

Graduation Project (II)



An- Najah National University

Faculty of Engineering & Information Technology

Department of Building Engineering

“Graduation project report [2nd Graduation project]”

“Educational Institute”

Prepared by:

Anas Maali

Ibrahim Ishtawi

Yahya Assi

Supervisor Name: Eng.Nirmeen AL-Barq.

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Dedication

Praise be to God, whose blessings are righteous. My graduation project has been successfully completed. I dedicate my graduation to the teacher of humanity, Muhammad, may God's prayers and peace be upon him, to my beloved country to a lady beneath her feet Heaven is my mother to a man who has spent his life for my father to all my family and my brothers to all the friends and colleagues in the study to my colleagues in the project, to those whose words stand puzzled in front of their grace and assistance to them, my dear teachers, to all of you, I bow my stature and present the fruits of my academic years mawla Almighty asked him to benefit from it and make it for his kind face.

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DISCLAIMER

This report was written by students at the Building Engineering Department, Faculty of Engineering and An-Najah National University. It has not been altered or corrected other than editorial corrections, as a result of assessment and it may contain language as well as content errors. The views expressed in it together with any outcomes and recommendations are solely those of the students. An-Najah National University accepts no responsibility or liability for the consequences of this report being used for a purpose other than the purpose for which it was commissioned.

Abstract

We chose this type of building because of the lack of Institute Educational in Palestine even it has a high importance to study and develop science and particular issue in order to rise up as a developing country. In terms of engineering, this center is located in Jericho (Dead Sea Rift) as it is a critical location in Palestine for earthquakes it adds potential to the challenges in this building. the design of this type of building differs from residential buildings, universities, schools, etc., through function, interior divisions and the furniture, and due to the high temperature of its location it adds more specifications and technical issues to take into consideration.

The importance of this type of building lies in necessary that both scientific research and the availability of information side by side, scientific research, mechanisms, and specific scientific steps, by specialists to study a problem, or a particular issue, and information is: quantitative description provides a realistic picture of the subject, or the issue to be studied and addressed in order to develop, improve for the better, also The need for scientific research nowadays is more severe than ever before. Both developed and underdeveloped are important in advancing the economy.

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Chapter 1: Introduction

1.1 Overview

The building is located in (Jericho city) 30 km from our capital, Jerusalem, the Educational Institute we selected our project is based on its area (1860 m²). This building includes three floors. the Educational Institute is the place where military and legal graduate studies, to create an educated and conscious generation for our country.

This type of building is not widespread in Palestine ,it needs good designs to get an integrated job performance, and a sense of comfort for the employees inside the building as well as research students and master students.

1.2 statement of the problem

There are many problems facing buildings during and after construction, and in our project there are many problems that will be adjusted with the best solutions to get good design results and ensure the operation of the building well.

1.3 objectives

The main objective of the project is to obtain an integrated design in all respects, where the building will be modified from an architectural point of view which includes environmental analysis and comparison of the project with the specifications and design standards, as well as from the structural, mechanical and electrical aspects.

Also. one of the goals that we hope to achieve good results in terms of design and operation, especially since this type of buildings is limited in Palestine, so we hope that this building will be a reference for buildings that will be designed

1.4 Methodology

There are many engineering problems facing the projects, whether they are related to the design, the state laws related to construction, the areas related to the project and many others.

In this project we will work to solve problems in all respects and then compare them with standards, and there is a case study that we will work on comparing with is the Korean Institute located at An-Najah National University in Nablus, in which seminars and administrative

meetings and lectures for graduate students, as it is similar to our project as there are many programs that helped us Architecturally there is the Revit program, structurally there are ETAPS and SAP programs and environmentally there is the Design Builder program.

1.5 codes and Specification

1.5.1 For Architectural Standards :

- Jordanian code of building space requirements.
- Metric and book planning and design data.
- Ernst and Peter Neufert Architect's Data third edition.

1.5.2 For Structural Design :

- ASCE-7 for combination & load .
- ACI 318-14.
- UBC 97

1.5.3 For Mechanical Design :

- (ASHRE): for heating, refrigeration and air conditioning design.
- (NPC): plumbing design.

Chapter2:Architectural Aspects

2.1 Introduction

Architecture is both the process and the product of planning, designing, and constructing buildings or any other structures. Architectural works, in the material form of buildings, are often perceived as cultural symbols and as works of art. Historical civilizations are often identified with their surviving architectural achievements.

In addition, architecture is closely related to the areas of city planning, urban planning, urban furnishings and interior design. In this region, finding an appropriate version of the design translates into the needs of the people first and then to the location later. Architectural and descriptive drawings must be prepared to determine the construction method, prepare schedules, estimate the cost, and manage construction.

2.2 Problem definition

Academic research building in AL-Istqlal University-Jericho consist of three floors with a total area of 1860 m² (ground600 m², first660 m² and second600 m²) contains conference halls, lecture halls, offices, Representation halls the plans are attached.

The architectural base and standards have been studied, and accordingly some architectural and functional modifications have been made to suit this type of buildings in order to have the best engineering solutions ,best operational performance . Where the amendments were made depending on the following:

2.3 Standard requirements

2.3.1 corridors:

The width of the corridor depends on the number of users, the space used and the areas required for movement, in general in this type of buildings the corridor can accommodate two people and must be at least 2 m.

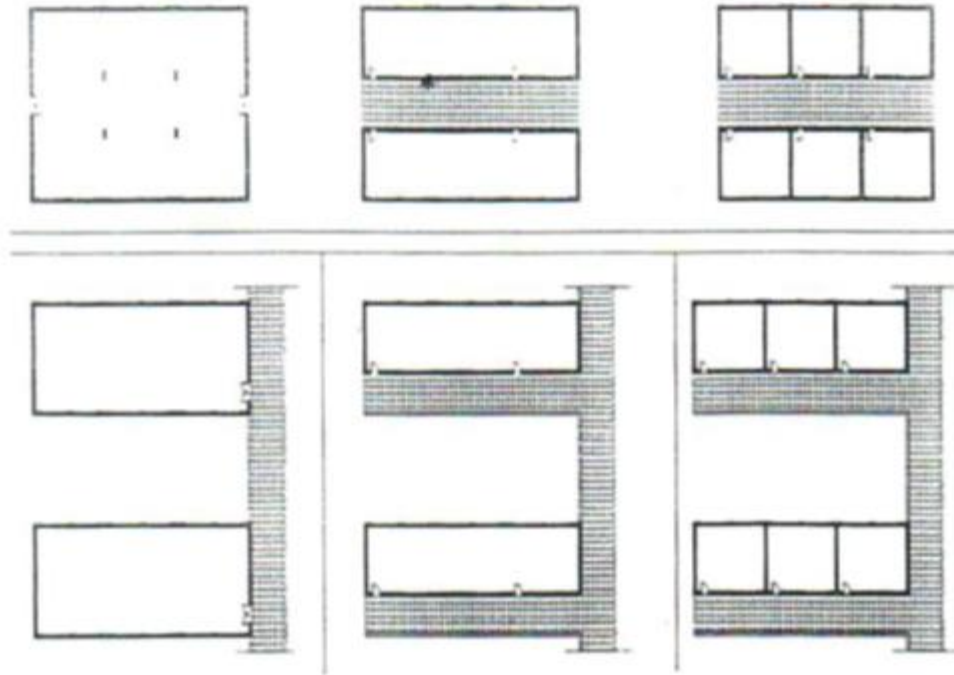


Figure 1: corridor width.

2.3.2 Stairs:

In this type of building, the width of the stairs should be not less than 1.6 m, as the movement is large on the stairs, the Slopes for handicap and special needs, the slope width shall not be less than 1.5 m.

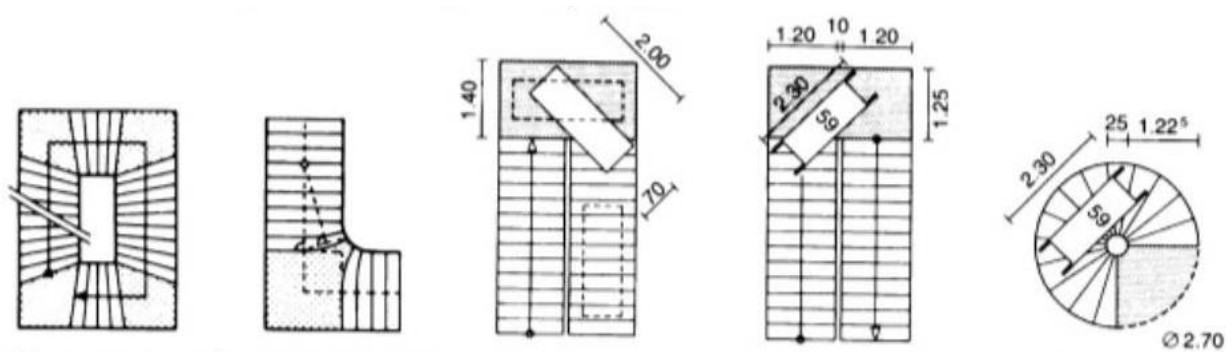


Figure 2: stair specification.

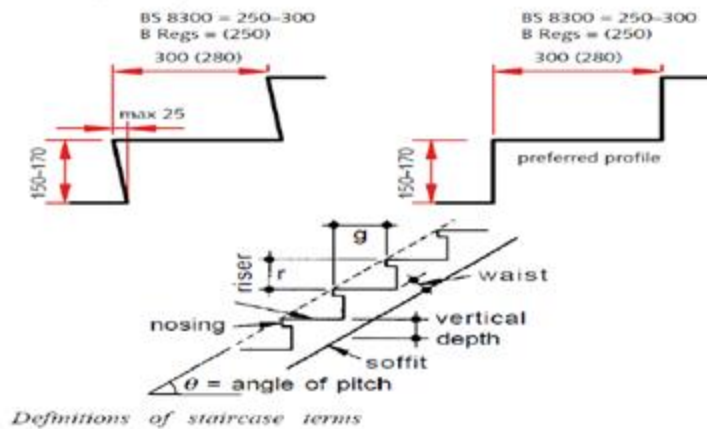


Figure 3: definition of staircase terms.

2.3.3 Ramp:

“The most common provision made for wheelchairs is a ramp. However, most such ramps are difficult to use, both in mounting and in descending. Except for very short ramps (less than 0.5 m) they should be no steeper than 8 per cent (preferably 6 per cent) and unbroken lengths of ramp no longer than 10 m. For a rise of only 650 mm, therefore, a good ramp would take up a considerable area. The use of a chair lift or of ordinary lifts is therefore often preferable to a ramp, although these suffer from the need for adequate maintenance, and problems arise when they break down.”

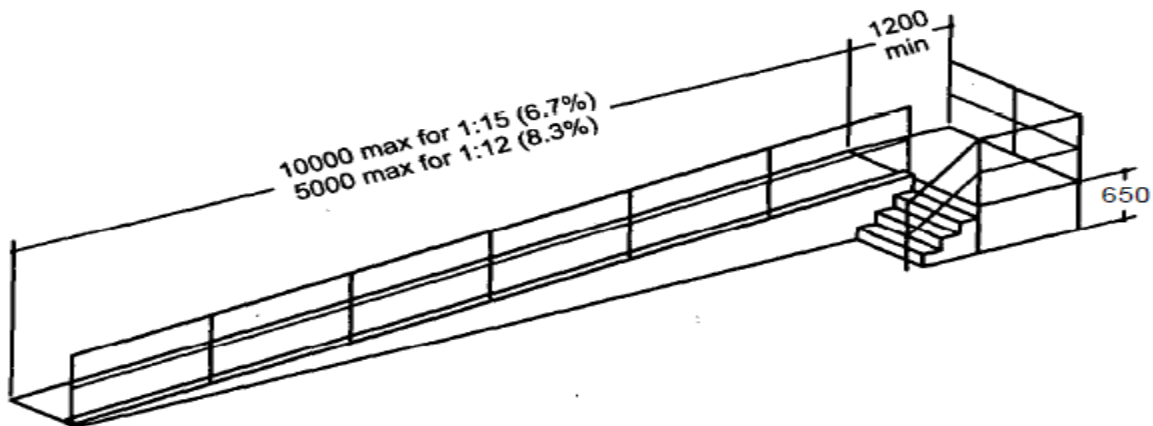


Figure 4: Wheelchair ramp of rise 650 mm.

2.3.4 Elevator:

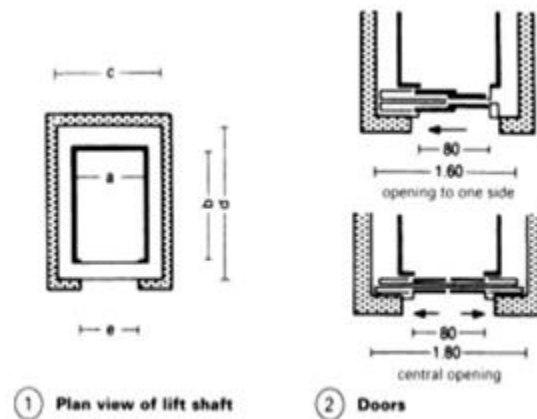


Figure 5: Elevator specification.

2.3.5 Bathrooms:

The distribution and number of toilets will depend on the population and the use of the building (Academic research building).

Standards dimension for Bath Rooms (length * width) in cm:

- Toilet (70*38) cm.
- Urinal bowl (30*35).
- Wash-Basin (60*50) or (70*60).
- Tow wash-Basin (120*60) or (140*60).
- disabled toilet min size (220*150).
- The free vertical height in W.C is not less 2.10 m.

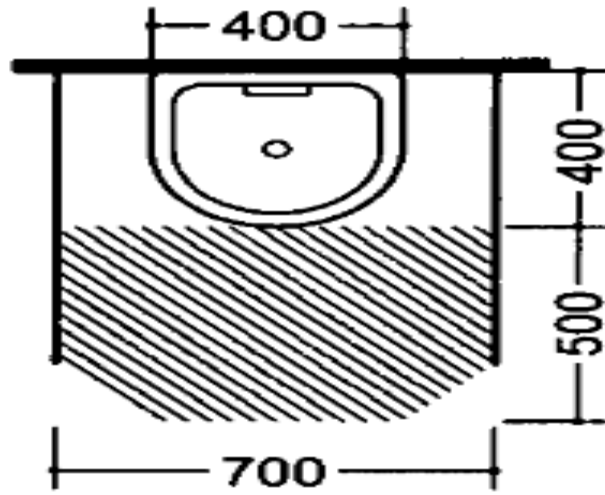


Figure 6 : Single urinal and activity space.

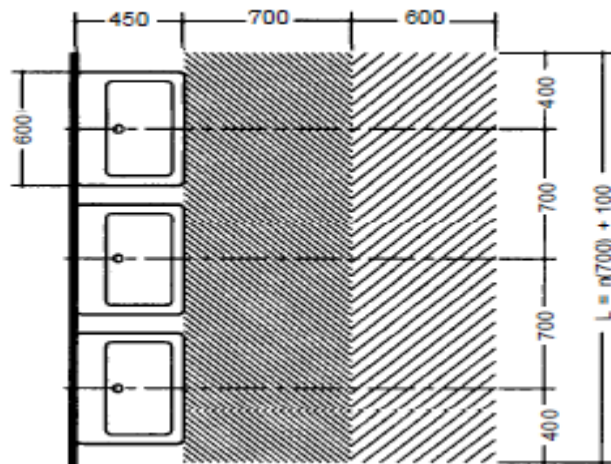


Figure 7: Range of non-domestic washbasins, activity and circulation spaces.

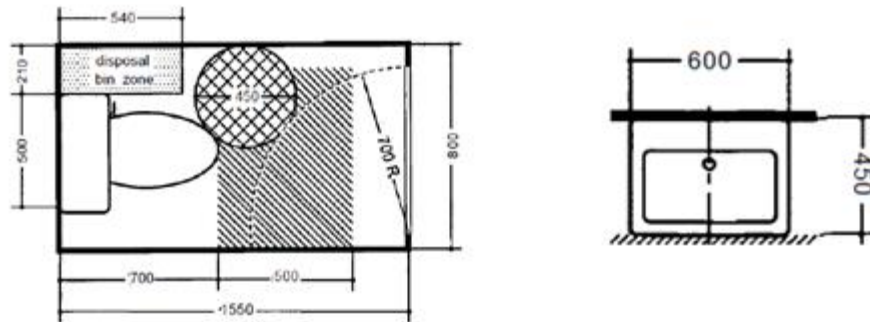


Figure 8: bathroom dimension.

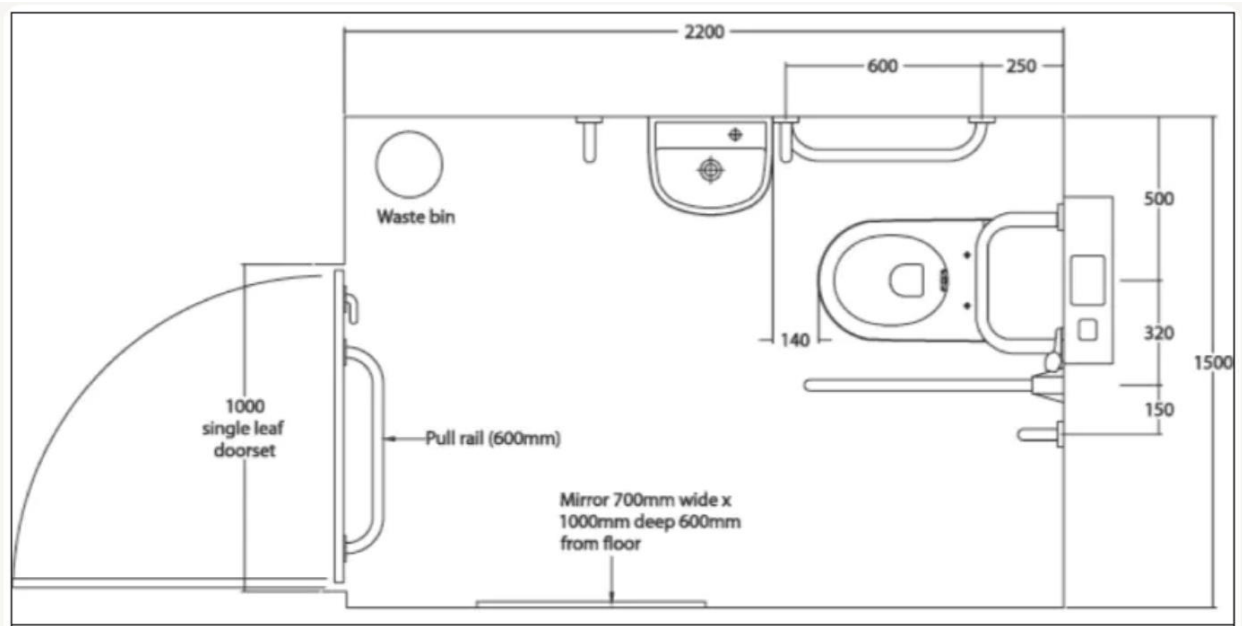


Figure 9: bathroom dimension.

2.3.6 Offices:

The standard office for one person have a table and one chair for a guest at least, secretarial office must be contain a table and Bookcase and photocopier, In lecture hall the minimum area required for each person is 0.70m².

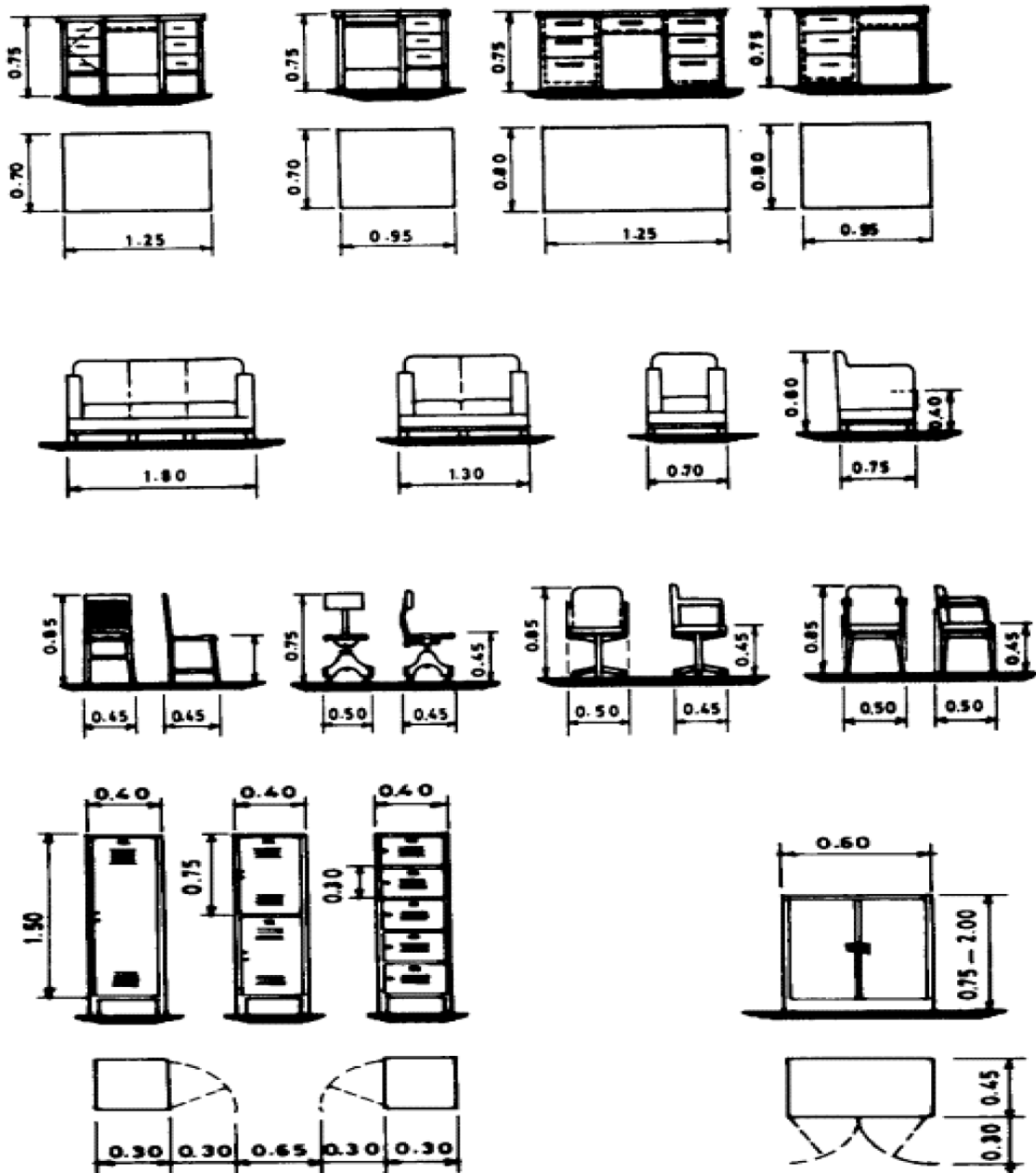


Figure 10: detailing of accessories for offices & lecture hall in cm .

2.3.7 Library:

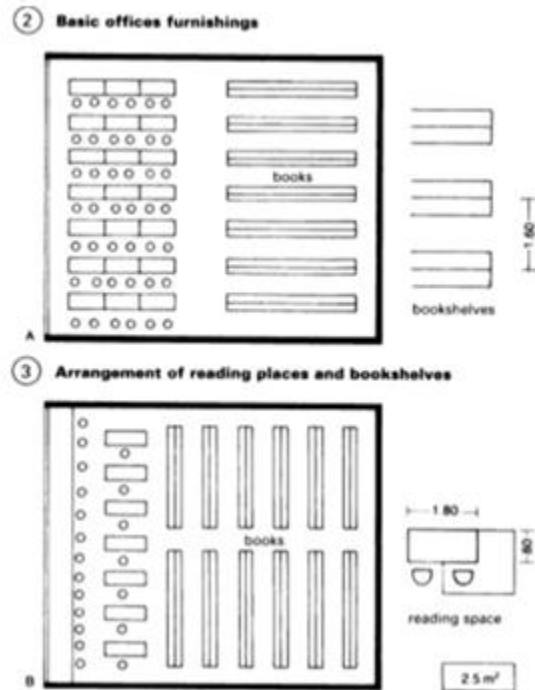
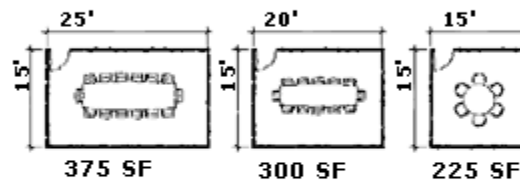


Figure 11: library specification.

2.3.8 Meeting room:

The magical standard conference room size

There are traditionally three sizes for meeting rooms:



1. Large Conference Rooms

15×25 sq. ft.

16-20 seats

Style could be boardroom, war room, team specific, classroom, theater or a modular configuration to meet various collaborative or training work environments.

Figure 12:Standard conference room.

1. Medium Conference Rooms

10×25 sq. ft.

8-10 seats

Style is most often a standard [conference room design](#) with table and chairs.

1. Small Conference Rooms

10×10 sq. ft.

4-6 seats

Style could be a standard conference, huddle, phone, interview, wellness, brainstorming. As these take up the least amount of space, you can get creative and experiment with different room styles to meet different styles of work.

There isn't one magical conference room size, but instead, three categories that you should use in different combinations depending on your office's work style.

Figure 13 :Standard conference room.

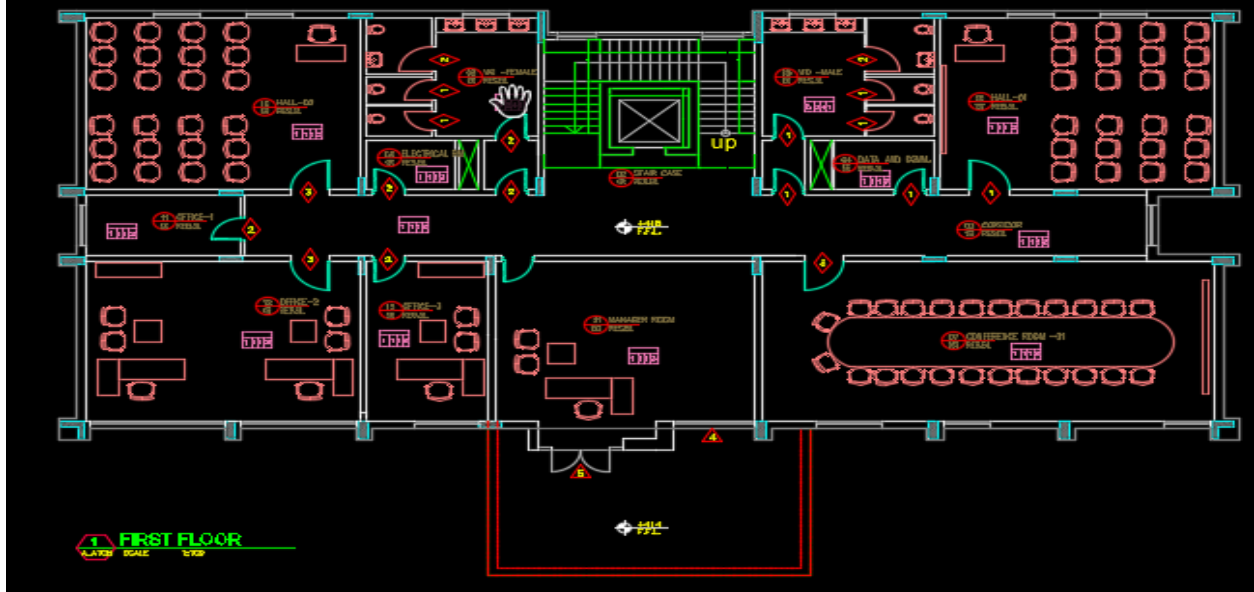


Figure 15: First Floor.

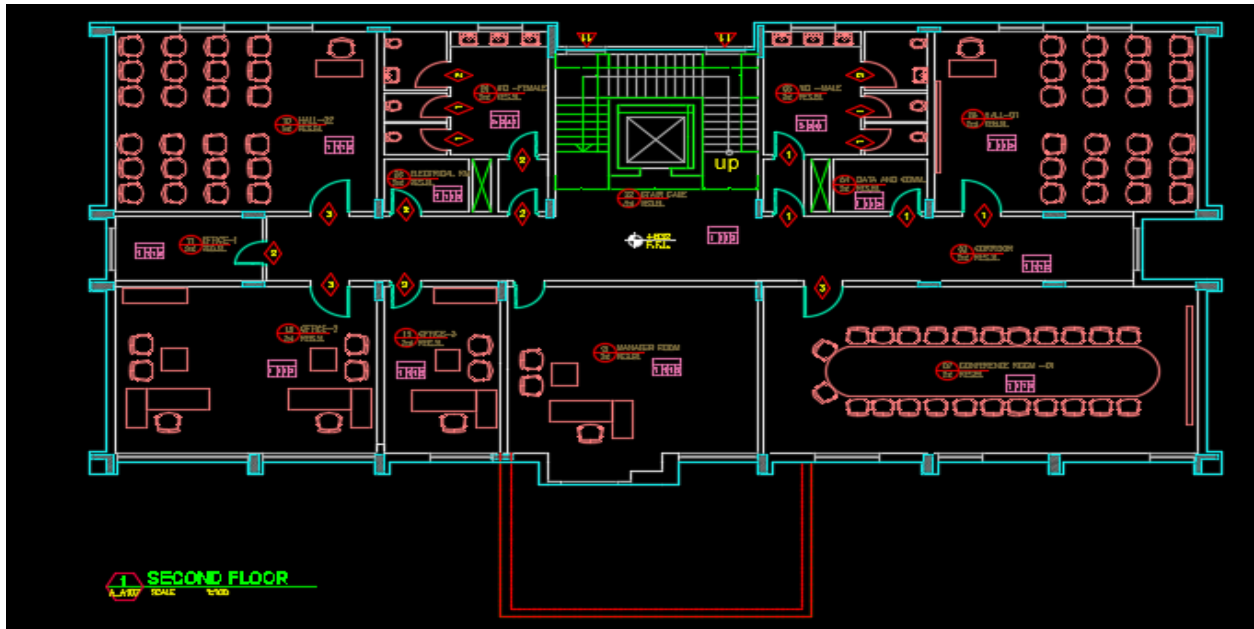


Figure 16: Second Floor.

2.4.2 Plans after modification:

2.4.2.1 Ground Floor:

* Two emergency stairs were added as mentioned above, according to the Palestinian Civil Defense .

*A library was added as standard instead of the meeting room .

*Computer lab was added.

* Male and female baths are becoming in one area.

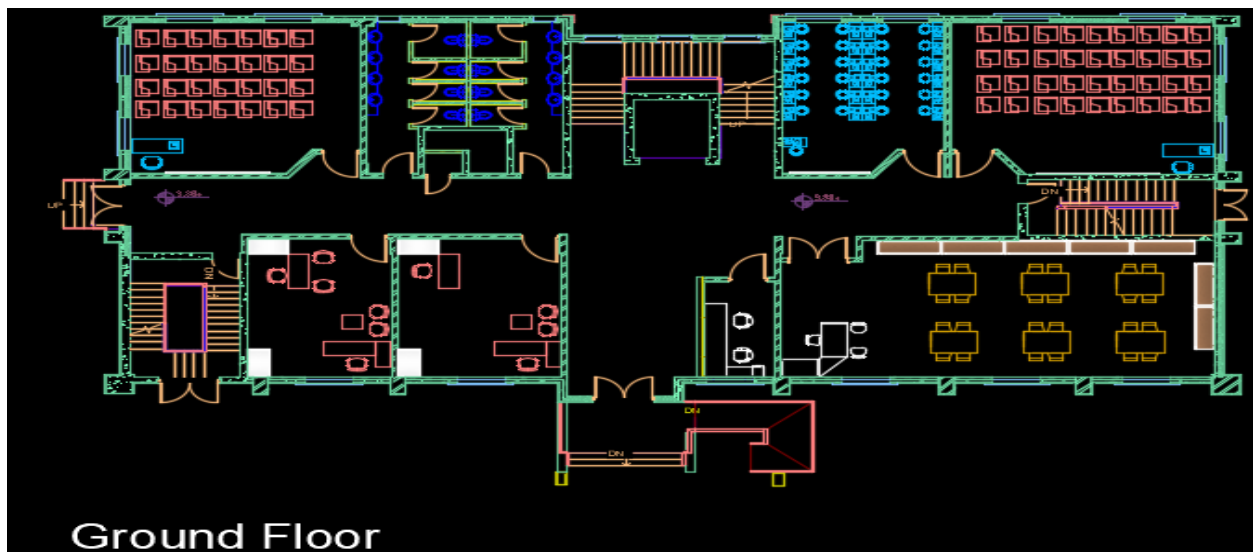


Figure 17: Ground Floor.

2.4.2.2 First Floor:

* Two emergency stairs were added as mentioned above, according to the Palestinian Civil Defense .

*Computer lab was added.

* Male and female baths are becoming in one area.

* Reduce meeting room space as standard.

* Office secretarial was added.

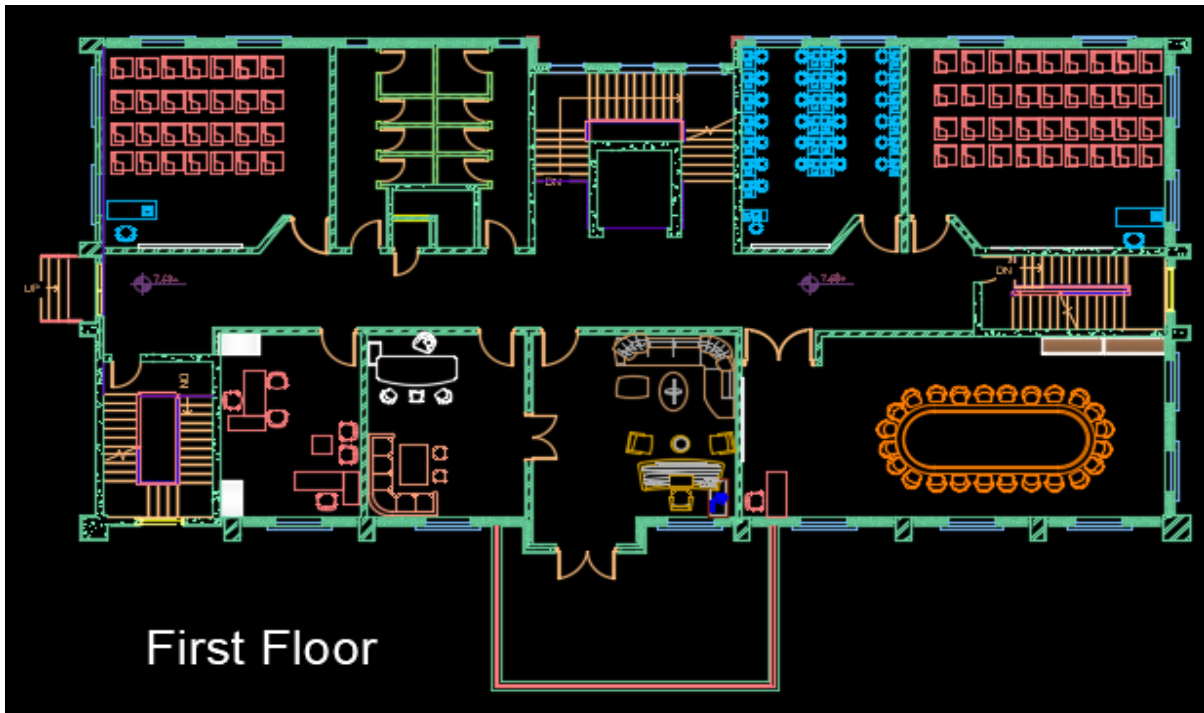


Figure 18: First Floor.

2.4.2.3 Second Floor:

* Two emergency stairs were added as mentioned above, according to the Palestinian Civil Defense .

*A Hall was added as standard instead of the meeting room .

*Computer lab was added.

* Male and female baths are becoming in one area.

*Class room was added instead of the manager room .

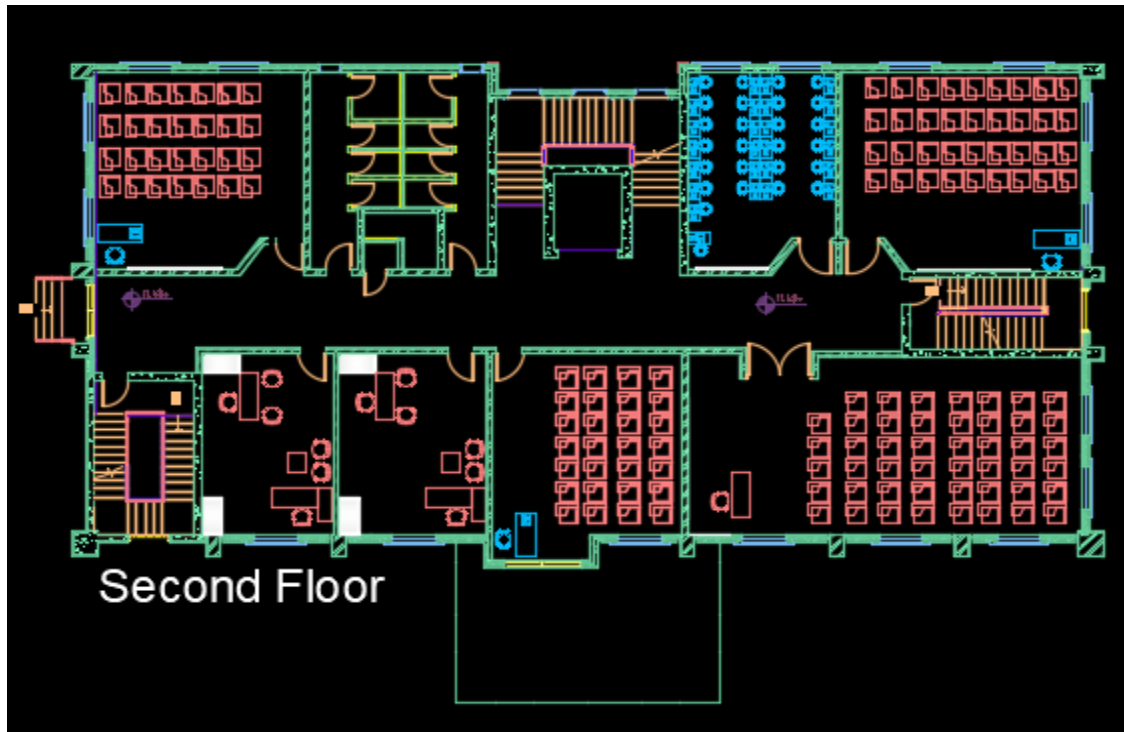


Figure 19: Second Floor.

Chapter 3: Environmental analysis

3.1 Site analysis

3.1.1 Overview:

During the design phase it is important to take into consideration the analysis of the site by the people responsible for the design process.

Site analysis is one of the main factors responsible for the success of the building operationally, so the building must be analyzed in several aspects such as the project area, sunlight, wind, rain level, natural lighting, solar radiation, acoustics and shadow.

3.1.2 Site location:

The building is located within AL- Istiqlal University in Jericho, it is Located 30 km from our capital, Jerusalem, the city of Jericho is located 258 meters (846 ft) below sea level in the Wadi al-Qalt in an oasis in the Jordan Valley, This city is characterized by its warm summer and mild winter conditions.

In terms of engineering, as this center located in Jericho (Dead Sea Rift) as it is a critical location in Palestine for earthquakes.



Figure 20: location of project.

3.1.3 Climate:

The climate of the city of Jericho is characterized by very hot in summer and mild climate in winter.

3.1.4 Temperature:

The average annual temperature in Palestine varies from month to month and from region to region according to astronomical, geographic and terrain location. January is the coldest month in Palestine, while July is the hottest month of the year. Below is an overview of the average temperature in Palestine.

*Average summer temperatures:

- 1- In the coastal plains 25 - 30 ° C.
- 2 - in the mountain highlands and plateaus 20 - 26 ° C.
- 3 - In the Jordan Valley 28 - 35 ° C.

The maximum temperature reaches 39 ° C in the city of Jericho in 2019.

*Average winter temperatures:

1. In the coastal plains 12 ° C.
- 2 - in the highlands bar 8 - 10 ° C.
- 3 - in the Jordan Valley 12 - 14 ° C.

The minimum temperature reaches 8 ° C in the city of Jericho in 2011.

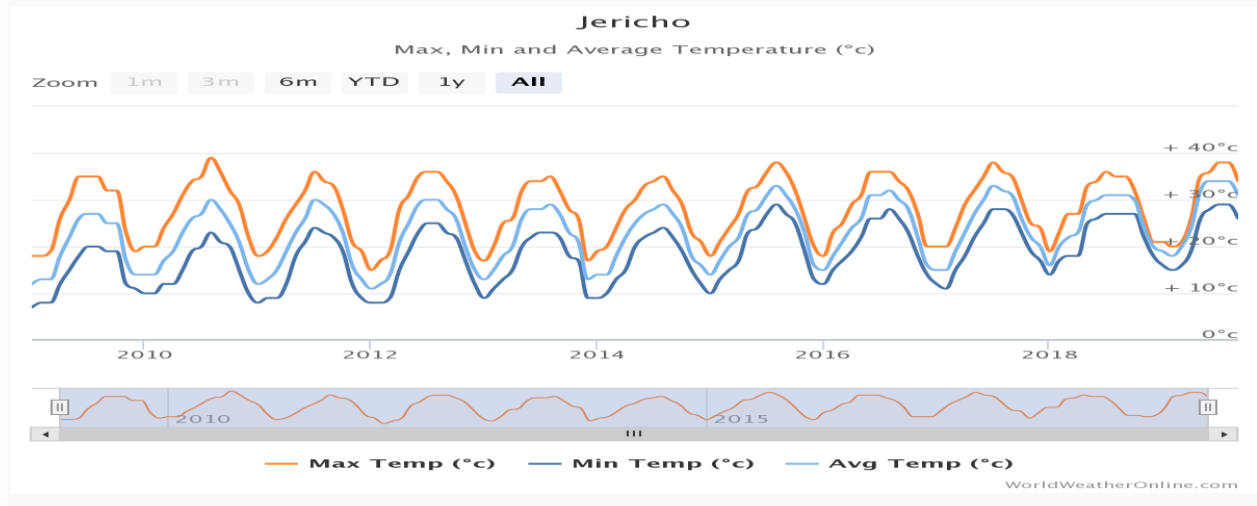


Figure 21:Min, avg and max temperatures in Jericho.

3.1.5 Rainfall:

Jericho is the lowest city in the world, is located 258 meters (846 feet) below sea level, The amount of rainfall is generally affected on Palestine near and far from the Mediterranean sea, the annual rainfall in the city of Jericho is 152 mm.

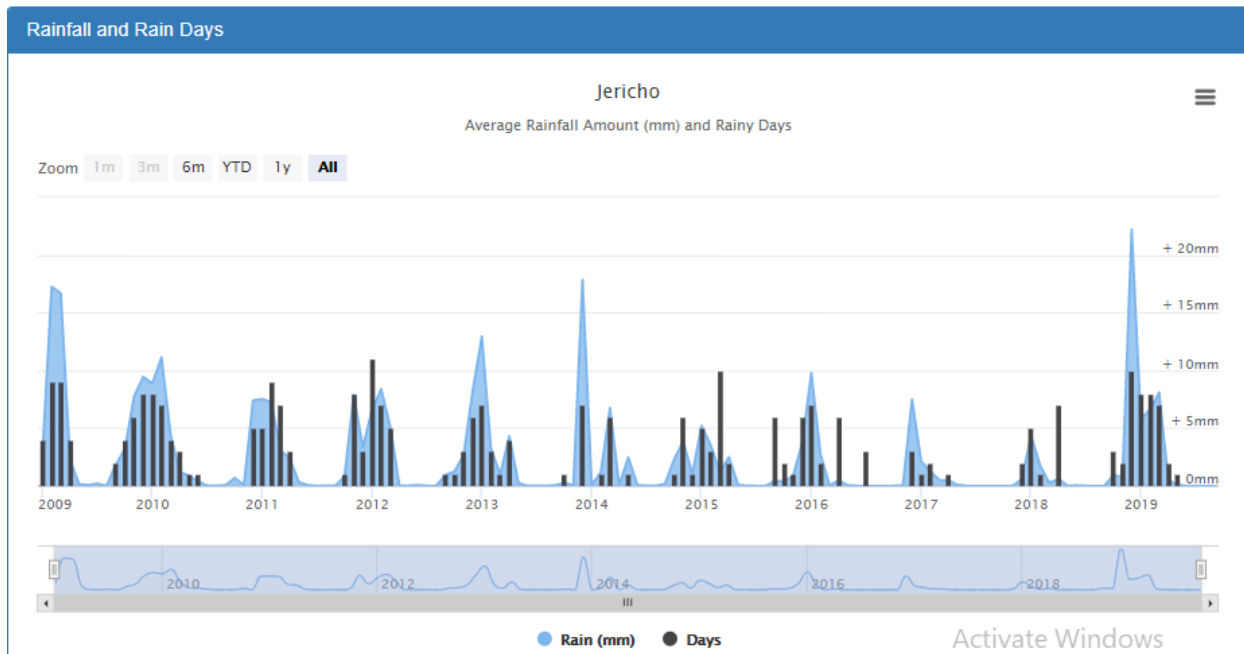


Figure 22: Rainfall and Rain Days in Jericho .

3.1.6 Wind:

In Winter:

*Western winds accompanying depressions.

*Cool East Wind.

In summer:

*Northwesterly Wind.

*Northeastern dry, hot winds .

*Summer winds are regularly characterized by gusts.

The following figure shows the wind speed during the ten years in the city of Jericho where as shown below the maximum wind speed reached 25 km per hour in 2019.

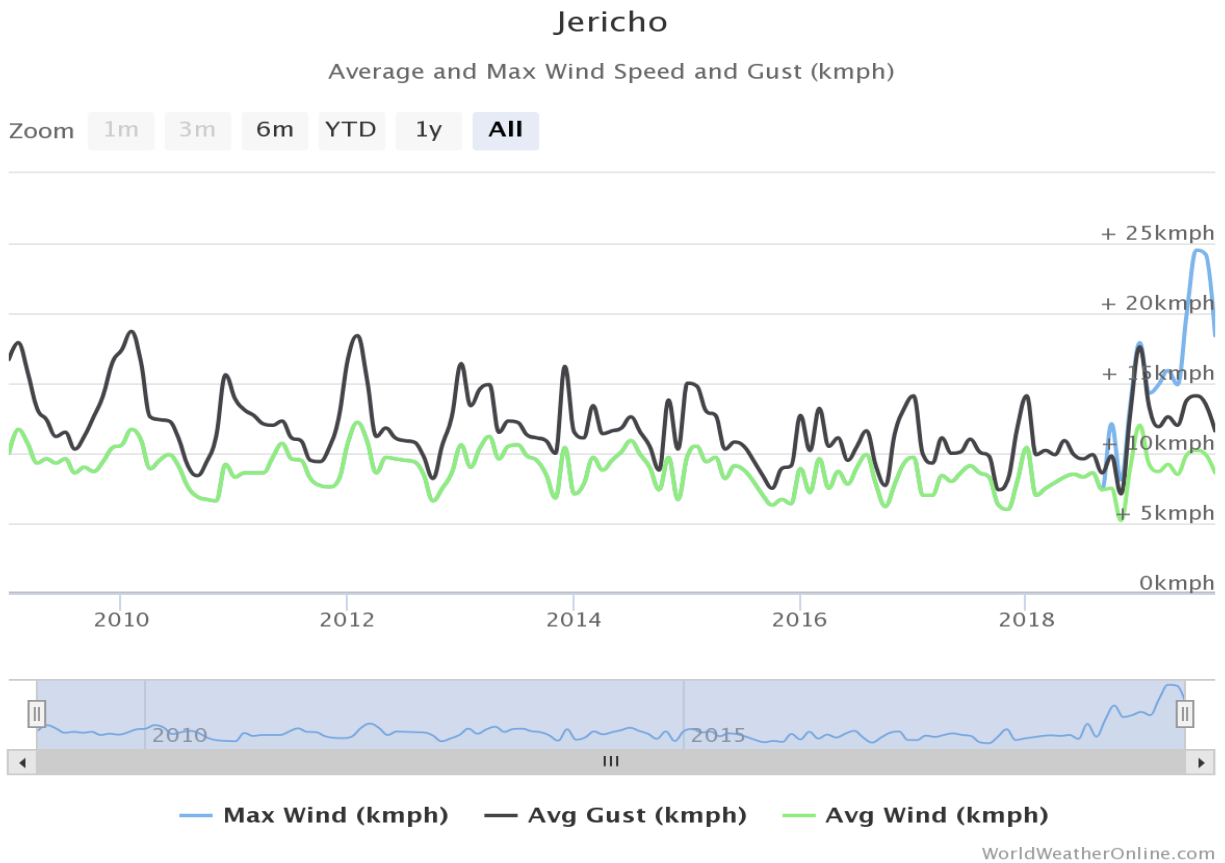


Figure 23: Max and Average Wind Speed and Wind Gust.

3.1.7 Humidity:

The importance of atmospheric humidity is that it is responsible for most major weather elements. The most humid months of the year are January and February, and the least humid months of the year are autumn - September / October, spring - April / May and the average humidity varies from place to place.

The city of Jericho is one of the least recorded cities of humidity and humidity varies from year to year and be at average (40%-60%).

The following figure shows the cloud and humidity during the ten years in the city of Jericho where as shown below the maximum humidity reached 63% in 2011.

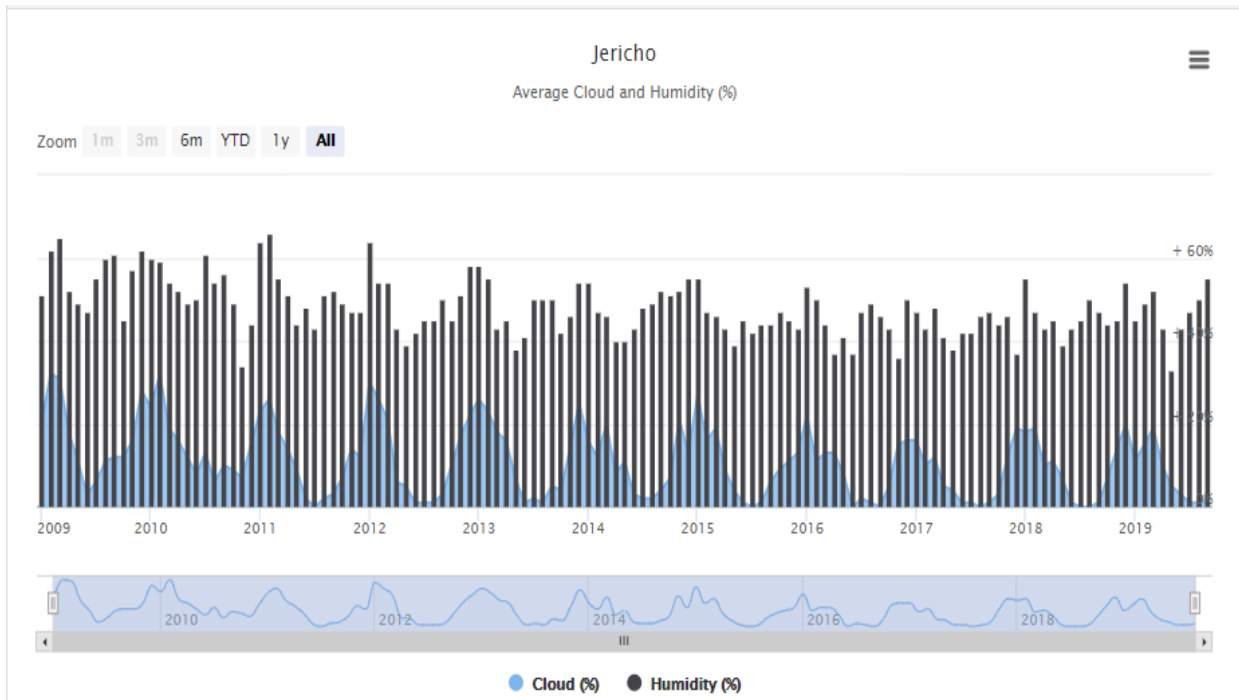


Figure 24: Cloud and Humidity.

3.2 Solar radiation

The analysis of the solar is important to ensure the thermal comfort inside the building and people feel comfortable and make sure there is no high glare.

The elevation of the building will be analyzed from the solar insolation using “Revit”, the following figure show solar analysis before and after treatment.

