



An-Najah National University

Faculty of Engineering & Information Technology

Building Engineering Department

Graduation Project Report- II

“Assessment and Redesign for Sameer Shanaa Mall (commercial building)”

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Dedication

We dedicate this project to God Almighty, our strong pillar, our source of inspiration, wisdom, knowledge and understanding. Our great teacher and messenger, Mohammed (May Allah bless and grant him), taught us the purpose of life. Our homeland Palestine, the warmest womb. The great martyrs and prisoners, the symbol of sacrifice. An-Najah National University; our second magnificent home. Our great parents; who never stop giving of themselves in countless ways. Our beloved brothers and sisters; who stand by us when things look bleak. To all my family, the symbol of love and giving. To our adviser who guided us in this project and the academic teachers who kept us on track. Our friends who encourage and support us. All the people in our life who touch our hearts, we dedicate this research.

Acknowledgment

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Finally, we thank God for all His blessings.

Disclaimer Statement

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List of symbols

Table 1: List of symbols

Symbols	Description
m ²	Meter square
m	Meter
"	Inch
ft.	Foot
CM	Centimeter
cfm	Cubic Feet per Minute
L/s	Liter per second
UV	Ultraviolet
h	Height
p	Depth
Kg	Kilogram
mm	Millimeter
m/s	Meter per second
lux	Illuminance unit
%	Percent sign
DF	Daylight factor
EH	Exterior illuminance
Ei	Indoor illuminance
SC	Sky component
ERC	Externally reflected component
IRC	Internally reflected components
RF	Reflected factor
W/ft ²	Watt per square foot
W/m ²	Watts per square meter
Hz	Hertz

Symbols	Description
E	East
N	North
kw/m ²	Kilowatt per square meter
kWh	Kilowatt-hour
lb	Pound
fpm	Foot per minute
AM	Ante Meriden
PM	Post Meriden
Wh	Watt-hour
Wh/m ²	Watt per square meter
Km/hour	Kilometers per hour
Mpa	Mega Pascal
KN/m ³	Kilo newton Per Cubic Meter
KN/m ²	Kilo newton per square meter
KN/m	Kilo newton per meter
D.l	Dead load
L.l	Live load
KN	Kilo Newton
KN.m	Kilo Newton Meter
H	Thickness
Fy	Yield stress of steel
f'c	Compressive stress for concrete
γ concrete	Normal weight concrete
knots/hour	Knot per hour

Abstract

This project aims to represent an integrated re-designing for Sameer Shanaa Mall (Commercial Building) in Nablus in order to be a model for the provision of various services to people include stores, offices, restaurant and playing hall for kids.

The building will be design according to systems that reduce energy consumption and achieve thermal, acoustical and visual comfort, through the use some insulators and the exploitation of solar energy. The design will take into account people with special needs in terms of the width of the corridors and their way of accessing to the building, similarly the general safety requirements of the buildings.

As regards to constructions, the appropriate structural system for this building will be determine and design ensuring the safety and serviceability. The Environmental modifications various types including thermal, acoustical and lightening will be designed.

For this project, the quantities and specifications will be calculated. In this project, a hard work will be made to achieve the integration between all the different systems to avoid any problems during the operation of the facility to reduce maintenance and operating costs.

To achieve all building aspects some computer software will be used such as AutoCAD, INSUL, EASE, Etabs, Design Builder and DIALux.

Redesign process include site analysis, Architectural re-design as standard and specifications, environmental analysis, structural design, HVAC and mechanical design that includes drainage and water supply, Electrical design contains lighting, power and control panel design and finally, fire system has been designed. All results had detailed in the report, drawings and bill of quantity.

Chapter 1: Introductory

1.1 Introduction

Shopping malls are a prominent feature of contemporary cities and one of their most popular attractions. The shopping mall meets all the requirements for shopping, leisure and commercial services (from shops, stores and markets) and it is a source of attraction for investors.

Sameer Shanaa Mall is a shopping center in the governorate of Nablus under construction in its early stages is built on 2813 square meter area and the estimated gross area of the building would be 9512 square meter which will feature two basement as a garage, Ground floor as retail outlet, three stores and a playing hall for kids.

The major goal of the project is to redesign Sameer Shanaa Mall in an integrated manner and more effective in achieving the objective of the building and accommodating the end-user's diverse needs.

1.2 Project Problem

After studying and analyzing the plans of Sameer Shanaa Mall, it was concluded that there are many problems, especially from the architectural aspects in terms of achieving some required specification. The number of parking and the width of its entrance are not enough and the location of emergency stairs without standard. There is no papering function for building.

Our design has addressed the problems in the project and achieved the desired objectives of the design and its integration in all aspects and disciplines, including structural, environmental, architectural and mechanical. Structural aspect Sameer Shanaa Mall design was not designed to be earthquake resistance.

1.3 Objectives

This project mainly purpose to arrive at a high-quality design for Sameer Shanaa Mall, designing it in compliance with international standards and specifications, and providing acoustic, thermal and visual comfort. In addition, aims to achieve and exchanges among divergent functions and aspects, also considered as a model and creativity that can be taken into consideration by designers and engineers in the future, and have to evaluate and redesign based on the codes and specifications. Furthermore, evaluation the architectural and environmental aspect of the design,

to solve the problems that may face the building in its life cycle. A structural study is conducted to select the optimal mechanical and electrical system, and design for an economical and environmentally friendly design.

1.4 Methodology

This project will be implemented in several stages, at first the data and information will be collected for the architectural aspect to understand the nature of the project. Then research and collect international specifications required to design of Sameer Shana Mall architectural, environmental, structural and mechanical design, based on internationally accredited scientific references and conduct a case study and analyze it to know the design criteria for this center. Later a complete analysis of the building will be carried out for each engineering aspects.

1.5 Limitations & constraints

The main limitations is redistribution and redesign of spaces, Main entrances to a parking, and adding an emergency stair and additional parking according to architectural standards and public safety standards without changing the concept of architectural design.

1.6 Codes and standards

Standards and codes of architectural design:

- Metric handbook planning and design data.
- Neufert architect's data 4th edition.
- Time saver standards

Standards and codes of environmental design.

- MEEB (mechanical and electrical equipment building book) 12th edition.

Standards and codes of structural design.

- The uniform building code UBC-97. (For Earthquakes Load).
- ASCE7.16 code (standard ASCE. 2016). Minimum Design Loads and Associated Criteria for Buildings and Other Structures for Find live load
- Building Code Requirements for Structural Concrete ACI 318-14 for Method of design (One-way design, Two-way design, direct method condition and equivalent frame method).

1.7 Earlier Course Work

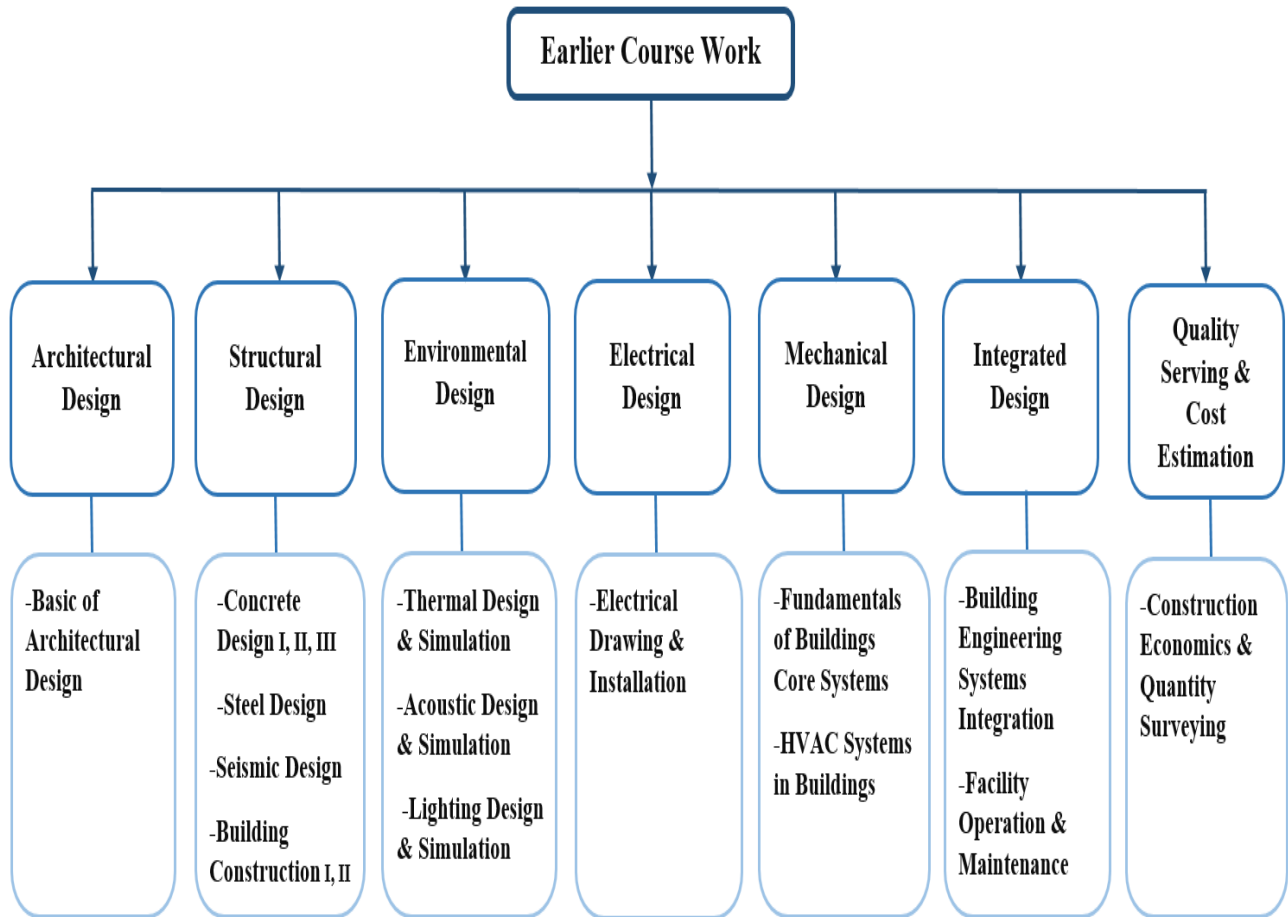


Figure 1 earlier course work Chart

Chapter 2: Architectural-Environmental Aspect

2.1 Architectural aspect

2.1.1 Needs

All these needs were brought from Arab Experts for Architecture and Consultation ARABEX.

2.1.1.1 Organization chart:

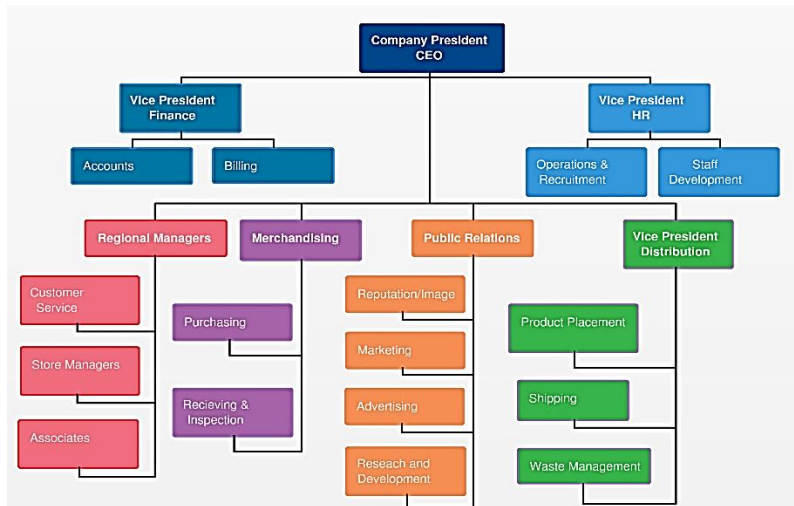


Figure 2 organization chart

2.1.1.2 Area and number of employees and customers in Sameer Shanaa Mall:

According to Shopping Centre & Retail Washroom Guide [1] the population density of a shopping Centre is 1 customer per 2m², find the number of customers by dividing the area of each floor per 2m².

Table 2 spaces Area

Space	Area (m ²)
Second basement	1485
First basement	1647
Ground floor	1263
First floor	1186
Second floor	1186
Third floor	1186
Fourth floor	1186

- Toilets:

Table 3 the number of toilets

Floor	# of Toilets
Parking	1
Ground Floor	5
First Floor	5
Second Floor	5
Third Floor	9
Fourth Floor	5

After the process of comparing the areas of the rooms in the Sameer Shanaa Mall shown in the table above, it was found that apply to international standards and Guideline.

2.2 Literature review:

2.2.1 Architectural and special needs standards:

2.2.1.1 Office

Types of offices according to room type:

1. Single-room offices:

Single and double rooms are still the most common form of office layout that arranging in rows along a mostly artificially lit corridor. Jointly used infrastructure occupies expensive window space in occupied rooms, because no furniture is allow in escape routes. The most economical occupation, by two or three people, disturbs concentrated work. Single rooms hinder internal communication. [1].

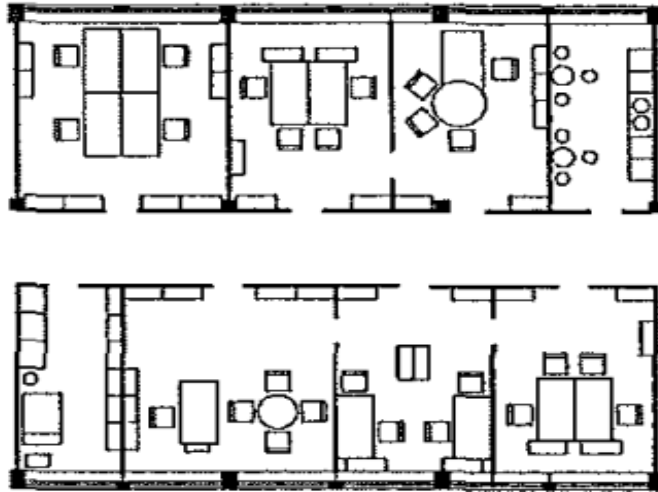


Figure 3: single-room office arrangement [1]

2. Open-plan offices

A form of office developed in the 1960s and 1970s of the last century. Large-scale office landscapes with 1 00 or more workstations are made possible by artificial lighting and ventilation; they stand free communication and openness. Economical cubic structures, however, have the disadvantage of high maintenance costs. This form is not very popular among users. [1]

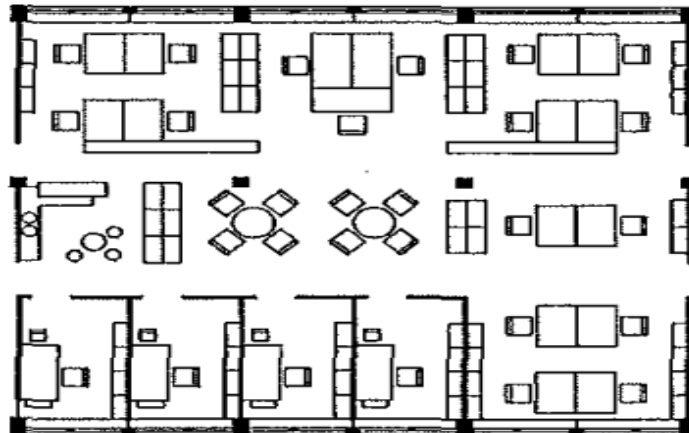


Figure 4: Open-plan office arrangement [1]

3. Group rooms

The experience with the open-plan layout led to the development of group offices with approx. 4-16 workstations, a single team or department uses each office. This arrangement is preferred above

all for creative, design or coordination and development activities with high internal communication needs. [1]

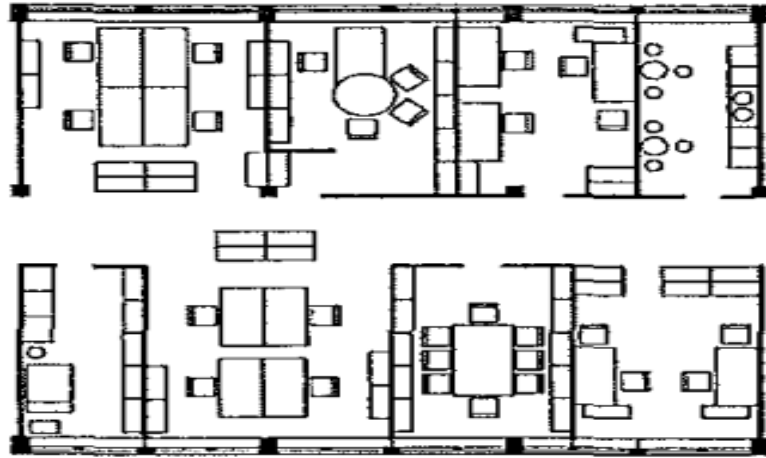


Figure 5: Group room arrangement [1]

- Types of offices according to room systems:
- Combine-office

Very small single offices are separated by glass walls from the deep connection zone, in which communally used infrastructure is located. The combine-office was developed in the 1980s as an attempt to combine the advantages of single-room and open-plan offices. Each employee is provided with an individual workstation for concentrated work and a jointly used room in the central zone, with its glass partitions, encourage communication

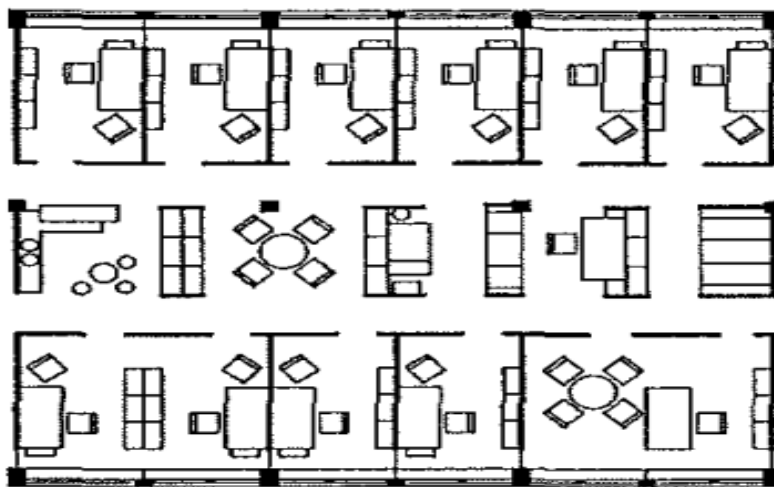


Figure 6: combine office arrangement [1]

- 'Hot desk' office, 'business club'[1]
- Satellite office[1]
- Reversible office[1]

2.2.1.2 Sports Hall (Playing hall for kids)

Based on the standards the sports halls sort into three types according to dimensions shown in table 2-1. The type of sports hall is a single sport hall.

Table 1: Dimensions of halls [1]

Hall type	Dimensions (m)	Usable playing area (m ²)	Hall sports ¹⁾	No. training courts/fields	No. competition courts/fields ²⁾
Multi-functional halls					
single hall	15 × 27 × 5.5	405	badminton basketball volleyball	4 1 1	
triple hall	27 × 45 × 7 ³⁾⁴⁾ divisible into 3 sections (15 × 27) ⁵⁾	1215	badminton basketball indoor football indoor handball indoor hockey volleyball	12 3 1 1 1 3	5 ⁶⁾ 1 1 1 1 1
quadruple hall	27 × 60 × 7 ³⁾ divisible into 4 sections (15 × 27) ⁵⁾	1620	badminton basketball indoor football indoor handball indoor hockey volleyball	16 4 1 1 1 4	7 ⁶⁾ 2 1 1 1 1
possibly also double hall	22 × 44 × 7 ³⁾⁴⁾ divisible into 2 sections (22 × 28 + 22 × 16 or 22 × 26 + 22 × 18) ⁵⁾	968	badminton basketball indoor football indoor handball indoor hockey volleyball	6 1 1 1 1 3	5 ⁶⁾ 1 1 1 1 1
Sports halls					
single hall	22 × 44 × 7 ³⁾⁴⁾	968	badminton basketball indoor football indoor handball indoor hockey volleyball	6 1 1 1 1 3	5 1 1 1 1 1
triple hall	44 × 66 × 8 ³⁾ divisible into 3 sections (22 × 44) ⁵⁾	2904	badminton basketball indoor football 20 × 40 30 × 60 indoor handball indoor hockey volleyball	24 1 1 3 3 9	15 4 ⁶⁾ 3 1 3 3 3
quadruple hall	44 × 88 × 9 ³⁾ divisible into 4 sections (22 × 44) ⁵⁾	3872	badminton basketball indoor football 20 × 40 40 × 80 indoor handball indoor hockey volleyball	32 5 ⁶⁾ 1 1 4 4 12	25 ⁶⁾ 4 4 1 4 4 4

Table 5 shown the required operational rooms for sports halls

Table 2: Operational rooms for sports halls [1]

Hall type	Entrance hall (m ²) m ²	Changing rooms (min. 20 m ²) ²⁾ min. no.	Showers (min. 15 m ²) ³⁾ no.	Toilets			Teaching room ⁴⁾ (min. 12 m ²) without first aid function (min. 8 m ²) min. no.	Equipment room		Cleaning equipment room min. 5 m ² min. no.	Waiting room min. 10 m ² no.
				per changing room min. no.	lobby min. no.			Multi-functional hall min. m ² ⁵⁾	Sports hall min. m ² ⁵⁾		
					F	M					
Single hall	15	2	1 ⁹⁾	1	1	1	1	60 ⁷⁾	20 ⁸⁾	1	1 ⁹⁾
Double hall	30	2	2	1	1	1	1	90 ⁷⁾	—	1	1 ⁹⁾
Triple hall	45	3 ¹⁰⁾	3 ¹⁰⁾	1	1	1	2	120 ⁷⁾	60 ⁸⁾	1	1
Quadruple hall	60	4 ¹⁰⁾	4 ¹⁰⁾	1	1	1	3	150 ⁷⁾	80 ⁸⁾	1	1

¹⁾ minimum room height generally 2.5 m
²⁾ space requirement per person is 0.7–1.0 m², based on allowances of 0.4 m bench length per person, 0.3 m sitting depth and min. 1.5 m between benches or between bench and wall (1.8 m recommended)
³⁾ 1 shower per 6 persons (but a minimum of 8 showers and 4 washbasins per facility), shower space including a minimum circulation area of 10 m² and circulation space at least 1.2 m wide
⁴⁾ training supervisors', umpire/referees' room, perhaps including first aid post (min. 8 m² for separate first aid room), with changing cubicle and shower; can also be used as an administration room if correctly positioned, designed and of sufficient size
⁵⁾ because the range of apparatus provided varies according to location, it is likely that these minimum dimensions will have to be exceeded; no hall section in a multi-functional hall should have less than a 6 m length apparatus room
⁶⁾ divided into 2 sections, each with half of the apparatus
⁷⁾ room depth normally 4.5 m, max. 6.0 m
⁸⁾ room depth normally 3 m, max. 5.5 m
⁹⁾ according to need
¹⁰⁾ alternatively, 2 bigger rooms with proportionally more shower and washing facilities

2.2.1.3 Toilets

Toilets should be situated on the entrance floors. Shoppers should not have to walk more than 150 m to toilets measured from shop entrances.

The number of toilets for the shopping centers:

Table 4: the number of WC, urinal and washbasin for customers at shopping centers [2]

Appliance	For Male Customers	For Female Customers
WC	1 per 500 males; plus 1 per every additional 1,000 males or part thereof Where urinals are not used, WC numbers to be half of those used for females	1 per 100 females up to 500, plus 1 per every additional 200 females or part thereof
Urinal	2 for up to 500 males, plus 1 for every additional 500 males, plus 1 for every additional 500 males or part thereof	N/A
Washbasin	1 per WC, plus 1 per 5 urinals or part thereof	1, plus 1 per 2 WCs or part thereof

The information in this table was taken from the document *British Standards 6465-1:2006+A1:2009 6.5*

Table 5: the number of WC, urinal and washbasin for Workers at shopping centers [2]

No. of people at work	Toilets	Washbasins
1 - 5	1	1
6 - 15	2	2
16 - 30	3	3
31 - 45	4	4
46 - 60	5	5
61 - 75	6	6
76 - 90	7	7
91 - 100	8	8
Above 100 - 8, plus 1 WC and washbasin for every unit or fraction of a unit of 25 persons		

- Dimensions for W.C:

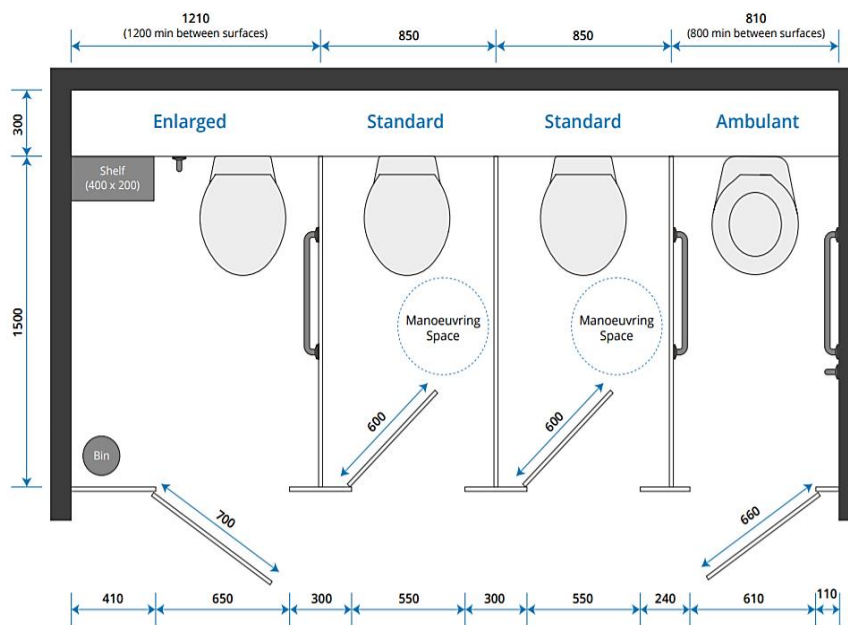


Figure 7: dimensions of WC [2]

2.2.1.4 Special needs w.c:

- Number of special needs W.C:

To determine the number of w.c for people with special needs, you must first determine the number of w.c in the building, then multiply it by the percentage shown in the following table:

Table 6: Minimum Number of Universal Washrooms per Building [4]

Number of Storeys in Building	Minimum number of Universal Washrooms per Building
1-3	1
4 - 6	2
Over 6	3, plus 1 for each additional increment of 3 storeys in excess of 6 storeys

- Dimensions special needs W.C:

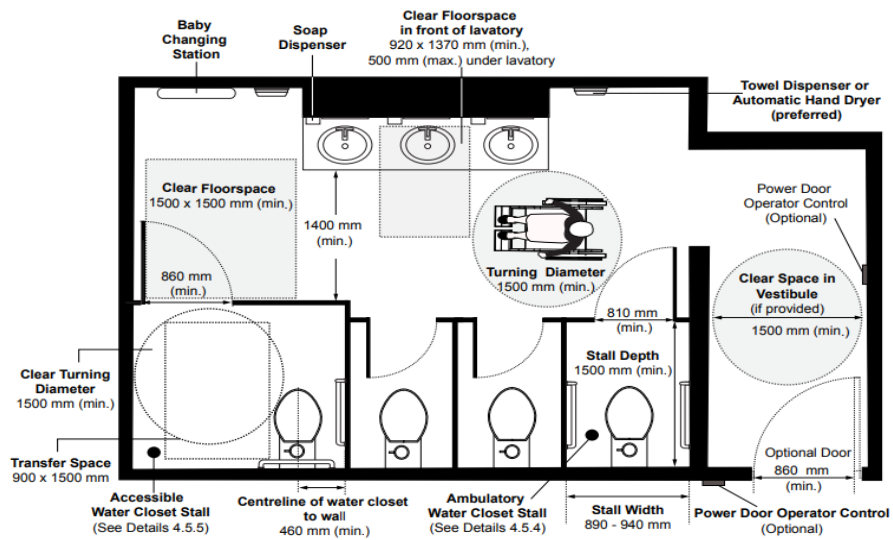


Figure 8: Example of Multiple Occupancy Washroom Layout [4]

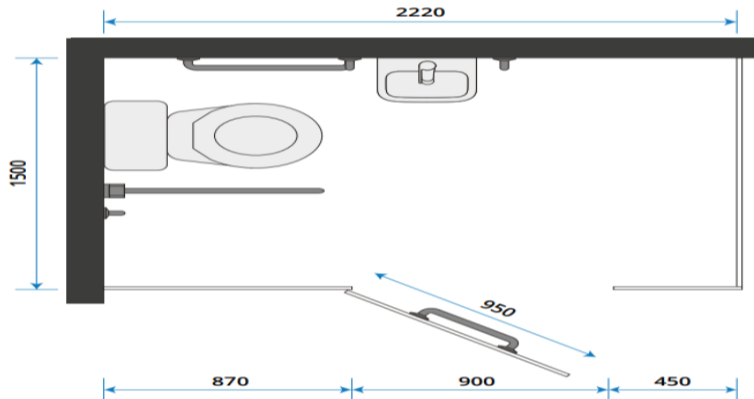


Figure 9: Dimensions special needs W.C [3]

2.2.1.5 Entrances

Table 7 entrance dimension for the Shopping center [1]

Building Type	Door opening entrance	Clear height
Shopping center	>2.00m ² at least	>2.00m

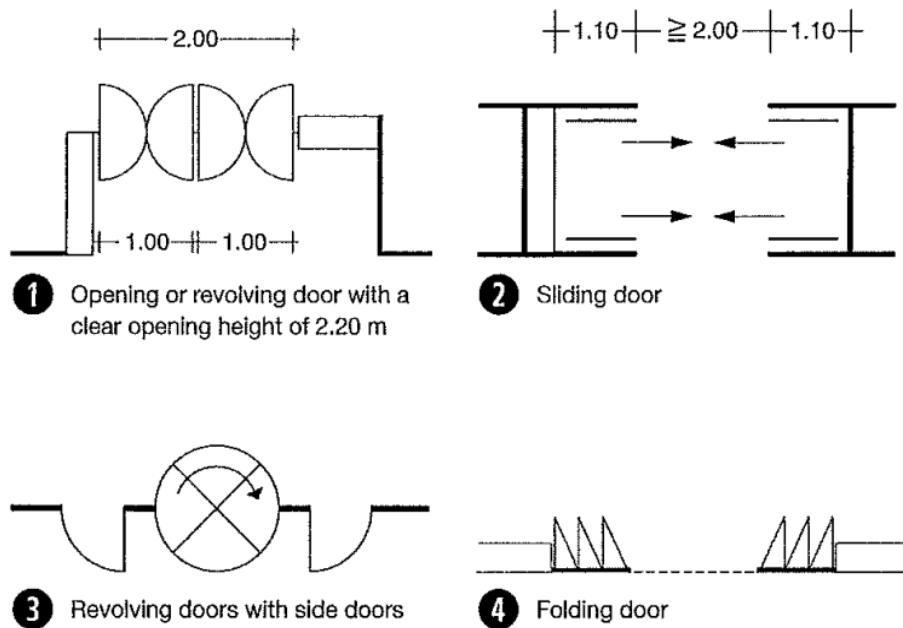


Figure 10 Entrance Door Type with Dimension for Shopping Center Escalator

Parallel Escalators that lie above one another in the same direction

One escalator needed for every 1000m² area.

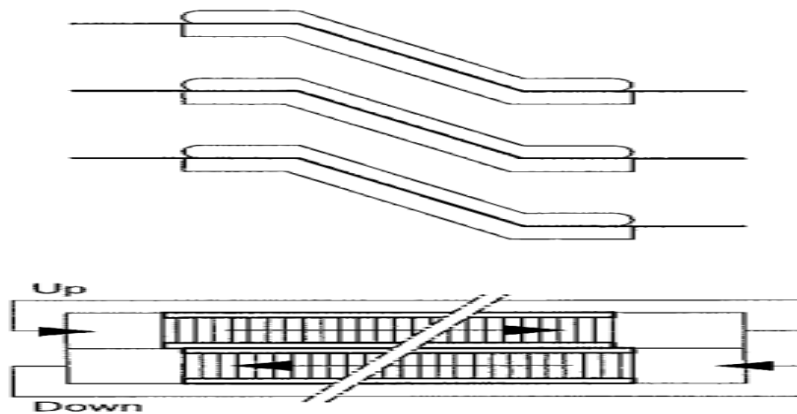


Figure 11 Parallel layout escalator [1]

2.2.1.6 **Stair**

Table 8 width of stair according to # of people to pass [1]

Building Type	# of person to pass	Width stair
Shopping center	1	0.55 m
Shopping center	2	1.25 m
Shopping center	3	1.87 m

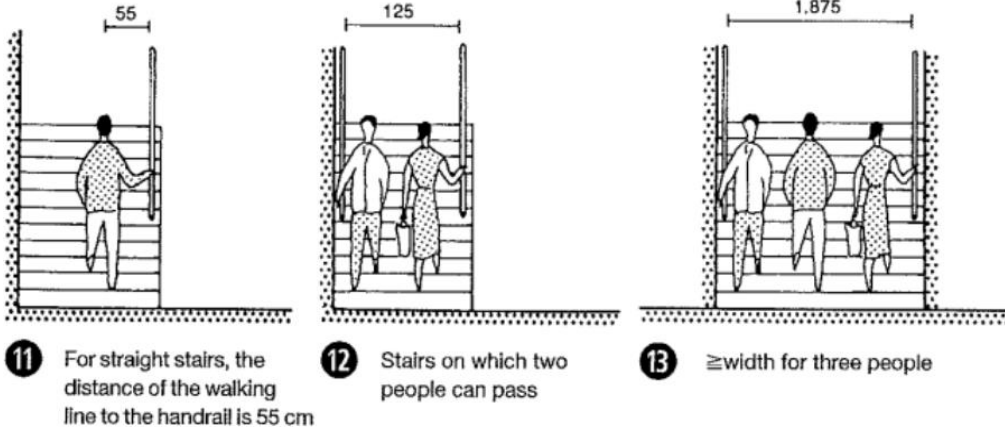


Figure 12 width of stair according to # of people to pass [1]

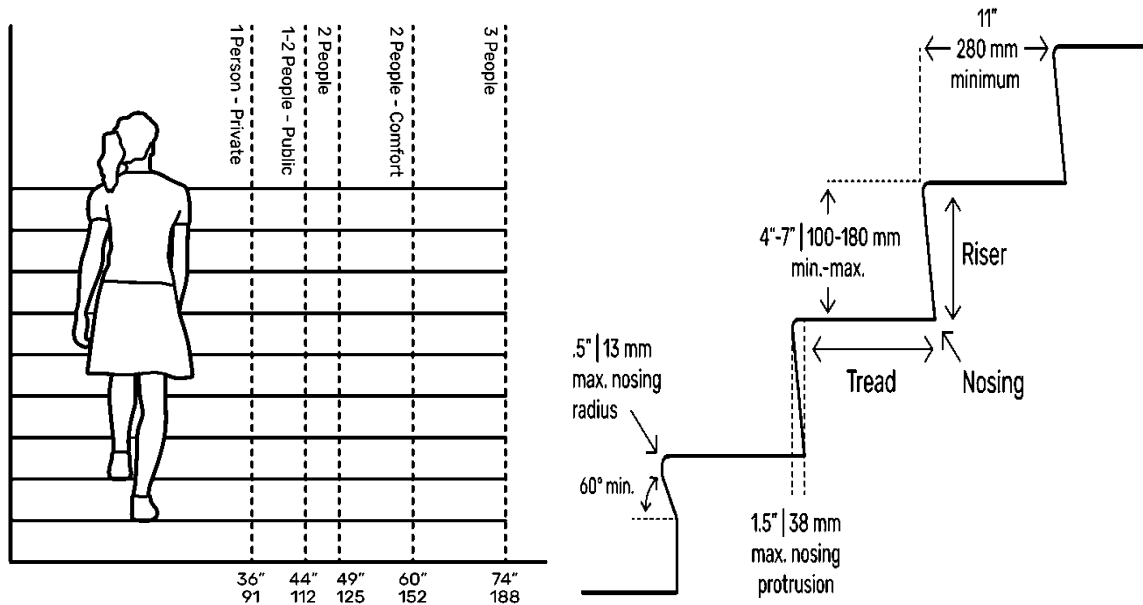


Figure 13 width of stair according to # of people to pass [7]

Figure 14 Riser and thread dimension [7]

Ramps for people with special need

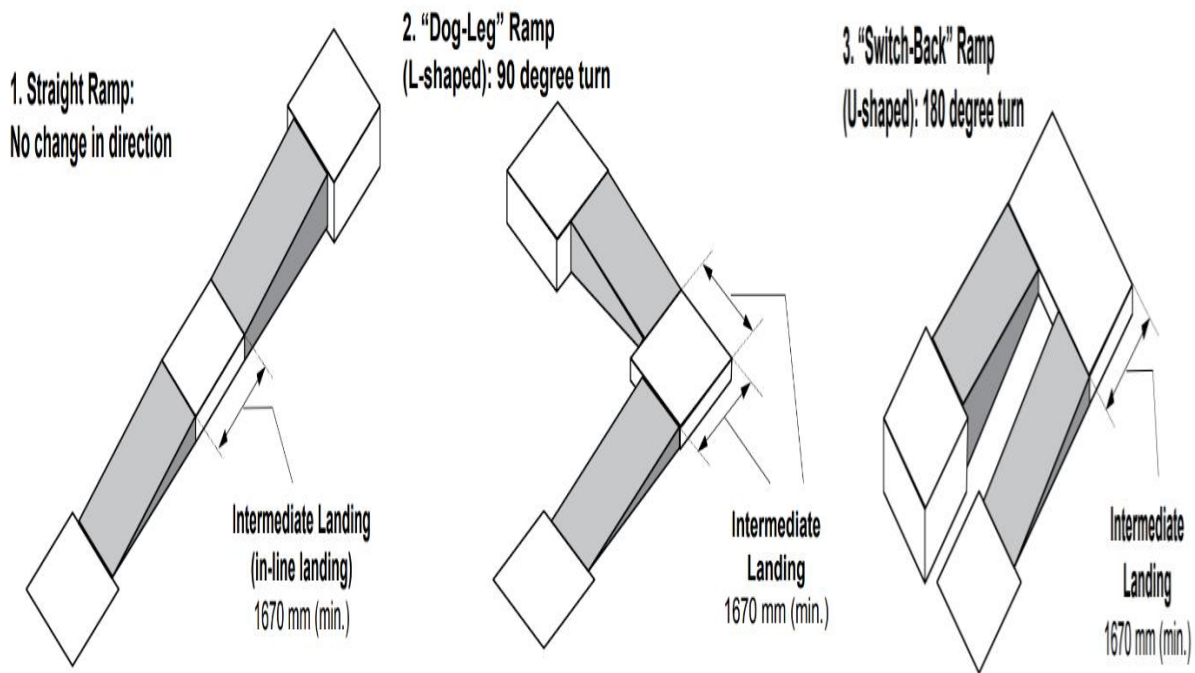


Figure 15 Ramp configuration

Table 9 Ramp standard dimension and slope

Ramp Type	Slope	Max length m	Ramp Width m
Smooth Slope	<5%	12	1.50-3.30
Medium Slope	5%-8%	6	1.50-3.30
Steep Slope	8%-12%	3	1.50-3.30
Extra Steep Slope	>12%	0.5	1.50-3.30

2.2.1.7 Emergency Stair

Table 10 Emergency stairway width [1]

Building Type	Area	Width emergency stair
Shopping center	<500 ²	1.25 m is adequate
Shopping center	>500 ²	>2.00 m , <2.5 ms

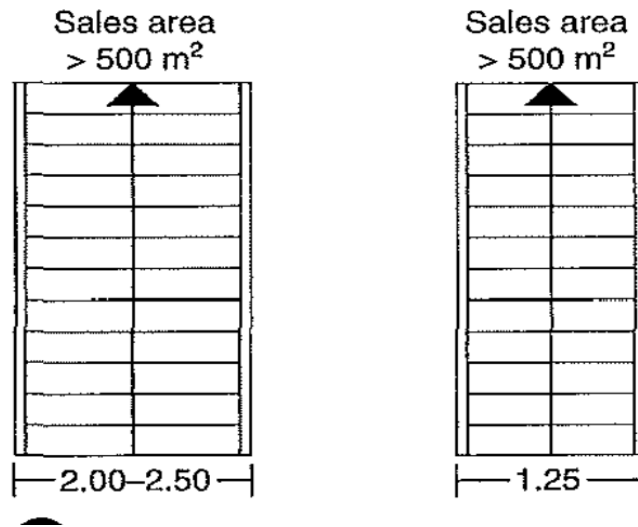


Figure 16 emergency stair width [1]

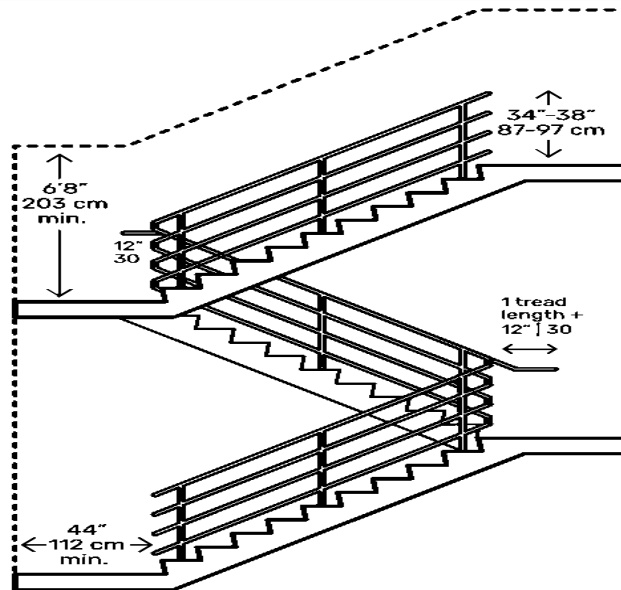


Figure 17 rail, height and landing dimension for emergency stair [7]

2.2.1.8 Parking

Based on Local Regulations (Local government) [8] for Retail buildings

- One car park for every 50 m² of stores and storages areas, one car park for every 70 m² of other spaces at retail building.
- The internal lanes width shall not be less than 5 m.

- The radius of the outer turn at least 8 m and the turn inner radius at least 8 m.
- The ramp slope shall not exceed 20%.

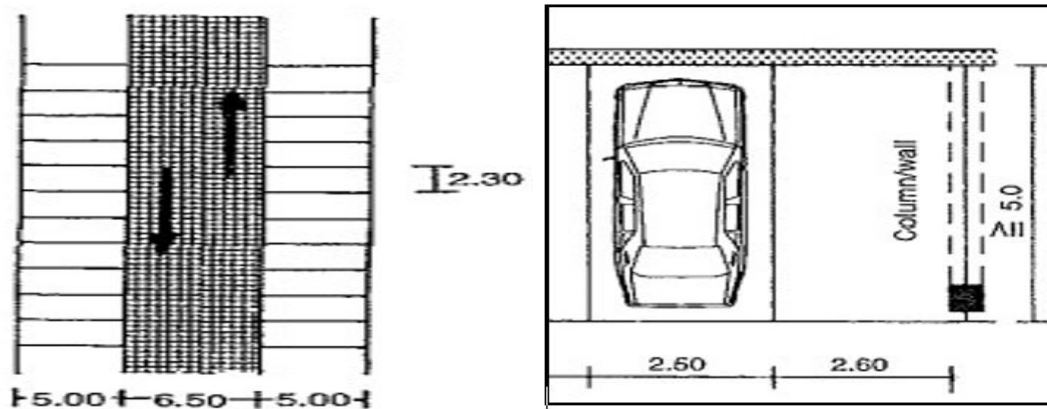


Figure 18 Dimension of cars parking and cars movement inside parking [1]

2.2.1.9 Parking for people with special needs:

Two types of accessible parking spaces

- Type A (minimum 3.40 m wide), car is not designed for people with special needs
- Type B (minimum 2.40 m wide), car designed for people with special needs

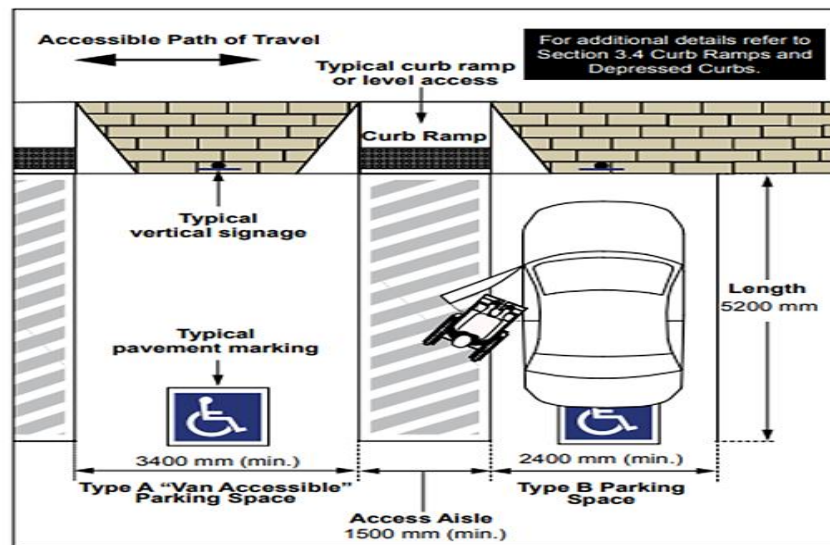


Figure 19 parking dimension for propel with special need [4]

Table 11 Number of Requirement Parking for people with special needs [4]:

Total Number of Parking Spaces	Total Number of Accessible Spaces Required	Number of Type A	Number of Type B
1 - 12	1	1	0
13 - 25	1	0	1
26 - 50	2	1	1
51 - 75	3	1	2
76 - 100	4	2	2
101 - 133	5	2	3
134 - 166	6	3	3
167 - 250	7	3	4
251 - 300	8	4	4
301 - 350	9	4	5
351 - 400	10	5	5
401 - 450	11	5	6
451 - 500	12	6	6
501 - 550	13	6	7
551 - 600	14	7	7
601 - 650	15	7	8
651 - 700	16	8	8
701 - 750	17	8	9
751 - 800	18	9	9
801 - 850	19	9	10
851 - 900	20	10	10
901 - 950	21	10	11
951 - 1000	22	11	11
1001 and over	11 +1 % of total	(1) Where an even number is required, provide equal number of Type A and B (2) Where an odd number is required, provide equal number of Type A and B plus an additional Type B.	

