	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	44.78	1.5	1.0568	0.0011	1
Toilet 3	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	43.79	1.5	1.0334	0.0011	1
Toilet 4	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	42.59	1.5	1.0051	0.0010	1
Toilet 5	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	6.32	1.5	0.1492	0.0002	1
Laundries area 1	28.4	10	284	0.8	1.147	1.320	1.518	1	1.77	39.66	1.5	0.9360	0.0049	1
Director's Room	33	8	264	0.8	1.067	1.227	1.411	1	1.77	15.46	1.5	0.3649	0.0018	1
GYM	49.1	27	1325.7	0.8	5.356	6.160	7.084	1	1.77	25.81	1.5	0.6091	0.0148	1
Laundries area 2	36	4	144	0.8	0.582	0.669	0.769	1	1.77	31.41	1.5	0.7413	0.0020	1
Shawer 1	28.4	10	284	0.8	1.147	1.320	1.518	1	1.77	34.39	1.5	0.8116	0.0042	1
Shawer 2	28.4	10	284	0.8	1.147	1.320	1.518	1	1.77	33.55	1.5	0.7918	0.0041	1
Shawer 3	28.4	10	284	0.8	1.147	1.320	1.518	1	1.77	32.67	1.5	0.7710	0.0040	1
Shawer 4	28.4	10	284	0.8	1.147	1.320	1.518	1	1.77	31.74	1.5	0.7491	0.0039	1
Shawer 5	28.4	10	284	0.8	1.147	1.320	1.518	1	1.77	30.86	1.5	0.7283	0.0038	1
Shawer 6	28.4	10	284	0.8	1.147	1.320	1.518	1	1.77	29.67	1.5	0.7002	0.0037	1
Shawer 7	28.4	10	284	0.8	1.147	1.320	1.518	1	1.77	28.56	1.5	0.6740	0.0035	1
Shawer 8	28.4	10	284	0.8	1.147	1.320	1.518	1	1.77	27.57	1.5	0.6507	0.0034	1
Shawer 9	28.4	10	284	0.8	1.147	1.320	1.518	1	1.77	26.57	1.5	0.6271	0.0033	1
Shawer 10	28.4	10	284	0.8	1.147	1.320	1.518	1	1.77	25.57	1.5	0.6035	0.0031	1
Laundries area 3	28.4	13	369.2	0.8	1.492	1.715	1.973	1	1.77	29.12	1.5	0.6872	0.0047	1
Toilet 6	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	27.5	1.5	0.6490	0.0007	1
Toilet 7	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	28.47	1.5	0.6719	0.0007	1
Toilet 8	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	29.47	1.5	0.6955	0.0007	1
Toilet 9	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	30.47	1.5	0.7191	0.0008	1
Toilet 10	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	31.47	1.5	0.7427	0.0008	1
Dressing room	29	4	116	0.8	0.469	0.539	0.620	1	1.77	25.73	1.5	0.6072	0.0013	1
corridor	29	3	87	0.8	0.352	0.404	0.465	1	1.77	22.31	1.5	0.5265	0.0008	1
Main stair	29	2	58	0.8	0.234	0.269	0.310	1	1.77	6.56	1.5	0.1548	0.0002	1

❖ Ground Floor

Table 68:Number of lighting breakers, current calculations, wire cross-sectional area, and low voltage for Ground Floor

Space	power lamps	N	power	D.F	I_{load}	I_{CB}	I_{Cable}	Area of cable (mm^2)	ρ	L	A (Use)	R	% Voltag drop	# CB
Shop 1	35	6	210	0.8	0.848	0.976	1.122	1	1.77	20.76	1.5	0.4899	0.0019	1
Shop 2	35	6	210	0.8	0.848	0.976	1.122	1	1.77	24.29	1.5	0.5732	0.0022	1
Toilet 1	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	13.23	1.5	0.3122	0.0003	1
Toilet 2	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	17.54	1.5	0.4139	0.0004	1
Laundries area 1	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	14.33	1.5	0.3382	0.0004	1
Laundries area 2	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	15.41	1.5	0.3637	0.0004	1
Reception and entrance	49.1	15	24	0.8	0.097	0.112	0.128	1	1.77	24.34	1.5	0.5744	0.0003	1
Emergency stair1	29	3	87	1	0.439	0.505	0.581	1	1.77	19.48	1.5	0.4597	0.0009	1
Emergency stair2	29	2	58	1	0.293	0.337	0.387	1	1.77	151.71	1.5	3.5804	0.0048	1
Main stair	29	2	58	0.8	0.234	0.269	0.310	1	1.77	27.65	1.5	0.6525	0.0007	1
Toilet 1	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	8.24	1.5	0.1945	0.0002	1
Toilet 2	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	6.51	1.5	0.1536	0.0002	1
Toilet 3	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	7.15	1.5	0.1687	0.0002	1
Toilet 4	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	13.88	1.5	0.3276	0.0003	1
Toilet 5	28.4	6	170.4	0.8	0.688	0.792	0.911	1	1.77	11.33	1.5	0.2674	0.0008	1
Toilet 6	28.4	6	170.4	0.8	0.688	0.792	0.911	1	1.77	9.7	1.5	0.2289	0.0007	1
Laundries area 3	28.4	8	227.2	0.8	0.918	1.056	1.214	1	1.77	6.24	1.5	0.1473	0.0006	1
Laundries area 4	28.4	8	227.2	0.8	0.918	1.056	1.214	1	1.77	12.92	1.5	0.3049	0.0013	1

❖ Attic

Table 69:Number of lighting breakers, current calculations, wire cross-sectional area, and low voltage for AtticFloor

Space	power lamps	N	power	D.F	I_{load}	I_{CB}	I_{Cable}	Area of cable (mm^2)	ρ	L	A (Use)	R	% Voltag drop	# CB
kitchen	48.9	5	244.5	0.8	0.988	1.136	1.306	1	1.77	19.25	1.5	0.454	0.002	1
restaurant	40	19	760	0.8	3.071	3.531	4.061	1	1.77	24.34	1.5	0.574	0.008	1
Gust room (Hall)	33.2	19	630.8	0.8	2.549	2.931	3.371	1	1.77	24.02	1.5	0.567	0.007	1
Emergency stair1	29	3	87	1	0.439	0.505	0.581	1	1.77	19.48	1.5	0.460	0.001	1
Emergency stair2	29	2	58	1	0.293	0.337	0.387	1	1.77	151.71	1.5	3.580	0.005	1
Main stair	29	2	58	0.8	0.234	0.269	0.310	1	1.77	27.65	1.5	0.653	0.001	1
Toilet 1	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	8.24	1.5	0.194	0.000	1
Toilet 2	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	6.51	1.5	0.154	0.000	1
Toilet 3	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	7.15	1.5	0.169	0.000	1
Toilet 4	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	13.88	1.5	0.328	0.000	1
Toilet 5	28.4	6	170.4	0.8	0.688	0.792	0.911	1	1.77	11.33	1.5	0.267	0.001	1
Toilet 6	28.4	6	170.4	0.8	0.688	0.792	0.911	1	1.77	9.7	1.5	0.229	0.001	1
Laundries area 1	28.4	8	227.2	0.8	0.918	1.056	1.214	1	1.77	6.24	1.5	0.147	0.001	1
Laundries area 2	28.4	8	227.2	0.8	0.918	1.056	1.214	1	1.77	12.92	1.5	0.305	0.001	1

- First Floor (Repeated Floor)

Table 70:Number of lighting breakers, current calculations, wire cross-sectional area, and low voltage for First Floor

Space	power lamps	N	power	D.F	I_{load}	I_{CB}	I_{Cable}	Area of cable (mm^2)	ρ	L	A (Use)	R	% Voltag drop	# CB
Bedroom 1	37	11	511	0.8	2.065	2.374	2.730	1	1.77	18.35	1.5	0.433	0.004	1
Bedroom 2	37	6	326	0.8	1.317	1.515	1.742	1	1.77	16.56	1.5	0.391	0.002	1
Bedroom 3	37	7	363	0.8	1.467	1.687	1.940	1	1.77	24.14	1.5	0.570	0.004	1
Bedroom 4	37	10	474	0.8	1.915	2.202	2.533	1	1.77	24.44	1.5	0.577	0.005	1
Bedroom 5	37	8	400	0.8	1.616	1.859	2.137	1	1.77	25.66	1.5	0.606	0.004	1
Bedroom 6	37	8	400	0.8	1.616	1.859	2.137	1	1.77	21.16	1.5	0.499	0.004	1
Bedroom 7	37	8	400	0.8	1.616	1.859	2.137	1	1.77	22.44	1.5	0.530	0.004	1
Bedroom 8	37	6	326	0.8	1.317	1.515	1.742	1	1.77	10.64	1.5	0.251	0.002	1
Bathroom 1	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	11.39	1.5	0.269	0.000	1
Bathroom 2	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	18.7	1.5	0.441	0.000	1
Bathroom 3	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	12.37	1.5	0.292	0.000	1
Bathroom 4	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	27.03	1.5	0.638	0.001	1
Bathroom 5	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	21.49	1.5	0.507	0.001	1
Bathroom 6	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	16.96	1.5	0.400	0.000	1
Bathroom 7	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	19.36	1.5	0.457	0.000	1
Bathroom 8	28.4	2	56.8	0.8	0.229	0.264	0.304	1	1.77	9.06	1.5	0.214	0.000	1
corridor	29	17	493	0.8	1.992	2.291	2.634	1	1.77	22.6	1.5	0.533	0.005	2
Emergency stair1	29	3	87	1	0.439	0.505	0.581	1	1.77	19.48	1.5	0.460	0.001	1
Emergency stair2	29	2	58	1	0.293	0.337	0.387	1	1.77	151.71	1.5	3.580	0.005	1
Main stair	29	2	58	0.8	0.234	0.269	0.310	1	1.77	27.65	1.5	0.653	0.001	1

- Roof Floor

Table 71:Number of lighting breakers, current calculations, wire cross-sectional area, and low voltage for First Floor

Space	power lamps	N	power	D.F	I_{load}	I_{CB}	I_{Cable}	Area of cable (mm^2)	ρ	L (m)	A (Use)	R	% Voltag drop	# CB
kitchen	48.9	6	293.4	0.8	1.1855	1.3633	1.5678	1	1.77	19.25	1.5	0.454	0.002	1
restaurant	40	25	1000	0.8	4.0404	4.6465	5.3434	1	1.77	24.34	1.5	0.574	0.011	1
balcony	40	11	440	0.8	1.7778	2.0444	2.3511	1	1.77	25.05	1.5	0.591	0.005	1
Emergency stair1	29	3	87	1	0.4394	0.5053	0.5811	1	1.77	19.48	1.5	0.460	0.001	1
Emergency stair2	29	2	58	1	0.2929	0.3369	0.3874	1	1.77	151.71	1.5	3.580	0.005	1
Main stair	29	2	58	0.8	0.2343	0.2695	0.3099	1	1.77	27.65	1.5	0.653	0.001	1
Laundries area 1	28.4	8	227.2	0.8	0.9180	1.0557	1.2140	1	1.77	5.45	1.5	0.129	0.001	1
Laundries area 2	28.4	8	227.2	0.8	0.9180	1.0557	1.2140	1	1.77	8.02	1.5	0.189	0.001	1

From outlet power:

From power outlet and special power outlet:

Gust room (Hall)

Number of power outlet = 5

Number special power outlet = 0

$I\ load\ =\ number\ of\ power\ outlet\ *2\ *\ 30\%$

$I\ special\ load\ =\ number\ special\ power\ outlet\ *2*100\%$

$I\ load\ =\ 5*2*30\%\ =\ 3\ Amp.$

$I\ special\ load\ =\ 0*2*100\%\ =\ 0$

$ICB\ =\ I\ load\ *1.15$

$ICB\ =\ 3\ *1.15\ =\ 3.45\ Amp.$

$I\ CB\ (special\ load)\ =\ I\ special\ load\ *1.15$

$I\ CB\ (special\ load)\ =\ 0*1.15\ =\ 0$

$I\ cable\ =\ I\ CB\ *1.15$

$I\ cable\ =\ 3.45\ *1.15\ =\ 3.97\ Amp.$

$I\ cable\ (special\ load)\ =\ I\ CB\ (special\ load)\ *1.15$

$I\ cable\ (special\ load)\ =\ 0\ *1.15\ =\ 0$

$Area\ of\ section\ to\ Cable\ =\ 1mm^2$

$Use\ Area\ of\ section\ to\ Cable\ =\ 2.5mm^2$

- **Calculation of voltage drop:**

$I\ Load\ = 3\ Amp.$

$R\ Wire\ =\ (1.77*10-8)\ *\ (2*\ 24.03)/2.5*10-6\ =\ 0.57$

$V\ Drop\ =\ I\ Load\ *\ R\ Wire$

$V\ Drop\ =\ 3*\ 0.57\ =\ 1.71$

$volt\ Percentage\ Voltage\ =\ (1.71/220)\ *100\%\ =\ 0.0077\ \%\ <\ 5\% \rightarrow\ ok.$

To find the electricity cable diameter for lighting switches we used the following formula:

$$I\ cable\ =\ 1.2\ *\ I\ circuit\ breaker$$

$$=1.2\ *\ 16=\ 19.2\ Ampere$$

$$According\ the\ following\ table, I\ cable\ =\ 2.5mm^2$$

Table 72:Cross-Sectional table

Single phase Current rating ((Amp	Nominal cross (sectional area (mm2
11	1.0
13	**1.5**
18	2.5
24	4.0
31	6.0
42	10
56	16
73	25
90	35

Current calculations, wire cross-sectional area, and low voltage for each space in the building.

For the outlets, 2.5 mm2 16 A wires are used.

- Basement 3

Table 73:Current calculations, wire cross-sectional area, and low voltage for Basement 3

Space	No.of power outlets	No.of Special outlets	I load	I (special load)	I CB (Power)	I CB (special load)	I cable (power)	Icable (special load)	Area of cable(mm2)	ρ	L	A (Use)	R	% Voltag drop
Parking	9	3	5.4	6	6.21	6.9	7.1415	7.935	1	1.77	41.79	1.5	0.9862	0.0278
Main stair	1	0	0.6	0	0.69	0	0.7935	0	1	1.77	30.53	1.5	0.7205	0.0023

- Basement 2

Table 74:Current calculations, wire cross-sectional area, and low voltage for Basement 2

Space	No.of power outlets	No.of Special outlets	I_{load}	$I_{(special\ load)}$	$I_{CB\ (Power)}$	$I_{CB\ (special\ load)}$	$I_{cable\ (power)}$	$I_{cable\ (special\ load)}$	Area of cable(mm^2)	ρ	L	A (Use)	R	% Voltag drop
Parking	8	0	4.8	0	5.52	0	6.348	0	1	1.77	33.43	1.5	0.788948	0.019795423
Main stair	1	0	0.6	0	0.69	0	0.7935	0	1	1.77	26.55	1.5	0.62658	0.001965183
Transformer room	2	2	1.2	4	1.38	4.6	1.587	5.29	1	1.77	11.12	1.5	0.262432	0.001646164
Electricity room	3	2	1.8	4	2.07	4.6	2.3805	5.29	1	1.77	21.41	1.5	0.505276	0.004754188

❖ Basement 1

Table 75:Current calculations, wire cross-sectional area, and low voltage for Basement 1

Space	No.of power outlets	No.of Special outlets	I_{load}	$I_{(special\ load)}$	$I_{CB\ (Power)}$	$I_{CB\ (special\ load)}$	$I_{cable\ (power)}$	$I_{cable\ (special\ load)}$	Area of cable(mm^2)	ρ	L	A (Use)	R	% Voltag drop
Worker Bed Room	5	0	3	0	3.45	0	3.9675	0	1	1.77	34.58	1.5	0.816	0.013
Workwear area	2	0	1.2	0	1.38	0	1.587	0	1	1.77	30.46	1.5	0.719	0.005
Prefabricated bedding area	2	0	1.2	0	1.38	0	1.587	0	1	1.77	25.82	1.5	0.609	0.004
Dirty laundry area	3	0	1.8	0	2.07	0	2.3805	0	1	1.77	22.24	1.5	0.525	0.005
Publishing area	3	0	1.8	0	2.07	0	2.3805	0	1	1.77	20.98	1.5	0.495	0.005
Laundry area &Drying area	9	0	5.4	0	6.21	0	7.1415	0	1	1.77	25.87	1.5	0.611	0.017
Laundry sorting &Ironing area	7	0	4.2	0	4.83	0	5.5545	0	1	1.77	13.32	1.5	0.314	0.007
Living room	3	0	1.8	0	2.07	0	2.3805	0	1	1.77	25.85	1.5	0.610	0.006
Kitchen 1	4	1	2.4	2	2.76	2.3	3.174	2.645	1	1.77	31.83	1.5	0.751	0.009
Kitchen 2	1	0	0.6	0	0.69	0	0.7935	0	1	1.77	10.9	1.5	0.257	0.001
Entrance	4	0	2.4	0	2.76	0	3.174	0	1	1.77	7.28	1.5	0.172	0.002
Laundries area 1	2	1	1.2	2	1.38	2.3	1.587	2.645	1	1.77	39.04	1.5	0.921	0.006
Director's Room	4	0	2.4	0	2.76	0	3.174	0	1	1.77	16.4	1.5	0.387	0.005
GYM	18	0	10.8	0	12.42	0	14.283	0	1	1.77	26.76	1.5	0.632	0.036
Laundries area 2	4	1	2.4	2	2.76	2.3	3.174	2.645	1	1.77	27.51	1.5	0.649	0.008
Laundries area 3	3	1	1.8	2	2.07	2.3	2.3805	2.645	1	1.77	28.66	1.5	0.676	0.006
Dressing room	3	0	1.8	0	2.07	0	2.3805	0	1	1.77	27.48	1.5	0.649	0.006
corridor	1	0	0.6	0	0.69	0	0.7935	0	1	1.77	22.63	1.5	0.534	0.002

❖ Ground Floor

Table 76:Current calculations, wire cross-sectional area, and low voltage for Groung Floor

Space	No.of power outlets	No.of Special outlets	I_{load}	$I_{(special\ load)}$	$I_{CB\ (Power)}$	$I_{CB\ (special\ load)}$	$I_{cable\ (power)}$	$I_{cable\ (special\ load)}$	Area of cable(mm^2)	ρ	L	A (Use)	R	% Voltag drop
Shop 1	3	0	1.8	0	2.07	0	2.3805	0	1	1.77	21.66	1.5	0.511	0.005
Shop 2	3	0	1.8	0	2.07	0	2.3805	0	1	1.77	25.19	1.5	0.594	0.006
Laundries area 1	1	1	0.6	2	0.69	2.3	0.7935	2.645	1	1.77	14.41	1.5	0.340	0.001
Laundries area 2	1	1	0.6	2	0.69	2.3	0.7935	2.645	1	1.77	14.97	1.5	0.353	0.001
Reception and entrance	7	0	4.2	0	4.83	0	5.5545	0	1	1.77	26.46	1.5	0.624	0.014
Gust room (Hall)	12	0	7.2	0	8.28	0	9.522	0	1	1.77	24.03	1.5	0.567	0.021
Emergency stair1	2	0	1.2	0	1.38	0	1.587	0	1	1.77	27.65	1.5	0.653	0.004
Emergency stair2	2	0	1.2	0	1.38	0	1.587	0	1	1.77	19.48	1.5	0.460	0.003
Main stair	1	0	0.6	0	0.69	0	0.7935	0	1	1.77	151.71	1.5	3.580	0.011
Laundries area 3	2	1	1.2	2	1.38	2.3	1.587	2.645	1	1.77	5.97	1.5	0.141	0.001
Laundries area 4	2	1	1.2	2	1.38	2.3	1.587	2.645	1	1.77	11.02	1.5	0.260	0.002

❖ Attic

Table 77:Current calculations, wire cross-sectional area, and low voltage for Attic Floor

Space	No.of power outlets	No.of Special outlets	I_{load}	$I_{(special\ load)}$	$I_{CB\ (Power)}$	$I_{CB\ (special\ load)}$	$I_{cable\ (power)}$	$I_{cable\ (special\ load)}$	Area of cable(mm^2)	ρ	L	A (Use)	R	% Voltag drop
kitchen	9	2	5.4	4	6.21	4.6	7.1415	5.29	1	1.77	20.64	1.5	0.487	0.014
restaurant	16	0	9.6	0	11.04	0	12.696	0	1	1.77	26.46	1.5	0.624	0.031
Emergency stair1	2	0	1.2	0	1.38	0	1.587	0	1	1.77	27.65	1.5	0.653	0.004
Emergency stair2	2	0	1.2	0	1.38	0	1.587	0	1	1.77	19.48	1.5	0.460	0.003
Main stair	1	0	0.6	0	0.69	0	0.7935	0	1	1.77	151.71	1.5	3.580	0.011
Laundries area 1	2	1	1.2	2	1.38	2.3	1.587	2.645	1	1.77	5.97	1.5	0.141	0.001
Laundries area 2	2	1	1.2	2	1.38	2.3	1.587	2.645	1	1.77	11.02	1.5	0.260	0.002

❖ First Floor (Repeated Floor)

Table 78:Current calculations, wire cross-sectional area, and low voltage for First Floor