3.2.1 Eastern elevation:

3.2.1.1 Before :

The eastern elevation is exposed to a lot of sun especially in the morning hours in summer and few in winter.

The following figures show the solar insolation in winter and summer.



Figure 25: cumulative insolation for East Elevation in winter.



Figure 26: cumulative insolation for East Elevation in summer.

3.2.1.2 After treatment :

This elevation is acceptable and there is not a lot of windows and no treatment.



Figure 27: cumulative insolation for East Elevation in winter.



Figure 28: cumulative insolation for East South Elevation in summer.

3.2.2 Western elevation:

3.2.2.1 Before:

The western elevation is exposed to a lot of sun especially in the evening hours in summer and few in winter.

The following figures show the solar insolation in winter and summer.

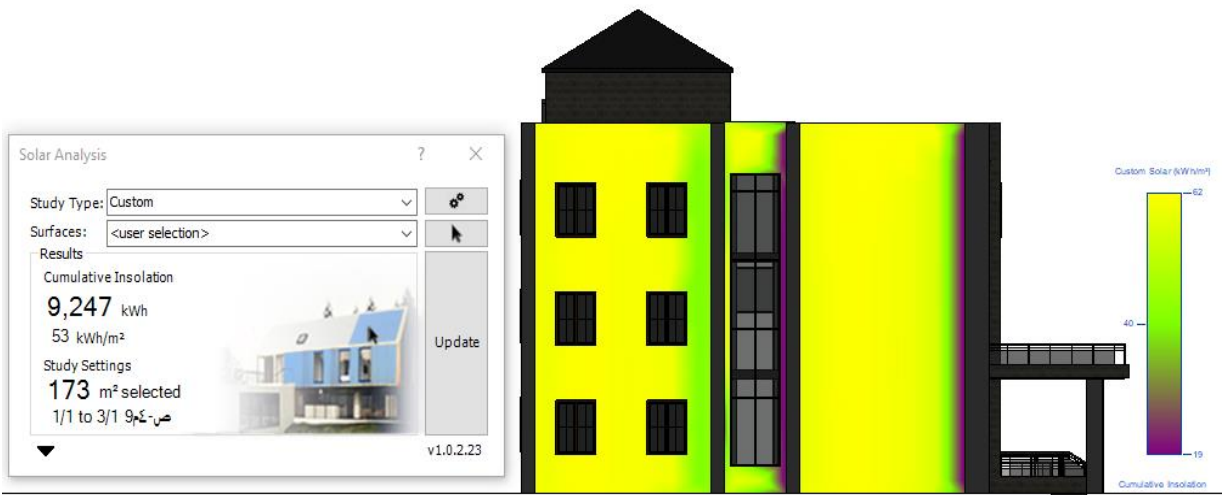


Figure 29: cumulative insolation for west Elevation in winter .

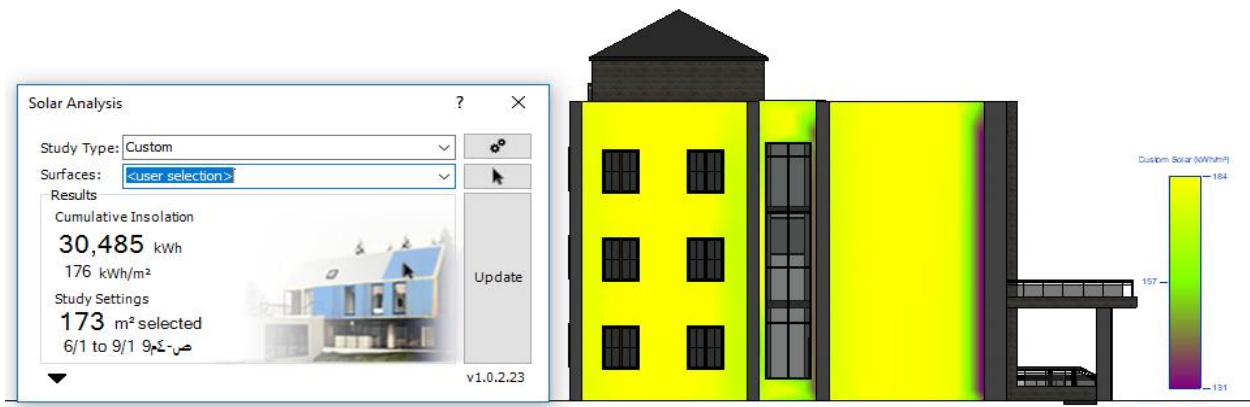


Figure 30: cumulative insolation for West Elevation in summer.

3.2.2.2 After treatment :

Trees were added in the western elevation to reduce solar in the summer thus, thermal comfort is better especially in summer.



Figure 31: cumulative insolation for West Elevation in summer.



Figure 32: cumulative insolation for West Elevation in Winter.

3.2.3 Northern elevation:

3.2.3.1 Before :

The northern elevation is exposed of good quantity to sun in summer and less in winter ,the north elevation is very good for ventilation and lighting

The following figures show the solar insolation in winter and summer.



Figure 33: cumulative insolation for North Elevation in winter.



Figure 34: cumulative insolation for North Elevation in summer.

3.2.3.2 After treatment :

The north elevation is less susceptible to the sun as the results are good and no improvements are required.



Figure 35: cumulative insolation for North Elevation in summer.



Figure 36: cumulative insolation for North Elevation in Winter.

3.2.4 Southern elevation:

3.2.4.1 Before:

The southern elevation is considered the best in terms of sun exposure in winter so it should be used as much as possible in winter and minimized in summer.

It is good to enter the sun in winter and low in the summer to ensure thermal comfort.



Figure 37: cumulative insolation for South Elevation in winter.



Figure 38: cumulative insolation for South Elevation in summer.

3.2.4.2 After treatment :

The sun light enters in very large quantities in the winter and less summer, so cantilever has been placed in an appropriate way to reduce the amount for greater comfort inside the building.



Figure 39: cumulative insolation for South Elevation in Winter.



Figure 40: cumulative insolation for South Elevation in summer.

Summary:

1- During the treatment of the walls we used cantilever in the southern elevation, we also used trees to reduce the amount solar gain in KWh in west elevation..

2- The amount of cumulative insolation is large and clearly on the Northern, Western & Eastern Elevations in the summer than winter, but southern elevation is large and clear in the winter than summer.

This table shows the cumulative insolation on Elevations :

Elevation	Summer(KWh)	Winter(KWh)
East elevation	18272(110 KWh/M2)	5646(34 KWh/M2)
West elevation	23304(87 KWh/M2)	6513(25 KWh/M2)
South elevation	29124 (62 KWh/M2)	29202(62 KWh/M2)
North elevation	23587(51 KWh/M2)	7452(16 KWh/M2)

Table 1: cumulative insolation on Elevations.

3.3 Day light

3.3.1 Introduction:

Design Builder Used for daylight analysis daylight factor(DF) should be within average (2%-5%) in order to ensure comfort within the building and avoid some problems such as glare and reflection.

If the value is high, some solutions should be found like use of tinted glass, cantilever ,louvers and plant as high tree .

If the values are low, some solutions should be used, such as the use of windows with a larger area , use a type of glass allows the passage of a greater amount of natural lighting and using artificial lighting.

3.3.2 Ground Floor:

3.3.2.1 Before :

The following figure shows the daylight of the ground floor, where the lighting is good in the areas near the windows and poor in other areas and in the corridor.

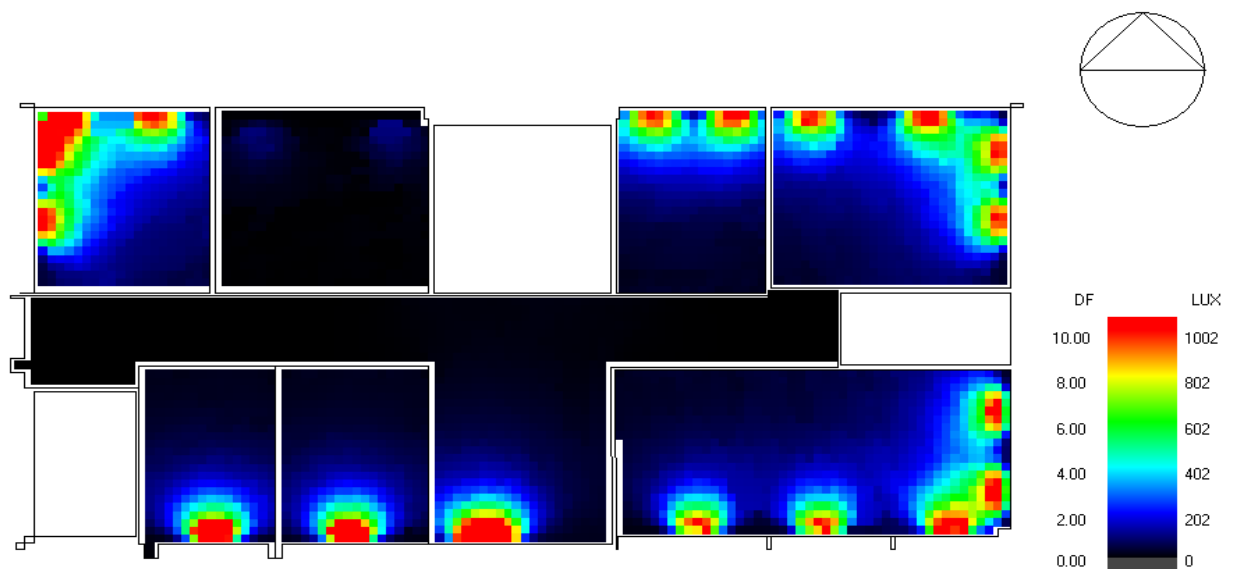


Figure 41: Daylight before (Ground Floor).

The following figure illustrate the analysis of natural lighting in Spaces using Design builder.

Summary Results	
Total area (m2)	472.218
Total area meeting requirements (m2)	195.532
% Area within illuminance threshold limits	41.4
LEED v4 Option 2 Credits	FAIL

Figure 42: Daylight analysis(before).

3.3.2.2 After Solution:

As shown below after the adjustment, which included the expansion of windows and the change in the type of the glass (clear glass) that works on the passage of a larger amount of light improved the results, Nevertheless some areas need artificial Light.

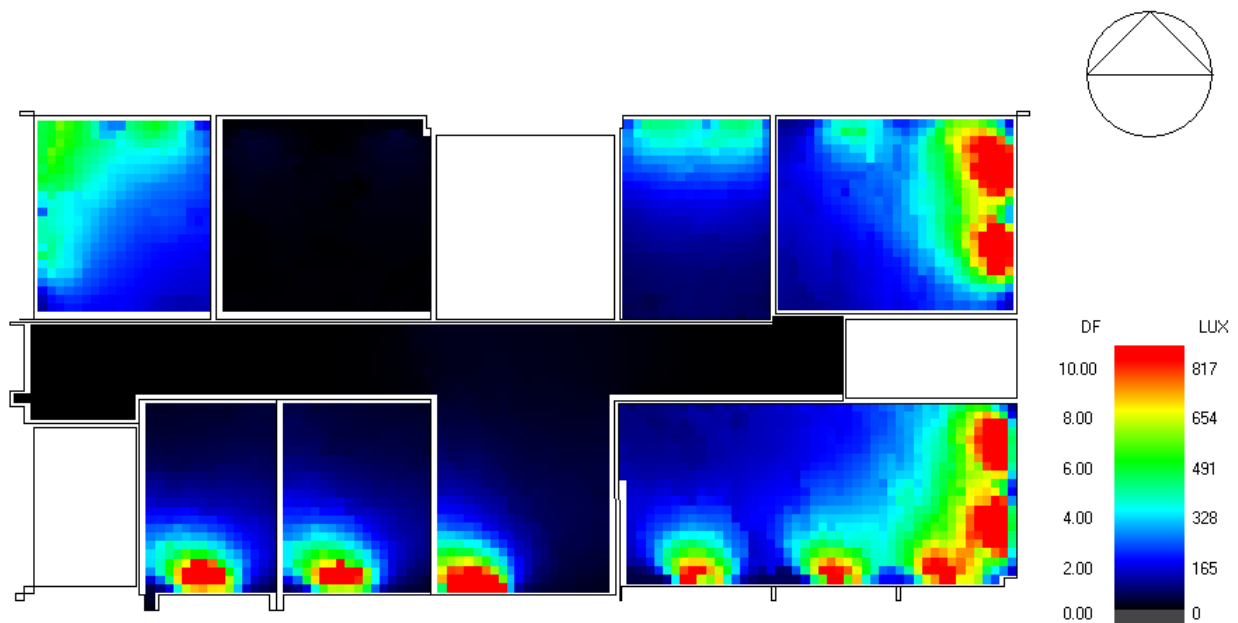


Figure 43: Daylight after solution (Ground Floor).

The following figure illustrate the analysis of natural lighting in Spaces using Design builder.

Summary Results	
Total area (m2)	472.218
Total area meeting requirements (m2)	206.972
% Area within illuminance threshold limits	43.8
LEED v4 Option 2 Credits	FAIL

Figure 44: Daylight analysis (after).

3.3.3 First Floor:

3.3.3.1 Before :

The following figure shows the daylight of the first floor, where the lighting is good in the areas near the windows and poor in other areas and in the corridor.

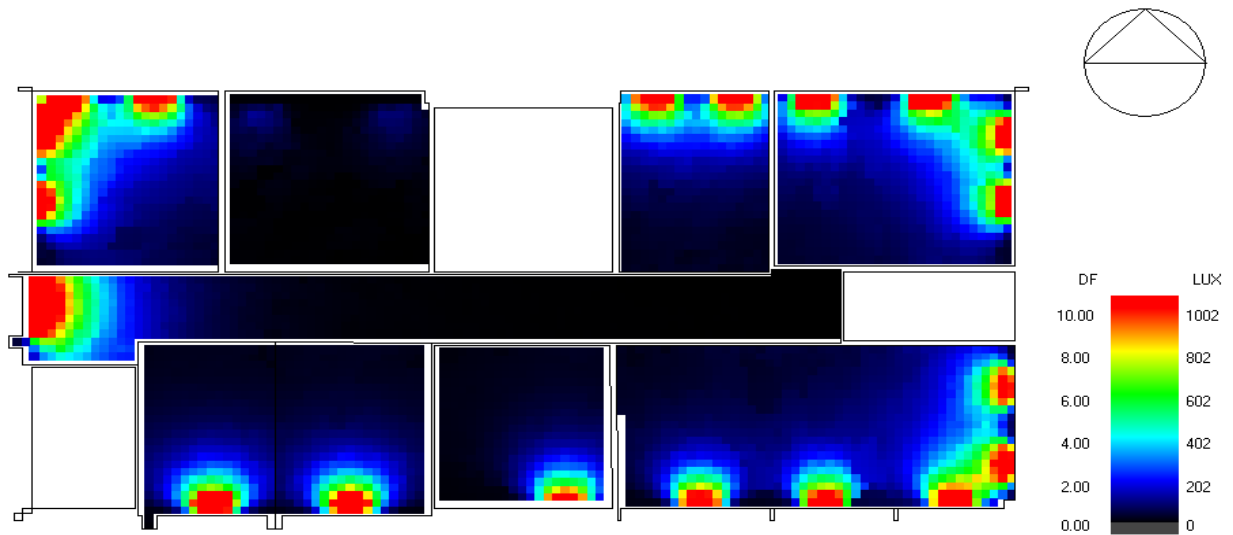


Figure 45: Daylight before (First Floor).

The following figure illustrate the analysis of natural lighting in Spaces using Design builder.

Summary Results	
Total area (m2)	468.258
Total area meeting requirements (m2)	209.499
% Area within illuminance threshold limits	44.7
LEED v4 Option 2 Credits	FAIL

Figure 46: Daylight analysis(before).

3.3.3.2 After Solution:

As shown below after the adjustment, which included the expansion of windows and the change in the type of the glass for windows and door in manager room (double clear glass) that works on the passage of a larger amount of light improved the results, Nevertheless some areas need artificial Light.

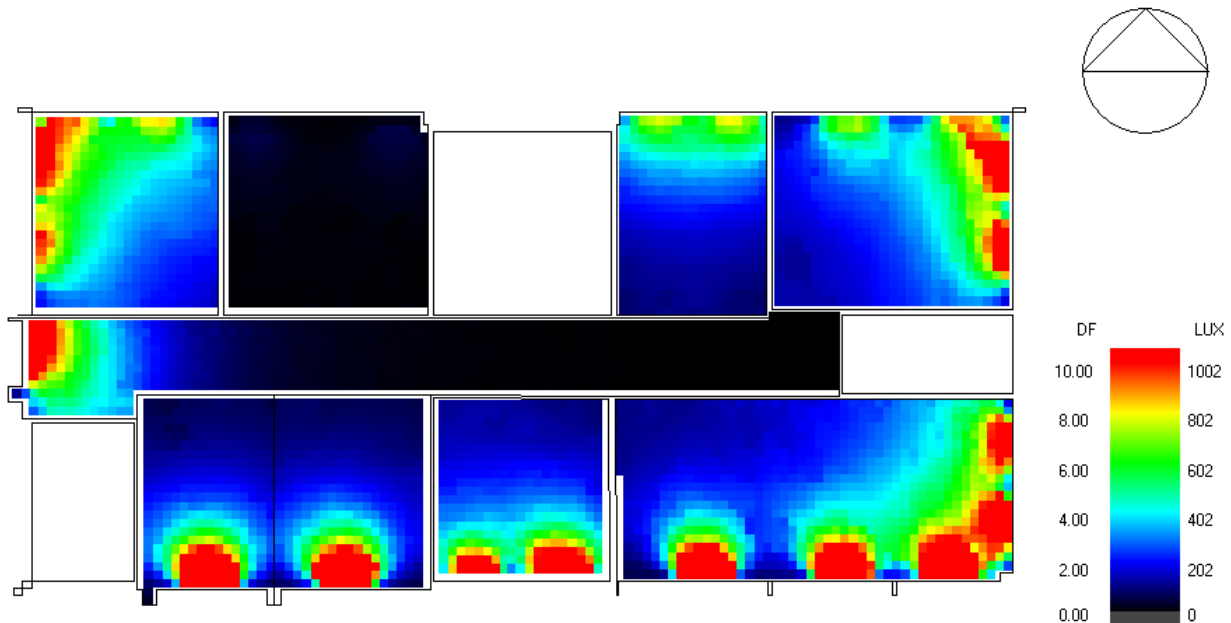


Figure 47: Daylight after solution (First Floor).

The following figure illustrate the analysis of natural lighting in Spaces using Design builder.

Summary Results	
Total area (m2)	468.258
Total area meeting requirements (m2)	230.918
% Area within illuminance threshold limits	49.3
LEED v4 Option 2 Credits	FAIL

Figure 48: Daylight analysis(after).

3.3.4 Second Floor:

3.3.4.1 Before :

The following figure shows the daylight of the second floor, where the lighting is good in the areas near the windows and poor in other areas and in the corridor.

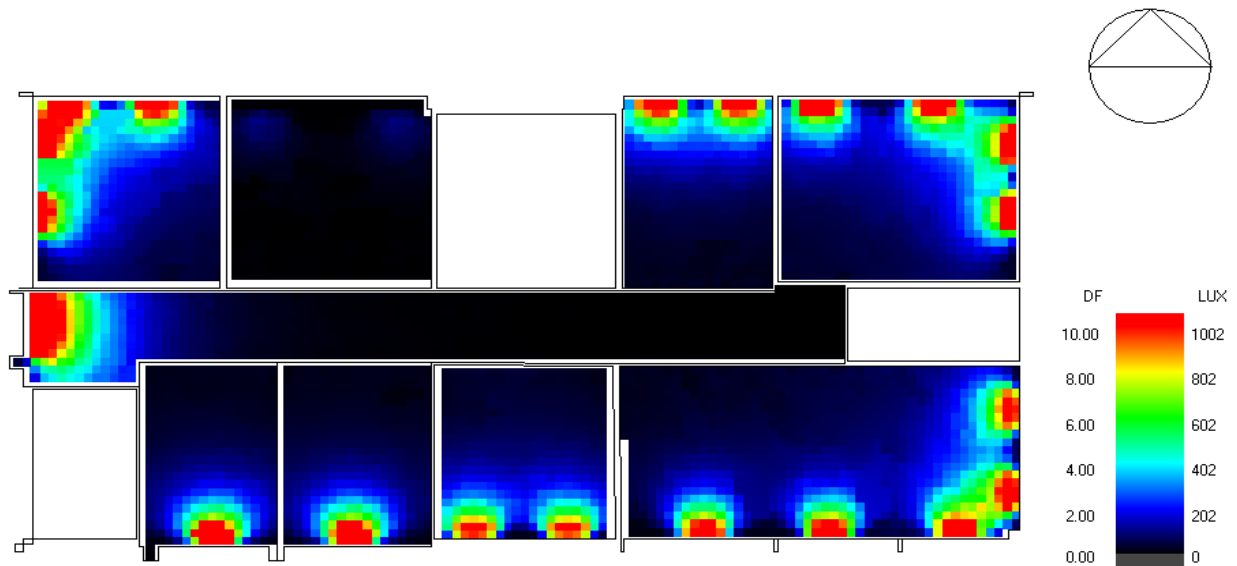


Figure 49: Daylight before (Second Floor).

The following figures illustrate the analysis of natural lighting in Spaces using Design builder.

Summary Results	
Total area (m2)	468.219
Total area meeting requirements (m2)	203.450
% Area within illuminance threshold limits	43.5
LEED v4 Option 2 Credits	FAIL

Figure 50: Daylight analysis(before).

3.3.4.2 After Solution:

As shown below after the adjustment, which included the expansion of windows and the change in the type of the glass(clear glass) that works on the passage of a larger amount of light improved the results, Nevertheless some areas need artificial Light.

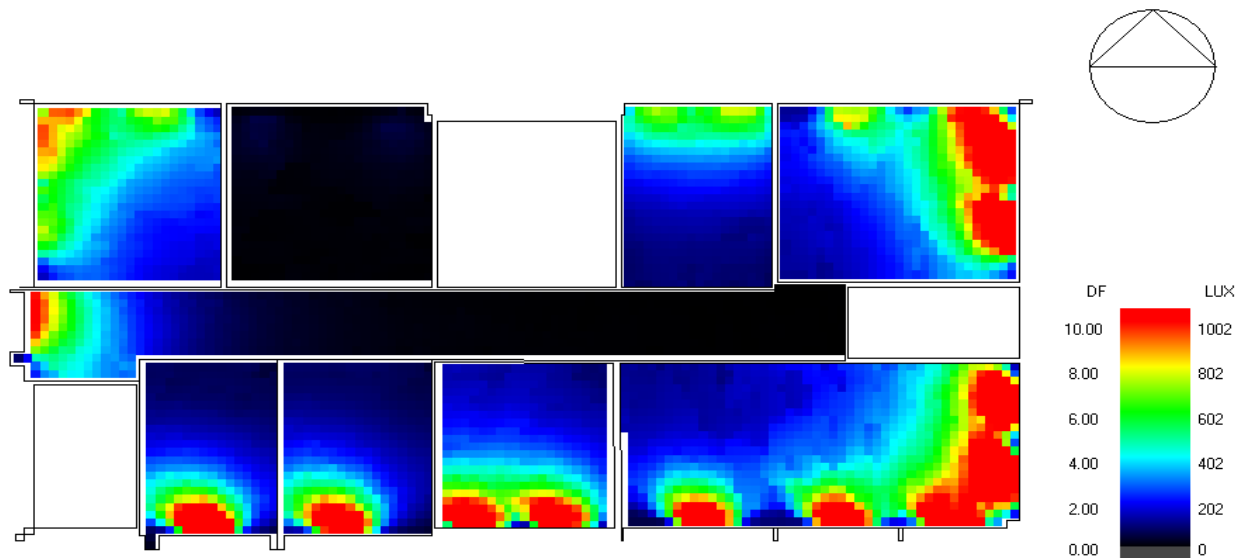


Figure 51: Daylight after solution (Second Floor).

The following figure illustrate the analysis of natural lighting in Spaces using Design builder.

Summary Results	
Total area (m2)	468.219
Total area meeting requirements (m2)	254.837
% Area within illuminance threshold limits	54.4
LEED v4 Option 2 Credits	FAIL

Figure 52: Daylight analysis (after).

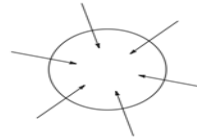
3.5 Ventilation

The prevailing wind direction in Palestine is northwest and west, so the spaces in these directions will be good in terms of ventilation.

Figure (54): Shows the ventilation style in the building.

Figure (55): Shows the ventilation and wind direction in the building.

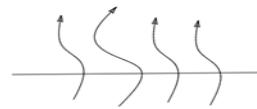
Cross ventilation



Good ventilation



Acceptable ventilation



Bad ventilation



Figure 53: ventilation style in the building.

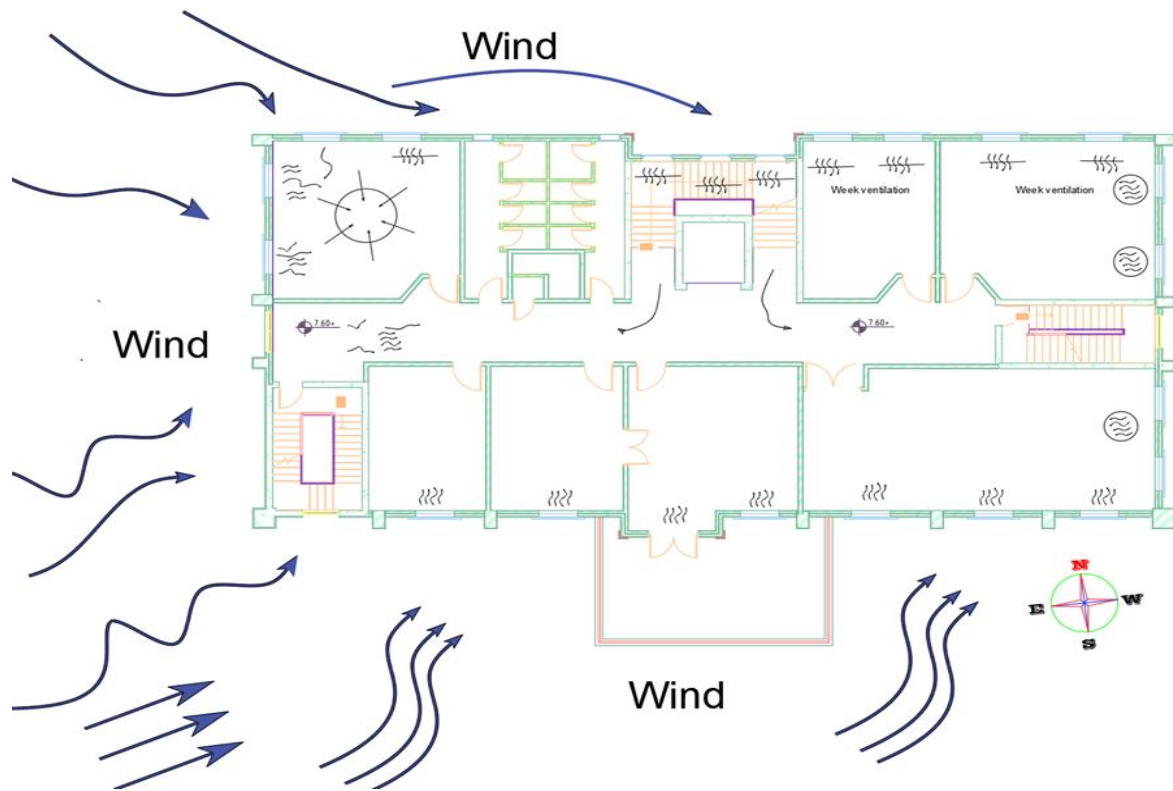


Figure 54:ventilation and wind direction in the building.

3.6 Shadow

3.6.1 In summer (21/7):

At 9:00 Am the shadow from west side because of the azimuth angle of sun.

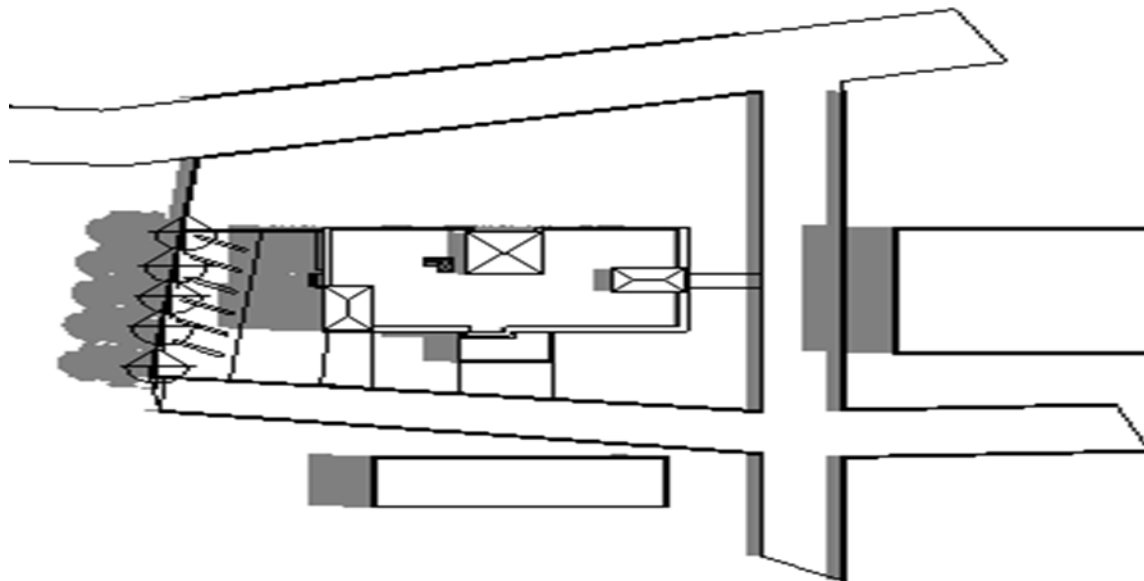


Figure 55: Shadow at 9:00 Am.

At 12:00 Pm the shadow nearly disappear because of perpindiculer of the sun , azimuth more than 80 .

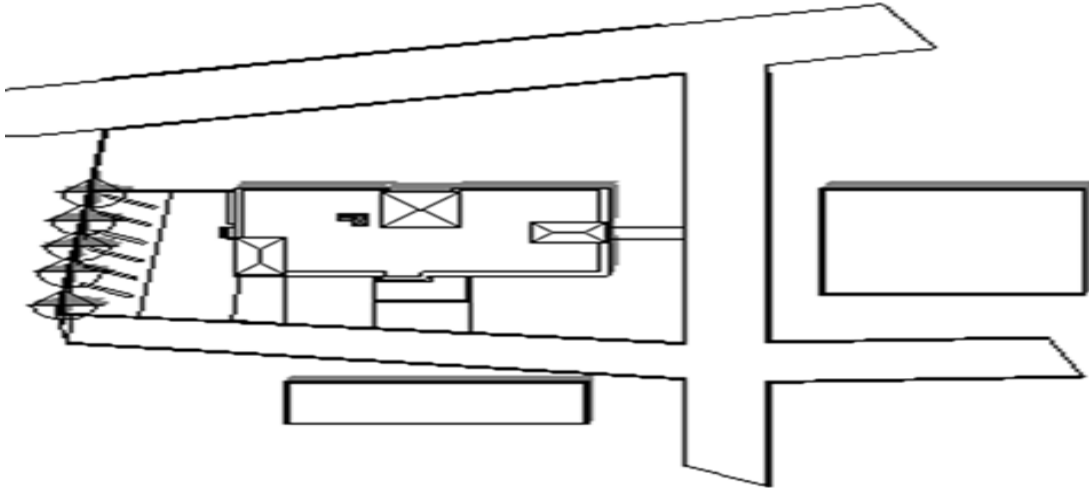


Figure 56: Shadow at 12:00 Pm.

At 3:00 Pm the shadow from east side .

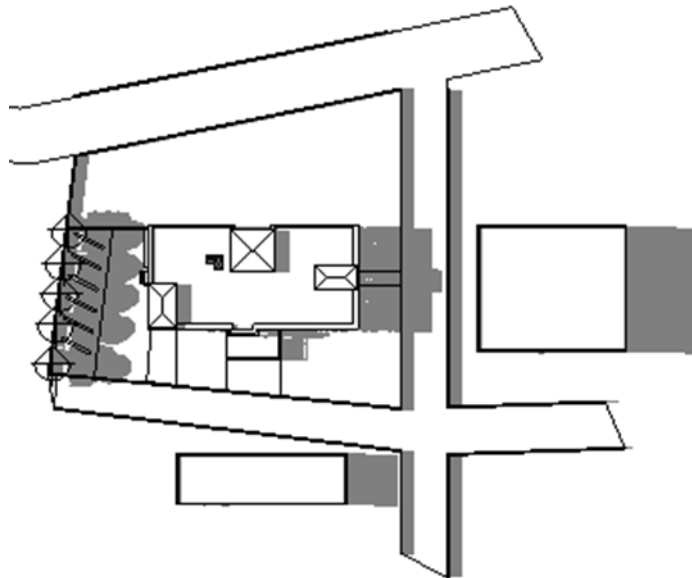


Figure 57: Shadow at 3:00 Pm.

3.6.2 In winter (21/1) :

The shadow from north west side because the azimuth more than in 21/7 9:00 Am.

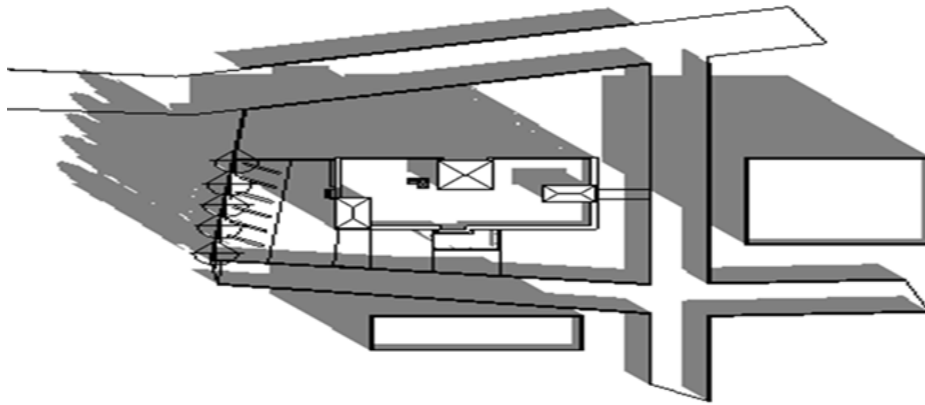


Figure 58: Shadow at 9:00 Am.

At 12:00 Pm the shadow is appeared from north side because the zenith angle of sun smaller than in 21/7 at 12:00 Pm.

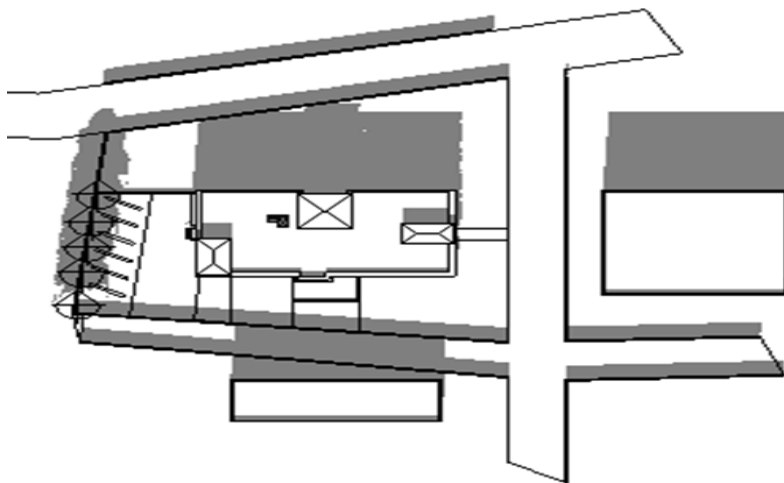


Figure 59: Shadow at 12:00 Pm.

At 3:00 Pm the shadow is from north east side because the zenith angle of sun smaller than in 21/7 at 3:00 Pm.

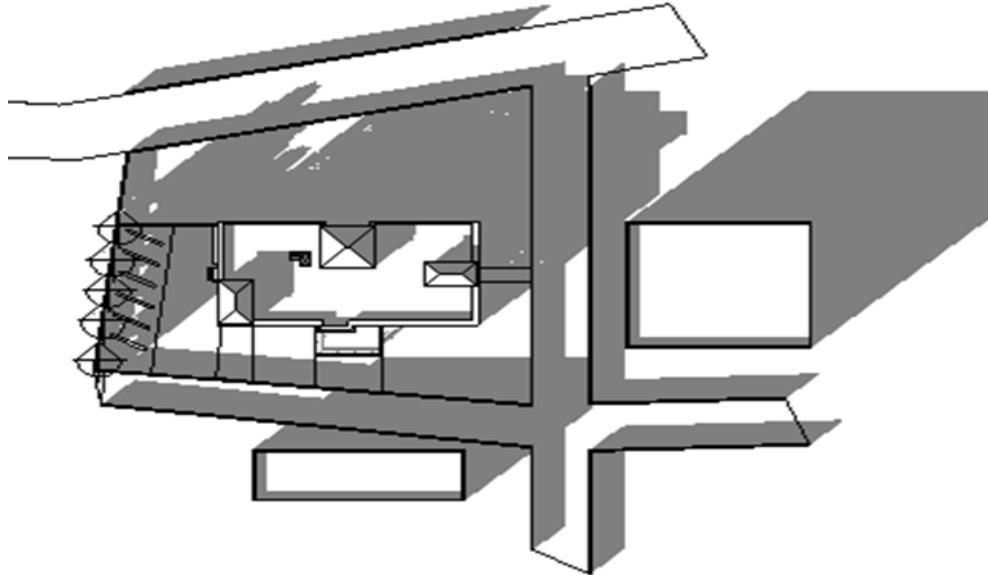


Figure 60: Shadow at 3:00 Pm.

3.7 Material properties

3.7.1 External Wall:

U-value from design builder=0.627(W/m².K).

Consists of 5 cm stone, 10 cm concrete, 5 cm EPS Expanded Polystyrene , 10 cm blok and 2 cm plaster .

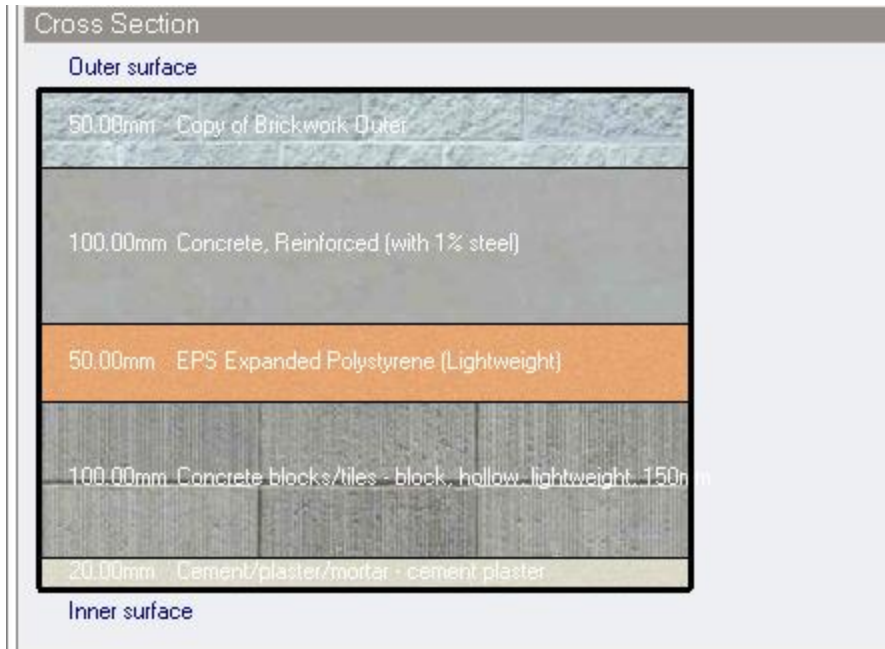


Figure 61: Section in an external wall .

3.7.2 Flat roof:

U-value from design builder=0.489(W/m².K).

Consists of 5cm XPS Extruded Polystyrene ,6 cm concrete, 24 cm blok , 80 cm air gap (False ceiling).

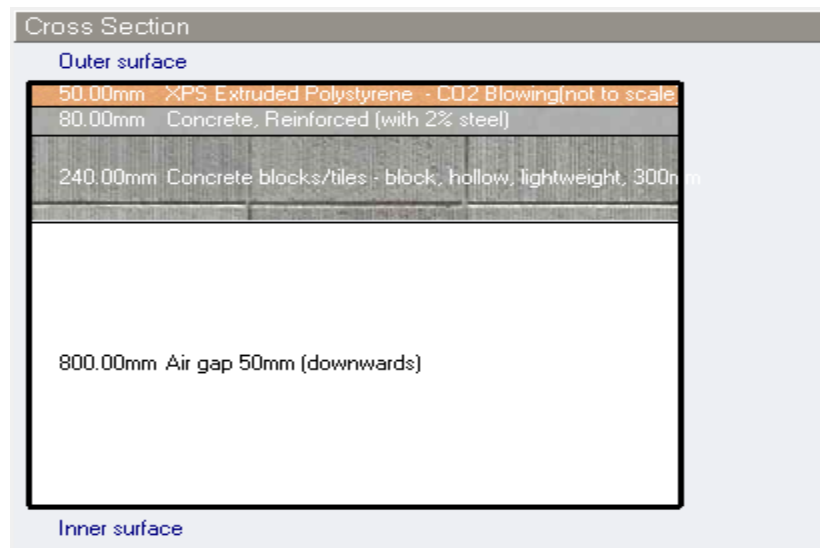


Figure 62: Section in an slab.

3.8 Acoustical analyses and design

The building is located in a convenient and this is good especially since the function of the building is educational.

The readings of three streets adjacent to the building were measured at different times (8:30 am, 12:00 pm and 5:30 pm). The back ground noise reading were taken by (Sound Level Application) from the mobile.

The following figure Shown the Streets adjacent to the building:

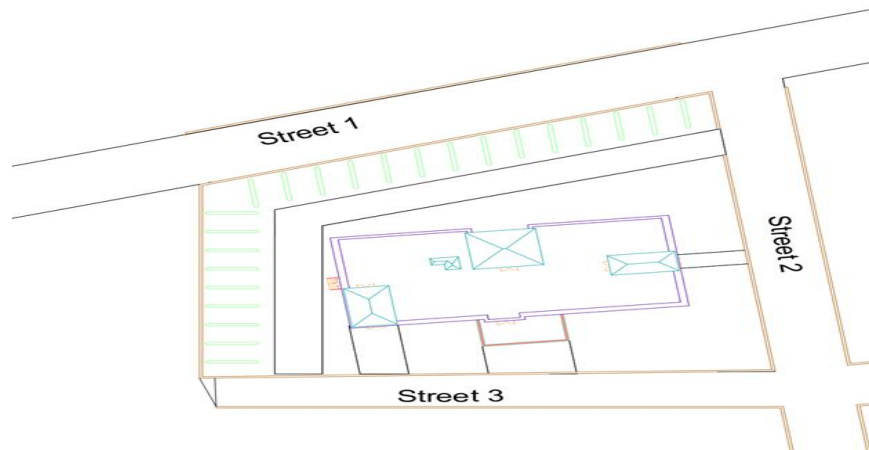


Figure 63: Streets adjacent to the building.

Street 1 main street behind the building and there is a medium movement and it is more noise than street 2 and street 3 which is considered sub-streets and often no movement.

The following table shows the noise at the site:

Time of measured	Street	Noise(dB)
8:30 AM	Street 1	78
	Street 2	64
	Street 3	62
12 PM	Street 1	82
	Street 2	71
	Street 3	69
5:30 PM	Street 1	73
	Street 2	66
	Street 3	61

Table 2: Noise at the site.

3.8.1 Acoustical design

The acoustic design of this building is very important because it contains many architectural functions that should be taken into account acoustic designs such as classrooms, conference room, office (staff room), library, headmaster room, computer room and multipurpose hall. In acoustic simulation of buildings there are several programs used for this, such as ECOTECT program and INSUL program.

Example Source	Sound Pressure Level (dB)								dBA
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	
Home									
Alarm clock at 4 to 9 ft (ringing)	--	46	48	55	62	62	70	80	80
Electric shaver at 1 1/2 ft	59	58	49	62	60	64	60	59	68
Vacuum cleaner at 3 ft	48	66	69	73	79	73	73	72	81
Garbage disposal at 2 ft	64	83	69	56	55	50	50	49	69
Clothes washer at 2 to 3 ft (wash cycle)	59	65	59	59	58	54	50	46	62
Toilet (refilling tank)	50	55	53	54	57	56	57	52	63
Whirlpool, six nozzles (filling tub)	68	65	68	69	71	71	68	65	74
Window air-conditioning unit	64	64	65	56	53	48	44	37	59
Telephone at 4 to 13 ft (ringing)	--	41	44	56	68	73	69	83	83
TV at 10 ft	49	62	64	67	70	68	63	39	74
Stereo (teenager listening level)	60	72	83	82	82	80	75	60	86
Stereo (adult listening level)	56	66	75	72	70	66	64	48	75
Violin at 5 ft (fortissimo)	--	--	91	91	87	83	79	66	92
Normal conversational speech at 3 ft	--	57	62	63	57	48	40	--	63
Outdoors									
Birds at 10 ft	--	--	--	--	--	50	52	54	57
Cicadas	--	--	--	--	35	51	54	48	57
Large dog at 50 ft (barking)	--	50	58	68	70	64	52	48	72
Lawn mower at 5 ft	85	87	86	84	81	74	70	72	86
Pistol shot at 250 ft (peak impulse levels)	--	--	--	83	91	99	102	106	106
Surf at 10 to 15 ft (moderate seas)	71	72	70	71	67	64	58	54	78
Wind in trees (10 mi/h)	--	--	--	33	35	37	37	35	43
Transportation									
Large trucks at 50 ft (55 mi/h)	83	85	83	85	81	76	72	65	86
Passenger cars at 50 ft (55 mi/h)	72	70	67	66	67	66	59	54	71
Motorcycle at 50 ft (full throttle, without baffle)	95	95	91	91	91	87	87	85	95
Snowmobile at 50 ft	65	82	84	75	78	77	79	69	85
Train at 100 ft (pulling hard)	95	102	94	90	86	87	83	79	94
Train siren at 50 ft	88	90	110	110	107	100	91	78	109
Car horn at 15 ft	--	--	--	92	95	90	80	60	97
Commercial turbofan airplane at 1 mile (from takeoff flight path)	77	82	82	78	70	56	--	--	79
Military helicopter at 500 ft (single engine, medium size)	92	89	83	81	76	72	62	51	80
Interiors									
Amplified rock music performance (large arena)	116	117	119	116	118	115	109	102	121
Audiovisual room	85	89	92	90	89	87	85	80	94
Auditorium (applause)	60	68	75	79	85	84	75	65	88
Classroom	60	66	72	77	74	68	60	50	78
Computer equipment room	78	75	73	78	80	78	74	70	84
Dog kennel	--	--	90	104	106	101	89	79	108
Gymnasium	72	78	84	89	86	80	72	64	90
Kitchen	86	85	79	78	77	72	65	57	81
Laboratory	65	70	73	75	72	69	65	61	77
Library	60	63	66	67	64	58	50	40	68
Mechanical equipment room	87	86	85	84	83	82	80	78	88
Music practice room	90	94	96	96	96	91	91	90	100
Racquetball court	82	85	80	85	83	75	68	62	86
Reception and lobby area	60	66	72	77	74	68	60	50	78
Teleconference	65	74	78	80	79	75	68	60	83

Figure 64: sound pressure level data

3.8.2 Reverberation time

The reverberation time is defined as the time it takes for sound to decrease by 60 dB to determine the length of this time, different parts of the reverberation curve are used.

The reverberation time is strongly influenced by the absorption coefficients of the surfaces as suggested in the illustration, but it also depends upon the volume of the room as shown in the Sabine formula. You won't get a long reverberation time with a small room.

3.8.2.1 Classroom

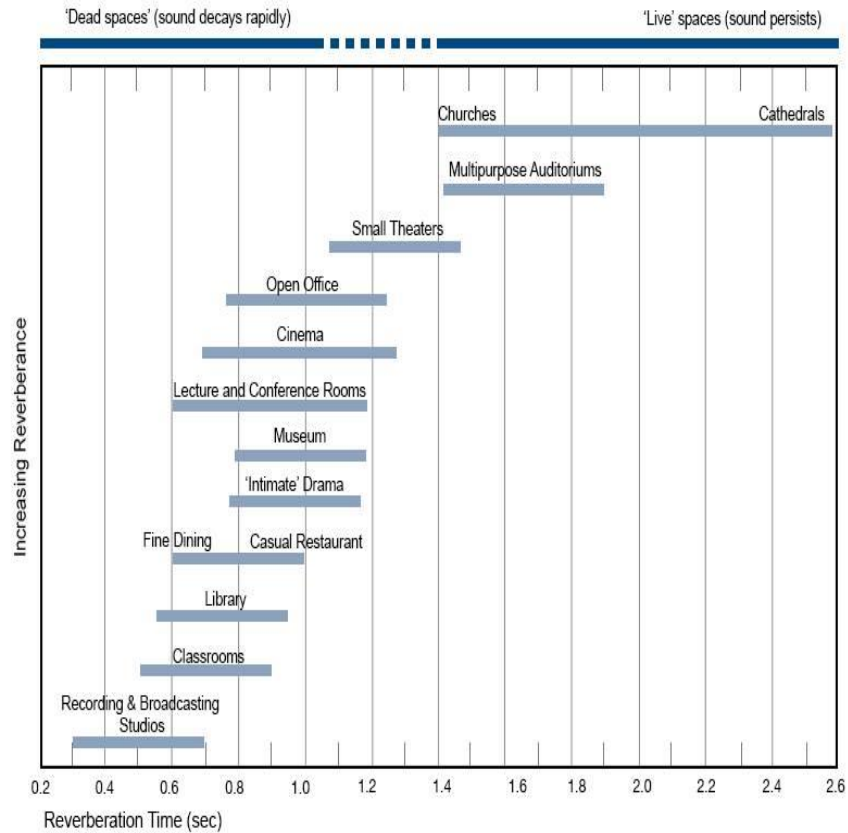


Figure 65: the recommended reverberation time for classroom

The classroom recommended $RT_{60} = (0.5 - 0.9)$.

Class room result (before add any acoustical solution)

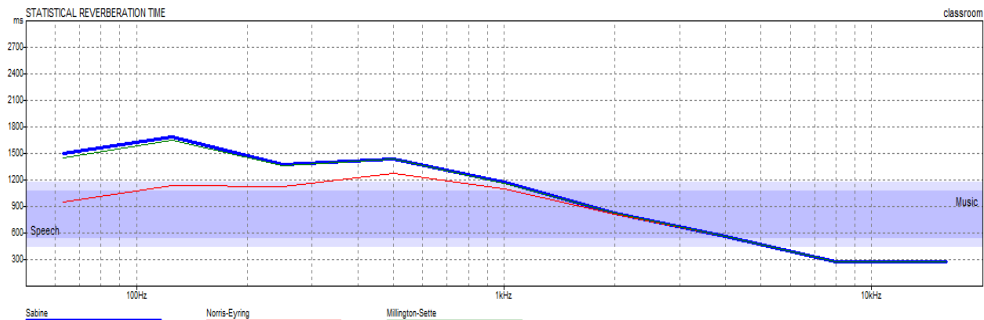


Figure 66: the reverberation time graph for classroom before modification

The result show that the RT (60) is away from standard value which is (0.5-0.9), so modification need to be done by add absorption material to ceiling.

