An- Najah National University

Faculty of Engineering

Building Engineering Department

Graduation Project 2

"Physio therapy and rehabilitation center"

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الإهداء

بسم الله الرحمن الرحيم

الى بلدنا الحبيب ...

الى من وهبونا روحهم نحوالحياة... أمهاتنا و ابائنا

الى من شاركناهم أجمل مراحل العمر ...أخوتنا, أصدقائنا,زملائنا...

الى كل من نشر العلم نحو الحلم الكبير... معلمينا الافاضل

من هنا نبدأ...

Disclaimer

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Acknowledgments

At the beginning we thank God who gave us the strength and challenge to meet the challenges and problems to complete this project which is the graduation project 1 for the B.Sc. degree at Al-Najah National University Faculty of Engineering & Information Technology, Building Engineering Department.

Much thanks to our supervisor in this project, Dr. Luay Dweikat, who helped and guided us to the right way and his supports during this semester until the completeness of the project, we appreciate the information and advices that he have shared.

We would like to thank the head of the building engineering department Dr. Muhannad Haj Hussein and all the staff who supported us with all the information we need.

Special thanks to our parents who supported us with all their possessions and provided us with what is necessary to complete the project.

List of symbols:

Mm: Millimeters

m: Meters

m^2: square meter

Hz: Hertz

dB: Decibel

STC: sound transition class

IIC: impact insulation class

TL: Transition loss

KN: kilo newton

PHC: percent handling capacity

Sec: second

RH: relative humidity

m/s: Meter per second

cm: Centimeter

":Inch

P: Pressure

Ft: foot

Gpm: Gallon per minute

Kg: Kilogram

Lux: Illuminance

Abstract:

The increasing in population induced an increase in health and physical problem, that emphasized the need of physiotherapy and rehabilitation center which provide a full treatment, such as rehabilitation and physical care services for persons with special needs, whether children or senior, and the rehabilitation aims to restore patients to their daily and life as much as possible, and to prevent complications of the problem.

Physiotherapy and rehabilitation centers include many facilities such as therapeutic pools, tailoring, clinics radiography rooms, cafeterias, gym, basketball and tennis stadium, classrooms for people with special needs and vocational departments, etc.

Our project is about design of the “physiotherapy and rehabilitation Centre”. This building will be designed according with conditions and requirements for this type of building.

The work on this project will be done in two semesters in academic year, the work will include three major aspects that need to be investigate; architectural, structural, and environmental aspects. Architectural aspects analysis of plans that had been designed to assess its compliance with specifications and standards, and determine deficiency if it exist. Structural aspect consists of full structural design of the building. Environmental aspects provide the acoustical, visual human comfort and suitable thermal according to codes and standards. In addition to Design other systems such as electrical and mechanical.

Many programs will be used to achieve the previous aspect such as “Revit” and “AutoCAD” for architectural design, “ETABS” and “SAP” for Structural design, also “Revit” for solar system.

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CHAPTER 1

1. Introductory

1.1 Introduction

Increase in population incudes an increasing in health and physical problem, that emphasized the need of physiotherapy and rehabilitation center that pay attention to the injured athletes and rehabilitate them to the maximum to return to exercise again.

Another reason is the Palestinian reality under occupation and the consequent increase in the number of injured parties who find it difficult to integrate into the community and get jobs suitable to their situation so there is urgent need to have a special center for treatment and rehabilitation and integration in society.

Physiotherapy and rehabilitation centers include many facilities that serve visitors to the center and facilitate their treatment. It includes classrooms, radiology rooms, therapeutic pools, outdoor playgrounds and ramps for people with special needs to facilitate their movement. This requires special design standards.

The West Bank lacks specialized centers for physiotherapy and rehabilitation, but only centers and clinics concerned with certain aspects and neglecting other aspects. Hence came the idea of the project

The Physiotherapy and Rehabilitation Center is expected to serve a large segment of the community by providing a center that begins with the patient from the treatment trip to rehabilitation and integration into society.

Services to be offered by the Physiotherapy and Rehabilitation Center:

1. **Dry therapy**
2. **Massage room:** Is a room of physiotherapy rooms that are interested in massage the injured muscles
3. **Clinic of prostheses:** provides prosthetic and orthotic care and strives to be the partner of choice for service and products that enhance human physical capability.
4. **Carpentry workshop:** Is a workshop that helps in teaching people with special needs the profession of carpentry to facilitate their chances of obtaining employment opportunities

5. **Study room:** Is a classroom for special needs students who are difficult to attend because of their health status
6. **Electrical workshop:** Is a workshop that helps in teaching people with special needs the profession of electrical to facilitate their chances of obtaining employment opportunities
7. **Cafeteria:** Provides nutrition services to those who are fit for the food program in addition to the service of persons accompanying the patient.
8. **Sauna:** is a small room or building designed as a place to experience dry or wet heat sessions and Helps relax muscles and stimulate sweating.
9. **Individual treatment baths:** They are a treatment room for one person where water is with other therapeutic components that help the patient and reduce the period of treatment.
10. **radiography rooms:** Are the imaging rooms for the injured to see their health status and the nature of the injury to begin treatment and rehabilitation The room includes a radiotherapy room and a control room.
11. **gym:** Sports club helps to soften the muscles and exercise the body and increase the licks and help to reduce the duration of treatment.
12. **Check Rooms:** Is the initial screening room to identify the patient's condition and the nature of the injury before starting treatment and rehabilitation.
13. **Sewing workshops:** Is a workshop that helps in teaching people with special needs the profession of sewing to facilitate their chances of obtaining employment opportunities.

1.2 Project problem

The absence of the city of Nablus to the existence of a specialized center and comprehensive physical therapy and rehabilitation care for the injured from the moment of injury and physical treatment through the stage of rehabilitation and integration in the community to take it as a case study on the project.

Where most of the existing facilities that are concerned with physical therapy and rehabilitation are clinics or centers interested in a specific aspect and neglect the other aspects.

1.3 Objective of the study

The establishment of a full and specialized center concerned with treating the injured and rehabilitating them and integrating them into society in a comfortable position that helps speed up the process of physical and psychological treatment is a main object of this project and there is many secondary object to be achieved:

- Analyzing and studying building space in term of architecture and environmental and ensuring their conformity with the specifications and standards required for this type of building, then solve all the problems in the design and finally design all the detailing and the proposed systems.
- Site study and analysis in terms of the direction of the building and the topographic nature of the land and study of climate and wind direction.
- Provide a suitable structural model for the building that serves the architectural form and meets the needs of the building in environmental and functional and design the chosen systems.

1.4 Methodology

A Systematic and theoretical analysis of methods used in scientific fields.

1. Literature review to find out standard for specification of architectural, environmental and structural element.
2. Study the topography of land and site weather specification.
3. Design a comfortable environmental and structure design.

1.5 Constrains & Limitations

1) There is no case study in west bank that matches our project specifications.
2) Lack of adequate and clear plans to understand the building architecturally.
3) Lack of a report on the soil characteristics of the project land.
4) The difficulty of moving to other cities in Palestine to find a case study similar to the project.

1.5 Design Codes

- In architecture design
    1. American with Disability Act (ADA)
    2. Physical rehabilitation center (ICRC)
    3. BC housing
    4. Sport England
    5. FIBA
- In structure design.

1. ASCE (for load combination).
2. ACI-318-14 for reinforced structural design.
3. UBC-97 for earthquake load computations.
4. IBC for earthquake load computations for steel cover.

- In electromechanical design

1. MEEB

CHAPTER 2

1.1 Site analysis

1.1.1 Land topography

The land is in the industrial area in front of Hisham Hijjawi College.

It's surrounded by sub-streets, easy to reach and has no obstructions or surrounding buildings, allowing the air and the sun to reach it.

Its direction in the northern part allows exposure to sunlight throughout the day with the presence of ventilation and natural lighting and create a healthy atmosphere commensurate with the function of the place.

Figure 1 Project land

Area of the land is 24 dunum with slop equal 1.13%

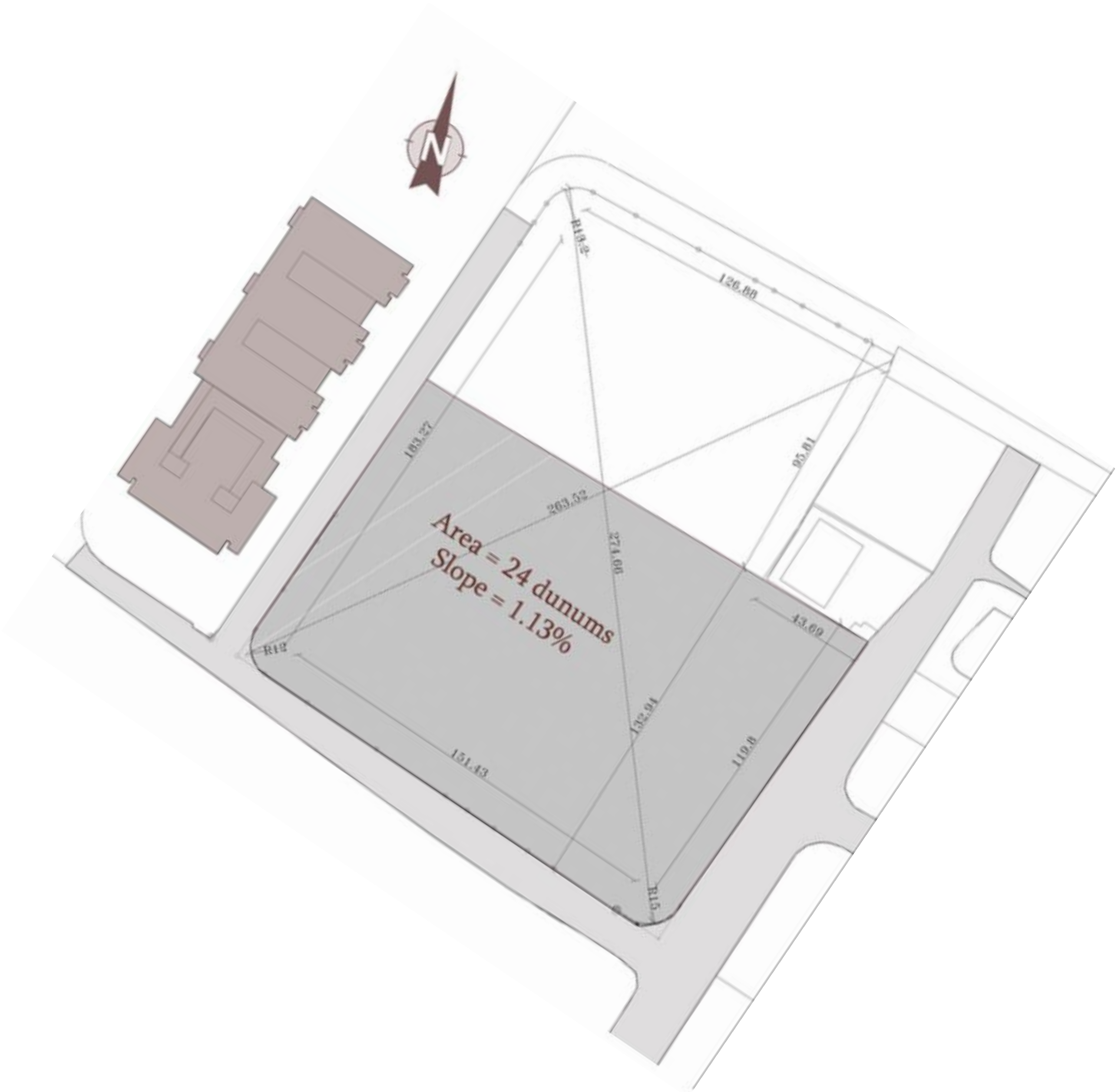


Figure 2 Project land area

1.1.2 Climate

1.1.2.1 Temperature

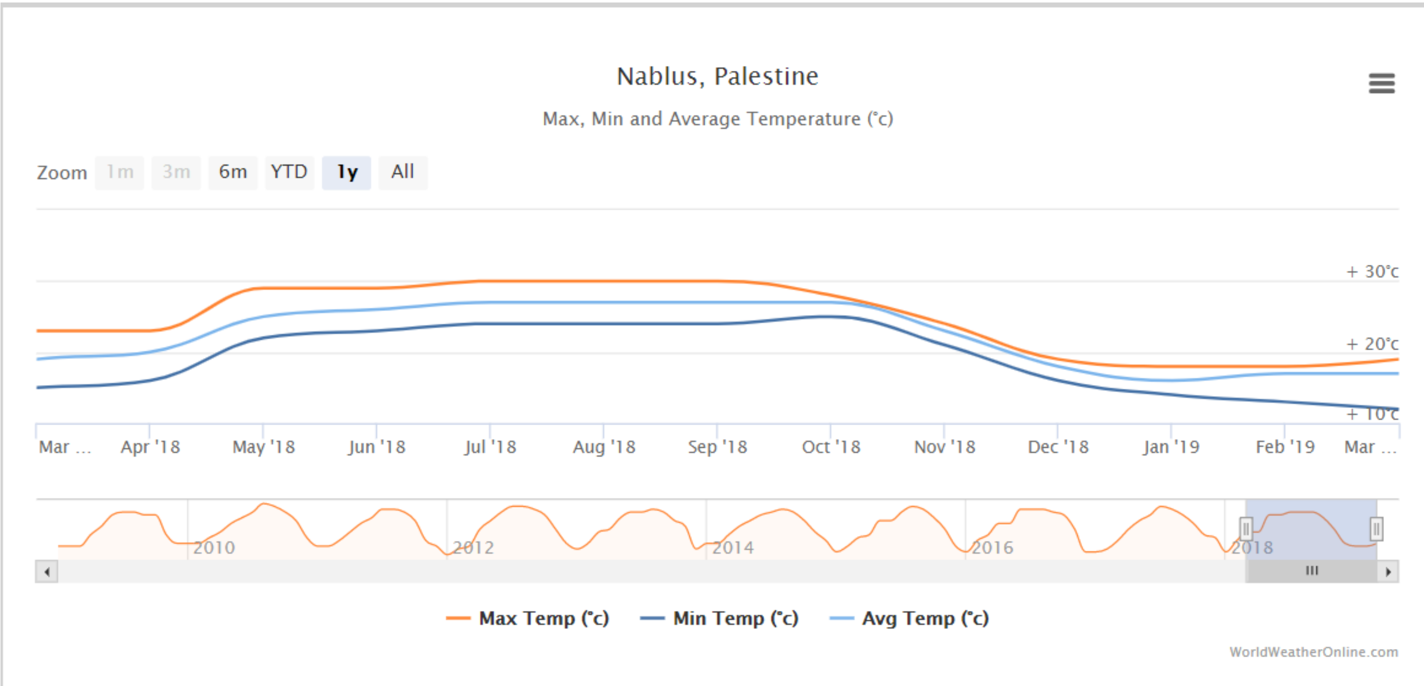


Figure 3 Climate in Nablus city

1.1.2.2 Relative humidity

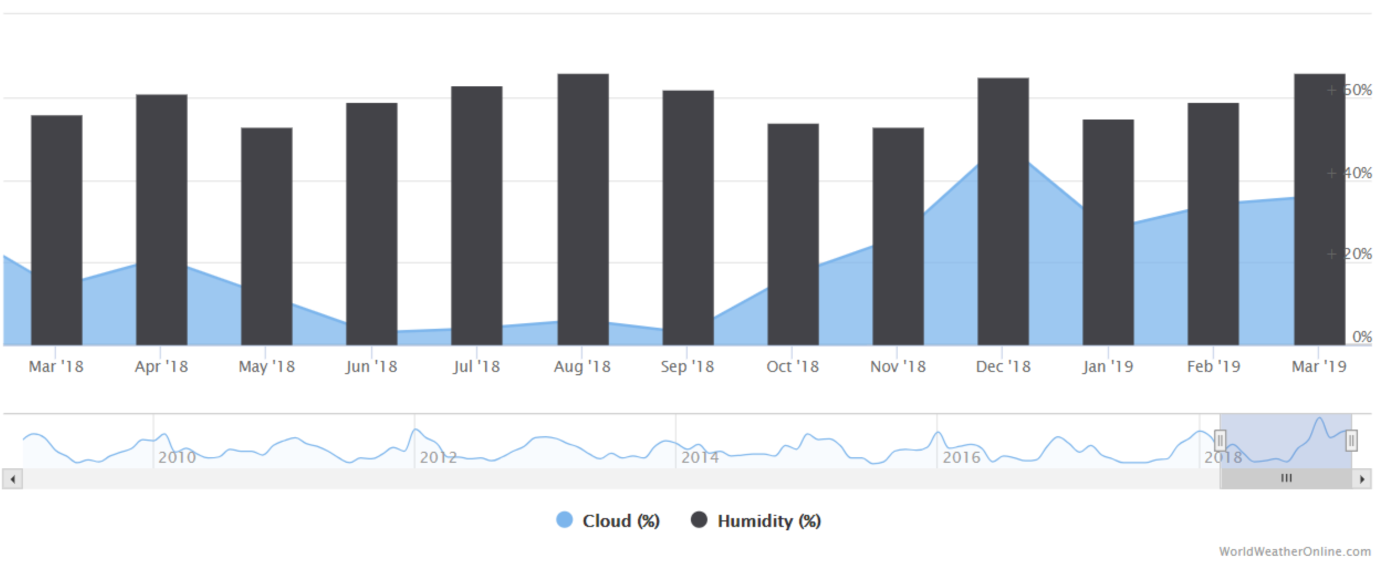


Figure 4 Relative humidity in Nablus

1.1.2.3 Wind speed

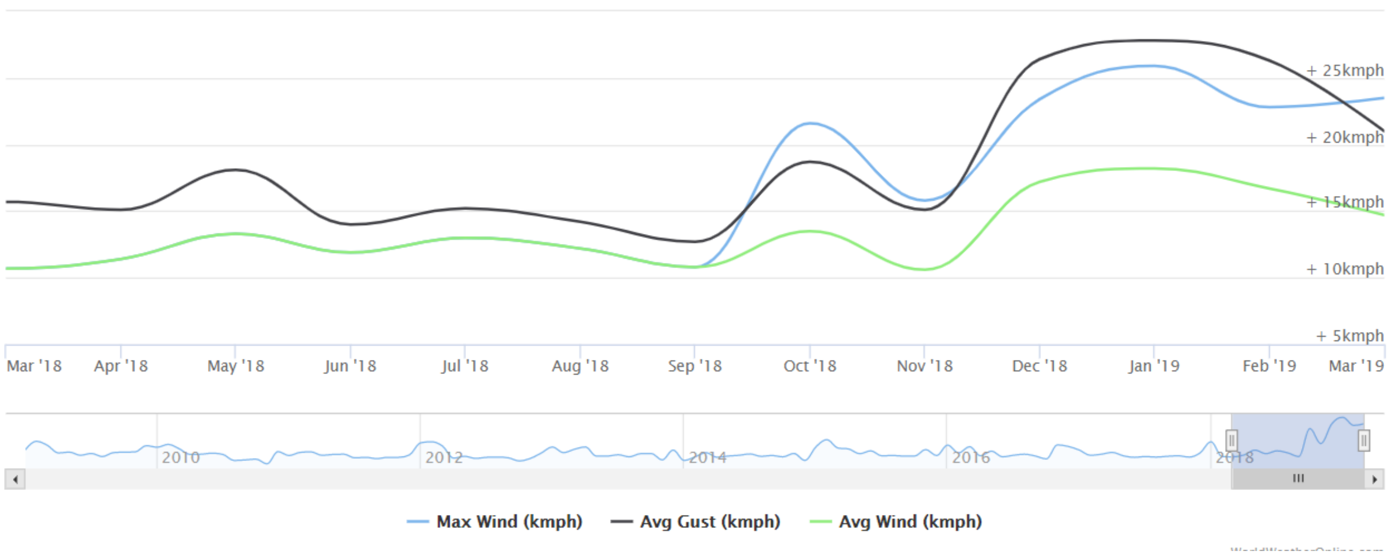


Figure 5 Wind speed in Nablus

1.1.2.4 Sun hour

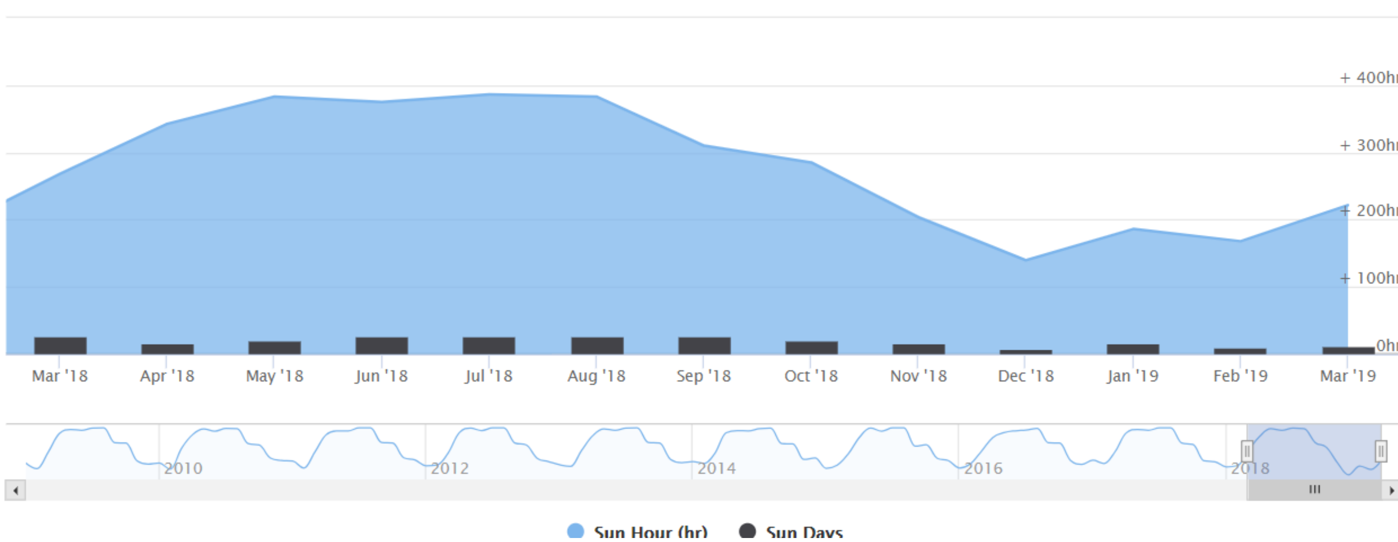


Figure 6 Sun hour in Nablus

1.1.3 Contour

Figure 7 Land Contour plan

Figure 8 Land contour plan

1.1.4 Noise analysis

In the project area, there is no noise resource around it, the little noise occurs from the natural cars moving through the street, especially the street is a secondary so there is not very much noise in this area.

Also this area is empty from industrial building or roads for a heavy truck. So noising in this area is normal, accepted and does not affect the people in this center.

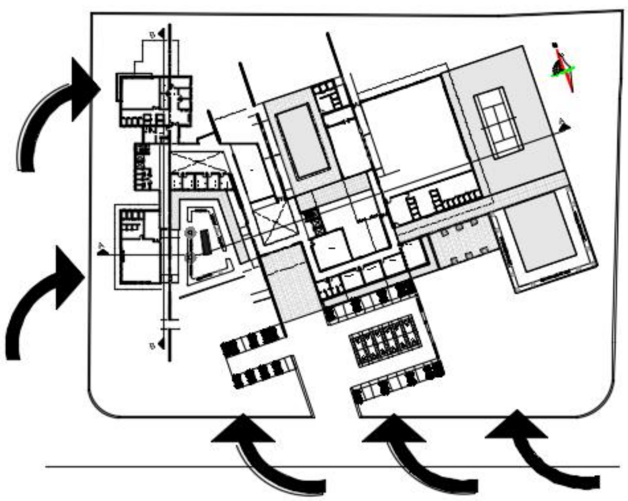


Figure 9 Noise distribution

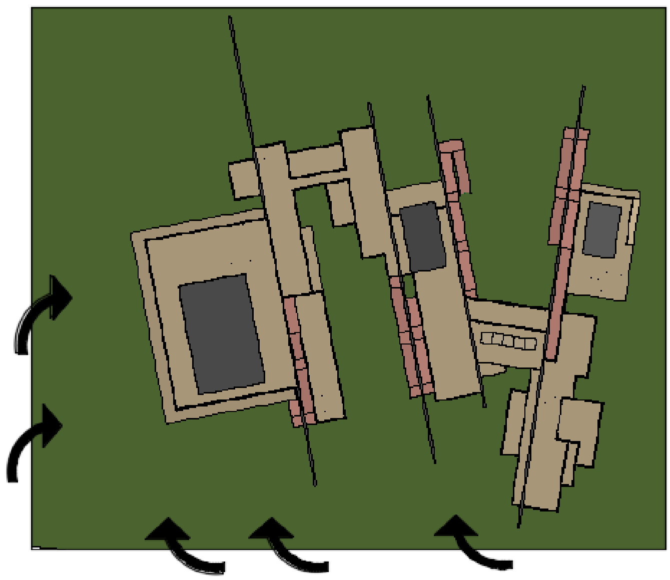


Figure 10 Noise distribution

1.1.5 Parking

- Parking: for disabled people, parking for cars should be minimum 2.5 m width and 5.4 m length and for vans it should be 3.5 m width with length 5.4 m.
- Pathway should be 1.5 m width and 5.4 m length, which is full length of parking space.
- Space requirement: 4 spaces for each practitioner plus 1 space per employee (including practitioner) OR 5 spaces per 300 m2 at highest shift whichever is greater. For the purpose of the parking ratio, employees include receptionist, rehabilitation specialists, nursing staff.