Space	No.of power outlets	No.of Special outlets	I_{load}	$I_{(special\ load)}$	$I_{CB\ (Power)}$	$I_{CB\ (special\ load)}$	$I_{cable\ (power)}$	$I_{cable\ (special\ load)}$	Area of cable(mm^2)	ρ	L	A (Use)	R	% Voltag drop
Bedroom 1	5	0	3	0	3.45	0	3.9675	0	1	1.77	19.51	1.5	0.460	0.007
Bedroom 2	4	0	2.4	0	2.76	0	3.174	0	1	1.77	17.38	1.5	0.410	0.005
Bedroom 3	4	0	2.4	0	2.76	0	3.174	0	1	1.77	25.76	1.5	0.608	0.008
Bedroom 4	6	0	3.6	0	4.14	0	4.761	0	1	1.77	23.98	1.5	0.566	0.011
Bedroom 5	5	0	3	0	3.45	0	3.9675	0	1	1.77	27.26	1.5	0.643	0.010
Bedroom 6	5	0	3	0	3.45	0	3.9675	0	1	1.77	22.91	1.5	0.541	0.008
Bedroom 7	5	0	3	0	3.45	0	3.9675	0	1	1.77	23.56	1.5	0.556	0.009
Bedroom 8	4	0	2.4	0	2.76	0	3.174	0	1	1.77	11.52	1.5	0.272	0.003
Bathroom 1	1	1	0.6	2	0.69	2.3	0.7935	2.645	1	1.77	9.21	1.5	0.217	0.001
Bathroom 2	1	1	0.6	2	0.69	2.3	0.7935	2.645	1	1.77	15.2	1.5	0.359	0.001
Bathroom 3	1	1	0.6	2	0.69	2.3	0.7935	2.645	1	1.77	11	1.5	0.260	0.001
Bathroom 4	1	1	0.6	2	0.69	2.3	0.7935	2.645	1	1.77	25.36	1.5	0.598	0.002
Bathroom 5	1	1	0.6	2	0.69	2.3	0.7935	2.645	1	1.77	19.93	1.5	0.470	0.001
Bathroom 6	1	1	0.6	2	0.69	2.3	0.7935	2.645	1	1.77	15.25	1.5	0.360	0.001
Bathroom 7	1	1	0.6	2	0.69	2.3	0.7935	2.645	1	1.77	17.83	1.5	0.421	0.001
Bathroom 8	1	1	0.6	2	0.69	2.3	0.7935	2.645	1	1.77	7.58	1.5	0.179	0.001
corridor	6	0	3.6	0	4.14	0	4.761	0	1	1.77	24.11	1.5	0.569	0.011
Emergency stair1	2	0	1.2	0	1.38	0	1.587	0	1	1.77	5.88	1.5	0.139	0.001
Emergency stair2	2	0	1.2	0	1.38	0	1.587	0	1	1.77	7	1.5	0.165	0.001
Main stair	1	0	0.6	0	0.69	0	0.7935	0	1	1.77	25.23	1.5	0.595	0.002

❖ Roof Floor

Table 79:Current calculations, wire cross-sectional area, and low voltage for Roof Floor

Space	No.of power outlets	No.of Special outlets	I_{load}	$I_{(special\ load)}$	$I_{CB\ (Power)}$	$I_{CB\ (special\ load)}$	$I_{cable\ (power)}$	$I_{cable\ (special\ load)}$	Area of cable(mm^2)	ρ	L	A (Use)	R	% Voltag drop
kitchen	10	2	6	4	6.9	4.6	7.935	5.29	1	1.77	19.58	1.5	0.462	0.013
restaurant	24	0	14.4	0	16.56	0	19.044	0	1	1.77	29.56	1.5	0.698	0.046
balcony	10	0	6	0	6.9	0	7.935	0	1	1.77	28.16	1.5	0.665	0.018
Emergency stair1	2	0	1.2	0	1.38	0	1.587	0	1	1.77	18.61	1.5	0.439	0.002
Emergency stair2	2	0	1.2	0	1.38	0	1.587	0	1	1.77	29.66	1.5	0.700	0.004
Main stair	1	0	0.6	0	0.69	0	0.7935	0	1	1.77	25.23	1.5	0.595	0.002
Laundries area 1	2	1	1.2	2	1.38	2.3	1.587	2.645	1	1.77	5.88	1.5	0.139	0.001
Laundries area 2	2	1	1.2	2	1.38	2.3	1.587	2.645	1	1.77	7	1.5	0.165	0.001

- **HVAC Calculation:**

We designed special load sockets for fan coil

Sample of calculation:

The power of fan coil is 154 W

$$Power = I * V * powerfacto$$

$$154 = I * 220 * .9 = 0.77\ Amp.$$

$$I\ design\ =\ I\ load\ *\ 1.15$$

$$I\ design\ =\ 0.77\ *\ 1.15\ =\ 0.89\ Amp.$$

$$We\ use\ Cross\ wire\ 1.5\ mm^2\ .$$

$$R=\ (L*\mathcal{P})/A\ =\ 1.77*\ 10-8\ *2*22.01/\ 10*10\text{^}-6=\ 0.52\Omega.$$

$$V\ Drop\ =\ 0.89*\ 0.52\ =\ 0.4628$$

$$volt\ Percentage\ Voltage\ =\ (0.4628/220)\ *100\%\ =\ 0.0021\ \%\ <\ 5\%.\rightarrow ok.$$

Table 80:Indoor units calculation

Floor	indoor Fancoil	indoor Fancoil power	Total power	I_{load}	I_{CB}	I_{Cable}	Area of cable (mm^2)	ρ	L (m)	A (Use)	R	% Voltag drop
B3	1	294	606	1.485	1.708	1.964	1	1.77	12.99	1.5	0.307	0.002
	2	79		0.399	0.459	0.528	1	1.77	14.14	1.5	0.334	0.001
	3	154		0.778	0.894	1.029	1	1.77	15.36	1.5	0.362	0.001
	4	79		0.399	0.459	0.528	1	1.77	33.56	1.5	0.792	0.001
B2	1	294	606	1.485	1.708	1.964	1	1.77	23.55	1.5	0.556	0.004
	2	79		0.399	0.459	0.528	1	1.77	11.28	1.5	0.266	0.000
	3	154		0.778	0.894	1.029	1	1.77	14.14	1.5	0.334	0.001
	4	79		0.399	0.459	0.528	1	1.77	17.3	1.5	0.408	0.001
B1	1	294	527	1.485	1.708	1.964	1	1.77	24.53	1.5	0.579	0.004
	2	79		0.399	0.459	0.528	1	1.77	16.77	1.5	0.396	0.001
	3	154		0.778	0.894	1.029	1	1.77	0.6	1.5	0.014	0.000
Ground floor	1	154	233	0.778	0.894	1.029	1	1.77	22.01	1.5	0.519	0.002
	2	79		0.399	0.459	0.528	1	1.77	19.73	1.5	0.466	0.001
Attic	1	294	588	1.485	1.708	1.964	1	1.77	15.37	1.5	0.363	0.002
	2	294		1.485	1.708	1.964	1	1.77	9.94	1.5	0.235	0.002
First floor	1	294	373	1.485	1.708	1.964	1	1.77	16.65	1.5	0.393	0.003
	2	79		0.399	0.459	0.528	1	1.77	9.26	1.5	0.219	0.000
Second floor	1	294	373	1.485	1.708	1.964	1	1.77	16.65	1.5	0.393	0.003
	2	79		0.399	0.459	0.528	1	1.77	9.26	1.5	0.219	0.000
Third floor	1	294	373	1.485	1.708	1.964	1	1.77	16.65	1.5	0.393	0.003
	2	79		0.399	0.459	0.528	1	1.77	9.26	1.5	0.219	0.000
Fourth floor	1	294	373	1.485	1.708	1.964	1	1.77	16.65	1.5	0.393	0.003
	2	79		0.399	0.459	0.528	1	1.77	9.26	1.5	0.219	0.000
Fifth floor	1	294	373	1.485	1.708	1.964	1	1.77	16.65	1.5	0.393	0.003
	2	79		0.399	0.459	0.528	1	1.77	9.26	1.5	0.219	0.000
Sixth floor	1	154	448	0.778	0.894	1.029	1	1.77	7.27	1.5	0.172	0.001
	2	294		1.485	1.708	1.964	1	1.77	23.59	1.5	0.557	0.004

Table 81:Outdoor units calculation

Floor	indoor Fancoil	indoor Fancoil power	Total power	I_{load}	I_{CB}	I_{Cable}	Area of cable (mm^2)	ρ	L (m)	A (Use)	R	% Voltag drop
Roof	1	1850	5550	9.343	10.745	12.357	1.5	1.77	16	1.5	0.378	0.016
	2	1850		9.343	10.745	12.357	1.5	1.77	12.87	1.5	0.304	0.013
	3	1850		9.343	10.745	12.357	1.5	1.77	10.58	1.5	0.250	0.011

Circuit breaker design calculation:

Total lighting in plan:

$Iload = (total\ power\ /\ (V * Power\ factor) = 3957.6\ /\ (220 * 0.9) = 18Amp$

$Iload = 18 * 0.8 = 14.4\ A$

$ICB = 14.4 * 1.15 = 16.56\ A$

$Icable = 16.56 * 1.15 = 19.044\ A$

$Nominal\ cross\ section\ area = 4\ mm2$

$Use\ cross\ section\ area = 10\ mm2$

$L = 60.4m$

$R\ Wire = (1.77 * 10 - 8) * (60.4 * 2)/1.5 * 10 - 6 = 1.4$

$Voltage\ drop = 18 * 1.4 = 25.65\ volt$

$Voltage\ drop\ \% = 25.66/220 * 100\% = 0.11\% < 5\% \rightarrow Ok$

Table 82:Total power lighting.

Floor	power
B3	1514
B2	1630
B1	7527.5
Ground floor	1896.6
Attic	2860.7
First floor	4350.4
Second floor	4350.4
Third floor	4350.4
Fourth floor	4350.4
Fifth floor	4350.4
Sixth floor	2390.8
total power	39571.6

- **Total power**

$(Power) = No.of\ room * Power\ in\ critical\ room\ (Laundry\ area) * Power\ factor$

$115 * (28800) * 0.3 = 993.600\ W$

$Total\ power\ for\ special\ load = 10423w$

$The\ total\ power\ load$

$$= (special\ load * demand\ factor) + (normal\ load * demand\ factor) + (lighting\ load * demand\ factor)$$

$= 10423 + 3957.6 + 993.600 = 15374.2\ W$

$Total\ current = ((Total\ power/ (V * power\ factor))$

$= (207713.6/ 220 \times .9)) = 77.65\ Amp.$

$Total\ current\ for\ the\ circuit\ breaker = 1.15 \times I\ load$

$= 1.15 * 77.65 = 89.3\ Amb.$

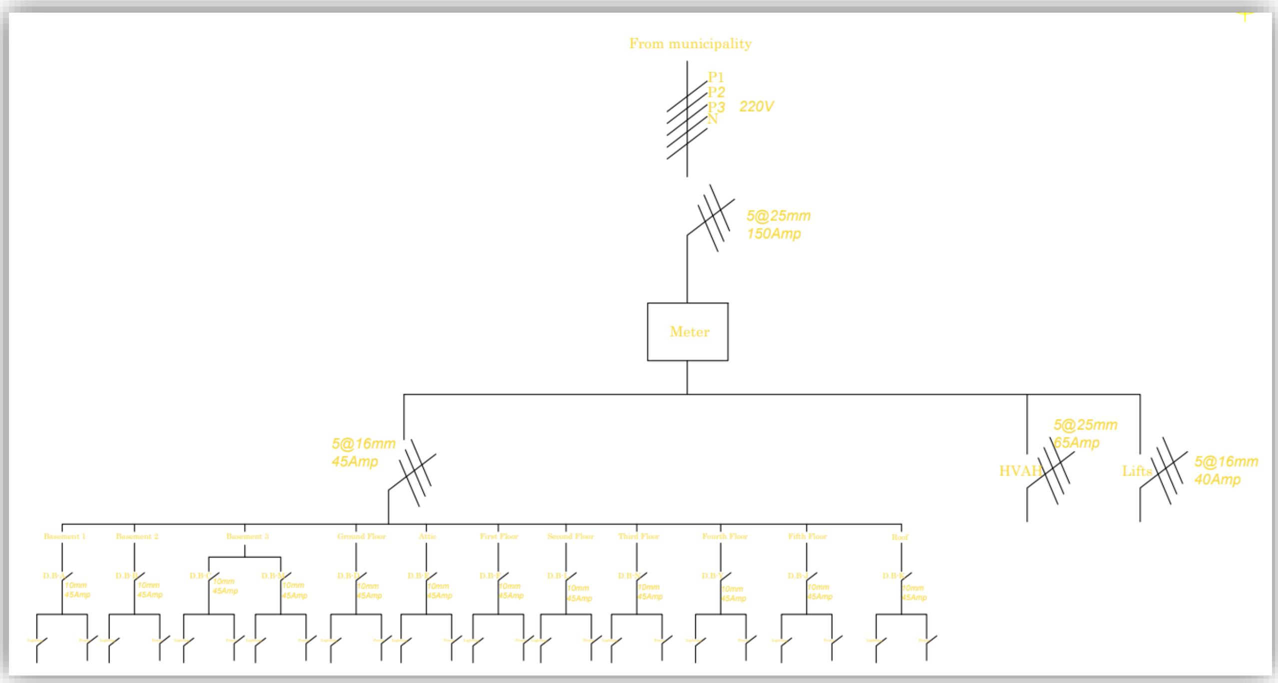


Figure 332:Main Distribution Board

4.4 Acoustical aspects

4.4.1 Introduction

One of the systems that must be carefully considered in the design of buildings is the audio system because of its impact on achieving auditory comfort for people inside the building by reducing noise and achieving clarity between people inside the space.

This means that there is a main goal of processing acoustic spaces, which is to reduce the level of noise that reaches this space in two ways, first, the noise transmitted by the structure: means the transmission of sound between architectural spaces by building elements, second, airborne noise: the transmission of sound between architectural spaces by air.

There are several ways to address sound noise within spaces:

The environment where the building will be built is far from the sources of inconvenience and the selection of appropriate building materials in sound insulation and finally the initial calculation of sound insulation before the construction process.

In general, you need to know the recommended sound for this space before starting the sound design process for any space, so you need to know the sound standards for architectural spaces in this project.

Architectural spaces must be known before that :(hotel bedrooms, restaurant, gymnasium, kitchens, cafeteria, waiting area, reception, restaurant, corridors, and cafeteria).

Reverberation Time (RT60)

Definition: It is the time it takes to drop the sound pressure level by 60 dB after the sound source is suddenly shut down, and depends on the absorption of the material room, the speed of sound, and the sizes of the room.

Importance: The increase in the reverberation time of the sound from the required limit within the space negatively affects the clarity of speech, and this means that it is necessary to know the reverberation time for any space to be processed according to its symbols and standards.

Symbols: Measures the reverberation time of performance spaces according to (ISO 3382-1) and normal rooms according to (ISO 3382-2) and standard according to (ASTM E2235).

Criteria: The following image shows the standard reverberation time value graph for many spaces within the building.

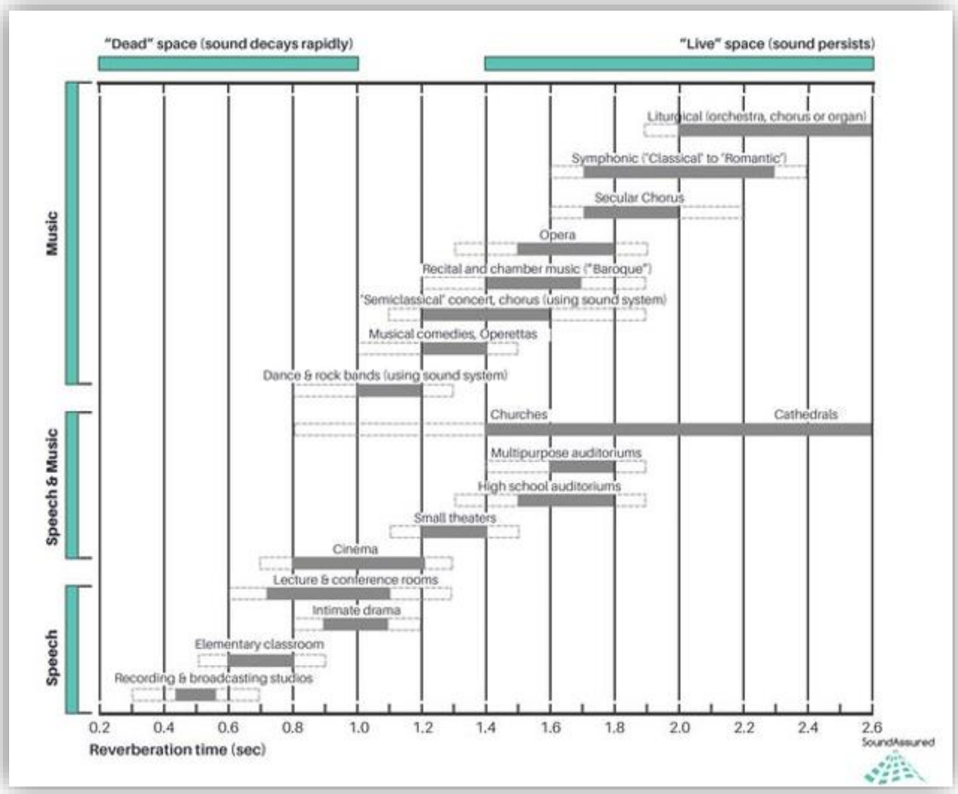


Figure 333:Diagrams show target Reverberation Time for many Spaces (MEEB).

You need to collect the criteria and the reverberation time of the spaces in the building as shown in the following table:

Table 83:Standard reverberation time for spaces in our building

Name of Space	Reverberation time
Hotel Bedroom	Not exceed 0.5
Kitchen	Not exceed 1
Resturant and Cafetrria	0.6-1
Office	0.5-1.1
Gym	Not exceed 1.5
Receotion	Not exceed 1.7
Corridors	Not exceed 0.7

Noise Calibrator (NC)

As it is a standard to describe the permissible noise level within a given space.

Criterial: The following table shows the value of noise standards for many spaces within the building.

Table 84:Noise Criteria in many Spaces (MEEB)

Type of Space (and Acoustical Requirements)	NC Curve	Equivalent[a] 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.	—	—

Table 85:Target Noise Criteria for spaces in our building

Name of Space	Noise Calibrator-NC (dB)
Hotel Bedroom	25-30
Kitchen	45-60
Resturant and Cafetrria	35-50
Office	30-35
Gym	35-50
Receotion	35-40
Corridors	45-45

Lost audio transmission (STC)

It is a parameter through which the effect of the walls is measured to mitigate the impact of airborne sound echo between different spaces at a frequency of 500 Hz.

The following tables show STC standard values for many types of partitions, walls, doors, and glass.

Table 86:STC values for layers of many Internal Partitions.

Door Construction	STC
Louvered door	15
Any door, 2-in. (51-mm) undercut	17
1½-in. (38-mm) hollow core door, no gasketing	22
1½-in. (38-mm) hollow core door, gaskets and drop closure	25
1¾-in. (45-mm) solid wood door, no gasketing	30
1¾-in. (45-mm) solid wood door, gaskets and drop closure	35
Two hollow core doors, gasketed all around, with sound lock	45
Two solid core doors, gasketed all around, with sound lock	55
Special commercial construction, with lead lining and full sealing	45–65

Table 87:STC values for many types of Doors.

Description	STC[c]
Basic partition: single wood studs, 16 in. (406 mm) on center, ½-in. (13-mm) gypsum board on both sides, air cavity	35
Add to basic partition	
Double gypsum board, one side	+2
Double gypsum board, both sides	+4
Single-thickness absorbent material in air cavity	+3
Double-thickness insulation	+6
Resilient channel supports for gypsum board	+5
Staggered studs	+9
Double studs	+13

Table 88:STC values for many types of windows constructions, airborne sound insulation between dwelling units.

Window Construction	STC
Operable wood sash, ⅛-in. (3.2-mm) glass, unsealed	23
Operable wood sash, ¼-in. (6.4-mm) glass, unsealed	25
Operable wood sash, ¼-in. (6.4-mm) glass, gasketed	30
Operable wood sash, laminated glass, unsealed	28
Operable wood sash, double-glazed, ⅛-in. (3.2-mm) panes, ⅜-in. (9.5-mm) air space, gasketed	29
Fixed sash, double ⅛-in. (3.2-mm) panes, 3-in. (76-mm) air space, gasketed	44
Fixed sash, double ⅛-in. (3.2-mm) panes, 4-in. (102-mm) air space, gasketed	48

Table 89:STC for different functions.

Partition Function between Dwellings: Apt. A		Apt. B	Grade II STC
Bedroom	to	Bedroom	52
Living room	to	Bedroom[a]	54
Kitchen[b]	to	Bedroom[a]	55
Bathroom	to	Bedroom[a]	56
Corridor	to	Bedroom[a,c]	52
Living room	to	Living room	52
Kitchen[b]	to	Living room[a]	52
Bathroom	to	Living room	54
Corridor	to	Living room[a,c,d]	52
Kitchen	to	Kitchen[e]	50
Bathroom	to	Kitchen	52
Corridor	to	Kitchen[a,c,d]	52
Bathroom	to	Bathroom	50
Corridor	to	Bathroom[a,c]	48

Table 90:STC values for layers of masonry walls with modifications.

Description	STC[a]
4-in. (102-mm) lightweight[b] hollow block	36
4 in. (102-mm) dense hollow block	38
6-in. (152-mm) lightweight hollow block	41
6-in. (152-mm) dense hollow block	43
8-in. (203-mm) lightweight hollow block	46
8-in. (203-mm) dense hollow block	48
12-in. (305-mm) lightweight hollow block	51
12-in. (305-mm) dense hollow block	53
4-in. (102-mm) brick	41
6-in. (152-mm) brick	45
8-in. (203-mm) brick	49
12-in. (305-mm) brick	54
6-in. (152-mm) solid concrete	47
8-in. (203-mm) solid concrete	50
10-in. (254-mm) solid concrete	53
12-in. (305-mm) solid concrete	56

[b]All ratings of lightweight block assume sealing with paint. Note that this reduces absorption.