Table 3: reverberation time value for classroom before modification

FREQ.	TOTAL ABSPT.	SABINE RT (60)	NOR-ER RT (60)	MIL-SE RT (60)
63Hz:	11.039	1.50	0.96	1.45
125Hz:	8.723	1.68	1.14	1.64
250Hz:	4.899	1.37	1.12	1.37
500Hz:	3.753	1.44	1.27	1.44
1kHz:	4.138	1.17	1.10	1.17
2kHz:	5.087	0.83	0.81	0.83
4kHz:	6.390	0.57	0.56	0.56
8kHz:	6.113	0.28	0.28	0.28
16kHz:	6.929	0.28	0.28	0.28

By use the following material for ceiling
placoplatre – gyptone sixto 63 SP



Figure 67: placoplatre-gyptone sixto 63 SP material

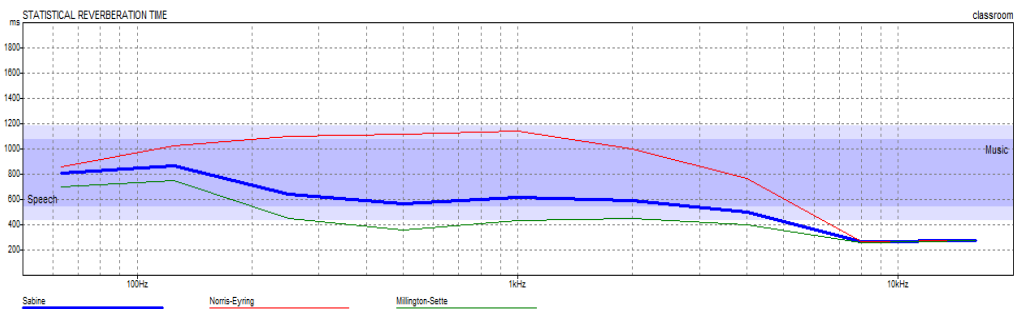


Figure 68: reverberation time graph for class room after modification

Table 4:reverberation time value for class room after modification

FREQ.	TOTAL ABSPT.	SABINE RT (60)	NOR-ER RT (60)	MIL-SE RT (60)
63Hz:	27.597	0.81	0.86	0.70
125Hz:	24.794	0.87	1.02	0.75
250Hz:	33.145	0.64	1.10	0.45
500Hz:	36.869	0.57	1.12	0.36
1kHz:	31.897	0.62	1.14	0.44
2kHz:	29.924	0.59	1.00	0.45
4kHz:	30.740	0.50	0.77	0.40
8kHz:	8.061	0.27	0.27	0.27
16kHz:	8.877	0.28	0.28	0.27

So, the result show that the RT60 are within the standard (0.5 – 0.9), human speech frq (512HZ-2048 HZ), then the result is acceptable.

3.8.2.2 Multipurpose hall

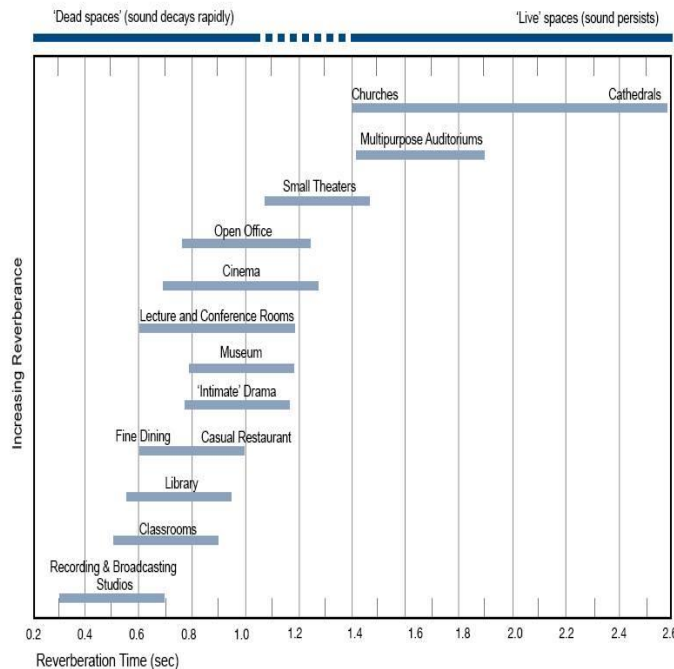


Figure 69: recommended reverberation time for lecture and conference room

Consider it as (lecture and conference room)

The require RT60 is (0.6- 1.2)

Before modification

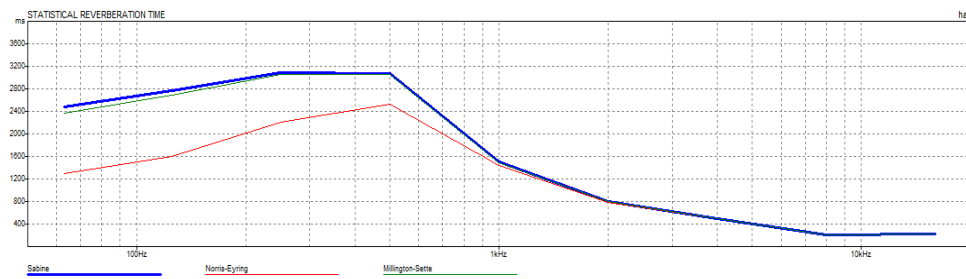


Figure 70: reverberation time graph for multipurpose hall before modification

Volume: 245.930 m³

Surface Area: 293.020 m²

Most Suitable: Sabine (Uniformly distributed)

Selected: Sabine (Uniformly distributed)

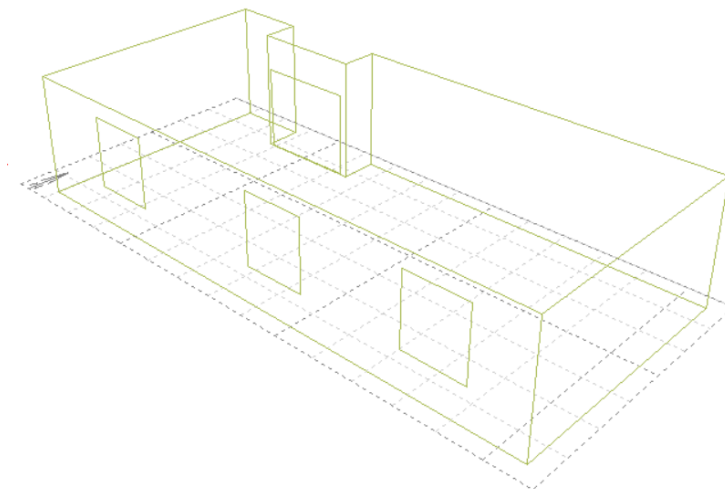


Figure 71: multipurpose hall

Table 5: reverberation time value for multipurpose hall before modification

FREQ.	TOTAL ABSPT.	SABINE RT (60)	NOR-ER RT (60)	MIL-SE RT (60)
63Hz:	15.068	2.48	1.29	2.36
125Hz:	12.086	2.76	1.61	2.68
250Hz:	7.017	3.08	2.20	3.05
500Hz:	5.497	3.06	2.52	3.05
1kHz:	7.058	1.50	1.45	1.50
2kHz:	7.827	0.80	0.80	0.80
4kHz:	9.761	0.50	0.50	0.50
8kHz:	9.440	0.22	0.22	0.22
16kHz:	10.555	0.23	0.23	0.23

The result show that the RT (60) is away from standard value which is (0.6-1.2), so modification need to be done by add absorption material to ceiling.

By use the following material for ceiling

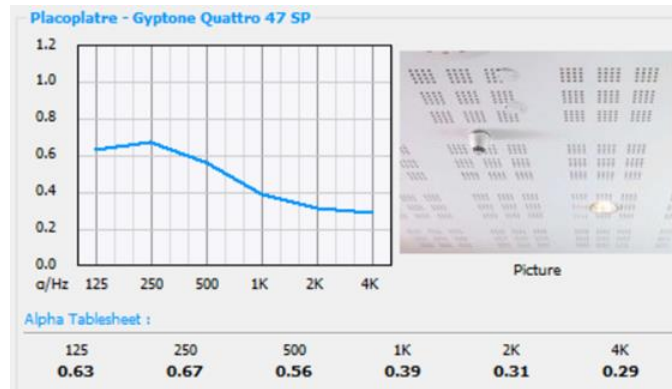


Figure 72:placoplatre-gyptone quattro 47 SP material

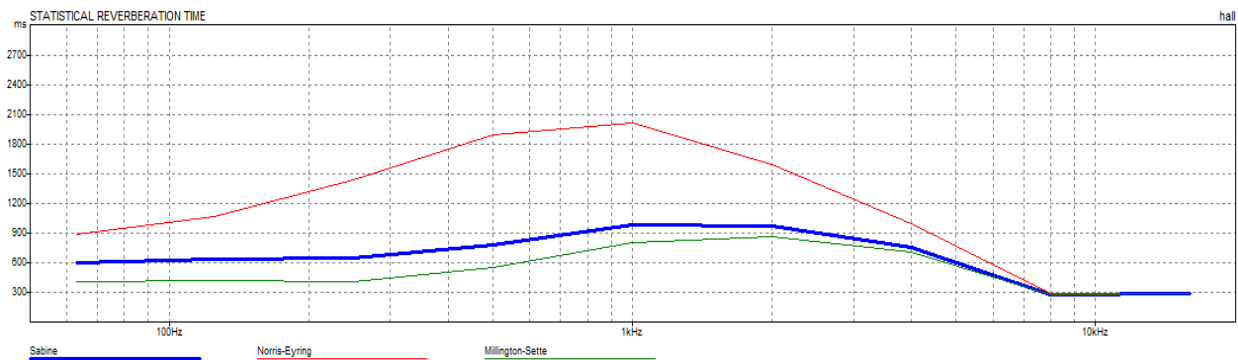


Figure 73: reverberation time graph for multipurpose hall after modification

Table 6: recommended reverberation time value for office

Location	Volume	Critical Distance D_c	Recommended RT60
Recording Studio	< 50 m ³	1.5 m	0.3 s
Classroom	< 200 m ³	2 m	0.4 - 0.6 s
Office	< 1'000 m ³	3.5 m	0.5 - 1.1 s
Lecture Hall	< 5'000 m ³	6 m	1.0 - 1.5 s
Concert Hall, Opera	< 20'000 m ³	11 m	1.4 - 2.0 s
Church			2 - 10 s

So, the result show that the RT60 are within the standard (0.6 – 1.2), human speech frq (512HZ-2048 HZ), then the result is acceptable.

3.8.2.3 Techer office (staff room) Before modification

Table 7: reverberation time graph for staff room before modification

FREQ.	TOTAL ABSPT.	SABINE RT (60)	NOR-ER RT (60)	MIL-SE RT (60)
63Hz:	65.839	0.60	0.89	0.41
125Hz:	62.039	0.63	1.07	0.43
250Hz:	60.246	0.65	1.45	0.41
500Hz:	49.718	0.78	1.89	0.55
1kHz:	36.539	0.98	2.02	0.81
2kHz:	29.937	0.97	1.59	0.86
4kHz:	26.958	0.76	1.00	0.71
8kHz:	12.716	0.28	0.29	0.28
16kHz:	13.831	0.29	0.30	0.29

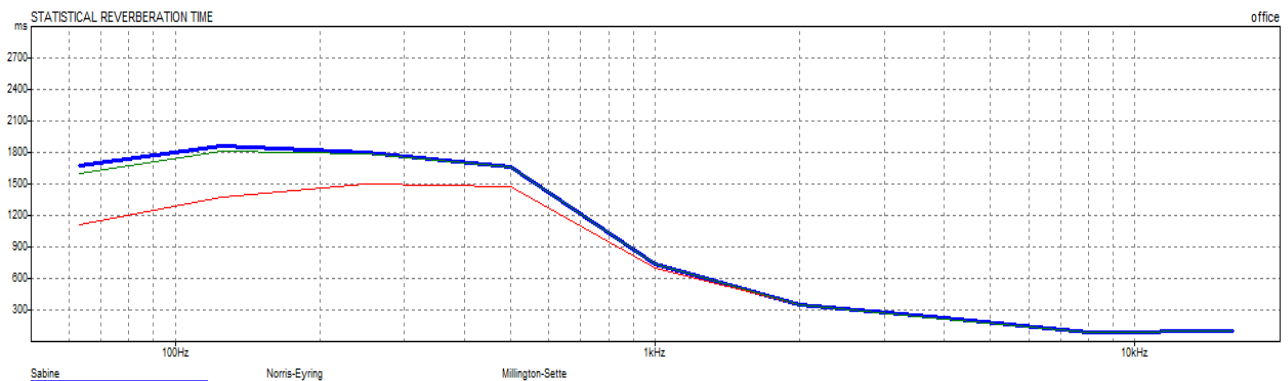


Figure 74: reverberation time graph for staff room before modification

Table 8: reverberation time value for multipurpose hall after modification

FREQ.	TOTAL ABSPT.	SABINE RT (60)	NOR-ER RT (60)	MIL-SE RT (60)
63Hz:	7.696	1.67	1.11	1.59
125Hz:	5.848	1.86	1.37	1.81
250Hz:	3.127	1.80	1.50	1.79
500Hz:	2.414	1.66	1.47	1.66
1kHz:	3.015	0.74	0.70	0.74
2kHz:	3.228	0.36	0.35	0.36
4kHz:	4.127	0.22	0.22	0.22
8kHz:	3.829	0.09	0.09	0.09
16kHz:	4.440	0.10	0.10	0.10

The result show that the RT (60) is away from standard value which is (0.5-1.1), so modification need to be done by add absorption material to ceiling.

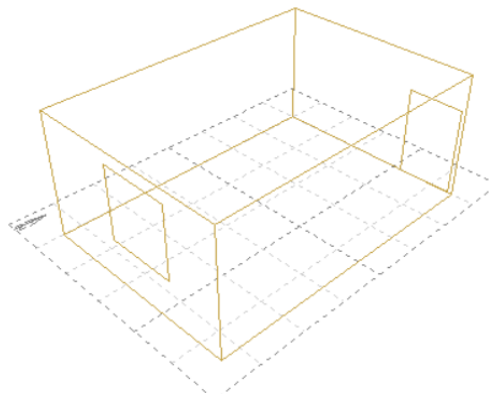


Figure 75: staff room

After add material

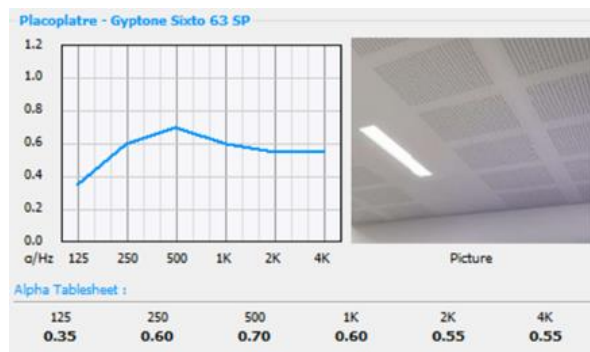


Figure 76: placoplatre – gyptone sixto 63 SP material

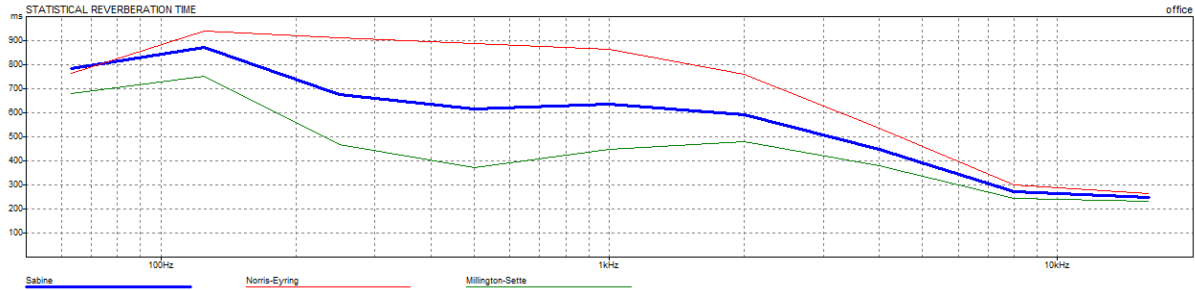


Figure 77: reverberation time graph for staff room after modification

Table 9:reverberation time value for staff room after modification

FREQ.	TOTAL ABSPT.	SABINE RT (60)	NOR-ER RT (60)	MIL-SE RT (60)
63Hz:	17.488	0.78	0.76	0.68
125Hz:	15.352	0.87	0.94	0.75
250Hz:	19.831	0.68	0.91	0.47
500Hz:	21.998	0.61	0.88	0.37
1kHz:	19.431	0.64	0.86	0.45
2kHz:	16.476	0.59	0.76	0.48
4kHz:	17.086	0.45	0.54	0.38
8kHz:	16.501	0.27	0.30	0.24
16kHz:	14.232	0.25	0.27	0.23

So, the result show that the RT60 are within the standard (0.5 – 1.1), human speech (500HZ-2000 HZ), then the result is acceptable.

3.8.2.4 Library

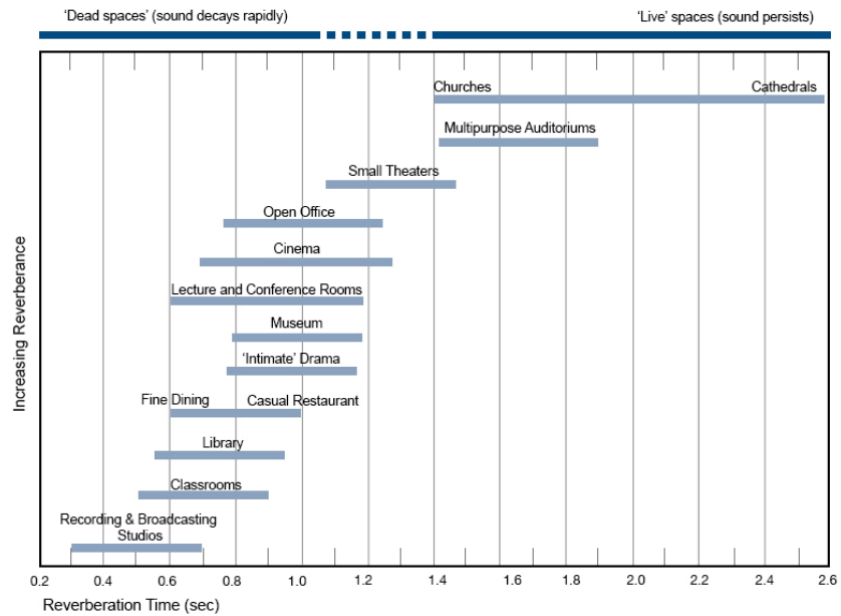


Figure 78: recommended reverberation time for library

The recommended value is (0.55 – 0.95)

Before modification

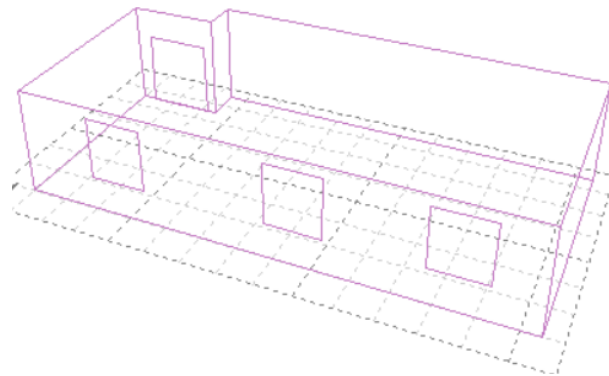


Figure 79: Library

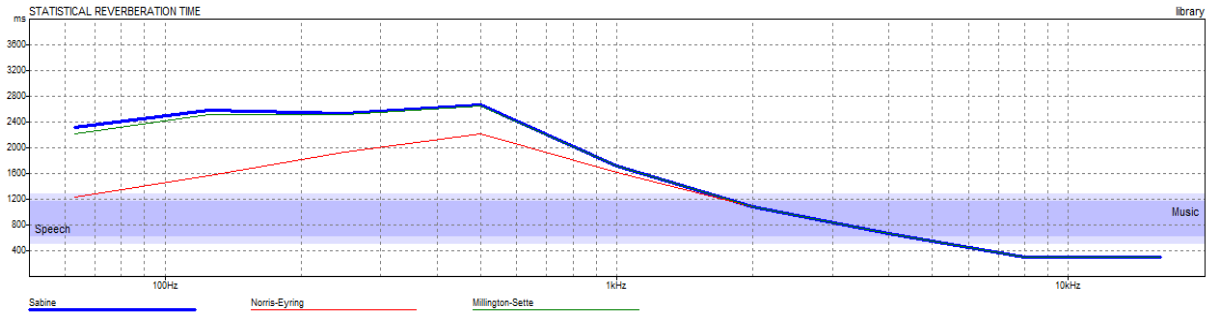


Figure 80:reverberation time graph for library before modification

Table 10:reverberation time value for library before modification

FREQ.	TOTAL ABSPT.	SABINE RT (60)	NOR-ER RT (60)	MIL-SE RT (60)
63Hz:	14.538	2.31	1.24	2.22
125Hz:	11.603	2.58	1.57	2.52
250Hz:	6.689	2.53	1.93	2.51
500Hz:	5.375	2.66	2.22	2.65
1kHz:	7.079	1.72	1.61	1.72
2kHz:	7.818	1.09	1.08	1.09
4kHz:	9.757	0.67	0.67	0.67
8kHz:	9.600	0.31	0.31	0.31
16kHz:	10.686	0.32	0.31	0.31

The result show that the RT (60) is away from standard value which is (0.55-0.95), so modification need to be done by add absorption material to ceiling.

After add material

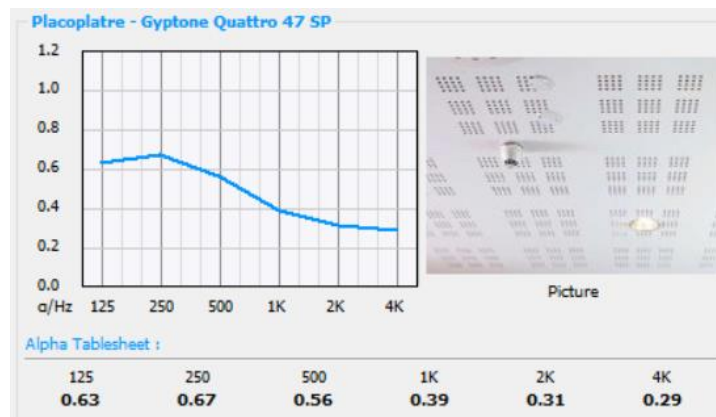


Figure 81:placoplatre-gyptone quattro 47 SP material

Table 11:reverberation time value for library after modification

FREQ.	TOTAL ABSPT.	SABINE RT (60)	NOR-ER RT (60)	MIL-SE RT (60)
63Hz:	67.393	0.59	0.83	0.41
125Hz:	63.605	0.62	1.00	0.42
250Hz:	62.102	0.60	1.15	0.39
500Hz:	51.410	0.70	1.39	0.51
1kHz:	37.769	0.87	1.51	0.74
2kHz:	30.836	0.88	1.32	0.79
4kHz:	27.659	0.76	0.98	0.71
8kHz:	13.010	0.36	0.37	0.36
16kHz:	14.096	0.36	0.37	0.36

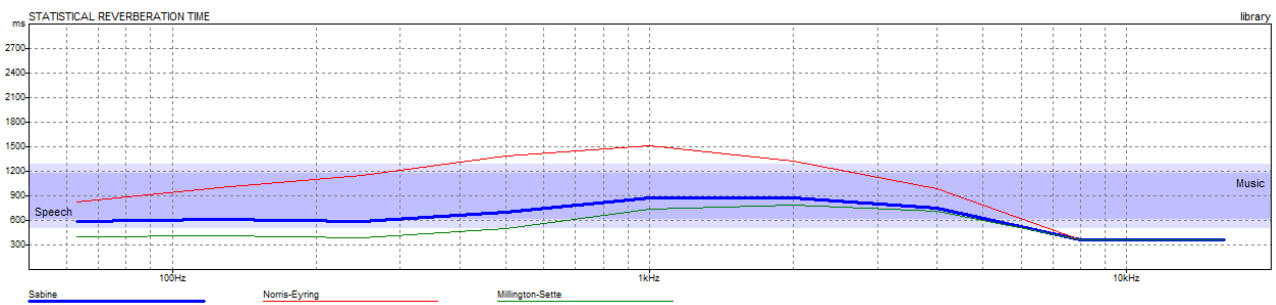


Figure 82:reverberation time graph for library after modification

So, the result show that the RT60 are within the standard (0.55 – 0.95), human speech (500HZ-2000 HZ), then the result is acceptable.

3.8.2.5 Conference room

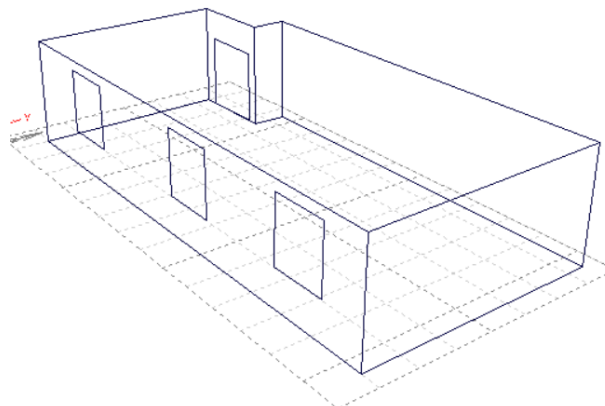


Figure 83:conference room

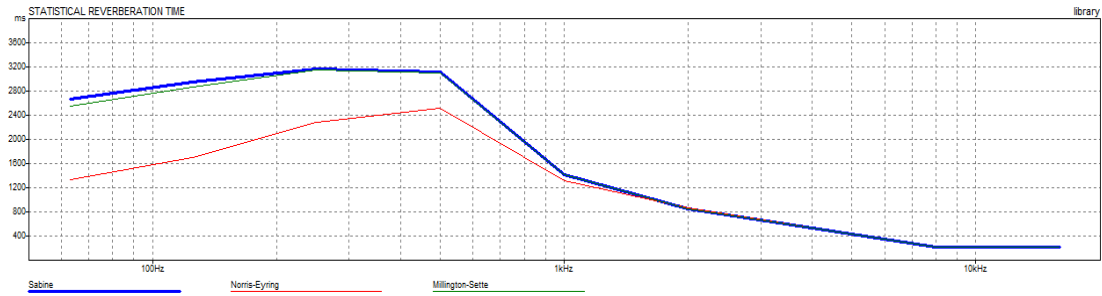


Figure 84: reverberation time graph for conference room before modification

Table 12:reverberation time value for conference room before modification

FREQ.	TOTAL ABSPT.	SABINE RT (60)	NOR-ER RT (60)	MIL-SE RT (60)
63Hz:	14.538	2.66	1.34	2.54
125Hz:	11.603	2.94	1.70	2.86
250Hz:	6.689	3.16	2.28	3.14
500Hz:	5.375	3.11	2.52	3.09
1kHz:	6.227	1.42	1.32	1.42
2kHz:	8.671	0.86	0.86	0.86
4kHz:	10.609	0.53	0.54	0.53
8kHz:	9.600	0.22	0.22	0.22
16kHz:	9.833	0.22	0.22	0.22

The result show that the RT (60) is away from standard value which is (0.6 - 1.2), so modification need to be done by add absorption material to ceiling.

After used material for ceiling

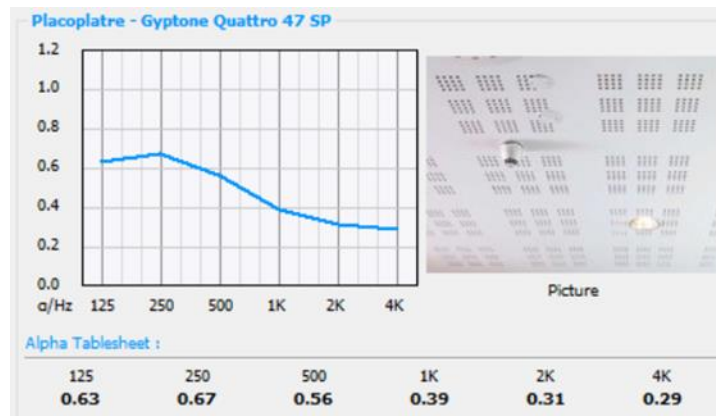


Figure 85:placoplatre-gyptone quattro 47 SP material

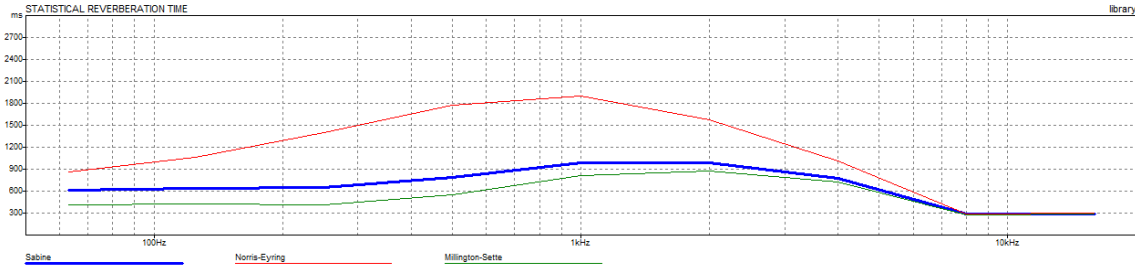


Figure 86:reverberation time graph for conference room after modification

Table 13:reverberation time value for conference room after modification

FREQ.	TOTAL ABSPT.	SABINE RT (60)	NOR-ER RT (60)	MIL-SE RT (60)
63Hz:	67.393	0.61	0.87	0.42
125Hz:	63.605	0.64	1.06	0.43
250Hz:	62.102	0.66	1.40	0.41
500Hz:	51.410	0.79	1.78	0.55
1kHz:	37.769	0.99	1.90	0.82
2kHz:	30.836	0.99	1.58	0.88
4kHz:	27.659	0.77	1.01	0.73
8kHz:	13.010	0.29	0.29	0.29
16kHz:	14.096	0.30	0.30	0.29

So, the result show that the RT60 are within the standard (0.6 – 1.2), human speech (500HZ-2000 HZ), then the result is acceptable.

3.8.2.6 Head office room

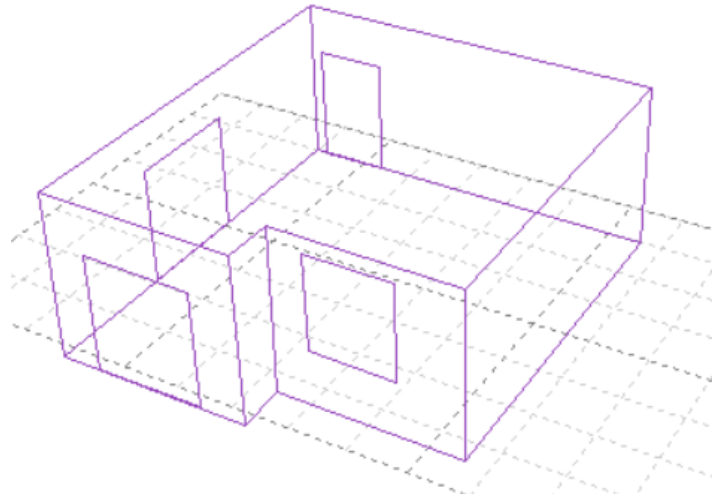


Figure 87: head office room

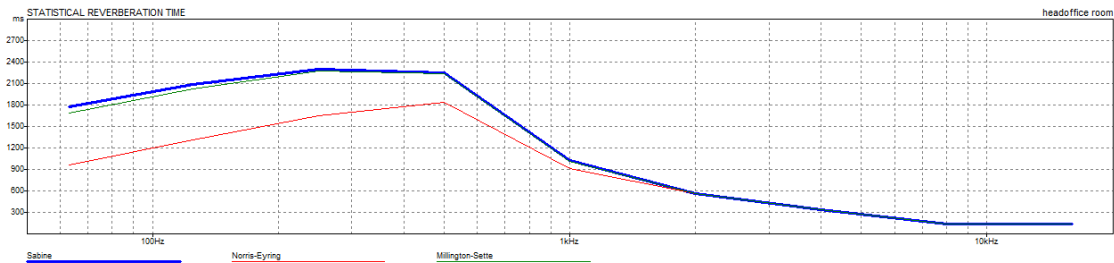


Figure 88: reverberation time graph for head office room before modification

Table 14:reverberation time value for head office room before modification

FREQ.	TOTAL ABSPT.	SABINE RT (60)	NOR-ER RT (60)	MIL-SE RT (60)
63Hz:	11.581	1.78	0.96	1.68
125Hz:	8.711	2.09	1.31	2.02
250Hz:	4.936	2.29	1.66	2.27
500Hz:	3.819	2.24	1.83	2.23
1kHz:	4.434	1.02	0.92	1.02
2kHz:	5.468	0.57	0.56	0.57
4kHz:	6.644	0.35	0.35	0.34
8kHz:	5.944	0.14	0.14	0.14
16kHz:	6.217	0.14	0.14	0.14

The result show that the RT (60) is away from standard value which is (0.5 - 1.1), so modification need to be done by add absorption material to ceiling.

After add material

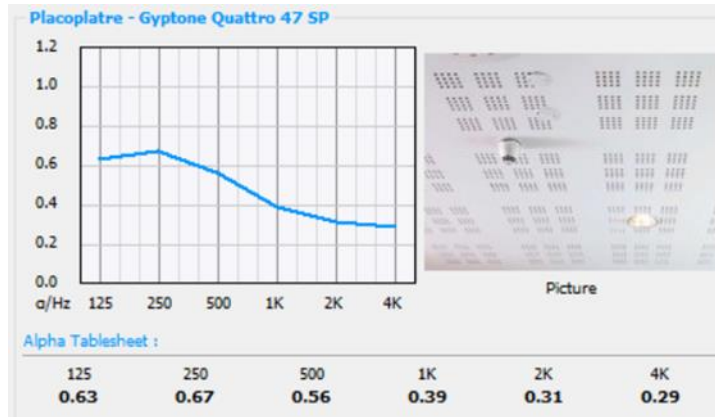


Figure 89:placoplatre-gyptone quattro 47 SP material

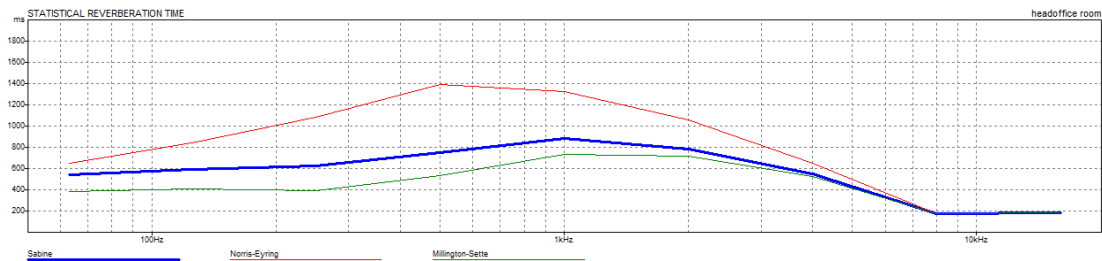


Figure 90: reverberation time graph for head master room after modification

Table 15:reverberation time value for head master room after modification

FREQ.	TOTAL ABSPT.	SABINE RT (60)	NOR-ER RT (60)	MIL-SE RT (60)
63Hz:	39.582	0.55	0.65	0.38
125Hz:	36.261	0.59	0.84	0.41
250Hz:	34.293	0.62	1.08	0.40
500Hz:	28.207	0.75	1.39	0.53
1kHz:	21.145	0.88	1.32	0.74
2kHz:	17.210	0.79	1.06	0.71
4kHz:	15.676	0.55	0.65	0.52
8kHz:	7.751	0.18	0.18	0.18
16kHz:	8.475	0.18	0.19	0.18

So, the result show that the RT60 are within the standard (0.5 – 1.1), human speech (500HZ-2000 HZ), then the result is acceptable.

3.8.2.7 Computer lab

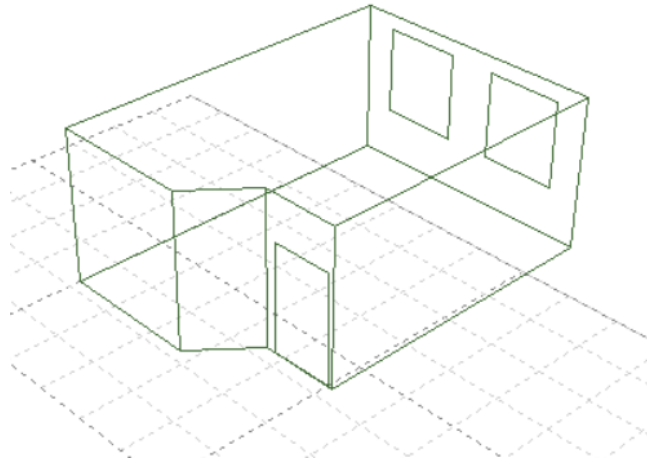


Figure 91: computer room

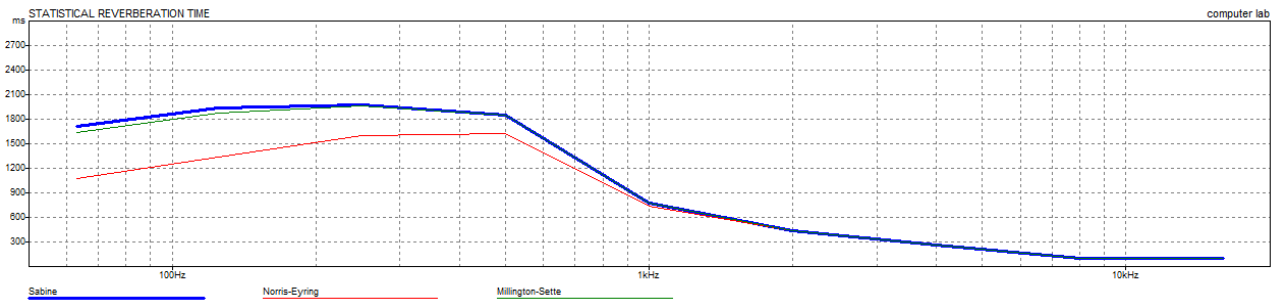


Figure 92: reverberation time graph for computer room before modification

The reverberation time for computer lab is the same for classroom which is (0.5 – 0.9)

Table 16:reverberation time value for computer room before modification

FREQ.	TOTAL ABSPT.	SABINE RT (60)	NOR-ER RT (60)	MIL-SE RT (60)
63Hz:	8.823	1.72	1.08	1.63
125Hz:	6.754	1.93	1.34	1.88
250Hz:	3.640	1.97	1.60	1.96
500Hz:	2.804	1.85	1.62	1.84
1kHz:	3.139	0.78	0.74	0.77
2kHz:	4.070	0.44	0.44	0.44
4kHz:	5.089	0.27	0.27	0.27
8kHz:	4.457	0.10	0.10	0.10
16kHz:	4.805	0.11	0.11	0.11

So, the result show that the RT60 are don't match the standard (0.5 – 0.9), a modification needs to be done by add material.

After add material for ceiling

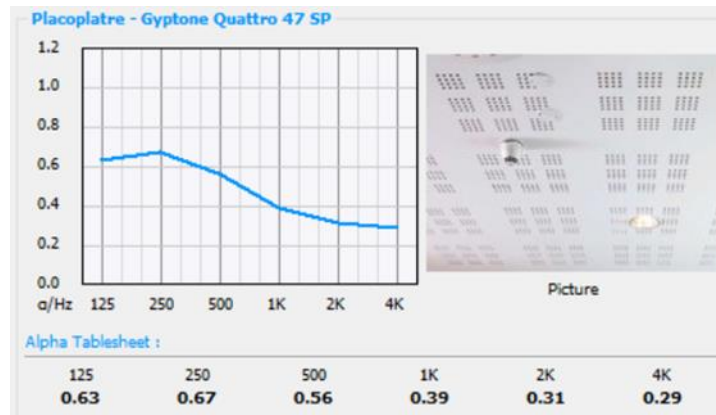


Figure 93:placoplatre-gyptone quattro 47 SP material

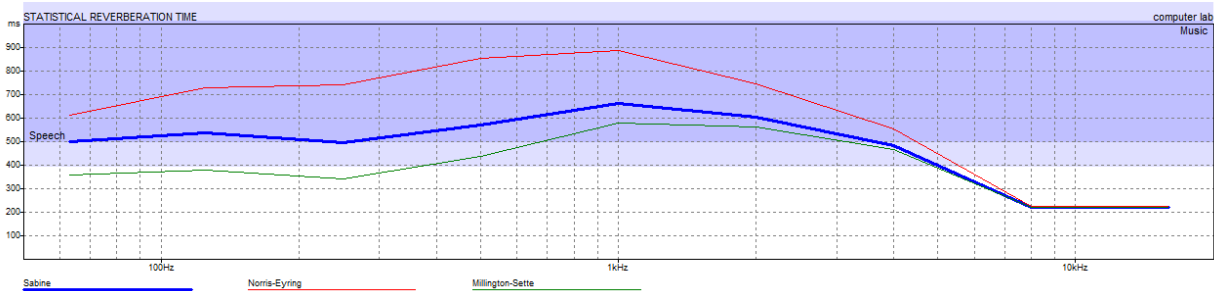


Figure 94: reverberation time graph for computer room after modification

Table 17:reverberation time value for computer room after modification

FREQ.	TOTAL ABSPT.	SABINE RT (60)	NOR-ER RT (60)	MIL-SE RT (60)
63Hz:	29.627	0.50	0.61	0.36
125Hz:	27.223	0.54	0.73	0.38
250Hz:	25.451	0.50	0.74	0.34
500Hz:	20.924	0.57	0.85	0.44
1kHz:	15.555	0.66	0.89	0.58
2kHz:	12.795	0.60	0.74	0.56
4kHz:	11.800	0.49	0.55	0.47
8kHz:	5.799	0.22	0.23	0.22
16kHz:	6.483	0.22	0.22	0.22

So, the result show that the RT60 are within the standard (0.5 – 0.9), human speech (500HZ-2000 HZ), then the result is acceptable.

3.8.3 Noise control

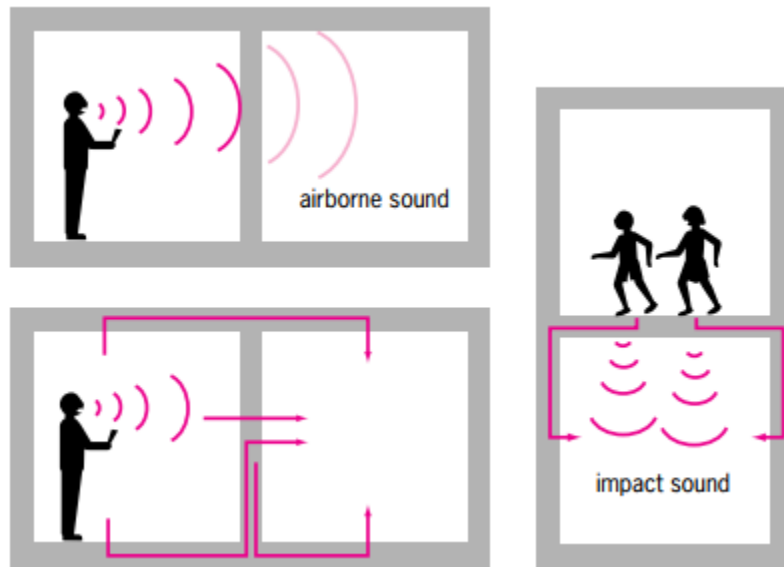


Figure 95: different noise impact

3.8.4 Sound Transmission Class

The amount of airborne sound blocked from transmitting through a partition is measured in a Sound Transmission Class (STC) rating. A higher STC rating will Sound transmission through walls will add to the background noise level in the space, degrading the ability to hear and understand speech.

([HTTPS://WWW.SOUNDPROOFINGCOMPANY.COM/SOUNDPROOFING_101/UNDERSTANDING-STC-AND-STC-RATINGS](https://www.soundproofingcompany.com/soundproofing_101/understanding-stc-and-stc-ratings))

3.8.5 STC recommended values

Type of Occupancy	Wall, Partition, or Panel Between		Sound Insulation Requirement: Background Level in Room Being Considered	
	Room Being Considered	and Adjacent Area	Quiet	Normal
Normal school buildings without extraordinary or unusual activities or requirements	Classrooms	Adjacent classrooms	STC 42	STC 40
		Corridor or public areas	STC 40	STC 38
		Kitchen and dining areas	STC 50	STC 47
		Shops	STC 50	STC 47
	Music practice rooms	Recreation areas	STC 45	STC 42
		Music rooms	STC 55	STC 50
		Mechanical equipment rooms	STC 50	STC 45
		Toilet areas	STC 45	STC 42
		Adjacent practice rooms	STC 55	STC 50
		Corridor and public areas	STC 45	STC 42
Executive areas, doctors' suites; confidential privacy requirements	Office	Adjacent offices	STC 50	STC 45
		General office areas	STC 48	STC 45
		Corridor or lobby	STC 45	STC 42
		Washrooms and toilet areas	STC 50	STC 47
Normal office; normal privacy requirements; any occupancy using rooms for group meetings	Office	Adjacent offices	STC 40	STC 38
		Corridor, lobby, exterior	STC 40	STC 38
		Washrooms, kitchen, dining	STC 42	STC 40
	Conference rooms	Other conference rooms	STC 45	STC 42
		Adjacent offices	STC 45	STC 42
		Corridor or lobby	STC 42	STC 40
		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

Figure 96: recommended STC for partitions specific occupancies

Summary for recommendation STC for rooms:

- For classroom adjacent classroom, corridors **the recommended STC value is 42, 40.**
- For office adjacent office, corridors, **the recommended STC value is 40.**
- For conference room adjacent office, corridors **the recommended STC value is 45, 42.**
- For Classroom doors should be rated as **STC-30** or more.

STC value for internal wall equal 47 which is within the requirements.

By using INSUL program to evaluate the STC for internal partition:

3.8.5.1 Internal wall

63	125	250	500	1k	2k	4k
37	41	39	40	48	54	60

STC 47 OITC 43

Description

Trial Mode

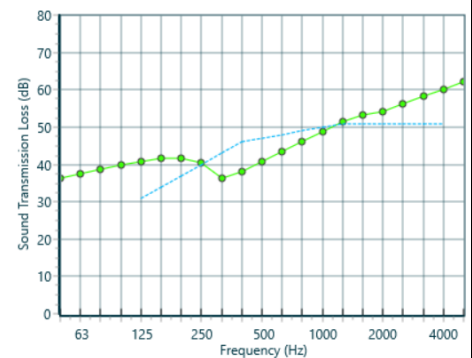


Figure 97: STC value for internal wall

STC value is 47 for internal wall.

OITC standard (depends on the outside SPL)

66 - 70 dBA

Where the outdoor background noise level is between 66 dBA and 70 dBA, the external walls designed to have an OITC rating not less than 27 dB below the greatest outdoor one-hour average A-weighted sound level. Construction techniques are not typical and construction workmanship must be carefully monitored. (<https://acousticalsolutions.com/what-is-iic-impact-insulation-class/>)

71 - 75 dBA

Where the outdoor background noise level is between 71 dBA and 75 dBA, the external walls designed to have an OITC rating not less than 28 dB below the greatest outdoor one-hour average A-weighted sound level. Construction techniques are not typical and construction

workmanship must be carefully monitored. (<https://ACOUSTICALSOLUTIONS.COM/WHAT-IS-IIC-IMPACT-INSULATION-CLASS/>)

76 - 80 dBA

Where the outdoor background noise level is between 76 dBA and 80 dBA, Construction techniques are not typical and construction workmanship must be carefully monitored and the external walls designed to have an OITC rating not less than 29 dB below the greatest outdoor one-hour average A-weighted sound level but not greater than 50 dB

(<https://ACOUSTICALSOLUTIONS.COM/WHAT-IS-IIC-IMPACT-INSULATION-CLASS/>).

By using INSUL program to evaluate the STC for exterior walls (Masonry walls).

3.8.5.2 External wall

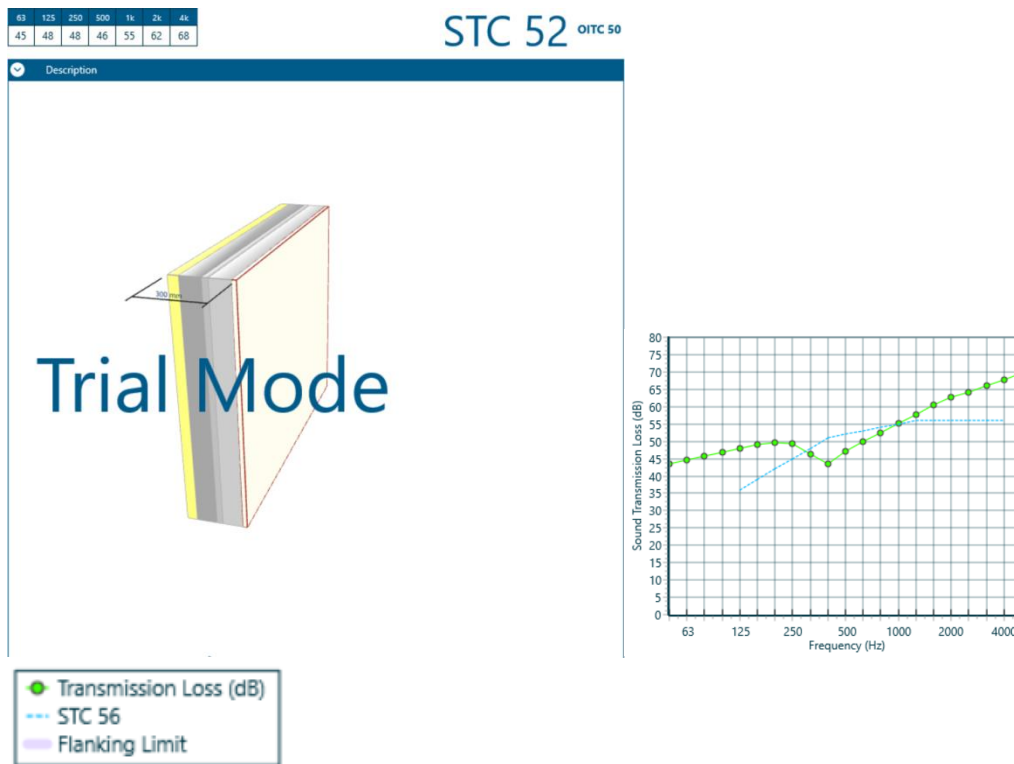


Figure 98: STC value for external wall

Panel 1 : 1 x 50.0 mm stone ($\rho:2600 \text{ kg/m}^3, E:11 \text{ GPa}, \eta:0.02$) + 1 x 100.0 mm Concrete ($\rho:2340 \text{ kg/m}^3, E:11 \text{ GPa}, \eta:0.03$) + 1 x 30.0 mm poly strene foam ($\rho:38 \text{ kg/m}^3, E:4.7 \text{ GPa}, \eta:0.01$) + 1 x 100.0 mm Hollow Conc Blocks (760 kg/m^3) + 1 x 20.0 mm mm Plasterboard ($\rho:710 \text{ kg/m}^3, E:2 \text{ GPa}, \eta:0.01$)

The OITC = 50, it enough to be acceptable and with required for 76 - 80 dBA outdoor background noise level that was equal 50 dB.

3.8.6 Impact Insulation Class

Impact Insulation Class is an acoustical rating used to quantify impact sound absorption.

- IIC ratings for floor-ceiling assemblies above core learning spaces should be at least **IIC-45** and preferably **IIC-50** (measured without carpeting on the floor).
- In new construction, gymnasias, dance studios or other high floor impact activities shall not be located above core learning spaces.
- In existing facilities **IIC-65-70** (depending on the volume of the space below) is recommended if -gymnasias, dance studios or other high floor impact activities are located above core learning spaces.

Impact Insulation Class

63	125	250	500	1k	2k	4k
60	66	68	64	57	49	40

IIC 54

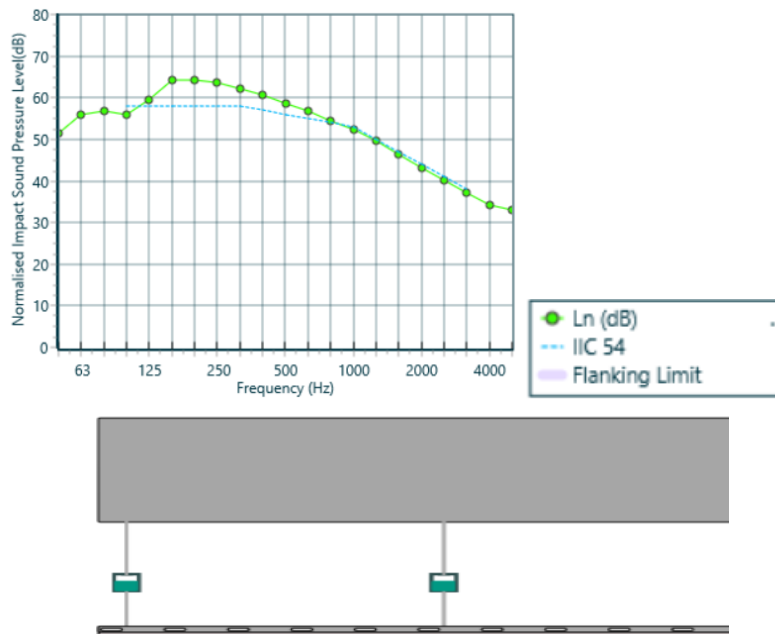


Figure 99: IIC value for floor

The result show that we achieve the standard IIC for classroom 54 dB > 50 dB, which is acceptable and with standard.

