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Design assessment and redesign of a bank building

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Dedication

First of all, we dedicate this work and our respect to our professors and supervisors at an-Najah university, they did their best for us to reach this stage.

We would also like to thank everyone who was a source of inspiration for us and supported us from family and friends.

And special thanks to our great supervisor, Dr. Luay Dwaikat for his support and guidance for us to reach this level.

And of course the greatest thanks be to God.

Thank God and thank you all.

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Finally, we would like to thank our colleagues who participate in our beautiful moments through the five years during our college life.

And all those who supported us in our graduation project.

God bless you all.

Disclaimer Statement

This report was written by students of the Department of Building Engineering at An-Najah National University, as it has not been reviewed or corrected, except for some editorial corrections, and as a result it may contain grammatical or content errors.

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Abstract

In this project, an administrative building (Bank) that is designed by architectural department students in NNU, located in Rafidia -Nablus in Palestine, to assessment a design for (structural, environmental ,architectural, electrical, mechanical, fire, acoustical) evaluation and improvement, to make sure that the design compliant for integrated design principles, then make a comparison between this project and standards and requirements that were collected for the same type of function of this building in the architectural field.

After that, an environmental analysis was conducted to understand the nature of the building site and the main requirements of the building in order to obtain proposals for improving the building and then try to resolve the environmental problems it suffers from achieving the greatest degree of comfort for the users, then make a comparison of the building before and after the improvements.

In the field of electro mechanics, many topics related to the building were designed based on the results obtained from programs in which the building is raised as a model, whether in terms of thermal or acoustic design or lighting in the building, whether natural or industrial lighting, HVAC system, fire suppression system in addition to Water, sanitation and energy design.

In the structural part, the positions of the columns have been changed to suit the architectural functions of the building, and the building ability of working structurally as well, then make a structural model by using Etabs software to obtain some results for Equilibrium, Compatibility, and Stress-strain checks.

Finally, after completing the previous stages, an estimated cost of the building was calculated in terms of materials and labor, and an estimate of the amount that will be spent on the project until it is complete.

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Nomenclature or list of symbols

symbol	meaning
m	meter
m^2	meter square
cm	cemtimeter
cm^2	cemtimeter square
mm	millimeter
mm^2	millimeter square
%	percentage
KN	kilo newton
KN/m	kilo newton per meter
KN/m^2	kilo newton per meter square
Mpa	mega pascal
C	celsius degree
km/h	kilo meter per hour
kg/m^2	kilogram per meter square
m/s	meter per second
m^2.k/h	meter square .kelvin per watt
ac/h	air shanging per hour
V	velocity
db	decibel
Ln	clear length of slab
h	thickness of slab
E	modulus of elasticity
Pu	the ultimate factored axial load
Fy	yielding strength of steel
Qz	static wind pressure
Kd	wind directionality factor
Kzt	topographic factor
kwh/m^2	kiloeatt hour per meter square
U	heat transfer coefficient
MWh	megawatt hour

Chapter 1 : Introduction

1.1: Introduction

An investment bank is a financial institution that deals in shares and bonds for companies and provides other financial services such as: assistance in mergers and acquisitions, pension fund management, financial support and payment solutions, that includes offices and waiting rooms, including the spread of these types of buildings in Palestine due to their investment importance and their role in developing them.

People have become in need of trading, spending and saving their money, and therefore it was necessary to develop the building and establishment of banks to meet their needs, so there were many types of banks with different services, and each type of them has its services and in different ways.

Banks also perform three main functions: saving and investment, money management, and financing. Banks contribute to facilitating individuals' access to many benefits, such as: educational opportunities, health treatment, housing, transportation, job creation, and other aspects of quality of life, in addition to basic banking services.

There are many types of banks such as retail banks, investment banks, commercial banks, private banks, electronic banks, credit unions and others.

Therefore, when designing banks, several aspects must be taken into account, the most important of which is the presence of neighboring buildings and their impact on the building and comfort of people inside, and presence of security elements in the design and where to put money and perform good foundation for this, in addition to the importance of architectural building shape.

1.2: Project problem

There are many problems that will be discussed in this project:

First of all, how will the architectural plans become after the modification and comparing them with the plans before the modification.

Studying the environmental analysis in some areas such as: thermal comfort of the building, light comfort and acoustics through the analysis of the building and try to get the best environmental design for the building.

structural plans design, make sure that the locations of the columns do not affect the architectural and environmental design of the building, especially when designing a parking for the building according to the standards and codes.

How the cost of the building will be estimated in this project, with taking into account not to increase the cost so that the building is economically effective and the limitation of the budget .

Finally, study the amount of integration between these aspects and how they work with each other.

1.3: Objectives

The main objective of the project is to obtain an integrated, energy efficient and environmentally treated building, and there are many other objectives, including:

1- Architectural design: considering internal spaces, and the functionality for each room.

2- Structural design: the building will be analyzed by using computer software such as ETABs and make some checks.

3- Environmental design: to calculate daylight factor, heating and cooling loads by computer software Revit and Design-Builder and perform the needed modifications.

4- full structural design by using the recommended codes and standards.

5- cost estimation for the project.

6- Make sure that all the aspects of the project achieve integration between each other.

1.4: Methodology

In order to achieve the project's main goal of integrated design of all aspects of the Investment Building (Bank), a set of methodologies were used after gathering information from literary references and numerous articles and books related to the project's topic,

The site is initially examined to determine whether it complies with the necessary standards in terms of its nature and surroundings. Following is the function of the building's integrated architectural design, which includes the design of the spaces, atmosphere, ventilation systems, lighting, and acoustics.

The structural design step involves using a computer program to analyze the building's 3D model and the design procedure. In the following phase, mechanical and electrical systems such as those for heating, ventilation, air conditioning, water and sewage systems, lighting and energy systems, and control panel design will be designed. Along with the design of structural, environmental, mechanical, and electrical systems and safety systems, the public safety design will also include emergency exits and an alert system.

1.5: Limitations & constraints

here is some limitation that delayed work and progress:

1) The shape of the building is a curve, and there was a problem with dealing with programs that do not have the option to draw a curve, such as Design Builder, DIALux, Ease, ETABS, and SAFE.

1) Commitment to certain limits for the plot of land, and thus a specific site plan, so we could not amend the site plan in terms of adding cars abroad or otherwise.

2) Adherence to the boundaries of the building itself, so we could not amend the external borders in the architectural schemes.

3) Not taking into account the design, allocating places for people with special needs, such as private parking, a private bathroom and sitting places in the waiting and meeting rooms.

4) Taking into account the nature and ethics of the community that uses this type of building, so that this will be taken into account in the new design, such as separating the bathrooms for users.

5) One of the difficulties was treating the façade of the whole glazed building without compromising the idea of architecture.

1.6 Standards and Specifications (Codes):

In order to complete the design process in all respects, used some codes during the project:

For architectural design:

• Neufert Architects data 4th edition.

• Time saver standards for building types 4th edition.

Through which the standard for spaces was found.

For structural design:

• The American concrete institute code ACI 318 for reinforced concrete design.

• Uniform Building Code -UBC-97 for seismic design and load combinations.

• American society of civil engineering ASCE for load combinations.

• Principles of Foundation Engineering.

Through which, basic checks were made for the building, identifying the materials and finding the loads on the building and the type of structural system used, in addition to the percentage of error in the checks allowed.

For environmental design:

• MEEB book.

• Architectural Acoustics.

For Lighting design:

• Illuminating Engineering Society of North America (IESNA) lighting handbook 10th edition.

• European lighting norm for lighting requirements.

1.7 Earlier coursework

In this part, reflected any earlier coursework and topics used in the project:

1) Architectural Design Foundations Course: used in the project of understanding the sauces of the building and the correct relationships that must be between the spaces to make the building more comfortable and work properly, and to assist in the process of finding the standard dimension for each fiction, and the process of assisting in the correct drawing of the plans in terms of the hatch for each material and the tones of lines.

2) Computerized Building Design Course: used in the project of using the Auto-CAD software to draw the plans and their modifications, and the Revit program was used to build a 3D model and took the plans, facades and sections from the rift and re-modified them on the Auto-CAD program, and the Revit program was used to analyze the building environmentally, in terms of the position of the sun relative to The location of the building and the amount of daylight, calculate the amount of heat and Cooling in the building.

3) Environmental Systems Design (Lighting) Course: used where we prefer in all buildings to go to natural lighting, taking into account as much as possible to reduce the amount of glare, but in the event of a deficiency in the availability of natural lighting, we resort to industrial lighting, as

we used the Revit program to analyze the lighting of our building and it was found that the size of the openings is small and unreliable for natural lighting By enlarging the holes, this gave a serious result. However, we will need some artificial lighting.

4) Solar energy systems design course: it is used to add photovoltaic cells and calculate how much energy they give and how much it saves from building consumption

5) Professional practice and technical writing Course: The information gained in the course helped us in the technical writing of the project, in addition to writing the citation texts correctly, and documenting them in the reference list according to a specific format.

6) Building economics quantity surveying and cost estimation course: The information gained in the course helped us in making an estimate for the project through Calculating the amount of materials used in the project, so that we get the costs of the materials from the suppliers, then the prices of labor and tools are added, thus we get the direct cost of the project, then the direct costs are added to the indirect costs and the contingency costs.

7) Concrete systems design course: The information we got from the course helped in distributing the columns appropriately and according to the architectural form, calculating the dimensions of columns and beams and the ability to make a correct decision about the structural system used, in addition to the ability to use engineering codes and engineering programs such as ETABS, which helps in the design process.

Chapter 2: Environmental Architectural Aspects

2.1 Introduction:

The proposed investment bank project is located in Nablus, Rafidia Street. In this chapter, the architectural details are in terms of dimensions and number for all project elements, and explained the interrelationship between them and studied them according to the standard of administrative buildings.

working on studying the environmental factors of the site that have an impact on architect aspects and the researching the existing problems and solving them

Banks are among the buildings whose information is most reserved in order to increase security. searched on the standard for the spaces have in terms of the minimum area and number, and that they take into account people with special needs, and compared them with what is in the project and amended as necessary.

2.2 Literature review

Architectural standards requirements for all projects Functions and voids and compare them with the functions in the original design by searching in the standards and codes.

2.2.1 Elevator:

Ease of movement in buildings without fatigue and quickly is considered an essential element and increases work efficiency and saves time for visitors. Therefore, elevators were the first component of the project to be reviewed.

1- number of elevator

According to International Building Code number of elevators sufficient is the number that allows the building to be evacuated of citizens in one hour.

Table 1Population of typical buildings(By, Adler, and Edition 2015)

Building Type	Net Area
OFFICE BUILDINGS	FT² PER PERSON (M²/PERSON)
Diversified (multiple tenancy)	
Normal	110–130 (10–12)[a]
Prestige	150–250 (14–23)
Single tenancy	
Normal	90–110 (8–10)
Prestige	130–200 (12–19)
HOTELS	PERSONS PER SLEEPING ROOM
Normal use	1.3
Conventions	1.9
HOSPITALS	VISITORS AND STAFF PER BED[b]
General private	3
General public (large wards)	3–4
APARTMENT HOUSES	PERSONS PER BEDROOM
High-rental housing	1.5
Moderate-rental housing	2.0
Low-cost housing	2.5–3.0

To find the number of Population in the bank has a total area of 6100 square meters, through Table Office building-Prestige-Prestige (12-19) person/ m².

Number of Population=5900/19=310 person

Minimum percent handling capacities (PHC):

Percent of population to be carried in 5 min (PHC)

Table 2 PHC (Grondzik et al. 2018)

Facility	Percent of Population to Be Carried in 5 Minutes
OFFICE BUILDINGS	
Center city	12–14
Investment	11.5–13
Single-purpose	14–16
RESIDENTIAL	
Prestige	5–7
Other	6–8[a]
Dormitories	10–11
Hotels—first quality	12–15
Hotels—second quality	10–12

office building-investment PHC= 11.5-13%

You got the worst study = 13%

handling capacities = 310 x 0.13 = 40.4 person/5m

Table 3 Car capacity is determined by building size, and car speed by rise(Grondzik et al. 2018)

Building Type	Car Capacity[a] lb	Car Capacity[a] kg	Rise ft	Rise m	Minimum[a] Car Speed fpm	Minimum[a] Car Speed m/s
Office building	2500	1250	0–125	0–40	350–400	2.0
	3000	1250	126–225	41–70	500–600	2.5
	3500	1600	226–275	71–85	700	3.15
			276–375	86–115	800	4.0
			Above 375	>115	1000	5.0

Elevator rise = 40m

Through Table the selection options for elevator are (2500lb, 3000lb and 3500lb).

Car speed options (350, 400) fpm.

Table 4 intervals time(Grondzik et al. 2018)

Facility Type	Interval (sec)	Waiting Time[a] (sec)
OFFICE BUILDINGS		
Excellent service	15–24	9–14
Good service	25–29	15–17
Fair service	30–39	18–23
Poor service	40–49	24–29
Unacceptable service	50+	30+
RESIDENTIAL		
Prestige apartments	50–70	30–42
Middle-income apartments	60–80	36–48
Low-income apartments	80–120	48–72
Dormitories	60–80	36–48
Hotels—first quality	30–50	18–30
Hotels—second quality	50–70	30–42

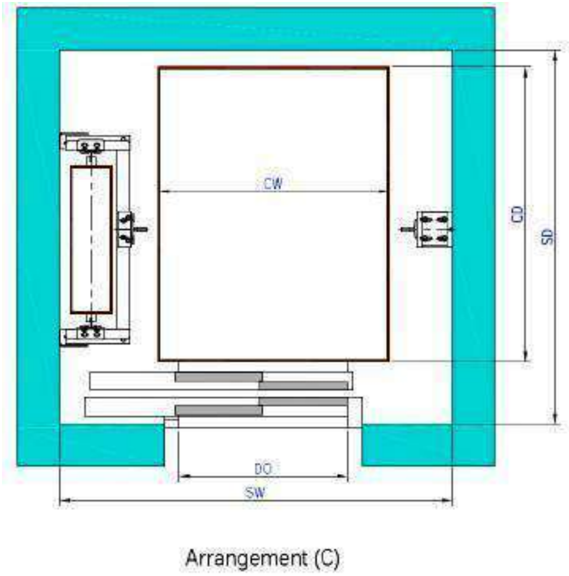
from table 4 Interval time for office (I) fair service = 30-39 sec.

Table 5 : Calculation of the number of elevators (excel page)

	2500/350	2500/400	3000/350	3000/400	3500/350	3500/400
normal capcity per trip	13	13	16	16	19	19
RT	119	111	129	123	140	135
hc	32.77	35.14	37.21	39.02	40.71	42.22
N	1.27	1.18	1.12	1.07	1.02	0.99
N1	1	1	1	1	1	1
HpC	10.24	10.98	11.63	12.20	12.72	13.19
check 1 (MIN HPC=11.5-13)	not ok	not ok	ok	ok	ok	ok
I	119	111	129	123	140	135
N2	2	2	2	2	2	2
HpC	20.48	21.96	23.26	24.39	25.45	26.39
I	59.5	55.5	64.5	61.5	70	67.5
check 2 (I=30-39)	not ok	not ok	not ok	not ok	not ok	not ok
N3	3	3	3	3	3	3
HpC	30.72	32.94	34.88	36.59	38.17	39.58
check 1 (MIN HPC=11.5-13)	ok	ok	ok	ok	ok	ok
I	39.67	37.00	43.00	41.00	46.67	45.00
check 2 (I=30-39)	not ok	ok	not ok	not ok	not ok	not ok

According to the calculations we need three elevators in the building in order to achieve good service . But in this performed design there’s only two elevators, which presents the need of adding another elevator.

2- elevator dimensions



Arrangement (C)

Type	Q (Kg)	Persons	CW(mm)	CD(mm)	DO(mm)	SW(mm)	SD(mm)
Type (I)	320	4	1000	900	800	1600	1500
			900	1000	800	1500	1500
	400	5	1100	1000	800	1700	1500
			1000	1100	800	1800	1600
	480	6	1200	1100	800	1850	1600
			1100	1200	800	1750	1600
	630	8	1400	1100	800	2000	1600
			1100	1400	800	1750	1800
			1200	1300	800	1850	1700
	750	10	1400	1300	800	2000	1700
			1300	1400	800	1900	1800
	800	10	1400	1350	800	2000	1500
			1350	1400	800	2000	1800
Type (II)	1000	13	1600	1400	1100	2300	1850
			1400	1600	1100	2100	2000
			1100	2100	800	1800	2500
	1050	14	1600	1500	1300	2400	1900
	1350	18	1800	1800	1300	2400	2200
	1600	21	2100	1600	1300	2900	2100
			1400	2400	1300	2400	2800

NOTE:
SD & SW VARY ACCORDING TO SELECTED DOOR SIZE, POSITION AND TYPE.

CW = Car Width. CD = Car Depth. DO = Door Opening. SW = Shaft Width.
SD = Shaft Depth. Q = Rated Load.

Figure 1 elevator sizes and dimensions. (fujiinteg)

Typical elevator machine room dimensions .

According to the table above and based on the fact that 3 elevators are used the needed dimensions are

7.9*5.8m

2.2.2 Stairs:

The stairs are another solution which supports vertical movement within the office building, stairs have a special use when the electricity cut off, in this case the mechanical equipment such as elevators and escalators cannot work, and thus the stairs are the unique solution. For the emergency cases (fires and earthquakes), the stairs should be exterior to avoid a lot of injured. Stairs are the primary means of vertical travel during fire emergencies and are generally effective and reliable.

Minimum width of stairs for governmental buildings, should be 1.5 meters. (Neufert, 4th edition).

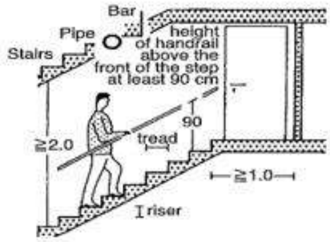


Figure 2 Stair dimensions(Neufert and Neufert 2012)

Table 6 Limits of dimensions (Neufert and Neufert 2012)

Row	Type of building	Type of stairs	Usable stair width (min)	Stair riser (R)[2]	Stair tread (T)[3]
1	residential buildings with not more than two storeys[1]	stairs leading to habitable rooms	80	20	23
2		cellar stairs, which do not lead to habitable rooms	80	21	21
3		loft stairs, which do not lead to habitable rooms	50	21	21
4	other buildings	legally essential stairs	100	19	26
5	all buildings	non-essential (additional) stairs	50	21	21

1. also excludes maisonette flats in buildings with more than two storeys
2. but not <14 cm
3. but not >37 cm = stipulation of the pitch riser/tread
4. for stairs with a tread <26 cm, the overhang (o) must be at least so large that a total tread of 26 cm ($t+o$) is given
5. for stairs with a tread <24 cm, the overhang must be at least so large that a total tread of 24 cm ($t+o$) is given

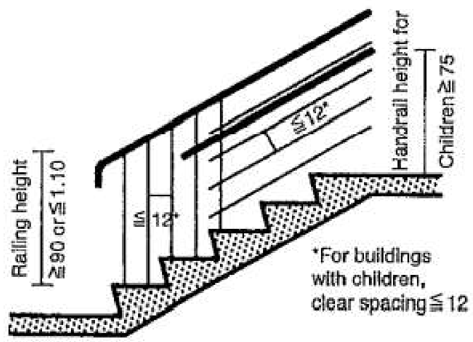


Figure 3 Limits of dimensions (Neufert and Neufert 2012)

Table 7 : Dimensions of stairs according to the number of people who use it. (Neufert and Neufert 2012)

# of people	Min width for stairs (m)	Step's width (m)	Height of steps (m)
200	1.05	0.25	0.165
> 200	1.35	0.3	0.165

According to the architectural plans, the width of the stairs is 1.2 meters, and this is acceptable according to the standards. And there is one staircase in the architectural plans that uses all floors, and another staircase that is used on the large floor with the visitor, and this is acceptable.

2.2.3 Emergency Stair :

2.1.3.1 stair

The stair in the bank needs a width to differ from (1.20-1.40) m for two people to pass according to the recommended specifications.

In this project, the width of the staircase is equal to 1.40 m, so it is sufficient according to the standard.

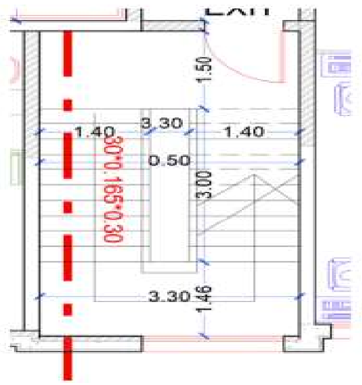


Figure 4: Staircase Criteria (International Code Council (ICC) 2018)

2.1.3.2Emergency stair and exits

International standard:

It's used to let people get out from the facility as fast as possible, in this project the facility serves less than 1000 person in the very most cases, so these are the requirements as shown below in the U.A.E standards.

Local Standard:

Table 8: Staircase of exits (By, Adler, and Edition 2015)

Requirements for internal inclusions in new buildings	
The lowest pure width for a staircase with an occupancy load of less than 50 people	90 cm
Minimum pure width of a staircase with an occupancy load equal to or greater than 50 persons	110 cm
Minimum distance between floor and ceiling	2.10 m
Maximum height between two consecutive grooves	3.7 m
Minimum dimensions of the extension in the direction of movement	110 cm

Emergency stairway and exits:

The emergency stairway is known as the fastest way for customers to escape from the building to the nearest safe place away from the danger zone ,without going through any intervening rooms but the corridors, Escape corridors, and escape routes must also provide access to at least approved exit.

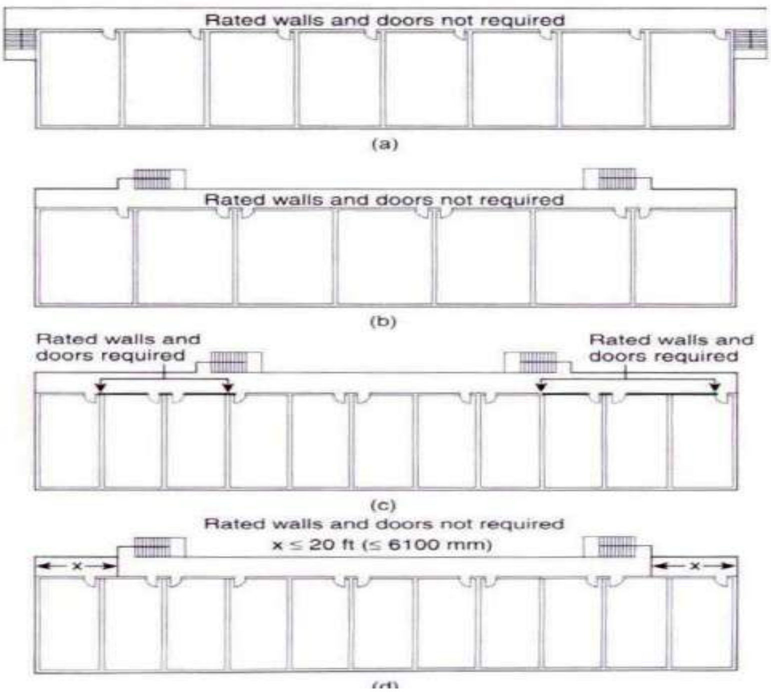


Figure 5: Staircase of exits Criteria (Grondzik et al. 2018)

(Local): In the local standard, the number of exits per floor should not be less than two or more exits, or 3 exits if the occupancy load ranges between 500 and 1000 people, but if there are more than 1000 people, there should be at least 4 exits according to Palestinian code for fire prevention and protection.

In this project , there is 2 exits so it is acceptable according to agreed standards, but But the location of the stairs is external, and this is not suitable from a safe point of view, so the stairs were placed inside the building, and their number is 2, and this is acceptable.

Minimum width for stairway

According to Palestinian code for fire prevention and protection,2021, page 42 :

1- The width of the exit path in commercial and administrative places should not be less than 110 cm, in educational places, at least 180 cm, and in health places, at least 240 cm.

2-The width of the exit path must not be less than the width of the exit.

3-The exit path must be free of obstacles and must not pass from a bathroom, room or place that can be closed.

4-Exit corridors are not allowed to pass from a high-risk area unless they are protected and isolated.

Maximum distance from the escape point to a stairway:

- D represents the diagonal of the building.
- D/2 represents the maximum distance from the escape point to the stairway.

Doors width:

According to UAE fire code cover Arabic sample file,page 148:

1- The door openings in the exit lanes shall not be less than 915 mm in their net width, and when a pair of doors is available, the net width of any of the doors shall not be less than 810 mm.

2-When fully opened, no door in the exit lane shall protrude beyond 810 mm in width required for a passageway or landing place.

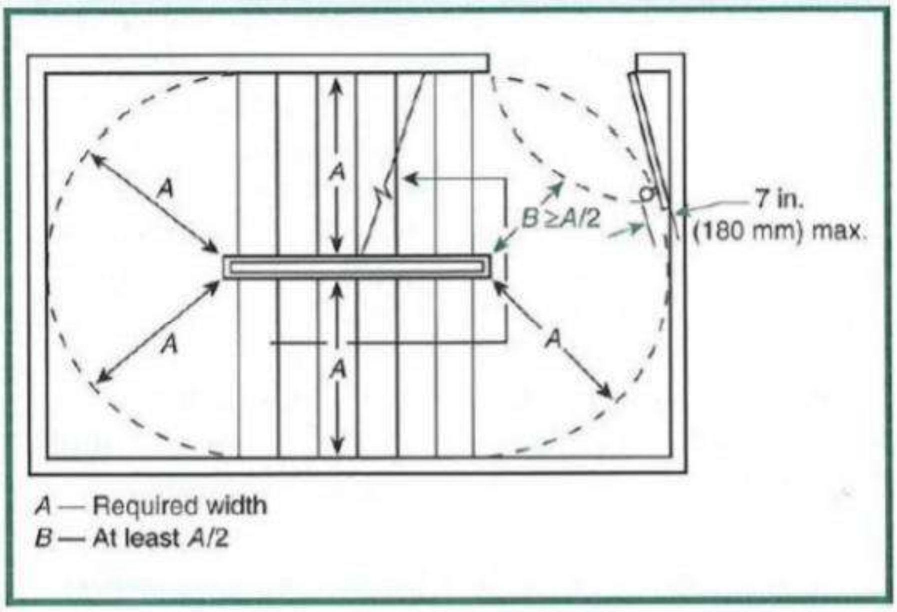


Figure 6: Door relationship with stair dimensions (By, Adler, and Edition 2015)

2.1.4 Parking:

One of the most important things that the design of any building must have is the parking in terms of its number, location and dimensions. In a bank project, attention must be paid to it more than any other project because it is usually in the city center and cars cannot park on the street.

1- number of parking :

The total area of building =5900 m^2

Population=310

Banks	Staff: one space for each managerial or executive staff, plus one per four others Customers: one space per 10 m^2 of net public floor space in banking hall

Figure 7 parking number (By, Adler, and Edition 2015)

In banks parking it should have one space for each staff in bank and one space per four customers

From standers one parking space for each managerial and executive staff

50 staff = 50 barking

One parking space for four visitor : 260/4 = 65

The bank need 65 parking space for visitor

Total barking need for bank =115 space

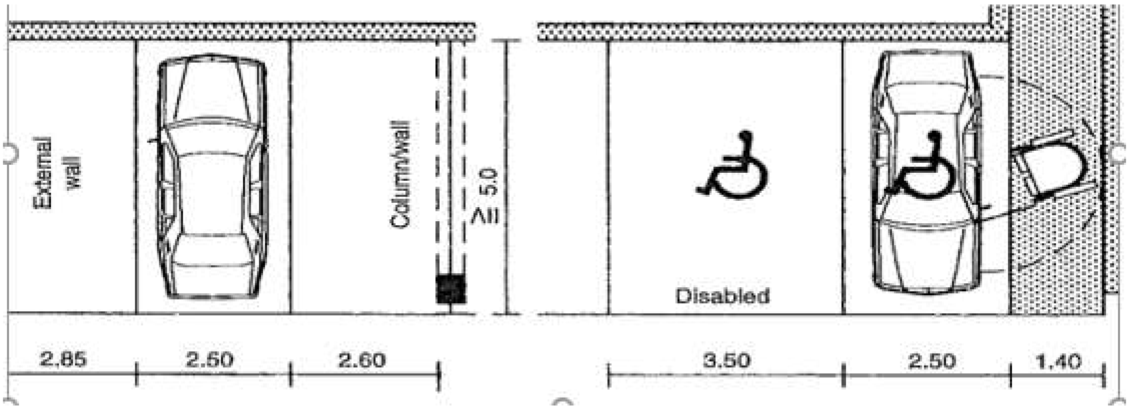


Figure 8 : parking spaces (By, Adler, and Edition 2015)

Parking space standard dimensions:

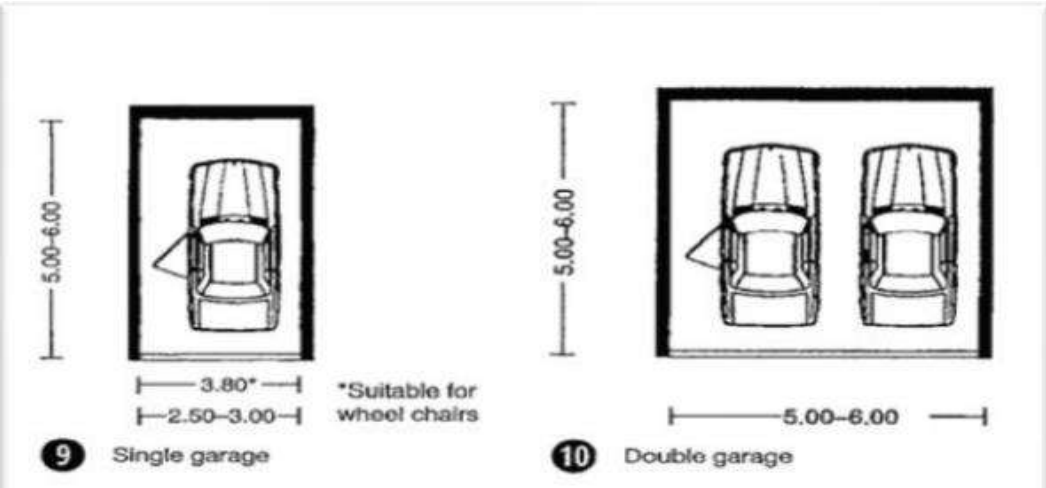


Figure 9 : Parking space standard dimensions (Neufert and Neufert 2012)

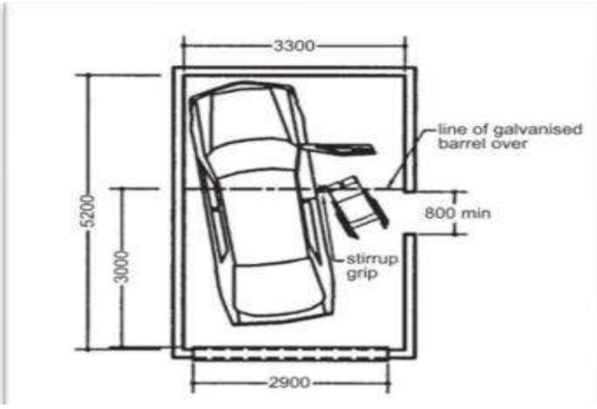


Figure 10 Parking Criteria (Neufert and Neufert 2012)

The following pictures show the required dimensions of the road according to the row angle that allows the car to move inside the parking lot.

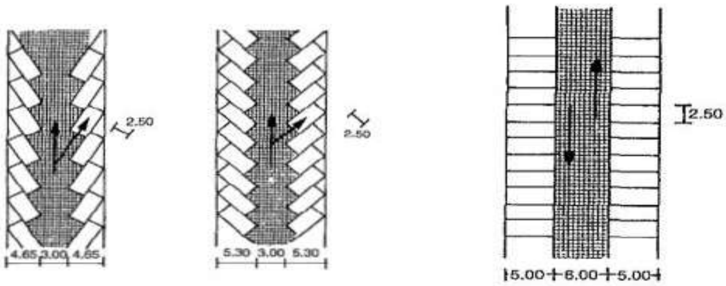


Figure 11 : Many types and forms of parking. (Neufert and Neufert 2012)

The picture below shows the minimum required for the car to rotate

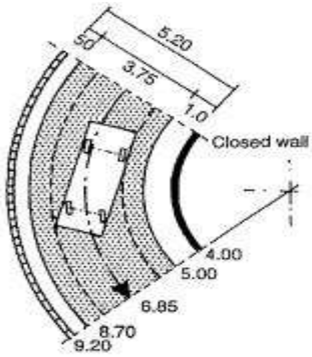


Figure 12 : Minimum ramp widths (Neufert and Neufert 2012)

According to the architect's plans, the parking had 50 storerooms, and this number is unacceptable according to the standard, and their number was increased to 120.

The distances of one row were not enough, so they were increased until they became acceptable, and parking was enlarged over the entire land area.

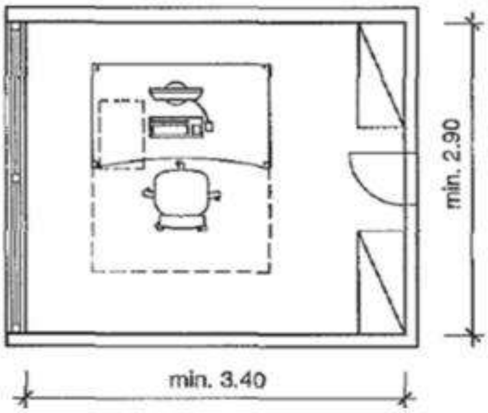
2.1.5 Offices:

Offices are considered one of the most important elements in administrative buildings, and offices vary according to the user's job and according to her job.

The nature and size of work determines the number of offices, according to the number of employees

Single Office:

The office of the mayor must be close to the director office in order to facilitate the process of communication between them, and there must be a secretarial office next to it, provided that the dimensions of the director’s room are (4.6 m* 3.6 m).



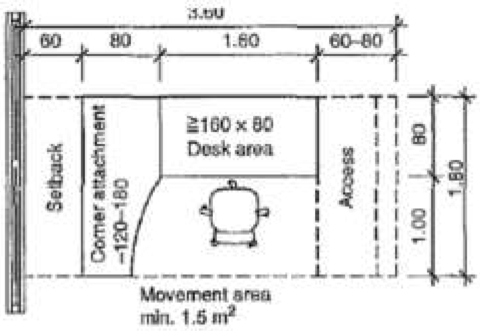


Figure 13:Dimention of single office room Figure 14: Minimum space requirement for a single workstation.(By, Adler, and Edition 2015)

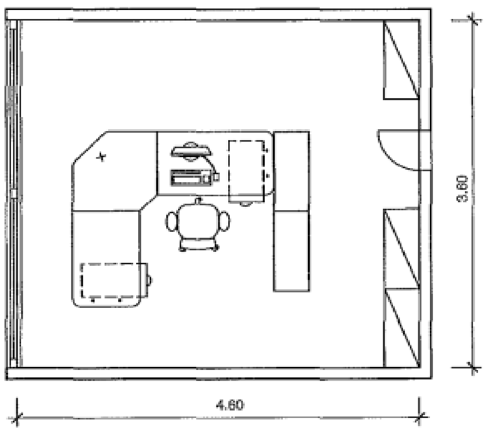


Figure 15 : office management (Neufert and Neufert 2012)

Double office:

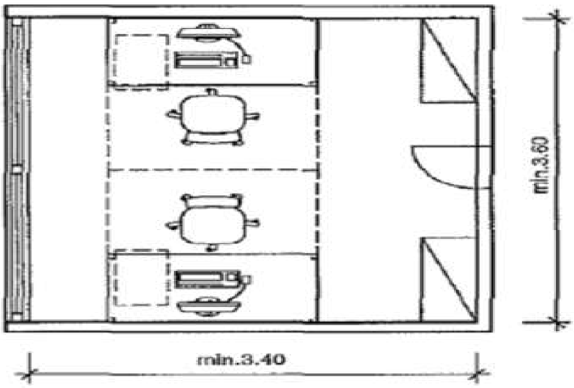


Figure 16 Dimention of double office room (Neufert and Neufert 2012)

Treble office:

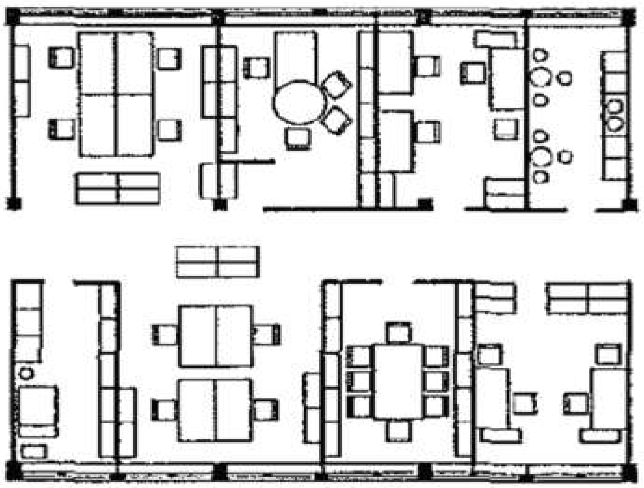
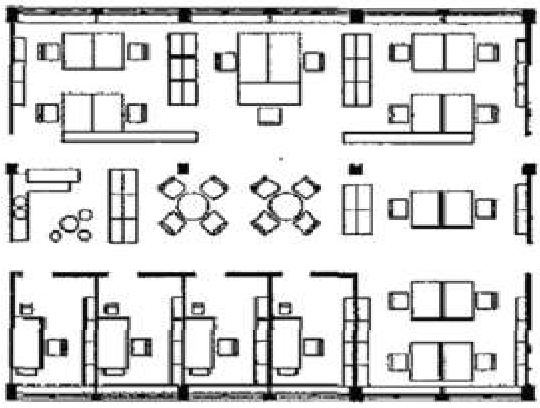


Figure 17 Group office distributed .(Neufert and Neufert 2012)



Open-plan office

Figure 18 open plan office (Neufert and Neufert 2012)

computer room :

The computer room is one of the most important spaces in the bank, which has high privacy and high security, and its area is determined according to the devices in which you are located.

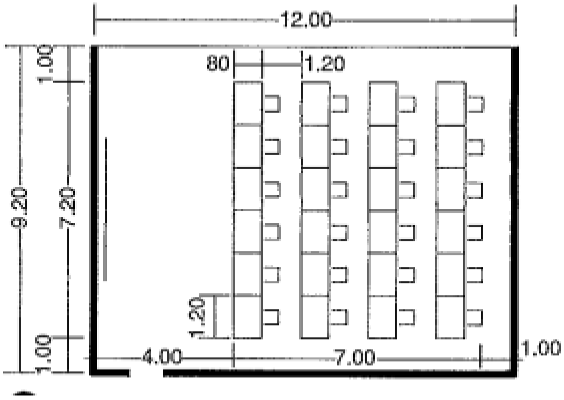


Figure 19 Dimensions of a computer room(Neufert and Neufert 2012)

According to architectural plans the officesAll of its dimensions are greater than the dimensions required by the standard , which acceptable.

2.1.6 Meeting Room:

it is taking a large area so that is why we must pay attention to and address the sound problems that will occur, that should have a directly access from the entrance, the distance between the seats ranges from, the three required dimensions for meeting room is 2.5m per seat, for a meeting room with 10 seats, the standard dimension 5100mm*3100mm.

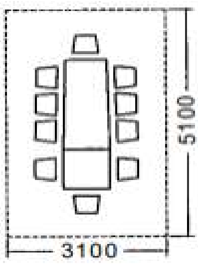


Figure 20 : Dimensions standard for meeting room in plans. [1]

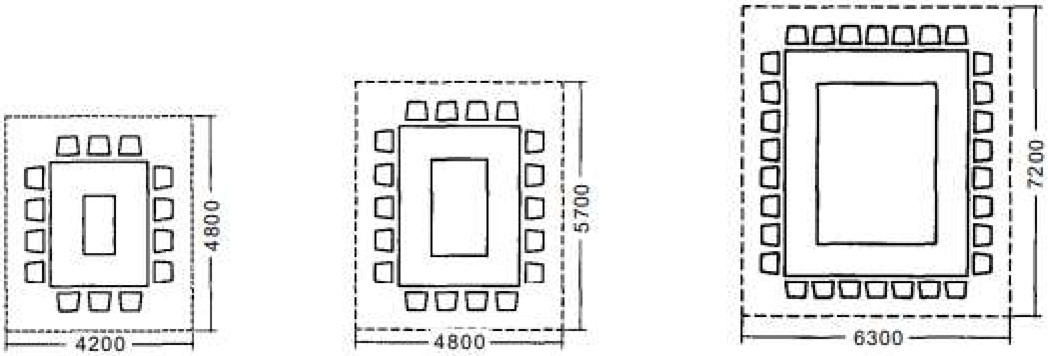


Figure 21 Space requirements for formal meetings (Neufert and Neufert 2012)

According to the architectural plans, all meeting rooms are larger than the required spaces, so it is acceptable.

2.1.7 Bathrooms

1. number of bathroom

The following table determines how many bathrooms should be available in an office building.

Table 9 Number of bathrooms required in office buildings by staff only(By, Adler, and Edition 2015)

Sanitary appliances for any group of staff		
Number of persons at work	**Number of WCs**	**Number of washing stations**
1 to 5	1	1
6 to 25	2	2
26 to 50	3	3
51 to 75	4	4
76 to 100	5	5
Above 100	One additional WC and washing station for every unit or fraction of a unit of 25 persons	

Number of Population in building =321 person

Number of staff = 50 person

According to the table the number of bathrooms for 50 staff is 3 WCs and the number of washing stations = 3

Average Number of customers = 271 person and assuming equal numbers of male and female customers

Table 10 Number of bathrooms required in office buildings by customers(By, Adler, and Edition 2015)

Appliances	For male customers	For female customers
WC	1 per 100 up to 400 males. For over 400 males, add at the rate of 1 per 250 males of part thereof	2 per 50 up to 200 females. For over 200, add at the rate of 1 per 100 females or part thereof
Urinal	1 per 50 males	—
Wash basin	1 per WC and in addition 1 per 5 urinals or part thereof	1 per WC

According to the table the number of bathrooms for 271 customers equal 1 WC for male customers and 2 WC for female customer , the number of washing stations for 271 customers equal 1 for male customers and 2 for female customer .

The required total number of bathrooms in the building equal 3+1+2=6WC

The required total number of washing stations in the building equal 3 +1+2=6

The number of bathrooms an actual in the building equal 28and the number of washbasins an actual equal 28, so the number of bathrooms and washbasins is enough.

2-dimension of bathroom

The following pictures show the dimensions of the required bathrooms

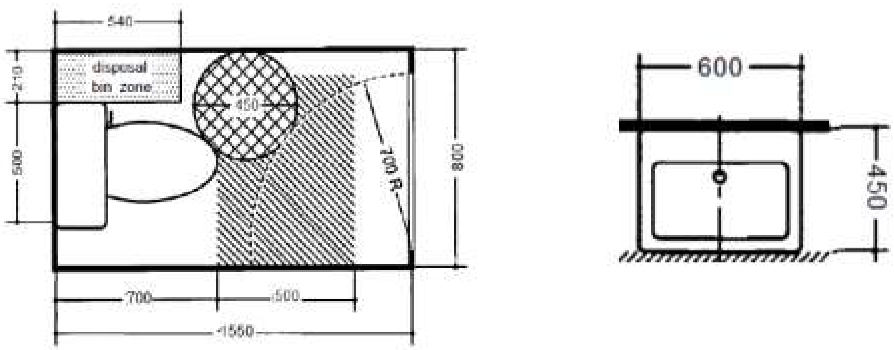


Figure 22 W.C dimension (By, Adler, and Edition 2015)

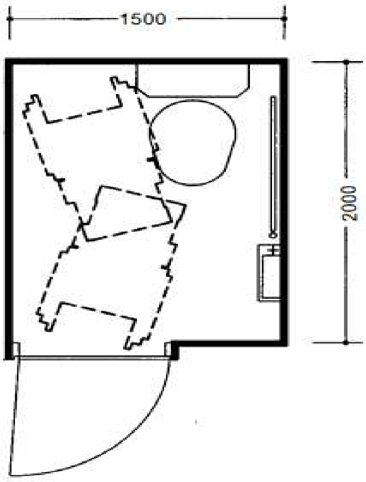


Figure 23 dimensions WC for the wheelchair user(By, Adler, and Edition 2015)

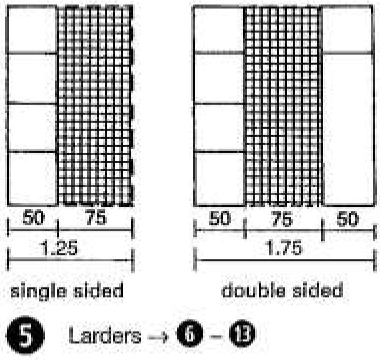


Figure 24 Dimensions of distribution of bathrooms (By, Adler, and Edition 2015)

The dimensions of the bathrooms in the project were equal1.7*1 m .

The dimensions of the bathrooms in the project are compatible with the standard, so we do not need to change them

But there were no bathrooms for the wheelchair user, so two bathrooms will be added for the wheelchair user.

2.1.8 Lobby

to the standards {the lobby area is equal to 18% of the floor area } (Neufert and Neufert 2012)

Due to the functions of the grand floors We the need for a waiting area lobby on the ground floor

the floor area equal 976 m^2 , 18% of the floor area equal 175.68m^2, the floor lobby in grand floor equal 240 m^2 .so Need to reduce the lobby space

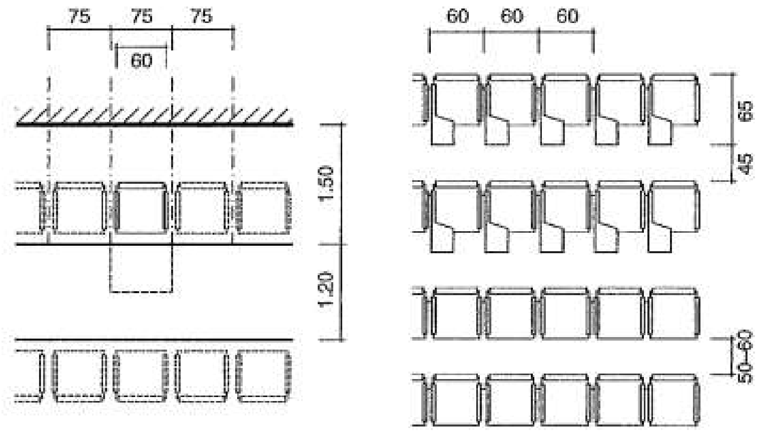


Figure 25 Space requirement for seating in conference (Neufert and Neufert 2012)

2.1.9 corridors

Following the requirements required by the design of the corridor is one of the most important parts because it is a major factor in the place, we must take the need to allow the movement of wheelchairs and the large number of people because it is a government building and the corridor must be in the necessary width so as not to hinder the exit in emergency situations. any corridor must have a wide with minimum wide 1850 mm.

According to the architectural plans, the cardboard is 1 meter wide, and this is unacceptable, and it was increased to 2 meters.

The following picture shows the dimensions required in the corridors

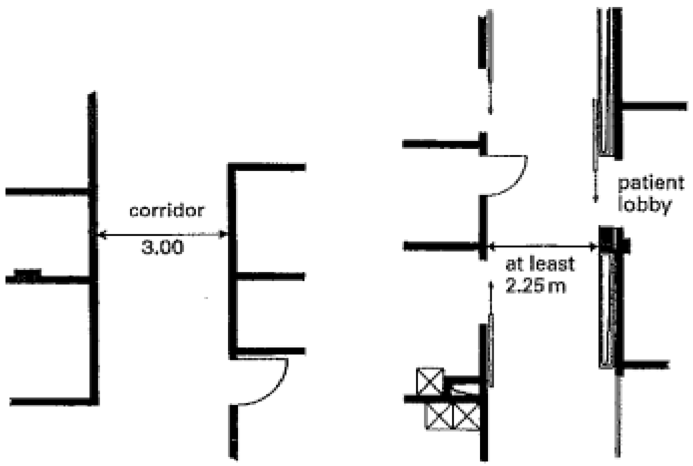


Figure 26 Main corridor

Figure 27 Working corridor,(Neufert and Neufert 2012)

2.1.10 Cashpoint

The following picture shows the dimensions required in the Cashpoint

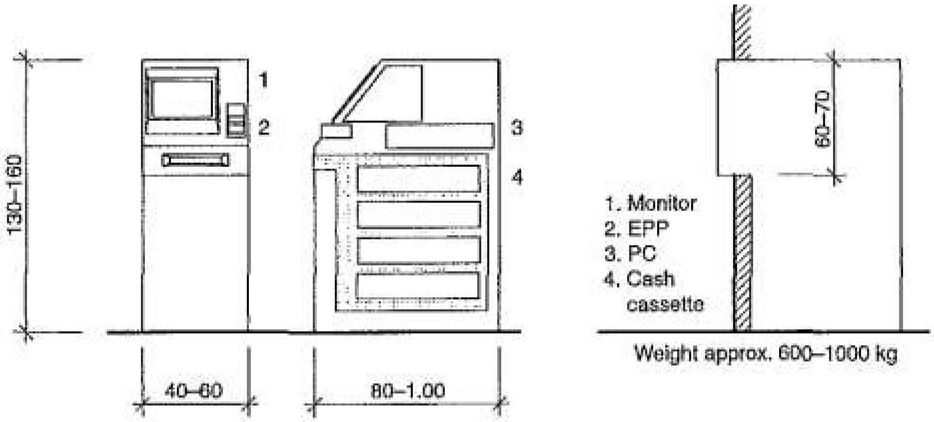


Figure 28 Cashpoint ATM cash (Neufert and Neufert 2012)

According to the architectural plans of ATM cash, its dimensions are larger than the dimensions of the stand, so it is acceptable.

2.1.11 Safes

{Wall thicknesses are in accordance with the security level, from 80 em (T1 0) to 100 em (T20). For the customer safe deposit boxes, 'fully automated safe deposit systems' open at all times are available} (Neufert and Neufert 2012)

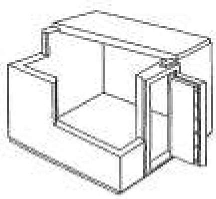


Figure 29 Container strong room(By, Adler, and Edition 2015)

2.1.12 Archive room and Reception

Files and written documents, which are seldom needed but have to be kept (statutory storage requirements), are stored here to take up as little space as possible (purely paper archives rapidly take up 10-20 m per workstation). For this reason, microfilming and some electronic archiving are worth looking into at an early stage. Archive rooms should be designed for save files.

L x W (filing furniture) = space for furniture

$^1/_2$L x W + 0.5 m = passage space

total space required - space for furniture+ passage space

2.1.13 Reception

The reception desk should be visible to the guest immediately on entry, and it should be on the route to the lifts and stairs.

In any reception, the following facilities are required:

- Counter, suitable for writing.

- Space for receptionist.

  -min dimension equal 1.2 m ^2

Table 11: Average gross space requirement for a workstation (By, Adler, and Edition 2015)

Area (m^2)		Range	Average	Total
Workstation	Immediate workstation	11–15	13	15.5
	Additional area (consulting, storage)	1.5–4.2	2.5	
Subsidiary areas	Sanitary facilities	0.6–0.8	0.7	9.0
	Conference/training	0.3–1.0	0.6	
	Archive	0.4–1.0	0.6	
	Stores	0.4–1.5	0.6	
	Canteen, cafeteria, tea kitchen	0.6–1.6	1.1	
	Entrance area	0.2–0.7	0.4	
	Supply and disposal	0.5–1.5	1.0	
	Post room	0.3–0.5	0.4	
	Server room	0.5–1.5	1.0	
	Garage parking	0–13	2.6	
Building	Construction area	1.9–3.8	3.0	10.5
	Building services	2.4–4.6	3.0	
	Traffic area	2.2–6.0	4.5	

2.1.14 services

Types of services found inside the bank:

1. customer services

It must be located on the floor that contains the entrance and is easily accessible

There are also offices for VIP customers

2.1.15 security room

It shall be at the entrance equipped with a bathroom, and it shall be suitable for security to sit in it all the time. It shall also be provided with first aid in relation to its dimensions, according to the available space. The most appropriate one shall be chosen.

2.1.16 Kitchen:

The kitchen is placed in the bank for the employees to prepare food and drinks during the work period, and there is a specific range for the dimensions of the kitchens.

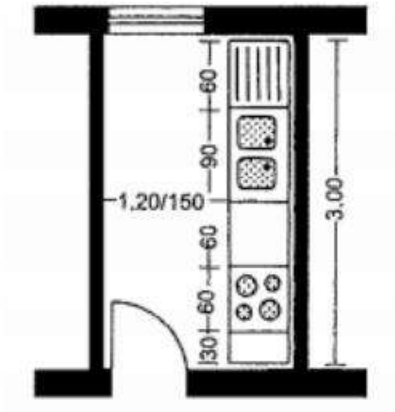


Figure 30 Kitchen Criteria (By, Adler, and Edition 2015)

2.1.16.Transformers room:

Each facility must have a room for transformers and electrical connections, which contains many extensions for building lighting, cameras, sensors, and screens used in the building and others.

2.1.17. Mechanical room(shafts):

There must be one or more skylights in the building for the purpose of fire, mechanics, electrical and ventilation installations. The dimensions of the skylights vary, but one of its dimensions must be one meter and the other dimension is not less than 80 cm in order to maintain the building, and it must be walls The skylight is made of reinforced concrete with a thickness of 20-30 cm.

2.1.19 Ramp:

The width of the ramp shall not be less than:

1. if the car parks did not exceed 30 cars shall be width 3.5 M.

2. if the car parks exceed 30 cars shall be width 5.25 M.

The slope of the ramp should not exceed (20%).

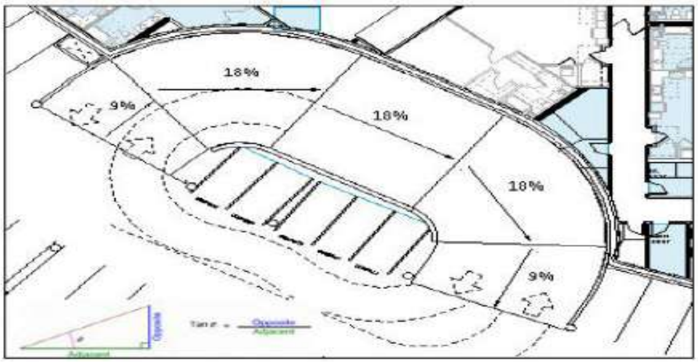


Figure 31 : Ramp (Neufert and Neufert 2012)

2.1.20 1analysis of the spaces within the project

The following table shows the dimensions of the spaces in the project and the comparison between them and the minimum dimensions that must be available

Table 12: Dimensions and number of spaces

	number			dimension		
space	plane	Standard	ok or not	in plane	Standard	ok or not
Lobby gruond	1	1	ok	24% of area	18% of area	ok
Offices: Single Office Double office Group office office management customer services room Computer Engineer	. 12 1 3 1 3 1	As needed	ok	. 4.1*4m 4*4.2m 13*9 4.9*8.2m 3*6m 9*11m	. 2.9*4.3 m 3.4*3.6 7*6m 4.6*3.6m 2.8 × 1.5 2.8 × 1.5m	ok
Meeting Room	3	As needed	ok	8.5*6.5	6.3*7.2 m	ok
Bathrooms	28	6	ok	1.1*1.8 m	0.92 × 1.6	ok
WC for the wheelchair user	0	2	not ok	-	1.5*2m	ok
corridors	1	1	ok	1.5	2.25 m	ok
Cashpoint	1	1	ok	1.5*1	1.5*1m	ok
Safes	1	1	ok	4*4m	-	ok
Archive room	1	1	ok	17 (m2)	0.6(m2)	ok
Reception	2	2	ok	16 (m2)	1.20-4.50(m2)	ok
stores	1	1	ok	9 (m2)	0.6(m2)	ok
entrance	5	2	not ok	3(m2)	0.4(m2)	ok
server room	1	1	ok	2(m2)	1(m2)	ok
Elevator in safes	0	1	not ok	-	1.8 × 2.85 m	ok
Elevator	2	3	not ok	2*5	1.8 × 2.85 m	ok
Stairs	1	2	not ok	2*1.7	1.5 × 1.5m	ok
Emergency Stair	1	2	not ok	-	1.5 × 1.5m	ok
Parking	30	115	not ok	1.5*2	5*2.5m	not ok
security	1	1	ok	26	13($m2$)	ok

2.3 Case study analysis :

Banks are among the buildings whose data and information are withheld, so there was difficulty in making a high-quality study bag

2.3.1 Fire suppression system

In this project , the used fire system is FM200 system .

FM200 gas extinguishes fire in two directions: the first is to cool the fire or flame to a level below the point of complete ignition and explosion, and the second is to break the chain of oxidation reactions of the fire by displacing the oxygen present in the air.

This system is commonly used in data centers, communication rooms (UPS rooms), medical facilities, banks and museums.

The percentage of FM200 gas concentration is determined for each facility, according to the level of protection required, and it is usually between 6% and 7%, and it is determined according to hydraulic calculations and engineering design.

Components of the FM200 gas fire extinguishing system

Components of the FM200 gas fire extinguishing system:

FM200 gas cylinder: the size of the cylinder is determined according to the need of the room to be extinguished (and there are cylinders of all sizes) by means of hydraulic calculations and according to the NFPA code.
Pipeline network for gas discharge: The pipe network is determined by its diameters according to the engineering design and hydraulic calculations, which determine the number of nozzles in the room according to the NFPA code.
Fire extinguishing panel and sensors: It is responsible for receiving the signal from the sensors and sending it to the solenoid to complete the unloading process.
Network wires and pipes for the alarm.
Fire alarm siren.
Fire alarm.

.The idea of the system:

When there is a fire, a signal is sent through the sensors in the room to the extinguishing panel, and then a signal is sent from the solenoid valve panel, so the process of emptying the gas in the room takes place, and it works to break the chain of oxidation reactions for the fire by displacing the oxygen in the air and replacing the FM200 gas in its place according to the specified ratio.

Figure 32: fair room .

2.3.2 Security surveillance cameras (IP camera)

.fixed cameras & moving cameras

1-Cameras must support audio inputs and outputs.

2-The type of lens must be variable according to the coverage area (lens focal-Vari.)

3-Cameras must work on IPv4, HTTPS, UDP, RTP, HTTP/v6,Qos network technology.

4-External cameras must operate at high efficiency at a temperature covering (-10 to+65 degrees Celsius or better) and humidity not less than 90.

5-Mobile cameras must have a minimum resolution of 2 megapixels.

Figure 33: External cameras

Figure 34: camera .

The location of cameras:

1-Cameras must be placed at entrances and exits.

2-There should be a camera above each employee's desk.

3-There should be cameras at the bank's safe location.

4-There must be cameras in the outer perimeter of the building, and their locations must reveal the entrances to the building from the surrounding streets.

5-Cameras must be located in parking lots.

Figure 35 : Teller in the bank and distribute it

Figure 36 : Lobby in the bank and distribution.

2.3.3.Private money safe in the bank:

The case study is VEIT Bank in Vietnam with total area=915 m^2.

Figure 37 : bank elevation

The idea of having the safe on the parking floor was taken from this project so that a special elevator was used for the car to deliver the money from the parking lot to the ground floor where the safe is located, as we notice in the parking plan the type of door designated for the car, so it has specific specifications commensurate with its function as well In the ground floor plan, there is an examination room before the money enters the safe, and one of the most important characteristics of the safe is that it has thick and armed walls to achieve safety and to avoid thefts, but there are no suitable dimensions for the safe because it differs according to the contents of the safe.

The dimensions of the safes vary according to the type of thing placed in them. The size of the money safe varies from Documents locker and valuables locker, the sizes vary in one type.

The weight of any safe should be less than 340 kilograms in order to be safe against theft.

The walls around the safe shall be made of reinforced concrete with a thickness of 30-34 cm.

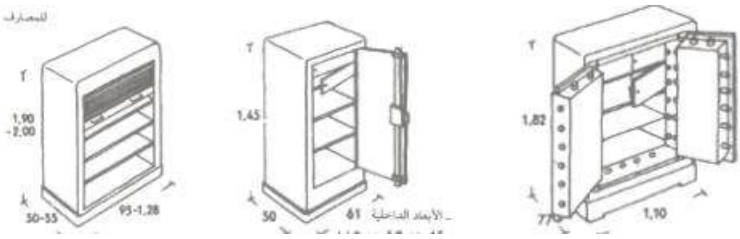


Figure 38: safe

The walls of the safe must be against ignition and bullets.

And glass facades have been used for the building so that there is contact between employees and customers with the external environment and so that the customer feels comfortable and reassured.

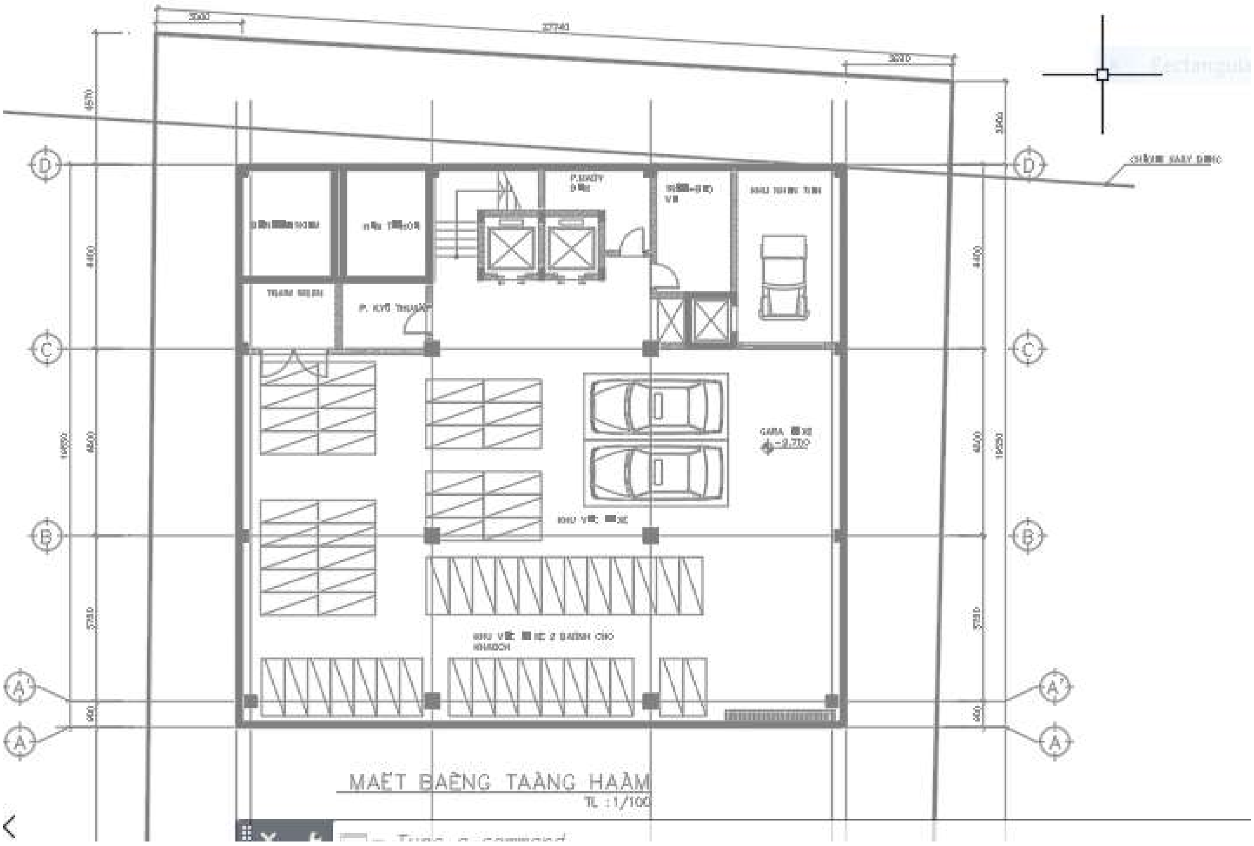


Figure 39 : Location safe it in the bank

2.3.4.Sensors

Sensors are everywhere. They're in our homes and workplaces, our shopping centers and hospitals, Sensors come in many shapes and sizes, some are purpose-built containing many built-in individual sensors, allowing you to monitor and measure many sources of data and using sensors in bank prevent theft attempts.

Here are 10 of the more popular types of Iota sensors and some of their use cases:

1- Temperature Sensors: Temperature sensors measure the amount of heat energy in a source, allowing them to detect temperature changes and convert these changes to data.

2- Humidity Sensors: These types of sensors measure the amount of water vapor in the atmosphere of air or other gases. Humidity sensors are commonly found in heating, vents and air conditioning (HVAC) systems in both industrial and residential domains.

3- Pressure Sensors: A pressure sensor senses changes in gases and liquids. When the pressure changes, the sensor detects these changes, and communicates them to connected systems.

4- Proximity Sensors: Proximity sensors are used for non-contact detection of objects near the sensor. These types of sensors often emit electromagnetic fields or beams of radiation such as infrared. Proximity sensors have some interesting use cases. In retail, a proximity sensor can detect the motion between a customer and a product in which he or she is interested. The user can be notified of any discounts or special offers of products located near the sensor. Proximity sensors are also used in the parking lots of malls, stadiums and airports to indicate parking availability. They can also be used on the assembly lines of chemical, food and many other types of industries.

5- Level Sensors: Level sensors are used to detect the level of substances including liquids, powders and granular materials.

6- Accelerometers: Accelerometers detect an object’s acceleration i.e. the rate of change of the object’s velocity with respect to time, they can also be used as anti-theft protection alerting the system if an object that should be stationary is moved.

7- Gyroscope: Gyroscope sensors measure the angular rate or velocity, often defined as a measurement of speed and rotation around an axis.

8- Gas Sensors: These types of sensors monitor and detect changes in air quality, including the presence of toxic, combustible or hazardous gasses.

9- Infrared Sensors: These types of sensors sense characteristics in their surroundings by either emitting or detecting infrared radiation. They can also measure the heat emitted by objects. Infrared sensors are used in a variety of different IoT projects including healthcare as they simplify the monitoring of blood flow and blood pressure. Televisions use infrared sensors to interpret the signals sent from a remote control. Another interesting application is that of art historians using infrared sensors to see hidden layers in paintings to help determine whether a work of art is original or fake or has been altered by a restoration process.

10- Optical Sensors: Optical sensors convert rays of light into electrical signals. There are many applications and use cases for optical sensors. In the auto industry, vehicles use optical sensors to recognize signs, obstacles, and other things that a driver would notice when driving or parking. Optical sensors play a big role in the development of driverless cars.

2.5 Security:

Security is a very important aspect in banking that must be considered and worked on to protect users from any incidents. The following measures were taken to increase security in the project:

1. Eliminating the sky light
2. Changing the type of glass used in the exterior facades from single to stronger and lead-resistant glass with insulation.
3. Studying the location of the vault, making its walls 500mm thick, and using shear walls. The external entrance to the vault from the back is eliminated, and an active transfer system is installed in the parking lot. There is also a room in the parking lot for receiving the money transport vehicle.
4. Eliminating the external emergency staircase and moving it inside.
5. Equipping the vault with an electronic system, sensors, and an alarm that automatically locks itself if anyone enters without permission.
6. Separating the employees' entrance from the visitors' entrance, with access to the employees' entrance only through a card.
7. Providing security personnel and a room for them at the visitors' entrance.
8. Distributing cameras throughout all reception areas and sensors in important rooms, and allowing access to the employees' rooms only through cards.
9. Designing two separate car parking areas, one for employees and the vault, and the other for visitors. Employees are only allowed to access their parking area with their card.
10. Locating the fire room in a place that is out of reach.
11. Implementing a fire suppression system suitable for protecting the information and data in the bank.

2.5 Site Analysis

2.5.1 Introduction about Nablus city

The Palestinian city of Nablus is located in the northern part of the West Bank, 60 km north of Jerusalem. According to its strategic location between Mount Ebal and Mount Gerizim, Nablus is the largest cultural and commercial center in Palestine.

The city covers an area of 28.6 km2 and has a population of approximately 388,321 people, according to 2017 statistics.

The city of Nablus contains many areas, the most famous of which is the Rafidia area, on one of whose lands this project was designed.

Figure 40: Nablus Map (Geomolg,ps)

2.5.2 Location

This picture shows the location of the plot of land on which the bank will be executed, which is located in the Rafidia area.

Figure41 : Site of land (Geomolg, ps)

2.5.3 Land Analysis:

The building is bounded from the north and west sides by two main and secondary streets. The northern side contains the main street with a level of 0.00, and it also contains the main entrance to the building and the new entrance to the parking is from the main street at level 0.00 , as the land of the building is located at a level of +0.15, while the ground floor is located at a level of +1.15.

As for the western street, its level is low, and with the rise it increases until it reaches a level of +2.00.

One of the most crucial factors in the design process is the terrain. A thorough survey and precise measurements should be done to identify property borders before the design process even begins.

It appears that we need to dig to provide enough space for car garages as the current area is insufficient to accommodate the required number of cars that must be achieved in the building the difference between the ground and ground level that will be Excavation is necessary because the building's access is above street level , and the constructed soil is a solid clay soil with a bearing capacity of 220 kN/m² after the bearing capacity soil test.

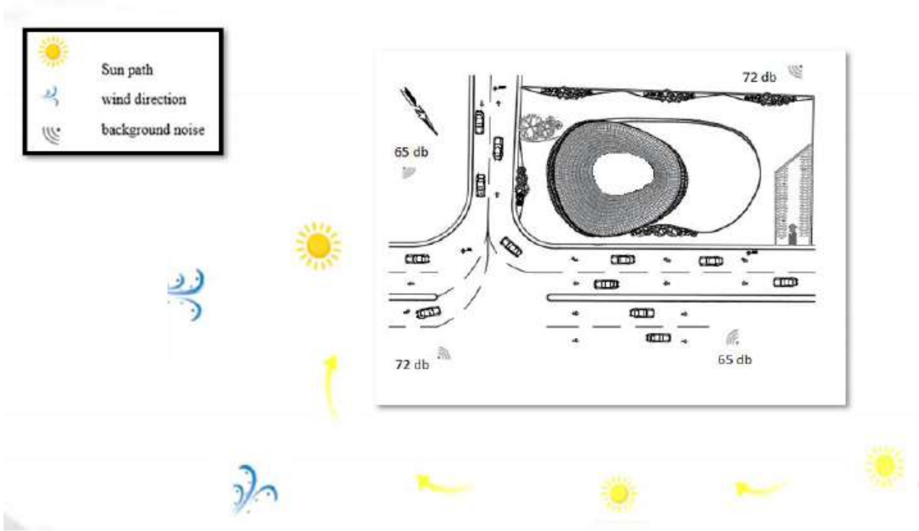


Figure42 : Site plan

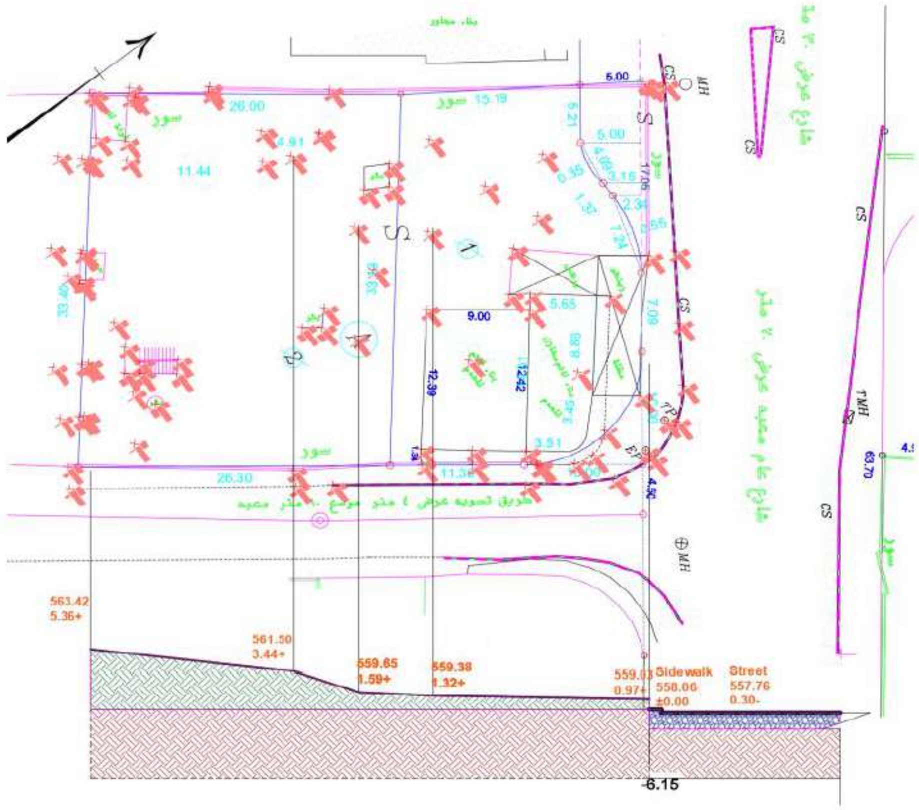


Figure43 : Section in the land

2.5.4. climate of the site area

The climate in Nablus is moderate due to its location in the Mediterranean region, which means that it experiences a dry summer season for several months. During the winter season, it experiences a cold rainy period.

As for the weather in the region, the rains are mainly concentrated in the spring and winter seasons, and they occur during the period between October and May. The average annual rainfall in the region is around 1660 mm. Due to the prevailing northwest winds, the average annual wind speed in the region is around 10 km per hour.

while the general average minimum temperature reaches (19.5) C^{o}.

As for the relative humidity in Nablus Governorate, the annual average annual rate reaches (61%).

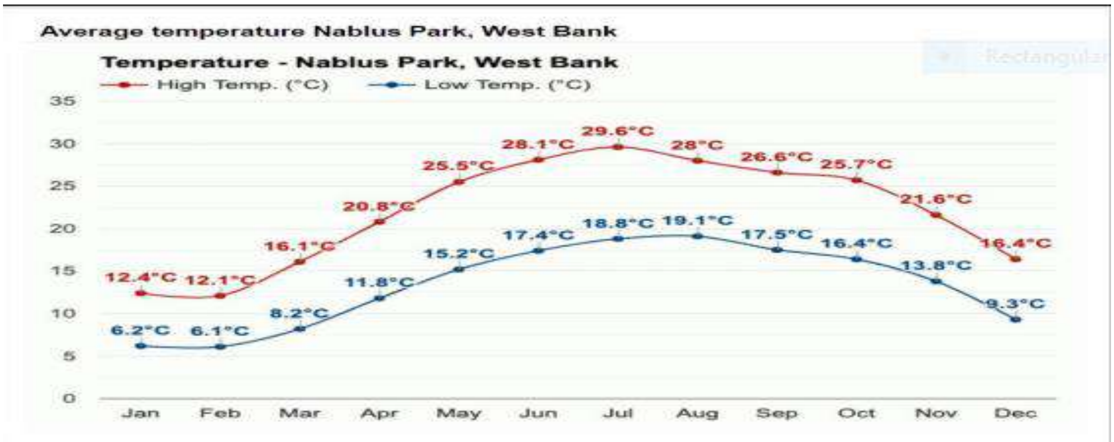


Figure 44: Elements of the General weather constituents in Nablus.

2.5.5. Summary of climate

Summary for the climate in Nablus:

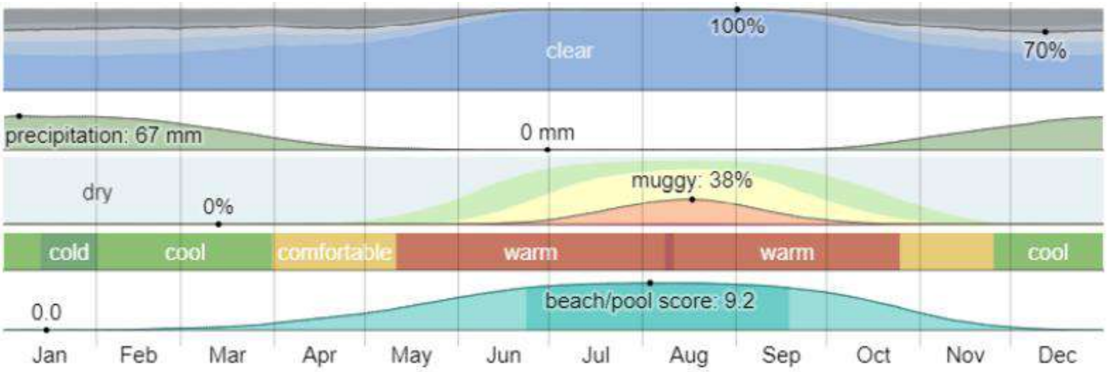


Figure45 : climate summary (weatherspark.com)

2.5.6 Clouds

In the city of Nablus, there is no specific picture of the spread of clouds in the sky, as the shape and distribution of clouds varies continuously, but there are certain months during the year in which the sky is very clear or very cloudy.

The cloudiest month of the year is December then November, with a percentage of 29%.

The clearest month of the year in Nablus is August then July, with a percentage of 100%.

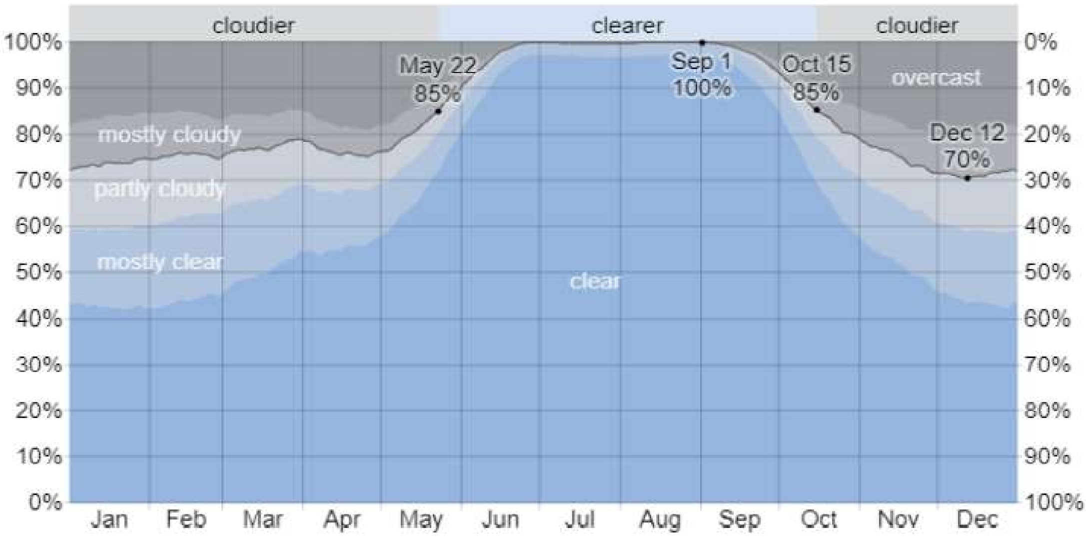


Figure46 : Clouds (weatherspark.com)

2.5.7 Temperature:

The coldest month of the year in Nablus is January, with an average between 6°C and 13°C.