Modifications	
Add sand to cores of hollow blocks	+3
Add plaster to one side	+2
Add plaster to both sides	+4
Add furring strips, lath and plaster: One side	+6
Add furring strips, lath and plaster: Two sides	+10
Add plaster via resilient mounting: One side	+10
Add plaster via resilient mounting: Two sides	+15

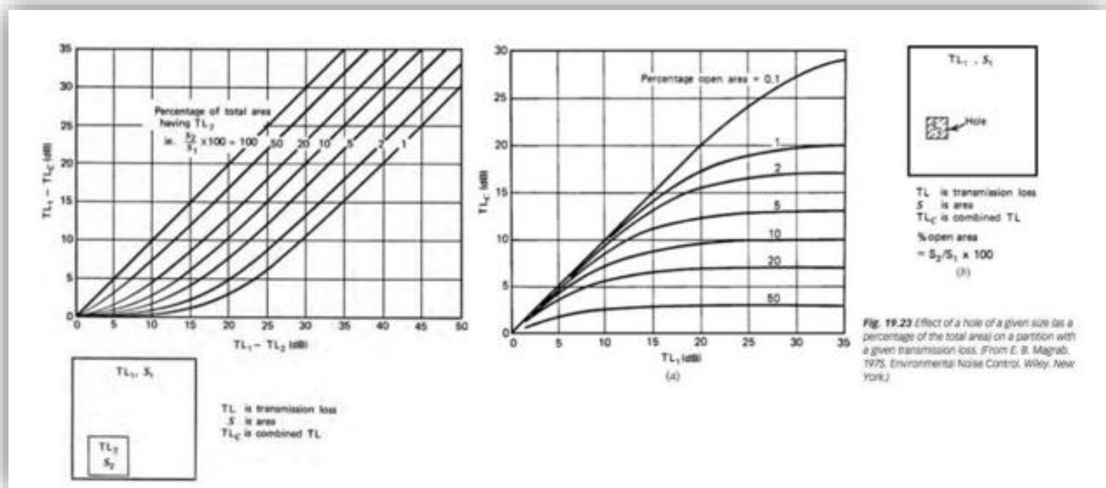


Figure 334:The figures show the STC values adjacent for composite walls and walls with holes.

Impact insulation class (IIC)

It is a parameter through which the impact of ceilings and floors is measured to mitigate the impact of airborne sound between floors at a frequency of 500 Hz

The following tables show the IIC value standards for many types of floors and ceilings.

Table 91:IIC values for layers of floors and ceilings.

Assembly No.	Description	STC	IIC
1.	6 in (150 mm) hollow core slabs	48	23
2.	Assembly 1 with carpet and pad	48	69
3.	Assembly 1 with ½ in (13 mm) wood block flooring adhered directly	48	48
4.	Assembly 1 with ½ in (13 mm) wood block flooring adhered to ½ in (13 mm) sound-deadening board underlayment adhered to concrete	49	49
5.	Assembly 1 with ¾ in (19 mm) gypsum concrete	50	41
6.	Assembly 1 with ¾ in (19 mm) gypsum concrete on ½ in (13 mm) sound-deadening board underlayment adhered to concrete	50	50
7.	Assembly 1 with carpet and pad on 3/4 in (19 mm) gypsum concrete	50	72
8.	on ½ in (13 mm) sound-deadening board underlayment adhered to	50	28
	concrete	50	73
	8 in (200 mm) hollow core slabs	51	47
9.	Assembly 8 with carpet and pad	52	54
10	Assembly 8 with ½ in (13 mm) wood block flooring adhered directly		
11.	Assembly 8 with ½ in (13 mm) wood block flooring adhered to ½ in (13 mm) sound-deadening board underlayment adhered to concrete	52	55
12.	Assembly 8 with ½ in (13 mm) wood block flooring adhered to ½ in (13 mm) plywood adhered to 7/16 in (11 mm) sound-deadening board underlayment adhered to concrete	50	51
13.	Assembly 8 with 5/16 in (8 mm) wood block flooring adhered to ¼ in (6 mm) polystyrene underlayment adhered to concrete	50	51

Table 92:IIC values for airborne and impact sound insulation of floors and ceilings between many Dwellings units

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

Speech Intelligibility

It is the percentage of the speaker's output that the listener can easily understand.

Clear speech classification where speech is understood within space through two criteria.

Signal/noise ratio (S/N).

It is the ratio of signal power to noise capacity.

Table 93:Signal noise ratio (Course Slides)

S/N	<10 dB	10 dB -30 dB	>30 dB
Intelligibility	Weak	Good	Excellent

Articulation Loss (%AL CONS)

It is the loss of clarity of speech that makes it difficult to hear.

Table 94:percentage of articulation loss (Course Slides).

(%AL CONS	100-33%	33-15%	15-7%	7-3%	3-0%
Intelligibility	Unacceptable	Proplem	Acceptable	Good	Excellent

- Reverberation Time

The echo time (RT60) values for some important spaces inside the hotel were processed using Ecotec 2011 analysis software.

Hotel Bed Room:

Reverberation time (RT60) for hotel bedrooms does not exceed (0.5)Sec, which has been achieved, following Figures and Tables show this

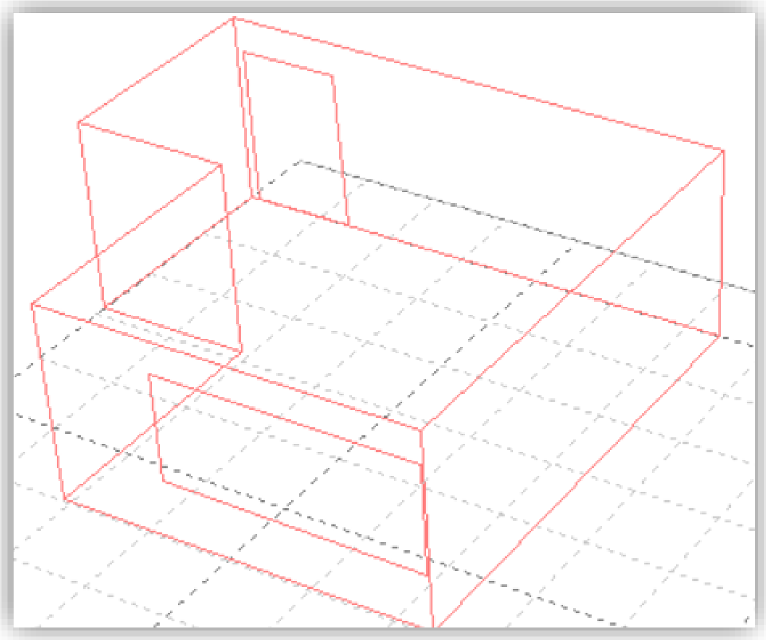


Figure 335:Hotel bedroom in Ecotec software

Table 95:Internal Finished Material Used for Hotel bedroom

Construction Element	Internal Finished Material Used
Ceiling	Plaster_Joists_Suspended
Walls	Brick Lime Plaster, Plaster _Partition,
Floor	Carpet
Door	HollowCore_Plywood
Window	Double Glazed ALU Frame

Table 96:Total Absorption and RT60 for Hotel Bedroom

Frequency (HRZ)	Total Absorption	Sabine (RT60)
63Hz:	29.157	0.42
125Hz:	26.843	0.46
250Hz:	25.942	0.46
500Hz:	24.657	0.49
1kHz:	25.612	0.45
2kHz:	25.103	0.42
4kHz:	8.072	0.37
8kHz:	6.937	0.16
16kHz:	8.036	0.17

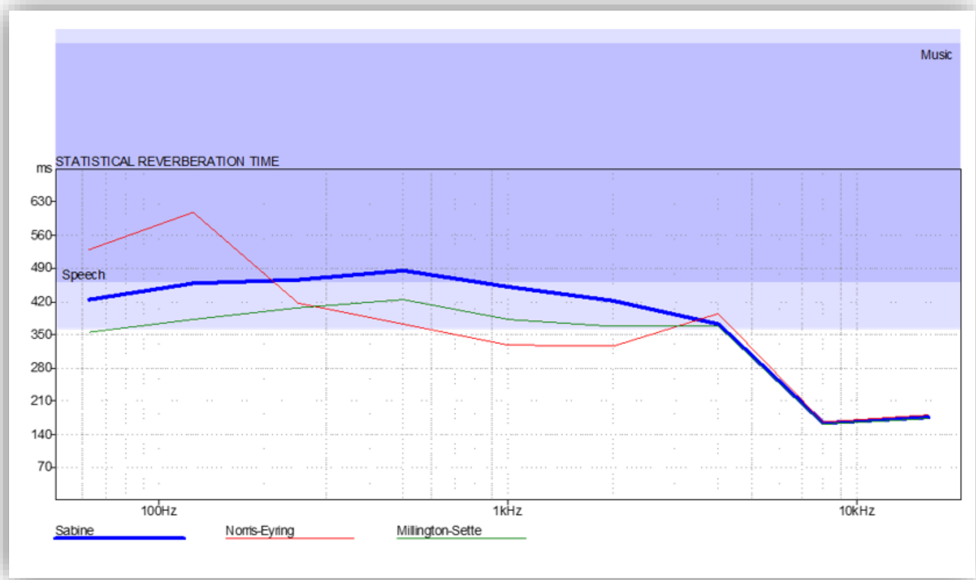


Figure 336:RT60 for Hotel Bedroom in Ecotec software

Gymnasium:

Reverberation time (RT60) for Gym does not exceed (1.5)Sec, which has been achieved, following Figures and Tables show this

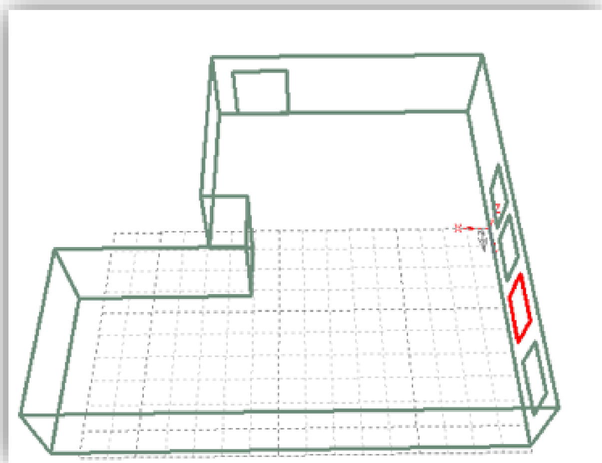


Figure 337:GYM in Ecotec software

Table 97:Internal Finished Material Used for Gym

Construction Element	Internal Finished Material Used
Ceiling	Plaster_Joists_Suspended
Walls	Brick Lime Plaster, Plaster _Partition
Floor	Linoleum
Door	Hollow Core_Plywood

Table 98:Total Absorption and RT60 for Gym

Frequency (HRZ)	Total Absorption	Sabine (RT60)
63Hz:	142.402	0.84
125Hz:	129.264	0.92
250Hz:	85.441	1.29
500Hz:	81.297	1.35
1kHz:	113.531	0.98
2kHz:	168.678	0.67
4kHz:	198.037	0.57
8kHz:	205.096	0.52
16kHz:	205.163	0.52

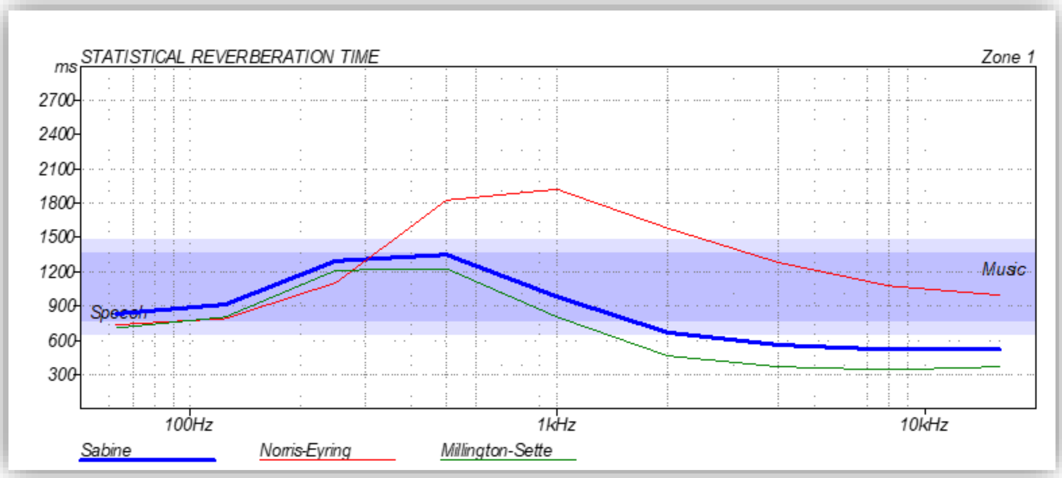


Figure 338:RT60 for GYM in Ecotec software

4.5 Firefighting system

4.5.1 Introduction

Fire safety requirements have become one of the most important standards that must be met These are considered when starting any design. Talking about these requirements is not limited to Insert escapes and exits. It includes the types of materials used in the design, In addition to manual fire extinguishing systems such as fire extinguishers and automatic systems such as Machine guns. Moreover, it includes sensor systems and alarm systems. It includes Preparing safe evacuation plans, providing safety training, and providing informational guidance on Emergency procedures.

These systems are used in a wide range of environments, including Residential and commercial buildings, factories, industrial facilities, medical centers, schools, and public places, to ensure the Safety of individuals and property in emergencies.

4.5.2 Escape stairs

Building codes and regulations often stipulate specific requirements for the design, construction, and maintenance of emergency stairs to ensure the safety of building occupants.

<u>All subsequent details provided are derived from the Palestinian Code for Fire Protection and Prevention.</u>

- ✓ **According to Clause (2/2/8)item D**
- The building needs two emergency exits that are far apart and separate from each other for all floors.

- ✓ **According to Clause (1/2/3): occupancy load**
- The occupancy load for design purposes is determined by dividing the floor area by a load factor of the occupancy.
- In multi-story buildings, the capacity of the exits at each floor is calculated to accommodate the occupancy load in it, or the occupancy load in any of the floors above it whose occupants use the same exits, and the capacity of the exits at the outlet is not equal to the sum of the capacities of the exits required for each floor, but rather is equal to the maximum capacity of any of the floors Which use those exits.

Hotel occupancy load = 18.6(Total area)

Table 99:Total occupancy load in hotel.

floor	Area of floor (m)	occupancy load in each floor
Basement 3 floor	972.67	52.29408602
Basement 2 floor	972.76	52.29892473
Basement 1 floor	868.82	46.71075269
Ground Floor	689.66	37.07849462
Attica Floor	569.94	30.64193548
First Floor	335.23	18.02311828
Second Floor	579.95	31.18010753
Thread Floor	579.95	31.18010753
Fourth Floor	579.95	31.18010753
Fifth Floor	579.95	31.18010753
Sixth Floor	405	21.77419355
total occupancy load		383.5419355

✓ **According to Clause (2/3/3)**

Details of the internal stairs

- Stairs and landings used to connect more than three floors are made of non-combustible materials.
- Do not use the spaces located within a staircase that is part of the means of egress for any purpose that hinders the exit of the building's occupants.
- Every staircase, landing, and balcony are designed to resist live loads.
- The upper surface of the threads and stalls landing be rough enough to prevent slipping while walking on it
- The use of spiral or winder stairs is only permitted for specific tasks and under specific conditions.

✓ **According to Clause (5/3)**

- Each exit must be distanced from the other to ensure that the possibility of using them together is reduced as a result of any emergency that may close access to them at the same time.
- The distance between the two emergency exits must not be less than half of the largest diameter of the building if the building is not equipped with automatic sprinklers, and

not less than a third of the largest diameter if the building is equipped with automatic sprinklers.

- The exit path is not allowed to pass through a bathroom, bedroom, or any other room that is subject to closure. Likewise, the exit path is not allowed to pass through a high-risk space unless it is protected and isolated.
- Exit paths and doors leading to exits must be such that they can be easily identified. It is not permitted to install curtains or hangings on these doors, exits, or outlets in a way that obscures them from view or makes them difficult to identify. It is not permitted to install mirrors in or near any exit, as this may confuse knowing the direction of the exit.
- The maximum length of the exit path in hotels equipped with automatic sprinklers is 100 meters, while the maximum length of the common corridor equipped with automatic sprinklers is 15 meters.

✓ **According to Clause (7/3)**

- All exits must end with outlets that open directly onto the street or public road.
- The location of the access is determined and signs indicating it are placed so that it is clear to the occupants of the building or facility the direction of exit to the public road. A barrier must also be placed on the stairs at the level of the access to prevent the occupants of the building from descending to the lower floors that do not lead outside the building.

✓ **According to Clause (8/3)**

- The means of exit must be continuously illuminated while the occupants of the building are in it.
- The entire floors of the exit pathways, including corners, intersections, corridors, stairs, landing, and exit doors, must be illuminated with a minimum brightness of 10 lux, measured at floor level.
- It is prohibited to use battery-operated lighting units for main lighting of means of exit, and it is permitted to use them for backup lighting purposes.
- The use of reflective lighting materials is not permitted.

- ✓ **According to Clause (9/3)**
- The duration of backup lighting must not be less than an hour and a half, and the batteries in the backup lighting system must be automatically rechargeable from the main power generator, and must be of a type approved by the competent official authority.

- ✓ **According to Clause (2/1/3)**
- Exits must provide the required protection from fire and smoke along their entire length by insulating their walls and fire-resistant doors according to specifications.
- The construction materials used to insulate exits must have a fire-resistance rating of no less than two hours, for exits that connect four or more floors, regardless of the location of the floors near the outlet or the public street.
- All openings at the outlet are undertaken with self-closing fireproof doors, it is contained in items (3/5/2) and (4/5/2) and (1/3/3).

The construction materials used to insulate exits must have a fire-resistance rating of no less than two hours, for exits that connect four or more floors, regardless of the location of the floors near the outlet or the public street

- ➢ According to Clause (1/3/3):
- The pure opening width of any door shall not be less than (80) cm, and the shutter size shall not be more than (120) cm. Where the building is provided with a pair of doors, it must not be less than the pure width of one of them is at least 80 cm.
- The doors are out of the way out of the type with side hinges, so that the door opens in the same way out, if it is used in a place with high-risk contents, or the occupancy load is more than (50) people.
- The power to open the door shutter should not exceed 225 Newton.
- The opening of the doors leading to the stairs house is in the direction of the exit path itself, on not to be opened directly on the stairs without using a stream of at least the width the door in the path leading to the port, as shown in Figure

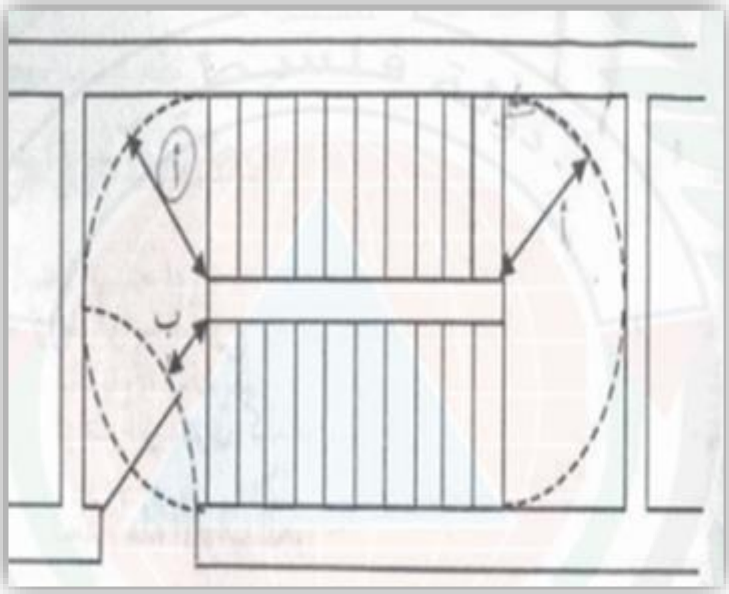


Figure 339:Escape staircase.

4.5.3 Fire Alarm System

- ✓ **According to Clause (3/2/8) item C**

The project needs automatic alarm systems and a voice evacuation system. Automatic alarm systems connected to either heat or smoke detectors were used based on the type of space as follows:

First, in the parking area, both types of detectors were used. Secondly, for kitchens and outdoor hallways, heat detectors were used. Thirdly, in the bedrooms, waiting area, and dining area, a smoke detector was used.

Table 100:Palestinian code requirements for fire alarm systems in hotel

	Type	Required cases
1	Alarm systems:	
Automatic addressable alarm system		All floors
2	Voice evacuation systems:	
Voice evacuation systems		All floors

Smoke detectors: Used in spaces that contain Rapid ignition characteristic materials, and should be placed away from undue airflow such as HVAC diffusers

Heat detectors: Used in spaces where smoke and vapors often exist, like parking and kitchens to avoid false alarms.

4.5.4 Fire Suppression Systems

- ✓ **According to Clause (3/2/8) item D**

The project needs manual extinguishers, hose stations, and sprinklers, so the hose station was relied on in the corridors. In contrast, the sprinklers were relied on in bedrooms, waiting and dining halls, and manual extinguishers in kitchens. In the gym, there are manual fire extinguishers, in addition to the presence of water sprinklers**.**

Table 101:Palestinian code requirements for Fire Suppression Systems in hotels

	Type	Required cases
1	Manual fire fighting equipment:	
Manual extinguishers		All floors
2	Fixed installations: water hose systems	
Wet system: rubber hoses		All floors
3	Automatic extinguishing systems	
Water sprinkler systems		For hotels in which the number of floors exceeds 4 floors, including service floors, or in which the number of guest rooms exceeds 40 hotel rooms, or in which the area of any service floor exceeds for 1000 m2

As for the parking lots, the machine gun was mainly relied on in addition to manual extinguishers and a hose station.

Table 102:Palestinian code requirements for Fire Suppression Systems in parking

	Type	Required cases
1	Manual fire fighting equipment:	
Manual extinguishers		All floors
2	Fixed installations: water hose systems	
rubber hose network		All floors for vaults over 500 m2
3	Fixed automatic systems	
1	Automatic fire fighting water sprinkler network	For vaults with an area of more than 1000m2
2	Automatic sprinklers network for Other materials	Particularly dangerous places where water cannot be used

In shops: According to Clause **(4/3/9):** In item C: Commercial occupancies with an area less than (280) square meters shall be equipped with handheld fire extinguishers only (Water mist) Provided that it is directly on the street.