Background noise table on learning spaces

Table 18: background noise on learning spaces

Learning Space	Greatest allowable one-hour-average A- and C-weighted background noise level (dB)
Core learning space with enclosed volume $\leq 283 \text{ m}^3$ ($\leq 10\,000 \text{ ft}^3$)	35 / 55
Core learning space with enclosed volume $> 283 \text{ m}^3$ and $\leq 566 \text{ m}^3$ ($> 10\,000 \text{ ft}^3$ and $\leq 20\,000 \text{ ft}^3$)	35 / 55
Core learning spaces with enclosed volumes $> 566 \text{ m}^3$ ($> 20\,000 \text{ ft}^3$)	40 / 60
Ancillary learning spaces (any volume)	40 / 60

Specific notes for this table are found in the ANSI/ASA S12.60 standard as Table 1 in Section 5.2.1.3.

3.8.6 NR for different spaces

Type of Space (and Listening Requirements)	Preferred Range of Noise Criteria	Equivalent dBA Level *
Concert halls, opera houses, broadcasting and recording studios, large auditoriums, large churches, recital halls (for excellent listening conditions)	< NC-20	< 30
Small auditoriums, theaters, music practice rooms, large meeting rooms, teleconference rooms, audiovisual facilities, large conference rooms, executive offices, small churches, courtrooms, chapels (for very good listening conditions)	NC-20 to NC-30	30 to 38
Bedrooms, sleeping quarters, hospitals, residences, apartments, hotels, motels (for sleeping, resting, relaxing)	NC-25 to NC-35	34 to 42
Private or semiprivate offices, small conference rooms, classrooms, libraries (for good listening conditions)	NC-30 to NC-35	38 to 42
Large offices, reception areas, retail shops and stores, cafeterias, restaurants, gymnasiums (for moderately good listening conditions)	NC-35 to NC-40	42 to 47
Lobbies, laboratory work spaces, drafting and engineering rooms, general secretarial areas, maintenance shops such as for electrical equipment (for fair listening conditions)	NC-40 to NC-45	47 to 52
Kitchens, laundries, school and industrial shops, computer equipment rooms (for moderately fair listening conditions)	NC-45 to NC-55	52 to 61

* Do *not* use A-weighted sound levels (dBA) for specification purposes. Spectrum shapes and noise characteristics can vary widely for background noises with identical A-weighted sound levels (see Chap. 1).

Figure 100: noise criteria different spaces

3.8.7 Speech transmission index

The Speech Transmission Index is an objective, physical measure of speech transmission quality. The STI is a 0 to 1 index, indicating the degree to which a transmission channel degrades speech intelligibility. This means that perfectly intelligible speech, when transferred through a channel with an associated STI of 1, will remain perfectly intelligible. The closer the STI value

approaches zero, the more information is lost. (WWW.EMBEDDEDACOUSTICS.COM/INDEX.PHP/SPEECH-TRANSMISSION-INDEX/9-INTRO/STI)

And the following figure show STI value needed to be accepted.

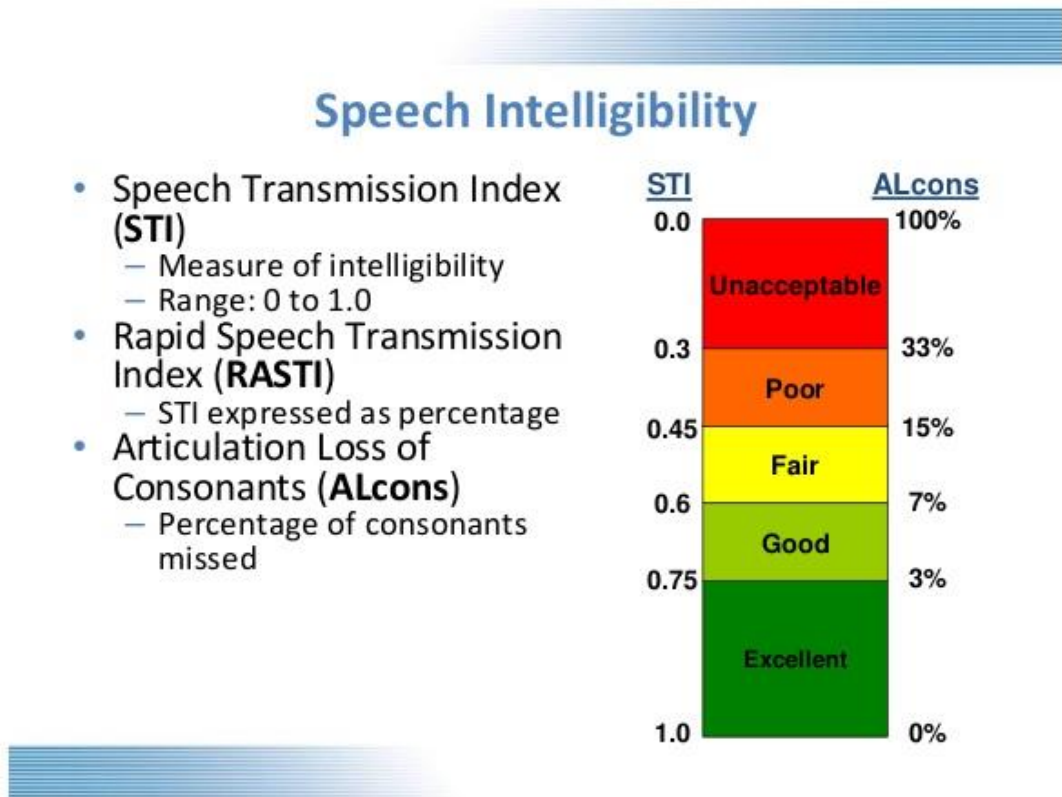


Figure 101: sound transmission index with articulation loss value

Chapter 4: Structural design

4.1 Introduction

Structural aspect is very important since it presents what the structural aims to regarding how to distribute the columns in internal partitions.

In addition the structural aspect showing the perfect view of building which concluded by the perfect integration in all the building elements which presented by the structural and architectural.

Our project contains structure of three floors, ground floor, first floor and second floor. Building had been analyzed by ETABS-2018, SAP and safe for footing tool using one-way ribbed slab and two-way ribbed slab.

As this construction system takes the environmental side in consideration including the acoustics, thermal resistance, and economical aspect, we will find that using two way system to solve the column issue which will have obvious divergence, also this will guide to apply thicker slab which will be grate saving with amazing landscape

4.2 Code & Specification

- ASCE-7 for combination & load
- ACI 318-14
- UBC 97

4.3 Material

1. Concrete.

- $\gamma_c = 25 \text{ KN/m}^3$.
- $F'_c = 28 \text{ Mpa}$.
- Modulus of elasticity (E) = 23025 Mpa.

2. Steel.

- Modulus of elasticity (E) = 200 Gpa.
- $F_y = 240 \text{ Mpa}$.

3. Concrete hollow Block.

- $\gamma_b = 12 \text{ KN/m}^3$.

4.4 Load combination.

- Ultimate load combinations:
 - $1.4D$
 - $1.2D+1.6L$
 - $1.38D+L\pm EQ_x\pm 0.3EQ_y$
 - $1.38D+L\pm 0.3EQ_x\pm EQ_y$
 - $0.72 D\pm EQ_x\pm 0.3EQ_y$
 - $0.72 D\pm 0.3EQ_x\pm EQ_y$

- Service load combinations:
 - D
 - $D+L$
 - $D\pm 0.714EQ_x\pm 0.21EQ_y$
 - $D\pm 0.21EQ_x\pm 0.714EQ_y$
 - $0.9D\pm 0.714EQ_x\pm 0.21EQ_y$
 - $0.9D\pm 0.21EQ_x\pm 0.714EQ_y$
 - $D+0.75L\pm 0.54EQ_x\pm 0.16EQ_y$
 - $D+0.75L\pm 0.16EQ_x\pm 0.54EQ_y$

4.5 Loads.

1- Dead loads (D.L): this includes all structural element, like weight of slab, columns and beams, which will be affected during life load.

2- Super Imposed Dead load (SID): included the furniture, tiles, weight of internal partitions and it considered as dead load.

3- Live load (L.L): the ASCE community recommended that live loads of the slab depend on the structure function.

5-Earthquake loads (EQ. L): are affect in three directions when conducting structural analysis, one in vertical and two in horizontal on the building. The force affect in vertical direction can be

neglected, because it's not causes forces in superstructure. But the forces affect in horizontal direction of the building must be considered in the design.

In the project the load is:

- I. Live load = 4.5 KN/m^2 .
- II. Super imposed dead load = 4 KN/m^2 .
- III. External wall load = 21 KN/m .
- IV. Weight = $\gamma_c * V_c + \gamma_b * V_b$.

The following figure shows the two-way ribbed slab

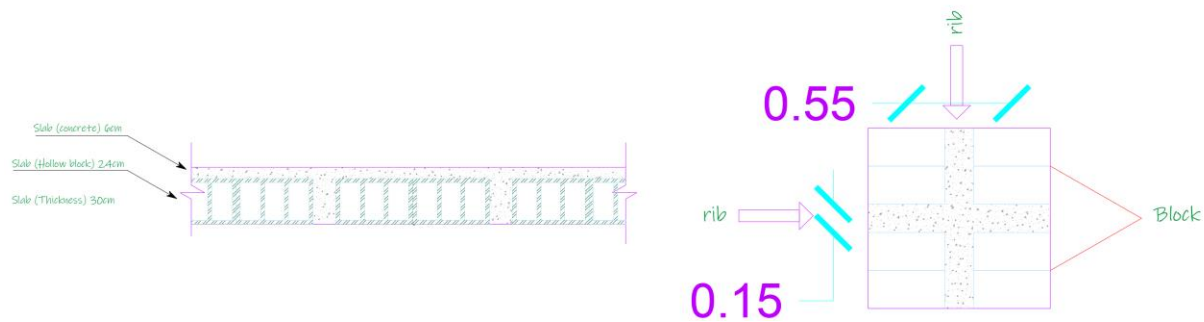


Figure 102: two-way ribbed slab.

4.5 Thickness of slab.

For all floor we used ribbed slab.

Max length of beam = 8.27 m.

Thickness of slab = $\frac{8.40}{18.5} = 45.7 \text{ cm}$, it's too much.

We will go to design two way.

First assumption for continues span $h = \frac{Ln}{25}$ (thickness of beam).

Second assumption for continues span $h = \frac{Ln}{25} * \frac{3}{4}$ (thickness of slab).

(α_m & α_f) will be calculated to find thickness of slab.

Figure shows the panel used for calculation of slab.

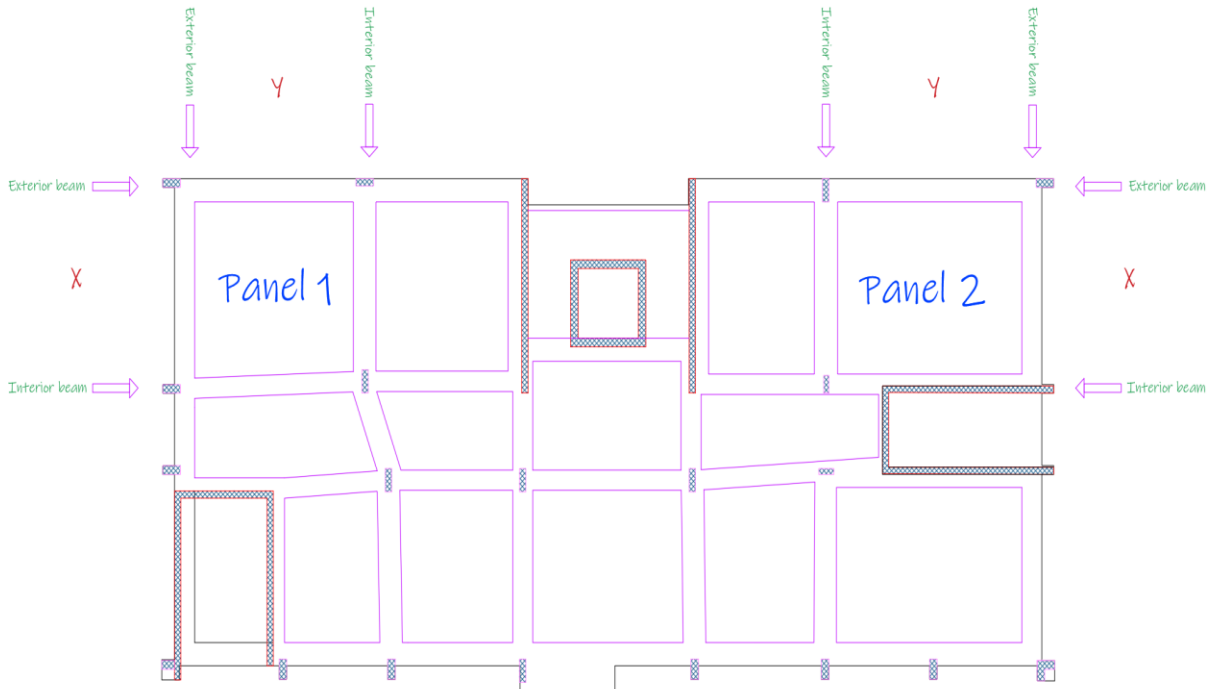


Figure 103: slab panel.

Table shows the calculation of slab thickness.

Path 1													
panel	L _{long}	L _{short}	β	h _{beam}	h _{slab}	Ln	diriction	L2	Fream type	I _{slab}	I _{beam}	α _f	α _m
1	7.70	7.10	1.085	280.0	210.0	7000	X	5270	Exterior	4.1E+09	1.5E+09	0.36	0.32
									interior	4.1E+09	1.3E+09	0.31	
						Y	6700	Exterior	5.2E+09	1.5E+09	0.28		
								interior	5.2E+09	1.6E+09	0.32		
2	8.70	6.70	1.299	330.8	248.1	8270	X	4900	Exterior	6.2E+09	1.5E+09	0.23	0.20
									interior	6.2E+09	1.3E+09	0.21	
						Y	6700	Exterior	8.5E+09	1.5E+09	0.17		
								interior	8.5E+09	1.6E+09	0.19		
Path 2 α _m <2													
panel	L _{long}	L _{short}	β	h _{beam}	h _{slab}	Ln	diriction	L2	Fream type	I _{slab}	I _{beam}	α _f	α _m
1	7.70	7.10	1.085	234.4	175.8	7000	X	5270	Exterior	2.4E+09	1.5E+09	0.61	0.54
									interior	2.4E+09	1.3E+09	0.54	
						Y	6700	Exterior	3.0E+09	1.5E+09	0.48		
								interior	3.0E+09	1.6E+09	0.54		
2	8.70	6.70	1.299	278.0	208.5	8270	X	4900	Exterior	3.7E+09	1.5E+09	0.40	0.34
									interior	3.7E+09	1.3E+09	0.35	
						Y	6700	Exterior	5.1E+09	1.5E+09	0.29		
								interior	5.1E+09	1.6E+09	0.33		
Path 3 α _m <2						h _{slab} (diferant between path1 & path2)		52.8					
panel	L _{long}	L _{short}	β	h _{beam}	h _{slab}	Ln	diriction	L2	Fream type	I _{slab}	I _{beam}	α _f	α _m
1	7.70	7.10	1.085	232.9	174.7	7000	X	5270	Exterior	2.3E+09	1.5E+09	0.63	0.55
									interior	2.3E+09	1.3E+09	0.55	
						Y	6700	Exterior	3.0E+09	1.5E+09	0.49		
								interior	3.0E+09	1.6E+09	0.55		
2	8.70	6.70	1.299	276.6	207.4	8270	X	4900	Exterior	3.6E+09	1.5E+09	0.40	0.34
									interior	3.6E+09	1.3E+09	0.35	
						Y	6700	Exterior	5.0E+09	1.5E+09	0.29		
								interior	5.0E+09	1.6E+09	0.33		
Path 4 α _m <2						h _{slab} (diferant between path1 & path2)		1.4		Use h _{slab} = 300 mm			

Table 19: calculation of slab thickness

We use h=300 mm for each floor.

4.6 structural Plans before and after modification

Figure shows the structural Plan before modification.

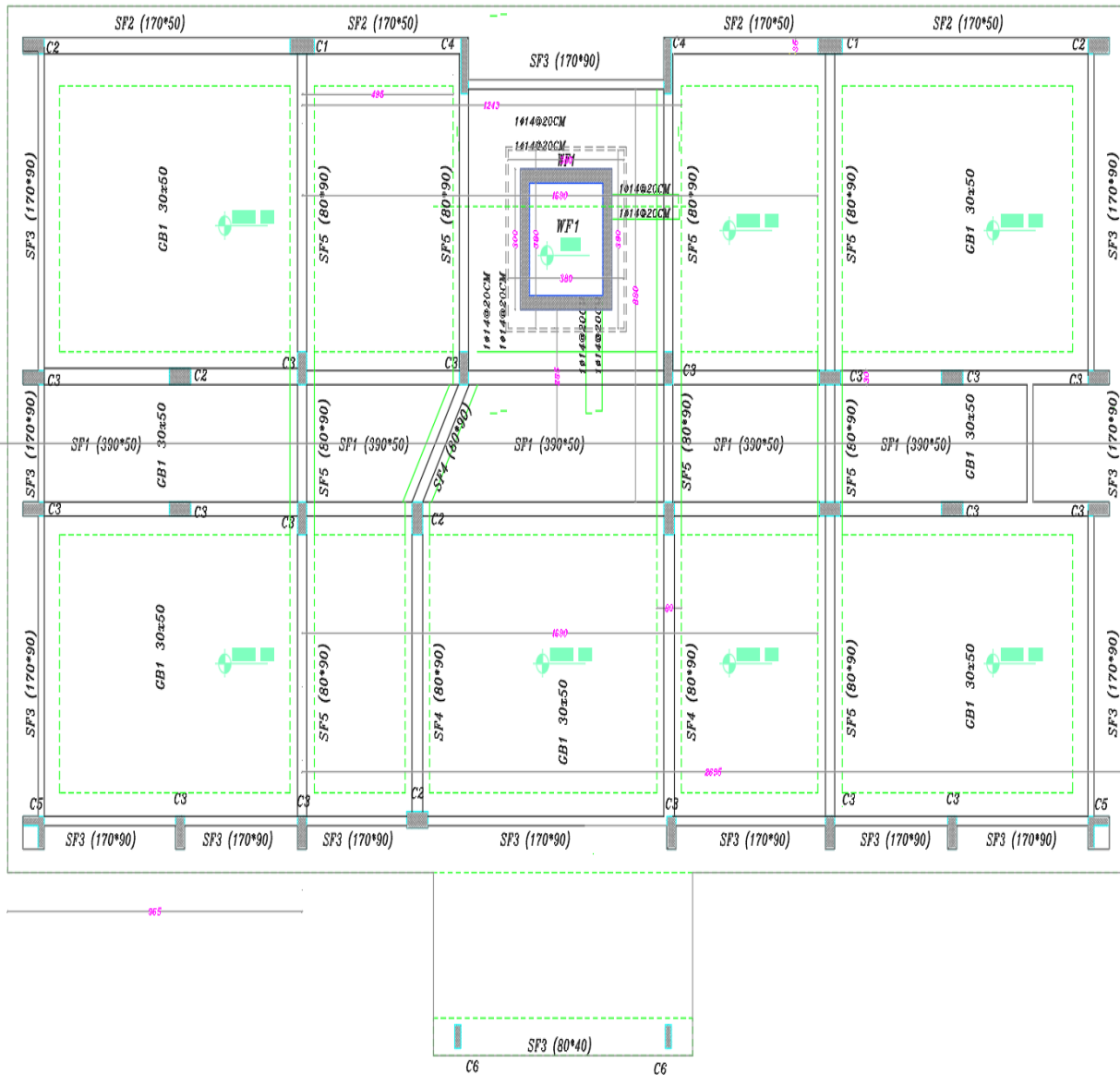


Figure 104: structural Plan before modification.

Figure shows the structural Plan after modification.

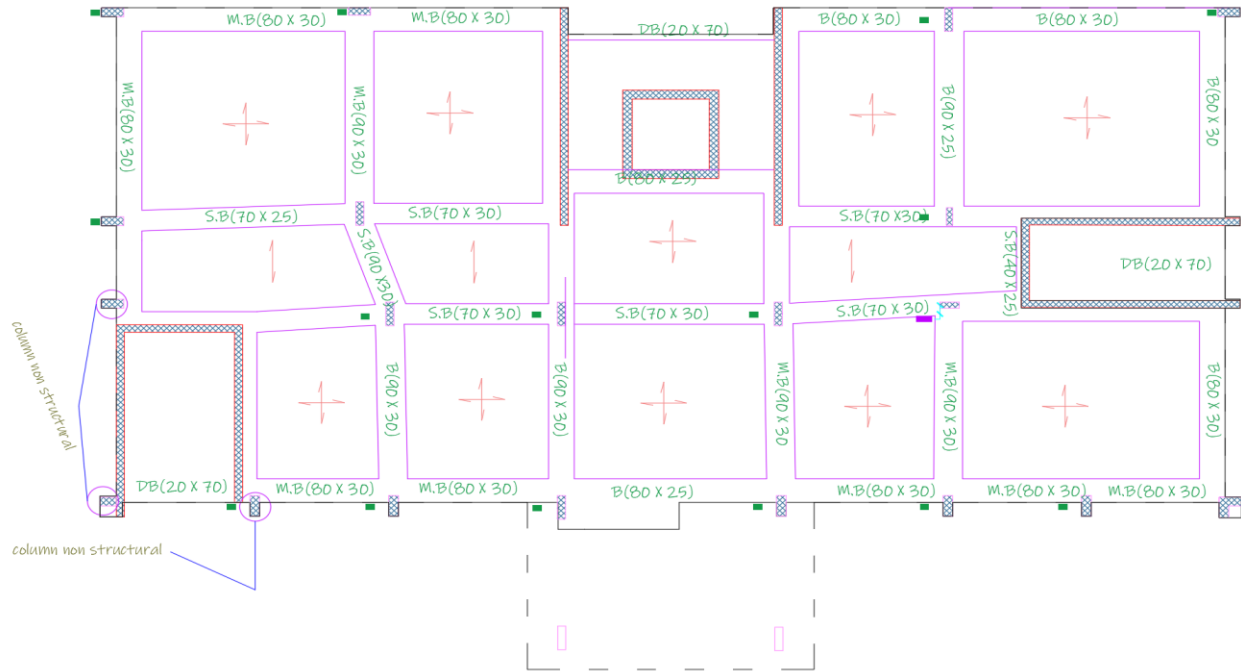


Figure 105: structural Plan after modification.

4.7 ETABS analysis

4.7.1 Computability check:

The figure (107) shows building (from front).

The figure (108) shows building (from back).

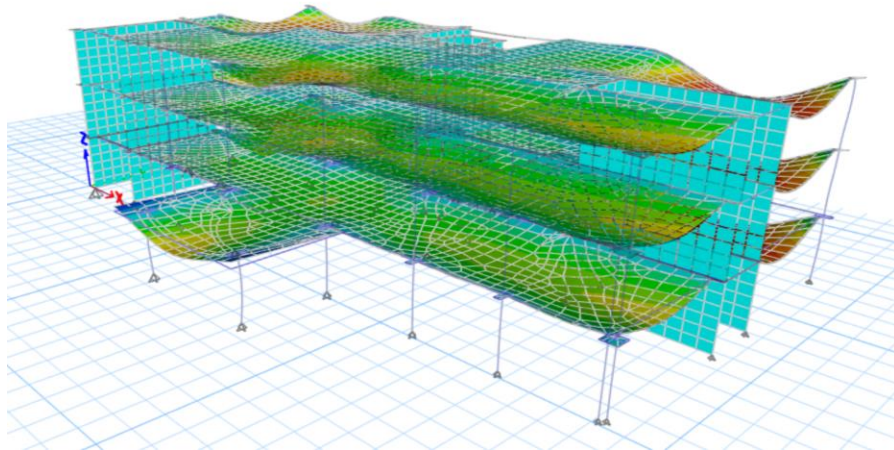


Figure 106:Computability check (from front)

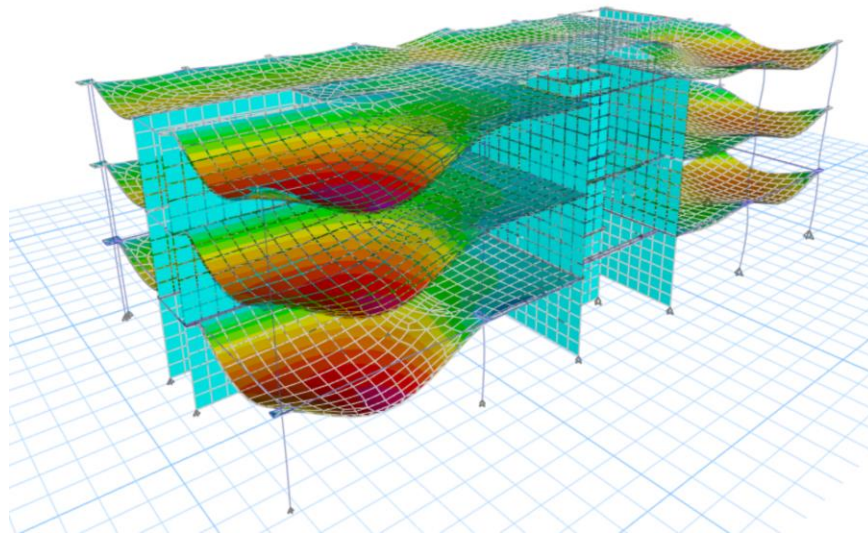


Figure 107::Computability check (from back)

The check is **OK** by start animation.

4.7.2 Deflection check

The figure (109) shows deflection for slab and beams (from ETABS).

The figure (110) shows (M3-3) for calculation of deflection for beam (from ETABS).

$$\text{Maximum deflection (manual)} = \frac{\text{long span}}{240} .$$

$$\text{Max Def} = \frac{8750}{240} = 36.5 \text{ mm.}$$

$$\text{Deflection in ETABS} = \text{deflection}_{\text{slab}} - \sum \text{deflection}_{\text{beams}} / 4.$$

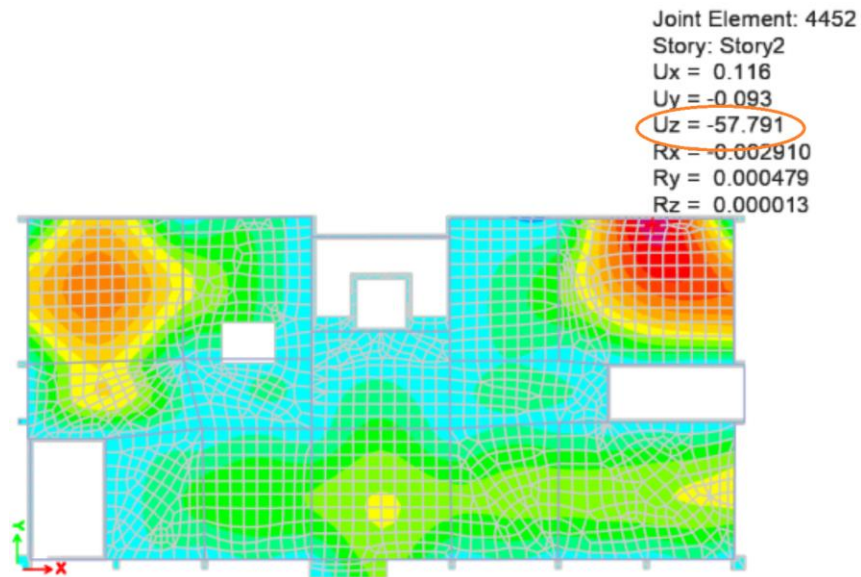


Figure 108: deflection for slab and beam.

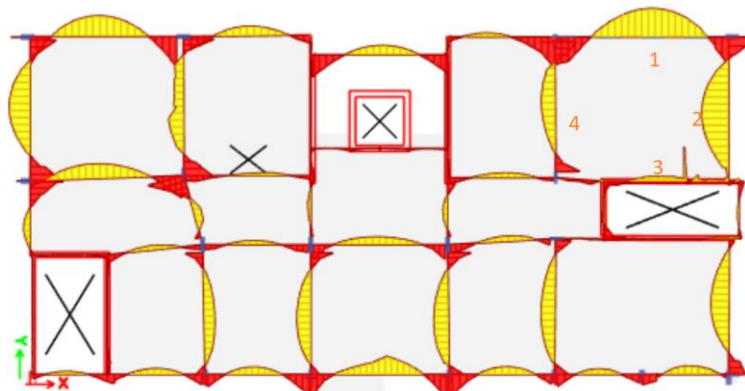


Figure 109: (M3-3) from ETABS.

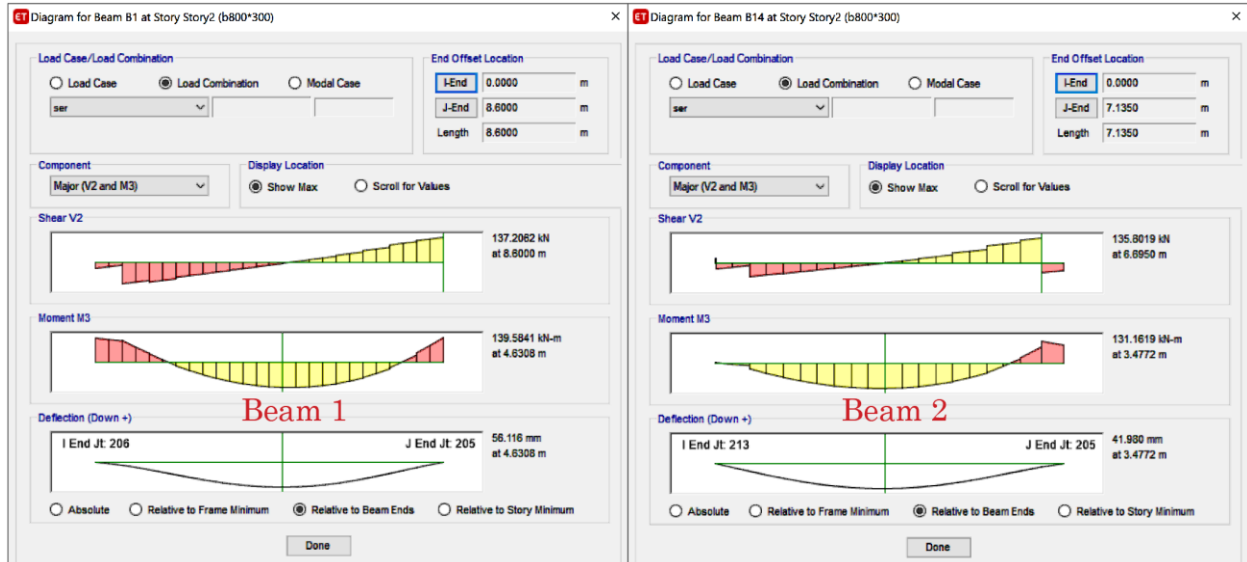


Figure 110: deflection for beam 1 & 2

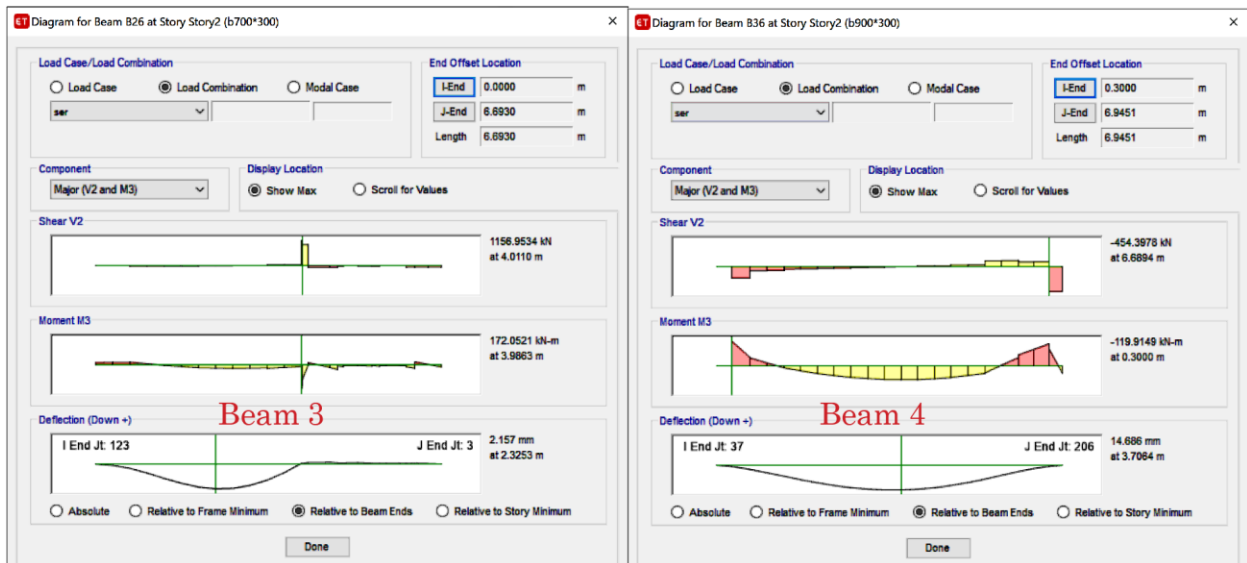


Figure 111: deflection for beam 3 & 4

Deflection in ETABS = $57.8 - ((56.116 + 41.98 + 2.157 + 14.686)/4)$.

Deflection in ETABS = 29.1 < 36.5 **OK**.

4.7.3 Equilibrium check

The table (21) shows base reaction from ETABS .

Output Case	Case Type	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Dead	LinStatic	0	0	19681.2789	167759.7466	-353831.1454	7.639E-07
Live	LinStatic	0	0	7122.2581	59374.8695	-129362.0688	0
S.I.D	LinStatic	0	0	13705.2355	114439.1704	-246677.381	-6.992E-07

Table 20:Base reaction (From ETABS).

Manual Calculation:

Live load

The table (22) shows manually calculation for live load

Floor NO.	Total area	Opening	Net area	Weight (L.L)
Ground Floor	629.8	65.21	564.59	2540.655
first floor	582.59	65.21	517.38	2328.21
second floor	582.59	65.21	517.38	2328.21
Sum				7197.075
Weight from ETABS (L.L)			7122.2581	
Error% = (M-E)/E * 100%			1.05%	

Table 21: manually calculation for live load.

$$\text{Error\%} = \frac{(\text{manually} - \text{ETABS}) * 100\%}{\text{ETABS}}$$

$$\text{Error\%} = \frac{(7197.075 - 7122.2581) * 100\%}{7122.2581}$$

$$\text{Error\%} = 1.05 \% < 5 \% \quad \mathbf{OK}$$

Super Imposed Dead

The table (23) shows manually calculation for live load

Floor NO.	Total area	Opening	Net area	Weight (S.I.D)
Ground Floor	629.8	65.21	564.59	2518.0714
first floor	582.59	65.21	517.38	2307.5148
second floor	582.59	65.21	517.38	2307.5148
EXT. Wall (all floors)		Perimeter	317.54	6668.34
Sum				13801.441
Weight from ETABS (L.L)			13705.2355	
Error% = (M-E)/E * 100%			0.70%	

Table 22:manually calculation for (S.I.D)

$$\text{Error\%} = \frac{(\text{manually} - \text{ETABS}) * 100\%}{\text{ETABS}}$$

$$\text{Error\%} = \frac{(13801.441 - 13705.2355) * 100\%}{13705.2355}$$

$$\text{Error\%} = 0.70\% < 5\% \quad \mathbf{OK}$$

Dead load

**** Slab weight

**** Slab weight

$$\text{Weight} = \gamma_c * V_c + \gamma_b * V_b.$$

$$W_{\text{two way}} = 25(0.55^2 * 0.30 - 0.40^2 * 0.24) + 12(0.40^2 * 0.24).$$

$$W_{\text{two way}} = 1.77 \text{ KN/rib}^2.$$

$$\text{Weight}_{\text{two way}} (\text{KN/m}^2) = 5.85 \text{ KN/m}^2.$$

$$W_{\text{one way}} = 25(0.55 * 0.06 + 0.15 * 0.24) + 12(0.2 * 0.24 * 0.4)$$

$$W_{\text{one way}} = 1.75 \text{ KN/rib}^2.$$

$$W_{\text{one way}} = 3.20 \text{ KN/m}^2.$$

The table (24) shows manually calculation for slab weight.

Type of slab	Aera net	Weight (KN)	W (KN/m ²)
Two way	1149.76	6726.096	5.85
One way	268.194	1568.9349	5.85
sum		8295.0309	

Table 23:manually calculation for slab weight

**** Shear Wall

Shear wall weight = γ_c * area cross section* height * number of floors.

Shear wall weight = 25 * 3 * 3.85 (3.886 + 3.24 + 3.695 + 3.998).

Shear wall weight = 4278.98 KN.

****Beams

The table (25) shows manually calculation for beam weight

Beam name	dimintion (mm)	Length (m)	Cross section (m ²)	Weight (KN)
M.B1	900*300	139.48	0.27	941.49
M.B2	800*300	338.58	0.24	2031.48
S.B1	700*300	208.98	0.21	1097.145
S.B2	400*300	8.5	0.12	25.5
S.B3	200*300	17.7	0.06	26.55
D.B	200*700	39.87	0.14	139.545
Sum				4261.71

Table 24:manually calculation for beam weight

*****Columns

The table (26) shows manually calculation for column weight

Column name	NO	Cross section (m ²)	Weight (KN)
C1	24	0.21	485.1
C2	3	0.175	50.53125
C3	17	0.2	327.25
C4	6	0.12	69.3
C5	3	0.33	95.2875
sum			1027.46875

Table 25:manually calculation for column weight

Dead Load weight (manually) = (slab + shear wall + column + beam) weight

Dead Load weight (manually) = 8149.73 + 4278.98 + 1027.47 + 4261.71

Dead Load weight (manually) = 18695KN

$$\text{Error\%} = \frac{(\text{manually} - \text{ETABS}) * 100\%}{\text{ETABS}}$$

$$\text{Error\%} = \frac{(18695 - 19681.3) * 100\%}{19681.3}$$

Error% = 5.01 % approximately 5 % **OK**

4.7.4 Stress-Strain check

We calculate stress-strain for Column, beam and slab.

Figure (113): shows the position of column and beam used in calculation.

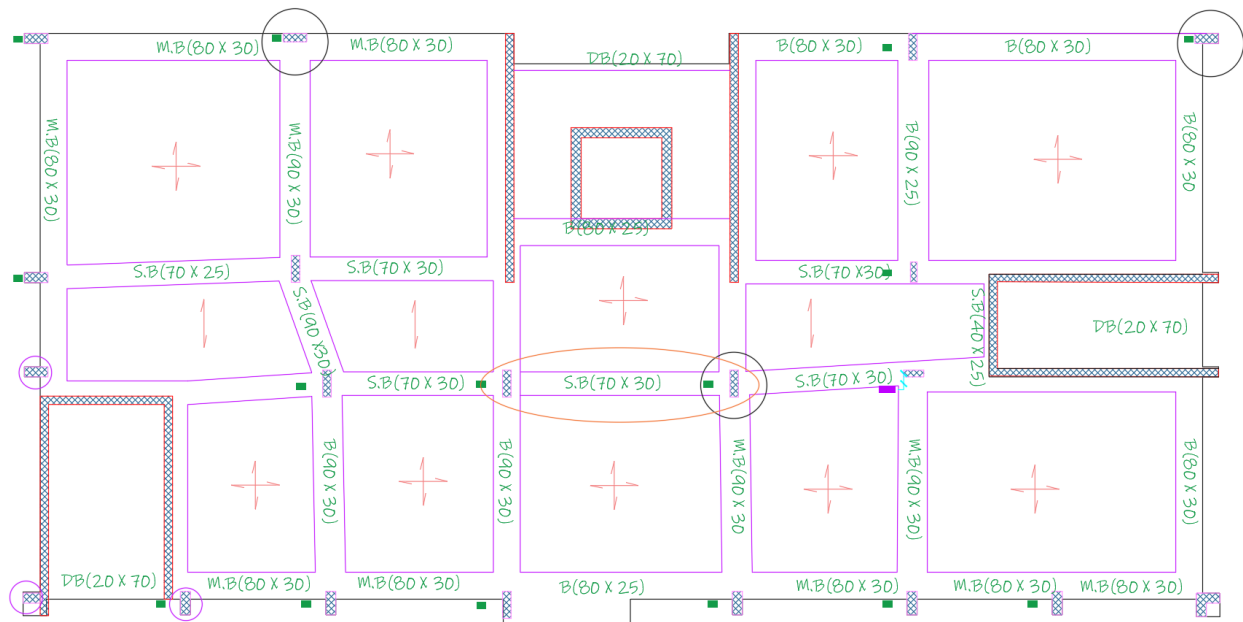


Figure 112: Position column and beam used in calculation

****** For Column (the center of the building)**

For column used live load by check stress-strain

Figure (114): shows the P_L for column mid in ETABS.

Figure (115): shows the tributary 1 area in AutoCAD.

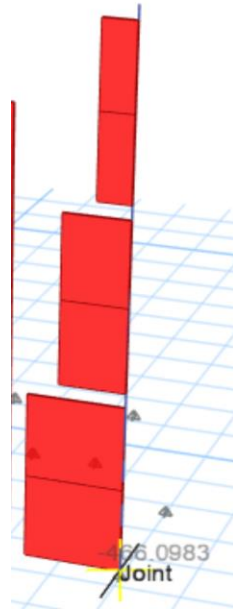


Figure 113: P_L for column mid (in ETABS)

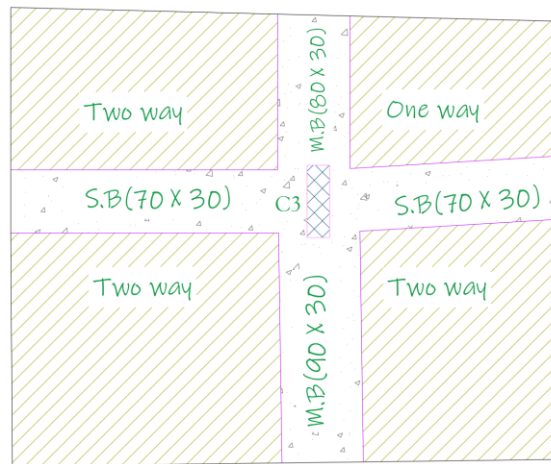


Figure 114: tributary area 1 (from AutoCAD)

P_L (by hand) = tributary area * Live load * number of floors

$$P_L \text{ (by hand)} = 34.5 * 3 * 4.5$$

$$P_L \text{ (by hand)} = 465.75$$

$$P_L \text{ (by ETABS)} = 466.1$$

$$\text{Error}\% = \frac{(\text{manually} - \text{ETABS}) * 100\%}{\text{ETABS}}$$

$$\text{Error\%} = \frac{(465.75 - 466.10) * 100\%}{466.10}$$

Error% = .08 % < 10 % **OK**

****** For Column (corner)**

For column used live load by check stress-strain

Figure (77): shows the P_L for column corner in ETABS.

Figure (78): shows the tributary area 2 in AutoCAD.

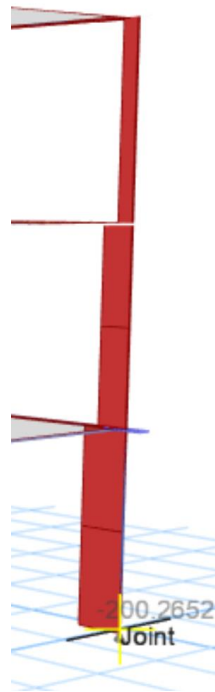


Figure 115: P_L for column corner (in ETABS)

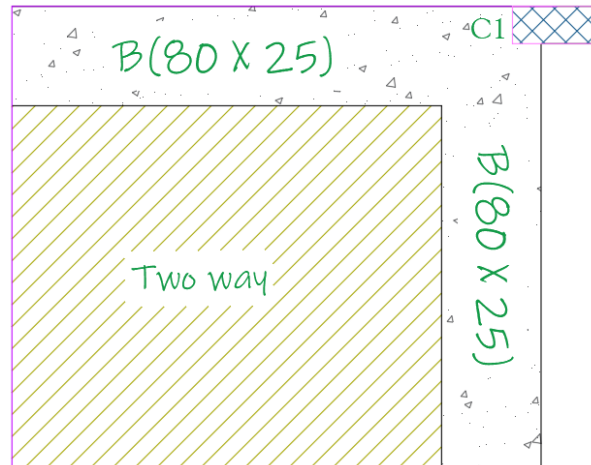


Figure 116:trbutry2 area (from AutoCAD)

P_L (by hand) = tributary area * Live load * number of floors

$$P_L \text{ (by hand)} = 15.7 * 3 * 4.5$$

$$P_L \text{ (by hand)} = 213$$

$$P_L \text{ (by ETABS)} = 200.3$$

$$\text{Error}\% = \frac{(\text{manually} - \text{ETABS}) * 100\%}{\text{ETABS}}$$

$$\text{Error}\% = \frac{(213 - 200.3) * 100\%}{200.3}$$

$$\text{Error}\% = 6.3 \% < 10 \% \quad \mathbf{OK}$$

****** For Column (Edge)**

For column used live load by check stress-strain.

Figure (118): shows the P_L for column edge in ETABS.

Figure (119): shows the tributary area 3 in AutoCAD.

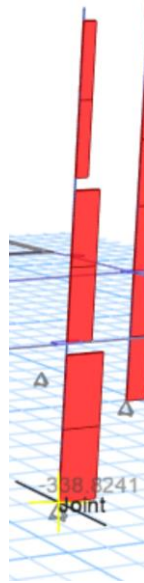


Figure 117: P_L for column edge (in ETABS)

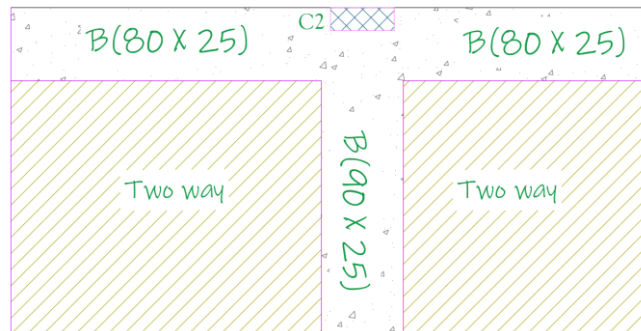


Figure 118: tributary area (from AutoCAD).

P_L (by hand) = tributary area * Live load * number of floors

$$P_L \text{ (by hand)} = 25.1 * 3 * 4.5$$

$$P_L \text{ (by hand)} = 338.9$$

$$P_L \text{ (by ETABS)} = 338.8$$

$$\text{Error}\% = \frac{(\text{manually} - \text{ETABS}) * 100\%}{\text{ETABS}}$$

$$\text{Error\%} = \frac{(338.9 - 338.8) * 100\%}{338.8}$$

Error% = 0.03 % < 10 % **OK**

****** For Slab and Beam**

By using the Direct design method, the direct design method process is:

- ✓ Three spans or more **OK**
- ✓ Rectangular panels with $L/B \leq 2$ **OK**

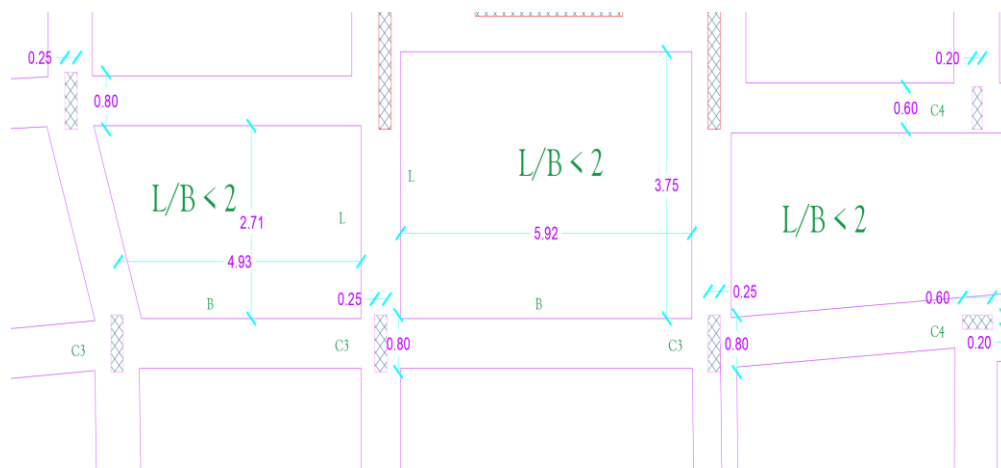


Figure 119:panels description L/B

- ✓ Column offset shall be $\leq 10\%$ of span in offset direction **OK**
- ✓ In successive spans $L_{\text{long}} / L_{\text{short}} \leq 1.5$ **OK**

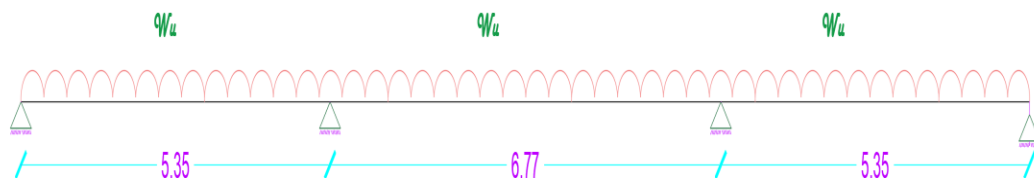


Figure 120:span used in stress-strain

- ✓ Uniformly distributed load with $W_L / W_D \leq 2$

$$\frac{Wl}{Wd} = \frac{4.5}{12.3} \leq 2 \dots \text{OK}$$

✓ For Slabs with beams OK

$$0.2 < \frac{\frac{\alpha f(AB) \cdot L^2_2(AB)}{L_1(AB)}}{\frac{\alpha f(AB) \cdot L^2_2(BD)}{L^2_1(BD)}} \leq 5$$

We can use direct design method because all conditions are satisfied.

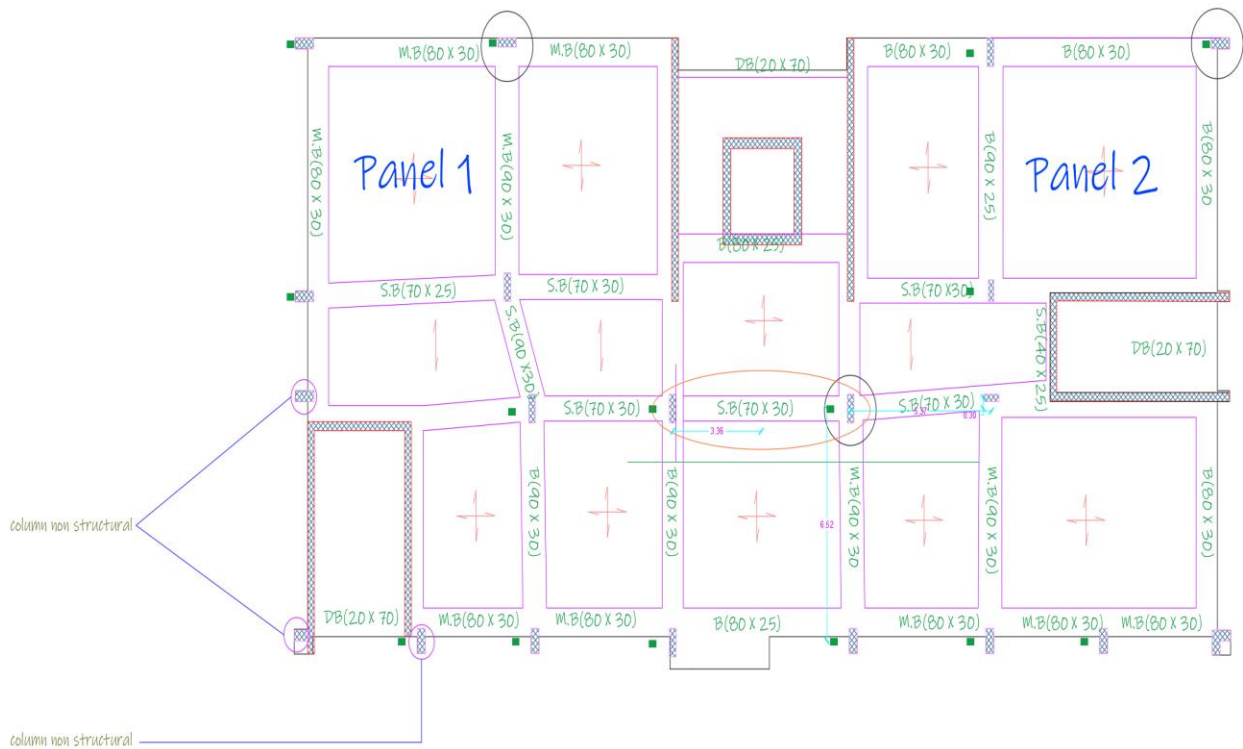


Figure 121: structural plan

Manual calculation

Figure (123): shows the frame section and rib section.