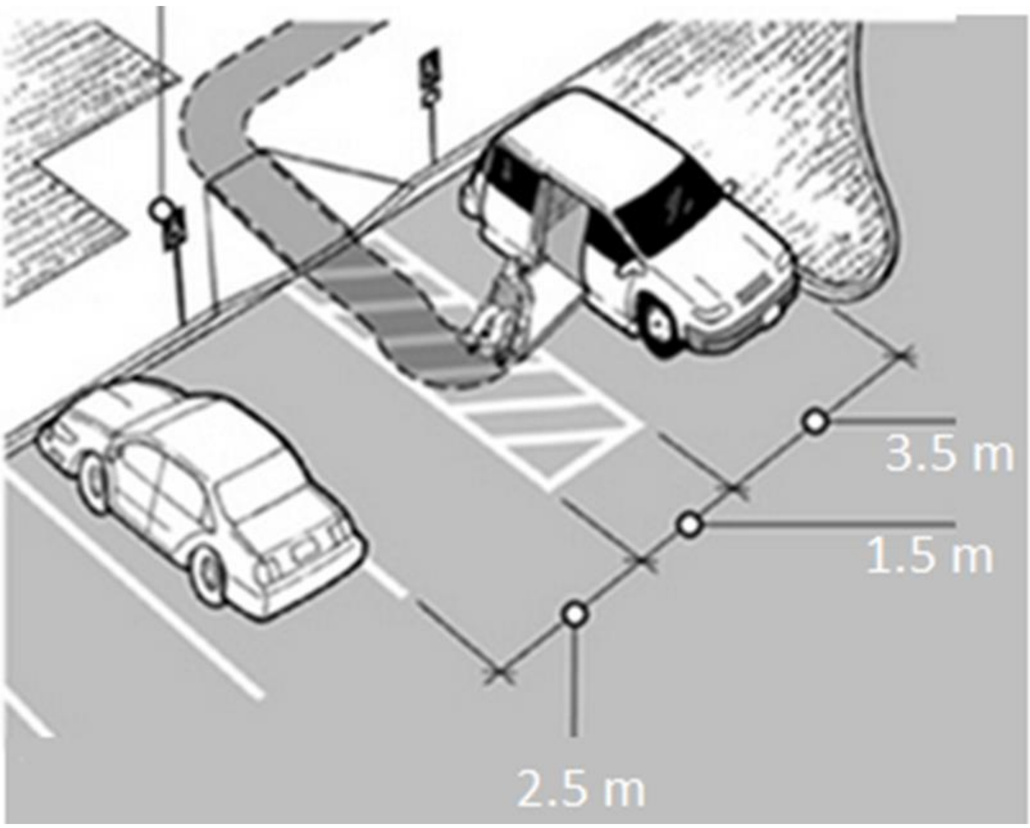


Figure 11 Parking

1.1.6 Entrance landing

- Entrance landing should be provided close to ramp with at least 1.8 x 2 m.
- Finishes should have a non-slip surface with a texture traversable by a wheelchair.

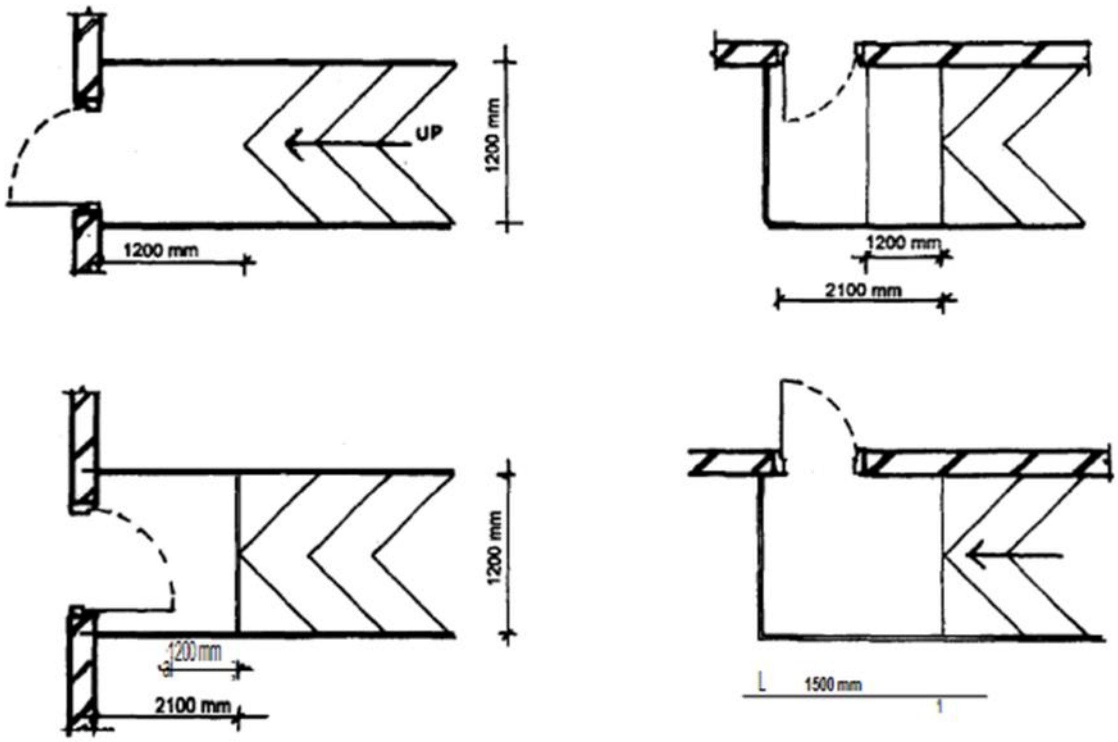


Figure 12 Entrance and landing

CHAPTER 3

3.1 Architectural

3.1.1 Architectural design Review

Many facilities are designed in the project commensurate with needs of disabled people for treatment, entertainment and education in the center, such like clinic rooms, radiology rooms, massage rooms, sauna room, workshops rooms, pools, GYM, sports yard, exhibition in addition of administration room, reception, waiting area, changing rooms, cafeteria, employees' rooms, etc.

The project is consisting of two floors, ground floor and first floor, the plans below is the previous plan before editing.

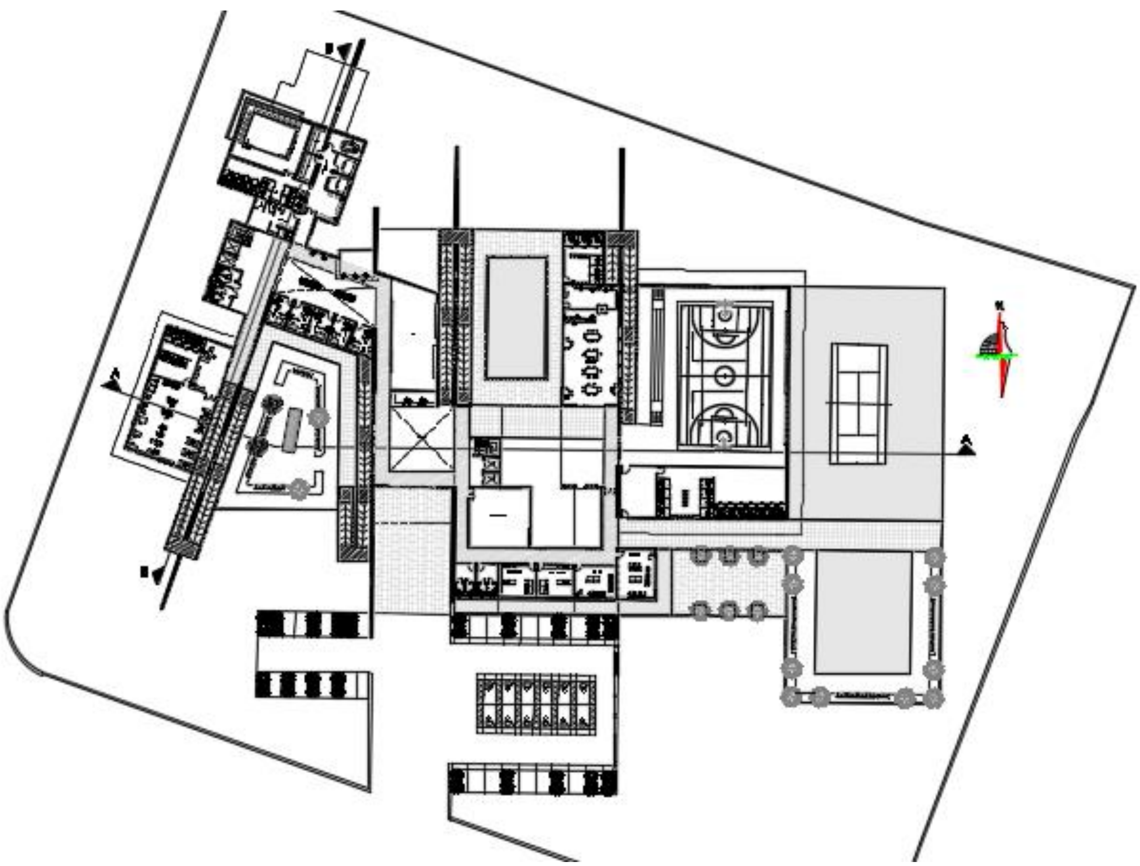


Figure 13 Ground floor plan

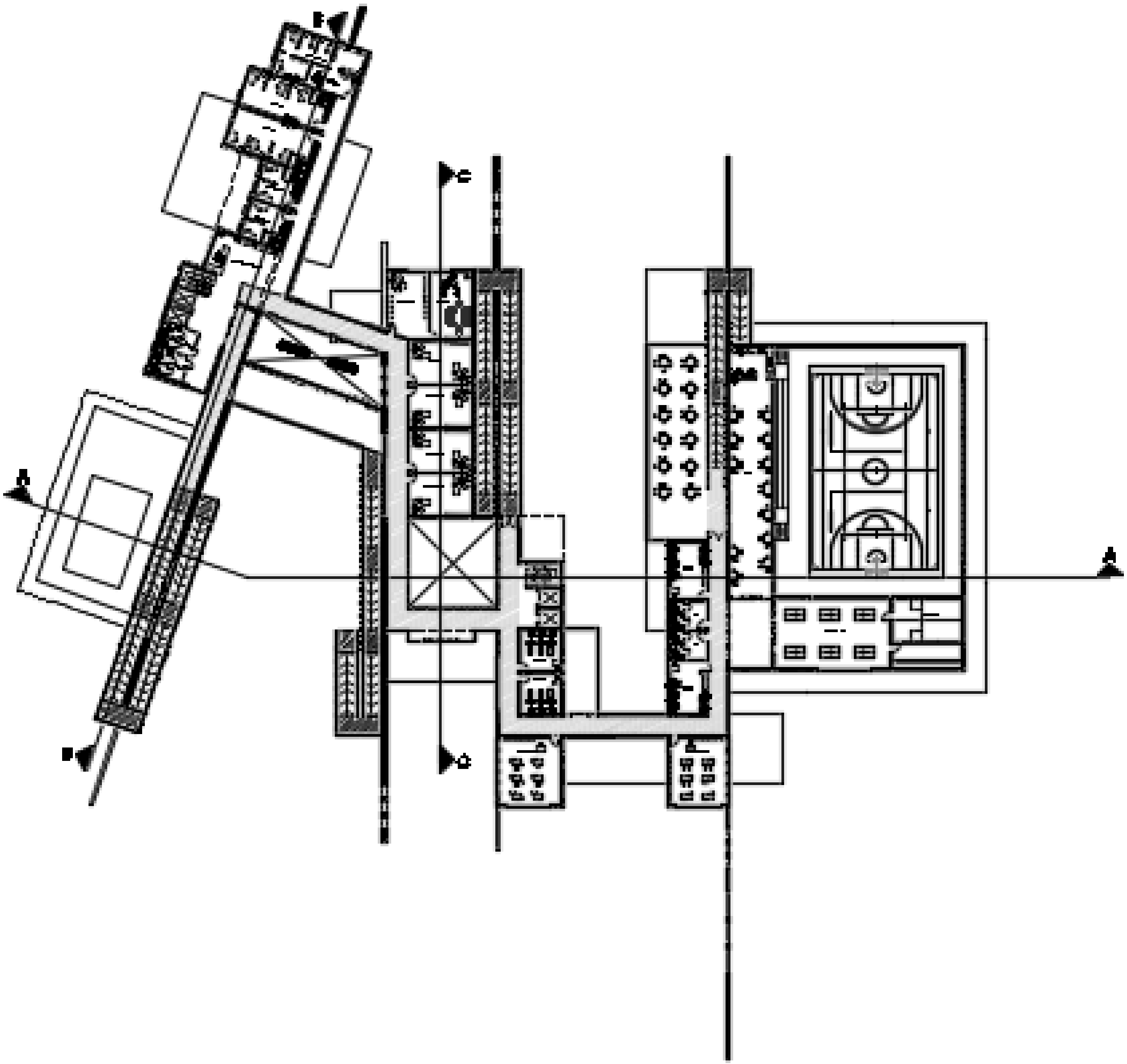


Figure 14 first floor plan

3 Problems identified in this plans

1. Radiology room needs well insulated place and materials insulation and needs to put door to separate the waiting zone with radiology zone and window should be add into the room.

   For insulation purposes, these materials should use:

   - Typically, 150 mm concrete floor of 2.3 g/cm^3 and 100mm concrete ceiling for shielding above and under the room.
   - At least 2mm. sheets of lead the door should be lined with
   - The lead glass window should be minimum 35 cm x70 cm
   - The thickness of lead should be between 0.5-2 mm depending on its distance from the patient, protective material and lead glass must overlap each other by minimum 25mm.

Figure 15 previous plan

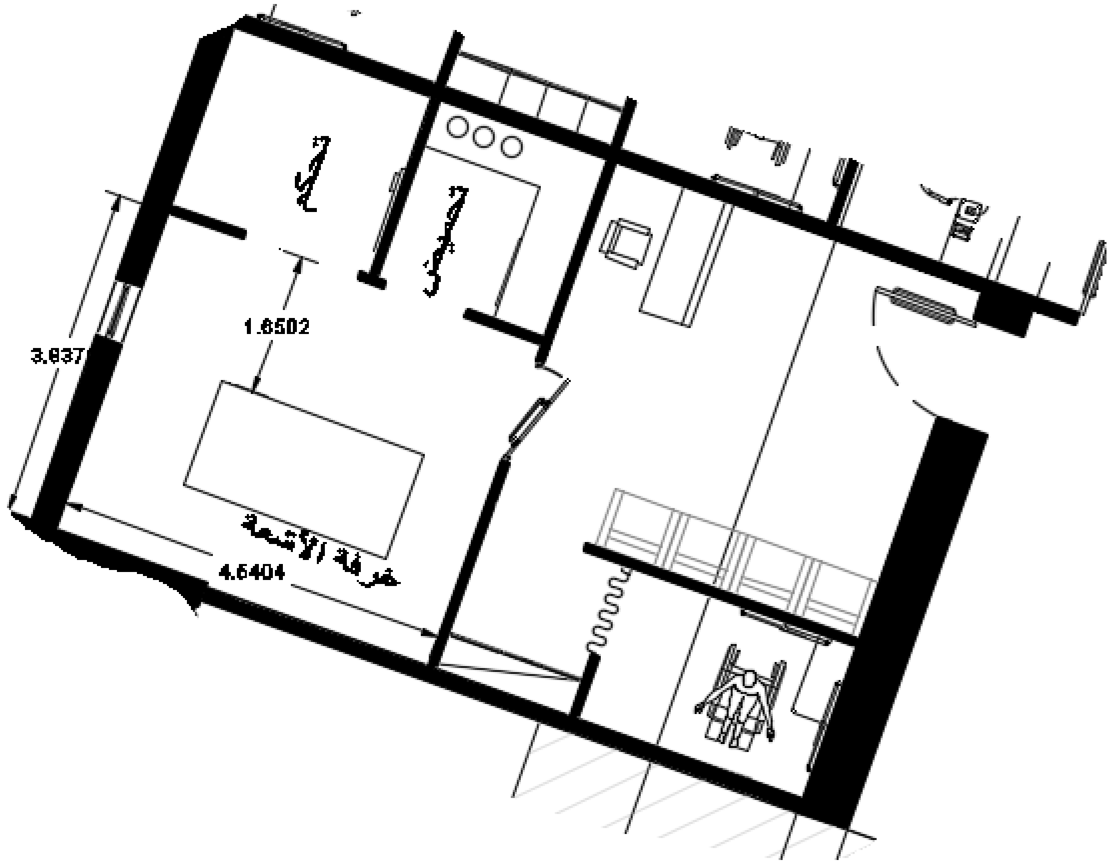


Figure 16 Radiology room after editing

2. Ramps: there was a problem in the ramps such that it’s slope higher than 1:12, and according to American with Disabilities Act (ADA) that the slope should be maximum 1:12.

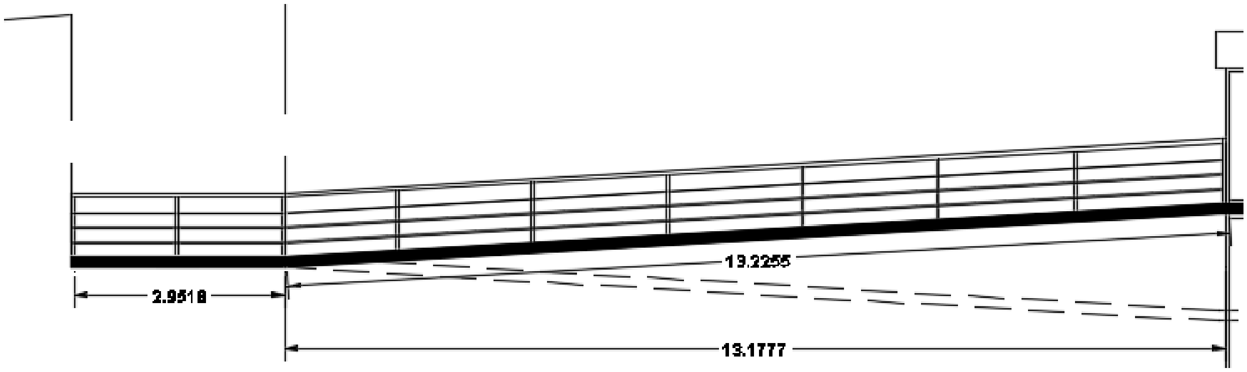
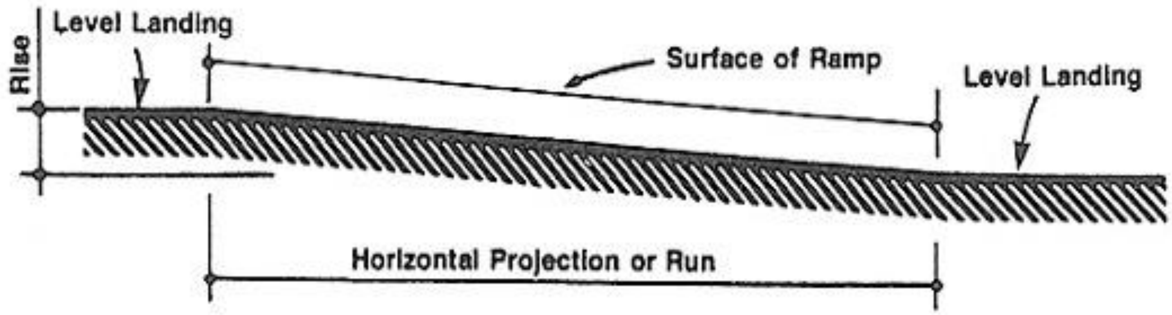


Figure 19 Ramps before editing



	Maximum Rise		Maximum Horizontal Projection	
Slope	in	mm	ft	m
1:12 to < 1:16	30	760	30	9

Figure 18 Ramps standard

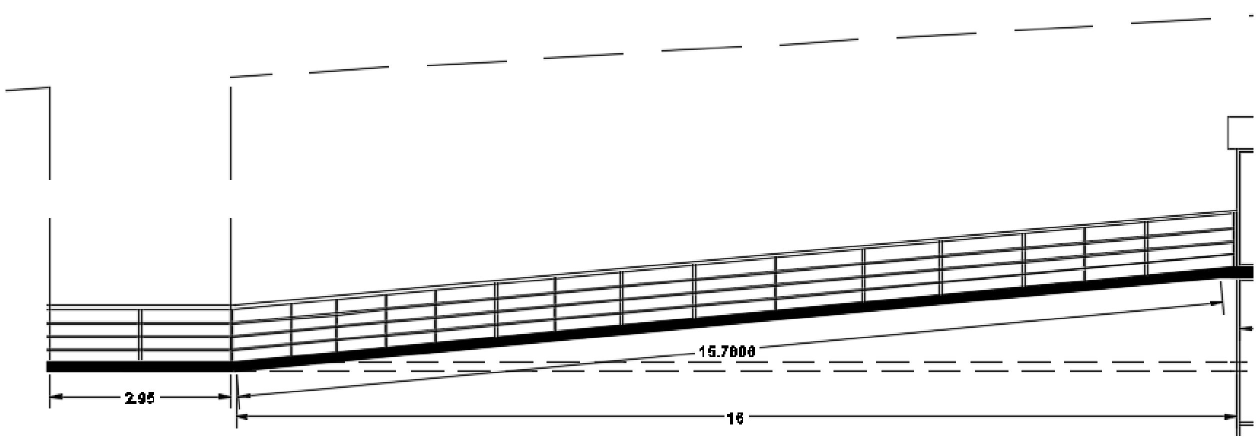


Figure 17 Ramps after editing

3. WC's: there was a problem such that the windows is in the direction with wind, changing the windows direction is the solution, for example, changing the windows instead of being in the western wall it become in the southern wall, it will solve the problem.
   Also added W C's for normal people, for the staffs, and for the companions such that number of companions almost equal 1/3 of the number of patient.

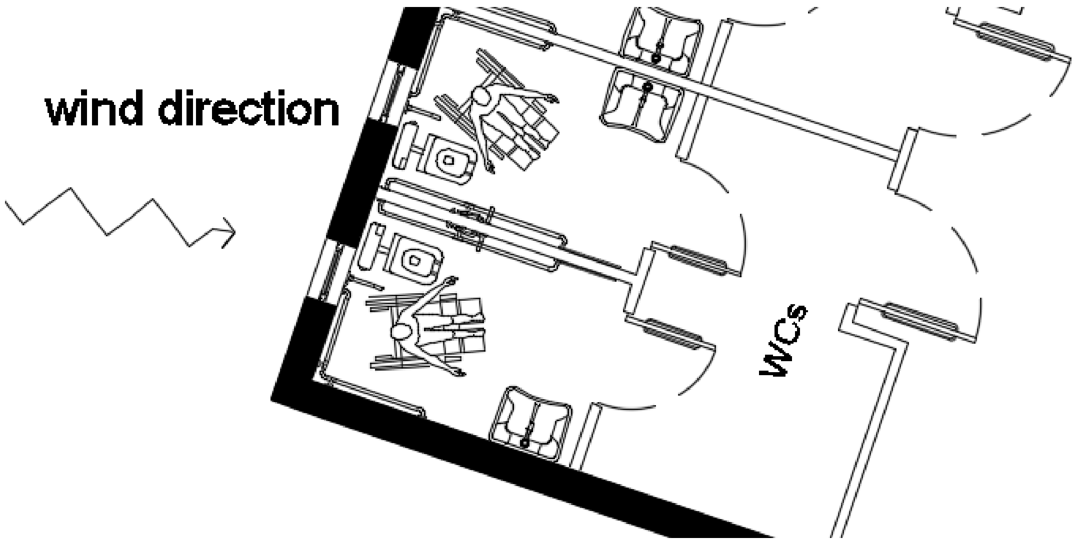


Figure 20 WC window after editing

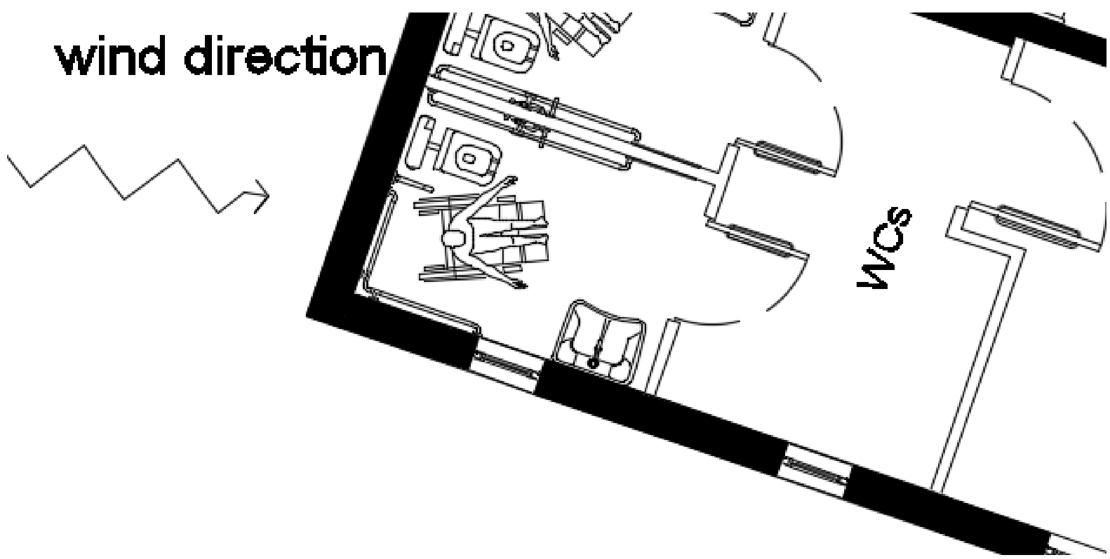


Figure 21 WC window before editing

CHAPTER 4

4 Structural

4.1 Introduction

Structural design is the methodical investigation of the stability, strength and rigidity of structure. The basic objective in structural analysis and design to produce a structure capable of resisting all applied loads without failure during its intended life. The primary purpose of a structure is to transmit or support loads. If the structure is improperly designed or fabricated, or if the actual applied loads exceed the design specification, the device will probably fail to perform its intended functions, with possible serious consequences. A well-engineered structure greatly minimizes the possibility of costly failures.