The cool seasons is from December 10 to March 13, with a temperature below 16°C.

The hottest month of the year in Nablus is August, with an average between 20°C and of 29°C.

The hot seasons is from May 30 to October 10, with a temperature below 16°C.

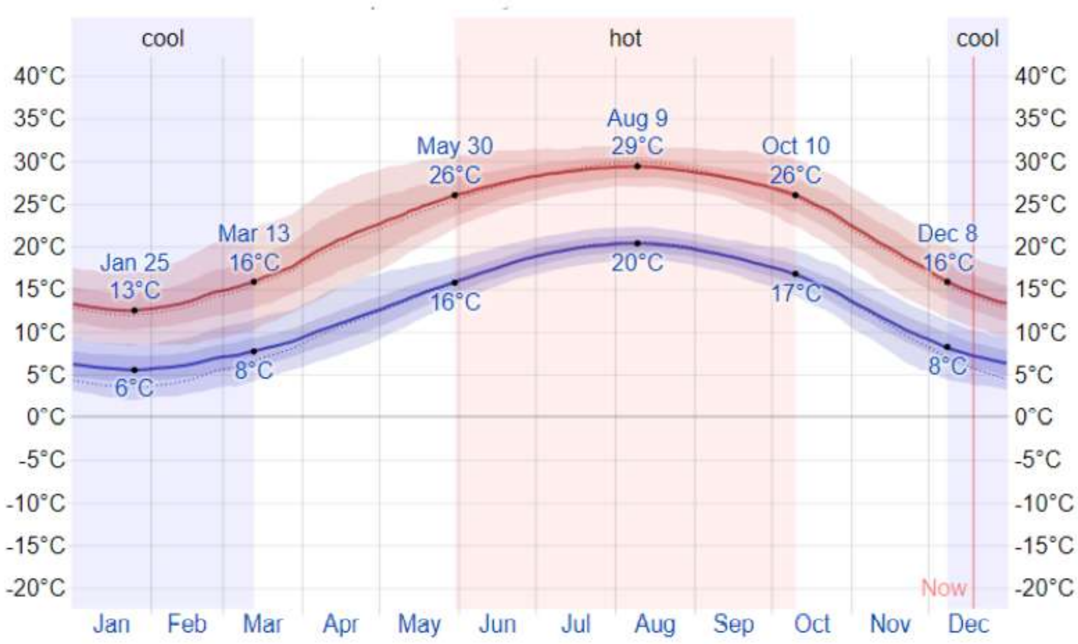


Figure47 :Temperature (weatherspark.com)

2.5.8 Precipitation

The chance of wet days and dry days varies from day to day and is not fixed.

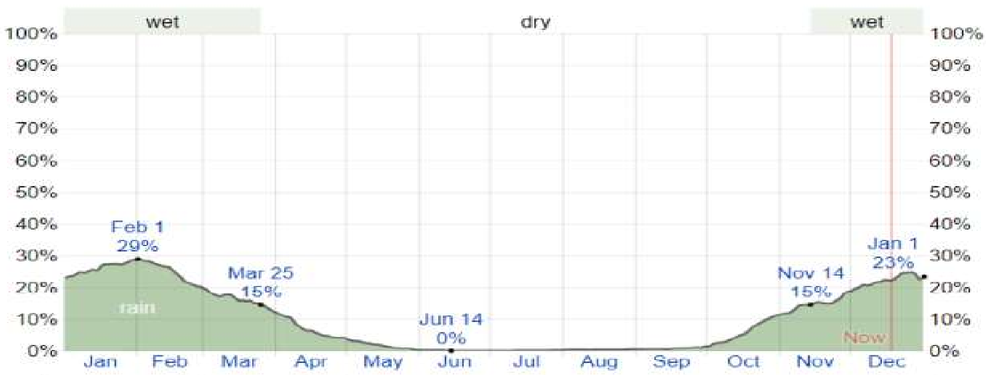
The month with the most wet days in Nablus is January, with an average with 1 millimeter of precipitation.

The wetter period is from November 14 to March 26, with a chance of 15% or more wet day.

The most percentage of precipitation is 29% on February 1.

The fewest percentage of precipitation is 0% on June 14.

The drier period is from March 26 to November 14.



The percentage of days in which various types of precipitation are observed, excluding trace quantities: rain alone, snow alone, and mixed (both rain and snow fell in the same day).

Figure48 : Precipitation (weatherspark.com)

2.5.9 Sun visibility

The shortest day in 2022 is December 21, with 10 hours, 2 minutes of daylight.

The longest day is June 21, with 14 hours, 16 minutes of daylight.

Figure49 : the number of hours for sun visibility (weatherspark.com)

2.5.10 Rainfall

The month with the most rain in Nablus is January, with an average of 66 millimeters.

The month with the least rain in Nablus is July, with an average rainfall of 0 millimeters.

Figure50 : Rainfall (weatherspark.com)

2.5.11 Humidity

A muggy day is typically followed by a muggy night.

The most muggy month in Nablus is August.

The least muggy month is March 13.

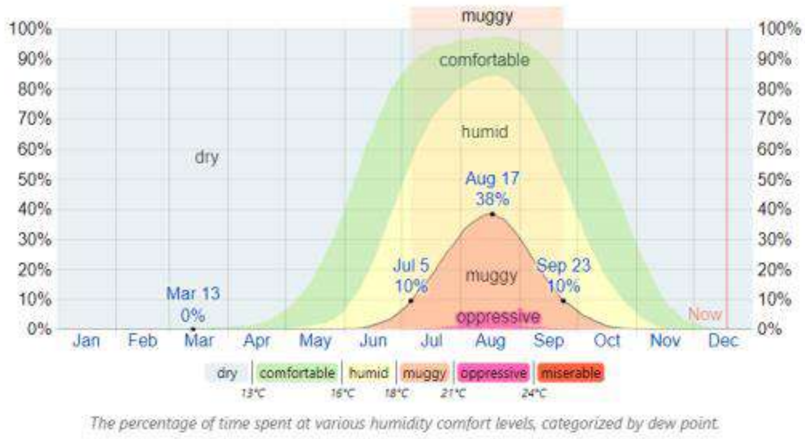
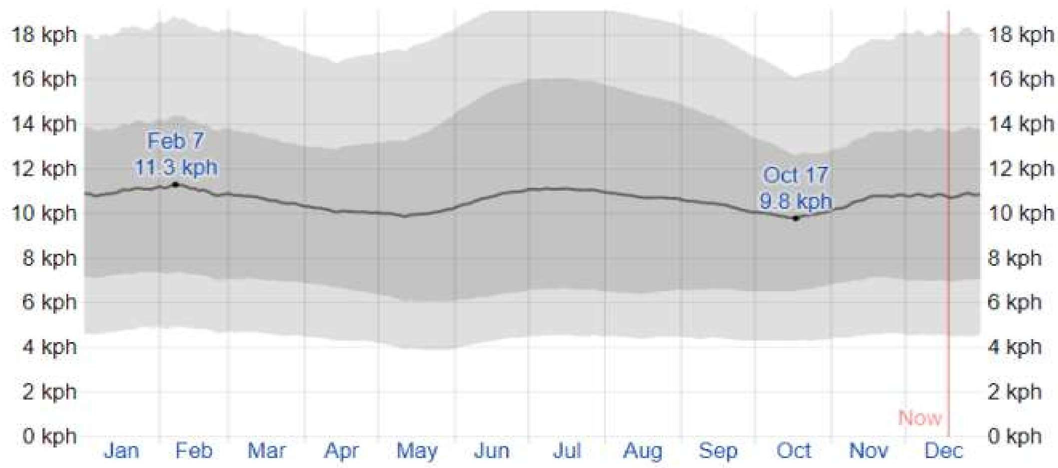


Figure51 : Humidity (weatherspark.com)

2.5.12 Wind

The average wind speed in Nablus is between 0.8 kilometers per hour of 10.5 kilometers per hour.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wind Speed (kph)	11.0	11.1	10.6	10.1	10.0	10.7	11.1	10.8	10.3	9.9	10.6	10.8

Figure52 : Wind (weatherspark.com)

Wind Direction in Nablus:

The prevailing winds in the north direction are confined between October 2 to November 3, with a percentage of 44% .

The prevailing winds in the west direction are confined between November 3 to November 11 October, with a percentage of 33%.

The prevailing winds in the west direction are confined between November 11 to December 22, with a percentage of 38%.

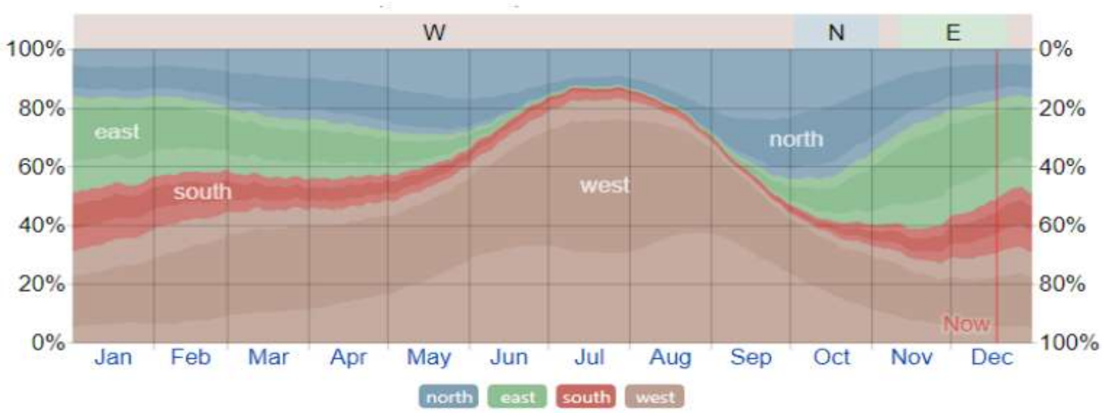


Figure53 : Wind direction in Nablus(weathersparks.com)

2.5.13 Ventilation:

Which is mean the process of "changing" or replacing air in any space to provide high indoor air quality.

The ventilation in commercial buildings within 2-3 (ach/h) , and for offices within 1-2 times per hour (ach/h).

There is a lot of type of ventilation :

1-Natural ventilation

2-Mechanical Ventilation

3-Spot Ventilation

4-Hybrid Ventilation

5-Task Ambient Conditioning (TAC)

2.5.14 Noise and inconvenience

There are many sources of chaos around the building, the most important of which are the northern and western streets, as the building is located in a public location where movement and movement abound, as the dB value of the building's perimeter ranges between 65 dB to 72 dB.

2.6 Architecture drawings

One of the most important parts of the project is the part through which the most important architectural modifications that were applied to the building by making and a comparison between the architectural plans before and after the modification.

2.6.1 Before & after modifications

This section shows the architectural plan for each floor before the modifications

- Basement 1

  The following figure shows the location of elevators and shafts, the distribution of cars, and the entrance ,the exit of these cars.

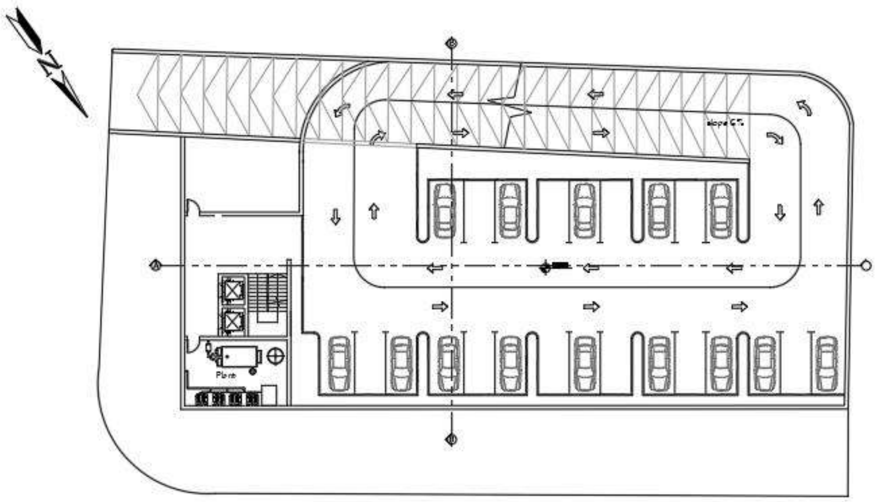


Figure 54: Basement 1 (Before modification)

- Basement1

  This floor is for people who are working in bank.

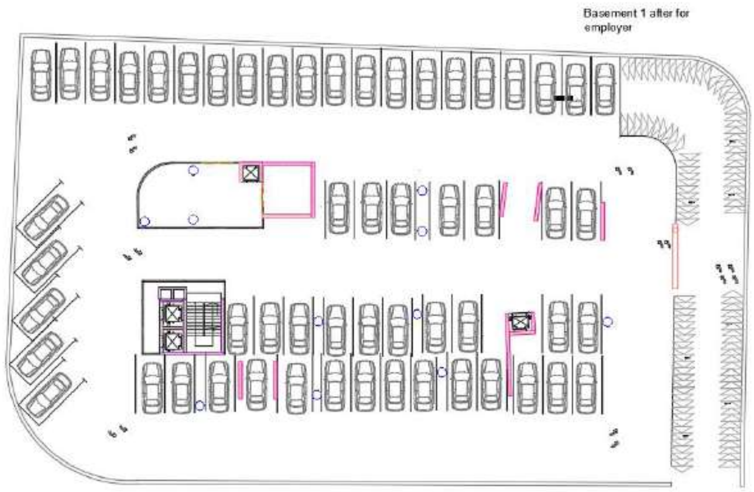


Figure 55: basement 1 (After modification)

- Basement 2

The following figure shows the location of elevators and shafts, the distribution of cars, and the entrance ,the exit of these cars.

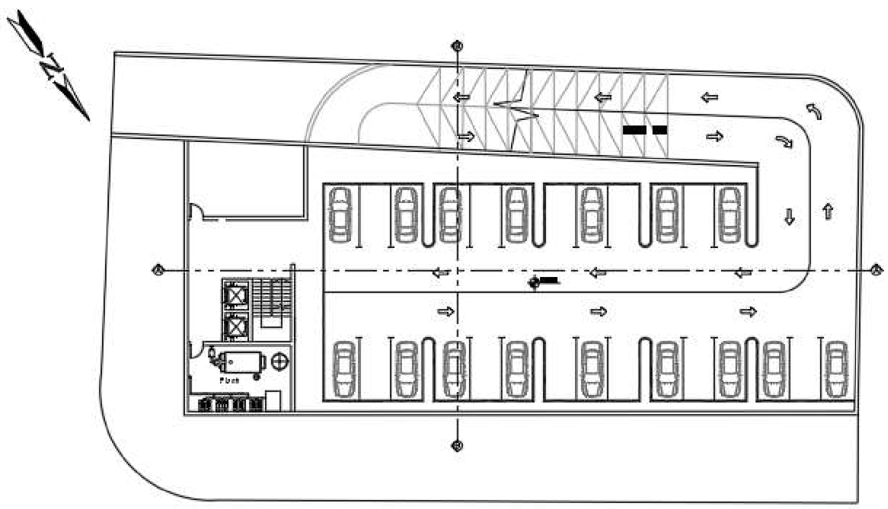


Figure 56: Basement 2 (Before modification)

- Basement2

This floor is for visitors.

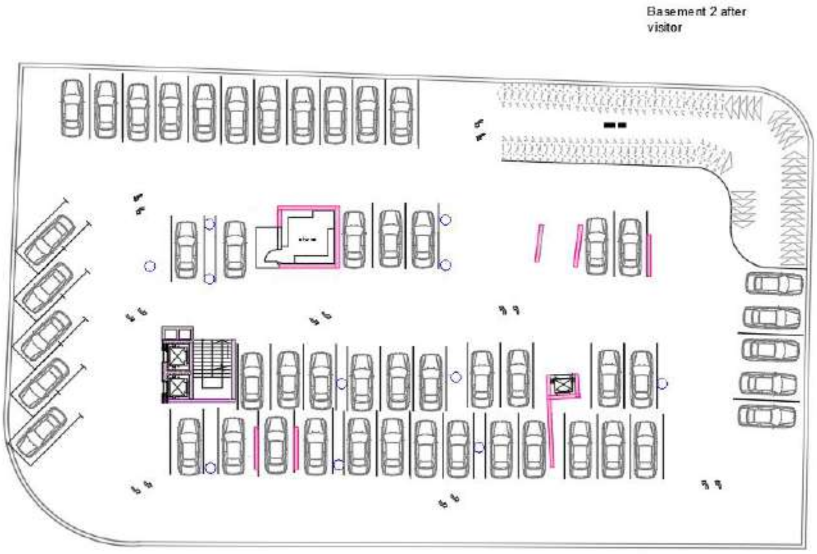


Figure 57: basement 2 (After modification)

- Ground floor

This floor contains many rooms that differ in their function, including: the bank manager's room, the reception room, a meeting room, special rooms for completing transactions, a special room in the safe, and a waiting room.

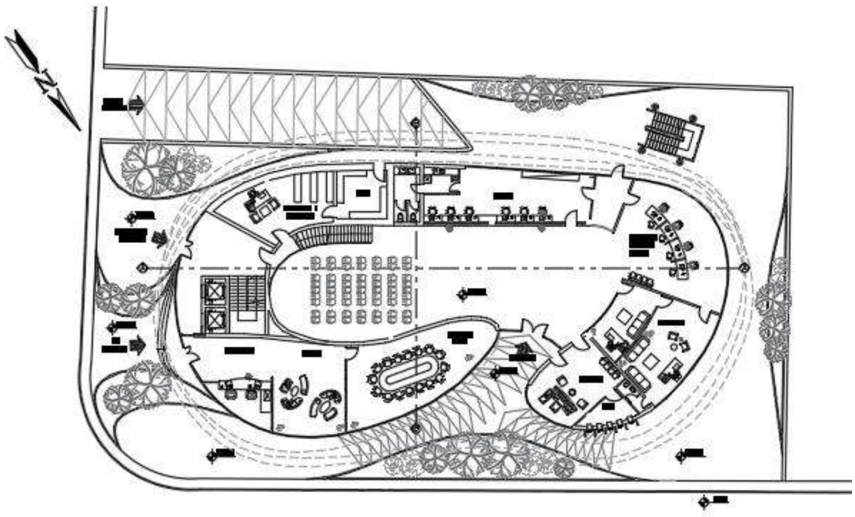


Figure 58: ground floor (Before modification)

- Ground floor

In this floor there is a lot of architectural modifications, first of all , another emergency exit was added inside the building according to the codes instead of the external emergency exits, a special fire room was added on the ground floor, a camera and surveillance room was added on the ground floor, the direction of the observation seats was changed towards the service rooms for ease of communication between employees and customers, In order to take into account the security and safety requirements, a special elevator has been set up in the safe to transport money from the entrance to the safe located in the garages to the ground floor, based on the codes and design standards, we need three elevators instead of two, the elevator was added to all floors except for the last two floors, the locations of the bathrooms and their number were changed based on the codes to suit the number of employees. An additional glass entrance has been added to the building to increase security.

The location of the reception room was replaced with the location of the meeting room to suit the location of each of them with its function, and in the end two shafts were added for special services for each of the HVAC, electrical and mechanical.

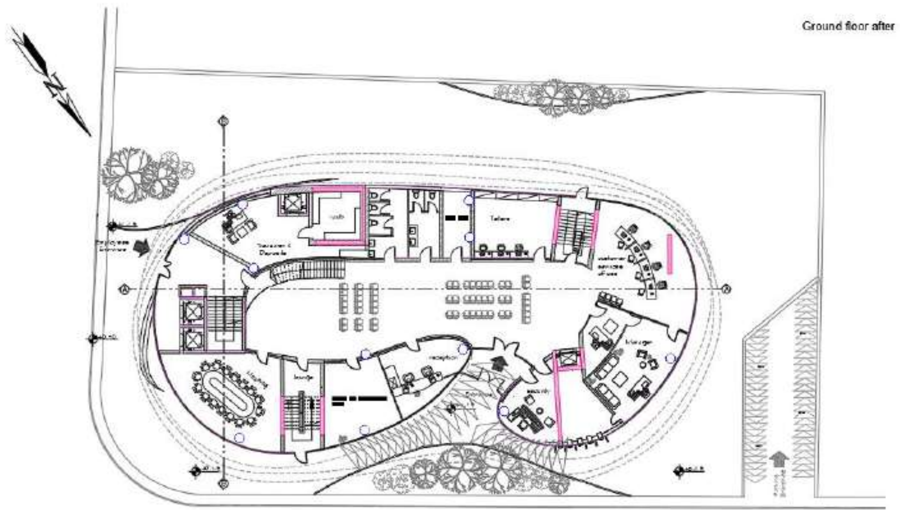


Figure 59: ground floor (After modification)

- first floor

This floor contains many rooms that differ in their function, including: the bank manager's room, the reception room, a meeting room, special rooms for completing transactions, a special room in the safe, waiting room and archive room.

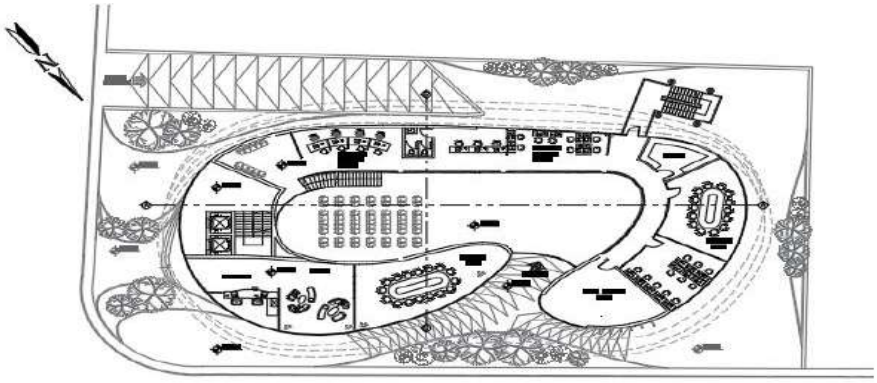


Figure60 : first floor (Before modification)

- first floor

The location of the reception room was replaced by the place of the meeting room to suit the desired function, two shafts were added to the building near to the elevators, a new emergency exit was added according to the codes, the emergency exits became internal and third elevator was added.

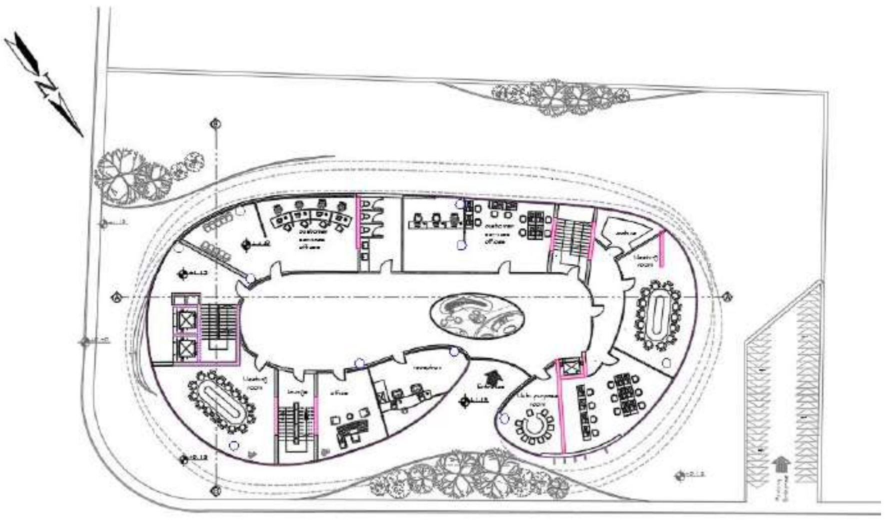


Figure 61: first floor (After modification)

- Second floor

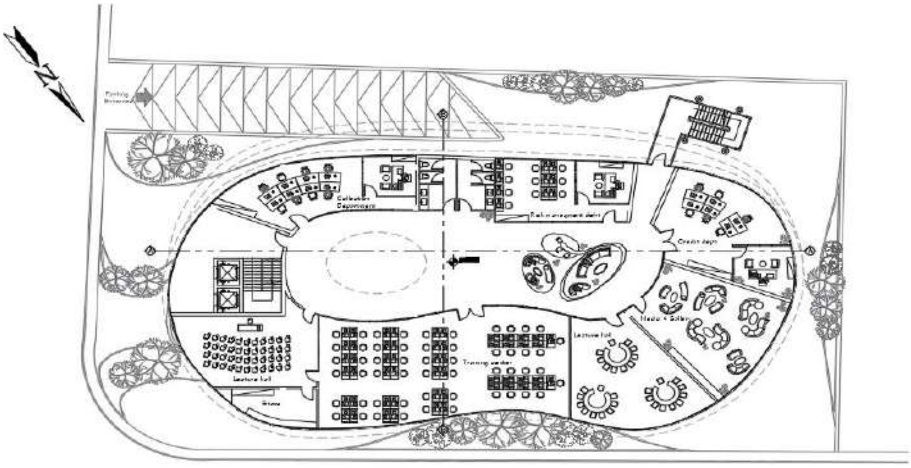


Figure62 : second floor (Before modification)

- second floor

  Two shafts were added to the building near to the elevator, a new emergency exit was added according to the codes, the emergency exits became internal and third elevator was added.

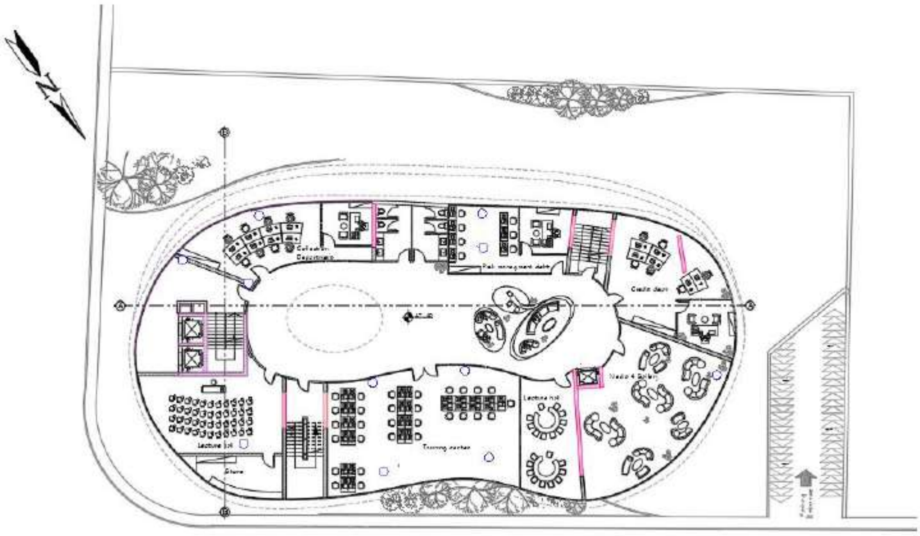


Figure 63: second floor (After modification)

- Third floor

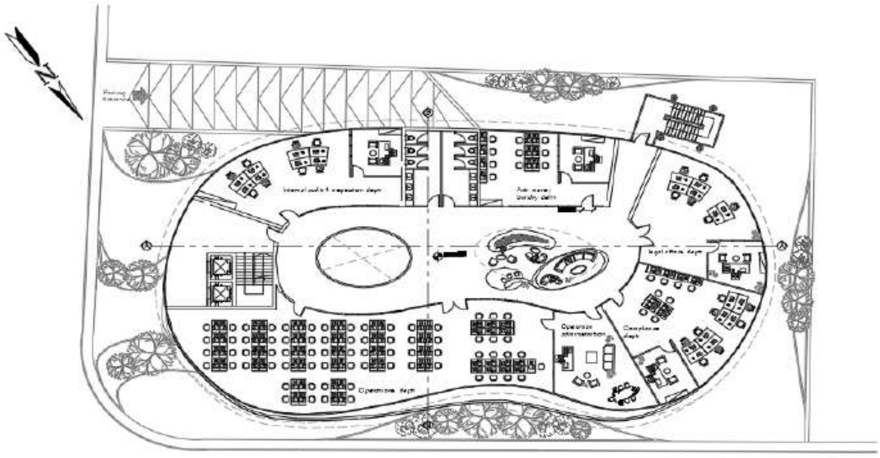


Figure 64: third floor (Before modification)

- Third floor

  Two shafts were added to the building near to the elevator, a new emergency exit was added according to the codes, the emergency exits became internal and third elevator was added.

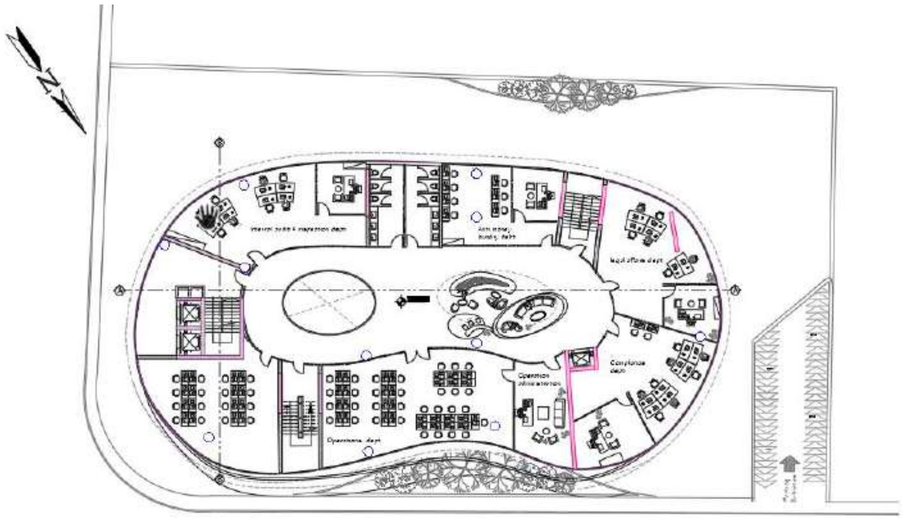


Figure 65: third floor (After modification)

- Fourth floor

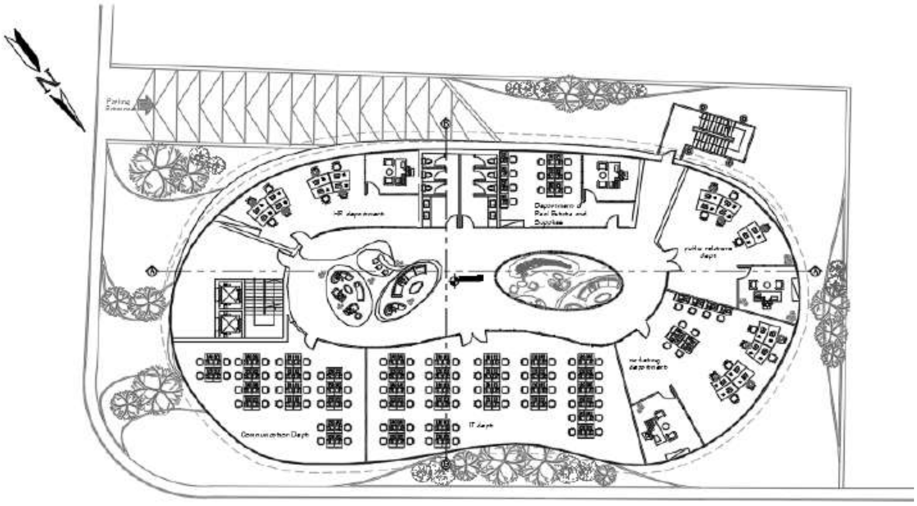


Figure 66: fourth floor (Before modification)

- Fourth floor

  Two shafts were added to the building near to the elevator, a new emergency exit was added according to the codes, the emergency exits became internal and third elevator was added.

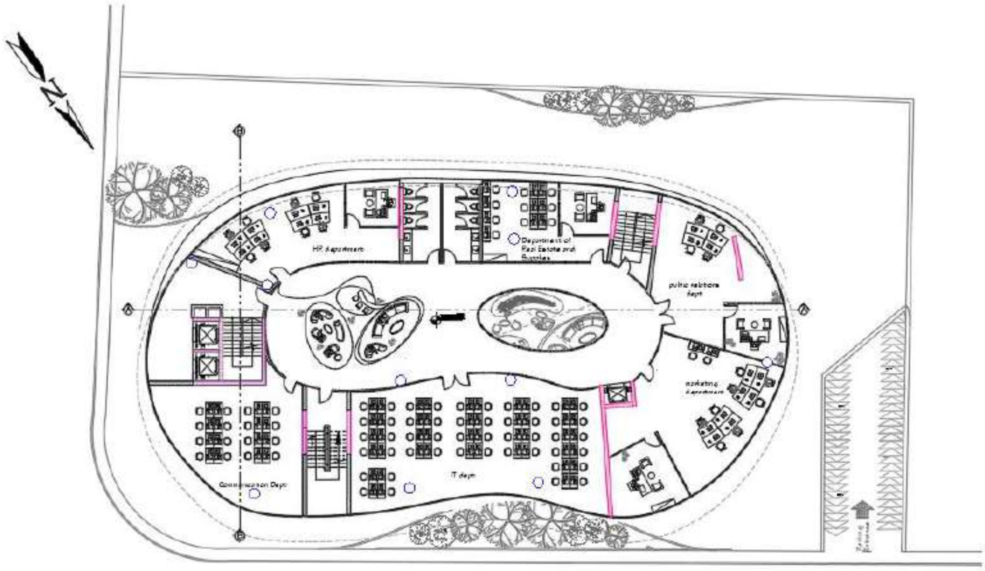


Figure 67: fourth floor (After modification)

- Fifth floor

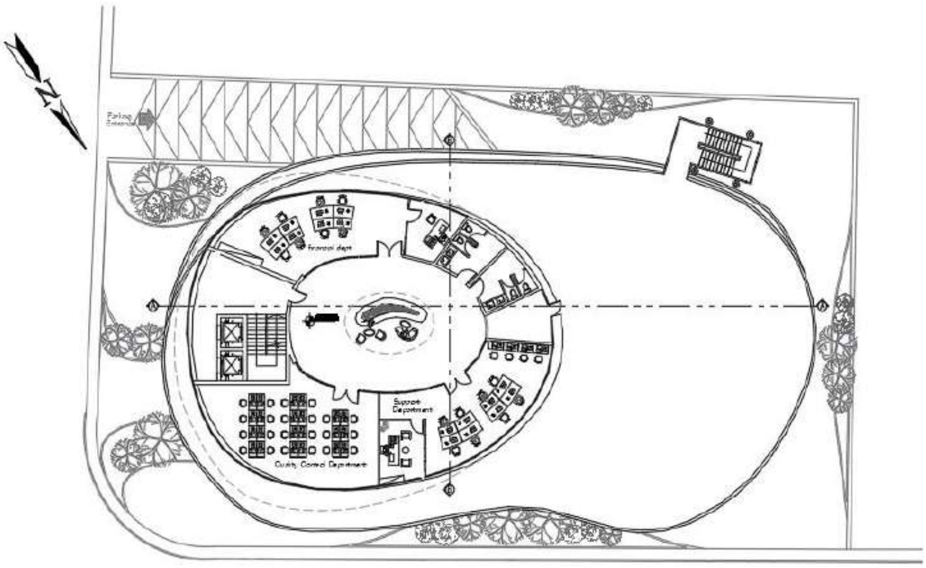


Figure 68: fifth floor (Before modification)

- Fifth floor

Two shafts were added to the building near to the elevator.

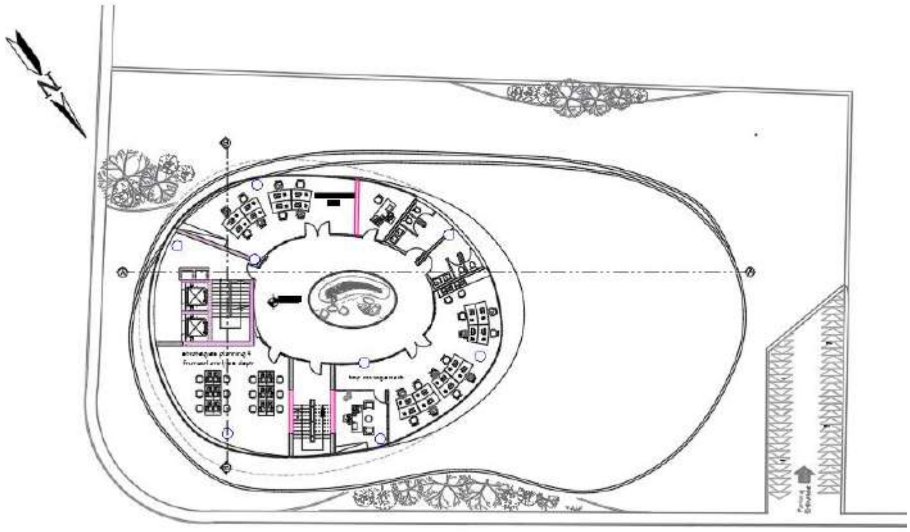


Figure 69: fifth floor (After modification)

- Sixth floor

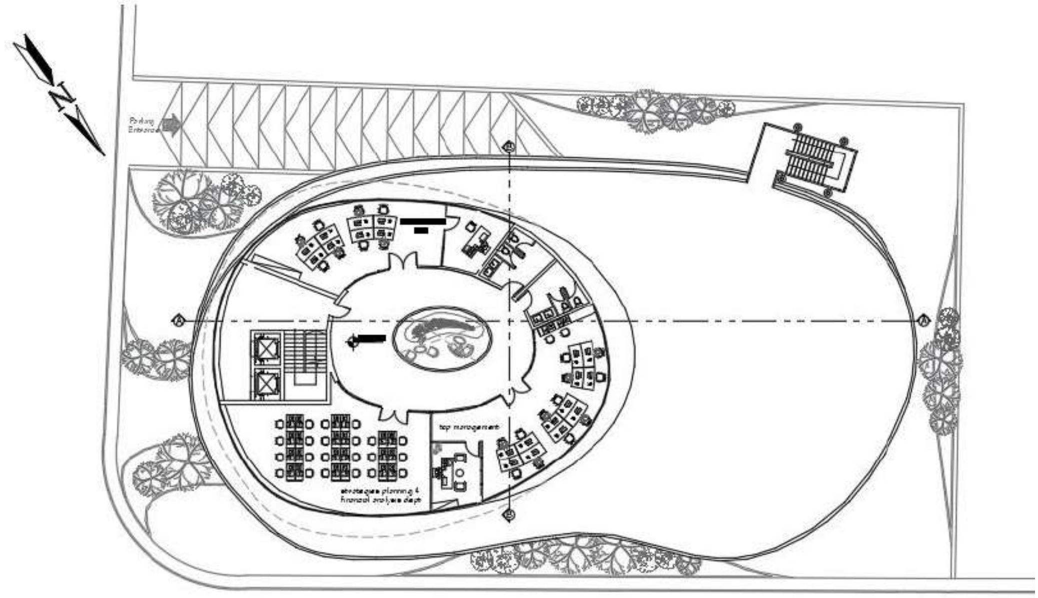


Figure 70: sixth floor (Before modification)

- Sixth floor

Two shafts were added to the building near to the elevator.

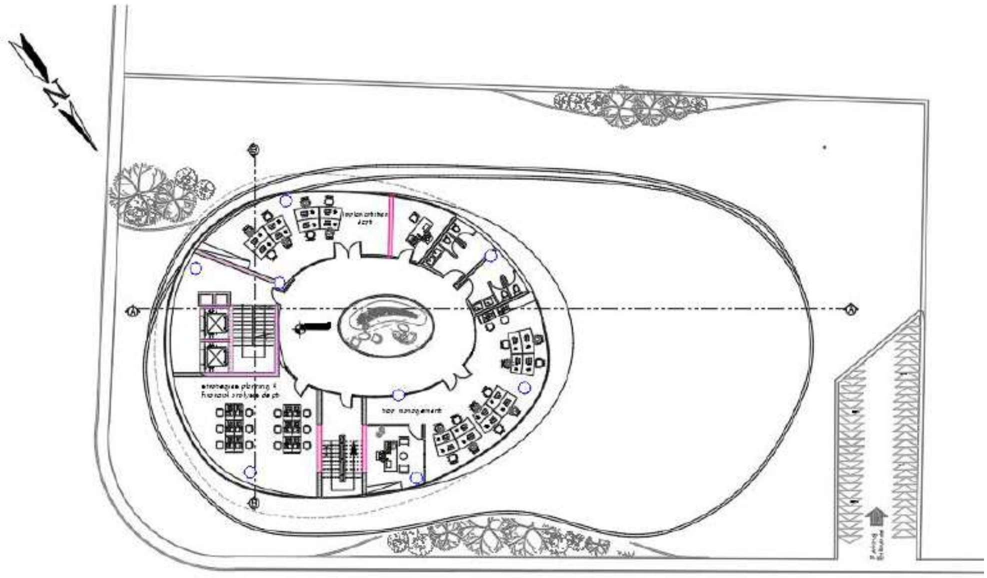


Figure71 : sixth floor (After modification)

- South elevation

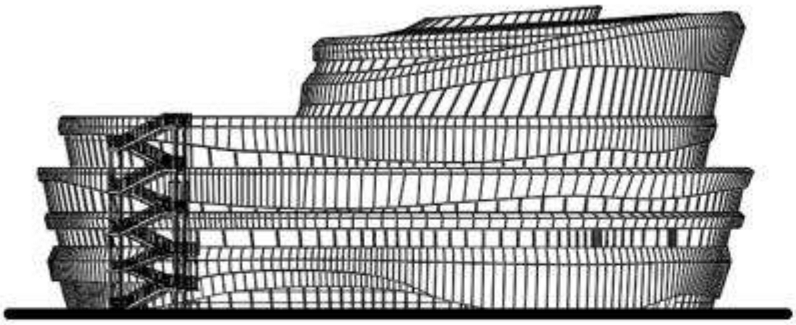


Figure 72: south elevation (Before modification)

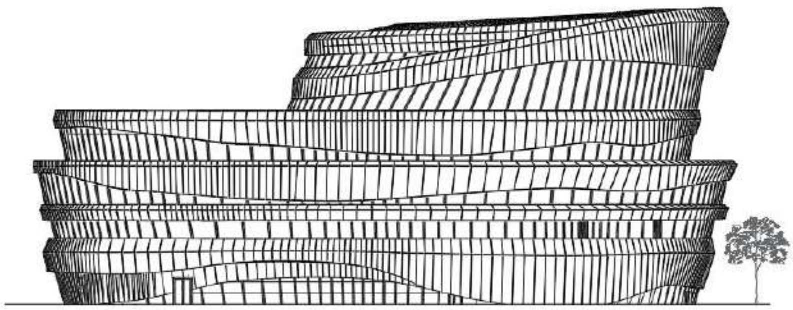


Figure 73: southern elevation (After modification)

- North elevation

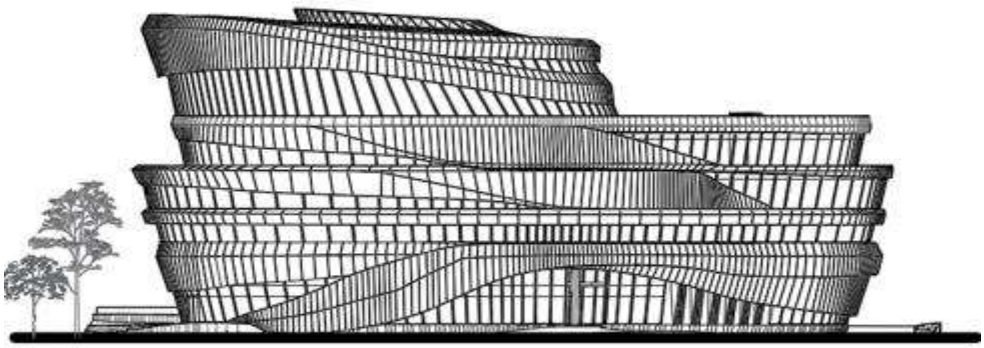


Figure 74: north elevation (Before modification)

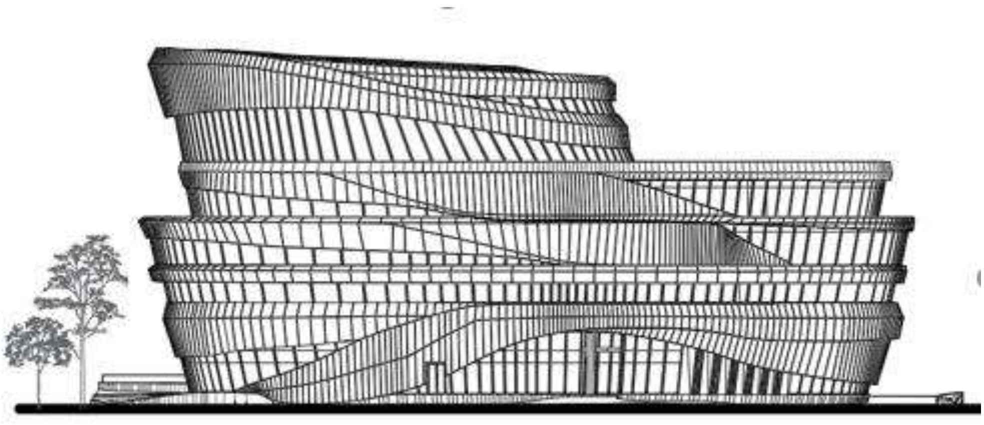


Figure 75: northern elevation (After modification)

- East elevation

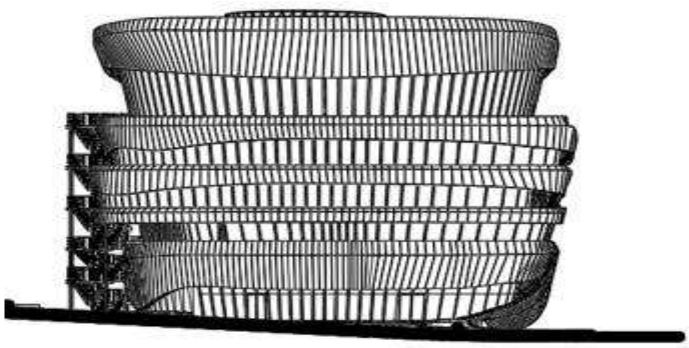


Figure 76: east elevation (Before modification)

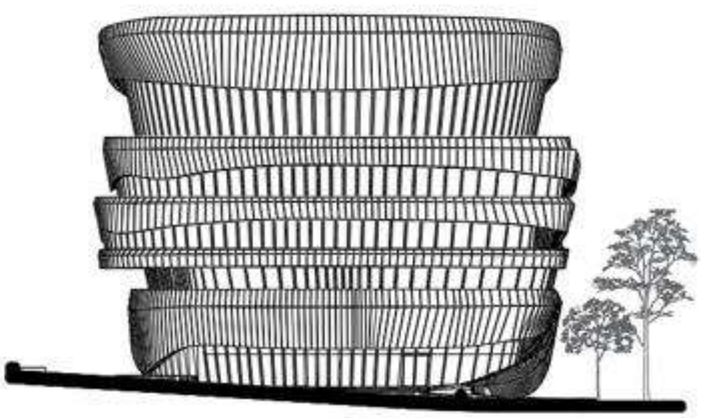


Figure 77: eastern elevation (After modification)

- West elevation

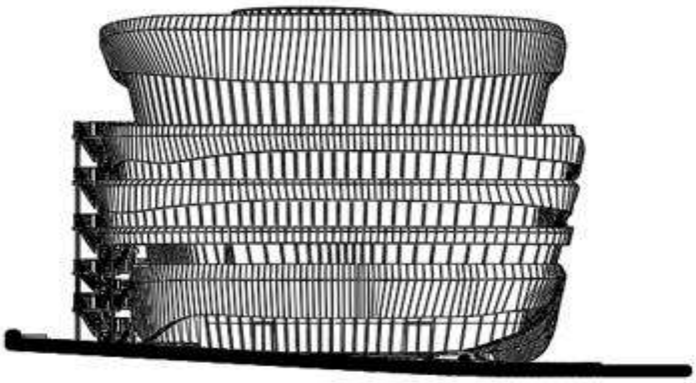


Figure 78: west elevation (Before modification)

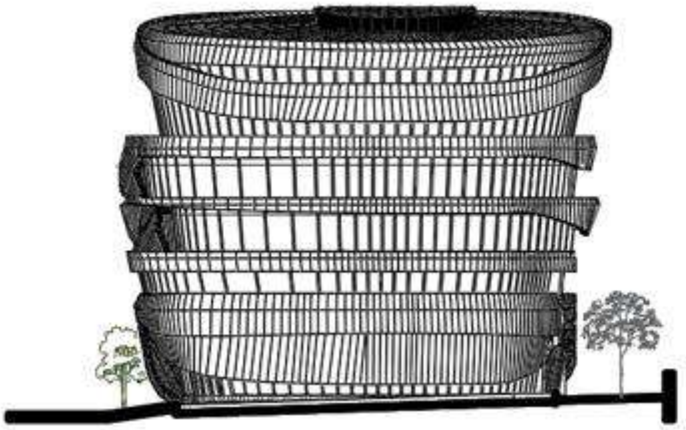


Figure 79: western elevation (After modification)

2.7 Environmental analysis

2.7.1 : Introduction

The study of environmental aspects is one of the most important steps to know the extent of its impact on our buildings. Therefore, in this chapter, we made an analysis of the component that will affect the environmental comfort will be carried out. The requirement for environmental aspects that we should study to achieve the environmental comfort in any building where it requires those in the building access to satisfaction, comfort and ease of work in order for them to be able to accomplish and develop in their work, we make analyses on design builder program to study this factor:

2.7.2 Before modification

In this part, the effect of each of the shadows and the effect of daylighting factor on the building will be presented before the modifications.

2.7.1.1 Shadowing and overshadowing

The figure shows the effect of the shadow at different times of the day.

Shadow at Summer:

At 9:00 AM

The figure shows that the location of the sun at this hour in relation to the building led to the emergence of a shadow on the western and southern facades of the building without affecting in the northern facade. So this is a good point due to the importance of the sun entering to the building in the morning hours.

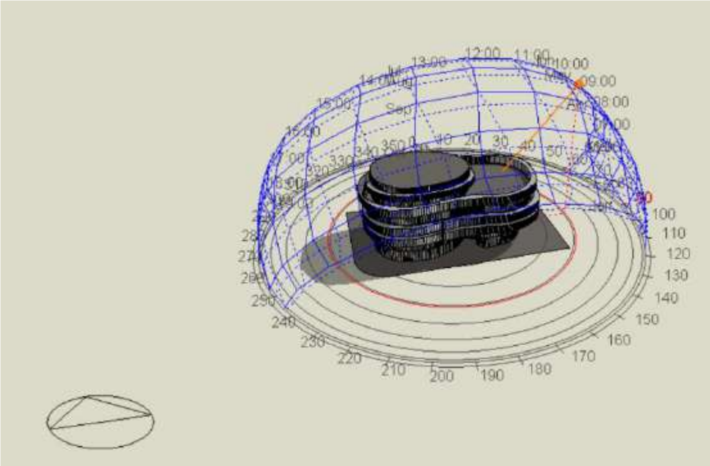


Figure80 : Shadowing at date 21/6 at 9:00 a.m.

At 12:00 PM

The figure shows that the position of the sun at this hour relative to the building led to the appearance of a small shadow on the southern facade of the building without affecting each of the other facades.

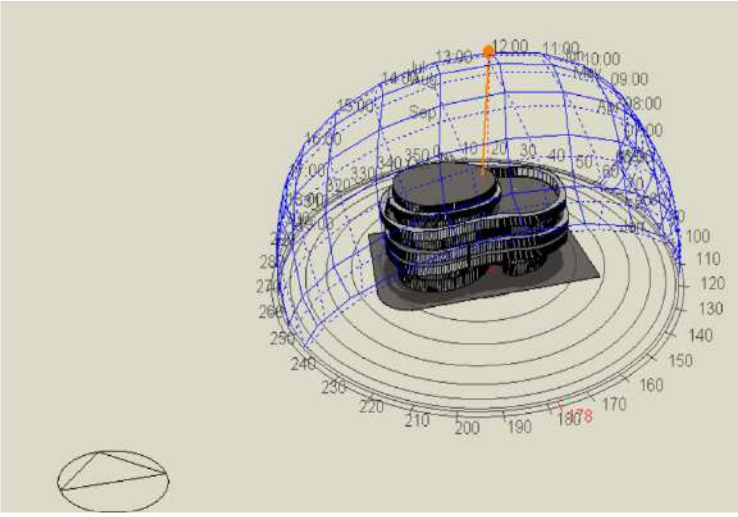


Figure 81: Shadowing at date 21/6 at 12:00 p.m.

At 3:00 p.m

The figure shows that the position of the sun at this hour relative to the building led to the appearance of a shadow on the western and sothern facades of the building without affecting both the eastern and northern facades, and therefore the sun's rays fall mainly on the western façade.

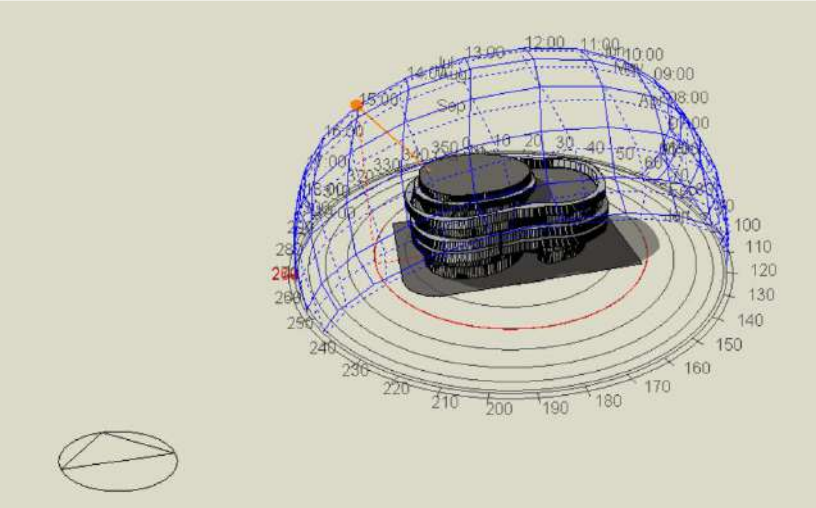


Figure 82: Shadowing at date 21/6 at 3:00 p.m

Shadow at winter

At 9:00 a.m.

The figure shows that the position of the sun at this hour relative to the building led to the appearance of a shadow on the southern facade of the building without affecting both the eastern and western facades, and therefore the sun's rays fall mainly on the nothern façade.

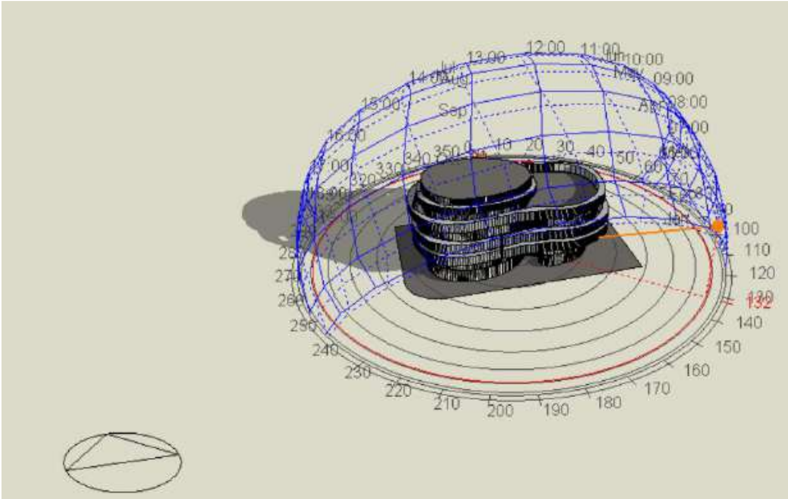


Figure83 : Shadowing at date 21/12 at 9:00 a.m.

At 12:00 p.m.

The figure shows that the position of the sun at this hour relative to the building led to the appearance of a shadow on the western facade of the building without affecting in the eastern facade, and therefore the sun's rays fall mainly on the northern façade.

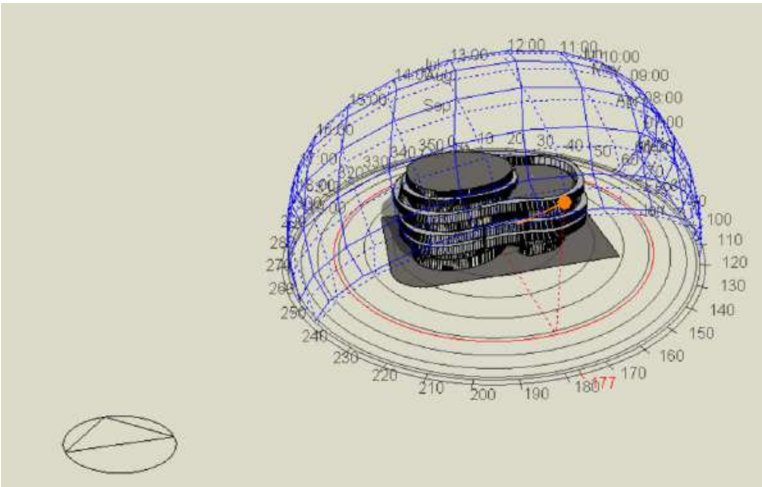


Figure84 : Shadowing at date 21/12 at 12:00 p.m.

At 3:00 p.m.

The figure shows that the position of the sun at this hour relative to the building led to the appearance of a shadow on the western and southern facades of the building without affecting both the northern and eastern facades, and therefore the sun's rays fall mainly on the northern façade.

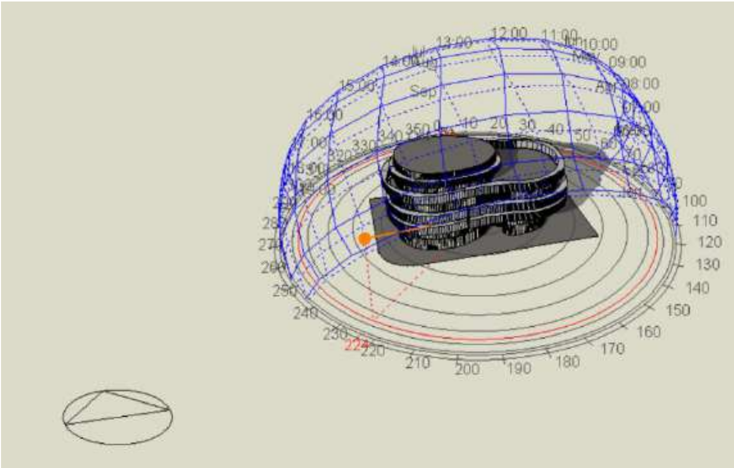


Figure 85: Shadowing at date 21/12 at 3:00 p.m.

2.7.1.2 Daylight factor

Daylight factor (DF) is a daylight availability metric that expresses as a percentage the amount of daylight available inside a room (on a work plane) compared to the amount of unobstructed daylight available outside under overcast sky conditions.

Daylight from Revit software:

Detailed in Graduation Project 1.

Daylight from Design Builder software

$$DF = \frac{\text{indoor illuminace from daylight}}{\text{outdoor illuminance}} \times 100\%$$

Figure 86: daylight factor equation

This equation shows the ratio between the light indoor the facility and the light outside the facility.

The natural light of the sky in the clouds in Palestine is 9000 lux.

This table shows the recommended values of daylight factor in different spaces:

Table 13: recommended values of daylight factor

TABLE 14.2 Recommended Daylight Factors

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%

Source: Millet and Bedrick (1980).

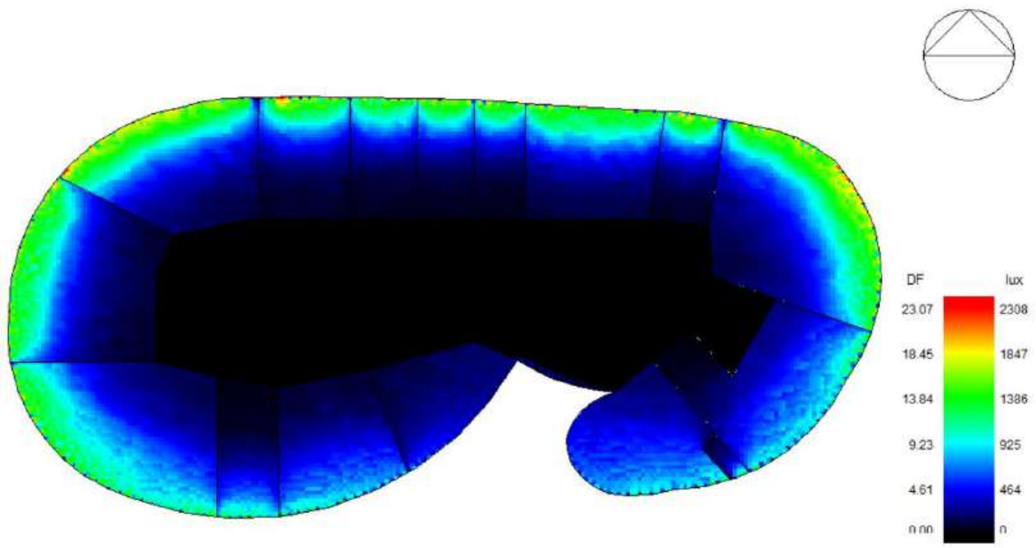
[a]Use the smaller DF values for southern latitudes with plentiful winter daylight.

Daylight factor analysis before modification:

This section shows the daylight factor analysis using design builder software before modifications.

- Ground floor analysis:

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



Figur87 : Daylight factor in GF before modification

The figure shows that the value of daylight factor in ground floor is meduim, so there is low natural light in this floor, so a solution must be found.

And there are dark areas where daylight is low in some spaces which means that there is a higher cost in industrial lighting.

- First floor

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

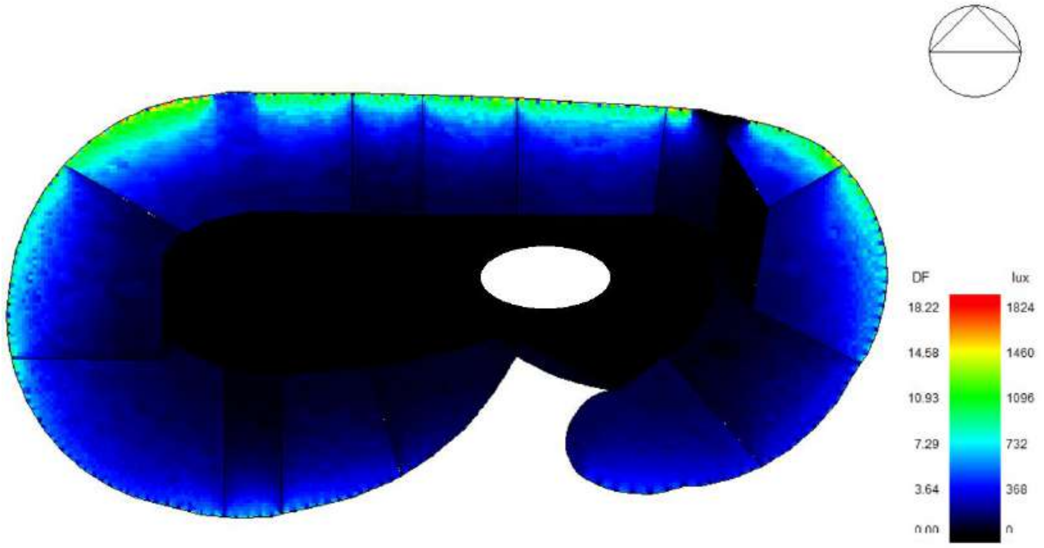


Figure88 : Daylight factor in first floor before modification

The figure shows that the value of daylight factor in first floor is low , so there is low natural light in this floor, so some improvement should made.

And there are dark areas where daylight is low in some spaces which means that there is a higher cost in industrial lighting.

- Second floor

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

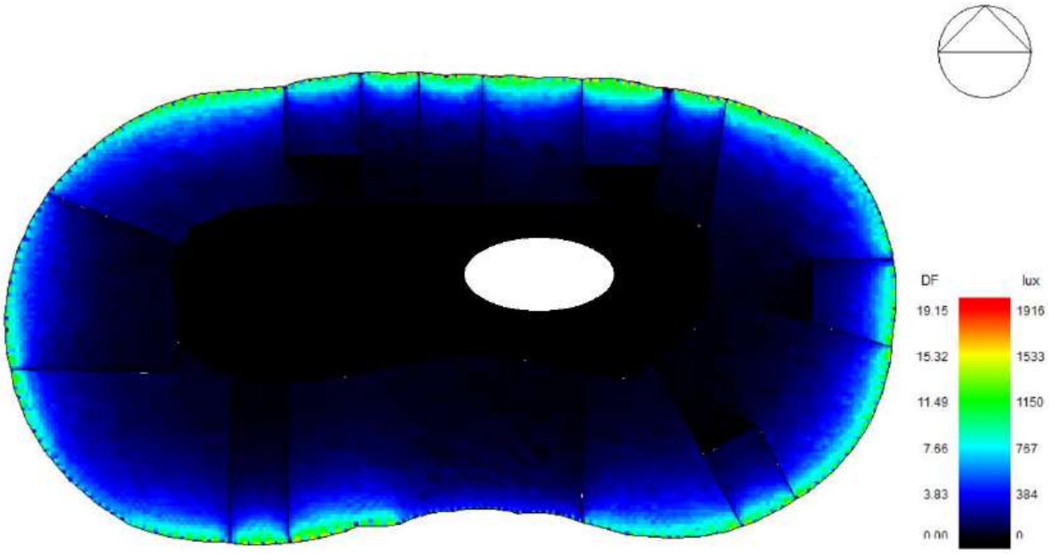


Figure89 : Daylight factor in second floor before modification

The figure shows that the value of daylight factor in first floor is very low , so there is no natural lighting in this floor, so some improvement should made.

And there are dark areas where daylight is low in some spaces which means that there is a higher cost in industrial lighting.

- Third floor

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

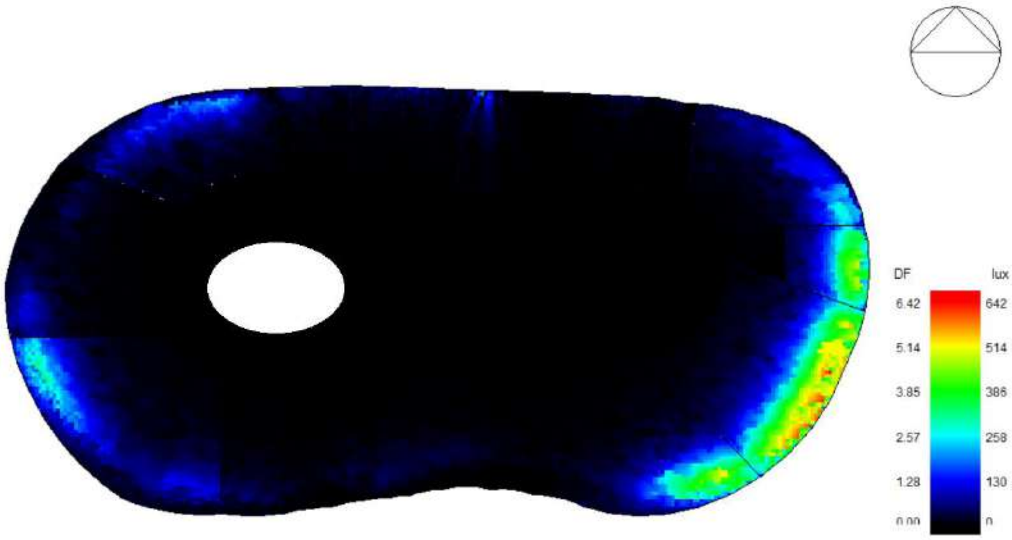


Figure90 : Daylight factor in third floor before modification

The figure shows that the value of daylight factor in first floor is very low , so there is no natural lighting in this floor, so some improvement should made.

And there are dark areas where daylight is low in some spaces which means that there is a higher cost in industrial lighting.

- Fourth floor

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

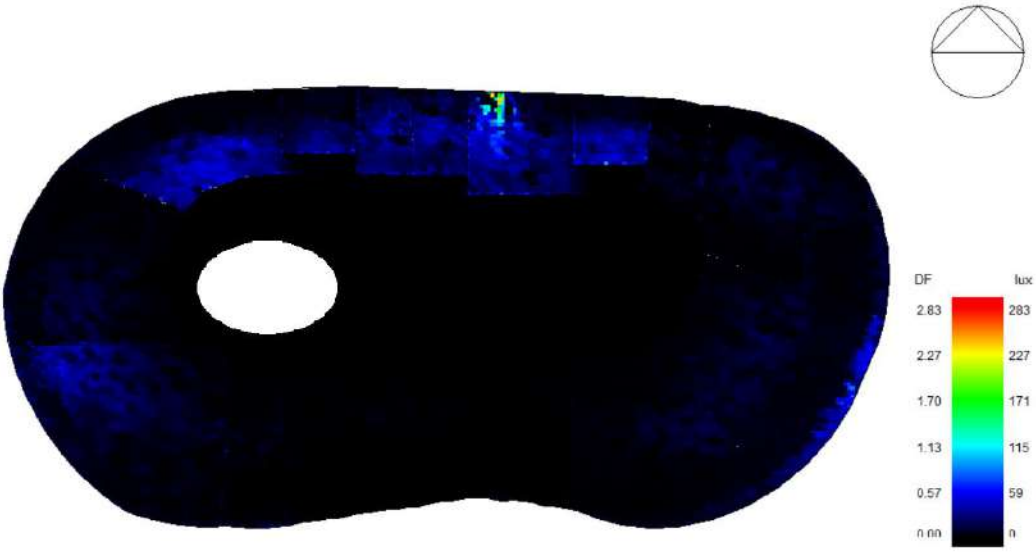


Figure91 : Daylight factor in fourth floor before modification

The figure shows that the value of daylight factor in third floor is low , so there is low natural light in this floor, so some improvement should made.

And there are dark areas where daylight is low in some spaces which means that there is a higher cost in industrial lighting.

- Fifth floor

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

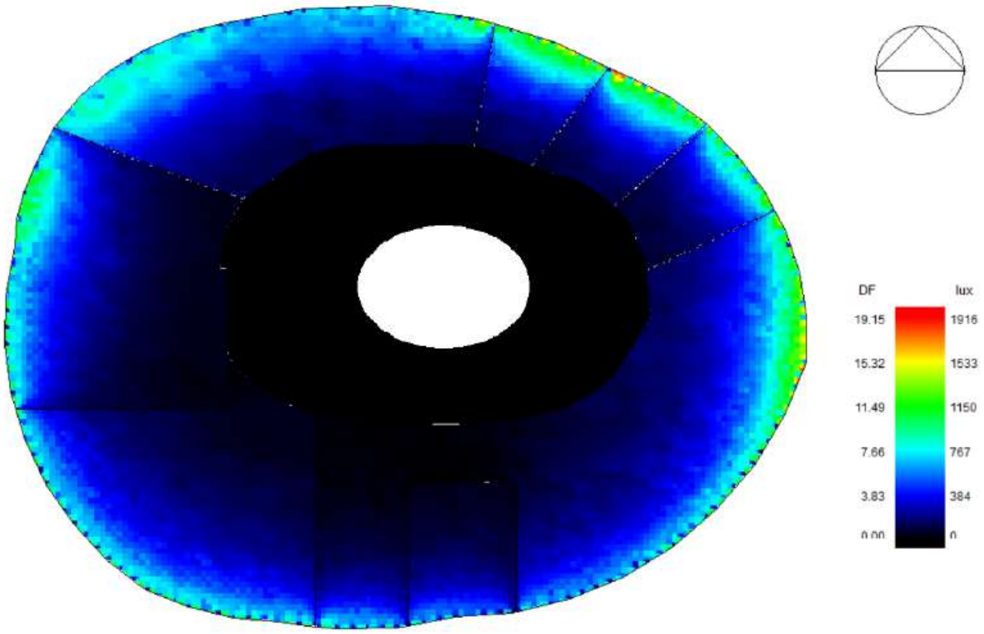


Figure92 : Daylight factor in fifth floor before modification

The figure shows that the value of daylight factor in fourth floor is low , so there is low natural light in this floor, so some improvement should made.

And there are dark areas where daylight is low in some spaces which means that there is a higher cost in industrial lighting.

- Sixth floor

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

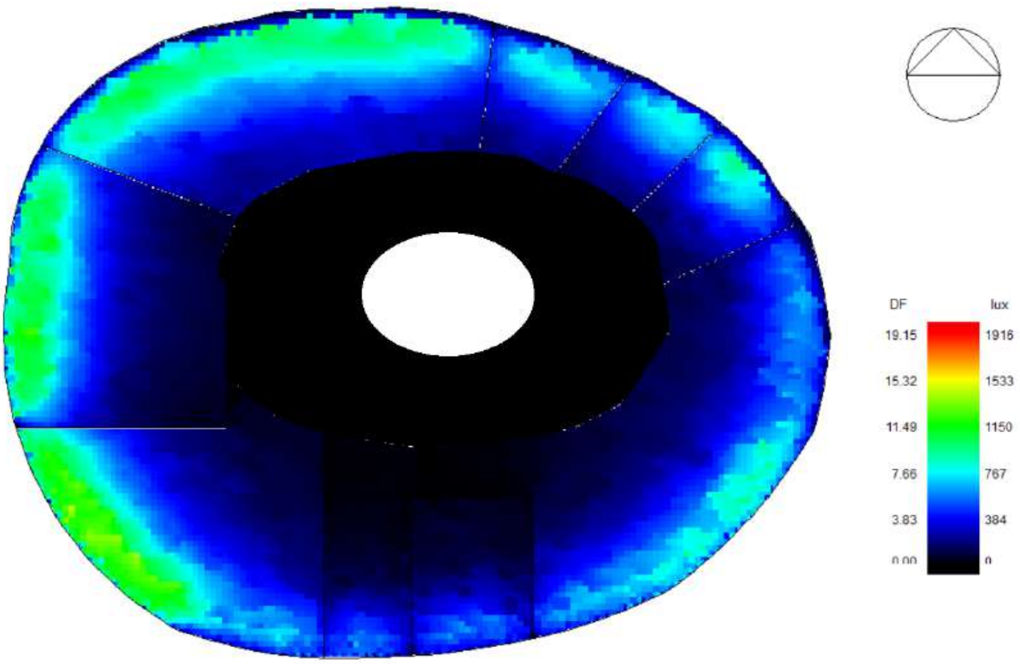


Figure93 : Daylight factor in sixth floor before modification

The figure shows that the value of daylight factor in fifth floor is low in some spaces , so there is low natural light in this floor, and medium in other spaces, so some improvement should made.

And there are dark areas where daylight is low in some spaces which means that there is a higher cost in industrial lighting.

2.7.3 After modification

This section shows the results of some of the modifications made to the environmental part of the project:

2.7.2.1 Shading system:

Many methods were used inside the building, including: insulation in the internal partitions and insulation in the ceiling, and the glass type SGG XT 60-28 6/16/4 was used of a type with good specifications (60% lighting, 26% solar energy and good insulation), using shutters.

• Using shutters which is an internal system putting on the window in the east and west of the building according to azimuth and zenith angle of the sun in Palestine.

The next picture shows the shape of shutters:

Figure94 : window shutters

• SGG XT 60-28 6/16/4 (60% lighting ,26% solar, good insulation)used on design builder software:

Calculated Values	
Total solar transmission (SHGC)	0.275
Direct solar transmission	0.252
Light transmission	0.608
U-value (ISO 10292/ EN 673) (W/m2-K)	1.041
U-Value (W/m2-K)	**1.349**

Figure95 : U-value and proprieties for SGG XT 60-28 6/16/4 (60% lighting ,26% solar, good insulation)

2.7.2.2 Daylight factor

Daylight form Design Builder software(after modification)

This section shows the daylight factor analysis using design builder software after modifications.

• Ground floor

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

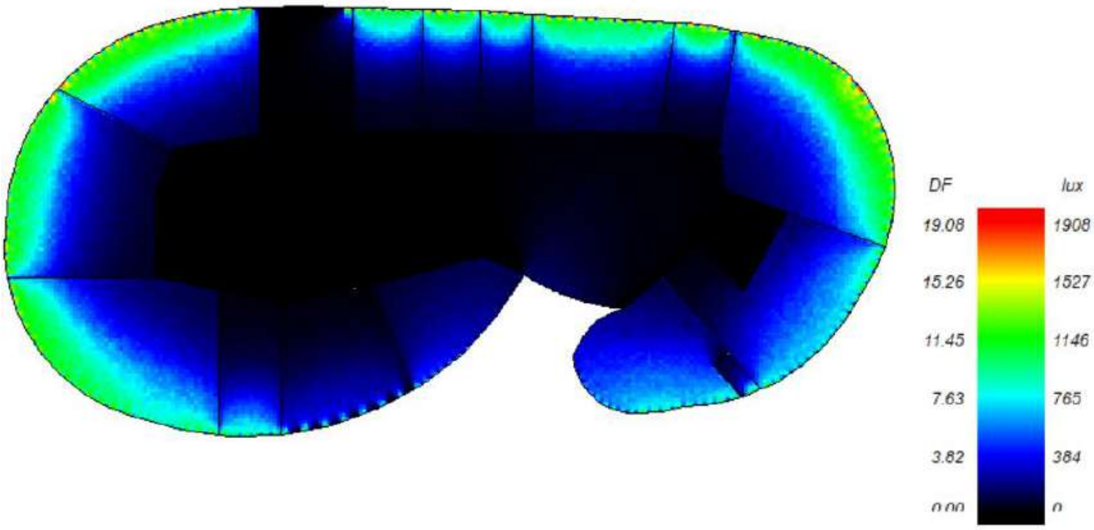


Figure96 : Daylight factor in ground floor after modification

After making several modifications and improvements to the building, the percentage of daylight in some areas of the building improved to become within the required range or slightly higher, and therefore energy consumption was rationalized and the use of artificial lighting in the building was reduced, so the energy consumption allocated for heating and cooling was reduced.