Figure (124): shows the moment of inertia for rib.

Table (27): shown the result by manual calculation.

$$h_{eq} = \sqrt[3]{\frac{12 \cdot I_{rib}}{bf}} = \sqrt[3]{\frac{12 \cdot 570 \cdot 10^6}{550}}$$

$$h_{eq} = 232 \text{ mm}$$

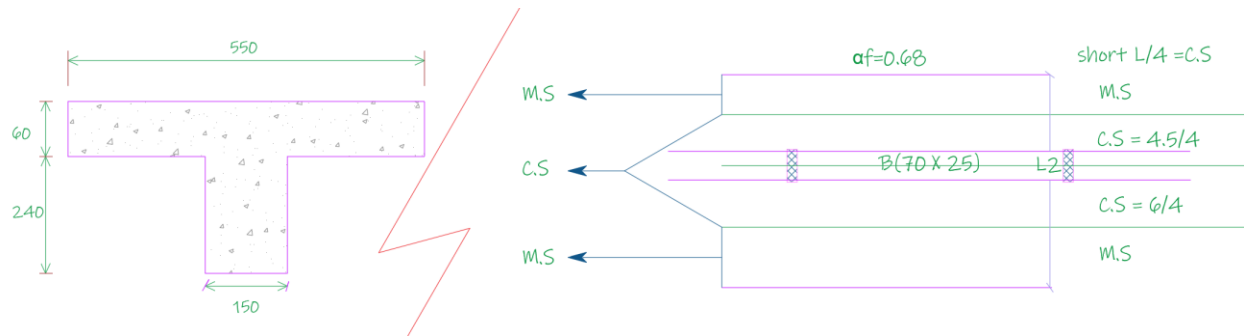


Figure 122:frame and rib section

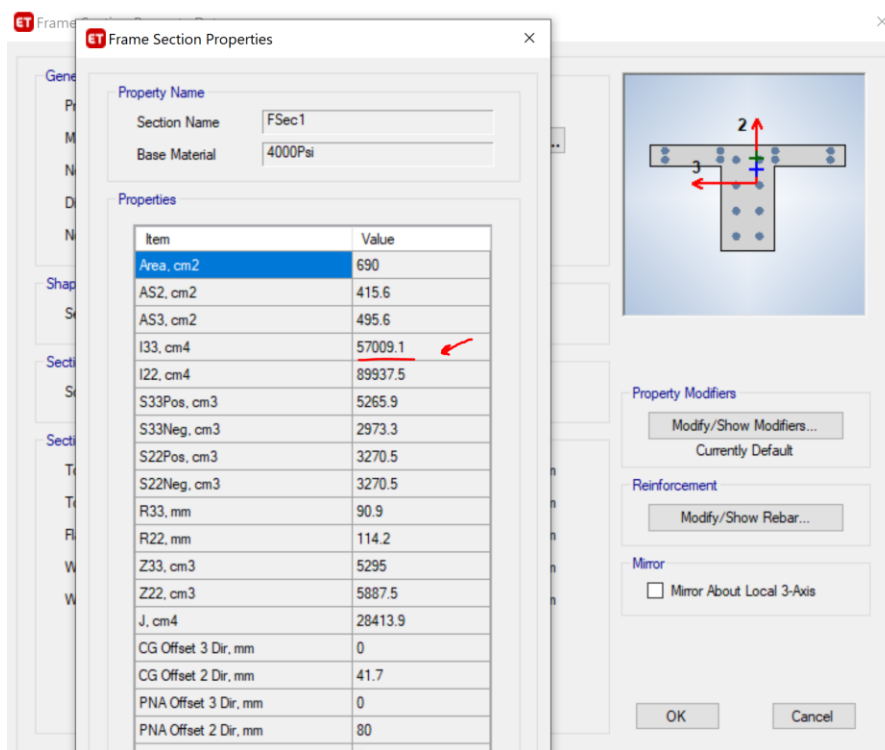


Figure 123:moment of inertia for rib

Calculation of ultimate load

$$W_u = 1.2(D. L) + 1.6(L. L).$$

$$W_u = 1.2(8.30 + 4) + 1.6(4.5).$$

$$W_u = 21.96 \text{ KN/m}^2$$

Calculation of moment

$$M_o = \frac{W_u \cdot L_2 \cdot L_n^2}{8}$$

$$M_o = \frac{4.5 \cdot 5.20 \cdot 6.52^2}{8}$$

$$M_o = 606.8 \text{ KN.m}$$

Calculation of β_t

$$H_{\text{equ}} = 232$$

$$I_{\text{solid}} = \frac{8000 \cdot 232^3}{12}$$

$$I_{\text{solid}} = 8.32 \cdot 10^9$$

$$\alpha_f = 0.68 \text{ (for proportionality)}$$

$$C = 1.93 \cdot 10^9$$

$$\beta_t = \frac{1.93 \cdot 10^9}{8.32 \cdot 10^9}$$

$$\beta_t = 0.23$$

L2/L1	β_t	$\alpha_f(L2/L1)$	M_o
0.80	0.23	0.54	606.80

Table 26: Result by manual calculation

Calculation of frame, middle strip, column strip, and beam.

Figure (125): shows the calculation of frame (by hand).

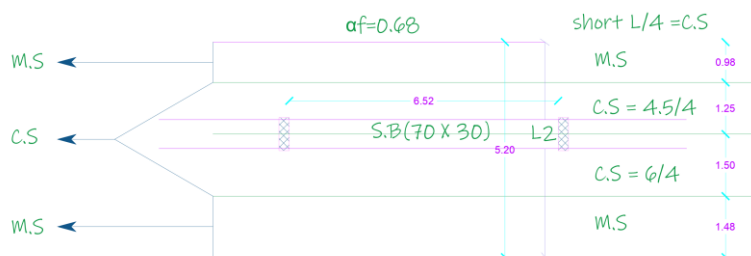


Figure 124: calculation (M.S.+C.S.+frame)

**** moment from frame.**

Figure (126): shows the moment from frame (by hand).

The moment static load equal 606.8 KN.m, this moment multiplies by factor.

The factor is 0.65 (left and right span) and 0.35 (mid span).

$$M_{\text{frame (by hand)}} = (M_R + M_L)/2 + M_M.$$

$$M_{\text{frame (by hand)}} = (394.4 + 394.4)/2 + 212.4 = 606.8 \text{ KN.m.}$$

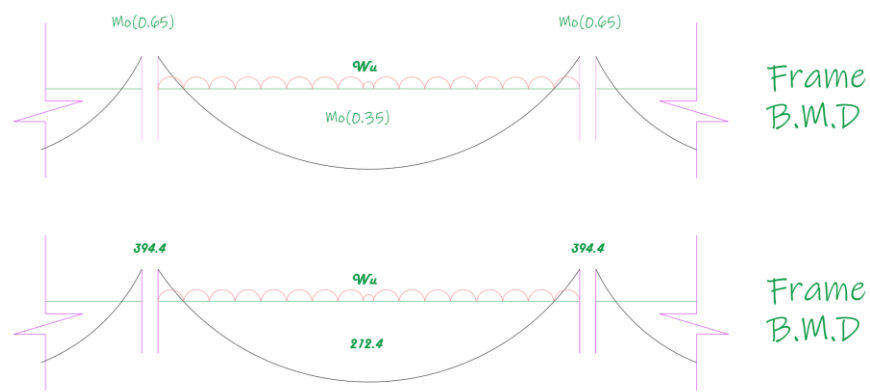


Figure 125: Moment frame (by hand)

Figure (127,128,129): shows the moment from frame (by ETABS).

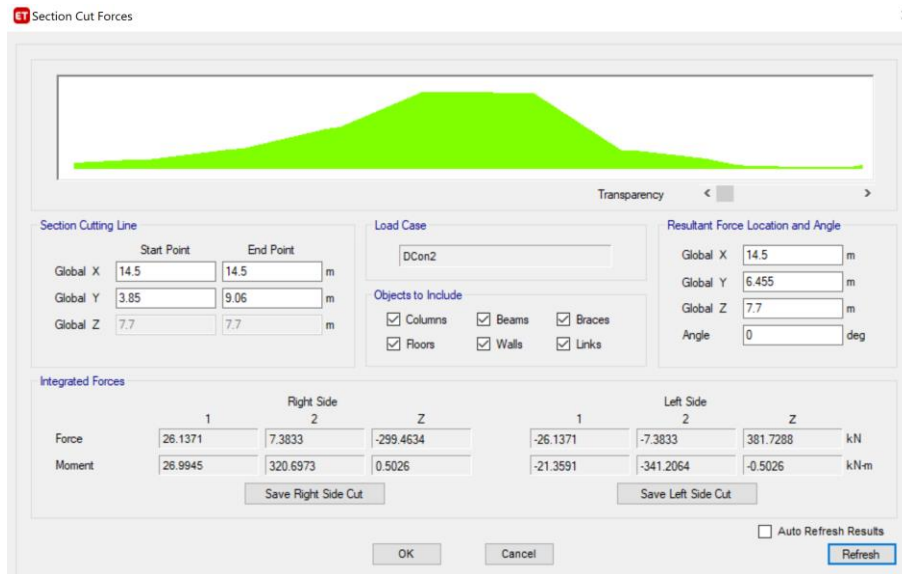


Figure 126:moment fram (M1)

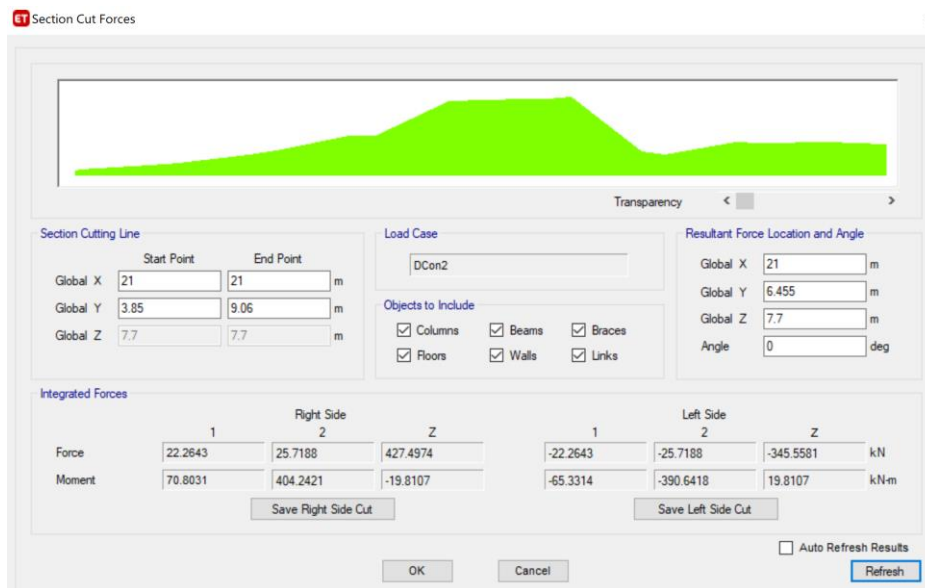


Figure 127:moment fram (M2)

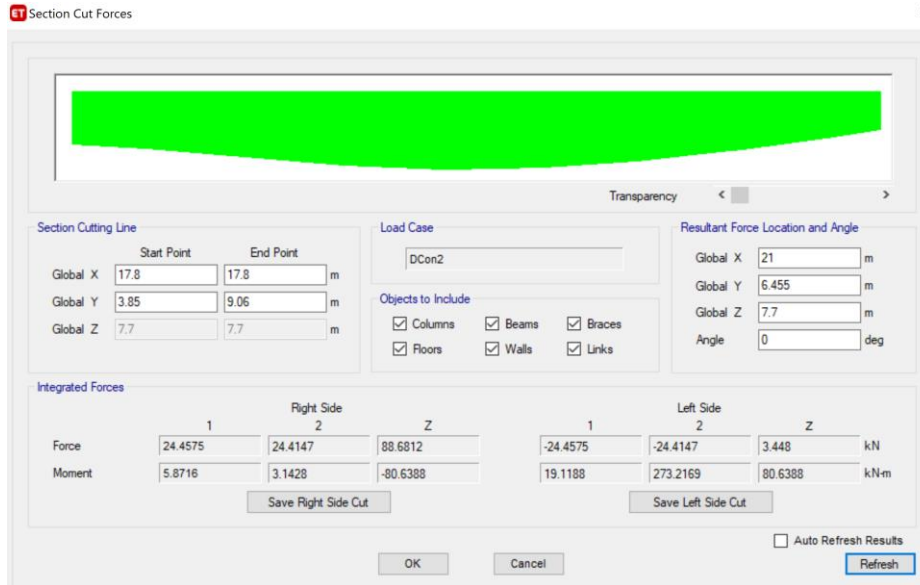


Figure 128:moment frame (M3)

$$M_{\text{frame}} \text{ (by ETABS)} = (M_R + M_L)/2 + M_M$$

$$M_{\text{frame}} \text{ (by ETABS)} = (341.2 + 404.2)/2 + 273.2 = 645.9 \text{ KN.m}$$

$$\text{Error}\% = \frac{(606.8 - 645.9) * 100\%}{645.9}$$

$$\text{Error}\% = 6\% < 25\% \quad \text{OK}$$

**** moment from column strip.**

Figure (91): shows the column strip moment (by hand).

The column strip percentage with beam equal 78% (left and right span) and 70.5% (mid span).

This percentage multiplies by frame moment the result is column strip with beam.

$$M_{\text{frame}} \text{ (by hand)} = (M_R + M_L)/2 + M_M$$

$$M_{\text{frame}} \text{ (by hand)} = (165.4 + 165.4)/2 + 80.5 = 246 \text{ KN.m}$$

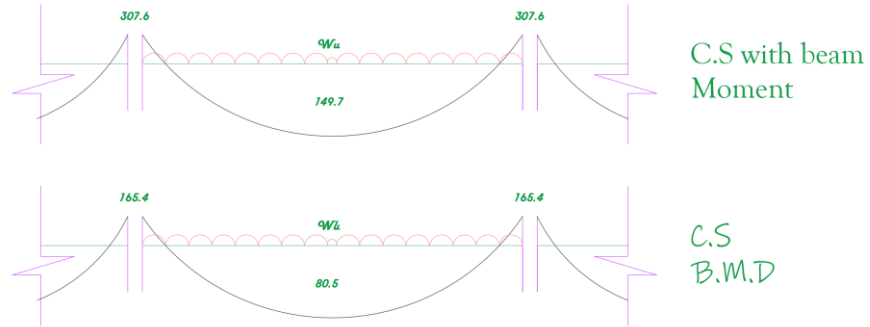


Figure 129:column strip Moment (by hand)

Figure (131,132,133): shows the column strip moment (by ETABS).

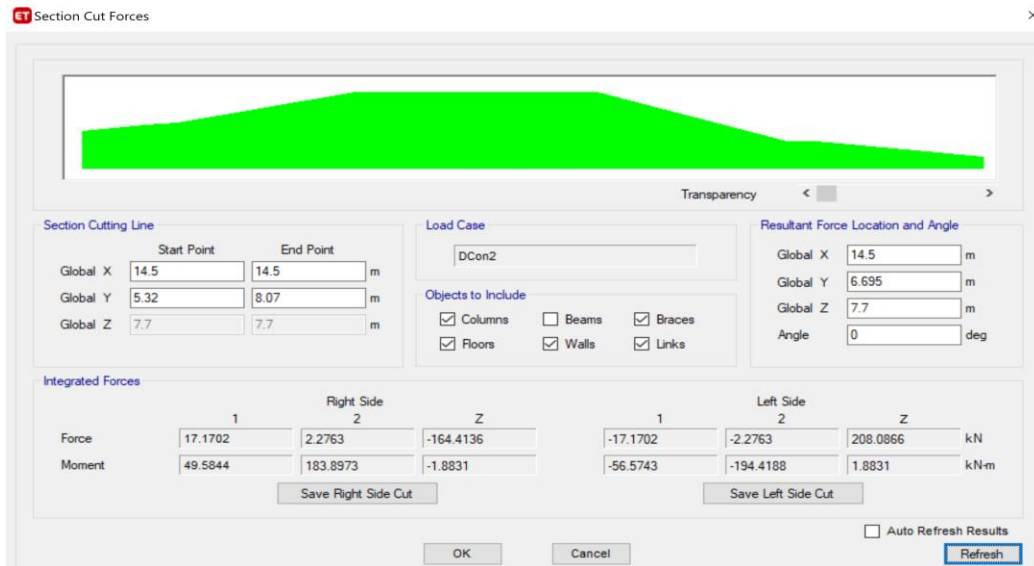


Figure 130:column strip moment (M1)

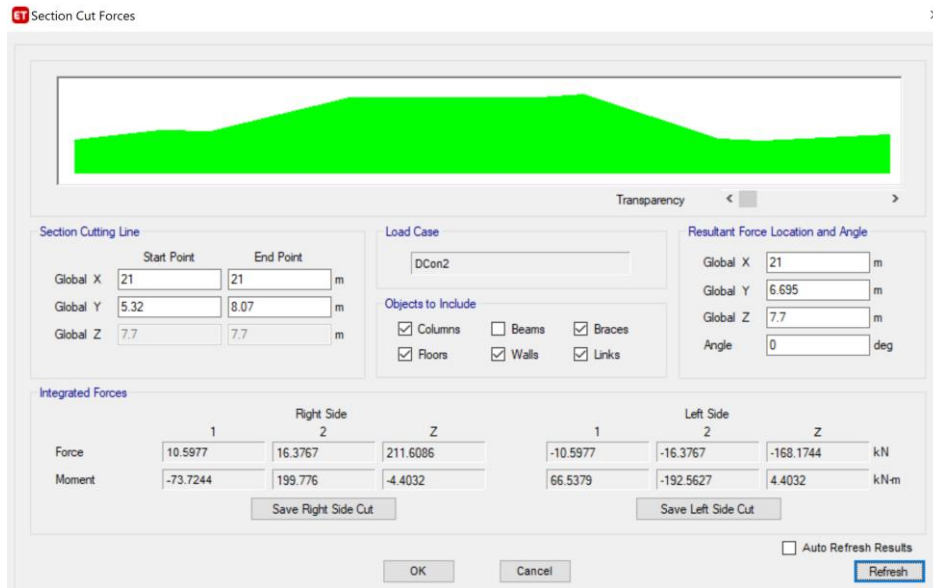


Figure 131:column strip moment (M2)

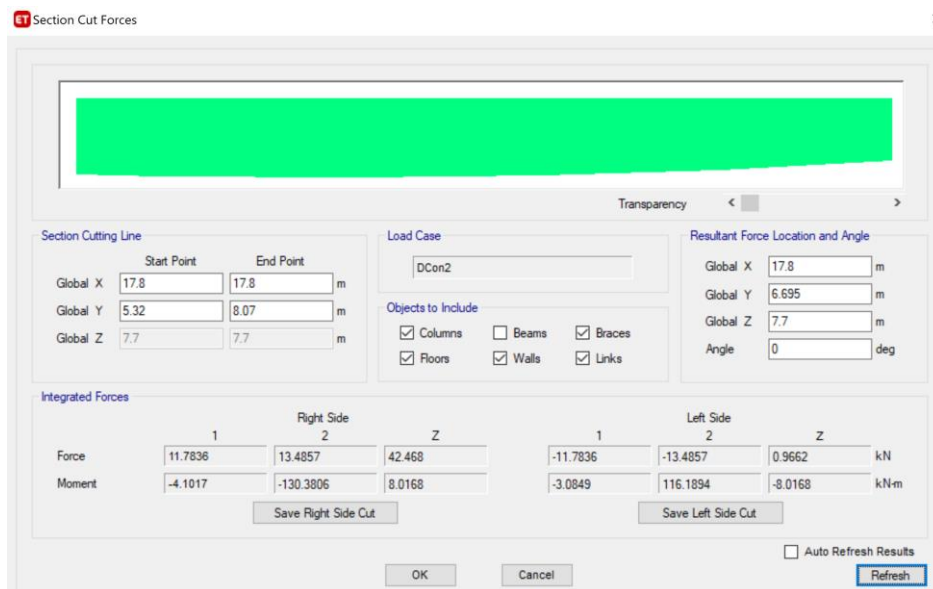


Figure 132:column strip moment (M3)

$$M_{\text{frame}} \text{ (by ETABS)} = (M_R + M_L) / 2 + M_M$$

$$M_{\text{frame}} \text{ (by ETABS)} = (194.4 + 199.8) / 2 + 130.4 = 327.5 \text{ KN.m}$$

$$\text{Error}\% = \frac{(246 - 327.5) * 100\%}{327.5}$$

Error% = 24.9 % < 25 % **OK**

**** moment from beam.**

Figure (95): shows the beam moment (by hand).

The beam moment equal column strip with beam multiplies by factor.

The factor equal $((\alpha_f * L_2/L_1) * 85\%) = 46.24\%$

$$M_{\text{frame}} (\text{by hand}) = (M_R + M_L)/2 + M_M$$

$$M_{\text{frame}} (\text{by hand}) = (142.2 + 142.2)/2 + 69.2 = 211.4 \text{ KN.m}$$

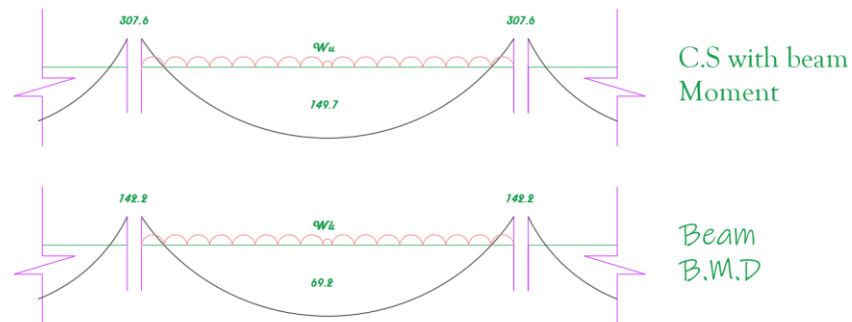


Figure 133: Beam Moment (by hand)

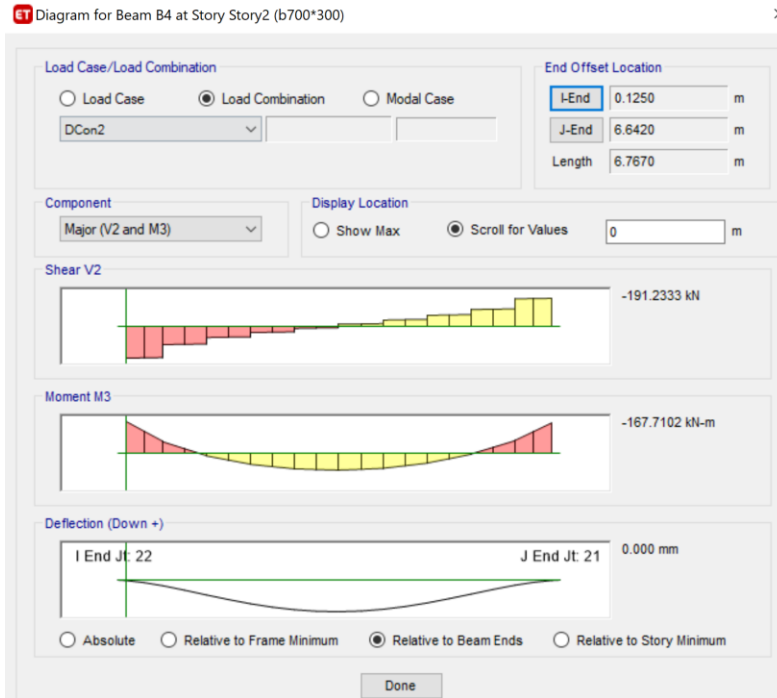


Figure 134: Beam moment (M1)



Figure 135: Beam moment (M2)

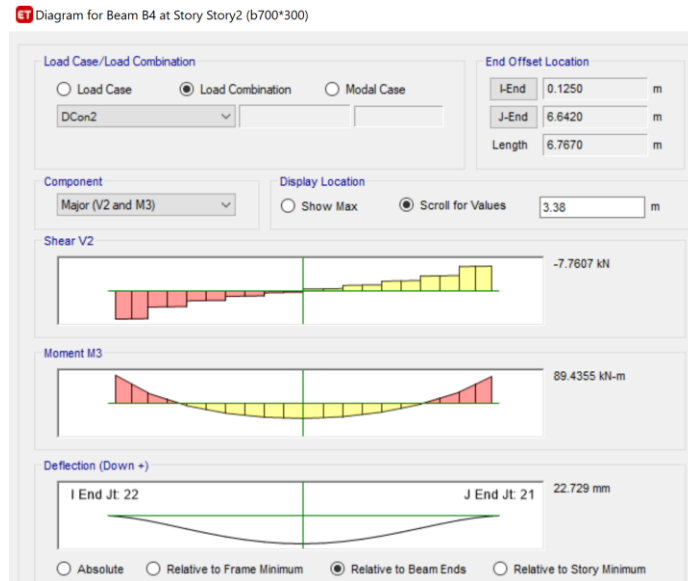


Figure 136: Beam moment (M3)

$$M_{\text{frame (by ETABS)}} = (M_R + M_L)/2 + M_M$$

$$M_{\text{frame (by ETABS)}} = (197.7 + 160.2)/2 + 89.4 = 268 \text{ KN.m}$$

$$\text{Error}\% = \frac{(211.4 - 268) * 100\%}{268}$$

$$\text{Error}\% = 21.1\% < 25\% \quad \text{OK}$$

**** moment from middle strip.**

Figure (36): shows the beam moment (by hand).

The middle strip moment equal column strip with beam subtracted from frame moment.

$$M_{\text{frame (by hand)}} = (M_R + M_L)/2 + M_M$$

$$M_{\text{frame (by hand)}} = (86.8 + 86.8)/2 + 149.7 = 236.5 \text{ KN.m}$$

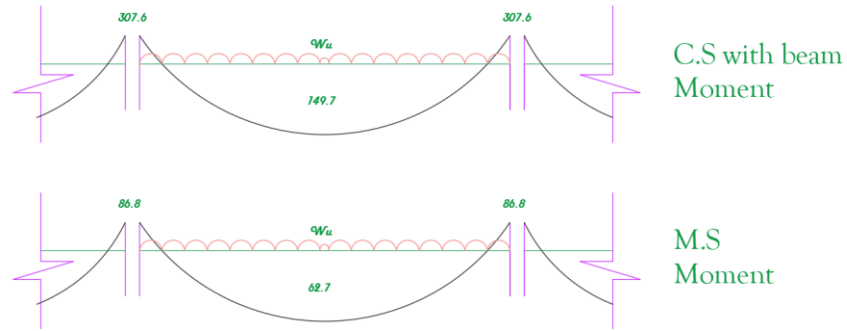


Figure 137:middle strip Moment (by hand)

Moment from ETABS

$$M(1,2,3) = \text{Moment}_{\text{frame}}(\text{ETABS}) - \text{Moment}_{\text{column strip}}(\text{ETABS})$$

$$M_1 = 341.2 - 194.4 = 146.8 \text{ KN.m.}$$

$$M_2 = 404.2 - 199.8 = 204.4 \text{ KN.m.}$$

$$M_3 = 273.2 - 130.4 = 142.8 \text{ KN.m.}$$

$$M_{\text{frame}}(\text{by ETABS}) = (M_R + M_L)/2 + M_M$$

$$M_{\text{frame}}(\text{by ETABS}) = (194.4 + 204.4)/2 + 142.8 = 342.2 \text{ KN.m}$$

$$\text{Error}\% = \frac{(236.5 - 342.2) * 100\%}{342.2}$$

$$\text{Error}\% = 30.9\% > 25\% \quad \text{NOT OK}$$

***** NOTE*****

If two-third moment acceptable the check is acceptable.

$$\text{Average Error}\% = (30.9 + 21.1 + 24.9 + 6)/4.$$

$$\text{Average Error}\% = 20.7\% < 25\%.$$

Check Stress-Strain is **OK**.

4.7.5 Period check:

The method A will be used to calculate manual value of period (T):

$$T_{\text{method A}} = C_t * (h_n)^{3/4}$$

$C_t = (0.0488)$ for all other buildings with shear wall.

$$H_n = 11.55 \text{ m.}$$

$$T_{\text{method A}} = C_t (h_n)^{3/4}$$

$$T_{\text{method A}} = 0.0488 * (11.55)^{3/4}$$

$$T_{\text{method A}} = 0.305 \text{ sec}$$

$$T_{\text{limit}} = 1.4 * T_{\text{method A}} = 1.4 * 0.305$$

$$T_{\text{limit}} = 0.45 \text{ sec.}$$

Figure (37): shows value of period check.

Table 27 : ;period check.

	T Method A	1.4 x T Method A	T ETABS x-axis	T ETABS y-axis
Period	0.305 sec	0.45 sec	0.354 sec	0.275 sec

Period from ETABS (x , y) < 1.4 *T_{method A}

The Period check is **OK**.

4.7.6 Drift check:

Drift check of the structure must be computed where required by using a following equation from UBC code:

Figure (37): shows value of drift check.

$$\Delta M (\text{Drift}) = 0.7 * R * \Delta S.$$

$$\Delta M (\text{Drift}) = 96.25\text{mm}.$$

Drift limitation = 2.5 % times the story height.

Table 28: drift check.

Story	Height	Displacement in X- axis	Displacement in Y- axis	Drift X	Drift Y	Delta X	Delta Y	Delta Limit
0	0	0.000	0.000					
1	3850	1.100	0.860	1.10	0.86	4.24	3.31	96.25
2	3850	2.680	2.400	1.58	1.54	10.32	9.24	96.25
3	3850	4.320	4.050	1.64	1.65	16.63	15.59	96.25

The all drift from two axis less than limit drift

The drift check is **OK**.

4.7.7 Modal mass Participation ratio check [MMPR]:

The Model Mass Participation Ratio check according to UBC code maximum error percent 10%, use by response spectrum analysis.

Figure (39): shows value of MMPR from ETABS.

Table 29: MMPR from ETABS.

Case	Mode	Period	UX	UY	UZ	Sum UX	Sum UY
		sec					
Modal	1	0.354	0.0182	0.2616	0	0.0182	0.2616
Modal	2	0.275	0.7682	0.0175	0	0.7863	0.2791
Modal	3	0.195	0.0044	0.4906	0	0.7908	0.7696
Modal	4	0.134	0.0011	0.0413	0	0.7918	0.8109
Modal	5	0.098	0.0119	0.003	0	0.8037	0.8139
Modal	6	0.097	0.053	0.0008	0	0.8568	0.8147
Modal	7	0.094	0.1009	0.0012	0	0.9577	0.8159
Modal	8	0.077	2.70E-05	1.48E-06	0	0.9577	0.8159
Modal	9	0.075	0.0014	3.59E-05	0	0.9591	0.8159
Modal	10	0.071	0.014	0.0004	0	0.973	0.8163
Modal	11	0.069	2.04E-05	0.0003	0	0.9731	0.8166
Modal	12	0.066	0.0009	0.0005	0	0.974	0.8171
Modal	13	0.063	0.0001	0.0289	0	0.9741	0.846
Modal	14	0.063	0	0.0005	0	0.9741	0.8465
Modal	15	0.063	0	0.0001	0	0.9741	0.8466
Modal	16	0.061	0.0003	0.1101	0	0.9744	0.9567

From the table as shown sum x and sum y equal 90%, when model 16.

The Model Mass Participation Ratio check is **OK**.

Base Shear check:

Table 30: Seismic factors in our project.

Z	I	R	Cv	Ca
0.20	1.00	5.50	0.84	0.36

Where:

Z= seismic zone factor as given from UBC code in Table 16-I.

I= importance factor as given from UBC code in Table 16-K.

R= numerical coefficient representative of the inherent overstrength and global ductility capacity of lateral force-resisting systems, as given from UBC code in Table 16-N or 16-P.

C_v = seismic coefficient, as given from UBC code in Table 16-R.

C_a = seismic coefficient, as given from UBC code in Table 16-Q.

Table 31: Base reactions from ETABS.

Load Case/Co	FX kN	FY kN	FZ kN
Dead	0	0	19197.96
Live	0	0	7197.301
SID	0	0	10116.03
EQx Max	3934.644	670.5243	6.22E-06
EQy Max	670.5244	2893.588	1.39E-06

Weight = Dead load + SID load + 0.25 * Live load.

Weight = 19197.96 + 10116.03 + 0.3 * 7197.3 = 31113.32 kN.

$V_{\text{manual}} = \min(2.5 * C_a, C_v/T) * I/R * W$

$V_{\text{manual}} = \frac{0.85}{0.45} * \frac{1}{5.5} * 31113.32 = 5091 \text{ kN.}$

Table 32: base shear from response spectrum cases for block E.

Axis	Period T (s)	Period limit (s)	Period use (s)	Weight(KN)	V(manual)	V(ETABS)	S.F old	S.F new
X	0.354	0.45	0.354	31113.32	5091.27	3934.64	1783.30	2307.52
Y	0.275	0.45	0.275	31113.32	5091.27	2893.59	1783.30	3137.72

The base shear check manually nearly equal the base shear reaction from ETAB software

The base shear check is **OK**.

4.8 Design of element for building:

4.8.1 Slab design

In this block of the building two- and one-way ribbed slab was used with slab thickness of 300mm.

The shear: the capacity of shear can be used this equation:

$$\phi V_c = (0.75 \cdot \sqrt{F_c} \cdot b \cdot d) / (6 \cdot 1000) = 1.1 \cdot (0.75 \cdot \sqrt{28} \cdot 150 \cdot 280) / (6 \cdot 1000)$$

$$\phi V_c = 30.6 \text{ kN/rib}$$

$$\phi V_c = 30.6 / 0.55 = 55.6 \text{ kN/m}$$

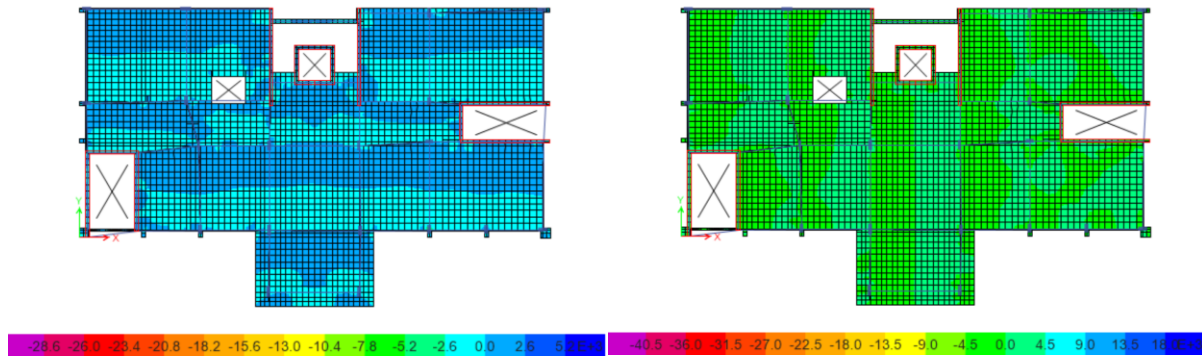


Figure138 :V13and V23 from ETABS

Max shear from ETABS $V_{max} = 45 \text{ KN}$

$$V_u = V_{max} - W_u \cdot d = 45 - 21.9 \cdot 0.28 = 38.9 \text{ kN.}$$

$$\phi V_c > V_u$$

The shear check is **OK**.

$$\text{If } \frac{V_u}{\phi} > \frac{V_c}{2}$$

$$\frac{38.9}{0.75} > \frac{40.8}{2} \text{ shear reinforcement will be needed.}$$

$$V_s = \frac{V_u}{\phi} - V_c = 51.8 - 40.8 = 11$$

$$V_s \text{ max} = 4 \cdot V_c = 4 \cdot 40.8 = 163.2$$

$V_s < V_s \text{ max}$ this check is **OK**.

$$\frac{A_v}{S} = \frac{V_s}{F_y \cdot d} = \frac{11 \cdot 10^3}{420 \cdot 280} = 0.09 \text{ mm}^2/\text{mm}$$

$$\frac{A_v}{S} \min = \frac{\varnothing \min}{4} * bw = \frac{(1.4/420)}{4} * 150 = 0.125 \text{ mm}^2/\text{mm}$$

Use $\frac{A_v}{S} \min$.

Assume 1 \varnothing 10 two legs

$$A_v = 157 \text{ mm}^2$$

$$S = \frac{(157)}{0.125} = 1256 \text{ mm}$$

use 1 \varnothing 10mm²/m

Design slab for flexural:

$$A_s \min = \rho \min * bw * d = 0.0033 * 150 * 270 = 133.65 \text{ mm}^2$$

Use 2 \varnothing 12 top and bottom steel.

$$\rho = 0.0033 = \frac{0.85 * f_c}{f_y} \left(1 - \sqrt{1 - \frac{2.61 * 10^6 * M_u}{b * d^2 * f_c}} \right) \rightarrow \varnothing M_n = 12.1 \text{ kN.m/rib} = 22 \text{ kN.m/m}$$

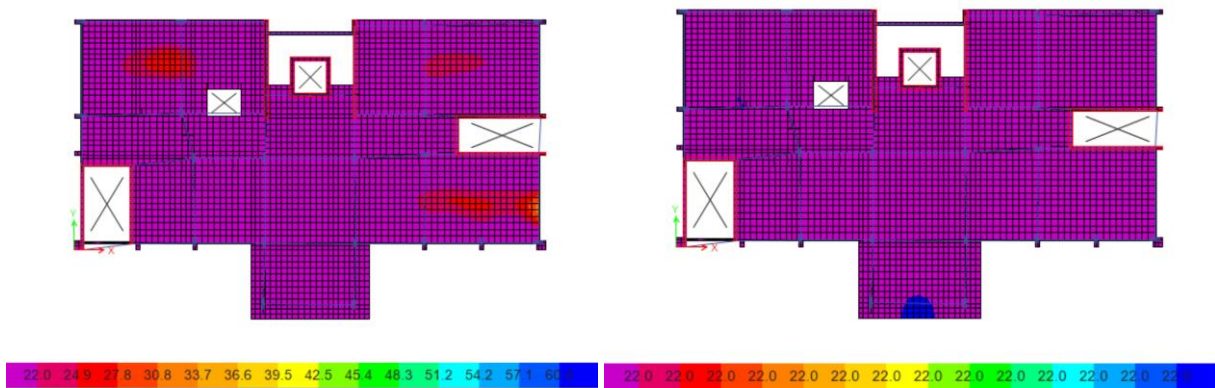


Figure 139: M11, M22 from ETABS.

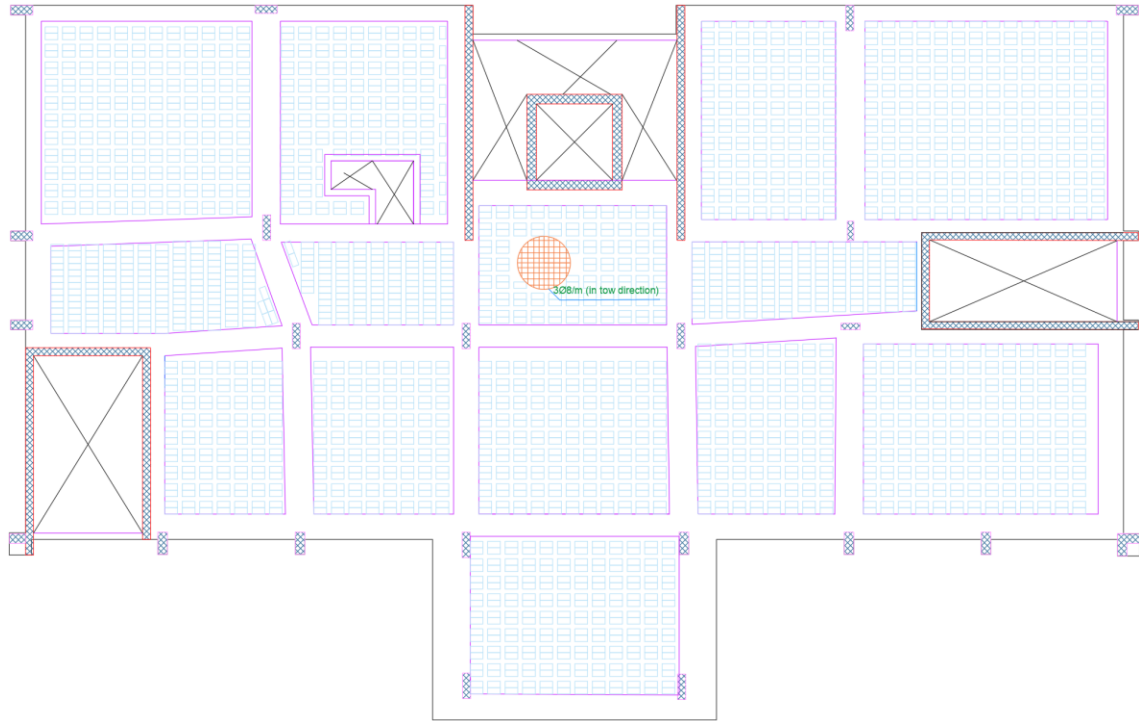


Figure 142: Rib detailing for first floor slab.

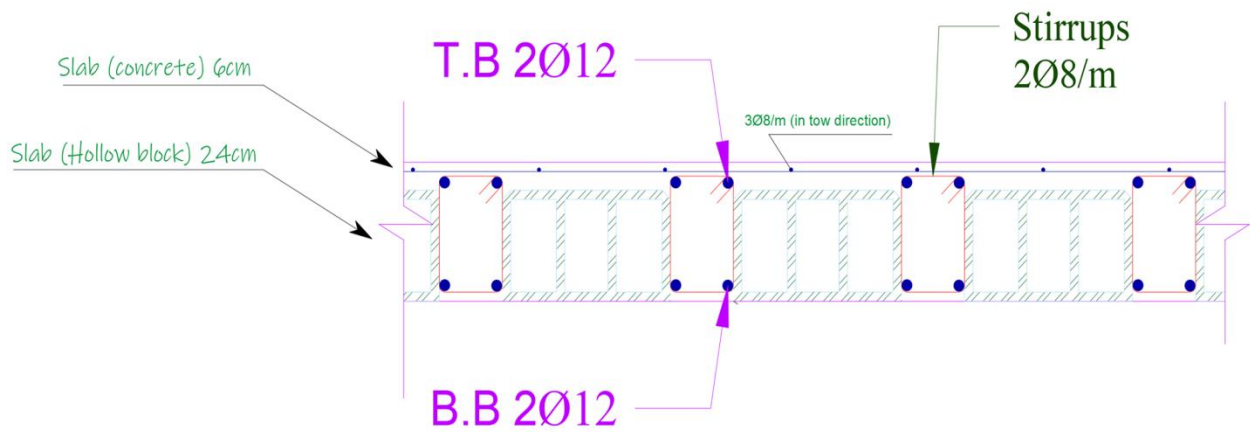


Figure 143:Section in slab.

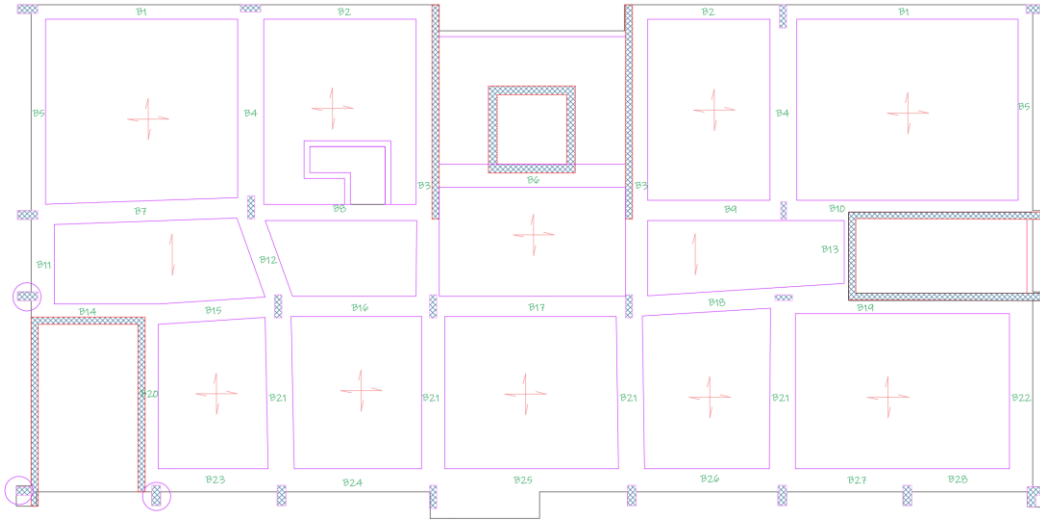


Figure 146: beam distribution in plan (second & third floor).

Requirements detailing for beam by using ACI code:

Where:

$$s_1 = \text{Min} \left\{ \begin{array}{l} 150 \text{ mm} \\ 6d_b \\ d/4 \end{array} \right\}$$

$$s_2 = d/2$$

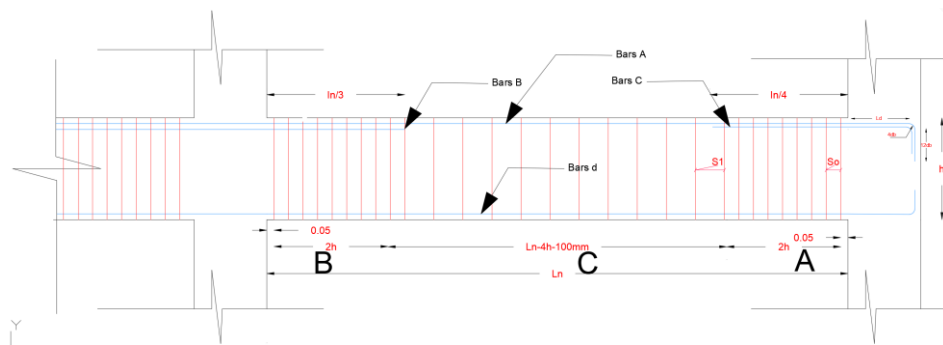


Figure 147: General detailing for beam.

Table 33: distribution beam for the building.

Beam name	Beam dimintion		bars			As min	S1	S2
	Width (mm)	length (mm)	Bar B	Bar C	Bar D			
B1	700	500	8φ14	8φ14	8φ14	8φ14	85	320
B2	700	500	8φ14	8φ14	8φ14	8φ14	85	320
B3	800	300	9φ14	5φ14	7φ14	5φ14	60	120
B4	900	300	6φ14	6φ14	10φ14	6φ14	60	120
B5	700	500	8φ14	8φ14	9φ14	8φ14	85	320
B6	800	300	5φ14	7φ14	5φ14	5φ14	60	120
B7	900	300	16φ16	12φ16	7φ16	5φ16	60	120
B8	700	300	5φ14	5φ14	5φ14	5φ14	60	120
B9	700	300	5φ14	5φ14	5φ14	5φ14	60	120
B10	700	300	5φ14	5φ14	5φ14	5φ14	60	120
B11	900	300	9φ14	6φ14	6φ14	6φ14	60	120
B12	900	300	14φ16	9φ16	5φ16	5φ16	60	120
B13	450	300	3φ14	3φ14	3φ14	3φ14	60	120
B14	700	300	5φ14	5φ14	5φ14	5φ14	60	120
B15	700	300	5φ14	5φ14	5φ14	5φ14	60	120
B16	700	300	5φ14	5φ14	5φ14	5φ14	60	120
B17	700	300	9φ14	9φ14	7φ14	5φ14	60	120
B18	700	300	6φ14	5φ14	5φ14	5φ14	60	120
B19	700	300	5φ14	5φ14	5φ14	5φ14	60	120
B20	700	300	5φ14	5φ14	5φ14	5φ14	60	120
B21	900	300	12φ14	6φ14	8φ14	6φ14	60	120
B22	800	300	6φ14	11φ14	5φ14	5φ14	60	120
B23	800	300	7φ14	7φ14	5φ14	5φ14	60	120
B24	800	300	7φ14	12φ14	5φ14	5φ14	60	120
B25	800	300	12φ14	12φ14	10φ14	5φ14	60	120
B26	800	300	12φ14	6φ14	5φ14	5φ14	60	120
B27	800	300	6φ14	8φ14	5φ14	5φ14	60	120
B28	800	300	8φ14	8φ14	6φ14	5φ14	60	120
B29	900	300	5φ14	11φ14	6φ14	6φ14	60	120
B30	900	300	10φ14	10φ14	10φ14	6φ14	60	120
B31	200	600	3φ12	3φ12	3φ12	3φ12	60	250
B32	200	600	3φ12	3φ12	3φ12	3φ12	60	250
B33	200	600	3φ12	3φ12	3φ12	3φ12	60	250
beam Type	hidden beam			drop beam h=700			drop beam h=600	
2H	600			1400			1200	

Sample of calculation for beam one and two:

Longitudinal reinforcement from ETABS.

Figure (66): shows the amount of steel for beam.

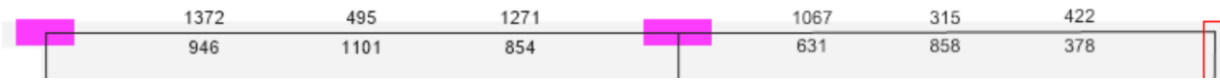


Figure 148: Longitudinal reinforcement for beam 50*70

****ETABS reinforcement results:**

Area of steel for bars C = 1101 mm²

Use 8 Ø 14.

As min = $f \times b \times d = 0.0033 \times 500 \times 640 = 1056 \text{ mm}^2$

Use 8 Ø 14 for As min.

Minimum spacing between bars = Max of $\left\{ \begin{array}{l} 20\text{mm} \\ \text{Diameter of bars} \\ 4/3 \text{ max aggregates size} \end{array} \right. = 20\text{mm the min value}$

Spacing = $\frac{500-8*14-60}{2} = 164 \text{ mm} > 20\text{mm}$ the spacing meet specification.

Area of steel for bars B = 1027 mm²

Use 8 Ø 14.

Area of steel for bars B = 422 mm²

Use As min 8 Ø 14.

Shear design for beam:

Figure (66): shows the shear reinforcement for beam:



Figure 149: shear reinforcement for beam 50*70

Stirrups spacing in the both sides area of the beam (S1):

Assume stirrups = 1Ø10 area = 78.5 with 2 legs and use 12 / m

From ETABS:-

Area mm²/ m = 304.44

S= 250 mm

From manual:-

$$s_1 = \text{Min} \left\{ \begin{array}{l} 150 \text{ mm} \\ 6 * 14 \\ 640/4 \end{array} \right\} = 85 \text{ mm this value is used.}$$

Stirrups spacing in the central area of the beam (S2):

Assume stirrups = 1Ø10 area = 78.5 with 2 legs and use 4 / m

From ETABS:-

S= 250 it's very large.

From manual:-

S2 = 640/2 = 320 mm this value is used.