2.2.1.10 Corridor

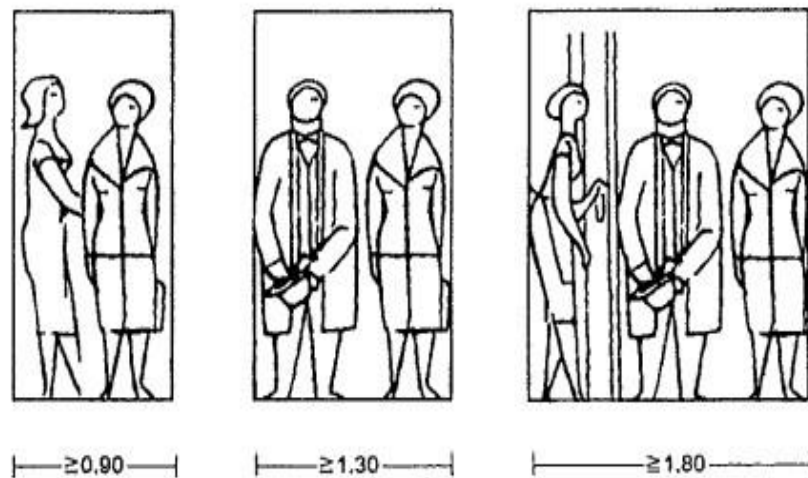


Figure 20 corridor width [1]

2.2.1.11 Corridors for people with special need

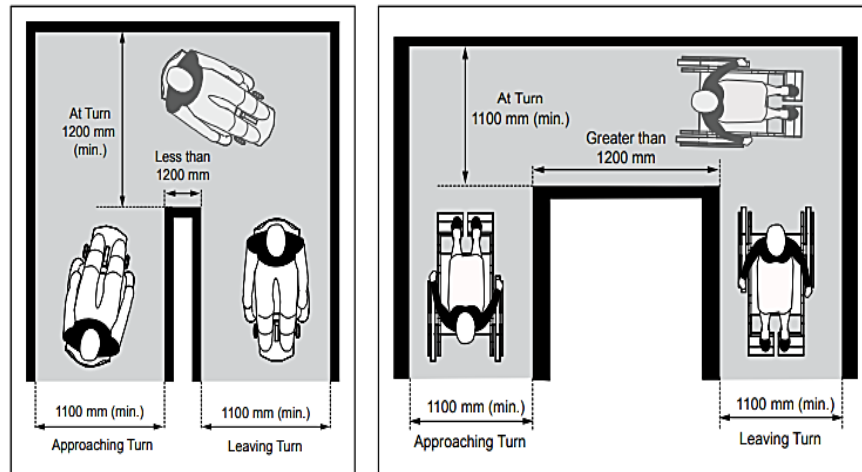


Figure 21 corridor dimension for special needs [4]

2.2.1.12 Emergency corridors

The width of emergency corridors for customers must be at least 2.00 m.

A width of 1.40 m is sufficient for emergency corridors that intended for sales areas <math>< 500\text{m}^2</math>

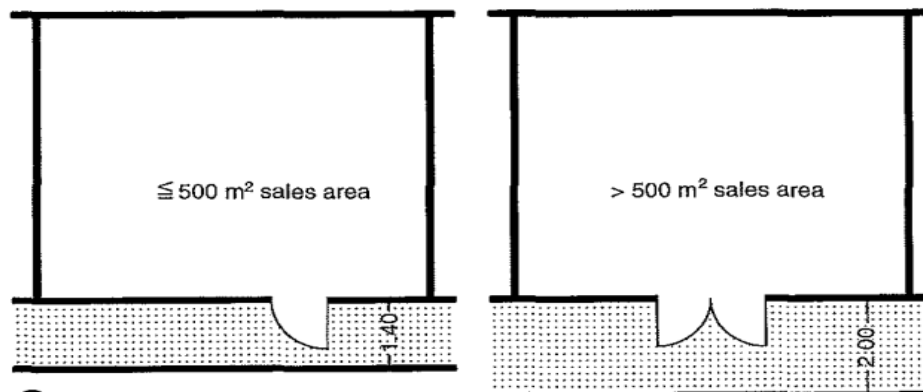


Figure 22 Width of emergency corridors [1]

2.2.1.13 Elevators

Car width	Car depth	Movement area width	Movement area depth
1.1 m at min	1.4 m at min	>1.5m	>1.5m

The movement area must not overlap with other movement areas and traffic routes.

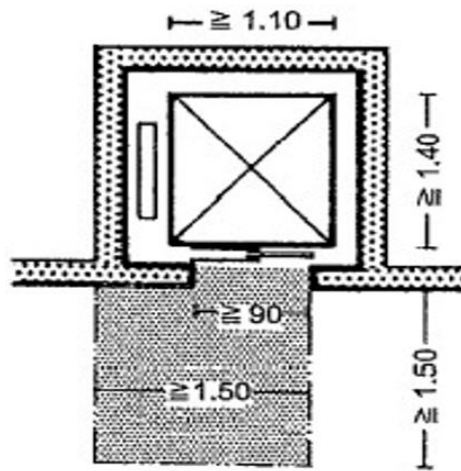


Figure 23 elevator car and movement area

2.2.1.14 Requirements for the means of escape

- For each room two exits must be provided, one of them is the room door and the other may be a balcony or. Door [11]
- The vacated time of the building should not exceed 3 minutes. [11]
- Number of exits on one floor is not less than two exits. [11]
- The minimum distance between any point and the emergency exit 30 m. [11]

2.3 Case study:

2.3.1 Project description

IKEA Store / Querkraft. The project located in Vienna, Austria, with 29480 m² total area. This building can make a significant contribution to the city and the future of retailing.



Figure 24 Project picture



Figure 25 IKEA Store location

The external shell of the building is a set of shelves with 4.5 meter deep, shelves runs around the building and provides shade, and also allows spaces to expand and, moreover, for servant elements like building services, escape stairs, and lifts.

2.3.2 Architectural and area analysis:

Total project area: 29480 m²

A building consisting seven floors, and a basement consisting two part, part one have one floors, second part have two floors.

Table 12 floor function

Floor	Function
Basement	Warehouse
Ground Floor	External retail store
First Floor	Retail store
Second Floor	Retail store
Third Floor	Retail store
Fourth Floor	Retail store and restaurant
Fifth Floor	Hostel
sixth Floor	Hostel
seventh Floor	Rooftop Terus



Figure 26 Project picture

2.3.3 Project Plans and Sections

Plans

retail



querkraft

0 10m ikea wien west 1:300 e03 31.08.2021

Figure 27 Retail floors plan

hostel



querkraft

0 10m ikea wien west 1:300 e06 31.08.2021

Figure 28 Hostel floors plan

rooftop terrace

querkraft

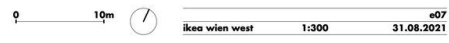


Figure 29 rooftop plan

site plan

querkraft



Figure 30 Site plan

Elevation and section

elevation south

querkraft



Figure 31 Front elevation

section

querkraft

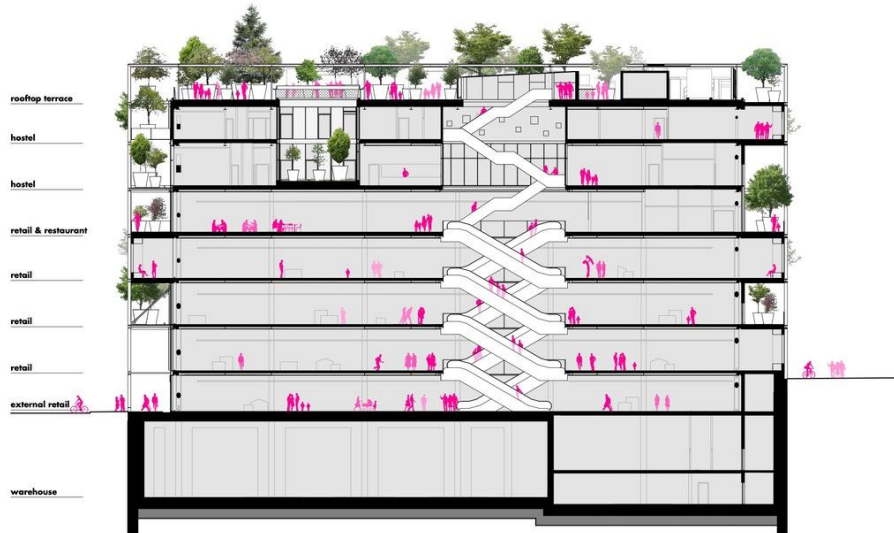


Figure 32 Section

2.4 Site Analysis:

2.4.1 Site location:

Sameer Shanaa Mall locate in Haifa Street in the center of the city of Nablus on latitude 32.231155 and 35.245252, next to Deals On Wheels Company and near the municipality of Nablus. Nablus rising on average (550 m) above sea level.

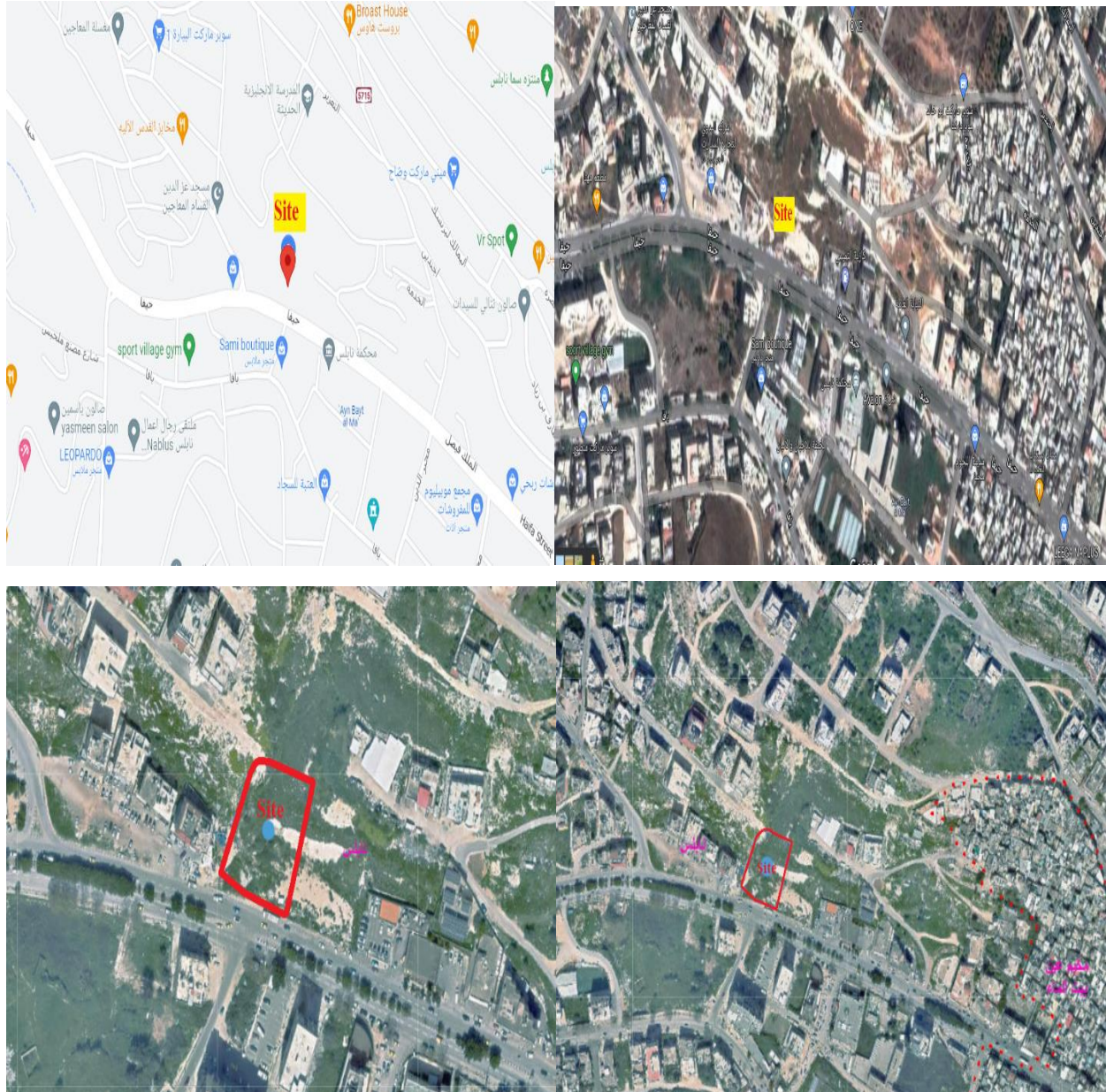


Figure 33 Site location [5]



Figure 34 Site Picture

2.4.2 Topography and contour lines:

The building is facing the street for easy access it is oriented towards the south. There is a different levels of the contour line, so the playing hall designed from the back of the building at the same back street level. As shown in Figure 35, Haifa Street height 451m will be considered 0.00 m, and the highest contour level of 465 m will be considered 14 m.



Figure 35 counters line for project land [5]

2.4.3 Surroundings and nearby buildings:

The site located at a so vital area, opposite Shini Supermarket. Next to it on the east side Deals On Wheels Company and on the west a residential building. Near to it the municipality of Nablus, public prosecution building and Al-Tamimi Petrol Station.

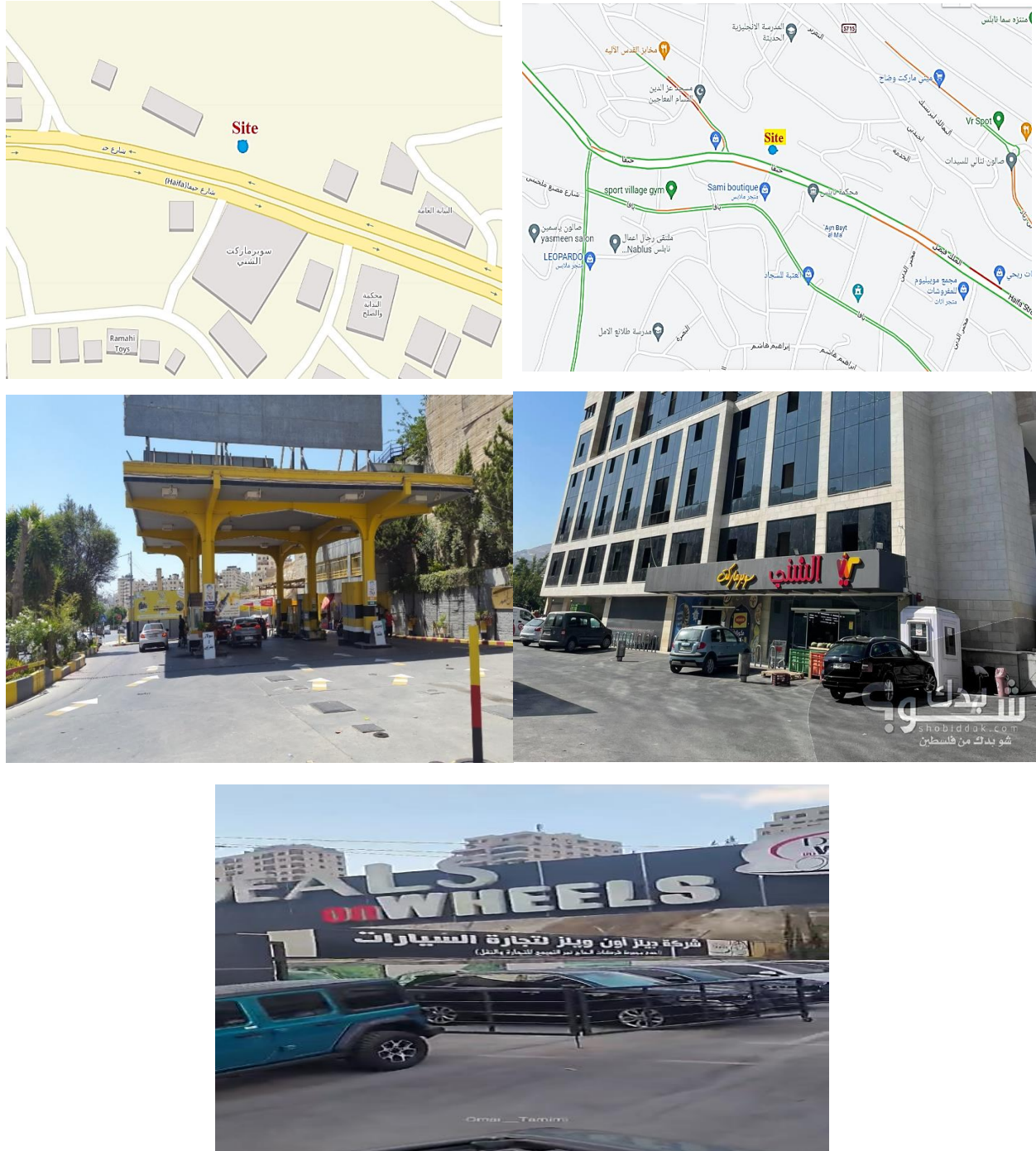


Figure 36 Surroundings and nearby building

2.4.4 Roads and surrounding streets:

As Shown in Figure 37, the site locate on Haifa Street in the southern direction, which is a main street and has two direction with 30 meter width. From the west there is a street with 10 meter width and from the north there is a street with 10 meter width.

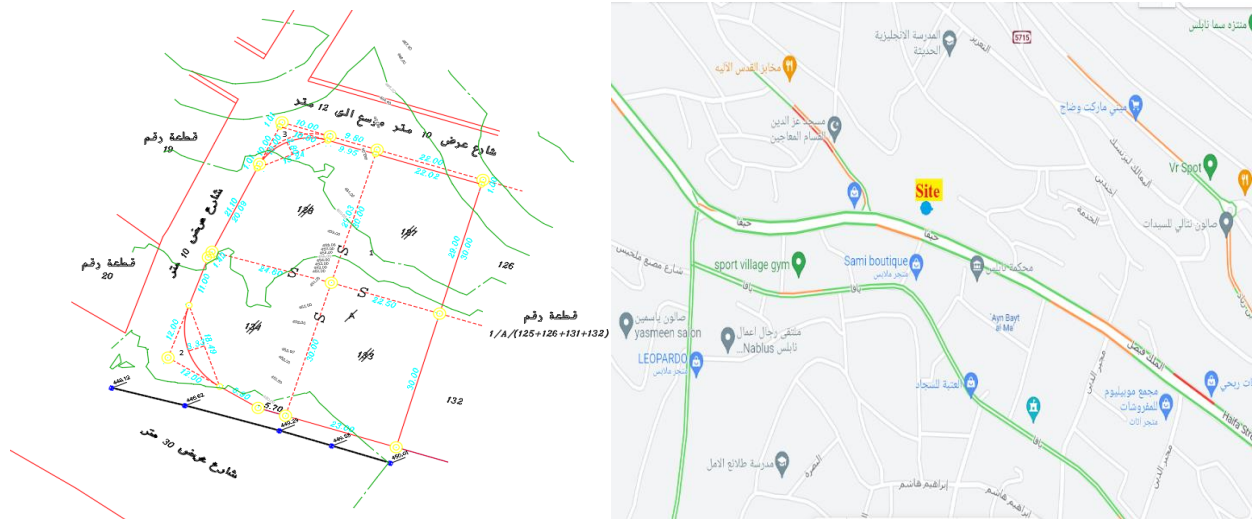


Figure 37 Roads and surrounding street

2.4.5 Local laws of the site:

Figure 38 shown that the site located in B area.



Figure 38 local laws [5]

2.4.6 Main axes and entrances:

Figure 39 shown main entrance and axes to the building

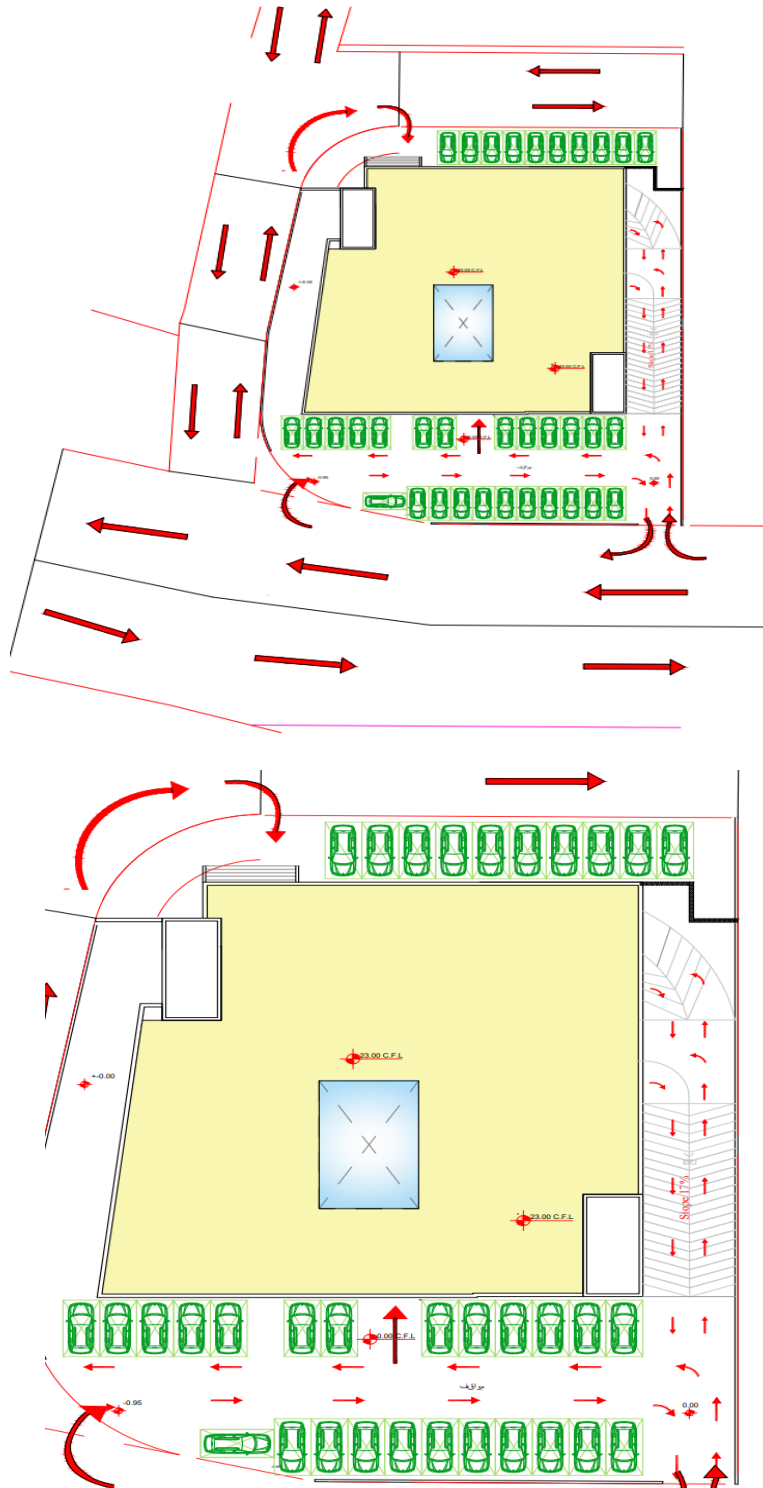


Figure 39 Main axes and entrances

2.4.7 Climatic conditions:

The weather greatly influences construction projects, so studying and analyzing site climate plays a major role in solving problems caused by weather factors, such as wind, rain, temperature, humidity, and sun radiation to provide human comfort. The information was fetched from Meteoblue website [6].

2.4.8 Temperature:

- Mean temperature

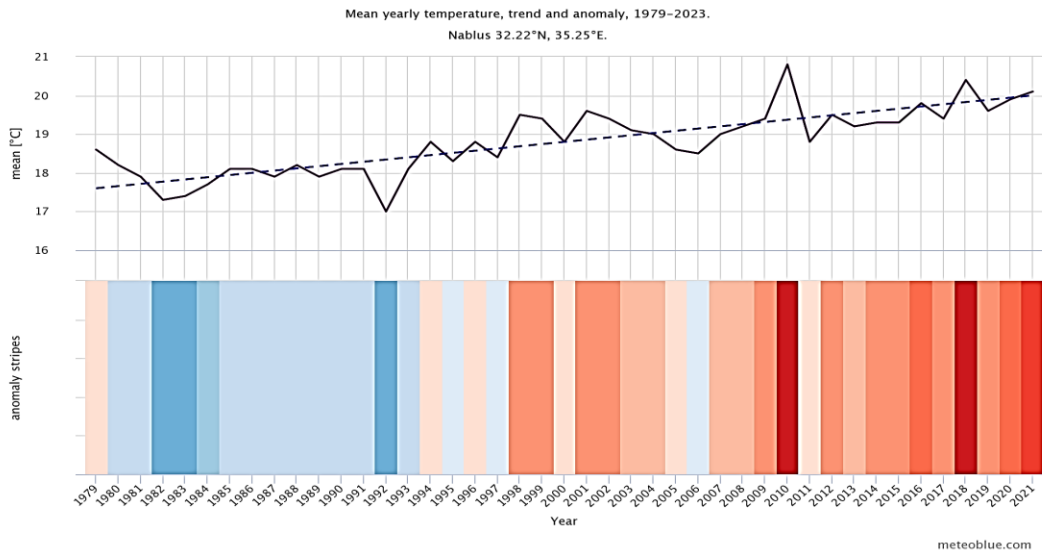


Figure 40 Mean Yearly temperature for Nablus [6]

Figure 40 Shown the mean yearly temperature for Nablus is from 1979 to 2021.

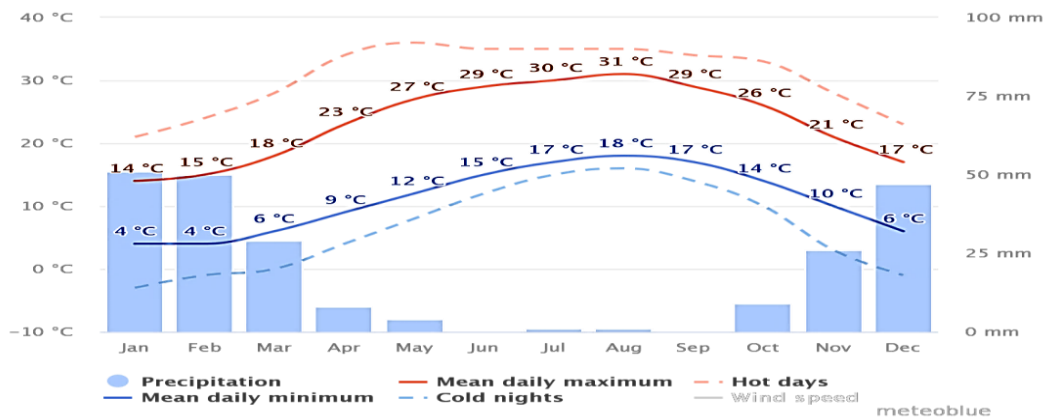


Figure 41 mean daily temperature for Nablus 2022[6]

Figure 41 shown the maximum mean temperature is 31 C° and lowest mean temperature is 4 C° at 2022.

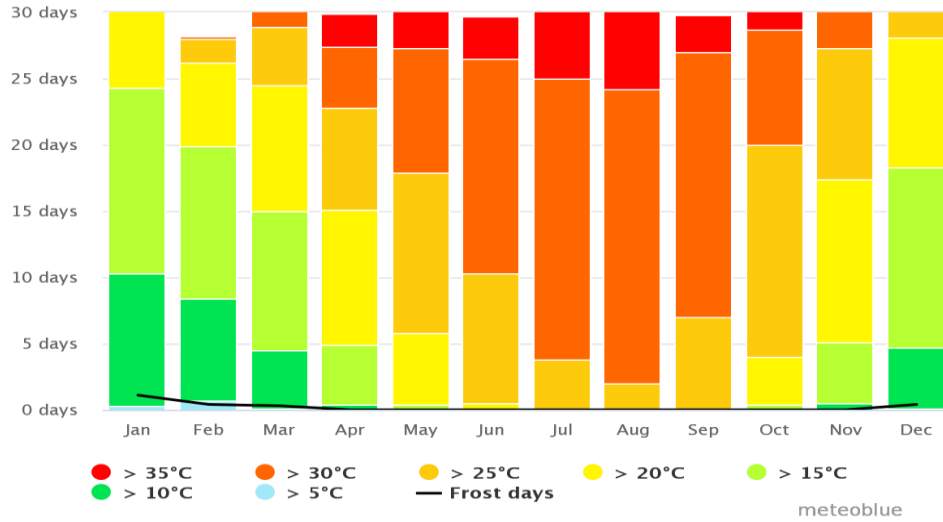


Figure 42 Nablus climate temperature 2022 [6].

Figure 42 shown Nablus climate temperature.

2.4.9 Precipitation amounts

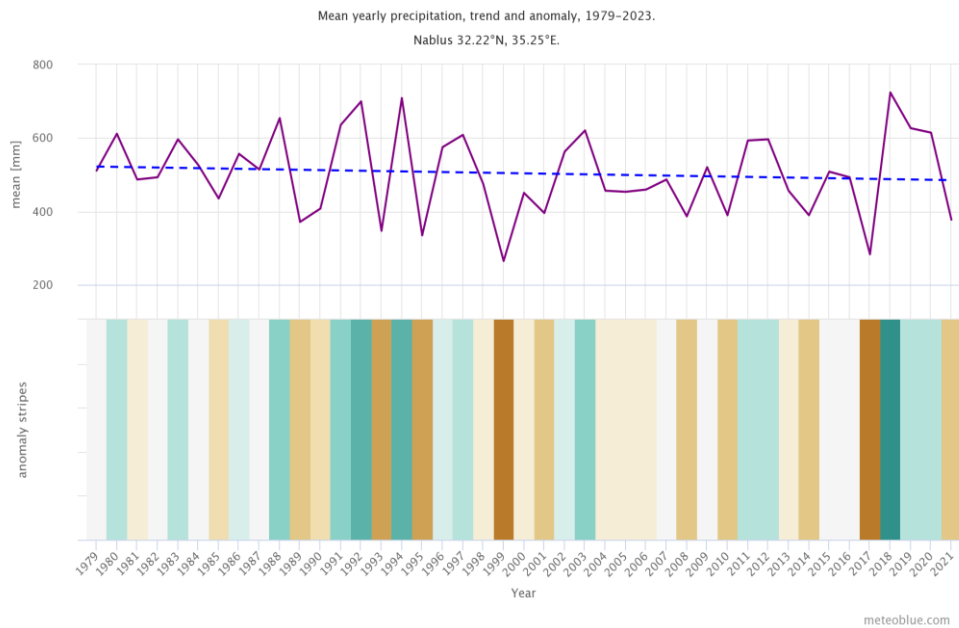


Figure 43 mean yearly perception amount at Nablus [6]

Figure 43 shown the mean yearly perception amount at Nablus from 1979 to 2021.

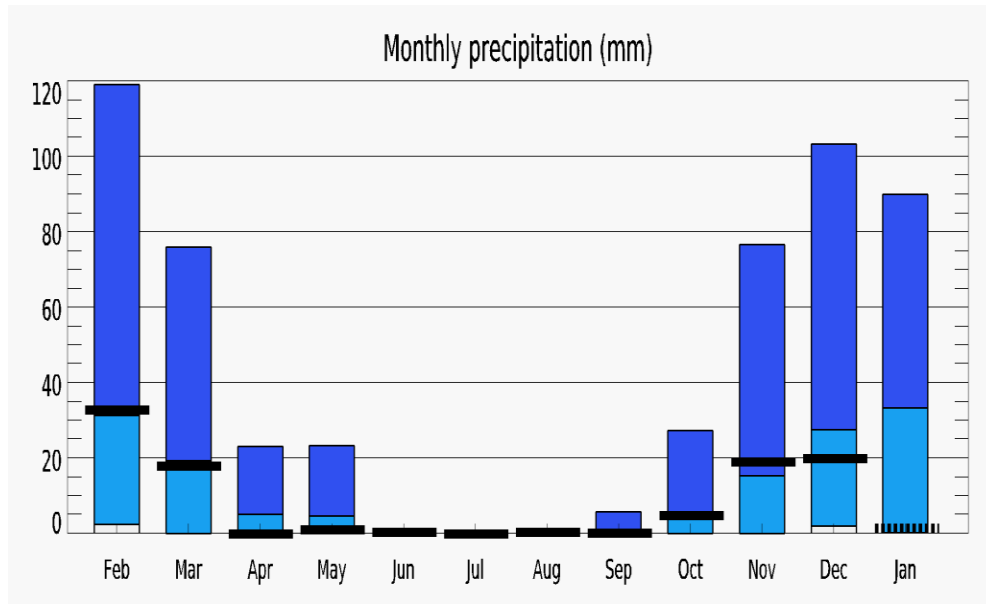


Figure 44 perception amount for Nablus 2022 [6]

Figure 44 shown monthly perception amount for Nablus.

2.4.10 Wind speed and direction

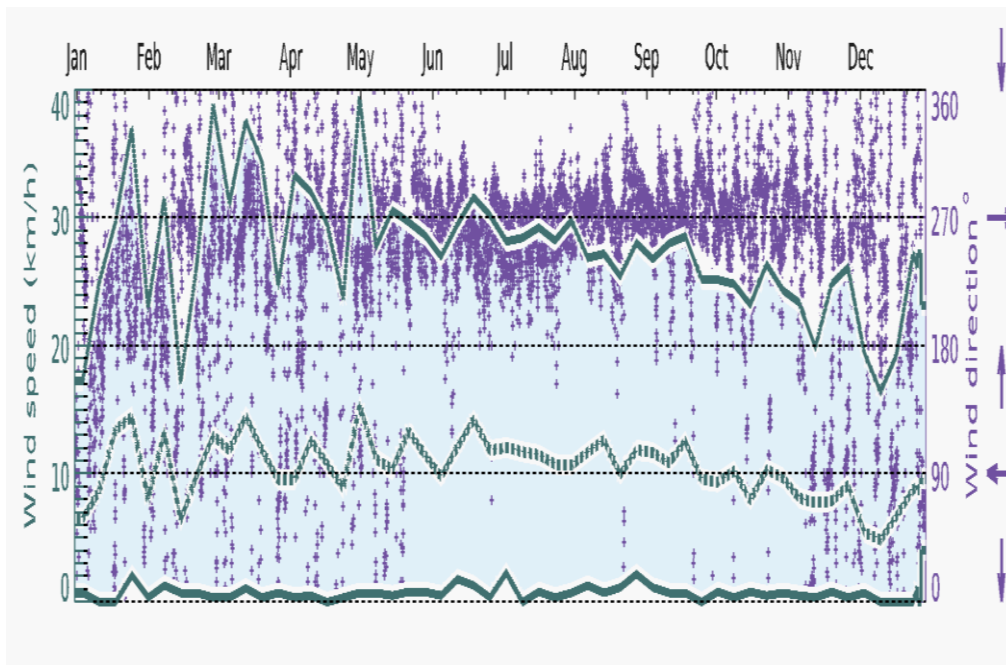


Figure 45 Wind speed and direction at Nablus 2022 [6]

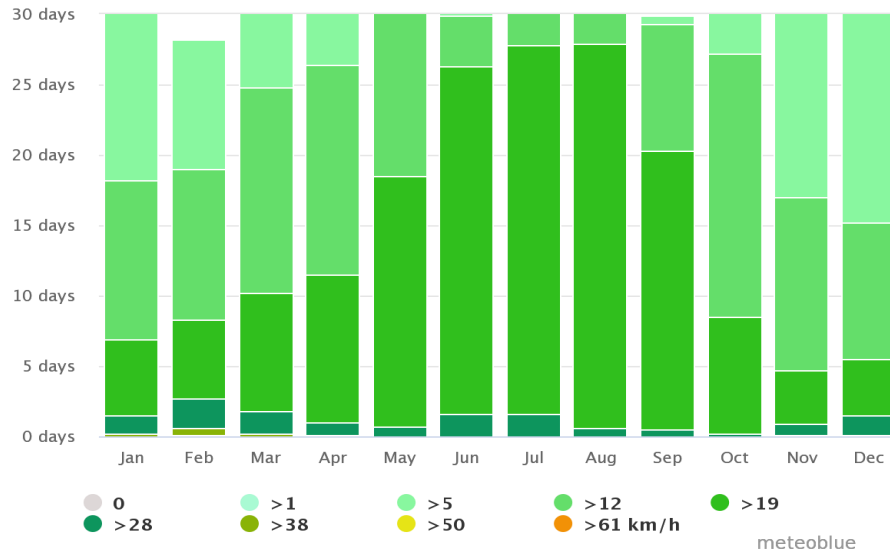


Figure 46 Wind speed and direction at Nablus 2022 [6]

Figure 45 and Figure 46 shown the speed and direction of wind for every month at Nablus.

Wind Rose for Nablus

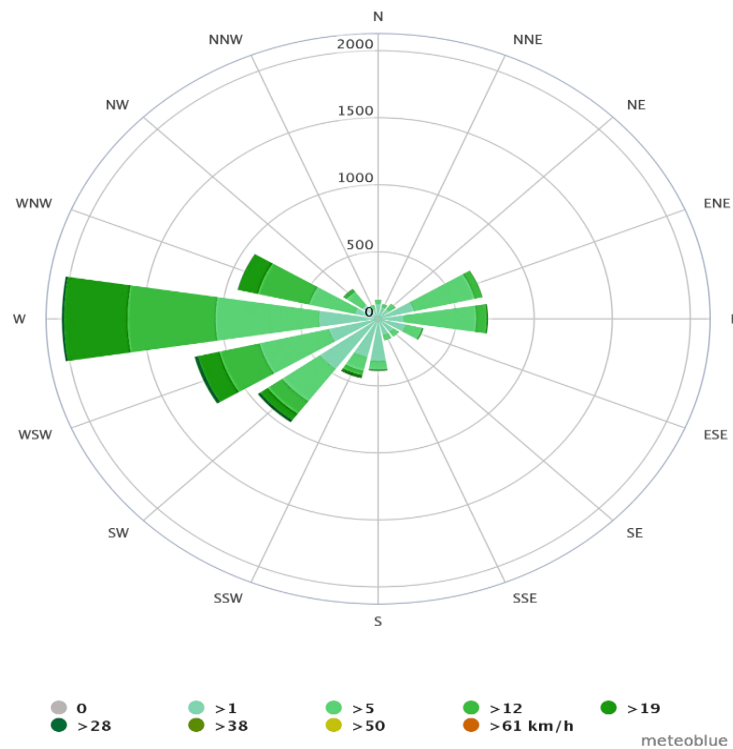


Figure 47 wind rose for Nablus 2022 [6]

Figure 47 shown wind rose for Nablus which shown the wind direction and speed.

The wind direction in Nablus from southwest to northeast



Figure 48 Wind Direction

Figure 48 shown wind direction in the site

2.4.11 Relative humidity

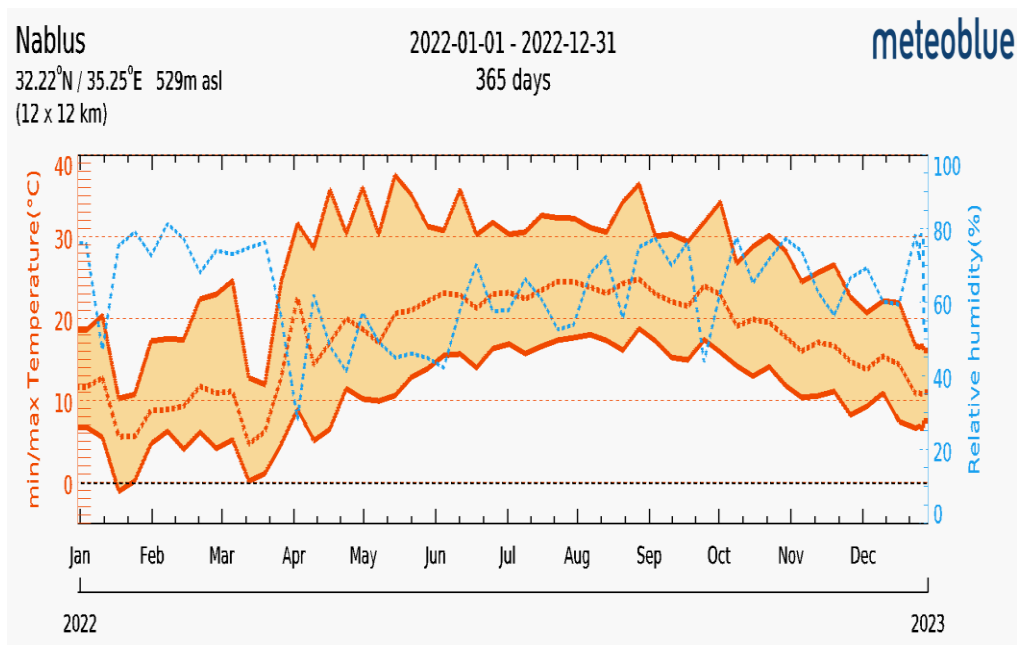


Figure 49 Relative Humidity at Nablus 2022 [6]

Figure 49 shown the Relative Humidity for every month at Nablus.