• First floor

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

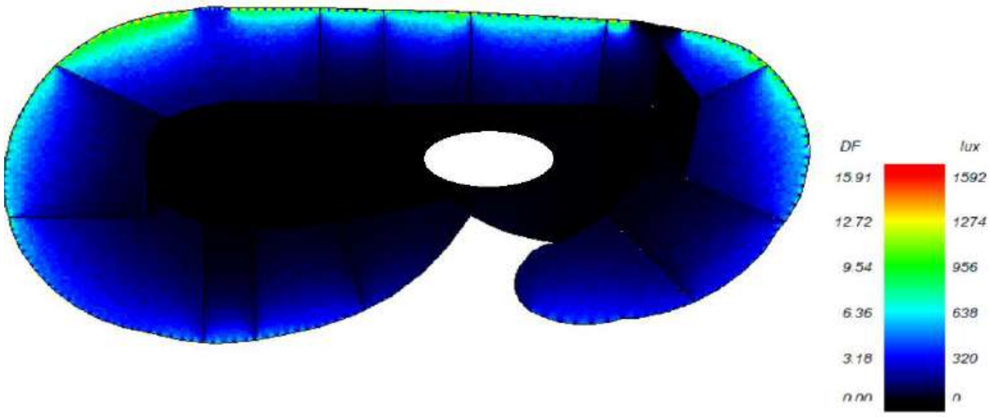


Figure97 : Daylight factor in first floor after modification

After making several modifications and improvements to the building, the percentage of daylight in some areas of the building improved to become within the required range or slightly higher, and therefore energy consumption was rationalized and the use of artificial lighting in the building was reduced, so the energy consumption allocated for heating and cooling was reduced.

• Second floor

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

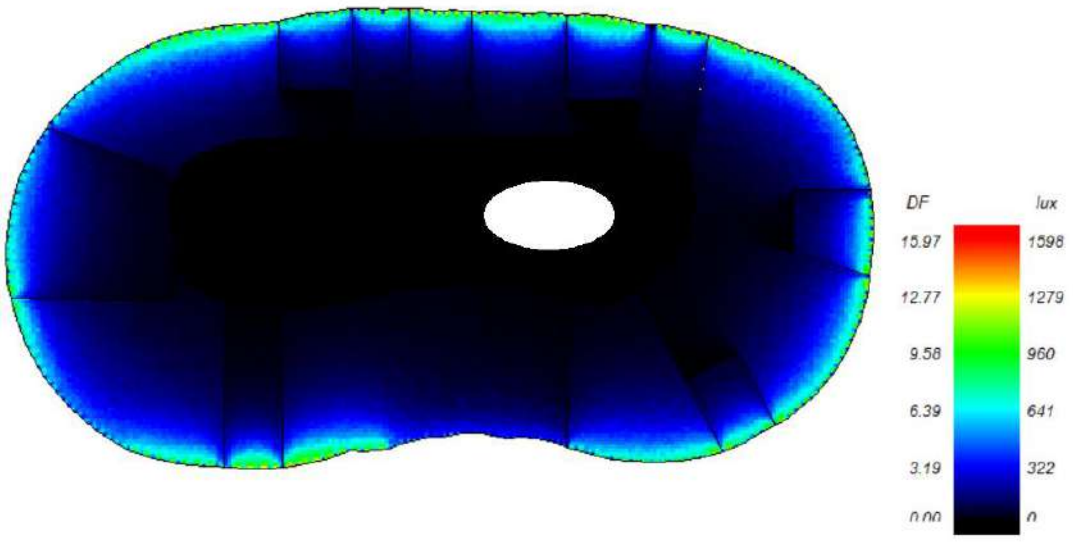


Figure98 :Daylight factor in second floor after modification

After making several modifications and improvements to the building, the percentage of daylight in some areas of the building improved to become within the required range or slightly higher, and therefore energy consumption was rationalized and the use of artificial lighting in the building was reduced, so the energy consumption allocated for heating and cooling was reduced.

• Third floor

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

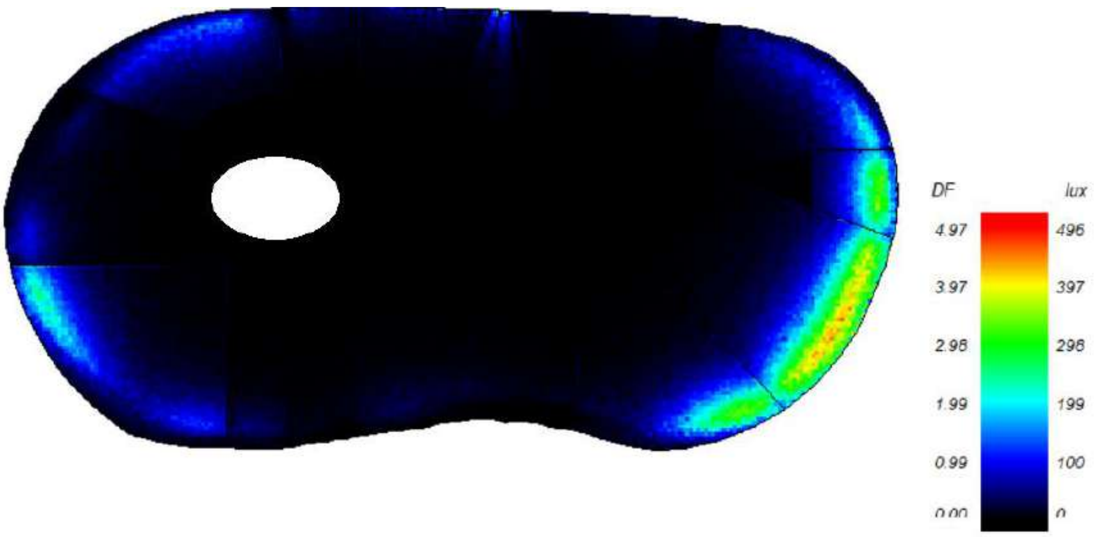


Figure99 : Daylight factor in third floor after modification

After making several modifications and improvements to the building, the percentage of daylight in some areas of the building improved to become within the required range or slightly higher, and therefore energy consumption was rationalized and the use of artificial lighting in the building was reduced, so the energy consumption allocated for heating and cooling was reduced.

• Fourth floor

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

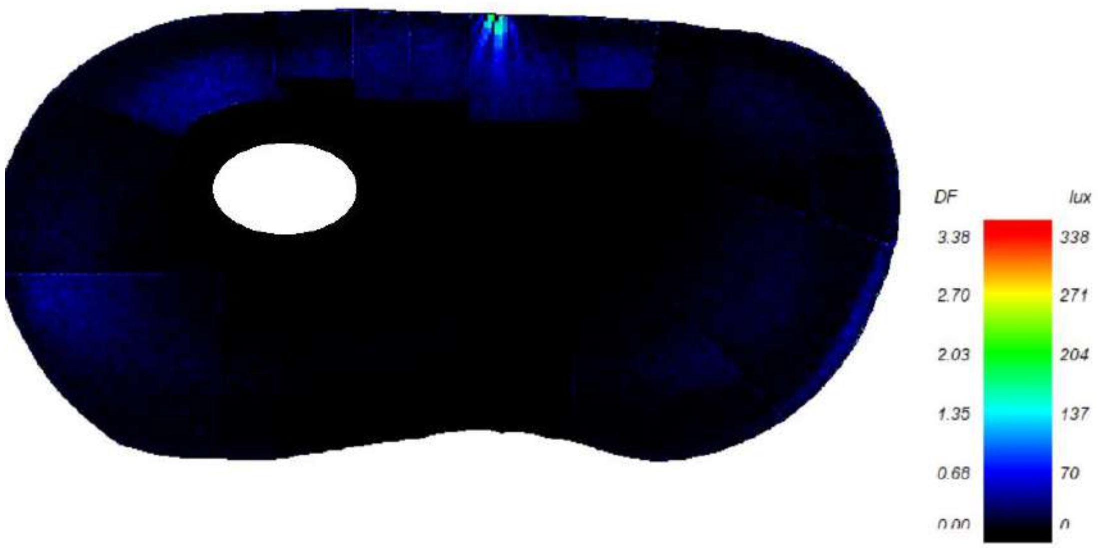


Figure100 : Daylight factor in fourth floor after modification

After making several modifications and improvements to the building, the percentage of daylight in some areas of the building improved to become within the required range or slightly higher, and therefore energy consumption was rationalized and the use of artificial lighting in the building was reduced, so the energy consumption allocated for heating and cooling was reduced.

• Fifth floor

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

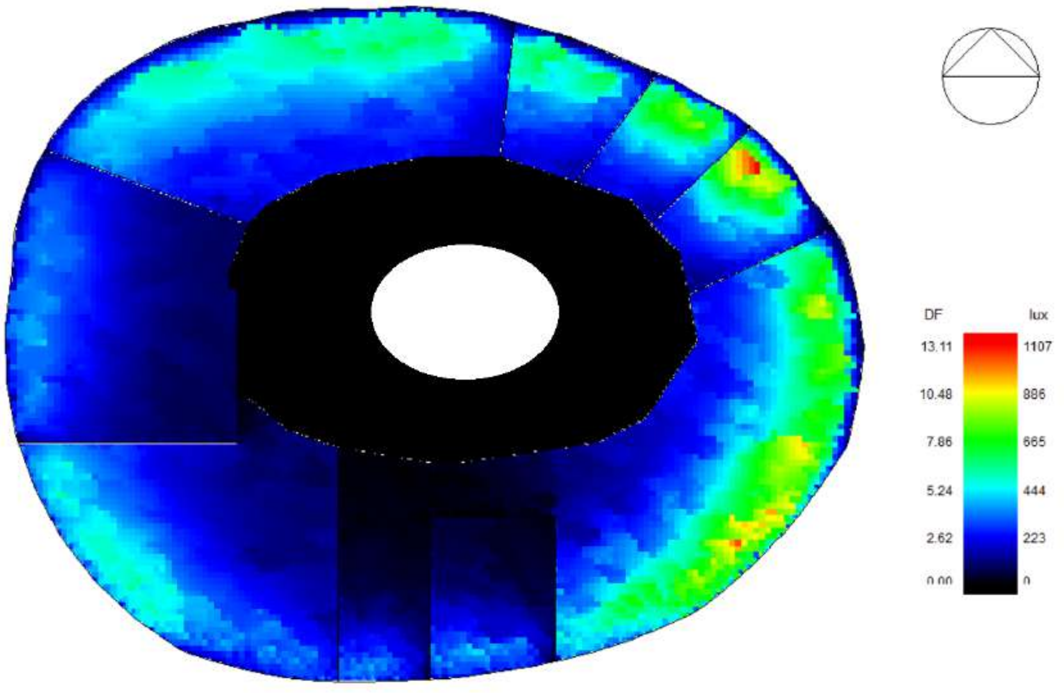


Figure101 : Daylight factor in fifth floor after modification

After making several modifications and improvements to the building, the percentage of daylight in some areas of the building improved to become within the required range or slightly higher, and therefore energy consumption was rationalized and the use of artificial lighting in the building was reduced, so the energy consumption allocated for heating and cooling was reduced.

• Sixth floor

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

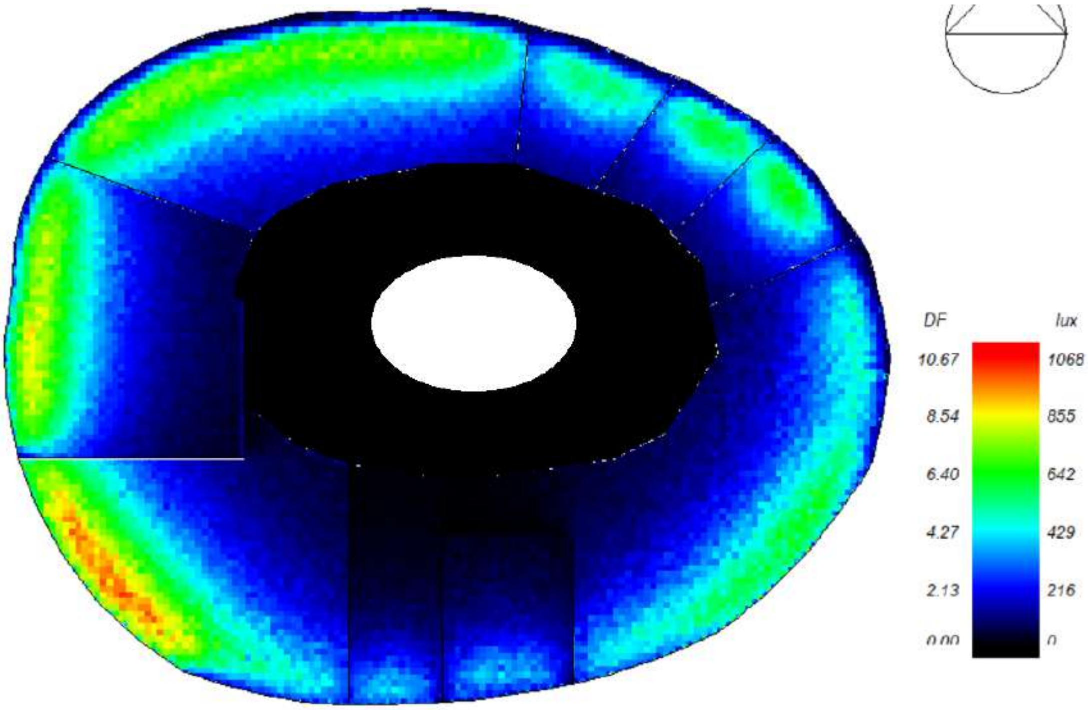


Figure102 : Daylight factor in sixth floor after modification

After making several modifications and improvements to the building, the percentage of daylight in some areas of the building improved to become within the required range or slightly higher, and therefore energy consumption was rationalized and the use of artificial lighting in the building was reduced, so the energy consumption allocated for heating and cooling was reduced.

2.7.2.3 Heating and Cooling Loads from Design Builder Software

Heating and cooling load after modification:

One of the most important things that must be taken into account in the building is heating and cooling, and the nature of the work inside the building must be ensured to improve heating and cooling. An evaluation of the building must be done to know the amount of loads inside it, and then improve the building in terms of thermal terms by treating the ceiling and walls and using glass It has low u-value , and thus the feeling of satisfaction and comfort and increased productivity.

The material used and their thermal properties:

First of all, it should be known that the walls, ceiling, and type of glass have a major role in the thermal energy reaching the building, and therefore some modifications must be made to them by adding thermal insulation, using shutters and using SGG XT 60-28 6/16/4 (60% lighting ,26% solar, good insulation) glass.

• External glazing walls

Figure 103: the layers of external glazing wall

External glazing area

The next figure shows the layers of external glass with the thickness of layers:

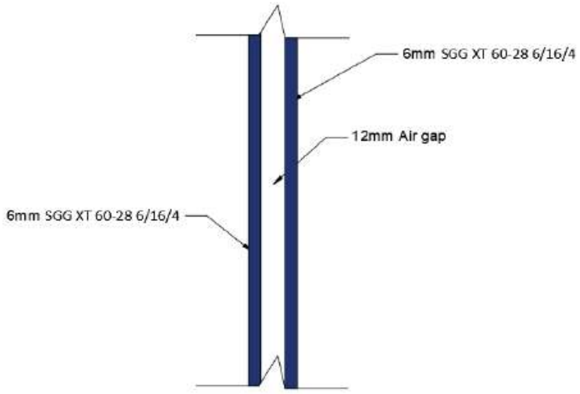


Figure 104: the layers and the thickness of external glass ()

6+12A+6mm Clear Argon Gas Insulated Double Glazed Glass for Windows Facades Curtain Wall

This type of glass was used in the building because of its many advantages, including: 26% solar energy, 60% lighting, and good building insulation.

This type consists of 3 layers, two layers of double glass with a thickness of 12 mm and a middle layer of argon gas with a thickness of 6 mm.

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

Among the most important specifications of this type:

Shape: flat

Type: floating glass

Structure: Hollow

Glass thickness: 3-19mm

Warranty: More Than 5 Years

Usage: Furniture, Door, Building, Window

Material: Qualified Tempered Float Glass

Transport Package: Strong Plywood Case

Energy Transfer: Radiation

Glass Color: Clear, Bronze, Gray, Blue, Green

Sheet Glass: Tinted Glass, Clear Glass. Tempered glass

Production Capacity: 1600000m2 Per Year.

Safety Corner: Blunted, Cutting and Round Corners as Your Request

Shapes: Rectangular, Square, Circle, Oval.

Table 14: properties for double glass

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

Double glazed glass:

commonly consists of two (sometimes more) panes of glass separated by an aluminum spacer and sealed together at the edge.

The insulating airspace is filled with dry air or a noble gas, such as argon or krypton inside to slow the heat exchange and reduce noise levels. The aluminum spacer is filled with silica desiccant pellets to ensure removal of any moisture in the airspace.

Low E glass (Low Emissivity):

provides excellent performance in situations where temperature separation is desired.

Low-E is used to help meet energy efficiency requirements by blocking UV light and providing heat insulation.

This is done with a special thin-film metallic or oxide coating which prevents the passage of short-wave solar energy into a building and also prevents long-wave energy produced by heating systems and lighting from escaping outside.

Low-e Insulated Glass :

it is made by 2pcs or more float glasses which filled with desiccant of Argon gas with Aluminum frame.

Primary seal(butyl)between glass and Aluminum frame, secondary seal(polysulfide or structure).

the insulated glass will be effectively protect radiation when coated Low-E film.

To ensure safe shipment, our glass will be taken good care of by this way:

1. Paper and Cork liner will be put between every two glass to prevent them hurt each other.
2. Glass will be put in suitable wooden crate with Corner Protectors.
3. Under wooden crate there will be legs for forklift easy loading and unloading.

Argon glass is a great material of lowering energy consumption, making it easy to clean. It is also water-resistant, and environmentally friendly.

The installation method:

The aluminum frame is first installed and fixed to the ceiling and floor using screws, and then the glass panels are installed on the sides of the frame and fixed using screws as well.

The next figure shows the installation detail in Revit :

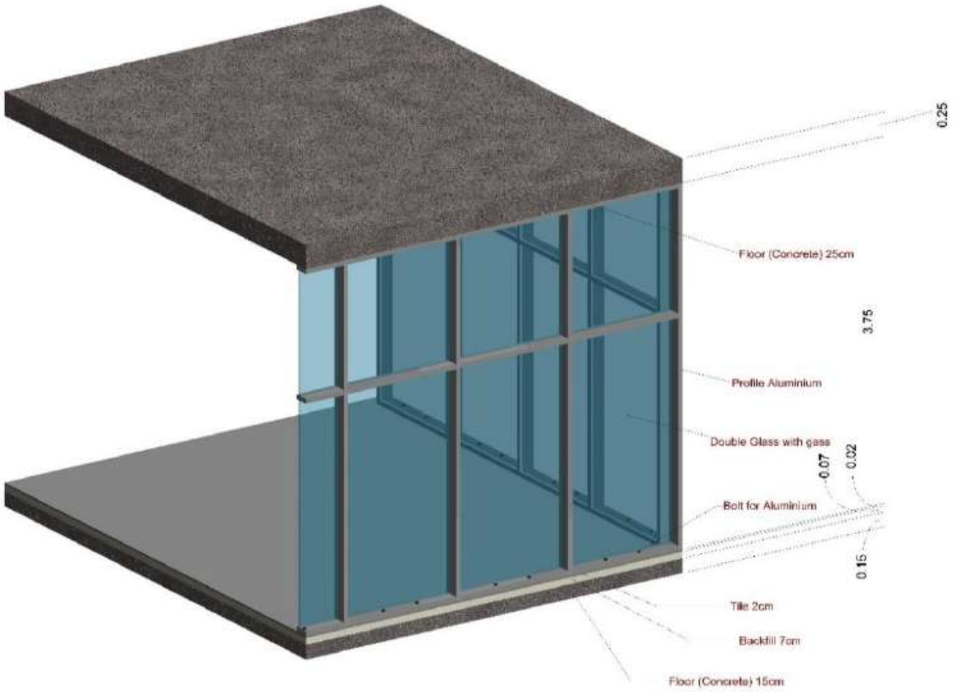


Figure105 : the installation detail in Revit

The next figure shows the installation detail in AutoCAD :

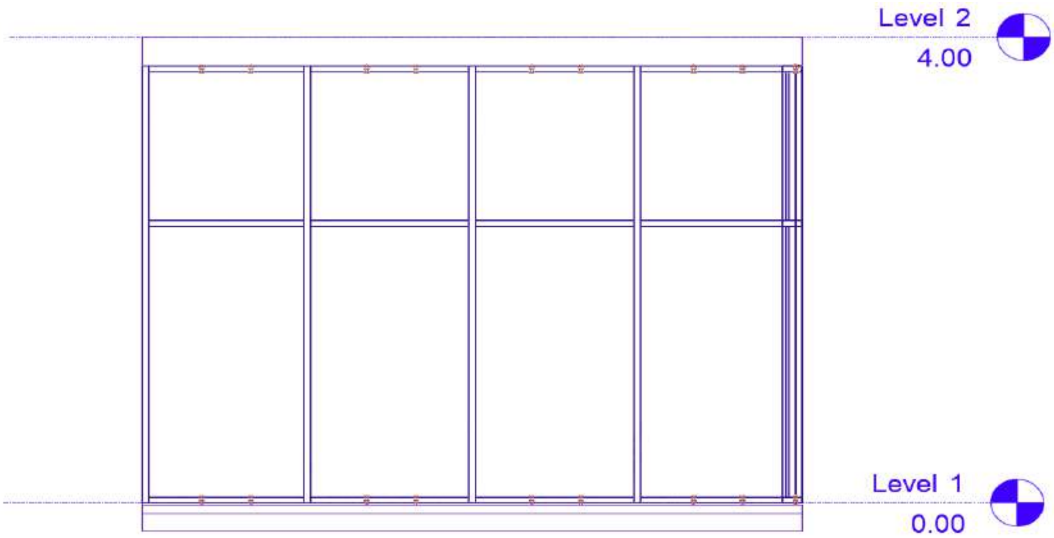


Figure106 : installation detail in Autocad

The next figure shows the solar gain for the floors:

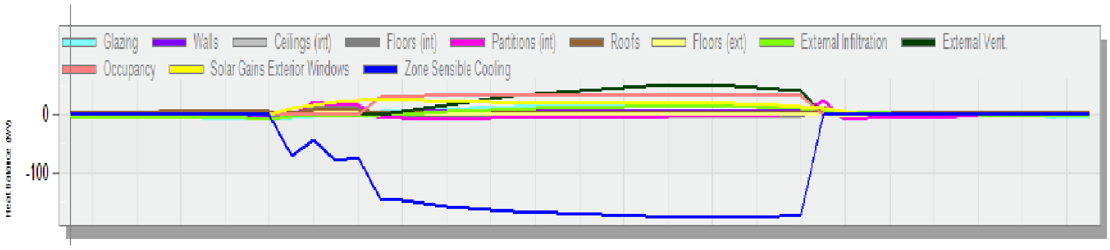


Figure 107: the solar gain for the floors

The solar gain from the glazing area was good as shown in the figure , and this is a good impression of the project because there is an insulation in floors and ceiling ,in addition there is a good type of external glazing area.

The next figure shows the sun path diagram in summer:

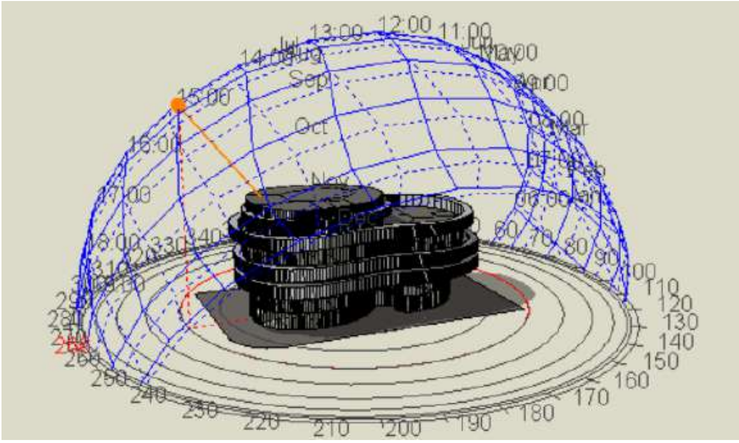


Figure 108: sun path diagram in summer from Design Builder software

As shown in the previous figure, the sun's rays do not fall directly on the building due to the presence of neighboring buildings on the eastern and western side, but the sun falls directly on the main facade of the building on the southern side of the building, but there is a component on that side, and also a type was used good glass with a low u value and features (60% lighting, 26% solar, good insulation), and this reduced the amount of solar gain for the building and this is a good property for the building.

The next figure shows solar properties and thermal properties for the external layer of the glazing area:

(SGG XT 60-28 6/16/4**):**

Figure 109: thermal properties for the external layer of the glazing area

Figure 110: Figure : solar properties for the external layer of the glazing area

This figure shows solar properties for the inner layer of the glazing area:

(SGG XT 60-28 6/16/4**):**

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

Figure 111 : solar properties for the inner layer of the glazing area

The next figure shows the U-Value of the used glazing area:

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

Figure 112: U-Value of the used glazing area

As shown in the previous figure that U-Value of the glazing area is equal to (1.289 w/m2-k) more than the U-Value of double glass which is 1.2 w/m2-k, that means that the building is an energy-efficient building.

And, the solar transmission (SHGC) is low, which decrease the cooling load of the building which means that there is a thermal comfort inside the building.

• Roof

The next figure shows the layers and thickness of the roof:

An insulator was added to the roof to modified it and reduce U-value less than 0.5 W/m.K.

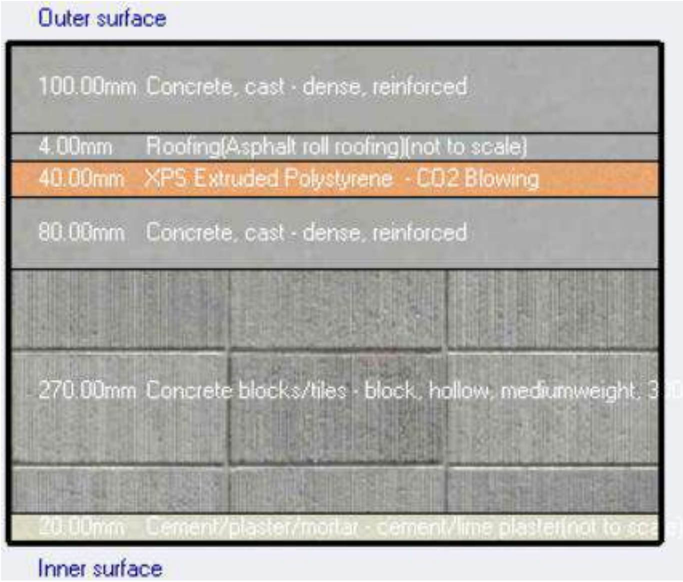


Figure 113: the layers and thickness of the roof

The next figure shows the properties and U-Value of the roof:

Inner surface	
Convective heat transfer coefficient (W/m2-K)	4.460
Radiative heat transfer coefficient (W/m2-K)	5.540
Surface resistance (m2-K/W)	0.100
Outer surface	
Convective heat transfer coefficient (W/m2-K)	19.870
Radiative heat transfer coefficient (W/m2-K)	5.130
Surface resistance (m2-K/W)	0.040
No Bridging	
U-Value surface to surface (W/m2-K)	0.484
R-Value (m2-K/W)	2.207
U-Value (W/m2-K)	**0.453**
With Bridging (BS EN ISO 6946)	
Thickness (m)	0.4930
Km - Internal heat capacity (KJ/m2-K)	123.6192
Upper resistance limit (m2-K/W)	2.211
Lower resistance limit (m2-K/W)	2.210
U-Value surface to surface (W/m2-K)	0.483
R-Value (m2-K/W)	2.211
U-Value (W/m2-K)	**0.452**

Figure 114: U-Value for the roof

As shown in the previous figure that U-Value of the roof is equal to (0.453w/m2-k) which is less than (0.5 w/m2-k) which means the roof is an energy-efficient roof.

• Interior partitions:

The next figure shows the layers of interior partitions:

Figure 115: the layers of interior partitions

The next figure shows the U-Value of interior partitions:

Inner surface	
Convective heat transfer coefficient (W/m2-K)	2.152
Radiative heat transfer coefficient (W/m2-K)	5.540
Surface resistance (m2-K/W)	0.130
Outer surface	
Convective heat transfer coefficient (W/m2-K)	2.152
Radiative heat transfer coefficient (W/m2-K)	5.540
Surface resistance (m2-K/W)	0.130
No Bridging	
U-Value surface to surface (W/m2-K)	1.679
R-Value (m2-K/W)	0.856
U-Value (W/m2-K)	**1.169**
With Bridging (BS EN ISO 6946)	
Thickness (m)	0.1500
Km - Internal heat capacity (KJ/m2-K)	81.9600
Upper resistance limit (m2-K/W)	0.856
Lower resistance limit (m2-K/W)	0.856
U-Value surface to surface (W/m2-K)	1.679
R-Value (m2-K/W)	0.856
U-Value (W/m2-K)	**1.169**

Figure116 : U-Value of interior partitions

• Floors in between

The next figure shows the cross-section of the interior floor.

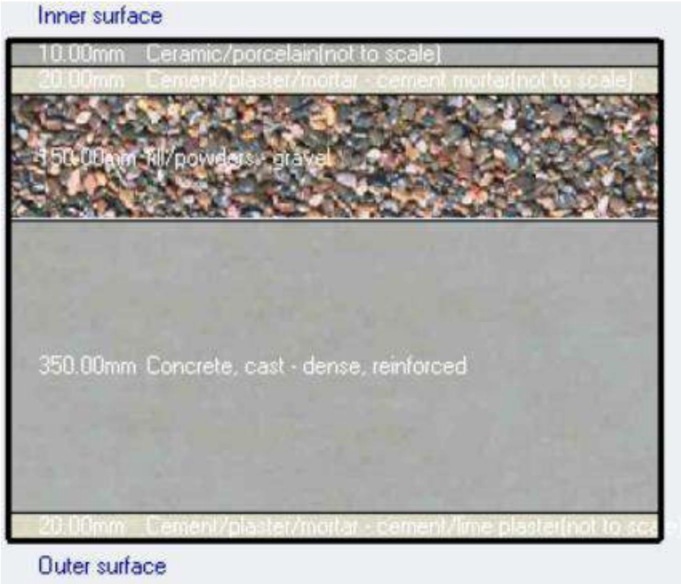


Figure117 : U-Value of interior partitions

The next figure shows the U-Value of floors in between:

Inner surface	
Convective heat transfer coefficient (W/m2-K)	0.342
Radiative heat transfer coefficient (W/m2-K)	5.540
Surface resistance (m2-K/W)	0.170
Outer surface	
Convective heat transfer coefficient (W/m2-K)	4.460
Radiative heat transfer coefficient (W/m2-K)	5.540
Surface resistance (m2-K/W)	0.100
No Bridging	
U-Value surface to surface (W/m2-K)	0.733
R-Value (m2-K/W)	1.635
U-Value (W/m2-K)	**0.612**
With Bridging (BS EN ISO 6946)	
Thickness (m)	0.5330
Km - Internal heat capacity (KJ/m2-K)	123.6192
Upper resistance limit (m2-K/W)	1.639
Lower resistance limit (m2-K/W)	1.638
U-Value surface to surface (W/m2-K)	0.731
R-Value (m2-K/W)	1.638
U-Value (W/m2-K)	**0.610**

Figure118 : U-value for internal floor

Cooling loads

The figure below shows the effect of components and the total thermal loads on the building:

Figure 119: the effect of components and the total thermal loads on the building

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

The solar gain has been reduced by using solutions mentioned earlier which comes from the glazing area.

The next tables show the cooling loads in G.F:

Table 15: cooling loads in G.F

Block	Zone	Design capacity(kw)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Design Cooling Load Per Floor Area(W/m2)
ground floor	GroundFloor:Hall	10.29	0.8335	8.95	46.1
ground floor	GroundFloor:Vault	3.54	0.284	3.08	78.9
ground floor	GroundFloor:FireRoom	1.09	0.087	0.94	64.7
ground floor	GroundFloor:Tellers	2.31	0.1716	2	57.1
ground floor	GroundFloor:customer services offices	4.9	0.369	4.26	69.4
ground floor	GroundFloor:Office3	0.73	0.0546	0.64	57.7
ground floor	GroundFloor:ManagerRoom	3.18	0.2368	2.77	60.9
ground floor	GroundFloor:Security	2.33	0.1733	2.03	61.5
ground floor	GroundFloor:Reception	1.62	0.1208	1.41	56.5
ground floor	GroundFloor:CameraRoom	4.29	0.3435	3.73	79.1
ground floor	GroundFloor:MeetingRoom	4.7	0.3488	4.09	72.8
ground floor	GroundFloor:Treasurer & Deposits	3.5	0.2593	3.04	67.3

From previous table, the value of design cooling load per floor area (w/m2) is between (46-79 w/m2) less than (100 w/m2), which means that the building is considered very energy-efficient.

The next table shows the cooling loads in first floor:

Table 16: cooling loads in first floor

Block	Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling	Design Cooling Load Per Floor
first floor	FirstFloor:Hall	9.22	0.7512	8.02	42.4
first floor	FirstFloor:Tellers4	1.77	0.1318	1.54	57.1
first floor	FirstFloor:customer services offices1	2.53	0.1879	2.2	57.8
first floor	FirstFloor:Tellers2	3.66	0.2726	3.18	56.6
first floor	FirstFloor:MeetingRoom1	3.3	0.2456	2.87	65.6
first floor	FirstFloor:multiple purpos room	2.78	0.2066	2.42	61.9
first floor	FirstFloor: customer services offices	4.8	0.3572	4.18	59.6
first floor	FisrtFloor:archive	1.21	0.0899	1.05	77.5
first floor	FirstFloor:MeetingRoom2	4.22	0.3135	3.67	61.4
first floor	FirstFloor:Office1	2.1	0.156	1.82	57
first floor	FirstFloor:Reception	1.75	0.1305	1.52	57.3

From previous table, the value of design cooling load per floor area (w/m2) is between (42-78 w/m2) less than (100 w/m2), which means that the building is considered very energy-efficient.

The next table shows the cooling loads in second floor:

Table 17: cooling loads in second floor

Block	Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Design Cooling Load Per Floor Area(W/m2)
second floor	Second floor:Hall	10.57	0.8583	9.19	44.4
second floor	Second floor:Collection Department	3.12	0.2321	2.71	57.4
second floor	Second floor:Risk management dept	2.09	0.1555	1.81	53.2
second floor	Second floor:Credit dept	3.51	0.2619	3.06	54.6
second floor	Second floor:Office2	1.14	0.0851	0.99	61.4
second floor	Second floor:Media&Gallery	5.12	0.4128	4.45	54.6
second floor	Second floor:Lecture hall	4.36	0.3511	3.79	56
second floor	Second floor:Training center	7.28	0.5437	6.33	49.6
second floor	Second floor:Lecture hall1	5.16	0.3843	4.49	55.6
second floor	Second floor:Office1	0.94	0.0696	0.81	62.1
second floor	Second floor:Office3	0.99	0.0736	0.86	61

From previous table, the value of design cooling load per floor area (w/m2) is between (44-62 w/m2) less than (100 w/m2), which means that the building is considered very energy-efficient.

The next table shows the cooling loads in third floor:

Table 18: cooling loads in third floor

Block	Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Design Cooling Load Per Floor Area(W/m2)
third floor	third Floor:Hall	9.75	0.7968	8.48	41
third floor	third Floor:Internal audio&inspection dept	2.94	0.2185	2.55	54.1
third floor	third Floor:Anti money laundry dept	2.01	0.1503	1.75	51.3
third floor	third Floor:legal affairs dept	3.46	0.2581	3.01	53.8
third floor	third Floor:Office2	1.15	0.0855	1	61.7
third floor	third Floor:Commpliance dept	5.07	0.4091	4.41	54.1
third floor	third Floor:Operation administration	4.17	0.3367	3.63	53.6
third floor	third Floor:Operations dept	7.09	0.5304	6.17	48.3
third floor	third Floor:Meetingroom	5.11	0.3804	4.44	55.1
third floor	third Floor:Office1	0.86	0.0641	0.75	57.1
third floor	third Floor:Office3	0.92	0.0682	0.8	56.4

From previous table, the value of design cooling load per floor area (w/m2) is between (41-62 w/m2) less than (100 w/m2), which means that the building is considered very energy-efficient.

The next table shows the cooling loads in fourth floor:

Table 19: cooling loads in fourth floor

Block	Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Design Cooling Load Per Floor Area(W/m2)
fourth floor	FourthFloor:Hall	11.05	0.8979	9.61	43.7
fourth floor	FourthFloor:Department of Real Estate and Supplies	2.73	0.203	2.37	60.5
fourth floor	FourthFloor:puplic relations dept	5.06	0.3756	4.4	65.8
fourth floor	FourthFloor:Office2	1.54	0.1162	1.34	80.1
fourth floor	FourthFloor:marketing department	5.01	0.3728	4.36	61.1
fourth floor	FourthFloor:ManagerRoom	3.46	0.2575	3.01	62
fourth floor	FourthFloor:IT dept	7.2	0.5363	6.26	53.8
fourth floor	FourthFloor:Communication Dept	5.13	0.3812	4.46	60.1
fourth floor	FourthFloor:HR department	4.61	0.3424	4.01	56.7
fourth floor	FourthFloor:Office1	1.13	0.0839	0.98	64.9
fourth floor	FourthFloor:Office4	1.42	0.1056	1.24	70.1
fourth floor	FourthFloor:Office3	1.06	0.0785	0.92	70.6

From previous table, the value of design cooling load per floor area (w/m2) is between (44-80 w/m2) less than (100 w/m2), which means that the building is considered very energy-efficient.

The next table shows the cooling loads in fifth floor:

Table 20: cooling loads in fifth floor

Block	Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Design Cooling Load Per Floor Area(W/m2)
fifth floor	FifthFloor:financial dept	3.9	0.2902	3.39	55.1
fifth floor	FifthFloor:Hall	5.36	0.4357	4.66	43.2
fifth floor	FifthFloor:Office1	0.86	0.0637	0.74	59.4
fifth floor	FifthFloor:Support Department	5.55	0.4128	4.82	60.4
fifth floor	FifthFloor:Quality Control Department	3.89	0.2889	3.38	60.2
fifth floor	FifthFloor:Office2	1.09	0.0814	0.95	59

From previous table, the value of design cooling load per floor area (w/m2) is between (43-61 w/m2) less than (100 w/m2), which means that the building is considered very energy-efficient.

The next table shows the cooling loads in sixth floor:

Table 21: cooling loads in sixth floor

Block	Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Design Cooling Load Per Floor Area(W/m2)
sixth floor	SixthFloor:Implementation dept	4.5	0.3603	3.91	62.9
sixth floor	SixthFloor:Office1	1.13	0.0843	0.99	68.2
sixth floor	SixthFloor:Toilets1	0.8	0.0549	0.7	58.3
sixth floor	SixthFloor:Hall	6.38	0.5142	5.55	51.6
sixth floor	SixthFloor:Toilets2	1.23	0.0912	1.07	73.7
sixth floor	SixthFloor:Stairecase	4.75	0.38	4.13	76.2
sixth floor	SixthFloor:top management	6.18	0.4583	5.37	69.3
sixth floor	SixthFloor:EmergenncyStaire	1.54	0.1143	1.34	70
sixth floor	SixthFloor:strategies &financial dept	3.24	0.2042	2.82	51.5
sixth floor	SixthFloor:Office2	1.44	0.1073	1.26	68.9

From previous table, the value of design cooling load per floor area (w/m2) is between (52-77 w/m2) less than (100 w/m2), which means that the building is considered very energy-efficient.

The next table shows the total cooling loads:

Table 22: the total cooling loads

Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Design Cooling Load Per Floor Area(W/m2)
Totals	267.88	20.5434	232.94	53.4

After making the necessary modifications and improvements to the building, including adding insulators to the ceiling and floor, and choosing a type of glass with several advantages (26% solar energy, 60% lighting, and good insulation), the result was very good which is (53.4w/m2) which is less than (100w/m2) this value means that the building is energy-efficient.

Heating load

The next figure shows the components involved in the heating of the origin.

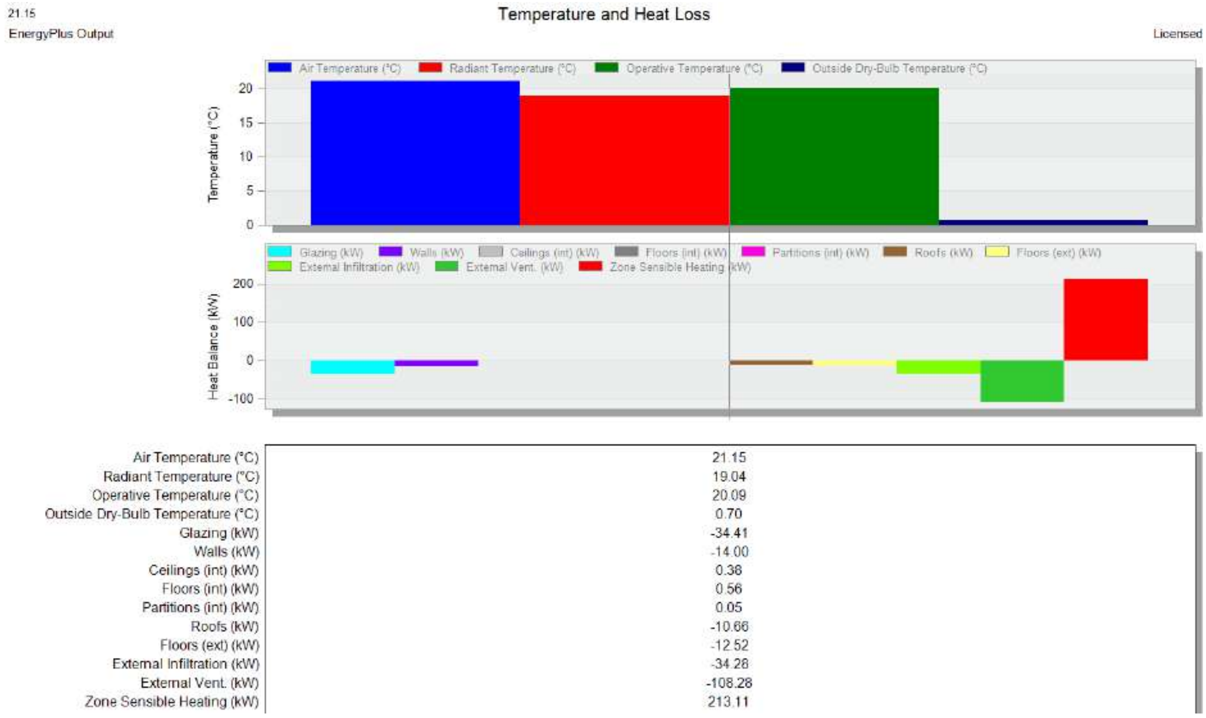


Figure120 : the components involved in the heating of origin

The previous figure shows that all the components involved in the heating load are acceptable.

The solar gain which comes from the glazing area has been reduced by many solutions.

In addition, the difference between operative temperature and air temperature is less than 1 degree so the HVAC system will work with high efficiency in the building.

The next table shows the values of heating load for the ground floor.

Table 23: values of heating load for the ground floor

Block	Zone	Comfort Temperature (°C)	Steady-State Heat Loss (kW)	Design Capacity (kW)	Design Capacity (W/m2)
ground floor	hall	18.65	10.4	13	58.2591
ground floor	vault	18.61	1.64	2.05	66.1543
ground floor	fire room	18.92	0.86	1.07	64.047
ground floor	tellers	20.27	2.27	2.83	70.1787
ground floor	customer services offices	19.98	4.01	5.02	71.0993
ground floor	office3	20.95	0.62	0.77	60.7543
ground floor	manager room	20.31	2.89	3.61	69.1678
ground floor	security	19.76	2.55	3.18	79.9552
ground floor	reception	20.06	1.85	2.31	80.4963
ground floor	camera room	18.48	2.07	2.59	67.2986
ground floor	meeting room	19.99	3.72	4.65	71.9118

The table shows the value of heating load of many spaces in ground floor, these values are between (59- 80w/m2) so the facility is considered energy-efficient.

This table shows the values of heating load in First floor.

Table 24: values of heating load in first floor

Block	Zone	Comfort Temperature (°C)	Steady-State Heat Loss (kW)	Design Capacity (kW)	Design Capacity (W/m2)
first floor	hall	19.7	6.73	8.41	38.6848
first floor	tellers4	21.07	1.36	1.7	54.7926
first floor	customer services offices1	20.97	1.95	2.43	55.6682
first floor	tellers2	21.13	2.71	3.38	52.3075
first floor	meeting room1	20.74	2.37	2.96	58.7706
first floor	Multiple purpose room	20.31	2.54	3.17	70.6361
first floor	customer services offices	20.75	3.75	4.68	58.1452
first floor	archive	20.57	0.96	1.2	76.905
first floor	meeting room2	20.77	3.21	4.01	58.3789
first floor	office1	20.92	1.67	2.09	56.9219
first floor	reception	20.68	1.59	1.99	64.9992

The table shows the value of heating load of many spaces in first floor, these values are between (39- 71w/m2) so the facility is considered energy-efficient.

This table shows the values of heating load in second floor.

Table 25: values of heating load in second floor

Block	Zone	Comfort Temperature (°C)	Steady-State Heat Loss (kW)	Design Capacity (kW)	Design Capacity (W/m2)
second floor	hall	19.26	8.41	10.51	44.1722
second floor	Collection Department	20.79	2.65	3.32	61.0935
second floor	Risk management dept	21.14	1.7	2.13	54.1815
second floor	Credit dept	20.81	3.04	3.8	59.0595
second floor	office2	20.67	1.02	1.27	68.185
second floor	Media&Gallery	19.12	3.86	4.82	51.4546
second floor	Lecture hall	18.86	3.52	4.41	56.5657
second floor	Training center	20.66	6.61	8.26	56.2845
second floor	Lecture hall1	20.6	4.37	5.46	58.8963
second floor	office1	20.91	0.78	0.97	64.3974
second floor	office3	20.96	0.82	1.02	62.9882

The table shows the value of heating load of many spaces in second floor, these values are between (44- 68w/m2) so the facility is considered energy-efficient.

This table shows the values of heating load in third floor.

Table 26: values of heating load in third floor

Block	Zone	Comfort Temperature (°C)	Steady-State Heat Loss (kW)	Design Capacity (kW)	Design Capacity (W/m2)
third floor	hall	19.96	6.89	8.61	36.1847
third floor	Internal audio&inspection dept	20.84	2.61	3.27	60.1892
third floor	Anti money laundry dept	21.18	1.67	2.09	53.3316
third floor	legal affairs dept	20.87	2.99	3.74	58.13
third floor	office2	20.8	0.97	1.22	65.2468
third floor	Commpliance dept	19.34	3.62	4.53	48.2911
third floor	Operation administration	19.23	3.17	3.96	50.8032
third floor	Operations dept	21.12	5.85	7.31	49.8221
third floor	meetingroom	20.85	4.07	5.08	54.8048
third floor	office1	20.91	0.78	0.97	64.4055
third floor	office3	20.95	0.82	1.03	63.4455

The table shows the value of heating load of many spaces in third floor, these values are between (36- 66w/m2) so the facility is considered energy-efficient.

This table shows the values of heating load in fourth floor.

Table 27: values of heating load in fourth floor

Block	Zone	Comfort Temperature (°C)	Steady-State Heat Loss (kW)	Design Capacity (kW)	Design Capacity (W/m2)
fourth floor	hall	19.77	7.68	9.6	37.9897
fourth floor	Department of Real Estate and Supplies	20.74	2.27	2.84	62.9081
fourth floor	puplic relations dept	20.45	4	5	65.1061
fourth floor	office2	20.54	1.09	1.36	73.2885
fourth floor	marketing department	20.57	4.01	5.01	61.0604
fourth floor	manager room	20.55	2.84	3.56	63.585
fourth floor	IT dept	20.85	5.79	7.24	54.0908
fourth floor	Communication Dept	20.62	4.08	5.1	59.799
fourth floor	HR department	20.82	3.71	4.64	57.0571
fourth floor	office1	20.73	0.95	1.19	68.3662
fourth floor	office4	20.46	1.21	1.51	74.4943
fourth floor	office3	20.68	0.85	1.06	70.6982

The table shows the value of heating load of many spaces in fourth floor, these values are between (38- 75w/m2) so the facility is considered energy-efficient.

This table shows the values of heating load in fifth floor.

Table 28: values of heating load in fifth floor

Block	Zone	Comfort Temperature (°C)	Steady-State Heat Loss (kW)	Design Capacity (kW)	Design Capacity (W/m2)
fifth floor	financial dept	20.63	3.48	4.35	61.5257
fifth floor	hall	19.93	3.62	4.52	36.4525
fifth floor	office 1	20.84	0.78	0.98	67.6846
fifth floor	Support Department	20.78	4.28	5.35	58.2774
fifth floor	Quality Control Department	20.71	3.11	3.89	60.2287
fifth floor	office2	21.05	0.87	1.09	58.8266

The table shows the value of heating load of many spaces in fifth floor, these values are between (37- 68w/m2) so the facility is considered energy-efficient.

This table shows the values of heating load in sixth floor.

Table 29: values of heating load in sixth floor

Block	Zone	Comfort Temperature (°C)	Steady-State Heat Loss (kW)	Design Capacity (kW)	Design Capacity (W/m2)
sixth floor	Implementation dept	18.49	3.6	4.5	62.9442
sixth floor	office1	20.37	1.08	1.35	80.1
sixth floor	toilets1	18.93	0.77	0.96	69.7821
sixth floor	hall	19.2	4.52	5.65	45.6736
sixth floor	toilets2	20.51	1.02	1.28	76.8506
sixth floor	staircase	18.63	2.97	3.71	59.4452
sixth floor	Top management	20.37	4.93	6.16	69.0875
sixth floor	emergennicy staire	20.77	1.18	1.48	67.2946
sixth floor	strategies &financial dept	18.61	2.29	2.86	45.407
sixth floor	office2	20.71	1.15	1.44	68.6633

The table shows the value of heating load of many spaces in fifth floor, these values are between (46- 80 w/m2) so the facility is considered energy-efficient.

Summarize the thermal modification:

Many solutions and modifications have been made to the building to obtain the best condition for the building specifically the thermal situation , and the most important of these modifications:

1- The use of thermal insulation with suitable U-value which helped to have very well energy-efficient walls and ceiling, in addition of use aluminum frame around windows.

2- The use of a suitable and useful type of glass that has feasible specifications in terms of heat and light transmission to and from the building and solar energy(26% solar ,60% lighting, good insulation).

3- Using shutters which is an internal system putting on the window in the east and west of the building according to azimuth and zenith angle of the sun in Palestine.

The site and source of energy:

After making the necessary modifications to the building in terms of adding insulators to the ceiling and walls and choosing the appropriate type of glass, and after we obtained the results compared to the building before the modifications, this indicates that it is an energy efficient building.

The next table shows the site energy source for the building from the design-builder software:

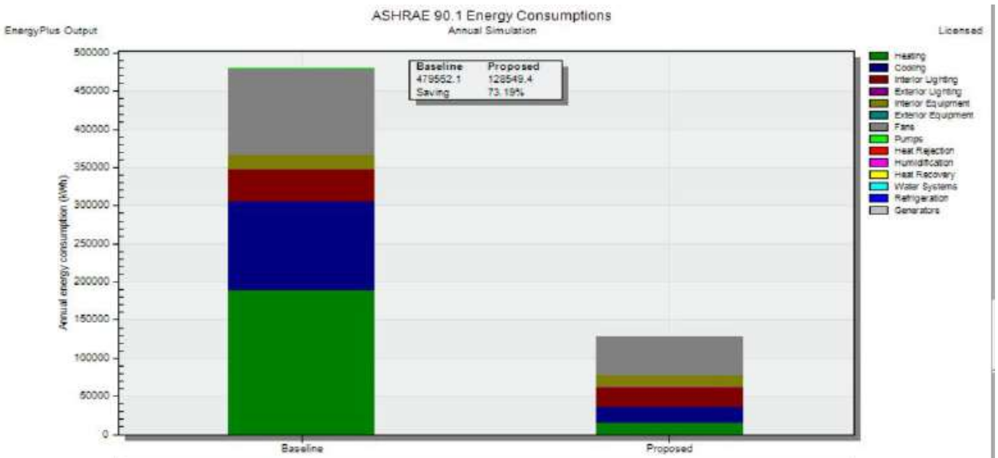
Table 30: site and source energy analysis

Site and Source Energy

	Total Energy [kWh]	Energy Per Total Building Area [kWh/m2]
Total Site Energy	378662.11	78.31
Net Site Energy	378662.11	78.31
Total Source Energy	1199222.90	248.02
Net Source Energy	1199222.90	248.02

The total site energy is 78.31 kwh/m^2 which is less than the range (150-160) kwh/m^2 and this is good.

Baseline energy building analysis:



	Baseline	Proposed
Heating	188670.27	14828.16
Cooling	115806.04	21356.32
Interior Lighting	42123.55	23990.21
Exterior Lighting	1091.33	1091.33
Interior Equipment	17301.28	16297.03
Exterior Equipment	0.00	0.00
Fans	114286.28	51987.38
Pumps	274.31	0.00
Heat Rejection	0.00	0.00
Humidification	0.00	0.00
Heat Recovery	0.00	0.00
Water Systems	0.00	0.00
Refrigeration	0.00	0.00
Generators	0.00	0.00

Figure 121 : Baseline energy building analysis

Thermal comfort:

One of the most important things that must be taken into account in the design of any building is the thermal comfort of the people in the building, and if thermal comfort is achieved inside the building, this means that the modifications that have been made to the building are feasible and useful, and thus the building becomes energy efficient building.

There is a measure of thermal comfort within the building which is obtained from a design builder software which is the PMV index (Predicated mean value) .

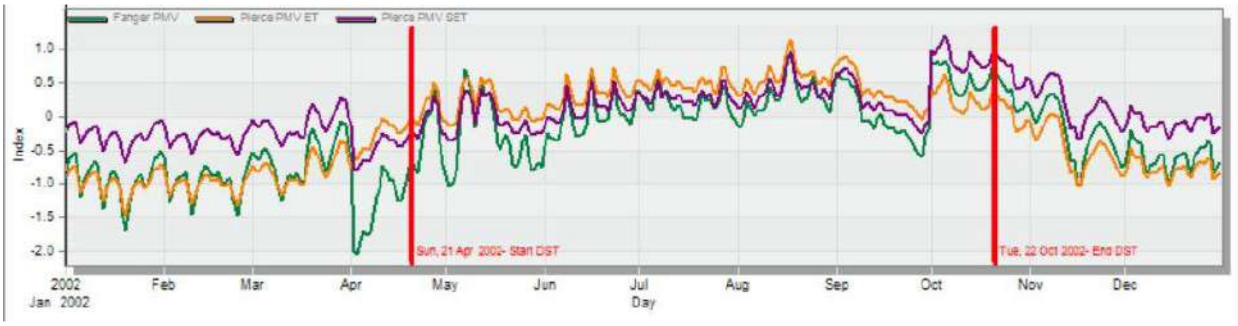


Figure122 : PMV index

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

CFD analysis:

The next figure shows the external CFD analysis for the building from the design-builder software:

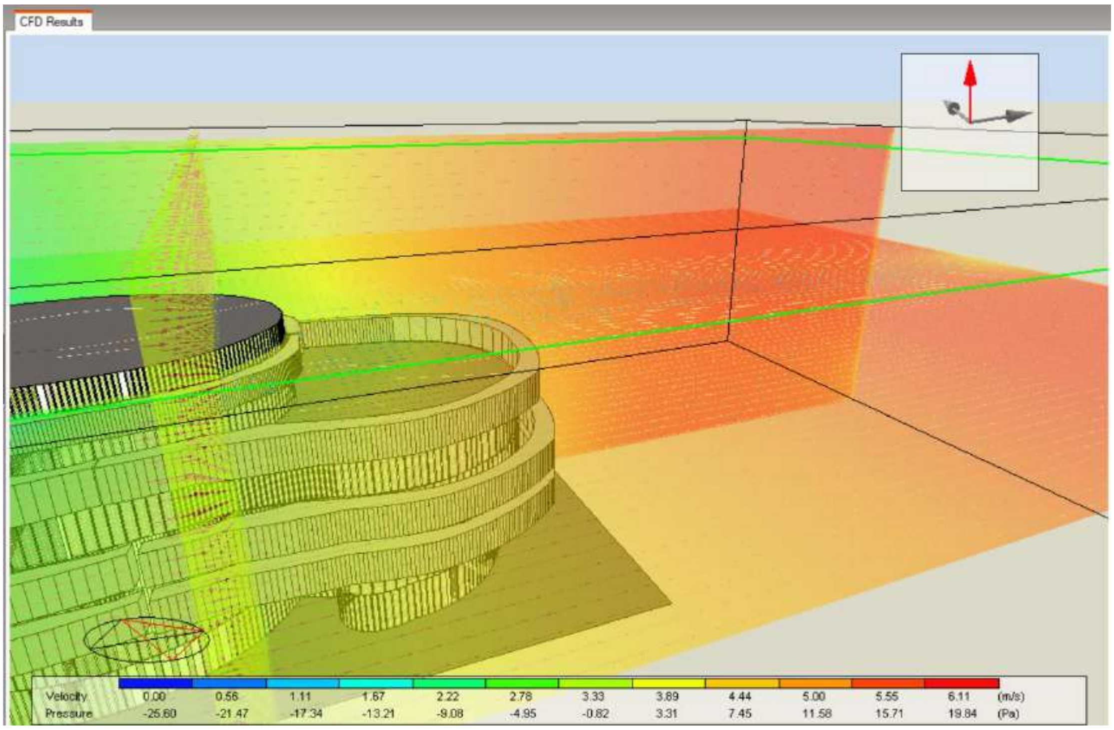


Figure123 : external CFD analysis 1

The next figure shows the external CFD analysis for the building from the design-builder software:

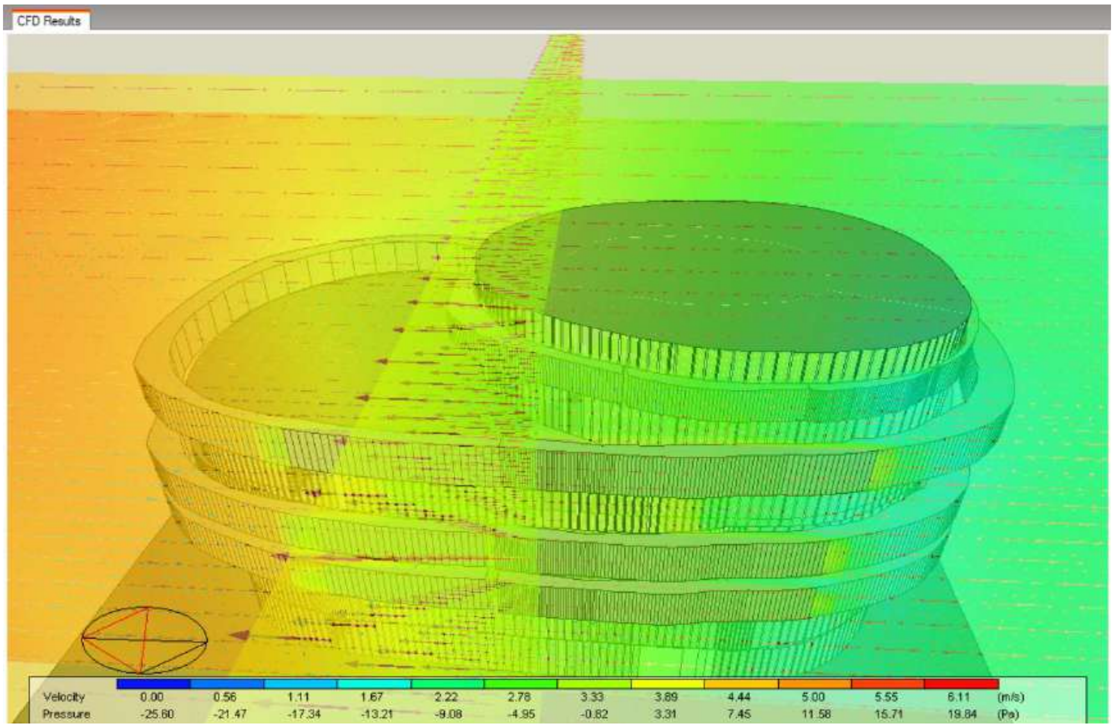


Figure124 : external CFD analysis 2

The next figure shows the internal CFD analysis for the building from the design-builder software:

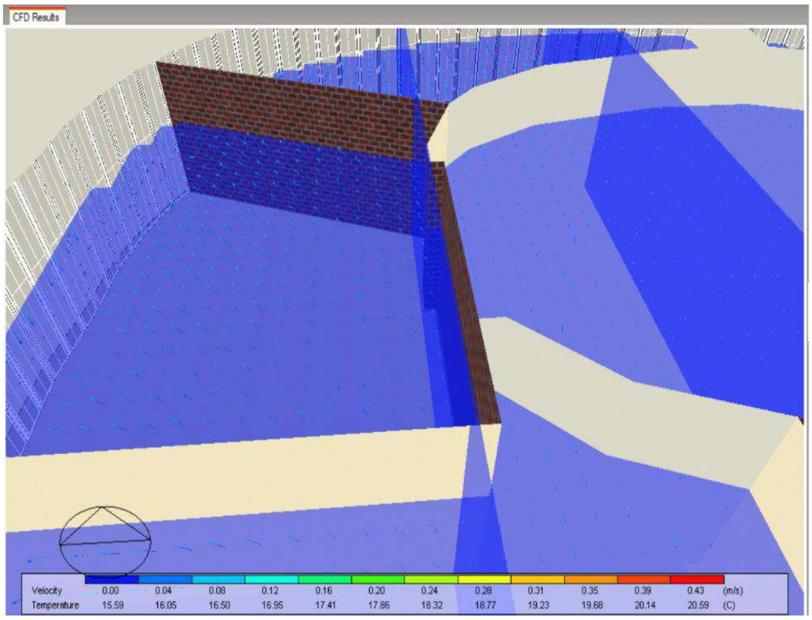


Figure125 : internal CFD analysis

These figures show that the wind movement is smooth with the building, and this indicates that there is no turbulant flow and the direction of the wind movement is regular and does not find obstacles to the arrival of air. We also note that the direction of air movement in the internal spaces is from the bottom up, and this is what it should be

2.8 : Photovoltaic design

2.8.1 Introduction

When designing a building, we must take into account the location of the building and the direction of the sun and its movement in relation to the building, through which it is possible to save energy consumption in the building in terms of solar cells and the distribution of windows and rooms

Solar cells were designed on the roof of the building on the south side to provide an environmentally friendly electric current and to save on the bank's electricity bill

2.8.3 Photovoltaic modules

At first we chose the type of cells

Table 31 : Types of photovoltaic

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

Photovoltaic design : Figure below show the specifications of cells that was used from Q CELLS company:

MECHANICAL SPECIFICATION

Format	2163mm × 1030mm × 35mm (including frame)
Weight	26kg
Front Cover	3.2mm thermally pre-stressed glass with anti-reflection technology
Back Cover	Composite film
Frame	Anodised aluminium
Cell	6 × 26 monocrystalline Q.ANTUM solar half cells
Junction box	53-101mm × 32-60mm × 15-18mm Protection class IP67, with bypass diodes
Cable	4mm² Solar cable; (+) ≥700mm, (−) ≥350mm*
Connector	Stäubli MC4-Evo2, Hanwha Q CELLS HQC4; IP68
	*Long cables (+) ≥1450mm, (−) ≥1450mm for landscape installation are available upon request.

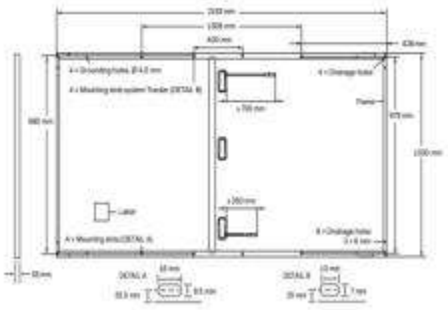


Figure 126 :Specifications of cells (Sheet Q. PEAK DUO XL-G9.2 445-465)

POWER CLASS			480	485	490	495	500
MINIMUM PERFORMANCE AT STANDARD TEST CONDITIONS, STC[1] (POWER TOLERANCE +5W/−0W)							
Power at MPP[1]	P_{MPP}	[W]	480	485	490	495	500
Short Circuit Current[1]	I_{SC}	[A]	13.51	13.54	13.57	13.60	13.63
Open Circuit Voltage[1]	V_{OC}	[V]	45.59	45.62	45.65	45.67	45.70
Current at MPP	I_{MPP}	[A]	12.78	12.83	12.89	12.95	13.00
Voltage at MPP	V_{MPP}	[V]	37.57	37.79	38.02	38.24	38.45
Efficiency[1]	η	[%]	≥20.6	≥20.8	≥21.0	≥21.3	≥21.5
MINIMUM PERFORMANCE AT NORMAL OPERATING CONDITIONS, NMOT[2]							
Power at MPP	P_{MPP}	[W]	360.1	363.8	367.6	371.3	375.1
Short Circuit Current	I_{SC}	[A]	10.89	10.91	10.94	10.96	10.98
Open Circuit Voltage	V_{OC}	[V]	43.00	43.02	43.05	43.08	43.10
Current at MPP	I_{MPP}	[A]	10.04	10.09	10.14	10.19	10.24
Voltage at MPP	V_{MPP}	[V]	35.87	36.07	36.26	36.45	36.63

[1]Measurement tolerances P_{MPP} ±3%; I_{SC}; V_{OC} ±5% at STC: 1000W/m², 25±2°C, AM 1.5 according to IEC 60904-3 • [2]800W/m², NMOT, spectrum AM 1.5

Figure 127 : Electrical data. (Sheet Q. PEAK DUO XL-G9.2 445-465)

TEMPERATURE COEFFICIENTS							
Temperature Coefficient of I_{SC}	α	[%/K]	+0.04	Temperature Coefficient of V_{OC}	β	[%/K]	−0.27
Temperature Coefficient of P_{MPP}	γ	[%/K]	−0.35	Nominal Module Operating Temperature	NMOT	[°C]	43±3

PROPERTIES FOR SYSTEM DESIGN

Maximum System Voltage	V_{SYS}	[V]	1500	PV module classification	Class II
Maximum Reverse Current	I_R	[A]	20	Fire Rating based on ANSI/UL 61730	C/TYPE 1
Max. Design Load, Push/Pull		[Pa]	3600/1600	Permitted Module Temperature on Continuous Duty	−40°C - +85°C
Max. Test Load, Push/Pull		[Pa]	5400/2400		

Figure 128 :Temperature rating (Sheet Q. PEAK DUO XL-G9.2 445-465)

For one single angle for year round

Θ tilt = (0.9 - 1) latitude

Latitude in Nablus =32 from pv system program

Θ tilt in Nablus = (28 -32)

So, use Θ tilt = 30

New dimension = old diminution* cos (Θ tilt)

New dimension = 2.163* cos (30) = 1.87 m

The space between cells vertically so as not to create shadows on each other not less

Then 3*H

The space between cells = 3*(1.87 Sin (30)) = 2.81 m

For the cells used the tempter = (-40 – 85) C°

V min at (85°) = Vmpp at 25° - (0.168*(85-25))

= 39- (0.168* 60) = 28.92 Volt

V max at (-40°) = Vmpp at 25° - (0.168*(-40-25))

= 39- (0.168*65) = 28 Volt

VOC at (-40°) = 39+ (0.168*65) = 49.92 Volt

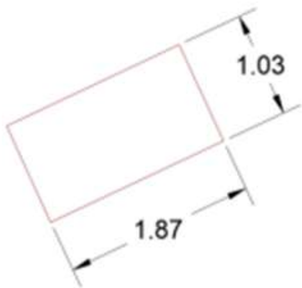


Figure 129 : dimensions of cell

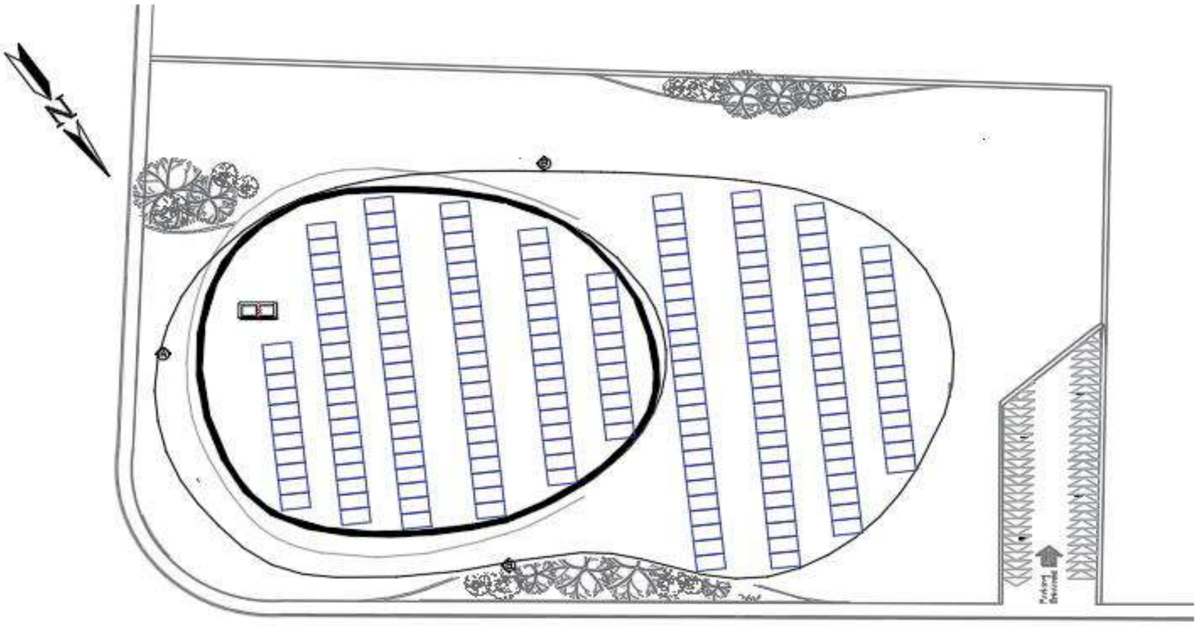


Figure 130: Destination of PV Modules in Roof

Number of modules =189

System size =189*500=94500wp

=94.5WP = 189708.75 KWH

The annual solar energy on the gross roof area is 189708.75 KWh/year, which mean that the coverage percentage equals 24%

Inverters:

An inverter is used to convert the electricity generated from DC to AC, this device is Expensive, it is changed every period and it is important to operate any device.

- Inverter capacity = (0.9 – 0.95) PV array peak power

Inverter capacity = (0.9-0.95) * 94.5 kW = 85- 89.7 kW

Figure 131: GoodWe GW80KBF-MT Solar Inverter. (Data sheet Zeversolar)

PLC Communication
The optional PLC communication offers stable data transmission and enables monitoring of large PV systems in remote areas.

- Max. PV Input Power: 104000 W
- MPPT Input voltage range: 200-1000 V
- Max. DC Input Voltage: 1100 V
- Starting Voltage: 200 V
- Protection Rating: IP65
- Display / Communication: LCD or WiFi+APP / RS485 or WiFi or PLC
- Size (Width x Height x Depth, mm): 586 x 788 x 267
- Weight: 65 kg

Figure 132: Technical data about three phase string inverters. (Data sheet Zeversolar)

Maximum number of modules = VPV upper/ VMPP (at -40°) = 1000V /49.92 V =20.03

Use 20 module

Minimum number of modules = VPV lower / VMPP (at 85°) = 200V /28.92 V = 6.9

Use 7 module

So, in order to stay within the voltage range at which the inverter will track MPP of array, the number of modules in each string must not be fewer than 7 and not be more than 21.

Cumulative cash flow from RET Screen:

The retard screen program will be used to determine the cache flow for this system because cumulative cash flow illustrates the time needed to recover the cost of the initial investment in the

PV system and the cost of the inverter and begin the process of making the owner a profit from this investment.

Initial cost, this value includes both equipment and installation costs.

Initial cost = 128 $/ UNIT.

Inverter price (15kw) = 2830.4 $.

Inverter price (7kw) = 1632.3 $.

Maintenance and operating cost = 33.31$/kW – year.

As shown in Figure, the pay pack period equals 5.4 years

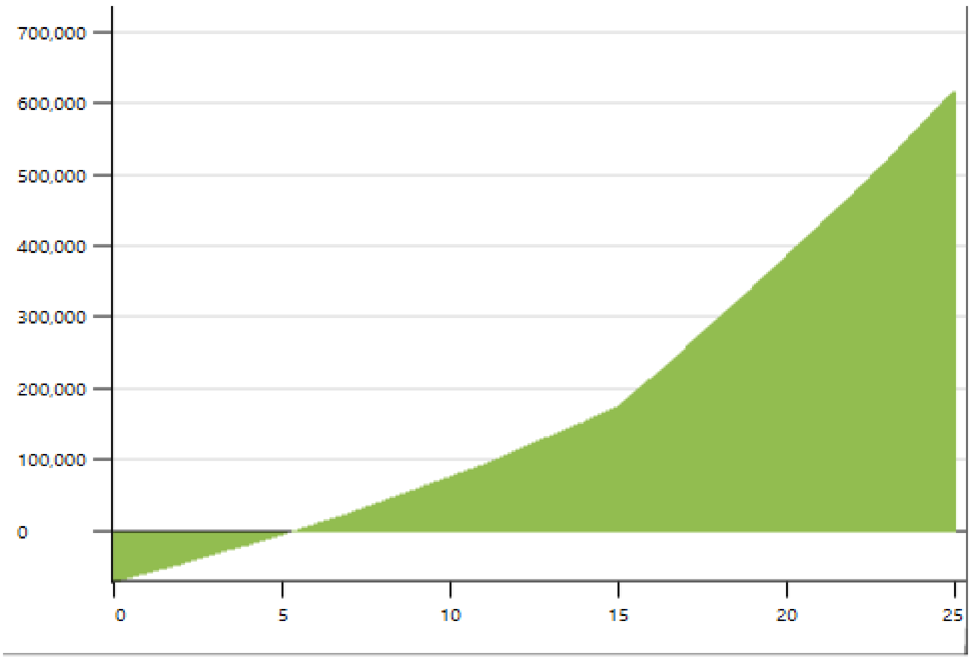


Figure 133 :Cumulative cash flow from RET Screen program

The table below is taken from the *RET Screen program*, showing the yearly cash flows

Table 32 : yearly cash flows *from RET Screen program*

Yearly cash flows		
Year	Pre-tax	Cumulative
#	$	$
0	-70,740	-70,740
1	11,837	-58,903
2	12,436	-46,467
3	13,047	-33,420
4	13,671	-19,749
5	14,307	-5,442
6	14,955	9,513
7	15,617	25,129
8	16,291	41,421
9	16,980	58,401
10	17,682	76,083
11	18,398	94,480
12	19,128	113,609
13	19,873	133,482
14	20,633	154,115
15	21,408	175,524
16	40,322	215,845
17	41,128	256,974
18	41,951	298,924
19	42,790	341,714
20	43,646	385,360
21	44,518	429,878
22	45,409	475,287
23	46,317	521,604
24	47,243	568,847
25	48,188	617,035

Chapter 3 : Structural aspects

3.1Introduction:

Structural system In this part, we will design the structural system of the building based on the system that was chosen and approved in Project 1, It is the presence of a structural concrete system and in the slabs there are two types, the Two Way Ribbed Slab system and the Solid Slab system on the floors of the building. The footing will also be studied, the appropriate type will be known, and the calculations will be made. A complete detailing will be drawn for the distribution of iron in the structural elements.

3.2 Structural and seismic aspect design

3.2.1 Load combinations

Buildings and other structures shall be designed using the provisions of either combining factored load using strength design or combining nominal loads using allowable stress design, the following combination adopted from ASCE 7-10.

3.2.2 Materials:

Concrete:

Unit weight ɣ concrete=25 KN/ mm^3

Concrete used has compressive strength fc = 28 MPa (B 450) for all elements in the

structure. $Linear\ Modulus\ of\ Elastisity$ = E = 4700 $\sqrt{fc}$= 24870 MP

Concrete used for slabs columns and beams

Steel rebar:

Modulus of elasticity = 200GPa. Steel yield strength Fy= 420Mpa.

glass

Bulletproof glass : The weight of this type of glass whose thickness is equal to 7 mm = 22.5 Kg/sm

Glass used in wall

3.2.2 Loads

Types of loads :

3.2.2.1 Gravity load

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

1. Dead load

Loads due to the own weight of the structure. It is the weight of the building that is calculated using the ETAP program.

2. Superimposed dead load (SID)

This load includes the loads that fall on the building from the weight of the tiles and the weight of the facades in our project. There are two types .

The first type is the weight of the glass facades, which is assume to 2 kn/m .

The second type includes the weight of the portable caponte, which is assume to 2 kn/m .

3. Live Loads

The value of the minimum live load differs according to the open space function depending on the space function and ACI code we reached for the live load values shown in the following table

Table 33: Live load from the ACI318-14

type	live load (KN/SM)
Offices	4.79
Storages and parking	6

4. *Walls load*

Concrete brick wall: the weight is 18KN/m2.

-Glass wall: the weight 3KN/m2.