4.5.4.1 Manual extinguishers

According to NFPA13

The location of portable fire extinguishers is determined by three primary factors: square footage and layout of an area, proximity to people, and presence of different types of combustible material. Assuming the presence of a combustible material, a Type A, C, or D extinguisher must always be within 75 feet of occupants of a building. A Type B extinguisher must always be within 30 to 50 feet of occupants, depending on the hazards that are present. A K-type extinguisher must be kept within 30 feet of a hazard at all times.

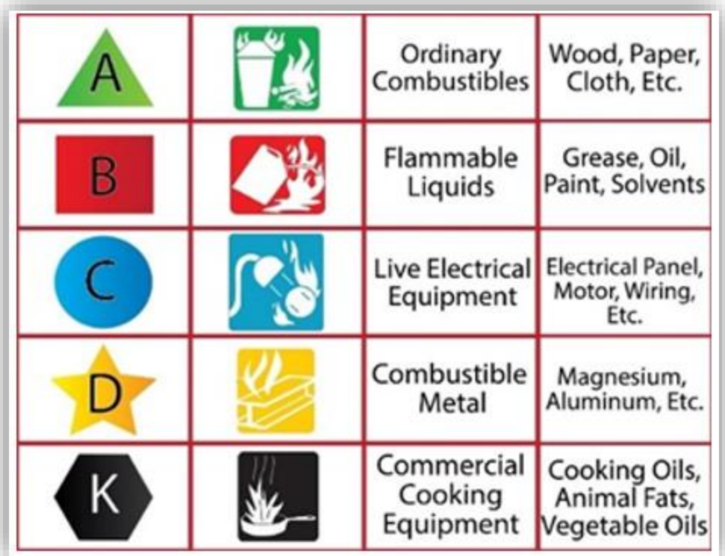


Figure 340:Extinguisher uses

Classifications of fire Extinguishers

Table 103:Classifications of fire Extinguishers

Class of Fire	Description
Class A Fires	Fires in ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics.
Class B Fires	Fires in flammable liquids, combustible liquids, petroleum greases, tars, oils, oil-based paints, solvents, lacquers, alcohols, and flammable gases.
Class C Fires	Fires that involve energized electrical equipment.
Class D Fires	Fires in combustible metals, such as magnesium, titanium, zirconium, sodium, lithium, and potassium.
Class K Fires	Fires in cooking appliances that involve combustible cooking media (vegetable or animal oils and fats).

- In Parking, GYM, Director's Room, Drying area, and Laundry area: Used powder extinguisher
- In the Kitchen: Used Wet chemical extinguisher class K.
- In shops and all other spaces: Used Water extinguisher class A

Figure 341:Powder extinguishers

4.5.4.2 Hose station

A fire hose was placed in a central area so that we could reach all spaces, provided that the maximum distance did not exceed 25 meters.

Figure 342:Hose station requirements

4.5.4.3 Sprinkler calculations:

- **Firstly:** Identifying the type of space in terms of its susceptibility to fire hazards.

"The hotel is considered to be of Ordinary hazard Group 1, including the garage, kitchens, bedrooms, etc."

- **Secondly:** Identify the type of Sprinkler system as a **wet pipe system** because we have space with normal temperatures of not less than 4 and not more than 70.

- **Thirdly:** An **upright-type sprinkler in the parking** to protect the sprinkler pipes in case of entry by loaded vehicles.

Selected a **Pendent-type sprinkler in the kitchen, bedrooms, and other spaces except the parking.**

Figure 344:Upright-type sprinkler

Figure 343:Pendent -type sprinkler

The area covered by the sprinkler head: **is $12.1m^2$ or ($130ft^2$), and the maximum spacing is 4.6 m, from the table at the bottom**

Note: The area may be less than 12.1m^2 depending on the nature of the ceiling and the presence of obstacles.

Table 104:Protected space and maximum sprinkler distance for normal hazard

Table 8.6.2.2.1(b)

Construction Type	System Type	Protection Area ft²	Protection Area m²	Maximum Spacing ft	Maximum Spacing m
All	All	130	12.1	15	4.6

Sample of calculation

Distribution of sprinklers for 3rd Basement floor

Num. of sprinklers = 694.7514/12.1 = 57.4≈ 58, we will use 58 sprinklers for this parking.

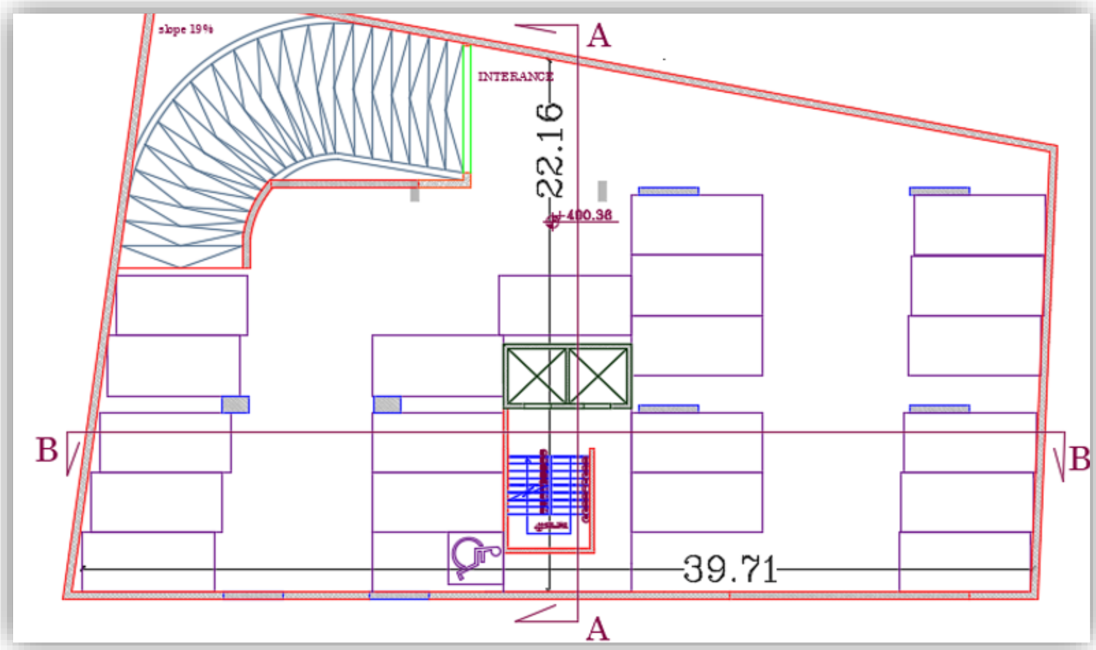


Figure 345:Parking dimensions

Spacing:

Number of Columns needed →Dist. Between sprinkler. = length of room/num. of sprinkler.

This value must be less than 4.6m, 39.71/58 =0.68 m … ok.

Dist. between edge sprinkler and wall = 0.5* dist. between sprinkler., 0.68/2 = 0.34 m

In the other direction

22.16/4.6 = 4.8, meaning we only need 5 rows.

Pipe sizing

The sizing of the pipes was done according to the following table.

Table 105:Pipe sizing for sprinklers

Steel		Copper	
1 in.	2 sprinklers	1 in.	2 sprinklers
1¼ in.	3 sprinklers	1¼ in.	3 sprinklers
1½ in.	5 sprinklers	1½ in.	5 sprinklers
2 in.	10 sprinklers	2 in.	12 sprinklers
2½ in..	20 sprinklers	2½ in.	25 sprinklers
3 in.	40 sprinklers	3 in.	45 sprinklers
3½ in.	65 sprinklers	3½ in.	75 sprinklers
4 in.	100 sprinklers	4 in.	115 sprinklers
5 in.	160 sprinklers	5 in.	180 sprinklers
6 in.	275 sprinklers	6 in.	300 sprinklers
8 in.	See Section 8.2	8 in.	See Section 8.2

The tree configuration was used to connect sprinklers to the supply.

Tree system: in this network the number of sprinkler heads in the branch should not exceed (branch) for 8 sprays.

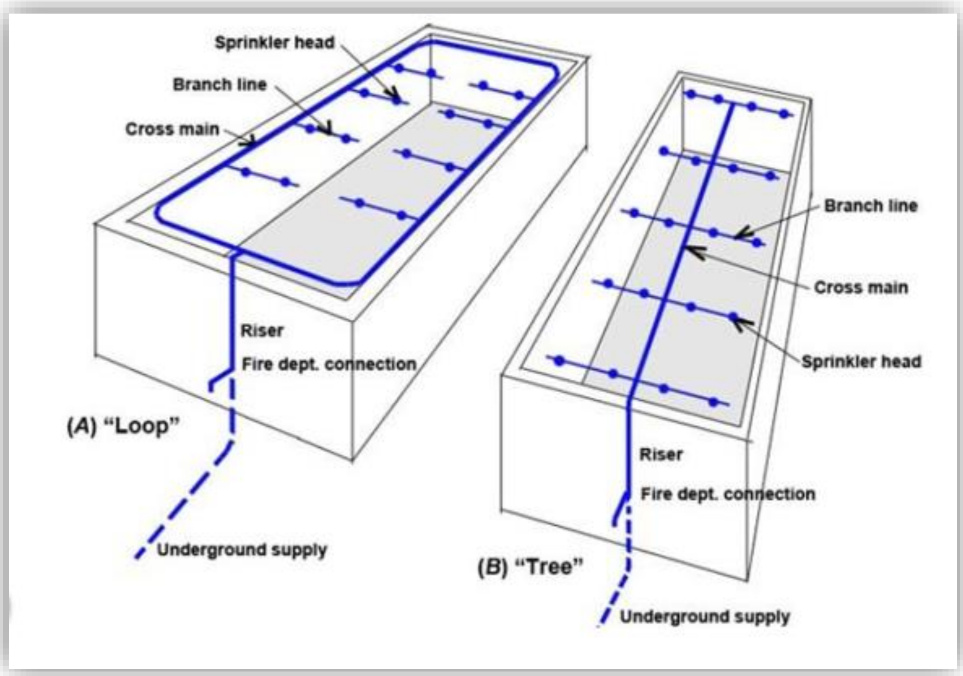


Figure 346:Tree system

Sprinkler placement

Figure 347:sprk spacing

Number of sprinklers and spacing for all spacing:

Table 106:Number of sprinklers 3rd Basement floor

3rd Basement floor									
Space	Area	Protection area	No. of sprinkler	length	spacing between rows	½ *S*	width	S max	number of columns
3rd Basement floor	694.7514	12.1	58	39.71	0.68	0.34	22.16	4.6	5

Table 107:Number of sprinklers 2nd Basement floor

2nd Basement floor									
Space	Area	Protection area	No. of sprinkler	length	spacing between rows	½ *S*	width	S max	number of columns
2nd Basement floor	553.0138	12.1	46	39.71	0.86	0.43	22.16	4.6	5

Table 108:Number of sprinklers 1st Basement floor

1st Basement floor									
Space	Area	Protection area	No. of sprinkler	length	spacing between rows	½ *S*	width	S max	number of columns
Gym	230.185	12.1	20	17.04	0.85	0.43	16.91	4.6	4
Worker bed room	24.3558	12.1	3	7.3	2.43	1.22	3.93	4.6	1
Workwear room	20.4363	12.1	2	6	3.00	1.50	4.12	4.6	1
Kitchen	23.4184	12.1	2	5.32	2.66	1.33	4.5	4.6	1
Living room	27.3811	12.1	3	6.08	2.03	1.01	4.5	4.6	1
Prefabricated bedding area	23.758	12.1	2	5.86	2.93	1.47	4.11	4.6	1
Dirty laundry area	18.226	12.1	2	5.66	2.83	1.42	3.25	4.6	1
Publishing area	24.6965	12.1	3	5.43	1.81	0.91	4.65	4.6	2
Laundry area and Drying area	24.6192	12.1	3	9.34	3.11	1.56	2.9	4.6	1
Laundry sorting and Ironing area	54.7578	12.1	5	9.75	1.95	0.98	6.67	4.6	2
Director's Room	38.4003	12.1	4	6.45	1.61	0.81	6.18	4.6	2

Table 109:Number of sprinklers 1st Ground Floor

Ground Floor									
Space	Area	Protection area	No. of sprinkler	length	spacing between rows	½ *S*	width	S max	number of columns
Reception	47.0153	12.1	4	7.55	1.89	0.94	6.15	4.6	2

Table 110:Number of sprinklers Attic Floor

Attic Floor									
Space	Area	Protection area	No. of sprinkler	length	spacing between rows	½ *S*	width	S max	number of columns
Breakfast room	176.4164	12.1	15	20.24	1.35	0.67	14.04	4.6	4
Rest Hall	154.5629	12.1	14	13.71	0.98	0.49	11.91	4.6	3

The first floor is the repeated floor up to the fifth floor.

Table 111:Number of sprinklers First Floor

First Floor									
Space	Area	Protection area	No. of sprinkler	length	spacing between rows	½ *S*	width	S max	number of columns
Bed room 1	38.8208	12.1	4	7.21	1.80	0.90	5.86	4.6	2
Bed room 2	29.1324	12.1	3	7.15	2.38	1.19	4.11	4.6	1
Bed room 3	26.1339	12.1	3	6.09	2.03	1.02	5.55	4.6	2
Bed room 4	35.7007	12.1	3	7.64	2.55	1.27	6.09	4.6	2
Bed room 5	30.7223	12.1	3	6.15	2.05	1.03	5.95	4.6	2
Bed room 6	32.5076	12.1	3	6.43	2.14	1.07	6.05	4.6	2
Bed room 7	34.1753	12.1	3	7.65	2.55	1.28	5.25	4.6	2
Bed room 8	25.0143	12.1	3	7.61	2.54	1.27	4.16	4.6	1

Table 112:Number of sprinklers Roof Floor

Roof Floor									
Space	Area	Protection area	No. of sprinkler	length	spacing between rows	½ *S*	width	S max	number of columns
Restaurant	240.78	12.1	20.00	31.16	1.56	0.78	14.04	4.6	4.00

4.6 Water Supply System

4.6.1 Introduction

The water supply system in buildings is considered very important, and we must ensure water supply in the appropriate quantity and quality. The supply should be continuous without interruption, and the water should be clean, healthy, suitable for drinking and consumption, and at the proper flow and pressure. Designing a water supply system involves selecting appropriate pipes sizing them correctly and choosing suitable water tanks and pumps.

4.6.2 Water tanks

The tank size depends on the daily consumption rate per person, the number of users in the building, and the maximum possible number of days of interruption. In hotels, the quantity of water is usually multiplied to avoid issues with guests. The average water consumption per person in a hotel ranges from 300 to 800 liters. However, since this hotel implements conservation measures, the calculation can be based on 300 liters per person daily. In Nablus, water is cut off for three days, and on the fourth day, it returns.

- Calculating the size of the tank:

Population (number of users):

Number of bedrooms in the building= 40 bedrooms

Population= 40*1.9 = 76 person

The size of the tank = Daily consumption rate * Maximum number of possible days of interruption * Population = 300 liter/ person/ day * 3days * 76 person = 68400 liters.

A 1000-liter (1m3) water tank was used from Royal company. Three tanks of this type were used.

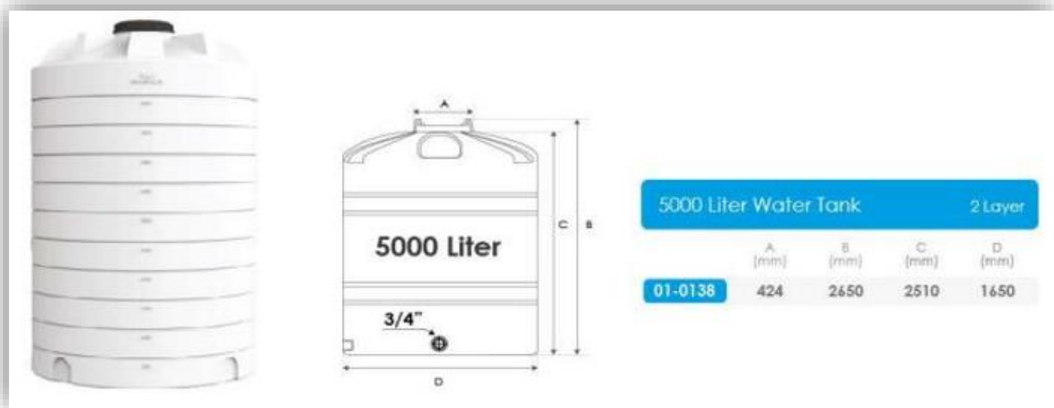


Figure 348:The water tank that was used in the project.

These tanks were placed on the roof. A well (a concrete tank) which has a volume of 120m3 was placed and designed under the third basement, so the water is collected in order to ensure that water is not cut off from the municipality and to reduce the number of water tanks on the roof. From this well, a consumption line comes out that enters a pump. Then, water is pumped to the upper tanks located on the hotel roof, which has a volume of 3 cubic meters. The well has been designed with a volume of 120 cubic meters to be sufficient for daily consumption and also for use in case of a fire.

Water tank stands: the picture below shows the water tank stand used in the project, which has a height of 6 meters and will carry the three tanks.

Figure 349:Water tank stand

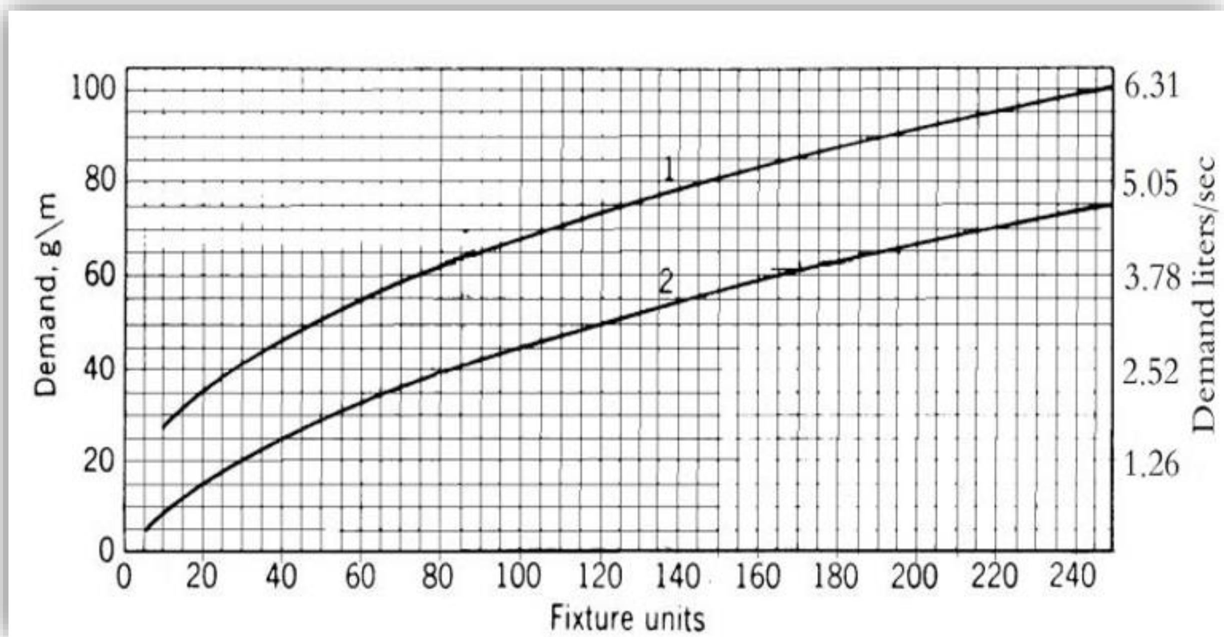
The following tables and figures are necessary in water system design:

Table 113:Water Supply Fixture Units (WSFU).

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
Bathtub	Private	Faucet	1	1	1.4
Bathtub	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.	⅜ 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

Table 114:Flow and Pressure to Typical Plumbing Fixtures.