4.2 Design code

Three design code are performed as following:

- ACI-318-14 for reinforced structural design
- UBC-97 for earthquake load computations
- IBC for earthquake load computations for steel cover

4.3 Site and geology

The structure will be built on soil profile has a bearing capacity of 250KN/m^2

4.4 Loads

Loads that act on structures can be divided into three board categories: dead load, live load, superimposed dead load and earthquake load.

- Dead load (D.L): the load due to own weight of the structure which will remain constant during the life of the building.
- Super imposed dead load (S.I): it is considering as dead load it results from the own weight of the backfill, the tile and mortar.
- Live load (L.L): the expected load that the structure will carry it such as the people, machines, and all movable load expected during the life of the structure.
- Earth quick load.

The table below, show the load name and its case type:

Load case name	Lode case type
Dead	Linear static
Live	Linear static
Super imposed dead	Linear static
EQx	Response spectrum
EQy	Response spectrum

Table 1 Load case name and type

The building design in order to carry

Type of load	Load (KN/m^2)
Live load	3.5
Super imposed	4
For steel cover	
Live load	1
Super imposed	2.5

Table 2 Load carry in the building

4.5 Steel Design (First block)

4.5.1 Steel cover

Clear covers: to protect steel from corrosion and fire:

- Slab cover = 2.5 cm
- Beam and column cover = 2.5 cm
- Footing cover= 5 cm

4.5.2 Material

1. **Concrete:**

Concrete is a substance used for building which is made by mixing together cement, sand, small stones, and water.

2. **Reinforcement steel:**

Steel bar or mesh of steel wires used as a tension device in reinforced concrete and reinforced masonry structures to aid the concrete under tension and strengthen it.

3. **Steel frames**

The material used in construction have the following characteristic:

- Compressive strength of concrete (f′c) of concrete:
    1. For shear wall and column.
    2. For beams and slabs.
- Steel yielding strength fy = 420 MPa

4.5.3 Steel design checks

4.5.3.1 Compatibility check

To make sure that the structural elements are connected to each other and to check the periodicity of the seismic origin.

4.5.3.2 Equilibrium check

To make sure the input loads are input correctly

4.5.3.3 Stress-strain beam check

Check the moment on the beam and make sure the building is working when exposed to the values of the moment.

4.5.3.4 Compatibility check

To make sure that the structural elements are connected to each other and to check the periodicity of the seismic origin.

4.5.3.5 Equilibrium check
To make sure the input loads are input correctly

4.5.3.6 Stress-strain beam check
Check the moment on the beam and make sure the building is working when exposed to the values of the moment.

4.5.3.7 Deflection check
To check the deflection in slab and compare it with allowable deflection.

4.5.3.8 Stress-strain in column check
To check the axial force in column

Preliminary design and construct model on ETABs

The design will be done on two block one is a steel structure block and the other is concrete structure block.

4.5.4 Block analysis and design
Design done by ETABs for one block

Block is a steel structure and 10 cm concrete cover

4.5.4.1 Concrete Column section

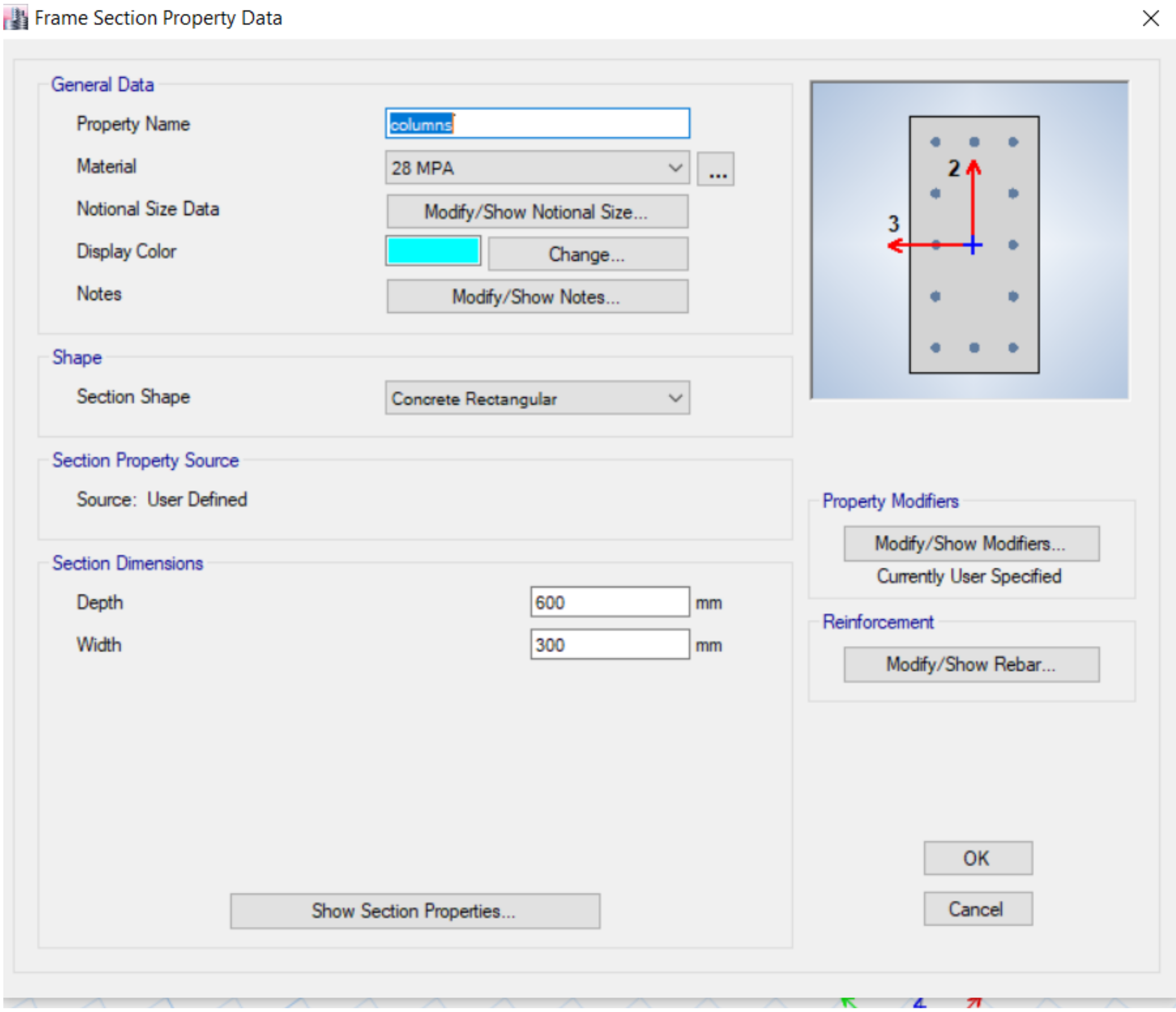


Figure 22 Concrete column section

4.5.4.2 Steel frame section

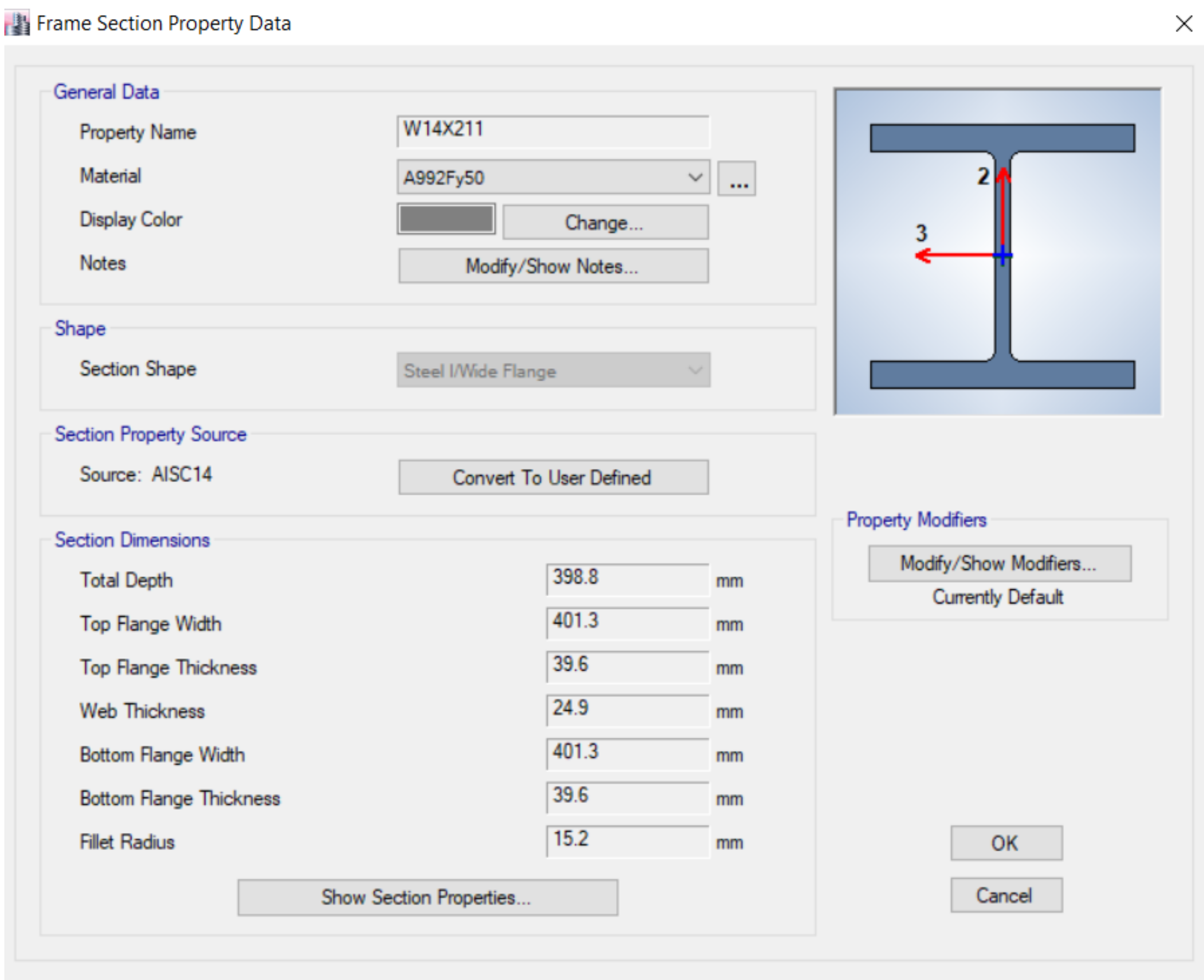


*Figure 23 Steel frame section (W14*211)*

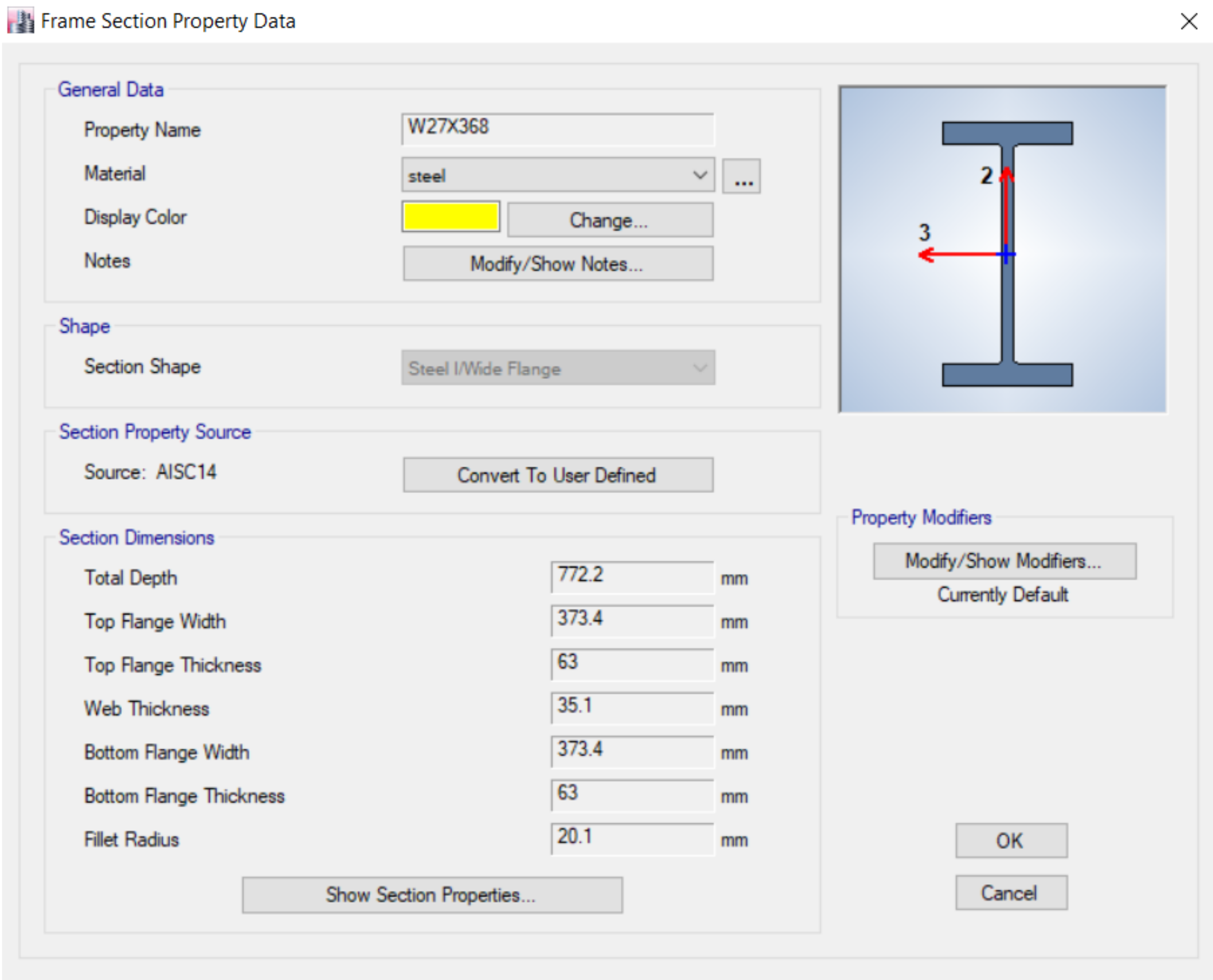


*Figure 24 Steel frame section (W27*368)*

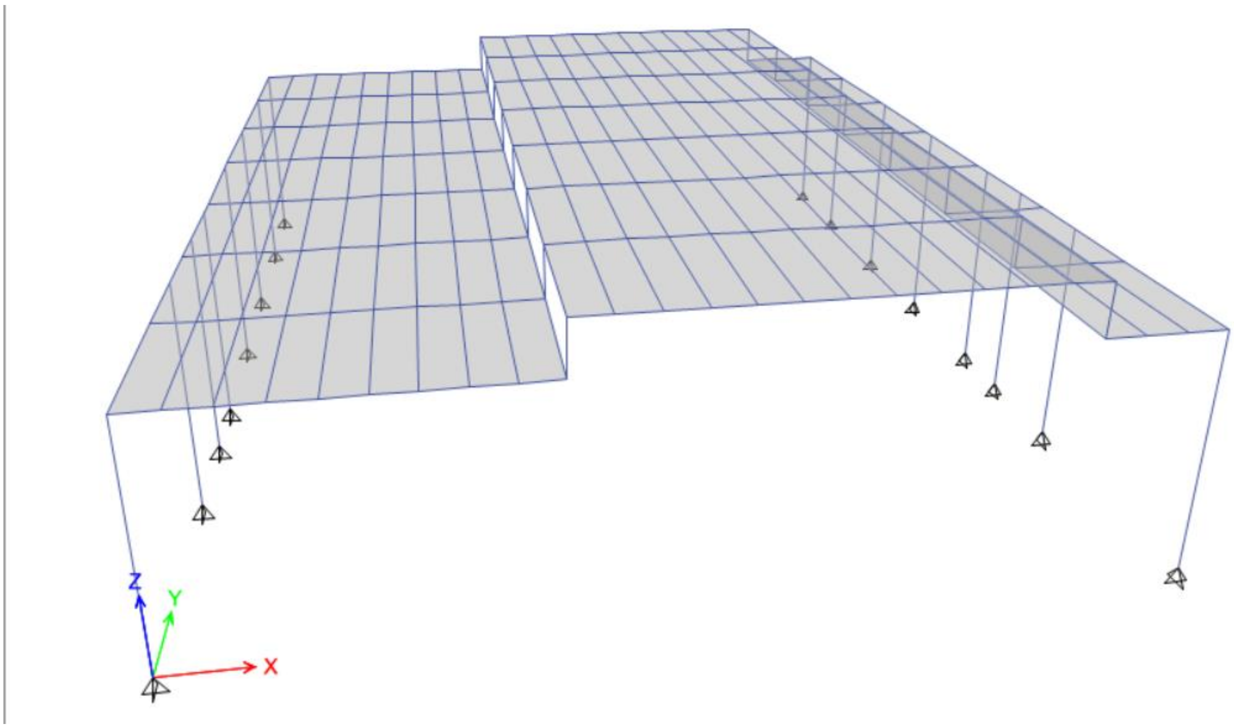


Figure 25 E-Tabs model

4.5.4.3 E-Tabs checks

1) Compatibility check

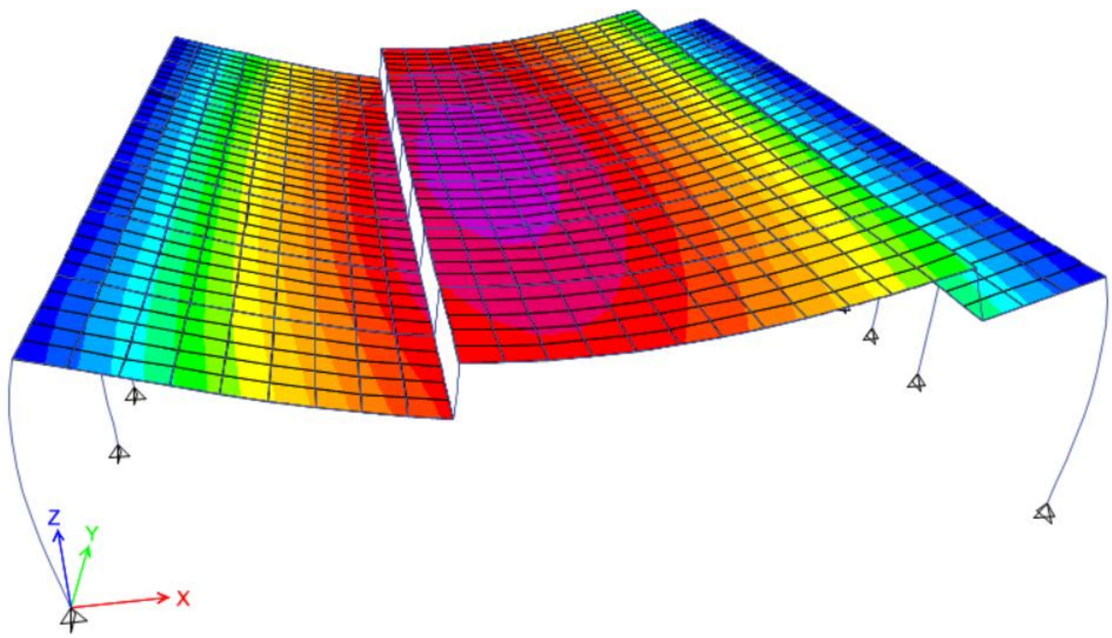
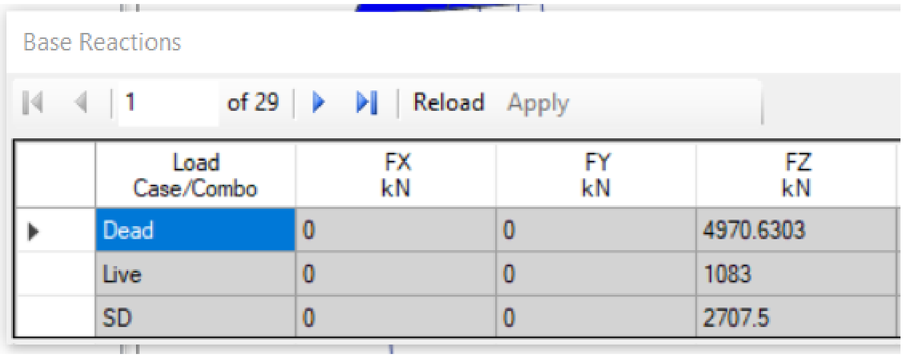


Figure 26 steel Compatibility check

2) Equilibrium check



Base Reactions

1 of 29 Reload Apply

	Load Case/Combo	FX kN	FY kN	FZ kN
▸	Dead	0	0	4970.6303
	Live	0	0	1083
	SD	0	0	2707.5

Figure 27 E-Tabs Equilibrium check

Load type	Base reaction from ETABs	Base reaction from manual calculation	Percentage of error (%)
Dead	4970.63	4951	3%
Live	1083	1083.6	0%
Super imposed	2707.5	2709	0%

Table 3 E-Tabs Equilibrium check

- Live load = (area of slab) * live load
- Live load = 1083.6*1 = 1083.6
- Super imposed dead
- SID = (area of slab) * SID
- SID= (1083.6) * 2.5 = 2709

3) Column stress-strain

Check from live load:

ETABs load (Kn)	Manual load (Kn)	Error%
39.79	36.33	8.6%

➤ Manual calculation:

Tributary area = 11.25*3.23 = 36.33 m

Axial load = tributary area * live load = 36.33*1 = 36.33 m

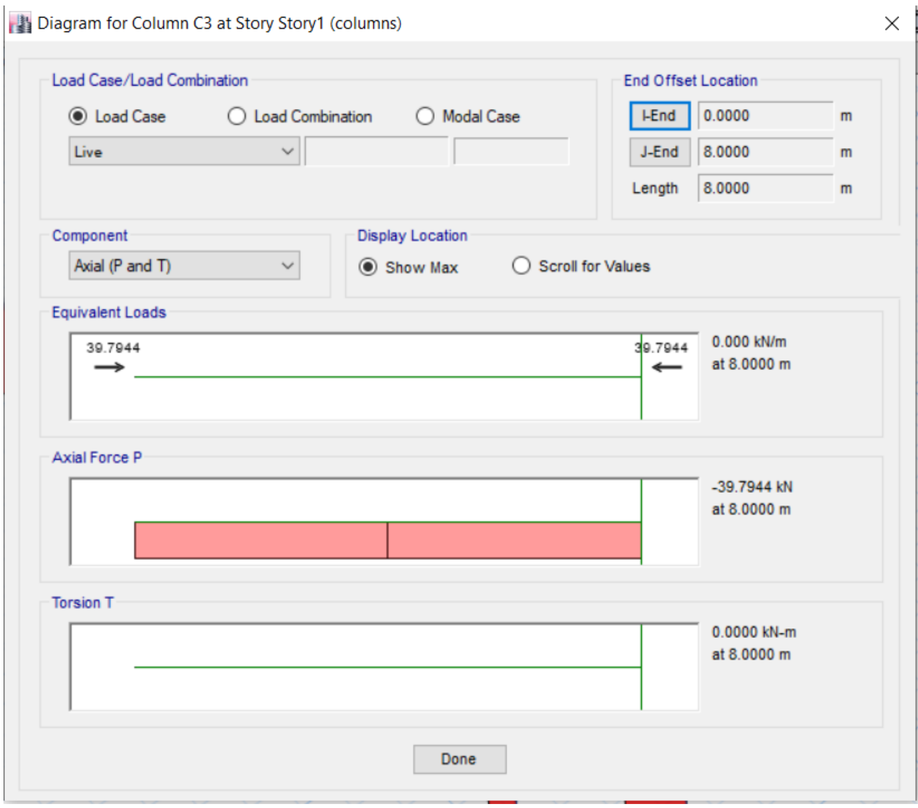


Figure 28 Column check

<u>Percentage of error = (39.79-36.33) / (39.79) * 100% = 8.6% < 10 % …. OK</u>

4.6 Seismic design

The design done on code IBC 2012. Static design done on model:

- Taking 100% dead and super imposed dead load and 25% live load
- Importance factor 1.25
- R = 3.5
- Omega = 3
- Cd = 3
- Fa = 1
- Fv =1

4.6.1 Load combination

- Ws = 1D. L + 1S. D
- Ws= 1D. L + 1L. L + 1 SD
- Ws=1.4DL+1.4SD
- Ws=1.2DL+1.6LL+1.2SD
- Ws=1.3DL+1LL+1.3SD+1EQx
- Ws=1.3DL+1LL+1.3SD-1EQx
- Ws=1.3DL+1LL+1.3SD+1EQy
- Ws=1.3DL+1LL+1.3SD-1EQy
- Ws=0.8DL+0.8SD+1EQx
- Ws=0.8DL+0.8SD-1EQx
- Ws=0.8DL+0.8SD+1EQy
- Ws=0.8DL+0.8SD-1EQy

4.6.2 Seismic load checks

1) ***Steel deflection check:***

- From IBC 2012 code $\Delta_{allowable} = L/180 = 32/180 = 0.177$ m = 177 mm

➢ Max deflection from Etabs = 29 mm< 319 mm (OK).