3.2.2.2 Site and geology:

The building will be built on clay with bearing capacity of 220 KN/m2

3.2.3 Seismic Data and analysis:

Designing an earthquake-resistant building is one of the most important factors in the design and one of the most important safety factors in the building. This part depends on the structure of the building, its shape, height, width, and soil type. The design will be done using code (UBC 97)

Earthquake loads are added and studied by entering them into ETAPS, in several steps depending on the UBC code, and for this we need to know and calculate the following

Step 1 Seismic zone: The building is located in the city of Nablus , which means that the seismic zone is 2B and the seismic zone factor (Z) = 0.2 which was taken from the map of the State of Palestine from UBC97 code.

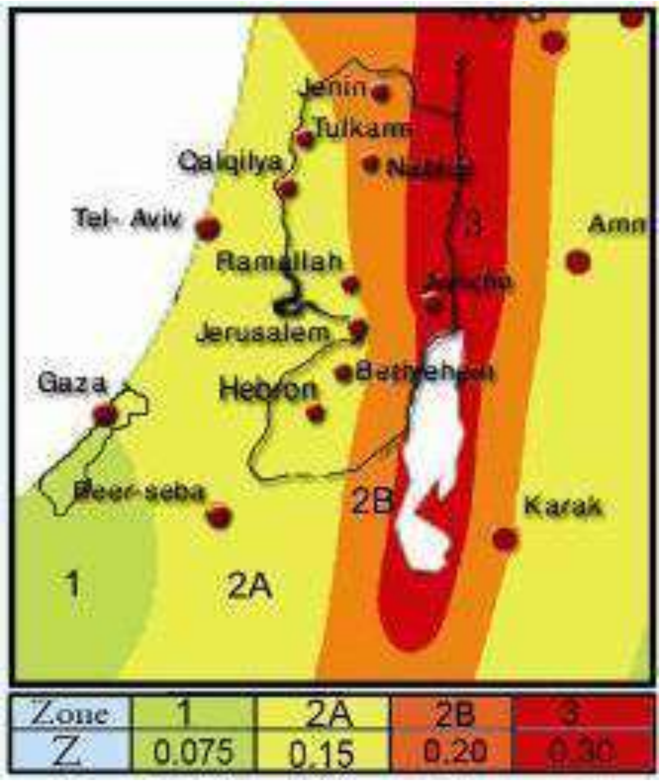


*Figure 134 Seismic zone factor (*UCB97)

Step 2: Soil profile

The type of soil under the building is medium-stiff hazard soil with a capacity of around 220

KN/m2, so the type of soil profile is SC. From UBC97 code TABLE 16-J—SOIL PROFILE TYPES.

Step 3: Seismic coefficient (Ca):

There are two seismic coefficients that depends on seismic factor and soil profile. Which are called C_v and C_a. The seismic coefficient (Ca) can be obtained from UBC97 code table [16-Q] (at Z=0.2, with the soil profile being SD), the Ca value = 0.24

Step 4: Seismic coefficient (Cv):

The seismic coefficient (Cv) = 0.32 (from UBC97 code table [16-R] (at Z= 0.2 and soil profile is Sc) .

Step 5: Importance factor (I):

The Importance factor (I)=1, from UBC97 code table [16-k] And that is through the space on the importance of the mini and its function, as it is considered a building that is not very important

Step 6.: Ductility Factor/ Response Reduction Factor (R):

The response reduction factor depends basically on the used structural system of the building: The basic structural system is a building frame system (shear wall)5 with R=5.5, as shown in the UBC97 code table [16-N].

Step 7 time period :

The time period is calculated according to the formula in the UBC code, T=Ct$(h)^{.75}$.

The choice of Ct depends on the seismic structural system of the building, in the building it is a sheer wall with a frame for that Ct = .0488

time period = .649 s

3.2.4 Slabs Structural System:

3.2.4.1. Slabs Type:

The two– way ribbed slab with dropped beams From the grand floor until the fifth.

The solid slab with dropped beam in the barking .

3.2.4.2 Preliminary Slab Thickness:

two-way ribbed slab

Use a two-way ribbed slabs in the building

According to ACI 318-14

Assume α m> 2

h= $\frac{1.1*(\,lnmax)}{36+9\beta}$= $\frac{1.1*(\,12.5)}{36+9(\frac{12.5}{10.3}}$ =.293

hreq. of solid slab = 293 mm

try ribbed slab thickness = 350 mm

I ribbed = 111801.7cm

bf = 700 mm

I solid = I ribbed

heq = 3 $\sqrt{\frac{12Ir}{bf}}$= 3 $\sqrt{\frac{12*111801.7}{70}}$ =27.24cm ➔ Heq > hrequired

assume h =350mm

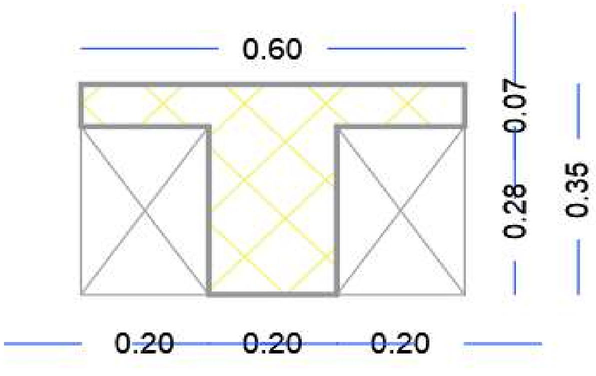


Figure 135: Two-way ribbed slab section

solid slab :

Use a solid slab in barking

$Assume\ \alpha_m > 2$

$$h = \frac{1.1Ln\_max}{36 + 9\beta} \geq 90mm$$

$$\beta = \frac{longer\ dimension}{shorter\ dimension} of\ panel$$

$$h = \frac{1.1 * 9.5}{36 + 9\frac{11.3}{9.6}} = .23m$$

Use slab thickness = 300mm

3.2.5 Beam dimension

The following table shows the dimensions of the beam that were used in the project

Table 34 : Beam dimension

Beam dimension	
in the grand slab until the fifth slab	in the barking slabs
Hedin Beam =350*600 mm (depth, width).	Main Beam =350*600 mm (depth, width)
Drop Beam =650*750mm (depth, width).	Drop Beam =600*700 mm (depth, width)
Drop Beam =600*600mm (depth, width).	Increased to beams after check of design:
Drop Beam =500*700mm (depth, width).	Drop Beam =600*750 mm (depth, width).
Drop Beam =600*750 mm (depth, width).	Drop Beam =650*800 mm (depth, width)
Drop Beam =500*750mm (depth, width).	
Drop Beam =500*500mm (depth, width).	
Hedin beam =350*500 mm (depth, width).	

3.2.5 Column dimensions :

All column Diameter (CM)=70

Some of the columns were inclined at an angle of 35 degrees due to the asymmetry of the floor while others were inclined at an angle of 41.

3.3 model

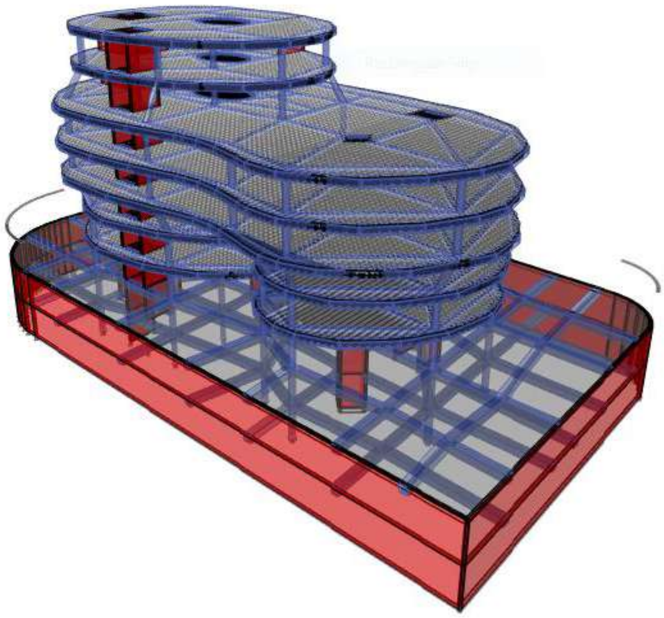


Figure 136 : model from Etabs

3.3.1. checks

To check the results from ETABS the following checks were made to verify the analysis results

3.3.1.1 Structural checks:

.1 Compatibility check

To make sure that all the structural elements are compatible with each other we make this heck. This is clear the animation of the deformed shape is compatible with each other of the model in ETABS as shown in Figure.

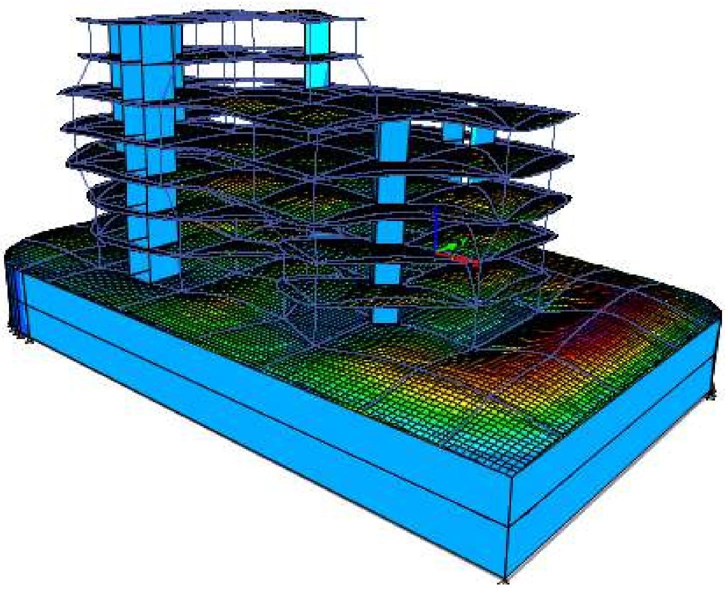


Figure 137 : Compatibility check

2- Equilibrium check

The aim of this check is to make sure that the loads we use are correct, the detailed calculations are presented at the following table. According to the tables notice that the errors are less than 10% which is ok.

By hand:

These are the equations used to calculate the values shown in the table below

$L.L = area\ of\ slab * Live\ load$

$Total\ weight\ for\ dead = Wall\ Load + Beams\ weight + Columns\ weight + Slab\ weight$

$Slab\ weight = area\ of\ slab * thickness * unit\ weight * weight\ modifier$

$Columns\ weight = height\ of\ column * dimensions * unit\ weight * \#\ of\ column$

$Beams\ weight = length\ of\ beams * width * depth * unit\ weight$

$Wall\ Load = Parameter\ beams\ length * weight\ of\ walls$

The following table shows *total live load by hand*

Table 35 total live load by hand

	Area(m2)	perimeter(M)	Total live (KN/m)
Basement2	2100	167	12390
Basement1	2100	167	12390
Ground floor	834.5	113.6	3997.255
attic floor	800	117.9	3832
first floor	1013	121.6	4852.27
Second floor	1025	123	4909.75
Third floor	1036	125	4962.44
Fourth floor	486.6	80.3	2330.814
Fifth floor	486.6	80.3	2330.814
total			51995.343

The following table shows *SID on wal*

Table 36 : SID on wal

	perimeter(M)	Total SID on wall
Basement2	167	501
Basement1	167	501
Ground floor	113.6	340.8
attic floor	117.9	353.7
first floor	121.6	364.8
Second floor	123	369
Third floor	125	375
Fourth floor	80.3	240.9
Fifth floor	80.3	240.9
total		3287.1

The following table shows total dead load

Table 37 : total dead load

	Type	volume	unit weight	Total Dead
columns	C 70	136.5	25	3412.5
beams	b 35*60	630	25	15750
	B60*70	1680	25	42000
	B80*70	967.12	25	24178
Slabs	T.W 35	2017.12	25	50428
	S.S 30	1680	25	42000
total dead				177768.5

The following table shows load from ETABS :

Table 38 : loads from etabs

	Output Case	Case Type	FZ kN
	Dead	LinStatic	191380.6234
	Live	LinStatic	47449.2853
	SD	LinStatic	3208.2399

$$\%error = \frac{etabs - Hand}{Hand} * 100\%$$

Table showed that the error rate is less than 10% in all cases if the check was ok

Table 39 : error rate by hande .

	in etabs	in hand	error%
live load	47449	51995.34	8.74
daed load	191380.6	177768.5	7.66
sid load	3208	3287.1	2.41

3. Check deflection for slab:

compare all interior and exterior spans two end or one end continues deflection from ETABS with L/360 for immediate deflection and L/240 for long term deflection.

According to Table 9.5 (b), the maximum allowable deflection 3.3.1.5 was taken

Deflection for hand $=\frac{L}{240}=\frac{12.5}{240}=$ 54mm

Deflection for Etabs = 49 mm

For ETABS < for hand its ok

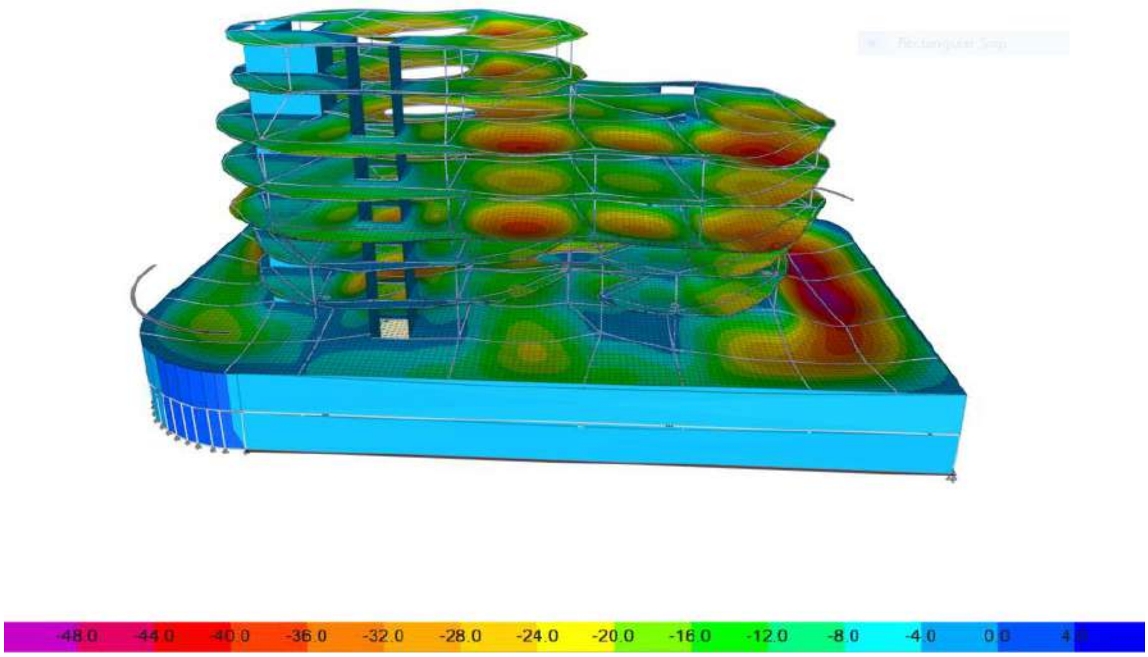


Figure 138 : Deflection check from ETABS 2016

4. Stress-strain check (Ultimate load)

1. Columns:

Manual calculation:

The equations used in the calculation

Load of slab = Tributary Area x W. per SM

W ult of columns = Area section x height x density

Cantilever load and edge cantilever beams load is transferred into the edg columns underneath .

W of walls = Length x Load/m x number

W of Beams = Length x Area section x Density x Number

Live Load = Tributary area x load/SM x Number of slab

Ultimate = (1.2 x D.L) + (1.6 x L.L)

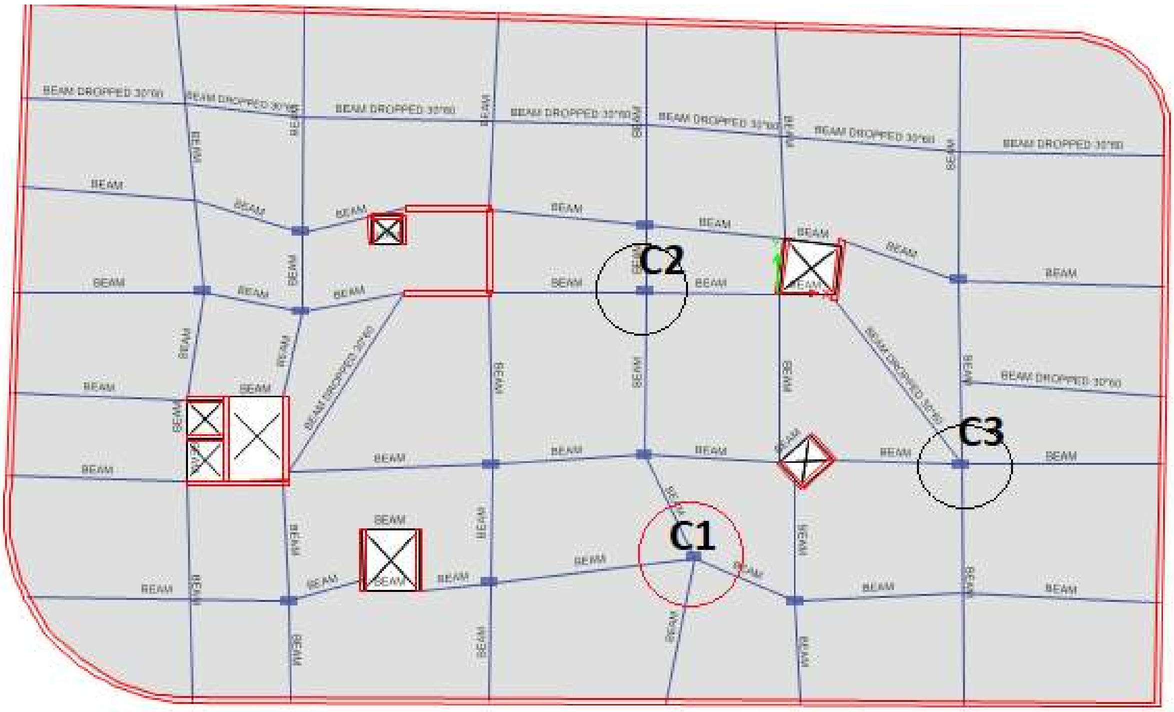


Figure 139 : The columns that were checked

The following table shows tributary area for column from hand.

Table 40 : tributary area for column from hand.

		Tributary area C1(m2)	Tributary area C2(m2)	Tributary area C3(m2)
SOLID	Basement2	50	61.4	70.3
	Basement1	50	61.4	70.3
	total	100	122.8	140.6
two way	Ground floor	33.6	34.6	48.6
	attic floor	35	34.6	48.6
	first floor	86.3	61.4	50.6
	Second floor	86.3	61.4	69.3
	Third floor	86.3	61.4	69.3
	Fourth floor	36.7	28.7	0
	Fifth floor	36.7	28.7	0
	total	400.9	310.8	286.4

The following table shows Ultimate load on column

Table 41: Ultimate load on column

	load on solid slab KN/m2	load on two-way slab KN/m2	load on WALL KN/m2	load on beam KN/m2	own weight	Live Load	dead load	Ultimate load (KN)
C1	1000	3523.911	1502.7	903	1211.9625	2592.473	8141.5735	13917.85
C2	1228	2731.932	1300.8	1176	1211.9625	2281.476	7648.6945	12828.8
C3	1406	2517.456	1281	1127	942.6375	2267.008	7274.0935	12356.13

FROM ETABS:

In c1 =13950.17 KN

In c2 = 13230KN

In C3= 11591.89KN

The following table shows Errors of stress-strain for columns

Table 42 : Errors of stress-strain for columns

Axial load	ETABS (KN)	Manual (KN)	%error
c1	13950	13917.845	0.23
c2	13230	12828.79	3.12
c3	11591.89	12356.12	6.18

2. Beam's stress-strain check

The picture below shows a third of Span in the same direction. We will make a check on them Frame ABCD in the first floor.

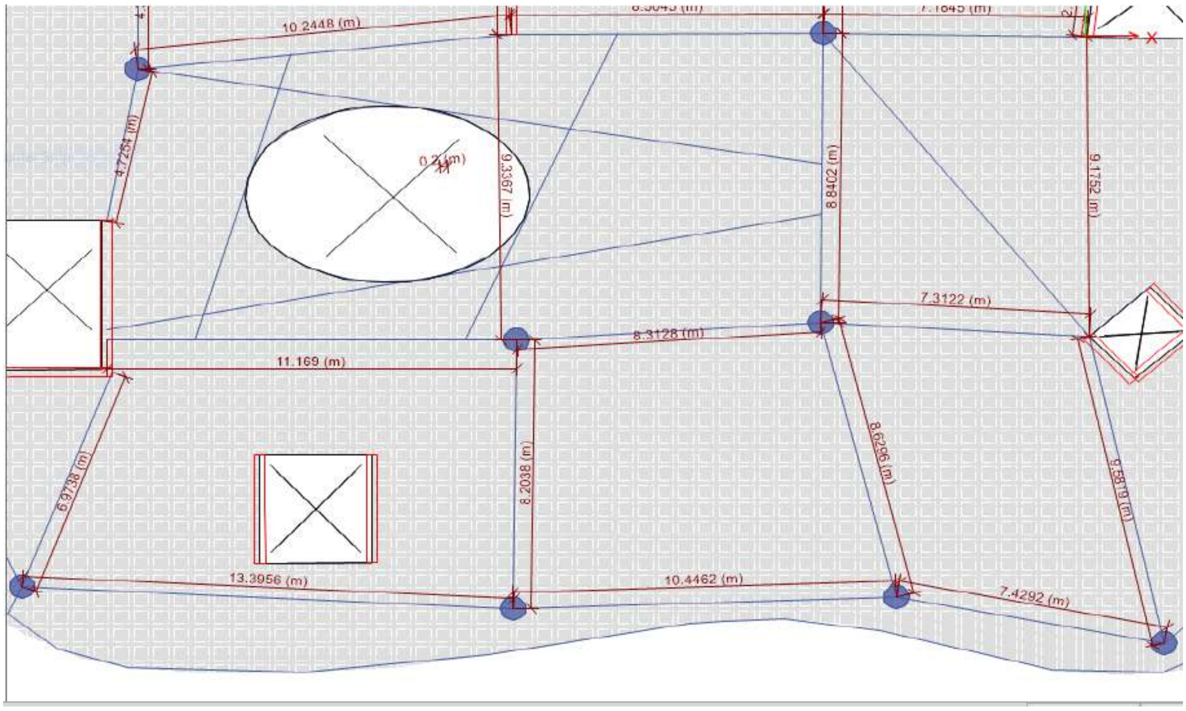


Figure 140 : Dimensions for beams from ETABS 2016.

frame length = L2= $(S_1+S_2)/2$ = 8.1 m

In order to use the direct design method, you must check the constraints Next:

1- 3 spans or more in each direction ✓

2- Rectangular panels with L_{long}/L_{short} in any panel ≤ 2

The following table shows Rectangular panels with L_{long}/L_{short} in any panel

Table 43 : Rectangular panels with L_{long}/L_{short} in any panel

panel	L_{long}	L_{short}	L_{long}/L_{short}
1	13.4	7	1.91
2	10.4	8.2	1.27
3	9.5	7.4	1.28

$L_{long}/L_{short} \leq 2$ its ok ✓

3-For successive spans $L_{long}/L_{short} \leq 1.5$

L_{long}/L_{short} = 11.1/8.3=1.3 its ok ✓

Llong/Lshort = 8.3/7.31=1.13 its ok ✓

4-Column offset ≤ 10% of smaller span in the column offset direction ✓

5- Uniform gravity load with LL/DL ≤ 2

LL/DL = 4.79/4= 1.197 its ok ✓

3- For slabs with beams:

$$0.2 \leq \frac{\alpha_{fAB}/{L_{AB}}^2}{\alpha_{fBC}/{L_{BC}}^2} \leq 5$$

I main beam = $\frac{600\ x\ 350^3}{12} = 2.143\ x\ 10^9 mm^4$

I main beam = $\frac{700\ x\ 600^3}{12} = 1.26\ x\ 10^{10}\ mm^4$

I slab = $\frac{8100\ x\ 350^3}{12} = 2.858\ x\ 10^9\ mm^4$

Table 44 : Alpha f for frames

	L2 (mm)	Thickness (mm)	I slab	I beam	α
1	8100	350	2.86E+09	2.14E+09	0.7498251
2	5000	350	2.86E+09	2.14E+09	0.7498251
3	9000	350	2.86E+09	1.26E+10	4.4086774
4	8500	350	2.86E+09	1.26E+10	4.4086774

$0.2 \leq \frac{\alpha_{fAB}/{L_{AB}}^2}{\alpha_{fBC}/{L_{BC}}^2} \leq 5$ $\quad$ $0.2 \leq \frac{.749/8100^2}{.44/9500^2} \leq 5$

$0.2 \leq 1.3 \leq 5$ its ok ✓

Since all constraints are successful then we can use the method.

Manual calculation:

Wu = 1.2 D.L + 1.6 L.L

Wu = 1.2 x (8) + 1.6 x 4.79 = 17.264 KN/SM

$M0 = \frac{Wu \times L2 \times Ln^{2}}{8}$

$M0$BC = $\frac{17.26 \times 8.1 \times 7.6^{2}}{8}$ = 1132.428 kN. M

$M0$AB = $\frac{17.26 \times 8.1 \times 10.6^{2}}{8}$ = 1963.57 kN. m

$M0$CD = $\frac{17.26 \times 8.1 \times 6.7^{2}}{8}$ = 784.48 kN. m

Interior Span {BC}

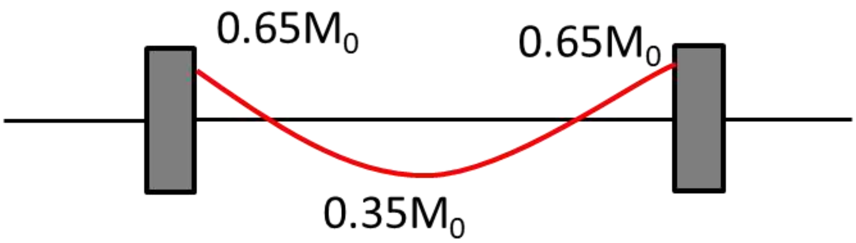


Figure 141: moments in interior span (ACI 318 2014)

M -ve = 0.65 Mo = 0.65 x1132.428= 736.0782

M +ve = 0.35 Mo = 0.35 x 1132.428 =396.3498

Exterior Span

The frame contains two external spans { AB,CD} The moment is distributed according to table 9.3 of the ACI-314 code.

The picture below shows the moment in the frame according to the previous schedule and previous laws.

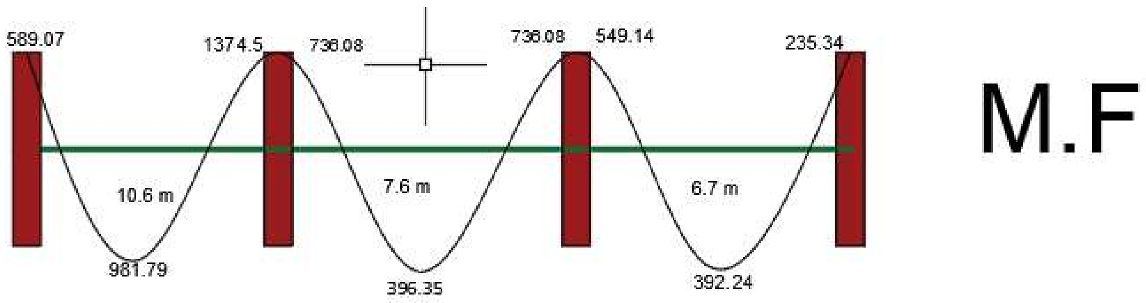


Figure 142 : frame BMD

$\alpha fi = \frac{EIb}{EIs}$for beam i in the panel

Ecb = modulus of elasticity of the beam concrete

Ecs = modulus of elasticity of the slab concrete

$Ib = \frac{BH3}{12}$, IS = $\frac{L2H3}{12}$

*Table 45 : Alpha f *L2/L1 for frames*

	panel	L2 (mm)	Thickness (mm)	I slab	I beam	αf	L2/L1	αf*L2/L1
AB	1	8100	350	2.89E+10	2.50E+09	0.086	1.914286	0.165432
BC	1	8100	350	2.89E+10	2.50E+09	0.086	1.268293	0.109606
CD	1	8100	350	2.89E+10	2.50E+09	0.086	1.283784	0.110944

$$C = \sum\left(1 - 0.63\frac{x}{y}\right)\frac{x^3y}{3} \qquad \beta_t = \frac{E_{cb}C}{2E_{cs}I_s}$$

C=∑(1-0.63$\frac{350}{8100}$)350^3*8100/3 = 1.1*10^{11}

β =$\frac{1.1*10^{11}}{2*2.89*10^{10}}$= 1.8

Depending on the values of Table No3-13 and with the help of the moment ratio tables, the following result was obtained:

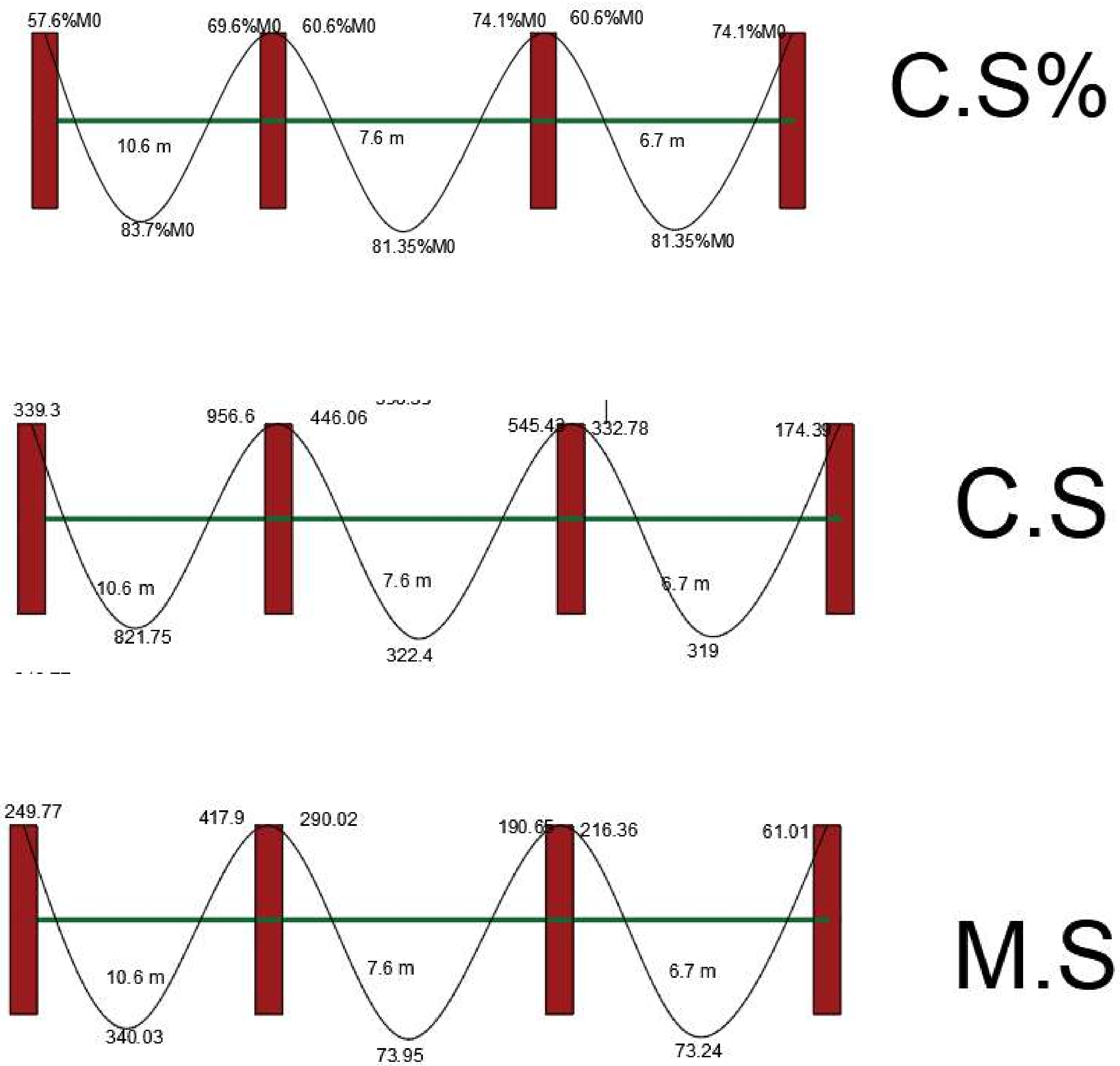


Figure 143 : Bending moment for each part.

made a cutting session on the ETAPS for the slab at the distance of the CS and the frame, and we took the results shown in the following table .

Table 46: MOMENT of beam

Moment of beam				
beam		Manual	Etabs	error%
AB	negative	125.9	195	-54.88
	positive	183.18	219	-19.55
BC	negative	97.3	88	9.56
	positive	66.9	40.6	39.31
CD	negative	11.5	18	-56.52
	positive	11.5	13	-13.04

Table 47 : Errors of stress-strain for frame

Frame				
		Manual	Etabs	error%
AB	negative	589.07	554.76	5.82
	positive	981.79	1043.76	6.31
	negative	1374.5	1467.5	6.77
BC	negative	736.08	817.25	11.03
	positive	396.35	445	12.27
	negative	739.08	737.46	0.22
CD	negative	549.14	543.95	0.95
	positive	392.24	376.2	4.09
	negative	235.34	281.19	19.48

Table 48 : Errors of stress-strain for Column strip (CS)

Column strip (CS)				
		Manual	Etabs	error%
AB	negative	339.3	332.74	1.93
	positive	821.75	862.3	4.93
	negative	956.6	956.3	0.03
BC	negative	446.06	501.2	12.36
	positive	322.4	387	20.04
	negative	545.43	588.19	7.84
CD	negative	332.78	276.8	16.82
	positive	319	322.13	0.98
	negative	174.33	138	20.84

Table 49 : Errors of stress-strain for middle strip (MS)

Middle strip				
		Manual	Etabs	error%
AB	negative	249.77	222.02	11.11
	positive	160.04	181.46	13.38
	negative	417.9	511.2	22.33
BC	negative	290.02	316.05	8.98
	positive	73.95	58	21.57
	negative	193.65	149.27	22.92
CD	negative	216.36	267.15	23.47
	positive	73.24	54.07	26.17
	negative	61.01	143.19	134.70

5-Shear check for slab:

In this check, the shear capacity of the slab (ØVc) must be greater than the ultimate shear on the slab (Vu).

Hence, the capacity for the shear formula (ØVc) is:

$$ØVc = \frac{.75}{6}\,\boldsymbol{x}\,\sqrt{f`c}\,\boldsymbol{x}\ \text{bw}\boldsymbol{x}\ \text{d}\ \boldsymbol{x}1.1$$

$$ØVc = \frac{.75}{6}\,\boldsymbol{x}\,\sqrt{28}\ \boldsymbol{x}\frac{200x320}{1000}\,\boldsymbol{x}1.1 = 46.56 \text{ KN/rib} \rightarrow ØVc = 77.6 \text{ KN/m}$$

The value of ultimate shear (Vu) could be restricted by contour range (-ØVc, ØVc) → (- 75.6,75.6) to ensure that all values are within the limit. The following figure shows the value of ultimate shear (Vu) in the x-direction (V1-3) on the ground floor:

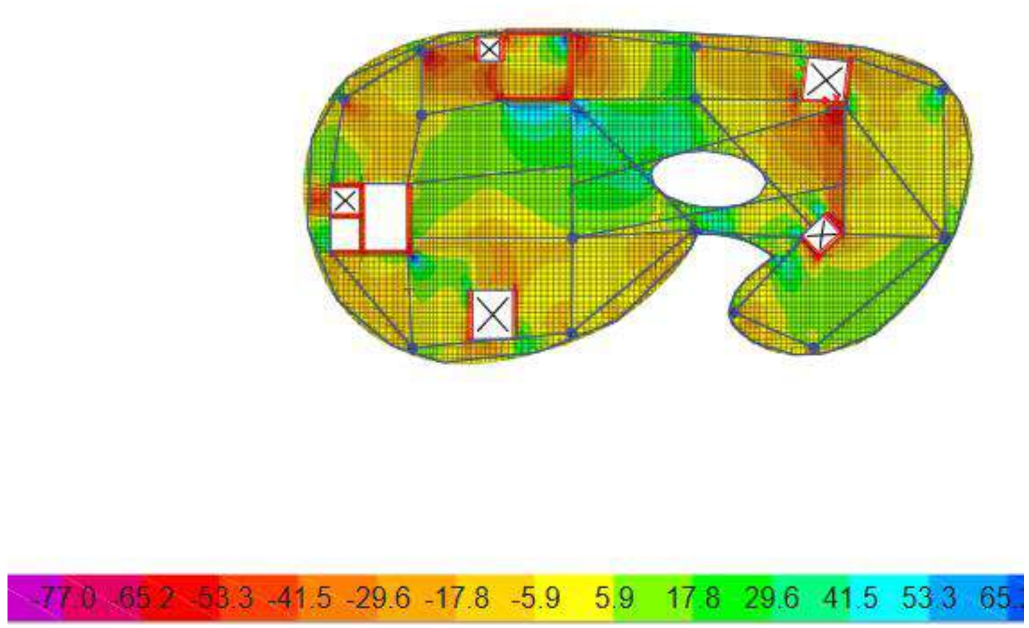


Figure 144 : the value of ultimate shear (Vu) in the x-direction (V1-3) on the ground floor.

The following figure shows the value of ultimate shear (Vu) in the y-direction (V2-3) on the ground floor :

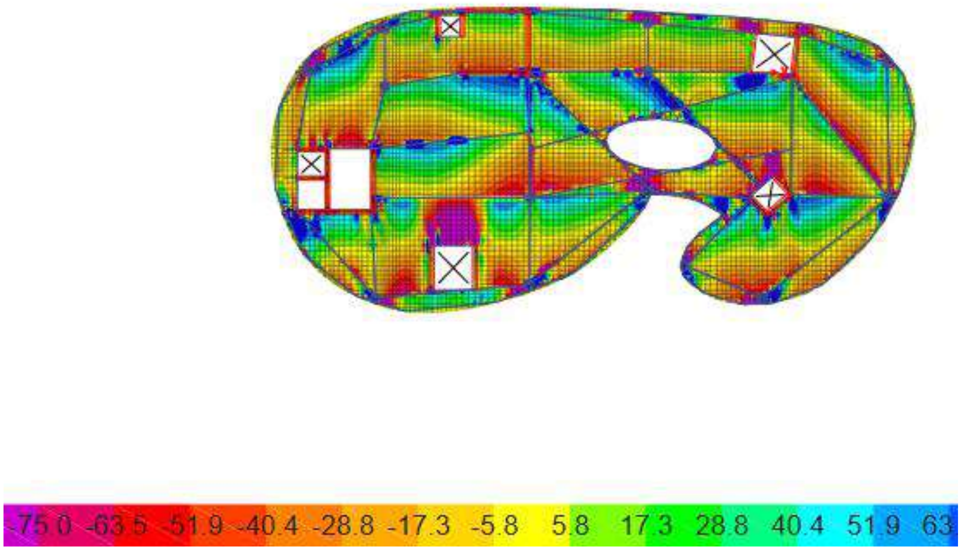


Figure 145 : the value of ultimate shear (Vu) in the y-direction (V2-3) on the ground floor

3.3.1.2 Seismic checks:

After response spectrum created on ETABS, there is checks needed to do to make sure the ETABS makes the analysis correctly, the checks needed is:

1. Model participation mass ratio.

2. Time period check.

3. Base shear check.

4. Drift check

1. Period check:

$TEtabs \leq 1.4\ TManual$

$1.4\ TManual = 1.4\ x\ Ct\ x\ (h)^{.75}$

Where:

Ct: is a factor given by:

Ct= (0.0853) for steel moment-resisting frames.

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

Ct = (0.0488) for all other buildings.

hn: the height of the building in meters.

In the first place, the building was considered another building Because of the presence of shear walls, hence the factor (Ct) used for the building was 0.0488. hn =33.5 m

1.4 $TManual$ =1.4 x .0488 x $(33.5)^{.75}$ =.908 s

The period of the building from the ETABS is equal to 1.07 s, as shown in the following picture

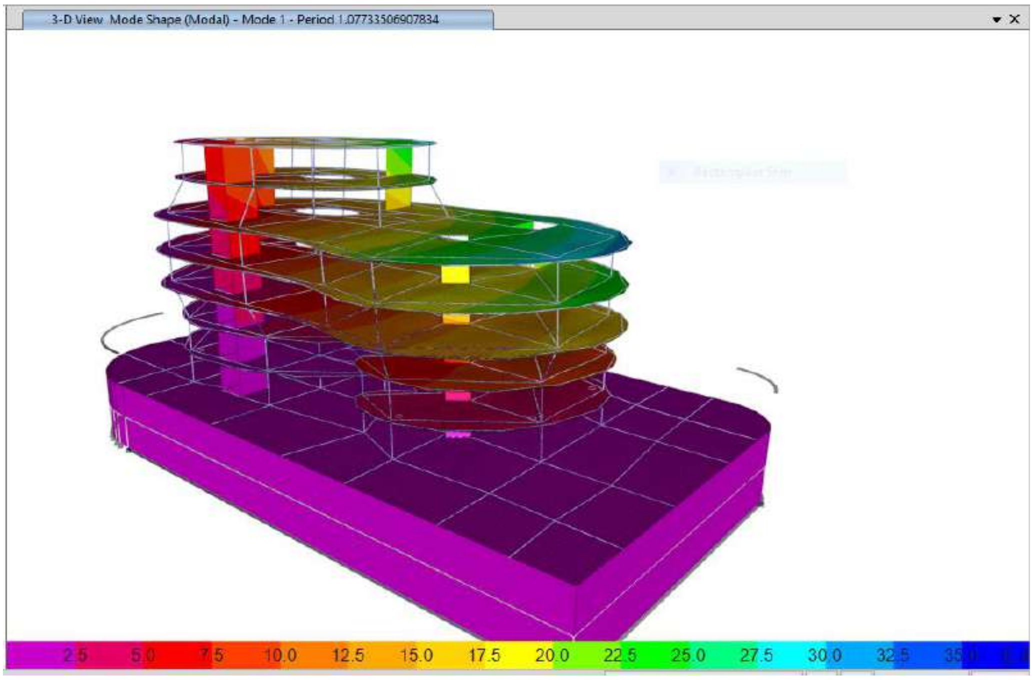


Figure 146 : Period check results from Etabs.

But we are allowed to increase the period value of the Etabs by 0.7 . Because of the coefficient Ct, therefore T ETABS is equal to 0.7* 1.07 =.749 s

If the value of the T Etabs is less than the T Manual, In this case, the periodic checks of the building is acceptable.

2. Modal participation mass ratio check:

In this test, we make sure that the model achieves at least 90% of the seismic loads in terms of displacement and movement in all directions.

	Case	Mode	Period sec	UX	UY	UZ	SumUX	SumUY	SumUZ
	Modal	1	1.2	0.153	0.1149	0	0.153	0.1149	0
▸	Modal	2	1.114	0.2354	0.1287	0	0.3884	0.2435	0
	Modal	3	0.848	0.0078	0.1685	0	0.3962	0.412	0
	Modal	4	0.361	0.0329	0.0292	0	0.4291	0.4413	0
	Modal	5	0.279	0.0801	0.0284	0	0.5092	0.4697	0
	Modal	6	0.204	0.0061	0.0168	0	0.5153	0.4865	0
	Modal	7	0.187	0.0039	0.0951	0	0.5192	0.5815	0
	Modal	8	0.136	0.0506	0.0097	0	0.5698	0.5912	0
	Modal	9	0.093	0.0176	0.0773	0	0.5874	0.6685	0
	Modal	10	0.086	0.016	0.0922	0	0.6034	0.7607	0
	Modal	11	0.079	0.0655	0.0041	0	0.6689	0.7649	0
	Modal	12	0.068	0.0152	0.0034	0	0.6841	0.7683	0

Figure 147: the modal participating mass ratio of the building from ETABS.

At modal 2 the building satisfies more than 90% of its component's displacement in each direction.

In other words, the summation of Ux & Uy > 90% ➔ check is ok. ✓

3. Base shear check:

In this check, the manually calculated base shear of the building should lie between the minimum and maximum base shear (Vmin & Vmax). The base shear can be calculated using the following formula:

$$v = \min\left(\frac{Cv\,I}{RT}W\right), \left(\frac{2.5Ca\,I}{R}W\right)$$

Where:

Cv: velocity seismic coefficient.

I: Importance factor of the building.

R: numerical coefficient representative of the inherent over strength and global ductility capacity of lateral-force-resisting systems.

T: This is the basic natural period of a simple one degree of freedom system which is the time required to complete one whole cycle during dynamic load.

Ca: Seismic coefficient

W: is the summation of the own weight of the structure, SID, and partial of live load (KN).

w= D.L + S.I.D + Wall wt. + 0.30 L.L

W= w-w beam

Table 50: Characteristics for the building

I	R	Ca	Cv
1	5.5	0.24	0.32
w (kn)	w beam (KN)	W (KN)	$Vmanua$(KN)
149979	8520	141459.2	14932

We are allowed to have an error of up to 5%.

V $_{ETABS}$ = 15142 KN

Error = $\frac{15142-14932}{15142}$*100% = 1.4% , so its ok ✓

The following table shows Base-shear reaction from ETABS

Table 51 : Base-shear reaction from ETABS

Output Case	Case Type	Step Type	FX kN	FY kN
Dead	LinStatic		-1.015E-06	-4.96E-05
Live	LinStatic		6.873E-07	-1.301E-05
SD	LinStatic		0	-1.125E-06
EQx	LinStatic	Step By Step	-15145.0379	-1.472E-05
EQx	LinStatic	Step By Step	-15145.0379	-3.746E-05
EQx	LinStatic	Step By Step	-15145.0379	8.028E-06
EQy	LinStatic	Step By Step	-0.0001	-15145.0376
EQy	LinStatic	Step By Step	-0.0001	-15145.0376
EQy	LinStatic	Step By Step	-0.0001	-15145.0377

The following table shows Manual calculation of base-shear reaction

Table 52 : Manual calculation of base-shear reaction.

Axis	T	Tlimit	Tused	Vmanual	Vetab	error	check
x	1.07	0.908	1.07	14932	15142	1.406376	ok
y	1.12	0.908	1.12	14932	15653	4.828556	ok

4- Drift check:

In this examination, we will calculate the displacement in all directions in the event of earthquakes in all directions .

drift limitation has two cases:

$$\text{If} \begin{cases} T < 0.7 \rightarrow \dfrac{\text{Lstory}}{40} \\ T \geq 0.7 \rightarrow \dfrac{\text{Lstory}}{50} \end{cases}$$

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

ΔX = drift(X)*0.7*$\frac{R}{5.5}$

ΔX should be $\leq$ drift limitation

Sample of calculation for story no.5 (in the x-direction):

Drift Delta x - (ΔSX) = 1.09 - .206 = 0.839 mm.

the Inelastic drift x - (ΔMX) = 0.7 x R x (ΔSX)= 0.7 x 5.5 x0.839=3.437 mm.

Delta Limit (ΔMAll) = 0.02 x story height = 0.02 x 3500 =70 mm. (as the period is greater than 0.7 sec)

To ensure that the drift check is accepted the following condition should be satisfied:

The delta limit (ΔMAll) > the in the Inelastic drift x - (ΔMX) ➔ 70 >3.437, then the check is ok.

The following table shows the check condition for other stories:

Table 53 Drift check

story	Story height	Dis-X (Ux) (from ETABs)	Dis-Y (Uy) (from ETABs)	Drift Delta x - (ΔSX)	Drift Delta y - (ΔSY)	Inelastic drift x - (ΔMX)	Inelastic drift y - (ΔMy)	Delta Limit (ΔMAll)	Check Status
Base	0	0	0	0	0	0	0	0	----
B2	3.5	0.019	0.225	0.019	0.225	0.072	0.866	70	OK
B1	3.5	0.070	0.806	0.051	0.581	0.196	2.237	70	OK
GF	3.5	0.232	5.185	0.162	4.380	0.625	16.862	70	OK
Attics	3.5	0.170	12.739	0.402	7.553	1.549	29.080	70	OK
1	3.5	0.423	22.456	0.252	9.718	0.971	37.413	70	OK
2	3.5	0.333	32.873	0.756	10.416	2.911	40.103	70	OK
3	3.5	1.252	40.685	0.919	7.812	3.536	30.078	70	OK
4	3.5	0.206	47.124	1.458	6.439	5.612	24.791	70	OK
5	3.5	1.099	50.744	0.893	3.620	3.437	13.937	70	OK

5- P-Delta effect check:

The effect of (Δ-P) could be neglected if the following condition is satisfied:

$\boldsymbol{\theta x} = \frac{p}{Sx\ h} \leq \mathbf{0.1}$ $\boldsymbol{\theta y} = \frac{p}{Sx\ h} \leq \mathbf{0.1}$

Where

P: is the maximum service axial force on the story.

Sx: is the lateral stiffness of the story in the x-direction.

Sy: is the lateral stiffness of the story in the y-direction.

h: is the height of the story.

Sample of calculation for the first story:

$\boldsymbol{\theta x} = \frac{p}{Sx\ h} \leq \mathbf{0.1}$

From ETABS the following results are obtained:

P=19822.6KN.

Sx = 149375.92 KN/m.

Sy =190115.668 KN/m.

h = 3.5m.

then:

$\boldsymbol{\theta x} = \frac{p}{Sx\ h} \leq \mathbf{0.1}$ = 0.038 ≤ $\mathbf{0.1}$ check is ok.

$\boldsymbol{\theta y} = \frac{p}{Sx\ h} \leq \mathbf{0.1}$ = 0.03 ≤ $\mathbf{0.1}$ check is ok.

The following table summarizes the p-delta check status for other stories

Table 54: P-Delta check

3.3.2. Design and Reinforcement:

In this part, we will explain the sample calculation for the design calculation of the elements in the building, and we will take the values for the building as a whole from the ETABS program and *design the detailing based on its* results

3.3.2.1. Slab design:

The design of the slab is in the case of a two-way ripped slab, its thickness is 35 cm. An iron is placed after showing the moment and tension, and a stirrup is placed for the share , it is calculated based on the As that is calculated from the moment in both directions, and we will depend on the moment from ETA

$$\rho_{min} = \max \begin{bmatrix} \frac{1.4}{Fy} \\ \frac{0.25\times\sqrt{f'c}}{Fy} \end{bmatrix}$$

$$Asmin = \max \begin{cases} \frac{1.40}{Fy}\ xb\ web\ x\ h \\ (0.25\ x\ \sqrt{fc})/Fy\ x\ b\ web\ x\ h \end{cases}$$

$$\emptyset Mn = \emptyset As_{used} \times fy \times (d - \frac{As\ used \times fy}{1.7\times f'c \times b})$$

Table 55 : Slab information

Fy	Fc	h(mm)	d (mm)	b web(mm)
420	28	350	320	200

Vertical direction:

The following photos from ETABS show the Moment in the direction of the Y-axes on the slab, first floor :

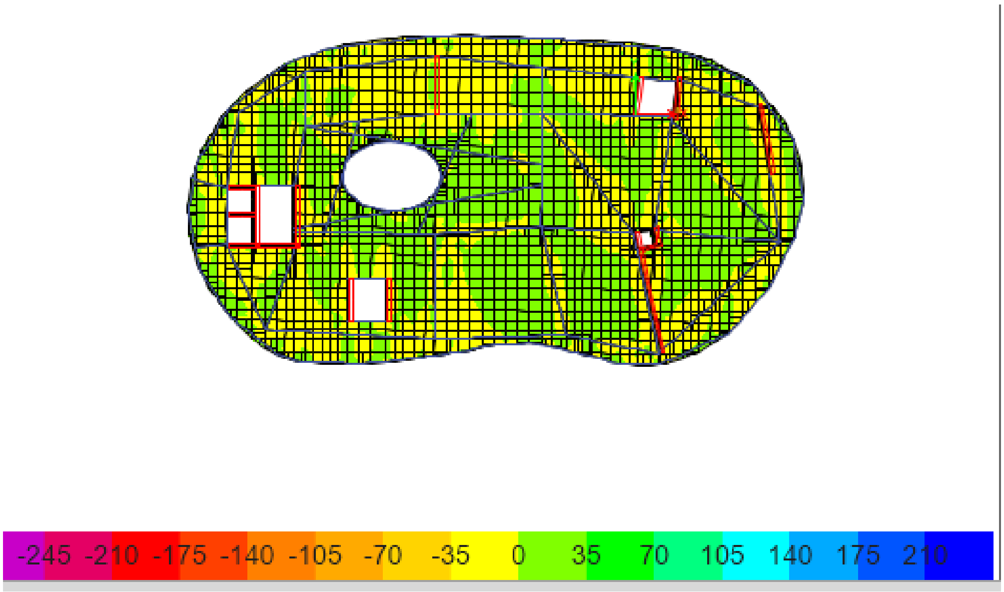


Figure 148: Negative moment distribution for vertical reinforcement (-M22)

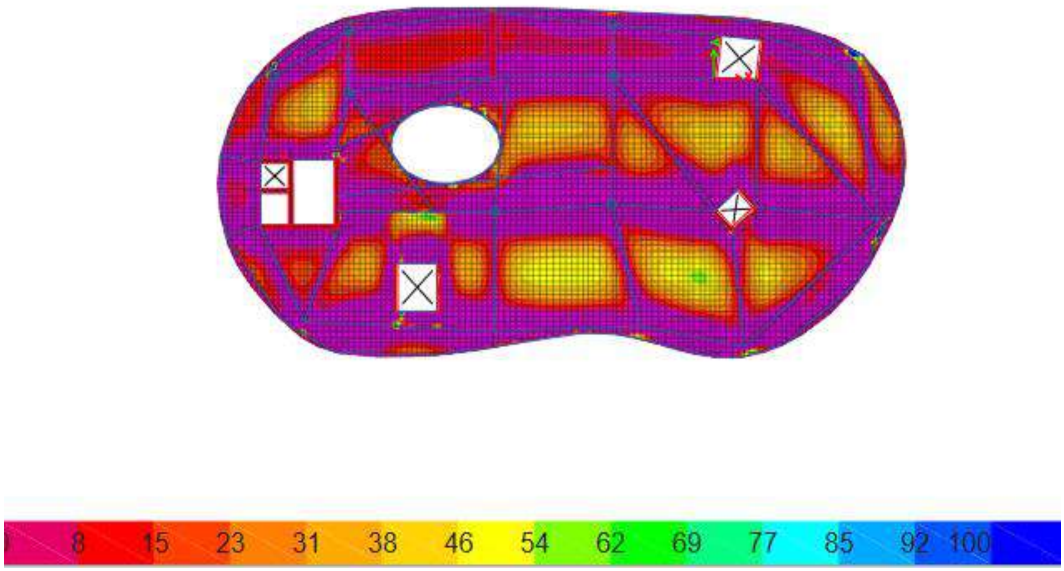


Figure 149 : Positive moment distribution for vertical reinforcement (+M22)

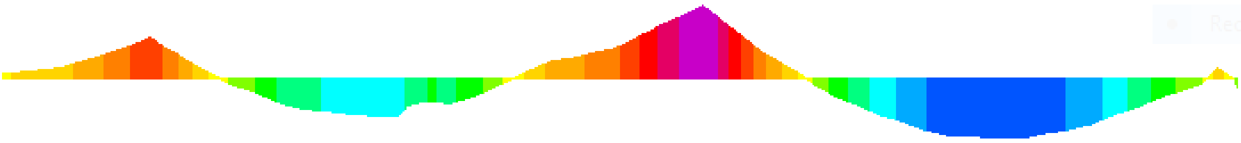


Figure 150 : Section cat moment in the slab of the first floor

We design the slab according to the following steps shown in the code ASCE7-10

1- We take the moment from Etabs ,

2- We calculate the value of ρ according to the following equation:

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

And Calculate ρ min :

3- Calculate the value of As according to the following equation :

$A_s = \rho$ *b*d

And Calculate As min : ρ_{min}= max $\left[\begin{array}{c} \frac{1.4}{Fy} \\ \frac{0.25 \times \sqrt{f'c}}{Fy} \end{array}\right.$

Asmin = max$\left\{\begin{array}{l} \frac{1.40}{Fy}\ xb\ web\ x\ h \\ (0.25\ x\ \sqrt{fc})/Fy\ x\ b\ web\ x\ h \end{array}\right.$

The following table shows Additional top and bottom reinforcement in vertical direction

Table 56 : Additional top and bottom reinforcement in vertical direction

Vertical direction (22)			
Additional top bars		Additional bottom bars	
Mu (KN.m/m)	150	Mu (KN.m/m)	63
ρ	0.0048	ρ	0.0020
ρ min	0.003	ρ min	0.003
As	308	As	127
As min	213	As min	213
As used	308	As used	213
#of bars	3	#of bars	2
	3Ø12		2Ø12

The following table shows Additional top and bottom reinforcement in horizontal direction

Table 57 Additional top and bottom reinforcement in horizontal direction

horizontal direction			
Additional top bars		Additional bottom bars	
Mu (KN.m/m)	245	Mu (KN.m/m)	210
ρ	0.0081	ρ	0.0068
ρ min	0.003	ρ min	0.003
As	516	As	438
As min	213	As min	213
As used	516	As used	438
#of bars	4	#of bars	3
	4Ø14		3Ø14

The ETABS program displays the slab moment in both directions. Take section and detail the moment into upper and lower iron and calculate it. Then we distribute the minimum reinforcement bar on the slab and increase it in the areas of high moment. Tension, pointing and design shown for them. And for the sake of accuracy and design for one ribbed, not per meter, worked on transferring the slab to the SAFE program and drawing the ribbed and design through it. The following tables show the design of one frame of slab by hand.

Table 58 : reinforcement for slab in y-direction in the first floor from hand.

	Mu(KN.m)	ρ	As	As min	As (mm)	# of bars	Ø of bars	Spacing (mm)	As used
Cantilever	14.5	0.0019	122	213.33	213	2	14	72	308
TOP (-)	22.30	0.0030	189	213.33	213	2	14	72	308
BOT (+)	16.50	0.0022	139	213.33	213	2	14	72	308
TOP (-)	50.50	0.0069	444	213.33	444	3	14	29	462
TOP (-)	46.59	0.0064	407	213.33	407	3	14	29	462
BOT (+)	30.69	0.0041	263	213.33	263	2	14	72	308
TOP (-)	77.20	0.0110	706	213.33	706	3	20	20	942
TOP (-)	41.30	0.0056	359	213.33	359	2	14	72	308
BOT (+)	31.78	0.0043	273	213.33	273	2	14	72	308
TOP (-)	35.60	0.0048	307	213.33	307	2	14	72	308
Cantilever	16.70	0.0022	141	213.33	213	2	14	72	308

2. Horizontal direction**:**

We follow the same steps in finding the vertical reinforcement, but we display from the M11 ETAPS.

Table 59 : reinforcement for slab in x- direction in the first floor from hand .

	Mu(KN.m)	ƒ	As	As min	As (mm)	# of bars	ø of bars	Spacing (mm	As used
Cantilever	18.9	0.0025	159	213.33	213	2	14	72	308
TOP (-)	29.60	0.0040	253	213.33	253	2	14	72	308
BOT (+)	20.50	0.0027	173	213.33	213	2	14	72	308
TOP (-)	60.39	0.0084	538	213.33	538	3	14	29	462
TOP (-)	50.78	0.0070	447	213.33	447	3	14	29	462
BOT (+)	41.60	0.0056	361	213.33	361	2	14	72	308
TOP (-)	68.97	0.0097	623	213.33	623	3	20	20	942
TOP (-)	47.36	0.0065	415	213.33	415	2	14	72	308
BOT (+)	38.90	0.0053	337	213.33	337	2	14	72	308
TOP (-)	42.90	0.0058	373	213.33	373	2	14	72	308
Cantilever	14.30	0.0019	120	213.33	213	2	14	72	308

2- Show the tension of ETABS in both directions and take the values , After showing the tension, the values that appear are half of them top and the second half bottom, they made reinforcement according to the tension values and added it to the moment.

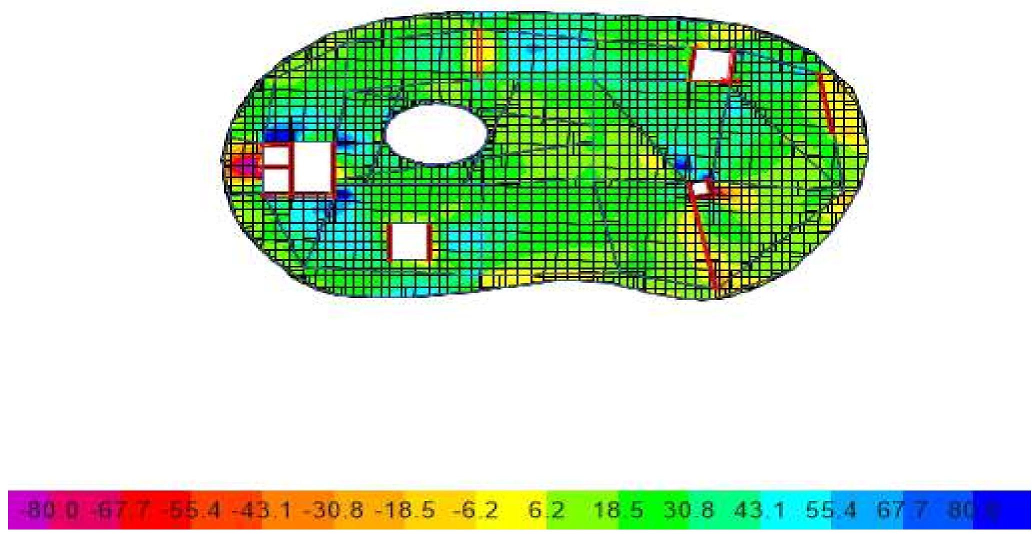


Figure 151 : Axial force diagram for horizontal reinforcement (F11)

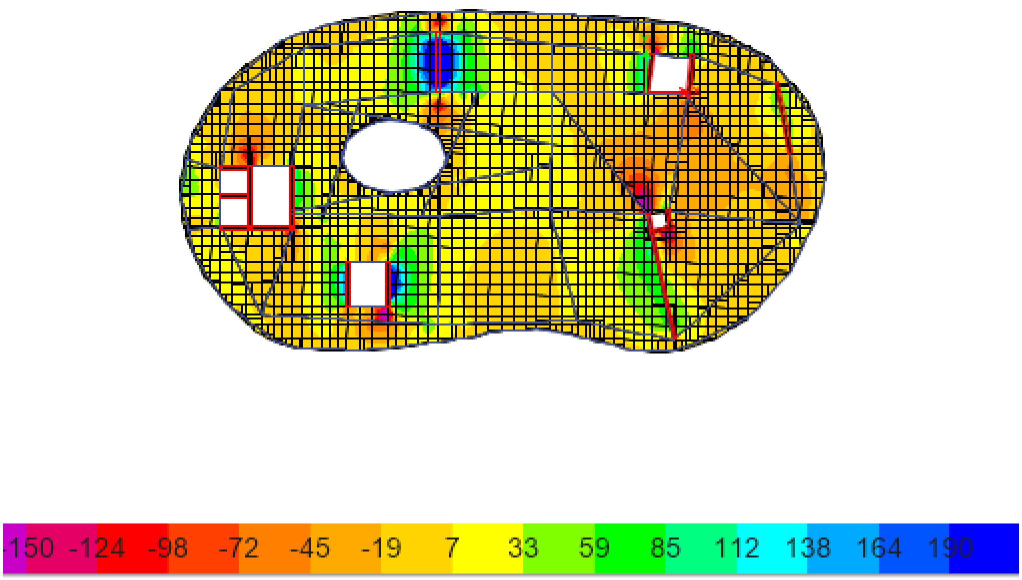


Figure 152: Axial force diagram for vertical reinforcement (F22)

The following table shows reinforcement for slab.

Table 60 : Mesh reinforcement for slab.

Axial Load for horizontal	
Pu	80
As	212
Diameter Ø14	153.86
#of bars	1.4
	2Ø14

Axial Load for vertical	
Pu	190
As	503
Diameter Ø14	153.86
#of bars	3.3
	4Ø14

Table 61 : Total horizontal and vertical reinforcement in ribbed .

Total horizontal direction		Total vertical direction	
Top	2Ø16	Top	2Ø16
Bottom	2Ø16	Bottom	2Ø116

Shear check and design for slab:

Vmax taken from ETABS as V13 and V23 = 530 KN/m

$VU = Vmax - (Wu \times d)$

$\emptyset Vc = \frac{0.75}{6}\sqrt{f'c} \times b \times d \times 10^{-3}$ ×1.1 = $\frac{0.75}{6}\sqrt{28} \times 200 \times 320 \times 10^{-3}$ ×1.1

= 46.56 KN\rib = 72.7 KN\m

Wu = 1.2D + 1.6 L.L

= 1.2 (4+3) + 1.6*4.76 = 16 KN\m^2

Vu = Vmax – Wu d = 530- 16×0.32 = 524 KN\m

$\emptyset Vc$ < Vu → need stirrups for shear

Vs = $\frac{Vu}{\emptyset}$ - Vc =601.7 KN

$\frac{Av}{S}$ = $\frac{Vs}{d \times Fy}$ = 4.4 mm^2\mm

Use 4Φ12 @ 200 mm

Detailing :

To see detailing for the slabs , go to Appendix.

3.3.2.2 Beams design:

the beams will be reinforced with longitudinal steel bars and stirrups, The reinforcement of the beams was taken and divided into bars from the detailing from ETABs.

According to the structural system used for earthquakes, seismic loads are carried on the sheer wall, and the moment, the beam and the coulomb are zeroed. Detailing is done as per chapter 18.14 at ACI-314 Members not designated as part of the seismic-force-resisting system.

According to the ACI, the details are for Members not designated as part of the seismic-force-resisting system Conforms to the requirements of beams and columns of special moment frames.

The top steel bars were divided into 3 zones in the beam and the bottom steel bars into one zone, and the stirrups were also divided into 3 zones where the stirrups were condensed near the columns.

Code dimension requirements:

Clear span of beam ≥ $4d$, where: d = effective depth of beam.

Beam width ≥ $min\begin{Bmatrix} 0.3h \\ 250 \text{ mm} \end{Bmatrix}$, where: h = total depth of beam.

Width of beam ≤ width of supporting column + x

where: x = $min\begin{Bmatrix} \text{least column dimension} \\ 0.75 \text{ maximum column dimension} \end{Bmatrix}$,.

Longitudinal reinforcement for beams:

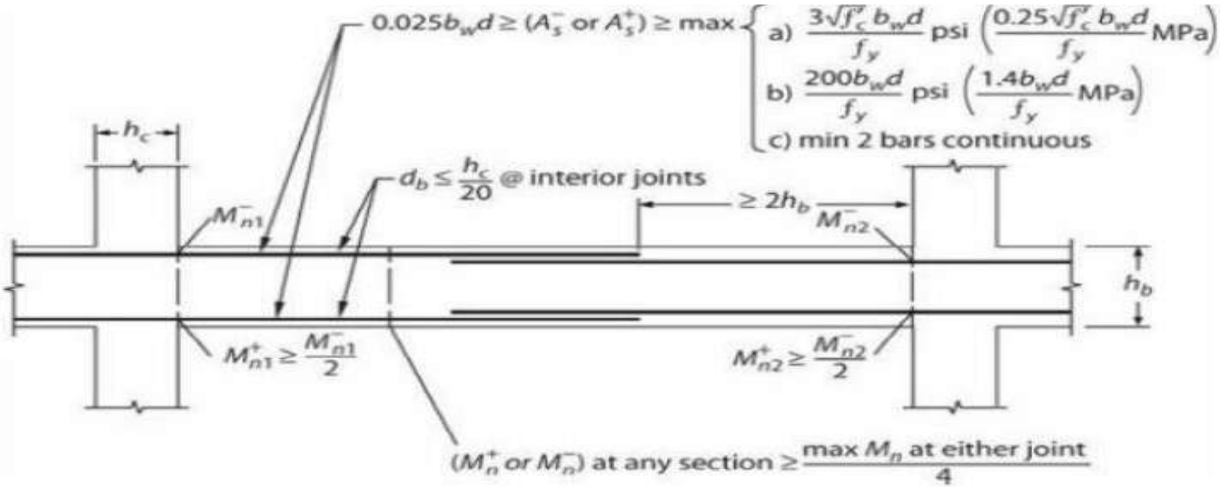


Figure 153 : Longitudinal reinforcement For ACI 318 . (ACI 318 2014)

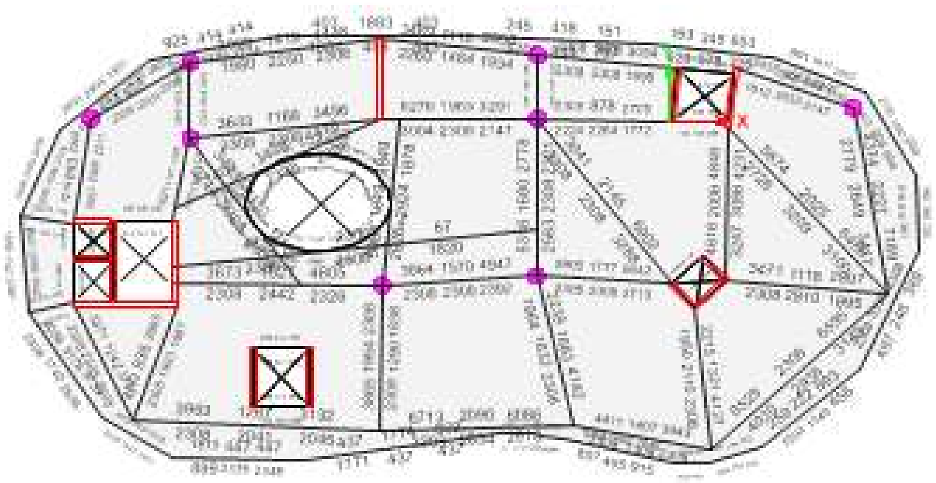


Figure 154 : Longitudinal reinforcement for first floor

ρ_{min}= max $\left[\begin{array}{l} \frac{1.4}{Fy} \\ \frac{0.25\times\sqrt{f'c}}{Fy} \end{array} \right.$

$$\rho = \frac{0.85\ f'c}{Fy} * (1 - \sqrt{1 - \frac{4 * Mu * 10^6}{0.9 * 1.7 * f'c * b * d^2}})$$

$$\rho = \frac{0.85\ (28)}{420} \times (1 - \sqrt{1 - \frac{4 \times 51.68 \times 10^6}{0.9 \times 1.7 \times 28 \times 500 \times 340^2}} = \ 0.00242$$

$A_S = \rho \times$ b×d

Calculation sample :

In order to make a sample account, I take the moment from the ETAPS and find ρ and AS from it..

The following table shows Longitudinal reinforcement for beams.

Table 62 : Longitudinal reinforcement for beams.

	Location	Moment	ƒ	As	As min	As (mm)	# of bars	ø of bars	Spacing (mm)	As used
B1	End-I (-) Moment	526.734	0.0068	2739.72	1350.00	2739.72	9	20	60	2826.00
	Middle (+) Moment	278.49	0.0035	1405.09	1350.00	1405.09	8	16	75	1607.68
	End-J(-) Moment	593.385	0.0077	3113.35	1350.00	3113.35	10	20	50	3140.00
B2	End-I (-) Moment	418.639	0.0053	2148.03	1350.00	2148.03	7	20	85	2198.00
	Middle (+) Moment	107.02	0.0013	529.55	1350.00	1350.00	7	16	90	1406.72
	End-J(-) Moment	418.094	0.0053	2145.09	1350.00	2145.09	7	20	85	2198.00
B3	End-I (-) Moment	137.361	0.0017	681.95	1350.00	1350.00	7	16	90	1406.72
	Middle (+) Moment	54.15	0.0007	266.37	1350.00	1350.00	7	16	90	1406.72
	End-J(-) Moment	172.989	0.0021	862.26	1350.00	1350.00	7	16	90	1406.72

Table NO-1 in Appendix shows the values taken from the ETABs and shows the distribution of the bars and their diameter for all the beams in detail.

Shear design for beams:

Transverse reinforcement:

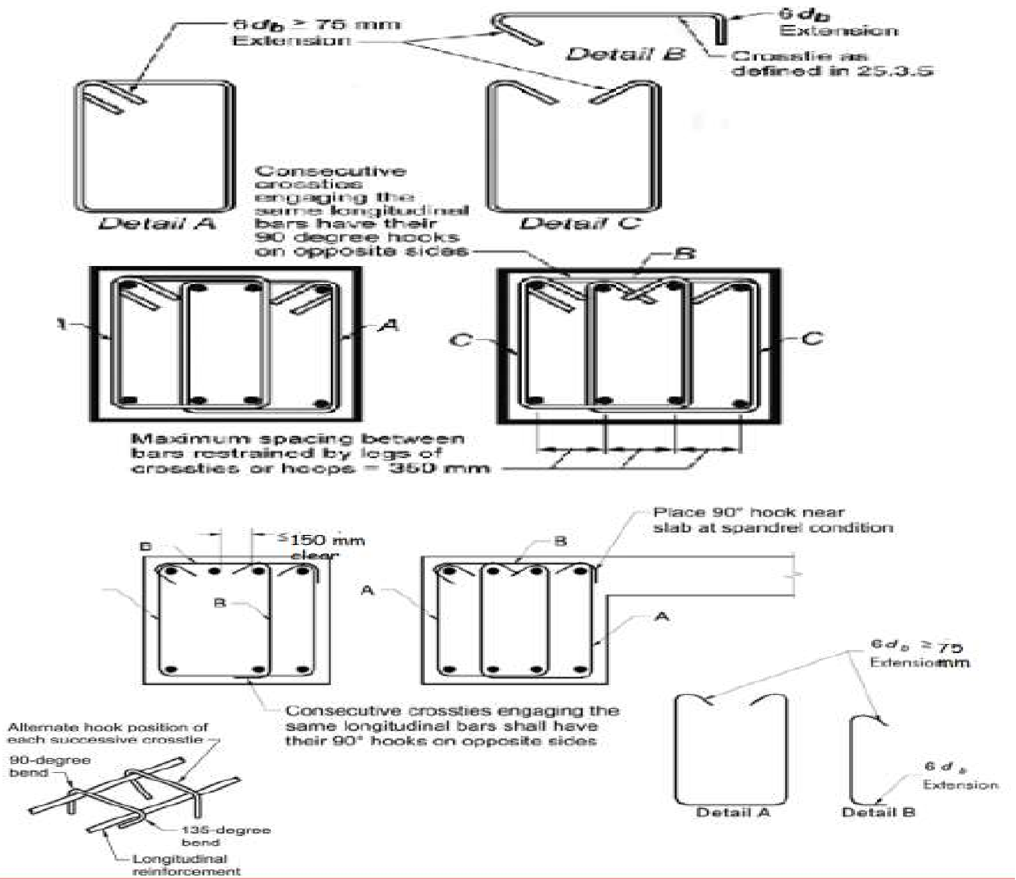


Figure 155: Stirrups dimensions and maximum spacing between bars from ACI-314. (ACI 318 2014)

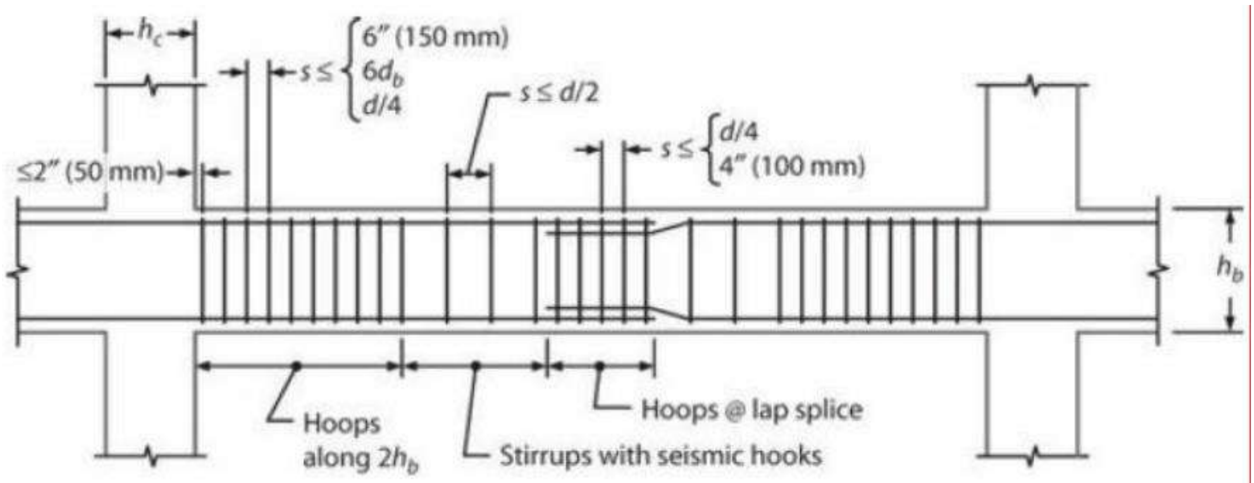


Figure 156 : Transverse reinforcement requirements from ACI-314.(ACI 318 2014)

The above images NO 3-26, 3-27 are taken from the ACI-314 code, illustrating the reinforcement requirements for beam Transverse:

$\frac{Vu}{Ø} = \frac{436.17}{0.75}$ = 581.6 KN

$$Vc = \frac{1}{6} \times \sqrt{28} \times b \times d$$

$$Vc = \frac{1}{6} \times \sqrt{28} \times 750 \times 540 = 357.2\ kN$$

$\frac{Vc}{2}$ = 178.6 kN $< \frac{Vu}{Ø} \rightarrow$ reinforcement is needed.