2.4.12 Sun path

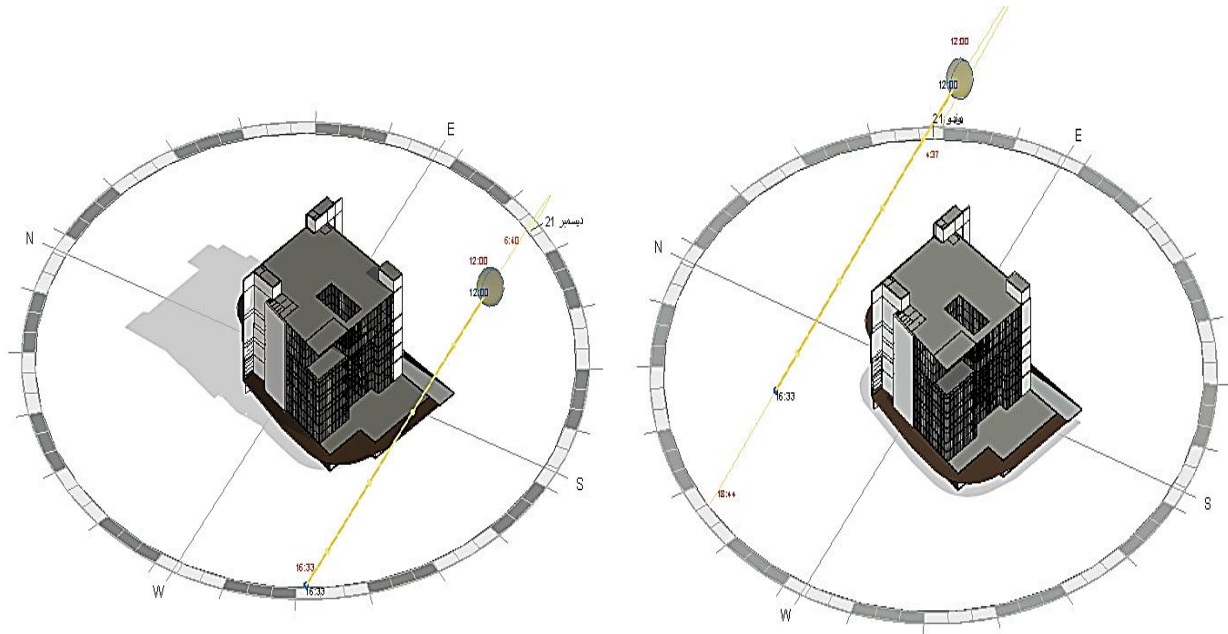


Figure 50 Sun path on 21/12 in winter and 21/6 in summer

2.5 Architectural Drawings

2.5.1 architectural drawings Before modification

Basement and Ground Floor



Figure 51 Basement Floor plan

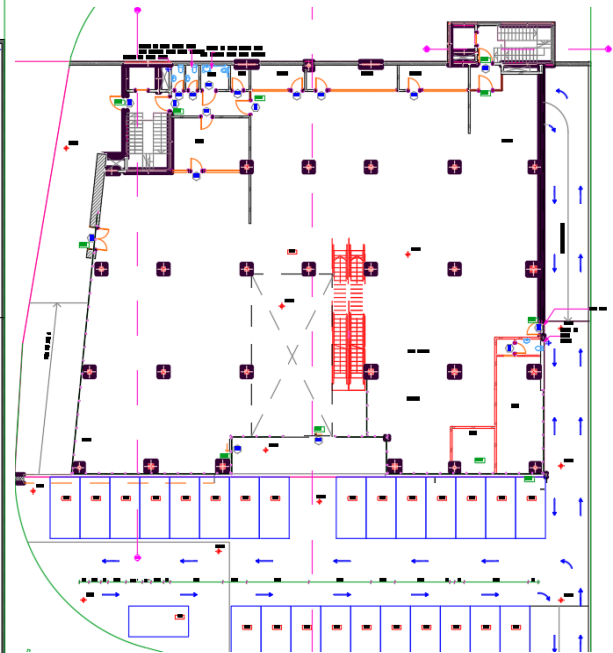


Figure 52 Ground floor plan

First and second floor

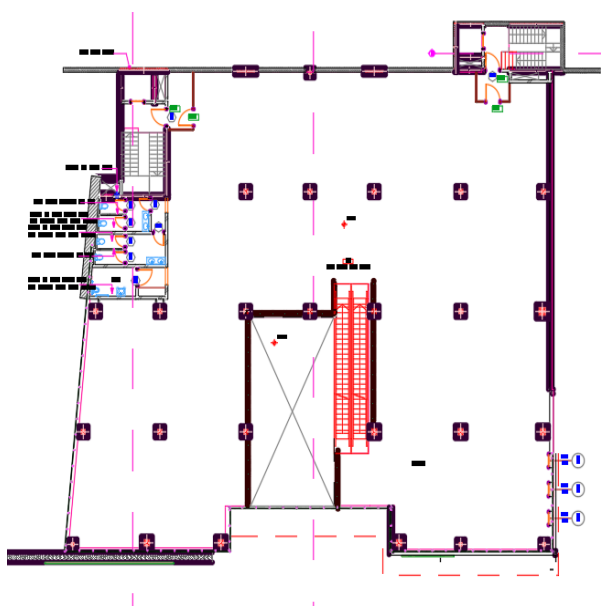


Figure 53 First Floor plan

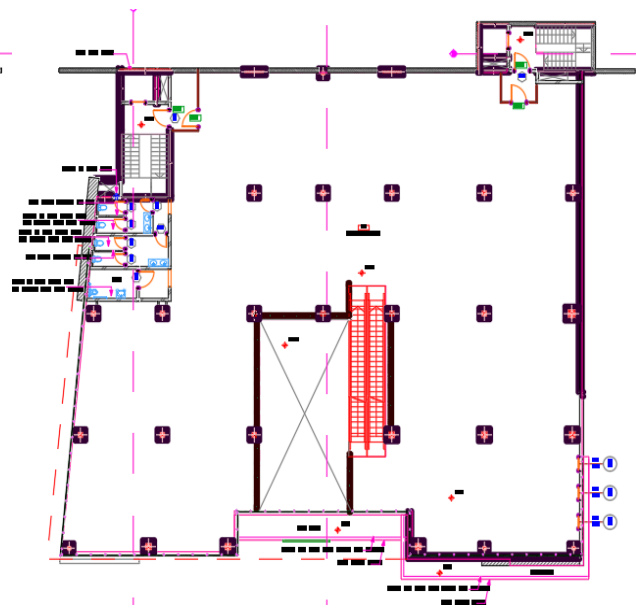


Figure 54 Second Floor plan

North and South elevation

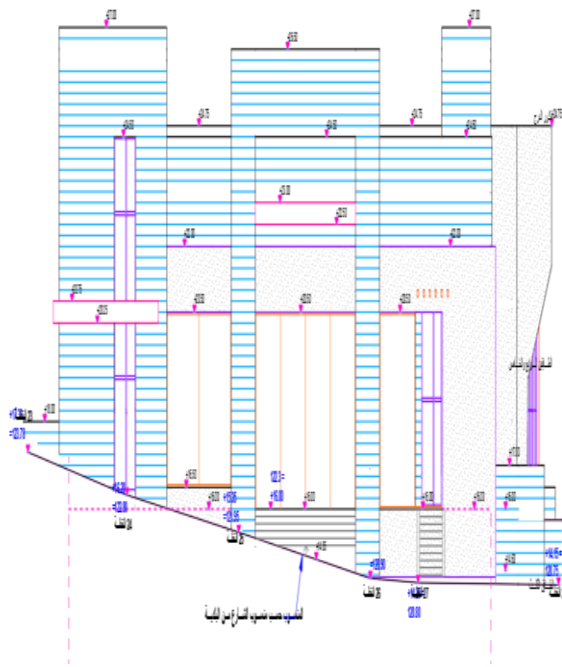


Figure 58 north elevation

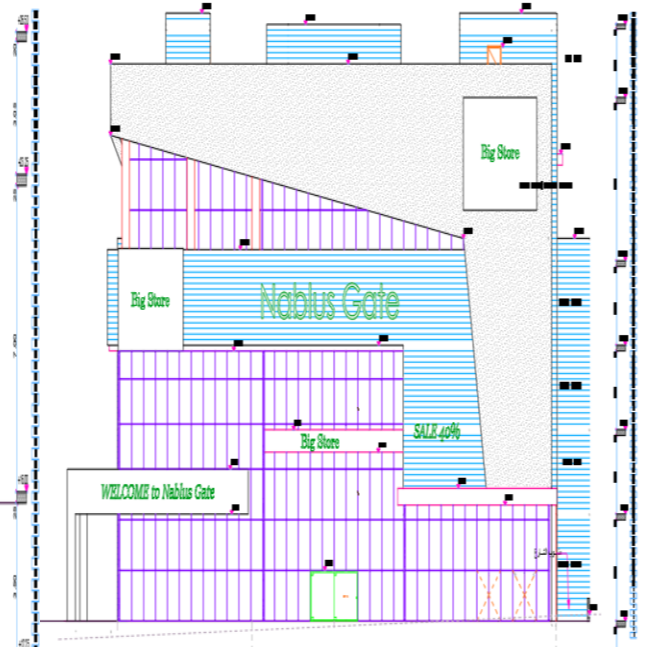


Figure 59 south elevation

East and West elevation

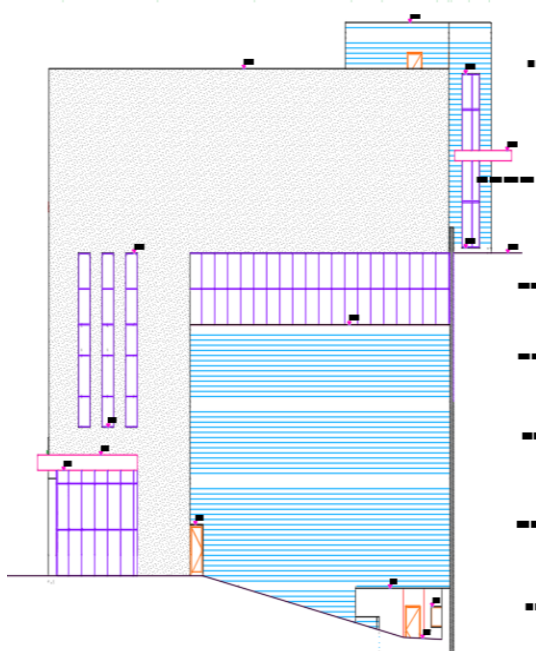


Figure 60 East elevation

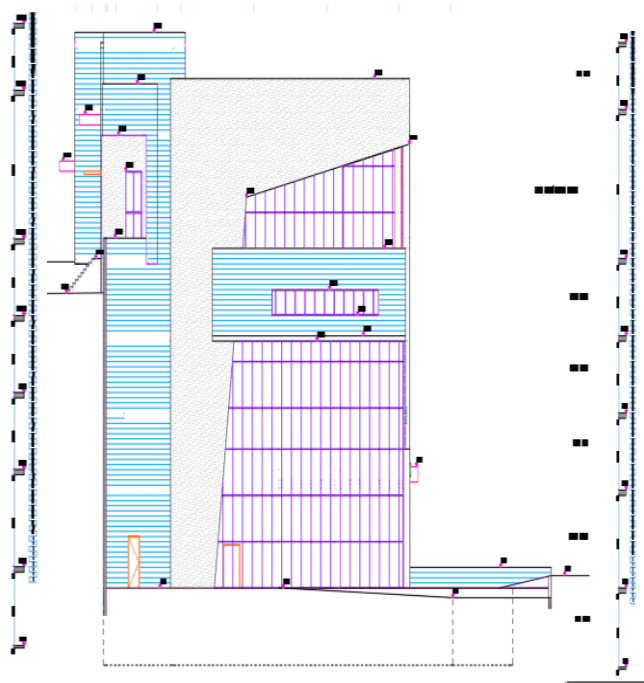


Figure 61 West Elevation

Section and Stair section

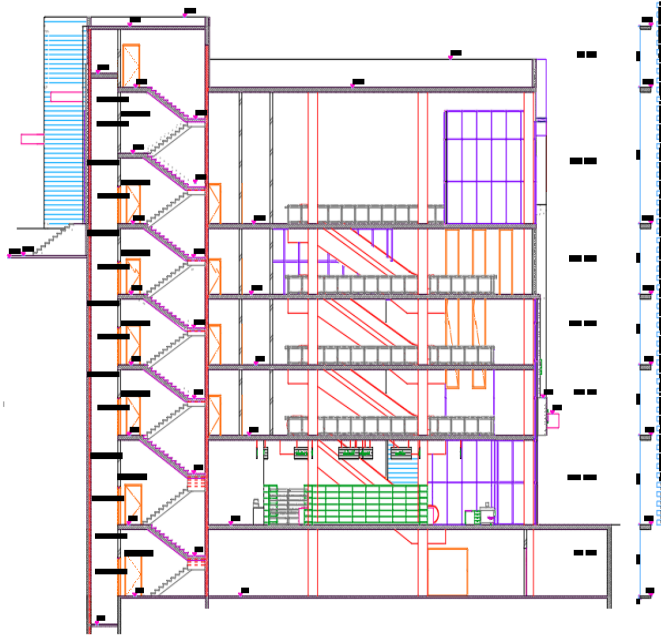


Figure 62 Section

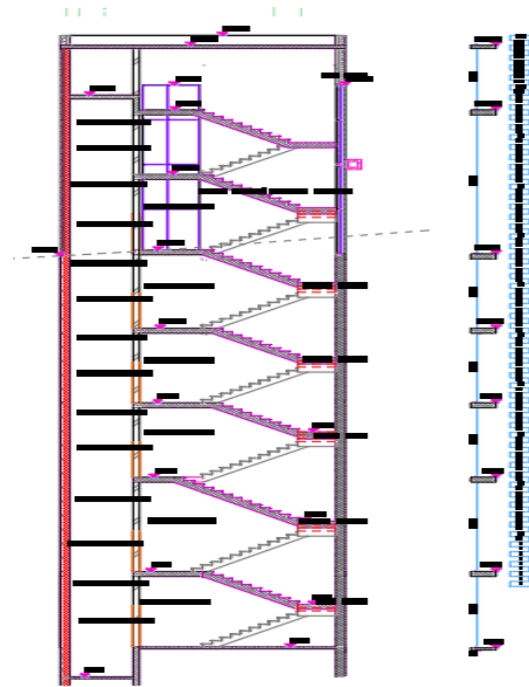


Figure 63 Stair section

2.5.2 architectural drawings after modification

First and Second Basement

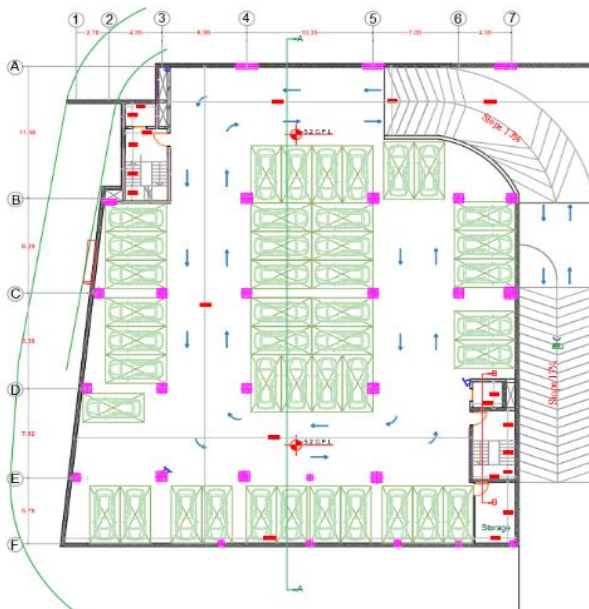


Figure 64 Second Basement Plan



Figure 65 First basement plan

Ground floor and first floor

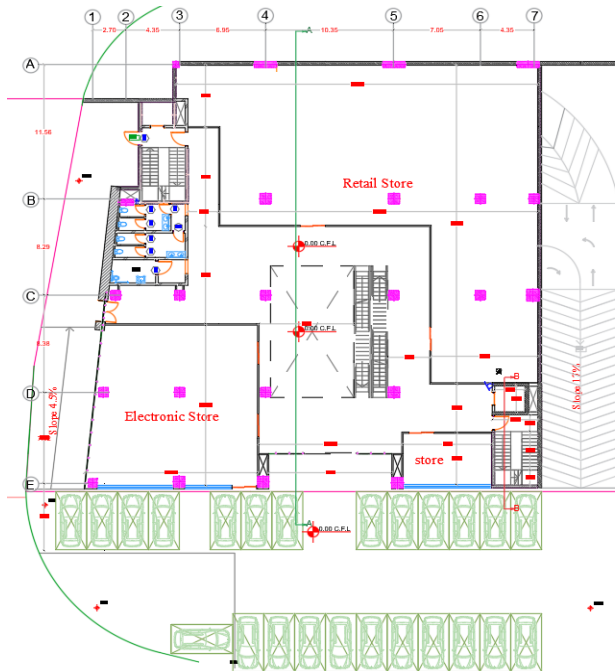


Figure 66 Ground Floor plan

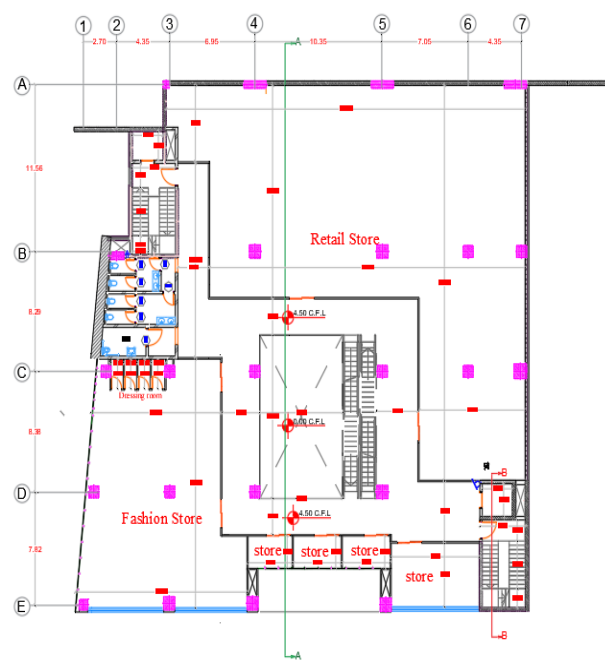


Figure 67 First floor plan

Second floor and third floor

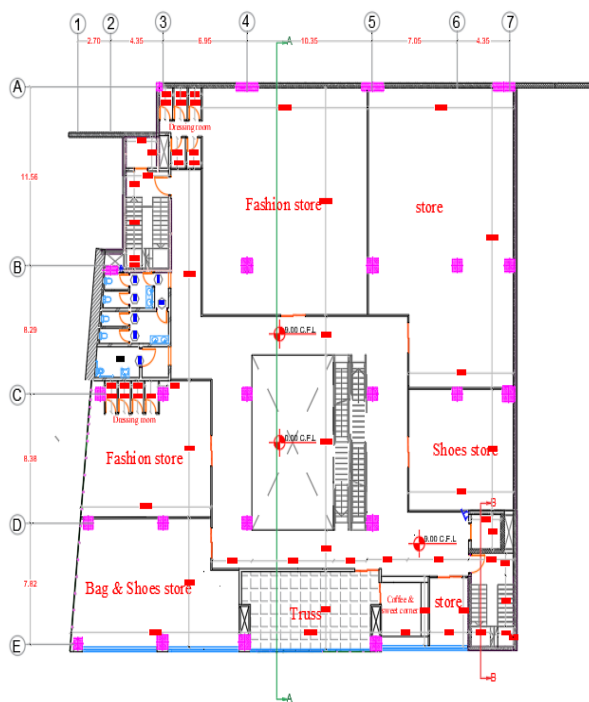


Figure 68 second floor plan

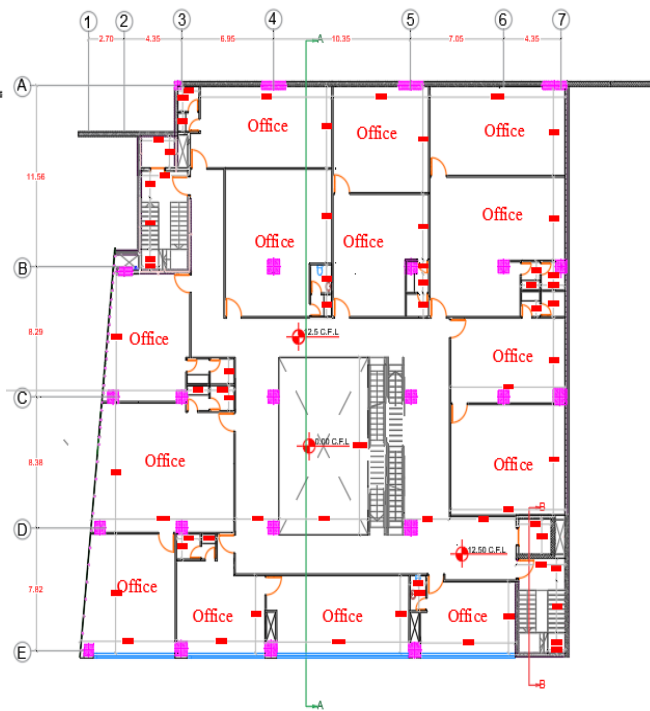


Figure 69 Third Floor plan

Fourth floor and Site Plan

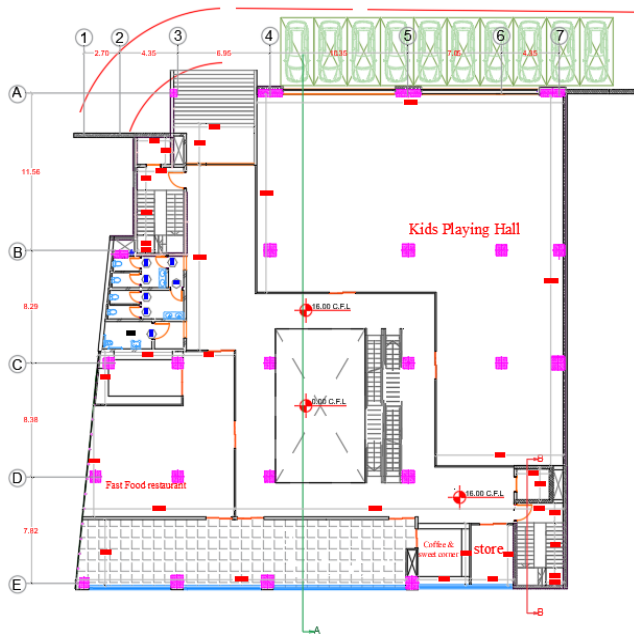


Figure 70 Forth Floor plan

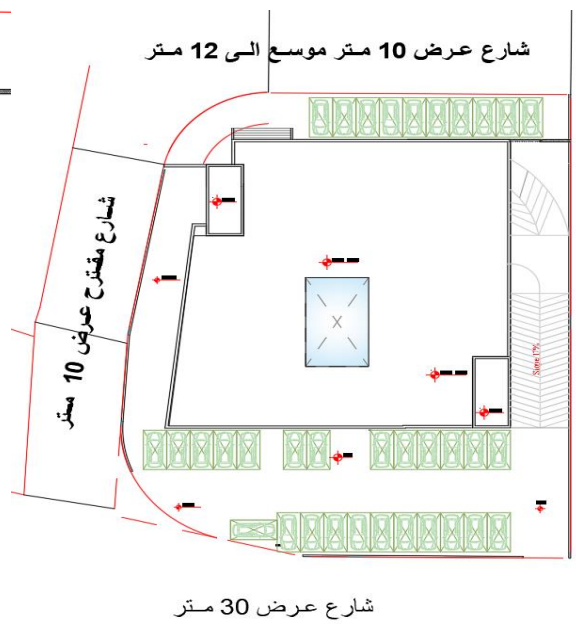


Figure 71 Site Plan

North and South elevation

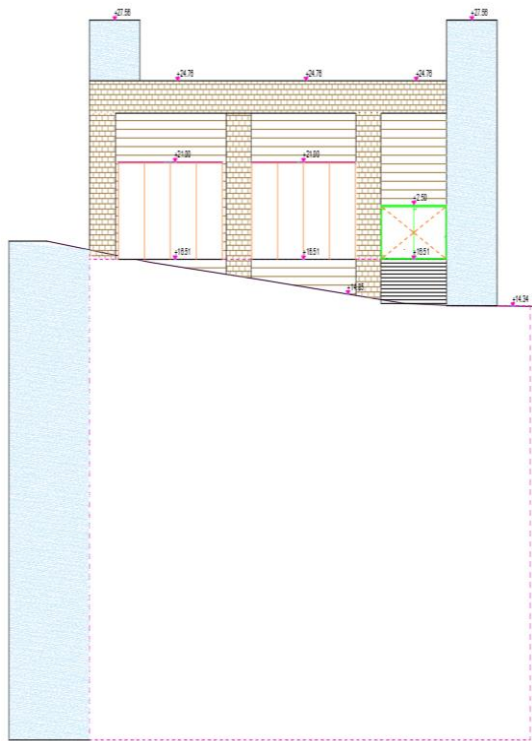


Figure 72 North Elevation

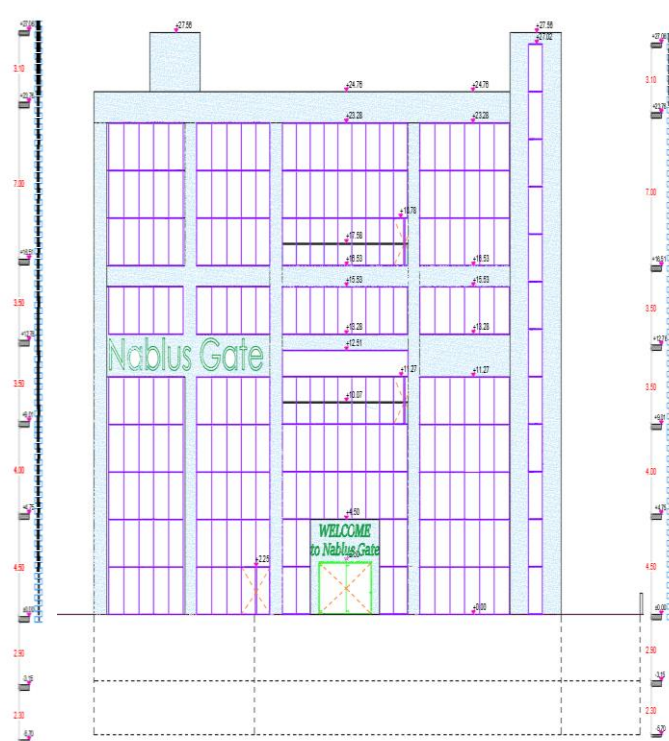


Figure 73 south elevation after

East and West elevation



Figure 74: East elevation

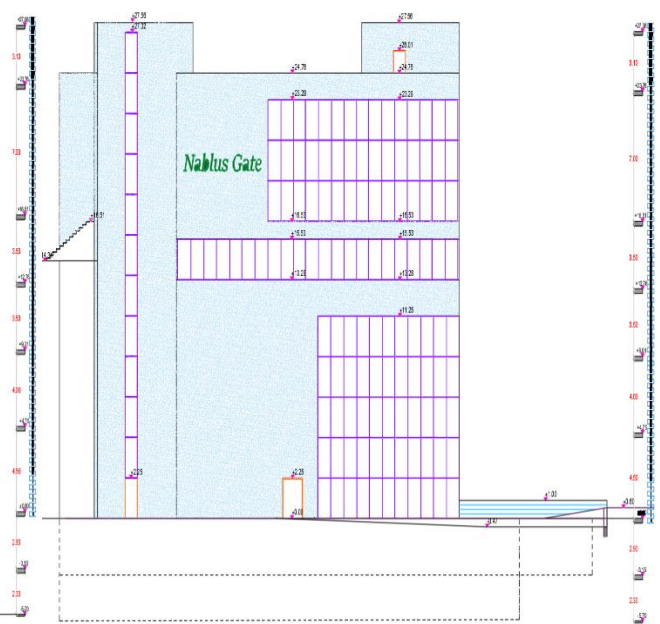


Figure 75 West elevation

Section and Stair section

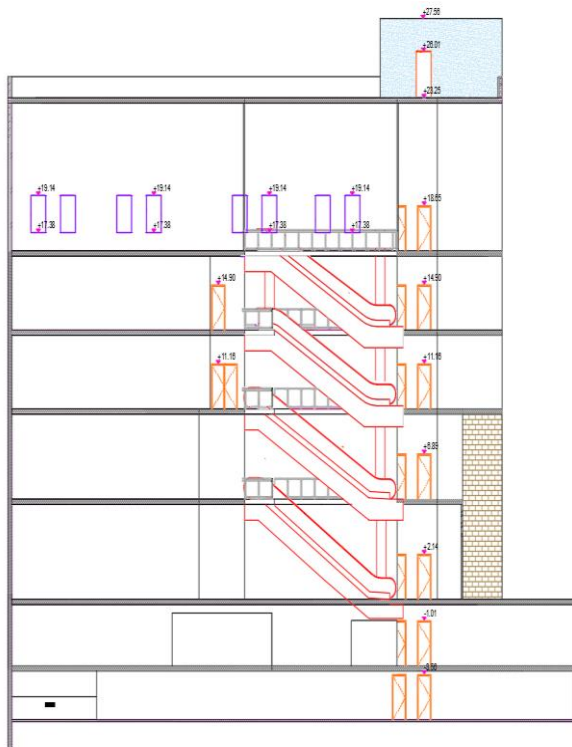


Figure 76: section A-A

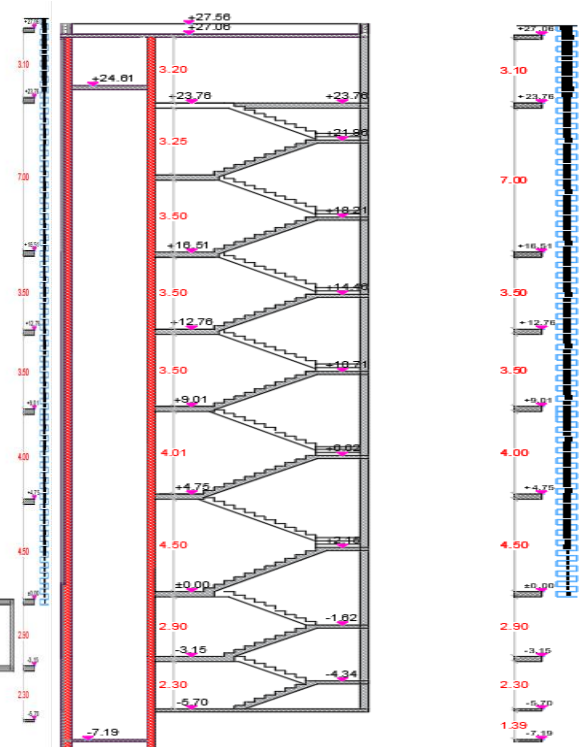


Figure 77: Stair Section

Ground floor and first floor furniture plans

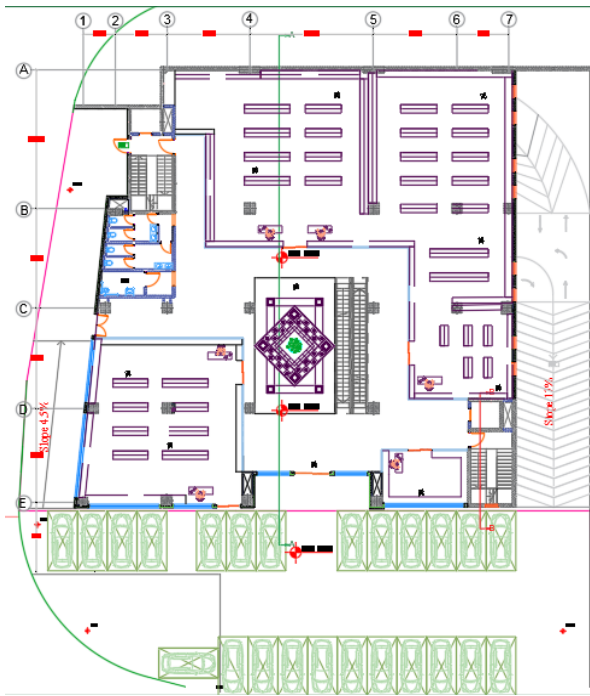


Figure 78 ground floor with furniture

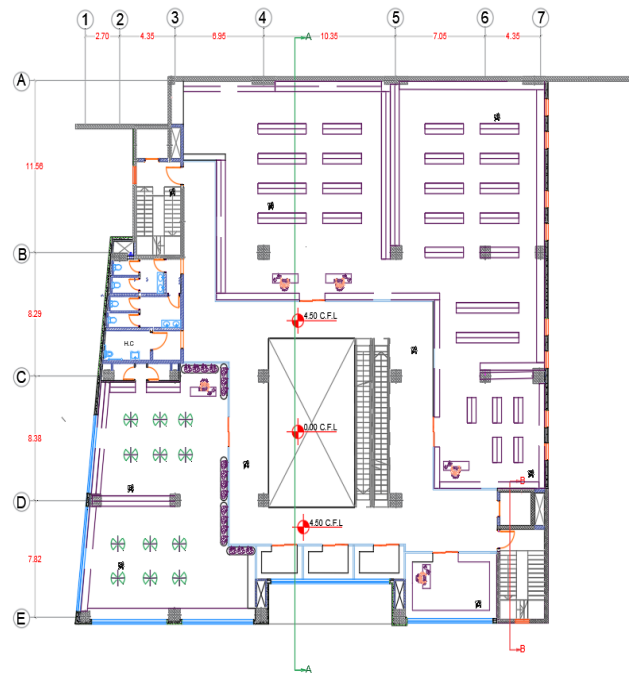


Figure 79 First floor with furniture

Second and third floor furniture plans

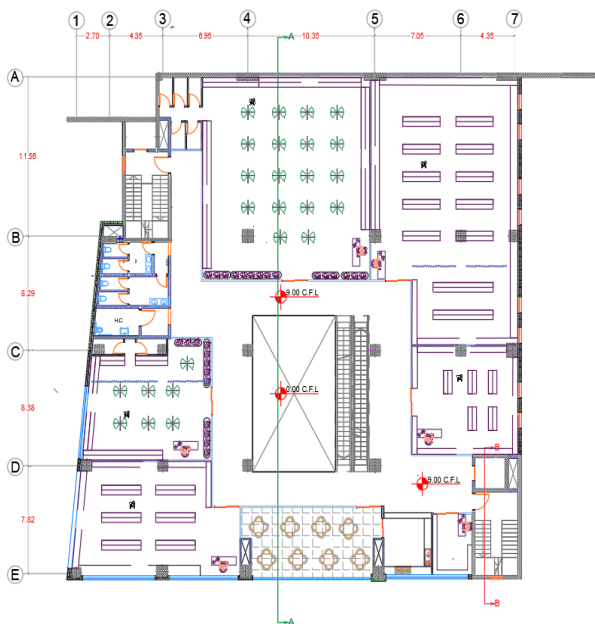


Figure 80 third floor with furniture

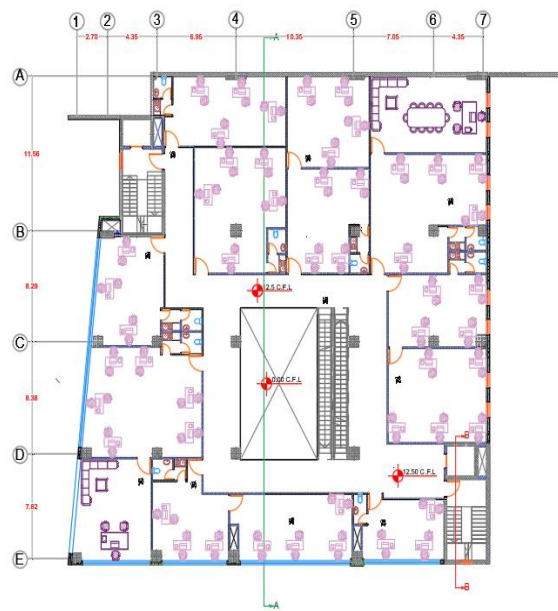


Figure 81 second floor with furniture

Fourth floor furniture plan

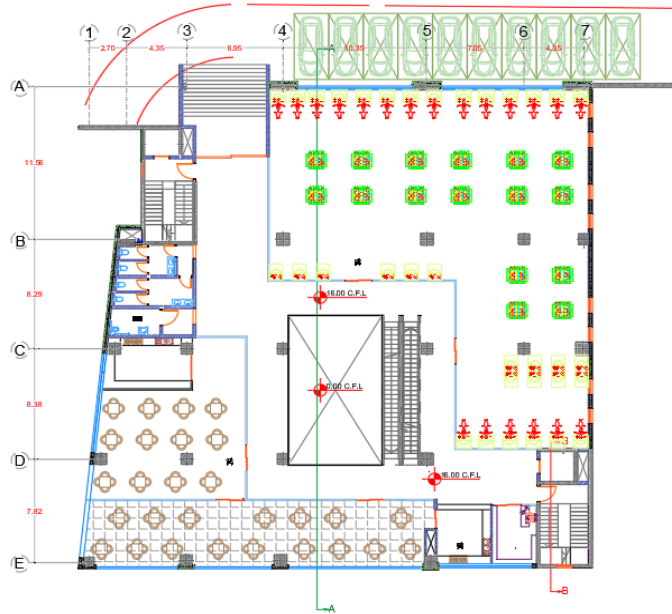


Figure 82 Fourth floor furniture plan

2.5.3 Relations between spaces

- Ground and first floor

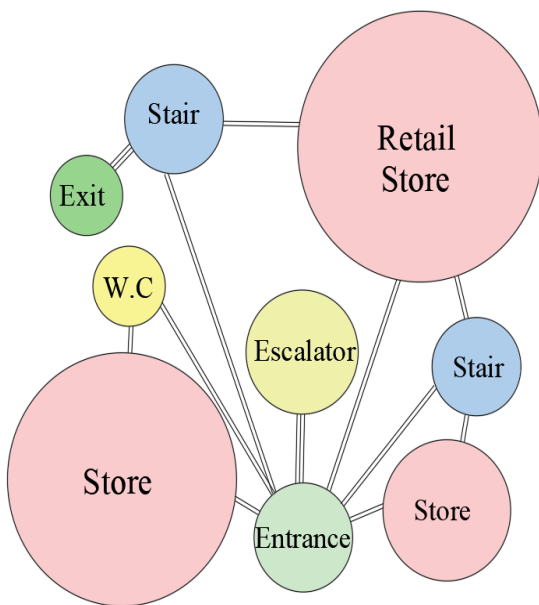


Figure 83 Ground floor relationship between spaces

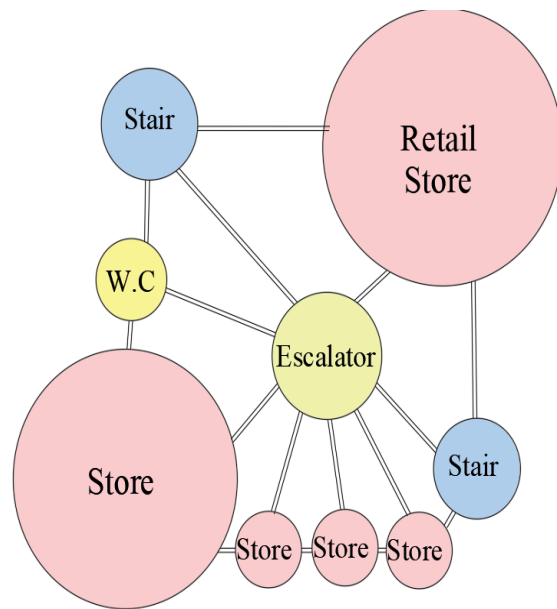


Figure 84 First floor relationship between spaces

- Second and third floor

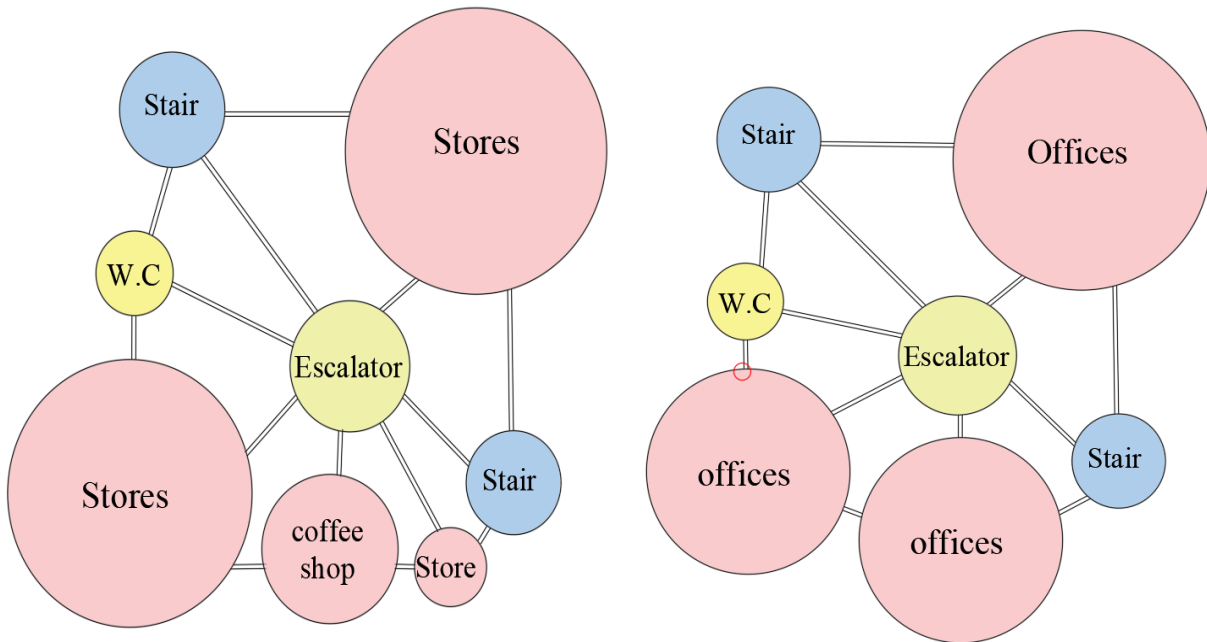


Figure 85 2nd and 3rd floors relationship between spaces

- Fourth floor

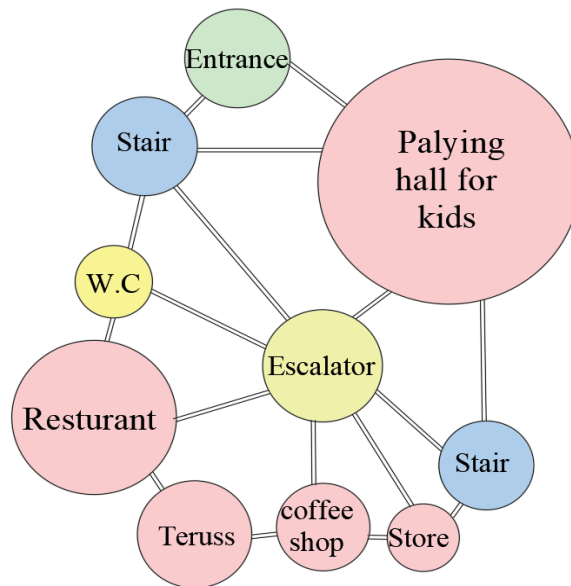


Figure 86 Fourth floor relationship between spaces

- Offices and restaurant

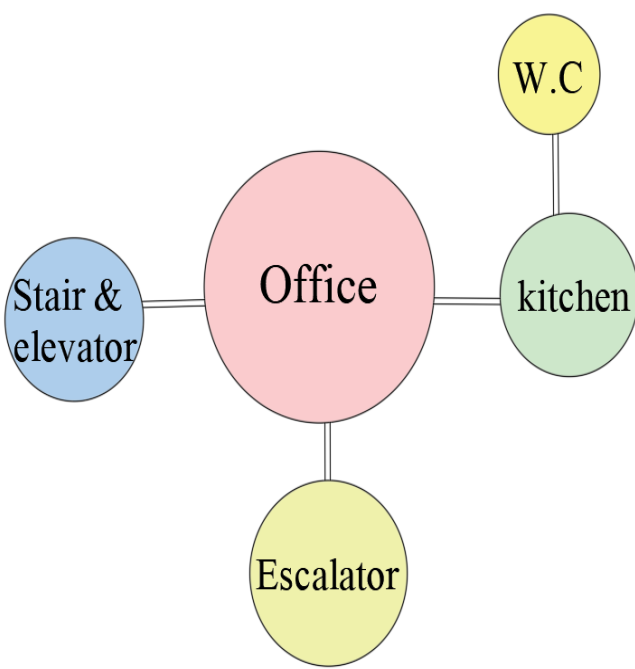


Figure 87 Offices space relationships

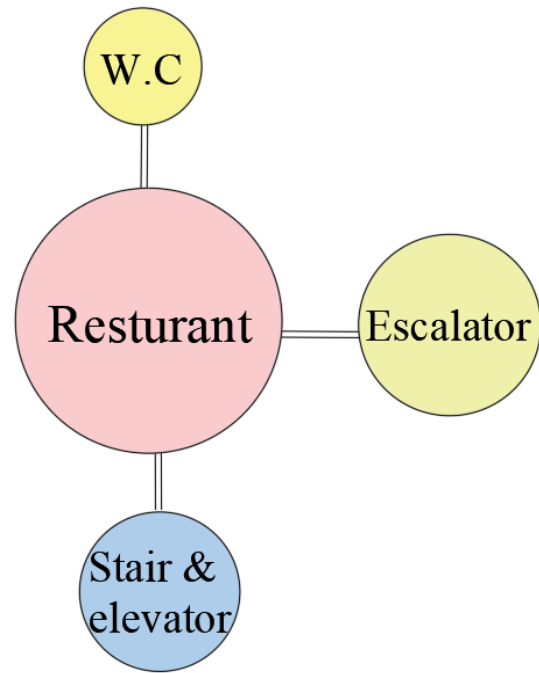


Figure 88 restaurant spaces relationships

2.6 Environmental Aspects

2.6.1 Introduction

Recently, interest in the environmental aspect has seemed to be an integral part of any project, from the smallest to the largest. The building has begun to be considered a reduced and interacting system from the larger ecosystem. The interest and strive towards obtaining buildings that consume less energy and preserve the environment from pollution has begun. Buildings are designed, implemented, and operated in different ways which are Modern and evolving to reduce their polluting environmental impact, reduce fuel consumption and reduce costs in terms of maintenance and operation to contribute to providing a safe and comfortable urban environment for its residents, thus opening the door to sustainable development and green buildings by appearing and applying on the ground to achieve ideal environmental goals.