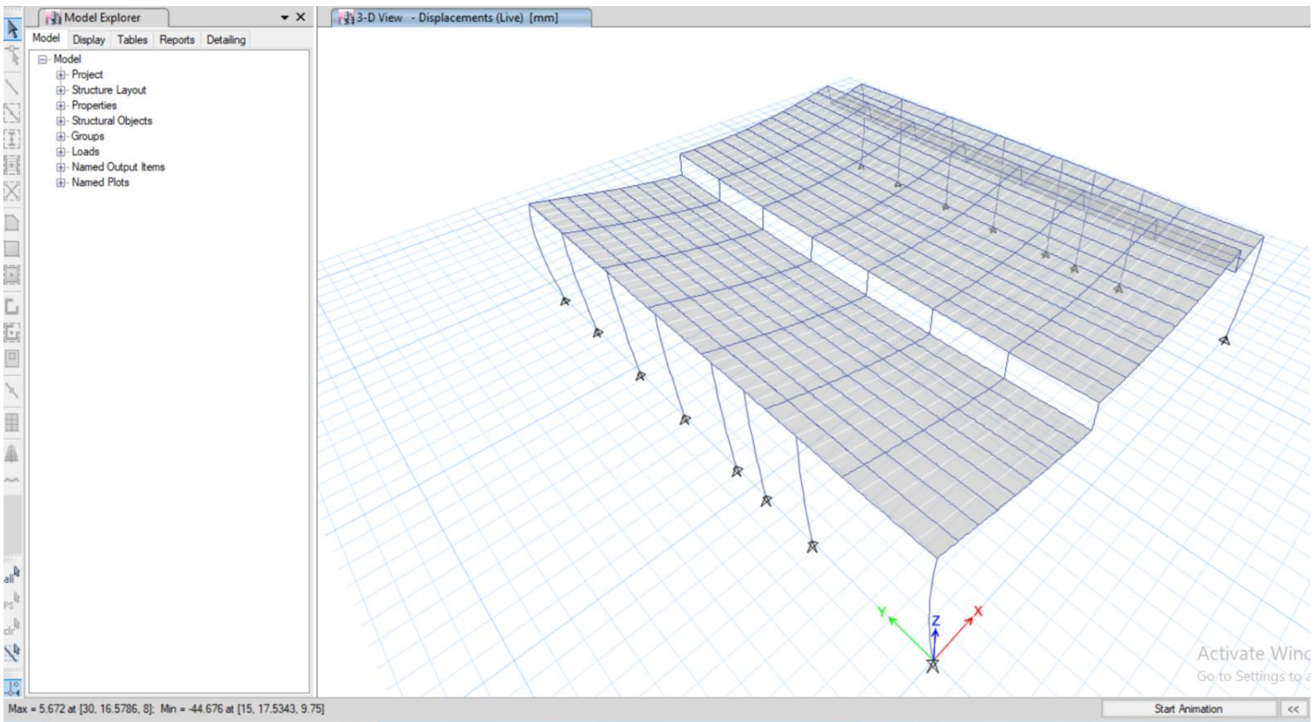


Figure 29 Seismic Etabs check

2) ***Check Modal Mass Participation Ratio:***

According to IBC Code, it should have a Modal Participating Mass Ratio (MPMR) more than 90% in X and Y directions. From 1st model we get 99% in Y and 99% in X.

Modal Participating Mass Ratios

1 of 12 Reload Apply

Case	Mode	Period sec	UX	UY	UZ	Sum UX	Sum UY	Sum UZ	RX	RY	
Modal	1	3.818	6.282E-07	0.9999	0	6.282E-07	0.9999	0	0.1215	0	0.00
Modal	2	3.198	0.9982	1.423E-06	0	0.9982	0.9999	0	0.0001	0.1173	0.00
Modal	3	2.289	0.0017	0.0001	0	1	1	0	0.0504	0.0002	0.99

Figure 30 Check Modal Mass Participation Ratio

3) Check period

Any structure has a special period and frequency, the period is the main factor which affect the seismic load and its damage on the structure. It depends on the structural mass and stiffness.

$$T_a = C_t * h_n^x$$

- T_a: Approximate fundamental period.
- T_n: Fundamental period.
- h_n: Structural height.
- C_t: Building period coefficient.
- X: factor depends on the structural system.

- $C_t = 0.0488$
- X = 0.75
- $T_a = 0.0488 * 9.75^{0.75} = 0.27\ sec$
- $T = C_u * T_a$

- T: the max. limit for approximated period.
- C_u: Coefficient for upper limit on calculated period.

- $T = 1.7 * 0.27 = 0.459\ \mathrm{sec} > 0.362\ sec$

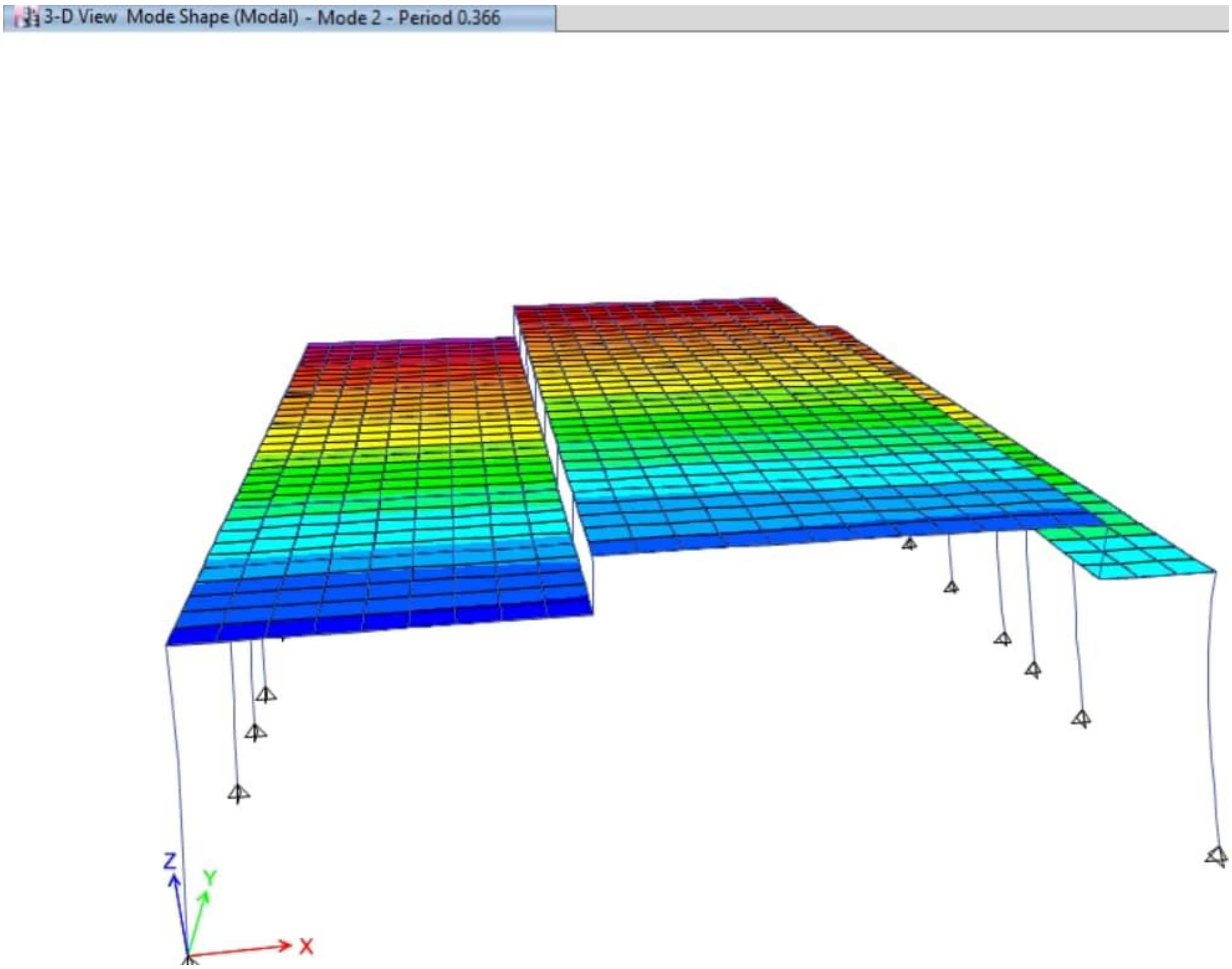


Figure 31 E-Tabs Period check

4) ***Base shear check:***

$V = C_s * W$

- V: Base shear.
- C_s: Seismic response coefficient.
- W: Total weight of the structure.

- $C_s = S_{Ds} * \frac{I}{R}$
- $C_s = 0.25*\frac{1.25}{1.03} = 0.3$
- W =7947 kN
- V = 0.3 * 7947 = 2384.1 kN
- $V_{min} = C_{s,min} * W$
- $C_{s,min} = 0.044 S_{Ds} * I > 0.01$
- $C_{s,min}$ = 0.044*0.25*1.25 = 0.01375 >0.01
- V_{min} = 0.01375*7947 = 109.27 kN
- $C_{s,max} = \frac{S_{D1}*1}{T*R}$
- $C_{s,max} = \frac{0.05*1.25}{0.362*1.03} = 0.167$
- V_{max} = 0.167* 7947 = 1332.1 kN.
- V_{ETABs} = 179 kN.
- $V_{max} > V_{ETABs} > V_{min}$

Base Reactions

1 of 29 Reload Apply

	Load Case/Combo	FX kN	FY kN
▶	Dead	0	0
	Live	0	0
	SD	0	0
	EQx 1	-179.6767	0
	EQx 2	-179.6767	0
	EQx 3	-179.6767	0
	EQy 1	0	-179.6767

Figure 32 Base shear check

5) Moment check

SECTION	ETABS	
	ØMn(kN.m)	Mu(kN.m)
W14*211	1982	453
W27*368	6304	1105

Table 4 Moment check from E-tabs

6) Lateral Torsional Buckling:

It is a failure happen in beams usually, if the beam is not laterally braced, then it may buckle laterally with twist. It is affected by unbraced length and week radius of gyration.

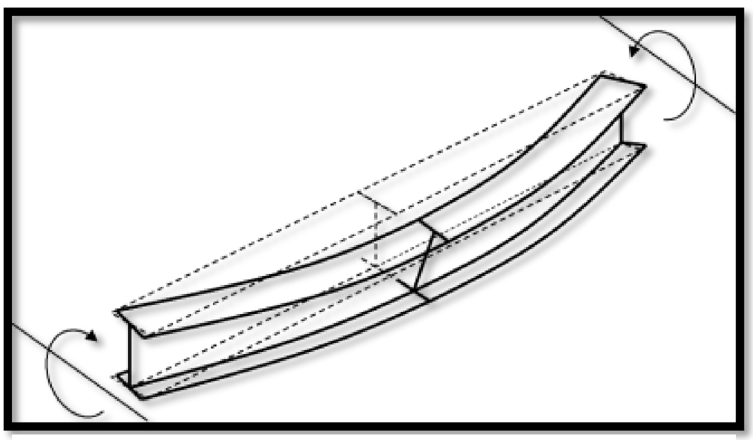


Figure 33Torsional buckling

- $L_p = 1.76*r_y*\sqrt{\frac{E}{Fy}}$
- $L_p = 1.76*103.3*\sqrt{\frac{200000}{250}}$ /1000=5.1m
- L_b = 5.1 m <L_p.

- So, no lateral torsional buckling.

4.7 U-Boot design (Second block)

4.7.1 Project Description

This block which represent the gym is part of the whole building, the building is consisted of two floor one of them is slopped floor.

The figure below shows the distribution of columns in the ground floor:

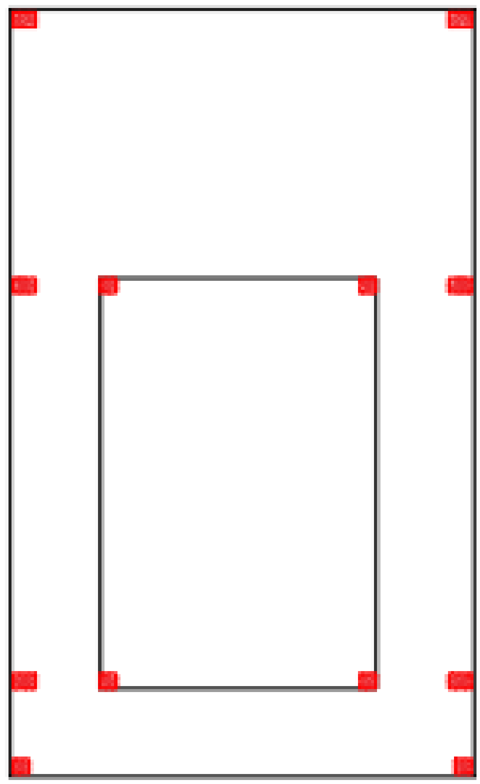


Figure 34 distribution of columns in the ground floor

The following figure is 3D view for the structure.

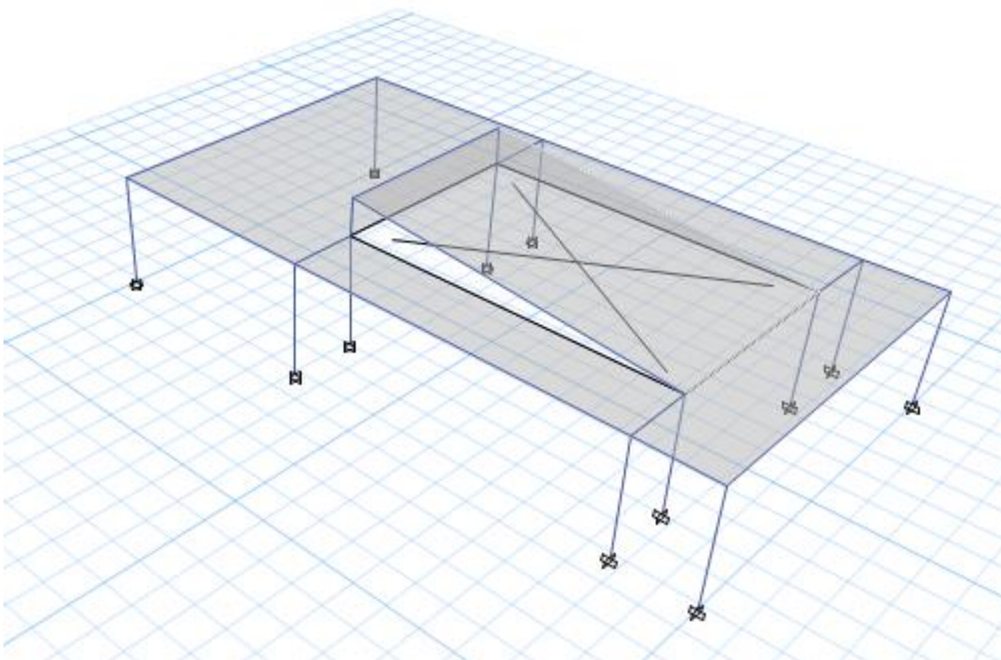


Figure 35 E-Tabs 3D view

4.7.2 Design codes

The following two codes were used:

1. ACI for structural concrete elements.

2. UBC to design the Seismic load.

4.7.3 Loads

This building consiste of one floor and will not add another floor in the future for architectural reasons

1. live load equals to 2.5KN/m².
2. Supper imposed load (SID) load equals to 4 KN/m².
3. Earthquake load: response spectrum method.

Loads that used in the building are:

- Dead load which represent the own weight of the building structures.

- SID load: includes tiles weight, sand, mortar, false ceiling and partition.
  - $SID = (\gamma \times h)tiles + (\gamma \times h)morter + (\gamma \times h)sand + false\ ceiling + partition\ walls.$

$$SID = (25.0 \times 0.03) + (23.0 \times .03) + (20.0 \times 0.1) + 0.2 + 0.4 = 4\ \mathrm{KN/m^2}.$$

- Live load: depending on ASCE code, the value of live load equal to 2.5KN/m^2 in this project.

- Earthquake load used response spectrum method for design.

<u>Load combinations</u>

The ultimate load combinations that were used in this design are- :

1. 1.4D
2. 1.2D+ 1.6L
3. 1.2D + 1.0E + 1.0L
4. 0.9D ± (1.3W or 1.0E)

- Where:

D: dead load.
L: live load.
W: wind load.
E: earthquake load.

- E = ρ Eh + Ev
- Where:

Ev = 0.5 *Ca *I *D

ρ = 1

ca (acceleration-dependent seismic coefficient) =0.20

I -Importance factor=1.25

- E = 1EQ + 0.125D
  1) 1.4D
  2) 1.2D+ 1.6L
  3) 1.325D + 1.0E+ 1.0L
  4) 0.775D ± 1.0E
- The service load combinations used for this design:
  1) Dead
  2) Dead+Live
  3) 0.9Dead± $\frac{1}{1.4}$Earth quick

4.7.4 Materials

The materials that used in the design have the following properties:

1. The compressive strength of concrete equal 24 MPa used for beams, slabs and footings.

2. compressive strength for columns concrete equal 28 MPa.

3. yielding strength for steel equal 420 MPa.

4.7.5 Design Stage

1) Slabs

Because of the large spans in the building U-Boot slab is used in this project.

The primary thickness for slab is=$\frac{4}{3} \times \frac{L\,max}{36}$.

L max = 14.1 m So, h =$\frac{4}{3} \times \frac{14.1\times10^3}{36}$ = 522.2mm…… use h=530mm as a primary value.

Double U boot system have 28cm of the top U-boot piece and 13 Centimeter of the lower according to catalogue of U-boot Company.

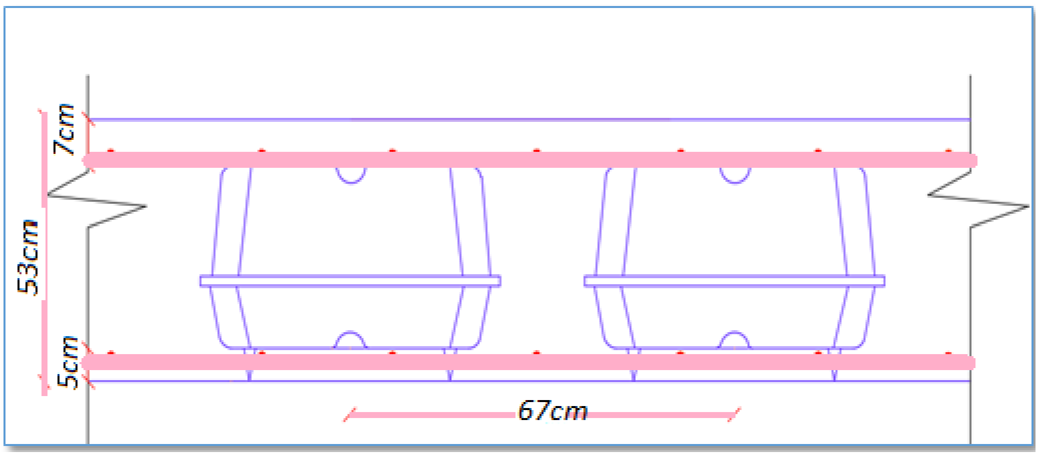


Figure 36 U-Boot

- Two-way Solid slab is used for inclined roof with thickness 700mm.

2) Beams

Beam thickness is defined according to the longest span.

h beam = $\frac{L}{18.5} = \frac{14.1}{18.5} \times 1.2 = 0.91 \rightarrow$ use h= 100cm.

3) Columns

Tributary area method is used to calculate the loads of each column. The following table, shows the initial dimensions of columns.

Column No.	Dimensions of column (cm)
C1	50×50
C2	50×70
C3	60×100

Table 5 Columns dimension

- For the ETABS modeling, shells and frames have modifiers
  - **Slab**
  - U-BOOT slab modifier

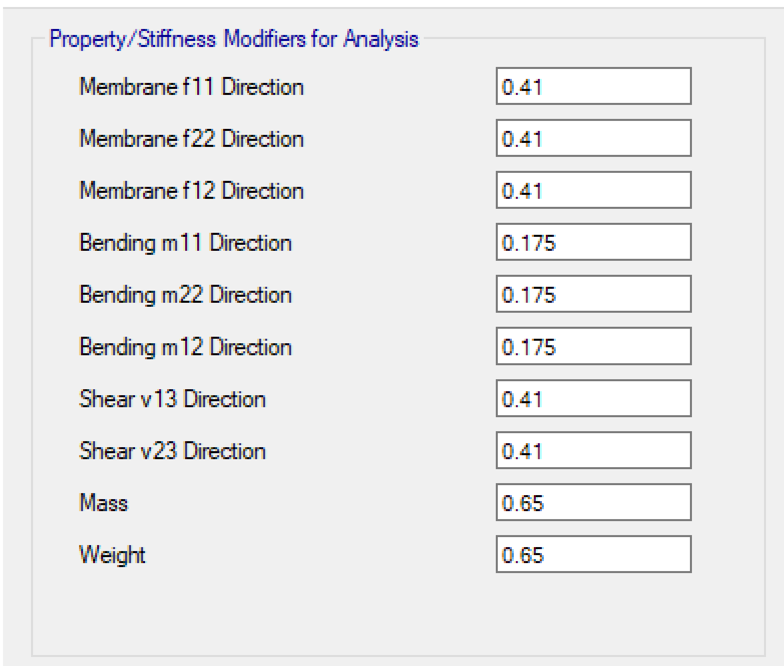


Figure 37 Modifiers for slab in E-Tabs

Moment modifier = 0.7 X 0.25 (solid slab moment modifier) = 0.175.

Solid slab modifiers

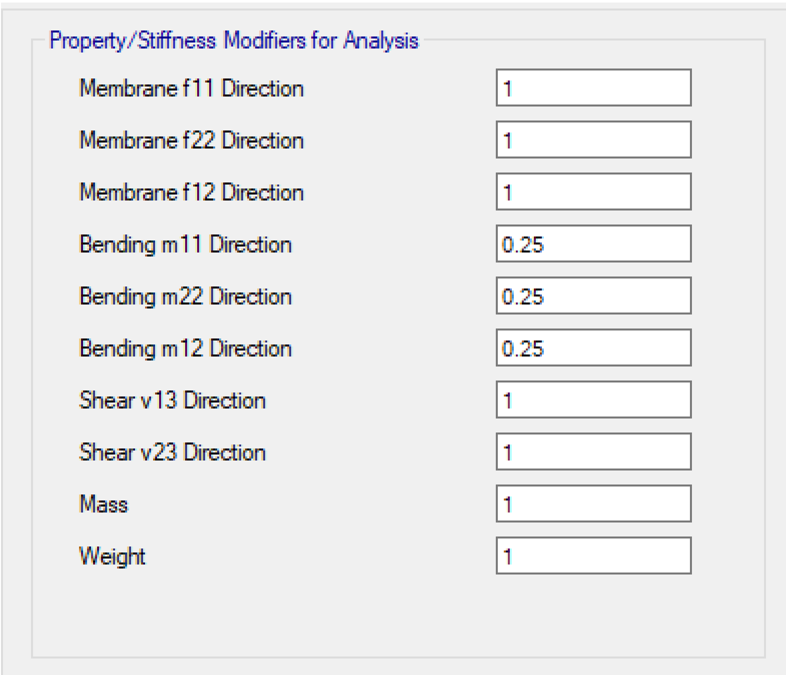
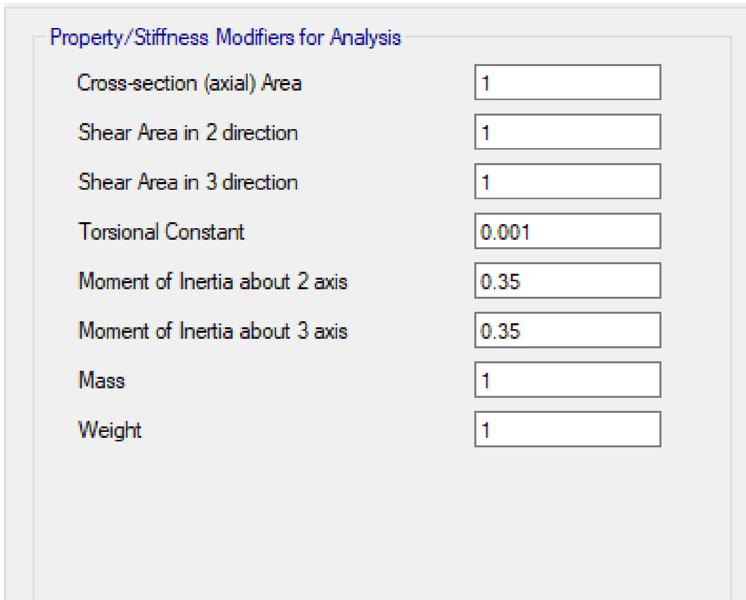


Figure 38 Solid slab modifiers

- **Beams**

These modifiers are used for all the sections of beams



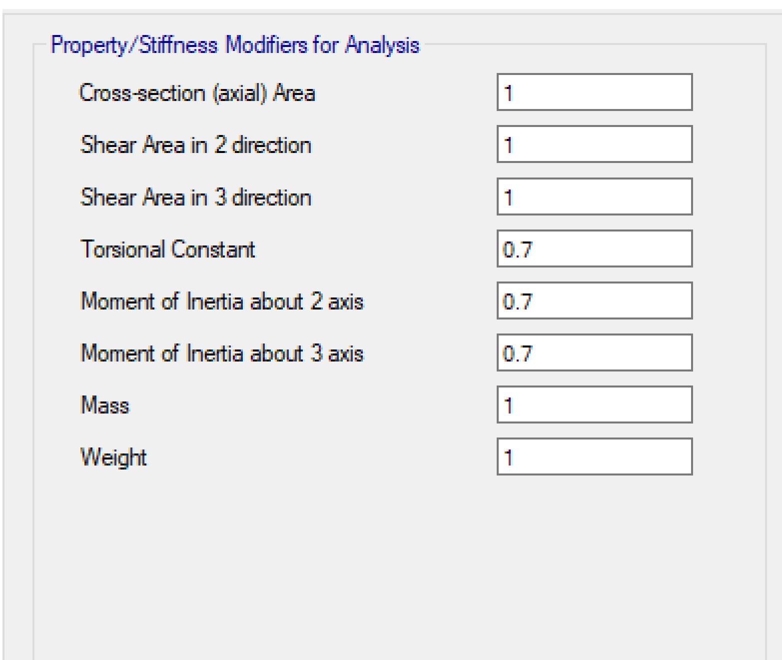
Property/Stiffness Modifiers for Analysis

Cross-section (axial) Area	1
Shear Area in 2 direction	1
Shear Area in 3 direction	1
Torsional Constant	0.001
Moment of Inertia about 2 axis	0.35
Moment of Inertia about 3 axis	0.35
Mass	1
Weight	1

Figure 39 Beam modifiers in E-Tabs

- **Columns**

These modifiers are used for all the sections of columns



Property/Stiffness Modifiers for Analysis

Cross-section (axial) Area	1
Shear Area in 2 direction	1
Shear Area in 3 direction	1
Torsional Constant	0.7
Moment of Inertia about 2 axis	0.7
Moment of Inertia about 3 axis	0.7
Mass	1
Weight	1

Figure 40 Columns modifiers in E-Tabs

4.7.6 Analysis of model and checks

To check if the results match the reality. The following checks are done

1. Check for compatibility
2. Check for deflection
3. Check for Equilibrium
4. Check for internal forces (stress strain relationship).