Fixture Served	Minimum Flow Rate gpm (L/s)[a]	Minimum Pressure psi (kPa)[b]	Maximum Flow Rate or Quantity
Bathtub	4 (0.25)	8 (55)	
Bidet	2 (0.13)	4 (28)	
Combination fixture	4 (0.25)	8 (55)	
Dishwasher, residential	2.75 (0.17)	8 (55)	
Drinking fountain	0.75 (0.05)	8 (55)	
Hose bibb	5 (0.32)	8 (55)	
Laundry tray	4 (0.25)	8 (55)	
Lavatory, private	2 (0.13)	8 (55)	2.5 gpm at 80 psi (0.16 L/s at 551 kPa)
Lavatory, public	2 (0.13)	8 (55)	0.5 gpm at 80 psi (0.03 L/s at 551 kPa)
Lavatory, public, metering or self-closing	2 (0.13)	8 (55)	0.25 gallon (0.95 L) per metering cycle
Shower head	3 (0.19)	8 (55)	2.5 gpm at 80 psi (0.16 L/s at 551 kPa)
Shower head, temperature controlled	3 (0.19)	20 (138)	2.5 gpm at 80 psi (0.16 L/s at 551 kPa)
Sink, residential	2.5 (0.16)	8 (55)	2.5 gpm at 60 psi (0.16 L/s at 414 kPa)
Sink, service	3 (0.19)	8 (55)	2.5 gpm at 60 psi (0.16 L/s at 414 kPa)
Urinal, valve	15 (0.95)	15 (103)	1.5 gallons (5.7 L) per flushing cycle[a] or 1.0 gallon (3.8 L) per flushing cycle
Water closet, blow out, flushometer valve	35 (2.21)	25 (172)	4 gallons (15 L) per flushing cycle
Water closet, siphonic, flushometer valve	25 (1.58)	15 (103)	4 gallons (15 L) per flushing cycle[a] or 1.6 gallons (6 L) per flushing cycle
Water closet, tank, close coupled	3 (0.19)	8 (55)	1.6 gallons (6 L) per flushing cycle
Water closet, tank, one piece	6 (0.38)	20 (138)	1.6 gallons (6 L) per flushing cycle



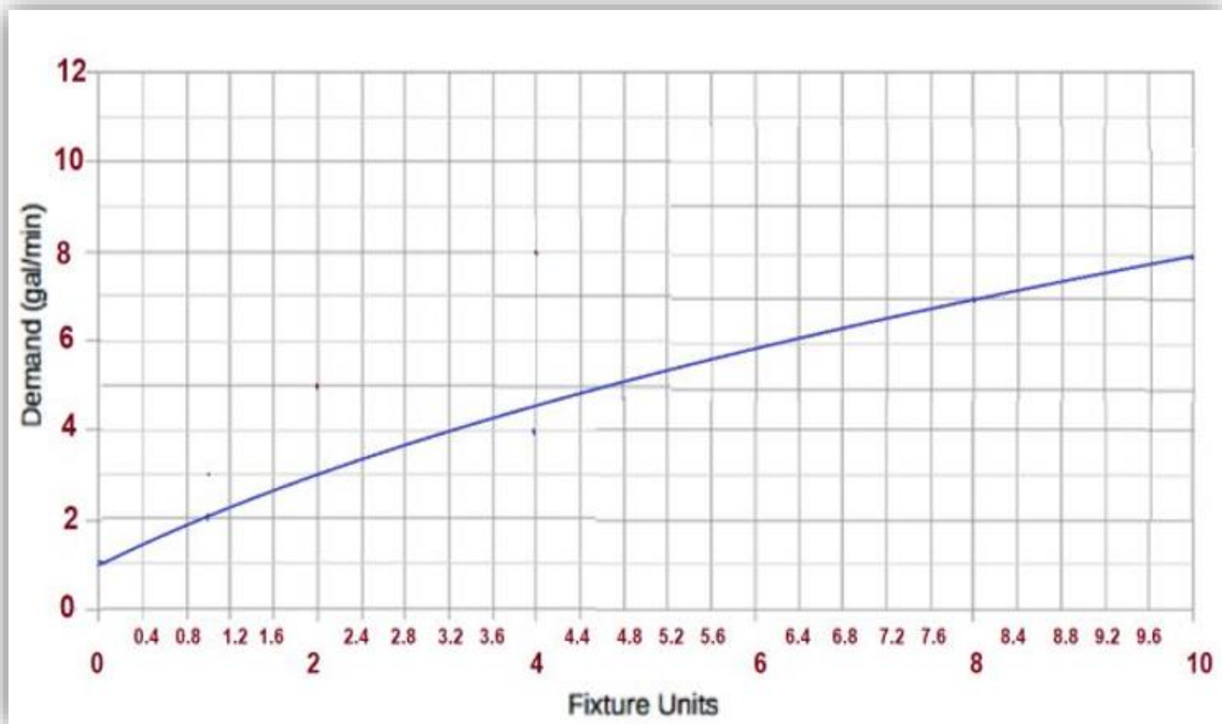


Figure 350:Water Flow as a Function of Fixture Units.

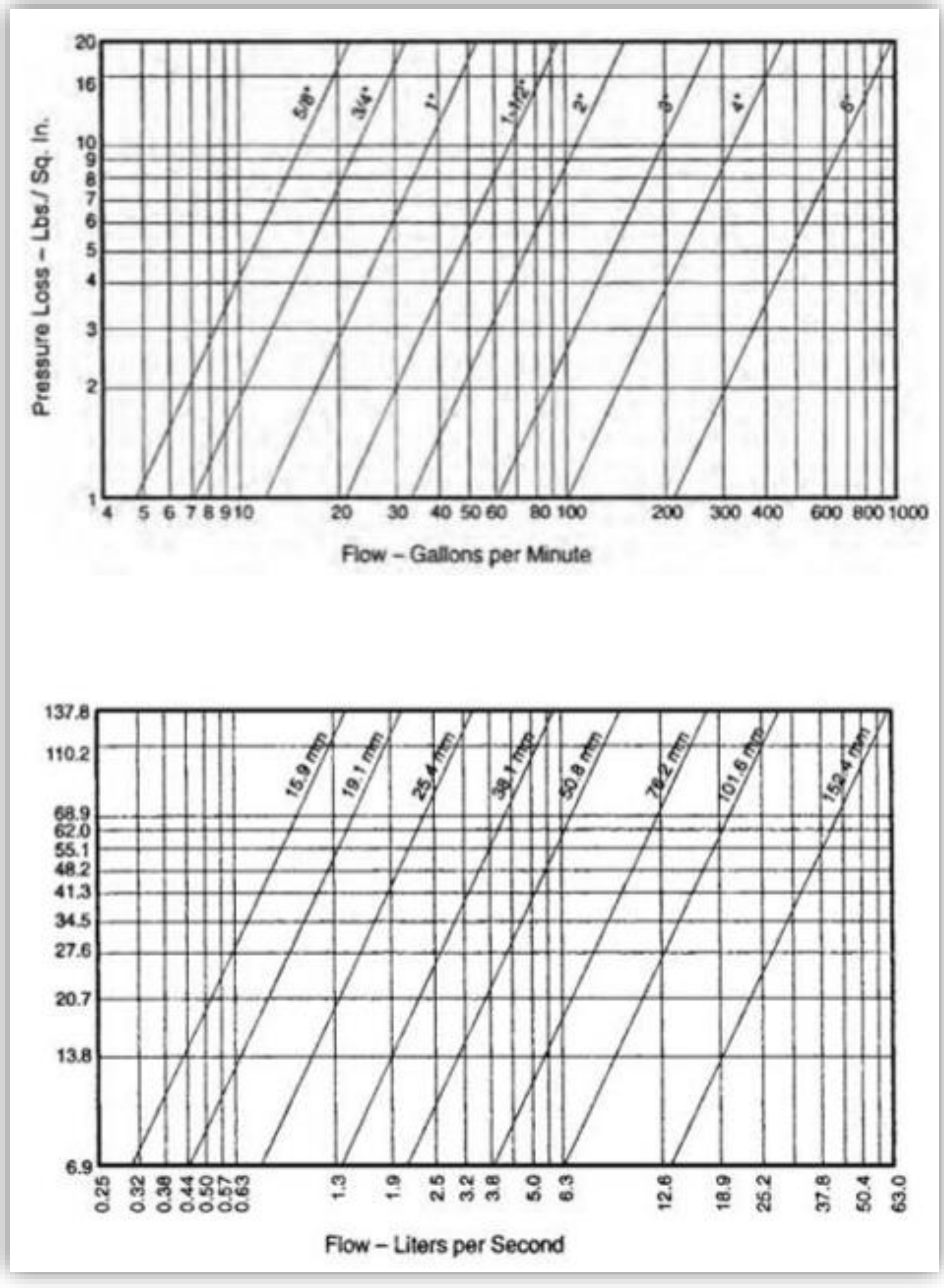
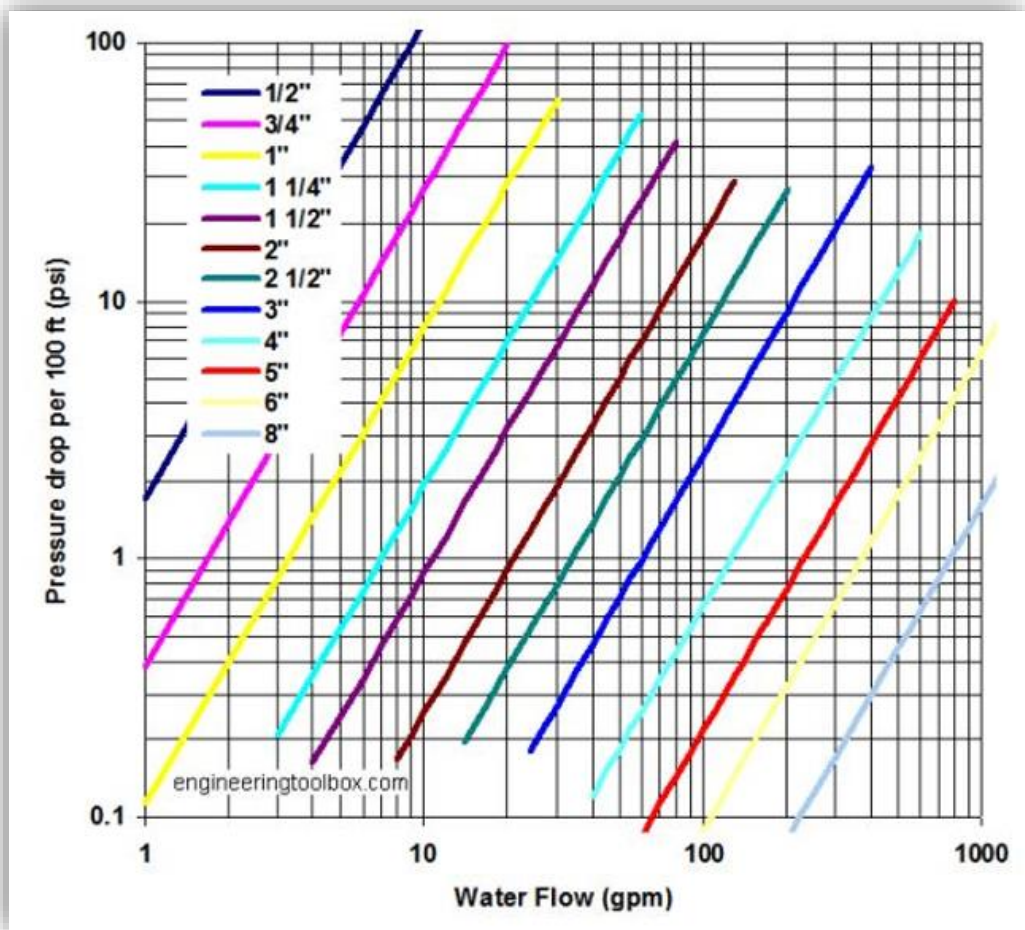


Figure 351:Friction Pressure Loss in Water Meter.

Table 115:Allowance in Equivalent Length of Pipe for Friction Loss in Valves and Threated Fittings.

PART A. I-P UNITS							
	Equivalent Length of Pipe for Various Fittings						
Diameter of Fitting (in.)	90° Standard Elbow (ft)	45° Standard Elbow (ft)	Standard Tee 90° (ft)	Coupling or Straight Run of Tee (ft)	Gate Valve (ft)	Globe Valve (ft)	Angle Valve (ft)
⅜	1	0.6	1.5	0.3	0.2	8	4
½	2	1.2	3	0.6	0.4	15	8
¾	2.5	1.5	4	0.8	0.5	20	12
1	3	1.8	5	0.9	0.6	25	15
1¼	4	2.4	6	1.2	0.8	35	18
1½	5	3	7	1.5	1.0	45	22
2	7	4	10	2	1.3	55	28
2½	8	5	12	2.5	1.6	65	34
3	10	6	15	3	2	80	40
3½	12	7	18	3.6	2.4	100	50
4	14	8	21	4.0	2.7	125	55
5	17	10	25	5	3.3	140	70
6	20	12	30	6	4	165	80

PART B. SI UNITS							
	Equivalent Length of Pipe for Various Fittings						
Diameter of Fitting (mm)	90° Standard Elbow (mm)	45° Standard Elbow (mm)	Standard Tee 90° (mm)	Coupling or Straight Run of Tee (mm)	Gate Valve (mm)	Globe Valve (mm)	Angle Valve (mm)
9.5	305	183	457	91	61	2438	1219
12.7	610	366	914	183	122	4572	2438
19.1	762	457	1219	244	152	6096	3658
25.4	914	549	1524	274	183	7620	4572
32	1219	732	1829	366	244	10668	5486
38	1524	914	2134	457	305	13716	6706
51	2134	1219	3048	610	396	16764	8534
64	2438	1524	3658	762	488	19812	10363
76	3048	1829	4572	914	610	24384	12192
102	4267	2438	6401	1219	823	38100	16764
127	5182	3048	7620	1524	1006	42672	21336
152	6096	3658	9144	1829	1219	50292	24384



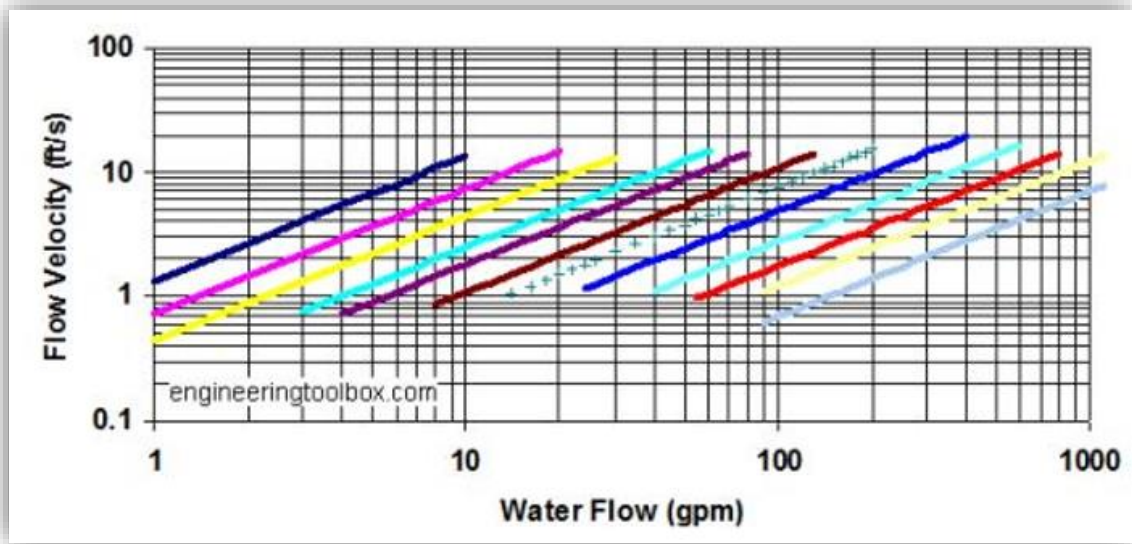


Figure 352: Friction Loss in Steel water pipes.

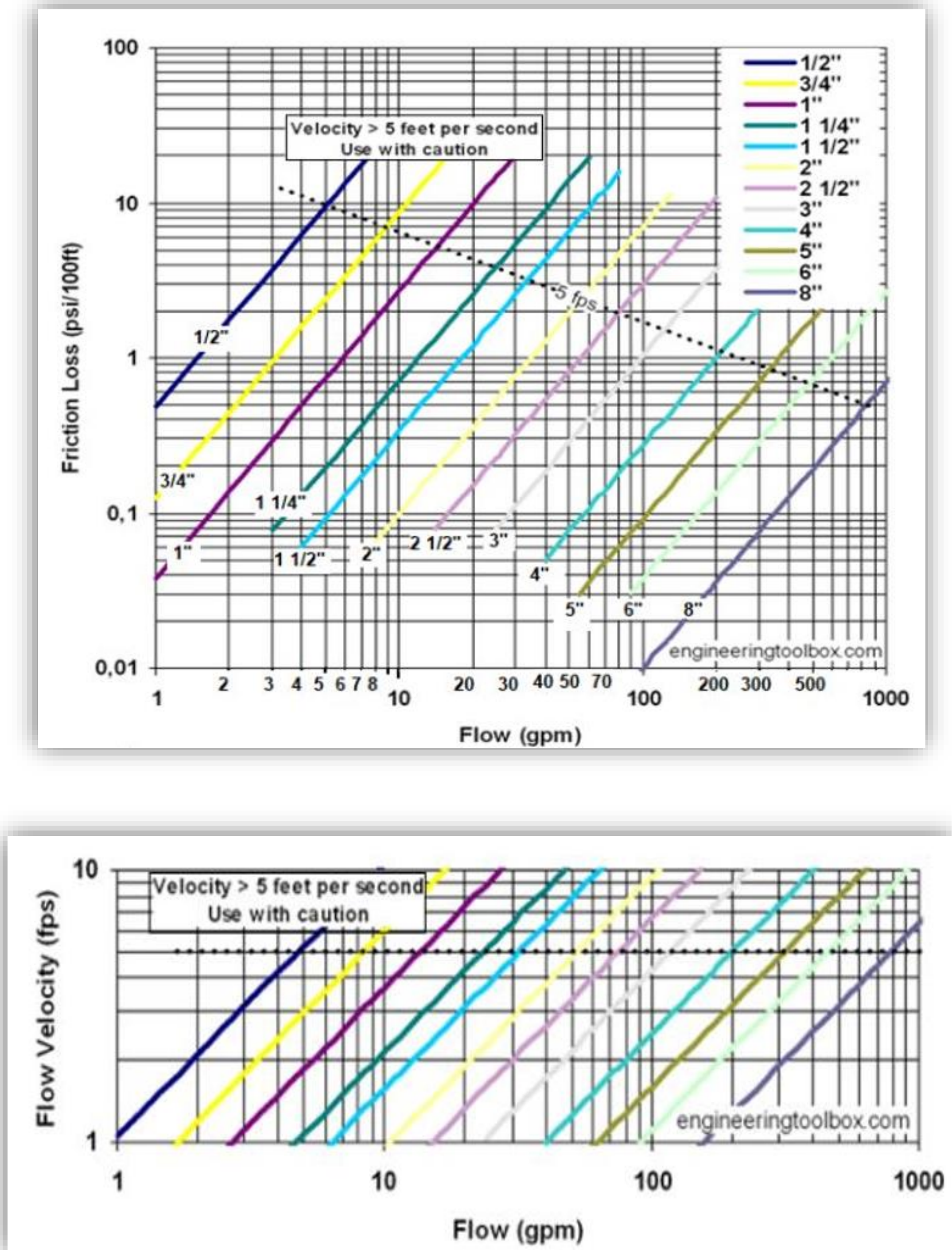


Figure 353:Friction Loss in PVC pipes.

4.6.3 Water Collector

Mechanical plans for the project have been prepared, illustrating the water supply process for various floors, where the locations of the water collectors have been identified, and a network for the water lines has been created, showing the locations of the lines, their directions, and how they exit from the water collector to the fixture units.

4.6.3.1 Water Supply Fixture units

The table below shows the types of water supply fixture units used in our project.

Table 116:Water supple FUs values for each fixture type used in our project.

Fixture	**Occupancy**	**Type of supply control**	**Load values in WSFU**		
			Cold	Hot	Total
Dishwashing machine	Private	Automatic	-	1.4	1.4
Kitchen sink	Hotel, Restaurant	Faucet	3	3	4
Kitchen sink	Private	Faucet	1	1	1.4
Lavatory	Private	Faucet	0.5	0.5	0.7
Lavatory	Public	Faucet	1.5	1.5	2
Washing machine, 15lb (6.8Kg)	Private	Automatic	1	1	1.4
Water closet	Public	Flush tank	5	-	5
Water closet	Private	Flush tank	2.2	-	2.2
Showerhead	Private	Mixing valve	1	1	1.4

The following table shows the number of Water Supply FUs for each floor in the hotel:

Table 117:Number of water supply FUs in each floor.

Fixture Type	Occupancy	# of Fixtures	FUs	Total FUs
Third Basement				
Lavatory	Private	1	0.7	0.7
Total				0.7
Second Basement				
Lavatory	Private	1	0.7	0.7
Total				0.7
First Basement				
Shower head	Private	10	1.4	1.4
Lavatory	Private	13	1.4	18.2
Water closet	Private	10	2.2	22
Dishwashing machine	Private	1	1.4	1.4
Kitchen sink	Private	3	1.4	4.2

Washing machine	Private	8	1.4	11.2
Total				58.4
Ground Floor				
Water closet	Private	8	2.2	17.6
Lavatory	Private	8	1.4	11.2
Total				28.8
Attic Floor				
Water closet	Private	6	2.2	13.2
Lavatory	Private	6	1.4	8.4
Dishwashing machine	Private	1	1.4	1.4
Kitchen sink	Private	4	1.4	5.6
Total				28.6
First Floor				
Water closet	Private	8	2.2	17.6
Lavatory	Private	8	1.4	11.2
Shower head	Private	8	1.4	11.2
Total				40
Second Floor				
Water closet	Private	8	2.2	17.6
Lavatory	Private	8	1.4	11.2
Shower head	Private	8	1.4	11.2
Total				40
Third Floor				
Water closet	Private	8	2.2	17.6
Lavatory	Private	8	1.4	11.2
Shower head	Private	8	1.4	11.2
Total				40
Fourth Floor				
Water closet	Private	8	2.2	17.6
Lavatory	Private	8	1.4	11.2
Shower head	Private	8	1.4	11.2
Total				40
Fifth Floor				
Water closet	Private	8	2.2	17.6
Lavatory	Private	8	1.4	11.2
Shower head	Private	8	1.4	11.2
Total				40
Sixth Floor				
Water closet	Public	6	5	30
Lavatory	Public	6	2	12
Dishwashing machine	Private	1	1.4	1.4
Kitchen sink	Hotel, Restaurant	4	4	16
Total				59.4

Section below illustrates water supply system process:

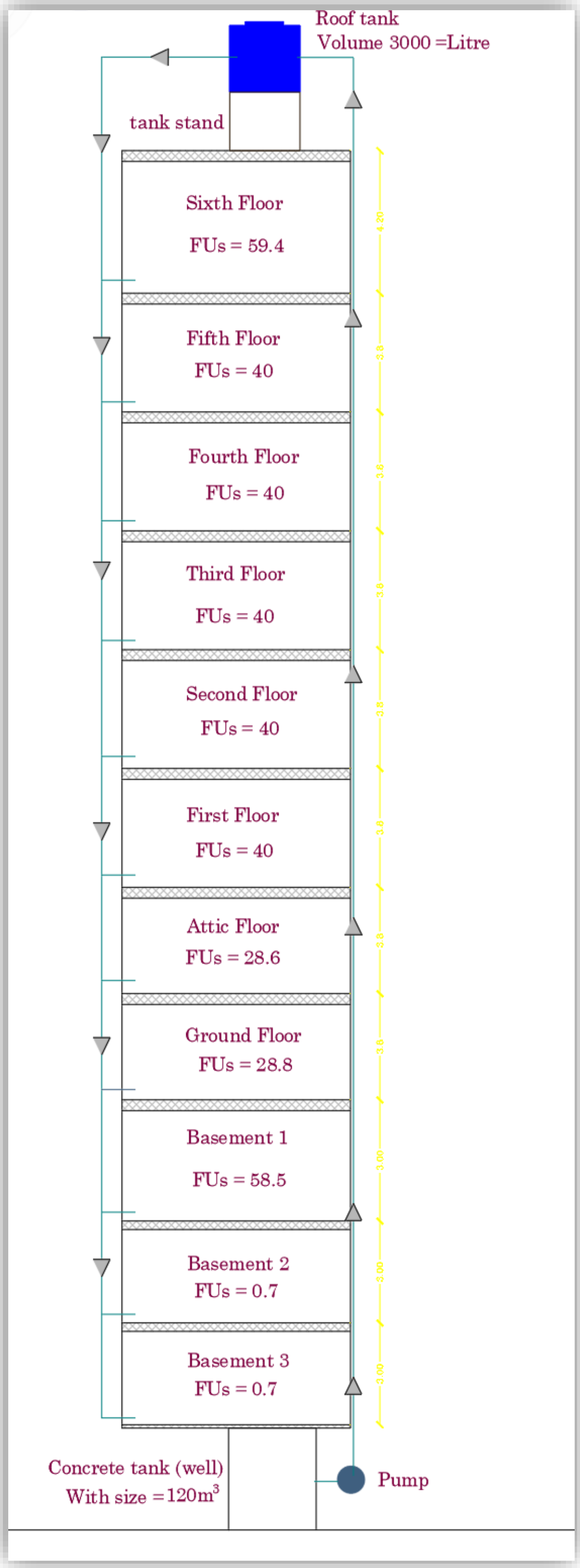


Figure 354: Water supply system process

Pressure calculations for each floor

P = 0.433 H

H: height of water (from mid of the tank to the faucet)

Average faucet height= 4 ft

Tank stand height= 19.7 ft

Tank height= 8.23 ft

For the ground floor:

P= 0.433 H = 0.433 (13.78 + 5*11.48 + 2*10.27 + 19.7 + 8.23/2 – 4) = 48.3 Psi.