This part of the project, which is called the environmental aspects, will study several important environmental factors as basic factors that must be studied in any project and no less important than the structural and architectural design of the building in case we are talking about the importance of providing human comfort of all kinds inside the building. It is worth noting that the types of human comfort that we seek to achieve inside the building are visual comfort, thermal comfort, acoustic comfort, and indoor air quality (providing fresh air). When studying the environmental aspects in an integrated manner, it becomes easy to achieve all these comforts for users. Quite simply, the environmental factors that we will deal with in this part are natural lighting, where an environmental analysis of the building will be done to study the daylight factor, and then based on the results, will be able to evaluate the natural lighting situation in this building and know the necessary procedures to improve these values if necessary. Then another analysis is conducted after the modifications to ensure that the solutions were effective. After that, will analyze the solar gain of the building, after that the situation will be evaluated and the necessary improvements will be made to achieve the greatest solar gain in the winter and the least in the summer, and in this way, the solar gain has been dealt with properly. After that, an analysis will be done to find out the values of each of the heating and cooling loads required in this project before making any modifications, and then think about effective solutions and modifications such as thermal insulation and the use of good quality glass to improve these values as much as possible. After that, a study will be done on the project as a whole. To know the amount of annual energy

consumption in this project and what is the share of each component of the project in this annual consumption and also several adjustments will be made to try to reduce this annual consumption as much as possible to save on energy consumption. After that, a study will be done for a building similar to the current building, as this similar building is being built based on the specifications and reference standards of a specific code to evaluate the building and find out whether there is a saving in energy consumption in this building or not. After that, the shadow phenomenon will be studied in summer and winter and how it affects the building, as the formation of shadows may be positive or negative, and we will take the procedures that enable us to benefit from this phenomenon properly. Then a study of wind movement inside and outside the building will be done to evaluate the ventilation in the project. Finally, an assessment of the thermal comfort of the users will be done and it will be known whether the building is thermally comfortable or not, and then the necessary measures will be taken to improve the building if thermal comfort is not achieved in both summer and winter.

2.6.2 Daylight factor analysis:

One of the things that must be taken into account when designing is to provide sufficient daylight that is commensurate with the nature of the space and the nature of the activity that will be done within this space to provide visual comfort for users and to make this space an energy-saving space. It is worth mentioning here that the study of natural lighting must be carried out in parallel with the study of the solar gain of the building so that a solution is reached that achieves satisfactory results from both, and it is not right to pay attention to one of them while neglecting the other.

Daylighting is the controlled admission of natural light into a space through windows to reduce or eliminate artificial lighting.

Daylighting design is not so much how to provide enough daylight to an occupied space, but how to do so without any undesirable side effects.

Daylight factor (DF) is defined as the ratio of the actual illuminance at a point in a room (lux) and the illuminance available from an identical unobstructed sky.

$$DF = (E \text{ internal}/E \text{ external}) * 100\%$$

In this project, the sky condition will be overcast with $E_{ext} = 9000$ lux and the Recommendations for daylight factors and illuminance are shown in Table 11

Table 13 recommendation values for illuminance.

Standard Maintained Illuminance (lux)	Characteristics of Activity/Interior	Representative Activities/Interiors
50	Interiors used rarely with visual tasks confined to movement and casual seeing without perception of detail	Cable tunnels, indoor storage tanks, walkways
100	Interiors used occasionally with visual tasks confined to movement and casual seeing calling for only limited perception of detail	Corridors, changing rooms, bulk stores, auditoria
150	Interiors used occasionally or with visual tasks not requiring perception of detail but involving some risk to people, plant, or product	Loading bays, medical stores, plant rooms
200	Interiors occupied for long periods or for visual tasks requiring some perception of detail	Foyers and entrances, monitoring automatic processes, casting concrete, turbine halls, dining rooms
300 ^a	Interiors occupied for long periods, or when visual tasks are moderately easy (i.e., large details >10-min arc) and/or high contrast	Libraries, sports and assembly halls, teaching spaces, lecture theaters, packing
500 ^a	Visual tasks moderately difficult (i.e., details to be seen are of moderate size [5–10 min arc] and may be of low contrast); also, color judgment may be required	General offices, engine assembly, painting and spraying, kitchens, laboratories, retail shops
750 ^a	Visual tasks difficult (i.e., details to be seen are small [3–5 min arc] and of low contrast); also, good color judgments or the creation of	Drawing offices, ceramic decoration, meat inspection, chain stores

Table 14 recommendation values for daylight factor.

Building Type	Location	DF _{avg} %	DF _{min} %
Concert Halls	Foyers, auditoria,	1	0.6
	Corridors,	2	0.6
	Stairs	2	0.6
General area	Entrance halls	2	0.6
Schools	Classrooms	5	2
	Assembly halls	1	0.3
Domestic	Lounges	1.5	0.5
	Bedrooms	1	0.3
	Kitchens	2	0.6

See Table 14 which shows us another classification for recommendation daylight factor according to the type of function that performs in space.

Table 15 recommendation daylight factor according to function.

Task	DF ^a
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%

2.6.3 Daylight factor analysis before modifications:

- Ground floor daylight factor analysis:

See Figure 89 daylight factor analysis for ground floor. Which show the results of daylight factor analysis for ground floor before modifications using design-builder.

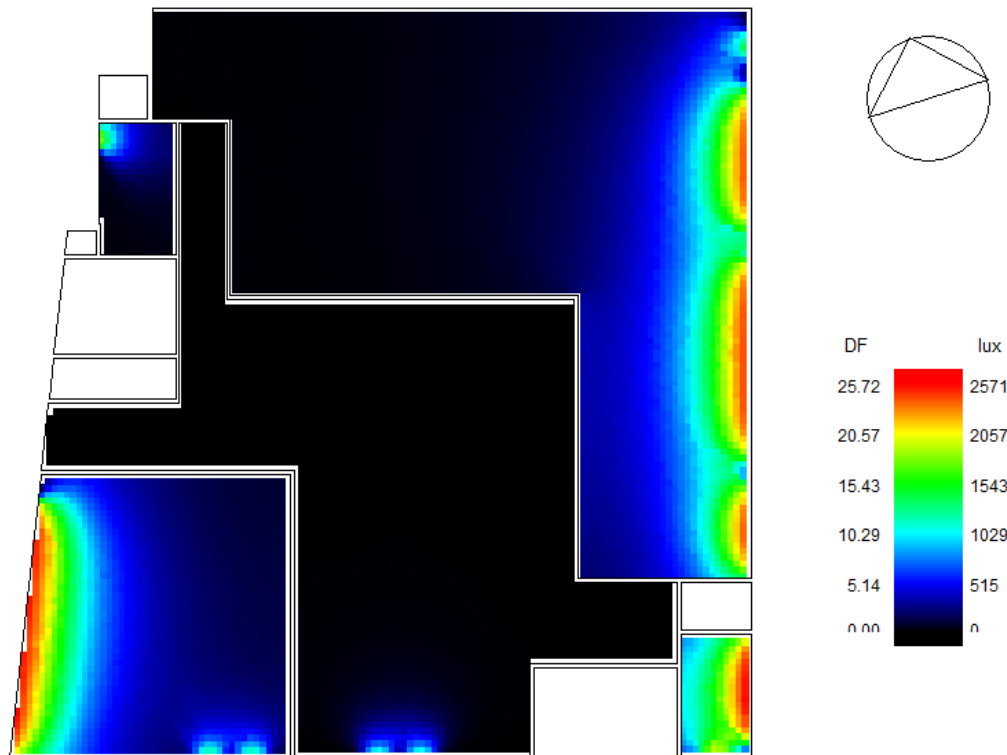


Figure 89 daylight factor analysis for ground floor.

From Figure 89 note that the values have divided the space into three levels, the first is less than the required limit, the second is within the required limit, the third is higher than the required limit,

and from here we realize the importance of environmental modifications in order to reduce the values that exceed the required limit.

- First floor daylight factor analysis:

See Figure 90 which show the results of daylight factor analysis for first floor before modifications using design-builder.

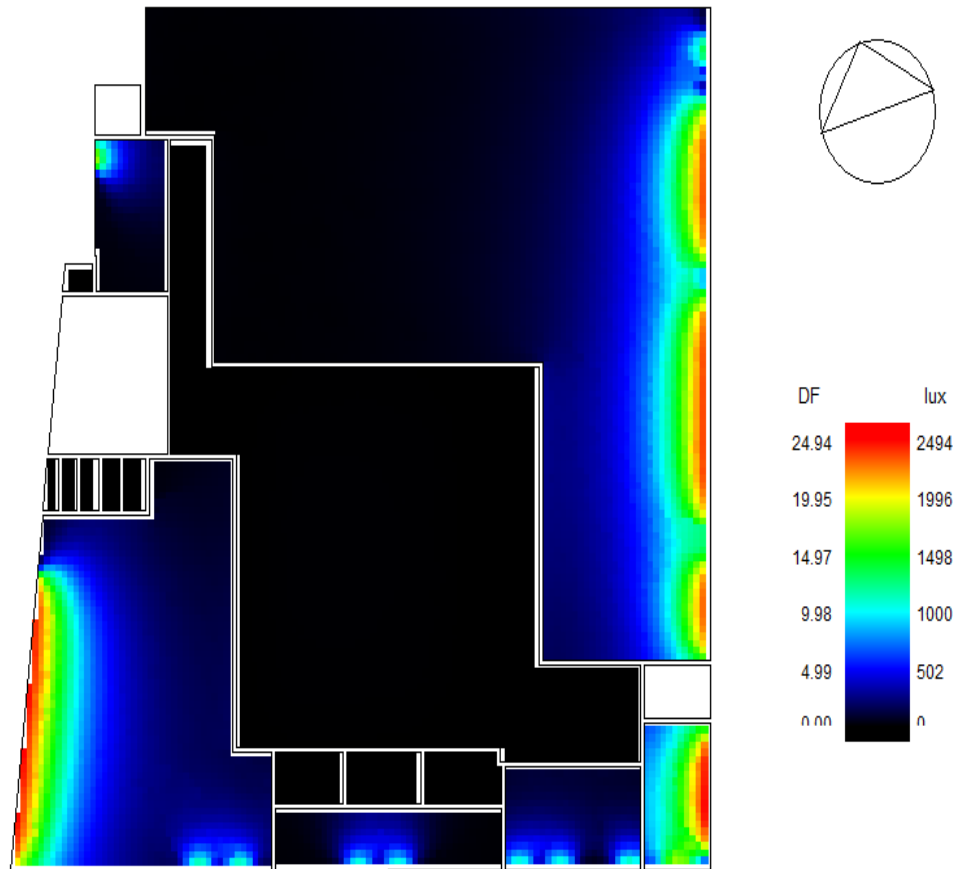


Figure 90 daylight factor analysis for first floor.

From Figure 90 note that the values have divided the space into three levels, the first is less than the required limit, the second is within the required limit, the third is higher than the required limit, and from here we realize the importance of environmental modifications in order to reduce the values that exceed the required limit.

- Second floor daylight factor analysis:

See Figure 91 which show the results of daylight factor analysis for second floor before modifications using design-builder.

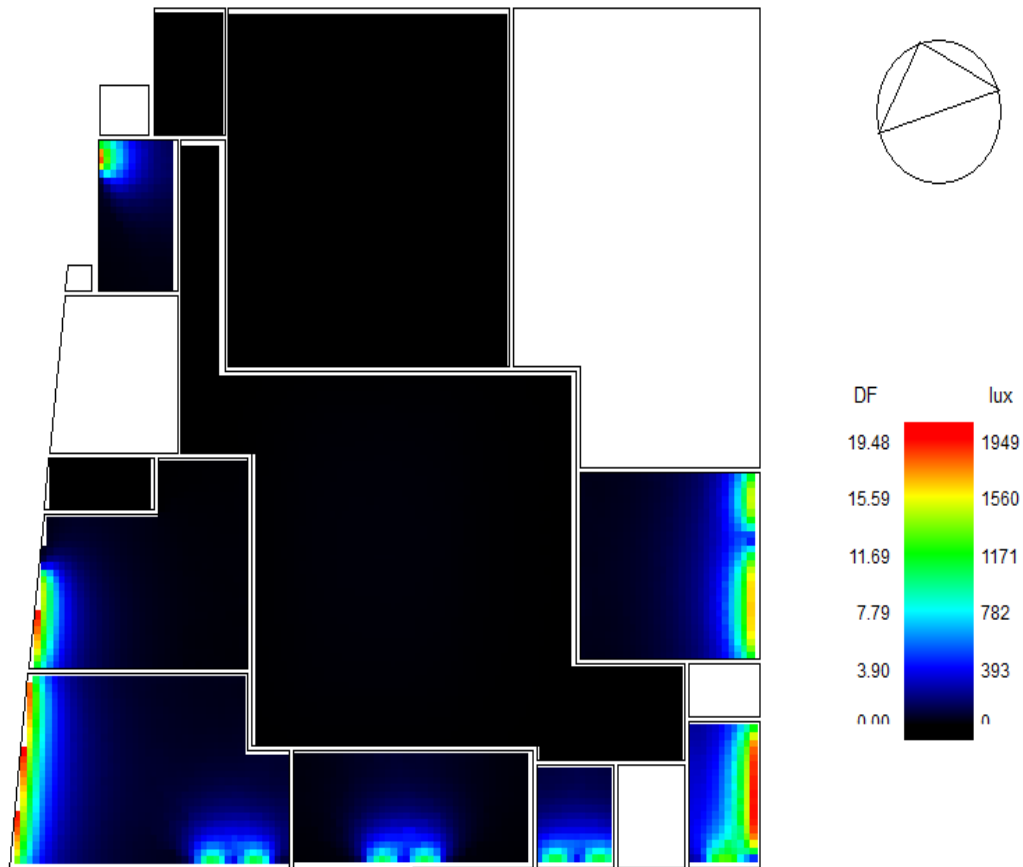


Figure 91 daylight factor analysis for second floor.

From Figure 91 note that the values have divided the space into three levels, the first is less than the required limit, the second is within the required limit, the third is higher than the required limit, and from here we realize the importance of environmental modifications in order to reduce the values that exceed the required limit.

- Third floor daylight factor analysis:

See Figure 92 which shows the results of daylight factor analysis for the third floor before modifications using design-builder.

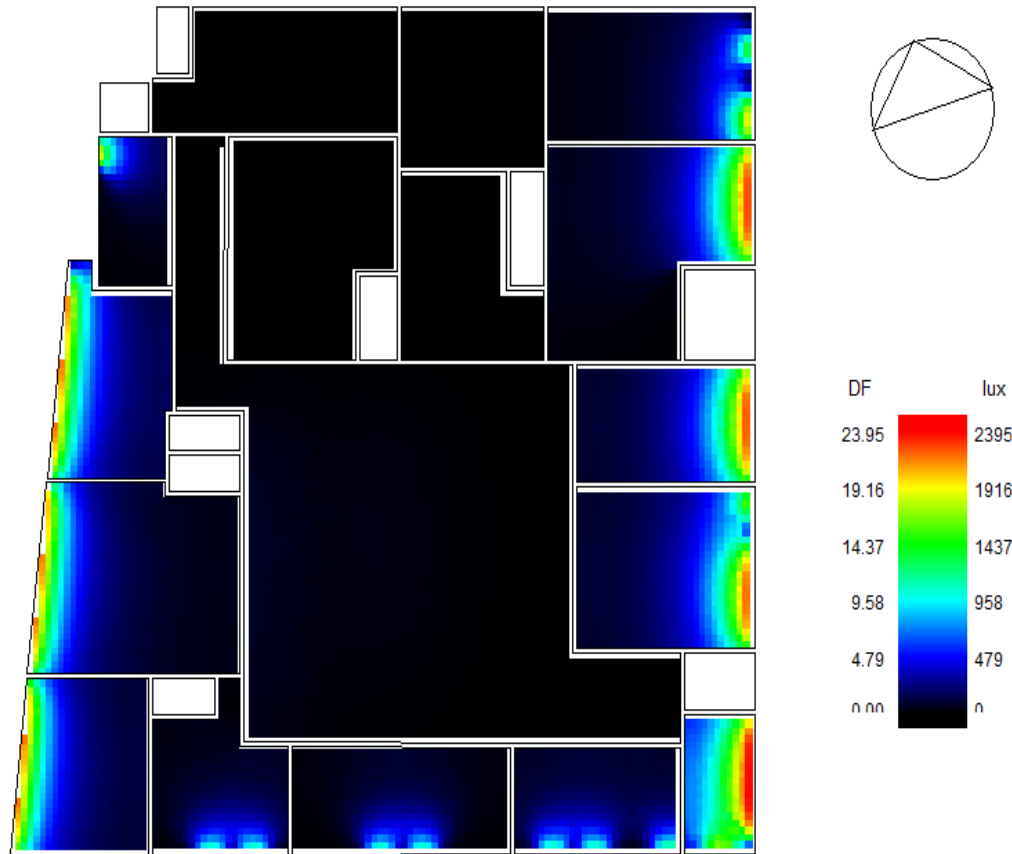


Figure 92 daylight factor analysis for third floor.

From Figure 92 note that the values have divided the space into three levels, the first is less than the required limit, the second is within the required limit, the third is higher than the required limit, and from here we realize the importance of environmental modifications in order to reduce the values that exceed the required limit.

- Fourth floor daylight factor analysis:
See Figure 93 which shows the results of daylight factor analysis for the fourth floor before modifications using design-builder.

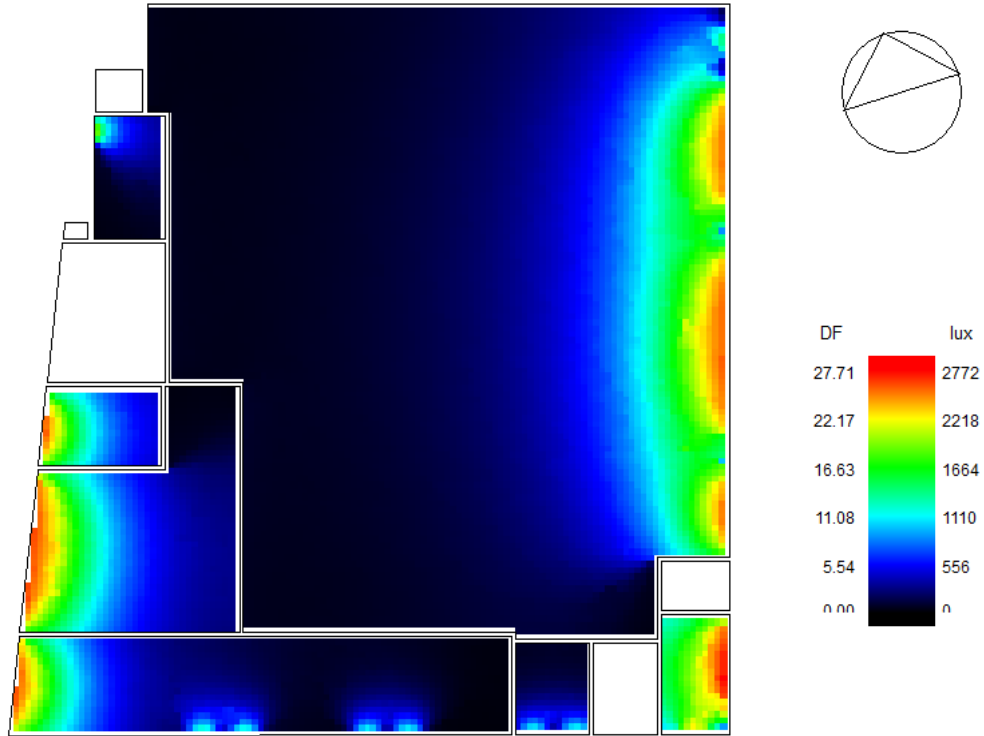


Figure 93 daylight factor analysis for fourth floor.

From Figure 93 note that the values have divided the space into three levels, the first is less than the required limit, the second is within the required limit, the third is higher than the required limit, and from here we realize the importance of environmental modifications in order to reduce the values that exceed the required limit.

2.6.4 Daylight factor analysis after modifications:

- Ground floor daylight factor analysis:

See Figure 94 which show the results of daylight factor analysis for ground floor after modifications using design-builder.

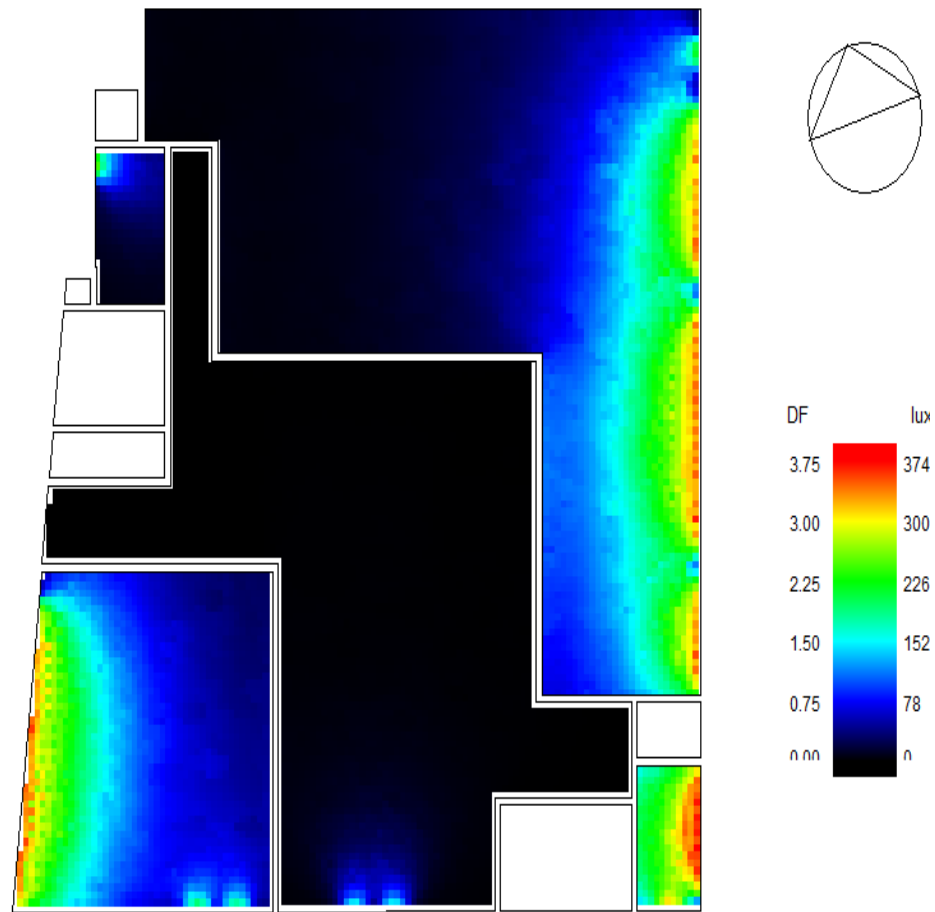


Figure 94 daylight factor analysis for ground floor.

After making the necessary and effective adjustments, it was noticed that the values had improved, as different areas were included, so that the values became standard, and this happened in particular in the areas near the windows, and thus the glare problem was solved.

- First floor daylight factor analysis:

Figure 95 show the results of daylight factor analysis for first floor after modifications using design-builder.

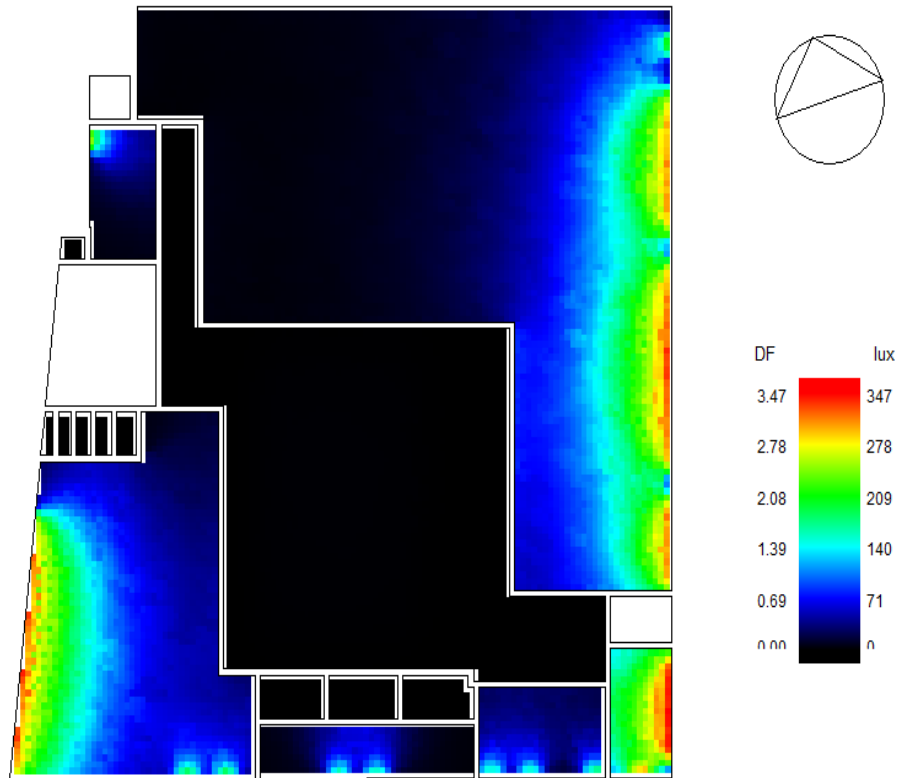


Figure 95 daylight factor analysis for first floor.

After making the necessary and effective adjustments, it was noticed that the values had improved, as different areas were included, so that the values became standard, and this happened in particular in the areas near the windows, and thus the glare problem was solved.

- Second floor daylight factor analysis:

See Figure 96 which shows the results of daylight factor analysis for the second floor after modifications using design-builder.

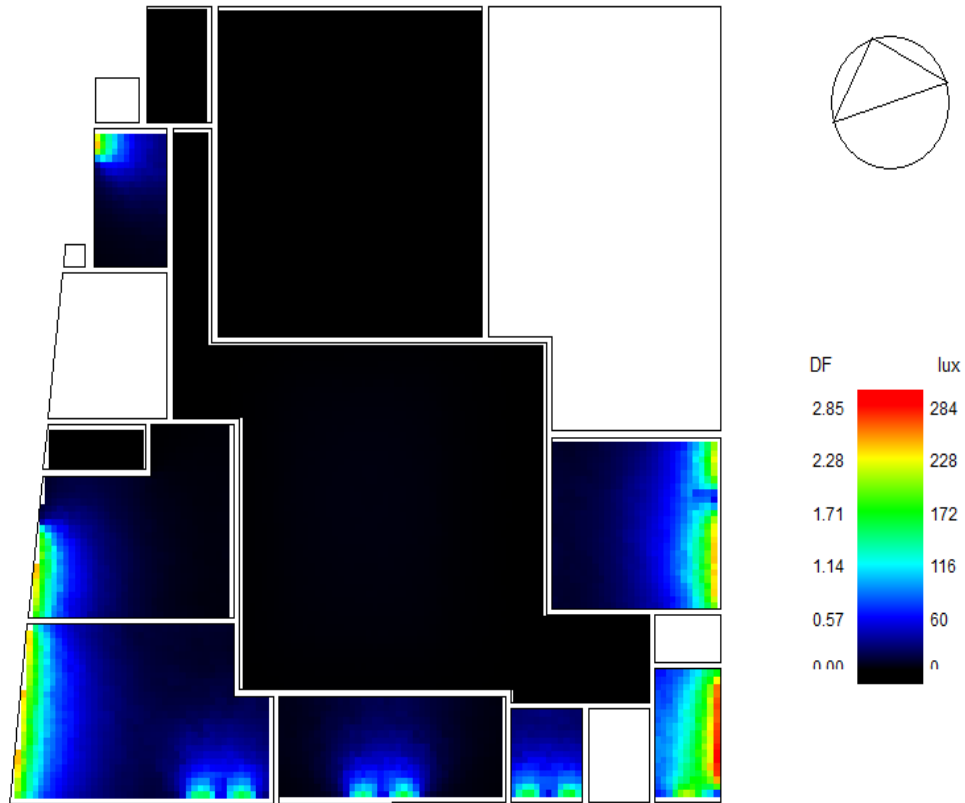


Figure 96 daylight factor analysis for second floor

After making the necessary and effective adjustments, it was noticed that the values had improved, as different areas were included, so that the values became standard, and this happened in particular in the areas near the windows, and thus the glare problem was solved.

- Third floor daylight factor analysis:

Figure 97 shown the results of daylight factor analysis for the third floor after modifications using a design-builder.

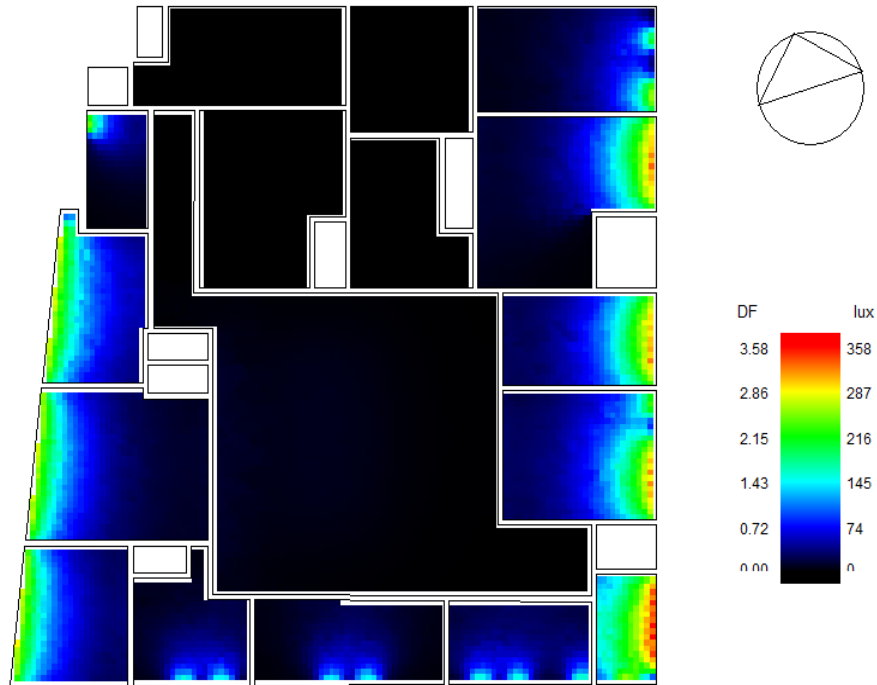


Figure 97 daylight factor analysis for third floor.

After making the necessary and effective adjustments, it was noticed that the values had improved, as different areas were included, so that the values became standard, and this happened in particular in the areas near the windows, and thus the glare problem was solved.

- Fourth floor daylight factor analysis:

Figure 98 shown the results of daylight factor analysis for the fourth floor after modifications using a design-builder.

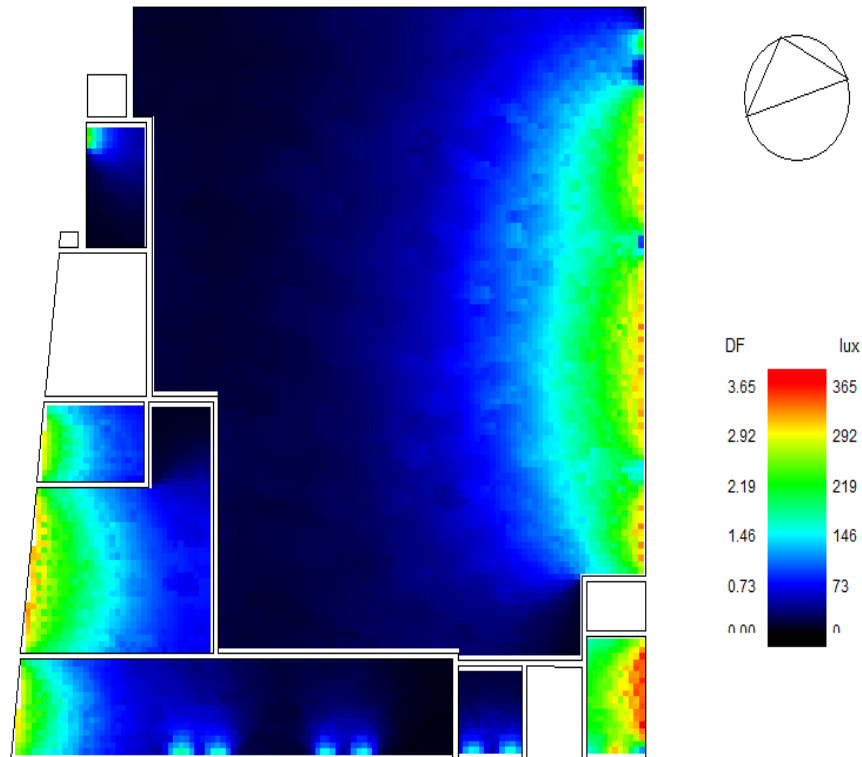


Figure 98 daylight factor analysis for fourth floor.

After making the necessary and effective adjustments, it was noticed that the values had improved, as different areas were included, so that the values became standard, and this happened in particular in the areas near the windows, and thus the glare problem was solved.

2.6.5 Heating and cooling loads:

Thermal comfort is one of the basic things that must be taken into account in the design because of its effects on the users, therefore for the space to be suitable for the purpose for which it was designed, all human comforts must be available as thermal comfort is one of these means. The heating and air conditioning system is a system that supplies the building with the heat loads necessary in both summer and winter to maintain a suitable working space temperature and it is also a system that supplies the building with fresh air and draws polluted air. For the heating and air conditioning system to function properly, we must make accurate calculations to know the capacity needed for this system to work efficiently in all conditions. Some factors affect the

capacity of the system such as the type of building, type of material used, glass type, conditions weather, and so on.

2.6.5.1 Heating and cooling loads before modifications:

Here I will present a general picture of the status of the heating and cooling loads in the building before any modifications, through which we can know the matters that need to be modified and propose effective solutions to improve these values.

Figure 99 which shows us how each element of the building contributes to the effect on heating loads before making modifications.

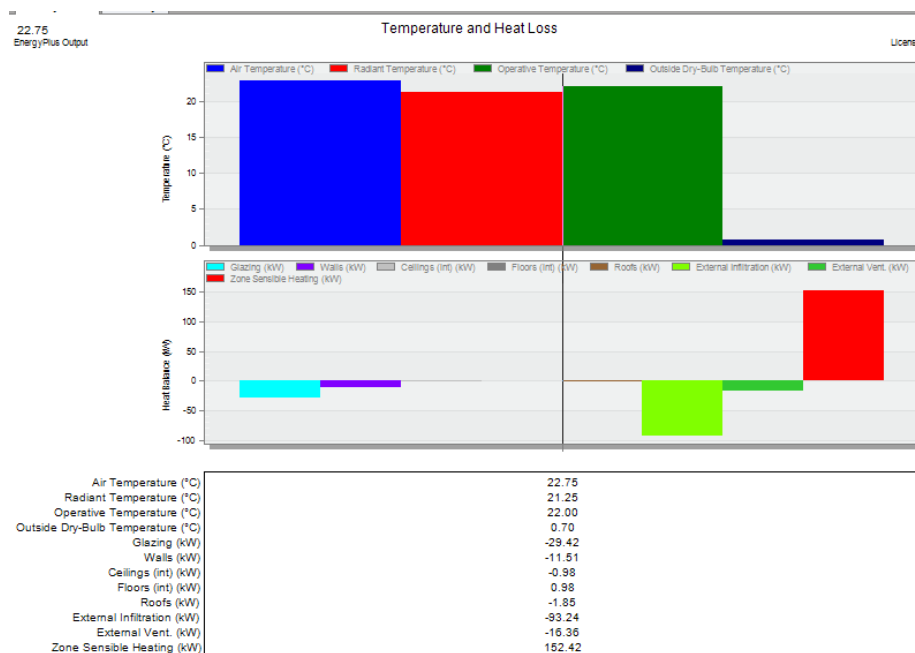


Figure 99 heating design before modification.

From Figure 99 we have noticed that there are high contribution values for the basic elements in the building that affect the heating loads, where the percentage of the contribution of the roof and walls has the largest share, and then comes the percentage of the contribution of glass, and from here we realize the importance of thermal insulation of the building and the use of a suitable type of glass as a kind of necessary adjustments to reduce The contribution of these elements thus reduces the necessary heating loads.

Figure 111 shows us how each element of the building contributes to the effect on cooling loads before making modifications.

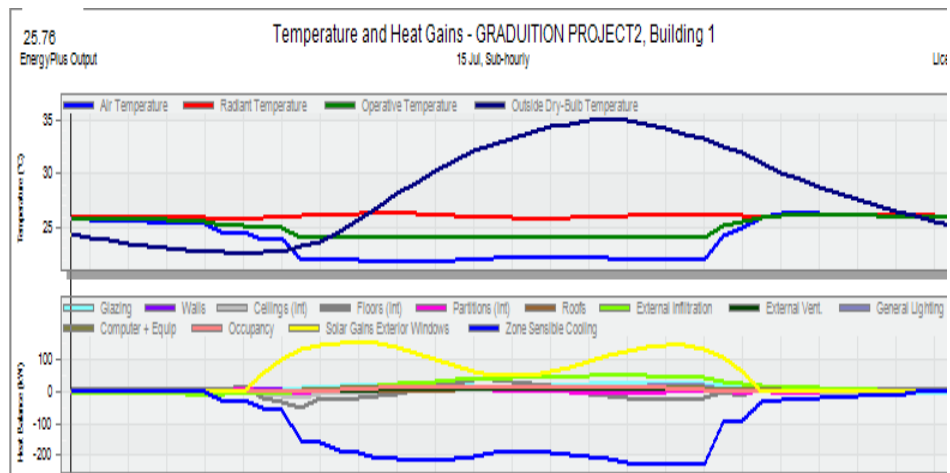


Figure 100 cooling design before modification.

From Figure 100 we have noticed that there are high amounts of solar gain that pass through the external windows, and this greatly affects the values of cooling loads. Therefore, an adjustment must be made to reduce the amount of solar gain in the summer as much as possible to reduce the necessary cooling loads.

2.6.5.2 Definitions of materials that were used:

Definitions of materials and their thermal properties that were used as a kind of modification to improve the heating and cooling values.

To improve the overall situation in the building in terms of heating and cooling values, I have defined the materials used in building each element of the project and what are the layers that each of these elements consists of, determining specific thicknesses for each layer so that satisfactory thermal properties have been achieved for each element. It is worth noting that thermal insulation of the building was done here using insulating materials that have certain properties.

Here I will provide a detailed explanation of some of the construction elements in the project, what are the layers that were formed from, and what is the thickness of each layer, which had a fundamental impact on the values of the heating and cooling loads.

- External walls:

Figure 101 which shows us the cross section for external walls.



Figure 101 Cross section for external walls.

Figure 102 which shows us the thermal properties of external walls.

Inner surface	
Convective heat transfer coefficient (W/m ² -K)	2.152
Radiative heat transfer coefficient (W/m ² -K)	5.540
Surface resistance (m ² -K/W)	0.130
Outer surface	
Convective heat transfer coefficient (W/m ² -K)	19.870
Radiative heat transfer coefficient (W/m ² -K)	5.130
Surface resistance (m ² -K/W)	0.040
No Bridging	
U-Value surface to surface (W/m ² -K)	0.319
R-Value (m ² -K/W)	3.305
U-Value (W/m²-K)	0.303
With Bridging (BS EN ISO 6946)	
Thickness (m)	0.3630
Km - Internal heat capacity (KJ/m ² -K)	95.2224
Upper resistance limit (m ² -K/W)	3.305
Lower resistance limit (m ² -K/W)	3.305
U-Value surface to surface (W/m ² -K)	0.319
R-Value (m ² -K/W)	3.305
U-Value (W/m²-K)	0.303

Figure 102 thermal properties for external walls.

The u-value for the external wall is $0.303 < 0.5$ which means that the thermal insulation in the external walls was effective.

- Flat roof:

Figure 103 shown us the cross section for the roof.

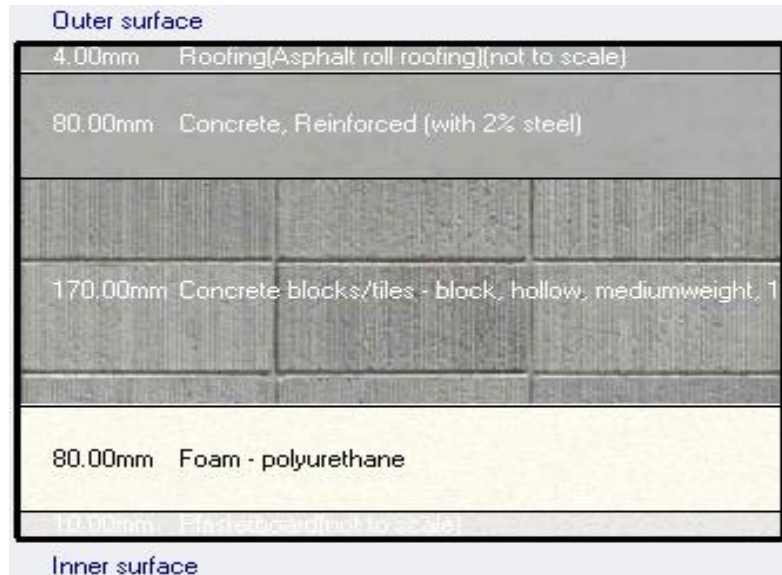


Figure 103 cross section for flat roof.

Figure 104 shows us the thermal properties of the roof.

Inner surface	
Convective heat transfer coefficient (W/m ² -K)	4.460
Radiative heat transfer coefficient (W/m ² -K)	5.540
Surface resistance (m ² -K/W)	0.100
Outer surface	
Convective heat transfer coefficient (W/m ² -K)	19.870
Radiative heat transfer coefficient (W/m ² -K)	5.130
Surface resistance (m ² -K/W)	0.040
No Bridging	
U-Value surface to surface (W/m ² -K)	0.310
R-Value (m ² -K/W)	3.370
U-Value (W/m²-K)	0.297
With Bridging (BS EN ISO 6946)	
Thickness (m)	0.3440
Km - Internal heat capacity (KJ/m ² -K)	37.3520
Upper resistance limit (m ² -K/W)	Km - Internal heat capacity (KJ/m ² -K)
Lower resistance limit (m ² -K/W)	3.220
U-Value surface to surface (W/m ² -K)	0.321
R-Value (m ² -K/W)	3.252
U-Value (W/m²-K)	0.307

Figure 104 thermal properties for the roof.

The u-value for the roof is $0.307 < 0.39$ which means that the thermal insulation in the roof was effective.

- Internal walls (partitions):

Figure 105 shown the cross section for partitions.

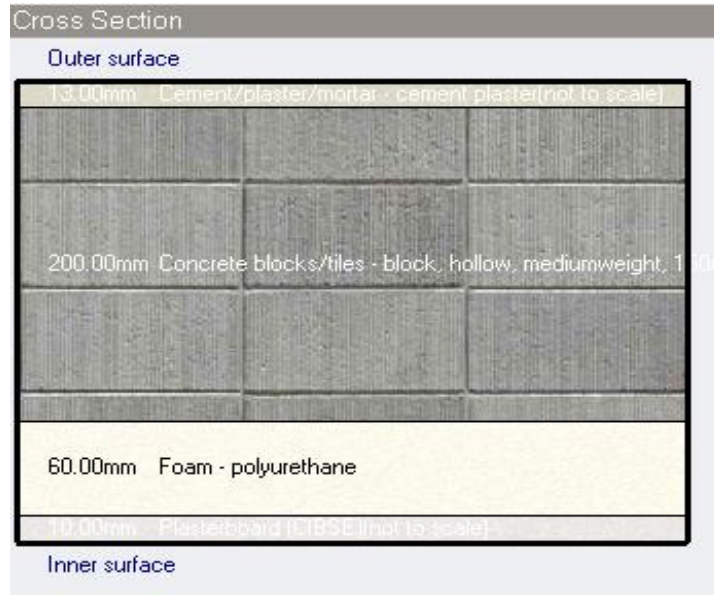


Figure 105 Cross section for partitions.

- Internal floors:

Figure 106 which shows us the cross-section of the internal floors.