Vs = $\frac{Vu}{Ø} - Vc$ = 224.4 KN

$\frac{Av}{S} = \frac{Vs}{d \times Fy} = \frac{224.4 \times 10^3}{540 \times 420}$ = 0.98

$(\frac{Av}{S})_{min} = \frac{\rho_{min} \times b}{4} = \frac{0.0033 \times 750}{4} = 0.625\ mm^2/mm$

Use $\frac{Av}{S}$ → assume Ø10 stirrups will be used – Av = 157 then S= 159 mm

S_{max} (side) = $Min \begin{Bmatrix} 150\ mm \\ 6d_b \\ d/4 \end{Bmatrix}$

S (middle) = d/2 → 540/2 = 270 mm

To see a table showing each Transverse side reinforcement for beams, go to Table No. 2 in the Appendix.

Detailing :

A general longitudinal section of the beam , one span, showing the details. To see a full detail, go to the Appendix file.

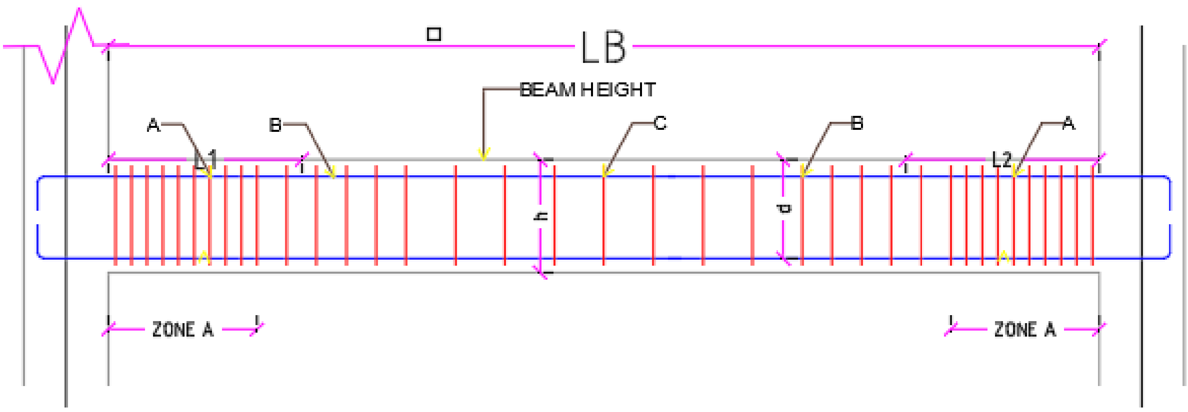


Figure 157: general longitudinal section of the beam from CAD.

3.3 2.3 Columns design

The columns are designed based on seismic and gravity loads according to ACI318-14 Code, All necessary reinforced steel calculations were taken from Etabs16. We will take four columns in different places and unify on their basis the detailing for the rest of the columns.

Longitudinal and transverse reinforcement for seismic requirements:

1. Rebar percentage ρ between 1% and 6%.
2. Lap splice of bars shall be used at the middle height of the column with lap splice length, and shall be designed as tension lap splices and enclosed within transverse reinforcement conforming to the following section.
3. Lap splice equals 50 db

Figure 158 : Longitudinal and transverse reinforcement for seismic requirements from ACI-314.

All columns are the same dimensions:

- Diameter = 700mm
- As = 6362 mm2 from ETABS

To find the number of bars with suitable spacing and suitable number of ties:

- D= 600 mm, cover = 80 mm, maximum spacing allowed between bars is 150 mm
- Use Ø20 → #of bars = 20
- 20Ø20

Transverse reinforcement

Transverse reinforcement (ends of columns), crossties shall be used as shown in the table below:

Table 63 : Column Reinforcement

Name	dimensions (mm)	As, ETABS	No of Bars	diameter Bars Ø	stirrups spacing (cm)		
					stirrups diameter	ZoneA&C	Zone B
C1	700	5027	16	20	2Ø10	12.5	25
C2	700	8797	18	25	2Ø10	12.5	25
C3	700	11420	14	32	2Ø10	12.5	25
C4	700	6362	20	20	2Ø10	12.5	25

In order to facilitate the construction process, we unified the iron on the entire column in all floors.

Detailing requirement :

Maximum spacing between ties was distributed according to these equations:

$$s_0 = \text{Min}\begin{Bmatrix} \text{least column dimension}/4 \\ 6d_b \\ 100 + (350 - h_x)/3 \\ 150 \text{ mm} \end{Bmatrix} \geq 100 \text{ mm}$$

$$s_1 = \text{Min}\begin{Bmatrix} \text{least column dimension} \\ 6d_b \\ 48d_s \\ 150 \text{ mm} \end{Bmatrix}$$

Where:

h_x = maximum horizontal spacing of crossties.

Development length and Lap splice of bars shall be used at mid-height of the column:

l_d = development length of the steel reinforcement in tension

$$l_0 = Max\begin{Bmatrix} \text{clear height of column}/6 \\ \text{maximum column dimension} \\ 450 \text{ mm} \end{Bmatrix}$$

$l_s = 1.3\, l_d$

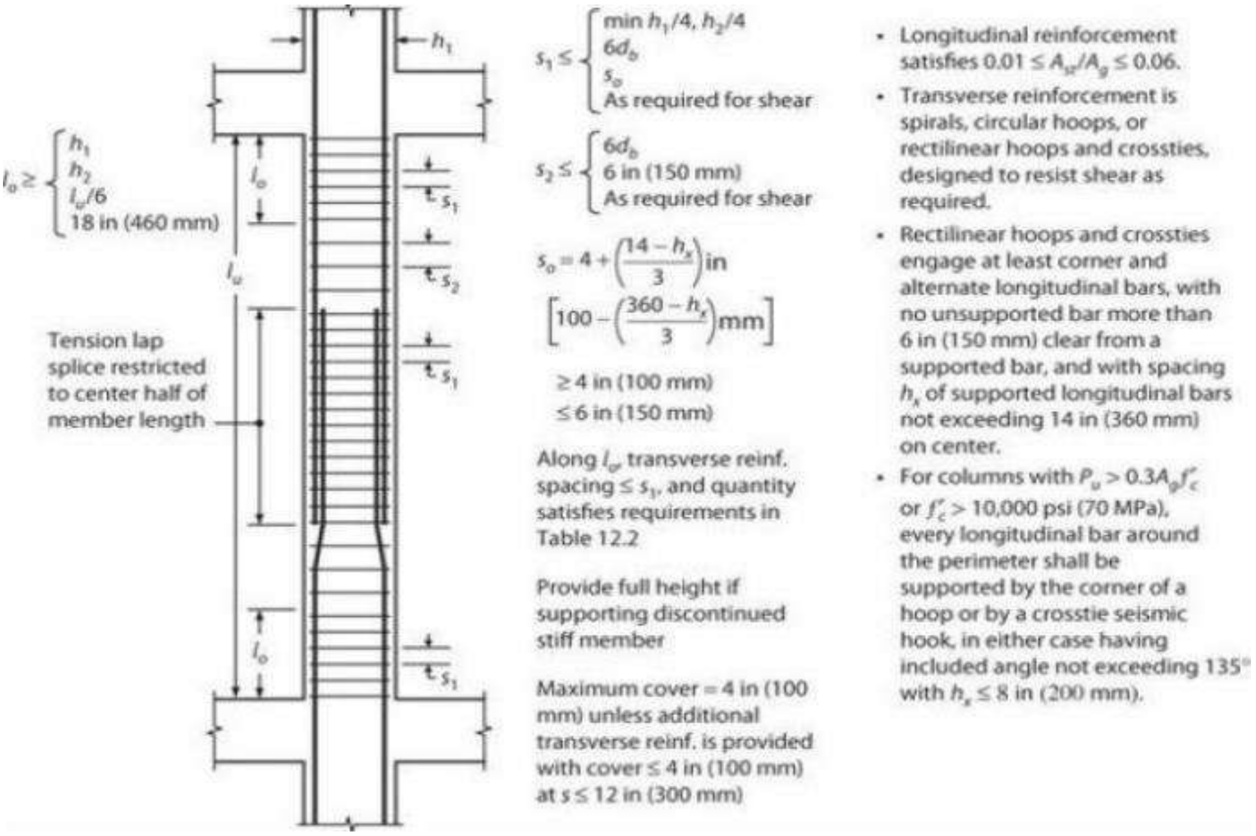


Figure 159 : Transverse reinforcement Columns from ACI-314. (ACI 318 2014)

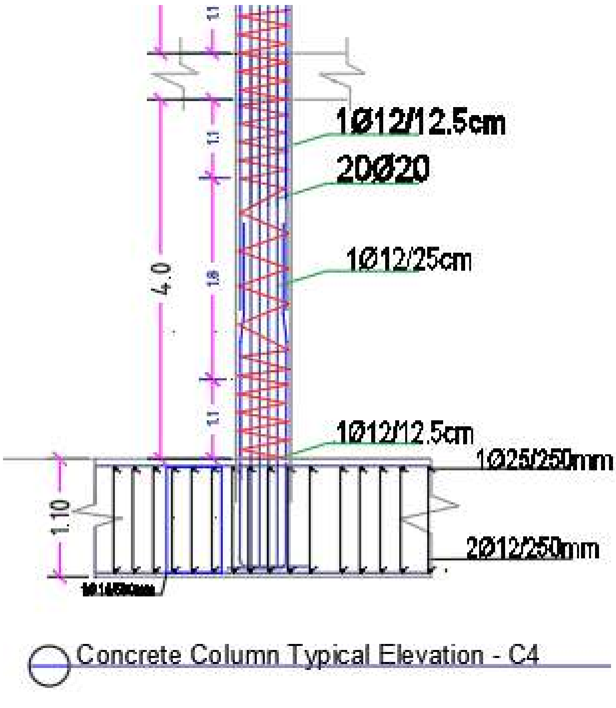


Figure 160 : Concrete Column Typical Elevation - C4.

3.3.2.4 Shear wall design

The shear wall will be designed from ETABS for web and for seismic requirements the boundary design will be computed by this equation:

The web reinforcement from ETABS in the longitudinal direction, this for two faces thus mean this value should be divided by half.

Sample of calculation:

The thickness of the shear wall $max \begin{cases} 15 \text{ cm} \\ \frac{H\ level}{20} \end{cases} = \begin{cases} 15 \text{ cm} \\ \frac{400}{20} = 20\ cm \end{cases}$ = 17.5 cm

$Take\ thickness\ of\ shear\ wall = 30cm$

The web reinforcement from ETABS is 35556 mm^2 in the longitudinal direction, this for two faces thus mean this value should be divided by half.

Thickness (b) = 300 mm

Length (h) = 4 m

34956/2 = 17478mm^2 in each face.

17250/4= 4370 mm^2/m in each face.

Use Ø25 → 9 bar/m

The boundary reinforcement:

H = min $\begin{cases} 0.1 * 4000 \\ 4 * 300 \end{cases}$ → H = 400 mm

$A_{S-\text{boundary}} = 1\% * 400 * 400$ =1600 mm^2

Use Ø20→ 6 bars

Transverse reinforcement:

This value will be taken from ETABS which is 1288 mm^2/m, use Ø20 → 5Ø20@1m.

The following table shows reinforcement details for shear wall

Table 64 : Reinforcement for shear walls

Shear wall No.	h	b	H	Vertical reinforcement								Horizontal reinforcement			
				Web				Boundary							
				Area of steel (mm2/m)	Ø	#	spacing	Area of steel (mm2)	Ø	#	spacing	Area of steel (mm2/m)	Ø	#	spacing
SW1	4000	300	400	4370	25	9	72	1200	18	5	325	1288	20	3	220
SW2	4000	350	400	5240	32	7	90	1400	18	6	325	1775	20	6	117
SW3	4000	300	400	2006	20	7	100	1200	18	5	325	1250	18	5	142
SW4	4000	300	400	1213	18	5	142	1200	18	5	325	2500	20	8	87
SW5	4000	350	400	3340	25	7	96	1400	18	6	325	1000	18	4	174
SW6	4000	300	400	2900	25	6	113	1200	18	5	325	937	18	4	174
SW7	4000	300	400	1750	20	6	117	1200	18	5	325	2260	20	8	87
SW8	4000	300	400	2160	20	7	100	1200	18	5	325	2900	25	6	113
SW9	4000	250	400	2370	20	8	87	1000	18	4	326	910	18	4	174
SW10	4000	250	400	1230	18	5	142	1000	18	4	326	1750	20	6	117
SW11	4000	250	400	1711	20	6	117	1000	18	4	326	843	18	4	174
SW12	4000	250	400	937	18	4	174	1000	18	4	326	760	18	3	222
SW13	4000	300	400	2200	20	8	87	1200	18	5	325	1700	20	6	117

Detailing :

The following figure show the detailing details of the ACI Sheer Wall

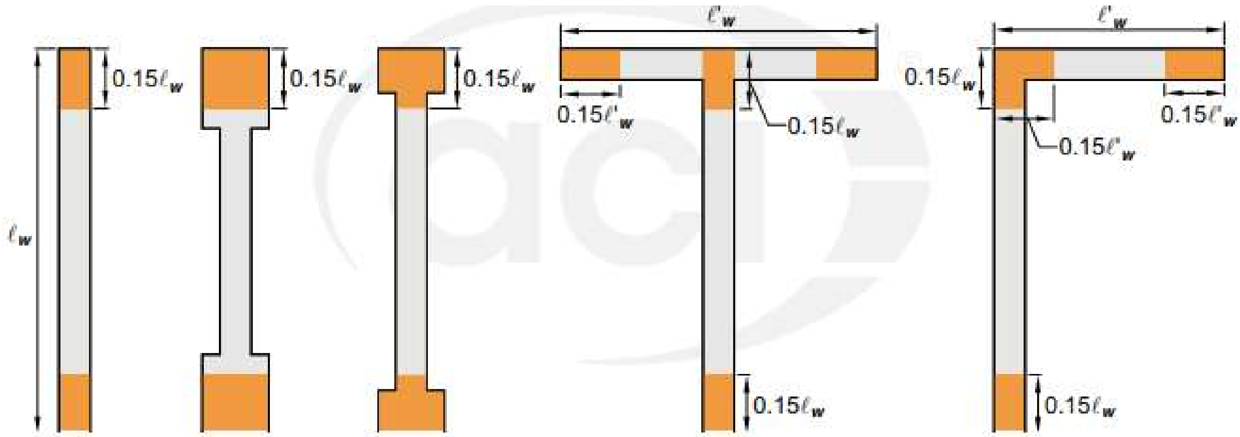


Figure 161: location of longitudinal .(ACI 318 2014)

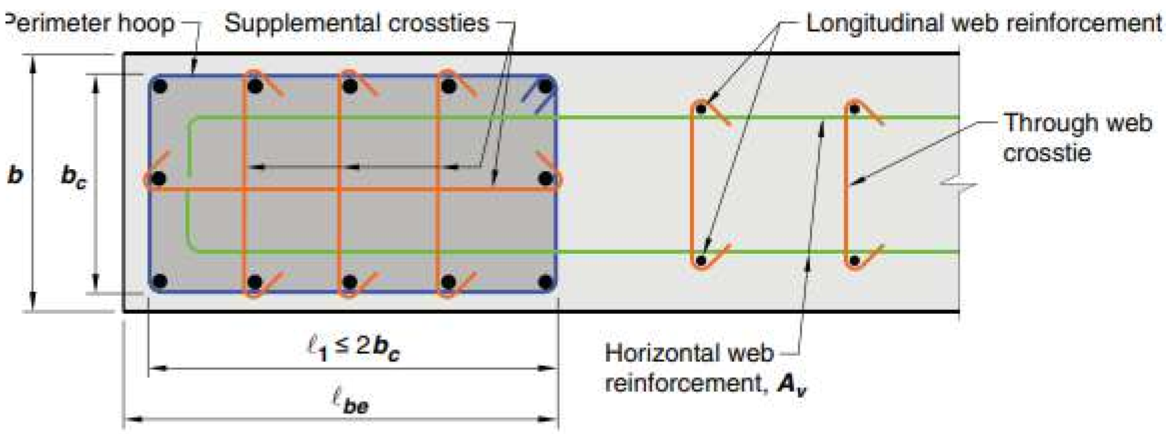


Figure 162 : detailing for shear wall . (ACI 318 2014)

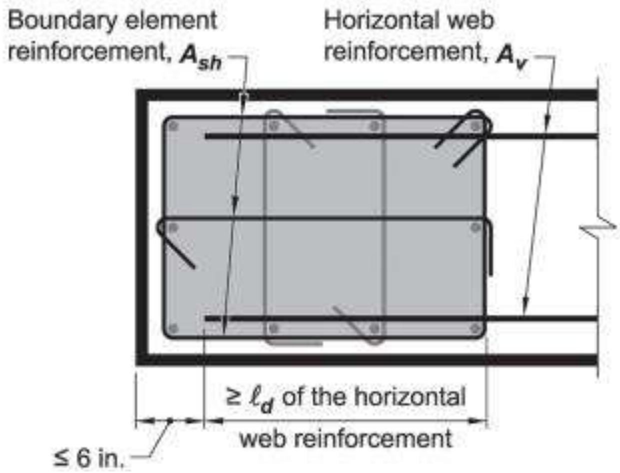


Figure 163: detailing for shear wall (ACI 318 2014)

3.3.2.5 Foundations:

Mat footing : It is footing contains three columns or more. Here we have 16 columns to design a mat footing

A mat footing. allowable bearing capacity of soil = 220 kN/m2.

Thickness of 1000mm.

Top cover for the foundation=70 mm

Bottom cover for the foundation= 70 mm

1- soil pressure check

The soil pressure of the ETAPS is displayed as shown in the following picture, and its value must be less than 220 KN. The highest value of the safe = 63.9KN

Figure 164 : soil pressure check from safe

2-Punching shear check for the footing:

As shown in the following figure, the punching shear ratio is < 1, except two the punching shear ratio is .127 > 1 and .1.02 > 1

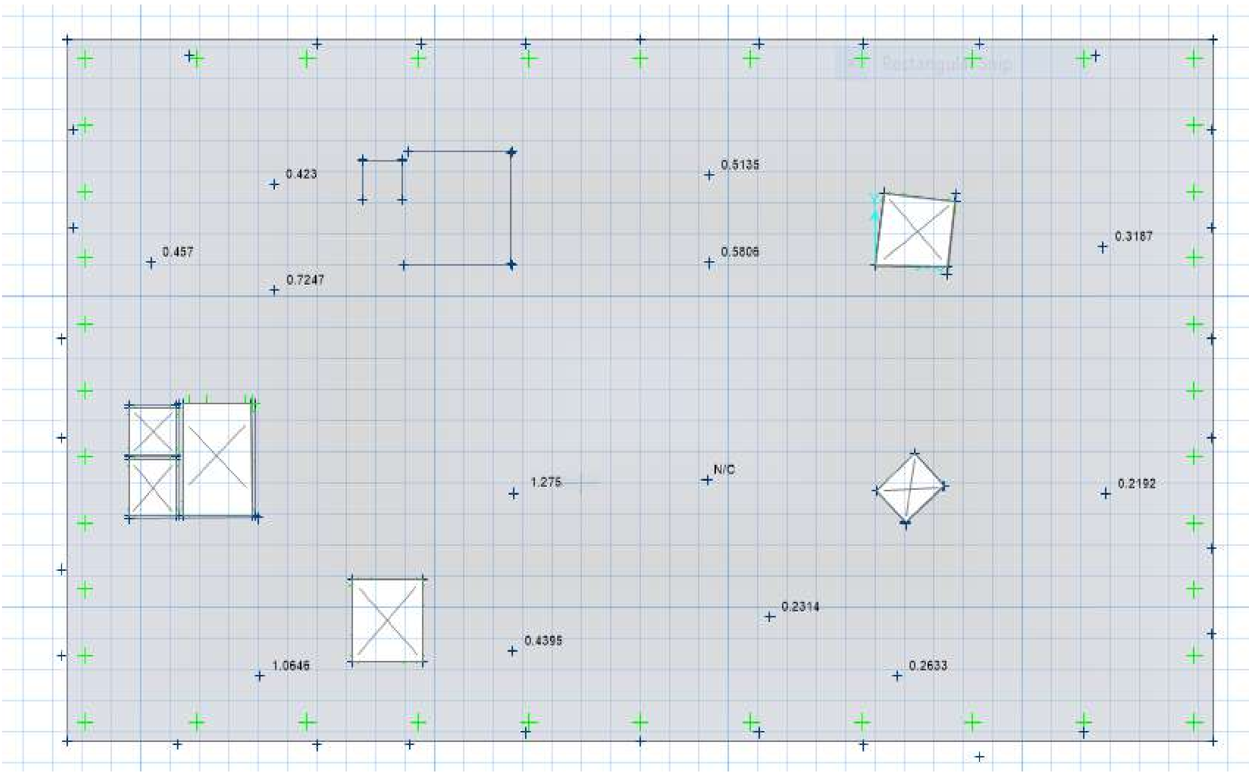


Figure 165: Punching shear check for footing

As shown there is value were above the limit, so In areas where there are high shear forces in the columns, we strengthen them through. In addition to the enhanced HDB-Z Z-shaped reinforcement, the resulting shear crack is crossed several times. In this way, the borders of the opposing slits are effectively held together. As a result, the resistance in the structural elements increases significantly compared to conventional solutions.

Figure 166 : optimized Z-shaped HDB-Z reinforcement.

3- Check wide beam shear:

$ØVc = \frac{0.75}{6} x \sqrt{fc}\ 2x\ b\ d = \frac{0.75}{6}\ x\ \sqrt{28}\ 2x\ 1000\ x\ 1000 = 687.9\ KN/m$

If the Maximum shear from ETABs is less than 687.9 KN/m, then the check is OK.

Reinforcement

The reinforcement will be taken from SAFE2016. All zones above the minimum reinforcement will be increased by the amount of steel rebar from SAFE software.

Am_{in} = 0.0018*b*h = 0.0018*1000*1000 = 1800mm^2/m → 6Ø25/m

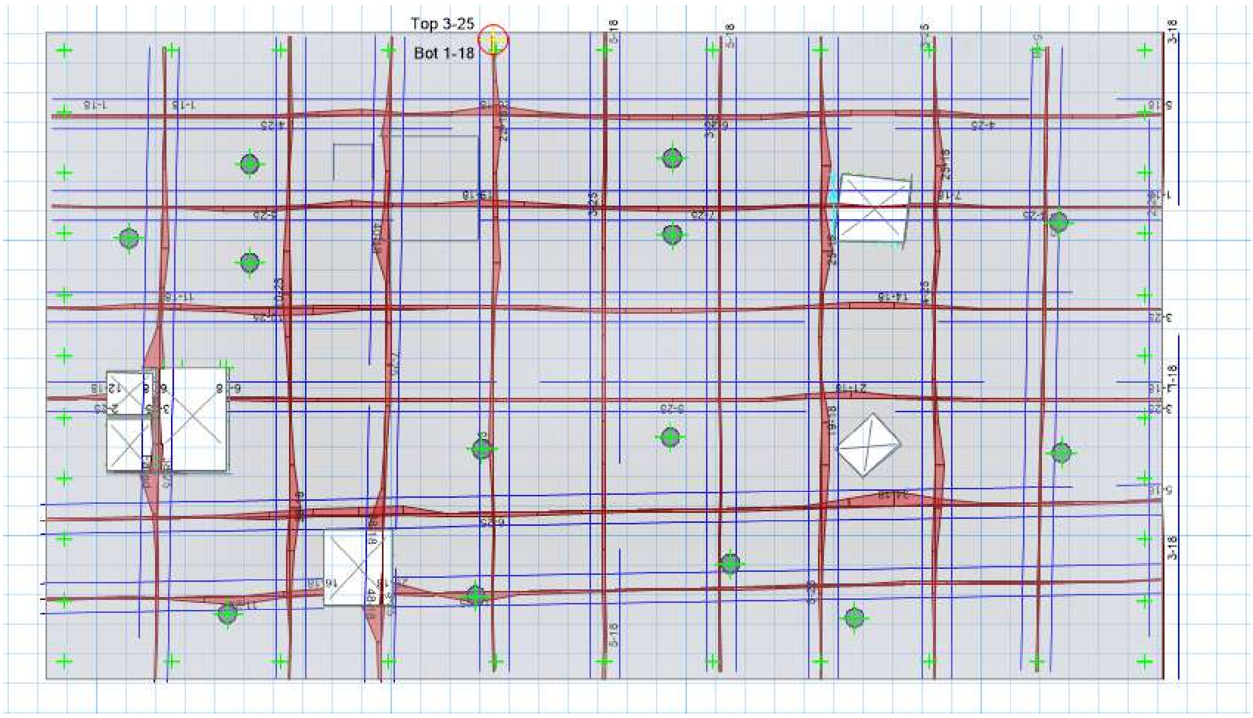


Figure 167 : ENV r Reinforcement from SAFE.

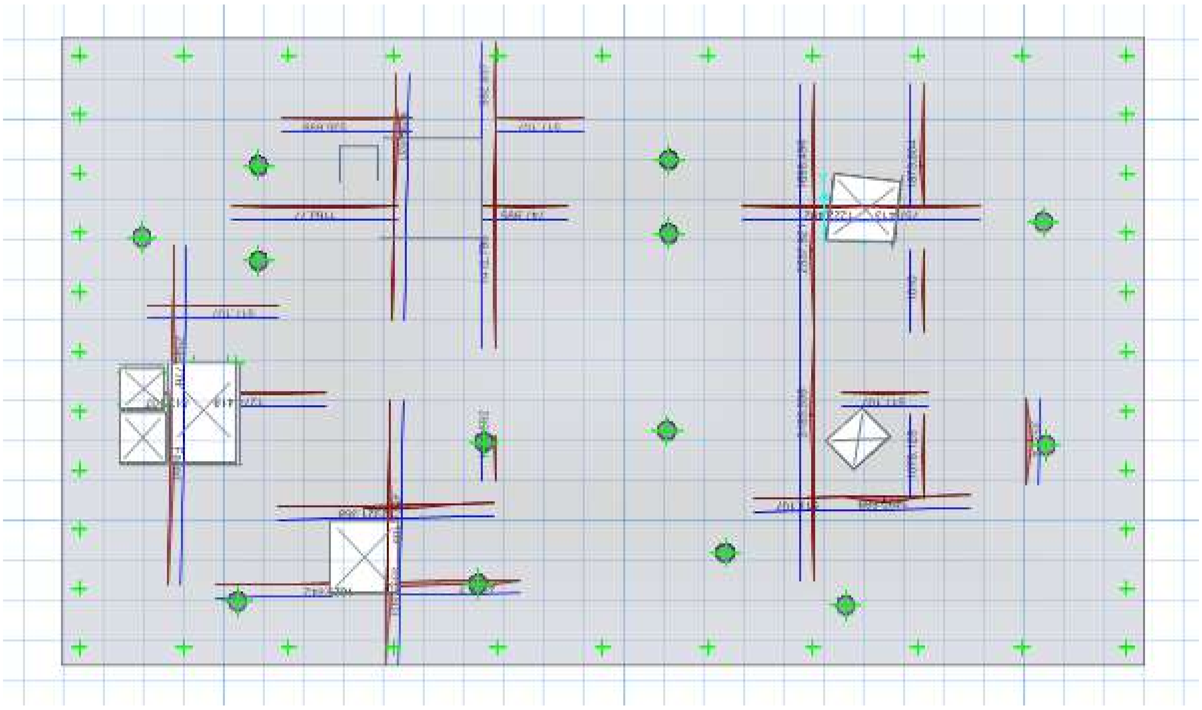


Figure 3-168 : shear Reinforcement from SAFE

Reinforcement Top rebar:

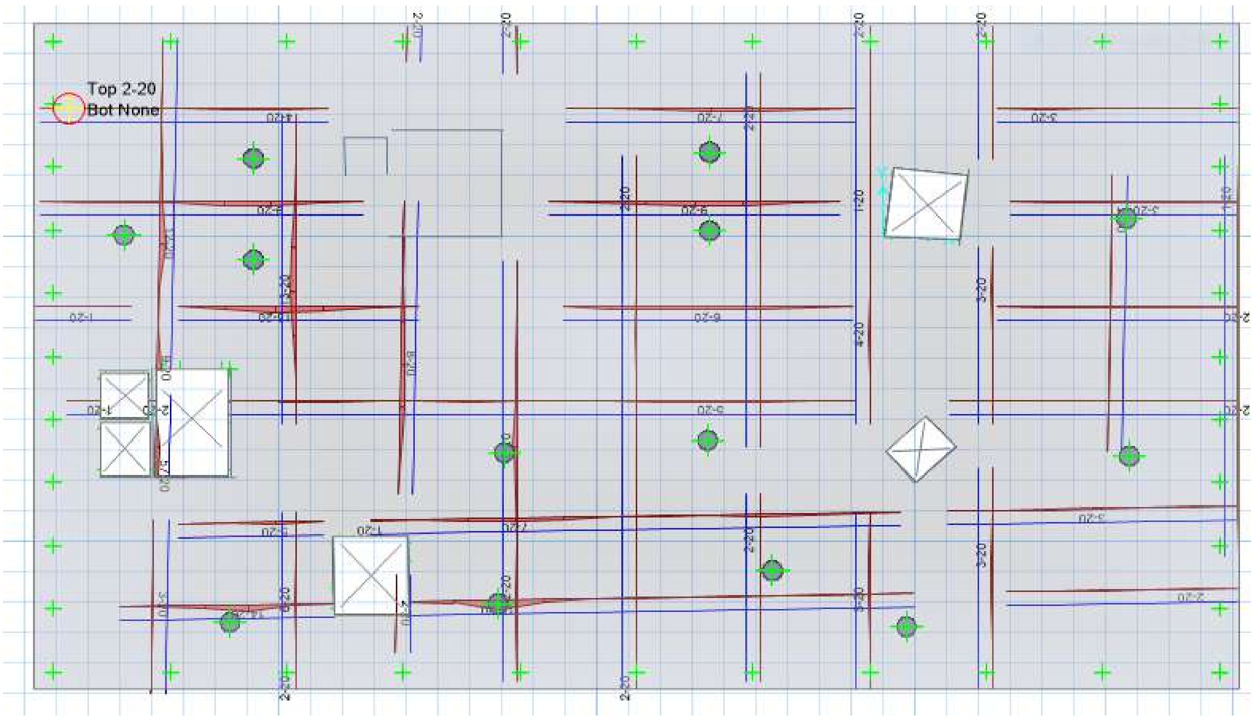


Figure 169: Top rebar in SAFE

Reinforcement Bottom rebar :

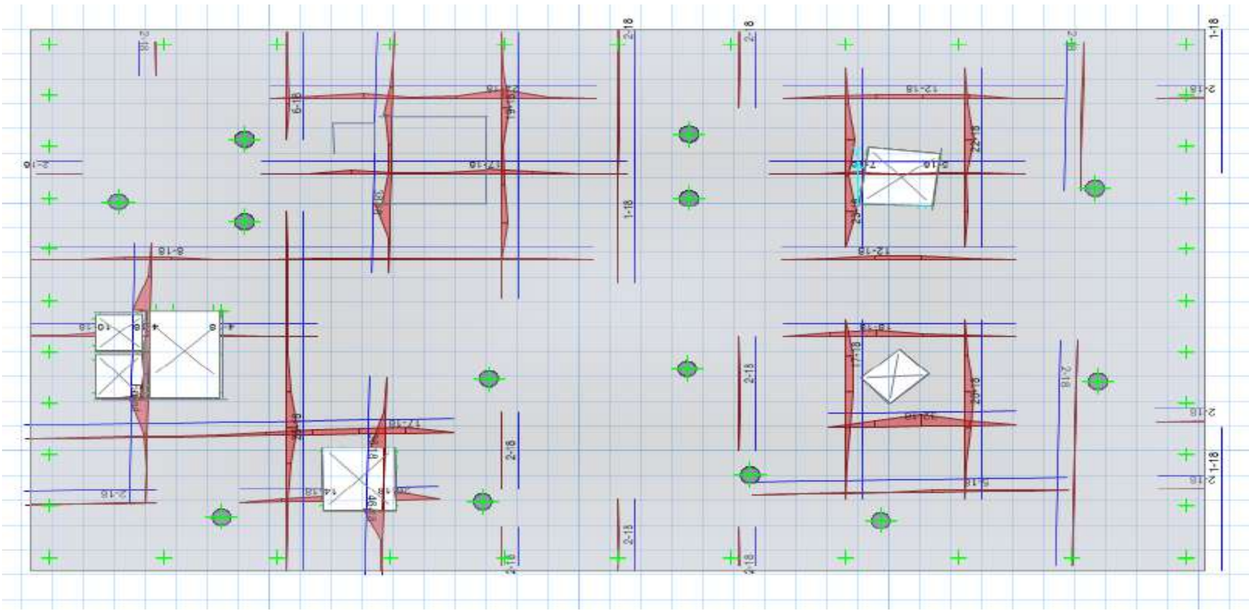


Figure 170: Bottom rebar in SAFE.

3.3.2.6 Design of stairs:

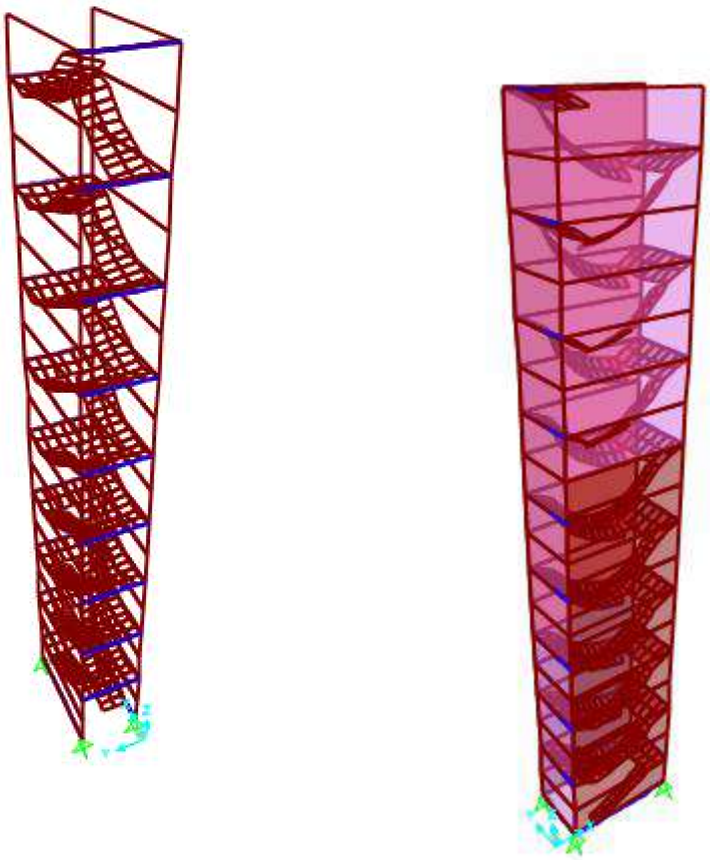


Figure 171 : model for stairs from SAP .

Loads on stairs:

The following assumptions are used for the design of stairs

Live load = 5 KN/m2

Super imposed dead load = 4 KN/ m2

Use slab thickness 20 cm, the Dead load = 0.2 x 25 = 3.75 KN/ m2

Design of stair span:

After adjusting Local Excel directions, we displayed Moment 11, and from it we distributed the upper and lower bars.

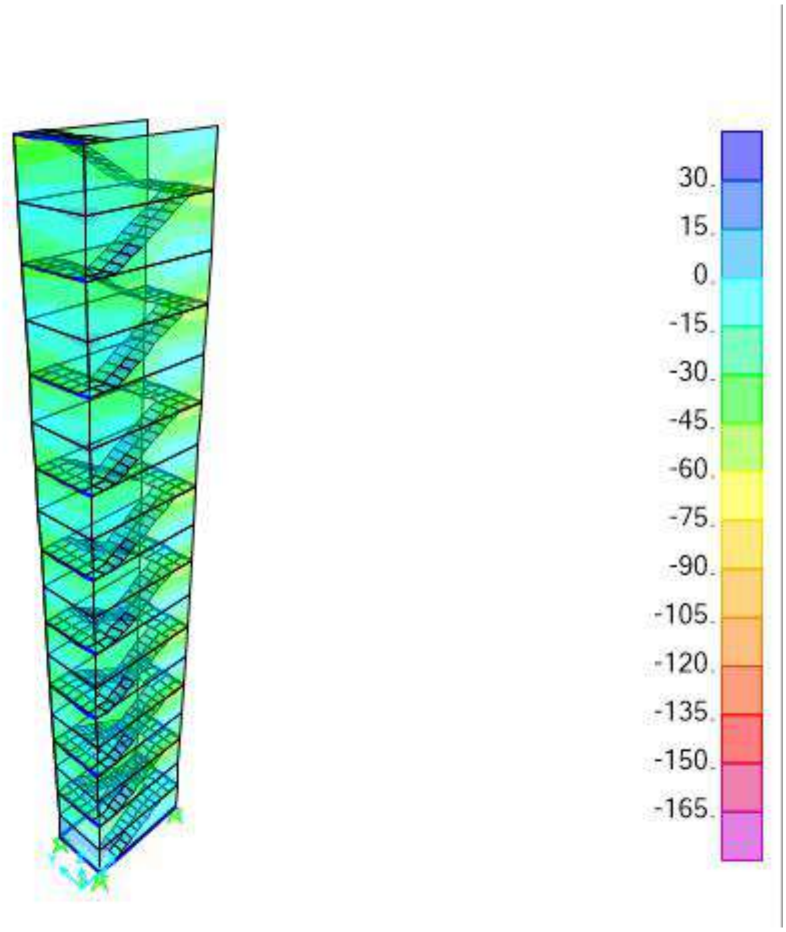


Figure 172 : Moment11 in the stairs

Sample Calculation

Concrete olm :

Ts =$\frac{span}{25}$ =$\frac{5750}{25}$ = 240 mm

Tsa= 240+70 =310 mm

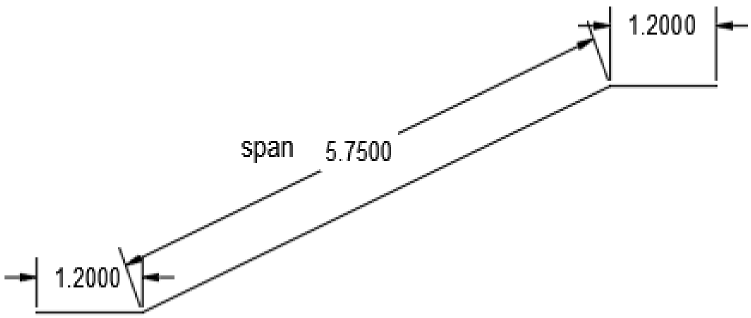


Figure 173 : stair

Load calculation by hand

Msu = 1.4 (ts*γe+Fc)+1.6 (L.L)

= 1.4(.24*25+1.5)+1.6*5= 15.3 KN/m

Wu =1.4*(.3*25+1.5)+1.6*5*cos(26.57) = 17.75

Take strip

∑ M =0

18.36*.6+59.46*2.7+18.36*4.8=R*5.4

Rb=48.1KN

Mu=69 KN

D=220=c*$\sqrt{\frac{69*10^6}{25*1000}}$ c=4.19 J=0.813

As = $\frac{Mu*10}{Fy*J*d}$ = 1077.6 mm^2 →7Ø14/m

Table 65: Reinforcement for slab stair from sap

staircase design						
Mu(KN.m)	ʄ	As	As min	As (mm)	# of bars	ø of bars
65.00	0.0056	1003	600.00	1003	7	14

Showed the moment from the back towards the Y to get the Transverse reinforcement

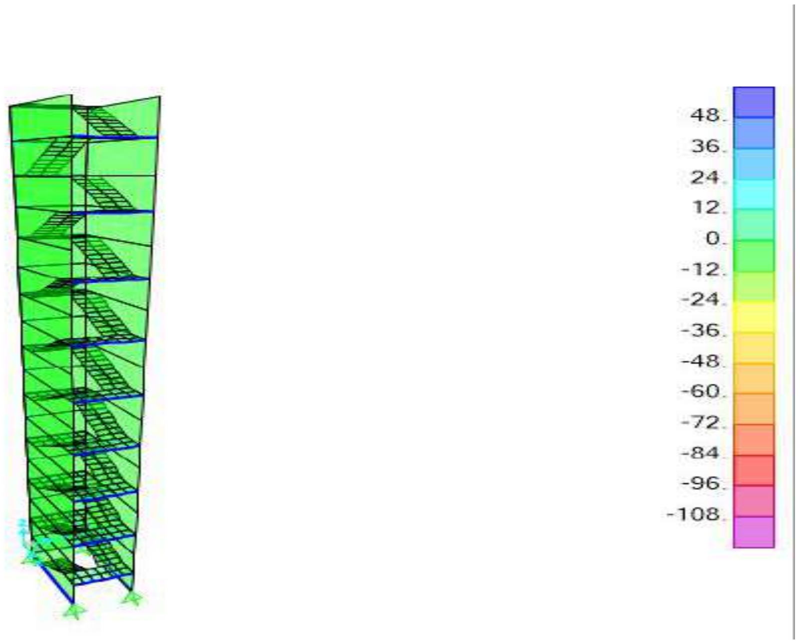


Figure 174: Moment22 the stairs for sap

The following table shows Transverse reinforcement in the stairs for sap

Table 66 : Transverse reinforcement in the stairs for sap

Transverse reinforcement: in the stairs							
	Mu(KN.m)	ʄ	As	As min	As (mm)	# of bars	ø of bars
TOP	65	0.0056	1003	600	1003	7	14
BOT	30	0.0025	450	600	600	6	12

Table 67 : reinforcement in the stairs for sap

reinforcement in the stair							
	Mu(KN.m)	ʄ	As	As min	As (mm)	# of bars	ø of bars
TOP	56	0.0048	858	600	858	2	14
BOT	55	0.0047	842	600	842	2	14

3.3.2.7 Ramp design :

Loads:

Live load = 7 KN/m2

SID = 1 KN/m2

Thickness = 20 cm

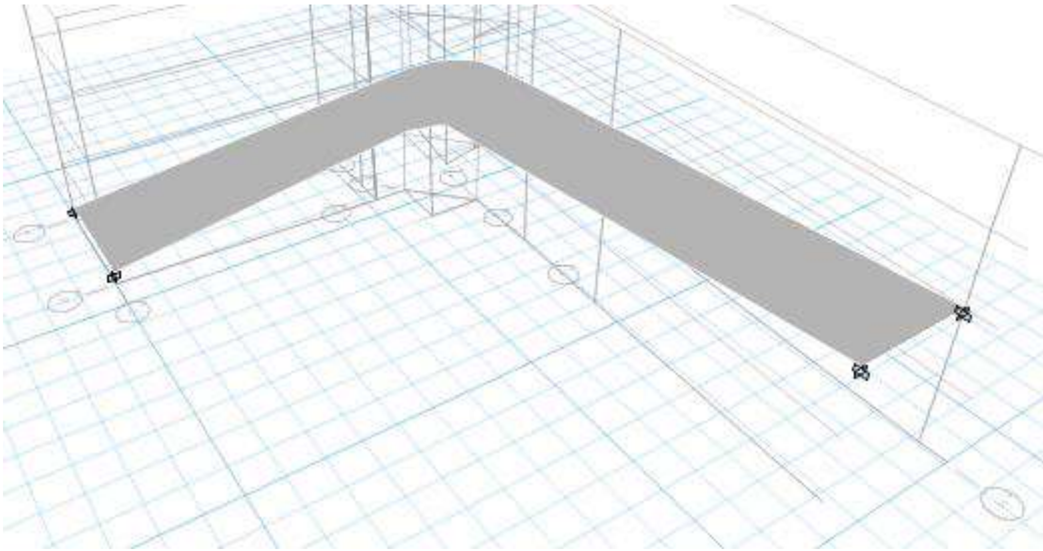


Figure 175 : model for ramp from sap.

Check shear for ramp:

ØVc $=\frac{0.75}{6} * \sqrt{28} * 1000 * 200 * 10-3 = 112.4\ KN/m$

Max Vu = 63.5 KN from ETABs, ØVc > Vu, it means no need reinforced for a shear then is OK

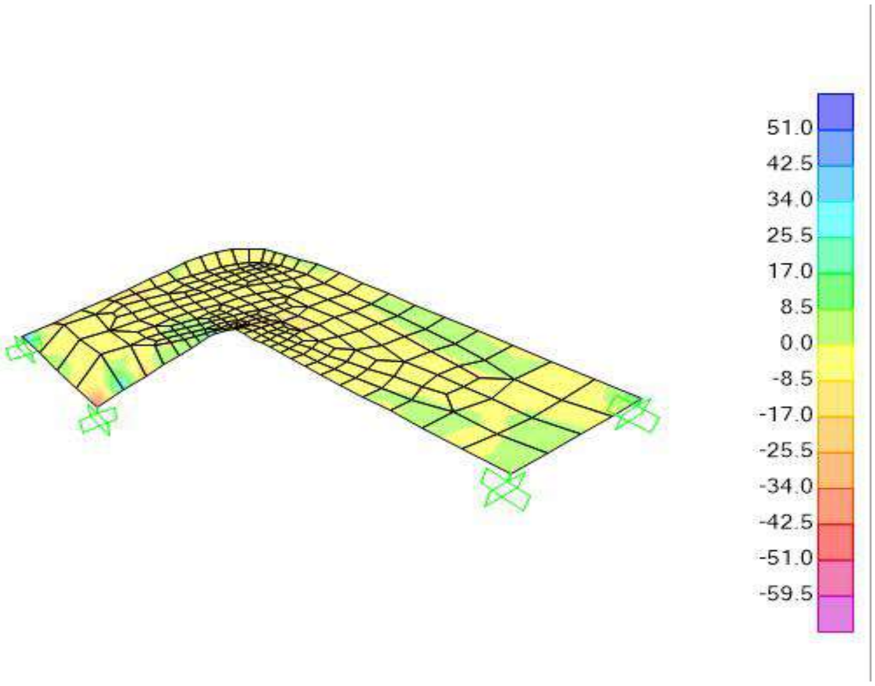


Figure 176 : Shear for the ramp

offer the Moment from Sap to get the reinforcement

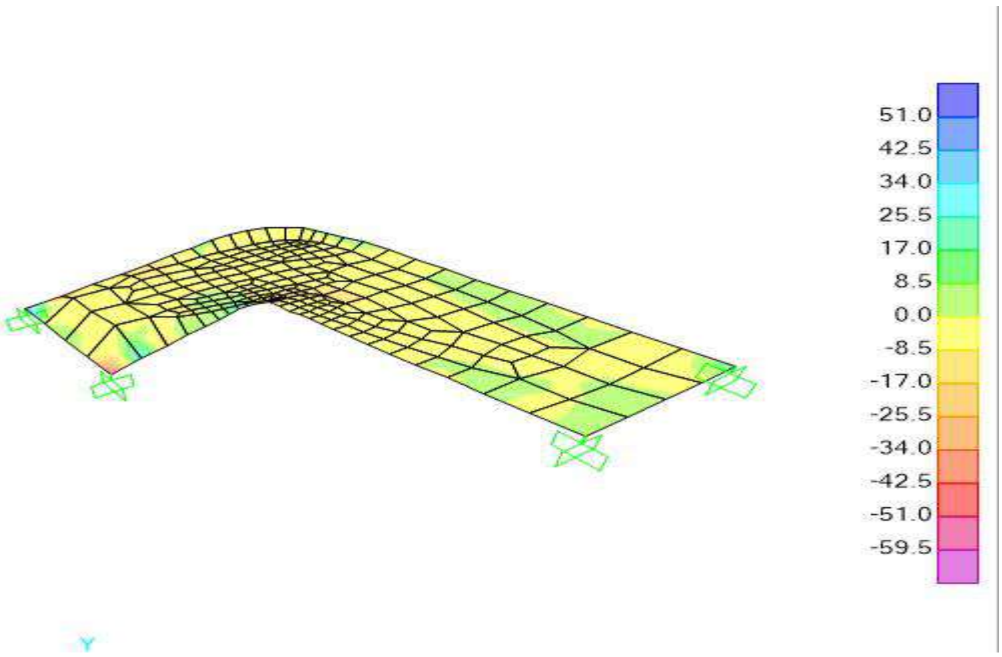


Figure 177 : M11 results in sap

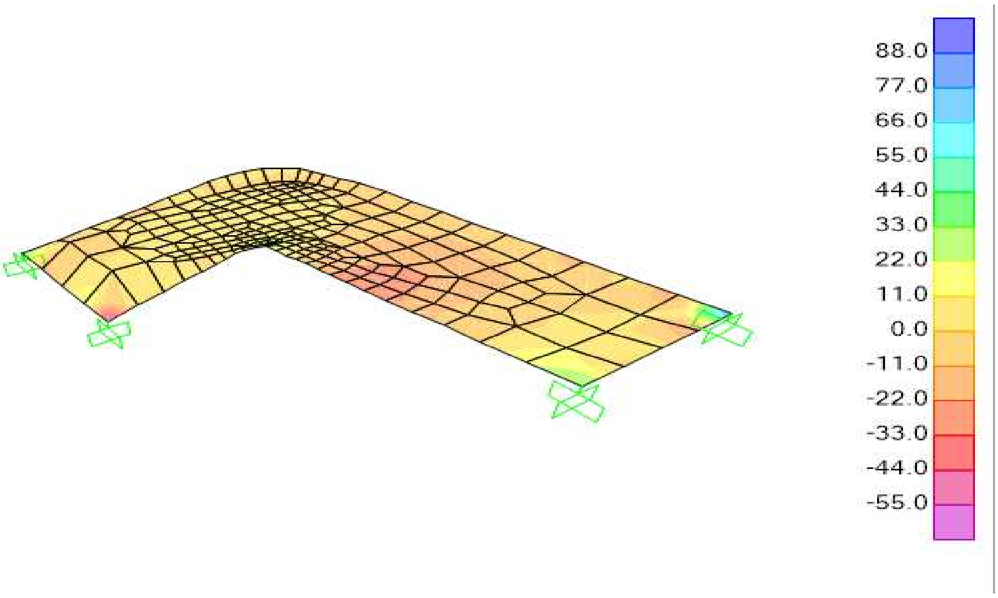


Figure 178: M11 results in sap

Distribution of the reinforcement pars according to the minimum moment and the increase in the areas in need. The following table shows reinforcement for ramp .

Table 68 : reinforcement for ramp .

	reinforcement in the ramp						
	Mu(KN.m)	ꝭ	As	As min	As (mm)	# of bars	ø of bars
TOP	56.00	0.0048	858	600.00	858	2	14
BOT	55.00	0.0047	842	600.00	842	2	14

3.3.2.8 Design of water tank

Designed one of them, and other water tank firefighting is designed based on the first water tank.

Design Water tank for daily use.

To calculate the volume and dimensions of the water tank at the beginning, calculated the volume of water inside the tank based on the following assumptions:

1.Number of people includes employees=50 and visitors = 270 peoples.

2. A employee consumption per day = 15 liters,

3. Number of days of storage = 4 days

The volume of water inside the tank = 50*15*4+270*5*4 =8400 liter/ 1000 = 8.4 m3

The volume of rainwater collected in the tank = 200 m3

According previous calculations, water tank will take a rectangular shape with supporting roof.

Dimensions: Base has an exterior dimension of 10*5*1.1m

Roof has a 4*5*0.5m, walls have a thickness of 0.3

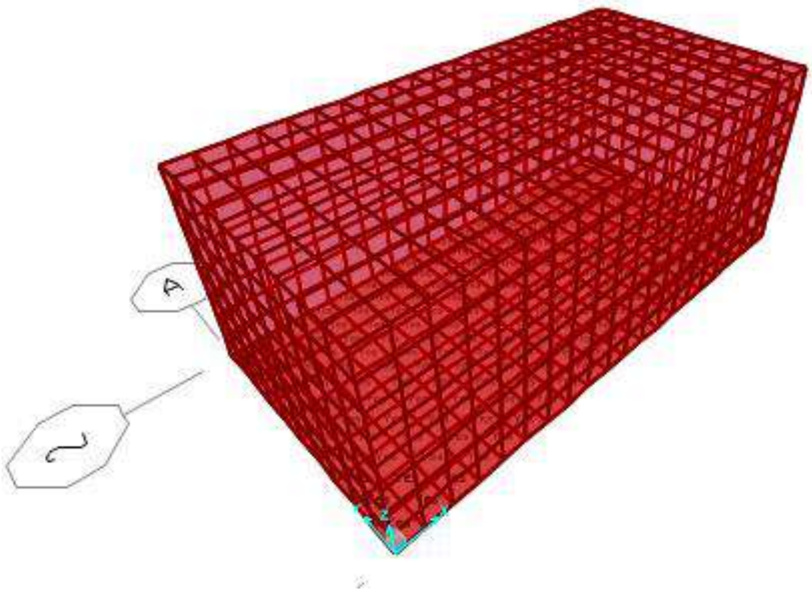


Figure 179 : 3D model in SAB

This tank will be underground thus, it has two cases of Loading the first one is to be full liquid without soil exposed, and the second case is to be empty Case with soil exposed.

Design steps:

L/H = $\frac{10}{4}$= 2.5< 4 Two-way model.

The critical case of tank will be designed based on soil stresses.

Empty with backfilled.

1. Vertical direction:

Vv = 0.35*ɣ*h ^{2} = 0.35* 10*4 ^{2}= 56 KN/m.(bottom)

Mv = ɣ * $\frac{h^2}{20}$= 10* $\frac{4^2}{20}$= 80 KN.m /m.

2. Horizontal direction:

Th = Vh = ɣ * $\frac{h^2}{8}$ =20 KN/m.

M h = ɣ * $\frac{h^3}{32}$= 20 KN.m/m.

Determine the Thickness of Walls:

Vv(ult) = 1.4*56= 28 KN/m

78.4= 0.75*$\frac{1}{6}$ * $\sqrt{28}$ * d

d= 118.52 mm use d=220 m.

the minimum thickness can be used is 250 mm ,Use h=250mm.

The same strategy to calculate thickness due to Vh

d=42.3mm but the minimum thickness can be used is 250mm

Take h=250mm and d= 190mm

Tension force in Walls:

Th =20KN

Tu =1.4*20= 28 KN/m.

Normal conditions ➔ f_{smax} = 138 MPa

$$S_d = \frac{\emptyset F_y}{\gamma f_{smax}} = \frac{0.9 \times 420}{1.4 \times 138} = 1.956$$

$$T_{udesign} = 1.956 \times 28 = 54.6 \frac{kN}{m}$$

$$A_s = \frac{T_{udesign}}{\emptyset F_y} = \frac{54.6 \times 1000}{0.9 \times 420} = 144 \frac{mm^2}{m}$$

Check thickness for tension

$\frac{T+CE_sA_s}{A_g+nA_s} \leq \frac{1}{3}\sqrt{f_c'}$ $= \frac{20*1000+60*144}{250000+8.04*144} \leq \frac{1}{3}\sqrt{28}$ =0.12 $Mpa \leq$ 1.76 Mpa So, thickness is ok.

Moment calculations:

1. Vertical moment

Mv = 80 KN.m/m

Mv (ult) = 1.4*20 =112 KN.m/m.

210 from normal exposure figure two way

$$S_d = \frac{\emptyset F_y}{\gamma f_{smax}} = \frac{0.9 \times 420}{1.4 \times 210} = 1.28$$

$M_{udesign}$ =Ψ*Sd*Mu

$$M_{udesign} = 1.06 \times 1.28 \times 112 = 151.9 \frac{kN.m}{m}$$

$$\rho = \frac{0.85 \times 28}{420}\left(1 - \sqrt{1 - \frac{2.61 \times 10^6 \times 151.9}{28 \times 1000 \times 190^2}}\right) = 0.0125$$

ρ= 0.0125> ρ min thus; use ρ.

$$A_s = 0.0125 \times 1000 \times 250 = 2373\ mm^2/m$$

Vertical Reinforcement (on the outside surface)

$$M_u = 1.4 \times 153.6 = 215\ kN.m/m$$

2. Horizontal moment

Mv = 20 KN.m/m

Mv (ult) = 1.4*20 =28 KN.m/m.

210 from normal exposure figure two way

$$S_d = \frac{\emptyset F_y}{\gamma f_{smax}} = \frac{0.9 \times 420}{1.4 \times 210} = 1.28$$

$M_{udesign}$ =Ψ*Sd*Mu

$$M_{udesign} = 1.06 \times 1.28 \times 28 = 37.9 \frac{kN.m}{m}$$

$$\rho = \frac{0.85 \times 28}{420}\left(1 - \sqrt{1 - \frac{2.61 \times 10^6 \times 37.9}{28 \times 1000 \times 190^2}}\right) = 0.0028$$

ρ= 0.0028< ρ min thus; use ρ min.

$$A_s = 0.003 \times 1000 \times 250 = 833.3\ mm^2/m$$

Use As min (V) for exterior face = 0.005/2*b*h 0.005/2*1000*250=625m2 /m. use 4 ϕ 14/m

As min(horizontal) = 0.003/2*1000*250 = 475mm2 /m. Use 4 ϕ 12/m

Water tank Checks:

1-Compatability check:

That model is compatible, all elements are moved as one element

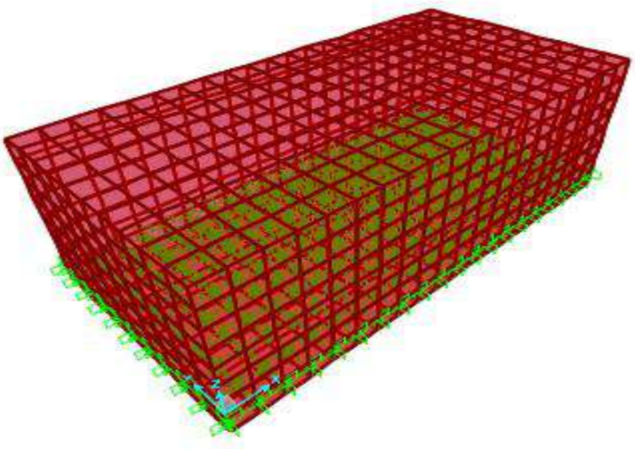


Figure 180 : Compatibility check for water tank

2-Deflection check:

The maximum deflection from water pressure.

= 5/240= 0.020 m.

Maximum allowable deflection from etabs = 0.001 < 0.02

So check is OK

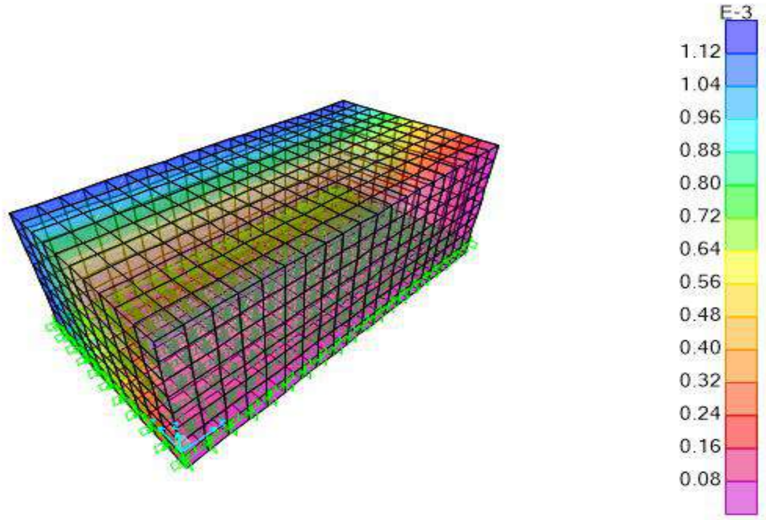


Figure 181 : Deflection check for water tank.

First case: Full liquid without soil exposed.

1- Tension

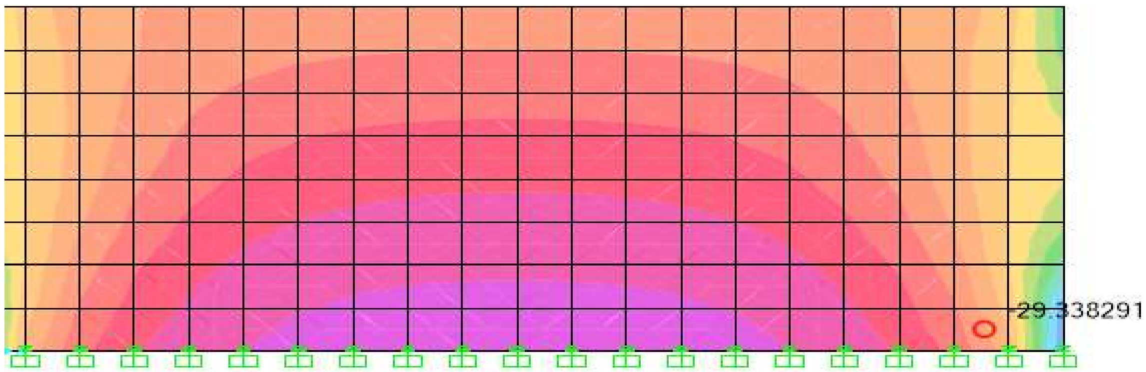


Figure 182 : F22 Diagram. From SAP.

T sap = 29.3 KN-y-direction

T u-design =1.96*29.3 = 57.4KN/m.

$$A_s = \frac{T_{udesign}}{\emptyset F_y} = \frac{57.4 \times 1000}{0.9 \times 420} = 152\frac{mm^2}{m}$$

$\frac{T+CE_sA_s}{A_g+nA_s} \leq \frac{1}{3}\sqrt{f_c'}$ $= \frac{57.4*1000+60*152}{250000+8.04*152} \leq \frac{1}{3}\sqrt{28}$ =0.26 $Mpa \leq 1.76$ Mpa So, thickness is ok.

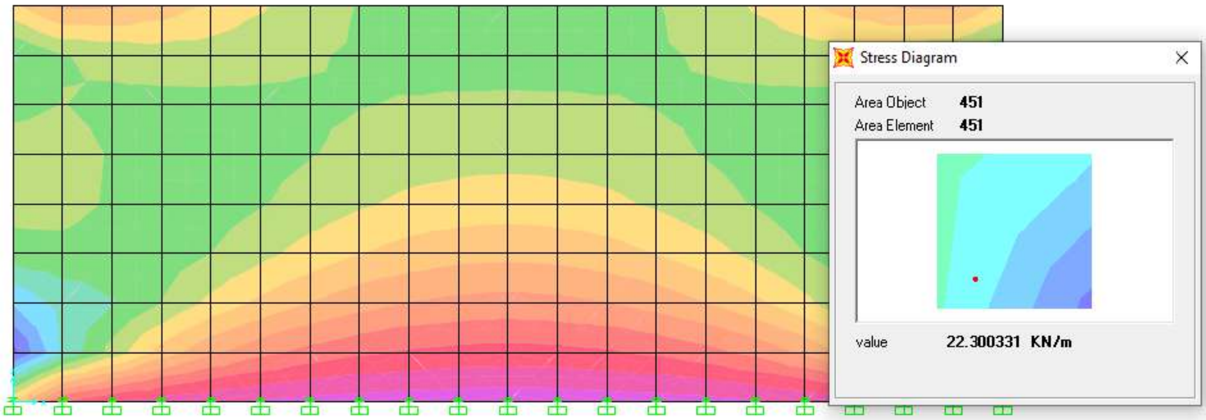


Figure 183 : F11 diagram from SAP.

T sap = 29.3 KN-x-direction

T u-design =1.96*22.3.3 = 43.7KN/m.

$$A_s = \frac{T_{udesign}}{\emptyset F_y} = \frac{43.7 \times 1000}{0.9 \times 420} = 116\frac{mm^2}{m}$$

$\frac{T+CE_sA_s}{A_g+nA_s} \leq \frac{1}{3}\sqrt{f_c'}$ $= \frac{43.7*1000+60*116}{250000+8.04*116} \leq \frac{1}{3}\sqrt{28}$ =0.2 $Mpa \leq 1.76$ Mpa So, thickness is ok.

2- Moment

Vertical moment:

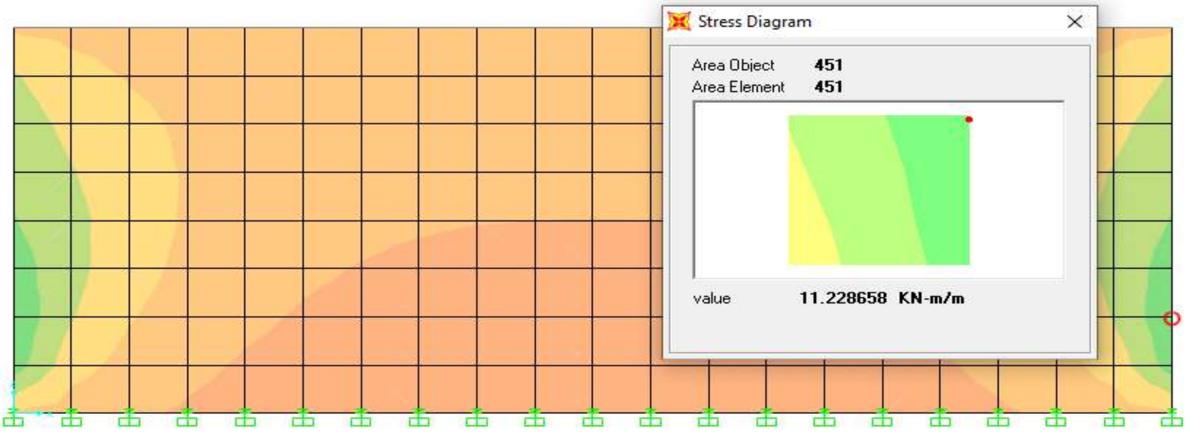


Figure 184 : M11 from SAP

My-sap = 11.2 KN.m

Mv (ult) = 1.4*11.2 = 16.8 KN.m

$$S_d = \frac{\emptyset F_y}{\gamma f_{smax}} = \frac{0.9 \times 420}{1.4 \times 210} = 1.28$$

$M_{udesign}$ =Ψ*Sd*Mu

$$M_{udesign} = 1.06 \times 1.28 \times 16.8 = 22.8 \frac{kN.m}{m}$$

d=190 mm, b=1000mm, fc=28 Map

ρ = 0.00011< Pmin thus; use ρ min

As =.00333*b*h=.00333*1000*250 = 825mm

Now Check for thickness:

Shear check:

ΦVc =0.75/6x $\sqrt{Fc}$ x bw x d x 10^{-3}

Check shear for roof:

ΦVc =0.75/6x √28 x 1000 x1000 x 10^{-3}

= 661.4 KN

Vu from SAP2000 =78.6 KN

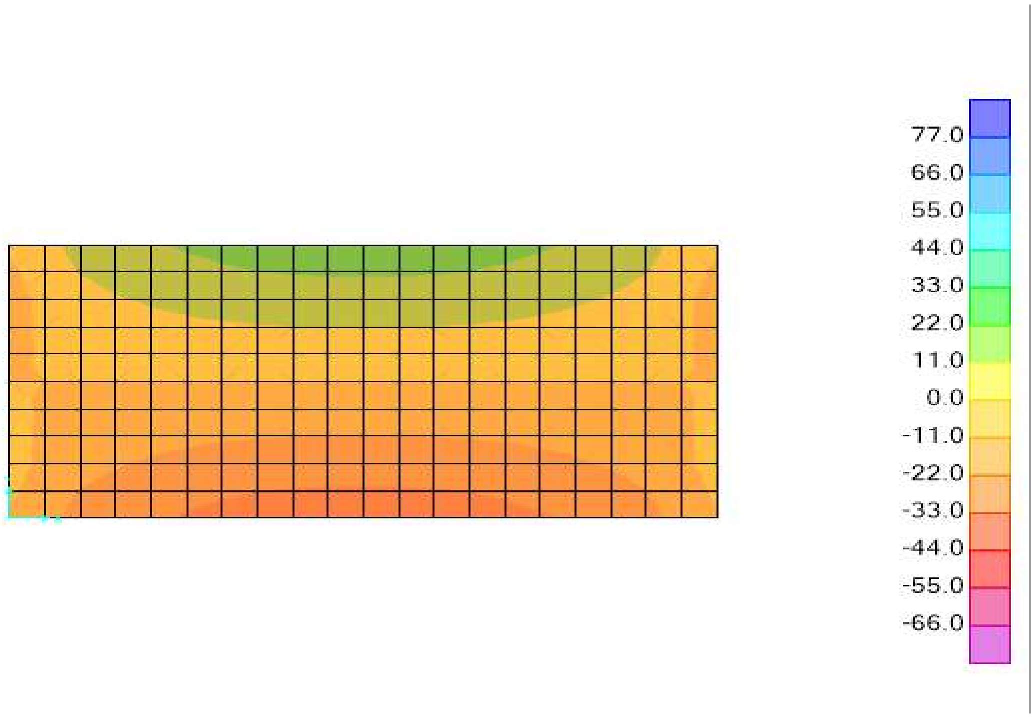


Figure 185 : Shear value for roof of water tank

Vu from SAP2000 = 78.6 KN < ØVc = 661.4

Check is OK

3-Check shear for Base:

ΦVc =0.75/6x √28 x 1000 x 340 x 10^{-3}

= 224.889

Vu from SAP2000 = 60 KN < ΦVc Check is OK

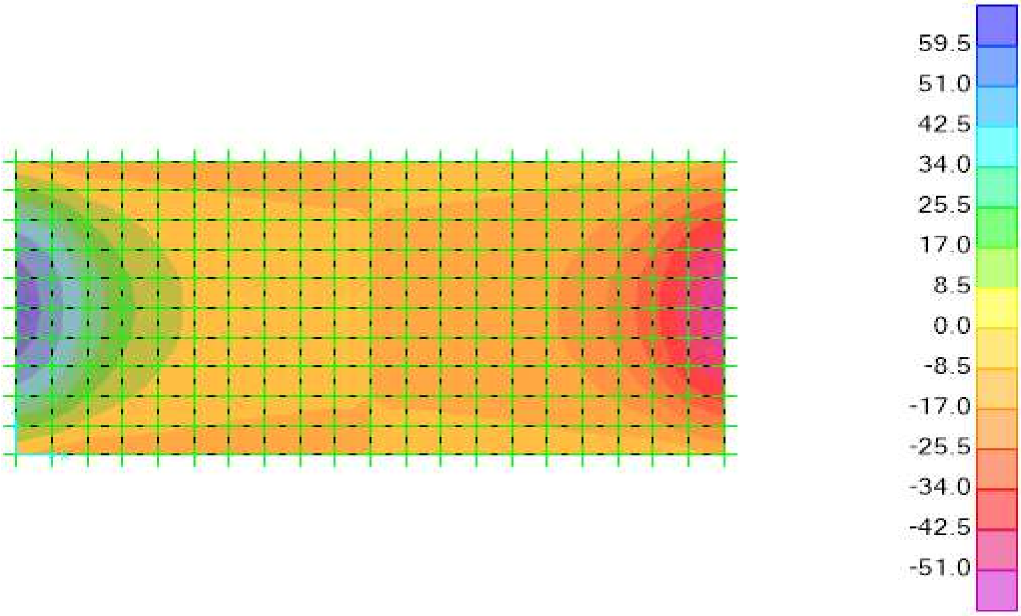


Figure 186 : Shear values for base of water tank

4-Check shear for Wall:

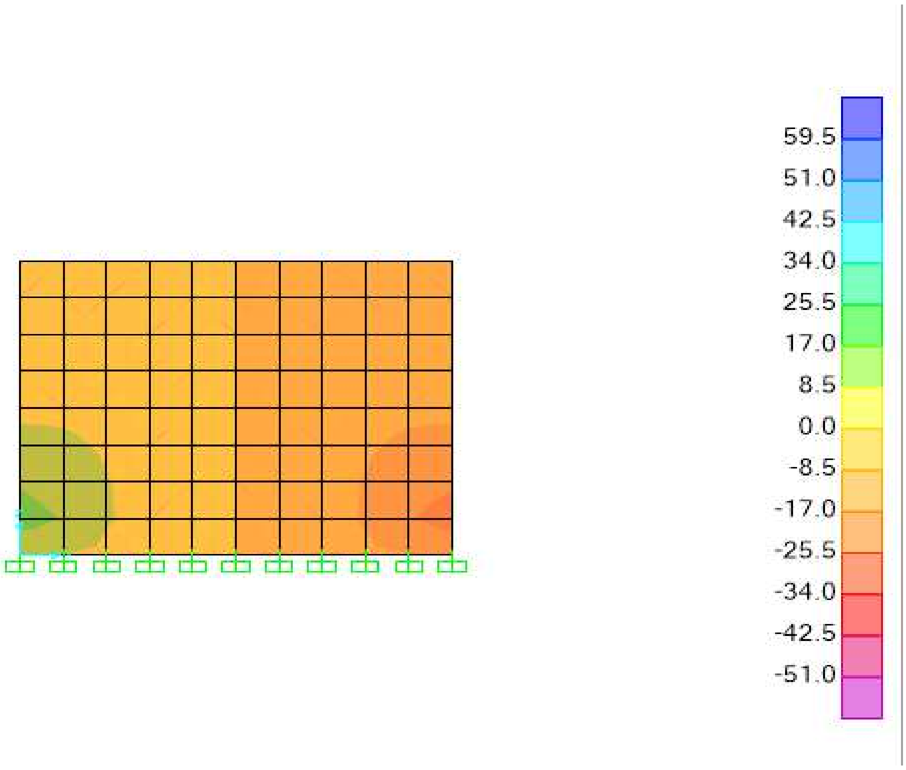


Figure 187 : shear values for wall of water tank

Design steps:

If $\frac{L}{H}$>4 →One way

The critical case of tank will be designed based on soil stresses.

1. Vertical direction:

Vv = 0.35*ɣ*h^2 = 0.35* 17*(4^2) = 95.2 KN/m.(bottom)

Mv = ɣ * $\frac{h^3}{20}$= 17*$\frac{4^3}{20}$= 54.4 KN.m /m.

2. Horizontal direction:

T h = V h = ɣ*$\frac{h^2}{8}$ = 34 KN/m.

M h = ɣ * $\frac{h^3}{32}$ = 34 KN.m/m.

Determine the Thickness of Walls:

Vv(ult) = 4*95.3= 381.2 KN/m

381= 0.75*$\frac{1}{6}$*$\sqrt{28}$*d

d= 576 mm use d= 600mm

Thus; the minimum thickness can be used is 250 mm Use h=250mm.

The same strategy to calculate thickness due to Vh

d=205mm but the minimum thickness can be used is 250 mm

Take h=250mm and d= 600mm

Design of wall:

Horizontal reinforcement:

Moment from sap = 20 KN/m.

Mu = 1.4 x 20 = 28

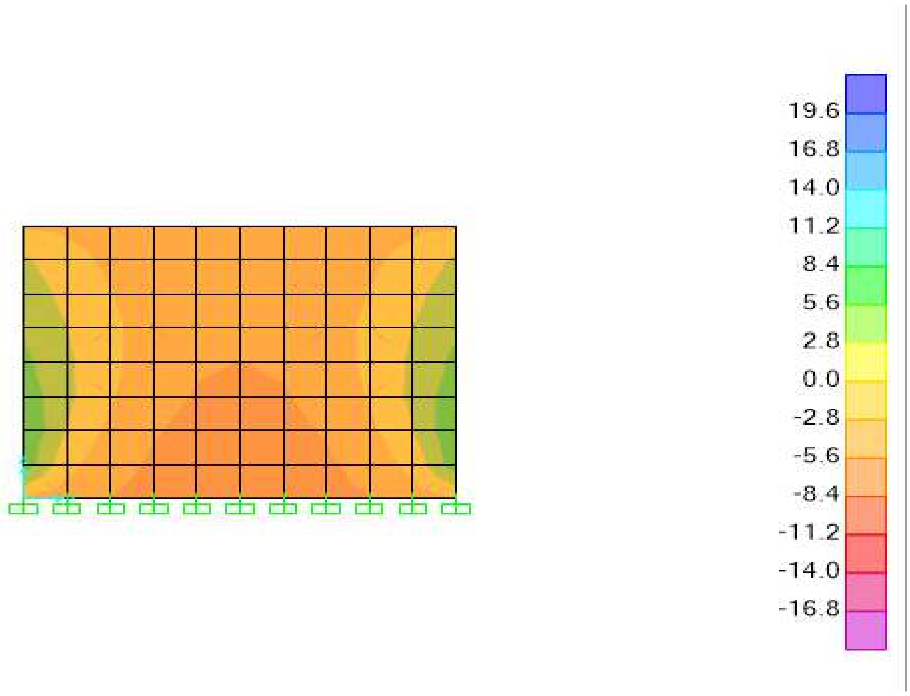


Figure 188: : Horizontal moment for wall of water tank.

. fs max = 170 from curve

Sd = $\frac{\emptyset\ Fy}{\gamma\ Fs\ max} = \frac{.9*420}{1.4*170}$ = 1.6

Tu-design =1. 6*28=44.8 KN/m tension.

P = .00027< ρ min thus; use ρ min.