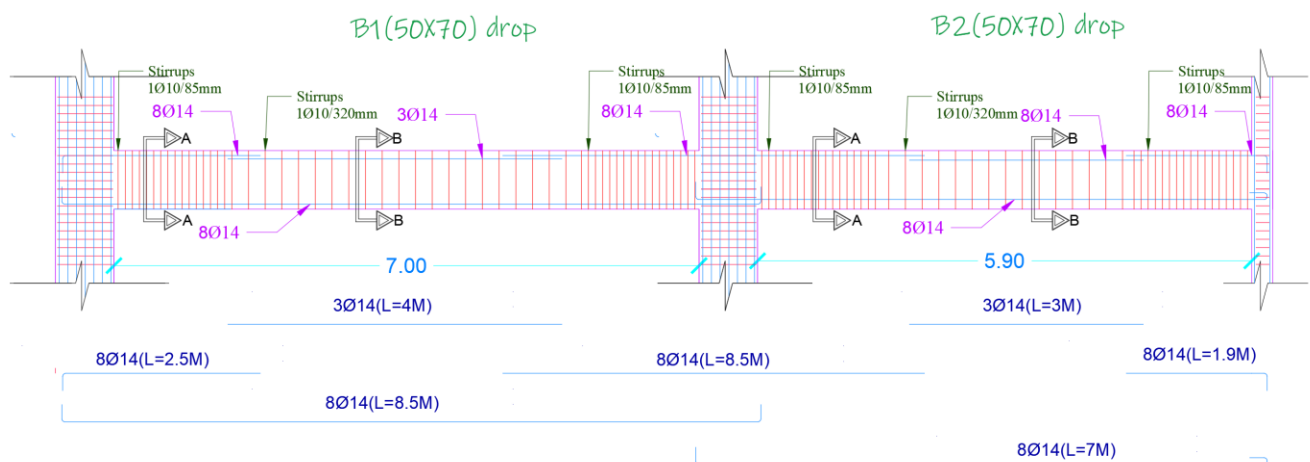
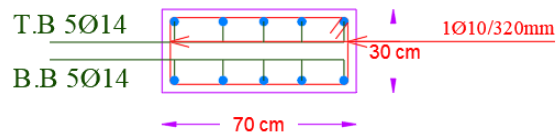
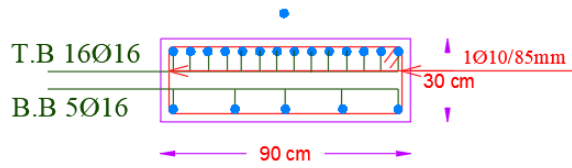


Figure 150: Detailing for beam(1&2) with diminution 50 x 70 cm.



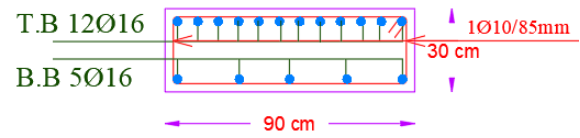
section B-B

Scale 1:20



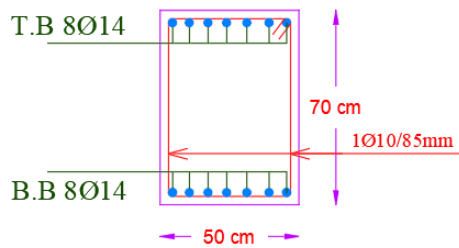
section A-A

Scale 1:20



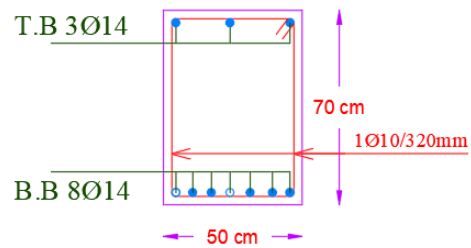
section A-A

Scale 1:20



section A-A

Scale 1:20



section B-B

Scale 1:20

Figure 151: Multiple sections of beams.

4.8.3 Columns design:

The column design used ETABS software and manual calculation in addition to we used special case for the design.

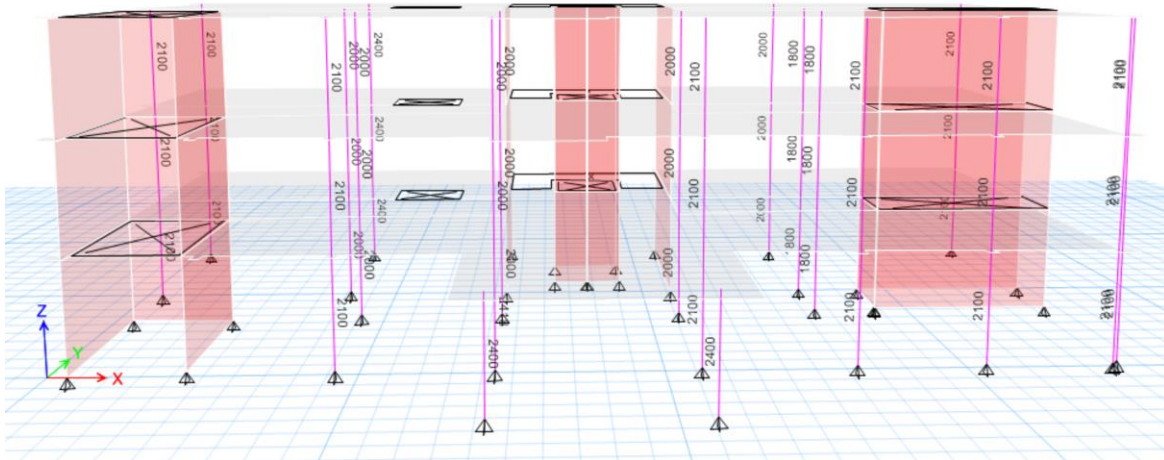


Figure 152: area of steel for column from ETABS.

Requirements detailing for column by using ACI code:

where:

$$s_0 = \text{Min} \left\{ \begin{array}{l} Bs/4 \\ 6d_b \\ 100 + (350 - h_x)/3 \\ 150 \text{ mm} \end{array} \right\} \geq 100 \text{ mm}$$

$$s_1 = \text{Min} \left\{ \begin{array}{l} Bs \\ 6d_b \\ 48d_s \\ 150 \text{ mm} \end{array} \right\} \geq 200 \text{ mm}$$

h_x = maximum horizontal spacing of crossies.

l_d = development length of the steel reinforcement in tension

$$l_0 = \text{Max} \left\{ \begin{array}{l} (\text{clear height of column}/6) \\ Bl \\ 450 \text{ mm} \end{array} \right\}$$

The development length between two bars = 48 db.

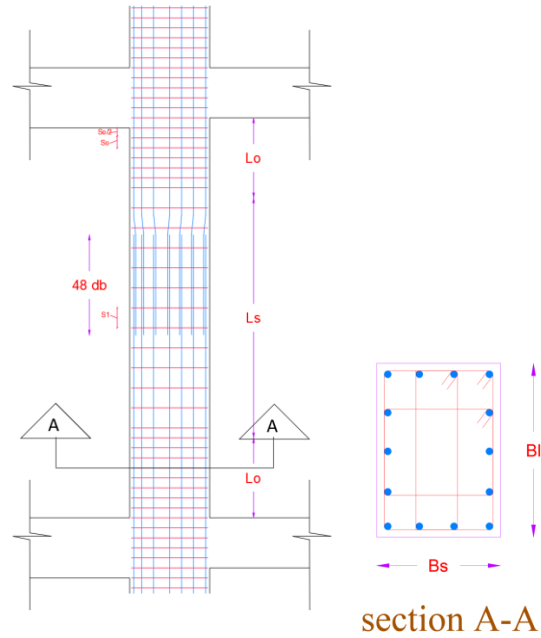


Figure 153: General detailing for column.

Sample of calculation:

$$s_0 = \text{Min} \left\{ \begin{array}{l} 300/4 \\ 6 * 14 \\ 100 + (350 - 14)/3 \\ 150 \text{ mm} \end{array} \right\} \geq 100 \text{ mm}$$

$$S_0 = 100 \text{ mm.}$$

$$s_1 = \text{Min} \left\{ \begin{array}{l} 300 \\ 6 * 14 \\ 48 * 10 \\ 150 \text{ mm} \end{array} \right\} \geq 200 \text{ mm}$$

$$S_1 = 200 \text{ mm.}$$

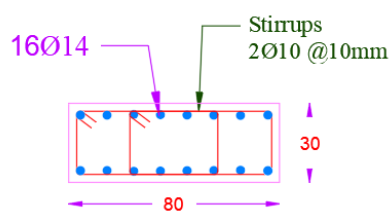
$$l_0 = \text{Max} \left\{ \begin{array}{l} 3800/6 \\ 800 \\ 450 \text{ mm} \end{array} \right\}$$

$$L_0 = 800 \text{ mm.}$$

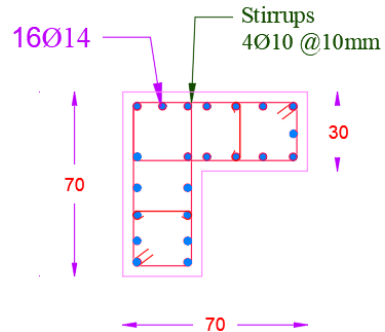
The development = 700mm.

Table 34: Table of reinforcing columns.

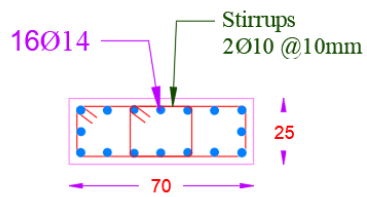
column name	column dimintion		As(mm ²)	bars	stirrups		development length	
	Width (mm)	length (mm)			both sides area	central area	Lo (mm)	Ls (mm)
C1	300	800	2400	16 ϕ 14	2 ϕ 10/100mm	2 ϕ 10/200mm	800	2200
C2	700	700	3300	22 ϕ 14	4 ϕ 10/100mm	4 ϕ 10/200mm	700	2400
C3	250	700	2400	16 ϕ 14	2 ϕ 10/100mm	2 ϕ 10/200mm	700	2400
C4	250	600	2100	14 ϕ 14	2 ϕ 10/100mm	2 ϕ 10/200mm	700	2400
C5	300	700	2100	14 ϕ 14	2 ϕ 10/100mm	2 ϕ 10/200mm	700	2400



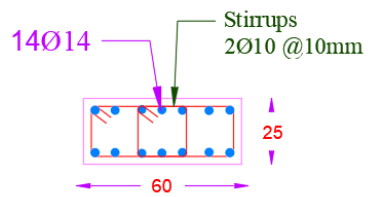
Section A-A for C1



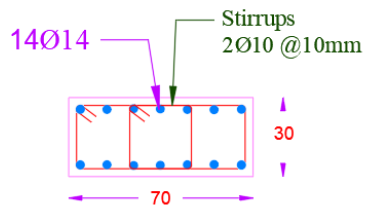
Section A-A for C2



Section A-A for C3



Section A-A for C4



Section A-A for C5

Figure 154: Sections in all Columns.

4.8.4 Shear walls design:

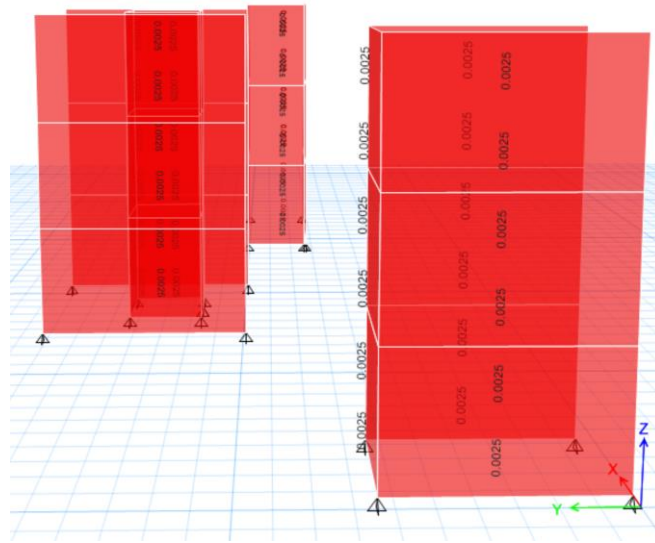


Figure 155:Area of steel for shear wall from ETABS

The values from ETABS were achieved minimum area of steel (0.025).

The all checks (thickness, moment, and acetal) is **OK**.

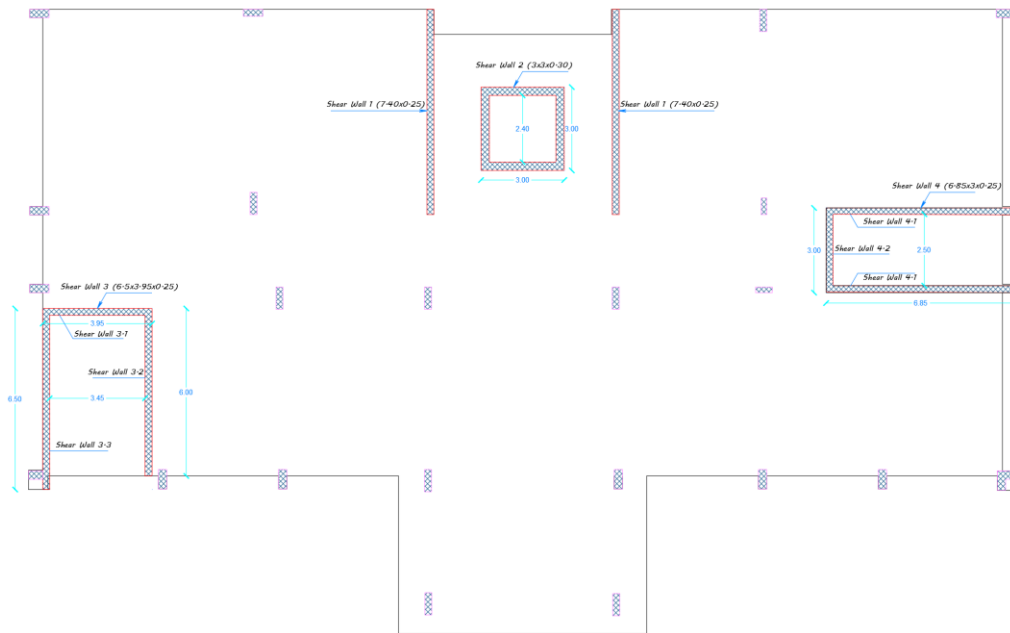


Figure 156:shear walls distribution on plan.

Table35 : distribution shear walls for the building.

S.W name	H(m)	B(m)	Hight(m)	Boundary(cm)	Bars	
					Boundary	Main
S.W 1	7.4	0.25	3.8	75	10 ϕ 16	8 ϕ 10/m
S.W 2	3	0.3	3.8	30	5 ϕ 16	10 ϕ 10/m
S.W 3.1	3.95	0.25	3.8	40	5 ϕ 16	8 ϕ 10/m
S.W 3.2	6	0.25	3.8	60	8 ϕ 16	8 ϕ 10/m
S.W 3.3	6.5	0.25	3.8	65	8 ϕ 16	8 ϕ 10/m
S.W 4.1	6.85	0.25	3.8	70	9 ϕ 16	8 ϕ 10/m
S.W 4.2	3	0.25	3.8	30	4 ϕ 16	8 ϕ 10/m

Sample of calculation: -

$$\text{Boundary} = \text{Min of } \begin{cases} 4b \\ 0.1 * h \end{cases}$$

$$\text{Boundary} = \text{Min of } \begin{cases} 1 \\ 0.74 \end{cases}$$

Used Boundary length = 75cm.

Compute the area of steel (As) required for the shear wall:

**For boundary: steel percentage will 1% (from UBC code)

$$A_s = 1 \% \times 250 \times 750 = 1875 \text{ mm}^2$$

Used 10 ϕ 14

**For web: steel percentage will 0.25% (from UBC code and ETABS)

$$A_s = 0.25 \% \times 250 \times 1000 = 625 \text{ mm}^2/\text{m}$$

Used 8 ϕ 12/m

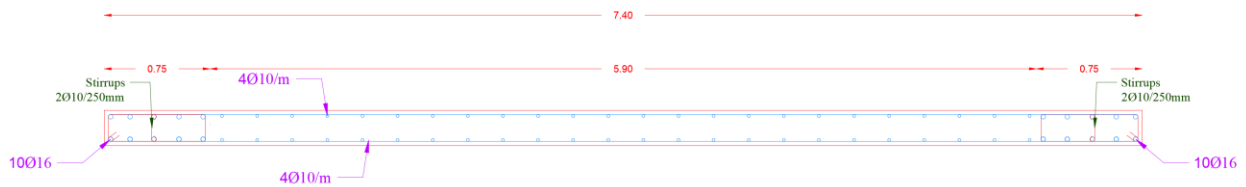


Figure 157: shear wall 1 detailing.

4.8.5 Design of staircase:

In project we have three staircase, one stair is main and others are emergence.

The staircase done by ETABS 2016 addition to manual checks.

Thickness calculations:

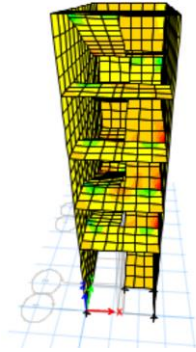


Figure 158: Shear force for staircase from ETABS.

V_u (ETABS) = 86KN

$$\phi V_c = 86 = \left(\frac{0.75}{6} * \sqrt{F_c} * b * d\right) / 1000 = \left(\frac{0.75}{6} * \sqrt{28} * 1000 * d\right) / 1000 ** d = 130 \text{ mm}$$

$$h = d + \text{cover} = 130 + 20$$

Use $h = 150$ mm with $d = 130$ mm

Staircase reinforcement:

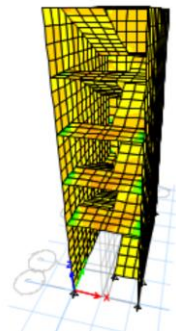


Figure 159: ultimate moment M11u from ETABS.

(M11)_u (ETABS) = 28 kN.m /m.

$$\rho = \frac{0.85 \cdot 28}{420} * \left(1 - \sqrt{1 - \frac{2.61 \cdot 10^6 \cdot 28}{28 \cdot 1000 \cdot 130^2}} \right) = 4.56 * 10^{-3}$$

$$A_s = 684 \text{ mm}^2.$$

$$A_s = 6 \text{ } \varnothing 12/m.$$

$$A_{s \text{ min}} = 0.0018 * b * h = 0.0018 * 1000 * 150.$$

$$A_{s \text{ min}} = 270 \text{ mm}^2 (3 \varnothing 12/m).$$

Use A_s 6 $\varnothing 12/m$.

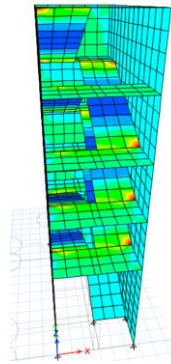


Figure 160: ultimate moment M22u from ETABS.

(M22)_u (ETABS) = 15 kN.m /m.

$$\rho = \frac{0.85 \cdot 28}{420} * \left(1 - \sqrt{1 - \frac{2.61 \cdot 10^6 \cdot 15}{28 \cdot 1000 \cdot 125^2}} \right) = 2.59 * 10^{-3}$$

$$A_s = 389 \text{ mm}^2.$$

$$A_s = 4 \text{ } \varnothing 12/m.$$

$$A_{s \text{ min}} = 0.0018 * b * h = 0.0018 * 1000 * 200 = 360 \text{ mm}^2/m$$

$A_s > A_{s \text{ min}}$ take A_s

Detailing for staircase:

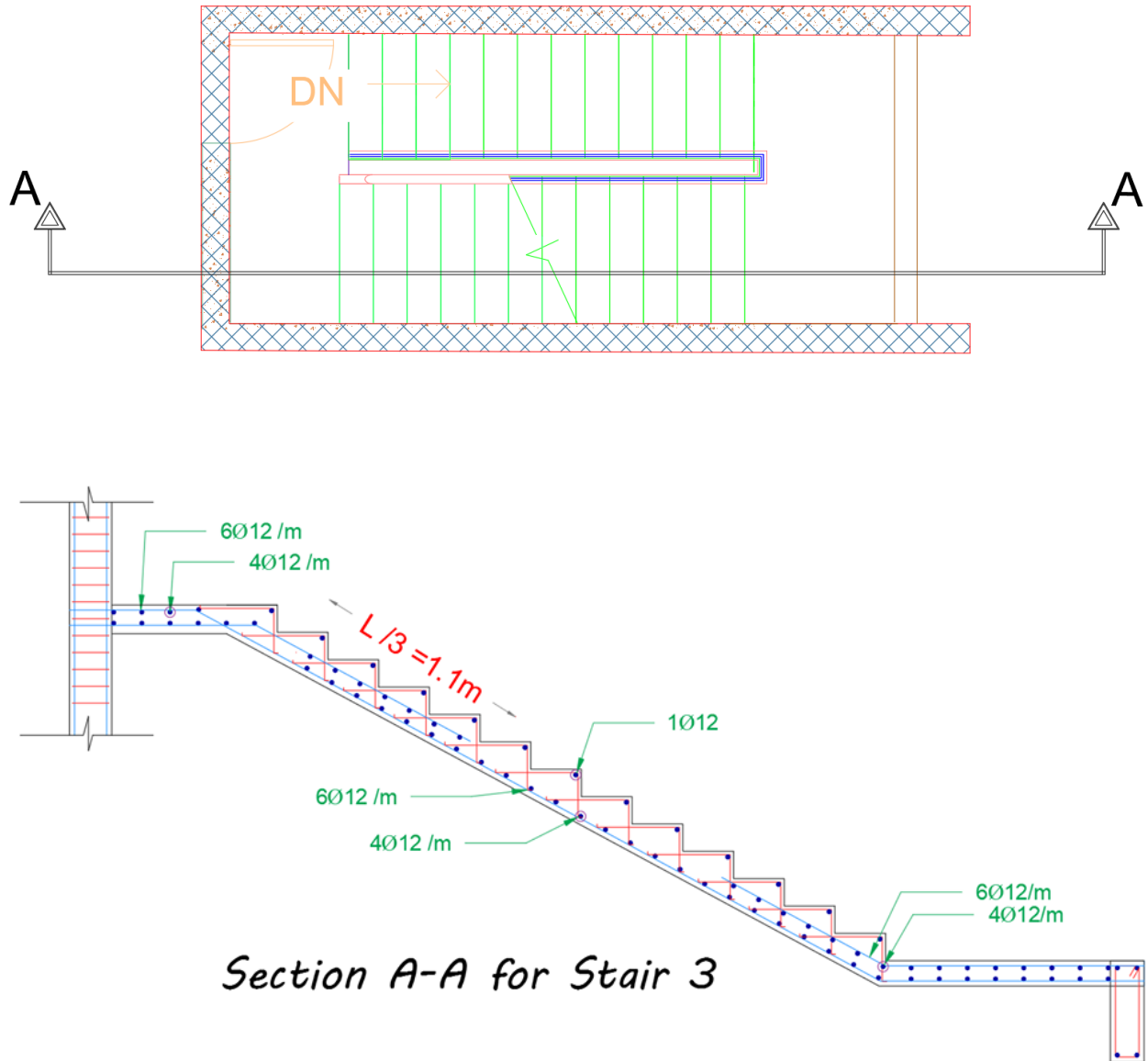


Figure 161: Detailing for staircase.

4.8.6 Design of mat foundation:

In our project the foundation system used is the mat foundation because:

- Bearing capacity for the soil equal 120 KN/m^2 , this value is very small.
- The area of isolated footings is very large.

Calculate dimension of footing:

Safe program will be used to solve dimensions of footing and check this footing is ok or not.

Area of footing = Area for building with add 80cm for all boundary of building.

Solve thickness by using rule of thumb:

Thickness = $10 \sqrt{Pu}$ for internal column (max) = $10 * \sqrt{2556} = 505.6 \text{ mm}$

Use $d = 500 \text{ mm}$ and $h = 600 \text{ mm}$.

ETABS check:

4.8.6.1 Check wide beam shear:

Shear capacity

$$\phi V_c = (0.75 * \sqrt{F_c} * b * d) / (6 * 1000)$$

$$\phi V_c = (0.75 * \sqrt{28} * 1000 * 500) / (6 * 1000)$$

$$\phi V_c = 331 \text{ kN/m}$$

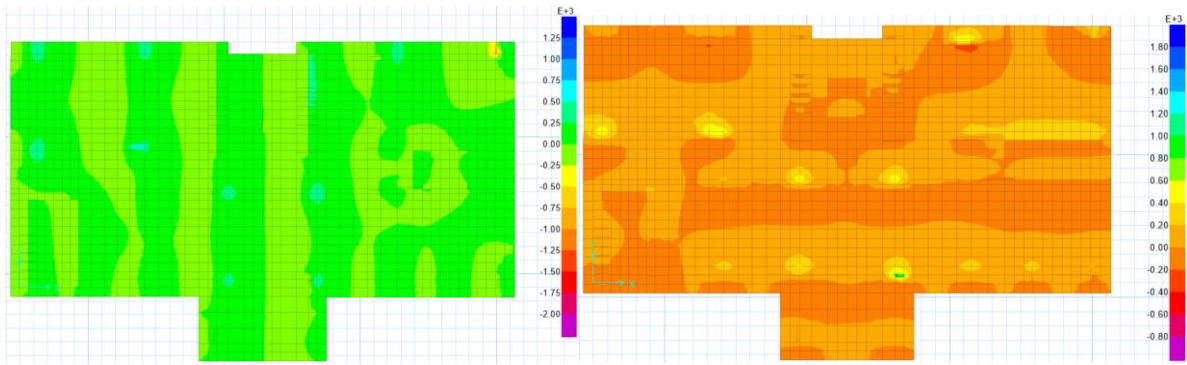


Figure 162: value of V12, V23 from safe program

Maximum = 311 < 331

all zone less than capacity, The check is **OK**.

4.8.6.2 punching shear check:

To make sure the punching shear value is ok, the ratio for allowable shear and ultimate shear from ETABs should be less than 1 then its ok.

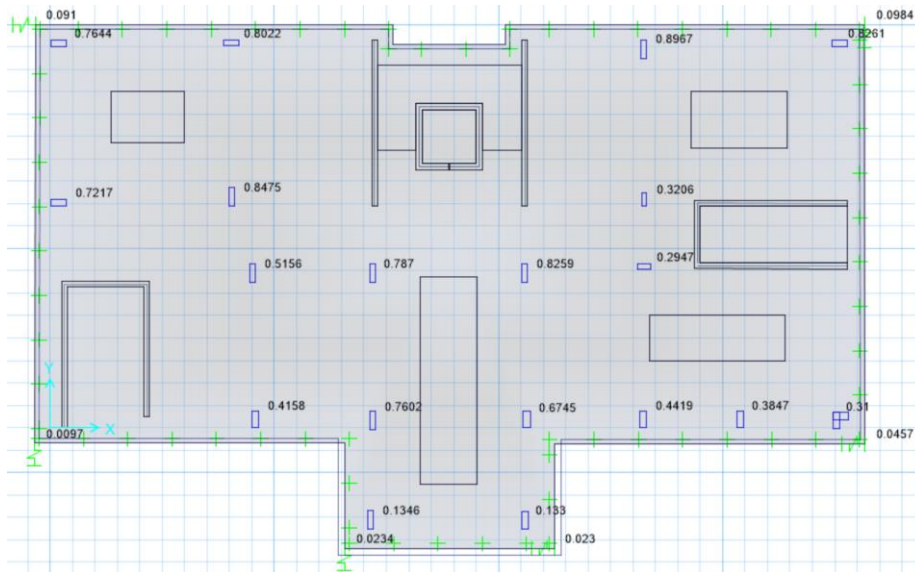


Figure 163: ratio for allowable shear and ultimate shear.

4.8.6.3 Bearing capacity check:

Bearing capacity for the soil equal 120 KN/m^2 , to ensure the success of bearing capacity check the stress under footing must be less than allowable bearing capacity of soil to carry all building loads.

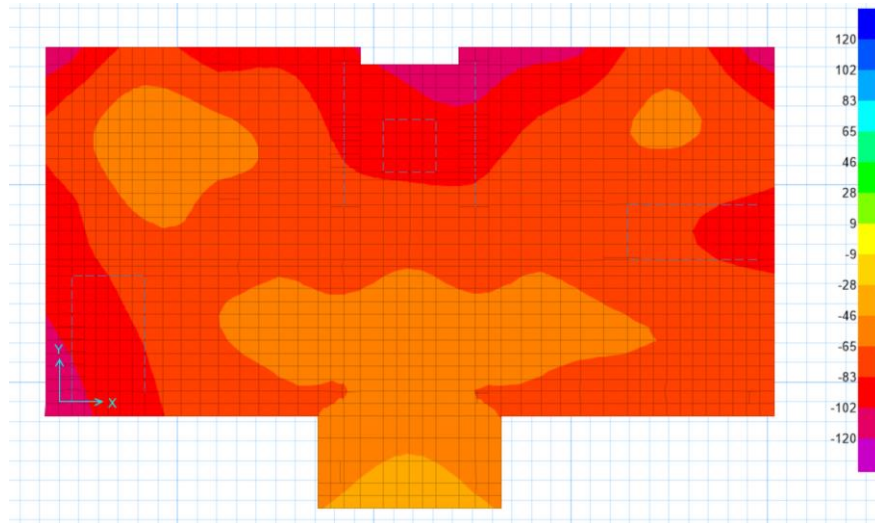


Figure164 : stress under mat foundation.

4.8.6.4 Check deflection:

Max Deflection = 8 mm allowable deflection = 12 mm then its ok.

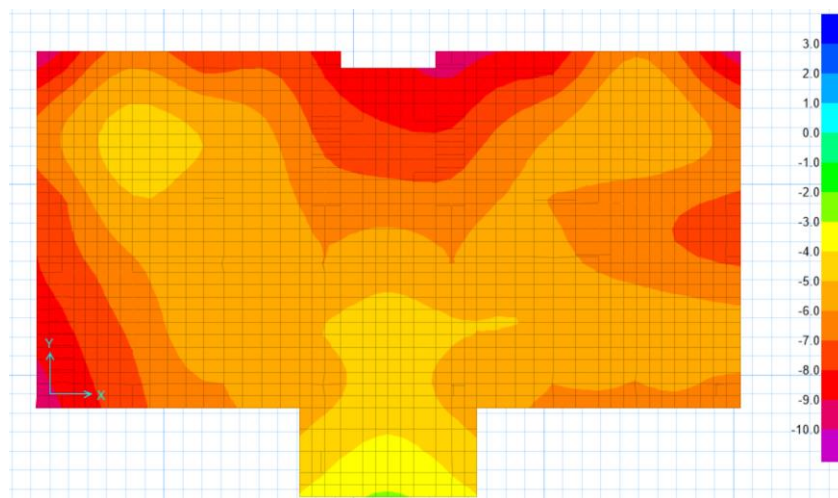


Figure 165: Deflection contour for mat foundation from ETABS.

4.8.6.5 Footing reinforcement:

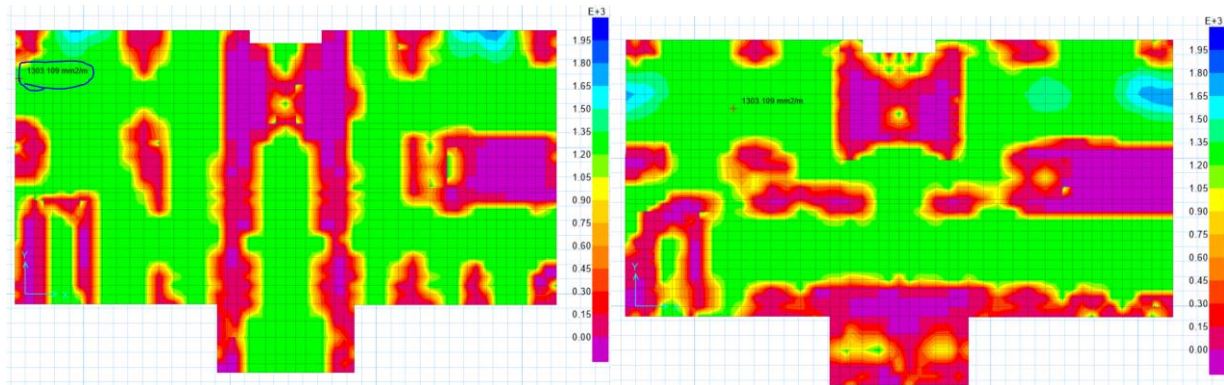


Figure166 :area of steel for top bars.

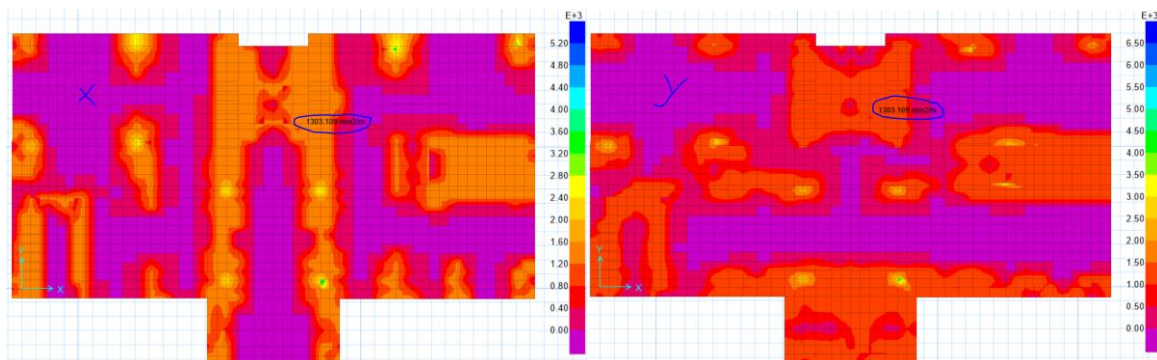


Figure167 : area of steel for bottom bars

Design of footing for flexural (longitudinal reinforcement).

$$\text{Area steel min} = 0.0018 * b * h = 0.0018 * 1000 * 700 = 1260 \text{ mm}^2$$

use $6\phi 16 / \text{m}$.

Summary for reinforcement:

The all steel (bottom and top) equal $7\phi 16 / \text{m}$ in two direction; but zone 4 used min area of steel.

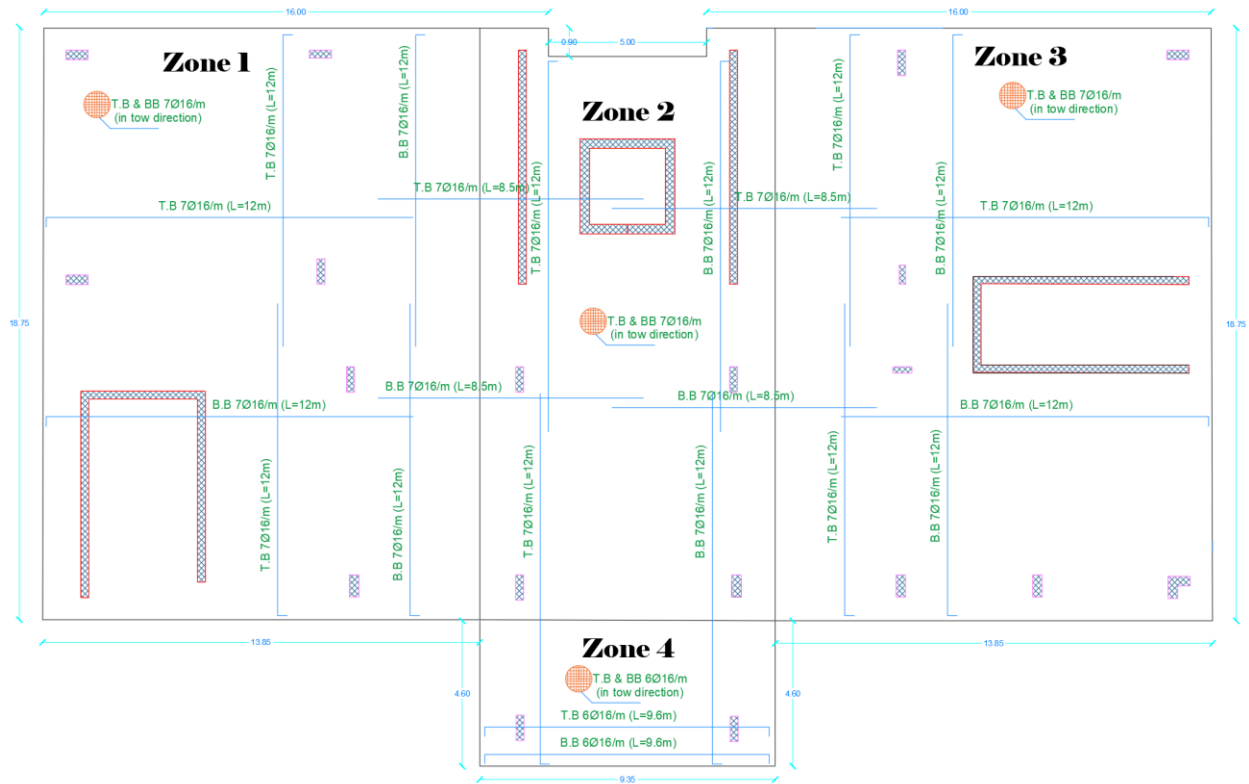


Figure 168:Detailing of mat foundation.

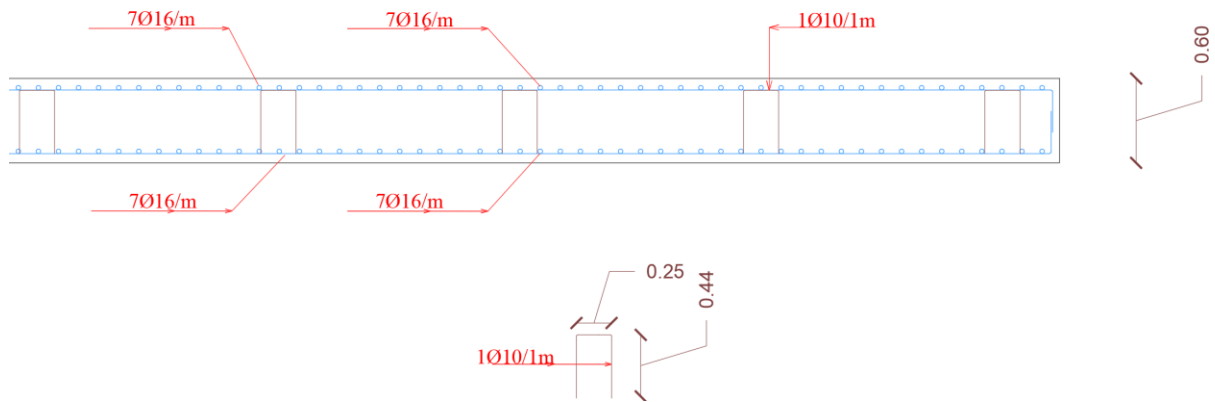


Figure 169:section for mat footing.

4.8.7 Water tank:

In our project the water tank volume needed 84 m^3 with dimension (7 x 4 x 3) m.

The analysis and designed by SAP 2000.

The material properties used for water tank.

- Bearing capacity for the soil(q) is 120 KN/m^2 .
- The full water without soil is critical case.
- Friction angle of soil (ϕ) is 30° .
- Unit weight for concrete (γ_{concrete}) = 24 KN/m^3 .
- Unit weight for soil (γ_{soil}) = 18 KN/m^3 .

The material properties used for water tank.

- Live load above water tank = 5 KN/m^2 .
- Superimposed dead above water tank = 0.7 KN/m^2 .
- weight of water tank.
- Load of water inside W.T.
- Load of soil from the sides and bottom.

SAP checks:

In this part we will need calculate three checks.

4.8.7.1 Compatibility check:

The check by start animation is **OK**.

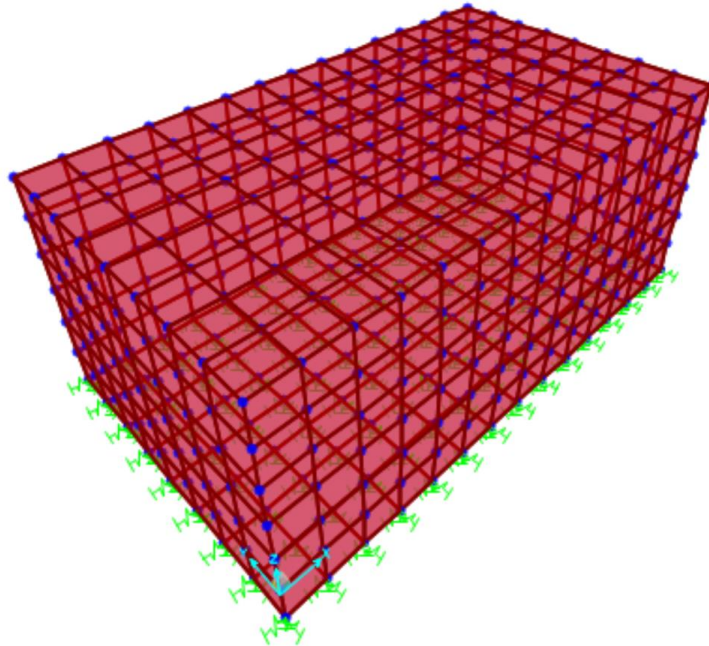


Figure 170: Deformed shape for water tank.

4.8.7.2 Bearing capacity check:

Coefficient of bearing capacity (K) = mesh size * allowable soil stress.

$$K = (0.5 * 0.5) * 120 = 30.$$

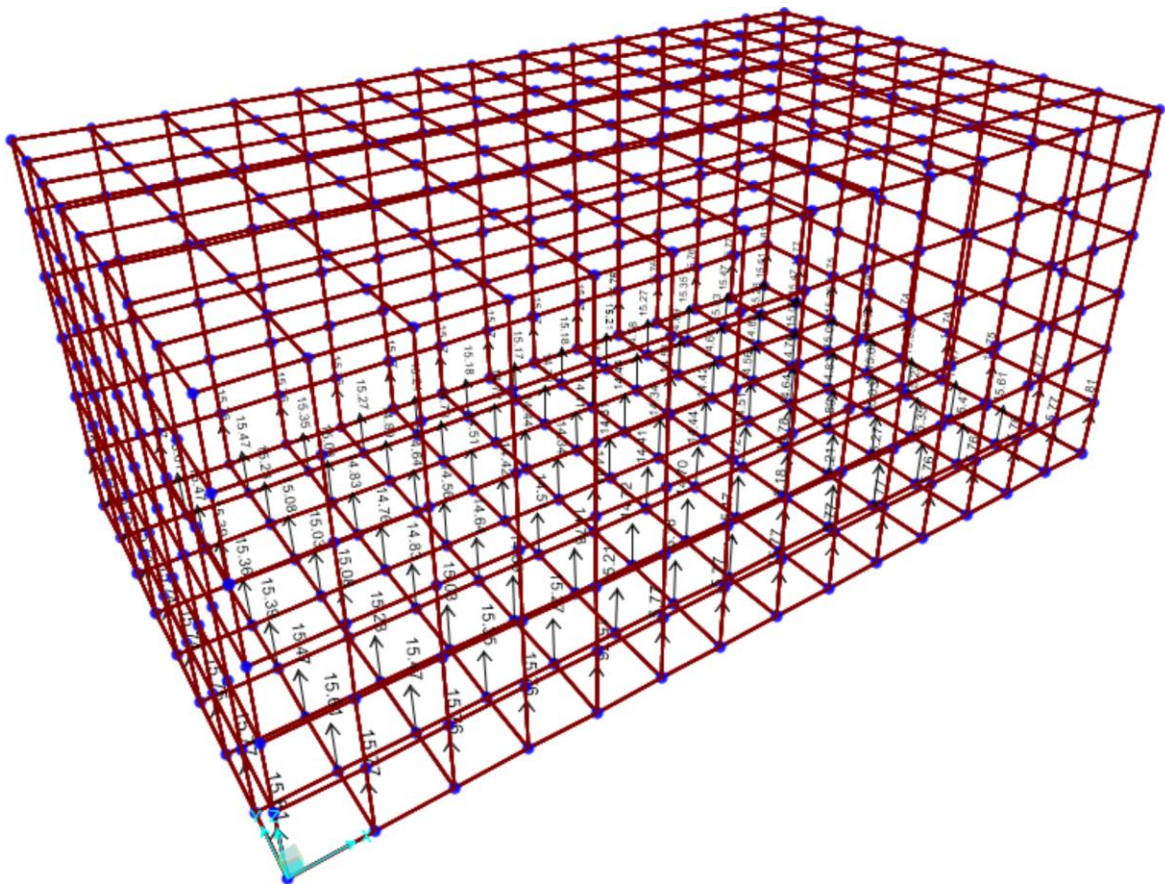


Figure 171: Joints stress on base of water tank.

The max value equal 15.5 and this is less than 30.

The bearing capacity check is **OK**.

4.8.7.3 Deflection check:

Manual deflection_{max} = $L/240 = 7000 / 240 = 29.2$ mm.

The Max deflection from SAP = 5.11 mm.

Δ manual SAP < Δ deflection manual $\rightarrow 5.11 < 29.2$

The deflection check is **OK**.

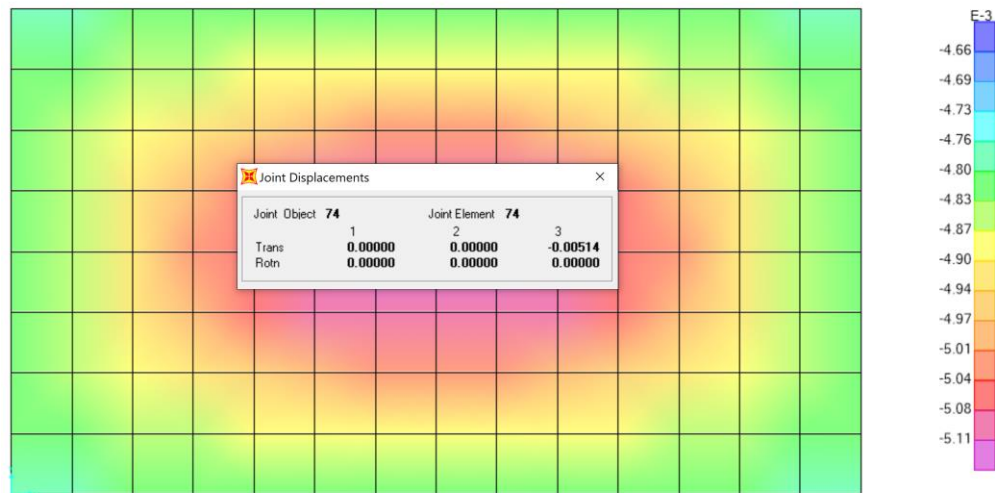


Figure 172: deflection for water tank from SAP.

Manual check:

4.8.7.4 Tension check:

$$\text{Durability factor} = S_d = \frac{\phi * F_y}{\gamma * F_{smax}} = \frac{0.9 * 420}{1.4 * 240} = 1.125$$

$$T_u \text{ design} = S_d * T_u = 1.125 * 90 = 101.25 \text{ KN/m}^2.$$

$$T_u \text{ design} = \phi * A_s * F_y$$

$$101.25 * 10^3 = 0.9 * A_s * 420$$

$$A_s = 268 \text{ mm}^2/\text{m}.$$

$$A_s \text{ min} = 0.003 * b * h$$

$A_s \text{ min} = 750 \text{ mm}^2$. Use $A_s \text{ min}$

$$\frac{T \cdot 10^3 + C \cdot E_s \cdot (A_s)}{n \cdot (A_s) + A_g} < \frac{\sqrt{f'c}}{3} \text{ required}$$

$$\frac{90 \cdot 10^3 + 0.0003 \cdot 200000 \cdot 1400}{8.01 \cdot 1400 + 1000 \cdot 250} < 1.51$$

$0.87 < 1.67$ so Tension check is acceptable.

Where:

S_d is durability factor.

γ is average load factor.

ϕ is capacity reduction factor and equal 0.9.

C is shrinkage strain in concrete and equal 0.0002 to 0.0004.

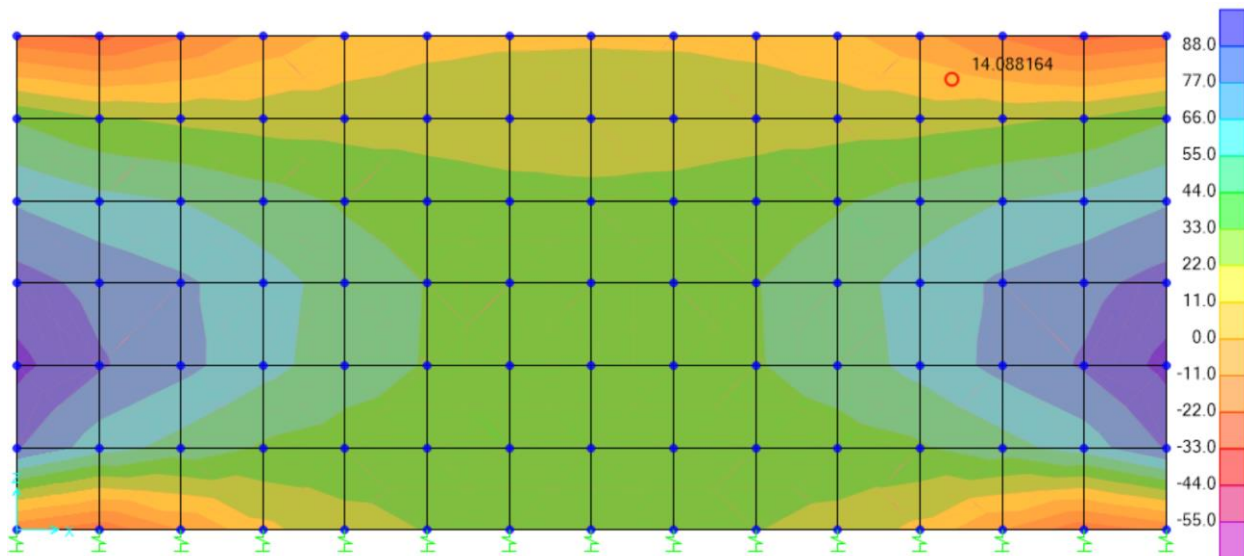


Figure 173: tension value for water tank walls.

Design elements:

$$\frac{L}{H} = \frac{4 \text{ m}}{3 \text{ m}} = 1.33 \text{ Intermediate water tank with roof.}$$

Wall thickness check and calculation:

Assuming wall thickness of water tank is 250 mm.

$$\phi V_c = \frac{0.75}{6} * \sqrt{f_c} * b * d * 10^{-3} = \frac{0.75}{6} * \sqrt{24} * 1000 * d * 10^{-3}$$

$$\phi V_c = 612.37(d) * 10^{-3} \text{ KN/m}$$

$$V_u < \phi V_c$$

$$63 < 612.37(d) * 10^{-3}$$

D=103 mm. less than required.

Used d=170.

The thickness is acceptable.

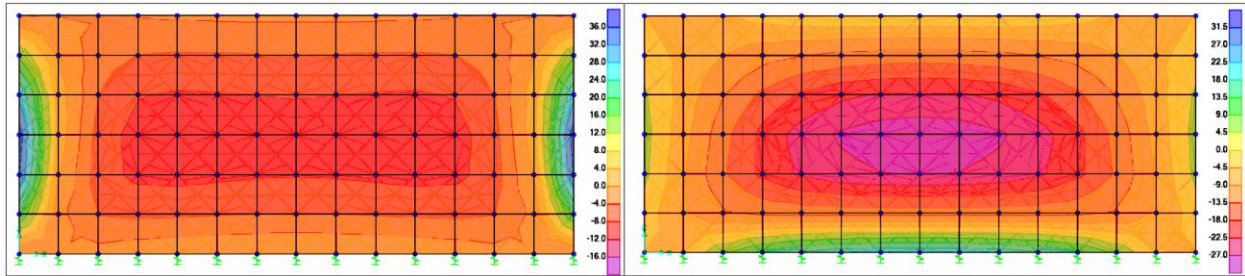


Figure 174: moment M11 and M22.