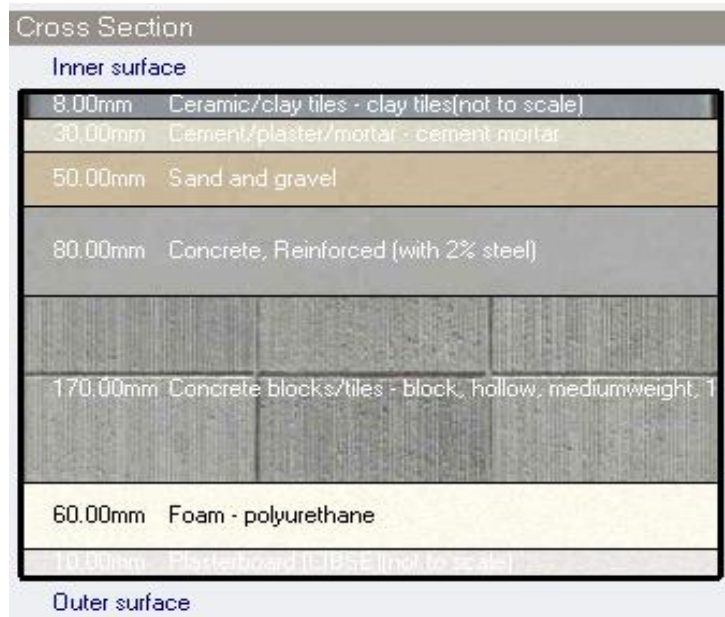


Figure 106 Cross section for the internal floor.

- Glazing:

Table 16 properties for glazing Shown a very important values for glazing that we used in the project.

Table 16 properties for glazing

Calculated Values	
Total solar transmission (SHGC)	0.282
Direct solar transmission	0.208
Light transmission	0.408
U-value (ISO 10292/ EN 673) (W/m2-K)	1.148
U-Value (W/m2-K)	1.338

U-value for glazing = 1.338 and this value is considered an acceptable value.

2.6.5.3 Heating and cooling loads after modifications:

- Heating load:

Figure 107 shows us how each building element contributes an impact to the heating load after modifications have been made.

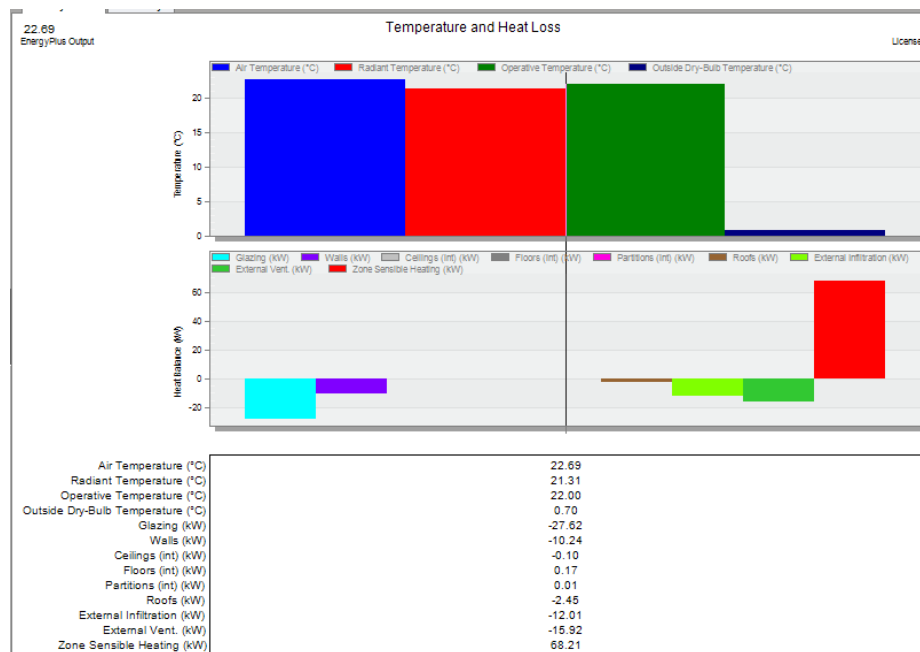


Figure 107 heating design after modifications.

From Figure 107 notice the clear difference in the amount of the contribution of each element of the building in affecting the heating loads if there is a significant decrease in the values in which these elements participate, due to the modifications that have been implemented to convert the building into a thermally insulated building, and therefore this thing will reduce the loads, The necessary heating in the building and provides a comfortable thermal environment.

It is also worth mentioning here that the thermal insulation process of the building reduced the amount of difference between each the air temperature and the radiant temperature, and this improves the performance of the heating and cooling system, which helps in providing a good operative temperature and thus creating a thermally comfortable environment. It also reduces the energy consumption used in running the system.

Table 1 shown some important values in heating design for the building.

Table 17 heating load for each space

Zone	Comfort Temperature (°C)	Steady-State Heat Loss (kW)	Design Capacity (kW)	Design Capacity (W/m2)
- Building 1 Total Design Heating Capacity = 85.300 (kW)				
- g.f Total Design Heating Capacity = 18.640 (kW)				
ENTRANCE	22.00	1.15	1.43	73.8015
ELECTRONIC...	22.00	3.74	4.67	26.6735
ENTRANCE	22.00	0.40	0.50	22.1960
RETAIL STORE	22.00	7.15	8.94	18.5128
LOBBY	22.00	2.48	3.10	7.8279
- f.f Total Design Heating Capacity = 18.870 (kW)				
STORE	22.00	0.10	0.13	90.9579
DRESSING R...	22.00	0.06	0.08	67.1154
ENTRANCE	22.00	1.07	1.34	66.5585
STORE	22.00	0.24	0.31	43.0115
STORE	22.00	0.25	0.31	39.3081
STORE	22.00	0.24	0.31	39.1508
STORE	22.00	0.74	0.92	31.6471
STORE	22.00	0.68	0.85	29.3602
FASHION ST...	22.00	3.37	4.22	23.9651
ENTRANCE	22.00	0.41	0.51	22.3177
RETAIL STORE	22.00	6.41	8.01	15.9084
LOBBY	22.00	1.47	1.84	8.1087
DRESSING R...	22.00	0.01	0.01	5.0408
DRESSING R...	22.00	0.01	0.01	4.3805
DRESSING R...	22.00	0.00	0.01	3.7004
DRESSING R...	22.00	0.00	0.01	3.3149

Zone	Comfort Temperature (°C)	Steady-State Heat Loss (kW)	Design Capacity (kW)	Design Capacity (w/m2)
- s.f Total Design Heating Capacity = 12.390 (kW)				
ENTRANCE	22.00	0.77	0.96	47.4636
ENTRANCE	22.00	0.73	0.91	39.3261
KITCHEN	22.00	0.43	0.54	35.1110
BAG&SHOES ...	22.00	1.80	2.26	22.8726
DRESSING R...	22.00	0.29	0.36	21.1905
SHOES STORE	22.00	1.12	1.40	21.1337
DRESSING R...	22.00	0.17	0.21	20.0668
CAFATERIA	22.00	0.89	1.11	19.9556
FASHION ST...	22.00	0.94	1.18	15.8123
FASHION ST...	22.00	1.53	1.92	9.5090
LOBBY	22.00	1.23	1.54	6.8689
- 3rd.f Total Design Heating Capacity = 17.410 (kW)				
ENTRANCE 1	22.00	0.89	1.11	57.2225
OFFICE1	22.00	1.14	1.42	32.0542
OFFICE3	22.00	1.14	1.42	30.9779
OFFICE8	22.00	0.88	1.10	25.8637
OFFICE7	22.00	1.13	1.41	24.1007
OFFICE10	22.00	1.06	1.32	23.8153
OFFICE6	22.00	0.65	0.81	22.9478
OFFICE2	22.00	1.30	1.62	21.1393
OFFICE4	22.00	0.56	0.70	19.4840
ENTRANCE	22.00	0.32	0.40	18.7265
OFFICE5	22.00	0.68	0.85	17.7545
OFFICE9	22.00	1.05	1.32	17.3246
OFFICE14	22.00	0.63	0.79	13.9792
OFFICE11	22.00	0.45	0.56	12.2863
OFFICE13	22.00	0.53	0.66	9.5203
OFFICE12	22.00	0.28	0.35	7.8921
LOBBY	22.00	1.25	1.57	6.8225
- 4th.f Total Design Heating Capacity = 17.990 (kW)				
ENTRANCE	22.00	2.12	2.65	136.2918
KITCHEN	22.00	1.49	1.86	83.0014
ENTRANCE	22.00	0.93	1.16	56.5716
CAFTAIREA	22.00	5.16	6.46	53.6364
KITCHEN	22.00	0.67	0.84	51.6083
RSTURANT	22.00	4.02	5.02	51.3393

The temperature in all spaces has been set at 22 Celsius, provided that it is the operative temperature, and this helps in achieving a thermally comfortable environment.

- It's easy to see the impact of the modifications that were made since all the values are logical and acceptable.
- Design capacity (w/m²) in all spaces < 80 which means the building is considered energy efficient.
- Cooling load:

Figure 108 shown how each building element contributes an impact to the cooling load after modifications have been made.

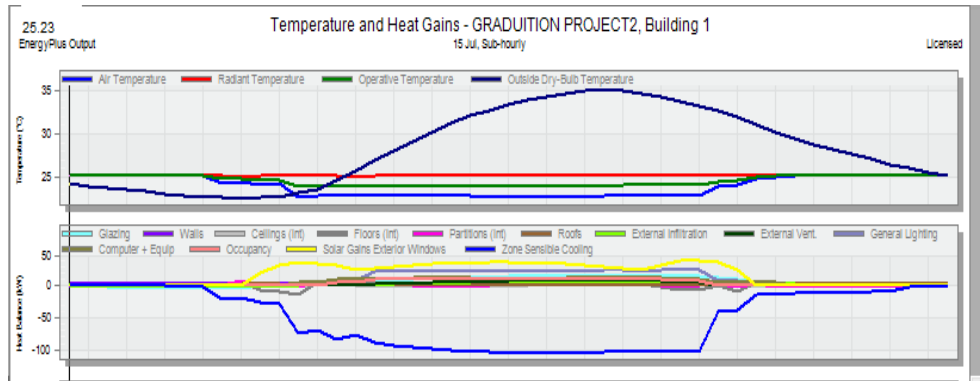


Figure 108 cooling design after modifications.

From Figure 108 notice the improvement in the values, especially the value of solar gain through the windows. In general, these values have become acceptable, and this is all as a result of the modifications that have been implemented, which in turn also caused a reduction in the necessary cooling loads and made the different temperatures as close to each other as possible, which contributes to saving the Thermally comfortable environment and reduces energy consumption.

Table 18 which shows us some important values in cooling design for the building.

Table 18 cooling load for each space

Design Cooling Load Per Floor Area(W/m2)	Total Cooling Load (kW)	Design Flow Rate (m3/s)	Design Capacity (kW)	Zone	Block	Building
13.2	4.54	0.3478	5.23	GXf:LOBBY	g.f	Building 1
31.4	13.2	1.2812	15.18	GXf:RETAILSTORE	g.f	Building 1
51.7	7.86	0.8169	9.04	ELECTRONICSTO	g.f	Building 1
116.5	1.97	0.2292	2.26	GXf:ENTRANCE	g.f	Building 1
36.9	0.73	0.0642	0.84	GXf:ENTRANCEQ1	g.f	Building 1
14.4	2.85	0.2125	3.28	FXf:LOBBY	f.f	Building 1
33	14.44	1.4155	16.61	FXf:RETAILSTORE	f.f	Building 1
101	1.77	0.2032	2.04	FXf:ENTRANCE	f.f	Building 1
29.5	0.74	0.0618	0.86	FXf:STORE	f.f	Building 1
27.9	0.71	0.0574	0.81	FXf:STOREQ1	f.f	Building 1
32	0.22	0.0193	0.25	FXf:STOREQ2	f.f	Building 1
43.4	6.64	0.6711	7.63	FXf:FASHIONSTORE	f.f	Building 1
34.7	0.69	0.06	0.79	FXf:ENTRANCEQ1	f.f	Building 1
97.3	0.12	0.0107	0.13	FXf:STOREQ3	f.f	Building 1
30.7	0.06	0.004896	0.07	f:DRESSINGROOM	f.f	Building 1
142.3	0.15	0.0138	0.17	f:DRESSINGROOM	f.f	Building 1
34.1	0.04	0.00336	0.05	f:DRESSINGROOM	f.f	Building 1
29.8	0.04	0.003382	0.05	f:DRESSINGROOM	f.f	Building 1
29.8	0.04	0.00342	0.05	FXf:DRESSINGROO	f.f	Building 1
35.7	0.22	0.0196	0.25	FXf:STOREQ4	f.f	Building 1
31.6	0.21	0.019	0.25	FXf:STOREQ5	f.f	Building 1

G	F	E	D	C	B	A
31.6	0.21	0.019	0.25	FXf.STOREQ5	f.f	Building 1
13.2	2.56	0.1919	2.94	SXf.LOBBY	s.f	Building 1
29.1	5.1	0.4324	5.86	SXf.FASHIONSTORE	s.f	Building 1
37.3	0.56	0.0469	0.64	Xf.DRESSINGROOM	s.f	Building 1
43.5	2.51	0.2303	2.88	SXf.SHOESSTORE	s.f	Building 1
65.4	1.15	0.1141	1.32	SXf.ENTRANCE	s.f	Building 1
32.2	1.56	0.1314	1.79	SXf.CAFATERIA	s.f	Building 1
58.1	0.78	0.0661	0.9	SXf.KITCHEN	s.f	Building 1
39.8	3.41	0.3181	3.92	f.BAGXSHOESSTO	s.f	Building 1
36.8	2.38	0.2116	2.74	f.FASHIONSTOREC	s.f	Building 1
44	0.4	0.0317	0.46	f.DRESSINGROOM	s.f	Building 1
45.1	0.91	0.0718	1.04	SXf.ENTRANCEQ1	s.f	Building 1
23.8	4.76	0.3956	5.47	3rdXf.LOBBY	3rd.f	Building 1
28.2	1.7	0.1379	1.96	3rdXf.OFFICE13	3rd.f	Building 1
25.8	1.01	0.0823	1.16	3rdXf.OFFICE12	3rd.f	Building 1
33.9	2.24	0.2015	2.58	3rdXf.OFFICE9	3rd.f	Building 1
44	1.63	0.1574	1.88	3rdXf.OFFICE8	3rd.f	Building 1
41.4	2.1	0.1991	2.42	3rdXf.OFFICE7	3rd.f	Building 1
81.9	1.38	0.1546	1.59	3rdXf.ENTRANCE1	3rd.f	Building 1
31.5	0.97	0.0852	1.11	3rdXf.OFFICE6	3rd.f	Building 1
27.3	1.13	0.0954	1.3	3rdXf.OFFICE5	3rd.f	Building 1
30.6	0.96	0.0795	1.1	3rdXf.OFFICE4	3rd.f	Building 1
37.7	2.52	0.2354	2.89	3rdXf.OFFICE2	3rd.f	Building 1
55.1	2.13	0.2164	2.44	3rdXf.OFFICE1	3rd.f	Building 1
25.6	0.48	0.0409	0.55	3rdXf.ENTRANCE	3rd.f	Building 1
48.1	1.92	0.1919	2.21	3rdXf.OFFICE3	3rd.f	Building 1
28.8	1.42	0.1163	1.63	3rdXf.OFFICE14	3rd.f	Building 1
27	1.07	0.0884	1.23	3rdXf.OFFICE11	3rd.f	Building 1
37.4	1.81	0.1644	2.08	3rdXf.OFFICE10	3rd.f	Building 1
67.3	1.2	0.1144	1.38	thX4XXf.ENTRANCE	fth(4).f	Building 1
80.2	6.82	0.7474	7.84	thX4XXf.RSTURAN	fth(4).f	Building 1
55.6	5.82	0.5803	6.69	thX4XXf.CAFTAIRE	fth(4).f	Building 1
173.4	2.93	0.3313	3.37	ix4XXf.ENTRANCE	fth(4).f	Building 1
63.8	0.9	0.0773	1.03	FthX4XXf.KITCHEN	fth(4).f	Building 1
151	2.94	0.3147	3.38	thX4XXf.KITCHENQ	fth(4).f	Building 1

The temperature in all spaces has been set at 24 Celsius, provided that it is the operative temperature, and this helps in achieving a thermally comfortable environment.

- It's easy to see the impact of the modifications that were made since all the values are logical and acceptable.
- Design capacity (w/m²) in all spaces < 80 which means the building is considered energy efficient.

2.6.6 Annual building utility performance summary:

- The site and source of energy:

Table 19 shown the annual energy consumed at the site, and the amount of energy consumed per square meter.

Table 19 site and source energy.

Site and Source Energy

	Total Energy [kWh]	Energy Per Total Building Area [kWh/m2]	Energy Per Conditioned Building Area [kWh/m2]
Total Site Energy	350698.88	82.64	82.64
Net Site Energy	350698.88	82.64	82.64
Total Source Energy	795692.98	187.49	187.49
Net Source Energy	795692.98	187.49	187.49

Based on the values given in Table 19 the general condition can be assessed in general as acceptable, but a comparison must be made with another similar building to accurately assess and reach the best possible condition.

- Thermal comfort:

It is very important to evaluate the situation of the building in terms of its ability to achieve comfort for the users, and there is no value for the building if people do not feel comfortable while they are inside it. Therefore, this examination is considered one of the very important examinations, and it must be dealt with smoothly and try to make it the best possible to achieve a thermally comfortable environment for all building users.

PMW index: It is an indicator that expresses the thermal comfort that people feel while they are in the building.

Figure 109 shows us the index values throughout the year.

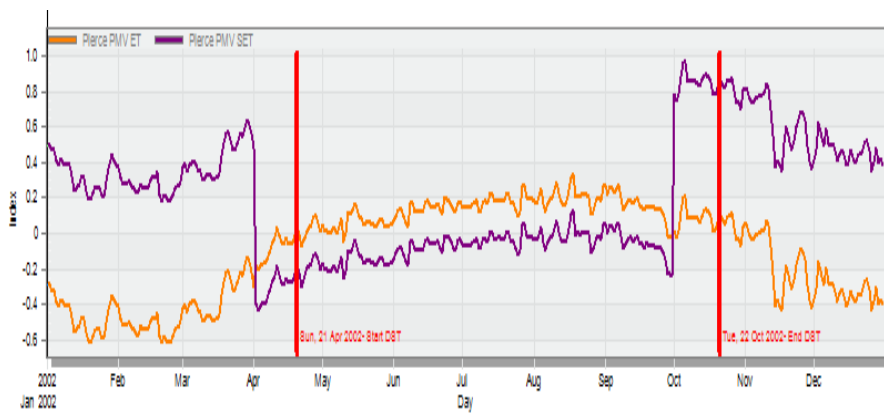


Figure 109 PMV index for users in building

From Figure 109 We have noticed that the values were acceptable throughout the year, and this means that people feel thermal comfort well while they are inside the building, except for short periods, which are when there are high climatic fluctuations, which occur when switching from one season to another.

Chapter 3: Structural Aspects

3.1 Overview

The structural design for any building is the most important part, and it must be integrate with the other design like architectural, mechanical and electrical design.

It includes many things like selection of the structural element in the building like columns size, beams and type of slab to carry the loads on the building.

The building will be design using ETABS program and the building consist five floors.

3.2 Design Codes

Two codes will be used in the structural design:

1. ACI 318-14
2. ASCE 7 for load design

3.3 Loads Definition

1. Dead loads

These loads include the weight of slabs, columns, beams and the other structural element of the building.

2. Live load

These loads will be change over time, so they are considered as temporary loads, for example people and movable elements. In this building live load will be $4\text{kN}/\text{m}^2$.

3. Super imposed dead loads

These loads are dead load and it contain tiles, portions and mortar weights.

In this building the super imposed dead loads will be $4\text{ kN}\cdot\text{m}^2$.

4. Wall

In this building, there is two types of walls: Brick wall and will be taken as $18\text{ kn}/\text{m}^2$ and glass wall and it will be taken 4 kN .

3.4 load combination

The combination that will be used in the ETABS program for analysis and design in this part of the project:

- 1.4 Dead
- 1.2Dead+ 1.6 Live

3.5 Materials

- For concrete used in footings, columns and shear walls: Compressive strength $f'c = 28$ MPa Modulus of elasticity $E = 26587$ MPa.
- For concrete used in beams and slabs: Compressive strength $f'c = 28$ MPa Modulus of elasticity $E = 24870$ MPa.
- For steel used in rebar: Yield strength $Fy = 420$ MPa Modulus of elasticity $E = 200$ GPa.

3.6 Preliminary design

- Slabs

Flat slab will be used in the building.

For Flat slab, in Figure 110 below shows the large span in the slab.

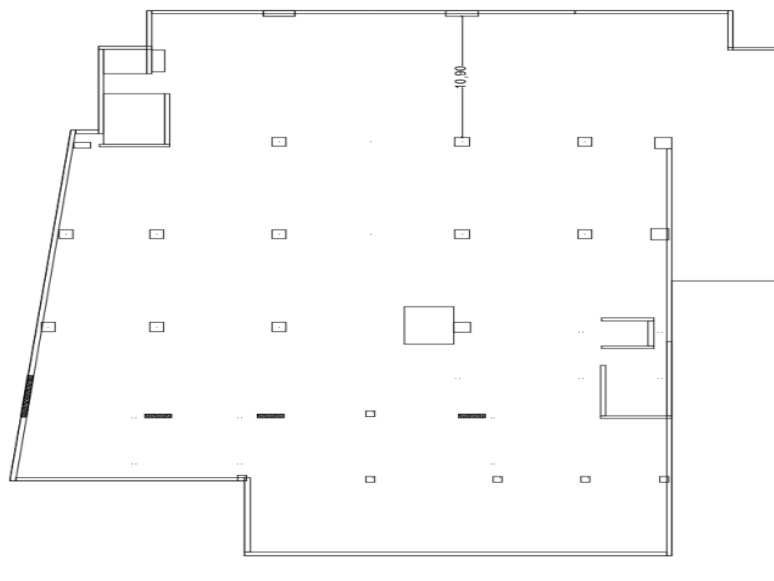


Figure 110 the largest span for Flat slab

By using rule of thumb for the thickness:

$$H = \frac{L_n}{30} = \frac{10.90}{30} = 0.36\text{m}$$

, Due to large SID and live load , thickness of 40 cm will be used and as

can be shown in Figure111 below:

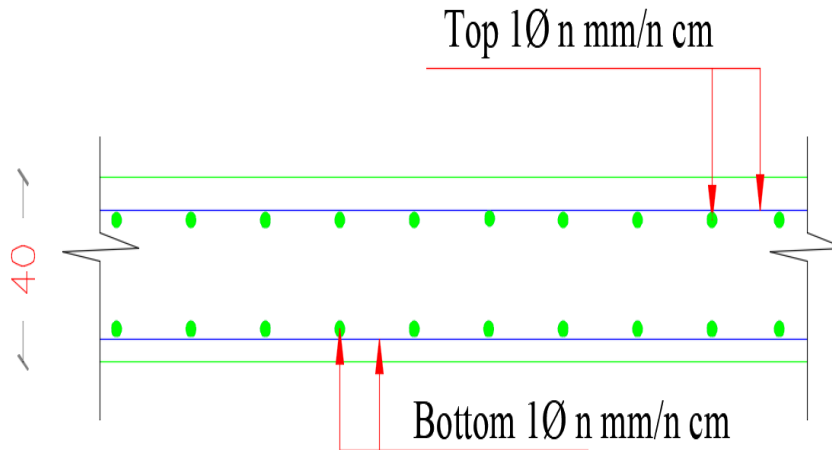


Figure111: Typical section for Flat slab of 40 cm thickness

- Columns

Columns sections will be determine using tributary area method then will be checked using ETABS program. In Figure 112 show the section of the columns that will be used.

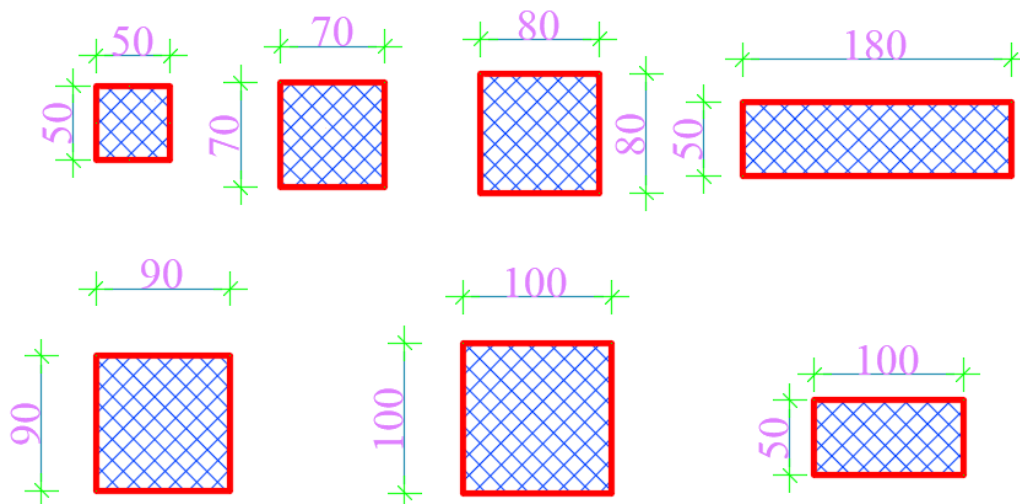


Figure 112: Columns sections that will be used in the building

In Figure 113, shows the distribution of columns and shear walls.

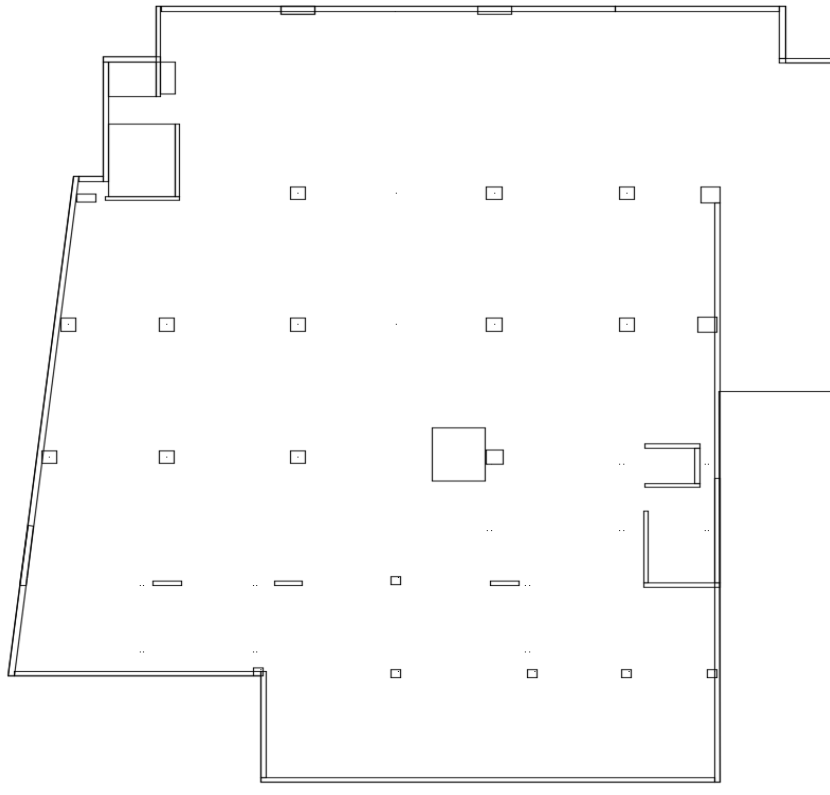


Figure 113: The distribution of columns and shear walls

- Beams

Drop beams at edge will be used in this building with thickness of = 60 cm and width of 30 cm.

- Shear walls

In this building shear walls thickness = 30 cm will be used.

3.7 ETABS Modle

The building is contain basement and five floors. In Figure 114 shows ETABS model of the building.

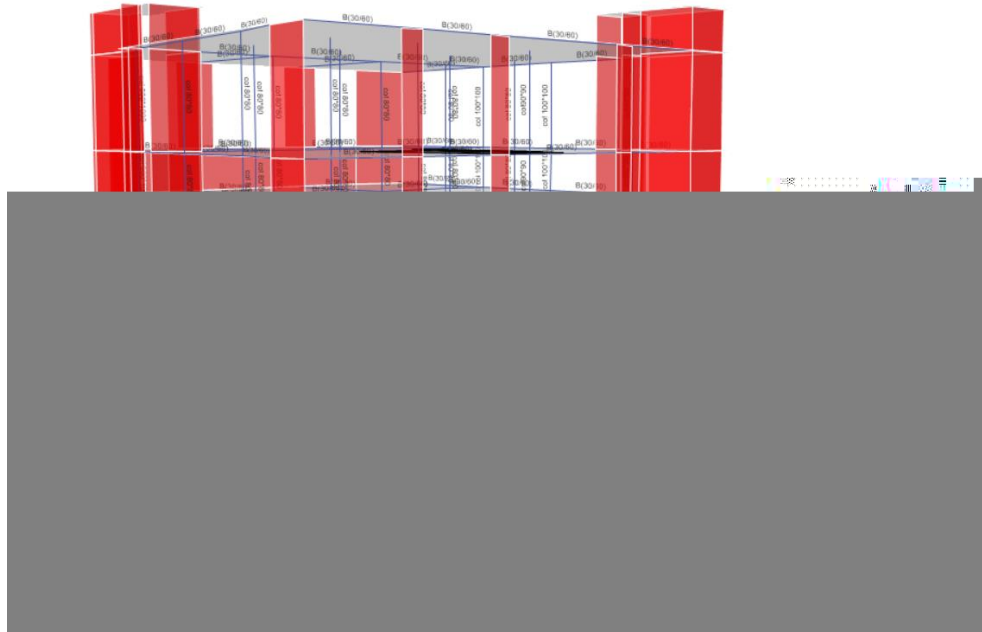


Figure 114: ETABS model of the building

3.8 Analysis of Model and Checks

To make sure that the model of the building is reliable, there are many checks to do

- Compatibility check

This check will be done to make sure that all of the building elements will move together as one block. Figure 115 shown the model of the etabs.

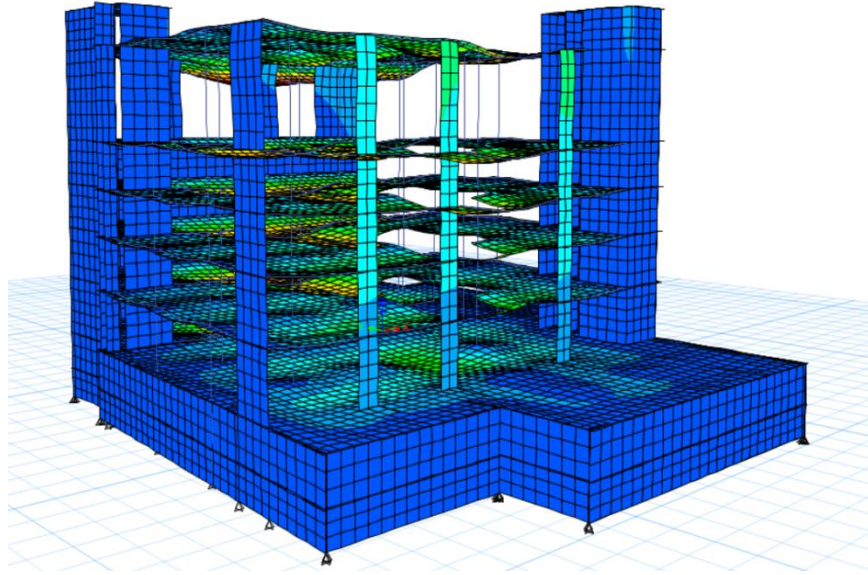


Figure 115: Compatibility check from ETABS program

- Equilibrium

This check will be done to make sure that the loads that was applied to the model are correct, and that will be done by comparing between manual calculation and the result from ETABS.

The error must be less than 5%, Dead and live loads reaction from ETABS are shown Table 20 Base reaction from ETABS below.

Table 20 Base reaction from ETABS

Dead	5.733E-07	7.845E-07	134209.0608
Live	0	0	37937.4252
Sid	0	0	37937.4252

- Dead load

Slab weight= Area * Thickness* 25

$$= 96500 \text{ kN.}$$

Column= height* number of columns *25* area of cross section

$$= 8000 \text{ kN.}$$

$$\text{Shear wall} = \text{Area} * \text{thickness} * 25 \\ = 26100 \text{ kN.}$$

$$\text{Wall load} = \text{length} * 18, \text{ Glass} = \text{length} * 7 \\ = 2430 \text{ kN.}$$

$$\text{Beams} = (\text{beam thickness}) * \text{width} * 25 * \text{length} \\ = 3180$$

$$\text{Weight} = (96500 + 8000 + 26100 + 2430 + 3180) = 136210 \text{ kN}$$

$$\text{Error} = ((136210 - 134209) / 134209) * 100 = 1.49 \% < 5\% \dots \text{check is ok.}$$

- Live load

$$\text{For manual calculation} = \text{Area of the slabs} * 5 \text{ kN. /m}^2 \\ = 37937.43 \text{ kN}$$

$$\text{Error} = ((37937.43 - 37937.43) / 37937.43) * 100 = 0 \% < 5\%, \text{ check is ok.}$$

- SID

$$\text{For manual calculation} = \text{Area of the slabs} * 4 \text{ kN/m}^2 \\ = 37937.43 \text{ kN}$$

$$\text{Error} = ((37937.43 - 37937.43) / 37937.43) * 100 = 0 \% < 5\%, \text{ check is ok.}$$

- Deflection check

According to ACI 318-14 code, the deflection limit in slab must not exceed $L/240$, which L is the longest span in the slab.

In this building the longest span 10.70 m and for the check the diagonal dimension must be taken so $L = 15.54$ m as can be noticed in Figure 116 is, so the deflection limit = $15.54/240 = 64.70$ mm.

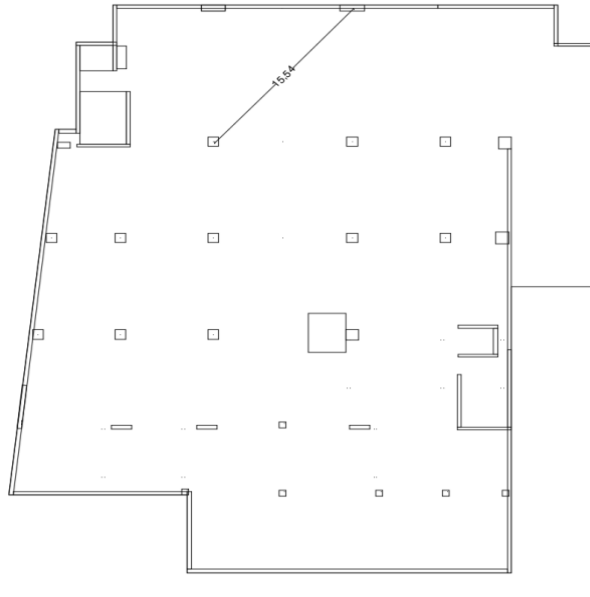


Figure 116: the longest span in the slab

In Figure 117 shows the deflection from ETABS in the first floor.

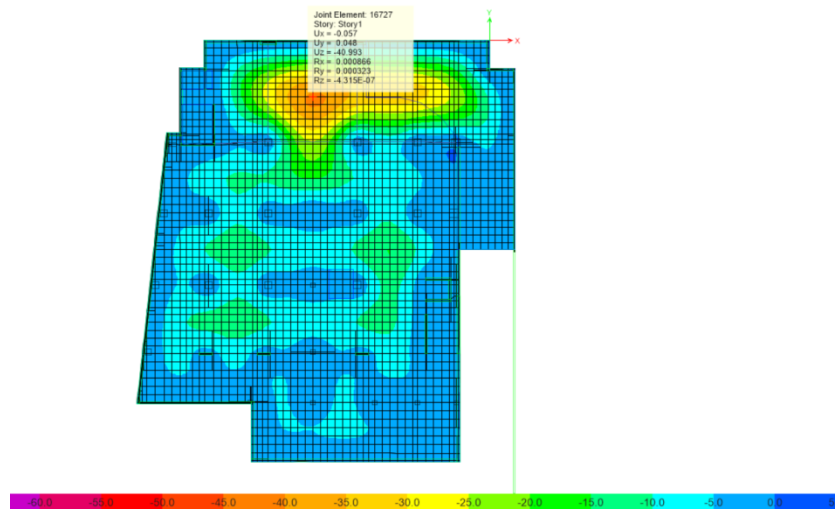


Figure 117: The deflection from ETABS in the basement slab from lateral load

From ETABS the deflection =41.00 mm which is less than the limit =64.70 mm, so the deflection check is ok.

- Check internal forces
 1. Check internal forces for column

In Figure 116: the longest span in the slab shows the columns that will be checked for internal forces.

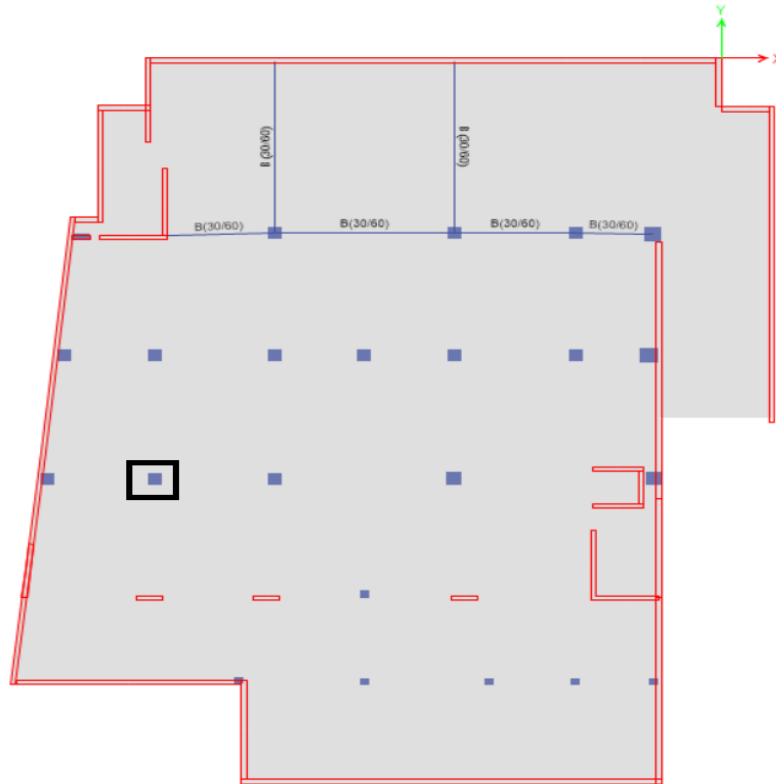


Figure 118 the columns that will be checked for internal forces

$$\begin{aligned}
 W_u(\text{Solid slab}) &= 1.4 * (\text{Dead} + \text{SID}) + 1.6 \text{ live} \\
 &= 1.2 * (1 * 1 * 0.4 * 25 + 4) + 1.6 * 5 \\
 &= 24.80 \text{ kN/m}^2.
 \end{aligned}$$

Trubitry area for the columns = 57m².

Figure 119 shown the internal forces for the columns from ETABS.

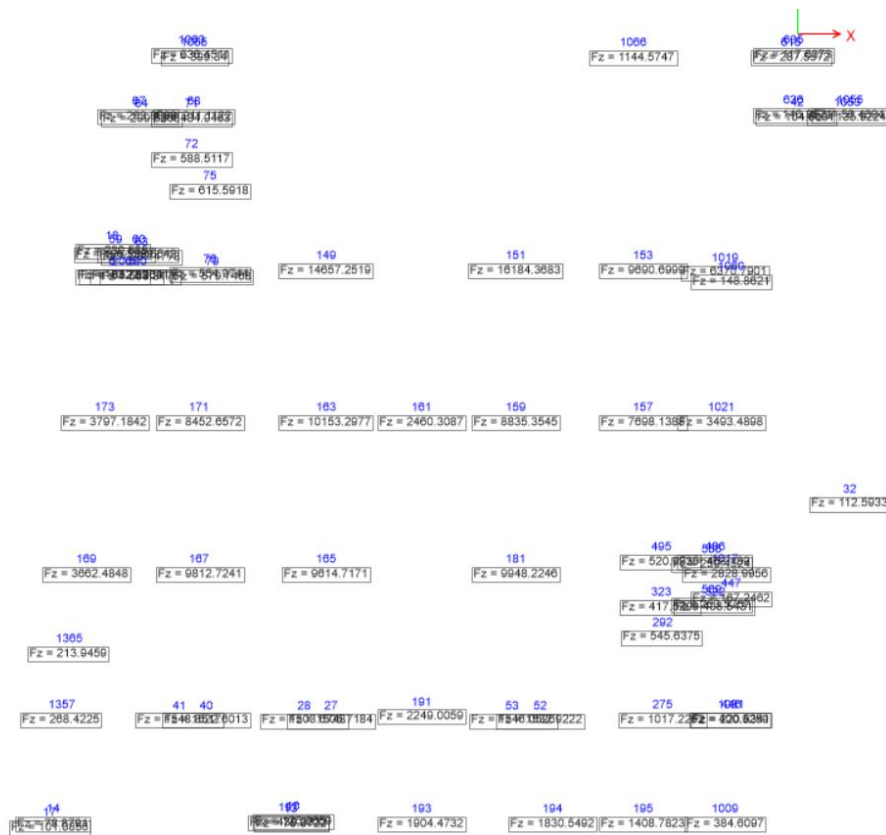


Figure 119 Internal forces in the columns that will be checked

From ETABS = 9813 Kn

From manual calculation = $W_u(\text{kN/m}^2) * \# \text{ of stories} * \text{Trubitry area}$

$$= 24.8 * 7 * 57$$

$$= 9895 \text{ kn}$$

$$\text{Error} = ((9895 - 9813) / 9813) * 100 =$$

$$= 0.84 \% < 10\% \dots \text{Check is ok}$$

3.9 Seismic analysis

According to UBC-97 code and with response spectrum method the ETABS model will be seismic analysis.

For seismic analysis there is some parameters that should be defined as can be showed in Figure 120

Mass source: 100% for dead laods and SID , 25% for live laods.
Seismic zone : The faculty is located in Nablus city Therefore, the seismic zone is 2B and the Z value is equal to 0.20.
Soil profile: The soil type is rock so the soil profile is SB .
Force Reduction Factor R = 5.5 (Building Frame System - shear wall)
Importance Factor I = 1.25
Acceleration-Dependent Seismic Coefficient Ca = 0.2
Velocity-Dependent Seismic Coefficient Cv = 0.2
Response spectrum scale factor = $\frac{I \times g}{R} = \frac{1.25 * 9810}{5.5} = 2230$

Figure 120: The parameters for seismic analysis

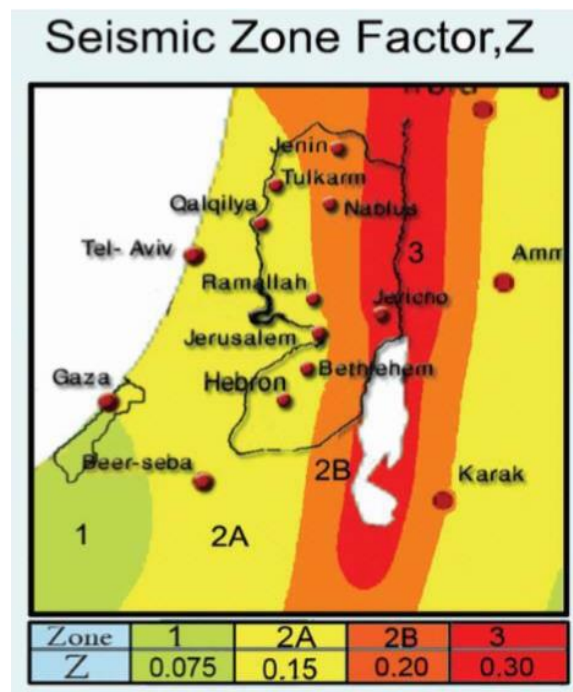


Figure 121: Seismic zone factor (z)

3.10 Load Combinations

There are two types of combinations according to UBC- 97 code:

1. Ultimate Load Combinations :

- a. $1.4 D$
- b. $1.2 D + 1.6 L$
- c. $1.2 D + 1 E + 1 L$
- d. $0.9 D \pm 1 E$

Which $E = \rho E_h + E_{va}$

P: Redundancy factor and it shall be taken (1), because the structure is located in seismic zone 2.

$$E_h = EQ_x + 0.3 EQ_y$$

$E_v = 0.5 Ca I D$, which it may be taken as zero for allowable stress design.