As = 1458 mm

Use 8 Ø 16

Base design:

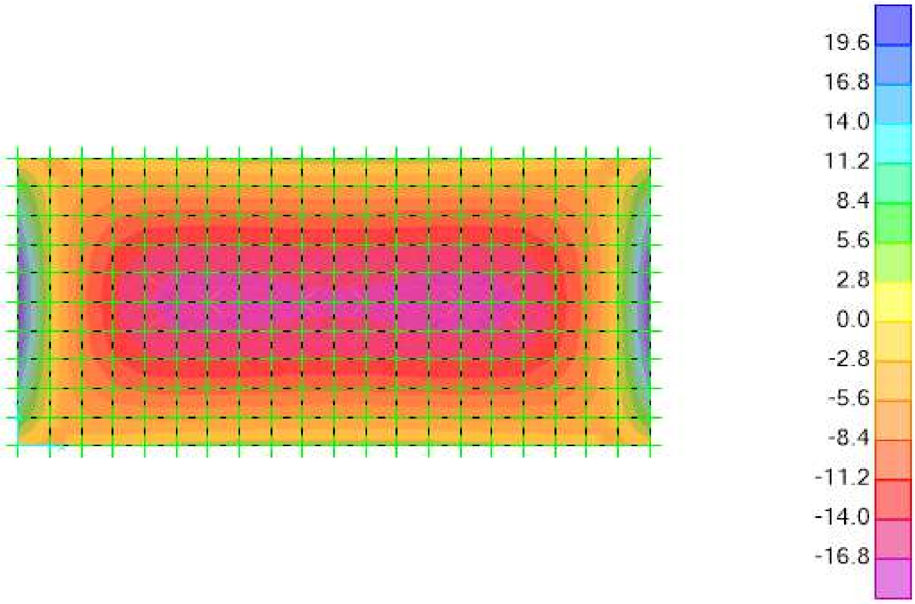


Figure 189 : Moment value for base of water tank

Mu = 15.6 KN/m

Mu = 1.4 x 15.6 = 21.84

Assume h = 400mm

Sd = $\frac{\text{Ø}\, Fy}{\gamma\ Fs\ max}$ = $\frac{.9*420}{1.4*170}$ = 1.6

Mu design = 1.06 * 1.6 * 21.84 = 37

ρ =.0001< ρ min thus; use ρ min

As=810 mm /m

Use 4 Ø 16 in both direction

Roof design:

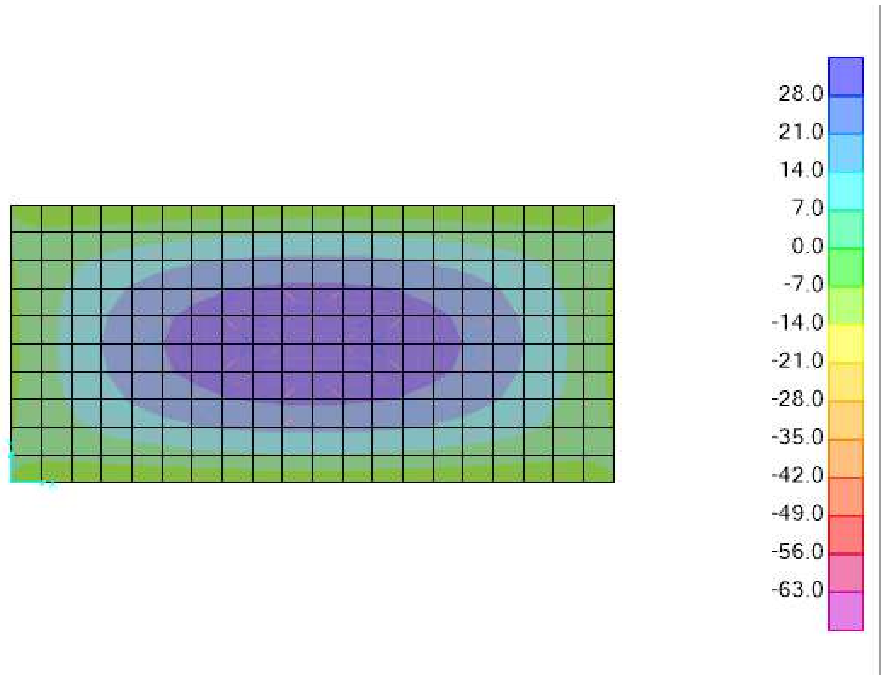


Figure 190: Moment value for roof of water tank

The roof for the tank is the same as the one for the foundations, where the tank was excavated under the foundations

Detailing :

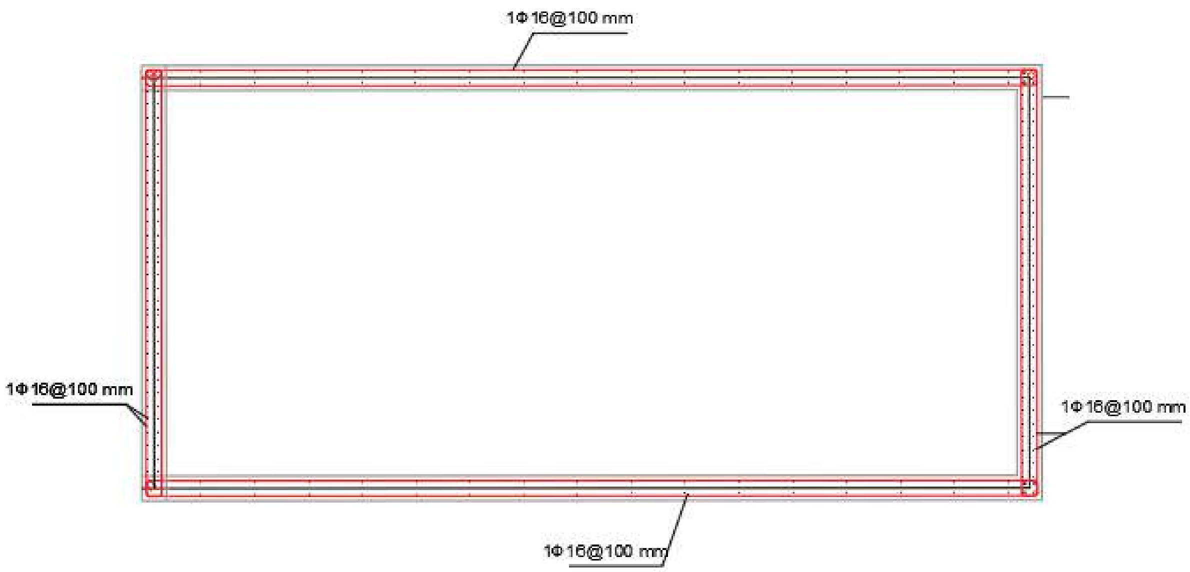


Figure 191 : TOP detailing for tank water

To see the full details of the tank, go to the Appendix file.

3.3.2.8 Sheet piles :

As defined previously, this project is in Nablus City and has a site class B with the following characteristics:

qall=220 KN/m

Ɣ=18 $KN/m3$

∅ =25

C=18 $KN/m3$

Non-Uniform Pressure:

Ɣ: Unit Weight of Soil.

∅: Internal Friction Angle of soil.

Ka: Rankine active pressure coefficient= tan^2(45 - ∅ /2)

Kp : Rankine passive pressure coefficient = tan^2(45 + ∅ /2)

Table 69 : input and rustle for sheet pails.

inpout	
Φ	25
γ	18
Ka	0.41
Kp	2.46
H	7.0 m
C	18.0

ruselt	
Z0	2.2632
D	2.769824971
M	9.498032381
Force	-0.152592816
D design	3.7 m
L design	10.7 m
Mmax	104.77 kn.m/m
v max	109.2942978

Table 70 : design data from EXAL sheet

data design		data design spiral	
dimeter	449.00	D	10.00 mm
L design	10.7 m	A	78.50 mm^2
vu design	174.8708765	D	449.00 mm
Mu design	167.63 kn.m/m	DC	309.00 mm
vu design	157.0340471	ϱs	3.33%
Mu design	150.5 KN.m/pile	s	192.00 mm
fc	28		
fy	420		
cover	70		
ɣ	0.69		
MU/(Fc*b*h^2)	0.30		
ϱ	1.50%	d	#
A steel	2373.85 mm^2	16.00 mm	8

The length of the entire pile is 10.7 m and its diameter is 50 cm. We chose a system to have a distance of 200 cm between each bale and bale from center to center.

An additional wall is placed after the pile used is of the permanent type, and the slab load for the parking lot will be placed on it.

Detailing :

8 Ø 16 Use diameter 500 mm

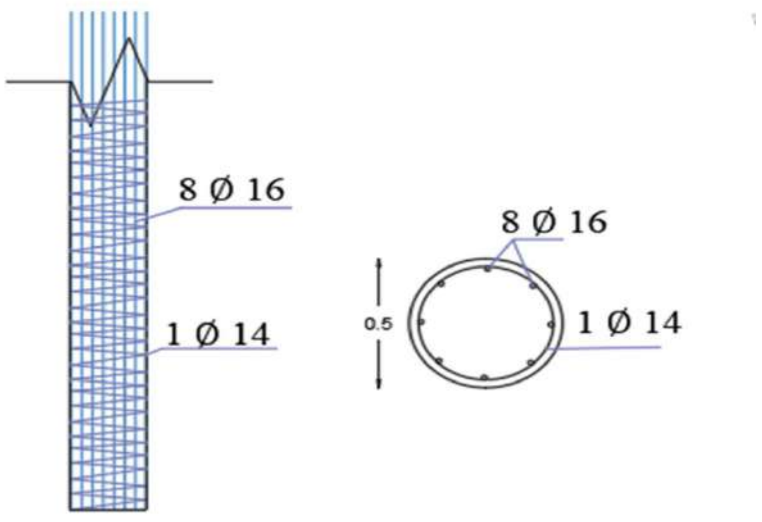


Figure 192 : detailing for sheet pails

3.3.2.9 design an alucobond

The external shape of the building contains alucobond slices in a beautiful architectural shape that has aesthetic and environmental importance in order to reduce the sun's rays entering the building. It was designed for it without changing the architectural idea.

Aluminum poles were used every 1 meter distance and alucobond was attached to them

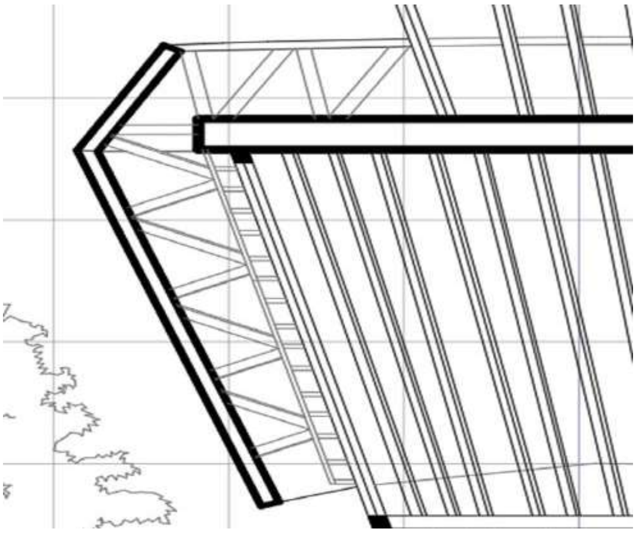


Figure 193 : Detail for alucobond

Chapter 4 : Electro-mechanical Aspects

4.1 Electrical design

4.1.1 Introduction:

Designing artificial lighting in the building aims to provide sufficient lighting inside the building in the event that sufficient natural lighting is not available in a regular and comfortable manner for the users of the building according to their needs and according to the following requirements:

Figure194 :factor of lighting design

Lighting calculations were made for some rooms using DIALux programs (one space of each functional category)

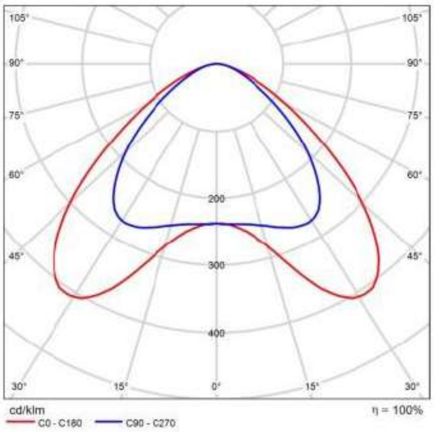
4.1.2Artificial lighting design

Types of luminaires that were used in the bank by DIALux programs and According to the types available in the market

Product data sheet

Philips - RC505B LED80S/PW935 DA45 HE

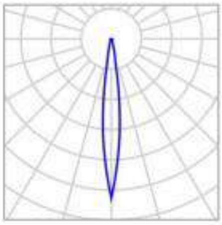
P	60.0 W
Φ_{Lamp}	8000 lm
$\Phi_{Luminaire}$	8003 lm
η	100.03 %
Luminous efficacy	133.4 lm/W
CCT	3500 K
CRI	90



Polar LDC

Figure 195 :Philips-RC505B from luminaires.dialux.com

Luminaire layout plan

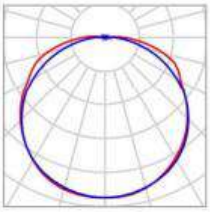


Manufacturer	ACEVEL
Article No.	46
Article name	Nano Q100 10°
Fitting	1x Q100 10°

P	18.0 W
$\Phi_{Luminaire}$	939 lm

Figure 196 :ACEVEL Nano Q100 from luminaires.dialux.com

Luminaire layout plan



Manufacturer	COLLINGWOOD	P	0.7 W
Article No.	LSC8640100	$\Phi_{Luminaire}$	66 lm
Article name	LSC86 4000K IP68 41.6mm		
Fitting	1x LSC86 4000K IP68 41.6mm		

Figure 197 :COLLINGWOOD lighting from luminaires.dialux.com

1. Lighting design for the it dept.

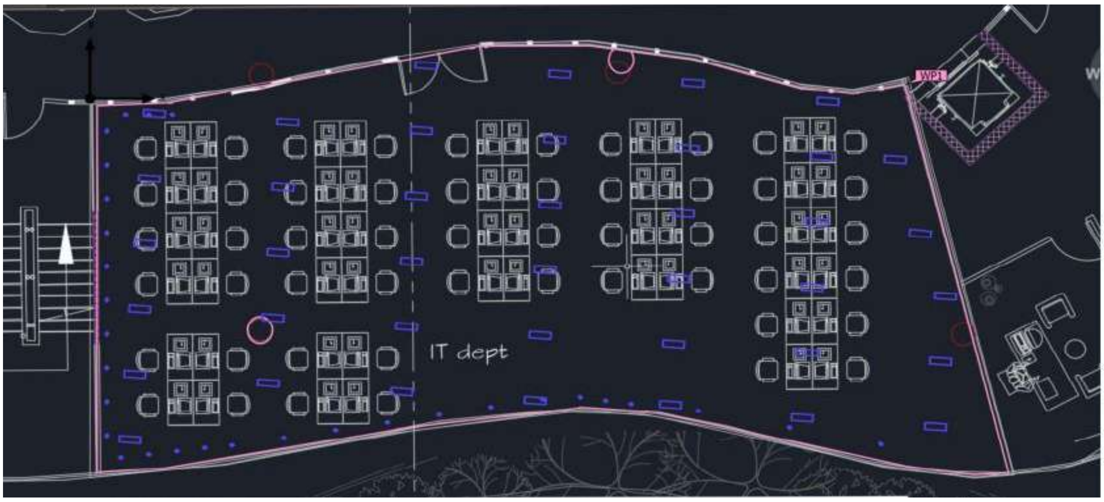


Figure 198 :lighting distribution in the it dept located on the ground floor

Figure shows the luminaires type that was used

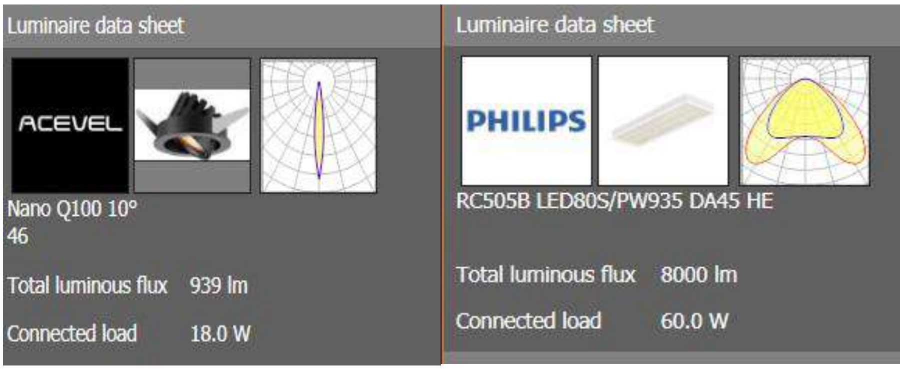


Figure 199 : luminaires type was used in the it dept

Using the European code in the DIALux evo 9.1 program, the standard required for cafeteria was equal 500 lux, and the glare did not exceed 19 .

Table 71 : luminance value for it dept

Building 1 · Storey 1 (Light scene 1)

Calculation objects

Working planes

Properties	Ē (Target)	E_{min}	E_{max}	g_1 (Target)
Working plane (Room 1) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	987 lx (≥ 500 lx) ✓	91.7 lx	2744 lx	0.67 (≥ 0.60) ✓

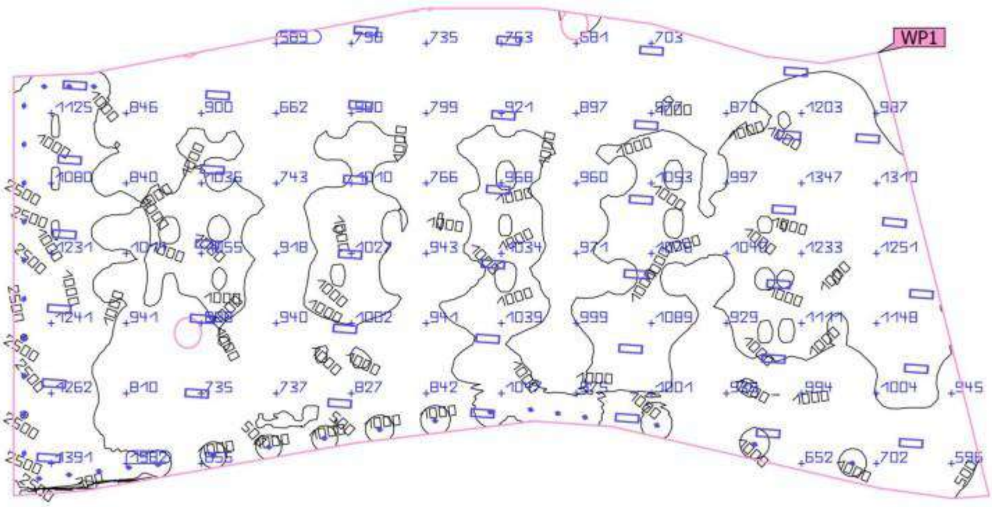


Figure 200 luminance distribution in it dept

Render result

Figure201 : it dept. render 1

Figure202 : it dept. render 2

2. Lighting design for the lobby.

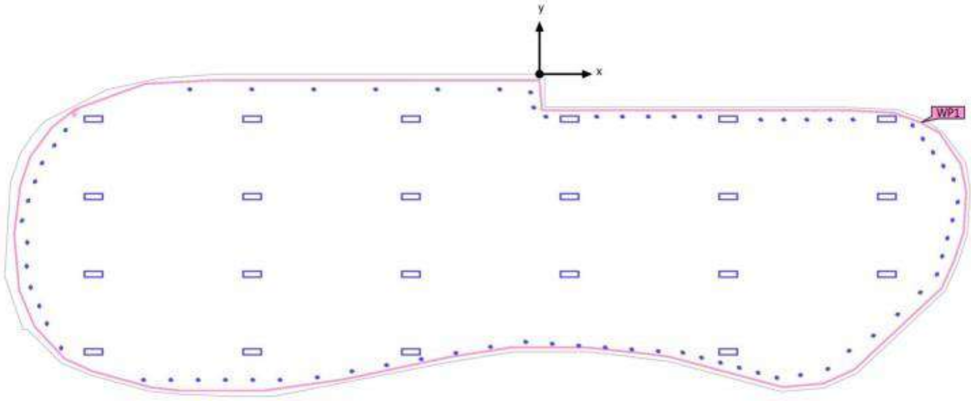


Figure203 : lighting distribution in the lobby

Located on the ground floor

Figure shows the luminaires type that was used

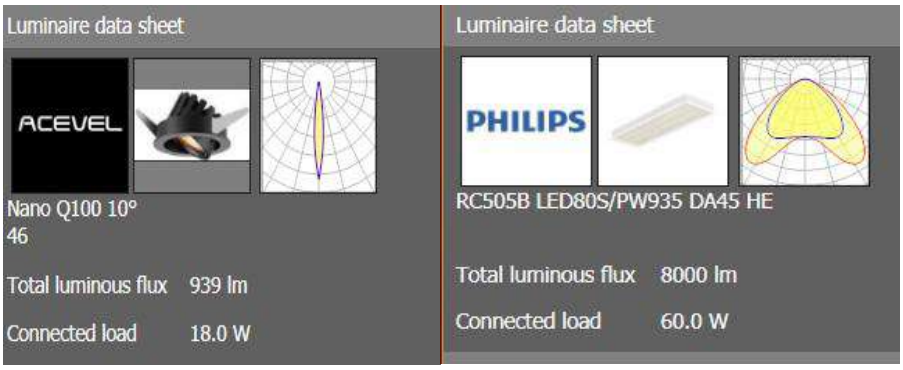


Figure204 : luminaires type was used in the lobby

Using the European code in the DIALux evo 9.1 program, the standard required for cafeteria was equal 270 lux, and the glare did not exceed 22.

Table 72 :luminance value for lobby

Building 1 · Storey 1 (Light scene 1)

Calculation objects

Working planes

Properties	Ē (Target)	E_{min}	E_{max}	g_1 (Target)
Working plane (Room 1) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	987 lx (≥ 500 lx) ✓	91.7 lx	2744 lx	0.67 (≥ 0.60) ✓

Table 73 : glare value for lobby

Results

	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{perpendicular}$	634 lx	≥ 100 lx	✓	WP1
	g_1	0.43	≥ 0.40	✓	WP1
Glare valuation(1)	$R_{UG, max}$	20	≤ 22	✓	
Energy estimation(2)	Consumption	[3467.42 - 5001.15] kWh/a	max. 9450 kWh/a	✓	
Room	Lighting power density	9.64 W/m²	–		
		1.52 W/m²/100 lx	–		

Summary

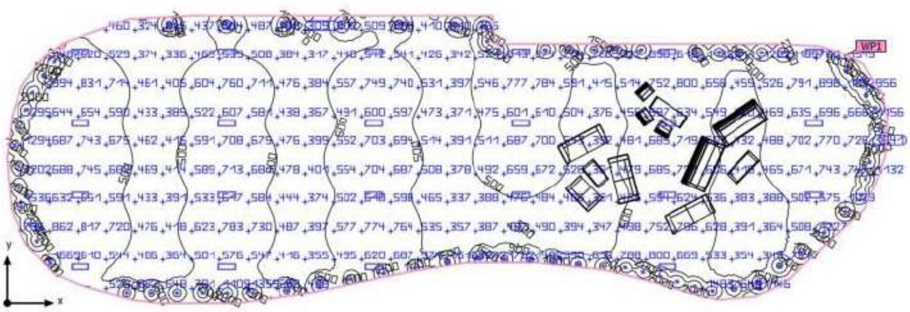


Figure 205 luminance distribution in lobby :

Render result

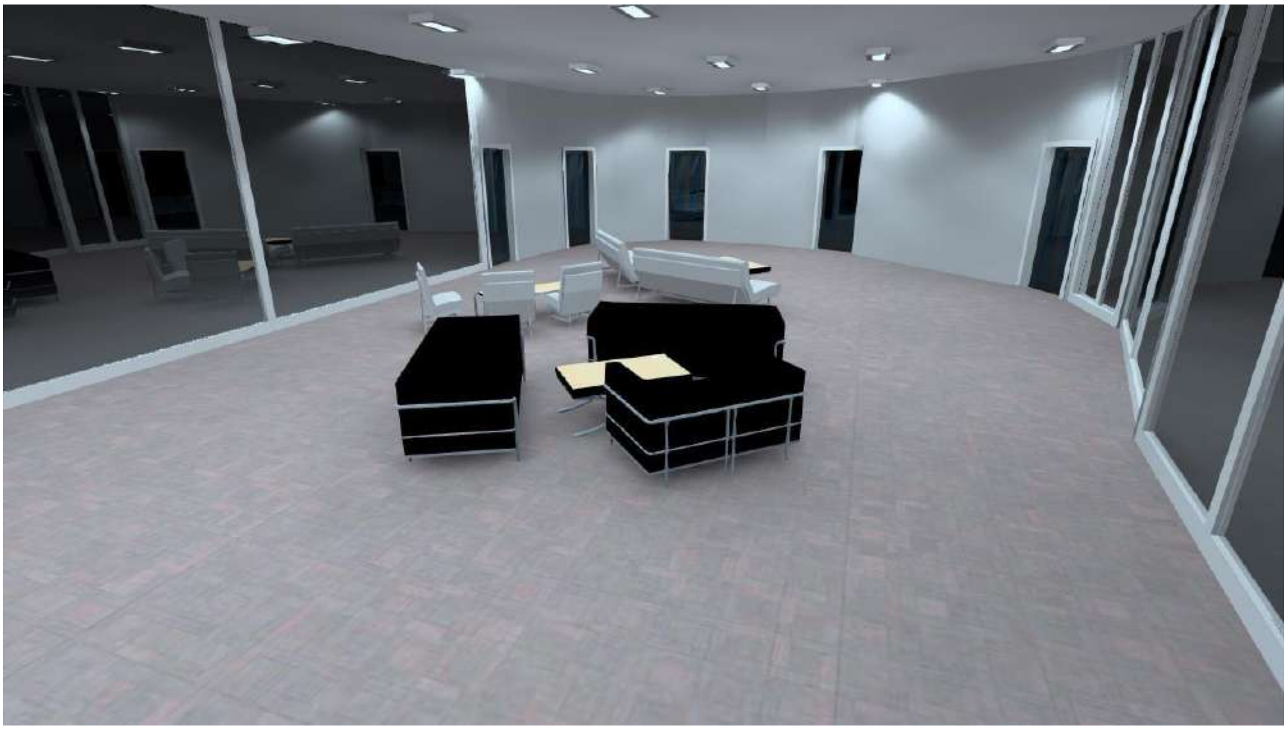


Figure206 : lobby. Render 1

Figure207 :lobby. render 2

3. Lighting design for the office.

Figure208 :lighting distribution in the office

Figure shows the luminaires type that was used

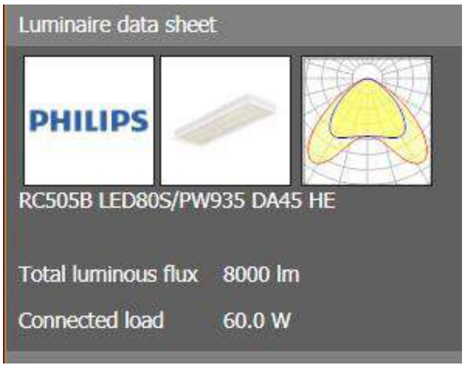


Figure209 : luminaires type was used in the office

Using the European code in the DIALux evo 9.1 program, the standard required for cafeteria was equal 300 lux, and the glare did not exceed 22.

Table 74 :luminance value for office

Calculation objects

Working planes

Properties	Ē (Target)	E_{min}	E_{max}	g_1 (Target)
Working plane (Room 1) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	2062 lx (≥ 300 lx) ✓	1040 lx	2652 lx	0.50 (≥ 0.40) ✓

Table 75 :glare value for office

Summary

Results

	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{perpendicular}$	2062 lx	≥ 300 lx	✓	WP1
	g_1	0.50	≥ 0.40	✓	WP1
Glare valuation[1]	$R_{UG, max}$	17	≤ 19	✓	
Energy estimation[2]	Consumption	[44.49 - 72.90] kWh/a	max. 650 kWh/a	✓	
Room	Lighting power density	29.90 W/m²	–		
		1.45 W/m²/100 lx	–		

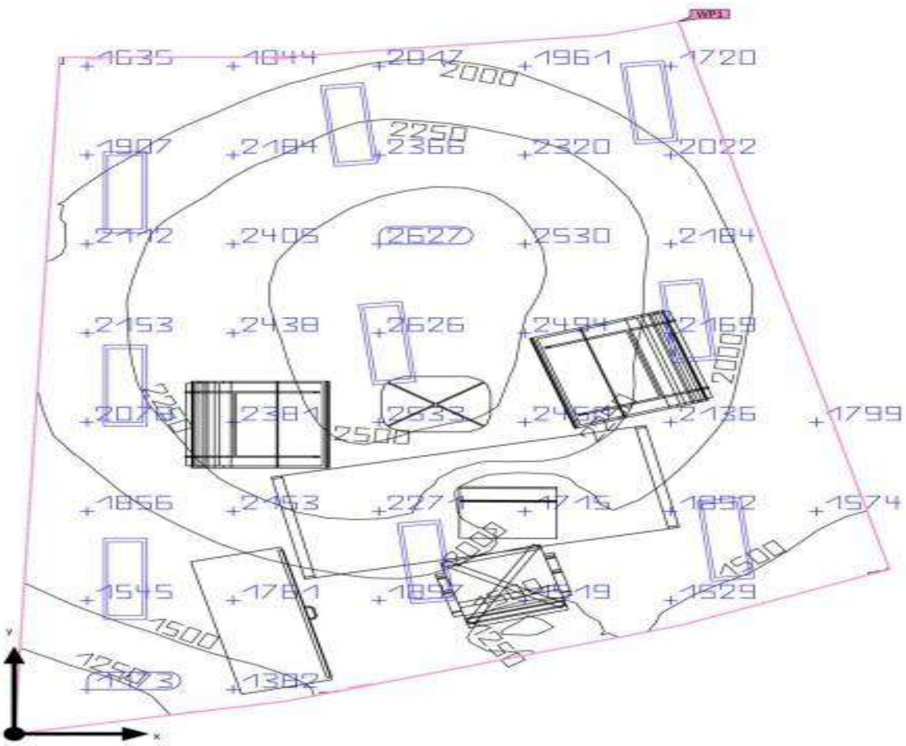


Figure210 luminance distribution in office:

Render result

Figure211 :office render

4. Lighting design for the lecture hall.

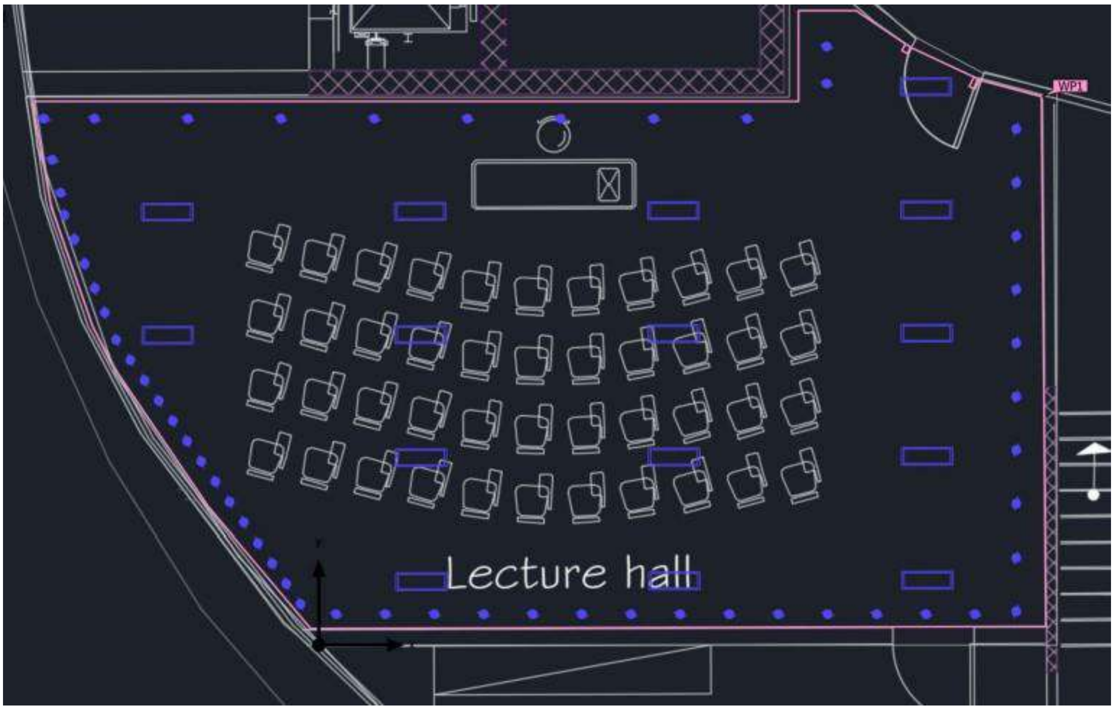


Figure212 :lighting distribution in the lecture hall

Figure shows the luminaires type that was used

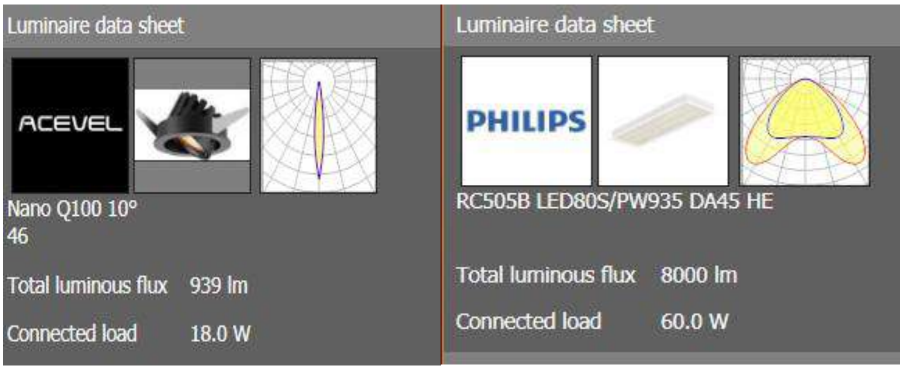


Figure213 :luminaires type was used in the lecture hall

Using the European code in the DIALux evo 9.1 program, the standard required for cafeteria was equal 500 lux, and the glare did not exceed 22.

Table 76 :luminance value for lecture hall

Calculation objects

Working planes

Properties	$\bar{E}$ (Target)	E_{min}	E_{max}	g_1 (Target)
Working plane (Room 1) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	1905 lx (≥ 500 lx) ✓	632 lx	3958 lx	0.66 (≥ 0.60) ✓

Table 77 :glare value for lecture hall

Summary

Results

	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{perpendicular}$	1905 lx	≥ 500 lx	✓	WP1
	g_1	0.67	≥ 0.60	✓	WP1
Glare valuation[1]	$R_{UG,max}$	15	≤ 19	✓	
Energy estimation[2]	Consumption	[1814.09 - 2537.64] kWh/a	max. 2550 kWh/a	✓	
Room	Lighting power density	26.45 W/m²	–		
		1.39 W/m²/100 lx	–		

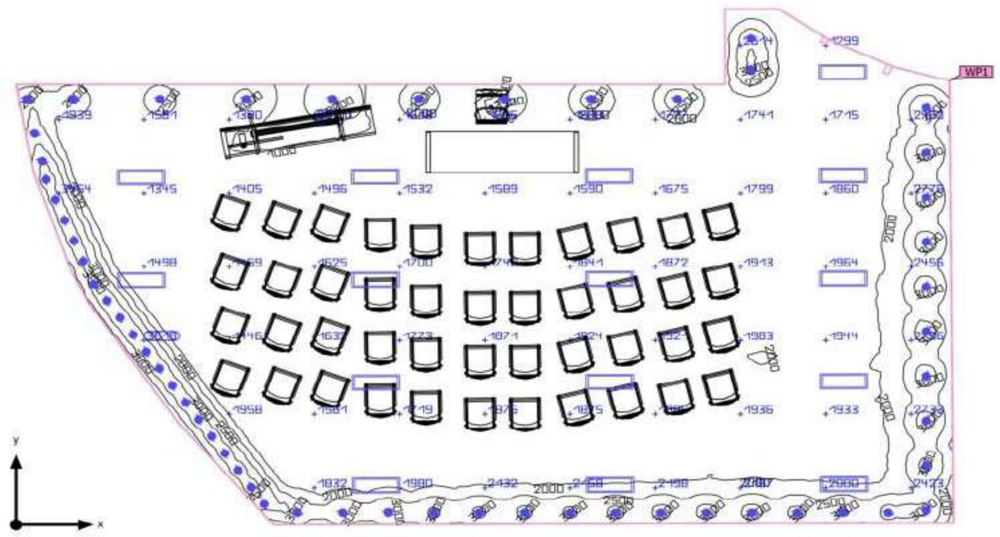


Figure214 :luminance distribution in lecture hall

Render result

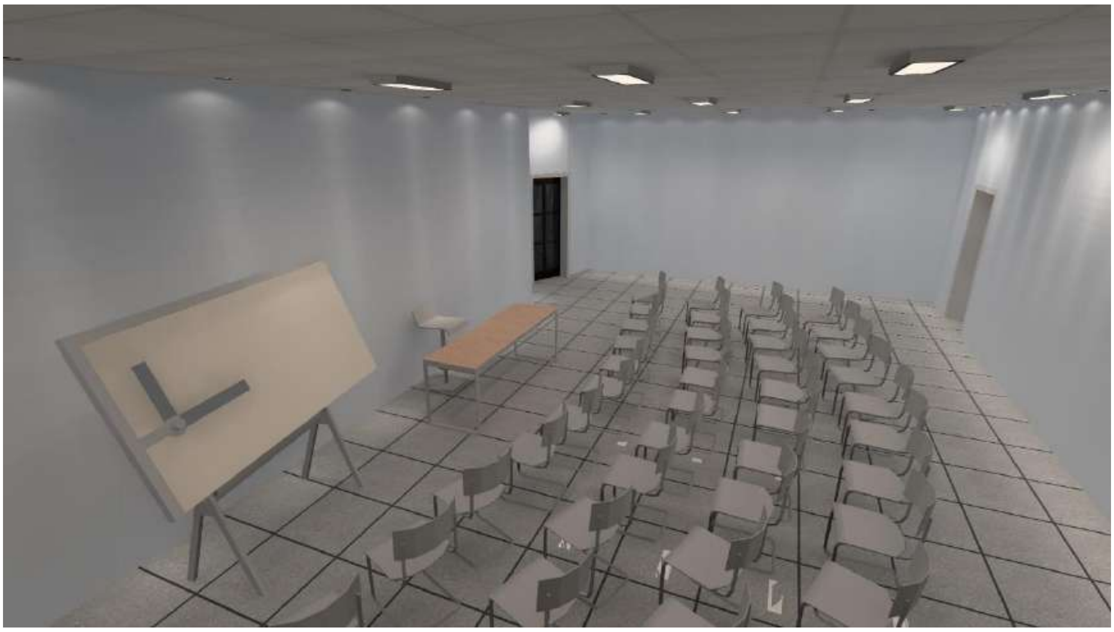


Figure215 : lecture hall render 1

Figure216 : lecture hall render 2

5. Lighting design for the bathrooms.

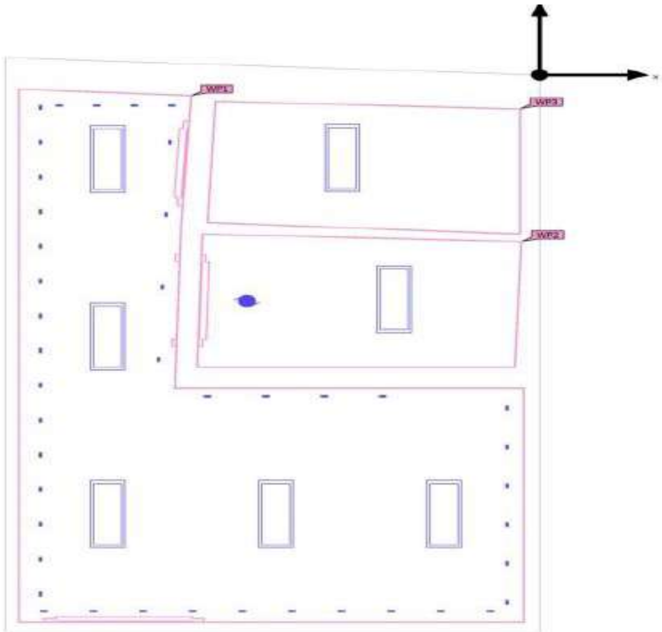


Figure217 : lighting distribution in the bathrooms

Figure shows the luminaires type that was used

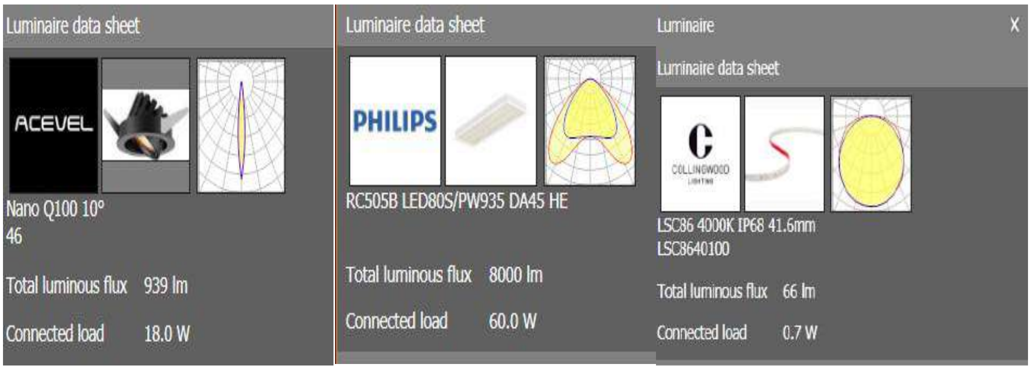


Figure218 : luminaires type was used in the bathrooms

Using the European code in the DIALux evo 9.1 program, the standard required for cafeteria was equal 500 lux, and the glare did not exceed 22.

Table78 : luminance value for bathroom

Working planes

Properties	Ē (Target)	E_{min}	E_{max}	g_1 (Target)
Working plane (bathroom) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	2072 lx (≥ 100 lx) ✓	133 lx	2711 lx	0.42 (≥ 0.40) ✓

Table79 : luminance value for bathroom

Calculation objects

Working planes

Properties	Ē (Target)	E_{min}	E_{max}	g_1 (Target)
Working plane (bathroom) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	2072 lx (≥ 100 lx) ✓	133 lx	2711 lx	0.42 (≥ 0.40) ✓
Working plane (Room 3) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	1346 lx (≥ 500 lx) ✓	516 lx	2282 lx	0.76 (≥ 0.60) ✓
Working plane (Room 4) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	1102 lx (≥ 500 lx) ✓	927 lx	1182 lx	0.84 (≥ 0.60) ✓

Table80 : glare value for bathroom

Summary

Results

✓	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{perpendicular}$	1102 lx	≥ 500 lx	✓	WP3
	g_1	0.84	≥ 0.60	✓	WP3
Glare valuation(1)	$R_{UG, max}$	15	≤ 19	✓	
Energy estimation(2)	Consumption	149 kWh/a	max. 100 kWh/a	✓	
Room	Lighting power density	27.12 W/m²	–		
		2.46 W/m²/100 lx	–		

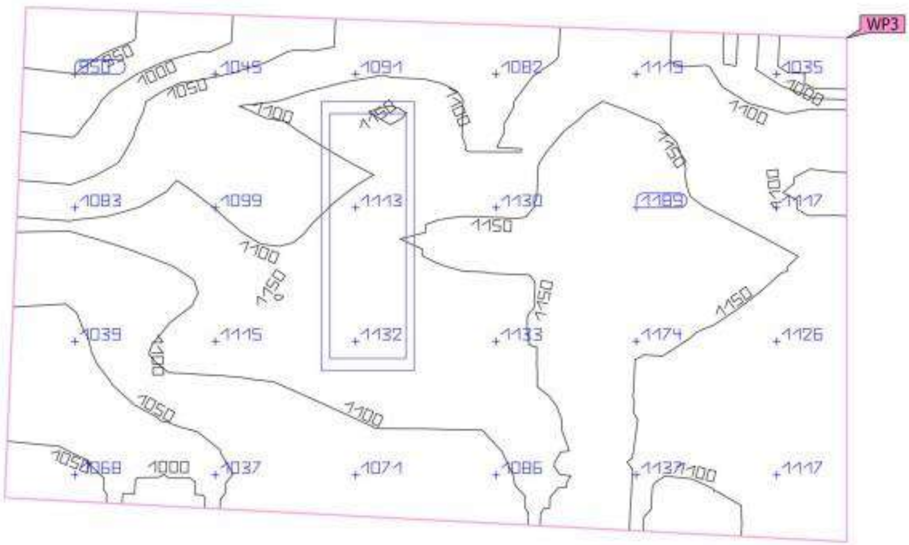


Figure219 luminance distribution in bathroom :

Render result

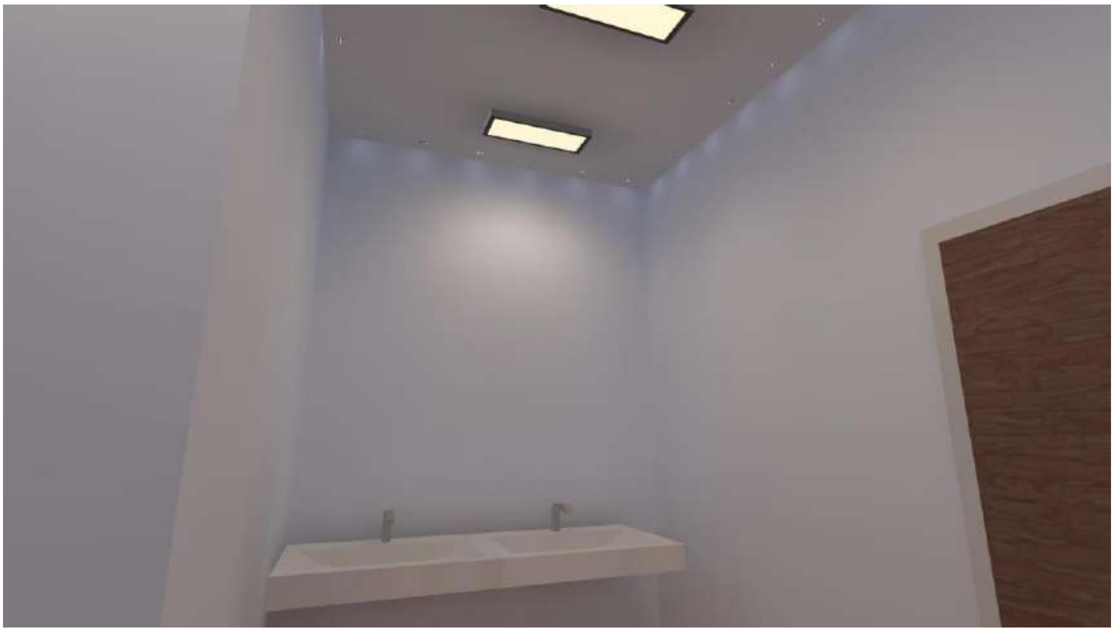


Figure220 : lecture bathroom 1

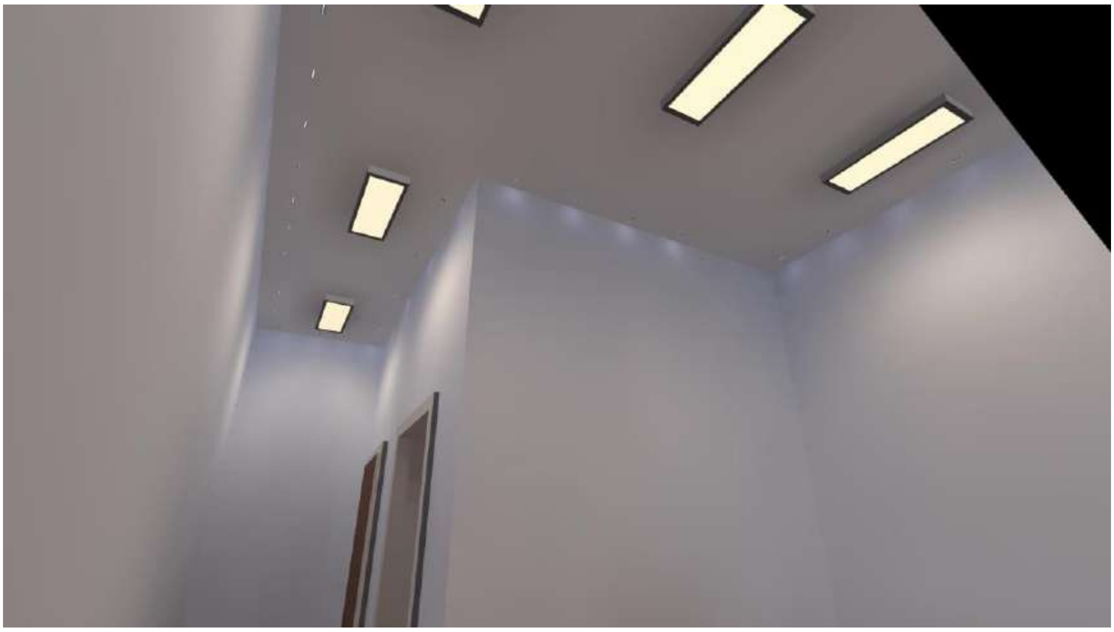


Figure221 : lecture bathroom 2

6. Lighting design for the reception.

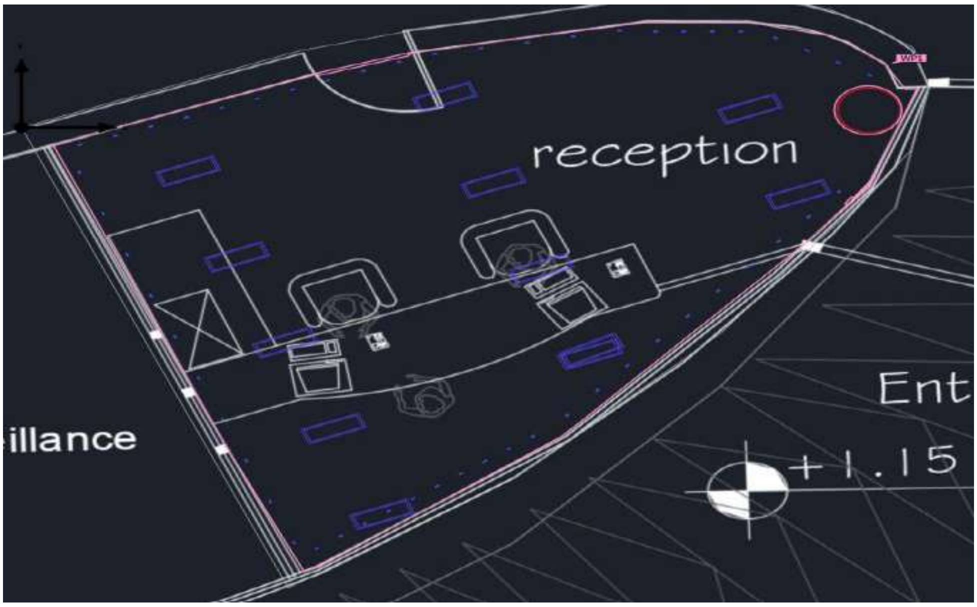


Figure222 : lighting distribution in the reception

Figure shows the luminaires type that was used

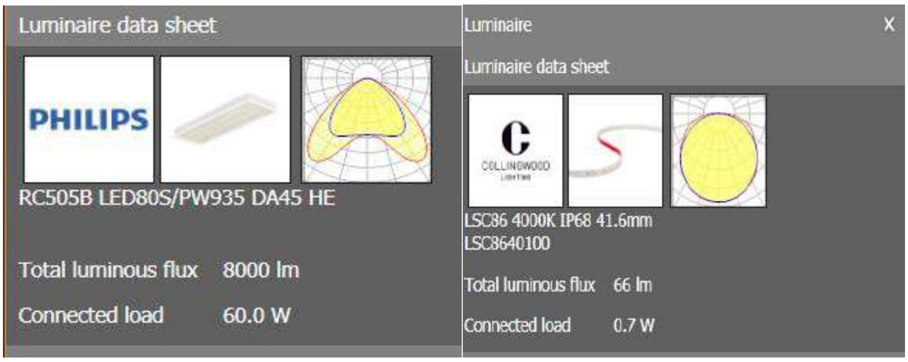


Figure223 : luminaires type was used in the reception

Using the European code in the DIALux evo 9.1 program, the standard required for cafeteria was equal 300 lux, and the glare did not exceed 22.

Table81 : luminance value for reception

Calculation objects

Working planes

Properties	Ē (Target)	E_{min}	E_{max}	g_1 (Target)
Working plane (Room 1) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	1592 lx (≥ 300 lx) ✓	5.22 lx	2294 lx	0.5 (≥ 0.40) ✓

Summary

Results

	Symbol	Calculated	Target	Check	Index
Working plane	$\bar{E}_{perpendicular}$	1592 lx	≥ 300 lx	✓	WP1
	g_1	0.5	≥ 0.40	✓	WP1
Glare valuation[(1)]	$R_{UG,max}$	18	≤ 19	✓	
Energy estimation[(2)]	Consumption	[62.42 - 102.28] kWh/a	max. 1400 kWh/a	✓	
Room	Lighting power density	19.54 W/m²	–		
		1.23 W/m²/100 lx	–		

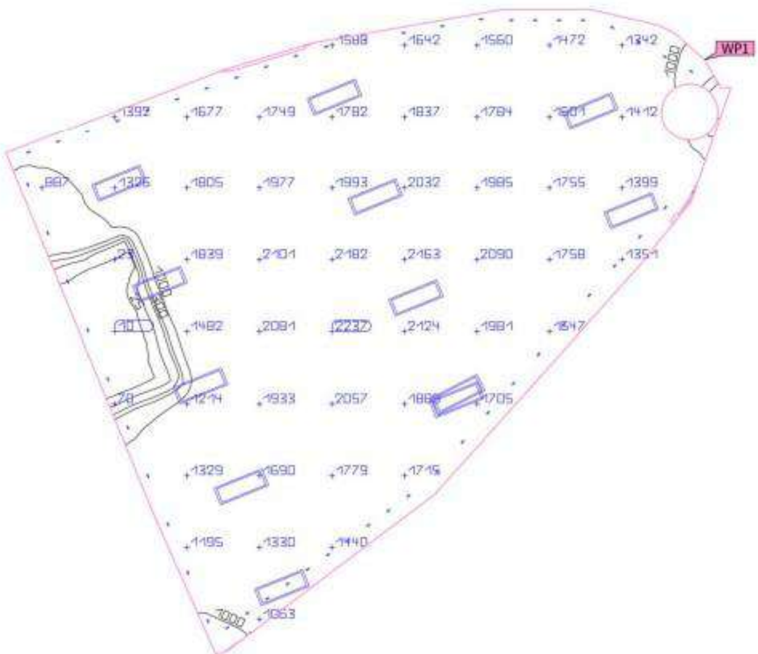


Figure 224: luminance distribution in reception

Render result

Figure32: reception render

Figure 225: reception render 2

7. Lighting design for the tellers.

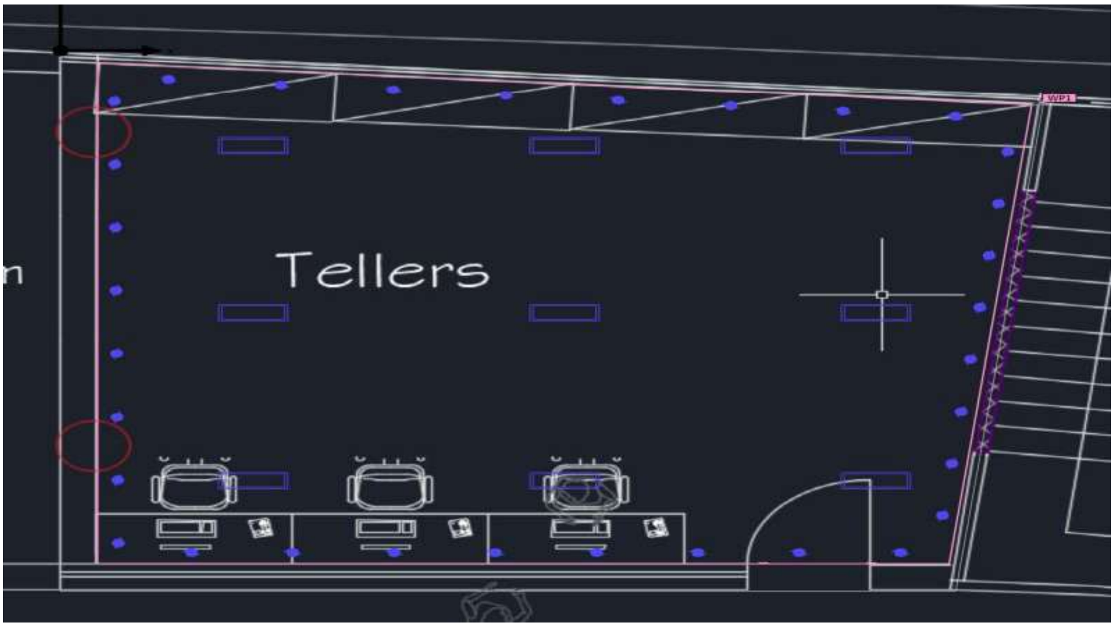


Figure 226: lighting distribution in the tellers

Figure shows the luminaires type that was used

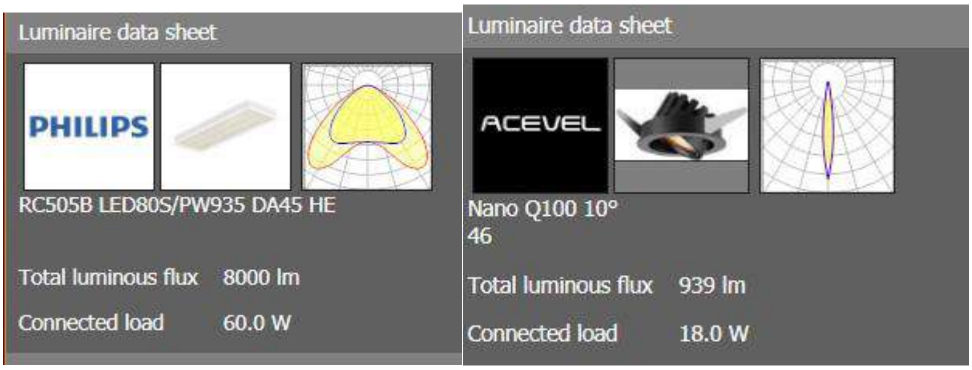


Figure 227 : luminaires type was used in the tellers

Using the European code in the DIALux evo 9.1 program, the standard required for cafeteria was equal 500lux, and the glare did not exceed 19.

Table 82 : : luminance value for reception

Properties	Ē (Target)	E_{min}	E_{max}	g_1 (Target)
Working plane (Room 1) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	1009 lx (≥ 500 lx) ✓	54.4 lx	2759 lx	0.7 (≥ 0.60) ✓

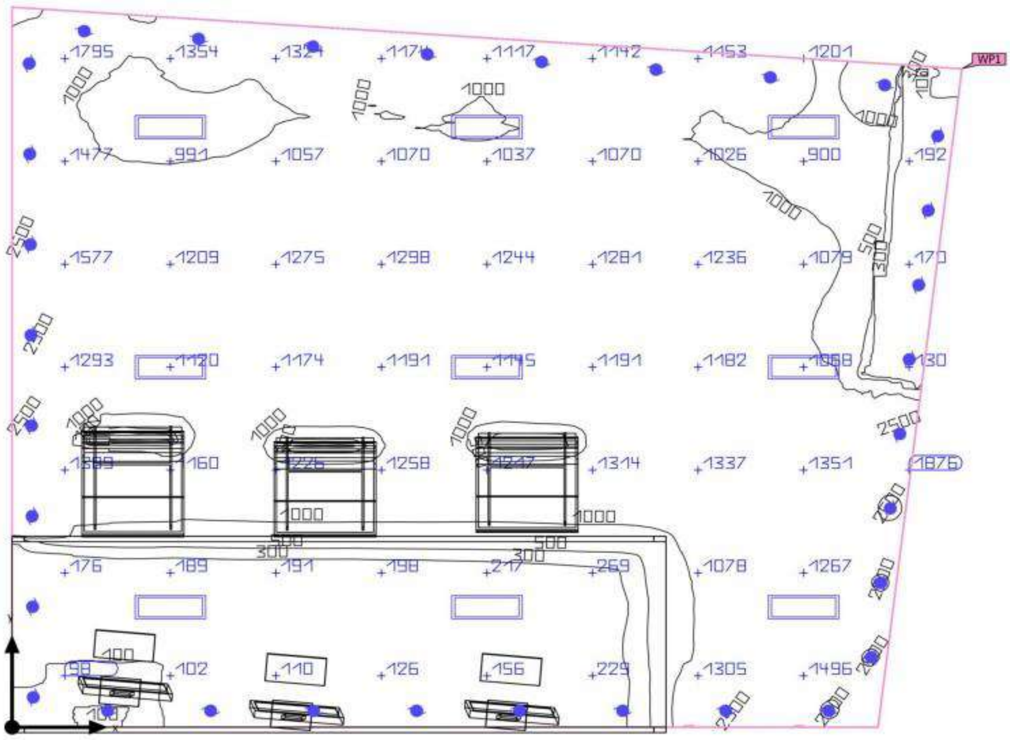
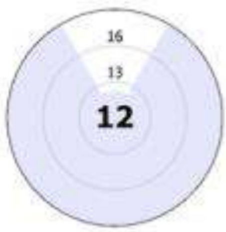


Figure 228: luminance distribution in tellers

Figure (229) has shown the result of calculations objects for UGR:

Calculation object 1 for glare



Calculation object 2 for glare

Figure 229 :Result of calculations objects for UGR

Render result

Figure 230 : tellers render1

Figure 231 : tellers render 2

8-Lighting design for the basement:

Figure shows the luminaires type that was used

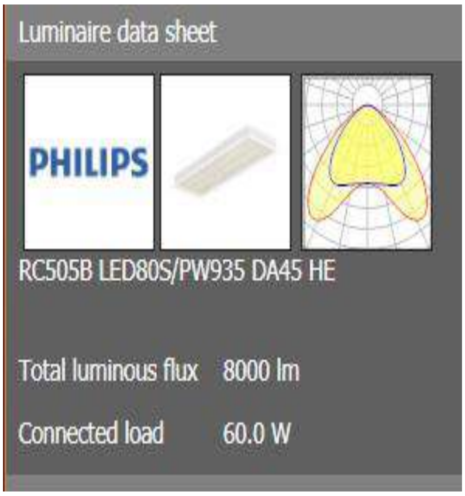


Figure 232: luminaires type was used

Motion sensors were used in the basement floors to turn on the lights at the entry of people or vehicles distributed in more than one area in order to turn on the lights in the area where there is movement only.

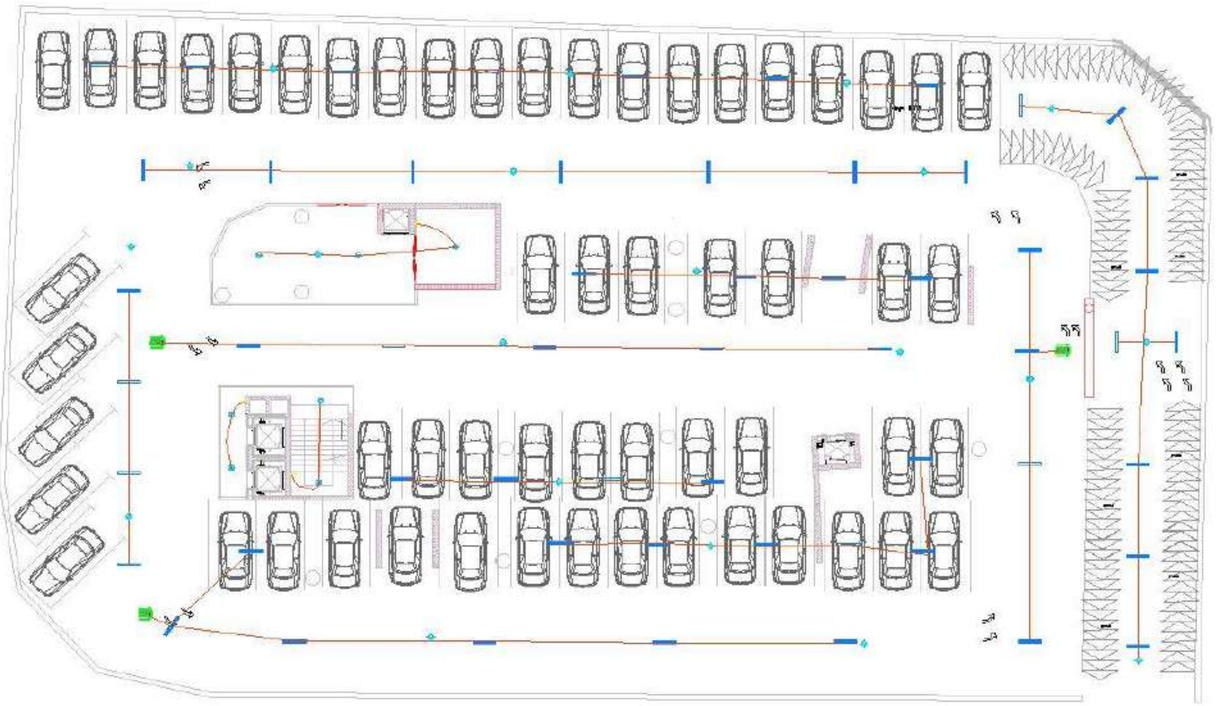


Figure 233: Lighting design for the basement

4.2 Power design:

4.2.1. Electrical system:

The electrical system is a system that delivers energy from the power generation source to the building through electrical networks (wires, transformers, and cables).

There are types of electrical connections according to the need of the building and the capacity required in it connections three phases for heavy loads and 1 phase for lighter loads ,Electric energy is taken from municipalities or electricity distribution companies by setting meters for each building and connecting it to the public electricity network .

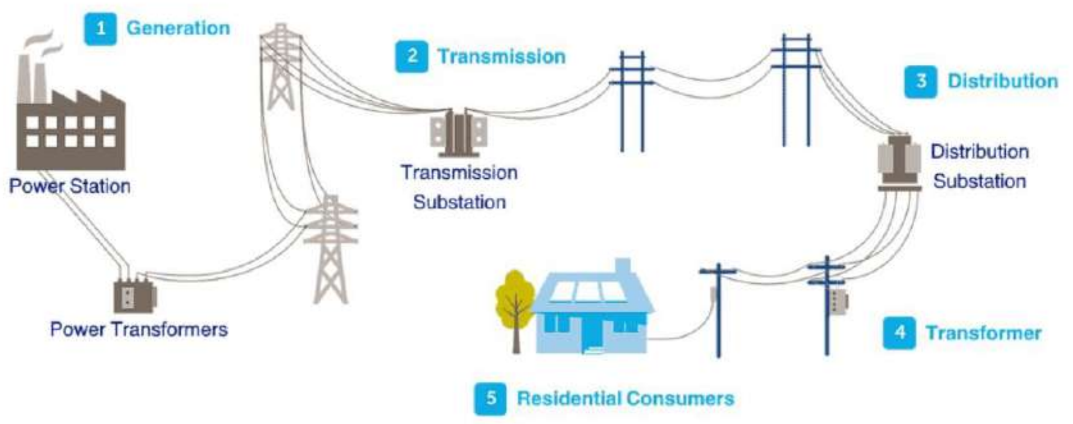


Figure 234 : Electrical system

4.2.2 Electrical system components:

The electrical network of buildings generally consists of wires, circuit breakers, a distribution board, sockets, and outlets for power and lighting

4.2.2.1 Weirs:

The wires used in electrical installations are made of copper and are divided into three types: earth, phase, and neutral.

Function	Old Color Code القديم	New Color Code الجديد
Single Phase Line (L) خط كهرباء ١ فاز	Red	Brown
Three Phase Line 1 (L1) خط كهرباء الفاز الاول	Red	Brown
Three Phase Line 1 (L2) خط كهرباء الفاز الثاني	Yellow	Black
Three Phase Line 1 (L3) خط كهرباء الفاز الثالث	Blue	Gray
Neutral (N) خط النيوترال	Black	Blue
Protective Earth or Ground (PE) خط التاريض	Green-and-Yellow	Green-and-Yellow

Figure 235: types of weirs

4.2.2.2 Distribution board:

The electrical panel is the link between the electricity coming from the network and the electricity inside the building. The panel carries a number of circuit breakers.

Figure 236: Distribution board

4.2.2.3 Circuit breaker:

The electrical circuit breaker works to protect the electrical network, as it cuts off the current when any defect occurs in the network or an increase in the current, and it performs its work automatically.

Figure 237: Distribution board

In the bank, a system 3-phase system will be used is required to meet the electricity needs for elevators, security systems, computers, lighting, air conditioning, and all that is needed inside the bank

4.2.3 Power load calculation :

The main electricity panel is placed on the ground floor and is connected to the public electricity network with cables, and then electricity is connected to the rest of the floors through the manhole.

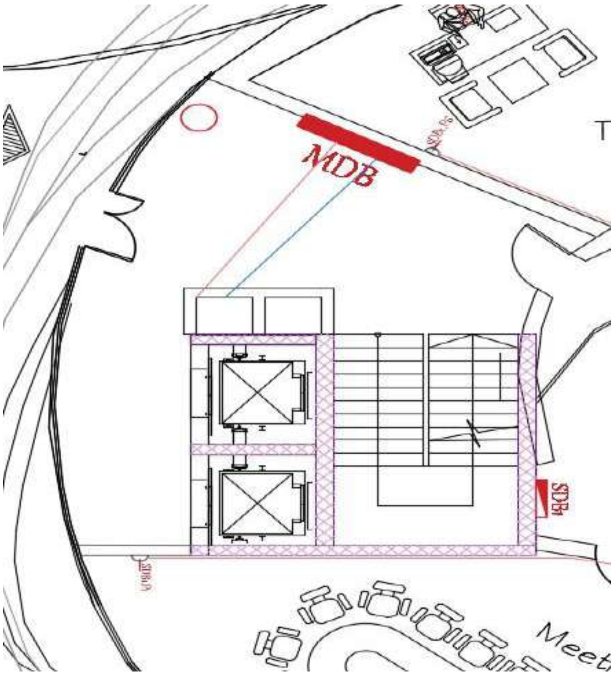


Figure 238 : position of main distribution boards

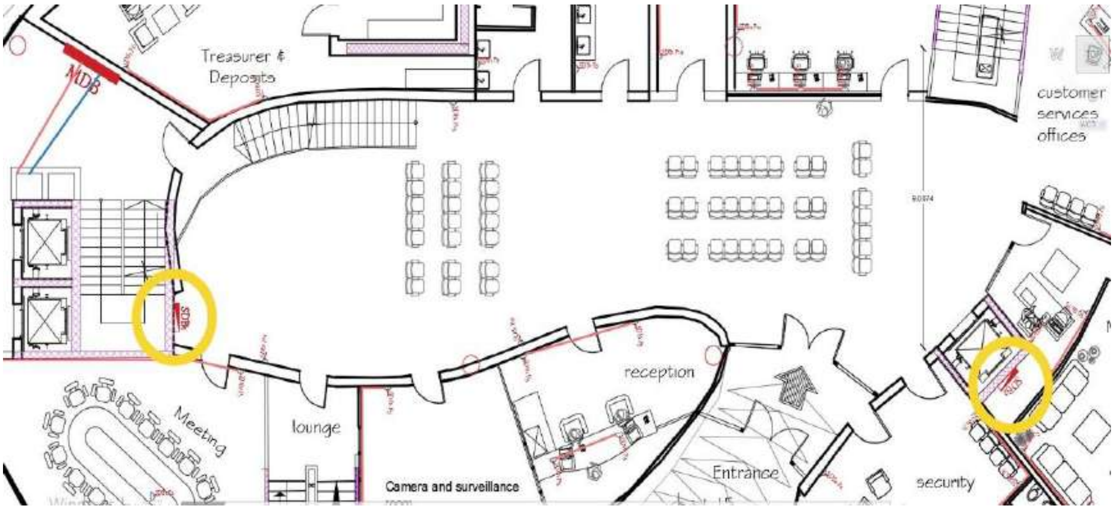


Figure 239 position of the main and branch distribution boards

4.2.3.1 Normal load:

For the normal socket, the maximum distance is 18 m

Resistance = ρ L/A

ρ: Copper resistivity

A: Cross section area of the wire

L: the maximum distance between the socket and D.B

$R = 1.68 *10^{-8} * (18) / (2.5*10^{-6}) = 0.120\ \Omega$

I = power* factor*Voltage = 1500*0.9*220

I = 7.6 Amp

Drop voltage = I × R wire

I: load current

R: wire Resistance

Drop Voltage = 7.6 × 0.120 = 0.912V

Drop Voltage % = 0.912/220 × 100% = 0.00414 % < 2 % … ok

4.2.3.2 : Special load

Resistance = ρ L/A

ρ: copper resistivity

A: Cross section area of the wire

L: the maximum distance between the socket and D.B.

R = 1.68 $*10^{-8}$ * (20) / (2.5$*10^{-6}$) = 0.1344 Ω

The Current for special socket according to the maximum assumed power:

I = power *factor *Voltage= 2000*0.9*220 = 10.1 Amp

Drop voltage = I × R wire

I: load current

R: wire Resistance

Drop voltage = 10.1 *0.1344=1.35V

Drop voltage % = 1.35/220*100% = 0.61% < 2% … ok

4.2.3.3 Light load:

The number of switches, the loads, and the power required for lighting were calculated according to the following tables, depending on the values used in the DIALux programs

1.first floor calculation

Table 83:The power loads for the lighting in the first floor in D.B.1

index	luminous	maintennce factor	connected load (w)	quantity	total power
philps-RC505B	8000	0.8	60	63	3780
LSC86	66	0.8	0.7	10	7
Nano Q100	939	0.8	18	61	1098
total power					4885

Demand factor for light = 0.8

Total power for light= power of light * demand factor

Total power for light= (4885)* (0.8) = 3908W

Socket

#of socket = 17

Demand factor for socket = 0.7

Power socket = 17 *250*0.7 = 2975W

Total power = power light + power socket = 3908 + 2975 = 6883W

Power factor = 0.92 lag for residential

I rated = 6883 / (230* 0.92) = 32.5 A

I c.b = 1.25 * 32.5A

Table 84: Current ratting with cross sectional area that can be used for cables

Nominal cross-sectional area	Single phase current rating	Three phase current rating
mm2	Amp	Amp
1.5	10	14
2.5	16	18
4	28	24
6	36	31
10	50	44
16	66	59
25	88	77
35	109	97
50	131	117
70	167	149
95	202	180
120	234	208

So, circuit breaker of 44 Amp with cross sectional area of 10 mm^2 will be used for D.B.1

Table 85: The power loads for the lighting in the first floor in D.B.2

index	luminous	maintennce factor	connected load (w)	quantity	total power
philps-RC505B	8000	0.8	60	84	5040
LSC86	66	0.8	0.7	25	17.5
Nano Q100	939	0.8	18	0	0
total power					5057.5

Demand factor for light = 0.8

Total power for light= power of light * demand factor

Total power for light= (5057.5)* (0.8) = 4046W

Socket

#of socket = 15

Demand factor for socket = 0.7

Power socket = 15 *250*0.7 = 2625W

Total power = power light + power socket = 4046 + 2625 = 6671W

Power factor = 0.92 lag for residential

I rated = 6671 / (230* 0.92) = 31.5 A

=39.4I c.b = 1.25 * 31.5A

Table 86: Current ratting with cross sectional area that can be used for cables

Nominal cross-sectional area	Single phase current rating	Three phase current rating
mm2	Amp	Amp
1.5	10	14
2.5	16	18
4	28	24
6	36	31
10	50	44
16	66	59
25	88	77
35	109	97
50	131	117
70	167	149
95	202	180
120	234	208

So, circuit breaker of 44 Amp with cross sectional area of 10 mm^2 will be used for D.B.2

2.Ground floor calculation

Table 87: The power loads for the lighting in the Ground floor in D.B.1

index	luminous	maintennce factor	connected load (w)	quantity	total power
philps-RC505B	8000	0.8	60	60	3600
LSC86	66	0.8	0.7	10	7
Nano Q100	939	0.8	18	55	990
total power					4597

Demand factor for light = 0.8

Total power for light= power of light * demand factor

Total power for light= (4597)* (0.8) = 3677W

Socket

#of socket = 15

Demand factor for socket = 0.7

Power socket = 15 *250*0.7 = 2625W

Total power = power light + power socket = 3677 + 2625 = 6302W

Power factor = 0.92 lag for residential

I rated = 6302 / (230* 0.92) = 29.78 A

=37.2I c.b = 1.25 * 29.78A

Table 88: Current ratting with cross sectional area that can be used for cables

Nominal cross-sectional area	Single phase current rating	Three phase current rating
mm2	Amp	Amp
1.5	10	14
2.5	16	18
4	28	24
6	36	31
10	50	44
16	66	59
25	88	77
35	109	97
50	131	117
70	167	149
95	202	180
120	234	208

So, circuit breaker of 44Amp with cross sectional area of 10 mm^2 will be used for D.B.1

Table 89:The power loads for the lighting in the ground floor in D.B.2

index	luminous	maintennce factor	connected load (w)	quantity	total power
philps-RC505B	8000	0.8	60	75	4500
LSC86	66	0.8	0.7	8	5.6
Nano Q100	939	0.8	18	10	180
total power					4685.6

Demand factor for light = 0.8

Total power for light= power of light * demand factor

Total power for light= (4685.6)* (0.8) = 3748.48W

Socket

#of socket = 15

Demand factor for socket = 0.7

Power socket = 15 *250*0.7 = 2625W

Total power = power light + power socket = 3748.48 + 2625 = 6373W

Power factor = 0.92 lag for residential

I rated = 6373 / (230* 0.92) = 2727 A

34.6 =I c.b = 1.25 * 27.7

Table 90: Current ratting with cross sectional area that can be used for cables

Nominal cross-sectional area	Single phase current rating	Three phase current rating
mm2	Amp	Amp
1.5	10	14
2.5	16	18
4	28	24
6	36	31
10	50	44
16	66	59
25	88	77
35	109	97
50	131	117
70	167	149
95	202	180
120	234	208

So, circuit breaker of 44 Amp with cross sectional area of 10 mm^2 will be used for D.B.2

3.First, second and third floor calculation

This floors has a similar area and similar room distribution and has the same internal lighting distribution

Table 91: The power loads for the lighting in the D.B.1 for every floor

index	luminous	maintennce factor	connected load (w)	quantity	total power
philps-RC505B	8000	0.8	60	70	4200
LSC86	66	0.8	0.7	10	7
Nano Q100	939	0.8	18	45	810
total power					5017

Demand factor for light = 0.8

Total power for light= power of light * demand factor

Total power for light= (5017)* (0.8) = 4013.6W

Socket

#of socket = 15

Demand factor for socket = 0.7

Power socket = 15 *250*0.7 = 2625W

Total power = power light + power socket = 4013.6 + 2625 = 6638W

Power factor = 0.92 lag for residential

I rated = 6638 / (230* 0.92) = 28.8 A

36 =I c.b = 1.25 * 28.8A

Table 92: Current ratting with cross sectional area that can be used for cables

Nominal cross-sectional area	Single phase current rating	Three phase current rating
mm2	Amp	Amp
1.5	10	14
2.5	16	18
4	28	24
6	36	31
10	50	44
16	66	59
25	88	77
35	109	97
50	131	117
70	167	149
95	202	180
120	234	208

So, circuit breaker of 44 Amp with cross sectional area of 10 mm^2 will be used for D.B.1

Table 93:The power loads for the lighting in the D.B.2 for every floor

index	luminous	maintennce factor	connected load (w)	quantity	total power
philps-RC505B	8000	0.8	60	68	4080
LSC86	66	0.8	0.7	8	5.6
Nano Q100	939	0.8	18	30	540
total power					5625.6

Demand factor for light = 0.8

Total power for light= power of light * demand factor

Total power for light= (5625.6)* (0.8) = 4500W

Socket

#of socket = 18

Demand factor for socket = 0.7

Power socket = 18 *250*0.7 = 3150W

Total power = power light + power socket = 4500 + 3150 = 7650W

Power factor = 0.92 lag for residential

I rated = 7650 / (230* 0.92) = 2727 A

36.1 =I c.b = 1.25 * 27.7

Table 94: Current ratting with cross sectional area that can be used for cables

Nominal cross-sectional area	Single phase current rating	Three phase current rating
mm2	Amp	Amp
1.5	10	14
2.5	16	18
4	28	24
6	36	31
10	50	44
16	66	59
25	88	77
35	109	97
50	131	117
70	167	149
95	202	180
120	234	208

So, circuit breaker of 44 Amp with cross sectional area of 10 mm^2 will be used for D.B.2

4.Fourth, fifth floor calculation

This floors has a similar area and similar room distribution and has the same internal lighting distribution

Table 95: The power loads for the lighting in the D.B.1 for every floor.

index	luminous	maintenance factor	connected load (w)	quantity	total power
philps-RC505B	8000	0.8	60	80	4800
LSC86	66	0.8	0.7	0	0
Nano Q100	939	0.8	18	20	360
total power					5160

Demand factor for light = 0.8

Total power for light= power of light * demand factor

Total power for light= (5160)* (0.8) = 4128W

Socket

#of socket = 18

Demand factor for socket = 0.7

Power socket = 18 *250*0.7 = 3150W

Total power = power light + power socket = 4128 + 3150 = 7278W

Power factor = 0.92 lag for residential

I rated = 7278 / (230* 0.92) = 34.4 A

43 =I c.b = 1.25 * 28.8A

Table 96: Current ratting with cross sectional area that can be used for cables

Nominal cross-sectional area	Single phase current rating	Three phase current rating
mm2	Amp	Amp
1.5	10	14
2.5	16	18
4	28	24
6	36	31
10	50	44
16	66	59
25	88	77
35	109	97
50	131	117
70	167	149
95	202	180
120	234	208

So, circuit breaker of 44 Amp with cross sectional area of 10 mm^2 will be used for D.B.1

5. First and second basement floors (parking) calculation

This floors has a similar area and similar room distribution and has the same internal lighting distribution .