1. ***Compatibility check:***

To make sure that the structural elements are connected to each other and to check the periodicity of the seismic origin.

- The result of this check from ETABS in this project is **Ok**. shape from dead and live loads.

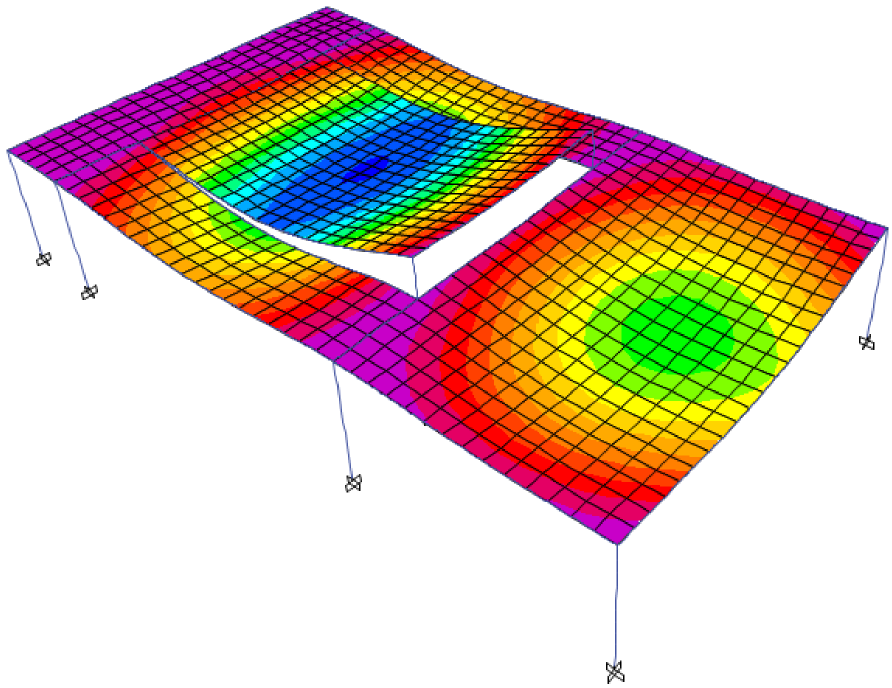


Figure 41 Compatibility check in E-Tabs

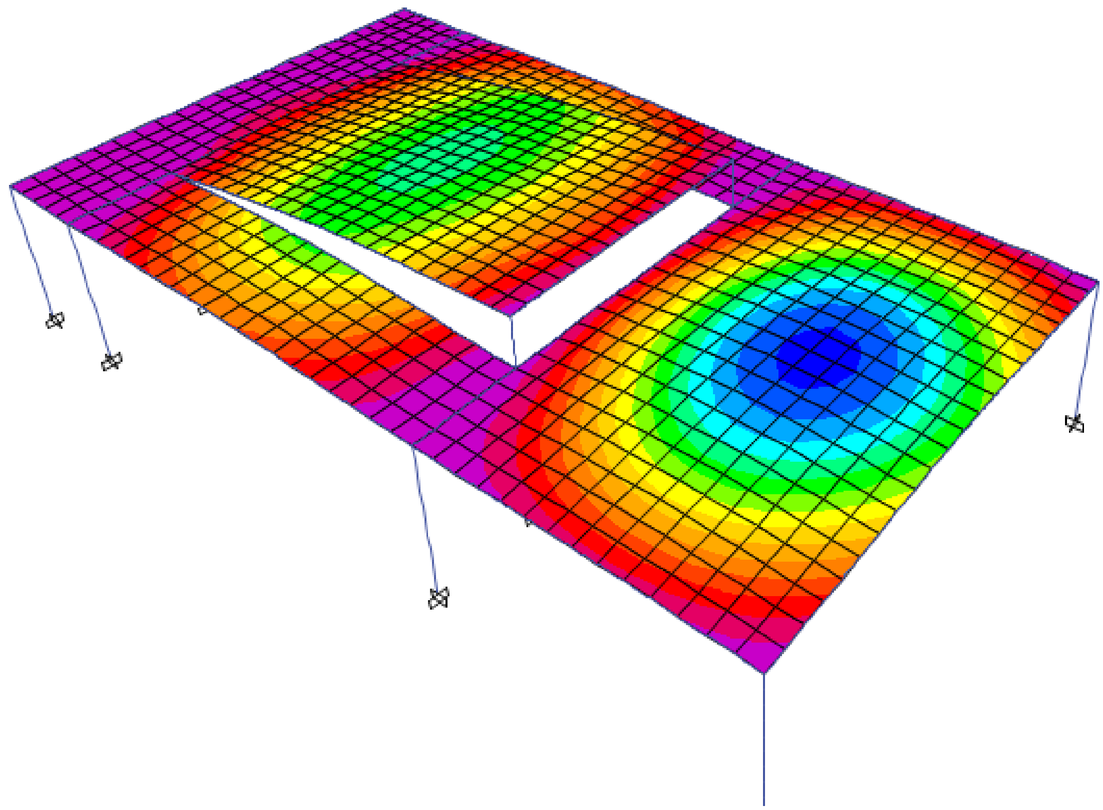


Figure 42 Compatibility check in E-Tabs

2. ***Deflection check***

a. Immediate deflection:

This check is done for slab from live load which has the longest span of length 14.1 m. The figure below shows the deflection on the slabs from Etabs for live load (L.L).

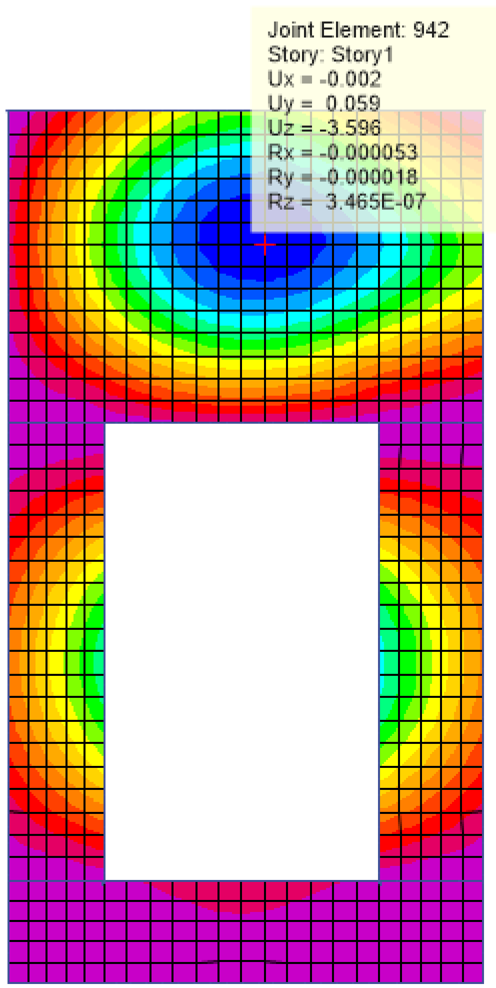


Figure 43 Immediate deflection

- Max allowable deflection = $\frac{14.1}{360} \times 1000 = 39.16\ mm$
- Max deflection from ETAB = 3.596 mm < 39.16mm the check is ok.

b. Service load deflection.

The following figure shows the deflection from service load.

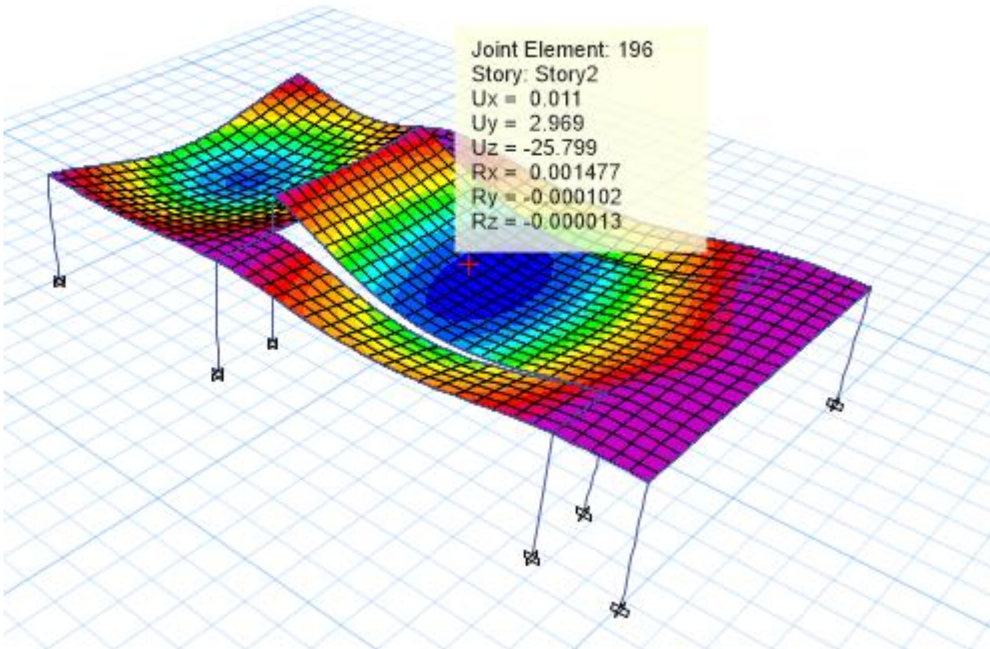


Figure 44 Service load deflection.

- Max allowable deflection = $\frac{14.1}{240} \times 1000 = 58.75\ mm$
- Δservice = $25.79\ mm$< 58.75 mm the check is ok.

3. ***Equilibrium check***

This check is done for the loads in the building which are dead, live and super imposed dead loads.

a. Live load (L.L)

Total live load = $L.L \times total\ area$

$= 2.5 \times 362.95 = 907.375\ kN.$

Live load from ETABS = 909.0541 kN.

The percentage of difference = $\frac{\text{ETAB load − Manual load}}{\text{Manual load}} \times 100\%$

$= \frac{909.0541 - 907.375}{907.375} \times 100\%$ = 0.1% < 5% the check is OK.

b. Super Imposed Dead Load

Because the block consists of one floor so there is noWall weight

Total SID load = SID× area + wall

= 4×362.95 =1451.8 KN.

From ETAB SID load equal= 1454.487 KN.

The percentage differenc = $\frac{\text{ETAB load − manual load}}{\text{manual load}} \times 100\%$

$= \frac{|1454.487 - 1451.8|}{1451.8} \times 100\%$ = 0.2% less than 5% then check is OK.

c. Dead load

- Columns

	Dimension	Height m	number	Weight KN
C1	50*70	4.5	6	236.25
C2	60*100	4.5	2	135
C3	50*70	1.5	2	26.25
C4	50*50	4.5	2	56.25
C5	60*90	4.5	2	121.5
Total	575.25			

Table 6 Columns detailing

- Beam

Beam type	Dimension cm	Weight KN
B1	80*100	2850.01
B2	50*53	179.9522
Total		3030.033

Table 7 Beams detailing

- ***slabs***

Solid slab=0.35*25*1*1=8.75 KN/m^2

U-boot slab=8.449 KN/m^2

Slab type	Weight KN/m^2	Area m^2.	Weight KN
Solid slab	17.5	111.44	975.1
u-boot slab	8.449	252.18	1950.2
Total			2925.3

Table 8 Slabs detailing

- Total manual dead load equal 6530.853 KN
- Etab dead load equal 6551.072 KN.

$$\text{Difference percentage} = \frac{\text{ETAB load} - \text{Manual load}}{\text{Manual load}} \times 100\%$$

$$= \frac{|6551.072 - 6530.853|}{6530.853} \times 100\% \quad = 0.3\% < 5\% \text{ the check is OK.}$$

*4. **Internal forces check***

a. For columns:
This check will be done by using live load for 2 columns.

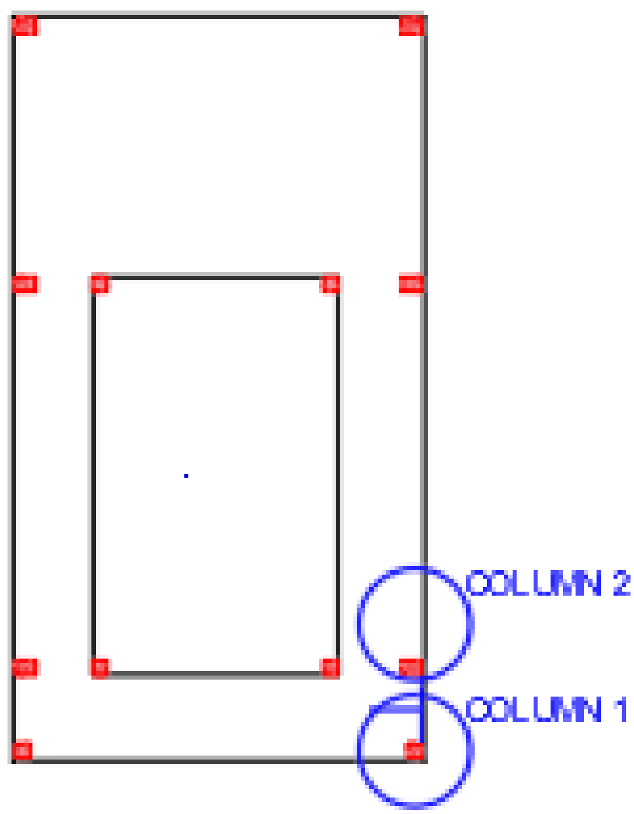


Figure 45 Columns

1. Column 1.

Manual axial load = load × Area

= 2.5×28.8= 72 KN.

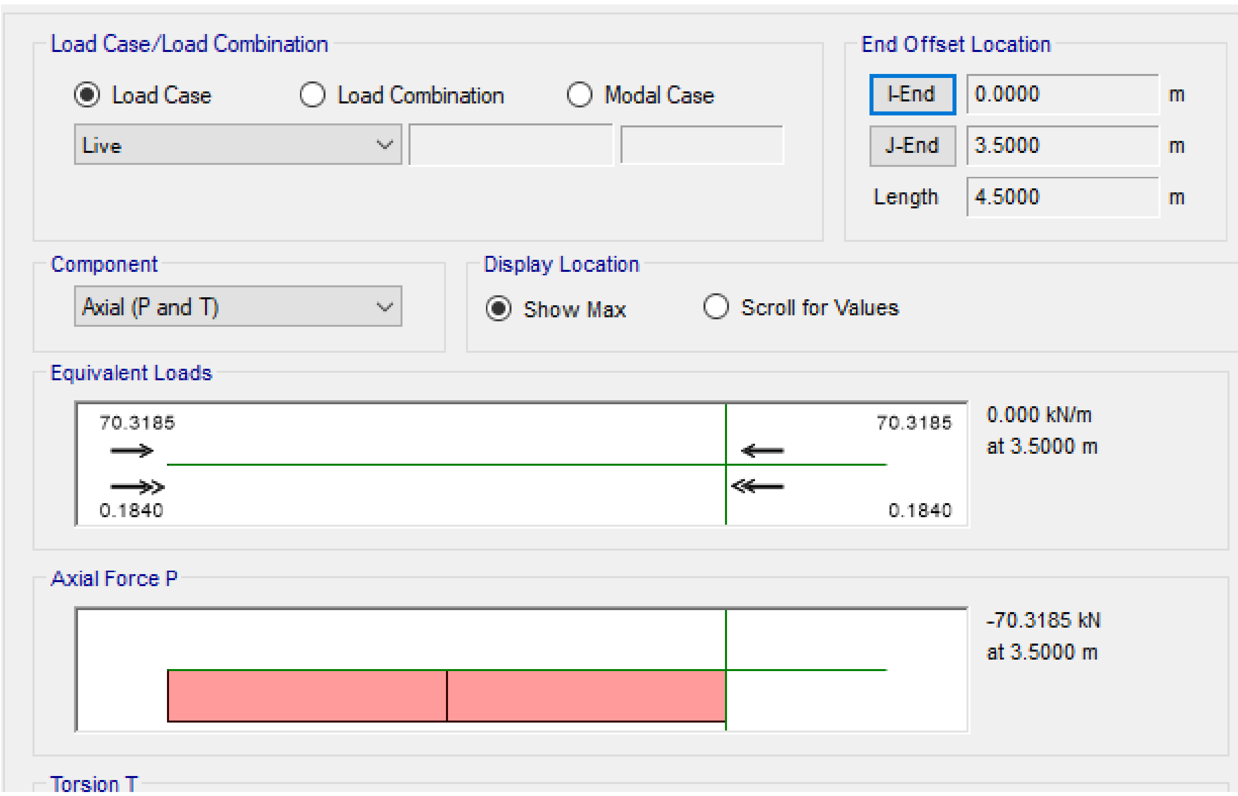


Figure 46 Column 1 check

The percentage of difference = $\frac{|70.32-72|}{70.32}$ ×100% =2.3% < 5% the check is OK.

2. Column 2.

Manual axial load = load × Area

= 2.5* 14.7922= 36.9805KN.

Axial load from ETAB =35.4196KN.

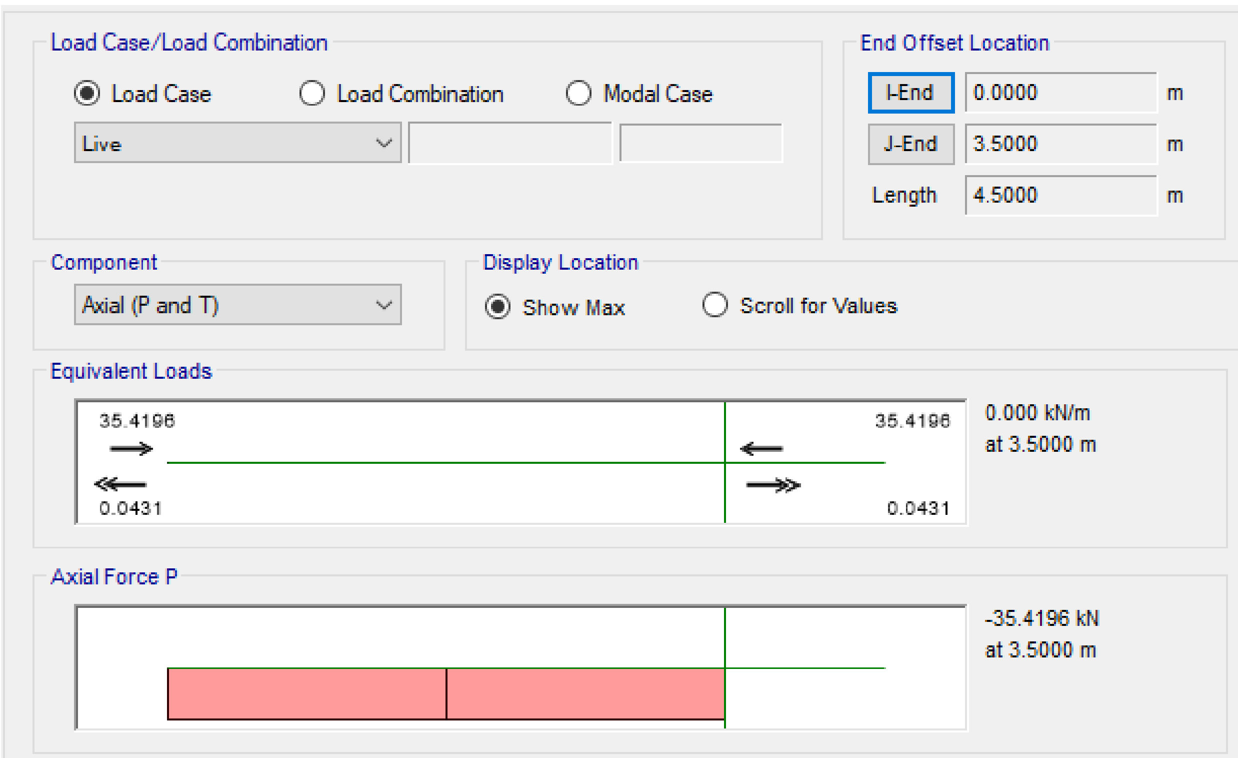


Figure 47 Column 2 check

Difference percentage = $\frac{|35.4196-36.98|}{35.4196}$ ×100% = 3.627% < 5% the check is OK.

b. For beam:

The check done from live load as shown the following figure.

Area = 32.37m².

Wu in beam = $\frac{\text{load} \times \text{Area}}{lenght} = \frac{2.5*32.37}{7.4558}$ = 10.8539 KN/m.

Mu manual = $\frac{\text{Wu}\times L^2}{10} = \frac{10.854\times 7.456^2}{12}$ = 50.28 KN.m.

Mu from ETAB = 26.6859 - $\frac{(-20.7422 + -20.4737)}{2}$ = 47.294 KN.m

Difference percentage = $\frac{|50.28-47.294|}{50.28}$ ×100% = 5.93% < 10% the check is OK.

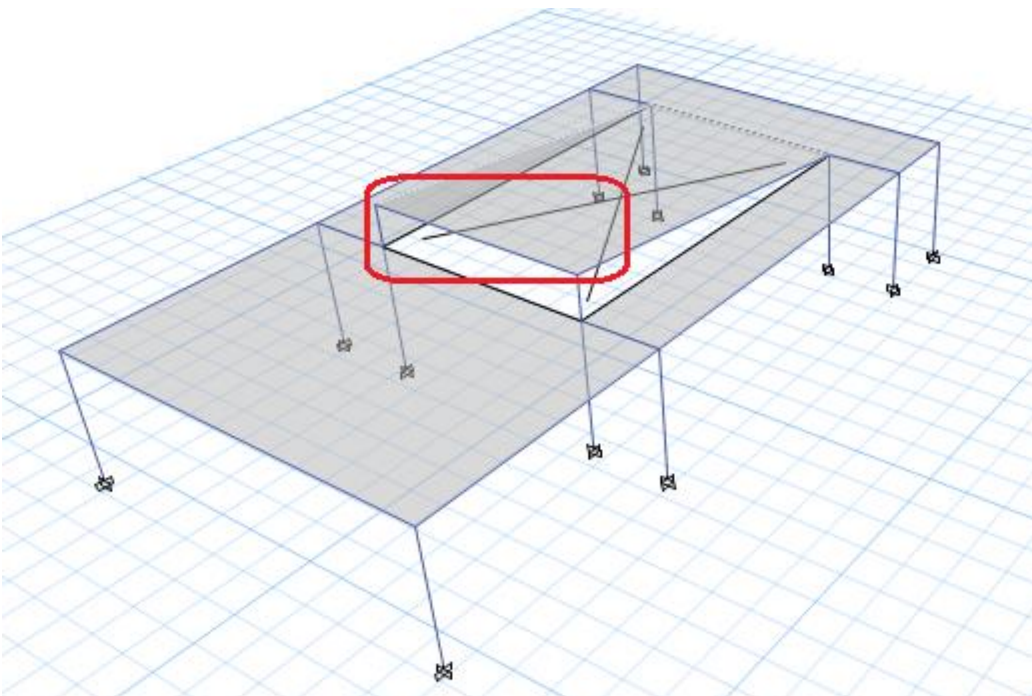


Figure 48 Check for beam

4.8 Seismic design

4.8.1 Definition of response spectrum seismic load

The following functions used to analysis and design the model for earthquake loads.

- The building mass is calculated by defining a mass source that includes total DL with the (SID), and also including 25% of the live loads.
- From the seismic hazard map Nablus seismic zone is **2B**. (Z= 0.20).