Mu vertical = 35 kN.m /m, as can be seen in Figure 174.

$$Mu_{\text{vertical (design)}} = 35 * S_d$$

$$Mu_{\text{vertical (design)}} = 35 * 1.125 = 39.4 \text{ kN.m /m}$$

$$\rho = \frac{0.85 * f_c}{f_y} \left(1 - \sqrt{1 - \frac{2.61 * 10^6 * Mu}{b * d^2 * f_c}} \right)$$

$$\rho = 3.3 * 10^{-3}$$

$$A_s = 563 \text{ mm}^2/\text{m} < A_{s \text{ min}}$$

$$A_{s \text{ min}} = 0.003 * b * h = 750 \text{ mm}^2/\text{m}. \text{ Use } A_{s \text{ min}}$$

Mu horizontal = 10 kN.m /m, as can be seen in Figure 174.

$$Mu_{\text{horizontal (design)}} = 30 * S_d = 10 * 1.125 = 33.75 \text{ kN.m /m}$$

$$\rho = \frac{0.85 * f_c}{f_y} \left(1 - \sqrt{1 - \frac{2.61 * 10^6 * Mu}{b * d^2 * f_c}} \right)$$

$$\rho = 2.82 * 10^{-3}$$

$$A_s = 480 \text{ mm}^2/\text{m} < A_{s \text{ min}}$$

$$A_{s \text{ min}} = 0.005 * b * h = 1250 \text{ mm}^2/\text{m}. \text{ Use } A_{s \text{ min}}$$

Base of water tank calculation:

$$V_u = 82 \text{ KN}.$$

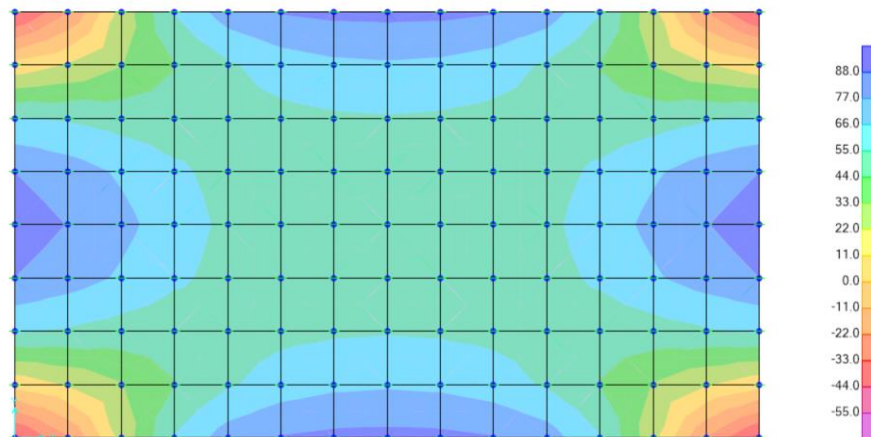


Figure 175: Vu for base of water tank.

$$\phi V_c = \frac{0.75}{6} * \sqrt{f_c} * b * d * 10^{-3} = \frac{0.75}{6} * \sqrt{24} * 1000 * d * 10^{-3} = 612.4d \text{ KN/m}$$

$$V_u < \phi V_c$$

$$82 < 612.4d \text{ KN/m}$$

D=184 mm, use d=220mm.

Use thickness equal 30cm.

Reinforcement steel for base water tank:

Bottom and Top steel in Y and X axes

Max Mu = 32 KN.m / m

$$\rho = \frac{0.85 * f_c}{f_y} \left(1 - \sqrt{1 - \frac{2.61 * 10^6 * M_u}{b * d^2 * f_c}} \right) = 1.8 * 10^{-3}$$

As = 396 mm²/m. < As_{min}

As_{min} = 0.0018 * b * h = 540 mm²/m. **Use As_{min}**

Roof of water tank calculation:

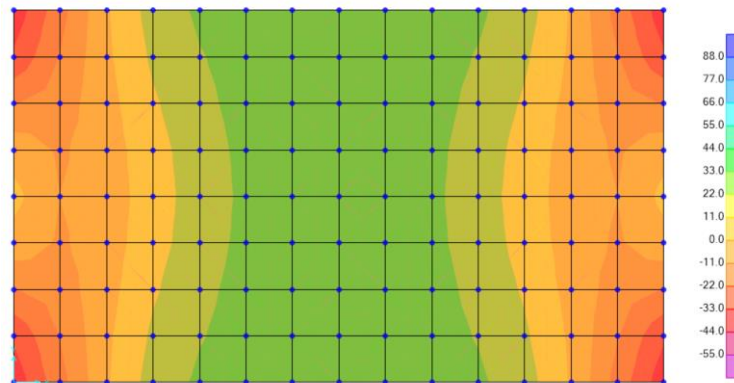


Figure 176: Vu for roof of water tank.

$$\phi V_c = \frac{0.75}{6} * \sqrt{f_c} * b * d * 10^{-3} = \frac{0.75}{6} * \sqrt{24} * 1000 * d * 10^{-3} = 612.4d \text{ KN/m}$$

Vu < ϕV_c

42 < 612.4d KN/m

D=68 mm, use d=140mm.

Use thickness equal 20cm.

Medium steel in X & Y axes

Max Mu = 18 KN.m /m

$$\rho = \frac{0.85 * f_c}{f_y} \left(1 - \sqrt{1 - \frac{2.61 * 10^6 * M_u}{b * d^2 * f_c}} \right) = 2.5 * 10^{-3}$$

$$A_s = 360 \text{ mm}^2/\text{m} = A_{s_{\min}}$$

$$A_{s_{\min}} = 0.0018 * b * h = 360 \text{ mm}^2/\text{m}$$

Table 36: steel reinforcement for water tank.

Item name	$A_{s_{\text{tension}}}$	$A_{s_{\text{moment}}}$	$A_{s_{\text{required}}}$	Steel bar	Comment
Wall (vertical)	—	1250	1250	7 ϕ 16/m	two faces
Wall (horizontal)	750	750	1125	6 ϕ 16/m	two faces
Roof (two direction)	—	350	350	4 ϕ 12/m	two face
Base(two direction)	—	540	396	5 ϕ 12/m	two faces

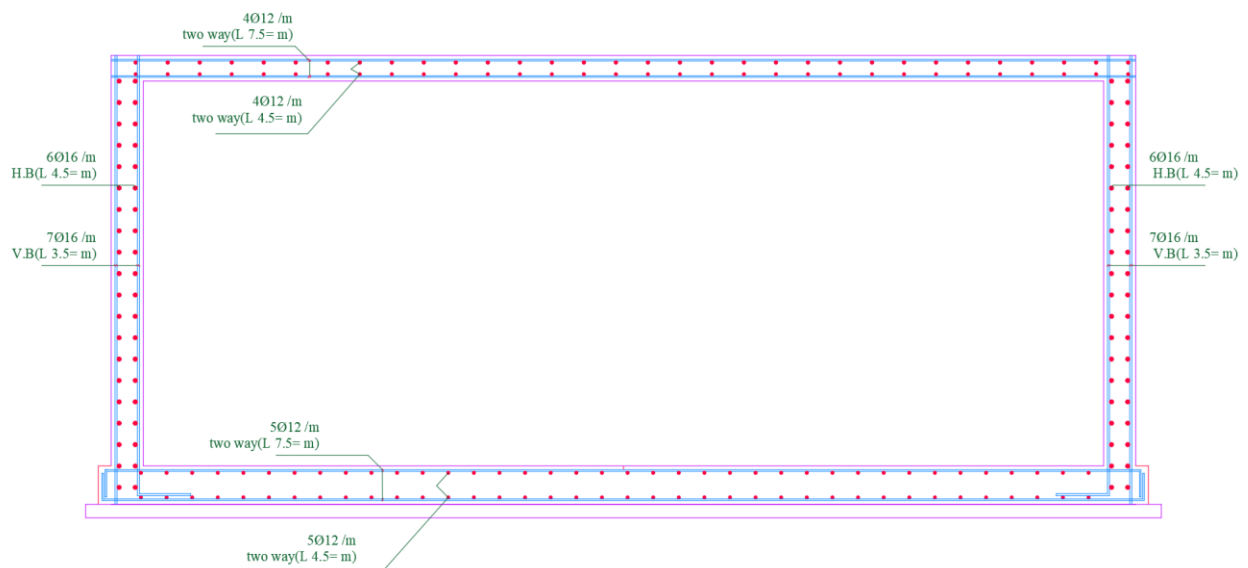


Figure 177:Detailing for water tank.

Chapter 5: ELECTROMECHANICAL DESIGN

5.1 Artificial Lighting:

5.1.1 Introduction:

The artificial lighting is very important in any building to achieve visual comfort for human when sun disappears or at night to reach the best performance, and artificial lighting was designed for all spaces for the Educational Institute, and the species is :-

5.1.2 Design:

1-Class Room

2-Staff Room

3-Corridor

5-computer lab

6-Stairs

7-Administration

8-Bath Room

9-Library

10-Store

11-Auditorium

DIALux evo 8.2 software was used for design lighting, and the percentages of Reflection used 70% ceiling, 50% Wall, and 30% Floor, Seven type of luminaire used for design the architectural collage:-

ARTEMIDE- L611120

PHILIPS- CR150B PSD

PHILIPS- DN130B D165

PHILIPS- DN135B D215

Table 37: specifications of luminaire used in project.

	luminaire type	Manufacturer	Dimensions (m)	Lux	Watt	Quantity	Luminous efficacy
1	L611120	ARTEMIDE	0.15 Radius	800 lm	53	12	9.2
2	CR150B PSD	PHILIPS	0.6*0.6*0.08	3500	40	208	87.5
3	DN130B D165	PHILIPS	0.16 Radius	1250	11.6	69	98.8
4	DN135B D215	PHILIPS	0.21 Radius	2000	28	6	71.4
Total						295	

Luminaires and their specifications from evo8.2:-


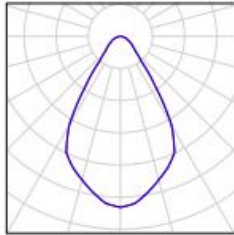

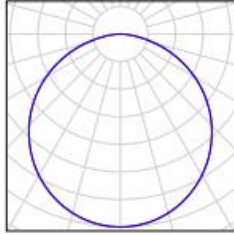

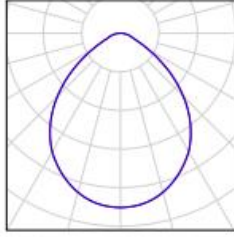

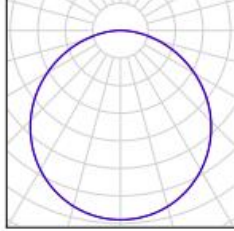
Quantity	Luminaire (Luminous emittance)		
12	Artemide – Artemide Group - L611120 AYRTON 156 QR-CBC51 MAX.50W WHITE Luminous emittance 1 Fitting: 1xHRGS/UB (GU5,3) Light output ratio: 61.07% Lamp luminous flux: 800 lm Luminaire luminous flux: 489 lm Power: 53.0 W Luminous efficacy: 9.2 lm/W Colourimetric data 1xHRGS/UB (GU5,3): CCT 2856 K, CRI 100		
208	Philips - CR150B PSD W60L60 IP54 1 xLED35S/840 Luminous emittance 1 Fitting: 1xLED35S/840/- Light output ratio: 99.97% Lamp luminous flux: 3500 lm Luminaire luminous flux: 3499 lm Power: 40.0 W Luminous efficacy: 87.5 lm/W Colourimetric data 1xLED35S/840/-: CCT 3000 K, CRI 100		
69	Philips - DN130B D165 1xLED10S/830 Luminous emittance 1 Fitting: 1xLED10S/830/- Light output ratio: 91.72% Lamp luminous flux: 1250 lm Luminaire luminous flux: 1147 lm Power: 11.6 W Luminous efficacy: 98.8 lm/W Colourimetric data 1xLED10S/830/-: CCT 3000 K, CRI 100		
6	Philips - DN135B D215 1xLED20S/830 Luminous emittance 1 Fitting: 1xLED20S/830/- Light output ratio: 100% Lamp luminous flux: 2000 lm Luminaire luminous flux: 2000 lm Power: 28.0 W Luminous efficacy: 71.4 lm/W Colourimetric data 1xLED20S/830/-: CCT 3000 K, CRI 100		

Figure 178 : Luminaire specification 1

5.1.3 Spaces: -

These sample of calculation for two different spaces show all result from DiaLux Program.

Class Room 1



Figure 179 : Class Room Shot

Floor Area =48 m²

Table 38 : Type of Luminaire and Specifications

Type of luminaire	Quantity	Total luminous flux	Total Load	Luminous Efficacy	Mounting Height
PHILIPS- CR150B PSD	11	38489 lm	440 W	87.5 lm/w	3 m
ARTEMIDE- L611120	1	489 lm	53 W	9.2 lm/w	3 m

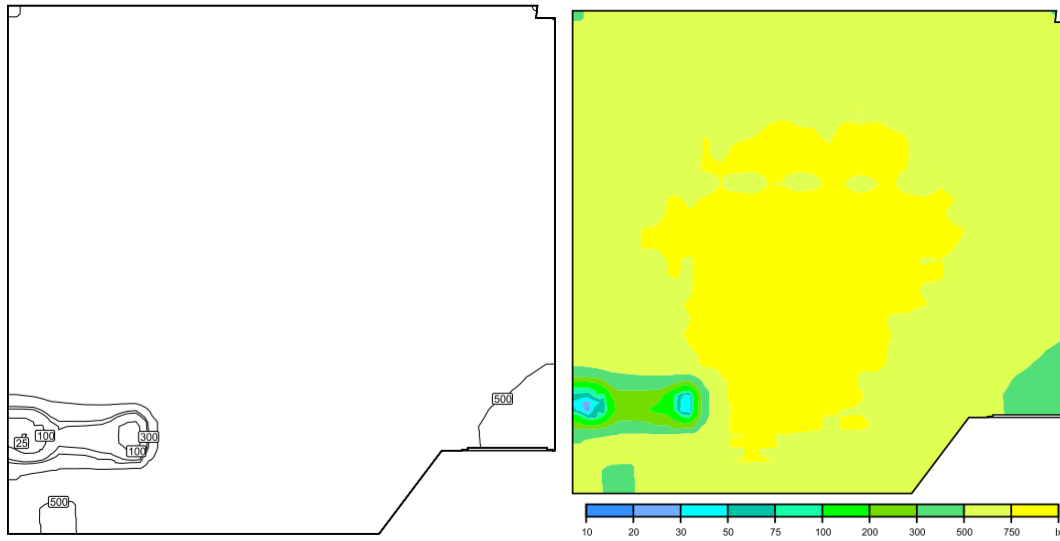


Figure 180 : Lux distribution

Table 39 : Class Room luminaires position.

Philips CR150B PSD W60L60 IP54 1 xLED35S/840

No.	X [m]	Y [m]	Mounting height [m]	Maintenance factor
1	6.340	3.495	3.097	0.80
2	6.340	5.825	3.097	0.80
3	4.528	1.165	3.097	0.80
4	4.528	3.495	3.097	0.80
5	4.528	5.825	3.097	0.80
6	2.717	1.165	3.097	0.80
7	2.717	3.495	3.097	0.80
8	2.717	5.825	3.097	0.80
9	0.906	1.165	3.097	0.80
10	0.906	3.495	3.097	0.80
11	0.906	5.825	3.097	0.80

Artemide – Artemide Group L611120 AYRTON 156 QR-CBC51 MAX.50W WHITE

No.	X [m]	Y [m]	Mounting height [m]	Maintenance factor
12	2.499	0.466	2.967	0.80

Result:-

Calculation surface:-

Surface	Result	Average (Target)	Min	Max	Mean/Min	Max/Min
1 Calculation surface 2	Perpendicular illuminance [lx] Height: 1.100 m	728	652	779	1.12	1.19
2 Calculation surface 3	Perpendicular illuminance [lx] Height: 0.700 m	761	678	795	1.12	1.17

Computer lab

Floor Area =34 m²

Table 40: Luminaire specification

Philips CR150B PSD W60L60 IP54 1 xLED35S/840

No.	X [m]	Y [m]	Mounting height [m]	Maintenance factor
1	4.304	3.505	3.097	0.80
2	4.304	5.842	3.097	0.80
3	2.583	1.168	3.097	0.80
4	2.583	3.505	3.097	0.80
5	2.583	5.842	3.097	0.80
6	0.861	1.168	3.097	0.80
7	0.861	3.505	3.097	0.80
8	0.861	5.842	3.097	0.80

Artemide – Artemide Group L611120 AYRTON 156 QR-CBC51 MAX.50W WHITE

No.	X [m]	Y [m]	Mounting height [m]	Maintenance factor
9	1.564	0.712	2.967	0.80

Type of luminaire	Quantity	Total luminous flux	Total Load	Luminous Efficacy	Mounting Height
PHILIPS- CR150B PSD	8	27992 lm	320 W	87.5 lm/w	3 m
ARTEMIDE- L611120	1	489 lm	53 W	9.2 lm/w	3 m

Lux distribution: -

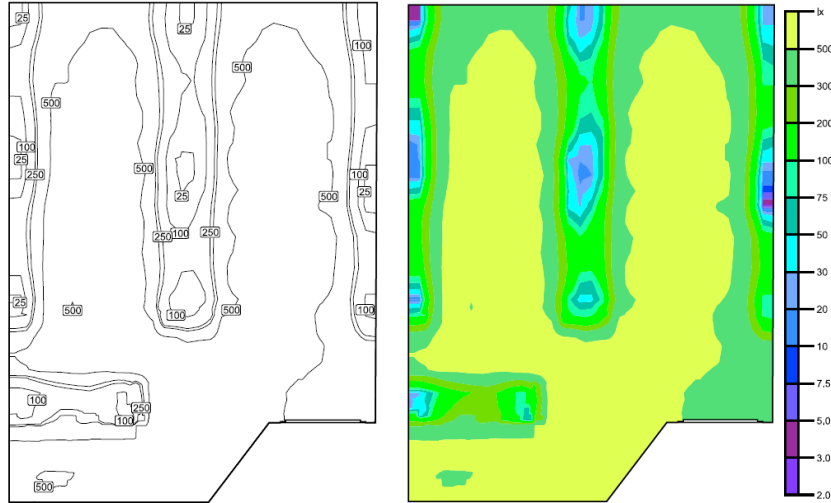


Figure 181 : Lux Distribution

Result:-

Calculation surface:-

Table 41: computer lab Result.

Surface	Result	Average (Target)	Min	Max	Mean/Min	Max/Min
3 Calculation surface 19	Perpendicular illuminance [lx] Height: 1.600 m	588	514	706	1.14	1.37

Surface	Result	Min	Max	Threshold value
1 Calculation surface 5	UGR Height: 1.020 m	<10	15.4	≤19.0
2 Calculation surface 6	UGR Height: 1.050 m	<10	15.8	≤19.0

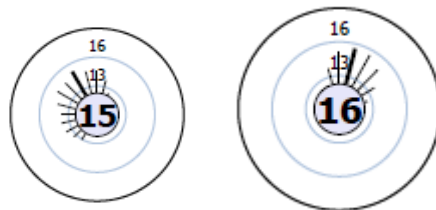


Table 42: UGR results for computer lab in different tables.

5.1.4 Electrical lighting plans.

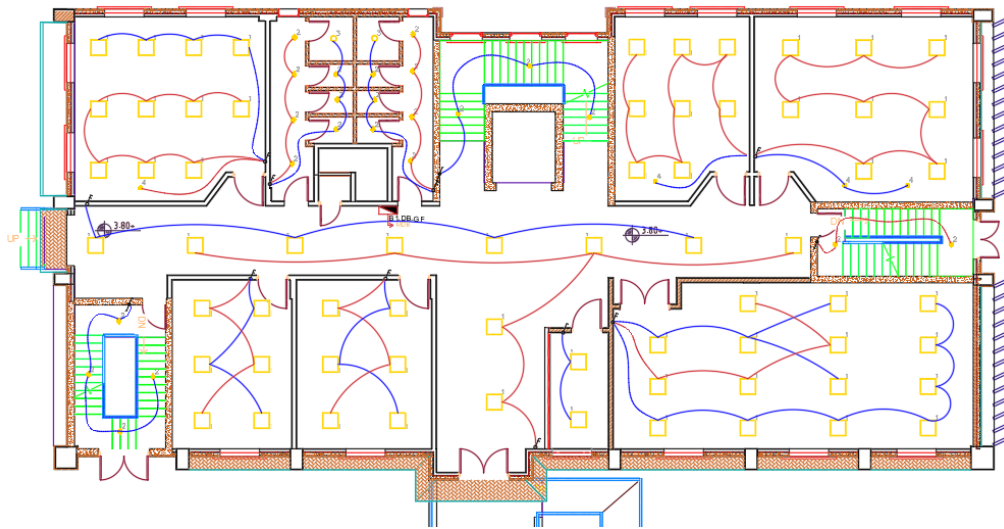


Figure 182 : Ground - luminaire

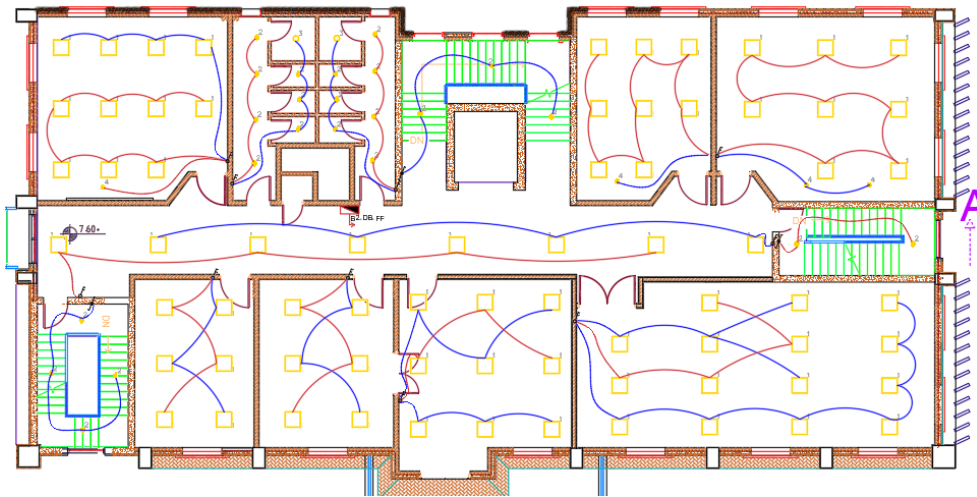


Figure 183 : First- luminaire.

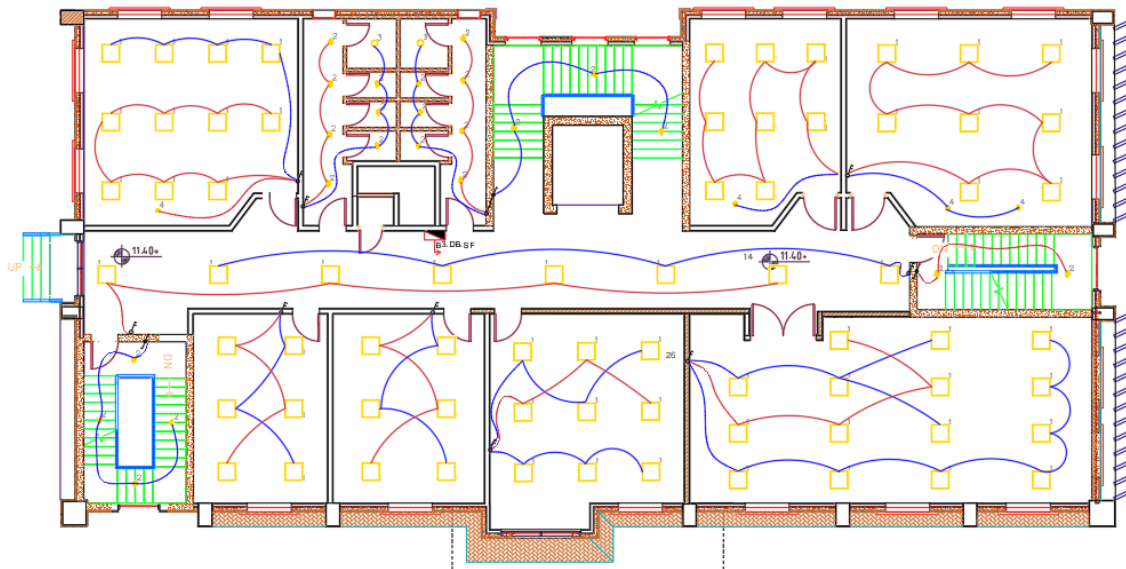


Figure 184 : Second- luminaire

5.2 Electrical Design: -

5.2.1 Introduction:

In this project electrical design designed to provide suitable power for all socket and luminaire and every machine need electric so after doing all calculation these result what get after applying electric equation.

5.2.2 Design:

The following tables show all results for load and power that will have in this project.

Table 43 : Summary of result for each floor

Floor	Total Power Lighting (W)	Total Loads (250 W)	Total Special Loads (Amp)
Ground Floor	3176.6	46	0
First Floor	3376.6	45	0
Second Floor	3376.6	45	0

5.2.3 Sample of Calculation:-

Table 44: Current for each type

current	
lighting	10Amp
socket	16Amp
special loads	16Amp

Calculation of Main Circuit Breaker (MCB).

DF: diversity factor for lighting = 0.9.

DF: for socket =0.3.

SF: safety factor = 1.2.

220: electrical voltage for 1 phase.

380: electrical voltage for 3 phase.

Table 45: Cross section area for cables

conductor	Burned and enclosed in conducting trunk		Clipped direct to the surface and unclosed	
	Single phase Current rating (Amp)	Three phase Current rating (Amp)	Single phase Current rating (Amp)	Three phase Current rating (Amp)
Nominal cross-sectional area (mm ²)				
1.0	11	9	13	12
1.5	13	11	16	15
2.5	18	16	23	20
4.0	24	22	30	27
6.0	31	28	38	34
10	42	39	51	46
16	56	50	68	61
25	73	66	89	80
35	90	80	109	98

Ground floor (DB-GF):

Table 46: total power of lighting and socket.

Total current of socket (W)	Total power of lighting(W)
11500	3176.6

For sockets:

Number of circuit breaker = 12

For lighting: → Number of circuit breaker = 12

Diameter for cables:

1.5 mm² Cross sectional area for lighting.

2.5 mm² cross sectional area for socket.

Calculation for Distribution board in ground floor B1-DB-GF:

For classroom 1 in ground floor at B1-DB-GF lighting calculation:

$$R \text{ wire} = \frac{R_{oh} * L}{A} = \frac{17.5 * 10^{-9} * 5}{1.5 * 10^{-6}} = 0.06$$

$$I \text{ load} = \frac{\text{Power (w)}}{V * Df} = \frac{493}{220 * 0.9} = 2.51$$

$$V \text{ drop} = I \text{ wire} * R \text{ wire} \rightarrow 0.06 * 2.51 = 0.15$$

$$\% \text{ drop Voltage} = \frac{0.15}{220} * 100\% = 0.06\% < 5\% , \text{ So it's Ok .}$$

$$I \text{ C.B} = I \text{ load} * 1.15 \rightarrow 2.51 * 1.15 = 2.88$$

$$I \text{ cable} = I \text{ C.B} * 1.15 \rightarrow 2.88 * 1.15 = 3.31$$

From table 12 the Cable Cross section area = 1.5*10⁻⁶ m → Circuit Breaker = 13

5.2.4 Main circuit breaker for lighting.

Table 47: power of lighting for G.F.

Lighting															
Floor	Block	Circuit name	Name L	Volt	Power (W)	material Roh	L _{wire}	I _{load} (Amp)	R _{wire}	V _{drop}	V _{drop} %	I _{C.B}	I _{cable}	Cable Cross section area	Circuit Breaker
Ground	B1														
		room 1	L 1	220	493	17.5*10 ⁻⁹	5	2.49	0.12	0.29	0.13	2.86	3.29	1.5	13
		bathroom	L 2	220	218.4	17.5*10 ⁻⁹	13	1.10	0.15	0.17	0.08	1.27	1.46	1.5	13
		comp lab	L 3	220	373	17.5*10 ⁻⁹	11.5	1.88	0.13	0.25	0.11	2.17	2.49	1.5	13
		room 2	L 4	220	426	17.5*10 ⁻⁹	17.5	2.15	0.20	0.44	0.20	2.47	2.85	1.5	13
		Corridor 1	L 5	220	400	17.5*10 ⁻⁹	18.5	2.02	0.22	0.44	0.20	2.32	2.67	1.5	13
		gallery	L 6	220	600	17.5*10 ⁻⁹	18	3.03	0.21	0.64	0.29	3.48	4.01	1.5	13
		resipation	L 7	220	80	17.5*10 ⁻⁹	5	0.40	0.06	0.02	0.01	0.46	0.53	1.5	13
		office 1	L 8	220	240	17.5*10 ⁻⁹	6	1.21	0.07	0.08	0.04	1.39	1.60	1.5	13
		office 2	L 9	220	240	17.5*10 ⁻⁹	6	1.21	0.07	0.08	0.04	1.39	1.60	1.5	13
		stairs 1	L 10	220	35	17.5*10 ⁻⁹	7	0.18	0.08	0.01	0.01	0.20	0.23	1.5	13
		stairs 2	L 11	220	24	17.5*10 ⁻⁹	5	0.12	0.06	0.01	0.00	0.14	0.16	1.5	13
		stairs 3	L 12	220	47.2	17.5*10 ⁻⁹	8	0.24	0.09	0.02	0.01	0.27	0.32	1.5	13
		sum				3176.6									

Table 48: power of lighting for F.F.

Lighting															
Floor	Block	Circuit name	Name L	Volt	Power (W)	material Roh	L _{wire}	I _{load} (Amp)	R _{wire}	V _{drop}	V _{drop} %	I _{C.B}	I _{cable}	Cable Cross section area	Circuit Breaker
first	B2														
		room 1	L 1	220	493	17.5*10 ⁻⁹	5	2.49	0.12	0.29	0.13	2.86	3.29	1.5	13
		bathroom	L 2	220	218.4	17.5*10 ⁻⁹	13	1.10	0.15	0.17	0.08	1.27	1.46	1.5	13
		comp lab	L 3	220	373	17.5*10 ⁻⁹	11.5	1.88	0.13	0.25	0.11	2.17	2.49	1.5	13
		room 2	L 4	220	426	17.5*10 ⁻⁹	17.5	2.15	0.20	0.44	0.20	2.47	2.85	1.5	13
		Corridor 1	L 5	220	320	17.5*10 ⁻⁹	16	1.62	0.19	0.30	0.14	1.86	2.14	1.5	13
		gallery	L 6	220	600	17.5*10 ⁻⁹	18	3.03	0.21	0.64	0.29	3.48	4.01	1.5	13
		office 3	L 7	220	360	17.5*10 ⁻⁹	5	1.82	0.06	0.11	0.05	2.09	2.40	1.5	13
		office 1	L 8	220	240	17.5*10 ⁻⁹	6	1.21	0.07	0.08	0.04	1.39	1.60	1.5	13
		office 2	L 9	220	240	17.5*10 ⁻⁹	6	1.21	0.07	0.08	0.04	1.39	1.60	1.5	13
		stairs 1	L 10	220	35	17.5*10 ⁻⁹	7	0.18	0.08	0.01	0.01	0.20	0.23	1.5	13
		stairs 2	L 11	220	24	17.5*10 ⁻⁹	5	0.12	0.06	0.01	0.00	0.14	0.16	1.5	13
		stairs 3	L 12	220	47.2	17.5*10 ⁻⁹	8	0.24	0.09	0.02	0.01	0.27	0.32	1.5	13
		sum				3376.6									

Table 49: power of lighting for S.F.

Lighting																
Floor	Block	Circuit name	Name L	Volt	Power (W)	material Roh	L _{wire}	I _{load} (Amp)	R _{wire}	V _{drop}	V _{drop} %	I _{C.B}	I _{cable}	Cable Cross section area	Circuit Breaker	
first	B3															
		room 1	L 1	220	493	17.5*10 ⁻⁹	5	2.49	0.12	0.29	0.13	2.86	3.29	1.5	13	
		bathroom	L 2	220	218.4	17.5*10 ⁻⁹	13	1.10	0.15	0.17	0.08	1.27	1.46	1.5	13	
		comp lab	L 3	220	373	17.5*10 ⁻⁹	11.5	1.88	0.13	0.25	0.11	2.17	2.49	1.5	13	
		room 2	L 4	220	426	17.5*10 ⁻⁹	17.5	2.15	0.20	0.44	0.20	2.47	2.85	1.5	13	
		Corridor 1	L 5	220	320	17.5*10 ⁻⁹	16	1.62	0.19	0.30	0.14	1.86	2.14	1.5	13	
		gallary	L 6	220	600	17.5*10 ⁻⁹	18	3.03	0.21	0.64	0.29	3.48	4.01	1.5	13	
		office 3	L 7	220	360	17.5*10 ⁻⁹	5	1.82	0.06	0.11	0.05	2.09	2.40	1.5	13	
		office 1	L 8	220	240	17.5*10 ⁻⁹	6	1.21	0.07	0.08	0.04	1.39	1.60	1.5	13	
		office 2	L 9	220	240	17.5*10 ⁻⁹	6	1.21	0.07	0.08	0.04	1.39	1.60	1.5	13	
		stairs 1	L 10	220	35	17.5*10 ⁻⁹	7	0.18	0.08	0.01	0.01	0.20	0.23	1.5	13	
		stairs 2	L 11	220	24	17.5*10 ⁻⁹	5	0.12	0.06	0.01	0.00	0.14	0.16	1.5	13	
		stairs 3	L 12	220	47.2	17.5*10 ⁻⁹	8	0.24	0.09	0.02	0.01	0.27	0.32	1.5	13	
		sum				3376.6										

5.2.5 Main circuit breaker for sockets.

Table 50: power of socket for G.F.

Socket																	
Floor	Block	Circuit name	# of socket	Volt	Amper	Toatl power	Power (W) *F (0.3)	material Roh	L _{wire}	I _{load} (Amp)	R _{wire}	V _{drop}	V _{drop} %	I _{C.B}	I _{cable}	Cable Cross section area	Circuit Breaker
Ground	B1																
		C1	4	220	16	1000	300	2.5*10 ⁻⁹	15.5	1.36	0.22	0.30	0.13	1.57	1.80	2.5	16
		C2	3	220	16	750	225	2.5*10 ⁻⁹	14	1.02	0.20	0.20	0.09	1.18	1.35	2.5	16
		C3	5	220	16	1250	375	2.5*10 ⁻⁹	5.5	1.70	0.08	0.13	0.06	1.96	2.25	2.5	16
		C4	5	220	16	1250	375	2.5*10 ⁻⁹	6	1.70	0.08	0.14	0.07	1.96	2.25	2.5	16
		C5	5	220	16	1250	375	2.5*10 ⁻⁹	7	1.70	0.10	0.17	0.08	1.96	2.25	2.5	16
		C6	4	220	16	1000	300	2.5*10 ⁻⁹	6	1.36	0.08	0.11	0.05	1.57	1.80	2.5	16
		C7	6	220	16	1500	450	2.5*10 ⁻⁹	6	2.05	0.08	0.17	0.08	2.35	2.71	2.5	16
		C8	3	220	16	750	225	2.5*10 ⁻⁹	13	1.02	0.18	0.19	0.08	1.18	1.35	2.5	16
		C9	4	220	16	1000	300	2.5*10 ⁻⁹	8.5	1.36	0.12	0.16	0.07	1.57	1.80	2.5	16
		C10	3	220	16	750	225	2.5*10 ⁻⁹	8	1.02	0.11	0.11	0.05	1.18	1.35	2.5	16
		C11	2	220	16	500	150	2.5*10 ⁻⁹	7	0.68	0.10	0.07	0.03	0.78	0.90	2.5	16
		C12	2	220	16	500	150	2.5*10 ⁻⁹	6.5	0.68	0.09	0.06	0.03	0.78	0.90	2.5	16
	Sum		46			11500											

Table 51: power of socket for F.F.

Socket																	
Floor	Block	Circuit name	# of socket	Volt	Amper	Toatl power	Power (W) *F (0.3)	material Roh	L wire	I _{load} (Amp)	R wire	V drop	Vdrop %	I C.B	I cable	Cable Cross section area	Circuit Breaker
First	B2																
		C1	4	220	16	1000	300	2.5*10 ⁻⁹	15.5	1.36	0.22	0.30	0.13	1.57	1.80	2.5	16
		C2	2	220	16	500	150	2.5*10 ⁻⁹	2	0.68	0.03	0.02	0.01	0.78	0.90	2.5	16
		C3	5	220	16	1250	375	2.5*10 ⁻⁹	5.5	1.70	0.08	0.13	0.06	1.96	2.25	2.5	16
		C4	5	220	16	1250	375	2.5*10 ⁻⁹	6	1.70	0.08	0.14	0.07	1.96	2.25	2.5	16
		C5	5	220	16	1250	375	2.5*10 ⁻⁹	7	1.70	0.10	0.17	0.08	1.96	2.25	2.5	16
		C6	4	220	16	1000	300	2.5*10 ⁻⁹	6	1.36	0.08	0.11	0.05	1.57	1.80	2.5	16
		C7	6	220	16	1500	450	2.5*10 ⁻⁹	6	2.05	0.08	0.17	0.08	2.35	2.71	2.5	16
		C8	3	220	16	750	225	2.5*10 ⁻⁹	13	1.02	0.18	0.19	0.08	1.18	1.35	2.5	16
		C9	4	220	16	1000	300	2.5*10 ⁻⁹	21	1.36	0.29	0.40	0.18	1.57	1.80	2.5	16
		C10	3	220	16	750	225	2.5*10 ⁻⁹	9	1.02	0.13	0.13	0.06	1.18	1.35	2.5	16
		C11	2	220	16	500	150	2.5*10 ⁻⁹	7	0.68	0.10	0.07	0.03	0.78	0.90	2.5	16
		C12	2	220	16	500	150	2.5*10 ⁻⁹	6.5	0.68	0.09	0.06	0.03	0.78	0.90	2.5	16
	Sum		45			11500											

Table 52: power of socket for S.F.

Socket																	
Floor	Block	Circuit name	# of socket	Volt	Amper	Total power	Power (W)*F (0.3)	material Roh	L wire	I _{load} (Amp)	R wire	V drop	Vdrop %	I C.B	I cable	Cable Cross section area	Circuit Breaker
Second	B1																
		C1	4	220	16	1000	300	2.5*10 ⁻⁹	15.5	1.36	0.22	0.30	0.13	1.57	1.80	2.5	16
		C2	2	220	16	500	150	2.5*10 ⁻⁹	2	0.68	0.03	0.02	0.01	0.78	0.90	2.5	16
		C3	5	220	16	1250	375	2.5*10 ⁻⁹	5.5	1.70	0.08	0.13	0.06	1.96	2.25	2.5	16
		C4	5	220	16	1250	375	2.5*10 ⁻⁹	6	1.70	0.08	0.14	0.07	1.96	2.25	2.5	16
		C5	5	220	16	1250	375	2.5*10 ⁻⁹	7	1.70	0.10	0.17	0.08	1.96	2.25	2.5	16
		C6	4	220	16	1000	300	2.5*10 ⁻⁹	6	1.36	0.08	0.11	0.05	1.57	1.80	2.5	16
		C7	6	220	16	1500	450	2.5*10 ⁻⁹	6	2.05	0.08	0.17	0.08	2.35	2.71	2.5	16
		C8	3	220	16	750	225	2.5*10 ⁻⁹	13	1.02	0.18	0.19	0.08	1.18	1.35	2.5	16
		C9	4	220	16	1000	300	2.5*10 ⁻⁹	21	1.36	0.29	0.40	0.18	1.57	1.80	2.5	16
		C10	3	220	16	750	225	2.5*10 ⁻⁹	9	1.02	0.13	0.13	0.06	1.18	1.35	2.5	16
		C11	2	220	16	500	150	2.5*10 ⁻⁹	7	0.68	0.10	0.07	0.03	0.78	0.90	2.5	16
		C12	2	220	16	500	150	2.5*10 ⁻⁹	6.5	0.68	0.09	0.06	0.03	0.78	0.90	2.5	16
	Sum		45			11500											

5.2.6 Main circuit breaker for elevators.

Table 53: Power of elevators.

Elevator calculations										
	Speed(m/s)	Weight of the cabinet	Number of the elevator	DF	power for one elevator (W)	I load	IC.B (A)	I cable	(A)C.B	Cross-section Cable
one elevator	2	1000Kg	1	0.77	12000	14.04	16.14	18.57	22	6 mm ²

Table 54: Main circuit breaker calculation.

Main Circuit Breaker								
Floor	Circuit board name	Total Power (W)	I _{load} (A)	I _{C.B} (A)	I _{cable} (A)	Circuit Breaker (A)	Cable Cross-section area	Phase
Ground	B1							
	Elevator	12000	14.04	16.15	18.57	22	6 mm ²	3 Phase
	M.C.B -GF	14676.6	60.04	69.05	79.40	80	35 mm ²	3 Phase
First	B2							
	C.B -FF	14876.6	60.86	69.99	80.49	90	35 mm ²	3 Phase
Second	B3							
	C.B -SF	14876.6	60.86	69.99	80.49	90	35 mm ²	3 Phase
M.C.B		44429.8	60.75	69.87	80.35	90	35 mm ²	3 Phase

5.2.7 Elevators Calculations:-

We relied on the evaluation method in calculation instead of relying on the requirements of the code, because it depends on many aspects such as population, handling capacity, speed, capacity, time interval, and waiting time instead of the code that depends on the area of the building.

Calculations:-

Total area of the building =1885 m².

Diversified normal Office Building (10-12) m² (MEEB book 12th).

Percent handling capacity (PHC) = (14-16) % (MEEB book 12th).

Interval (I) for good service (25-29) sec (MEEB book 12th).

Waiting time (15-17) sec (MEEB book 12th).

$$1/ \text{Population} = \frac{\text{Total area of the building}}{\text{Diversified normal Office Building}} = \frac{1885}{10} = 188.5$$

$$2/\text{Handling capacity (HC)} = \text{PHC} * \text{Population} = 16\% * 188.5 = 30.16 \text{ Persons/5min}$$

3/ Selection Options

Table 55: elevators options and selection.

Options	2500/350	2500/400	3000/350	3000/400	3500/350	3500/400
P	13	13	16	16	19	19
RT	57	55	62	60	68	66

hc	68.42	70.91	77.42	80.00	83.82	86.36
N	0.44	0.43	0.39	0.38	0.36	0.35
N*	1	1	1	1	1	1

We note that the building does not need elevators, but we put one for urgent cases

Select (2500/350) ib/m²

P: Car passenger capacity.

RT: Round trip time.

hc: Handing capacity..... $hc = \frac{300 \times p}{RT}$.

N: No. of elevators..... $N = \frac{H}{hc}$.

N*: No. of elevators.

5.3 Photovoltaic System Design (PV):-

5.3.1 Introduction:

The PV system design is a system produce electric from sun rays and it's consider green energy, by using this system it can reducing the cost of the building electricity bill .

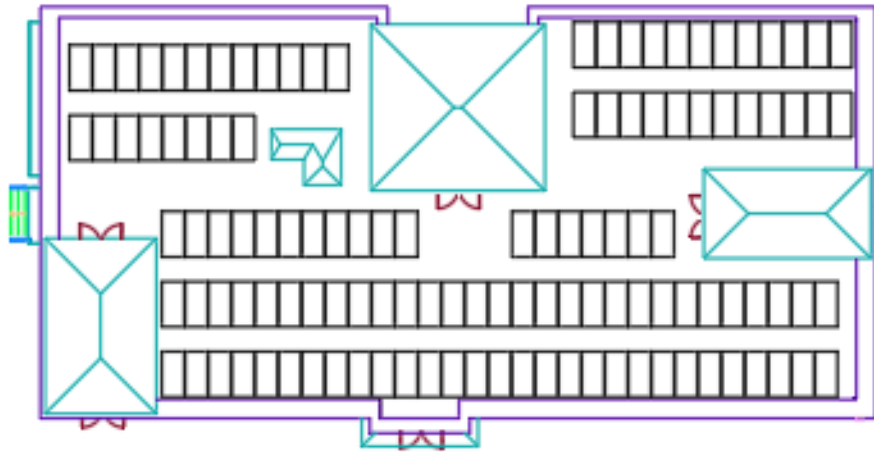
5.3.2 Design:

After check what the best design for land panel portrait or landscape the portrait gives 120 panel and landscape gives 112 panel so the portrait is the best.

The capacity of system = 120*320 wp = 38.5 KWp.

Active Area = 120 * (1.95* 0.99) = 231.66 m^{^2}

5.3.3 AutoCAD design:



120 module

Figure 185: portrait panel distribution in AutoCAD.

5.3.4 Module specification:

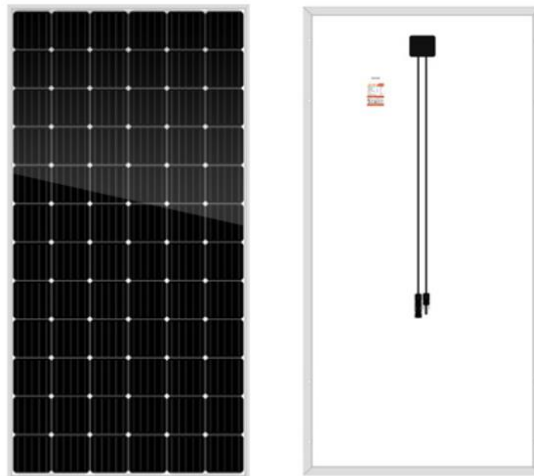


Figure 186: Panel specification.

Quick Details

Brand Name:	sunket	Model Number:	SKT400M-0265
Type:	Standard Solar Panel	Size:	1956*992*40mm
Name:	400 watt solar panel	color:	silvery
Weight:	23kg	Solar Cells:	156*156(72pcs)
Front Glass:	3.2 mm tempered, low iron	Frame:	Anodized aluminum alloy
Junction Box:	IP67	Mechanical Load:	5400 Pa
Warranty:	25 Years	Certificate:	TUV/CQC/CE/ISO

Module Type	SKT395M6-24	SKT400M6-24
Maximum Power- Pmax(W)	395	400
Open Circuit Voltage - Voc(V)	49.5	49.8
Short- Circuit Current - Isc(A)	10.23	10.36
Voltage at Pmax -Vmp(V)	41.4	41.7
Current at Pmax - Imp(A)	9.55	9.60
Module Efficiency - η_m (%)	19.92	20.17

Figure 187: Panel specification.

5.3.5 Design PV module by using PVsyst program :

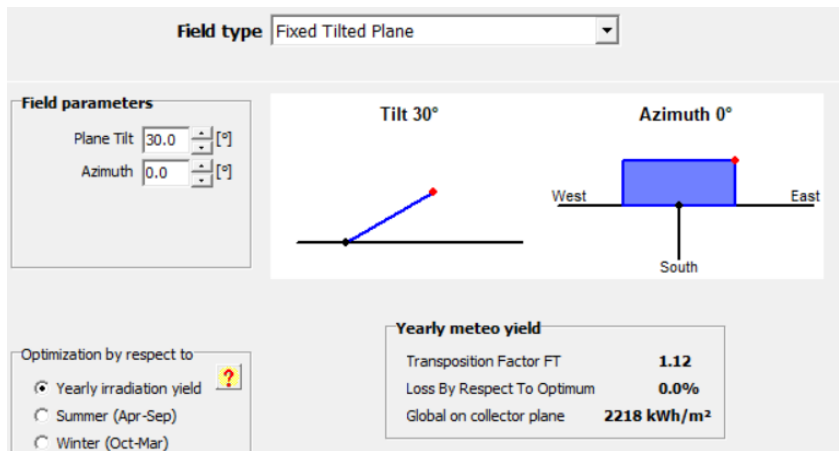


Figure 188: Orientation of panel.

Global System configuration		Global system summary	
1	Number of kinds of sub-arrays	Nb. of modules	120
		Module area	233 m ²
		Nb. of inverters	2.5
		Nominal PV Power	38.4 kWp
		Maximum PV Power	37.5 kWdc
		Nominal AC Power	30.0 kWac

Sub-array name and Orientation		Presizing Help	
Name	PV Array	<input type="radio"/> No sizing	Enter planned power <input type="text" value="41.3"/> kWp
Orient.	Fixed Tilted Plane	<input type="radio"/> Resize	... or available area(modules) <input type="text" value="250"/> m ²
	Tilt 30° Azimuth 0°		

Select the PV module	
Available Now	Filter All PV modules
Eurener	320 Wp 32V Si-poly Eurener Clear PEPV/72 320w Since 2017 Manufacturer 2019
Sizing voltages : Vmpp (60°C) 32.0 V Voc (-10°C) 51.9 V	

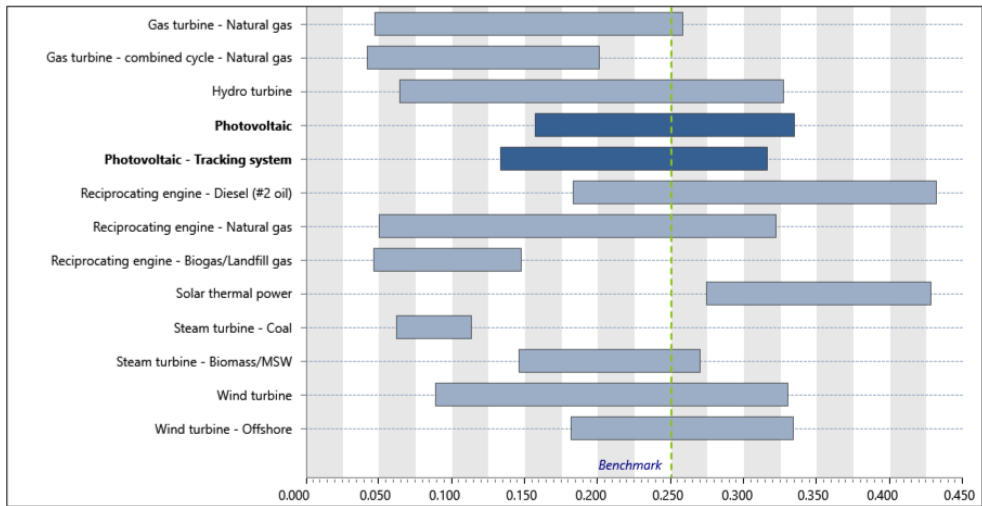
Select the inverter	
Available Now	Output voltage 400 V Tri 50Hz
Generic	12 kW 350 - 600 V TL 50/60 Hz 12 kWac inverter with 2 MPPT Since 2012
Nb of MPPT inputs	5
<input checked="" type="checkbox"/> Use multi-MPPT feature	Operating Voltage: 350-600 V Input maximum voltage: 800 V
Inverter power used 30.0 kWac inverter with 2 MPPT	

Design the array		Operating conditions		The inverter power is slightly undersized.	
Number of modules and strings		Vmpp (60°C)	384 V	<input type="radio"/> Max. in data Max. operating power 34.5 kW at 1000 W/m ² and 50°C	
Mod. in series	12 <input type="checkbox"/> between 11 and 15	Vmpp (20°C)	462 V		
Nbre strings	10 <input type="checkbox"/> between 8 and 10	Voc (-10°C)	622 V		
Overload loss	0.7 %	Plane irradiance	1000 W/m ²		
Pnom ratio	1.28 <input type="button" value="Show sizing"/>	Imp (STC)	85.5 A		
Nb. modules	120	Isc (STC)	90.6 A		
Area	233 m ²	Isc (at STC)	90.6 A	Array nom. Power (STC) 38.4 kWp	

Figure 189 : Design PV from PVsyst 1

5.3.6 Design PV module by using RETscreen program :

Energy production cost - Central-grid - Range (\$/kWh)



Benchmark: 0.25 \$/kWh

Figure 190: Benchmark-power plants.

Location | Climate data

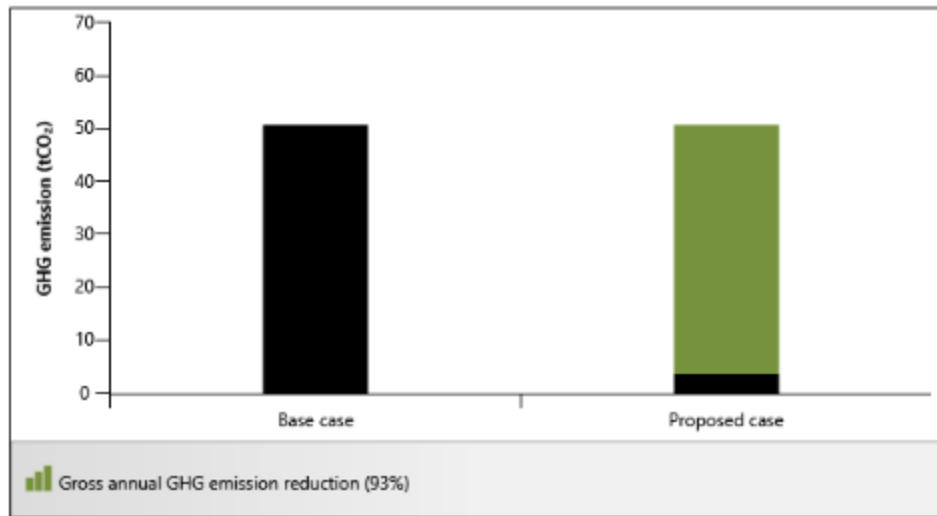
Location



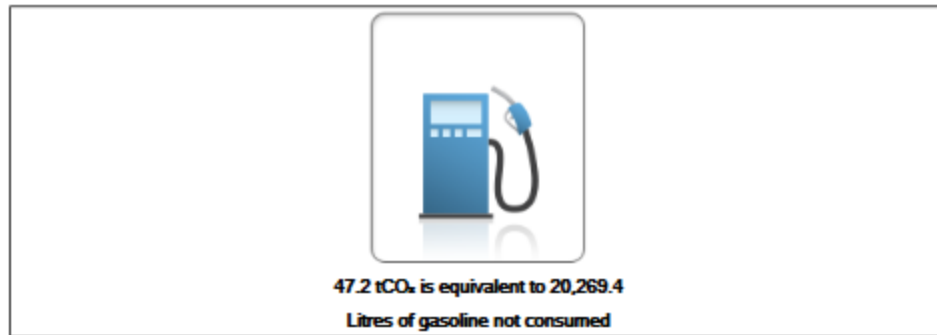
	Unit	Climate data location	Facility location
Name		Israel - Jericho	Israel
Latitude	'N	31.9	32.2
Longitude	'E	35.5	35.2
Climate zone		3B - Warm - Dry	3B - Warm - Dry
Elevation	m	-275	-275

Figure 191 : Location Data.