Table 97: The power loads for the lighting in the D.B.1 for every floor.

index	luminous	maintennce factor	connected load (w)	quantity	total power
philps-RC505B	8000	0.8	60	90	5400
LSC86	66	0.8	0.7	0	0
Nano Q100	939	0.8	18	10	180
total power					5580

Demand factor for light = 0.8

Total power for light= power of light * demand factor

Total power for light= (5580)* (0.8) = 4464W

Socket

#of socket = 5

Demand factor for socket = 0.7

Power socket = 5 *250*0.7 = 875W

Total power = power light + power socket = 4464 + 875 = 5339W

Power factor = 0.92 lag for residential

I rated = 5339 / (230* 0.92) = 25.5 A

31.5 =I c.b = 1.25 * 25.5A

Table 98: Current ratting with cross sectional area that can be used for cables

Nominal cross-sectional area	Single phase current rating	Three phase current rating
mm2	Amp	Amp
1.5	10	14
2.5	16	18
4	28	24
6	36	31
10	50	44
16	66	59
25	88	77
35	109	97
50	131	117
70	167	149
95	202	180
120	234	208

So, circuit breaker of 44 Amp with cross sectional area of 10 mm^2 will be used for D.B.1

Table 99: The power loads for the lighting in the D.B.2 for every floor

index	luminous	maintenance factor	connected load (w)	quantity	total power
philps-RC505B	8000	0.8	60	85	5100
LSC86	66	0.8	0.7	0	0
Nano Q100	939	0.8	18	10	180
total power					5280

Demand factor for light = 0.8

Total power for light= power of light * demand factor

Total power for light= (5280)* (0.8) = 4080W

Socket

#of socket = 7

Demand factor for socket = 0.7

Power socket = 7 *250*0.7 = 1225W

Total power = power light + power socket = 4080 + 1225 = 5305W

Power factor = 0.92 lag for residential

I rated = 5305 / (230* 0.92) = 25A

31.33 =I c.b = 1.25 * 25

Table 100: Current ratting with cross sectional area that can be used for cables

Nominal cross-sectional area	Single phase current rating	Three phase current rating
mm2	Amp	Amp
1.5	10	14
2.5	16	18
4	28	24
6	36	31
10	50	44
16	66	59
25	88	77
35	109	97
50	131	117
70	167	149
95	202	180
120	234	208

So, circuit breaker of 44Amp with cross sectional area of 10 mm^2 will be used for D.B.2

4.2.3.4: Main distribution board

Total power = total power DB1+ total power DB2……..(for all floors)

Total power = 83192.4W

(3phase system)

I rated = 83192.4/ (3^0.5 *400* 0.92) = 130.5 A

I c.b = 1.25 * 130.5 A

I c.b = 163.1 A

So Ic.b = 3*400A

Cable = 5*240mm^2

175

The power of elevator is = 6700 watt

I rated = 6700 / (3^0.5 *400 * 0.85) = 11.377A

I c.b= 1.25 * 11.377 A

I c.b =14.22A

4.2.3.4 Chiller

calculate the power of chiller:

I rated =83192.4/ (3^0.5 *400 *0.85) =130.5 A

I c.b = 1.25 *130.5 A=163.1A

Table 101 : summary of energy calculation.

	Bank	Total power	I load	IC.B	I cable	C.B	Cable
3phases	M.D.B	83192.4	130.5	163.1	230	250	$125mm^2$

4.3 Mechanical design

The mechanical aspect is an important aspect in the design of any building, which includes water supply system, drainage system, HVAC system, safety and security system (firefighting system), elevator system.

4.3.1 Water supply design:

4.3.1.2 Introduction:

Water supply design is a critical component of building design, ensuring that buildings have access to clean and reliable water .the design of a water supply system involves the selection and sizing of pipes ,pumps, and other components to ensure that water is delivered to all parts of the building in sufficient quantity and with adequate pressure.

4.3.1.3 Pipe design:

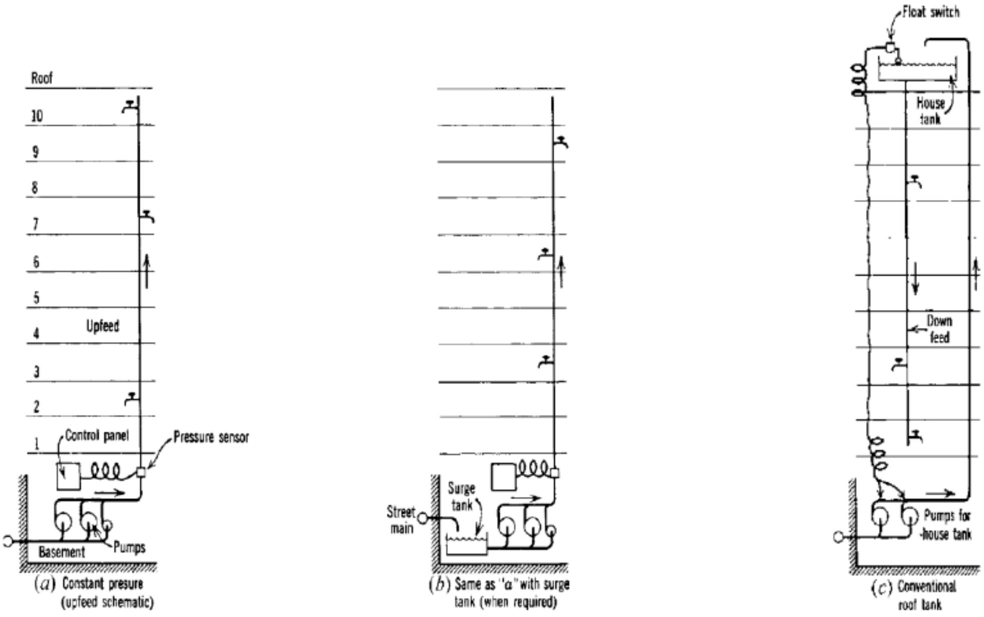


Figure 240:water supply

for water supply we used roof tank (type c) with pump system in floor GF and F1.

Table 102:water supply units (Grondizk et al, 2010)

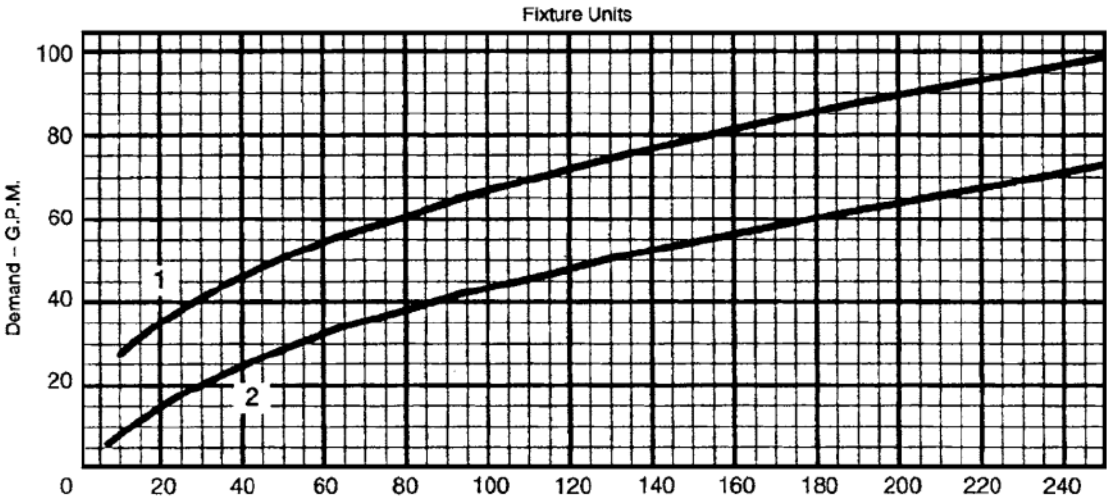
TABLE 21.15 Water Supply Fixture Units (WSFU)

Fixture	Occupancy	Type of Supply Control	Load Values in WSFU		
			Cold	Hot	Total
Bathroom group	Private	Flush tank	2.7	1.5	3.6
Bathroom group	Private	Flush valve	6	3	8
Bathtub	Private	Faucet	1	1	1.4
Bathtub	Public	Faucet	3	3	4
Bidet	Private	Faucet	1.5	1.5	2
Combination fixture	Private	Faucet	2.25	2.25	3
Dishwashing machine	Private	Automatic		1.4	1.4
Drinking fountain	Offices, etc.	⅜ in. (9.5 mm) valve	0.25		0.25
Kitchen sink	Private	Faucet	1	1	1.4
Kitchen sink	Hotel, restaurant	Faucet	3	3	4
Laundry trays (1 to 3)	Private	Faucet	1	1	1.4
Lavatory	Private	Faucet	0.5	0.5	0.7
Lavatory	Public	Faucet	1.5	1.5	2
Service sink	Offices, etc.	Faucet	2.25	2.25	3
Shower head	Public	Mixing valve	3	3	4
Shower head	Private	Mixing valve	1	1	1.4
Urinal	Public	1 in. (25 mm) flush valve	10		10
Urinal	Public	¾ in. (19 mm) flush valve	5		5
Urinal	Public	Flush tank	3		3
Washing machine, 8 lb (3.6 kg)	Private	Automatic	1	1	1.4
Washing machine, 8 lb (3.6 kg)	Public	Automatic	2.25	2.25	3
Washing machine, 15 lb (6.8 kg)	Public	Automatic	3	3	4
Water closet	Private	Flush valve	6		6
Water closet	Private	Flush tank	2.2		2.2
Water closet	Public	Flush valve	10		10
Water closet	Public	Flush tank	5		5
Water closet	Public or private	Flushometer tank	2		2

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

Table 103:pressure for fixture served. (Grondizk et al, 2010)

Fixture Served	Minimum Flow Rate gpm (L/s)[a]	Minimum Pressure psi (kPa)[b]	Maximum Flow Rate or Quantity
Bathtub	4 (0.25)	8 (55)	
Bidet	2 (0.13)	4 (28)	
Combination fixture	4 (0.25)	8 (55)	
Dishwasher, residential	2.75 (0.17)	8 (55)	
Drinking fountain	0.75 (0.05)	8 (55)	
Hose bibb	5 (0.32)	8 (55)	
Laundry tray	4 (0.25)	8 (55)	
Lavatory, private	2 (0.13)	8 (55)	2.5 gpm at 80 psi (0.16 L/s at 551 kPa)
Lavatory, public	2 (0.13)	8 (55)	0.5 gpm at 80 psi (0.03 L/s at 551 kPa)
Lavatory, public, metering or self-closing	2 (0.13)	8 (55)	0.25 gallon (0.95 L) per metering cycle
Shower head	3 (0.19)	8 (55)	2.5 gpm at 80 psi (0.16 L/s at 551 kPa)
Shower head, temperature controlled	3 (0.19)	20 (138)	2.5 gpm at 80 psi (0.16 L/s at 551 kPa)
Sink, residential	2.5 (0.16)	8 (55)	2.5 gpm at 60 psi (0.16 L/s at 414 kPa)
Sink, service	3 (0.19)	8 (55)	2.5 gpm at 60 psi (0.16 L/s at 414 kPa)
Urinal, valve	15 (0.95)	15 (103)	1.5 gallons (5.7 L) per flushing cycle[a] or 1.0 gallon (3.8 L) per flushing cycle
Water closet, blow out, flushometer valve	35 (2.21)	25 (172)	4 gallons (15 L) per flushing cycle
Water closet, siphonic, flushometer valve	25 (1.58)	15 (103)	4 gallons (15 L) per flushing cycle[a] or 1.6 gallons (6 L) per flushing cycle
Water closet, tank, close coupled	3 (0.19)	8 (55)	1.6 gallons (6 L) per flushing cycle
Water closet, tank, one piece	6 (0.38)	20 (138)	1.6 gallons (6 L) per flushing cycle



(*a*)

Figure 241:fixture units /demand-G.P.M. (Grondizk et al, 2010)

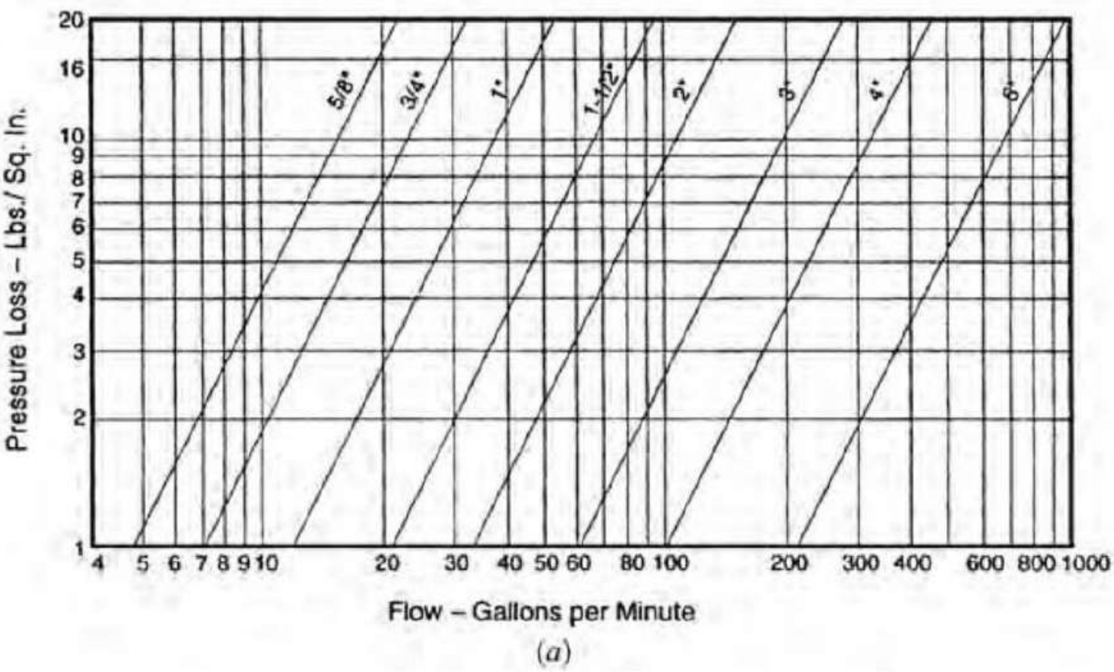


Figure 242:flow/pressure loss (Grondizk et al, 2010)

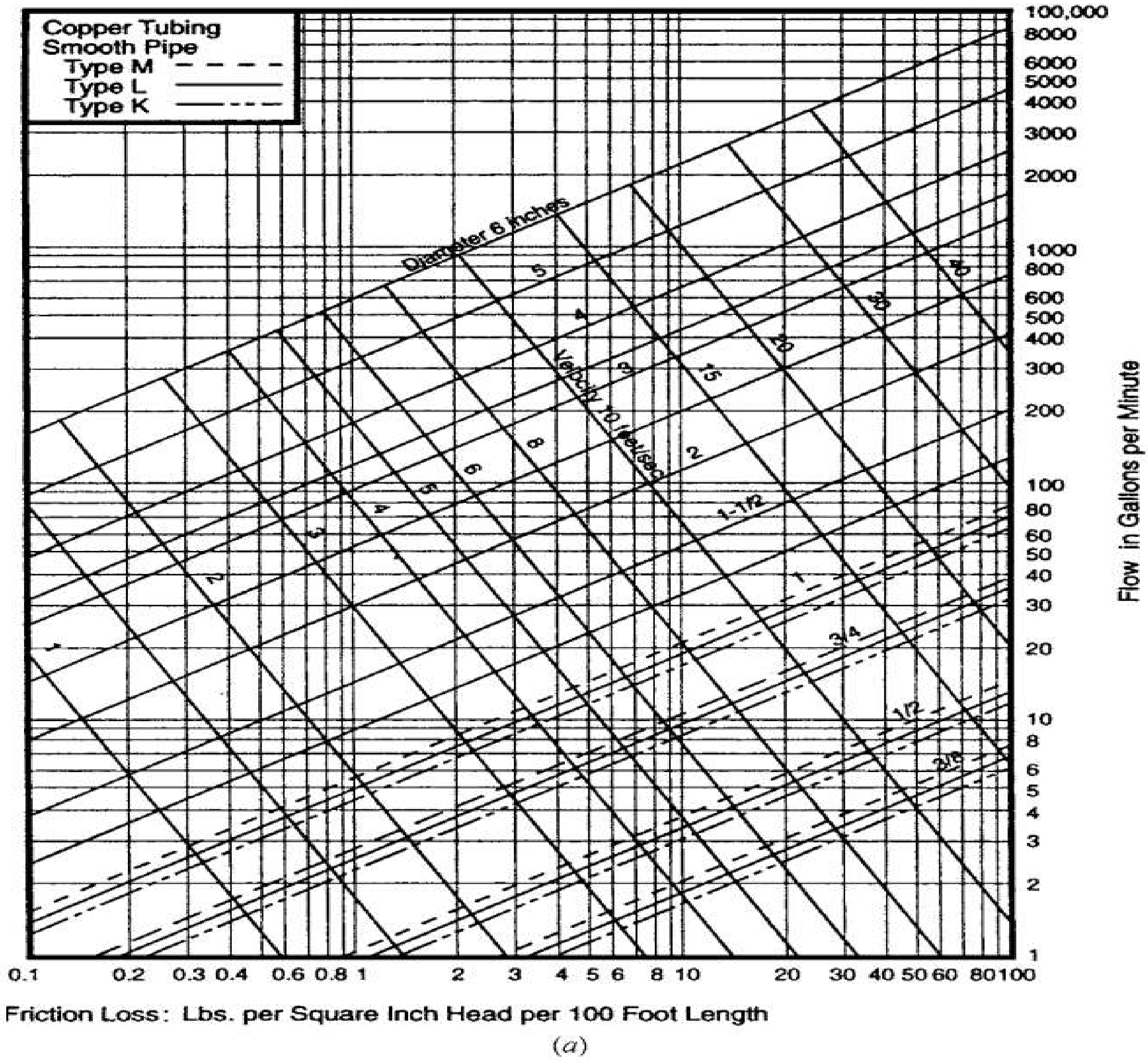


Figure 243:flow/pressure loss (Grondizk et al, 2010)

1. Design pipes size

Weight in fixture units :

Fixture sink (lavatory)=2 units.

Water closet (flush tank) = 5 units.

Table 104:Weight in fixture units

floor	Fixture sink (lavatory)	Water closet (flush tank)	weigh in fixture unit
gf	4	4	28
f1	4	4	28
f2	4	6	38
f3	4	6	38
f4	2	3	19
f5	4	5	33
f6	4	4	28
sum			212

2. Pressure calculations:

P =0.433 *h (cumulative height of floors in feet)

H tank =8 ft

h floor = 11.48

Number of floor =7 floor

Table 105:Pressure calculations

floor	h floor	(Cumulative height of floors in feet)	pressure	weigh in fixture unit
gf	11.48	80.36	34.80	28
f1	11.48	68.88	29.83	28
f2	11.48	57.4	24.85	38
f3	11.48	45.92	19.88	38
f4	11.48	34.44	14.91	19
f5	11.48	22.96	9.94	33
f6	11.48	11.48	4.97	28

3. Design vertical pipes :

Type :steel pipes.

Total weigh in fixture unit=212 unite

Flow =67gpm

Actual length =83.36 ft

Equivalent length = 129.54 ft

Table 106:Design vertical pipes

Dim	3	2	1.5
loss/100ft	1.3	4.9	12.5
loss/eq. length	1.68	6.35	16.19

4. Design for horizontal pipes:

Table 107:Design for horizontal pipes

floor	weigh in fixture unit	flow	Actual length ft	Equivalent length ft
gf	28	19	34.83	41.80
f1	28	19	35.49	42.59
f2	38	23	39.36	47.23
f3	38	23	40.02	48.02
f4	19	14	37.69	45.22
f5	33	21	37.88	45.46
f6	28	19	30.96	37.16

Fraction loss each dimeter for Gf:

Table 108:Fraction loss each dimeter for Gf

Dim	3	2.5	2	1.5	1.25	1
loss/100ft	0	0.19	0.6	2.4	5.9	23
loss/eq. length	0.00	0.08	0.25	1.00	2.47	9.61

Fraction loss each dimeter for F1:

Table 109:Fraction loss each dimeter for F1

Dim	3	2.5	2	1.5	1.25	1
loss/100ft	0	0.19	0.6	2.4	5.9	23
loss/eq. length	0.00	0.08	0.26	1.02	2.51	9.80

Fraction loss each dimeter for F2:

Table 110:Fraction loss each dimeter for f2.

Dim	3	2.5	2	1.5	1.25	1
loss/100ft	0.12	0.27	0.8	3	8	23
loss/eq. length	0.06	0.13	0.38	1.42	3.78	10.86

Fraction loss each dimeter for F3:

Table 111:Fraction loss each dimeter for f3

Dim	3	2.5	2	1.5	1.25	1
loss/100ft	0.12	0.27	0.8	3	8	23
loss/eq. length	0.06	0.13	0.38	1.44	3.84	11.05

Fraction loss each dimeter for F4:

Table 112:Fraction loss each dimeter for f4.

Dim	3	2.5	2	1.5	1.25	1
loss/100ft	0	0.12	0.37	1.4	3.5	10
loss/eq. length	0.00	0.05	0.17	0.63	1.58	4.52

Fraction loss each dimeter for F5:

Table 113:Fraction loss each dimeter for f5

Dim	3	2.5	2	1.5	1.25	1
loss/100ft	0	0.22	0.72	3	8	20
loss/eq. length	0.00	0.10	0.33	1.36	3.64	9.09

Fraction loss each dimeter for F6:

Table 114:Fraction loss each dimeter for f6

Dim	3	2.5	2	1.5	1.25	1
loss/100ft	0	0.19	0.6	2.4	5.9	23
loss/eq. length	0.00	0.09	0.27	1.09	2.68	10.45

5. Design branch pipes:

Type :pvc pipes.

Total weigh in fixture unit=5 unite

Flow =5gpm

Actual length =25 ft

Equivalent length = 30 ft

Table 115:Design branch pipes.

Dim	1.5	1.25	1	0.75	0.5
loss/100"	0.19	0.5	1.4	5.6	40
loss/eq. length	0.057	0.15	0.42	1.68	12

Pipes size for all floors:

Table 116:Pipes size for all floors.

floor	vertical design		horizontal design		branch design		total loss	NACHRAL pressure	actual pressure	check pump
	steel pipes dimeter	loss/eq. length	PVC pipes dimeter	loss/eq. length	PVC pipes dimeter	loss/eq. length				
GF	2	6.35	1	9.61	(3/4)	1.68	17.64	34.8	17.16	not need pump
f1	2	6.35	1	9.8	(3/4)	1.68	17.83	29.83	12	not need pump
f2	2	6.35	1.25	3.78	(3/4)	1.68	11.81	24.85	13.04	not need pump
f3	3	1.68	1.25	3.84	(3/4)	1.68	7.2	19.88	12.68	not need pump
f4	3	1.68	1.25	1.58	(3/4)	1.68	4.94	14.91	9.97	not need pump

f5	3	1.68	1.5	0.33	(3/4)	1.68	3.69	9.94	6.25	need pump
f6	3	1.68	1.5	1.09	(3/4)	1.68	4.45	4.97	0.52	need pump

4.3.1.4 Tank sizing calculation:

60 liter /person needed in building

In building 370 person

There size of tank = 370*60 =22200 liter =22.2 m3

We used tank 2m3 Size.

So we need 12 tank size 2m3.

The following figures show Water supply plan:

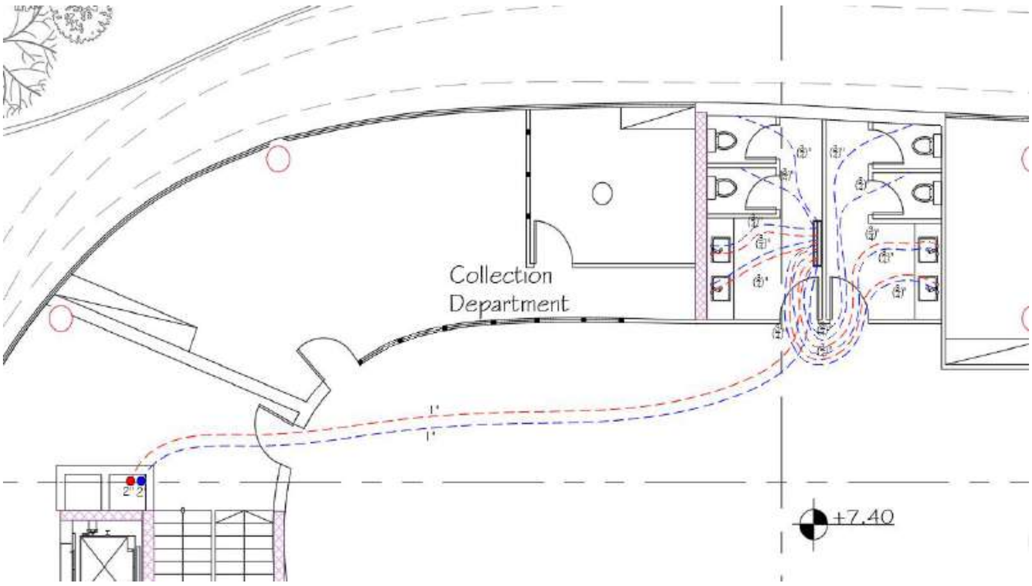


Figure 244:Water supply plan

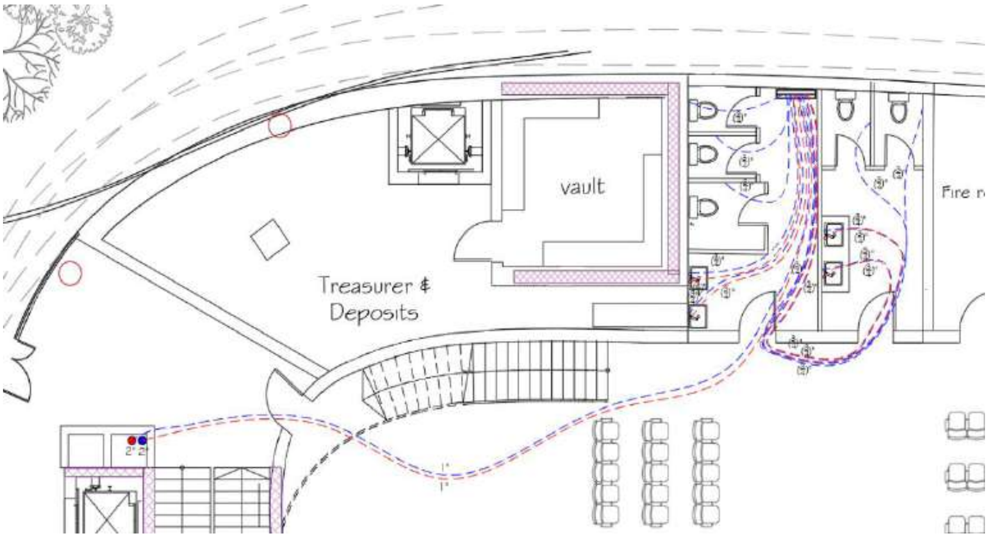


Figure 245:Water supply in first floor

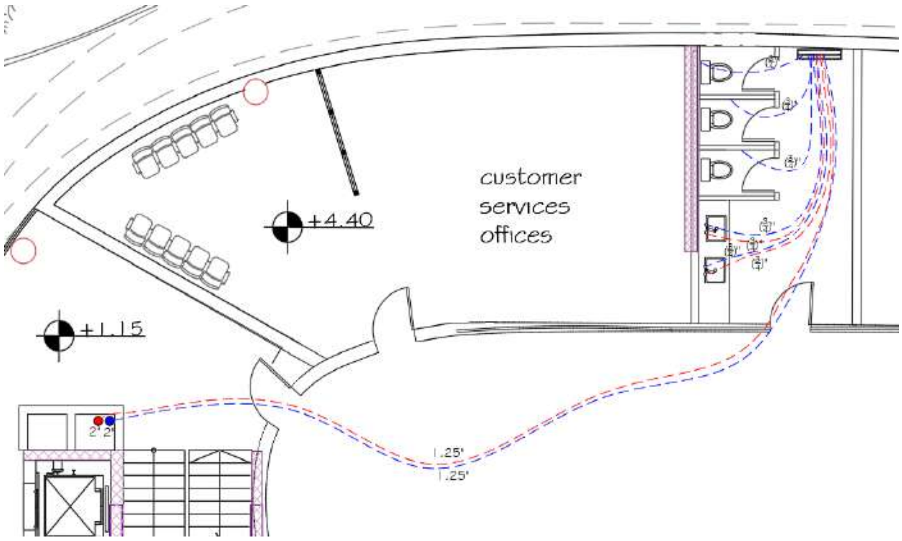


Figure 246:Water supply in 2^{nd} floor

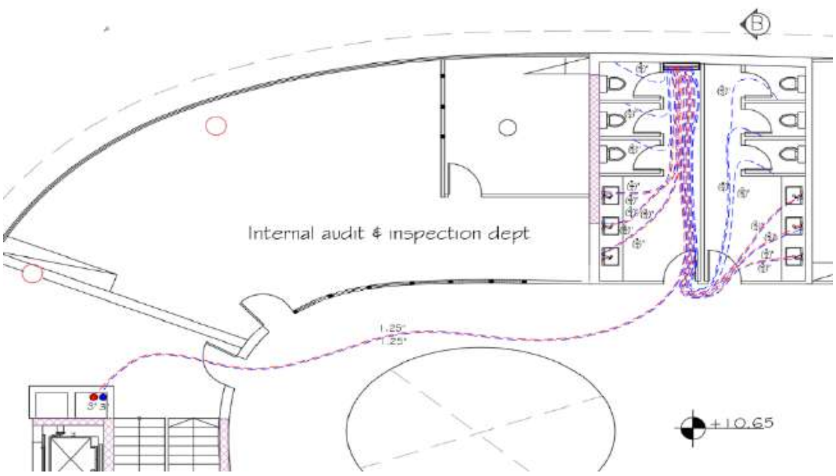


Figure 247:Water supply in 3^{rd} floor

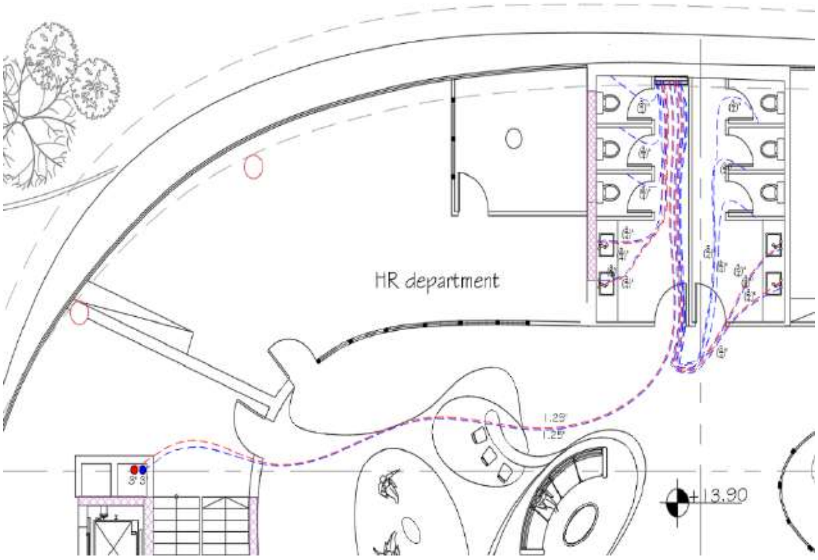


Figure 248:Water supply in 4th floor

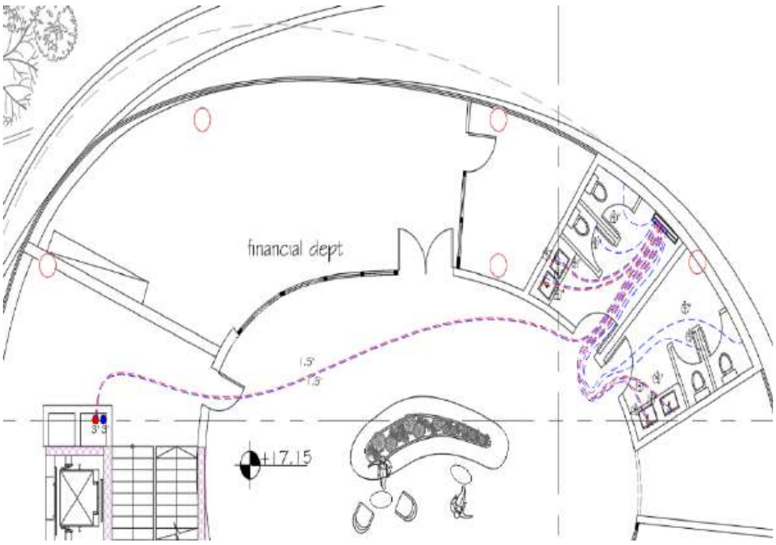


Figure 249:Water supply in 5th floor

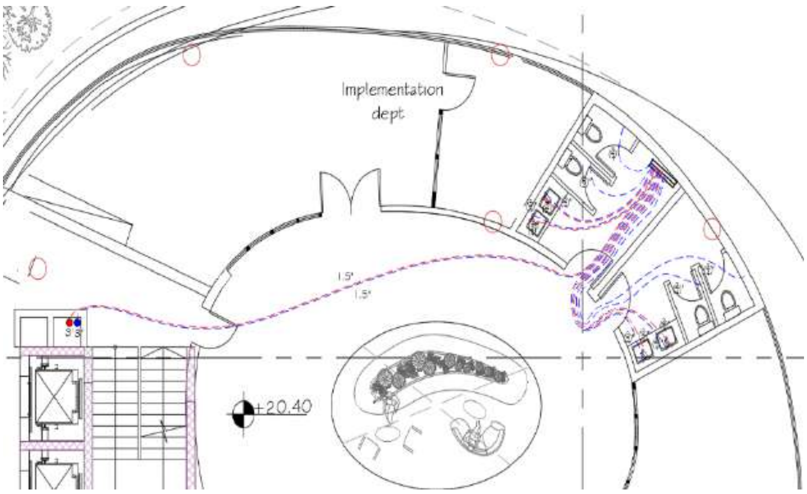


Figure 250:Water supply in 6th floor

4.4 Drainage system:

The sewage system is one of the most important systems that must be designed in any building, as it transports liquid waste from the building and disposes of it properly to the public sewage lines through special pipes

After completing the design of the toilets, the sewage system was designed according to the following specifications and tables

Table 117 : drainage fixture units (Grondizk et al, 2010)

Fixture(s)	Drainage Fixture Units (dfu)	*Minimum Trap Size* in.	mm[a]
Automatic clothes washers: Commercial[b]	3	2	51
Residential	2	2	51
Bathroom group: Water closet (1.6 gpf [6 Lpf]), lavatory, and bathtub or shower; with or without a bidet and emergency floor drain	5	—	—
Bathroom group: Water closet (>1.6 gpf [6 Lpf]), lavatory, and bathtub or shower; with or without a bidet and emergency floor drain	6	—	—
Bathtub[c] (with or without overhead shower or whirlpool	2	1½	38
Bidet	1	1¼	32
Combination sink and tray	2	1½	38
Dental lavatory	1	1¼	32
Dental unit or cuspidor	1	1¼	32
Dishwashing machine[d], domestic	2	1½	38
Drinking fountain	0.5	1¼	32
Emergency floor drain	0	2	51
Floor drains	2	2	51
Kitchen sink, domestic	2	1½	38
Kitchen sink, domestic, with food waste grinder and/or dishwasher	2	1½	38
Laundry tray (1 or 2 compartments)	2	1½	38
Lavatory	1	1¼	32
Shower	2	1½	38
Service sink	2	1½	38
Sink	2	1½	38
Urinal	4	[e]	
Urinal, 1 gal (3.8 L) per flush or less	2[f]	[e]	
Urinal, nonwater supplied	0.5	[e]	
Wash sink (circular or multiple) each set of faucets	2	1½	38
Water closet, flushometer tank, public or private	4[f]	[e]	
Water closet, private (1.6 gpf [6 Lpf])	3[f]	[e]	
Water closet, private (>1.6 gpf [6 Lpf])	4[f]	[e]	
Water closet, public (1.6 gpf [6 Lpf])	4[f]	[e]	
Water closet, public (flushing >1.6 gpf [6 Lpf])	6[f]	[e]	

Table 118 : size of building drains and sewers (Grondizk et al, 2010)

Diameter of Pipe		*Maximum Number of dfu Connected to Any Portion of the Building Drain or Building Sewer, Including Branches of the Building Drain[a] Fall, in. per ft (% slope)*			
in.	mm[b]	1/16 (0.5%)	⅛ (1.04%)	¼ (2.1%)	½ (4.2%)
2	51			21	26
2½	64			24	31
3	76		36	42	50
4	102		180	216	250
5	127		390	480	575
6	152		700	840	1000
8	203	1400	1600	1920	2300
10	254	2500	2900	3500	4200
12	305	3900	4600	5600	6700
15	381	7000	8300	10,000	12,000

Table 119 : diameter of horizontal pipes (Grondizk et al, 2010)

Diameter of Pipe			Maximum Total Number of dfu Allowable		
			Stacks[b]		
in.	mm[c]	Horizontal Branch	One Branch Interval	Three Branch Intervals or Less	Greater than Three Branch Intervals
1½	38	3	2	4	8
2	51	6	6	10	24
2½	64	12	9	20	42
3	76	20	20	48	72
4	102	160	90	240	500
5	127	360	200	540	1100
6	152	620	350	960	1900
8	203	1400	600	2200	3600
10	254	2500	1000	3800	5600
12	305	3900	1500	6000	8400
15	381	7000	d	d	d

Table 120: Summary for diameter and pipe slope

Type of pipe	Diameter	slope
Vertical vent	4in	0%
Vertical stack	4in	0%
Horizontal sewers	4in , 2in	0.15%
branches	4in	0.15%
Horizontal drain	4in	0.15%

Sample of calculation:

Max dfu for 2 inch =21 dfu with slope 1.5%

Max dfu for 4 inch =180 dfu with slope 1.5%

The following shows the distribution of all points and then gives each pipe its diameter by dfu per unit:

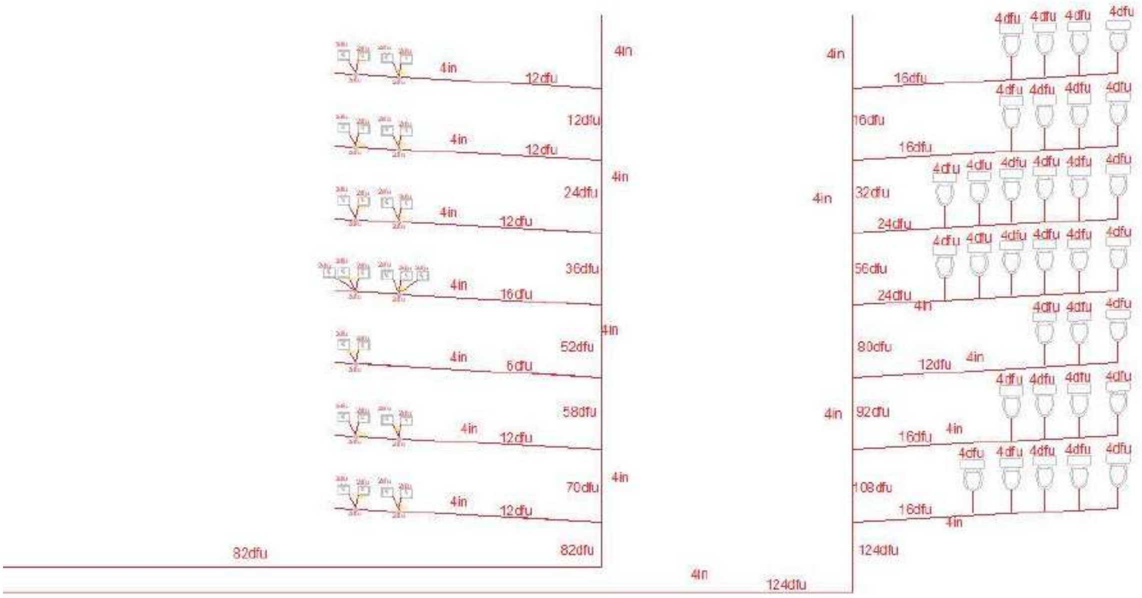


Figure 251 :dfu per unit for building

Figure 252: water drain system for building

The following figure show Water drain plan in Ground floor distribution

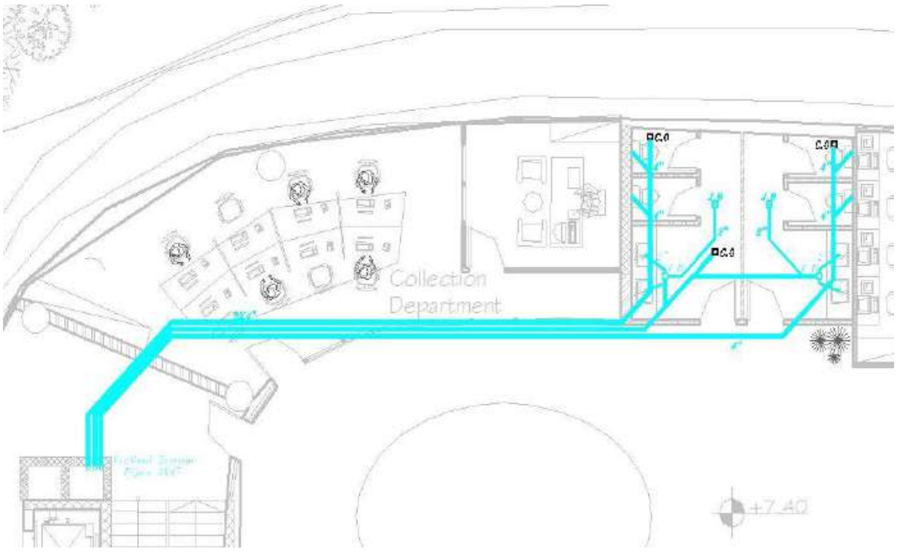


Figure 253: Ground floor distribution

4.4.1 Rain water drainage

The rainwater drainage system is designed to collect rainwater in a tank under the building instead of draining it into the public sewage network to save the building's water consumption bill, as it can be used in clearing operations and for outdoor gardens, and it can be considered as a reserve for the tanks of the fire extinguishing system.

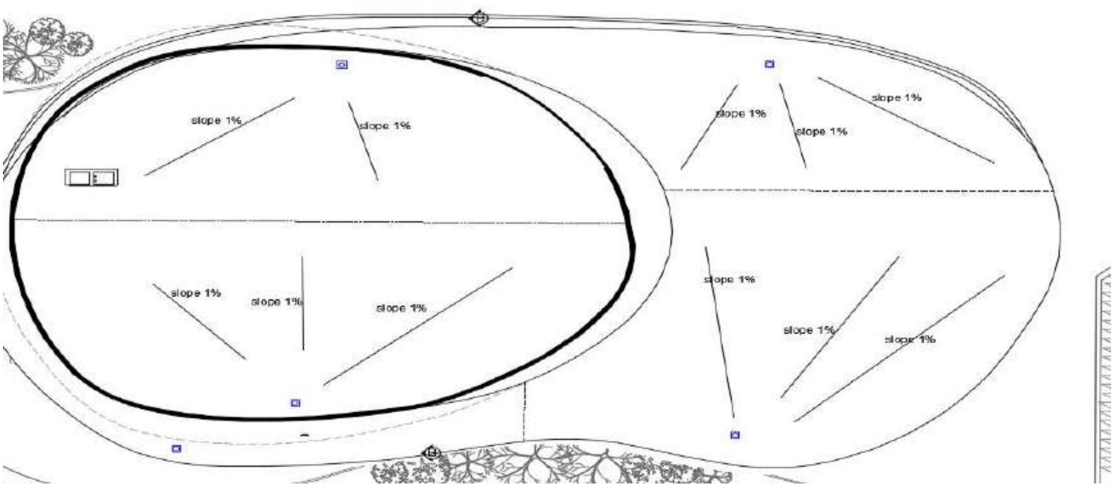


Figure 254: Rainwater plane for the roof

4.4.2 Design Water tank for daily use.

To calculate the volume and dimensions of the water tank at the beginning, calculated the

Volume of water inside the tank based on the following assumptions:

1. Number of people includes employees=50 and visitors = 270 peoples.

2. employee consumption per day = 15 liters,

3. Number of days of storage = 4 days

The volume of water inside the tank = 50*15*4+270*5*4 =8400 liter/ 1000 = 8.4 m3

The volume of rainwater collected in the tank = 200 m3

Figure 255: Rainwater tank

4.5 Fire system:

4.5.1 Introduction:

The specifications in modern buildings stipulate the need for fire-fighting systems and stairs to escape in the event of a fire or any problem in the building.

In the bank building that we worked on, we designed a fire-fighting system and an escape staircase according to civil defense and international specifications

The following were used in the design of the bank's fire extinguishing system fire extinguishers inside rooms, offices and corridors and Fire hose stations in corridors and Sprinkler system inside corridors and parking

The firefighting system, which was designed, contains sensors for heat and smoke, in addition to alarm devices, loudspeakers, and warning signs in cases of evacuation.

Detection and alarm system from (Palestinian code): It is an audible, visual or signal indicating the outbreak of a fire or emergency that requires the exit of the building's occupants and a quick response from the civil defense agencies.

4.5.2 Firefighting systems design:

According to the specifications of the civil defense, the bank building is classified as (D) in terms of the number of people and the severity. According to the standard, the building is provided with manual fire extinguishing equipment, in addition to sprinklers in dangerous areas such as kitchens.

The bank's firefighting system contains several equipment such as:

1. Water sprinklers system
2. Fire extinguishers
3. Fire hose stations
4. Sprinkler system
5. Pipes
6. Electrical pump
7. Water tank
8. conventional fire-detection control pane

Table121 : selection chart for fire extinguishers.

	Class A Flammable Materials (eg: paper & wood)	Class B Flammable Liquids (eg: paint & petrol)	Class C Flammable Gases (eg: butane & methane)	Class D Flammable Metals (eg: lithium & potassium)	Class E Electrical Equipment (eg: computers & generators)	Class F Cooking Fats and Oils (eg: fryers & chip pans)
Water	✓	✗	✗	✗	✗	✗
Dry Chemical Powder ABE	✓	✓	✗	✗	✓	✗
Dry Chemical Powder BE	✗	✓	✗	✗	✓	limited ✓
Carbon Dioxide CO2	limited ✓	limited ✓	✗	✗	✓	✗
Foam	✓	✓	✗	✗	✗	limited ✓
Wet Chemical	✓	✗	✗	✗	✗	✓

A dry fire extinguisher was used for every 10 meters in the corridors that comply with the specifications of the civil defense for fire fighting .

Figure256 : Fire extinguisher

4.5.2.1 Fire hose stations:

A system of hoses is used in large areas and is usually used after the evacuation of the building by civil defense personnel

Figure 257: Fire hose

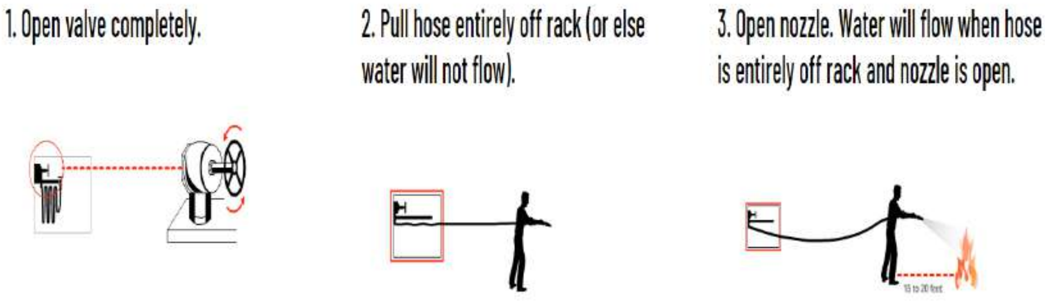


Figure258 : how to use Fire hose

The Fire hose system was designed in waiting room in every floor Contains two Fire hose distributed according to the specifications of the Civil Defense

Figure259 : Fire hose in first.

4.5.2.2 Sprinkler system:

Dry-type fire extinguishing sprinklers were used in the waiting halls, where each sprinkler covers an area of 12 square meter It was selected by the company Ever safe fire safety

Table122 catalogue for fire Sprinkler system [10]

Sprinkler Type	Conventional	Pendent		Upright		Horizontal Sidewall	
SIN	ET401	ET301	ET302	ET201	ET202	ET101	ET102
Response Type	SR	SR	QR	SR	QR	SR	QR
Temp. Rating	135°F (57°C) / 155°F (68°C) / 175°F (79°C) / 200°F (93°C) / 286°F (141°C)						
K Factor	5.6						
Min. Working Pressure	7 PSI (0.5 bar)						
Max. Working Pressure	175 PSI (12 bar)						
Nominal Thread Size	1/2" NPT and 1/2" BSPT						
Finishing	Brass or Chrome Plated or White Plated						
Manufactured & Certified to	UL 199						

Table 123: The area covered by each sprinkler

Hazard level	Coverage area	Maximum distance between sprinklers
Light or low hazard	18 m^2 up to 20 m^2	4.5 m
Medium ordinary hazard	12 m^2	4.5 m
High hazard	9 m^2	3.6 m

Table 124: number of sprinkler for every floor

floor	Number of sprinkler/ m^2	Area m^2	Number of sprinkler
Ground floor	12	250	21
First floor	12	250	21
Second floor	12	250	21
Third floor	12	250	21
Fourth floor	12	250	21
Fifth floor	12	125	11
Sixth fioor	12	125	11
Basement 1	12	2100	175
Basement2	12	2100	175

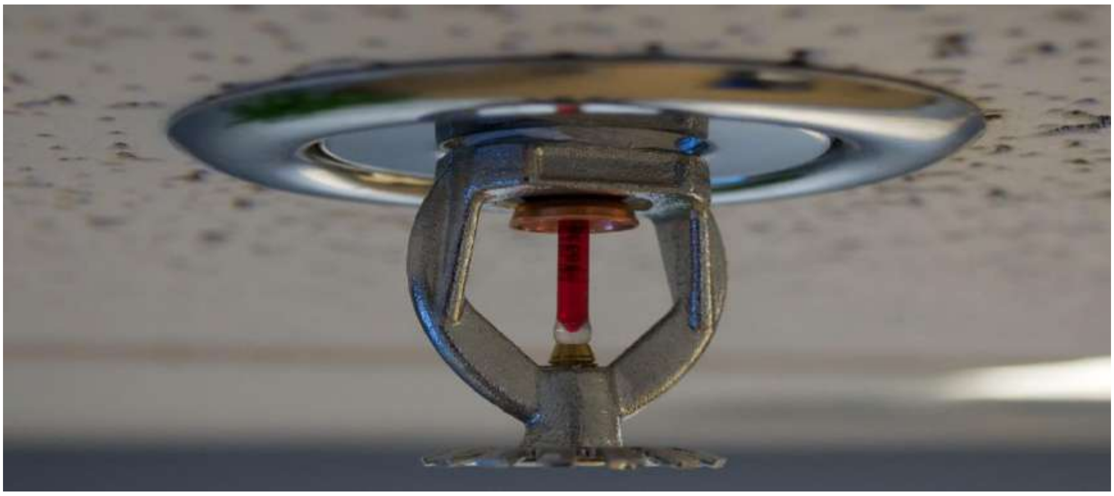


Figure 260: Fire sprinkler

To see the distribution of Sprinkler, see the appendix

4.5.2.3Pipes:

In the fire extinguishing networks, steel pipes to connect between the tank and each floor and the sprinklers

The following table shows the diameters of the pipes that must be used according to the specifications of the civil defense. Pipes of diameter (3.5 in) were used to connect between floors, and pipes of diameter (2.5in) were used to reach sprinklers horizontally inside each floor.

Table125 : Pipes design for fire system

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

4.5.2.4 Water tank

6water tanks were used, each tank with a capacity of 2000 liters on the roof of the building to supply the firefighting system with water, in addition to connecting the tanks with the rain water tank located under the building to supply them with water in the event of a shortage of water, in addition to extending a water hose outside the building so that the system is supplied with water through fire trucks and Civil Defense

4.5.2.5Emergency Lighting and signs:

Signs must be placed inside the building, whether electronic or written, to show the way to the escape exits and to evacuate the building in the event of a fire, because the visitors of the building do not clearly know the entrances and exits of the building.

Figure261 : Fire alarm system

Figure262 : Exit sign

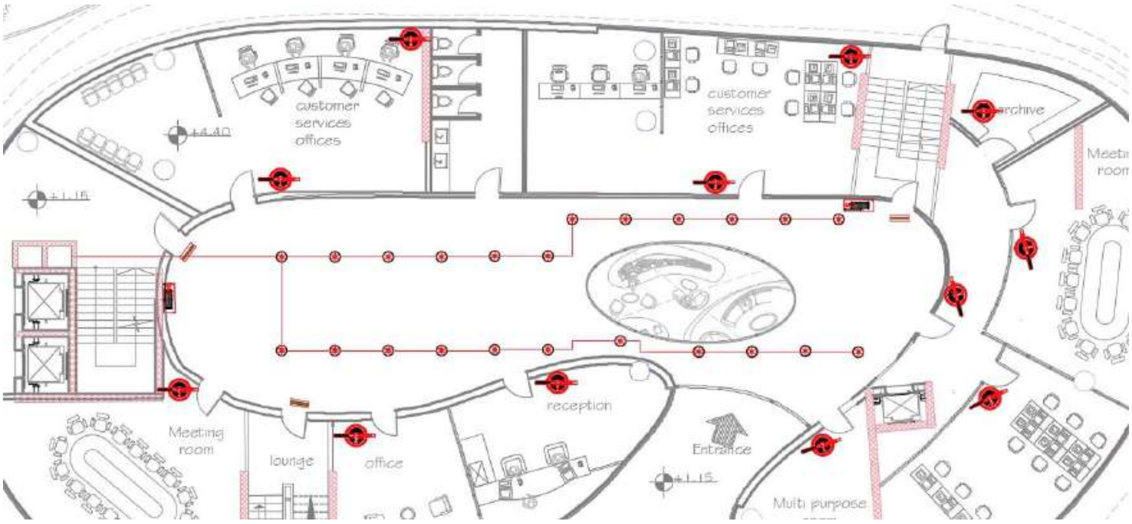


Figure263 : Fire system in first floor

4.6 Acoustical design

The acoustical design of a building is one of the most crucial components to achieving comfort since it minimizes noise inside the rooms and outside the structure.

4.6.1 Architectural side:

4.6.1.1 Reverberation time (RT60)

Ease program will used to calculate RT60 and it's depended on the volume of the space

And the absorption coefficient for finish material.

The table below shows the standard for each space of RT60:

Table 126 : Standard of RT60

	Recommended reverberation time, RT (sec)	Satisfactory design sound level, dB (A)
Call centres, open office	0.1 to 0.4	40
General office	0.4 to 0.6	40
Private office	0.6 to 0.8	35
Meeting/quiet rooms	0.4 to 0.6	35

Material used for spaces as shown below:

Gypsum board for ceiling

Marble for floor

Argon glass

Hard wood for door

For rooms:

Meeting room :

The figure below shows the results of meeting room in ease program

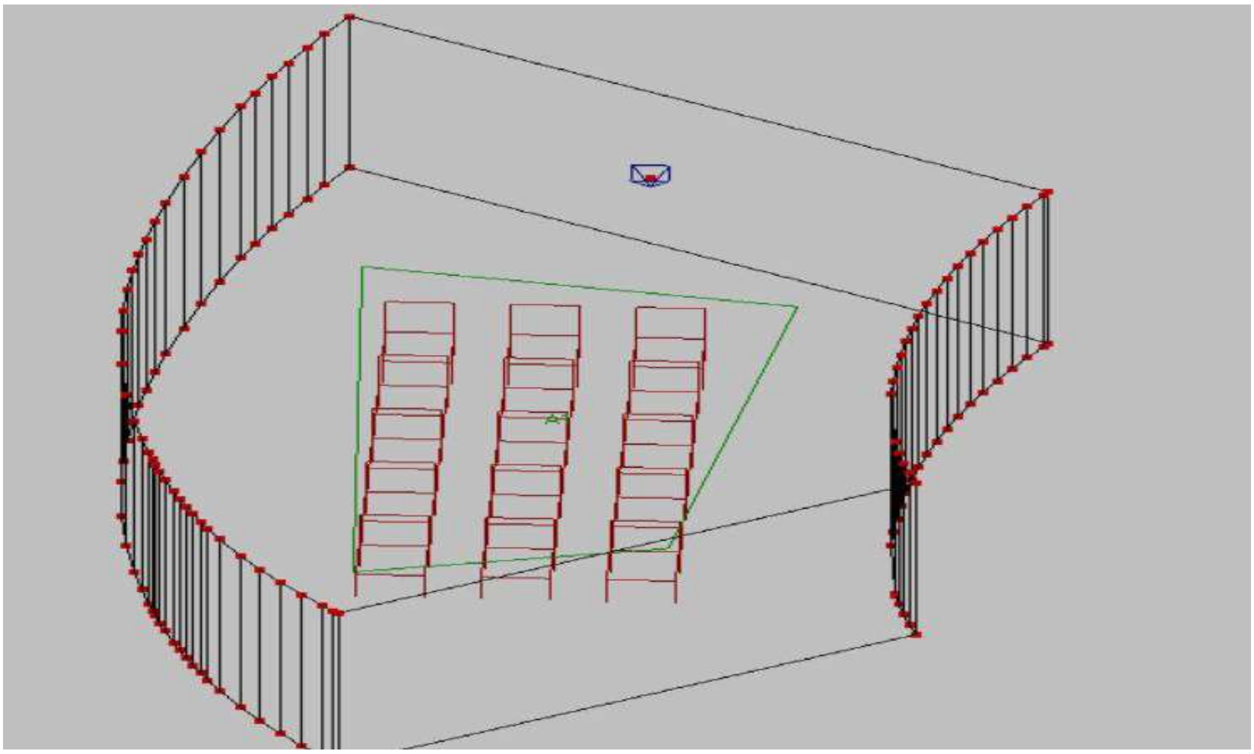


Figure 264: 3D view for meeting room in ease program.

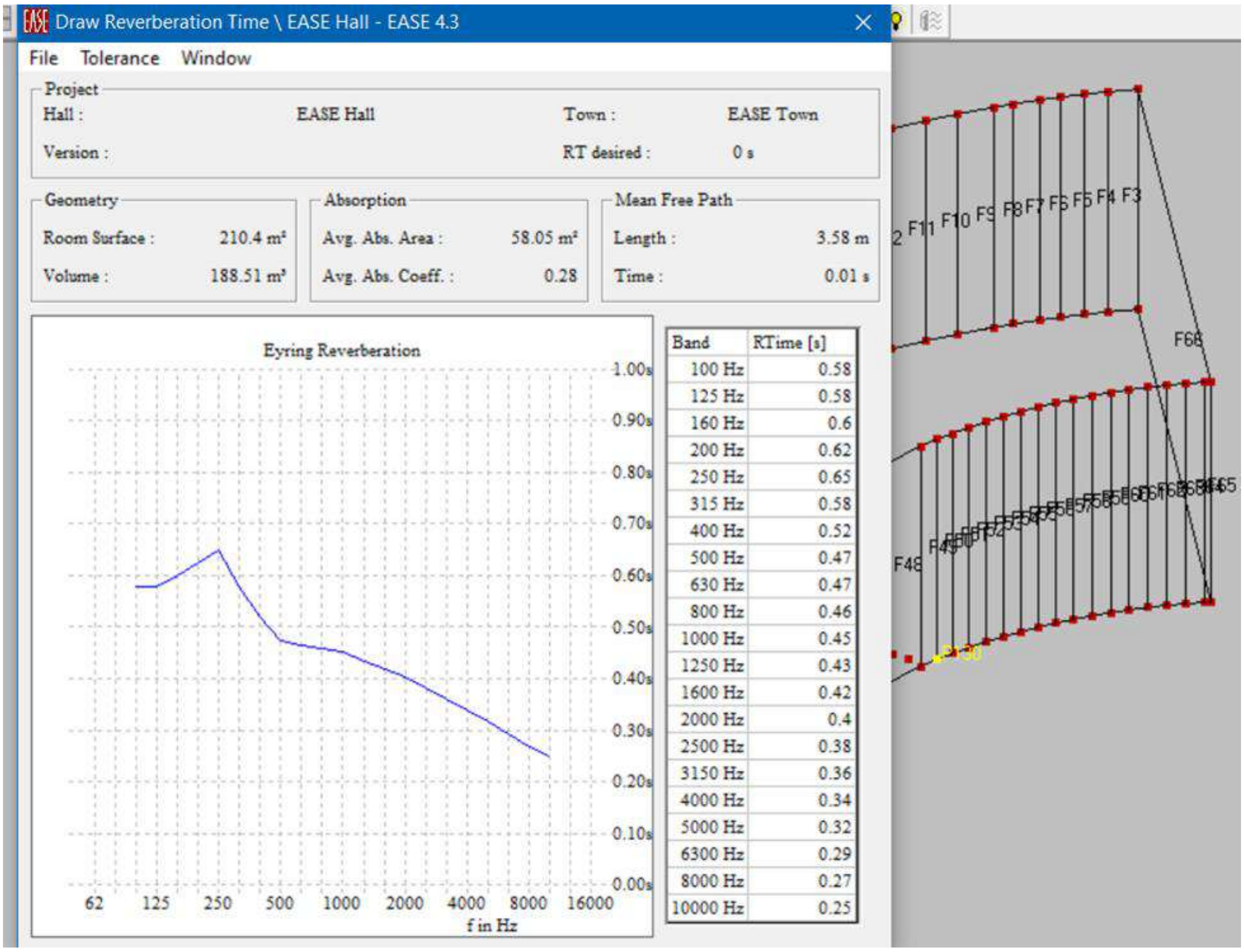


Figure 265 : Reverberation time for meeting room.

As shown in the previous figure, RT60 is between 0.4-0.6 at most frequencies which is ok

Loopy

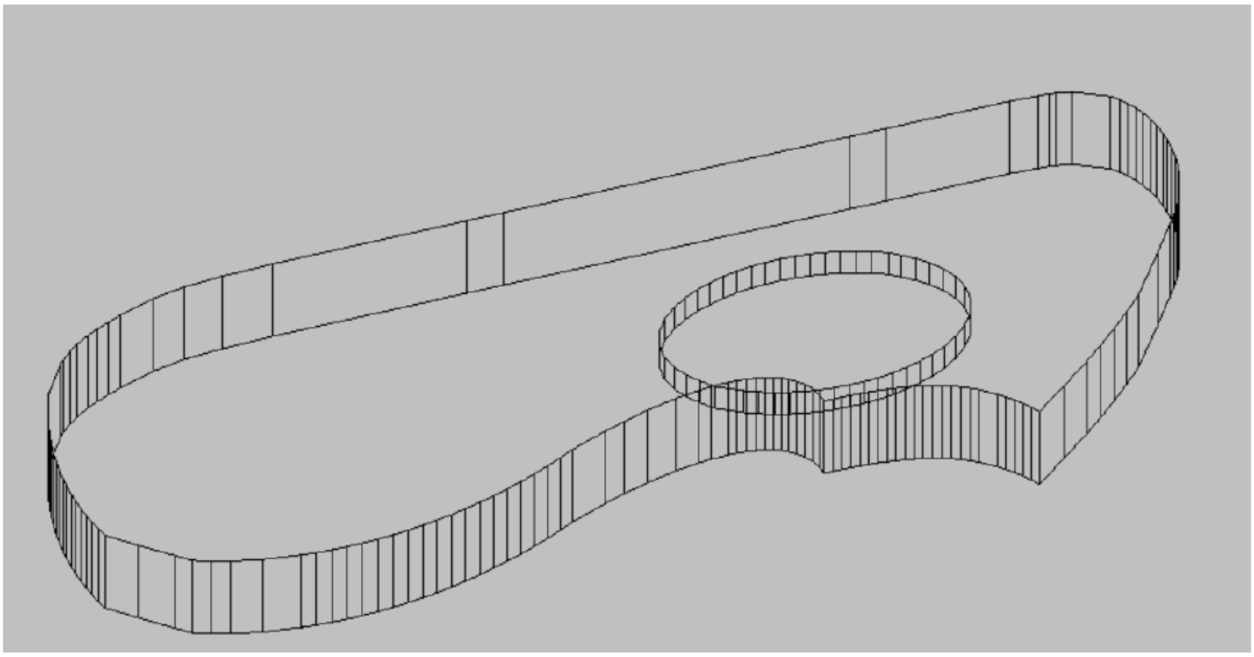


Figure 266 : 3D view for lobby in ease program

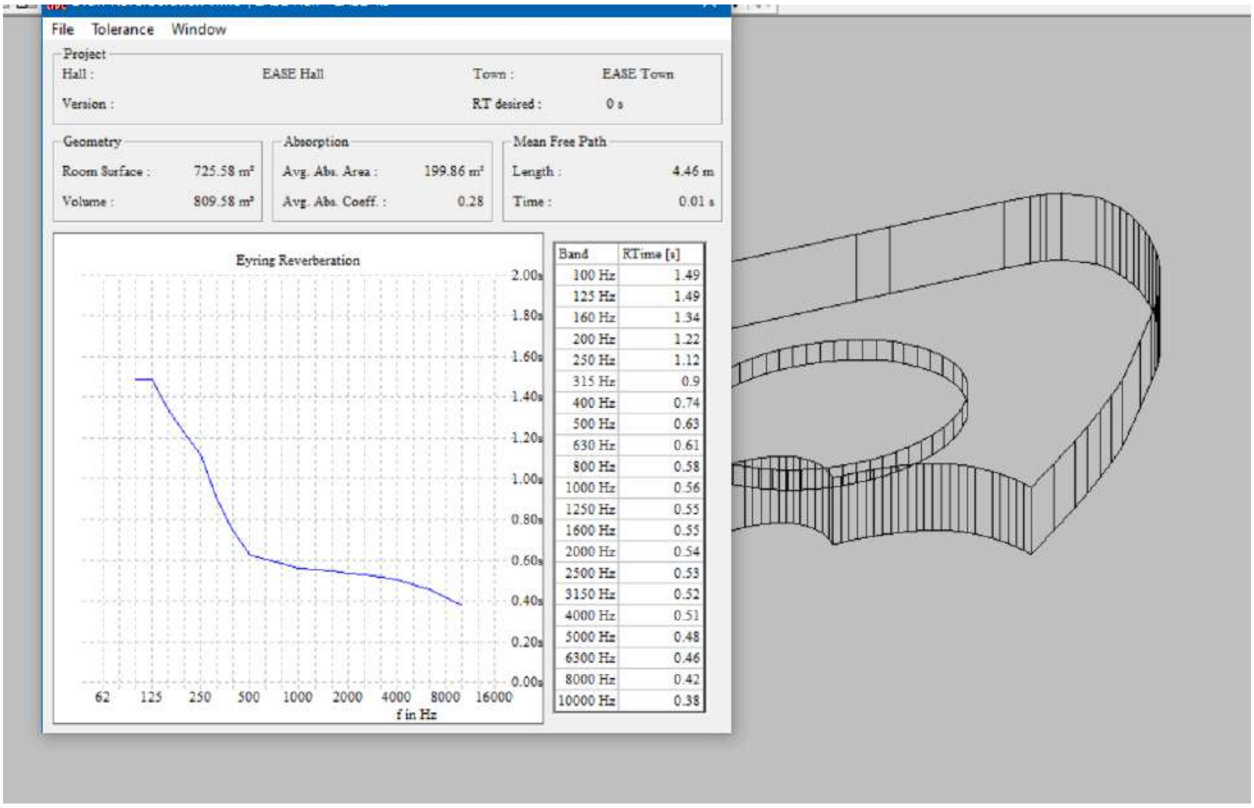


Figure 267: Reverberation time for loopy.

As shown in the previous figure, RT60 is between 0.5-1 at most frequencies which is ok

4.6.1.2 Sound Transmission Loss (STC)

The sound transmission loss is one of the most crucial factors in acoustic design, and we utilized the insul program to calculate it. The image below illustrates the standard for it between two adjacent areas:

Table 127 : Standard of Sound Transmission Loss (STC)

Type of Occupancy	Wall, Partition, or Panel Between: Room Being Considered	and Adjacent Area	Sound Isolation Requirement: Background Level in Room Being Considered: Quiet	Normal
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
		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
	Music practice rooms	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
		Exterior of building	STC 40	STC 38
		Kitchen and dining areas	STC 45	STC 42
Large offices, drafting areas, banking floors, etc.	Large general office areas	Corridors, lobby, exterior	STC 38	STC 35
		Data-processing area	STC 40	STC 38
		Kitchen and dining areas	STC 40	STC 38
Motels and urban hotels, Hospitals and dormitories	Bedrooms	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

External wall:

The figure below shows STC result from INSUL program for the external wall

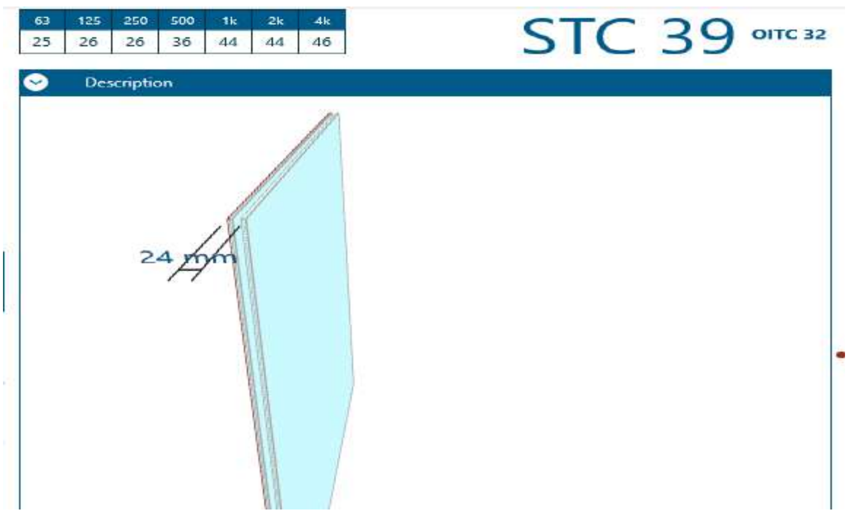


Figure 268: External wall layout and STC value

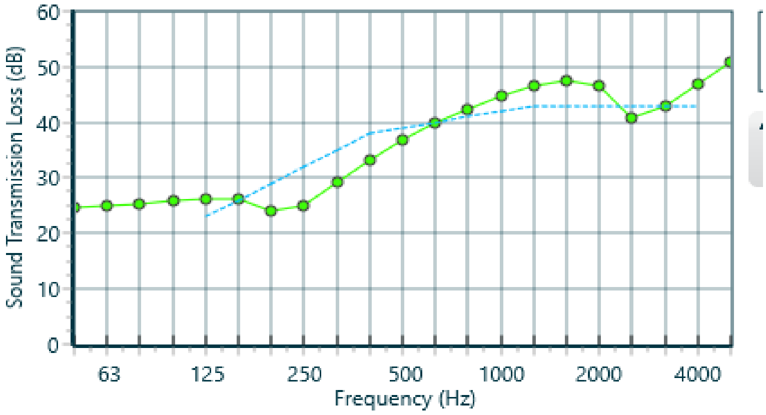


Figure 269: glass STC value

39 dB > 38 dB (standard), so it is ok.

Internal wall:

The figure below shows INSUL result and section of the internal wall

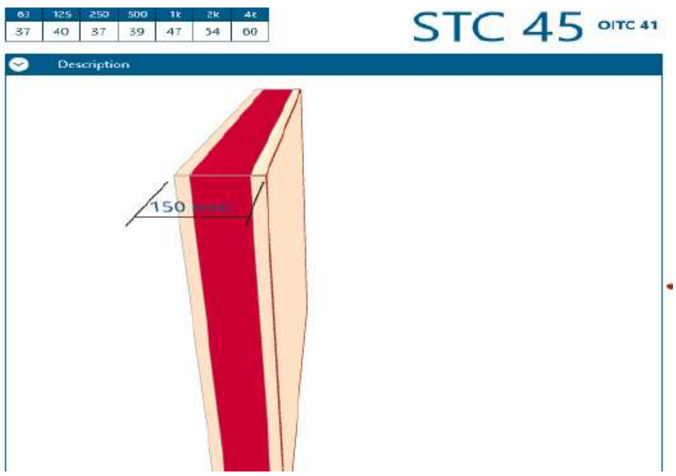


Figure 270: internal wall layout and STC value

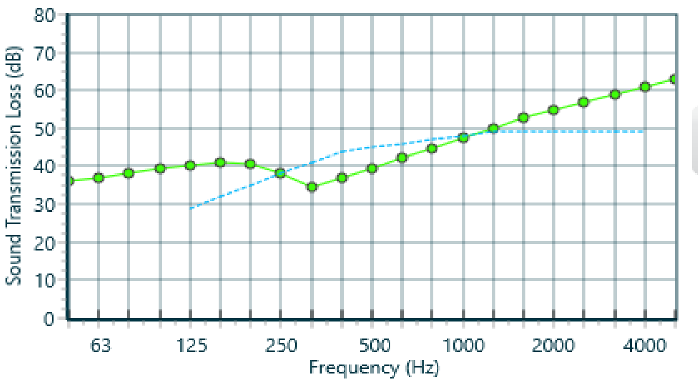


Figure 271: internal wall STC value

45 dB > 38 dB (standard), so it is ok.

4.6.1.3 Impact Insulation Class (IIC)

Used INSUL program to calculate Impact Insulation Class for ceiling, the standard IIC should be > 52 dB (Meeb), and the figure below shows INSUL result and ceiling layer.

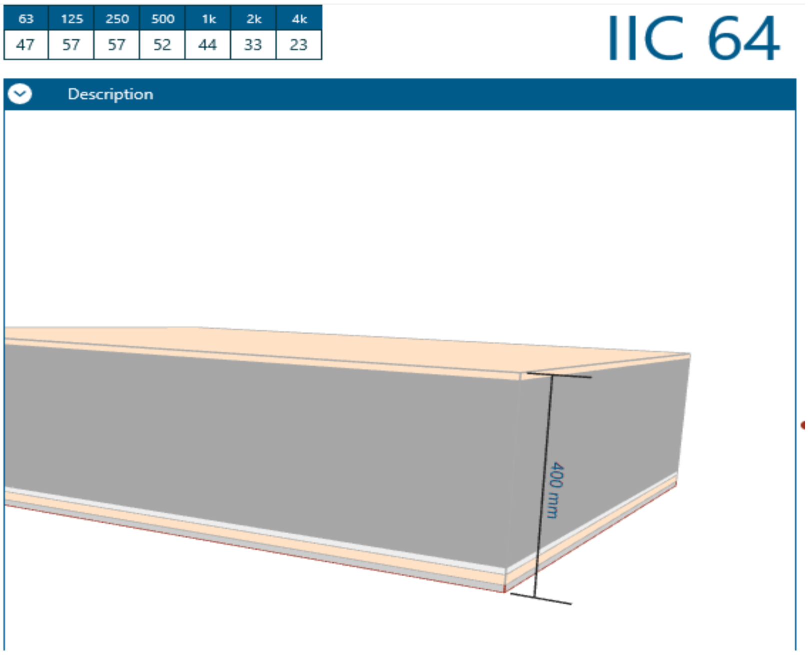


Figure 272: Impact Insulation Class (IIC) values.