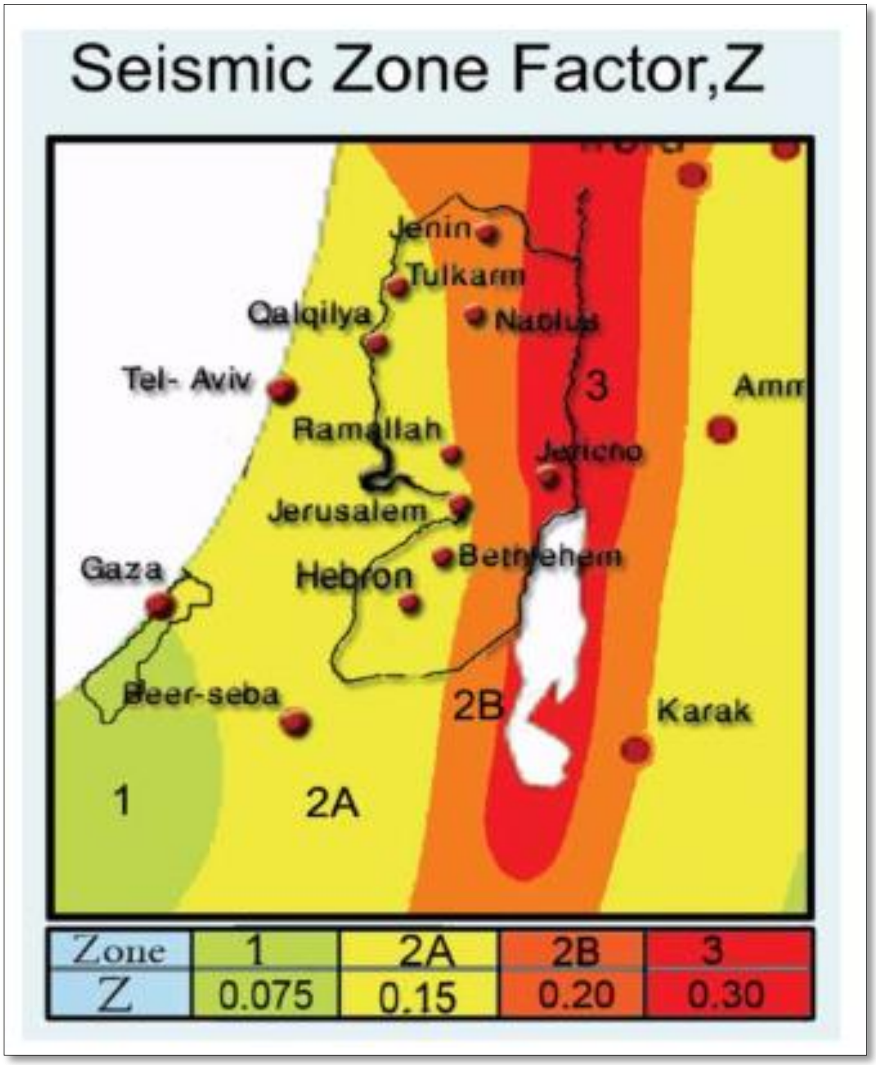


Figure 49 Seismic plan in Palestine

- Importance factor, I = 1.25
- Soil profile is Sc.
- Acceleration-dependent seismic coefficient, Ca = 0.20
- Velocity-dependent seismic coefficient, Cv = 0.20
- Force reduction factor, R= 5.5 (IMRF)

4.8.2 Validation of seismic loads checks

.

1. ***Period check***

Building period check is calculated manually according to the UBC 97 code:

$T = Ct \times hn3/4$

- Ct = (0.0731) for reinforced concrete moment-resisting frames.
- hn: building height = 6 m.

➢ Then T method equation: A= 1.4× $Ct \times hn3/4$

➢ 1.4*0.0731* 6 3/4= 0.3923sec

Also, the period was obtained from ETABS, it was found to be equal to 0.349 sec as shown in the figure below:

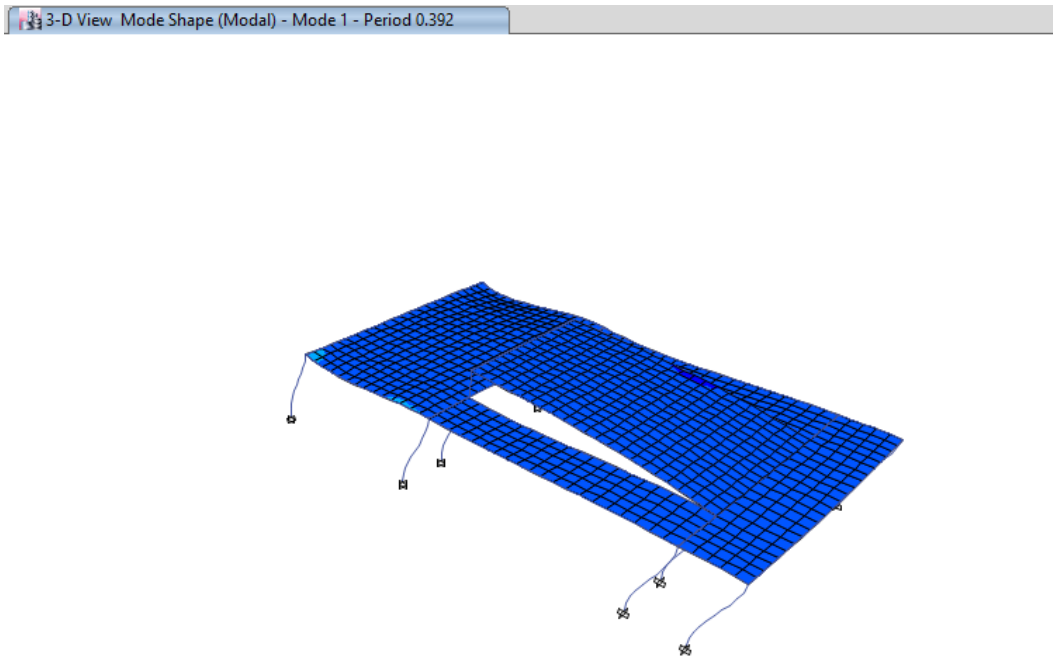


Figure 50 Period check

Period from ETABS equals period from T method A ➔ the check is **Ok**.

2. ***Base shear check.***

$V = min\left(\frac{2.5\times Ca}{Cv/T}\right)\times W\times\frac{I}{R}$

Such that:

- V = Base shear.
- W = building weight.
- W1 = D + SID + 0.25L
  - = 7526.1642 + 1454.4865+ 0.25× 909.0541 = 9207.914225 KN.
- $V = min\left(\frac{2.5\times 0.20}{0.20/0.329}\right)\times 9207.914\times\frac{1.25}{5.5}$ = 1046.354 KN.

Load Case/Combo	FX kN	FY kN	FZ kN	MX kN-m
Dead	0	0	6551.0727	81047.237
Live	0	0	909.0541	11745.2729
SID	0	0	1008.7304	14412.4113

Figure 51 Base shear check

Base shear value for Fx value and Fy value is defined from ETABS is less than the value of manually base shear, so the values enlarged by maximizing the scale.

Load Case/Combo	FX kN	FY kN
EQX Max	1010.5221	0.8389
EQy Max	0.8389	1014.849

Figure 52 Base shear before modification

As shown, EQx in X- direction =1010.5221 KN which is less than V manual, so the response spectrum factor will be changed.

1010.5221 KN	→	**2228.78**
1046.354KN	→	**??**
?? = 2307.81		

And EQy in Y- direction = 1014.849 KN which is less than V manual so the response spectrum scale factor will be changed.

1014.849KN	→	**2228. 78**
1046.354KN	→	**??**
?? = 2297.97		

Base shear after change scale factor is became as in figure

Load Case/Combo	FX kN	FY kN	FZ kN
EQX Max	1046.3476	0.8686	0
EQy Max	0.8649	1046.352	0

Figure 53 base shear check

<u>Drift limitation</u>

Drift limitation (Δm) = $\frac{H\ story}{50}$, if > 0.7

Where, Δm = 0.7× R × Δ Etab

Δm < Δ limit , OK!

height	Ux	Uy	Driftx	drifty	deltax	deltay	limit
	0	0	0	0	0	0	0
4500	1.717	3.486	1.717	3.486	6.61045	13.4211	90
1500	1.849	5.407	0.132	1.921	0.5082	7.39585	30

Figure 54 Drift limitation check

4.9 Shear wall design

Boundary:

B= 0.1*L = 0.1*2712 = 271

H= 300 mm

ρ = 1% ----As = ρ * b * h = 1%*271*300 = 813

Wall label	H (mm)	L(mm)	L (b)	As	Bar used
S.W 1	300	2712	271	813	5 ϕ16mm
S.W 2	300	3099	309.9	929.7	5 ϕ16mm
S.W 3	200	1839	183.9	367.8	2 ϕ16mm

Figure 55 shear wall design boundary

For web:

Steel in horizontal direction:

P = 0.25 % ----- As = ρ * b*h = 1626

Steel in vertical direction:

P = 0.25 % ----- As = ρ * b* h = 1626

Wall	H (mm)	L(mm)	L web	As	Bar used in each side
S.W 1	300	2712	2169	1626	9 ϕ16mm
S.W 2	300	3099	2479	1859	10 ϕ16mm
S.W 3	200	1839	1471	735.5	5 ϕ16mm

Figure 56 shear wall design

4.9.1 Design and reinforcement stage

This part represents the design of the structural elements in the building which contain columns, footing, beam and slab. As it is noticed from the figure, no problem found in building members.

1- For slab.

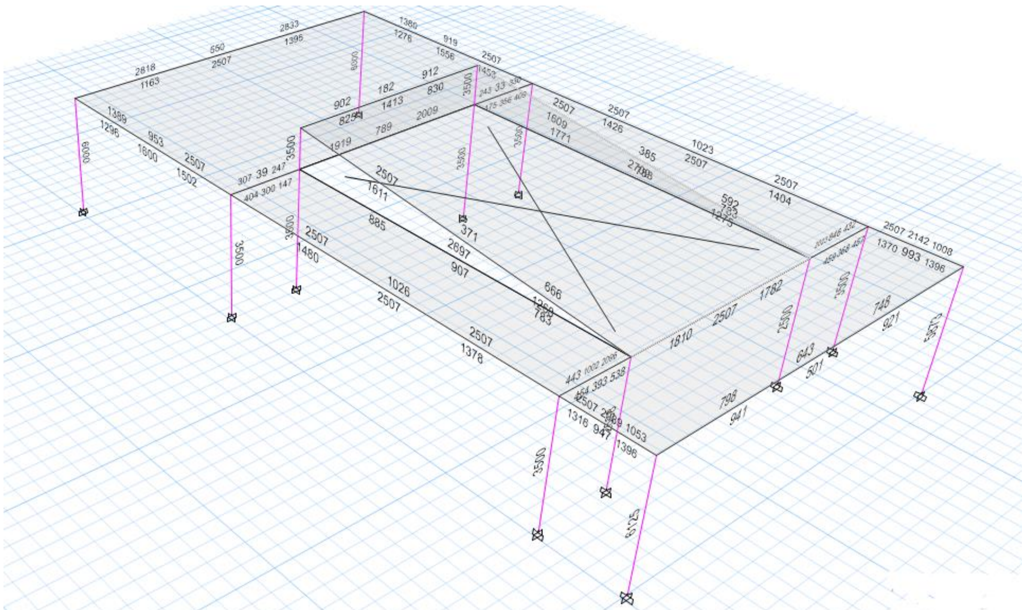


Figure 57 Design and reinforcement phase

U-Boot two-way voided slabs with thickness equal to 53 cm is used for first slab. And two –way solid slab used for inclined slab with thickness 70 cm.

Firstly, to design the slab area of steel min is calculated based on ρmin.

$$\rho min = \max \begin{cases} 1.4/Fy = (0.0033) \\ \frac{0.25 \times \sqrt{fc}}{Fy} = (0.0029 \end{cases}$$

- = 0.0029.

- $As\ min$ (voided $slab$) = $\max\begin{pmatrix} \rho min * bw * d \\ 0.0018 * area_{slab\ section} * area\ modifier \end{pmatrix}$

$$= \max\begin{pmatrix} 0.0033 * 150 * 500 \\ 0.0018 * 670 * 530 * 0.41 \end{pmatrix}$$

$$= 262.06\ mm^2 \rightarrow 4\ \phi\ 12\ mm/m$$

- $As_{used} = 452\ mm^2/m.$
- Now, the capacity of the section is calculated to compare the moment values with it and to reinforce slabs that have moment with value less than it.
- $\emptyset Mu = \emptyset As_{used} \times fy \times (d - \frac{As\ used \times fy}{1.7 \times f'c \times b})$

$$= 0.9 \times 452 \times 420 \times \left(500 - \frac{452 \times 420}{1.7 \times 24 \times 150}\right) \times 10^{-6}$$

$$= 80.1\ KN.m/m$$

- Then, the values of –ve and +ve moment from the ultimate combination were found as the following figures.
- Positive moment for slab (m11) in kN.m/m as the following figure.

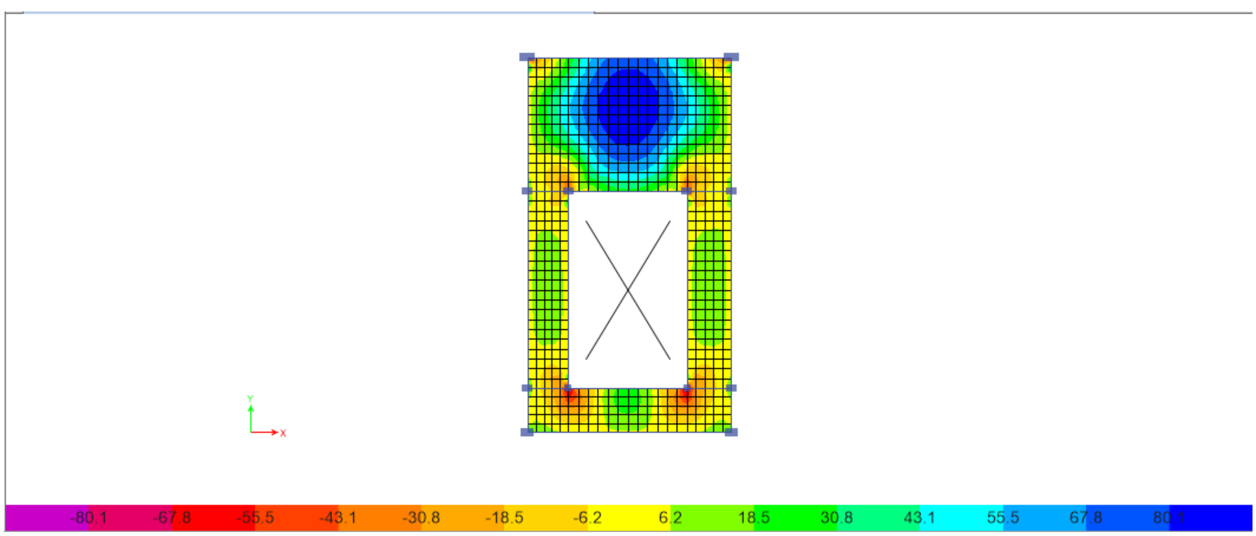


Figure 58 positive moment for (m11)

Positive moment for slab (m22) in kN.m/m as the following figure

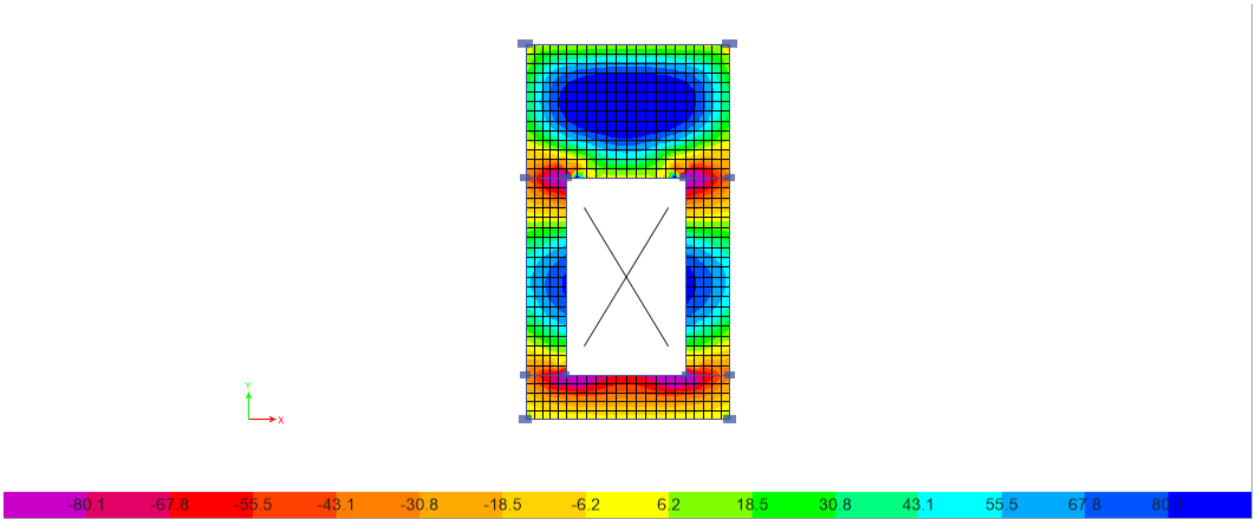


Figure 59 positive moment for the slab (m22)

Negative moment for the slab (m11) in kN.m/m as the following figure

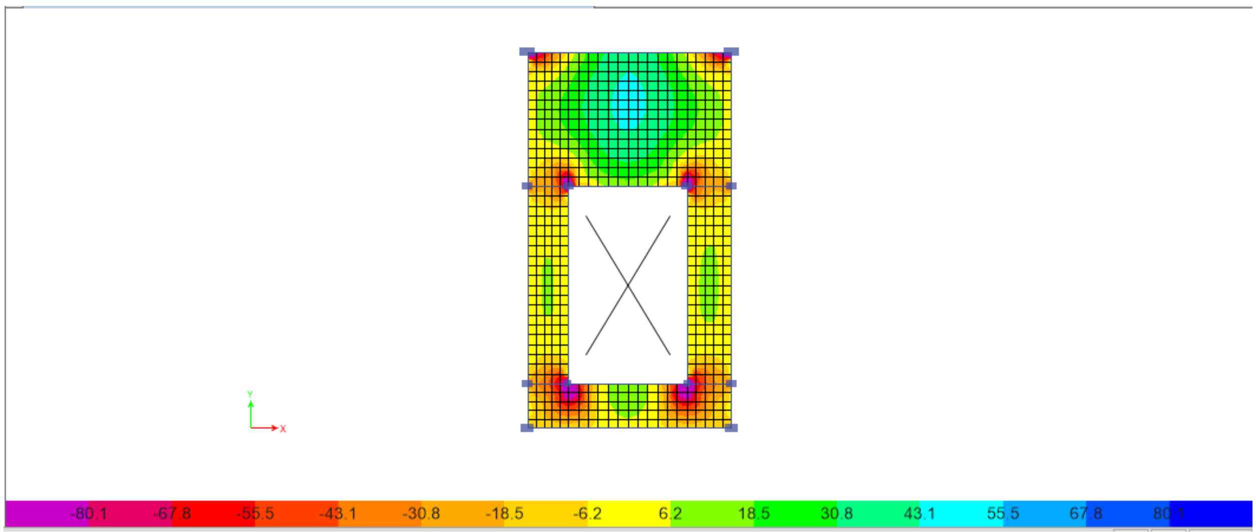


Figure 60 Negative moment for the slab(m11)

Negative moment for the slab (m22) in kN.m/m as shown in Figure

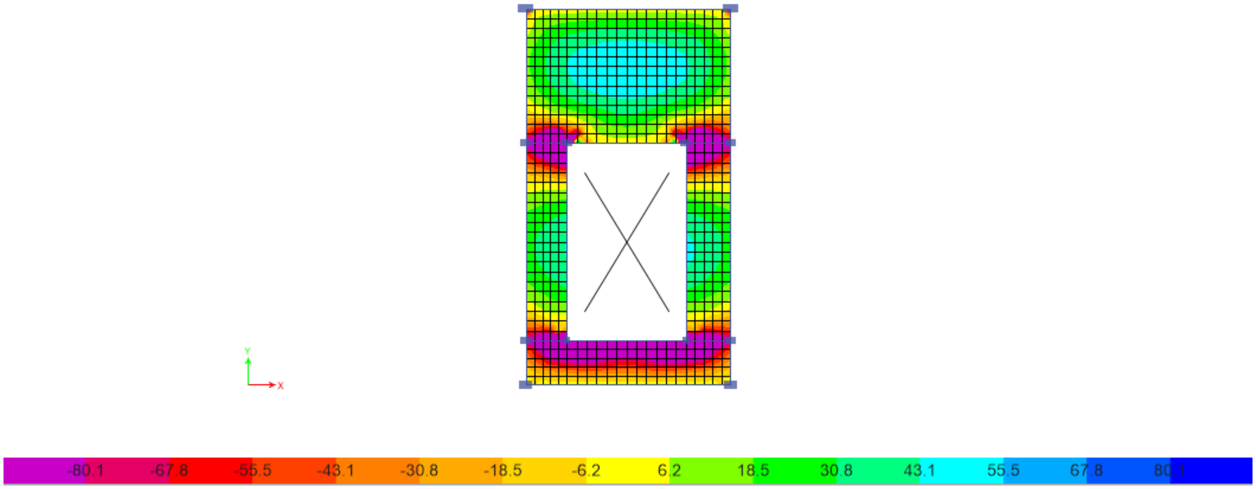


Figure 61 Negative moment for the slab (m22)

- As shown in the previous figures, there are some areas need steel more than the minimum value.

4.9.2 Design of beams

All beams are designed by ETABS program. The following figure shows a sample calculation.

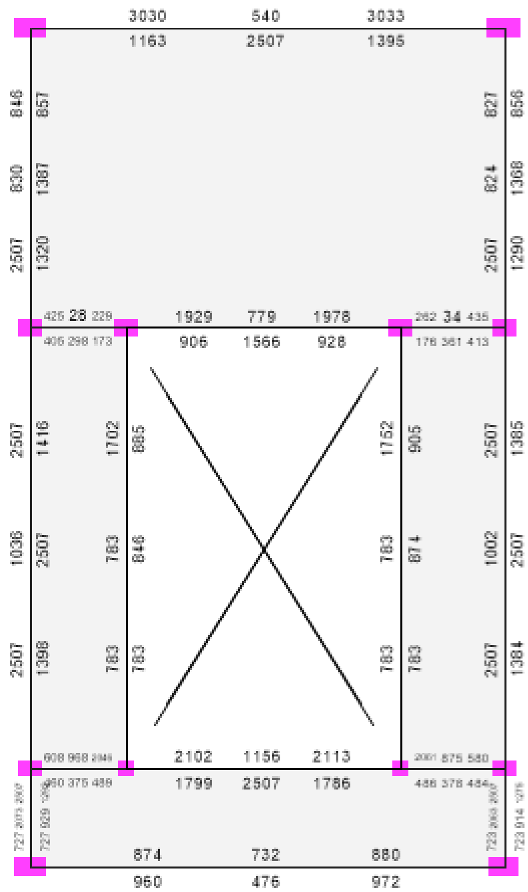


Figure 62 Beams design

- Beam moment.

Beam section= 1000*800 mm

Positive moment = 313.0896 kN.m. as the following figure.

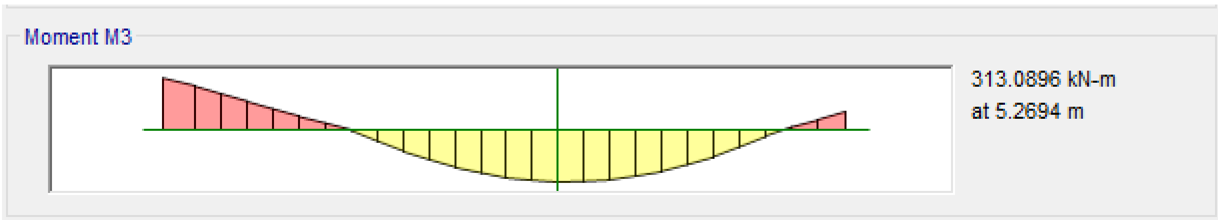


Figure 63 Beam moment

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

$$\rho = \frac{0.85\,(24)}{420} \times \left(1 - \sqrt{1 - \frac{2.61 \times 313.0896 \times 10^6}{24 \times 800 \times 940^2}}\right)$$

$$= 0.0018$$

A_S =0.0018× 800 × 940= 1353.6 mm^2

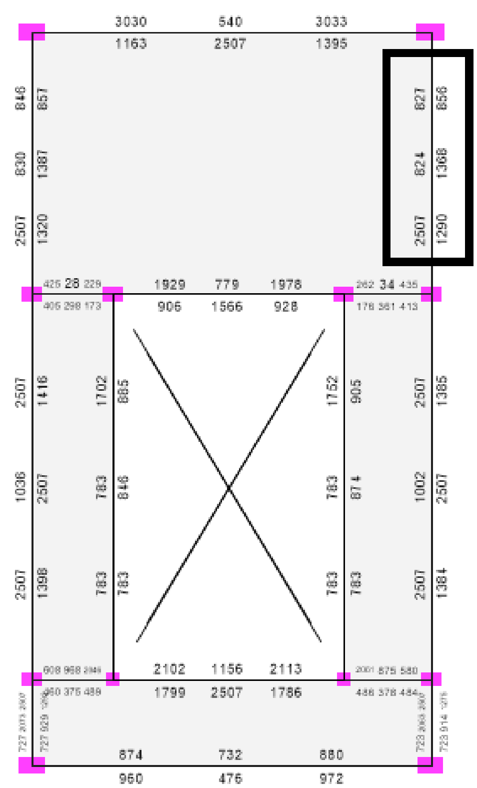


Figure 64 beam design

Longitudenal steel reinforcement from ETABS for posotive moment equal to 1368 as shown in which is close to hand calculation result.

- Beam shear

Vu= 271.66 kN. As shown in Figure below:

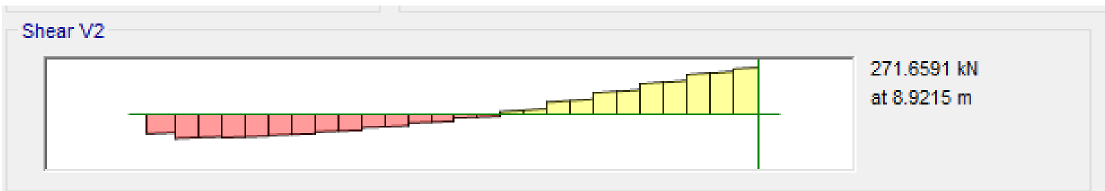


Figure 65 Ultimate shear value

$\frac{Vu}{Ø} = \frac{271.65}{0.75}$ = 362.2 KN

$$Vc = \frac{1}{6} \times \sqrt{fc} \times bw \times d$$

$$Vc = \frac{1}{6} \times \sqrt{24} \times 800 \times 940 = 614\ kN$$

$\frac{Vc}{2}$ = 307 kN < $\frac{Vu}{Ø}$ → reinforcement is needed.