For the first floor:

P= 0.433 H = 0.433 (13.78 + 5*11.48 + 19.7 + 8.23/2 – 4) = 39.4 Psi.

Table 118:Pressure values for each floor.

Floor	Floor height (foot)	Pressure (Psi)
Basement3	9.84	61.9
Basement2	9.84	57.62
Basement1	11.7	53.36
Ground floor	10.27	48.3
Attic floor	10.27	43.85
First floor	11.48	39.4
Second floor	11.48	34.43
Third floor	11.48	29.5
Fourth floor	11.48	24.5
Fifth floor	11.48	19.52
Sixth floor	13.78	14.55

The following table shows the water demand in gallon per minute for all collectors in all floors.

Table 119:Water demand in gallon per minute for all collectors in all floors.

	Total Fus	Demand (gallon per minute)
Basement3		
Vertical	1.4	2.5
Horizontal	0.7	1.9
Basement2		
Vertical	1.4	2.5
Horizontal	0.7	1.9
Basement1		

Collector1		
Vertical	14	12
Horizontal	14	12
Critical branch	1.4	2.5
Collector2		
Vertical	7	6.5
Horizontal	7	6.5
Critical branch	1.4	2.5
Collector3		
Vertical	155.2	58
Horizontal	16.6	13
Critical branch	2.2	3.2
Collector4		
Vertical	48.8	28
Horizontal	17.2	14.9
Critical branch	2.2	3.2
Collector5		
Vertical	16.2	13
Horizontal	16.2	13
Critical branch	2.2	3.2
Ground floor		
Collector1		
Vertical	21.6	16
Horizontal	21.6	16
Critical branch	2.2	3.2
	Collector2	
Vertical	48.8	28
Horizontal	7.2	6.6
Critical branch	2.2	3.2
Attic floor		
Collector1		
Vertical	155.2	58
Horizontal	21.6	16
Critical branch	2.2	3.2
Collector2		
Vertical	48.8	28
Horizontal	7	6.5
Critical branch	1.4	2.5
First floor (repeated to fifth floor)		
Collector1		
Vertical	155.2	58
Horizontal	15	12
Critical branch	2.2	3.2
Collector2		
Vertical	125	52
Horizontal	15	12
Critical branch	2.2	3.2
Collector3		

Vertical	125	52
Horizontal	10	9
Critical branch	2.2	3.2
Sixth floor		
Collector1		
Vertical	155.2	58
Horizontal	42	26
Critical branch	5	5
Collector2		
Vertical	48.8	28
Horizontal	17.4	14.9
Critical branch	4	4

4.6.4 Design of pipes

4.6.4.1 Pipes Sizing

The process of sizing pipes is critical in water supply, through which the size of water pipes is calculated, determining the appropriate diameter for these pipes, to ensure proper water flow without any problems. Two types of Pipes are used in the water system, Galvanized steel for vertical pipes and PVC for horizontal pipes.

For collector1 in basement1:

Pressure= 53.36 psi

For horizontal feeder: True length= 9 ft, Equivalent length (PVC)= 1.2*9 = 10.8 ft.

Amount of losses in the pipes are as follows:

Table 120:Amount of losses in pipes for horizontal feeder for collector1in basement1.

Diameters	1 1/2"	1 1/4"	1"
loss/100	0.5	1	3.9
loss/10.8'	0.05	0.1	0.4

For vertical feeder: True length= 11.7 + 2*10.27 + 5*11.48 + 13.78 + 20 + 19.7=143.12 ft

Equivalent length (steel pipe) = 1.5*143.12 = 214.7 ft.

Amount of losses in the pipes are as follows:

Table 121:Amount of losses in pipes for vertical feeder for collector1 in basement1.

Diameters	1 1/4"	1"	3/4"
loss/100	3	5	8
loss/214.7'	6.5	10.8	17.2

For meter:

Table 122::Amount of losses in meter for collector1 in basement1.

Diameters	1"	3/4"	5/8"
loss	0.2	3.1	7

For branch: True length= 31.2 ft, Equivalent length (PVC) = 1.2*31.2 = 37.44 ft.

Amount of losses in the branch are as follows:

Table 123:Amount of losses for branch for collector1 in basement1.

Diameters	1"	3/4"	1/2"
loss/100	0.2	0.65	2.8
loss/37.44'	0.07	0.24	1.1

Critical fixture required pressure = 8 psi.

Water pressure = 53.36 psi

Maximum possible loss in pressure = 53.36 – 8 = 45.36 psi

Diameter selection:

Table 124:The selected pipe diameters for collector1 in basement1.

Line	Vertical	Meter	Horizontal	Branch
Diameter	3/4"	1"	1"	3/4"
loss	17.2	0.2	0.4	0.24

Total loss = 17.2 + 0.2 + 0.4 + 0.24 = 18.04 psi < maximum loss → the diameter of the pipes selected is ok.

For collector2 on the attic floor:

Pressure= 43.85 psi

For horizontal feeder, True length = 2.95 ft, Equivalent length (PVC) = 1.2*2.95 = 3.54ft

Amount of losses in the pipes are as follows:

Table 125:Amount of losses in pipes for horizontal feeder for collector2 in attic floor.

Diameter	1 1/4"	1"	3/4"
loss/100	0.3	1.2	4
loss/3.54'	0.01	0.04	0.14

For vertical feeder: True length= 10.27 + 5*11.48 + 13.78 + 20 + 19.7 = 121.15ft

Equivalent length (steel pipe) = 1.5*121.15 = 181.7 ft.

Amount of losses in the pipes are as follows:

Table 126:Amount of losses in pipes for vertical feeder for collector2 in attic floor.

Diameter	2"	1 1/2"	1 1/4"
loss/100	1.8	6	7
loss/181.7'	3.2	10.9	12.7

For meter:

Table 127:Amount of losses in meter for collector2 in attic floor.

Diameter	1"	3/4"	5/8"
loss	2	5.4	10.6

For branch: True length= 30.2 ft, Equivalent length (PVC) = 1.2*30.2 = 36.24 ft.

Amount of losses in the branch are as follows:

Table 128:Amount of losses for the branch for collector2 in the attic floor.

Diameter	1"	3/4"	1/2"
loss/100	0.23	0.71	3
loss/36.24'	0.08	0.3	1.1

Critical fixture required pressure = 8 psi.

Water pressure = 43.85 psi

Maximum possible loss in pressure = 43.85 – 8 = 35.8 psi

Diameter selection:

Table 129:The selected pipe diameters for collector2 in attic floor.

Line	Vertical	Meter	Horizontal	Branch
Diameter	1 1/4"	1"	1"	3/4"
loss	12.7	2	0.04	0.3

Total loss = 12.7+ 2 + 0.04 + 0.3 = 15.04 psi < maximum loss □ the pipes diameter selected is ok.

The tables below illustrate the selected pipes, pipes sizing, and the amount of losses in vertical pipes, horizontal pipes, and branches in all floors.

Table 130:The selected pipes in basement 3.

Basement3			
Horizontal			
Diameters	1"	3/4"	1/2"
loss/100	0.12	0.38	1.6
loss/12.24'	0.01	0.05	0.2
Vertical			
Diameters	1"	3/4"	1/2"
loss/100	0.6	1.1	3
loss/244.2'	1.5	2.7	7.3

Table 131:The selected pipes in basement 2.

Basement2			
Horizontal			
Diameters	1"	3/4"	1/2"
loss/100	0.12	0.38	1.6
loss/12.24'	0.01	0.05	0.2
Vertical			
Diameters	1"	3/4"	1/2"
loss/100	0.6	1.1	3
loss/229.44'	1.4	2.5	6.9

Table 132:The selected pipes in basement1.

Basement1			
Collector1			
Horizontal			
Diameters	1 1/2"	1 1/4"	1"
loss/100	0.5	1	3.9
loss/10.8'	0.05	0.1	0.4
Vertical			
Diameters	1 1/4"	1"	3/4"
loss/100	3	5	8
loss/214.7'	6.5	10.8	17.2
Meter loss			
Diameters	1"	3/4"	5/8"
loss	0.2	3.1	7
Branch			
Diameters	1"	3/4"	1/2"
loss/100	0.2	0.65	2.8
loss/37.44'	0.07	0.24	1.1
Collector2			
Horizontal			
Diameters	1 1/4"	1"	3/4"
loss/100	0.3	1.2	3.8

loss/3.4'	0.01	0.04	0.1
Vertical			
Diameters	1"	3/4"	1/2"
loss/100	4	5	9
loss/214.7'	8.6	10.7	19.3
Meter loss			
Diameter	5/8"		
loss	2		
Branch			
Diameters	1"	3/4"	1/2"
loss/100	0.2	0.7	2.8
loss/24.4'	0.05	0.2	0.7
Collector3			
Horizontal			
Diameters	1 1/2"	1 1/4"	1"
loss/100	0.52	1.1	4.2
loss/43.2'	0.2	0.5	1.8
Vertical			
Diameters	3"	2 1/2"	2"
loss/100	0	2.8	7
loss/214.7'	1.9	6	15
Meter loss			
Diameter	1"	3/4"	5/8"
loss	0.2	3	7
Branch			
Diameters	1"	3/4"	1/2"
loss/100	1	2.2	5
loss/20.9'	0.2	0.5	1
Collector4			
Horizontal			
Diameters	2"	1 1/2"	1 1/4"
loss/100	0.18	0.58	1.2
loss/19.7'	0.04	0.1	0.2
Vertical			
Diameters	2"	1 1/2"	1 1/4"
loss/100	1.7	5	7
loss/214.7'	3.6	10.7	15
Meter loss			
Diameter	1"	3/4"	5/8"
loss	1.8	5	10.1
Branch			
Diameters	1"	3/4"	1/2"
loss/100	1.5	2.4	5
loss/48.5'	0.7	1.2	2.4
Collector5			
Horizontal			
Diameters	1 1/2"	1 1/4"	1"
loss/100	1.4	3	5

loss/8.64'	0.1	0.3	0.4
Vertical			
Diameters	1 1/4"	1"	3/4"
loss/100	3	6	9
loss/8.64'	0.3	0.5	0.8
Meter loss			
Diameter	1"	3/4"	5/8"
loss	0.2	3.2	8
Branch			
Diameters	1"	3/4"	1/2"
loss/100	0.42	1.3	6
loss/28.5'	0.12	0.4	1.71

Table 133:The selected pipes in ground floor.

Ground floor			
Collector1			
Horizontal			
Diameters	2"	1 1/2"	1 1/4"
loss/100	0.23	0.8	1.9
loss/18.7'	0.04	0.2	0.4
Vertical			
Diameters	1 1/2"	1 1/4"	1"
loss/100	2.1	5	6
loss/197.13'	4	10	12
Meter loss			
Diameters	1"	3/4"	5/8"
loss	2	6	10.5
Branch			
Diameters	1"	3/4"	1/2"
loss/100	1.5	1.2	4.5
loss/60.24'	0.9	0.72	2.7
Collector2			
Horizontal			
Diameter	1"	3/4"	1/2"
loss/100	3	5	9.9
loss/20'	0.6	1	2
Vertical			
Diameter	2"	1 1/2"	1 1/4"
loss/100	0.7	2.7	5.7
loss/197.13'	0.2	0.8	1.6
Meter loss			
Diameter	5/8"		
loss	1.8		
Branch			
Diameters	1"	3/4"	1/2"

loss/100	0.36	1.2	4.5
loss/6.6'	0.02	0.08	0.3

Table 134:The selected pipes in attic floor.

Attic floor			
Collector1			
Horizontal			
Diameters	2"	1 1/2"	1 1/4"
loss/100	0.23	0.8	1.9
loss/15'	0.03	0.1	0.3
Vertical			
Diameters	3"	2 1/2"	2"
loss/100	0.9	2.8	5
loss/181.7'	1.6	5	9
Meter loss			
Diameter	1"	3/4"	5/8"
loss	1.2	3.2	8
Branch			
Diameter	1"	3/4"	1/2"
loss/100	4	2.5	5
loss/44.9'	1.8	1.1	2.2
Collector2			
Horizontal			
Diameter	1 1/4"	1"	3/4"
loss/100	0.3	1.2	4
loss/3.54'	0.01	0.04	0.14
Vertical			
Diameter	2"	1 1/2"	1 1/4"
loss/100	1.8	6	7
loss/181.7'	3.2	10.9	12.7
Meter loss			
Diameter	1"	3/4"	5/8"
loss	2	5.4	10.6
Branch			
Diameter	1"	3/4"	1/2"
loss/100	0.23	0.71	3
loss/36.24'	0.08	0.3	1.1

Table 135::The selected pipes in first floor.

First floor			
Collector1			
Horizontal			
Diameters	1 1/4"	1"	1 1/2"
loss/100	3	12	1.5
loss/24.84'	0.75	3	0.4

Vertical			
Diameters	3"	2 1/2"	2"
loss/100	0.9	2.8	5
loss/166.32'	1.5	4.7	8.3
Meter loss			
Diameter	1"	3/4"	5/8"
loss	1.2	3.2	8
Branch			
Diameter	1"	3/4"	1/2"
loss/100	4	2.5	5
loss/44.9'	1.8	1.1	2.2
Collector2			
Horizontal			
Diameter	1 1/2"	1 1/4"	1"
loss/100	0.5	1.2	4.1
loss/14.7'	0.07	0.2	0.3
Vertical			
Diameter	2 1/2"	2"	1 1/2"
loss/100	2.5	6	9.8
loss/166.32'	4.2	10	16.3
Meter loss			
Diameter	1"	3/4"	5/8"
loss	1.3	3.8	8
Branch			
Diameter	1"	3/4"	1/2"
loss/100	0.35	1.2	4.5
loss/44.9'	0.2	0.5	2
Collector3			
Horizontal			
Diameter	1 1/2"	1 1/4"	1"
loss/100	0.3	0.7	2.7
loss/5.4'	0.02	0.04	0.1
Meter loss			
Diameter	3/4"	5/8"	
loss	1.6	3.4	
Vertical			
Diameter	2 1/2"	2"	1 1/2"
loss/100	2.6	6	9.9
loss/166.32'	3.9	9	14.8
Branch			
Diameter	1"	3/4"	1/2"
loss/100	0.39	1.1	5
loss/52.8'	0.2	0.6	2.6

Table 136:The selected pipes in second floor.

Second floor			
Collector1			
Horizontal			
Diameters	1 1/4"	1"	1 1/2"
loss/100	3	12	1.5
loss/24.84'	0.75	3	0.4
Vertical			
Diameters	3"	2 1/2"	2"
loss/100	0.9	2.8	5
loss/149.1'	1.3	4.2	7.5
Meter loss			
Diameter	1"	3/4"	5/8"
loss	1.2	3.2	8
Branch			
Diameter	1"	3/4"	1/2"
loss/100	4	2.5	5
loss/44.9'	1.8	1.1	2.2
Collector2			
Horizontal			
Diameter	1 1/2"	1 1/4"	1"
loss/100	0.5	1.2	4.1
loss/14.7'	0.07	0.2	0.3
Vertical			
Diameter	2 1/2"	2"	1 1/2"
loss/100	2.5	6	9.8
loss/149.1'	3.7	9	14.6
Meter loss			
Diameter	1"	3/4"	5/8"
loss	1.3	3.8	8
Branch			
Diameter	1"	3/4"	1/2"
loss/100	0.35	1.2	4.5
loss/44.9'	0.2	0.5	2
Collector3			
Horizontal			
Diameter	1 1/2"	1 1/4"	1"
loss/100	0.3	0.7	2.7
loss/5.4'	0.02	0.04	0.1
Meter loss			
Diameter	3/4"	5/8"	
loss	1.6	3.4	
Vertical			
Diameter	2 1/2"	2"	1 1/2"

loss/100	2.6	6	9.9
loss/149.1'	3.9	9	14.8
Branch			
Diameter	1"	3/4"	1/2"
loss/100	0.39	1.1	5
loss/52.8'	0.2	0.6	2.6

Table 137:The selected pipes in third floor.

Third floor			
Collector1			
Horizontal			
Diameters	1 1/4"	1"	1 1/2"
loss/100	3	12	1.5
loss/24.84'	0.75	3	0.4
Vertical			
Diameters	3"	2 1/2"	2"
loss/100	0.9	2.8	5
loss/131.88'	1	3.2	5.7
Meter loss			
Diameter	1"	3/4"	5/8"
loss	1.2	3.2	8
Branch			
Diameter	1"	3/4"	1/2"
loss/100	4	2.5	5
loss/44.9'	1.8	1.1	2.2
Collector2			
Horizontal			
Diameter	1 1/2"	1 1/4"	1"
loss/100	0.5	1.2	4.1
loss/14.7'	0.07	0.2	0.3
Vertical			
Diameter	2 1/2"	2"	1 1/2"
loss/100	2.5	6	9.8
loss/131.88'	2.9	6.9	11.2
Meter loss			
Diameter	1"	3/4"	5/8"
loss	1.3	3.8	8
Branch			
Diameter	1"	3/4"	1/2"
loss/100	0.35	1.2	4.5
loss/44.9'	0.2	0.5	2
Collector3			
Horizontal			
Diameter	1 1/2"	1 1/4"	1"
loss/100	0.3	0.7	2.7
loss/5.4'	0.02	0.04	0.1

Meter loss		
Diameter	3/4"	5/8"
loss	1.6	3.4
Vertical			
Diameter	2 1/2"	2"	1 1/2"
loss/100	2.6	6	9.9
loss/131.88'	3	6.9	11.4
Branch			
Diameter	1"	3/4"	1/2"
loss/100	0.39	1.1	5
loss/52.8'	0.2	0.6	2.6

Table 138:The selected pipes in fourth floor.

Fourth floor			
Collector1			
Horizontal			
Diameters	1 1/4"	1"	1 1/2"
loss/100	3	12	1.5
loss/24.84'	0.75	3	0.4
Vertical			
Diameters	3"	2 1/2"	2"
loss/100	0.9	2.8	5
loss/114.66'	1	3.2	5.7
Meter loss			
Diameter	1"	3/4"	5/8"
loss	1.2	3.2	8
Branch			
Diameter	1"	3/4"	1/2"
loss/100	4	2.5	5
loss/44.9'	1.8	1.1	2.2
Collector2			
Horizontal			
Diameter	1 1/2"	1 1/4"	1"
loss/100	0.5	1.2	4.1
loss/14.7'	0.07	0.2	0.3
Vertical			
Diameter	2 1/2"	2"	1 1/2"
loss/100	2.5	6	9.8
loss/114.66'	2.9	6.9	11.2
Meter loss			
Diameter	1"	3/4"	5/8"
loss	1.3	3.8	8
Branch			
Diameter	1"	3/4"	1/2"
loss/100	0.35	1.2	4.5

loss/44.9'	0.2	0.5	2
Collector3			
Horizontal			
Diameter	1 1/2"	1 1/4"	1"
loss/100	0.3	0.7	2.7
loss/5.4'	0.02	0.04	0.1
Meter loss			
Diameter	3/4"	5/8"	
loss	1.6	3.4	
Vertical			
Diameter	2 1/2"	2"	1 1/2"
loss/100	2.6	6	9.9
loss/114.66'	3	6.9	11.4
Branch			
Diameter	1"	3/4"	1/2"
loss/100	0.39	1.1	5
loss/52.8'	0.2	0.6	2.6

Table 139:The selected pipes in fifth floor.