IIC (64)>52(standard), so it is ok.

4.6.2 Electro acoustic side (Load speaker design):

Loudspeaker design in different places such as hall, corridor and servers.

The load speaker was used in the building from JBL Company for corridors (ceiling speakers-8100 series ceiling with stylized grille-8128) as shown in the figure below:

Figure 273: Load speaker used in corridor (JBL Company)

The table below shows the specification of loud speaker :

Table 128 : Specifications for corridor load speaker. (JBL Company)

Drivers	8 in (200 mm), Full-range Driver
Frequency Range	50 Hz – 16 kHz
Sensitivity	97 dB (1 kHz – 8 kHz)
Coverage Angle	90° conical
Transformer Taps	6W, 3W, 1.5W (0.75W at 70V only)
Input Connectors	Bare wires
Dimensions (Diameter x Depth)	11.3 in (287mm) x 4.1in (105mm)
Weight	3lb (1.4kg)
Included Accessories	Sculpted Grille
Optional Accessories	MTC-8124C C-ring, MTC-Rail tile rails
Power Rating	See transformer taps
Maximum SPL (1m)	105 dB (top 70V/100V tap)
Color	White
Backcan	No
Baffle/Rim	Plastic
Ceiling Cutout Size	260 mm diameter (10.1 in)
Plenum Usage	Not intended for use in return air plenums

Ease program results:

5) Sound pressure level (SPL)

The figure below shows SPL values by EASE program:

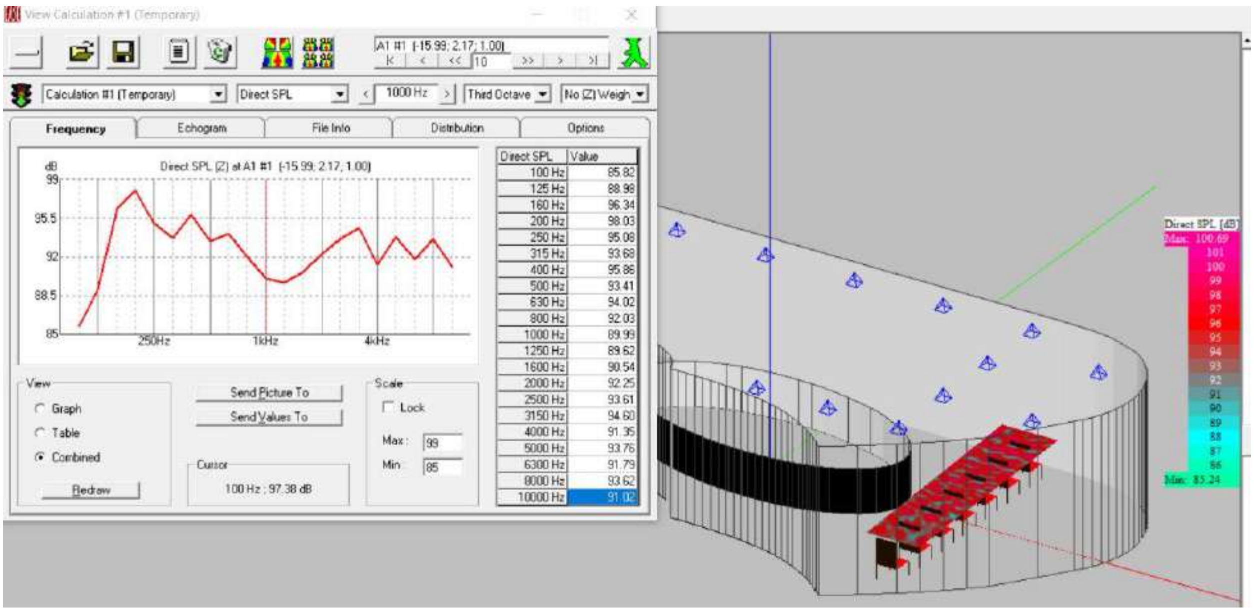


Figure 274 : SPL values for lobby

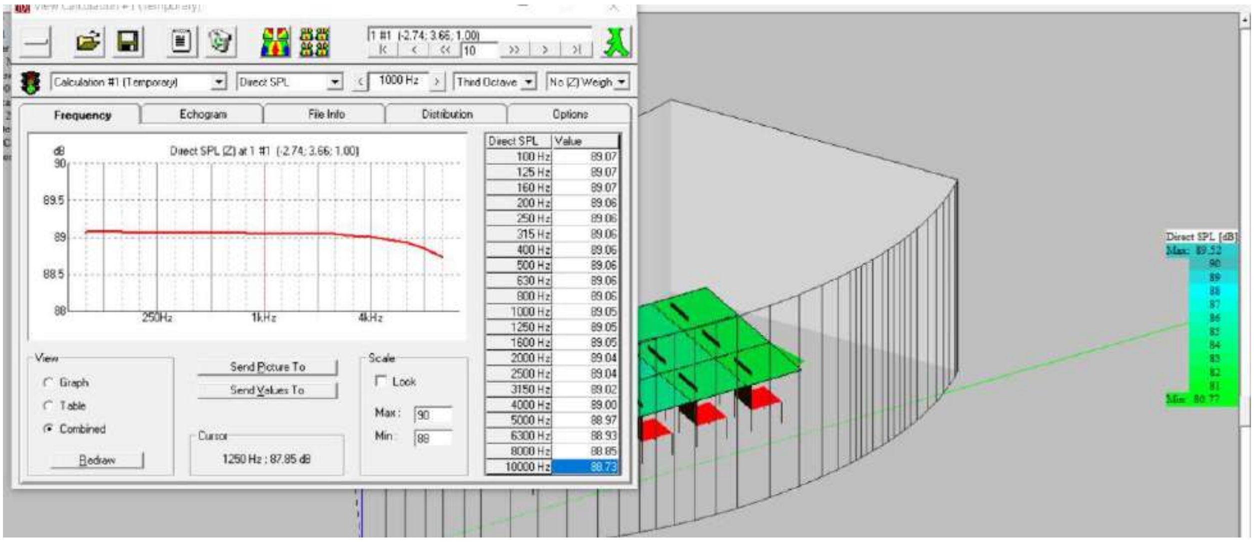


Figure 275 : SPL values for meeting room

All the value are than 70 so its ok.

4.6.2 Articulation loss

Sound transmission loss (STI) It is the amount of sound that is isolated in a room and is measured in dB and by used ease program, we design for different spaces and get STI for each as we will show below:

The figure below shown the standard of Sound transmission loss(STI):

STI	0 - 0.3	0.3 - 0.45	0.45 - 0.6	0.60 - 0.75	0.75 - 1.0
	unexceptable	poor	fair	good	excellent
ALcons	100 - 33%	33 - 15%	15 - 7%	7 - 3%	3 - 0%

Figure 276 : Standard of Sound transmission loss (STI)

Lobby

The figure below shows Sound transmission loss (STI) values by EASE program:

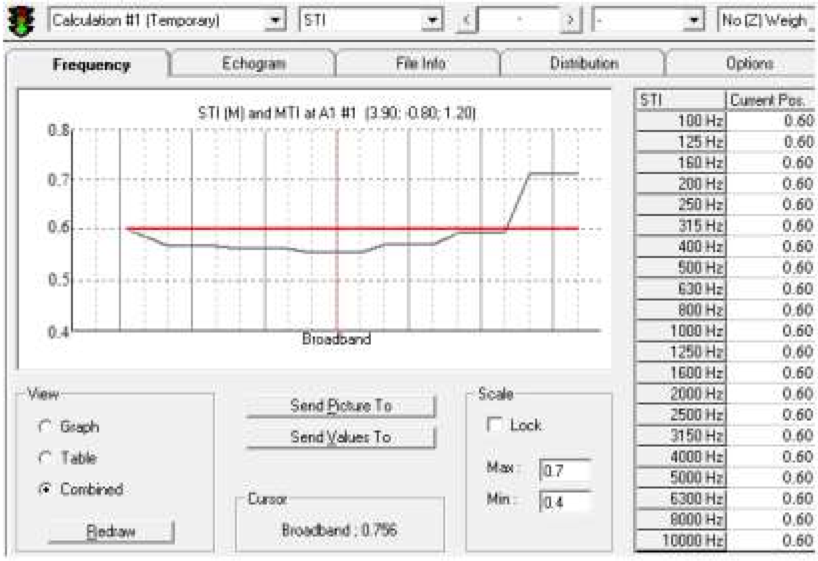


Figure 277 : Sound transmission loss (STI) for lobby .

in this space the value approximately 0.6 so its status was good

Meeting room :

The figure below shows Sound transmission loss (STI) values by EASE program:

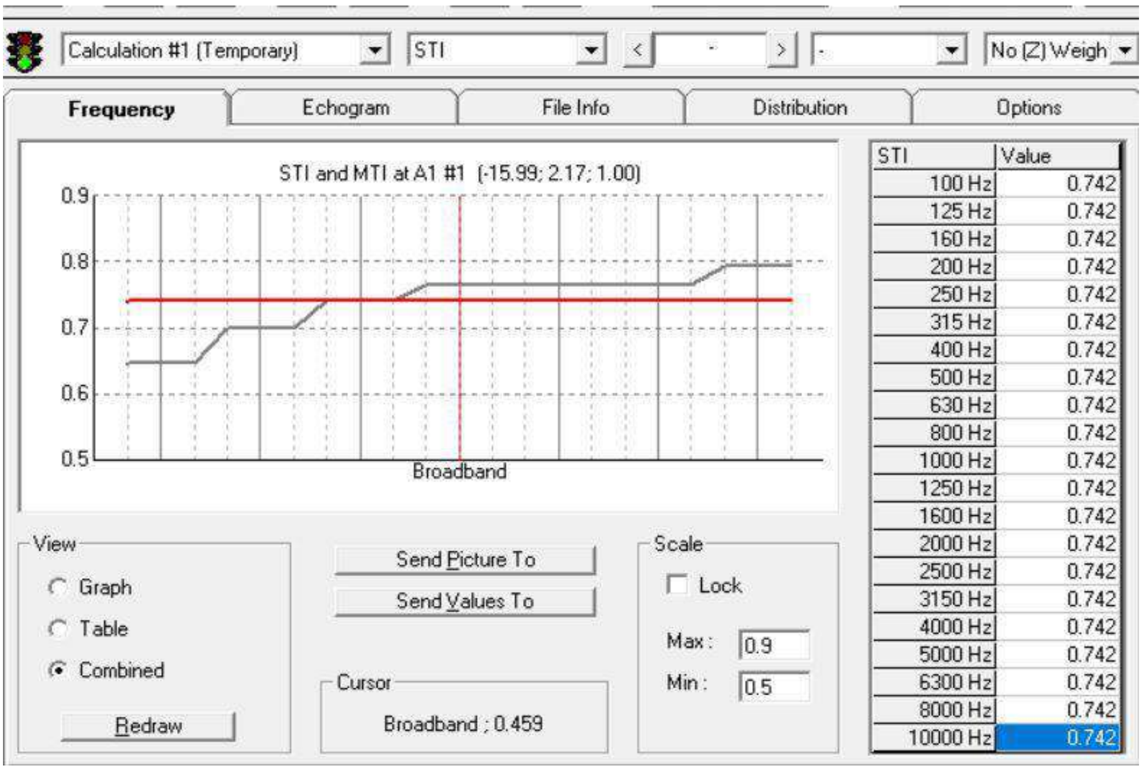


Figure 278 : Sound transmission loss (STI) for meeting room .

In this space the value approximately 0.75 so its status was excellent

4.7 HVAC design :

The term HVAC is used to describe a complete home comfort system that can be used to heat and cool your home, as well as provide improved indoor air quality.

HVAC design needs cooling load tables from design builder software.

Table129 : Total heating and cooling load in the building

Total heating and cooling load in the building	
Cooling load	**267.88 kw**
Heating load	**266.35 kw**

For Ground Floor:

The next table shows the cooling loads in ground floor:

Table 130: the designing load for the ground floor

Zone name	Zone	Design Flow Rate(m3/s)	Peak Cooling Load(kw)
ground floor	Ground Floor:Hall	0.8335	10.29
ground floor	Ground Floor:Vault	0.284	3.54
ground floor	Ground Floor:FireRoom	0.087	1.09
ground floor	Ground Floor:Tellers1	0.1716	2.31
ground floor	Ground Floor:Offices	0.369	4.9
ground floor	Ground Floor:Office3	0.0546	0.73
ground floor	Ground Floor:ManagerRoom	0.2368	3.18
ground floor	Ground Floor:Security	0.1733	2.33
ground floor	Ground Floor:Reception	0.1208	1.62
ground floor	Ground Floor:CameraRoom	0.3435	4.29
ground floor	Ground Floor:MeetingRoom	0.3488	4.7
ground floor	Ground Floor:Office1	0.2593	3.5

The next table shows the cooling loads in first floor:

Table 131: the designing load for first floor

Zone name	Zone	Design Flow Rate(m3/s)	Peak Cooling Load(kw)
first floor	FirstFloor:Hall	0.7512	9.22
first floor	FirstFloor:Tellers4	0.1318	1.77
first floor	FirstFloor:Tellers	0.1879	2.53
first floor	FirstFloor:Tellers2	0.2726	3.66
first floor	FirstFloor:MeetingRoom1	0.2456	3.3
first floor	FirstFloor:multiple purpos room	0.2066	2.78
first floor	FirstFloor:Tellers3	0.3572	4.8
first floor	FirstFloor:archive	0.0899	1.21
first floor	FirstFloor:MeetingRoom2	0.3135	4.22
first floor	FirstFloor:Office1	0.156	2.1
first floor	FirstFloor:Reception	0.1305	1.75

The next table shows the cooling loads in second floor:

Table 132 : the designing load for second floor

Zone name	Zone	Design Flow Rate(m3/s)	Peak Cooling Load(kw)
second floor	Secondfloor:Hall	0.8583	10.57
second floor	Secondfloor:Tellers1	0.2321	3.12
second floor	Secondfloor:Tellers2	0.1555	2.09
second floor	Secondfloor:Tellers3	0.2619	3.51
second floor	Secondfloor:Office2	0.0851	1.14
second floor	Secondfloor:WaitingRoom	0.4128	5.12
second floor	Secondfloor:Waitingroom1	0.3511	4.36
second floor	Secondfloor:TellersRoom	0.5437	7.28
second floor	Secondfloor:Meetingroom	0.3843	5.16
second floor	Secondfloor:Office1	0.0696	0.94
second floor	Secondfloor:Office3	0.0736	0.99

The next table shows the cooling loads in third floor:

Table 133: the designing load for third floor

Zone name	Zone	Design Flow Rate(m3/s)	Peak Cooling Load(kw)
third floor	ThirdFloor:Hall	0.7968	9.75
third floor	ThirdFloor:Tellers1	0.2185	2.94
third floor	ThirdFloor:Tellers2	0.1503	2.01
third floor	ThirdFloor:Tellers3	0.2581	3.46
third floor	ThirdFloor:Office2	0.0855	1.15
third floor	ThirdFloor:WaitingRoom	0.4091	5.07
third floor	ThirdFloor:Waitingroom1	0.3367	4.17
third floor	ThirdFloor:TellersRoom	0.5304	7.09
third floor	ThirdFloor:Meetingroom	0.3804	5.11
third floor	ThirdFloor:Office1	0.0641	0.86
third floor	ThirdFloor:Office3	0.0682	0.92

The next table shows the cooling loads in fourth floor:

Table 134: the designing load for fourth floor

Zone name	Zone	Design Flow Rate(m3/s)	Peak Cooling Load(kw)
fourth floor	FourthFloor:Hall	0.8979	11.05
fourth floor	FourthFloor:Tellers3	0.203	2.73
fourth floor	FourthFloor:Tellers4	0.3756	5.06
fourth floor	FourthFloor:Office2	0.1162	1.54
fourth floor	FourthFloor:Tellers2	0.3728	5.01
fourth floor	FourthFloor:ManagerRoom	0.2575	3.46
fourth floor	FourthFloor:Tellers5	0.5363	7.2
fourth floor	FourthFloor:Tellers6	0.3812	5.13
fourth floor	FourthFloor:Tellers1	0.3424	4.61
fourth floor	FourthFloor:Office1	0.0839	1.13
fourth floor	FourthFloor:Office4	0.1056	1.42
fourth floor	FourthFloor:Office3	0.0785	1.06

The next table shows the cooling loads in fifth floor:

Table 135: the designing load for fifth floor

Zone name	Zone	Design Flow Rate(m3/s)	Peak Cooling Load(kw)
fifth floor	FifthFloor:Tellers3	0.2902	3.9
fifth floor	FifthFloor:Hall	0.4357	5.36
fifth floor	FifthFloor:Office1	0.0637	0.86
fifth floor	FifthFloor:Tellers2	0.4128	5.55
fifth floor	FifthFloor:TellersRoom1	0.2889	3.89
fifth floor	FifthFloor:Office2	0.0814	1.09

The next table shows the cooling loads in sixth floor:

Table 136: the designing load for sixth floor

Zone name	Zone	Design Flow Rate(m3/s)	Peak Cooling Load(kw)
sixth floor	SixthFloor:Office1	0.0843	1.13
sixth floor	SixthFloor:Hall	0.5142	6.38
sixth floor	SixthFloor:Stairecase	0.38	4.75
sixth floor	SixthFloor:TellersRoom	0.4583	6.18
sixth floor	SixthFloor:EmergenncyStaire	0.1143	1.54
sixth floor	SixthFloor:Meetingroom	0.2042	3.24
sixth floor	SixthFloor:Office2	0.1073	1.44

VRF outdoor unit:

This is the catalog for various types of VRF outdoor units from the Air stage company

Energy Efficiency Combination

Rating Capacity range		HP	16	18	20	24	26	28	30
Set Model name			AJY144LALBHH	AJY162LALBHH	AJY180LALBHH	AJY216LALBHH	AJY234LALBHH	AJY252LALBHH	AJY270LALBHH
Unit 1 Unit 2 Unit 3			AJY072LALBH AJY072LALBH	AJY090LALBH AJY072LALBH	AJY108LALBH AJY072LALBH	AJY072LALBH AJY072LALBH AJY072LALBH	AJY090LALBH AJY072LALBH AJY072LALBH	AJY108LALBH AJY072LALBH AJY072LALBH	AJY126LALBH AJY072LALBH AJY072LALBH
Maximum Connectable Indoor Unit*1			34	39	43	52	56	60	64
Indoor unit connectable capacity		kW	22.4-67.2	25.2-75.6	28.0-83.8	33.6-100.8	36.4-109.2	39.2-117.4	42.4-127.2
Power source			3-phase 4 wire, 400 V, 50Hz						
Capacity	Cooling	kW	44.8	50.4	55.9	67.2	72.8	78.3	84.8
	Heating		50.0	56.5	62.5	75.0	81.5	87.5	95.0
Input power	Cooling	kW	10.40	12.48	14.16	15.60	17.68	19.36	21.36
	Heating		10.34	12.42	13.82	15.51	17.59	18.99	21.51
EER	Cooling	W/W	4.31	4.04	3.95	4.31	4.12	4.04	3.97
COP	Heating	W/W	4.84	4.55	4.52	4.84	4.63	4.61	4.42
Airflow rate	High	m^3/h	11,100×2	11,100×2	13,000+11,100	11,100×3	11,000×3	13,000+11,100×2	13,000+11,100×2
Sound pressure level*2/ Power level	Cooling	dB(A)	59 / 80	60 / 81	60 / 81	61 / 82	62 / 83	61 / 82	63 / 84
	Heating		61 / 83	62 / 84	62 / 85	63 / 85	63 / 85	64 / 86	65 / 87
Maximum external static pressure		Pa	82	82	82	82	82	82	82
Compressor motor output		kW	7.5×2	7.5×2	11.0+7.5	7.5×3	7.5×3	11.0+7.5×2	11.0+7.5×2
Minimum Recommended MCB		AMP	20 + 20	25 + 20	40 + 20	20 + 20 + 20	25 + 20 + 20	40 + 20 + 20	40 + 20 + 20
Net Dimensions	Height	mm	1,690	1,690	1,690	1,690	1,690	1,690	1,690
	Width		930×2	930×2	1,240+930	930×3	930×3	1,240+930×2	1,240+930×2
	Depth		765	765	765	765	765	765	765
Weight		kg	252×2	252×2	275+252	252×3	252×3	275+252×2	275+252×2
Refrigerant	Type		R410A	R410A	R410A	R410A	R410A	R410A	R410A
	Charge	kg	11.7×2	11.7×2	11.8+11.7	11.7×3	11.7×3	11.8+11.7×2	11.8+11.7×2
Connection pipe diameter	Liquid	Inch	1/2	5/8	5/8	5/8	5/8	5/8	3/4
	Gas		1 1/8	1 1/8	1 1/8	1 3/8	1 3/8	1 3/8	1 3/8
Operation range	Cooling	°CDB	-5 to 46	-5 to 46	-5 to 46	-5 to 46	-5 to 46	-5 to 46	-5 to 46
	Heating		-20 to 21	-20 to 21	-20 to 21	-20 to 21	-20 to 21	-20 to 21	-20 to 21

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

Figure279 : VRF catalog (fujitsu-general)

The total Peak cooling load of outdoor units need to cover all indoor unit = 267.88 kw

The selected type is (AJY180LALBHH) with a total peak load of 55.9 kW.

The number of outdoor units = 267.88/55.9 = 4.79 units

An exact number of outdoor units = 5 units.

Indoor unit system:

VRF

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

Wall Mounted

Specifications

Model name			ASYA004GTEH	ASYA007GTEH	ASYA009GTEH	ASYE004GTEH	ASYE007GTEH	ASYE009GTEH
Power source			Single phase, ~230V, 50Hz			Single phase, ~230V, 50Hz		
Capacity	UK Total Cooling	kW	0.80	1.60	2.10	0.80	1.60	2.10
	UK Sensible Cooling		0.70	1.60	1.90	0.70	1.50	2.00
	UK Heating		1.20	2.60	3.00	1.20	2.60	3.00
	Nominal Cooling		1.10	2.20	2.80	1.10	2.20	2.8
	Nominal Heating		1.30	2.80	3.20	1.30	2.80	3.2
Input power		W	13	19	34	13	19	34
Airflow rate	High	m^3/h	430	550	720	430	550	720
	Med-H		420	460	570	420	460	570
	Med		390	420	500	390	420	500
	Med-L		380	390	410	380	390	410
	Low		360	360	360	360	360	360
	Quiet		330	330	330	330	330	330
Sound pressure level	High	dB(A)	31	35	43	31	35	43
	Med-H		30	32	38	30	32	38
	Med		28	30	34	28	30	34
	Med-L		26	27	29	26	27	29
	Low		24	24	24	24	24	24
	Quiet		22	22	22	22	22	22
Net Dimensions (H × W × D)		mm	262 x 820 x 206	262 x 820 x 206	262 x 820 x 206	262 x 820 x 206	262 x 820 x 206	262 x 820 x 206
Weight		kg(lbs)	7.5 (17)	7.5 (17)	7.5 (17)	7.0 (15)	7.0 (15)	7.0 (15)
Connection pipe diameter	Liquid (Flare)	Inch	1/4					
	Gas (Flare)		3/8					
EV Kit (option)			–			UTI-EV09XB		

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

Figure280 : split unit type used(fujitsu-general)

Sample calculation:

first floor : first floor Office3:

The peak cooling load for this space from the design-builder is 1.21 kW

The chosen split units are {ASYA007GTEH} with a capacity equal to 1.6 kW

The number of indoor split unit = 1.21/1.6 = 0.75625 unit.

An exact number of split unit = 1 unit.

Cassette unit system:

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

Compact Cassette
Grid type

Specifications

Model name			AUXB004GLEH	AUXB007GLEH	AUXB009GLEH	AUXB012GLEH	AUXB014GLEH	AUXB018GLEH	AUXB024GLEH
Power source			Single phase, ~230V, 50Hz						
Capacity	UK Total Cooling	kW	0.80	1.60	2.10	2.70	3.30	4.20	5.30
	UK Sensible Cooling		0.70	1.50	1.70	2.30	2.70	3.20	4.40
	UK Heating		1.20	2.60	3.00	3.80	4.70	5.90	7.40
	Nominal Cooling		1.10	2.20	2.80	3.60	4.50	5.60	7.10
	Nominal Heating		1.30	2.80	3.20	4.10	5.00	6.30	8.00
Input power		W	23	25	25	29	35	36	84
Airflow rate	High	m^3/h	530/530	540	550	600	680	710	1,030
	Med-H		490/480	500	520	560	620	660	910
	Med		450/430	460	480	520	560	590	790
	Med-L		420/380	420	440	480	500	520	680
	Low		390/340	390	400	430	440	460	560
	Quiet		350/300	350	350	390	390	400	450
Sound pressure level	High	dB(A)	34/34	34	35	37	38	41	50
	Med-H		32/31	32	33	34	37	39	46
	Med		30/29	30	31	33	34	36	43
	Med-L		28/26	28	29	31	32	33	39
	Low		27/24	27	27	29	30	30	35
	Quiet		25/21	25	25	27	27	27	30
Net Dimensions (H × W × D)		mm	245 × 570 × 570	245 × 570 × 570	245 × 570 × 570	245 × 570 × 570	245 × 570 × 570	245 × 570 × 570	245 × 570 × 570
Weight		kg(lbs)	14.5 (32)	15 (33)	15 (33)	15 (33)	15 (33)	17 (37)	17 (37)
Connection pipe diameter	Liquid (Flare)	Inch	1/4					3/8	
	Gas (Flare)		1/2					5/8	
Cassette Grille	Model name		UTG-UFYE-W						
	Net Dimensions (H×W×D)	mm	50 × 620 × 620						
	Weight	kg(lbs)	2.3(5.1)						

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

Figure281 : cassette unit type used(fujitsu-general)

Sample calculation:

first floor: first floor tellers4:

The peak cooling load for this space from the design-builder is 1.77 kW

The chosen cassette units are {AUXB007GLEH} with a capacity equal to 1.6 kW

The number of indoor cassette unit = 1.77/1.6 = 1.10625 units.

An exact number of cassette unit = 2 units.

The next table shows the required number of indoor units used in ground floor.

Table 137: number of units in ground floor

Zone name	Zone	Design Flow Rate(m3/s)	Peak Cooling Load(kw)	Used HVAC System	HVAC System cooling capacity (kw)	Number of units	Exact number
ground floor	GroundFloor:Vault	0.284	3.54	AUXB009GLEH	2.1	1.6857	2
ground floor	GroundFloor:FireRoom	0.087	1.09	AUXB004GLEH	0.8	1.325	2
ground floor	GroundFloor:Tellers	0.1716	2.31	AUXB004GLEH	0.8	2.8875	3
ground floor	GroundFloor:customer services offices	0.369	4.9	AUXB009GLEH	2.1	2.3333	3
ground floor	GroundFloor:Office3	0.0546	0.73	ASYA004GTEH	0.8	0.9125	1
ground floor	GroundFloor:ManagerRoom	0.2368	3.18	AUXB007GLEH	1.6	1.9875	2
ground floor	GroundFloor:Security	0.1733	2.33	AUXB007GLEH	1.6	1.45625	2
ground floor	GroundFloor:Reception	0.1208	1.62	ASYA007GTEH	1.6	1.0125	2
ground floor	GroundFloor:CameraRoom	0.3435	4.29	AUXB007GLEH	1.6	2.68125	3
ground floor	GroundFloor:MeetingRoom	0.3488	4.7	AUXB007GLEH	1.6	2.9375	3
ground floor	GroundFloor:Treasurer&Deposits	0.2593	3.5	AUXB007GLEH	1.6	2.1875	3

The next table shows the required number of indoor units used in first floor.

Table 138: number of units in first floor

Zone name	Zone	Design Flow Rate(m3/s)	Peak Cooling Load(kw)	Used HVAC System	HVAC System cooling capacity	Number of units	Exact number
first floor	FirstFloor:Tellers4	0.1318	1.77	AUXB007GLEH	1.6	1.10625	2
first floor	FirstFloor:hall	0.3424	4.61	AUXB004GLEH	0.8	5.7625	6
first floor	FirstFloor:corridor	0.364	4.87	AUXB007GLEH	1.6	2.2851	3
first floor	FirstFloor : customer services offices1	0.1879	2.53	AUXB007GLEH	1.6	1.58125	2
first floor	FirstFloor:Tellers2	0.2726	3.66	AUXB007GLEH	1.6	2.2875	3
first floor	FirstFloor:MeetingRoom1	0.2456	3.3	AUXB007GLEH	1.6	2.0625	3
first floor	FirstFloor:multiple purpos room	0.2066	2.78	AUXB007GLEH	1.6	1.7375	2
first floor	FirstFloor:customer services offices	0.3572	4.8	AUXB009GLEH	2.1	2.28571	3
first floor	FirstFloor:archive	0.0899	1.21	ASYA007GTEH	1.6	0.75625	1
first floor	FirstFloor:MeetingRoom2	0.3135	4.22	AUXB007GLEH	1.6	2.6375	3
first floor	FirstFloor:Office1	0.156	2.1	AUXB007GLEH	1.6	1.3125	2
first floor	FirstFloor:Reception	0.1305	1.75	ASYA004GTEH	0.8	2.1875	3

The next table shows the required number of indoor units used in second floor.

Table 139: number of units in second floor

Zone name	Zone	Design Flow Rate(m3/s)	Peak Cooling Load(kw)	Used HVAC System	HVAC System cooling capacity (kw)	Number of units	Exact number
second floor	Secondfloor:Collection Department	0.2321	3.12	AUXB007GLEH	1.6	1.95	2
second floor	Secondfloor:Risk management dept	0.1555	2.09	AUXB007GLEH	1.6	1.30625	2
second floor	Secondfloor:Credit dept	0.2619	3.51	AUXB007GLEH	1.6	2.19375	3
second floor	Secondfloor:Office2	0.0851	1.14	ASYA007GTEH	1.6	0.7125	1
second floor	Secondfloor:Media&Gallery	0.4128	5.12	AUXB007GLEH	1.6	3.2	4
second floor	Secondfloor:Lecture hall	0.3511	4.36	AUXB007GLEH	1.6	2.725	3
second floor	Secondfloor:Training center	0.5437	7.28	AUXB009GLEH	2.1	3.4666	4
second floor	Secondfloor:Lecture hall1	0.3843	5.16	AUXB007GLEH	1.6	3.225	4
second floor	Secondfloor:Office1	0.0696	0.94	ASYA007GTEH	1.6	0.5875	1
second floor	Secondfloor:Office3	0.0736	0.99	ASYA007GTEH	1.6	0.61875	1

The next table shows the required number of indoor units used in third floor.

Table 140: number of units in third floor

Zone name	Zone	Design Flow Rate(m3/s)	Peak Cooling Load(kw)	Used HVAC System	HVAC System cooling capacity (kw)	Number of units	Exact number
third floor	ThirdFloor:Internal audit&inspection dept	0.2185	2.94	AUXB007GLEH	1.6	1.95	2
third floor	ThirdFloor:Anti money laundry dept	0.1503	2.01	AUXB007GLEH	1.6	1.30625	2
third floor	ThirdFloor:legal affairs dept	0.2581	3.46	AUXB007GLEH	1.6	2.19375	3
third floor	ThirdFloor:Office2	0.0855	1.15	ASYA007GTEH	1.6	0.7125	1
third floor	ThirdFloor:Compliance dept	0.4091	5.07	AUXB007GLEH	1.6	3.2	4
third floor	ThirdFloor:Operation administration	0.3367	4.17	AUXB007GLEH	1.6	2.725	3
third floor	ThirdFloor:Operations dept	0.5304	7.09	AUXB009GLEH	2.1	3.4666	4
third floor	ThirdFloor:Meetingroom	0.3804	5.11	AUXB007GLEH	1.6	3.225	4
third floor	ThirdFloor:Office1	0.0641	0.86	ASYA007GTEH	1.6	0.5875	1
third floor	ThirdFloor:Office3	0.0682	0.92	ASYA007GTEH	1.6	0.61875	1

The next table shows the required number of indoor units used in fourth floor.

Table 141: number of units in fourth floor

Zone name	Zone	Design Flow Rate(m3/s)	Peak Cooling Load(kw)	Used HVAC System	HVAC System cooling capacity (kw)	Number of units	Exact number
fourth floor	FourthFloor: Department of Real Estate and Supplies	0.203	2.73	AUXB007GLEH	1.6	1.70625	2
fourth floor	FourthFloor:puplic relations dept	0.3756	5.06	AUXB007GLEH	1.6	3.1625	4
fourth floor	FourthFloor:Office2	0.1162	1.54	ASYA007GTEH	1.6	0.9625	1
fourth floor	FourthFloor:marketing department	0.3728	5.01	AUXB007GLEH	1.6	3.13125	4
fourth floor	FourthFloor:ManagerRoom	0.2575	3.46	AUXB007GLEH	1.6	2.1625	3
fourth floor	FourthFloor:IT dept	0.5363	7.2	AUXB007GLEH	1.6	4.5	5
fourth floor	FourthFloor:Communication Dept	0.3812	5.13	AUXB007GLEH	1.6	3.20625	4
fourth floor	FourthFloor:HR department	0.3424	4.61	AUXB004GLEH	0.8	5.7625	6
fourth floor	FourthFloor:Office1	0.0839	1.13	ASYA007GTEH	1.6	0.70625	1
fourth floor	FourthFloor:Office4	0.1056	1.42	ASYA007GTEH	1.6	0.8875	1
fourth floor	FourthFloor:Office3	0.0785	1.06	ASYA007GTEH	1.6	0.6625	1

The next table shows the required number of indoor units used in fifth floor.

Table 142: number of units in fifth floor

Zone name	Zone	Design Flow Rate(m3/s)	Peak Cooling Load(kw)	Used HVAC System	HVAC System cooling capacity (kw)	Number of units	Exact number
fifth floor	FifthFloor:financial dept	0.2902	3.9	AUXB007GLEH	1.6	2.4375	3
fifth floor	FifthFloor:Office1	0.0637	0.86	ASYA007GTEH	1.6	0.5375	1
fifth floor	FifthFloor:Support Department	0.4128	5.55	AUXB007GLEH	1.6	3.46875	4
fifth floor	fthFloor:Quality Control Departme	0.2889	3.89	AUXB007GLEH	1.6	2.43125	3
fifth floor	FifthFloor:Office2	0.0814	1.09	ASYA007GTEH	1.6	0.68125	1

The next table shows the required number of indoor units used in sixth floor.

Table 143: number of units in sixth floor

Zone name	Zone	Design Flow Rate(m3/s)	Peak Cooling Load(kw)	Used HVAC System	HVAC System cooling capacity (kw)	Number of units	Exact number
sixth floor	SixthFloor:Office1	0.0843	1.13	ASYA007GTEH	1.6	0.7063	1
sixth floor	SixthFloor:top management	0.4583	6.18	AUXB007GLEH	1.6	3.8625	4
sixth floor	SixthFloor:strategies &financial dept	0.2042	3.24	AUXB007GLEH	1.6	2.025	3
sixth floor	SixthFloor:Office2	0.1073	1.44	ASYA007GTEH	1.6	0.875	1
sixth floor	SixthFloor:Implementation dept	0.3603	3.91	AUXB007GLEH	1.6	2.4375	3

Chapter 5 : Quantity surveying & Cost Estimate

5.1 Introduction

Before beginning work on the project, anticipated expenditures must be approved and are computed during the project planning stage. In order for all activities to be included in the cost management plan, where the predicted costs are compared to the actual costs after the project is over, setting standards for the following projects, expenses must also be documented and tracked during project execution. specific preparations for management of future costs and budgets.

5.2 Methodology :

In the first phase, determined the work breakdown structure (WBS).

The second part involved calculating the amounts for all of the activities based on plans, productivity rate based on data from the labor market, and analyzing the economics course project.

In the third phase, determined the labor cost for each item of work and determined the material cost for each item of work.

Calculate the total direct cost for each item in the fourth phase, and then for all projects, calculate the unit cost.

In the final phase, summarized the results in tables Bell of Quantity (BOQ).

5.3 Information about project :

The area of Bank is 10150 m^2

Soil bearing capacity of 220 kg/ m^2

The Concrete Compressive Strength is B350 for structural elements

The reinforcement steel yield strength = 4200 kg/cm^2

Table 144 cost in project .

Name	cost	%
Earthworks	687800	3.21
Structural	8571402	40
Finishing	9010139	42.04
Electrical and low voltage	1266890	5.91
Mechanical	1893865	8.84
Total Cost(ILS)	Unit Cost (ILS/m2)	
21430096	2111	

Table 145 : Bill of Quantity (BOQ) for the project

Item No	Description	Unit	Quantity	Total Cost	
				Unit Cost (ILS/m2)	Total Cost(ILS)
1	Project	-	-	2111	21430096
1.1	Earthworks	-	-	68	687800
1.1.1.1	Sheet piles excavation	m	1260.00	50.00	ILS 63,000.00
1.1.1.2	Land excavation	m3	15620	40.00	ILS 624,800.00
1.2	Structural			844	8571402
1.2.1	Sub-structural			241	2444125
1.2.1.1	Sheet piles	-	-	-	ILS 578,916.80
1.2.1.1.1	Sheet piles reinforcmeent	Ton	10.80	3500.00	ILS 37,800.00
1.2.1.1.2	Sheet piles concrete	m3	795.76	680.00	ILS 541,116.80
1.2.1.2	Water tank	-	-	-	ILS 48,928.00
1.2.1.2.1	Water tank formwork	m2	135.00	40.00	ILS 5,400.00
1.2.1.2.2	Water tank reinforcement	Ton	2.53	3500.00	ILS 8,848.00
1.2.1.2.3	Water tank concrete	m3	51.00	680.00	ILS 34,680.00
1.2.1.3	Mat foundation	-	-	-	ILS 1,811,780.00
1.2.1.3.1	Mat foundation formwork	m2	228.00	10.00	ILS 2,280.00
1.2.1.3.2	Mat foundation reinforcement	Ton	109.00	3500.00	ILS 381,500.00
1.2.1.3.3	Mat foundation concrete	m3	2100.00	680.00	ILS 1,428,000.00
1.2.1.4	Footing insulation	m3	450.00	10.00	ILS 4,500.00
1.2.2	super-structural			604	6127277
1.2.2.1	Structural elements			604	6127277

1.2.2.1.1	Columns concrete	m3	623.20	680.00	ILS 423,776.00
1.2.2.1.1.1	Basement 2 columns concrete	m3	77.90	680.00	ILS 52,972.00
1.2.2.1.1.2	Basement 1 columns concrete	m3	77.90	680.00	ILS 52,972.00
1.2.2.1.1.3	Ground floor columns concrete	m3	77.90	680.00	ILS 52,972.00
1.2.2.1.1.4	Attic floor columns concrete	m3	77.90	680.00	ILS 52,972.00
1.2.2.1.1.5	First floor columns concrete	m3	77.90	680.00	ILS 52,972.00
1.2.2.1.1.6	Second floor columns concrete	m3	77.90	680.00	ILS 52,972.00
1.2.2.1.1.7	Third floor columns concrete	m3	77.90	680.00	ILS 52,972.00
1.2.2.1.1.8	Fourth floor columns concrete	m3	77.90	680.00	ILS 52,972.00
1.2.2.1.1.9	Fifth floor columns concrete	m3	77.90	680.00	ILS 52,972.00
1.2.2.1.2	Columns reinforcement	Ton	7.00	3500.00	ILS 26,950.00
1.2.2.1.2.1	Basement 2 columns reinforcement	Ton	0.90	3500.00	ILS 3,150.00
1.2.2.1.2.2	Basement 1 columns reinforcement	Ton	0.90	3500.00	ILS 3,150.00
1.2.2.1.2.3	Ground floor columns reinforcement	Ton	0.90	3500.00	ILS 3,150.00
1.2.2.1.2.4	attic floor columns reinforcement	Ton	0.90	3500.00	ILS 3,150.00
1.2.2.1.2.5	First floor columns reinforcement	Ton	0.90	3500.00	ILS 3,150.00
1.2.2.1.2.6	Second floor columns reinforcement	Ton	0.90	3500.00	ILS 3,150.00
1.2.2.1.2.7	Third floor columns reinforcement	Ton	0.90	3500.00	ILS 3,150.00
1.2.2.1.2.8	Fourth floor columns reinforcement	Ton	0.70	3500.00	ILS 2,450.00
1.2.2.1.2.9	Fifth floor columns reinforcement	Ton	0.70	3500.00	ILS 2,450.00
1.2.2.1.3	Columns formwork	m2	1468.10	3.00	ILS 4,404.30
1.2.2.1.3.1	Basement 2 columns formwork	m2	188.30	3.00	ILS 564.90
1.2.2.1.3.2	Basement 1 columns formwork	m2	188.30	3.00	ILS 564.90
1.2.2.1.3.3	Ground floor columns formwork	m2	188.30	3.00	ILS 564.90
1.2.2.1.3.4	Attic floor columns formwork	m2	188.30	3.00	ILS 564.90
1.2.2.1.3.5	First floor columns formwork	m2	188.30	3.00	ILS 564.90

1.2.2.1.3.6	Second floor columns formwork	m2	188.30	3.00	ILS 564.90
1.2.2.1.3.7	Third floor columns formwork	m2	188.30	3.00	ILS 564.90
1.2.2.1.3.8	Fourth floor columns formwork	m2	150.00	3.00	ILS 450.00
1.2.2.1.3.9	Fifth floor columns formwork	m2	150.00	3.00	ILS 450.00
1.2.2.1.4	Slabs concrete	m3	2549.30	680.00	ILS 2,349,128.00
1.2.2.1.4.1	Basement 1 slab concrete	m3	735.00	680.00	ILS 499,800.00
1.2.2.1.4.2	Basement 2slab concrete	m3	735.00	680.00	ILS 499,800.00
1.2.2.1.4.3	Ground floor slab concrete	m3	292.00	680.00	ILS 198,560.00
1.2.2.1.4.4	Attic slab concrete	m3	280.00	680.00	ILS 190,400.00
1.2.2.1.4.5	First floor slab concrete	m3	354.50	680.00	ILS 241,060.00
1.2.2.1.4.6	Second floor slab concrete	m3	358.75	680.00	ILS 243,950.00
1.2.2.1.4.7	Third floor slab concrete	m3	358.75	680.00	ILS 243,950.00
1.2.2.1.4.8	Fourth floor slab concrete	m3	170.30	680.00	ILS 115,804.00
1.2.2.1.4.9	fifth slab concrete	m3	170.30	680.00	ILS 115,804.00
1.2.2.1.5	Slabs formwork	m2	9003.00	10.00	ILS 95,090.00
1.2.2.1.5.1	Basement 1 slab formwork	m2	2100.00	10.00	ILS 21,000.00
1.2.2.1.5.2	Basement 2 slab formwork	m2	2100.00	10.00	ILS 21,000.00
1.2.2.1.5.3	Ground floor slab formwork	m2	840.00	10.00	ILS 8,400.00
1.2.2.1.5.4	Attic slab formwork	m2	814.00	10.00	ILS 8,140.00
1.2.2.1.5.5	First floor slab formwork	m2	1013.00	10.00	ILS 10,130.00
1.2.2.1.5.6	Second floor slab formwork	m2	1040.00	10.00	ILS 10,400.00
1.2.2.1.5.7	Third floor slab formwork	m2	1040.00	10.00	ILS 10,400.00
1.2.2.1.5.8	Fourth floor slab formwork	m2	56.00	10.00	ILS 560.00
1.2.2.1.5.9	Fifth slab formwork	m2	506.00	10.00	ILS 5,060.00
1.2.2.1.6	Slabs reinforcement	Ton	87.16	3500.00	ILS 305,048.80
1.2.2.1.6.1	Basement 1 slab reinforcement	Ton	19.95	3500.00	ILS 69,825.00
1.2.2.1.6.2	Basement 2 slab reinforcement	Ton	19.95	3500.00	ILS 69,825.00
1.2.2.1.6.3	Ground floor slab reinforcement	Ton	7.17	3500.00	ILS 25,102.00
1.2.2.1.6.4	Atticfloor slab reinforcement	Ton	7.10	3500.00	ILS 24,850.00
1.2.2.1.6.5	First floor slab reinforcement	Ton	9.42	3500.00	ILS 32,970.00
1.2.2.1.6.6	Second floor slab reinforcement	Ton	9.63	3500.00	ILS 33,721.80
1.2.2.1.6.7	Third floor slab reinforcement	Ton	9.63	3500.00	ILS 33,705.00

1.2.2.1.6.8	Fourth floor slab reinforcement	Ton	4.30	3500.00	ILS 15,050.00
1.2.2.1.6.9	Fifrth floor slab reinforcement	Ton	4.30	3500.00	ILS 15,050.00
1.2.2.1.7	Ribs block	Unit	37137.20	2.70	ILS 100,270.44
1.2.2.1.7.1	Basement 1 slab concrete	Unit	8400.00	2.70	ILS 22,680.00
1.2.2.1.7.2	Basement 2 slab concrete	Unit	8400.00	2.70	ILS 22,680.00
1.2.2.1.7.3	Ground floor slab concrete	Unit	3372.00	2.70	ILS 9,104.40
1.2.2.1.7.4	attic floor slab concrete	Unit	3256.00	2.70	ILS 8,791.20
1.2.2.1.7.5	First floor slab concrete	Unit	4052.00	2.70	ILS 10,940.40
1.2.2.1.7.6	Second floor slab concrete	Unit	4160.00	2.70	ILS 11,232.00
1.2.2.1.7.7	Third floor slab concrete	Unit	4160.00	2.70	ILS 11,232.00
1.2.2.1.7.8	Fourth floor slab concrete	Unit	200.00	2.70	ILS 540.00
1.2.2.1.7.9	Fifth floor slab concrete	Unit	200.00	2.70	ILS 540.00
1.2.2.1.8	Beams concrete	m3	937.20	-	ILS 678,300.00
1.2.2.1.8.1	Basement 2 beams concrete	m3	210.00	680.00	ILS 142,800.00
1.2.2.1.8.2	Basement 1 beams concrete	m3	210.00	680.00	ILS 142,800.00
1.2.2.1.8.3	attic floor beams concrete	m3	81.00	680.00	ILS 55,080.00
1.2.2.1.8.4	Ground floor beams concrete	m3	81.00	680.00	ILS 55,080.00
1.2.2.1.8.5	First floor beams concrete	m3	96.30	680.00	ILS 65,484.00
1.2.2.1.8.6	Second floor beams concrete	m3	99.30	680.00	ILS 67,524.00
1.2.2.1.8.7	Third floor beams concrete	m3	99.30	680.00	ILS 67,524.00
1.2.2.1.8.8	Fourth floor beams concrete	m3	60.30	680.00	ILS 41,004.00
1.2.2.1.8.9	Fifth floor beams concrete	m3	60.30	680.00	ILS 41,004.00
1.2.2.1.9	Beams formwork	m2	4854.00	12.00	ILS 58,248.00
1.2.2.1.9.1	Basement 2 beams formwork	m2	680.00	12.00	ILS 8,160.00
1.2.2.1.9.2	Basement 1 beams formwork	m2	680.00	12.00	ILS 8,160.00
1.2.2.1.9.3	Ground floor beams formwork	m2	560.00	12.00	ILS 6,720.00
1.2.2.1.9.4	attic floor beams formwork	m2	560.00	12.00	ILS 6,720.00
1.2.2.1.9.5	First floor beams formwork	m2	637.00	12.00	ILS 7,644.00
1.2.2.1.9.6	Second floor beams formwork	m2	637.00	12.00	ILS 7,644.00
1.2.2.1.9.7	Third floor beams formwork	m2	637.00	12.00	ILS 7,644.00
1.2.2.1.9.8	Fifth floor beams formwork	m2	463.00	12.00	ILS 5,556.00
1.2.2.1.9.9	Fourth floor beams formwork	m2	463.00	12.00	ILS 5,556.00

1.2.2.1.10	Beams reinforcement	Ton	97.27	3500.00	ILS 340,445.00
1.2.2.1.10.1	Basement 2 beams reinforcement	Ton	15.50	3500.00	ILS 54,250.00
1.2.2.1.10.2	Basement 1 beams reinforcement	Ton	15.50	3500.00	ILS 54,250.00
1.2.2.1.10.3	Ground floor beams reinforcement	Ton	10.47	3500.00	ILS 36,645.00
1.2.2.1.10.4	attic floor beams reinforcement	Ton	10.40	3500.00	ILS 36,400.00
1.2.2.1.10.5	First floor beams reinforcement	Ton	12.30	3500.00	ILS 43,050.00
1.2.2.1.10.6	Second floor beams reinforcement	Ton	12.60	3500.00	ILS 44,100.00
1.2.2.1.10.7	Third floor beams reinforcement	Ton	12.60	3500.00	ILS 44,100.00
1.2.2.1.10.8	Fourth floor beams reinforcement	Ton	7.90	3500.00	ILS 27,650.00
1.2.2.1.10.9	Fifth floor beams reinforcement	Ton	7.90	3500.00	ILS 27,650.00
1.2.2.1.11	Ramp	-	-	-	ILS 63,960.00
1.2.2.1.11.1	Ramp formwork	m2	240.00	10.00	ILS 2,400.00
1.2.2.1.11.2	Ramp reinforcement	Ton	3.60	3500.00	ILS 12,600.00
1.2.2.1.11.3	Ramp concrete	m3	72.00	680.00	ILS 48,960.00
1.2.2.1.12	stairs (3)				ILS 284,258.40
1.2.2.1.12.1	Stairs formwork	m2	1305.70	4.00	ILS 5,222.80
1.2.2.1.12.2	Stairs reinforcement	Ton	7.90	3500.00	ILS 27,650.00
1.2.2.1.12.3	Stairs concrete	m3	91.00	680.00	ILS 61,880.00
1.2.2.1.13	stairs (internal)				ILS 16,548.00
1.2.2.1.13.1	Stairs formwork	m2	145.00	4.00	ILS 580.00
1.2.2.1.13.2	Stairs reinforcement	Ton	2.60	3500.00	ILS 9,100.00
1.2.2.1.13.3	Stairs concrete	m3	10.10	680.00	ILS 6,868.00
1.2.2.1.14	Shear wall formwork	m2	2345.00	50.00	ILS 117,250.00
1.2.2.1.15.1	Basement 2 Shear wall formwork	m2	357.00	50.00	ILS 17,850.00
1.2.2.1.15.2	Basement 1 Shear wall formwork	m2	357.00	50.00	ILS 17,850.00
1.2.2.1.15.3	atiic floor Shear wall formwork	m2	357.00	50.00	ILS 17,850.00
1.2.2.1.15.4	Ground floor Shear wall formwork	m2	261.00	50.00	ILS 13,050.00

1.2.2.1.15.5	First floor Shear wall formwork	m2	261.00	50.00	ILS 13,050.00
1.2.2.1.15.6	Second floor Shear wall formwork	m2	261.00	50.00	ILS 13,050.00
1.2.2.1.15.7	Third floor Shear wall formwork	m2	261.00	50.00	ILS 13,050.00
1.2.2.1.15.8	Fifth floor Shear wall formwork	m2	230.00	50.00	ILS 11,500.00
1.2.2.1.15.9	Fourth floor Shear wall formwork	m2	230.00	50.00	ILS 11,500.00
1.2.2.1.16	Shear wall reinforcement	Ton	124.00	3500.00	ILS 434,000.00
1.2.2.1.16.1	Basement 2 Shear wall reinforcement	Ton	16.00	3500.00	ILS 56,000.00
1.2.2.1.16.2	Basement 1 Shear wall reinforcement	Ton	16.00	3500.00	ILS 56,000.00
1.2.2.1.16.3	Ground floor Shear wall reinforcement	Ton	16.00	3500.00	ILS 56,000.00
1.2.2.1.16.4	attic floor Shear wall reinforcement	Ton	13.00	3500.00	ILS 45,500.00
1.2.2.1.16.5	First floor Shear wall reinforcement	Ton	13.00	3500.00	ILS 45,500.00
1.2.2.1.16.6	Second floor Shear wall reinforcement	Ton	13.00	3500.00	ILS 45,500.00
1.2.2.1.16.7	Third floor Shear wall reinforcement	Ton	13.00	3500.00	ILS 45,500.00
1.2.2.1.16.8	Fourth floor Shear wall reinforcement	Ton	12.00	3500.00	ILS 42,000.00
1.2.2.1.16.9	Fifth floor Shear wall reinforcement	Ton	12.00	3500.00	ILS 42,000.00
1.2.2.1.17	Shear wall concrete	m3	1220.00	680.00	ILS 829,600.00
1.2.2.1.17.1	Basement 2 Shear wall concrete	m3	160.00	680.00	ILS 108,800.00
1.2.2.1.17.2	Basement 1 Shear wall concrete	m3	160.00	680.00	ILS 108,800.00
1.2.2.1.17.3	Ground floor Shear wall concrete	m3	160.00	680.00	ILS 108,800.00
1.2.2.1.17.4	Attic floor Shear wall concrete	m3	132.00	680.00	ILS 89,760.00
1.2.2.1.17.5	First floor Shear wall concrete	m3	132.00	680.00	ILS 89,760.00
1.2.2.1.17.6	Second floor Shear wall concrete	m3	132.00	680.00	ILS 89,760.00
1.2.2.1.17.7	Third floor Shear wall concrete	m3	132.00	680.00	ILS 89,760.00
1.2.2.1.17.8	Fourth floor Shear wall concrete	m3	106.00	680.00	ILS 72,080.00

1.2.2.1.17.9	Fifth floor Shear wall concrete	m3	106.00	680.00	ILS 72,080.00
1.2.2.2	Finishing			888	9010139
1.2.2.2.1	Interior tiles	m2			ILS 0.00
1.2.2.2.1.1	basment 1(helicopter)	m2	2100.00	8.00	ILS 16,800.00
1.2.2.2.1.2	basment 2(helicopter)	m2	2100.00	8.00	ILS 16,800.00
1.2.2.2.1.3	ground floor tiles	m2	814.00	200.00	ILS 162,800.00
1.2.2.2.1.4	attic floor tiles	m2	840.00	200.00	ILS 168,000.00
1.2.2.2.1.5	first floor tiles	m2	1040.00	200.00	ILS 208,000.00
1.2.2.2.1.6	second floor tiles	m2	1100.00	200.00	ILS 220,000.00
1.2.2.2.1.7	third floor tiles	m2	1100.00	200.00	ILS 220,000.00
1.2.2.2.1.8	fourth floor tiles	m2	530.00	200.00	ILS 106,000.00
1.2.2.2.1.9	fifrth floor tiles	m2	530.00	200.00	ILS 106,000.00
1.2.2.2.2	gypsum board	m2			ILS 0.00
1.2.2.2.2.1	ground floor	m2	1700.00	70.00	ILS 119,000.00
1.2.2.2.2.2	attic floor	m2	1650.00	70.00	ILS 115,500.00
1.2.2.2.2.3	first floor	m2	1850.00	70.00	ILS 129,500.00
1.2.2.2.2.4	second floor	m2	1800.00	70.00	ILS 126,000.00
1.2.2.2.2.5	third floor	m2	1800.00	70.00	ILS 126,000.00
1.2.2.2.2.6	fourth floor	m2	750.77	70.00	ILS 52,553.90
1.2.2.2.2.7	fifrth floor	m2	750.77	70.00	ILS 52,553.90
1.2.2.2.3	Doors	Unit			ILS 0.00
1.2.2.2.3.1	glazed single doors	Unit	120	1500.00	ILS 180,000.00
1.2.2.2.3.2	wooden single doors	Unit	60	2500.00	ILS 150,000.00
1.2.2.2.3.3	glazed double doors	Unit	3	3500.00	ILS 10,500.00
1.2.2.2.4	Fire doors	Unit	6	3000.00	ILS 18,000.00
1.2.2.2.5	elevators	Unit	4	220000.00	ILS 880,000.00
1.2.2.2.6	Exterior wall	m2			ILS 0.00
1.2.2.2.6.1	ground floor	m2	498.6	1000.00	ILS 498,600.00
1.2.2.2.6.2	attic floor	m2	490.5	1000.00	ILS 490,500.00
1.2.2.2.6.3	first floor	m2	738.6	1000.00	ILS 738,600.00
1.2.2.2.6.4	second floor	m2	738.6	1000.00	ILS 738,600.00
1.2.2.2.6.5	third floor	m2	753.42	1000.00	ILS 753,420.00

1.2.2.2.6.6	fourth floor	m2	310.2	1000.00	ILS 310,200.00
1.2.2.2.6.7	fifth floor	m2	310.2	1000.00	ILS 310,200.00
1.2.2.2.7	Alcabond	m2			ILS 0.00
1.2.2.2.7.1	ground floor	m2	137.875	350.00	ILS 48,256.25
1.2.2.2.7.2	attic floor	m2	133.75	350.00	ILS 46,812.50
1.2.2.2.7.3	first floor	m2	307.75	350.00	ILS 107,712.50
1.2.2.2.7.4	second floor	m2	307.75	350.00	ILS 107,712.50
1.2.2.2.7.5	third floor	m2	313.925	350.00	ILS 109,873.75
1.2.2.2.7.6	fourth floor	m2	88.0625	350.00	ILS 30,821.88
1.2.2.2.7.7	fifth floor	m2	88.0625	350.00	ILS 30,821.88
1.2.2.2.6	interior partition	m2			ILS 0.00
1.2.2.2.6.1	block	m2	2200	30.00	ILS 66,000.00
	painting	m2	2200	50.00	ILS 110,000.00
1.2.2.2.6.2	plaster	m2	2200	40.00	ILS 88,000.00
1.2.2.2.6.3	glass	m2	1550	800.00	ILS 1,240,000.00
1.3	Electrical and low voltage			125	1266890
1.3.1	Ceiling loud speakers	Unit	20.00	500.00	ILS 10,000.00
1.3.2	PV system	-	1.00	500000.00	ILS 500,000.00
1.3.3	Lighting circuit braker(10A)	Unit	140.00	40.00	ILS 5,600.00
1.3.4	Power circuit braker	Unit	154.00	85.00	ILS 13,090.00
1.3.4.1	SDB	Unit	18.00	2000.00	ILS 36,000.00
1.3.4.2	MDB	Unit	2.00	9000.00	ILS 18,000.00
1.3.4.3	Single Switches	Unit	40.00	90.00	ILS 3,600.00
1.3.4.4	Double Switches	Unit	60.00	160.00	ILS 9,600.00
1.3.4.5	Triple socketes	Unit	140.00	200.00	ILS 28,000.00
1.3.4.6	Telephone socket outlet	Unit	120.00	150.00	ILS 18,000.00
1.3.4.7	LSC86	Unit	70.00	250.00	ILS 17,500.00
1.3.4.8	Spot light	Unit	150.00	150.00	ILS 22,500.00
1.3.4.9	Stair light	Unit	50.00	200.00	ILS 10,000.00
1.3.4.10	philps-RC505B	Unit	1150.00	500.00	ILS 575,000.00
1.4	Mechanical			187	1893865
1.4.1	Lavatory	unit	32.00	500.00	ILS 16,000.00

1.4.2	Sink	unit	28.00	450.00	ILS 12,600.00
1.4.3	manhole(60*60 cm)	unit	3.00	1000.00	ILS 3,000.00
1.4.4	floor drainage	unit	40.00	80.00	ILS 3,200.00
1.4.5	PVC pipe 4"	m	180.00	10.00	ILS 1,800.00
1.4.6	pvc pipe 6” slope 1%	m	150.00	20.00	ILS 3,000.00
1.4.7	pvc pipe 2”	m	30.00	6.00	ILS 180.00
1.4.8	Pvc fitting (4”)	Unit	40.00	4.00	ILS 160.00
1.4.9	Pvc fitting(2”)	Unit	30.00	3.00	ILS 90.00
1.4.10	w.c elbow(4”)	Unit	32.00	5.00	\
1.4.11	PVC fitting (6”)	Unit	15.00	8.00	ILS 120.00
1.4.12	collector	Unit	7.00	45.00	ILS 315.00
1.4.13	Cold water pipe(pvc 1")	m	200.00	3.00	ILS 600.00
1.4.14	Hot water pipe(pvdc 1")	m	200.00	4.00	ILS 800.00
1.4.15	Steel pipes(2.5")	m	0.00	55.00	ILS 0.00
1.4.16	Tanks	Unit	12.00	500.00	ILS 6,000.00
1.4.17	HVAC system	m2	5954.00	250.00	ILS 1,488,500.00
1.4.17.1	AC central system	m2	0.00	175.00	ILS 0.00
1.4.18	Fire system	-	0.00	-	ILS 178,750.00
1.4.18.1	Water sprinklers	Unit	477.00	200.00	ILS 95,400.00
1.4.18.2	Dry powder extingushers	Unit	96.00	100.00	ILS 9,600.00
1.4.18.3	Fire Hose Cabinet class 1	Unit	12.00	1000.00	ILS 12,000.00
1.4.18.4	Steel pipes	m	400.00	50.00	ILS 20,000.00
1.4.18.5	detector	Unit	65.00	300.00	ILS 19,500.00
1.4.18.6	Fire Bell	Unit	9.00	250.00	ILS 2,250.00
1.4.18.7	Fire system pumps	Unit	1.00	20000.00	ILS 20,000.00

Chapter 6 : Conclusion

6.1 Results:

As a result of taken Investment Building (Bank) to redesign the following conclusion is the final result in the first stage of graduation project, and will be divided into several fields, which are:

In this project, the bank was designed according to the standards and codes in all aspects of design, whether in terms of architectural, environmental, structural, and electro mechanics, in order to obtain an integrated building in all systems and energy efficient as well.

In the architectural aspect, for example, the division of the internal spaces of the building was reconsidered, adding what the building needed such as camera and fire rooms, for example, and changing the number of bathrooms to fit the building standard, adding a third elevator and shafts ,remove the skylight, making the emergency exits internal and other modifications to make the building integrated according to the standard.

For the environmental aspects, several methods were used to obtain an energy-efficient and effective building, including the use of a type of glass that gives a new percentage of both lighting and solar energy and contains good insulators, the use of a shutters to prevent the occurrence of glare inside the building due to sunlight, in addition to the use of insulation in both walls and ceiling, finally, the use of a solar system to help save energy in the building.

The structural system chosen in the building is a concrete system and the seismic system is a structural system is a building frame system (shear wall)

Use the two– way ribbed slab with dropped beams From the grand floor until the fifth.

Hedin Beam =350*600 mm (depth, width).

Drop Beam =650*750mm (depth, width).

Drop Beam =600*600mm (depth, width).

Drop Beam =500*700mm (depth, width).

Drop Beam =600*750 mm (depth, width).

Drop Beam =500*750mm (depth, width).

Drop Beam =500*500mm (depth, width).

Hedin beam =350*500 mm (depth, width).

Use the solid slab with dropped beam in the barking

Main Beam =350*600 mm (depth, width)

Drop Beam =600*700 mm (depth, width)

Drop Beam =600*750 mm (depth, width).

Drop Beam =650*800 mm (depth, width)

All Column diameter 70 cm .

Electricity and lighting installations were designed for all floors, where the loads needed for lighting systems and energy in the bank were calculated, as the system contains the main electrical panels in addition to two sub panels on each floor.

The DIALux program was used to distribute lighting units inside the building according to the standards for offices and banks.

The building was provided with a firefighting system, where fire sprinklers were used, in addition to hose stations and manual extinguishers, and fire, smoke and alarm detection systems were used.

The HVAC system is designed for the bank and uses the VRF system as the outdoor unit and the diffusers, and the cassette unit for some small offices as internal units In addition to extending a water drainage network for the system, which is connected with the main drainage system.

The building was provided with water tanks on the roof to distribute water from it to all buildings, and the building was provided with a sewage system for sewage water connected to the public network, in addition to making a network to drain rainwater into a large concrete tank under the building that was designed.

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Appendix

Longitudinal reinforcement for beams.

Table 146 : Longitudinal reinforcement for beams.

	Location	**As,min**	**As**	**As**	**# of bars**	**ø of bars**	**As used**
B1	End-I (-)	2308	2308	2308	8	20	2512
	Middle (+)	2308	2308	2308	8	20	2512
	End-J(-)	2308	2926	2926	8	20	2512
B2	End-I (-)	2308	2034	2308	8	18	2034.72
	Middle (+)	2308	1463	2308	6	18	1526.04
	End-J(-)	2308	2034	2308	8	20	2512
B3	End-I (-)	1570	17	1570	8	16	1607.68
	Middle (+)	1570	34	1570	8	16	1607.68
	End-J(-)	1570	17	1570	8	16	1607.68
B4	End-I (-)	1570	659	1570	8	16	1607.68
	Middle (+)	1570	767	1570	8	16	1607.68
	End-J(-)	1570	831	1570	8	16	1607.68
B5	End-I (-)	1570	2283	2283	8	20	2512
	Middle (+)	1570	1460	1570	8	16	1607.68
	End-J(-)	1570	834	1570	8	16	1607.68
B6	End-I (-)	1570	3490	3490	5	32	4019.2

	Middle (+)	1570	1124	1570	8	32	6430.72
	End-J(-)	1570	3086	3086	4	32	3215.36
B7	End-I (-)	1570	2653	2653	9	20	2826
	Middle (+)	1570	862	1570	8	16	1607.68
	End-J(-)	1570	2308	2308	8	20	2512
B8	End-I (-)	2308	2436	2436	8	20	2512
	Middle (+)	2308	2308	2308	8	38	9068.32
	End-J(-)	2308	3062	3062	4	32	3215.36
B9	End-I (-)	2308	2308	2308	8	20	2512
	Middle (+)	2308	966	2308	8	20	2512
	End-J(-)	2308	2783	2783	9	20	2826
B10	End-I (-)	2308	1512	2308	8	20	2512
	Middle (+)	2308	679	2308	8	20	2512
	End-J(-)	2308	1469	2308	8	20	2512
B11	End-I (-)	2308	3624	3624	5	32	4019.2
	Middle (+)	2082	2140	2140	8	20	2512
	End-J(-)	1963	2308	2308	8	20	2512
B12	End-I (-)	1963	2737	2737	9	20	2826
	Middle (+)	1963	888	1963	7	20	2198
	End-J(-)	1963	2668	2668	9	20	2826
B13	End-I (-)	1963	1583	1963	7	20	2198

	Middle (+)	1963	716	1963	7	20	2198
	End-J(-)	1963	2079	2079	7	20	2198
B14	End-I (-)	1963	371	1963	7	20	2198
	Middle (+)	1963	527	1963	7	20	2198
	End-J(-)	1963	1500	1963	7	20	2198
B15	End-I (-)	1963	1724	1963	7	20	2198
	Middle (+)	1963	586	1963	7	20	2198
	End-J(-)	1963	426	1963	7	20	2198
B16	End-I (-)	1963	2308	2308	8	20	2512
	Middle (+)	1963	2060	2060	7	20	2198
	End-J(-)	1963	1796	1963	7	20	2198
B17	End-I (-)	1963	2308	2308	8	20	2512
	Middle (+)	2299	2308	2308	8	20	2512
	End-J(-)	2304	2308	2308	8	20	2512
B18	End-I (-)	2308	1116	2308	8	20	2512
	Middle (+)	2308	1978	2308	8	20	2512
	End-J(-)	2308	2308	2308	8	20	2512
B19	End-I (-)	2308	229	2308	8	20	2512
	Middle (+)	2308	454	2308	8	20	2512
	End-J(-)	2308	922	2308	8	20	2512
B20	End-I (-)	2308	101	2308	8	20	2512

	Middle (+)	2308	101	2308	8	20	2512
	End-J(-)	2227	101	2227	8	20	2512
B21	End-I (-)	2227	336	2227	8	20	2512
	Middle (+)	2227	744	2227	8	20	2512
	End-J(-)	2227	1355	2227	8	20	2512
B22	End-I (-)	2227	1676	2227	8	20	2512
	Middle (+)	2227	2308	2308	8	20	2512
	End-J(-)	2227	2664	2664	9	20	2826
B23	End-I (-)	2227	3097	3097	10	20	3140
	Middle (+)	2227	2308	2308	8	20	2512
	End-J(-)	2227	1792	2227	8	20	2512
B24	End-I (-)	2227	1196	2227	8	20	2512
	Middle (+)	2227	575	2227	8	20	2512
	End-J(-)	2227	829	2227	8	20	2512
B25	End-I (-)	2227	843	2227	8	20	2512
	Middle (+)	2227	543	2227	8	20	2512
	End-J(-)	2227	1046	2227	8	20	2512
B26	End-I (-)	2227	1441	2227	8	20	2512
	Middle (+)	2227	1689	2227	8	20	2512
	End-J(-)	2227	1539	2227	8	20	2512
B27	End-I (-)	2227	758	2227	8	20	2512

	Middle (+)	2308	189	2308	8	20	2512
	End-J(-)	2308	189	2308	8	20	2512
B28	End-I (-)	2308	253	2308	8	20	2512
	Middle (+)	2308	1663	2308	8	20	2512
	End-J(-)	2308	1321	2308	8	20	2512
B29	End-I (-)	2308	1392	2308	8	20	2512
	Middle (+)	2308	701	2308	8	20	2512
	End-J(-)	2308	345	2308	8	20	2512
B30	End-I (-)	2308	2274	2308	8	20	2512
	Middle (+)	2308	1150	2308	8	20	2512
	End-J(-)	2308	559	2308	8	20	2512
B31	End-I (-)	2308	1221	2308	8	20	2512
	Middle (+)	2308	1365	2308	8	20	2512
	End-J(-)	2308	1919	2308	8	20	2512
B32	End-I (-)	2308	921	2308	8	20	2512
	Middle (+)	2118	921	2118	7	20	2198
	End-J(-)	1680	1104	1680	6	20	1884
B33	End-I (-)	2308	1492	2308	8	20	2512
	Middle (+)	2308	1492	2308	8	20	2512
	End-J(-)	2308	4689	4032	5	32	4019.2
B34	End-I (-)	2308	4002	4002	5	32	4019.2

	Middle (+)	2308	1283	2308	8	20	2512
	End-J(-)	1925	1283	1925	7	20	2198
B35	End-I (-)	1168	339	1168	4	20	1256
	Middle (+)	1183	84	1183	4	20	1256
	End-J(-)	670	808	808	5	16	1004.8
B36	End-I (-)	259	2308	2308	8	20	2512
	Middle (+)	259	2308	2308	8	20	2512
	End-J(-)	259	2789	2789	9	20	2826
B37	End-I (-)	259	2049	2049	7	20	2198
	Middle (+)	259	1730	1730	6	20	1884
	End-J(-)	259	2193	2193	7	20	2198
B38	End-I (-)	259	17	259	2	14	307.72
	Middle (+)	259	17	259	2	14	307.72
	End-J(-)	259	17	259	2	14	307.72
B39	End-I (-)	259	1656	1656	9	16	1808.64
	Middle (+)	259	2308	2308	8	20	2512
	End-J(-)	259	2640	2640	9	20	2826
B40	End-I (-)	259	3158	3158	4	32	3215.36
	Middle (+)	259	2308	2308	8	20	2512
	End-J(-)	259	1819	1819	6	20	1884
B41	End-I (-)	2308	1220	2308	8	20	2512

	Middle (+)	2308	599	2308	8	20	2512
	End-J(-)	2308	833	2308	8	20	2512
B42	End-I (-)	2308	839	2308	8	20	2512
	Middle (+)	2145	556	2145	7	20	2198
	End-J(-)	2145	1100	2145	7	20	2198
B43	End-I (-)	2145	1509	2145	7	20	2198
	Middle (+)	2145	1641	2145	7	20	2198
	End-J(-)	2145	1485	2145	7	20	2198
B44	End-I (-)	2145	927	2145	7	20	2198
	Middle (+)	2145	230	2145	7	20	2198
	End-J(-)	2145	230	2145	7	20	2198
B45	End-I (-)	2145	257	2145	7	20	2198
	Middle (+)	2145	1648	2145	7	20	2198
	End-J(-)	2145	1322	2145	7	20	2198
B46	End-I (-)	2145	1397	2145	7	20	2198
	Middle (+)	2145	711	2145	7	20	2198
	End-J(-)	2145	346	2145	7	20	2198
B47	End-I (-)	2145	2308	2308	8	20	2512
	Middle (+)	2145	1208	2145	7	20	2198
	End-J(-)	2145	575	2145	7	20	2198
B48	End-I (-)	2145	1217	2145	7	20	2198

	Middle (+)	2145	1401	2145	7	20	2198
	End-J(-)	2145	1974	2145	7	20	2198
B49	End-I (-)	2145	1988	2145	7	20	2198
	Middle (+)	2145	1037	2145	7	20	2198
	End-J(-)	2145	1087	2145	7	20	2198

Transverse side reinforcement for beams.

	Vu	Vu design/ø	Vc	Vs	Vs max	Av/s	Av/s min	Av/s use	Av (ø10)	S	S max	S use	stirrups
B1	436.18	581.57	357.18	224.39	1428.7	0.99	0.63	0.99	157	158.69	270	159	1ø10
B2	426.37	568.49	357.18	211.31	1428.7	0.93	0.63	0.93	157	168.51	270	169	1ø10
B3	416.56	555.41	357.18	198.23	1428.7	0.87	0.63	0.87	157	179.63	270	180	1ø10
B4	310	413.34	357.18	56.16	1428.7	0.25	0.63	0.63	157	251.2	270	251	1ø10
B5	299.47	399.3	357.18	42.12	1428.7	0.19	0.63	0.63	157	251.2	270	251	1ø10
B6	288.94	385.26	357.18	28.08	1428.7	0.12	0.63	0.63	157	251.2	270	251	1ø10
B7	278.42	371.22	357.18	14.04	1428.7	0.06	0.63	0.63	157	251.2	270	251	1ø10
B8	159.64	212.85	357.18	-144.33	1428.7	-0.64	0.63	0.63	157	251.2	270	251	1ø10
B9	149.11	198.81	357.18	-158.37	1428.7	-0.7	0.63	0.63	157	251.2	270	251	1ø10
B10	138.58	184.77	357.18	-172.41	1428.7	-0.76	0.63	0.63	157	251.2	270	251	1ø10
B11	128.05	170.73	357.18	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
B12	7.76	10.34	102.3	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
B13	18.29	24.38	102.3	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
B14	28.81	38.42	102.3	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)

B15	39.34	52.46	102.3	-49.84	511.51	-0.24	0.42	0.42	157	376.8	270	270	1ø10
B16	175.71	234.28	357.18	-122.9	1428.7	-0.54	0.63	0.63	157	251.2	270	251	1ø10
B17	186.24	248.32	357.18	-108.86	1428.7	-0.48	0.63	0.63	157	251.2	270	251	1ø10
B18	196.77	262.36	357.18	-94.82	1428.7	-0.42	0.63	0.63	157	251.2	270	251	1ø10
B19	207.3	276.4	357.18	-80.78	1428.7	-0.36	0.63	0.63	157	251.2	270	251	1ø10
B20	341.24	454.98	357.18	97.81	1428.7	0.43	0.63	0.63	157	251.2	270	251	1ø10
B21	351.77	469.02	357.18	111.85	1428.7	0.49	0.63	0.63	157	251.2	270	251	1ø10
B22	362.3	483.06	357.18	125.88	1428.7	0.56	0.63	0.63	157	251.2	270	251	1ø10
B23	372.83	497.1	357.18	139.92	1428.7	0.62	0.63	0.63	157	251.2	270	251	1ø10
B24	512.85	683.8	380.99	302.81	1524	0.9	0.67	0.9	157	174.21	270	174	1ø10
B25	522.66	696.88	380.99	315.89	1524	0.94	0.67	0.94	157	166.99	270	167	1ø10
B26	532.47	709.96	380.99	328.97	1524	0.98	0.67	0.98	157	160.35	270	160	1ø10
B27	555.36	740.48	380.99	359.49	1524	1.07	0.67	1.07	157	146.74	270	147	1ø10
B28	546.95	729.27	380.99	348.28	1524	1.04	0.67	1.04	157	151.46	270	151	1ø10
B29	538.55	718.06	380.99	337.07	1524	1	0.67	1	157	156.5	270	157	1ø10
B30	391.83	522.44	380.99	141.46	1524	0.42	0.67	0.67	157	235.5	270	236	1ø10
B31	382.81	510.41	380.99	129.42	1524	0.39	0.67	0.67	157	235.5	270	236	1ø10
B32	373.78	498.38	127.88	370.5	511.51	1.63	0.42	1.63	157	96.11	145	96	1ø10
B33	231.44	308.58	127.88	180.7	511.51	0.8	0.42	0.8	157	197.05	145	145	1ø10
B34	240.46	320.61	127.88	192.74	511.51	0.85	0.42	0.85	157	184.75	145	145	1ø10
B35	249.49	332.65	127.88	204.77	511.51	0.9	0.42	0.9	157	173.89	145	145	1ø10
B36	258.51	344.68	127.88	216.8	511.51	0.96	0.42	0.96	157	164.24	145	145	1ø10
B37	444.5	592.67	357.18	235.49	1428.7	1.04	0.63	1.04	157	151.2	270	151	1ø10
B38	453.53	604.71	357.18	247.53	1428.7	1.09	0.63	1.09	157	143.85	270	144	1ø10
B39	462.55	616.74	357.18	259.56	1428.7	1.14	0.63	1.14	157	137.18	270	137	1ø10
B40	471.58	628.77	357.18	271.6	1428.7	1.2	0.63	1.2	157	131.1	270	131	1ø10
B41	666.86	889.15	357.18	531.97	1428.7	2.35	0.63	2.35	157	66.94	270	67	1ø10
B42	675.27	900.36	357.18	543.18	1428.7	2.39	0.63	2.39	157	65.55	270	66	1ø10
B43	683.68	911.57	357.18	554.39	1428.7	2.44	0.63	2.44	157	64.23	270	64	1ø10

B44	555.36	740.48	357.18	383.3	1428.7	1.69	0.63	1.69	157	92.9	270	93	1ø10
B45	546.95	729.27	357.18	372.09	1428.7	1.64	0.63	1.64	157	95.7	145	96	1ø10
B46	538.55	718.06	357.18	360.88	1428.7	1.59	0.63	1.59	157	98.67	145	99	1ø10
B47	391.83	522.44	357.18	165.27	1428.7	0.73	0.63	0.73	157	215.45	145	145	1ø10
B48	382.81	510.41	357.18	153.23	1428.7	0.68	0.63	0.68	157	232.38	145	145	1ø10