$\frac{Vu}{Ø}$ between Vc and $\frac{Vc}{2}$ so use $\frac{Av}{S}$ min.

$(\frac{Av}{S})$ min = $\frac{\rho_{min} \times bw}{4}$

$$= \frac{0.0033 \times 800}{4} = 0.66\ \mathrm{mm^2/mm}$$

Assume using 2Ø8 with 2 legs → Av = 201 mm^2

$S = \frac{201}{0.99} = 203$ mm.

$S\ max = \frac{d}{2} = \frac{940}{2} = 470$mm.

Use S = 20cm → use 2Ø8mm @ 20 cm.

According to earthquake design.

$$S = \min \begin{cases} d/4 \\ 8db \\ 24ds \\ 300 \end{cases} = \min \begin{cases} 940/4 \\ 8 \times 20 \\ 24 \times 8 \\ 300 \end{cases} = 16\text{cm.}$$

use 2Ø8mm @ 16 cm.

4.9.3 Design of columns

ETABS Software is used to design all columns. Shear and longitudinal reinforcement for columns are obtained from the software. The rebar percentage for most columns equals 1%.

Column ID	Dimension mm	Longitudinal reinforcement	Stirrups @ support	Stirrups @ Mid
C1	50*70	12Ø20	4Ø10/100mm	4Ø10/150mm
C2	60*100	20Ø20	6Ø10/100mm	6Ø10/150mm
C3	50*50	12Ø18	3Ø10/100mm	3Ø10/150mm
C4	60*90	20Ø20	6Ø10/100mm	6Ø10/150mm

Table 9 columns design

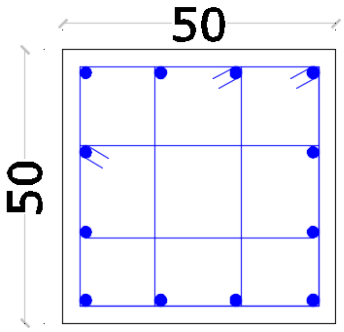


Figure 67 columns detailing

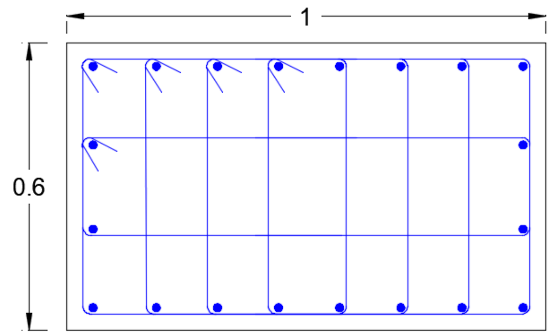


Figure 66 columns design

4.9.4 Footing design

In this project, since the loads on footings aren't relatively big, and the bearing capacity of soil in the site equals to 250kN/m2.

The suitable type of footing in this project is isolated.

The service load and ultimate loads from ETABS were found to be as in the table below:

	Length (mm)	Width (mm)	P(service) (kN)	P(ultimate) (kN)
C1	50	50	1796.21	2221.27
C2	100	60	690.455	856.82
C3	70	50	1609.76	1997.44
C4	90	60	189.5	235.88

Table 10 Footing design

Taking the footing of column C2 as a sample of calculations, the following steps are calculated for by using SAP program:

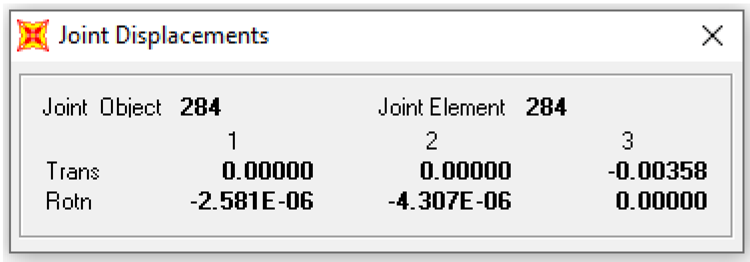
Area of footing for C2 =$\frac{P}{qall}$=$\frac{690.4552}{250}$=2.7m^2→ use the dimensions of (1.7×1.3) m2.

Footings are designed with a thickness h of 300 mm and d = 240 mm.

4.9.4.1Design checks

1) Deflection check

The maximum allowable value for displacement in the footing is 10 mm. From SAP softeare, the maximum value of displacement in the footing F2 = 3.5mm which is smaller than 10 mm ➔ **Ok**. The figure below, shows the deflection from service load on footing.



Joint Displacements

Joint Object 284		Joint Element 284	
	1	2	3
Trans	0.00000	0.00000	-0.00358
Rotn	-2.581E-06	-4.307E-06	0.00000

Figure 68 Deflection check

2) Shear check

- $\emptyset Vc = \frac{1}{6} * \frac{0.75*\sqrt{24}*b*d}{1000}$

- $\emptyset Vc = \frac{1}{6} * \frac{0.75*\sqrt{24}*240*1000}{1000}$ = 146.96KN

- From SAP, the values of ultimate shear from V23 and V13 is less than $\emptyset Vc$, then the check is **Ok**. The figures below, shows the values from V13 and V23 respectively.

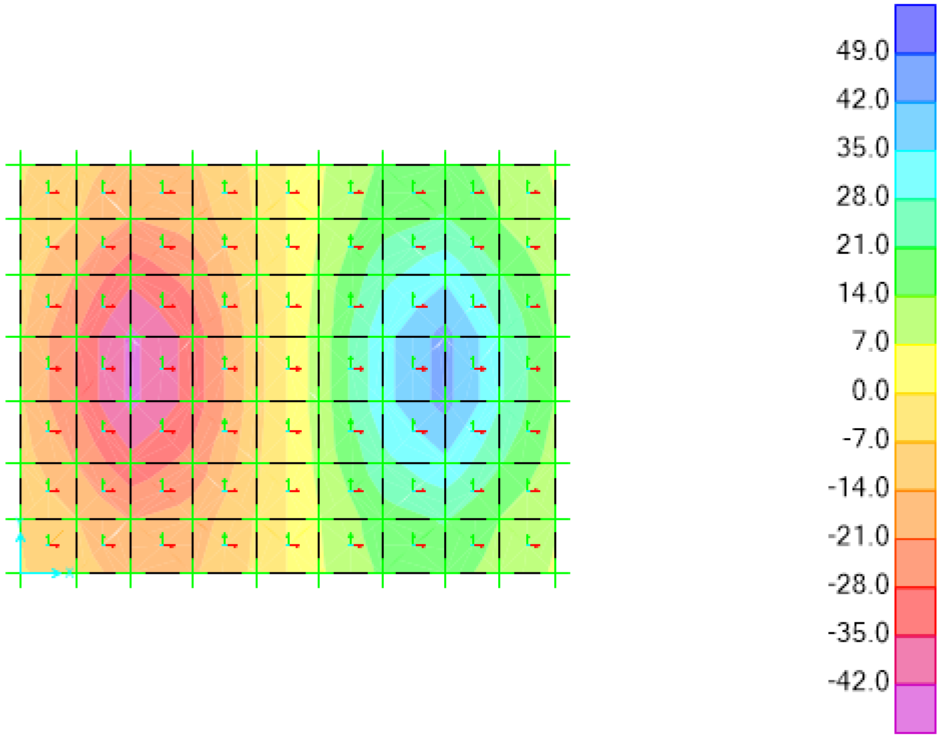


Figure 69 (V13)

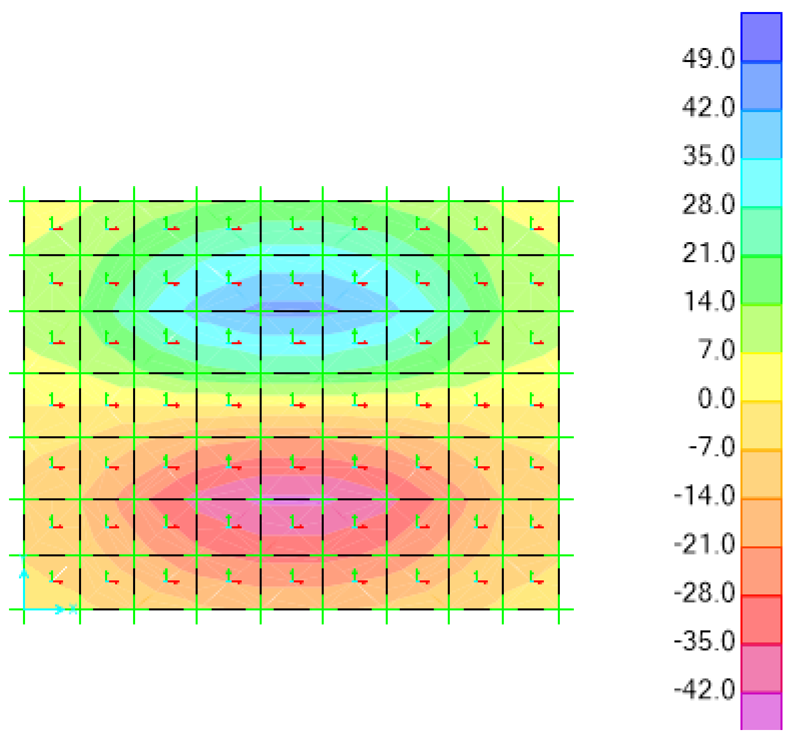


Figure 70 (V23)

3) Moment design

H = 300 mm.

d = 240 mm.

bw = 1000 mm.

- Asmin = 0.0018×1000×240 = 432 mm2/m ➔ 3Ø14/m.
- ØMn = $0.9 \times As \times Fy \times (d - \frac{\text{Fy}\times\text{As}}{1.7\times\text{fc}\times\times\text{bw}})$

$= 0.9 \times 432 \times 420 \times (240 - \frac{420*432}{1.7*24*1000}) \times 10^{-6}$ =38.5kN.m/m

From SAP software, the values of ultimate moment from M22 and M11 equal to 24.16 and 15.32 kN/m respectively. These values are less than ØMn, use As min for the bottom reinforcement of footing. The following two figures shows the ultimate moment from M11 and M22 respectively.

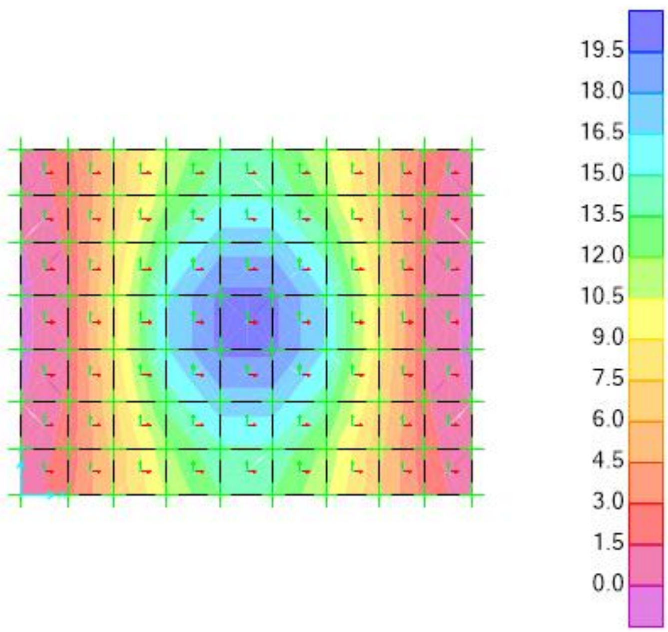


Figure 71 Ultimate moment from M11.

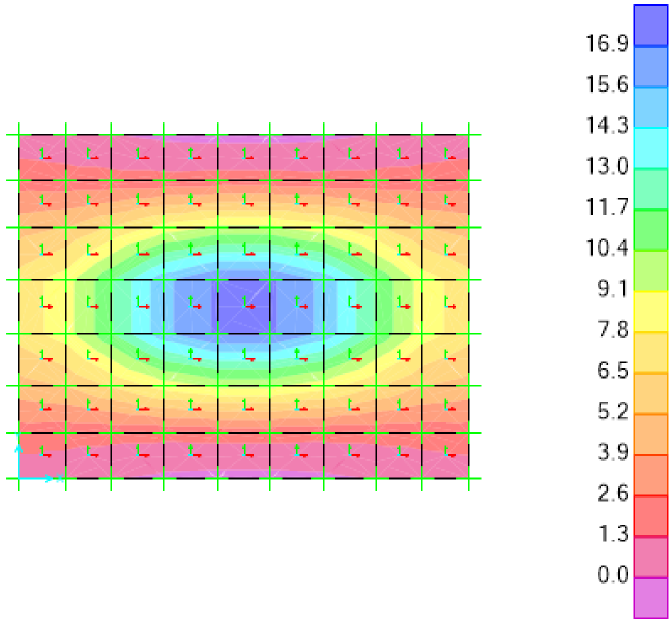


Figure 72 Ultimate moment from M22

- The table below clarifies the reinforcement of the isolated footing in the building

Footing ID	Length(m)	Width(m)	Thickness(m)	Reinforcement in Longitudinal direction	Reinforcement in short direction
F1	2.4	2.4	0.45	16Ø14	16Ø14
F2	1.7	1.3	0.3	7Ø12	9Ø12
F3	2.4	2.2	0.4	13Ø14	14Ø14

Table 11 Reinforcement of the isolated footing

The following figures show the dimensions of F2 footing and the detailing of F2 respectively:

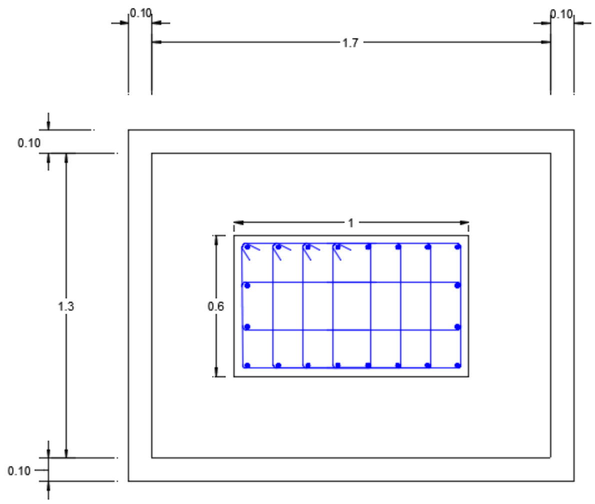


Figure 73 Footing (F2) dimensions

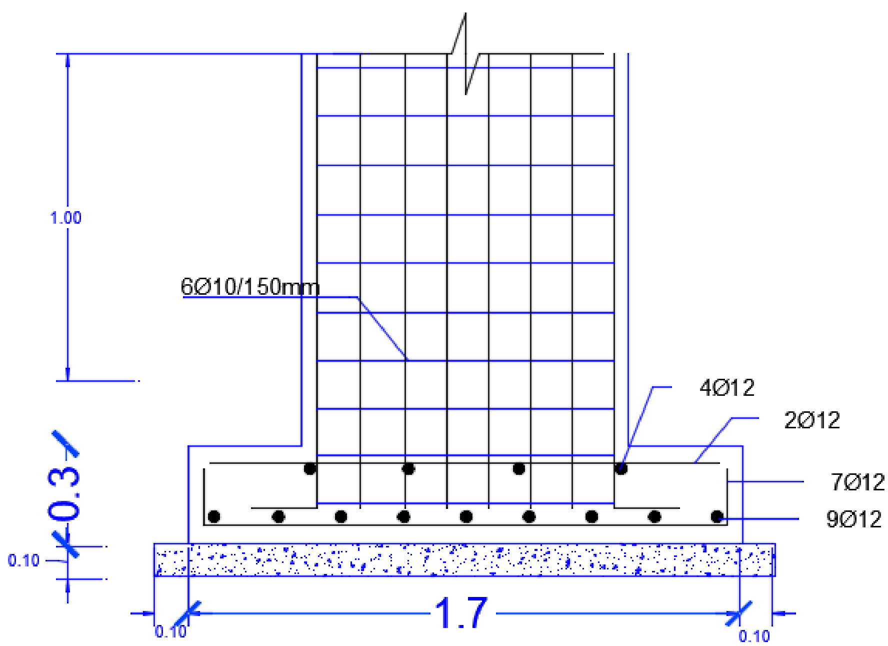


Figure 74 Footing (F2) detailing

4.10 Stair design

- Dimension for stair:
- Riser = 15 cm
- Length of step = 150 cm
- width of step= 30 cm
- Length of landing = 310 cm
- width of landing = 145 cm
- Length of span = 6m
- Slab thickness = 20cm

➢ Load on stairs:

Live load	**3 Kn/m**
Super dead	3.5 Kn/m
Dead load	5 (0.2*25) Kn/m

Figure 75 Load on stairs

4.10.1 Step design

Wu= (1.2*(3+5) + (1.6*3) = 15 Kn/m^2

Mu = $\frac{wu* L^2}{8}$ = 67.5

ρ used = $\frac{0.85* fc}{Fy}$ (1- $\sqrt{1-\frac{2.61*10^6*Mu}{fc*b*d*d}}$))= 0.00755

As =1132.5 -------- 6 ϕ16 mm for longitudinal bottom steel.

For horizontal steel use ρ shrinkage ----As =270 ---4 ϕ10mm

4.10.1.1 Shear check

- Vu = Wu * L =15*1.45 = 21.75 Kn/m

Vc = $\frac{1}{6}$ * $\sqrt{fc}$ * bw *d =130 KN/m

- Øvc > Vu its ok

4.10.2 Landing design

Wu = 15 Kn/m^2

Mu = 19.2 KN.m

ρ used = $\frac{0.85*fc}{Fy}$ (1-$\sqrt{1-\frac{2.61*10^6*Mu}{fc*b*d*d}}$))= 0.002

As=300------2 ϕ16mm for longitudinal bottom steel.

For horizontal steel use ρ shrinkage ----As =4 ϕ10mm

4.10.2.1 Shear check

- Vu = Wu * L =15*3.1 = 46.5 Kn/m

Vc = $\frac{1}{6}$ * $\sqrt{fc}$ * bw *d = 130 KN/m

- ✓ Øvc > Vu its ok

4.10 Tie beam design

- Dimensions of tie beams is 60*30
- Reinforced steel of tie beam
- ƿ = 1.4/Fy = 0.0033
- B=300 h=500
- ASmin = 0.0033*300*500 = 505 mm2/m

➢ 3ϕ 16 in positive and negative.

CHAPTER 5

5.0Mechanical

5.1 Introduction

Drainage system means an assembly of pipes, fittings, fixtures and appurtenances on a property that is used to convey sewage and clear water waste to a main sewer or a private sewage disposal system, and includes a private sewer, but does not include subsoil drainage piping.

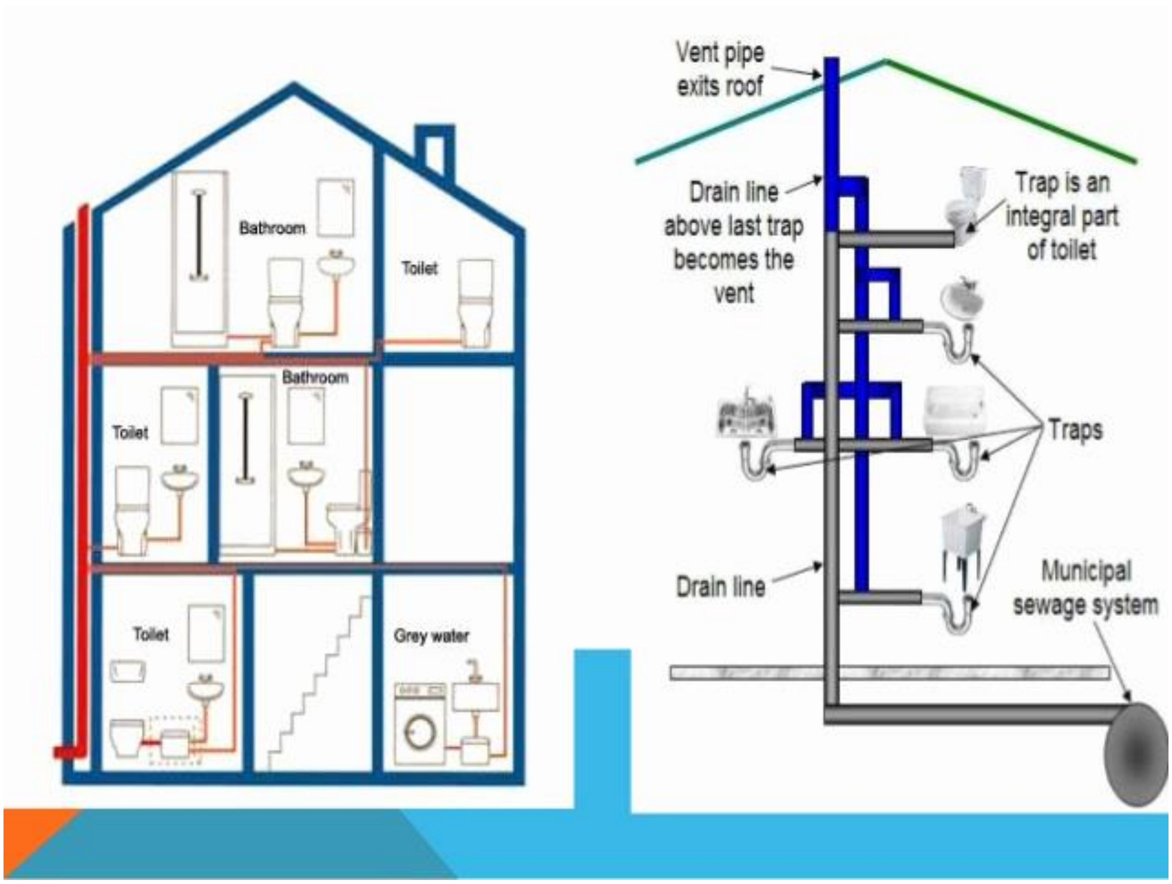


Figure 76 Drainage system

PART A. BY TYPE OF FIXTURE			
Fixture(s)	**Drainage Fixture Units (dfu)**	***Minimum Trap Size*** in.	mm[a]
Automatic clothes washers: Commercial[b]	3	2	51
Residential	2	2	51
Bathroom group: Water closet (1.6 gpf [6 Lpf]), lavatory, and bathtub or shower; with or without a bidet and emergency floor drain	5	—	—
Bathroom group: Water closet (>1.6 gpf [6 Lpf]), lavatory, and bathtub or shower; with or without a bidet and emergency floor drain	6	—	—
Bathtub[c] (with or without overhead shower or whirlpool)	2	1½	38
Bidet	1	1¼	32
Combination sink and tray	2	1½	38
Dental lavatory	1	1¼	32
Dental unit or cuspidor	1	1¼	32
Dishwashing machine[d], domestic	2	1½	38
Drinking fountain	0.5	1¼	32
Emergency floor drain	0	2	51
Floor drains	2	2	51
Kitchen sink, domestic	2	1½	38
Kitchen sink, domestic, with food waste grinder and/or dishwasher	2	1½	38
Laundry tray (1 or 2 compartments)	2	1½	38
Lavatory	1	1¼	32
Shower	2	1½	38
Service sink	2	1½	38
Sink	2	1½	38
Urinal	4	[e]	
Urinal, 1 gal (3.8 L) per flush or less	2[f]	[e]	
Urinal, nonwater supplied	0.5	[e]	
Wash sink (circular or multiple) each set of faucets	2	1½	38
Water closet, flushometer tank, public or private	4[f]	[e]	
Water closet, private (1.6 gpf [6 Lpf])	3[f]	[e]	
Water closet, private (>1.6 gpf [6 Lpf])	4[f]	[e]	
Water closet, public (1.6 gpf [6 Lpf]),	4[f]	[e]	
Water closet, public (flushing >1.6 gpf [6 Lpf])	6[f]	[e]	

PART B. BY SIZE OF TRAP		
Fixture Drain or Trap Size		
in.	**mm[a]**	**Drainage Fixture Unit (dfu) Value**
1¼	32	1
1½	38	2
2	51	3
2½	64	4
3	76	5
4	102	6

Figure 77 Fixtures drain and sizes

Diameter of Pipe			Maximum Total Number of dfu Allowable		
			Stacks[b]		
in.	mm[c]	Horizontal Branch	One Branch Interval	Three Branch Intervals or Less	Greater than Three Branch Intervals
1½	38	3	2	4	8
2	51	6	6	10	24
2½	64	12	9	20	42
3	76	20	20	48	72
4	102	160	90	240	500
5	127	360	200	540	1100
6	152	620	350	960	1900
8	203	1400	600	2200	3600
10	254	2500	1000	3800	5600
12	305	3900	1500	6000	8400
15	381	7000	d	d	d

Figure 78 Pipes diameter

5.2 projects' drainage system

Fixture(s)	Drainage Fixture Units (dfu)	Minimum Trap Size	
		in.	mm[a]
Automatic clothes washers: Commercial[b]	3	2	51
Residential	2	2	51
Bathroom group: Water closet (1.6 gpf [6 Lpf]), lavatory, and bathtub or shower; with or without a bidet and emergency floor drain	5	—	—
Bathroom group: Water closet (>1.6 gpf [6 Lpf]), lavatory, and bathtub or shower; with or without a bidet and emergency floor drain	6	—	—
Bathtub[c] (with or without overhead shower or whirlpool)	2	1½	38
Bidet	1	1¼	32
Combination sink and tray	2	1½	38
Dental lavatory	1	1¼	32
Dental unit or cuspidor	1	1¼	32
Dishwashing machine[d], domestic	2	1½	38
Drinking fountain	0.5	1¼	32
Emergency floor drain	0	2	51
Floor drains	2	2	51
Kitchen sink, domestic	2	1½	38
Kitchen sink, domestic, with food waste grinder and/or dishwasher	2	1½	38
Laundry tray (1 or 2 compartments)	2	1½	38
Lavatory	1	1¼	32
Shower	2	1½	38
Service sink	2	1½	38
Sink	2	1½	38
Urinal	4	e	
Urinal, 1 gal (3.8 L) per flush or less	2[f]	e	
Urinal, nonwater supplied	0.5	e	
Wash sink (circular or multiple) each set of faucets	2	1½	38
Water closet, flushometer tank, public or private	4[f]	e	
Water closet, private (1.6 gpf [6 Lpf])	3[f]	e	
Water closet, private (>1.6 gpf [6 Lpf])	4[f]	e	
Water closet, public (1.6 gpf [6 Lpf]),	4[f]	e	
Water closet, public (flushing >1.6 gpf [6 Lpf])	6[f]	e	