Fifth floor			
Collector1			
Horizontal			
Diameters	1 1/4"	1"	0 1/2"
loss/100	3	12	1.5
loss/24.84'	0.75	3	0.4
Vertical			
Diameters	3"	2 1/2"	2"
loss/100	0.9	2.8	5
loss/97.44'	0.9	2.7	4.9
Meter loss			
Diameter	1"	3/4"	5/8"
loss	1.2	3.2	8
Branch			
Diameter	1"	3/4"	1/2"
loss/100	4	2.5	5
loss/44.9'	1.8	1.1	2.2
Collector2			
Horizontal			
Diameter	1 1/2"	1 1/4"	1"
loss/100	0.5	1.2	4.1
loss/14.7'	0.07	0.2	0.3
Vertical			
Diameter	2 1/2"	2"	1 1/2"
loss/100	2.5	6	9.8

loss/97.44'	2.4	5.9	9.6
Meter loss			
Diameter	1"	3/4"	5/8"
loss	1.3	3.8	8
Branch			
Diameter	1"	3/4"	1/2"
loss/100	0.35	1.2	4.5
loss/44.9'	0.2	0.5	2
Collector3			
Horizontal			
Diameter	1 1/2"	1 1/4"	1"
loss/100	0.3	0.7	2.7
loss/5.4	0.02	0.04	0.1
Meter loss			
Diameter	3/4"	5/8"	
loss	1.6	3.4	
Vertical			
Diameter	2 1/2"	2"	1 1/2"
loss/100	2.6	6	9.9
loss/97.44'	3	6.9	11.4
Branch			
Diameter	1"	3/4"	1/2"
loss/100	0.39	1.1	5
loss/52.8	0.2	0.6	2.6

Table 140:The selected pipes in sixth floor.

Sixth floor			
Collector1			
Horizontal			
Diameters	2"	1 1/2"	1 1/4"
loss/100	0.16	2	4
loss/14.76'	0	0.3	0.6
Vertical			
Diameters	2 1/2"	2"	1/2"
loss/100	2.7	5	19
loss/80.22'	2.2	4	15
Meter loss			
Diameter	1"	1 1/2"	3/4"
loss	1.7	4.9	14
Branch			
Diameters	1"	3/4"	1/2"
loss/100	0.75	2.5	10
loss/38.3'	0.3	1	4
Collector2			

Horizontal			
Diameters	2"	1 1/2"	1 1/4"
loss/100	0.2	0.7	2
loss/3.36'	0	0.2	0.7
Vertical			
Diameters	2"	1 1/2"	1 1/4"
loss/100	1.7	6	10.3
loss/80.22'	1.4	4.8	8.3
Meter loss			
Diameters	1"	3/4"	5/8"
loss	1.9	5	10.3
Branch			
Diameters	1"	3/4"	1/2"
loss/100	0.5	1.6	6
loss/34.8'	0.2	0.6	2

There is a need for a water limiter on the floors: from basement 3 to the fourth floor. And there is a need for a pump on the sixth floor.

Water supply system for some floors in the project:

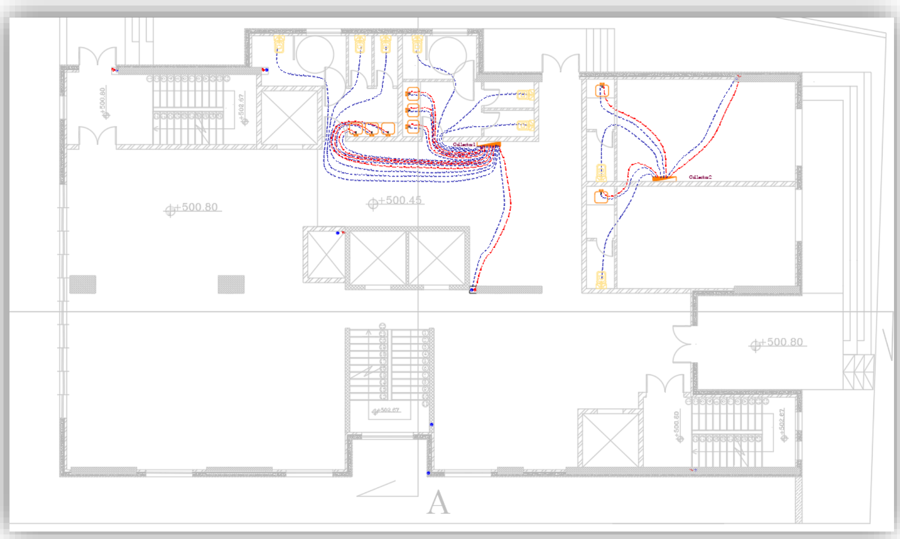


Figure 355:Water supply system for ground floor.

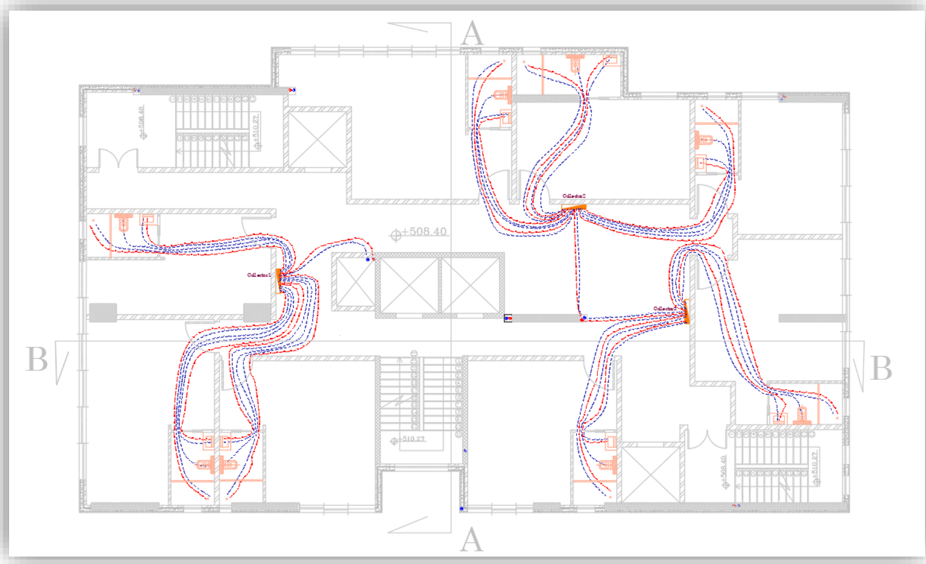


Figure 356:Water supply system for first floor.

4.7 Drainage and Rainwater

4.7.1 Drainage system

One of the important mechanical systems in buildings is the sewage system, which ensures the transport of sewage water from buildings for treatment or disposal. The process of designing the sewage system must be done correctly, taking into account that the sewer lines must be perfectly sealed, with no blockages and no leaks, and we must ensure that unpleasant odors do not return.

Several types of water need to be drained: Black water: Resulting from human waste, it is the water that comes out of the bathroom and kitchen. Grey water: Comes from sources like the shower, washing machine, and laboratories, and can be used in agriculture. Storm water: Rainwater.

Table 141:Drainage Fixture Units (DFU), and the size of the trap used for many types of fixtures used in the building.

PART A. BY TYPE OF FIXTURE

Fixture(s)	Drainage Fixture Units (dfu)	*Minimum Trap Size* in.	*Minimum Trap Size* mm[a]
Automatic clothes washers: Commercial[b]	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[c] (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[d], 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	
Urinal, 1 gal (3.8 L) per flush or less	2[f]	e	
Urinal, nonwater supplied	0.5	e	
Wash sink (circular or multiple) each set of faucets	2	1½	38
Water closet, flushometer tank, public or private	4[f]	e	
Water closet, private (1.6 gpf [6 Lpf])	3[f]	e	
Water closet, private (>1.6 gpf [6 Lpf])	4[f]	e	
Water closet, public (1.6 gpf [6 Lpf])	4[f]	e	
Water closet, public (flushing >1.6 gpf [6 Lpf])	6[f]	e	

PART B. BY SIZE OF TRAP

Fixture Drain or Trap Size in.	*Fixture Drain or Trap Size* mm[a]	Drainage Fixture Unit (dfu) Value
1¼	32	1
1½	38	2
2	51	3
2½	64	4
3	76	5
4	102	6

Table 142:Maximum number of fixture units allowed to be connected to branch or stacks pipes in the sewage system.

Diameter of Pipe			Maximum Total Number of dfu Allowable		
			Stacks[b]		
in.	mm[c]	Horizontal Branch	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

Table 143:Maximum number of fixture units allowed to be connected to Drain or Sewer pipes by the recommended slope.

Diameter of Pipe		Maximum Number of dfu Connected to Any Portion of the Building Drain or Building Sewer, Including Branches of the Building Drain[a] Fall, in. per ft (% slope)			
in.	mm[b]	1/16 (0.5%)	1/8 (1.04%)	1/4 (2.1%)	1/2 (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 144:Size and developed length of stack vents and vents stacks.

Diameter of Soil or Waste Stack In. (mm)[b]	Total Fixture Units Being Vented (dfu)	Maximum Developed Length[a] of Vent, Feet (m)[b]									
		Diameter of Vent, In. (mm)[b]									
		1¼ (32)	1½ (38)	2 (51)	2½ (64)	3 (76)	4 (102)	5 (127)	6 (152)	8 (203)	10 (254)
1¼ (32)	2	30 (9.1)									
1½ (38)	8	50 (15.2)	150 (45.7)								
1½ (38)	10	30 (9.1)	100 (30.5)								
2 (51)	12	30 (9.1)	75 (22.9)	200 (61.0)							
2 (51)	20	26 (7.9)	50 (15.2)	150 (45.7)							
21/2 (64)	42		30 (9.1)	100 (30.5)							
3 (76)	10		42 (12.8)	150 (45.7)	360 (109.7)	1040 (317)					
3 (76)	21		32 (9.8)	110 (33.5)	270 (82.3)	810 (246.9)					
3 (76)	53		27 (8.2)	94 (28.7)	230 (70.1)	680 (207.3)					
3 (76)	102		25 (7.6)	86 (26.6)	210 (64.0)	620 (189.0)					
4 (102)	43			35 (10.7)	85 (25.9)	250 (76.2)	980 (298.7)				
4 (102)	140			27 (8.2)	65 (19.8)	200 (61.0)	750 (228.6)				
4 (102)	320			23 (7.0)	55 (16.8)	170 (51.8)	640 (195.0)				
4 (102)	540			21 (6.4)	50 (15.2)	150 (45.7)	580 (176.8)				
5 (127)	190				28 (8.5)	82 (25.0)	320 (97.5)	990 (301.8)			
5 (127)	490				21 (6.4)	63 (19.2)	250 (76.2)	760 (231.6)			
5 (127)	940				18 (5.5)	53 (16.2)	210 (64.0)	670 (204.2)			
5 (127)	1400				16 (4.9)	49 (14.9)	190 (57.9)	590 (179.8)			
6 (152)	500					33 (10.1)	130 (39.6)	400 (121.9)	1000 (304.8)		
6 (152)	1100					26 (7.9)	100 (30.5)	310 (94.5)	780 (237.7)		
6 (152)	2000					22 (6.7)	84 (25.6)	260 (79.2)	660 (201.2)		
6 (152)	2900					20 (6.1)	77 (23.5)	240 (73.2)	600 (182.9)		
8 (203)	1800						31 (9.4)	95 (29.0)	240 (73.2)	940 (286.5)	
8 (203)	3400						24 (7.3)	73 (22.3)	190 (57.9)	720 (219.5)	
8 (203)	5600						20 (6.1)	62 (18.9)	160 (48.8)	610 (185.9)	
8 (203)	7600						18 (5.5)	56 (17.1)	140 (42.7)	560 (170.7)	
10 (254)	4000							31 (9.4)	78 (23.8)	310 (94.5)	960 (292.6)
10 (254)	7200							24 (7.3)	60 (18.3)	240 (73.2)	740 (225.6)
10 (254)	11,000							20 (6.1)	51 (15.5)	200 (61.0)	630 (192.0)
10 (254)	15,000							18 (5.5)	46 (14.0)	180 (54.9)	570 (173.7)

Table 145:Dfu's values for each fixture type used in our building.

Fixture type	Dfu value
Lavatory	1
Water closet	4
Shower	2
Bathtub	2
Kitchen sink	2
Water closet public	6
Dishwashing machine	2
Washing machine	2

The table below shows the number of Dfu's for each floor in the project.

Table 146:Number of Dfu's for each floor in the project.

Fixture type on each floor	Fixture	Number	Unit per fixture	Total Dfu's	Dfu for each branch
Ground Floor					
Bathroom1	WC	3	4	12	15
	Lavatory	3	1	3	
Bathroom2	WC	3	4	12	15
	Lavatory	3	1	3	
Bathroom3	WC	1	4	4	5
	Lavatory	1	1	1	
Bathroom4	WC	1	4	4	5
	Lavatory	1	1	1	
Attic Floor					
Bathroom1	WC	3	4	12	15
	Lavatory	3	1	3	
Bathroom2	WC	3	4	12	15
	Lavatory	3	1	3	
Kitchen	Kitchen sink	2	2	4	8
	Dishwashing machine	1	2	2	
	Washing machine	1	2	2	
First Floor (which is a repetitive floor to the fifth floor)					
Bathroom1	WC	1	4	4	7
	Lavatory	1	1	1	
	Shower	1	2	2	
Bathroom2	WC	1	4	4	7
	Lavatory	1	1	1	
	Shower	1	2	2	
Bathroom3	WC	1	4	4	7
	Lavatory	1	1	1	

	Shower	1	2	2	
Bathroom4	WC	1	4	4	7
	Lavatory	1	1	1	
	Shower	1	2	2	
Bathroom5	WC	1	4	4	7
	Lavatory	1	1	1	
	Shower	1	2	2	
Bathroom6	WC	1	4	4	7
	Lavatory	1	1	1	
	Shower	1	2	2	
Bathroom7	WC	1	4	4	7
	Lavatory	1	1	1	
	Shower	1	2	2	
Bathroom8	WC	1	4	4	7
	Lavatory	1	1	1	
	Shower	1	2	2	
Sixth Floor					
Bathroom1	WC public	3	6	18	21
	Lavatory	3	1	3	
Bathroom2	WC public	3	6	18	21
	Lavatory	3	1	3	
Kitchen	Kitchen sink	2	2	4	8
	Dishwashing machine	1	2	2	
	Washing machine	1	2	2	

Diameters of the drainage pipes

Table 147:Summary for the diameters of the pipes and slope values.

Fixture	Diameter	Slope	Type of pipe material
Vent	4"	0%	pvc
Stack	4"	0%	pvc
Drainage	4"	1%	pvc
Sewer	2"	2%	pvc
Between manholes	6"	1%	pvc

Distribution of sewage networks for some floors

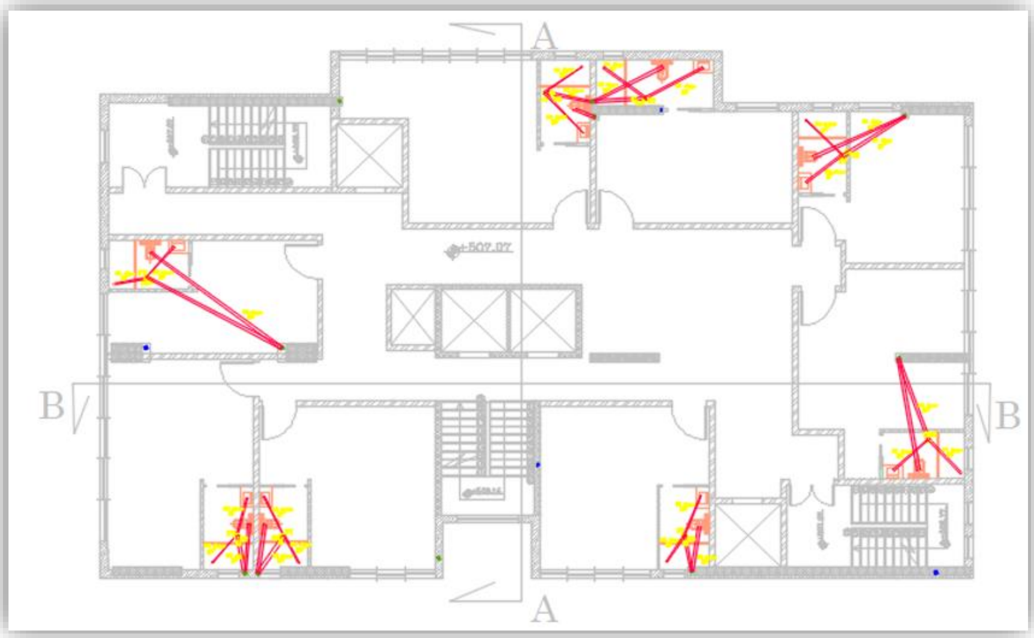


Figure 357:Sewage network for first floor.

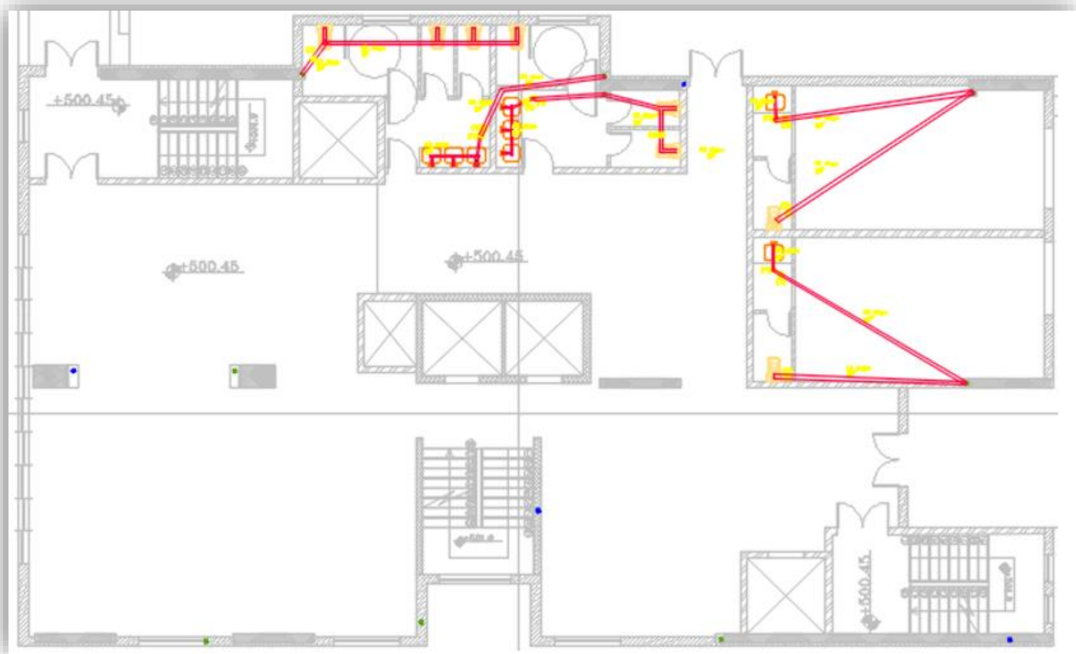


Figure 358:Sewage network for ground floor.

4.7.2 Rain water drainage

Rainwater is considered clean water and can be utilized to meet various human needs. It is suitable for drinking and daily consumption in all its forms. In this project, rainwater was utilized by collecting on the hotel's roof and then allowing it to flow through risers to the third basement, where a tank (well) collects it. The water is then pumped to tanks located on the roof to supply the building with water.

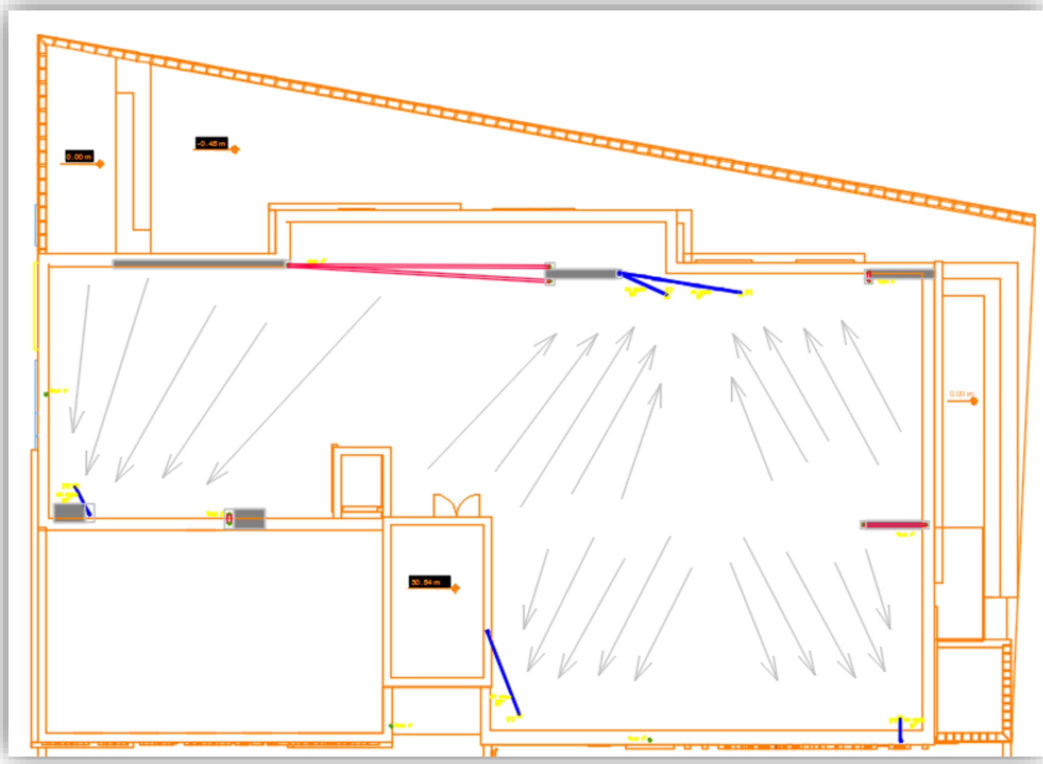


Figure 359:Rainwater drainage.

4.8 Vertical and horizontal transportation:

4.8.1 Stair

Building codes and regulations often stipulate specific requirements for the design, construction, and maintenance of emergency stairs to ensure the safety of building occupants.

All subsequent details provided are derived from the Palestinian Code for Fire Protection and Prevention.

✓ **According to Clause (2/2/8)item D**

- we need two emergency exits spaced apart and separated from each other for all floors.