2. Service Load Combinations :

- a) $1 D$
- b) $1 D + 1 L$
- c) $1 D + \frac{E}{1.4}$
- d) $0.9 D \pm \frac{E}{1.4}$
- e) $D + 0.75 (L + \frac{E}{1.4})$

Figure 122 below shows the ultimate combination that will be used for seismic analysis;

Ultimate Load Combinations

$1.4 D + 1.4 SID$	
$1.2 D + 1.2 SID + 1.6 L + S$	
$1.325 D + 1.325 SID + 1.0 EQ_x + 0.3 EQ_y$	
$1.325 D + 1.325 SID + 0.3 EQ_x + 1.0 EQ_y$	
$0.775 D + 0.775 SID + 1.0 EQ_x + 0.3 EQ_y$	
$0.775 D + 0.775 SID + 0.3 EQ_x + 1.0 EQ_y$	

Figure 122 the ultimate combination that will be used for seismic analysis

Figure 123 below shows the service combination that will be used for seismic analysis;

Service Load Combinations

1.0	D	+	1.0	SID				
1.0	D	+	1.0	SID	+	1.0	L	
1.0	D	+	1.0	SID	+	0.71	EQx	+ 0.21 EQy
1.0	D	+	1.0	SID	+	0.21	EQx	+ 0.71 EQy
0.9	D	+	0.9	SID	+	0.71	EQx	+ 0.21 EQy
0.9	D	+	0.9	SID	+	0.21	EQx	+ 0.71 EQy
1.0	D	+	1.0	SID	+	0.75	L	+ 0.54 EQx + 0.16 EQy
1.0	D	+	1.0	SID	+	0.75	L	+ 0.16 EQx + 0.54 EQy

Figure 123: the service combination that will be used for seismic analysis

Figure 124 below shows the mass source definition in ETABS:

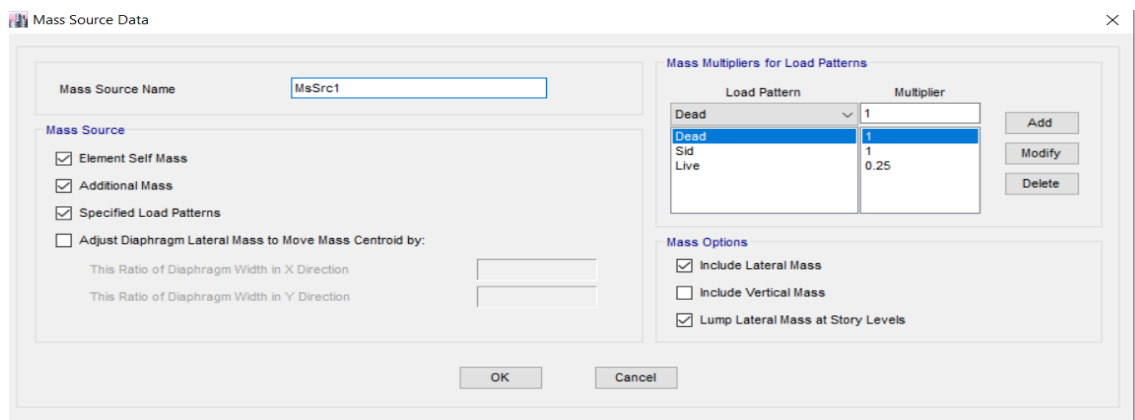


Figure 124: the mass source definition in ETABS

Figure 125 below shows the response spectrum definition in ETABS:

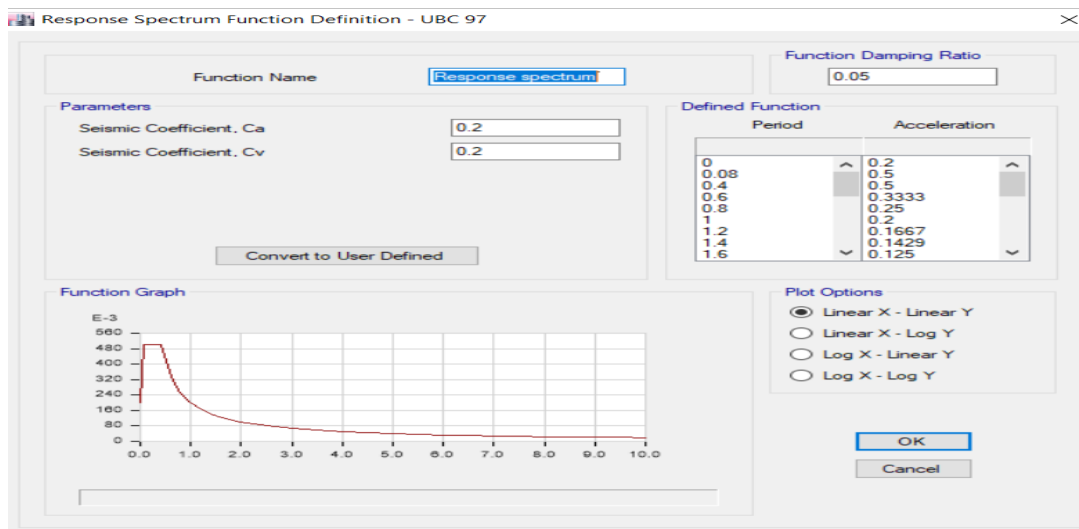


Figure 125: The response spectrum definition in ETABS

Figure 126 below shows the combination in ETABS:

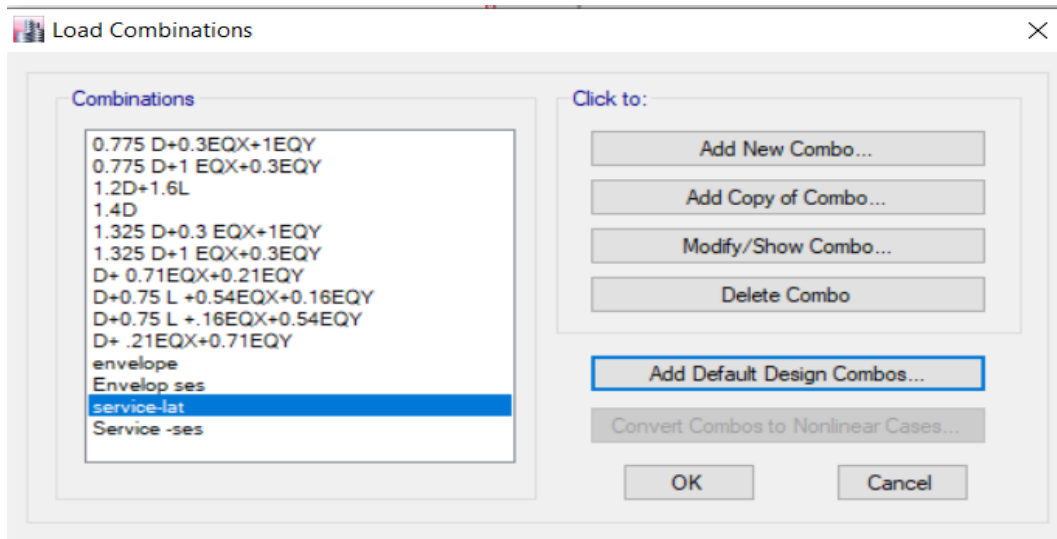


Figure 126: the combination in ETABS:

3.11 Seismic checks

To make sure that the seismic analysis are correct, there are four checks must be done:

1. Period Check

According to UBC-97, the time period will be calculated and it must be greater than the result form ETABS program.

- Manually calculation:

Using method A from UBC-97 code:

$$T = Ct \times hn^{3/4}, \text{ which:}$$

$$Ct = 0.0488$$

h_n : The height of the building (m).

$$T_{\text{method A}} = 0.0488 \times 33.91^{3/4} = 0.685 \text{ec.}$$

- ETABS calculation

Time period from ETABS $\leq 1.4 T_{method A} = 1.4 \times 0.685 = 1.00 \text{ sec}$.

Time period from mode 1 (T_x) = 1.28 sec > 1.00 sec, the check is ok if the drift check is ok.

Time period from mode 2 (T_y) = 1.00 sec < 1.00 sec, the check is ok.

2. Modal Mass Participating Ratios Check

Table 21 below shows the modal mass participating ratios from ETABS and it shall be > 0.90

Table 21 the modal mass participating ratios from ETABS

TABLE: Modal Participating Mass Ratios								
Case	Mode	Period sec	UX	UY	UZ	Sum UX	Sum UY	Sum UZ
Modal	1	1.286	0.355	0.0008	0	0.355	0.0008	0
Modal	2	1.089	0.0062	0.5049	0	0.3613	0.5057	0
Modal	3	0.479	0.0749	0.0204	0	0.4362	0.5261	0
Modal	4	0.409	0.194	0.0069	0	0.6302	0.5331	0
Modal	5	0.341	0.0269	0.1098	0	0.6571	0.6429	0
Modal	6	0.227	0.0332	0.0085	0	0.6903	0.6514	0
Modal	7	0.208	0.0428	0.0081	0	0.7331	0.6596	0
Modal	8	0.169	0.0333	0.0594	0	0.7664	0.719	0
Modal	9	0.138	0.0604	0.021	0	0.8268	0.74	0
Modal	10	0.129	0.0316	0.0011	0	0.8584	0.7411	0
Modal	11	0.128	0.0189	0.0008	0	0.8773	0.7419	0
Modal	12	0.127	0.0003	0.0002	0	0.8776	0.7421	0
Modal	13	0.126	0.0094	0.0003	0	0.8871	0.7424	0
Modal	14	0.121	0.0014	0.0014	0	0.8884	0.7438	0
Modal	15	0.116	0.0041	0.0736	0	0.8925	0.8174	0
Modal	16	0.114	0.0034	0.0177	0	0.896	0.8351	0
Modal	17	0.11	0.0025	0.0076	0	0.8985	0.8427	0
Modal	18	0.109	0.0013	0.0007	0	0.8998	0.8434	0
Modal	19	0.109	0.0261	0.0301	0	0.9259	0.8736	0
Modal	20	0.107	0.0002	0.0103	0	0.9261	0.8839	0
Modal	21	0.107	0.003	0.00003587	0	0.9291	0.8839	0
Modal	22	0.106	0.0001	0.0024	0	0.9292	0.8863	0
Modal	23	0.104	0.0003	0.0002	0	0.9295	0.8865	0
Modal	24	0.103	0.0001	0.0002	0	0.9295	0.8867	0
Modal	25	0.102	0.0025	0.0034	0	0.932	0.89	0
Modal	26	0.101	0.0001	0.00003911	0	0.9321	0.8901	0
Modal	27	0.099	0.0004	0.0266	0	0.9325	0.9167	0
Modal	28	0.097	0.0059	0.019	0	0.9384	0.9357	0
Modal	29	0.096	0.0021	0.001	0	0.9404	0.9367	0
Modal	30	0.096	0.0004	0.0005	0	0.9408	0.9372	0
Modal	31	0.096	0.00001869	0.00000689	0	0.9409	0.9372	0
Modal	32	0.095	0.00003701	0.0012	0	0.9409	0.9384	0
Modal	33	0.095	0.0035	0.0063	0	0.9444	0.9446	0
Modal	34	0.093	0.00004457	0.0001	0	0.9445	0.9447	0
Modal	35	0.093	0.000006101	0.0005	0	0.9445	0.9452	0
Modal	36	0.092	0.0001	0.0012	0	0.9446	0.9464	0
Modal	37	0.092	0.0002	0.0042	0	0.9448	0.9506	0
Modal	38	0.091	0.0004	0.0024	0	0.9453	0.9531	0
Modal	39	0.087	0.0003	0.0001	0	0.9455	0.9531	0
Modal	40	0.084	0.0001	0.0002	0	0.9456	0.9534	0
Modal	41	0.081	0.0006	0.0001	0	0.9462	0.9535	0
Modal	42	0.081	0.001	0.0003	0	0.9472	0.9537	0
Modal	43	0.078	0.00002061	0.0001	0	0.9472	0.9538	0
Modal	44	0.077	0.0007	0.001	0	0.9479	0.9548	0
Modal	45	0.077	0.0011	0.001	0	0.949	0.9558	0
Modal	46	0.076	8.652E-07	0.00002682	0	0.949	0.9558	0
Modal	47	0.074	0.0001	0.000005722	0	0.9491	0.9558	0
Modal	48	0.073	0	0	0	0.9491	0.9558	0
Modal	49	0.072	0.0002	7.627E-07	0	0.9494	0.9558	0
Modal	50	0.071	0.0006	0	0	0.9499	0.9558	0

Table 21 shown that the summation of the mass participation ratio > 0.90, so the check is ok.

3. Base shear check

The result from ETABS shall be less or equal than the manually calculation.

1. Manually calculations

According to UBC-97 code: $V = \left(\frac{I \times W}{R} \right) \min \left\{ \frac{2.5 C_a}{C_v}, \frac{C_a}{T} \right\}$

Where: $W = \text{Dead} + \text{SID} + 0.25 \text{ Live}$

Table 22 shown the load cases from ETABS:

Table 22 Building weight from ETABS

Load Case/Combo	FZ kN
Dead	134209.0608
Live	37937.4252
SID	37937.4252

$$W = 134209 + 37937.4 + 0.25 \times 37937.4 = 181631 \text{ kN.}$$

$$F_x = \left(\frac{1.25 \times 152128.4}{5.5} \right) \min \left\{ \frac{2.5 \times 0.2}{0.469}, 0.2 \right\} = 8256 \text{ kN.}$$

$$F_y = \left(\frac{1.25 \times 83875}{5.5} \right) \min \left\{ \frac{2.5 \times 0.2}{0.414}, 0.2 \right\} = 8265 \text{ kN.}$$

2. ETABS calculations

Table 23 shows base shear values from ETABS

Table 23 Base shear values from ETABS

Load Case/Comb	FX	FY
EQx Max	10726.4153	3333.673
EQy Max	3333.6759	10374.43

From **Error! Reference source not found.** Above Base shear results from ETABS are more than manual calculations, so check is ok.

4. Drift check

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

If $T > 0.7$, the drift limitation = $0.02 \times H$

Drift limitation = $0.02 \times H \times 1000$

Table 24 Drift check from ETABS

Story	Height	Dis. X	Dis. Y	Drift x (ΔS)	Drift y (ΔS)	Delta x (ΔM)	Delta y (ΔM)	Limit
	m	mm	mm	mm	mm	mm	mm	mm
0	0	0	0	0	0	0	0	0
1	2.3	0.3	0.2	0.3	0.2	1.155	0.77	46
2	2.9	0.8	0.5	0.5	0.3	1.925	1.155	58
3	4.5	2.5	2.9	1.7	2.4	6.545	9.24	90
4	4	4.2	5.6	1.7	2.7	6.545	10.395	80
5	3.5	7.8	5.5	3.6	-0.1	13.86	-0.385	70
6	3.5	10.4	7.7	2.6	2.2	10.01	8.47	70
7	7	15.13	12	4.73	4.3	18.2105	16.555	140

Table 24 shown that all drifts in floors < limit, so the check is ok.

5. Shear check

- Wide beam shear check

To make sure that the slabs don't need to shear reinforcement this check will be done.

The maximum V_u from V12 and V13 from ETABS = 55 kN/m

$$V_u = V_{\max} - W_u \times (d).$$

$$\begin{aligned} W_u &= 1.2 \times (1 \times 1 \times 0.4 \times 25 + 4) + 1.6 \times 5 \\ &= 24.80 \text{ kN/m}^2. \end{aligned}$$

$$V_u = 55 - 24.80 \times (0.40 - 0.05) = 46.30 \text{ kN}.$$

$$\phi V_c = \frac{0.75}{6} \sqrt{28} \times 1000 \times (400 - 40) \times 10^{-3} = 231 \text{ kN./m}$$

Thus, $\phi V_c > V_u$ so the solid slab does not need for shear reinforcement.

- Punishing shear check

Figure 127 shown the punishing shear check result from ETABS.

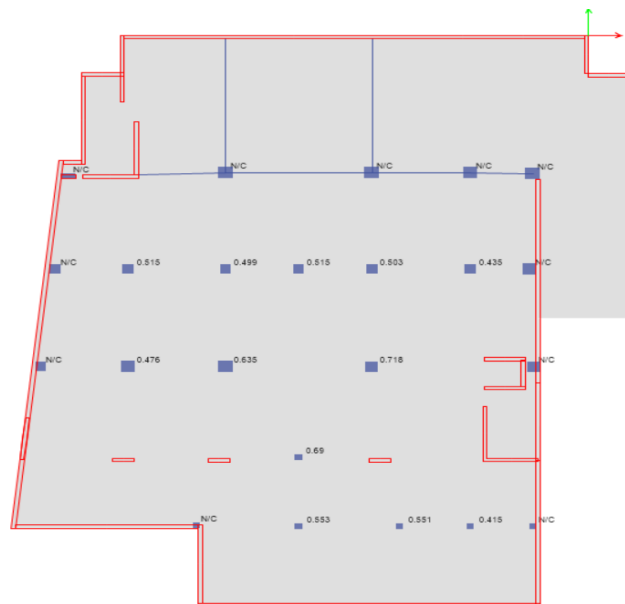


Figure 127: The punishing shear check result from ETABS.

3.12 Flexure design

3.12.1 Slab

For solid slab flexure design:

The minimum reinforcement:

$$A_{smin} = \rho_{min} \times b \times h = 0.0018 \times 1000 \times 400 = 720 \text{ mm}^2/\text{m}$$

Thus, the minimum reinforcement will be 5Ø14

To find the requirement reinforcement in the slab, slab concrete design in ETABS by finite elements based will be used.

For example, as can be shown in Figure 128 bellows, the top reinforcement in the slabs in the X-direction for second floor.

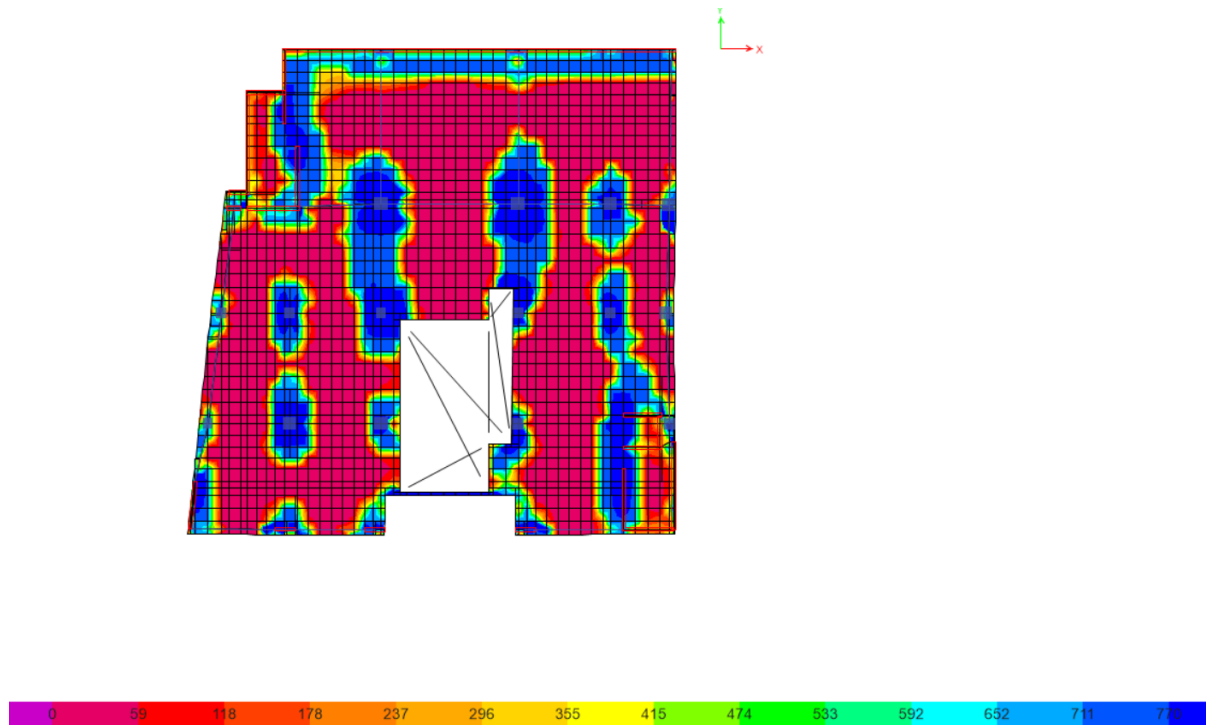


Figure 128 the top reinforcement in the slabs in the X-direction for second floor.

As can be noticed in Figure 128 the top reinforcement in the X- direction in the slab is with the minimum reinforcement and there is additional steel on the columns of 4 \varnothing 16.

Figure 129 the slab reinforcement for the second floor

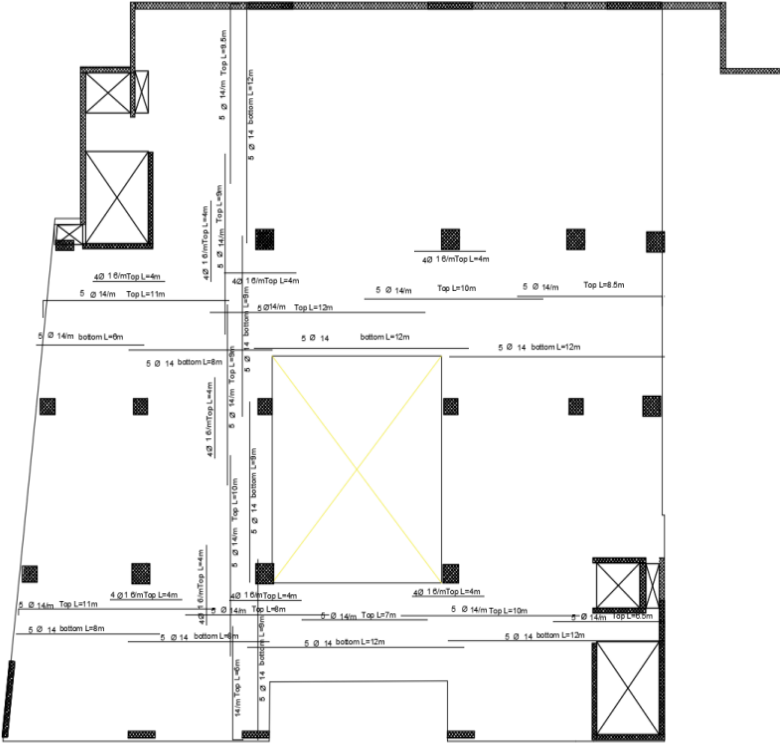


Figure 129 the slab reinforcement for the second floor

3.12.2 Columns

Figure 130 shows columns the distribution of the columns

Figure 132 shows the detailing for columns

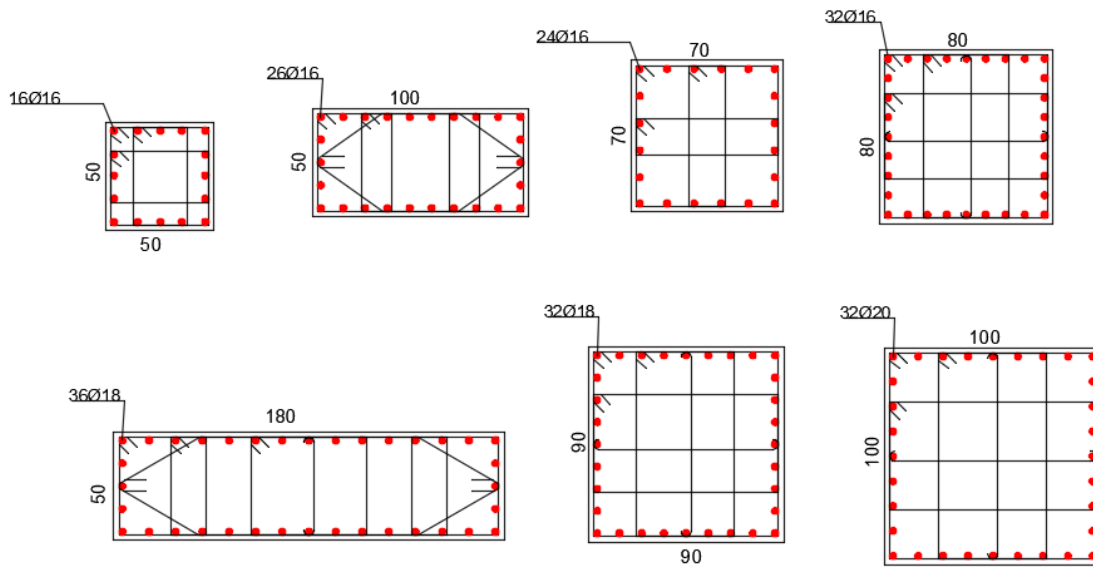


Figure 132: the detailing for columns

3.12.3 Beams

Figure 133 shows the design result from ETABS for Basement slab beams.

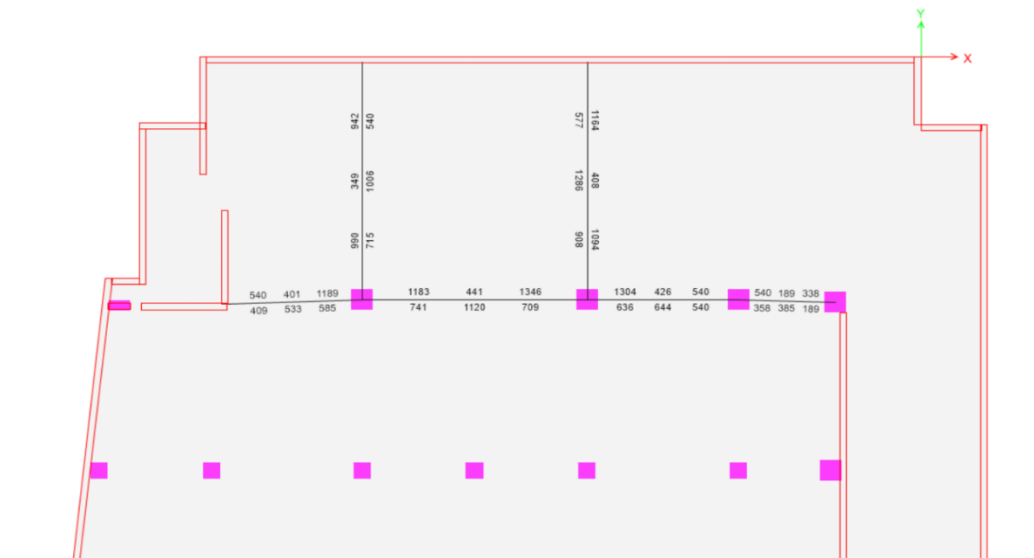


Figure 133: the design result from ETABS for Basement slab beams

$$\begin{aligned}
 \text{Area of steel minimum for beams} &= 0.00333 \times b \times d \\
 &= 0.00333 \times 300 \times 360 \\
 &= 360 \text{ mm}^2
 \end{aligned}$$

We will use 5Ø16 for top and bottom reinforcement for beams as can be show Figure 134 below.

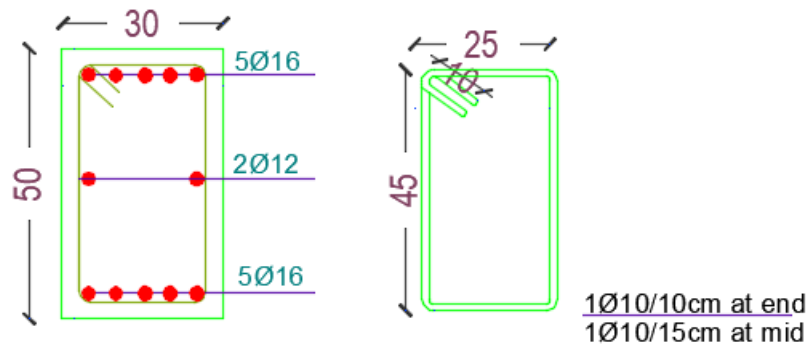


Figure 134: Section in beam

3.12.4 Shear wall

Shear wall design will be done using the maximum moment, shear and axial load on the shear wall.

$$\text{Length of Wall} = 3.60 \text{ m}$$

$$M_{u \text{ max.}} = 2572 \text{ KN.m}$$

$$V_{u \text{ max.}} = 563 \text{ KN}$$

$$\text{Normal load} = 1670 \text{ KN.}$$

$$F_c \text{ all} = (0.3-0.4) f'c$$

$$F_c \text{ all} = 0.3 f'c = 0.3 \times 28 = 8.40 \text{ MPa}$$

$$\frac{H}{B} = \frac{33.89}{3.60} = 9.40 > 2$$

Thus, we design for Moment and check for shear.

$$\text{Thickness of shear wall (b)} = \max \left\{ \begin{array}{l} 15\text{cm} \\ H_{\text{level}}/20 \end{array} \right\}$$

Use $b = 30\text{cm}$.

$$f = -\frac{N}{A} \pm \frac{M}{I} Y$$

$$A_w = 0.3 \times 3.60 = 1.08\text{m}^2$$

$$I = \frac{bh^3}{12} = \frac{0.3 \times 3.6^3}{12} = 1.17\text{m}^4, \quad Y = \frac{h}{2} = \frac{3.60}{2} = 1.8\text{ m}$$

$$f = -\frac{1670 \times 10^3}{1.08 \times 10^6} \pm \frac{2572 \times 10^3}{1.17 \times 10^6} (1.8) = 1.22\text{ MPa} < 9.6\text{ MPa}, \text{ so check is OK.}$$

It needs to reinforce two regions in the wall (boundaries & Web).

$$\text{Boundary dimensions: } \min \left\{ \begin{array}{l} 0.1h \\ 4b \end{array} \right\} = \left\{ \begin{array}{l} 0.1 \times 3.6 = 0.36\text{m} \\ 4 \times 0.3 = 1.2\text{m} \end{array} \right\} \rightarrow \text{use } (0.40 \times 0.3)\text{m.}$$

According to the code:

- S_v & S horiz. = 250 mm .
- ρ bound. = 1%.
- Min. ρ_v or ρ_H = 0.25%.
- Max. ρ_v = 0.035.

Take $\rho_b = 1\%$ in boundaries & $\rho_s = 0.25\%$ in Web, then compute the area of steel as follows:

$$\text{In Boundary: } A_s = 0.01 \times 300 \times 0.4 = 1200\text{ mm}^2 \text{ so, use } 6\emptyset 16\text{mm} .$$

In Web:

$$A_s = 0.0025 \times 300 \times 1000 = 750\text{ mm}^2 .$$

Use $4\emptyset 12\text{mm/m}$ on each side ($S = 250\text{mm}$) .

3.12.5 Basement wall design

The Basement wall high is 5 m. • Thickness = 0.3 m

- $\gamma_{\text{soil}} = 18\text{ kN. /m}^3$

- Friction Angle $\phi = 30^\circ$
- $K_a = 1/3 \text{ Load} = \gamma \times h \times K_a \times 1.6 = (18 \times 8 \times 1.6)/3 = 76.8 \text{ kN. /m}$

The wall will be designed using ETABS.

From ETABS, $V_u = 165.50 \text{ kN}$.

$$\phi V_c = \frac{0.75}{6} \sqrt{28} \times 1000 \times (300 - 40) \times 10^{-3} = 172 \text{ kN. /m}$$

$\phi V_c > V_u$, so shear check is ok.

For stem rebar:

From ETABS the vertical will be used $2\phi 14/15 \text{ cm}$ and for horizontal rebar will be used $2\phi 12/15 \text{ cm}$ as can shown Figure 135 below:

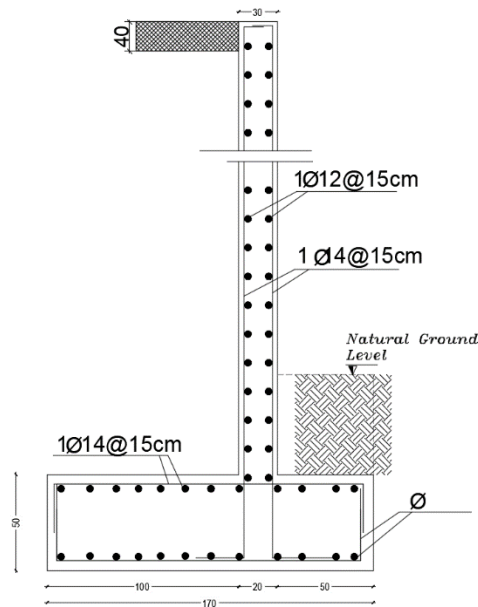


Figure 135 Basement wall detailing

3.12.6 Stair design

This Building staircase contains two pieces that are connected by a corner. Figure 136 shows stair in the building.

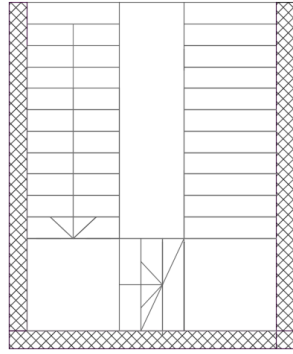


Figure 136: The stair in the building

The slab thickness will be assumed as a 0.20 m. Table 25 shows the loads on the stair.

Table 25 the load on the stair

Live load	5 KN/m ²
SID load	6.5 KN/m ²
Dead load	0.20*25=5 KN/m ²

Ultimate loads on slab equal $(1.2D + 1.6L) = (1.2 \times (6.5 + 5)) + (1.6 \times 4) = 20.2 \text{KN/m}^2$

$$M_U = \frac{W L^2}{8} = \frac{20.2 \times 3.6^2}{8} = 32.72 \text{ KN.m}$$

Longitudinal reinforcement ratio:

$$\rho = \frac{0.85 \times 28}{420} \left(1 - \sqrt{1 - \frac{2.61 \times 32.72 \times 10^6}{28 \times 1000 \times 170^2}} \right) = 0.003$$

So, $A_s = 0.0026 \times 1000 \times 170 = 510 \text{ mm}^2$ ► Use 1Ø12 /250 mm (5Ø12/m).

$A_{s, \text{Shrinkage}} = 0.0018 \times 1000 \times 200 = 360 \text{ mm}^2$ ► Use 1Ø10 /250 mm (5Ø12/m), in each direction.

Shear check for the step of the stair

$$V_u = \frac{W_u \times L}{2} = \frac{20.2 \times 3.6}{2} = 36.36 \text{ KN/m.}$$

$$\phi V_c = \frac{0.75}{6} \times \sqrt{f_c} \times b_w \times d = \frac{0.75}{6} \times \sqrt{28} \times 1000 \times 170 \times 10^{-3} = 112.44 \text{ KN/m.}$$

$\phi V_c > V_u$ so, shear check is ok.

Figure 137 shows the detailing of the stair.

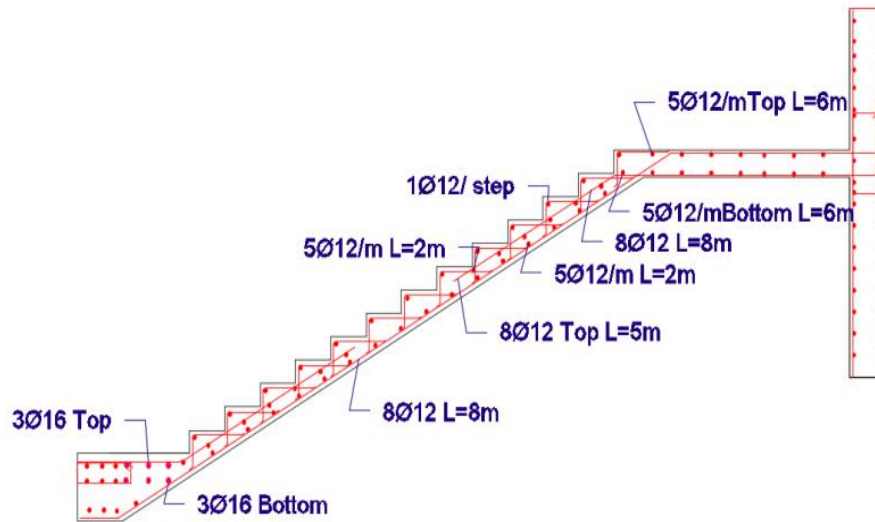


Figure 137: The detailing of the stair

3.12.7 Footing

For this building soil type is rock so Q_{all} will be 300 KN/m^2 .

Mat foundation will be used because there is large load and moment on the columns and shear walls and it will be designed using SAFE program.

Figure 138 shows the layout of the mat foundation

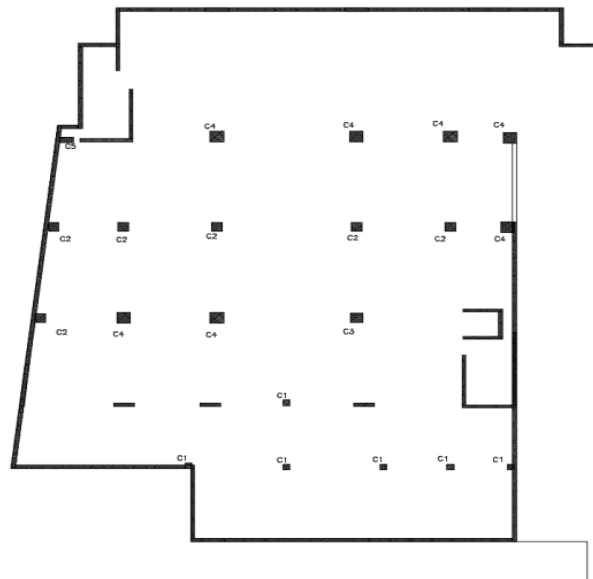


Figure 138 the layout of the mat foundation

Thicknese will be 1.30 m,Figure 139 shows the model is safe

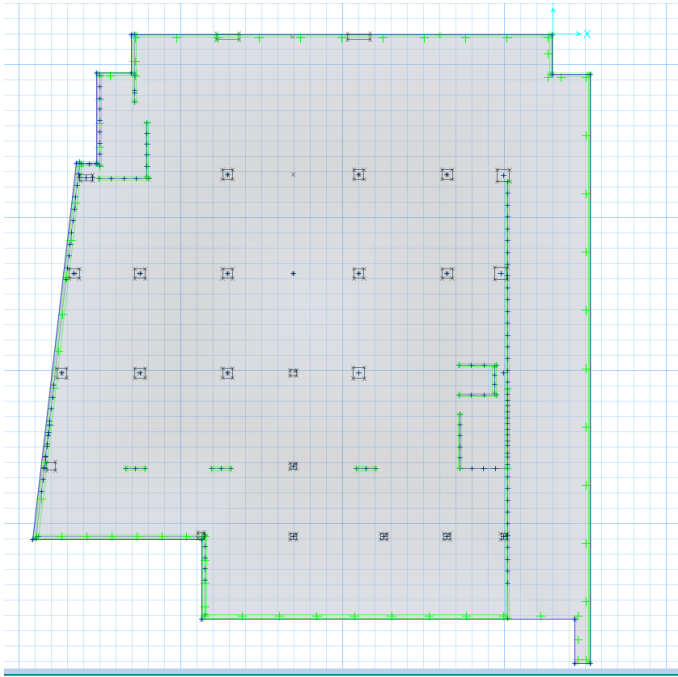


Figure 139 Mat foundation model is safe

Figure 140 shown punishing check

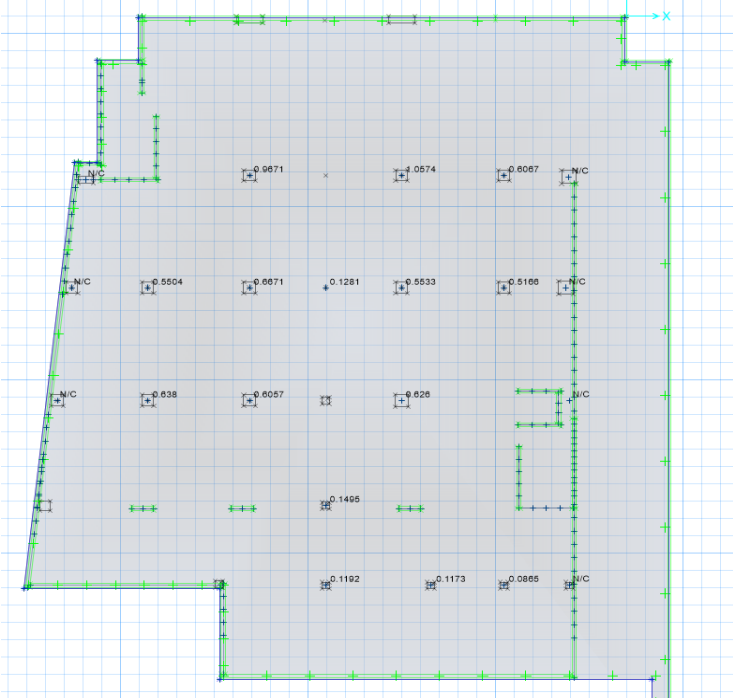


Figure 140 punishing check in safe

Figure 141 shows that all value of punishing shear are more than 1, so check is ok.

For soil bearing capacity check , $Q_{all} = 300 \text{ KN/m}^2$, so the stress valuse shall be less than Q_{all} .As can be noticed from Figure 141, all values are less than Q_{all} , so check is ok.

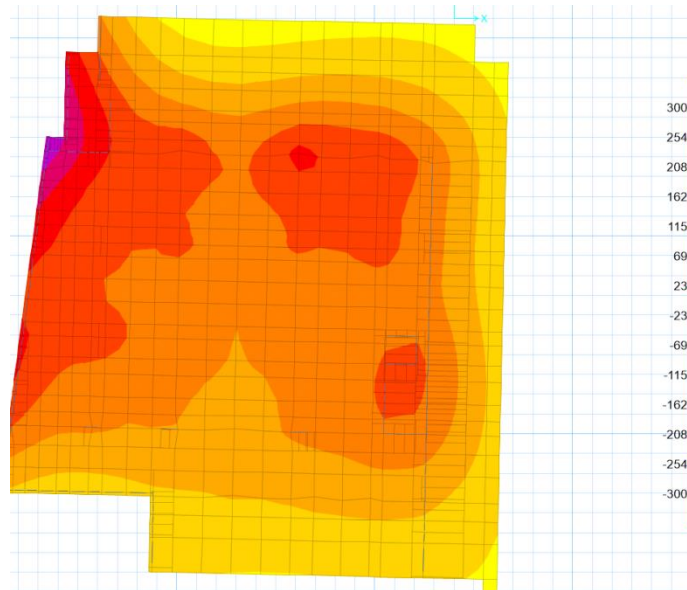


Figure 141 soil bearing capacity check in safe

Figure 142 below shows mat foundation detailed.

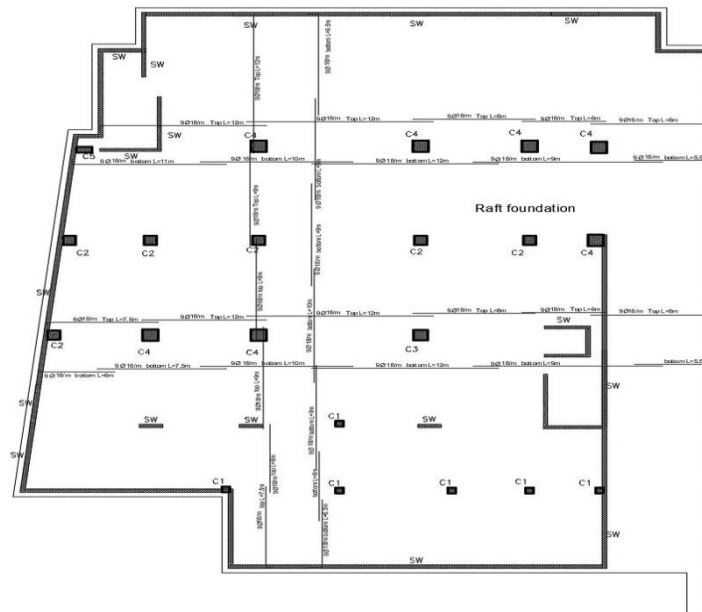


Figure 142 mat foundation detailed

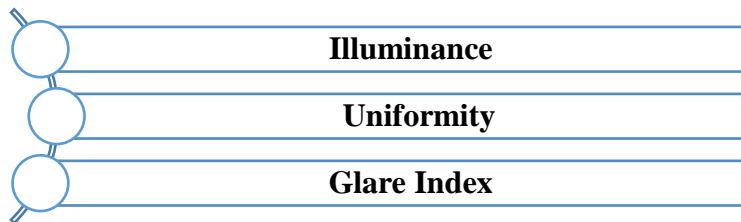
Chapter 4: electro-mechanical aspects:

4.1 Artificial lighting design:

4.1.1 Introduction:-

One of the most important elements that must be available in the design of buildings, there are several goals, including providing lighting in an appropriate quantity and quality to achieve visual comfort.