GHG emission



GHG equivalence



GHG emission		
Base case	50.7	tCO ₂
Proposed case	3.6	tCO ₂
Gross annual GHG emission reduction	47.2	tCO₂

Figure 192 : Emissions result.

Financial viability

Financial parameters

Inflation rate	%	2%
Project life	yr	20
Debt ratio	%	70%
Debt interest rate	%	7%
Debt term	yr	15

Costs | Savings | Revenue

Initial costs			
Feasibility study	0%	\$	0
Development	0%	\$	0
Engineering	0.43%	\$	500
Power system	99.5%	\$	115,500
Balance of system & miscellaneous	0.04%	\$	50
Total initial costs	100%	\$	116,050
Annual costs and debt payments			
O&M		\$	1,617
Debt payments - 15 yrs		\$	8,919
Total annual costs		\$	10,536
Periodic costs (credits)			
Periodic costs - 8 yrs		\$	1,500
User-defined - 16 yrs		\$	1,500
End of project life - cost		\$	0
Annual savings and revenue			
Electricity export revenue		\$	16,233
GHG reduction revenue		\$	2,335
Total annual savings and revenue		\$	18,568

Financial viability

Pre-tax IRR - equity	%	21.2%
Pre-tax IRR - assets	%	5.5%
Simple payback	yr	6.8
Equity payback	yr	5.2

Figure 193: Financial Viability.

Cash flow

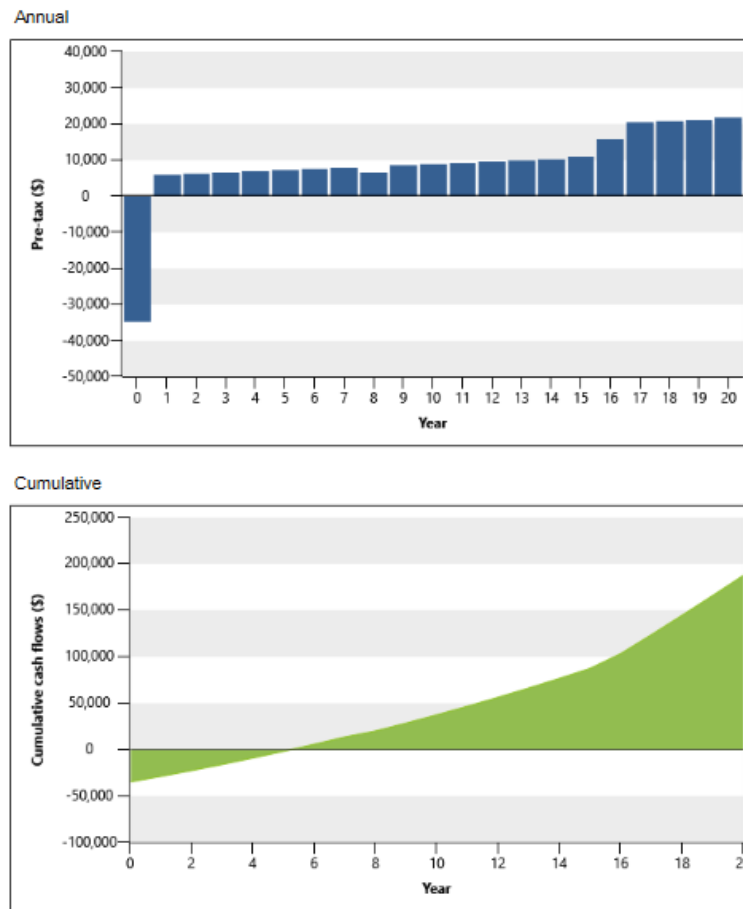


Figure 194 : Cash Flow Diagram.

Target	Electricity exported to grid MWh	Electricity export revenue \$	GHG emission reduction tCO ₂
Proposed case	64.9	16,233	47.2

Figure 195: Target from energy.

5.3.7 Energy Cost

NIS/KWh = 0.7

Convert NIS/KWh to \$/KWh = $0.6/3.5 = 0.18$ USD → 0.25CAD

So 1 MWh = 180 USD

The system Electricity exported to grid = 64.9 MWh

Energy cost = 16233 \$/year from RET screen Program

5.3.8 PV system Cost:

Power system consist of:

- 1) Cost of modules

$$= \text{No. of module} * \text{watt} * \text{price/watt}$$

$$= 120 \text{ module} * 320 * 0.5\$/\text{watt} = 19200 \$$$

Custom fees: assume an interest of 1.7 to delivered to Palestine so &

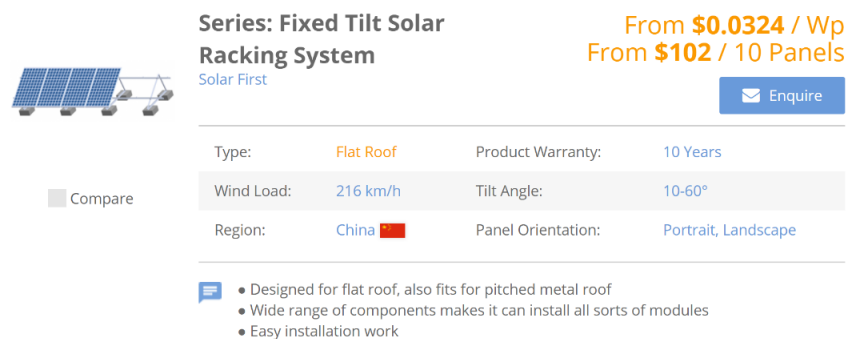
$$\text{The cost of modules} = 1.7 * 19200 = 32640 \$$$

- 2) cost of inverter

The following figure shows the price of inverter

$$\text{Inverter cost} = \text{Price} * \text{No. of inverter}$$

$$= 300\$ * 5 = 1500 \$$$



Series: Fixed Tilt Solar Racking System
Solar First

From **\$0.0324 / Wp**
From **\$102 / 10 Panels**

[Enquire](#)

Type:	Flat Roof	Product Warranty:	10 Years
Wind Load:	216 km/h	Tilt Angle:	10-60°
Region:	China	Panel Orientation:	Portrait, Landscape

- Designed for flat roof, also fits for pitched metal roof
- Wide range of components makes it can install all sorts of modules
- Easy installation work

Figure 196: PV stand cost.

- 3) Stand 102\$/10panels so → 120 cost 1224 \$.

- 4) Cables the 4.8 KW cost 1400\$ so the 38.5 KW cost 11229 \$.

The following figure shows the cost of cable from BESTSUN site.

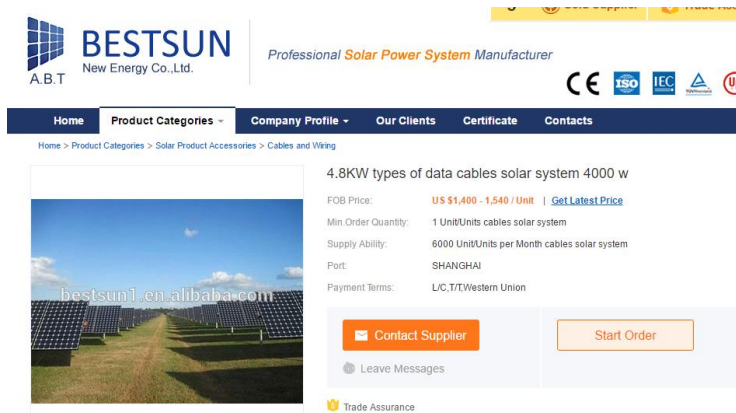


Figure 197: Cable cost from BESTSUN

5) Cost of installation:

Each meter of cable the workers take 2\$ for 1000 meter length as a total length of 250 m² area of roofing.

$$\text{Cost} = 2 \times 1000 = 2000\$$$

6) Fixed cost = 32640 \$ + 1500 \$ + 1224 \$ + 11229 \$ + 2000 \$ = 48593\$.

8) Cost each year = operation cost = 2432 \$/year

Summary For tilted modules:

PV modules:	poly technology
Configuration:	landscape tilt = 30
Active Area	231.66 m ²
Nominal power of module	320 Wp
No of modules	120
#Inverter capacity	12 kW // 5 inverters
# of series	12
# of strings	10
Electricity production	64.9 MWh/year
Fixed cost	= 48593 \$
Cost each year	= 2432 \$/year
Energy Cost	= 16233 \$
Total annual savings	= 18568 \$

Payback period	5.2 years
----------------	-----------

5.4 Mechanical design

5.4.1 Introduction:-

The mechanical system is considered one of the important systems for any building, and attention must be paid to the design through many problems in the buildings due to the poor design of the mechanical system such as gathering water on the roof and slow water drainage and leakage.... etc.

The mechanical design that includes many aspects such as water supply system, sewage system, elevators, ventilation, heating, air conditioning, and fire extinguishing system, will be designed in this section.

5.4.2 Capacity of tanks:-

Looking at the following table, the average person consumes water daily

Person in school is 57 liters (0.057 m³/day).

The number of student in the building =380 student.

Water consumptions per student = $0.057 \text{ m}^3/\text{day}$.

Quantity of water consumption = $0.057 * 380 = 21.66 \text{ m}^3/\text{day}$.

Assume we use 30% of the volume of the tank, and we will use it for firefighting.

The volume of water that we will use to fight fires = $0.3 * 21.66 = 6.50 \text{ m}^3/\text{day}$.

The volume of water required to be provided daily = $21.66 + 6.50 = 28.16 \text{ m}^3/\text{day}$.

We will create rainwater and gray water tanks to reduce fresh water consumption.

Building Usage	Per Capita (as Listed) Daily Usage	
	Gallons	Liters
Airports (per passenger)	3-5	11-19
Apartments, multiple-family (per resident)	60	227
Bath houses (per bather)	10	38
Camps		
Construction, semipermanent (per worker)	50	189
Day with no meals served (per camper)	15	57
Luxury (per camper)	100-150	378-568
Resorts, day and night, with limited plumbing (per camper)	50	189
Tourist, with central bath and toilet facilities (per person)	35	132
Cottages with seasonal occupancy (per resident)	50	189
Courts, tourist, with individual bath units (per person)	50	189
Clubs		
Country (per resident member)	100	378
Country (per nonresident member present)	25	95
Dwellings		
Boardinghouses (per boarder)	50	189
Additional kitchen requirements for nonresident boarders	10	38
Luxury (per person)	100-150	378-568
Multiple-family apartments (per resident)	40	151
Rooming houses (per resident)	60	227
Single family (per resident)	50-75	189-284
Estates (per resident)	100-150	378-568
Factories (per person per shift)	15-35	57-132
Highway rest area (per person)	5	19
Hotels with private baths (two persons per room)	60	227
Hotels without private baths (per person)	50	189
Institutions other than hospitals (per person)	75-125	284-473
Hospitals (per bed)	250-400	946-1514
Laundries, self-service (per washing)	50	189
Livestock (per animal)		
Cattle (drinking)	12	45
Dairy (drinking and servicing)	35	132
Goat (drinking)	2	8
Hog (drinking)	4	15
Horse (drinking)	12	45
Mule (drinking)	12	45
Sheep (drinking)	2	8
Steer (drinking)	12	45
Motels with bath, toilet, and kitchen facilities (per bed space)	50	189
With bed and toilet (per bed space)	40	151
Parks		
Overnight, with flush toilets (per camper)	25	95
Trailer, with individual bath units, no sewer connection (per trailer)	25	95
Trailer, with individual baths, connected to sewer (per person)	50	189
Picnic		
With bath houses, showers, and flush toilets (per picnicker)	20	76
With toilet facilities only (per picnicker)	10	38
Poultry		
Chickens (per 100)	5-10	19-38
Turkeys (per 100)	10-18	38-68
Restaurants with toilet facilities (per patron)	7-10	26-38
Without toilet facilities (per patron)	2.5-3	9-11
With bar/cocktail lounge (additional quantity per patron)	2	8
Schools		
Boarding (per pupil)	75-100	284-378
Day, with cafeteria, gymnasium, and showers (per pupil)	25	95
Day, with cafeteria but no gymnasiums or showers (per pupil)	20	76
Day, without cafeteria, gymnasiums, or showers (per pupil)	15	57
Service stations (per vehicle)	10	38
Stores (per toilet room)	400	1514
Swimming pools (per swimmer)	10	38
Theaters		
Drive-in (per car space)	5	19
Movie (per auditorium seat)	5	19
Workers		
Construction (per person per shift)	50	189
Day (school or office, per person per shift)	15	57

Figure 198: Average daily water consumption per person .

5.4.3 Volume of Rainwater Tank:-

The amount of rainfall is generally affected on Palestine near and far from the Mediterranean Sea, The annual rainfall in the city of Jericho is $166 \text{ mm}/\text{m}^2 \text{ year}$ (Jericho Yearly Climate 2018).

The total surface area = 634.55 m^2

The actual surface area of the building from which water will be collected = 532.91 m^2 .

The amount of rain falling on the roof = $0.166 * 530 = 88 \text{ m}^3 / \text{year} = 0.0086 \text{ m}^3 / \text{day}$.

The volume of the used water tank is 88 m^3 , which constitutes approximately 1% of the daily water consumption.

5.4.4 Volume of gray water tank:-

Every day a person produces $0.002 \text{ m}^3 / \text{day}$ of gray water (Grondzik et al.2011).

Volume = $380 * 0.002 = 0.76 \text{ m}^3 / \text{day}$.

The grace period for using gray water is 3 days. So, the amount of gray water for about 3 days is $2.28 \text{ m}^3 / 3 \text{ day}$.

The total volume of fresh water $28.16 - 0.0086 = 28.15 \text{ m}^3 / \text{day}$.

Water is provided by the municipality every three days.

The total fresh water volume = $28.15 * 3 = 84.45 \text{ m}^3 / 3 \text{ day}$.

You can use a water tank on the surface with the following dimensions Radius of 75 cm and height of 180 cm.

The volume of the water tank on the roof = $3.14 * (0.75^2) * 1.80 = 3.17 \text{ m}^3$.

The size of the underground water tank we will use is = $(7 * 4 * 3) \text{ m}^3$.

5.4.5 Water supply system:-

The building's water supply network is one of the most important components of the mechanical system, as it means supplying the building with water to provide the required amount of water for the building. We use galvanized steel tubes for vertical pipes and use horizontal feeders and PVC pipes for the branches.

In this section, we will calculate the diameters of vertical pipes and horizontal and branch pipes. The following figure shows a small tank on the upper roof and a water tank at the bottom as well as a pump to pump the water up.

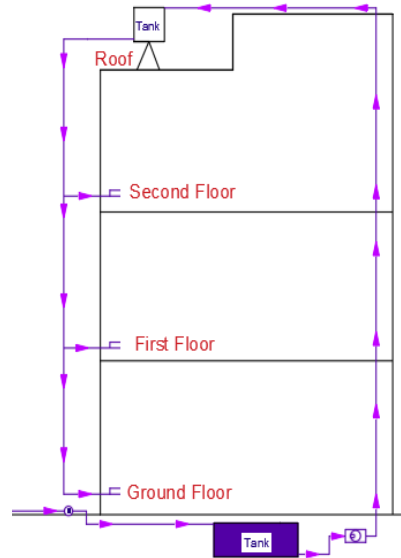


Figure 199: small tank on the upper roof and a water tank at the bottom.

5.4.6 Diameter calculations

The height of the tank is 6ft (1.8m)

The tank rises from the roof surface 6ft (1.8m)

The lavatory rises from ground floor 4ft.

This table shows the demand weights of fixtures unit.

Table 56: the demand weights of fixtures unit.

Fixture type	Occupancy	Type of supply control	Weight in fixture
Water closet	Public	Flush tank	5
Lavatory	Public	Faucet	2
Service sink	Office	Faucet	3

Table 57: Fixtures unit that connected with vertical pipe.

Fixture type	Number of fixture	Weight in fixture units (Fu's)	Total
Water closet	24	5	120
Lavatory	24	2	48
Total			168

The following diagram shows the weight of the fixture unit on each floor connected with the vertical pipe which we will use in calculating the pipe diameters.

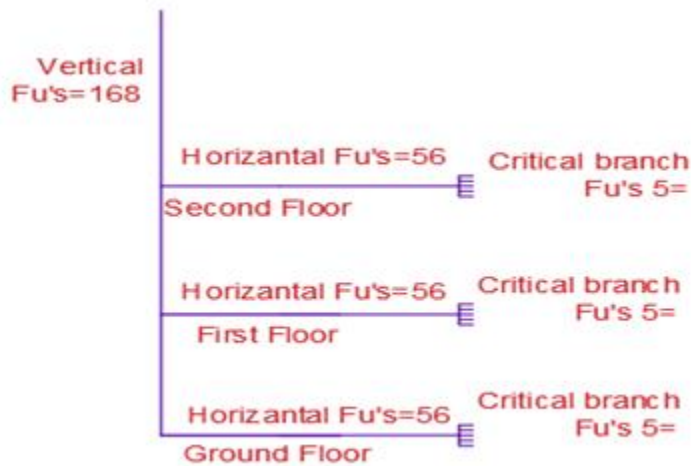


Figure 200: The total unit weight of the fixtures on each floor is connected with a stack.

For Ground Floor :-

Available pressure at ground floor (p) =0.433*h

$$h = 3*12+6+\frac{8}{2}-4 =42 \text{ ft}$$

$$p=0.433*42=18.2 \text{ psi}$$

Length_{vertical} =10+6+12*3 =52 ft.

Equivalent length_{vertical} =52*1.5=78 ft.

Length_{Horizontal} = 19 ft.

Equivalent length_{Horizontal} = 19 * 1.2 = 23 ft.

Length_{Branch} = 22 ft.

Equivalent length_{Branch} = 22 * 1.2 = 27 ft.

Fu's for vertical pipe = 168 Fu's.

According to followings figures the demand load = 56 GPM .the possible diameter for vertical pipe is shown table.

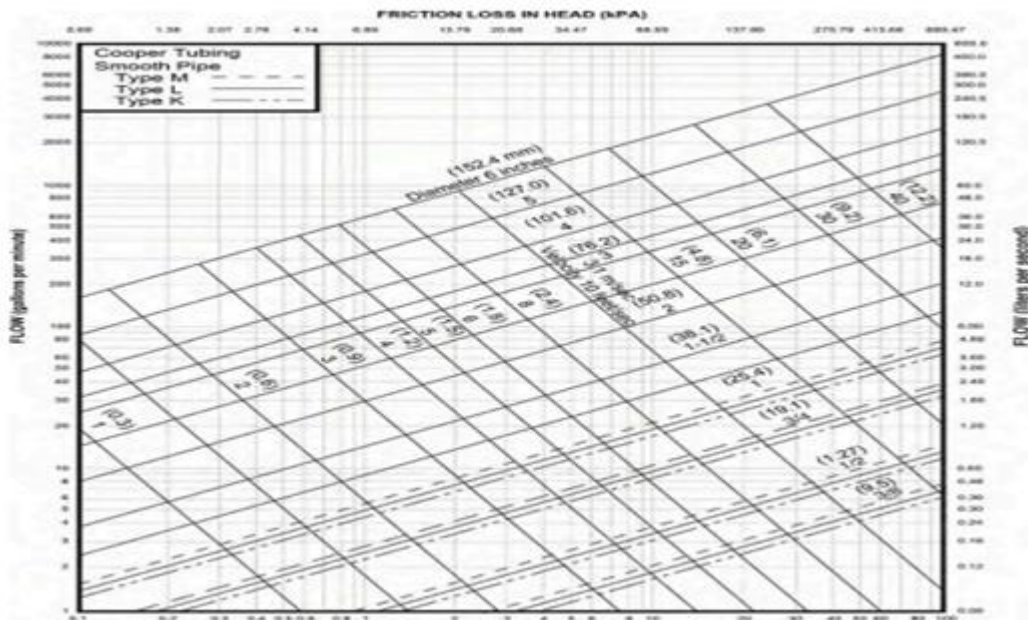
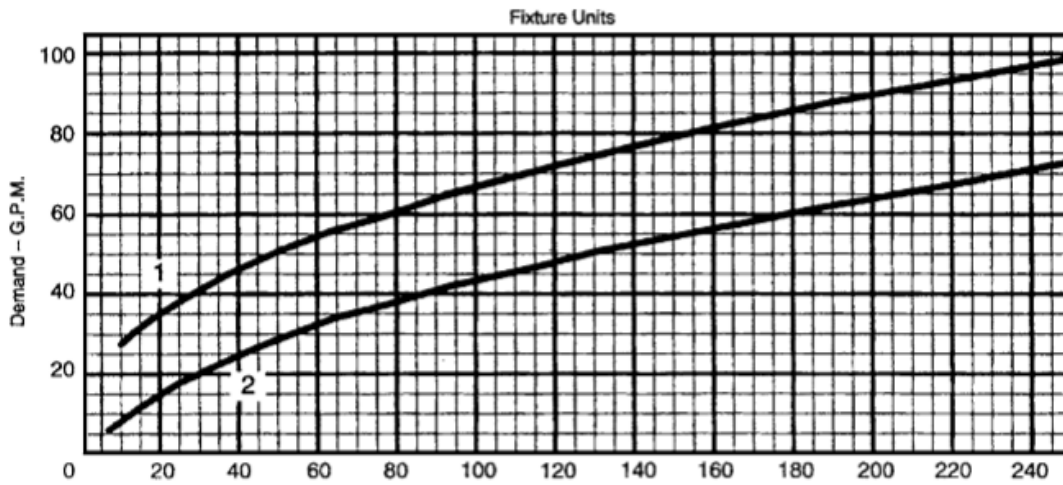


Figure 201: Friction loss chart for smooth pipe.

Fu's for Horizontal pipe = 56 Fu's.

According to figures the demand load =30 GPM .the possible diameter for Horizontal pipe is shown table.

Fu's for critical branch pipe =5 Fu's.

According to figures the demand load =5 GPM .the possible diameter for critical branch pipe is shown table.

Water flow (demand)

Vertical = 56 GPM

Diameter of the vertical Pipe

Possible Diameter(inch)	4"	3.5"	3"	2.5"	2"
Loss/100	0.12	0.25	0.4	1.1	2.8
Loss/78	0.01	0.2	0.31	0.86	2.19

Horizontal=30 GPM

Diameter of the horizontal Pipe

Possible Diameter(inch)	3"	2.5"	2"	1.5"	1.25"
Loss/100	0.13	0.3	0.9	3.4	8
Loss/23	0.03	0.07	0.21	0.78	1.84

Branch = 5 GPM

Diameter of the critical branch Pipe

Possible Diameter(inch)	1.5"	1.25"	1"	0.75"	0.5"
Loss/100	0.17	0.35	1	3.1	18
Loss/27	0.046	0.01	0.27	0.84	4.86

Summary of pipes diameters for the ground floor

Vertical pipe (losses=2.19 psi) → 2"

Horizontal pipe (losses=1.84 psi) → 1.25"

Branch pipe (losses=4.86 psi) → 0.5"

Total losses = 2.19+1.84+4.86 =8.89 psi < 10.2 psi

Table 58: Flow and pressure of typical plumbing fixtures

Fixture Served	Minimum		Maximum Flow Rate or Quantity
	Flow Rate gpm (L/s)	Pressure psi (kPa)	
Bathtub	4 (0.25)	20 (138)	
Bidet	2 (0.13)	20 (138)	
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)	2.2 gpm at 60 psi (0.14 L/s at 414 kPa)
Lavatory, public	2 (0.13)	8 (55)	0.5 gpm at 60 psi (0.03 L/s at 414 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)	2.2 gpm at 60 psi (0.14 L/s at 414 kPa)
Sink, service	3 (0.19)	8 (55)	2.2 gpm at 60 psi (0.14 L/s at 414 kPa)
Urinal, valve	12 (0.76)	25 (172)	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	25 (1.58)	45 (310)	4 gallons (15 L) per flushing cycle ^a
Water closet, siphonic, flushometer valve	25 (1.58)	35 (241)	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)	20 (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

According to table cleanses the critical pressure in the building is lavatory

So, Critical pressure = 8 Psi

The maximum allow losses = Available pressure - critical pressure = 18.2-8 = 10.2 psi.

- For first floor :-

Available pressure at first floor (p) = 0.433 * h

$$h = 2 * 12 + 6 + \frac{8}{2} - 4 = 30 \text{ ft}$$

$$p = 0.433 * 30 = 13 \text{ psi}$$

Length_{vertical} = 10 + 6 + 12 * 2 = 40 ft.

Equivalent length_{vertical} = 40 * 1.5 = 60 ft.

Length_{Horizontal} = 19 ft.

Equivalent length_{Horizontal} = 19 * 1.2 = 23 ft.

Length_{Branch} = 22 ft.

Equivalent length_{Branch} = 22 * 1.2 = 27 ft.

Fu's for vertical pipe = 112 Fu's.

According to followings figures the demand load =45 GPM .the possible diameter for vertical pipe is shown table.

Fu's for Horizontal pipe = 56 Fu's.

According to figures the demand load =30 GPM .the possible diameter for Horizontal pipe is shown table.

Fu's for critical branch pipe =5 Fu's.

According to figures the demand load =5 GPM .the possible diameter for critical branch pipe is shown table.

Water flow (demand)

Vertical = 45 GPM

Diameter of the vertical Pipe

Possible Diameter(inch)	3.5"	3"	2.5"	2"	1.5"
Loss/100	0.18	0.28	0.74	2	7.4
Loss/60	0.1	0.17	0.45	1.6	4.45

Horizontal=30 GPM

Diameter of the horizontal Pipe

Possible Diameter(inch)	3"	2.5"	2"	1.5"	1.25"
Loss/100	0.13	0.3	0.9	3.4	8
Loss/23	0.03	0.07	0.21	0.78	1.84

Branch = 5 GPM

Diameter of the critical branch Pipe

Possible Diameter(inch)	1.5"	1.25"	1"	0.75"	0.5"
Loss/100	0.17	0.35	1	3.1	18
Loss/27	0.046	0.01	0.27	0.84	4.86

Flow and pressure of typical plumbing fixtures

According to table cleanses the critical pressure in the building is lavatory

So, Critical pressure =8 Psi

The maximum allow losses = Available pressure -critical pressure = 13-8 =5 psi.

Summary of pipes diameters for the first floor

Vertical pipe (losses=1.6 psi) → 2"

Horizontal pipe (losses=1.84 psi) → 1.25"

Branch pipe (losses=0.84psi) → 0.75"

Total losses = 1.6+1.84+0.84 = 4.28 psi < 5 psi

- For Second Floor :-

Available pressure at first floor (p) =0.433*h

$$h = 12+6+\frac{8}{2}-4 = 18 \text{ ft}$$

$$p=0.433*18=7.8 \text{ psi}$$

Length_{vertical} =10+6+12= 28 ft

Equivalent length_{vertical} =40*1.5=42 ft

Length_{Horizontal} = 19 ft

Equivalent length_{Horizontal} =19*1.2 =23 ft

Length_{Branch} = 22 ft.

Equivalent length_{Branch} =22*1.2 =27 ft.

Fu's for vertical pipe = 112 Fu's.

According to followings figures the demand load =25 GPM .the possible diameter for vertical pipe is shown table.

Fu's for Horizontal pipe = 56 Fu's.

According to figures the demand load =30 GPM .the possible diameter for Horizontal pipe is shown table.

Fu's for critical branch pipe =5 Fu's.

According to figures the demand load =5 GPM .the possible diameter for critical branch pipe is shown table.

Water flow (demand)

Vertical = 25 GPM

Diameter of the vertical Pipe

Possible Diameter(inch)	2.5"	2"	1.5"	1.25"	1"
Loss/100	0.24	0.6	2.4	5	14
Loss/42	0.1	0.25	1	2.1	5.9

Horizontal=30 GPM

Diameter of the horizontal Pipe

Possible Diameter(inch)	3"	2.5"	2"	1.5"	1.25"
Loss/100	0.13	0.3	0.9	3.4	8
Loss/23	0.03	0.07	0.21	0.78	1.84

Branch = 5 GPM

Diameter of the critical branch Pipe

Possible Diameter(inch)	1.5"	1.25"	1"	0.75"	0.5"
Loss/100	0.17	0.35	1	3.1	18
Loss/27	0.046	0.01	0.27	0.84	4.86

Flow and pressure of typical plumbing fixtures

According to table cleanses the critical pressure in the building is lavatory

So, Critical pressure =8 Psi

The maximum allow losses = Available pressure -critical pressure = 7.8-8 =-0.2 psi.

Summary of pipes diameters for the second floor

Vertical pipe (losses=0.25 psi) → 2"

Horizontal pipe (losses=0.78 psi) → 1.5"

Branch pipe (losses=0.84 psi) → 0.75"

Total losses = 0.25+0.78+0.84=1.87 psi >-0.2 psi

Due to our use of the worst case design, we do not need a pump.

5.4.7 Pumping

The pressure we need to raise water at a height of 15.65 meters is 29.42 psi.

5.5 Drainage system

The drainage system is the most important challenges facing us in the design process, so it must work to be integrated with other systems. It is used to drain black and gray water out of the building through the drainage network. We may design it in a place that does not contradict from other systems such as the construction system ... etc.

Calculations of the diameters of horizontal and vertical pipes:-

In this section, the diameters of horizontal pipe (sewer) and vertical pipes (stack) will be calculated. The following table shows the type of fixture and drainage fixture unit value.

Table shows the type of fixture and drainage fixture unit value

Table 59: type of fixture and drainage fixture unit value.

Type Fixture	Drainage Fixture
Water Closet	4
Sink	2
Lavatory	1

Diameter of Pipe		Maximum Total Number of dfu Allowable			
		Horizontal Branch	Stacks ^b		
in.	mm ^c		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	<i>d</i>	<i>d</i>	<i>d</i>

Figure 202: Diameter of pipes and maximum total number of diffuser.

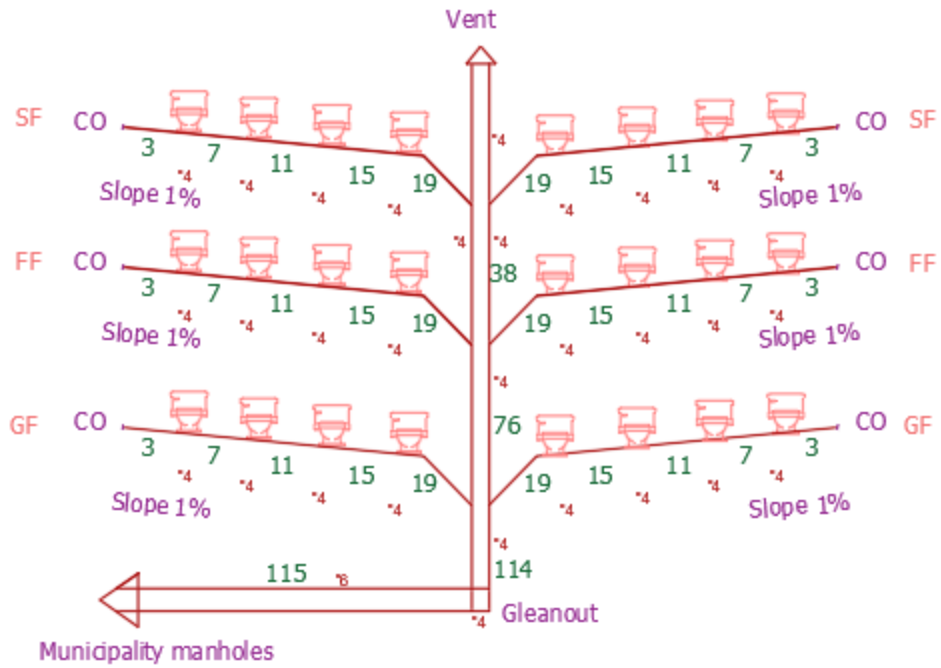


Figure 203: Required stack and sewer.

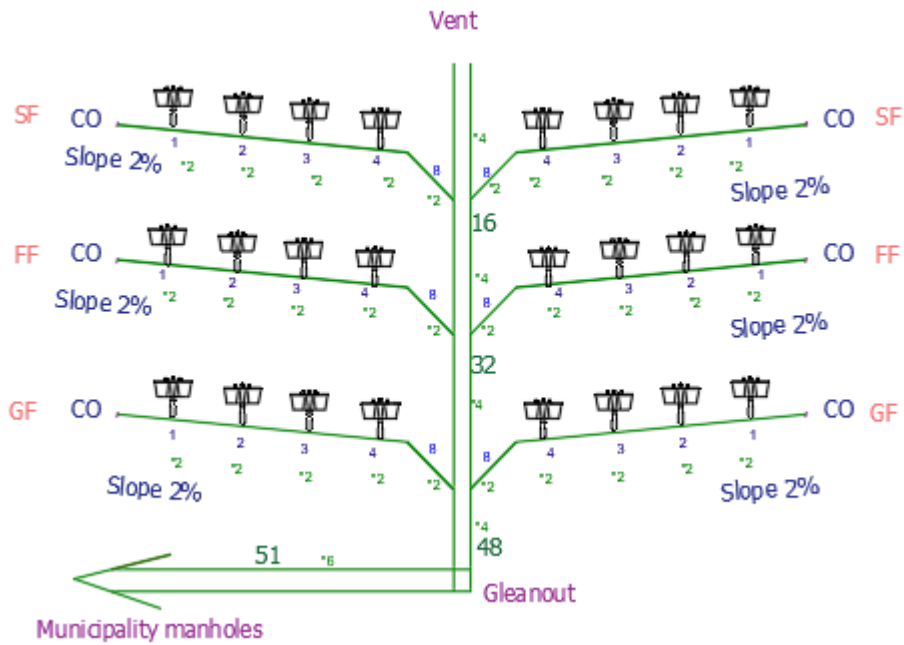


Figure 204: Required stack and sewer.

5.6 Designing heating, air-conditioning and ventilation systems

The HVAC system is generally regarded as heating only, cooling only, or ventilation only, or an air conditioning system, and can be a domestic or central system, used for thermal comfort in buildings. Therefore, the VRF system will be used to heat and cool the building because it is useful in public places, has high efficiency, reduces energy consumption and this system can connect more indoor unit to one outdoor unit.

The main component are:

- Outdoor unit.
- Control panel.
- Fan coil.
- Diffuser.

To design the VRF system, a simulation was taken from the Revit program. After simulation, the cooling capacity is greater than the heating capacity. The outdoor unit was chosen based on the cooling capacity of 138.751 kW (39.45 ton)

Air stage™ (AOUA264TLBVG-VRF systems)

Air Processor Company will be Air stage™ (VRF system) with a cooling capacity of 20 tons .We chose 2 of this type.



Figure 205: AOUA264TLBVG Air handler

The characteristics of the Air handler are:

- High operating energy efficiency
- Energy saving technology that boosts operating efficiency
- Perfect control of the path of the heat exchanger
- Advanced operating control

- Flexible pipe connection
- Flexible installation of the refrigerant with the refrigerant

First of all, find the volumetric flow rate for each area on the ground floor. Then the choice of the fan coil can be based on volumetric flow. The following calculations are an example of the volumetric flow rate

$$Q = \dot{v} \times \rho \times C_p \times (T_i - T_s)$$

Where

\dot{v} : the volumetric flow rate

ρ : the air density = 1.25Kg/m³

C_p air: 1KJ/Kg.K

$T_i(\text{inside}) = 36\text{C}^\circ$, $T_s(\text{supply}) = 5\text{C}^\circ$

Table 60: the volumetric flow rate for each building area.

Space Name	Area (m²)	Volume (m³)	Q (KW)	ú(m³/s)
<u>27 Class</u>	48	143.09	5.01	0.30
<u>31 Class</u>	55	138.43	5.34	0.32
<u>32 Corrdor</u>	124	309.79	5.32	0.32
<u>33 Dr Room</u>	33	81.92	1.50	0.09
<u>34 Lab</u>	34	84.41	3.10	0.19
<u>35 Labuarty</u>	86	213.77	5.50	0.33
<u>36 Police</u>	10	25.59	0.67	0.04
<u>37 Dr Room</u>	29	73.03	1.56	0.09
<u>38 Dr Room</u>	29	87.64	1.63	0.10
<u>39 Dr Room</u>	33	98.3	1.55	0.09
<u>40 Class</u>	48	143.09	4.97	0.30
<u>41 Class</u>	55	166.12	5.49	0.33
<u>42 Corrdor</u>	89	268.23	2.45	0.15
<u>43 Dr Room</u>	45	134.41	1.82	0.11
<u>44 Lab</u>	34	101.29	3.18	0.19
<u>45 Meet</u>	86	256.53	4.27	0.26
<u>46 Class</u>	48	143.09	4.97	0.30
<u>47 Class</u>	55	166.12	5.49	0.33
<u>48 Class</u>	45	134.41	3.88	0.23
<u>49 Corrdor</u>	89	268.23	2.45	0.15
<u>50 Dr Room</u>	29	87.64	1.63	0.10
<u>51 Dr Room</u>	33	98.3	1.55	0.09
<u>52 Lab</u>	34	101.29	3.26	0.20
<u>54 stage</u>	86	256.53	7.99	0.48

On the ground floor, there are three fan coils. The volumetric flow rate of one fan coil is calculated by adding the volumetric flow rate for each area connected to it, and it depends on the volumetric flow rate of the diffusers. The volumetric flow rate is 0.33 m³ / s (5.5 kw). Fan coil 1 (AP0246BHP1-E / TR) from Toshiba with a cooling capacity of about 7.1 kw which depends on the volumetric volume of the chosen diffuser. The figure shows the unit of the fan coil.



Figure 206: AP0246BHP1-E / TR fan coil

The characteristics of the fan coil are:

- Slim line design, with a depth of just 275mm helps

To simplify the installation, even when space is limited.

- Superior low noise operation. Noise output at low fan equates to just 26 dB(A).
- External static pressure can be raised up to 120 Pa for extensive ducting.
- Possible to connect a fresh air inlet duct to the unit, to maximize air quality and room air quality.
- Flexible design, allows the inlet air configuration to be configured between the standard rear inlet designs or, from the underside of the unit.
- Built-in high-lift drain pump.
- Air discharge spigot available as an option.



Figure 207: Kavadra diffuser.

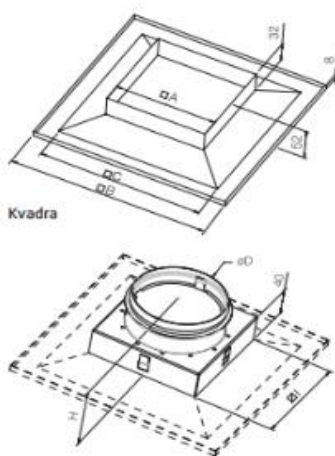


Figure 208: Kavadra dimension.

The volumetric flow rate for diffuser as shown in and the dimension of diffuser as shown in Table.

Table 61: The volumetric flow rate for diffuser.

KVADRA																
Size	Art No			Air flow range (m ³ /h, l/s) and throw l _{0,2} (m)										ΔP ₁ - Pressure drop (Pa)		
	KVADRA	KRC	PER	3	4	6										
150	6540	6530	6522	3	4	6								7	21	37
225	6541	6531	6523			4	5	6						8	19	30
300	6542	6532	6525					5	6	8				9	20	30
375	6543	6533	6526					4	6	8				4	18	25
450	6544	6534	6527						6	7	10			5	10	21
				m ³ /h	100	150	200	275	350	475	600	725	1075	20-25	30	35-40
				l/s	28	42	56	76	97	132	167	201	299			dB (A)

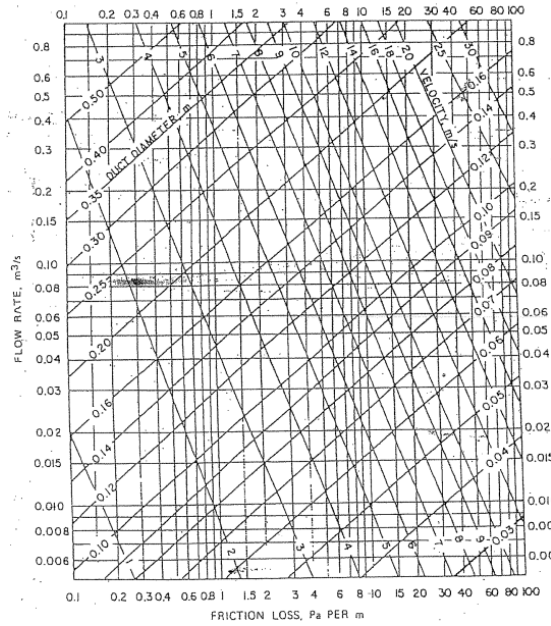


Figure 211: Pressure drop ($\Delta P/EL$) for low flow rates of round duct.

Using the balance pressure drop method, we can establish the volume of each channel as

To find diameter of b-c = $\dot{v} = 0.33 - (0.027 + 0.027) = 0.25 \text{ m}^3 / \text{s}$

$\Delta P/EL = 0.81 \text{ Pa/m}$, from Figure, Diameter of b-c = 0.28m with velocity 4.7 m/s

By using balance pressure drop method, the size of duct will be as shown in Table below

Table 62: Duct diameter and volumetric flow rate for duct section for fan coil 1

Duct	Volumetric flow rate (m^3/s)	$\frac{\Delta P}{EL}$ (pa/m)	Diameter (m)	Velocity (m/s)
a-b	0.25	0.81	0.28	4.8
b-c	0.265	0.81	0.17	4.6
c-d	0.265	0.81	0.17	4.6
d-e	0.265	0.81	0.17	4.5
d-f	0.23	0.81	0.15	4.1
c-g	0.23	0.81	0.15	4.1
g-h	0.3	0.81	0.2	4.4
g-i	0.3	0.81	0.2	4.4
b-j	0.3	0.81	0.2	4.4
j-k	0.3	0.81	0.2	4.4
j-l	0.03	0.81	0.07	2.4

Fan coil 2

We selected the second fan coil from Toshiba company (AP0246BHP1-E / TR) with a cooling capacity of 7.1 kW it also depends on the volumetric flow rate of the chosen diffuser

The diffuser (Kvadra) is chosen from a company Systemair with a volumetric flow rate 0.027 m³/s was selected, which depends on the volumetric flow rate for each area. The following figure shows the diffuser associated with the fan coil 2.

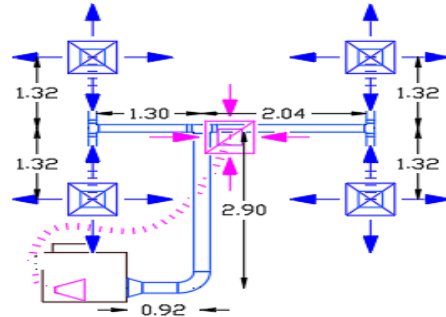


Figure 212: The distribution of diffuser for fan coil 2.

Fan coil 3

We selected the second fan coil from Toshiba company (AP0246BHP1-E / TR) with a cooling capacity of 7.1 kW it also depends on the volumetric flow rate of the chosen diffuser

The diffuser (Kvadra) is chosen from a company System air with a volumetric flow rate 0.027 m³/s was selected, which depends on the volumetric flow rate for each area. The following figure shows the diffuser associated with the fan coil 3.

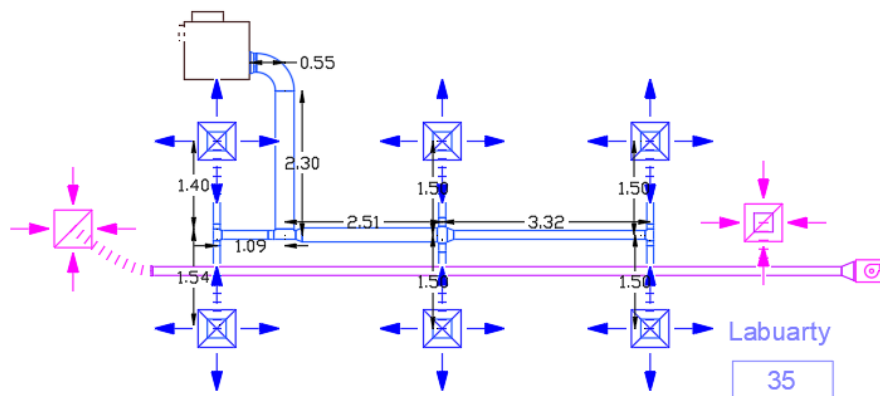


Figure 213: The distribution of diffuser for fan coil 3.

5.7 Fire Protection

The fire protection system is considered one of the most important systems in buildings, and the importance of this system increases in government and community buildings that provide services to society as is the case in this building (the Scientific Research Building at AL-Istiqlal University). The firefighting system consists of fire extinguisher, fire sprinklers , detection devices Smoke and fire alarms.

5.7.1 Fire extinguisher

Fire extinguishers can be used as a first line of defense in suppression fires of limited scale, it is best to put it on large spaces, it can be located away from fire hazards and near an exit, there should choose an accessible location for it.

Fire extinguisher has several of limitations made the system unreliable alone

(MEEB Book 2012):

- Limited amount of extinguishing agent.
- Need special recharging facilities.
- Limit rang of the discharge agent; the range may be from1.22 to 1.83.
- Extinguishers are designed for specific situations.

The following figure show the types of extinguishers that are dependent on hazard. Class A involving ordinary combustibles such as wood, cloth, paper, rubber, and many plastics.



Figure 214: Fire extinguisher types

5.7.2 Sprinklers

It is a component of fire suppression that pumps water when the temperature exceeds a certain temperature.

Fire sprinklers are used in offices, meeting rooms, halls, reception and garage. The table shows the classification of risk, and the table shows the number of sprinklers required in each space.

Table 63: classification of risk

Hazard classification	High hazard	Medium hazard	Low hazard
coverage area(m ²)	9	12	20
Maximum distance(m)	3.6	3.9	4.6

Table 64: number of sprinklers required in each space.

Space	Space area(m ²)	Hazard Classification	Max. Coverage area per sprinkler(m ²)	Number of sprinkler
Entrance hall	34.7	High hazard	9	4.00
Waiting room	10	High hazard	9	2.00
Lobby	265.41	High hazard	9	30.00

Sample of calculations

For waiting room

Area = 10 m²

Max. Coverage area per sprinkler (m²) =9 m²

Number of sprinkler = 10/9 =1.11 ≈2 sprinkler



Figure 215: Fire sprinkler

5.7.3 Smoke Detector

Smoke detector is one of the systems used for fire alarm. Smoke detector is used in the municipality building, as it is used in places confined to buildings. It is placed 4 inches from the wall and away from excess air movement.

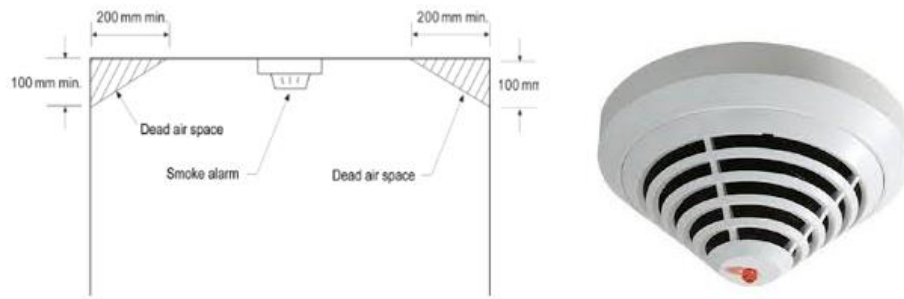


Figure 216 Smoke detector and its location

5.7.4 Circulation

Exit routes

According to Occupational Safety and Health Administration (OSHA), the exit path must be continuous and without any obstacles in the workplace for a safe space.

Usually, the exit road should be available for evacuation during the emergency. However, if there is no emergency exit, additional routes should be available to facilitate exit.

The Exit routes and emergency action plans for 2012.

Emergency Exit

The emergency exit is used in emergency situations such as fire. Also, the exit is considered as an emergency exit if the following conditions

- Control exit from inside the building.
- Isolating the exits with fireproof materials.
- The exit paths must lead directly to the outside or to a safe space outside that leads to the outside.
- Post signs to guide people out along the exit path.
- Providing adequate lighting in the exits.
- Sufficient exit routes must be provided.

Emergency stair

These items are according to the Jordanian building code

The minimum width for doors and corridors is $\geq 1.25\text{m}$.

The minimum width of a stairs is 1.65.

Height of the emergency door 2.2 m.

Stair handrail ≥ 20 cm.

The distance between the handrails <10 cm.

The width of major walkways is more than or equal to 1.5 m.

Riser depth (15-18) cm.

Run width 28 cm.

Exit signals

Exit signals to evacuate buildings are a major part of the emergency exit, which indicates the direction of the emergency.

The following figure shows the exit signal



Figure 217: exit signal

Chapter 6: Quantity surveying and cost estimation

6.1 Introduction:

In this chapter, we will be fully calculating the financial expenses and the quantities for this building, in order to make these calculation realistic and to prevent any confusion between the contractor and the owner, in addition all the details will be calculated and related to the building area to be able to know the cost per square meter.

6.2 Bill of quantities (BOQ):

There is a PDF attachment at the end of the report

6.3 Summary:

After we divide the building to multifunction and apply the work break down structure WBS for the building in order to make quantities sorting with estimating the cost as shown in BOQ table. The total cost of the building estimated to be (4270904.8) NIS, or (1220258.5) \$ roughly in conversion, and with keeping in mind, the estimated cost per square meter is (2440.5) NIS, approximately (697.2) \$. The building total area is measured to be 1750 m². And by using these two data the area and cost per meter squared we estimated the total cost of this building project to be about (4270904.8) NIS or approximately (1220258.5) \$ in conversion depending on dollar price.

Chapter 7: Conclusion

7.1 Conclusion

The first stage was an evaluation phase of the building according to the standards and recommendations, while the second stage was a redesign of the building with all the particles and architectural and mechanical fields, etc., so that access to the building is more comfortable and more in line with the requirements.

From the architectural aspects, some areas have been modified and distributed to make the function easier.

The structural design was carried out by the ETAPS 18,SAP and safe, and the seismic loads and effects were taken into consideration and as far as possible the architectural design did not contradict the structural design.

The general and main objective was to reach a comfortable building in all respects, the Dialux program was used to design and distribute the lighting appropriately. A sound design, Ecotect and Insul program was used in the building, and the VRF system was used for heating and air conditioning.

The electrical sockets were distributed in good locations where employees are allowed easy use and access. Also, lighting circuit breakers were designed and well connected.

Finally, work on calculating quantities and costs for the building .

7.2 References

1- Neufert, E., Neufert, P., Kister, J., Sturge, D., & Brockhaus, M. (2015). Architect's Data (4th ed.). Chichester, West Sussex: Wiley-Blackwell.

2- <http://site.iugaza.edu.ps/uesawi/files/2015/04/The-Metric-Handbook-Architecture-must-have.pdf>

3- The Jordanian National Building Code. number 7 (1993). The building requirements for spaces code.

4- ACI 318 Committee. (2011). Building Code Requirements for Structural Concrete (ACI 318-

5- Load cases and load combinations

<https://www.sciencedirect.com/topics/engineering/load-combination>

6- UBC 97. (1997). "Uniform Building Code, 1997". International Code Council

7- World weather online. (2019). Retrieved from

<https://www.worldweatheronline.com/lang/ar/jericho-weather-averages/ps.aspx>.

8- (<HTTPS://ACOUSTICALSOLUTIONS.COM/WHAT-IS-IIC-IMPACT-INSULATION-CLASS/>)

9- (<WWW.EMBEDDEDACOUSTICS.COM/INDEX.PHP/SPEECH-TRANSMISSION-INDEX/9-INTRO/STI>)

10- المرجع في التمديدات الكهربائية, أ.د. محمود الجيلاني, 2444 , جامعة القاهرة , مصر

11-Procedures for Calculating Natural Ventilation Airflow Rates in Buildings, Muthusamy V. Swami, Florida (1987).

12- Meeb “mechanical and electrical equipment of building” 11th edition. Walter T. Grondzik