✓ **According to Clause (1/2/3)** :**occupancy load**

- The occupancy load for design purposes is determined by dividing the floor area by a load factor of the occupancy.
- In multi-story buildings, the capacity of the exits at each floor is calculated to accommodate the occupancy load in it, or the occupancy load in any of the floors above it whose occupants use the same exits, and the capacity of the exits at the outlet is not equal to the sum of the capacities of the exits required for each floor, but rather is equal to the maximum capacity of any of the floors Which use those exits.

Table 148: Total occupancy load in hotel

floor	Area of floor (m)	occupancy load in each floor
Basement 3 floor	972.67	52.29408602
Basement 2 floor	972.76	52.29892473
Basement 1 floor	868.82	46.71075269
Ground Floor	689.66	37.07849462
Attica Floor	569.94	30.64193548
First Floor	335.23	18.02311828
Second Floor	579.95	31.18010753
Thread Floor	579.95	31.18010753
Fourth Floor	579.95	31.18010753
Fifth Floor	579.95	31.18010753
Sixth Floor	405	21.77419355
total occupancy load		383.5419355

Hotel occupancy load = 18.6(Total area)

- ✓ **According to Clause (2/3/3)**

  Details of the internal stairs

- Stairs and landings used to connect more than three floors are made of non-combustible materials.
- Do not use the spaces located within a staircase that is part of the means of egress for any purpose that hinders the exit of the building's occupants.
- Every staircase, landing, and balcony are designed to resist live loads.
- The upper surface of the threads and stalls landing be rough enough to prevent slipping while walking on it
- The use of spiral or winder stairs is only permitted for specific tasks and under specific conditions.
- ✓ **According to Clause (5/3)**
- each exit must be distanced from the other to ensure that the possibility of using them together is reduced as a result of any emergency that may close access to them at the same time.
- The distance between the two emergency exits must not be less than half of the largest diameter of the building if the building is not equipped with automatic sprinklers, and not less than a third of the largest diameter if the building is equipped with automatic sprinklers.
- The exit path is not allowed to pass through a bathroom, bedroom, or any other room that is subject to closure. Likewise, the exit path is not allowed to pass through a high-risk space unless it is protected and isolated.
- Exit paths and doors leading to exits must be such that they can be easily identified. It is not permitted to install curtains or hangings on these doors, exits, or outlets in a way that obscures them from view or makes them difficult to identify. It is not permitted to install mirrors in or near any exit, as this may confuse knowing the direction of the exit.
- The maximum length of the exit path in hotels equipped with automatic sprinklers is 100 meters, while the maximum length of the common corridor equipped with automatic sprinklers is 15 meters.

✓ **According to Clause (7/3)**

- All exits must end with outlets that open directly onto the street or public road.
- The location of the access is determined and signs indicating it are placed so that it is clear to the occupants of the building or facility the direction of exit to the public road. A barrier must also be placed on the stairs at the level of the access to avoid the occupants of the building descending to the lower floors that do not lead outside the building.

✓ **According to Clause (8/3)**

- The means of exit must be continuously illuminated while the occupants of the building are in it.
- The entire floors of the exit pathways, including corners, intersections, corridors, stairs, landing, and exit doors, must be illuminated with a minimum brightness of 10 lux, measured at floor level.
- It is prohibited to use battery-operated lighting units for main lighting of means of exit, and it is permitted to use them for backup lighting purposes.
- The use of reflective lighting materials is not permitted.

✓ **According to Clause (9/3)**

- The duration of backup lighting must not be less than an hour and a half, and the batteries in the backup lighting system must be automatically rechargeable from the main power generator, and must be of a type approved by the competent official authority.

✓ **According to Clause (2/1/3)**

- Exits must provide the required protection from fire and smoke along their entire length by insulating their walls and fire-resistant doors according to specifications.
- The construction materials used to insulate exits must have a fire-resistance rating of no less than two hours, for exits that connect four or more floors, regardless of the location of the floors in relation to the outlet or the public street.
- All openings at the outlet are undertaken with self-closing fireproof doors, it is contained in items (3/5/2) and (4/5/2) and (1/3/3).

➢ According to Clause (3/5/2): Fire resistant doors: Are doors manufactured to resist fire for a specific period, provided that they have a certificate of conformity from the Palestinian Standards and Metrology Institution.

➢ According to Clause (4/5/2): Self-closing doors: These are doors equipped with an automatic means of closing the door, and must have a certificate of conformity from the Palestinian Standards and Metrology Institution.

➢ According to Clause (1/3/3):

- The pure opening width of any door shall not be less than (80) cm, and the shutter size shall not be more than (120) cm. Where the building is provided with a pair of doors, it must not be less than the pure width of one of them is at least 80 cm.
- The doors are out of the way out of the type with side hinges, so that the door opens in the same way out, if it is used in a place with high-risk contents, or the occupancy load is more than (50) people.
- The power to open the door shutter should not exceed 225 Newton.

- The opening of the doors leading to the stairs house is in the direction of the exit path itself, on not to be opened directly on the stairs without using a stream of at least the width the door in the path leading to the port, as shown in Figure

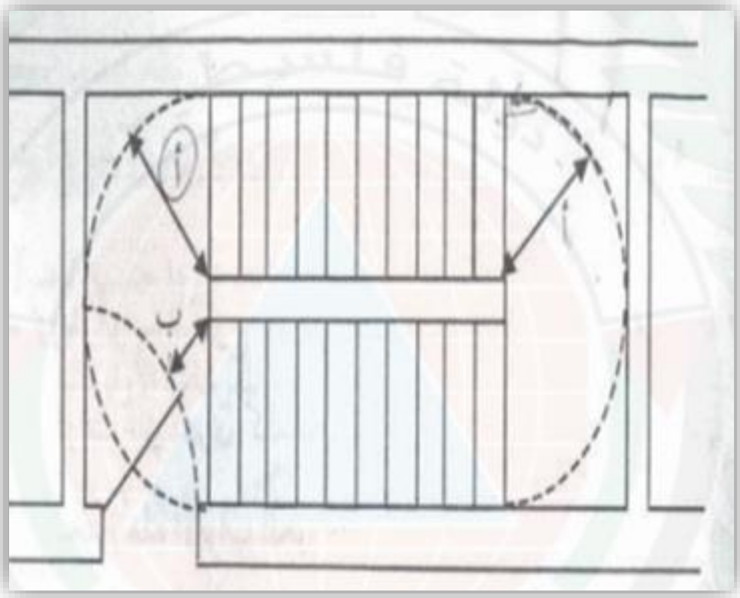


Figure 360:Escape staircase.

4.8.2 Elevator

Calculating the number of elevators:

Total floor area = 7079 m2

Rise = 35.78

Number of floors without ground floor = 11

Number of bedrooms in all building = 40

Population = 40*1.3 = 52 person

PHC = (12%-15%) (Hotel - first quality)

HC = PHC% * Population= 0.15 * 52= 7.8 person/5min

Capacity options = (2500,3000) lb.

Minimum car speed = (350, 400) fpm

$Interval\ (I) = (30 - 50)\ S \rightarrow (Hotel - first\ quality)$

Table 149:Elevator calculations.

option	2500\350	2500\400	3000\350	3000\400
P	13	13	16	16
RT (S)	123	118	136	130
h_c	31.71	33.05	35.29	36.92
N	0.217615385	0.208769231	0.1955	0.186875
N1	1	1	1	1
PHC%	60.98	71.85	76.73	80.27
I < 50 (S)	123	118	136	130
N2	2	2	2	2
PHC%	121.95	127.12	135.75	142.01
I < 50 (S)	61.5	59	68	65
N3	3	3	3	3
PHC%	182.93	190.68	203.62	213.02
I < 50(S)	41	39.33333333	45.33333333	43.33333333

- Use (2500 lb /350 fpm)
- Number of elevators = 3 + 1 (service) = 4 elevator

The following tables are used in the calculation:) from MEEB)

Table 150: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[a]
Dormitories	10–11
Hotels—first quality	12–15
Hotels—second quality	10–12

Table 151: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[a]
Dormitories	10–11
Hotels—first quality	12–15
Hotels—second quality	10–12

Table 152:Car Passenger Capacity (p)

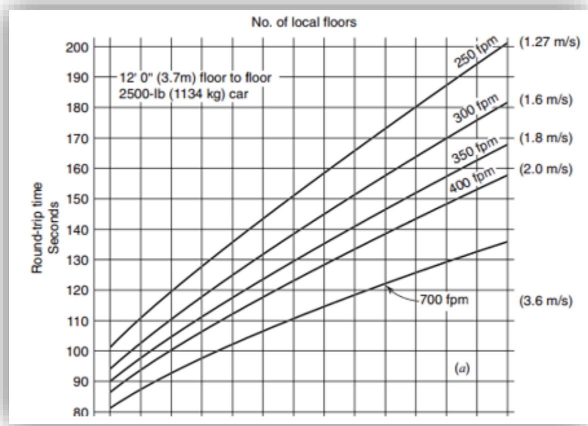
Elevator Capacity lb (kg)	Maximum Passenger Capacity	Normal Passenger[a] Load per Trip
2000 (907)	12	10
2500 (1134)	17	13
3000 (1361)	20	16
3500 (1588)	23	19
4000 (1814)	28	22

Table 153:Population of Typical Buildings for Estimating Elevator and Escalator Requirements

Building Type	Net Area
OFFICE BUILDINGS	FT2 PER PERSON (M2/PERSON)
Diversified (multiple tenancy)	
Normal	110–130 (10–12)[a]
Prestige	150–250 (14–23)
Single tenancy	
Normal	90–110 (8–10)
Prestige	130–200 (12–19)
HOTELS	PERSONS PER SLEEPING ROOM
Normal use	1.3
Conventions	1.9

Table 154:Elevator Equipment Recommendations.

	Car Capacity[a]		Rise		Minimum[a] Car Speed	
Building Type	lb	kg	ft	m	fpm	m/s
Office building	2500	1250	0–125	0–40	350–400	2.0
	3000	1250	126–225	41–70	500–600	2.5
	3500	1600	226–275	71–85	700	3.15
			276–375	86–115	800	4.0
			Above 375	>115	1000	5.0
Hotel	2500	1250	As above		As above	
	3000	1250				



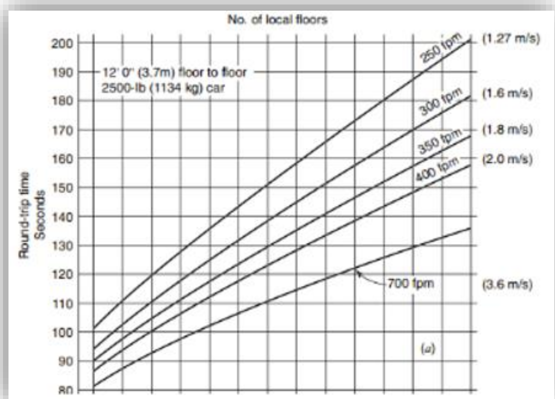


Figure 361:SEQ Figure \ ARABIC 169:Elevator Equipment

Chapter Five

Quantity surveying & Cost Estimate

Chapter Five: Quantity surveying & Cost Estimate

5.1: Introduction

The cost estimation process is a crucial task in construction projects, serving as a vital and foundational step in determining the project budget. Cost estimation is conducted before the project commences, making it essential to consider during the planning phase of initiating a building or construction project.

Several factors influence the cost of any project, including the project's nature and size. As the project size increases, its cost rises due to the need for more materials and labor. The quality of materials used also impacts the project cost, with higher-quality materials leading to increased expenses. Labor costs play a significant role, as the number of required workers and their wages contribute to the overall project cost.

Effectively managing the costs of construction projects is a crucial step that aids in increasing project profitability, reducing unnecessary expenses, and contributing to time and effort savings. In essence, it facilitates the success of construction projects.

5.2 Methodology

The methodology for calculating the tentative budget in our project, which is Royal Suites Hotel was by inquiries about the cost per square meter for regular floors (above the ground floor) and the cost per square meter for floors below the ground floor (basements). The result was approximately 4000 shekels per square meter for above-ground floors and about 2000 shekels per square meter for below-ground floors. We multiplied the area of each floor by the respective cost per square meter and then summed up the costs for all the floors, resulting in our approximate initial project cost.

5.3 Calculations

	Activity Name	Unit	Quantity	Unit cost (Material and Labor cost)	Total Cost
1	Earth Works				
1.1	Excavation and disposal	m3	7423.176	18	133617.168
2	Sub - structural				
2.1	Foundations				
2.1.1	Mat Foundatiom				
2.1.1.1	Concrete	m3	884.7	Material: 340	300798
2.1.1.2	Reinforcment	Ton	361	Material: 3400	1227400
2.1.1.3	Water profing	L	812.97	Material: 9.3	7641.918
2.1.1.4	Concrete, Reinforcement, Formwork	m2	836.03	Labor cost for all elements: 250	209007.5
2.2	Slabs				
2.2.1	Two way solid slab (40cm)				
2.2.1.1	Concrete	m3	221.291	Material: 300	66387.3
2.2.1.2	Reinforcment	Ton	34.24	Material: 3400	116416
2.2.1.3	Concrete, Renforcemet, formwork	m2	745.947	Labor cost for all elements:250	186486.75
2.2.2	Two way ribbed slab (40cm)				
2.2.2.1	Concrete	m3	1687.042	Material: 300	506112.6
2.2.2.2	Concrete, Renforcemet, formwork	m2	5021.14	Labor cost for all elements: 250	1255285
2.2.2.3	Ribs	unit	12555	Material: 5	62775
2.2.2.4	Reinforcment	Ton	868.75	Material: 3400	2953750
2.2.3	Ramp soild slab				
2.2.3.1	Concrete	m3	72.96	Material: 300	21888
2.2.3.2	Reinforcment	Ton	0.163	4200	684.6
2.2.4	Stair				
2.2.4.1	Concrete	m3	28.72	Material: 320	9190.4
2.2.4.2	Reinforcment	Ton	29.3	Material: 3400	99620
2.3	columns				
2.3.1	Concrete	m3	46.9	340	15946
2.3.2	Reinforcment	Ton	19.42	3400	66028
2.4	walls				
2.4.1	shear wall				
2.4.1.1	Concrete	m3	4301.054	340	1462358.36
2.4.1.2	Reinforcment	Ton	898	Material: 3400	3053200
2.4.2	External wall				
2.4.2.1	Stone	m2	2122	120	254640
2.4.2.2	Voncrete	m3	286.784	300	86035.2
2.4.2.3	Fome polyrethane	m2	2122	15	31830
2.4.2.4	Block(10cm)	piece	52800	1.5	79200
2.4.3	Internal wall				
2.4.3.1	Block(20cm)	piece	36925	2.5	92312.5

2.4.3.2	Block(10cm)	piece	37500	1.5	56250
3	Finishing				
3.1	Plastering				
3.1.1	Wall plaster	m2	10877.1	25	271927.5
3.2	Panting				
3.2.1	Paint	m2	10877.1	30	326313
3.3	Tiles				
3.3.1	Tiles floor	m2	5044.9	40	201796
3.4	False ceiling	m2	5044.9	40	201796
3.5	Doors				
3.5.1	Single wooden doors	pieces	80	1000	80000
3.5.2	Double glass doors	pieces	11	2500	27500
3.5.3	Single metal doors	pieces	10	2200	22000
3.5.4	Parking doors	m2	30.75	220	6765
3.5.5	Revolving door	pieces	1	6000	6000
3.5.6	Windows	m2	1279.925	1000	1279925
4	Electric work				
4.1	Socket				
4.1.1	Single socket	Number	386	20	7720
4.1.2	Water proofing sockrt	Number	188	35	6580
4.2	lighting unit				
4.2.1	Square LED lamp Luxiona	Number	23	45	1035
4.2.2	Wall lighting	Number	2	85	170
4.2.3	LED lamp Luxiona	Number	45	45	2025
4.2.4	Table lamp	Number	80	65	5200
4.2.5	LED spot in Bedroom	Number	326	35	11410
4.2.6	LED spot in Bathroom	Number	257	40	10280
4.2.7	LED lamp Norka	Number	200	50	10000
4.2.8	LED lamp Philips	Number	4	45	180
4.2.9	LED TRILUX	Number	54	50	2700
4.2.10	LEDS C4 S.A.	Number	15	75	1125
4.2.11	LED hanging lighting	Number	52	40	2080
4.2.12	LED luminaires	Number	20	45	900
4.3	Electric switches				
4.3.1	Single switches	Number	125	20	2500
4.3.2	Three way switches	Number	214	35	7490
4.3.3	Circuit breaker	count	436	750	327000
4.3.4	Distribution Board	count	15	200	3000
4.3.5	Wire (1.5mm^2)	Length	5837	16	93392
4.3.6	Wire (2.5mm^2)	Length	6489	16.5	107068.5
4.3.7	Wire (10mm^2)	Length	281	6	1686
5	Mecanical work				
5.1	HVAC				
5.1.1	Fan coil unit with 10.3KW	unit	3	5200	15600
5.1.2	Fan couil unit with 6.4 KW	unit	3	4836	14508
5.1.3	Fan coil unit with 3.5 KW	unit	2	3534	7068

5.1.4	Fan coil unit with 2.6 KW	unit	1	3348	3348
5.1.5	Fan coil unit with 8.6 KW	unit	4	5022	20088
5.1.6	Fan coil unit with 5 KW	unit	4	4650	18600
5.1.7	Fan coil unit with 7.5 KW	unit	1	4836	4836
5.1.8	Outdoor unit	unit	3	31520	94560
5.1.9	Linear diffuser	m	61	350	21350
5.1.10	Floor drain with cover	unit	10	230	2300
5.1.11	Square diffuser 9" * 9"	unit	30	230	6900
5.1.12	Square diffuser 12" * 12"	unit	5	310	1550
5.1.13	Ducts	m2	2879.6	100	287960
5.2	water system				
5.2.1	Pump	unit	1	400	400
5.2.2	Tank	unit	3	450	1350
5.2.3	Tank stand	unit	1	400	400
5.2.4	Collector	one line from the collector	401	25	10025
5.2.5	PVC pipe 1/2"	m	4395.3	60	263718
5.2.6	Steel pipe 1"	m	186	30	5580
5.2.7	Steel pipe 3/4"	m	186	90	16740
5.2.8	Pipes installation	point	228	Labor: 150	34200
5.3	Draingae system				
5.3.1	Floor drain	unit	65	20	1300
5.3.2	Clean out	unit	61	150	9150
5.3.3	Vents	unit	7	120	840
5.3.4	Manhole	unit	10	40	400
5.3.5	plastic pipes 2"	m	234.62	6.25	1466.375
5.3.6	palstic pipes 4"	m	242.97	12.5	3037.125
5.3.7	palstic pipes 6"	m	67.96	18	1223.28
5.3.8	Pipes installation	point	147	150	22050
5.4	fixture unit				
5.4.1	W.C	Number	70	170	11900
5.4.2	Bathtub	Number	40	1200	48000
5.4.3	Sink	Number	10	260	2600
5.4.4	Shower	Number	10	350	3500
5.4.5	Lavatory	Number	63	160	10080
5.5	fire fighting				
5.5.1	Pipes	m	1098	150	164700
5.5.2	Sprinkler	Number	357	30	10710
5.5.3	Fire hose station	Number	11	680	7480
5.5.4	Fire extinguisher	Number	117	160	18720
5.5.5	Detector	Number	132	70	9240
5.5.6	Speaker	Number	45	250	11250
5.5.7	Wire	m	2242.84	16	35885.44
5.6	elevator				
5.6.1	Elevator	Number	4	1501940	1501940
5.7	Solar panels				

5.7.1	Solar panels including labor and installation	-	-	-	179679.72
TOTAL COST				18268657	

Chapter Six

Conclusion

Chapter Six:Conclusion

6.1 Conclusion

The Royal Suites Project is located in Nablus, on Rafidia Street, next to the Rawda Mosque. The project covers an area of 975 square meters, with a total built-up area of 6,460 square meters spread over 11 floors. Initially, the building was architecturally redesigned to function as a 3-star hotel, meeting user needs and ensuring aesthetic appeal. Several necessary environmental analyses were conducted to determine insulation details and the building's energy consumption. A solar panel system was designed to reduce the building's energy consumption.

Structurally, the building was redesigned using a Two-Way Solid Slab system for the basement and a Two-Way Ribbed Slab system for the other floors. A mat foundation system was chosen for the base. Earthquake resistance and reinforcement tests were conducted to ensure the building's resilience to seismic activities and other loads.

Regarding the electromechanical systems:

- Lighting: Different spaces were designed using DIALux evo software to achieve the required lux, uniformity, and glare according to standards. The lighting for other spaces was then distributed accordingly.
- Heating and Cooling: The project uses a VRV system for heating and cooling, offering ease of installation and reducing the number of external units needed. The heating and cooling load values were derived from DesignBuilder software, and the design was implemented to ensure user comfort. The necessary system components, including internal and external units, were selected.
- Acoustics: Important spaces were analyzed using Ecotect software to ensure the RT value was within the required range.

- Fire Safety: Based on the Palestinian Code for Fire Prevention and protection, the design includes automatic sprinkler systems, hose stations to cover areas such as corridors, and manual extinguishers. Two separate emergency exits were determined to be necessary.

A comprehensive study and design of the water supply system were carried out to ensure water reaches all fixture units efficiently. The project utilizes rainwater, collected in a well and pumped to the building, ensuring a sustainable water supply.

The sewage system design features a combined system where black and grey water are not separated. Pipes with appropriate diameters were selected to ensure proper sewage flow with the correct slope.

In addition, the total cost of the building amounted to approximately 19 million shekels.

6.1 References:

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6.3 Appendix

- Architectural plans before modifications PDF.
- Architectural plans after modifications PDF.
- Structural plans PDF.
- Lighting plans PDF.
- HCAC plans PDF.
- Fier plans PDF.
- Water Supply System plans PDF.
- Drainage and rain water plans PDF.
- Integration of all systems plans PDF.
- Final AutoCAD draw.
- Catalog HVAC.
- Catalog Water Supply.
- Catalog Design Builder.
- Catalog Solar.
- Catalog Structural

6.4 Turnitin similarity check

Submission Title	Turnitin Paper ID	Submitted	Similarity	Grade	
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Figure 362: Turnitin similarity check