Among the factors that must be taken into account in the design:



The industrial lighting of the building was designed through the DIALux program.

The table below shows the appropriate Lux for each building area.

Table 26 standard of the spaces in the building (DIALux evo)

Space	Lux
Store	300
Office	500
Kids playing hall	300
Fast food restaurant	200
Bathroom	200
Parking	100

4.1.2 Recommended Lux Levels:

The recommended Interior Lighting lux levels for specific working areas according to CIBSE (Chartered Institute of Building Services Engineers). [12]

Table 27 recommended interior lighting lux level [12]

Illuminance (lux)	Activity	Area
100	Casual seeing	Corridors, changing rooms, stores
150	Some perception of detail	Loading bays, switch rooms, plant rooms
200	Continuously occupied	Foyers, entrance halls, dining rooms
300	Visual tasks moderately easy	Libraries, sports halls, lecture theatres.
500	Visual tasks moderately difficult	General offices, kitchens, laboratories, retail shops.
750	Visual tasks difficult	Drawing offices, meat inspection, chain stores.
1000	Visual tasks very difficult	General inspection, electronic assembly, paintwork, supermarkets.
1500	Visual tasks extremely difficult	Fine work and inspection, precision assembly.
2000	Visual tasks exceptionally difficult	Assembly of minute items, finished fabric inspection.

Table 28 recommended interior lighting lux level for hotel and restaurant [12]

Hotels and Restaurants

Area	Illuminance (lux)	Limiting Glare rating	Minimum colour rendering (R_a)
Kitchen	500	22	80
Restaurant, dining room, function room.	-	-	80
Self service restaurant	200	22	80
Conference rooms	500	19	80

Table 29 recommended interior lighting lux level for offices [12]

Offices

Area	Illuminance (lux)	Limiting Glare rating	Minimum colour rendering (R_a)
Filing, copying etc.	300	19	80
Writing, typing, reading, data processing	500	19	80
Technical drawing	750	16	80
CAD work stations	500	19	80
Conference and meeting rooms	500	19	80
Reception desk	300	22	80
Archives	200	25	80

Table 30 recommended interior lighting lux level for retail premises [12]

Retail Premises

Area	Illuminance (lux)	Limiting Glare rating	Minimum colour rendering (R _a)
Sales area	300	22	80
Till area	500	19	80
Wrapper table	500	19	80

Table 31 recommended interior lighting lux level for multispecies [12]

Area	Illuminance (lux)
Lifts	100
Corridors and stairs	100
Toilets	100
Canteens	300
Mess rooms	150 - 300
Plant rooms	150 - 300
Store rooms	100

The table below provides recommended light levels from the IESNA Lighting Handbook and LPD levels from the IECC 2021 (using the Space-By-Space Method for calculations). [13]

Table 32 recommended light level (lux) [13]

ROOM TYPE	LIGHT LEVEL (FOOT CANDLES)	LIGHT LEVEL (LUX)
Bedroom - Dormitory	20-30 FC	200-300 lux
Cafeteria - Eating	20-30 FC	200-300 lux
Classroom - General	30-50 FC	300-500 lux
Conference Room	30-50 FC	300-500 lux
Corridor	5-10 FC	50-100 lux
Exhibit Space	30-50 FC	300-500 lux
Gymnasium - Exercise / Workout	20-30 FC	200-300 lux
Gymnasium - Sports / Games	30-50 FC	300-500 lux
Kitchen / Food Prep	30-75 FC	300-750 lux
Laboratory (Classroom)	50-75 FC	500-750 lux
Laboratory (Professional)	75-120 FC	750-1200 lux
Library - Stacks	20-50 FC	200-500 lux
Library - Reading / Studying	30-50 FC	300-500 lux
Loading Dock	10-30 FC	100-300 lux
Lobby - Office/General	20-30 FC	200-300 lux

Locker Room	10-30 FC	100-300 lux
Lounge / Breakroom	10-30 FC	100-300 lux
Mechanical / Electrical Room	20-50 FC	200-500 lux
Office - Open	30-50 FC	300-500 lux
Office - Private / Closed	30-50 FC	300-500 lux
Parking - Interior	5-10 FC	50-100 lux
Restroom / Toilet	10-30 FC	100-300 lux
Retail Sales	20-50 FC	200-500 lux
Stairway	5-10 FC	50-100 lux
Storage Room - General	5-20 FC	50-200 lux
Workshop	30-75 FC	300-750 lux

4.1.3 Artificial lighting design:

4.1.3.1 Office

The figure below shows the type of luminaire in office.

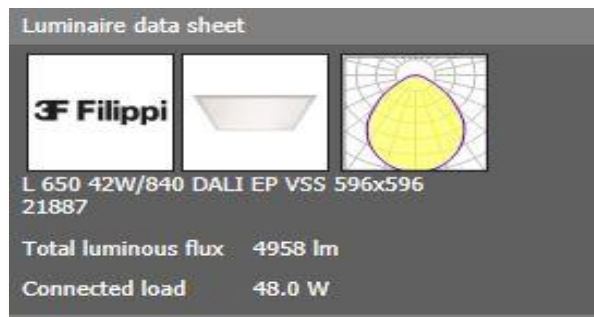


Figure 143 luminaire type chosen to office

Results: The average illuminance in the office is 569 lux and the limit is 300 lux, the glare is 16.6.

The figure below shows the result for office from DIALux evo.

Calculation surface 2			
▶		571 lx	0.00
▶		16.6	< 10
▶		> 90	< 10
Working plane (Office)			
▶		569 lx	0.083

Figure 144 the result for office from DIALux evo

The figure below shows the 3D view for office from DIALux evo.

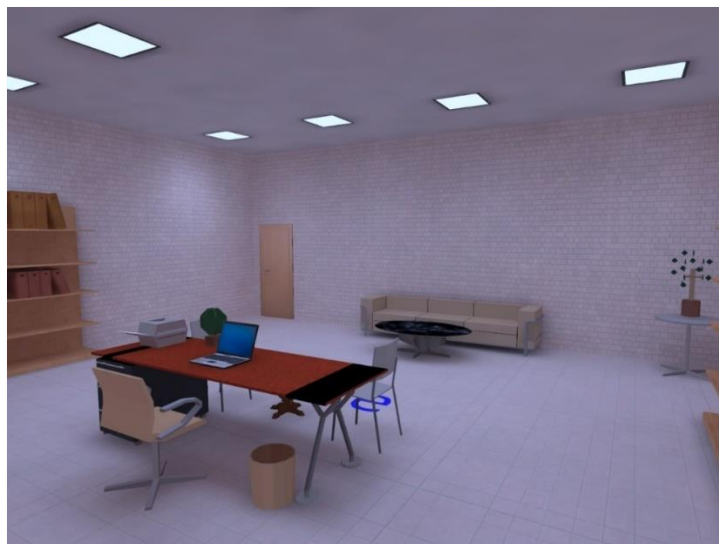


Figure 145 3D view for office from DIALux evo

4.1.3.2 Fast food restaurant

The figure below shows the type of luminaire in fast food restaurant.

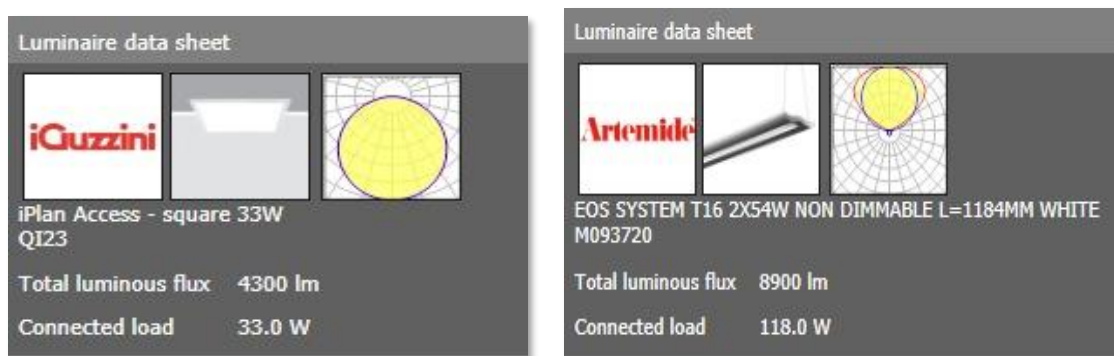


Figure 146 luminaire types chosen to fast food restaurant

Results: The average illuminance in the fast food restaurant is 231 lux and the limit is 200 lux, the glare is 11.8.

The figure below shows the result for fast food restaurant from DIALux evo.

Calculation surface 2			
	126 lx	0.39	<input type="checkbox"/>
	283 lx	0.93	<input checked="" type="checkbox"/>
	11.8	< 10	<input checked="" type="checkbox"/>
	> 90	> 90	<input type="checkbox"/>
Working plane (Fast food restaurant)			
	231 lx	0.004	<input checked="" type="checkbox"/>

Figure 147 : The result for office fast food restaurant from DIALux evo

The figure below shows the 3D view for fast food restaurant from DIALux evo.



Figure 148 3D view for fast food restaurant from DIALux evo

4.1.3.3 shoes store

The figure below shows the type of luminaire in shoes store.

Luminaire data sheet

M52 - SPY 93018 DIM5
24422 9315

Total luminous flux: 1128 lm
Connected load: 12.0 W

Description
24422 9315 M52 - SPY 93018 DIM5

Luminaire data sheet

LED-Louver
NLED4014C/4x9W-6500K

Total luminous flux: 3060 lm
Connected load: 36.0 W

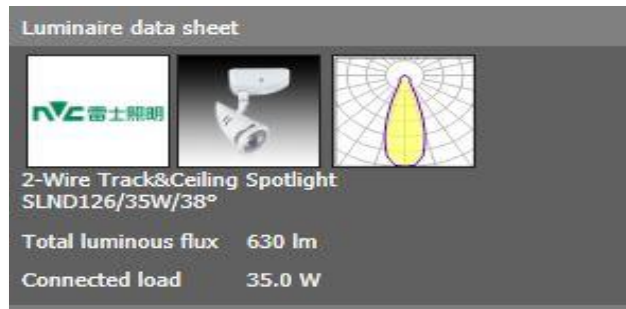


Figure 149 luminaire types chosen to shoes store

Results: The average illuminance in the shoes store is 399 lux and the limit is 300 lux, the glare is 16.1.

The figure below shows the result for shoes store from DIALux evo.

Calculation surface 1			
	470 lx	0.75	
	225 lx	0.000	
	16.1	< 10	
	> 90	< 10	
Working plane (Shoes store)			
	399 lx	0.002	

Figure 150 the result for shoes store from DIALux evo

The figure below shows the 3D view for shoes store from DIALux evo.

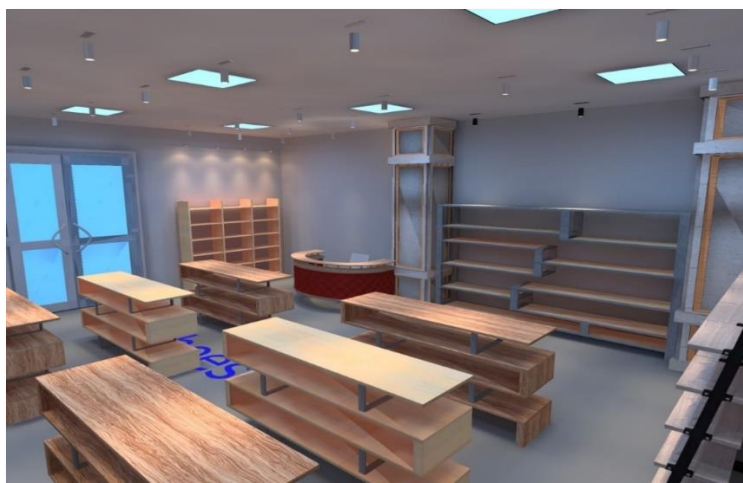


Figure 151 3D view for shoes store from DIALux evo

4.1.3.4 Retail store

The figure below shows the type of luminaire in retail store.



Figure 152 luminaire types chosen to retail store

Results: The average illuminance in the retail store is 505 lux and the limit is 300 lux, the glare is 28.2.

The figure below shows the result for retail store from DIALux evo.

Calculation surface 2			
	400 lx	0.15	
	395 lx	0.48	<input checked="" type="checkbox"/>
	28.2	< 10	
	> 90	< 10	
Working plane (Retail store)			
	505 lx	0.010	<input checked="" type="checkbox"/>

Figure 153 the result for retail store from DIALux evo

The figure below shows the 3D view for retail store from DIALux evo.



Figure 154 3D view for retail store from DIALux evo

4.1.3.5 W.C

The figure below shows the type of luminaire in W.C.



Figure 155 luminaire types chosen to W.C

Results: The average illuminance in the W.C is 316 lux and the limit is 200 lux.

The figure below shows the result for W.C from DIALux evo.



Figure 156 the result for W.C from DIALux evo

4.1.3.6 Parking

The figure below shows the type of luminaire in parking.

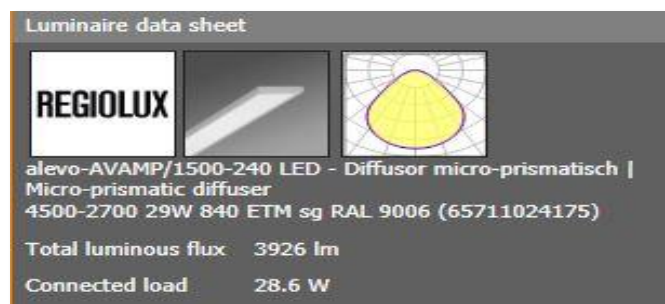


Figure 157 luminaire types chosen to parking

Results: The average illuminance in the parking is 118 lux.

The figure below shows the result for parking from DIALux evo.



Figure 158 the result for parking from DIALux evo

The figure below shows the 3D view for parking from DIALux evo.

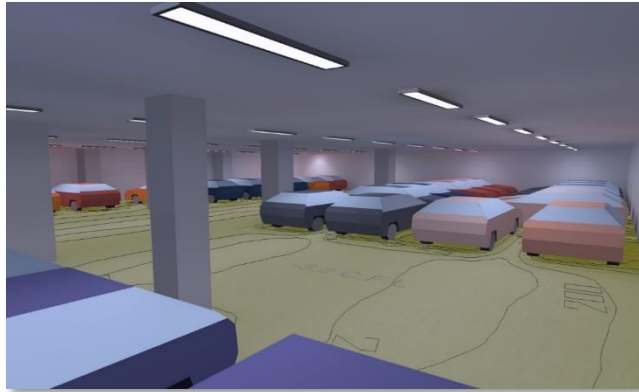


Figure 159 3D view for parking from DIALux evo

4.2 Power design

4.2.1 Introduction:

Electrical design for building one of the most important phase of any project, where every single thing need electricity at this time. The power design have to be determined, considering the existing or planned using equipment.

4.2.2 Problem definition

The building is a commercial building with multi-functional spaces that contains stores, offices, kids playing hall and restaurant. Each space design in accordance with its energy needs.

4.2.3 Lighting power calculations

4.2.3.1 Sample of calculation

A circuit breaker load for lighting = 10 amperes (A)

The maximum load from 10 A at lighting circuit breaker:

$$I_{cb} = 1.2 \times I_{lode}$$

$$10 = 1.2 \times I_{lode}$$

$$I_{lode} = 8.33 \text{ A}$$

Sample of calculation for required number of circuit breakers:

In second basement the total lighting power = 1716

$$\text{Power (W)} = I_{load} \text{ (A)} \times \text{Volt (V)} \times \text{Power factor}$$

$$1716 \text{ W} = I_{load} \times 220 \times 0.9$$

$$I_{load} = 8.6 \text{ A}$$

Number of required circuit breaker for second basement = $8.66/8.33 = 1$ circuit breaker

- Ground Floor

Table 33 :No. of lighting circuit breaker for ground floor.

Space	Type of luminaire	Luminaire Power (W)	No. of luminaires	power	I lode	No. of CB
electronic store	Downlight	36	37	1332	6.73	1
retail store	Downlight	36	80	2880	14.55	2
store	Downlight	36	6	216	1.09	1
entrance and circulation	Downlight	28.6	24	686.4	3.47	1
W.Cs	Downlight	24	10	240	1.21	1

- First Floor

Table 34 No. of lighting circuit breaker for First floor

Space	Type of luminaire	Luminaire Power (W)	No. of luminaires	power	I lode	No. of CB
Fashion Store	Downlight	36	36	1296	6.55	1
Dressing rooms	Downlight	36	2	72	0.36	1
retail store	Downlight	36	80	2880	14.55	2
store1	Downlight	36	6	216	1.09	1
store2	Downlight	36	2	72	0.36	1
store3	Downlight	36	2	72	0.36	1
store4	Downlight	36	2	72	0.36	1
entrance and circulation	Downlight	28.6	21	600.6	3.03	1
W.Cs	Downlight	24	10	240	1.21	1

- Second Floor

Table 35 No. of lighting circuit breaker for second floor

Space	Type of luminaire	Luminaire Power (W)	No. of luminaires	power	I lode	No. of CB
Fashion Store 1	Downlight	36	36	1296	6.55	1
Dressing rooms	Downlight	36	5	180	0.91	1
Fashion Store2	Downlight	36	13	468	2.36	1
Dressing rooms	Downlight	36	2	72	0.36	1
store1	Downlight	36	42	1512	7.64	1

Shoes store	Downlight	36	16	576	2.91	1
Store2	Downlight	36	4	144	0.73	1
Bag and shoes store	Downlight	36	23	828	4.18	1
Coffee and sweet corner	Downlight	36	6	216	1.09	1
Terrace	Downlight	36	9	324	1.64	1
entrance and circulation	Downlight	28.6	21	600.6	3.03	1
W.Cs	Downlight	24	10	240	1.21	1

- Third Floor

Table 36 No. of lighting circuit breaker for third floor

Space	Type of luminaire	Luminaire Power (W)	No. of luminaires	power	I lode	No. of CB
office1	Downlight	48	7	336	1.70	1
office2	Downlight	48	10	480	2.42	1
office3	Downlight	48	9	432	2.18	1
office4	Downlight	48	8	384	1.94	1
office5	Downlight	48	8	384	1.94	1
office6	Downlight	48	11	528	2.67	1
office7	Downlight	48	8	384	1.94	1
office8	Downlight	48	9	432	2.18	1
office9	Downlight	48	6	288	1.45	1
office10	Downlight	48	8	384	1.94	1
office11	Downlight	48	8	384	1.94	1
office12	Downlight	48	9	432	2.18	1
office13	Downlight	48	10	480	2.42	1
office14	Downlight	48	9	432	2.18	1
entrance and circulation	Downlight	28.6	21	600.6	3.03	1

- Third Floor W.Cs and small Kitchens

Table 37 No. of lighting circuit breaker of WCs and small kitchen at third floor

Space	Type of luminaire	Luminaire Power (W)	No. of luminaires	power	I lode	No. of CB
W.Cs 1	Downlight	24	1	24	0.12	1
kitchen 1	Downlight	24	1	24	0.12	1

W.Cs 2	Downlight	24	1	24	0.12	1
kitchen 2	Downlight	24	1	24	0.12	1
W.Cs 3	Downlight	24	1	24	0.12	1
kitchen 3	Downlight	24	1	24	0.12	1
W.Cs 4	Downlight	24	1	24	0.12	1
kitchen 4	Downlight	24	1	24	0.12	1
W.Cs 5	Downlight	24	1	24	0.12	1
kitchen 5	Downlight	24	1	24	0.12	1
W.Cs 6	Downlight	24	1	24	0.12	1
kitchen 6	Downlight	24	1	24	0.12	1
W.Cs 7	Downlight	24	1	24	0.12	1
kitchen 7	Downlight	24	1	24	0.12	1
W.Cs 8	Downlight	24	1	24	0.12	1
kitchen 8	Downlight	24	1	24	0.12	1
W.Cs 9	Downlight	24	1	24	0.12	1
kitchen 9	Downlight	24	1	24	0.12	1

- Fourth Floor

Table 38 No. of lighting circuit breaker for fourth floor

Space	Type of luminaire	Luminaire Power (W)	No. of luminaires	power	I lode	No. of CB
Restaurant	Downlight	36	20	720	3.64	1
Kitchen	Downlight	36	6	216	1.09	1
kids playing hall	Downlight	36	74	2664	13.45	2
store	Downlight	36	6	216	1.09	1
Coffee and sweet corner	Downlight	36	6	216	1.09	1
Terrace	Downlight	28.6	18	514.8	2.60	1
entrance and circulation	Downlight	28.6	23	657.8	3.32	1
W.Cs	Downlight	24	10	240	1.21	1

4.2.4 Cable size

Calculation of an electricity cable diameter for lighting switches:

$$I_{\text{cable}} = 1.2 \times I$$

Circuit breaker = $1.2 \times 10 = 12 \text{ A}$

According to Table 39, I cable = 1.5 mm^2 .

Table 39 cable cross-sectional area due to current [31]

Nom. Cross Sectional Area for Cu.	Cu. Conductor Current Rating	Voltage Drop Cu. Conductor	Voltage Drop Al. Conductor	Equivalent Current Rating of Al. Conductor	Nom. Cross Sectional Area for Al.
mm ²	(A)	mV/A/m	mV/A/m	(A)	mm ²
1.5	18	25	11.82	28	6
2.5	25	15	11.82	28	6
4	33	9.5	7.91	39	10
6	43	6.4	4.2	57	16
10	59	3.8	4.2	57	16
16	79	2.4	2.7	79	25
25	104	1.5	1.35	123	35
35	129	1.1	1.35	123	50
50	167	0.84	0.94	159	70
70	214	0.6	0.58	226	120
95	261	0.47	0.48	261	150
120	303	0.4	0.41	299	185
150	349	0.34	0.35	354	240
185	400	0.31	0.31	410	300
240	472	0.27	0.28	472	400
300	545	0.25	0.26	546	500
400	634	0.24	0.24	626	630
500	723	0.23	0.23	709	800
630	826	0.22	0.22	823	1000

4.2.5 Voltage drop

Calculation of voltage drop:

Copper resistivity $P = 1.7 \times 10^{-8}$

L: max length between lighting unit and electrical distribution bored.

A: cross-sectional area for cable.

Voltage drop formula: $V_{\text{drop}} = I_{\text{load}} \times R$.

$$V_{\text{drop}} = I \times (P \times 2L / A).$$

The farthest distance between distribution board and lighting unit approximately 32m:

$$V_{\text{drop}} = I_{\text{load}} \times R$$

Maximum allowable voltage drops = $5\% \times 220\text{V} = 11 \text{ V}$

$$V_{\text{drop}} = I \times (P \times 2L / A)$$

$$= 12 \times (1.7 \times 10^{-8} \times (2 \times 32) / 1.5 \times 10^{-6}) = 8.7 < 11 \dots \text{ok.}$$

Electrical wire resistance:

$$R = (2L/P) / A$$

$$= (2 \times 32 / 1.7 \times 10^{-8}) / 1.5 \times 10^{-6} = 0.25 \Omega$$

4.2.6 Sockets design:

- Special load Assumption:

Device	Power (W)
Fridge	1200
Oven	2000
microwave	700
Dishwasher	1800
Kitchen Hoods	900
Split unit	500
Fan coil	4500

- Special load Calculation:

Second floor

Device	Power (W)
Fridge	1200
Oven	2500
Kitchen Hoods	900

L: max length between socket and electrical distribution bored.

A: Wire cross-sectional area.

P: Copper resistivity = 1.7×10^{-8} .

R: electrical wire resistance.

Power (watt) = I (current) \times V (220 volt) \times power factor (0.9)

$$1200 = I \times 220 \times 0.9 \dots I = 6.06 \text{ A.}$$

$$I_{\text{design}} = I_{\text{load}} \times 1.15^2$$

$$= 6.06 \times 1.15^2$$

$$I_{\text{design}} = 8.014 \text{ A.}$$

From Table 39 Cable cross sectional area = 1 mm^2

For fridge at coffee and sweet corner electrical wire resistance:

$$R = (2L/P)/A$$

$$R = (2L/P) / A$$

$$= (2 \times 1.18 \times 1.7 \times 10^{-8}) / 1.5 \times 10^{-6} = 0.026 \Omega$$

$$\text{Drop voltage} = (I \times R)/220 < 5\%$$

$$= (8 \times 0.026)/220 = 0.009 < 0.05 \text{ it is ok.}$$

Table 40 voltage drop for special lode from spaces

space	special lode device	power	Distance between socket & S.D.B	I lode	I design	wire Cross sectional(mm^2)	R	drop voltage
Coffee and sweet corner	Fridge.	1200	1.18	6.06	8.02	1.5	0.11	0.004
	Oven	2500	3.6	12.63	16.70	2.5	0.20	0.015
	Kitchen Hoods	900	3.6	4.55	6.01	1.5	0.34	0.009
Coffee and sweet corner	Fridge.	1200	1.18	6.06	8.02	1.5	0.11	0.004
	Oven	2500	3.6	12.63	16.70	2.5	0.20	0.015
	Kitchen Hoods	900	3.6	4.55	6.01	1	0.50	0.014
Restaurant	Oven	2500	2	12.63	16.70	2.5	0.11	0.009
	Kitchen Hoods	900	2	4.55	6.01	1	0.28	0.008
	microwave	1000	1	5.05	6.68	1	0.14	0.004
	Fridge.	1200	2	6.06	8.02	1	0.28	0.010
	Dishwasher	2000	5	10.10	13.36	1.5	0.47	0.028

- Special lode for HVAC design:
Design special load of Split unit at offices.

$$\text{Split unit power} = 500 \text{ W.}$$

L: max length between socket and electrical distribution bored.

A: Wire cross-sectional area.

P: Copper resistivity = 1.7×10^{-8} .

R: electrical wire resistance.

Power (watt) = I (current) \times V (220 volt) \times power factor (0.9)

$$500 = I \times 220 \times 0.9 \dots I = 2.52 \text{ A.}$$

$$I_{\text{design}} = I_{\text{load}} \times 1.15^2$$

$$= 2.52 \times 1.15^2$$

$$I_{\text{design}} = 3.33 \text{ A.}$$

From Table 39 Cable cross sectional area = 1 mm^2

For cable of split unit at office1 Electrical wire resistance:

$$R = (2L/P)/A$$

$$R = (2L/P) / A$$

$$= (2 \times 6.1 \times 1.7 \times 10^{-8}) / 1 \times 10^{-6} = 0.2 \Omega$$

Drop voltage = $(I \times R)/220 < 5\%$

$$= (3.33 \times 0.2)/220 = 0.003 < 0.05 \dots \text{Ok}$$

- Normal lode:

$$I_{\text{Normal lode}} = 2 \text{ A}$$

$$\text{Power Normal lode} = 400 \text{ W}$$

$$I_{\text{of the circuit breaker}} = 10 \text{ A}$$

$$\text{No. of sockets that loaded from the circuit breaker load} = 10/2 = 5 \text{ Sockets}$$

Power = I \times V \times power factor

$$400 = I \times 220 \times 0.9 \dots I = 2.02 \text{ A.}$$

$$I_{\text{design}} = I_{\text{load}} \times 1.15^2$$

$$= 2.02 \times 1.15^2$$

$$I_{\text{design}} = 2.67 \text{ A.}$$

From Table 39 Cable cross sectional area = 1 mm²

For cable of split unit at office1 Electrical wire resistance:

$$R = (2L/P)/A$$

$$R = (2L/P) / A$$

$$= (2 \times 2 \times 1.7 \times 10^{-8}) / 1 \times 10^{-6} = 0.068 \Omega$$

$$\text{Drop voltage} = (I \times R) / 220 < 5\%$$

$$= (2.67 \times 0.068) / 220 = 0.008 < 0.05 \dots \text{ok.}$$

4.2.7 circuit breaker:

A circuit breaker is an electrical safety device that shut off current flow when protective relays reveal a fault. Each special load sockets have a special switch in circuit barker

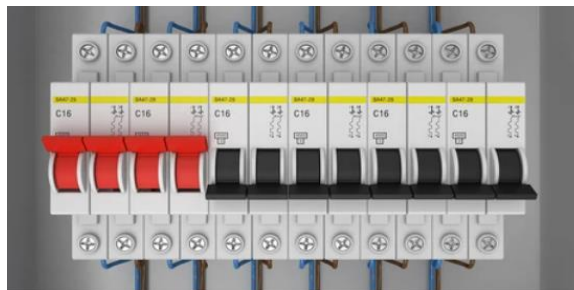


Figure 160 picture for circuit breaker

4.2.8 Demand factor:

The demand factor is always equal to or less than one.

Table 41 demand factor for some appliances

Home Appliances	Power (kW)	Demand factor	Length (m)
Electrical Panel	8.88	0.72	30
LED Lighting	0.15	1.00	15
LED Lighting	0.18	1.00	20
Low Power Home App.	0.90	0.40	35
Low Power Home App.	0.60	0.40	30
Vacuum cleaner / iron	1.00	0.70	18
Electric oven	2.00	0.80	20
Washing machine	1.15	0.75	20
Kitchen equipment	1.56	0.70	25
Dishwasher	1.30	0.80	20
Clothes dryer	1.50	0.75	28
Air cond. outdoor unit	2.00	0.65	38

Table 42 using demand factor

Type	demand factor
Lighting	1
Normal Load	0.4
Special Load	1

Calculation of Demand factor:

Table 43 lighting power

floors	power
Second basement	1716
First basement	1850
Ground floor	5354.4
first floor	5520.6
second floor	6456.6
third floor	5032
fourth floor	5444.6
total power	31374.2

Calculation:

Total power for lighting = total power × demand factor

$$= 31374.2 \times 1 = 31374.2 \text{ W}$$

Total power for normal lode = No. of normal power circuits × Power of socket × DF

$$= 130 \times 400 \times 5 \times 0.4 = 104000 \text{ W}$$

Total power for special lode = (Power of restaurant + Power of sweet corner1 + Power of sweet corner1+ power of office split units) × demand factor

Table 44 Total power for special lode

Space	Device	power	No. of socket	Total power
Coffee and sweet corner	Fridge.	1200	1	1200
	Oven	2500	1	2500
	Kitchen Hoods	900	1	900
Coffee and sweet corner	Fridge.	1200	1	1200
	Oven	2500	1	2500
	Kitchen Hoods	900	1	900

restaurant	Oven	2500	1	2500
	Kitchen Hoods	900	1	900
	Dishwasher	2000	1	2000
	microwave	1000	1	1000
	Fridge.	1200	1	1200
Offices	Split unit	500	9	4500
Total Power				21300

The total power load = lighting load + normal load + special load

$$= 31374.2 + 104000 + 21300 = 156674.2 \text{ W}$$

Total current = Total power / ($\sqrt{3} \times \text{power factor}$)

$$= 156674.2 / (\sqrt{3} \times 220 \times 0.9) = 456.84 \text{ A}$$

Total current for the circuit breaker = $1.15 \times I_{\text{load}} = 1.15 \times 456.84 = 525.366 \text{ A}$.

The cable total current = $1.15 \times I_{\text{C.B}} = 1.15 \times 525.366 = 604.17 \text{ A}$.

4.3 HVAC Design

4.4 Acoustical Design

4.4.1 Introduction

Acoustical performances is one of the main design step that are designed in an integrated manner with the architectural, structural and finishing designing to achieve the human comfort.

4.4.2 Problem definition

The project is a commercial building that contains different functions so it is necessary to ensure that spaces doesn't affect negatively on each other's.

Certain requirements to be achieved:

- The recommended sound pressure level (SPL).
- The acceptable reverberation time (RT60) for each space according to its function.

- The recommended intelligibility.
- The allowable background noises.
- The insulation between sequent spaces by sound transmission class (STC) and impact isolation class (IIC)

4.4.3 Acoustical standards and recommendations

4.4.3.1 The acceptable reverberation time RT(60)

The reverberation time T is defined as the time required, in seconds, for the average sound in a room to decrease by 60 dB after a source stops generating sound. [13]

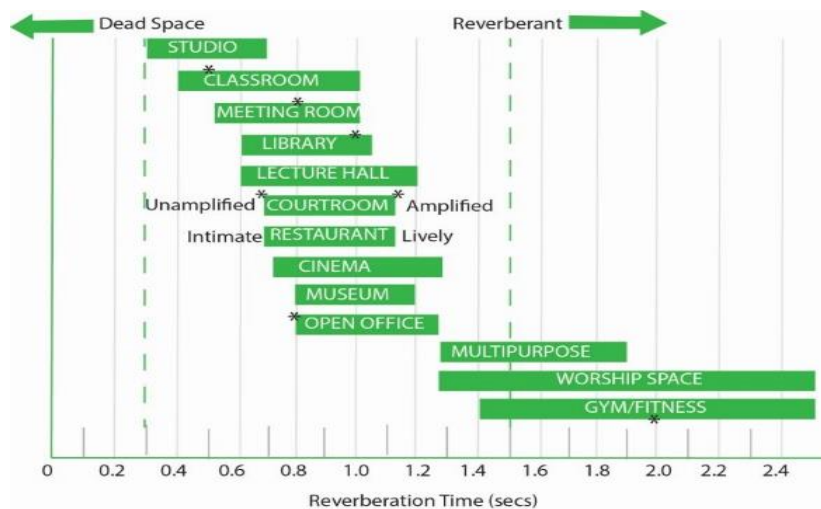


Figure 161 recommended reverberation time for different functions [14]

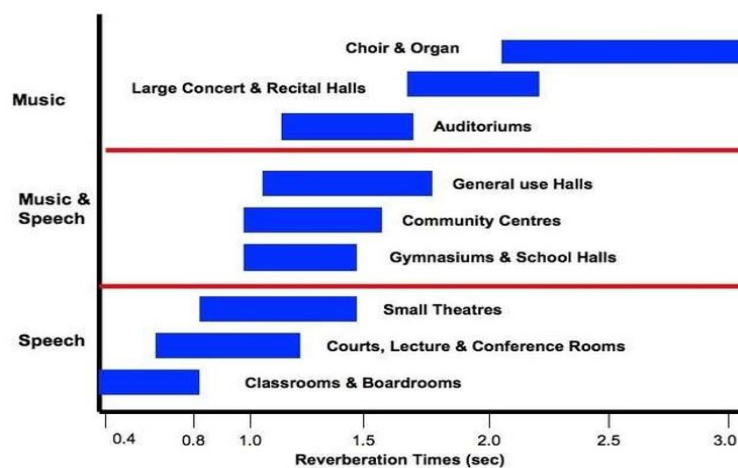


Figure 162 recommended reverberation time for different functions [13]

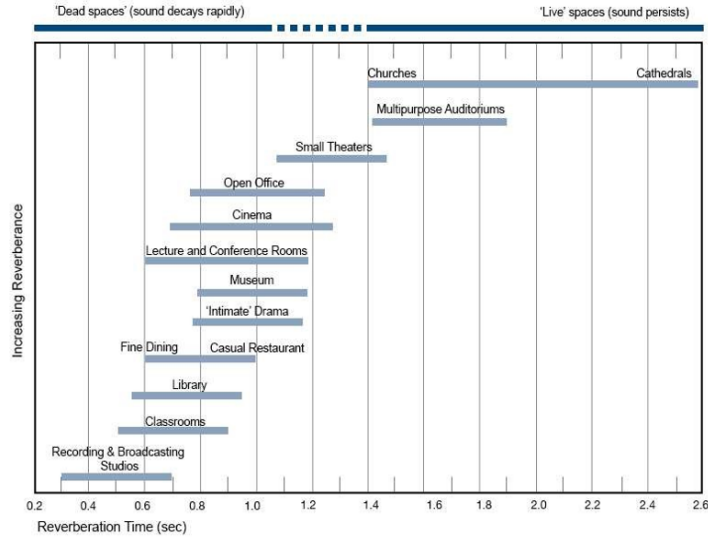


Figure 163 recommended reverberation time for different functions [13]

4.4.3.2 Sound Pressure level (SPL)

The sound pressure level is a logarithmic measure of the effective pressure of a sound relative to a reference value, defined in dB (decibel). [15]

Table 45 SPL for various spaces functions [17]

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

Table 46 SPL for various spaces [16]

Type of room	A-weighted sound pressure level L_{PA} dB(A)	Average reverberation time T in s
Hospital		
- hospital ward at night	30	1
- hospital ward during the day	35	1
- operating room	40	3
- examination room	40	2
- hall, corridor	40	2
Auditoriums		
- radio studio	15	1
- television studio	25	1,5
- concert hall	25	2
- opera house	25	1,5
- theatre	30	1
- cinema	35	1
- lecture hall	35	1
- reading hall	35	1
- seminar room	40	1
- school classroom	40	1
Offices		
- conference room	35	1
- relaxation room	35	0,5
- break room	40	0,5
- small office	40	0,5
- open-plan office	45	0,5
Church	35	3
Museum	40	1,5
Counter hall	45	1,5
Computer room	45	1,5
Laboratory	50	2
Sports hall	45	1,5
Swimming pool	50	2
Restaurant	40 bis 55	1
Kitchen	45 bis 50	1,5
Salesroom	45 bis 50	1

4.4.3.3 Noise level and noise reduction

Table 47 noise level and noise reduction for different spaces [18]

ROOM / SPACE	DBA	NR	NC/NCB	RC/RCM2
Theaters, Concert Halls, Recording Studios	25-30	20	10-20	20
Bedrooms, Libraries, Religious Prayer Rooms	25-30	25	20-25	25
Living Rooms, Classrooms, Lecture Halls, Conference Rooms	30-35	30	30-40	30
Offices, Courtrooms, Private Work Rooms	40-45	35	30-40	35
Corridors, Open Offices, Bathrooms, Toilet Rooms, Reception, Lobbies, Shopping	45-55	40	40-40	40
Kitchens, Shopping, Common Spaces, Dining Halls, Computer Rooms, Workshops	45-55	45	40-50	45

Table 48 suggested noise criteria for different spaces [20]

Type of Space (and Acoustical Requirements)	NC Curve	Equivalent* 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.	—	—

Source: Extracted with permission from E. B. Magrab, *Environmental Noise Control*, Wiley, New York, 1975.

*For information only. These data are not part of the NC information and do not appear in the source.

Table 49 recommended background noise criteria [19]

CATEGORY OF SPACE	SPECIFIC USES	NC, NCB OR RC(N) RANGE	dBA LIMIT
Sensitive listening spaces	Broadcast and recording studios, concert halls	15 to 20	25 dBA
Performance spaces	Theaters, churches, video and teleconferencing	20 to 25	30 dBA
Presentation spaces	Large conference rooms, small auditoriums, movie theaters, courtrooms, meeting and banquet rooms, executive offices	25 to 30	35 dBA
Private spaces	Offices, small conference rooms, classrooms, private residences, hospitals, hotels, libraries	30 to 35	40 dBA
Public spaces	Restaurants, lobbies, open-plan offices, clinics	35 to 40	45 dBA
Service and support spaces	Computer equipment rooms, public circulation areas, arenas, convention centers	40 to 45	50 dBA

Figure 3 of 3 - Figure 2: Recommended background noise criteria for common spaces. For more information, consult the Springer Handbook of Acoustics, edited by Thomas Rossing and published in 2014. Table © Springer Handbook of Acoustics

4.4.3.4 Sound transmission loss (STC)

Sound transmission loss (STC) is classification of sound isolation of a building wall assembly, that indicator how much the sound can pass from space by air-borne in the partitions and access to spaces that have similar air-borne.

Table 50 recommended STC level for various spaces [14]

Target STC		
Adjacencies		STC
Hotel Room	Hotel Room	55
	Corridor	50
Residence (Apartment or Condo)	Residence (Apartment or Condo)	50
	Corridor	50
Residence or Hotel	Retail	60
Retail	Retail	50
Standard Office	Standard Office	45
Executive Office	Executive Office	50
Conference Room	Conference Room	50
	Admin, Admissions	45
Office or Conference Room	Corridor	50
Mechanical Room	Occupied Area	60
Movie Theater	Movie Theater	65
Hospital Room	Hospital Room	45
	Classroom, Corridor, or Classroom	50
Classroom	Restroom	53
	Electrical or Mechanical Room	60
	Dining, Corridor	60
Music Drama	Restroom	53
Entry	Teachers Support or Waiting Rooms	45

Table 51 recommended values for STC [20]

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

4.4.3.5 Impact insulation class (IIC)

Impact Insulation Class (IIC) is a classification to the ability of a floor-ceiling assembly to block impact/structure-borne noise from transmitting to the spaces below

Table 52 recommended values for IIC for various spaces functions [14]

Target IICs	
Application	IIC Rating Rqmts
Hotels	55+
Apartments	50+
Condos (depending on level of luxury)	50-60+
Offices/Commercial	40
Schools (ancillary and core learning spaces)	40-45

Table 53 recommended values for IIC between spaces [20]

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

Table 54 recommendation values for some spaces [20]

Space	RT60	SPL (dB)	NR (dB)	Noise level (dB)
Restaurants	0.7 - 1.2	40-55	45	40- 50
Commercial function (stores)	1-1.7	45-50	45	40-50
Open Offices	0.8 - 1.3	45	40	40
Kids playing hall	1-1.5	45	45	40-50

4.4.4 Acoustical software results

- RT60

Open Office

Edit Room Data \ GP Office - EASE 4.3

Reverb. Time

Formula : Eyring

Locked

Interpolate

Desired [s] : 0.00

Air Parameters

Humidity : 60 %

Temperature : 20 °C

Pressure : 1013 hPa

Rev. Time	Absorp. Coe
100 Hz	81.77
125 Hz	81.50
160 Hz	87.49
200 Hz	93.98
250 Hz	100.91
315 Hz	120.03
400 Hz	144.34
500 Hz	172.77
630 Hz	150.00
800 Hz	122.66
1000 Hz	94.47
1250 Hz	67.18
1600 Hz	46.31
2000 Hz	31.14
2500 Hz	20.59
3150 Hz	13.40
4000 Hz	8.62
5000 Hz	5.51
6300 Hz	3.51
8000 Hz	2.22
10000 Hz	1.40

Recompute Apply Ok Cancel

Restaurant

Edit Room Data \ GP Restaurant - EASE 4.3

Reverb. Time

Formula : Eyring

Locked

Interpolate

Desired [s] : 0.00

Air Parameters

Humidity : 60 %

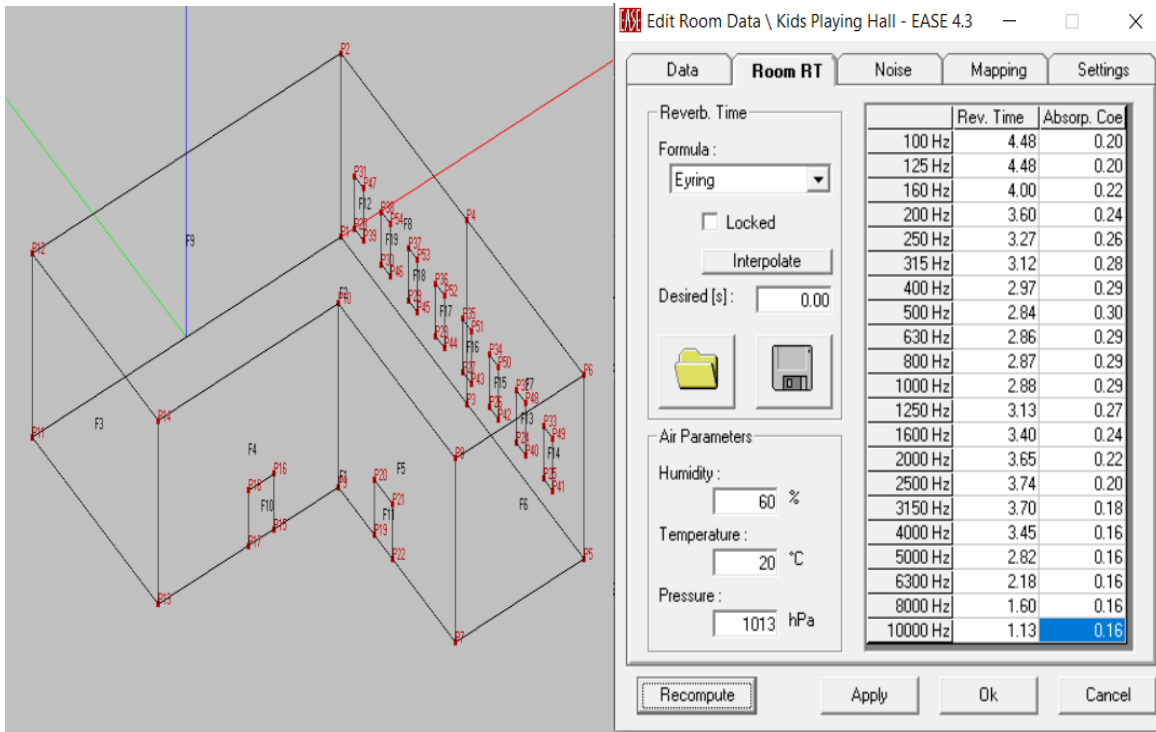
Temperature : 20 °C

Pressure : 1013 hPa

Rev. Time	Absorp. Coe
100 Hz	10.02
125 Hz	10.02
160 Hz	9.44
200 Hz	8.91
250 Hz	8.43
315 Hz	7.55
400 Hz	6.80
500 Hz	6.17
630 Hz	5.81
800 Hz	5.47
1000 Hz	5.13
1250 Hz	4.94
1600 Hz	4.71
2000 Hz	4.42
2500 Hz	4.13
3150 Hz	3.74
4000 Hz	3.25
5000 Hz	2.68
6300 Hz	2.09
8000 Hz	1.56
10000 Hz	1.11

Recompute Apply Ok Cancel

Kids playing hall



4.4.5 Using Material for space elements

Each type of material has different absorption coefficient what influences on acoustics values.

- Absorption coefficient [24]

Table 55 Absorption coefficient for using material

Element	Finishing material	Absorption coefficient					
		125 Hz	250Hz	500 Hz	1000Hz	2000 Hz	5000 Hz
Ceiling	Gypsum plaster tiles, 17% perforated, 22mm	0,45	0,70	0,80	0,80	0,65	0,45
Floor	Tile floor	0,15	0,11	0,10	0,07	0,06	0,07
	Rubber floor	Rubber with 920kg/m ³ density and 4mm thickness					
Door	Wood hollow core door	0,30	0,25	0,15	0,10	0,10	0,07

	Glass 4mm	0,30	0,30	0,20	0,10	0,07	0,05
Window	Double glazing, 2-3mm glass, 10mm air gap	0,15	0,05	0,03	0,03	0,02	0,02
wall	plaster	0,04	0,05	0,06	0,08	0,04	0,06
Wall	Glass 4mm	0,30	0,20	0,10	0,07	0,05	0,02

4.4.6 Structural Elements design acoustically

- Floor

Restaurant, stores and kids playing hall floor



Figure 164 restaurant and kids playing hall floor

Figure 164 shown Impact insulation class (IIC) for restaurant and kids playing hall equal 95, the value is critical for restaurant and kids playing hall where there is a heavy movement.

- Ceiling
Office ceiling

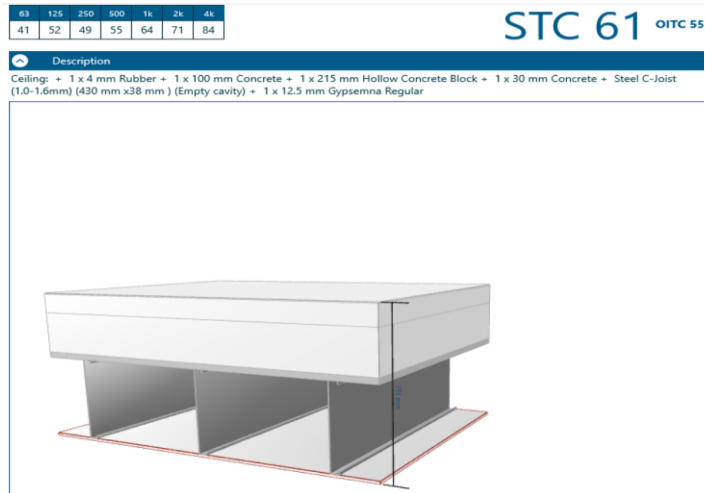


Figure 165 STC for Office ceiling

Figure 165 shown the Sound transmission loss (STC) for office ceiling equal 61 acceptable.

- Walls
Office adjacent to office/toilet

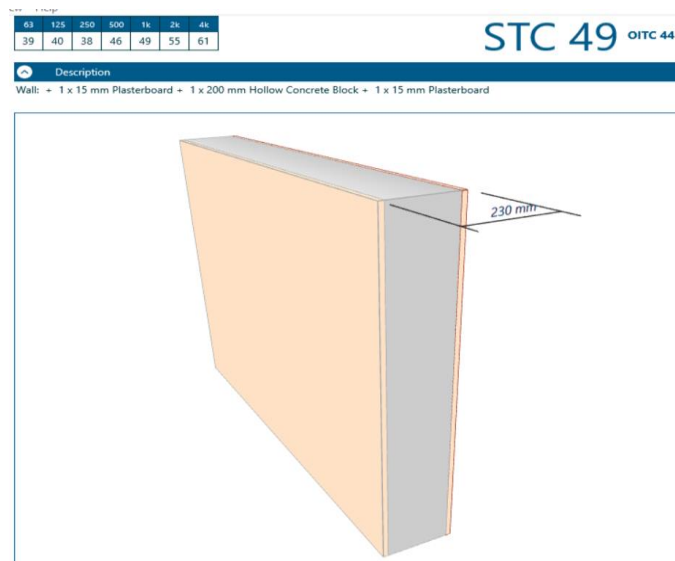


Figure 166 STC wall office-office/toilet

Figure 166 shown the Sound transmission loss (STC) for wall between adjacent office equal 49 the recommended STC for Office adjacent to office is 45(normal)-50(quiet) and Office adjacent to toilet is 47(normal)-50(quiet).

Office adjacent to lobby wall

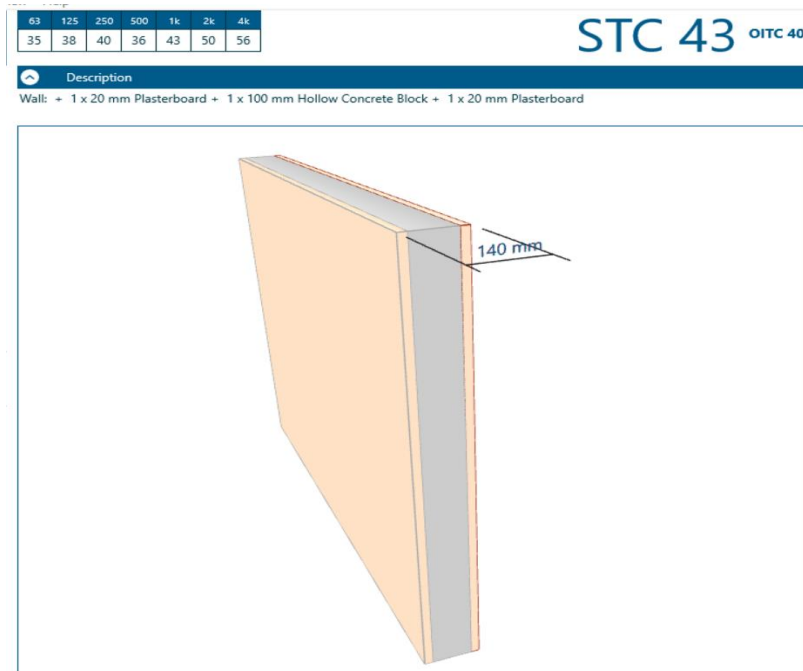


Figure 167 STC for wall between Office and lobby/corridor wall

Figure 167 shown the Sound transmission loss (STC) for wall between office and lobby/corridor equal 43 the recommended STC for Office adjacent to lobby/corridor is 42(normal)-45(quiet)

4.5 Fire alarm and Fire Fighting System

4.5.1 Introduction

A firefighting system is designed for prevention during a fire spread in building, using of proper fire safety equipment such as fire monitors, extinguisher, nozzles, hose pipes and hose reels. It is aim to protect human life and property.

There are five common types of fire protection systems:

- Water-Based Fire Suppression Systems
- Chemical Foam Suppression Systems
- Pneumatic Heat Detection Tube
- Pressurized Gas System
- Foam Deluge Systems

4.5.2 Design for the system

The choice of fire system in the building depends on the interior spaces function and their users.

Table 56 shown the fire suppression systems that used for various spaces in the building.

Table 56: fire suppression systems for various spaces.

Type of spaces	Used fire suppression system	Fire detector system
Kids playing hall	Fire extinguisher(class A),Water sprinkler	Smoke detector
Restaurant and café shop	Fire extinguisher (class K) ,Water sprinkler	Heat detector
offices	Fire extinguisher (class A) ,Water sprinkler	Smoke detector
retail store	Fire extinguisher(class A),Water sprinkler	Smoke detector
Corridor	Water sprinkler , Hose station, Fire extinguisher (class A)	Smoke detector
Parking	Water sprinklers, Fire extinguisher (class A)	Heat detector
Electrical room.	CO ₂ sprinkler, fire extinguisher (class C)	Smoke detector

Transformer room	CO ₂ sprinkler, fire extinguisher (class C)	Smoke detector
------------------	--	----------------

4.5.3 Sprinklers

A sprinkler system is made up of pipes along a ceiling that contain water under pressure, with an extra source of water for a constant flow. It's connected to the pipes, automatic sprinklers and are placed at specific locations. In case of fire, a seal in the sprinkler head ruptures at a pre-established temperature, and a steady stream of water flows.

Type of sprinkler system:

- Dry Pipe Fire Sprinkler System
- Wet Pipe Fire Sprinkler System
- Pre-Action Fire Sprinkler System
- Deluge Fire Sprinkler System

4.5.3.1 Sprinkler distribution and design process

There are rules should take into consideration when designing fire sprinklers to ensure the efficacy of the system:

- Minimum Distance Between Sprinklers is 1.8m
- Maximum Distance from Wall equal to half of the maximum distance between sprinkler heads.
- Maximum area covered by sprinkler equal 20.9m²

Table 57 shown Protection Areas and Maximum Spacing for CMSA (Control Mode Specific Application) Sprinklers

Table 57 Protection Areas and Maximum Spacing for CMSA (Control Mode Specific Application) Sprinklers

Construction Type	Protection Area		Maximum Spacing	
	ft ²	m ²	ft	m
Noncombustible unobstructed	130	12.1	12	3.7
Noncombustible obstructed	130	12.1	12	3.7
Combustible unobstructed	130	12.1	12	3.7
Combustible obstructed	100	9.3	10	3.1
Rack storage applications	100	9.3	10	3.1

Table 58 shown the maximum allowable protection area of coverage for sprinklers for ordinary Hazard occupancies

Table 58 the maximum allowable protection area of coverage for sprinklers for ordinary Hazard occupancies

Construction Type	System Type	Protection Area		Spacing (maximum)	
		ft ²	m ²	ft	m
All	All	130	12.1	15	4.6

Table 59 shown the maximum allowable protection area of coverage for sprinklers for Light Hazard occupancies [21]

Table 59 the maximum allowable protection area of coverage for sprinklers for Light Hazard occupancies [21]

Table 8.6.2.2.1(a) Protection Areas and Maximum Spacing (Standard Spray Upright/Standard Spray Pendent) for Light Hazard

Construction Type	System Type	Protection Area		Spacing (maximum)	
		ft ²	m ²	ft	m
Noncombustible obstructed and unobstructed and combustible unobstructed with members 3 ft (0.91 m) or more on center	Pipe schedule	200	18.6	15	4.6
Noncombustible obstructed and unobstructed and combustible unobstructed with members 3 ft (0.91 m) or more on center	Hydraulically calculated	225	20.9	15	4.6
Combustible obstructed with members 3 ft (0.91 m) or more on center	All	168	15.6	15	4.6
Combustible obstructed or unobstructed with members less than 3 ft (0.91 m) on center	All	130	12.1	15	4.6
Combustible concealed space under a pitched roof having combustible wood joist or wood truss construction with members less than 3 ft (0.91 m) on center with slopes having a pitch of 4 in 12 or greater	All	120	11.1	15 parallel to the slope 10 perpendicular to the slope*	4.6 parallel to the slope 3.05 perpendicular to the slope*

*Where the dimension perpendicular to the slope exceeds 8 ft (2.4 m), the minimum pressure shall be 20 psi (1.4 bar).

Table 60 shown the maximum allowable protection area of coverage for sprinklers for high Hazard occupancies [21]

Table 60 the maximum allowable protection area of coverage for sprinklers for high Hazard occupancies [21]

Construction Type	System Type	Protection Area		Spacing (maximum)	
		ft ²	m ²	ft	m
All	Pipe schedule	90	8.4	12	3.7
				[In buildings with storage bays 25 ft (7.6 m) wide, 12 ft 6 in. (3.8 m) shall be permitted.]	
All	Hydraulically calculated with density ≥ 0.25	100	9.3	12	3.7
				[In buildings with storage bays 25 ft (7.6 m) wide, 12 ft 6 in. (3.8 m) shall be permitted.]	
All	Hydraulically calculated with density < 0.25	130	12.1	15	4.6

Table 61 shown the maximum allowable protection area of coverage for sprinklers for high piled storage [21]

Table 61 shown the maximum allowable protection area of coverage for sprinklers for high piled storage [21]

Construction Type	System Type	Protection Area		Spacing (maximum)	
		ft ²	m ²	ft	m
All	Hydraulically calculated with density ≥ 0.25	100	9.3	12	3.7
				[In buildings with storage bays 25 ft (7.6 m) wide, 12 ft 6 in. (3.8 m) shall be permitted.]	
All	Hydraulically calculated with density < 0.25	130	12.1	15	4.6

Table 62 coverage area for sprinklers according hazard classification.

Hazard classification	coverage area m ²	maximum distance m
High hazard	9	3.6
medium hazard	12	3.9
low hazard	21	4.6

- Parking floors:

Table 63 Number of sprinkler for parking floors.

spaces	space area	hazard classification	Max. coverage area per sprinkler (m ²)	# of sprinkler
first parking	1283	low hazard	21	61
second parking	1435	low hazard	21	68

- Ground floor:

Table 64 Number of sprinkler for ground floor.

spaces	space area	hazard classification	Max. coverage area per sprinkler (m ²)	# of sprinkler
retail Store	491.8	medium hazard	12	41

Electronic Store	182.8	medium hazard	12	15
store	31.5	medium hazard	12	3
Entrance and circulation	337	low hazard	21	10

- First floor:

Table 65 Number of sprinkler for First floor.

spaces	space area	hazard classification	Max. coverage area per sprinkler (m2)	# of sprinkler
retail Store	491.8	medium hazard	12	41
fashion store	182.8	medium hazard	12	15
store	31.5	medium hazard	12	3
store	8.7	medium hazard	12	1
store	8.7	medium hazard	12	1
store	8.7	medium hazard	12	1
Entrance and circulation	212.6	low hazard	21	10

- second floor:

Table 66 Number of sprinkler for second floor.

spaces	space area	hazard classification	Max. coverage area per sprinkler (m2)	# of sprinkler
fashion store	201	medium hazard	12	17
store	215.6	medium hazard	12	18
shoes store	67	medium hazard	12	6
fashion store	90.6	medium hazard	12	8
bag and shoes store	104.9	medium hazard	12	9
store	14	medium hazard	12	1
coffee and sweet corner	18	medium hazard	12	2
Entrance and circulation	212.6	low hazard	21	10

- third floor:

Table 67 Number of sprinkler for third floor.

spaces	space area	hazard classification	Max. coverage area per sprinkler (m2)	# of sprinkler
office1	53.6	low hazard	21	3
office2	71.4	low hazard	21	3
office3	49.4	low hazard	21	2
office4	49.7	low hazard	21	2
office5	58	low hazard	21	3
office6	79.3	low hazard	21	4
office7	47	low hazard	21	2
office8	60.9	low hazard	21	3
office9	32.6	low hazard	21	2
office10	53.1	low hazard	21	3
office11	39.8	low hazard	21	2
office12	52.2	low hazard	21	2
office13	84	low hazard	21	4
office14	50	low hazard	21	2
Entrance and circulation	212.6	low hazard	21	10

- fourth floor:

Table 68 Number of sprinkler for fourth floor.

spaces	space area	hazard classification	Max. coverage area per sprinkler (m2)	# of sprinkler
kids playing hall	422	medium hazard	12	35
fast food restaurant	105	medium hazard	12	9
kitchen	24	medium hazard	12	2
store	14	medium hazard	12	1

coffee and sweet corner	18	medium hazard	12	2
Terus	123	medium hazard	12	10
Entrance and circulation	260	low hazard	21	12

4.5.3.2 The piping size

Piping Network system consist of pipes and trenches which supply suitable quality and quantity water to end users. The piping network design have to be carefully prepared for make sure that there is enough flow pressure to supply hygienically safe water. Once piping network construction done, it should be inspected, tested and maintained regularly.



Figure 168 sprinkler pipes

Table 69 shown Pipe sizes shall be in accordance for Light Hazard Pipe Schedules

Table 69 light hazard pipe sizes [21]

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.	30 sprinklers	2½ in.	40 sprinklers
3 in.	60 sprinklers	3 in.	65 sprinklers
3½ in.	100 sprinklers	3½ in.	115 sprinklers
4 in.	See Section 8.2	4 in.	See Section 8.2

For SI units, 1 in. = 25.4 mm.

Table 70 shown Pipe sizes shall be in accordance for ordinary Hazard Pipe Schedules (which used at project).

Table 70 ordinary hazard pipe sizes [21]

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

For SI units, 1 in. = 25.4 mm.

Table 71 shown pipe sizes shall be in accordance for extra Hazard Pipe Schedules

Table 71 extra hazard pipe sizes [21]

Steel		Copper	
1 in.	1 sprinkler	1 in.	1 sprinkler
1¼ in.	2 sprinklers	1¼ in.	2 sprinklers
1½ in.	5 sprinklers	1½ in.	5 sprinklers
2 in.	8 sprinklers	2 in.	8 sprinklers
2½ in.	15 sprinklers	2½ in.	20 sprinklers
3 in.	27 sprinklers	3 in.	30 sprinklers
3½ in.	40 sprinklers	3½ in.	45 sprinklers
4 in.	55 sprinklers	4 in.	65 sprinklers
5 in.	90 sprinklers	5 in.	100 sprinklers
6 in.	150 sprinklers	6 in.	170 sprinklers

For SI units, 1 in. = 25.4 mm.

Table 72 number of sprinklers above and below a ceiling [21]

Steel		Copper	
1 in.	2 sprinklers	1 in.	2 sprinklers
1¼ in.	4 sprinklers	1¼ in.	4 sprinklers
1½ in.	7 sprinklers	1½ in.	7 sprinklers
2 in.	15 sprinklers	2 in.	18 sprinklers
2½ in.	30 sprinklers	2½ in.	40 sprinklers
3 in.	60 sprinklers	3 in.	65 sprinklers

For SI units, 1 in. = 25.4 mm.

4.5.3.3 Fire hose station

The fire hose station is the location of a fireplug and associated equipment. It located to provide a reasonably accessible and controlled supply of water to combat a potential fire risk. A control nozzle attached to the end of the hose enables the operator to control the direction and flow of water to the fire.

The fire hose station coverage 400 m² area and 25m distance.

Floor	Area (m)	Number of fire hose station
Second Parking	1283	4
First Parking	1435	4
Ground Floor	1097	3
First Floor	1097	3
Second Floor	1127	3
Third Floor	1127	3
Fourth Floor	1127	3
Total number of fire hose station		23



Figure 169 fire hose station

4.5.3.4 Fire tank

Fire-fighting tanks are water storage containers that provides water to a fire pump. According to their manufacturing standards and use they can be of different types. The size of the tank is determined by the flow and duration requirements of the systems the tank is supplying.

Fire-fighting tanks can have different shapes and manufactures with a wide range of materials.

The size of the water tank in the building supplied for fire fighting purposes shall depend on the degree of severity:

Table 73 the degree of risk with how long a fire network has to operate until civil defense arrives [22]

degree of severity	Time(min)
Light hazard	30-60
Ordinary hazard	60-90
High hazard	90-120

Formula for calculating the volume of fire water tank [22]

$$V = (QT \times 3.785 \times T) / 1000$$

QT= Total flow rate

V= capacity of tank

T= duration time according to hazard

4.5.3.5 Water tank fire capacity

- Water tank fire capacity for sprinkler system

Sample of calculation:

$$1\text{m}^3 = 264.17 \text{ gallons}$$

Sprinkler system flowrate per area according to ordinary hazard = 0.1 gpm/m²

Ground floor Area assumed as fire zone = 992 m²

$$\text{Total capacity} = 0.1 \times 992 = 99 \text{ gpm}$$

$$99 \times 60 \text{ mins} = 5941 \text{ gallons}$$

$$\text{Total storage tank volume for ground floor} = 23 \text{ m}^3$$

Table 74 Total storage tank volume for building from sprinkler.

Floor	Area(m2)	Total capacity	Total volume(gal)	Total volume(m ³)
second basement	1283	128.3	7698	29.1
first basement	1435	143.5	8610	32.6
ground floor	992	99.2	5952	22.5
first floor	992	99.2	5952	22.5
second floor	992	99.2	5952	22.5
third floor	992	99.2	5952	22.5
fourth floor	992	99.2	5952	22.5

total water tank volume	174.4
-------------------------	-------

- Water tank fire capacity for fire hose station

Duration time according to ordinary hazard = 60-90 min

Number of fire hose station = 23

Fire hose station flow rate = 5 gpm.

Total volume required = total flow rate × number of FHS × duration time

Total volume required = $5 \times 23 \times 60 = 6900$ gallons.

Total storage tank volume = 26 m³.

Total storage tank volume for building = water tank volume for sprinkler + fire hose station Total tank volume = $175 + 23 = 198$ m³.

4.6 Water Supply

4.6.1 Introduction

Water supply systems are one of the most significant infrastructure buildings. The primary purpose of Water supply systems is to supply suitable quality and quantity water to end users. Water must be delivered in sufficient quantity and at acceptable pressure

There are two types of water supply:

- Gravitational water supply system
- Pressure water supply system

4.6.2 Water supply system standards

- Water consumption:

Table 75 water consumption value

Space	Water consumption:
Commercial building	190 L/year [22]
Restaurant(employee)	80 L/day/employee [23]
restaurant(seat)	20 L/day/seat [23]
Offices	15 L/day

Table 75 table shown values of water consumption that taken from previous studies that carried out by researchers in a group of similar buildings.

4.6.3 Water consumption for the building

Commercial

Table 76 water consumption for commercial function daily

Function of the space	Total area (m ²)	Total water consumption (L)
Commercial	3437	1818

Offices

Table 77 water consumption for office daily

Function of the space	No. of users	Avg consumption L/person/ day	Total water consumption (L)
Offices	195	15	2925

Restaurant

Table 78 water consumption for users in restaurants daily

Function of the space	No. of seats /employee	Avg consumption L/person/ day	Total water consumption (L)
Restaurants(users)	112	20	2240
Restaurants(employee)	10	80	800

Total water consumption = 7783 L

The required amount of water for this building about 8 m³ daily.

The municipality pumping water every 5-6 days and to ensure that water will never run out at a non-pumped day, roof tanks will be placed on the roof to store water at least 7 days.

Table 79 Tank size for each owned space

Owned spaces	Tank volume (L)	Size of tank (m ³)
Office 1	1000	1
Office 2	1000	1
Office 3	1000	1
Office 4	1000	1
Office 5	1000	1
Office 6	1000	1
Office 7	1000	1
Office 8	1000	1
Office 9	1000	1
Fast Food restaurant	1000	1
Sweet and coffee shop 1	1000	1
Sweet and coffee shop 1	1000	1
Commercial function	1818	2 tank 1m ³ for each one
Storage Tank for 7 days at least	54481	36 tank 1.5m ³ for each one

The needed number of tank is 36 Tank with 1.5m³ volume and 14 Tank with 1m³



Figure 170 one cubic meter roof tank



Figure 171 one cubic meter roof tank

4.6.4 Piping design

4.6.4.1 Introduction

Piping Designs is a crucial element in engineering projects design. Piping system consist of pipe, pipe fittings, flanges, Pumps, heat exchanges, valves and tanks.

Types of plumbing pipe materials:

- copper
- Galvanized steel
- Polyvinyl chloride (PVC)
- Acrylonitrile butadiene styrene (ABS)
- Cross-linked polyethylene (PEX)
- Chlorinated polyvinyl chloride (CPVC)

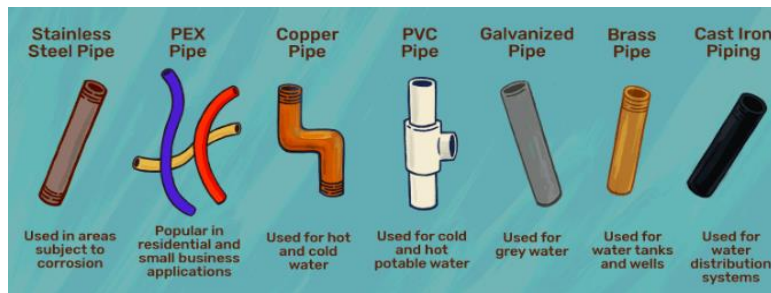


Figure 172 Types of Pipes Are Used for Underground Water Supply Lines

4.6.4.2 Design standards and recommendations

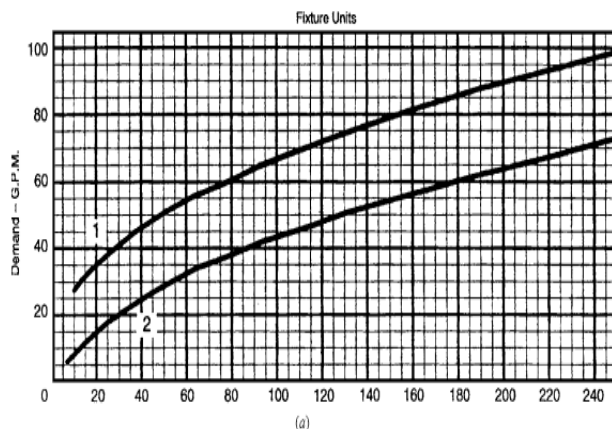


Figure 173 water supply fixture units: (a) I-P units [20]

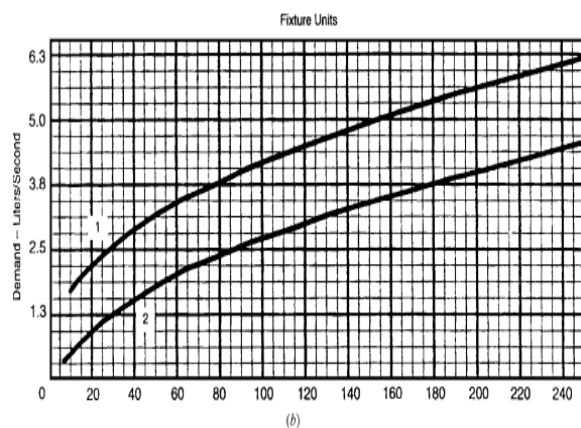


Figure 174 water supply fixture units: (a) SI units [20]

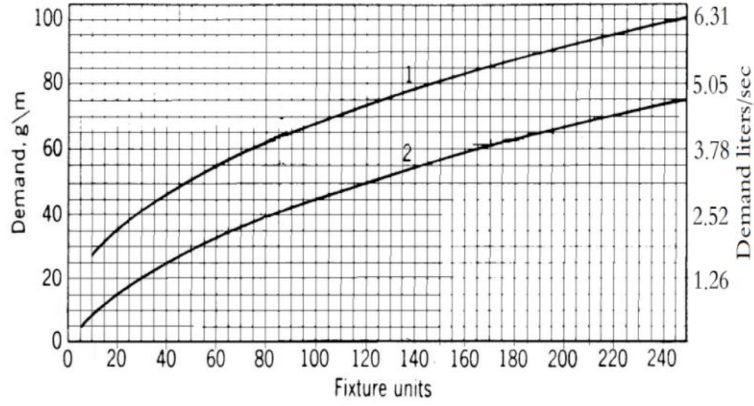


Figure 175 water flow in pipes

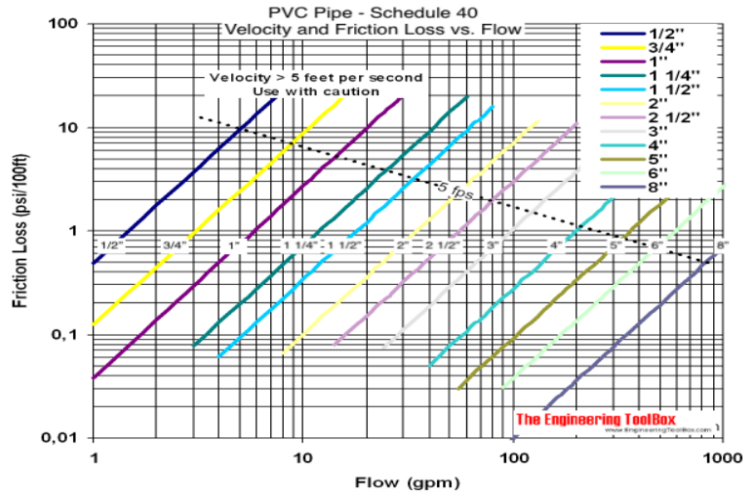


Figure 176 Friction loss in PVC pipes [25]

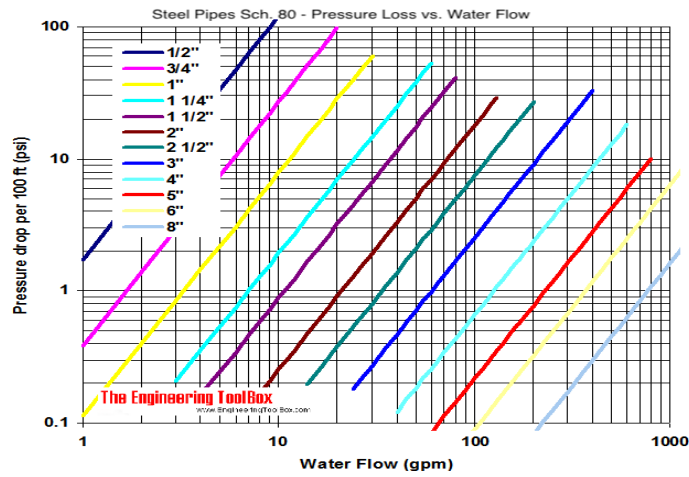


Figure 177 Friction loss in Steel pipes [25]

Table 80 Water Supply Fixture Units (WSFU) [20]

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.	$\frac{3}{8}$ 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	$\frac{3}{4}$ in. (19 mm) flush valve	5		5
Urinal	Public	Flush tank	3		3
Washing machine, 8 lb (3.6 kg)	Private	Automatic	1	1	1.4
Washing machine, 8 lb (3.6 kg)	Public	Automatic	2.25	2.25	3
Washing machine, 15 lb (6.8 kg)	Public	Automatic	3	3	4
Water closet	Private	Flush valve	6		6
Water closet	Private	Flush tank	2.2		2.2
Water closet	Public	Flush valve	10		10
Water closet	Public	Flush tank	5		5
Water closet	Public or private	Flushometer tank	2		2

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

Table 81 recommendation designed for PVC and steel pipes

	Steel Pipe	PVC Pipe
Water Line	Using for vertical water lines	Using for other water lines
Maximum velocity in pipe	10 ft./s	5 ft./s
The equivalent pipe length	1.5× actual length	1.2×actual length

- The water pressure from the municipal 30 psi
- The minimum pressure should arrive to each unit 8 psi

4.6.4.3 Calculation of the flow in the pipes from fixture units

The load values in WSFU for each fixture unit

space	fixture unit	Occupancy	Type of Supply Control	FU value	numbers of sanitary units	Total FU
Kitchen	Kitchen sink	Private	Faucet	1.4	1	1.4
Toilet	water closet	Public	Flush tank	5	1	5
	Lavatory	Public	Faucet	2	1	2
	Bidet	Private	Faucet	2	1	2

4.6.4.4 Calculations for pipes sizing

Sample of calculations for the critical loop (the higher flow and longest lines)

First basement floor

fixture unit	Occupancy	Type of Supply Control	FU value	numbers of sanitary units	Total FU
water closet	Public	Flush tank	5	1	5
Lavatory	Public	Faucet	2	1	2
Bidet	Private	Faucet	2	1	2
Total FU					9

Line type	vertical	horizontal	critical
NO. of FUs	9	9	5
water flow (gpm)	7.5	7.5	5

4.7 Green roof:

4.7.1 Introduction [26]

The buildings occupies the world!

With increasing of population, the need for more housing build on green land areas increase which lead to deterioration of the natural vegetation. That's where a green roof came in.

A green roof is a wonderful way to create an attractive design feature, not only that, it have more benefits such as improve the performance of the roof, extend the roof life, cutting energy costs, improving air quality in particular in urban areas and have a positive environmental impact where it attracting wildlife like insects and birds.

Type of green roof:

1- Extensive green roofs

The common choice for homeowners both existing and new build, it is lightweight and require a little maintenance without requiring additional watering. It has a height around 80 - 100mm low layer of vegetation like grass, moss, sedum or small flowers. Sedum green roofs are the commonest type in view of it is hardiness and low maintenance requirements of the plant.

2- Intensive green roofs

Define as roof gardens where it support a wider variety of plants like bushes and small tree. It is common in larger commercial projects where recreational use is expected. it require medium layer of soil and need more deeper substrates, What it is mean additional weight on building that requires supported . This type need more attention and maintenance.

3- Semi-extensive green roof

This type rests on the extensive roof principles. With 100 – 200 mm growing substrate depth. It support a greater diversity.

- Intensive green roof need Typical maintenance:
 - 1- Weeding and removal of unwanted vegetation;
 - 2- Cutting and trimming;
 - 3- Preventative measures to protect plants from pests and diseases;

- 4- Fertilization;
- 5- Watering

- Irrigations system:
 - 1- Spray irrigation
 - 2- Rotors irrigation
 - 3- Drip irrigation

- Types of drainage patterns:
 - 1- Dendritic drainage
 - 2- Trellis drainage
 - 3- Radial drainage.



Figure 178 Chicago City Hall Green Roof

4.7.2 Project Problem and Objectives

Studying, analyzing and design a green roof for Sameer Shanaa Mall, in term of: [27]

- Improve the drainage system.
- Increase the lifespan of the roof.
- Boosting thermal and acoustical performance.
- Helping out the environment CO₂.

- Supporting wildlife habitats.
- Aiding air quality.

4.7.3 Methodology

This project will be implemented in several stages, at first the data and information will be collected for green roof to understand the nature of the project. Then research and collect international specifications and required data to design the green roof for Sameer Shanaa Mall, environmental, structural and mechanical design, based on internationally accredited scientific references and conduct a case study and analyze it to know the design criteria for this green roof.

4.7.4 Standards

There are no specific design standards for green roof systems,

Green roof system components:

Green roof over Metal deck:

- metal deck;
- thermal barrier (if required by code);
- rigid insulation;
- waterproofing membrane;
- drainage composite;
- growing medium;
- vegetation

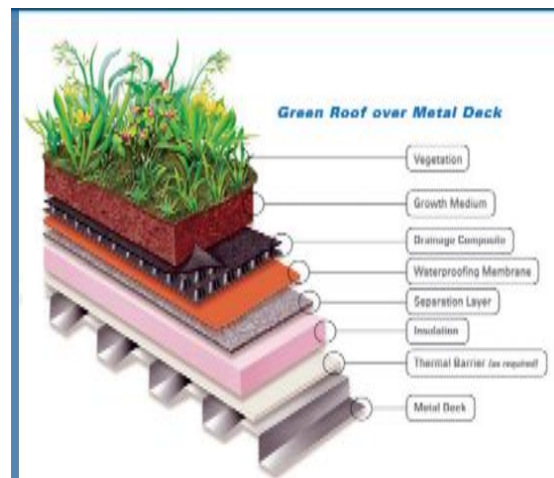


Figure 179 Green roof system components over a Metal deck [29]

Green roof over Metal deck:

- structural concrete deck
- leveling layer (if required by membrane manufacturer)
- Waterproofing membrane;
- protection/drainage layer (optional);

- XPS insulation;
- drainage composite
- growing medium
- Vegetation

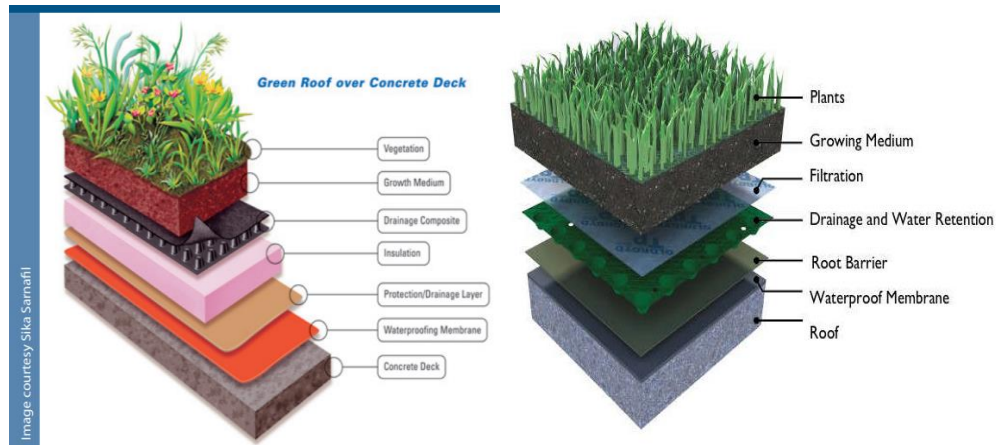


Figure 180 Green roof system components over a concrete deck [29]

Table 82 plant type and min growing medium depth [28]

Plant type	Minimum growing medium depth	Green roof type
Sedums	25 mm to +75 mm (1 in. to +3 in.)	Extensive
Groundcovers and grasses	150 mm to +250 mm (6 in. to +10 in.)	Extensive/intensive
Shrubs	450 mm to +600 mm (18 in. to +24 in.)	Intensive
Large shrubs and small trees	600 mm to +900 mm (24 in. to +36 in.)	Intensive
Trees	+900 mm (+36 in.)	Intensive

Table 82 shown a rule of thumb guideline for general spaces and green roof types [29]

Table 83 Extensive vs intensive green roofs [29]

Type of green roof	Plants Types	Maintenance	layer shallow (mm)	Thickness (m)	Fully saturated weight (Kg/m ²)
Extensive	Limited range	low	25.4	80-100	58.8-171.5
Intensive	Wide range	high	152 or more	100-200	245-1470

- Extensive green roof can be sustained without automatic irrigation in a growing medium layer as shallow as 25.4 mm (1 in.).

Table 84 recommended sprinkler spacing under windy condition [30]

Wind velocity km/hr.	Max. spacing	
	Square spacing	Triangle spacing
0-4.8	55% of diameter	60% of diameter
4.8-9.6	50% of diameter	55% of diameter
9.6-19.2	45% of diameter	50% of diameter
Above 19	40% of diameter	45% of diameter

4.7.5 Case study:

Project description

The U.S. Environmental Protection Agency (EPA) is located at 1595 Wynkoop Street, Denver, CO 80202, with 248849 ft² m² total area. That serves approximately 850 employees



Figure 181 The U.S. Environmental Protection Agency (EPA) Green roof

Project picture



Figure 182 Pictures of EPA project [29]

From previous pictures noted that the - Extensive green roof and drip irrigation system were used

4.7.6 Design of green roof

- Data and information

Type of green roof	Plants Types	Maintenance	Irrigation system	layer shallow (mm)	Area of roof total(m ²)
Extensive	sedum	low	Sprinkler system	25.4	817 roof 60 for stair

Use sedum pieces with 25.4 layer shallow (mm) since Sedum green roofs are the most common type due to the hardiness and low maintenance requirements of the plant. As recommendation Extensive green roof can be sustained without automatic irrigation in a growing medium layer as shallow as 25.4 mm (1 in.).

- Plan and section:

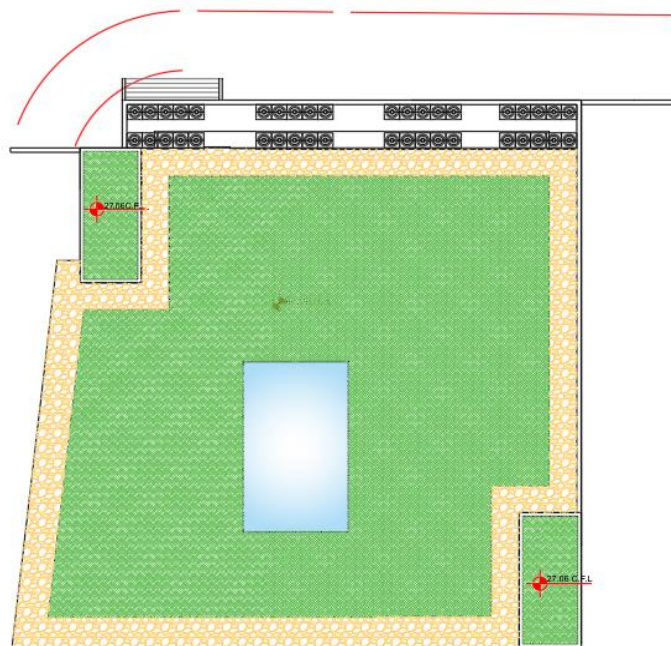


Figure 183 Green Roof Plan

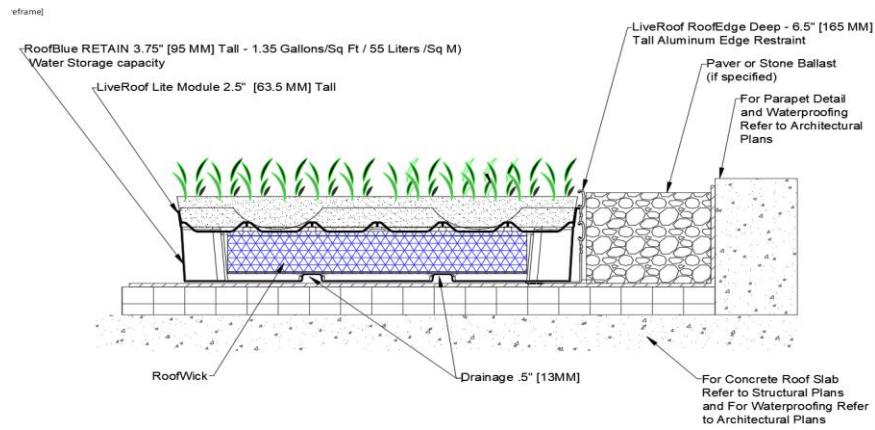


Figure 184 green roof section

• **Suggestion for sprinkler Irrigation Design**

Type of sprinkler used for spray irrigation is spray pad sprinkler

Calculation of daily max. Water supply requirement for area:

Windy condition at Nablus 28-38 Km/hr

From Table 84 Max. Spacing between sprinklers for triangle spacing is 45% of diameter of diameter sprinklers Impact Circuit

Using a Sprinkler LF series form Rain Bird Company [31]



25BPJ-FP-ADJ-DA-TNT Performance					
Pressure bar	Nozzle	Radius m	Flow m ³ /h	Precip mm/h	Precip mm/h
2.1	09	11.6	0.70	10	12
	10	11.9	0.86	12	14
2.5	09	11.8	0.77	11	13
	10	12.1	0.95	13	15
3.0	09	12.0	0.85	12	14
	10	12.3	1.05	14	16
3.5	09	12.2	0.91	12	14
	10	12.5	1.14	15	17

Specifications

- Radius: 11.6 to 12.5 m
- Pressure: 2.1 to 3.5 bars
- Flow: 0.70 to 1.14 m³/h
- ½" NPT male threaded inlet
- Nozzle outlet trajectory: 25°

Table 85 specification of sprinkler

Diameter sprinklers Impact Circuit = 12.6 m

Sprinklers watering (q) = 1.14 m³/h

Chapter 5: quantity surveying and cost estimation:

6.1 Introduction

Quantity surveying and cost estimation is known the quantity of materials and their cost for a project with a specific scope. It is the most crucial part of managing the financial costs of a project, which also includes planning, monitoring, and regulating those costs.

As part of this project, we are needed to provide a provisional cost estimate, In order to obtain the total cost of the shopping mall. To do this, we will produce an approximation of the cost and determine whether the project is within our budget.

Methodology

The unit price approach was employed. It is a quick and uncomplicated estimating technique. It does, however, have some room for mistake. Where an engineer was questioned about the price per square meter of these kinds of buildings.

6.2 Budget development and tentative cost estimate

After asking about shopping mall unit cost, the unit cost is 1550\$.

Shopping mall floor	Floor area (m²)	Unit cost (\$/m²)	Floor cost (\$)
Basement 1	1640	1550	2542000
Basement 2	1474	1550	2284700
Ground floor	1245	1550	1929750
First floor	1245	1550	1929750
Second floor	1245	1550	1929750
Third floor	1245	1550	1929750
Fourth floor	1245	1550	1929750

Table: cost for each floor in shopping mall

Total shopping mall cost = 14475450\$

Chapter 6: Conclusion:

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