Figure 79 drainage fixtures units

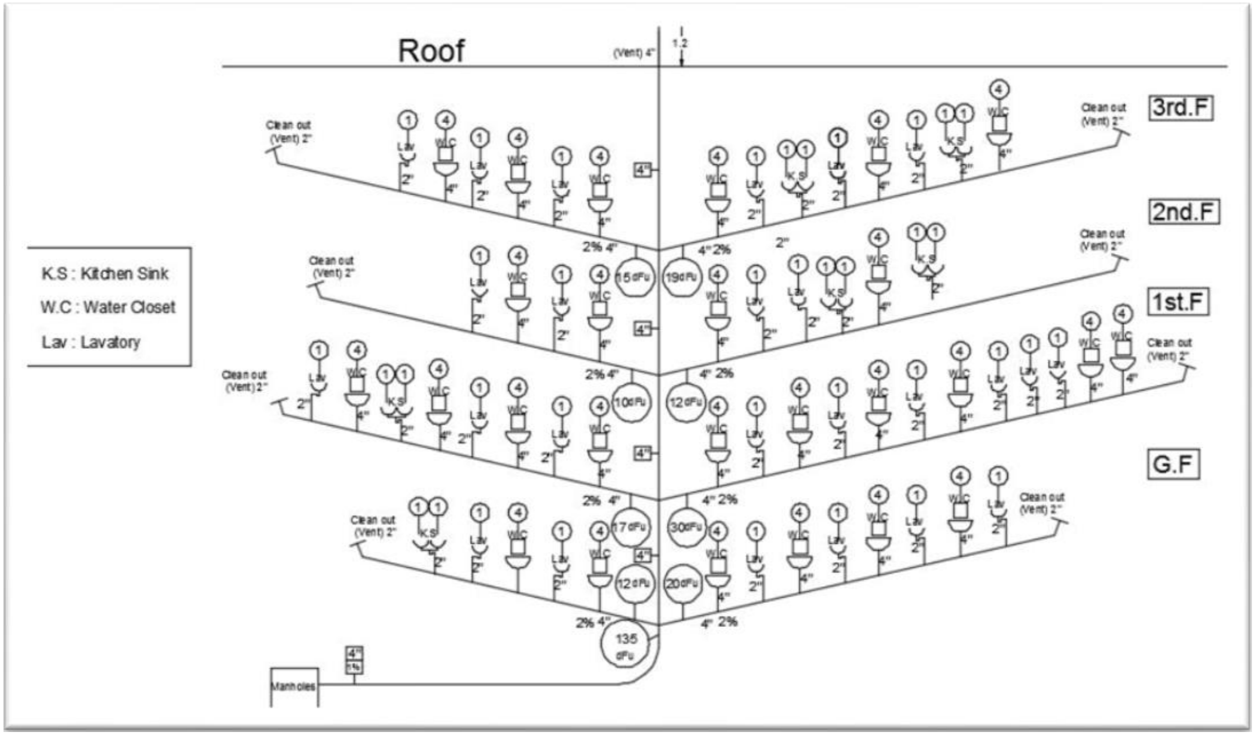


Figure 80 Distribution of drainage system

Un-plasticized polyvinyl chloride (UPVC) pipe are used as drainage pipe in our project

Based on number of DFu's in our project = 226 main stack diameter = 4 in

- 4-inch horizontal pipe for water closet (W.C) with slope 1%
- 2-inch horizontal pipe for lavatory pipe with slope of 2 %
- 2-inch horizontal pipe for kitchen sink with slope of 2%
- 4-inch vertical pipe for main stack
- 2-inch pipe for vent
- 6-inch pipe between manhole with slope of 1%
- 4-inch pipe for vertical rain water pipe
- 4-inch pipe for horizontal rain water pipe

5.2.1 1 Manholes

Two types of manhole were used in our project one for black water to collect it and move it to main municipality manhole system and the second type for gray water to collect it and move it to a tank to reused it in our building and for firefighting system.

5.3 Rain water

- Rain water harvesting from 6 % of roof total area. (roof total area = 5943) = 345
- Annual rainfall rate per square meter = 700 ml/m^2
- Volume of rain water to reuse in firefighting & for flush water = 345*0.7 = 241.5 m^3
- Using 4 inch vertical and horizontal pipe and (40cm * 40cm) drainage on roof

5.4 water supply system

5.4.1 Introduction

“Water supply system, infrastructure for the collection, transmission, treatment, storage, and distribution of water for homes, commercial establishments, industry, and irrigation, as well as for such public needs as firefighting and street flushing. Of all municipal services, provision of potable water is perhaps the most vital. People depend on water for drinking, cooking, washing, carrying away wastes, and other domestic needs. Water supply systems must also meet requirements for public, commercial, and industrial activities. In all cases, the water must fulfill both quality and quantity requirements.”

(Nathanson, 2019)

5.4.2 Water consumption

Institutions	Litres per head per day
Hospital (including laundry)	
a) No. of beds exceeding 100	450 (per bed)
b) No. of beds not exceeding 100	340 (per bed)
Hotels	180 (per bed)
Hostels	135
Boarding schools/ colleges	135
Restaurants	70 (per seat)
Day schools/ colleges	45
Offices	45
Factories	45(could be reduced to 30 where no bathrooms are provided)
Cinema, concert halls and theatre	15

Figure 81 water consumption in the building

- **Daily water consumption**

Type		consumption	Number of occupancies	Total daily	Water cycle	Tank volume
domestic	flush	9	160	1440	5	7200
	Hand washing	4	160	640	5	3200
	shower	20	160	3200	5	16000
	Drinking & cooking	3	160	480	5	2400
	Dish washing	4.2	160	672	5	3360
	Food preparation	6	160	960	5	4800
Swimming pool		84600	-	84600	-	84600
Therapeutic tubs		24000	-	24000	-	24000
Fire fighting		-	-	-	-	255000

Table 12 Daily water consumption

Also we need a 15% of total domestic water as a hot water 5500 L

Tank volume:

- domestic tank volume = $36m^3$
- Swimming pool tank volume = $46m^3$

Swimming pool	Volume
	45.12

Table 13 Swimming pool tank volume

- Therapeutic tubs tank volume = 24 m^3

Therapist tubs	Number of tubs	Area of each tubs	Volume of each tubs	Number of water change	Volume
	3	4	2	4	24

Table 14 Therapeutic tubes tank volume

- Firefighting tank volume = 255 m^3

  Firefighting tank volume = (Q*TIME*3.78)/1000

Q: water flow rate (750 gpm)

Time: hazard type (in our case is high hazard so the time is 90 minute)

Firefighting tank volume = 750*90*3.78 /1000 = 255 m^3

Also we need to benefit from rain water and gray water for flush supply & firefighting system to minimize the total load taken from municipality

- ➢ Total gray water to reuse in our building = 4*160*5 = 3200 litter (3.2 m^3)
- ➢ Total flush water consumption in our building = 9*160*5 = 7200 litter (7.2 m^3)
- ✓ Wish mean we will cover 44% of flush water from reuse the gray water in our building and the rest can be cover from rain water.

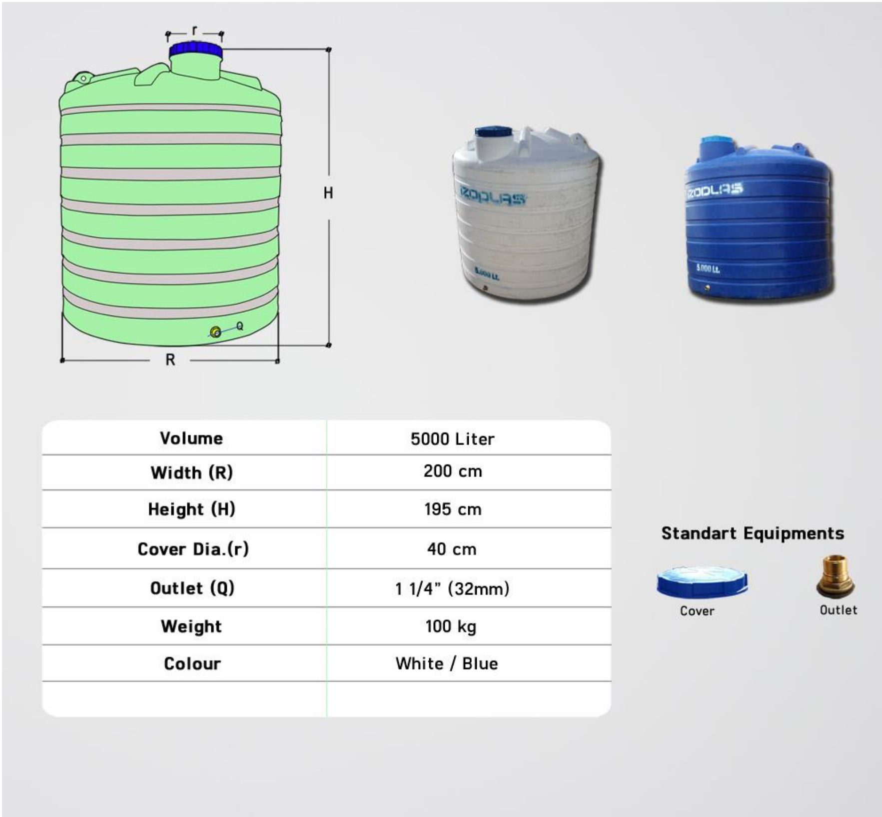


Figure 82 Tank used

Tank type	**Underground tank volume(m^3)**	**Roof tank number**
Domestic water	29	6 (using 5000 L tank)
Swimming pool	46	9 (using 5000 L tank)
Therapist tubs	12.5	3 (using 5000 L tank)
Firefighting & recycled gray water	260	-

Table 15 Tank number

- **Also we need a tank for surge water from pool with a volume of 2400L**
- Water supply system.
- The system used to supply water in our building is a basement tank & roof tank & pump and underground with pump for recycle gray water and rain water tank.

4.5.2.1 Water supply pipes

- **Design vertical, horizontal and branch pipes for each tank**

Fixture or Group	Occupancy	Cold Water (CW) only	Hot Water (HW) only	Total Building Supply HW & CW
Water Closet (Flush Valve)	Public	10	--	10
Water Closet (Flush Tank)	Public	5	--	5
Pedestal Urinal (Flush Valve)	Public	10	--	10
Stall or Wall Urinal (Flush valve)	Public	5	--	5
Stall or Wall Urinal (Flush Tank)	Public	3	--	3
Lavatory (Faucet)	Public	1-1/2	1-1/2	2
Bathtub (Faucet)	Public	3	3	4
Shower Head (Mix valve)	Public	3	3	4
Service Sink (Faucet)	Office	2-1/4	2-1/4	3
Kitchen Sink (Faucet)	Hotel/ Restaurant	3	3	4
Water Closet (Flush valve)	Private	6	--	6
Water Closet (Flush tank)	Private	3	--	3
Lavatory (Faucet)	Private	¾		1
Bathtub (Faucet)	Private	1-1/2	1-1/2	2
Shower Head (Mix valve)	Private	1-1/2	1-1/2	2
Bathroom Group (Flush valve)	Private	8.25	2.25	8
Bathroom Group (Flush tank)	Private	5.25	2.25	6
Shower (Mix valve)	Private	1-1/2	1-1/2	2
Kitchen Sink (Faucet)	Private	1-1/2	1-1/2	2
Laundry Trays (Faucet)	Private	2-1/4	2-1/4	3
Combination Fixture (Faucet)	Private	2-1/4	2-1/4	3
Washer	Private	3	3	4

Figure 83 water supply pipes

- **<u>For domestic tank</u>**

Fixture type	Number of fixture	Wight(Fu)	Total
WC	26	3	78
Lavatory	26	1	26
Shower	18	2	36
Kitchen sink	4	4	16
Laborite sink	6	1.5	9
Total			165

Table 16 Number of fixtures tank for ground floor

Fixture type	Number of fixture	Wight(Fu)	Total
WC	8	3	24
Lavatory	8	1	8
Kitchen sink	2	4	8
Laborite skin	4	1.5	6
Total			46

Table 17 Number of fixtures for first floor

- Total number of vertical fixture unit for ground floor= 211
- Total number of horizontal fixture unit for ground floor = 165
- Total number of vertical fixture unit for first floor = 46
- Total number of horizontal fixture unit for first floor = 46

Select diameter of pipes need firstly to know water flow rate in each pipes

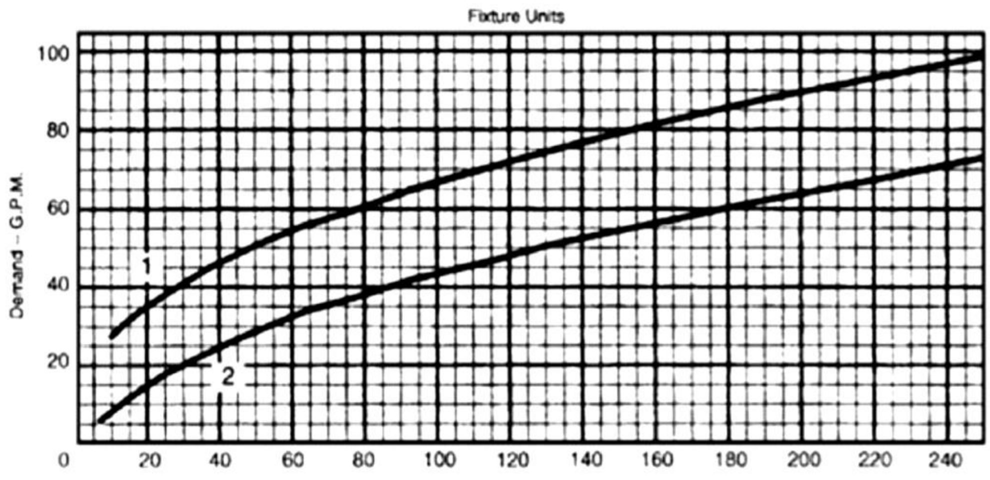


Figure 84 pipes diameter (fixtures unit VS. Demand)

Pipe type	Total number of fixture unit	Flow rate
Vertical	211	67
Horizontal	165	60
Branch	4	4

Table 18 Flow rate for each pipe

- Available pressure at ground floor

H = 27.3

P = 0.433*H = 27.3*0.433 = 11.82

Pipe type	Length	Actual length
Vertical	37.3	56.4
Horizontal	269	322.8
Branch	32	38.4

Table 19 Actual length for pipes

- Vertical pipe

diameter	2	2.5	3
loss/100	6	2	0.8
Loss/56.4	3.384	1.128	0.45

Table 20 Vertical pipes information

- Horizontal pipe

diameter	2	2.5	3
loss/100	5.5	1.7	0.7
Loss/314	17.27	5.33	2.19

Table 21 Horizontal pipes information

- Branch pipe

diameter	0.5	$\frac{3}{4}$	1
loss/100	30	3.5	0.6
Loss/38.4	11.52	1.344	0.23

Table 22 Branch pipes information

Pipe type	Diameter (inch)
Horizontal	2
Vertical	2
Branch	1

Table 23 Pipe type and its diameter

- **For swimming pool tank**

Fixture type	Number of fixture	Wight(Fu)	Total
Swimming pool	1	9	9

Table 24 Swimming pool tank

- Total number of vertical fixture unit for ground floor= 9
- Total number of horizontal fixture unit for ground floor = 9
- Select diameter of pipes need firstly to know water flow rate in each pipes

Pipe type	Total number of fixture unit	Flow rate
Vertical	9	9
Horizontal	9	9
Branch	9	9

Table 25 Number of fixtures

- Available pressure at ground floor

H = 27.3

P = 0.433*H = 27.3*0.433 = 11.82

Pipe type	Length	Actual length
Vertical	37.3	56.4
Horizontal	262	314
Branch	10	12

Table 26 Pipes actual length

- Vertical pipe

diameter	$1\frac{1}{4}$	1	$\frac{3}{4}$
loss/100	1.5	3.5	18
Loss/56.4	0.846	1.974	10.12

Table 27 Vertical pipe information

- Horizontal pipe

diameter	$1\frac{1}{4}$	1	$\frac{3}{4}$
loss/100	1.5	3.5	18
Loss/314	4.71	10.99	56

Table 28 Horizontal pipe information

- Branch pipe

diameter	$1\frac{1}{4}$	1	$\frac{3}{4}$
loss/100	1.5	3.5	18
Loss/12	0.18	0.42	2.16

Table 29 Branch pipe information

Pipe type	Diameter (inch)
Horizontal	$1\frac{1}{4}$
Vertical	$1\frac{1}{4}$
Branch	1

Table 30 Pipes diameter used for swimming pool

- **For therapist tubes**

Fixture type	Number of fixture	Wight(Fu)	Total
Therapist tubs	3	5	15

Table 31 Therapist tube fixtures

- Total number of vertical fixture unit for ground floor= 15
- Total number of horizontal fixture unit for ground floor = 15
- Select diameter of pipes need firstly to know water flow rate in each pipes.

Pipe type	Total number of fixture unit	Flow rate
Vertical	15	10
Horizontal	15	10
Branch	5	5

Table 32 Flow rate for the tubes

- Available pressure at ground floor

H = 27.3

P = 0.433*H = 27.3*0.433 = 11.82

Pipe type	Length	Actual length
Vertical	37.3	56.4
Horizontal	249	298.8
Branch	28.8	34.56

Table 33 Pipes Actual length

- Vertical pipe

diameter	1.5	$1\frac{1}{4}$	1
loss/100	1.5	4	11
Loss/56.4	0.846	2.25	6.2

Table 34 Vertical pipe information

- Horizontal pipe

diameter	1.5	$1\frac{1}{4}$	1
loss/100	1.5	4	11
Loss/298.8	4.48	11.95	32.8

Table 35 Horizontal pipe information

- Branch pipe

diameter	0.5	$\frac{3}{4}$	1
loss/100	25	6	1.5
Loss/34.56	8.46	2.07	0.5184

Table 36 Branch pipe information

Pipe type	Diameter (inch)
Horizontal	1.5
Vertical	1.5
Branch	1

Table 37 Pipe diameter used in therapist tubes

Pump selection:

- One pump needs to move water from domestic underground tank to domestic roof tank.
- One pump needs to move water from swimming pool underground tank to roof swimming pool tank.
- One pump needs to move water from therapist underground tank to therapist roof tank.
- One pump needs to move water from rain water tank to domestic roof tank.
- Two pump needs to move water from rainwater tank to hoses and sprinkler system.
- One pump needs to move water from domestic roof tank to branch.
- One pump needs to move water from swimming pool roof tank to pool.
- One pump needs to move water from therapist roof tank to tubs.

CHAPTER 6

6.0 Electro mechanic design

6.1 Lighting design

6.1.1 Introduction

Types of lighting: Natural lighting and artificial lighting.

1. Natural lighting: is the light generated naturally, the sun, is the most common source for natural lighting, it is received during sunlight hours, it should be exploited as much as possible according to needs.

➢ The recommended daylight factors according to MEEB:

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

Figure 85 MEEB standards

2. Artificial lighting: It is generated by artificial sources, such as LEDs, Incandescent, etc.

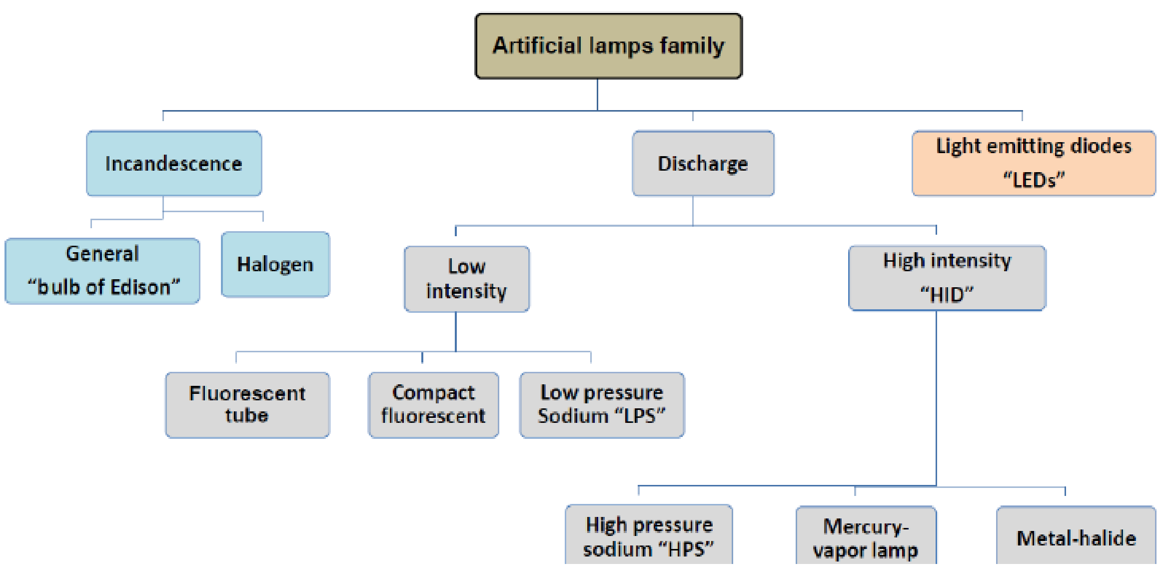


Figure 86 Artificial Lamps family

6.1.2 Types of Light Distribution for Indoor Luminaires

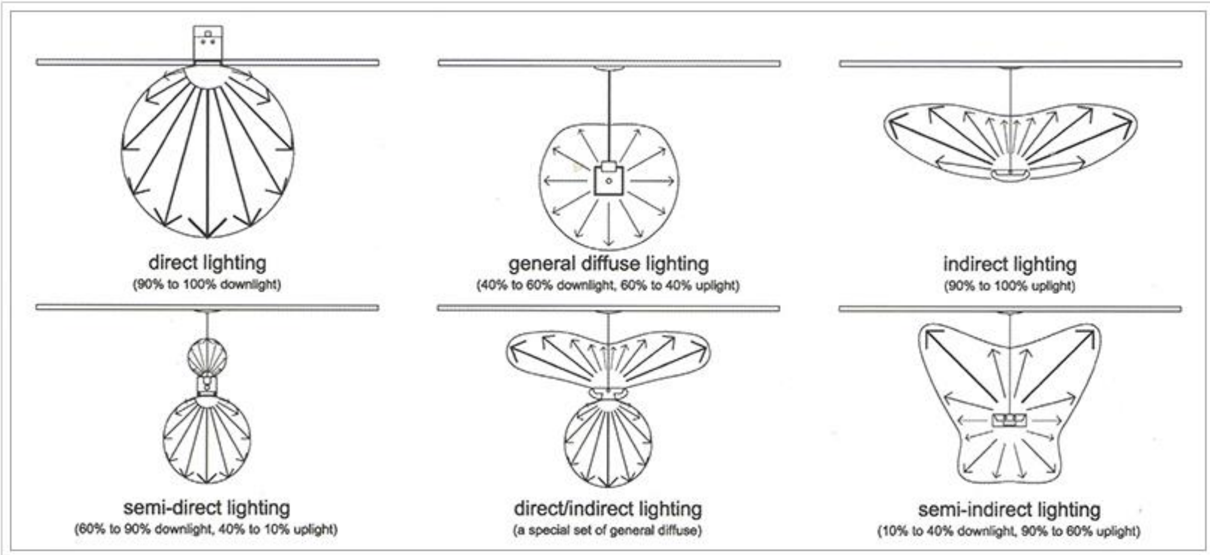


Figure 87 Types of light distribution

a) Direct lighting: 90 -100 % of the emitted light from the lamp is directed to the surface to be illuminated.

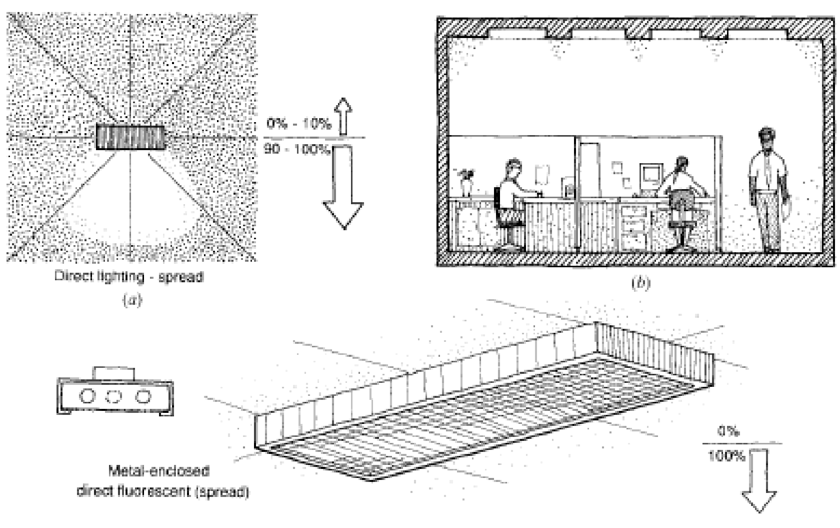


Figure 88 Direct lighting

b) Semi-direct lighting: 60-90 % of the emitted light downlight and 40-10 % up light, it is comfortable and doesn't cause glare or discomfort.

For example, it is used where there is no need for strong light as corridors, stairways, etc.

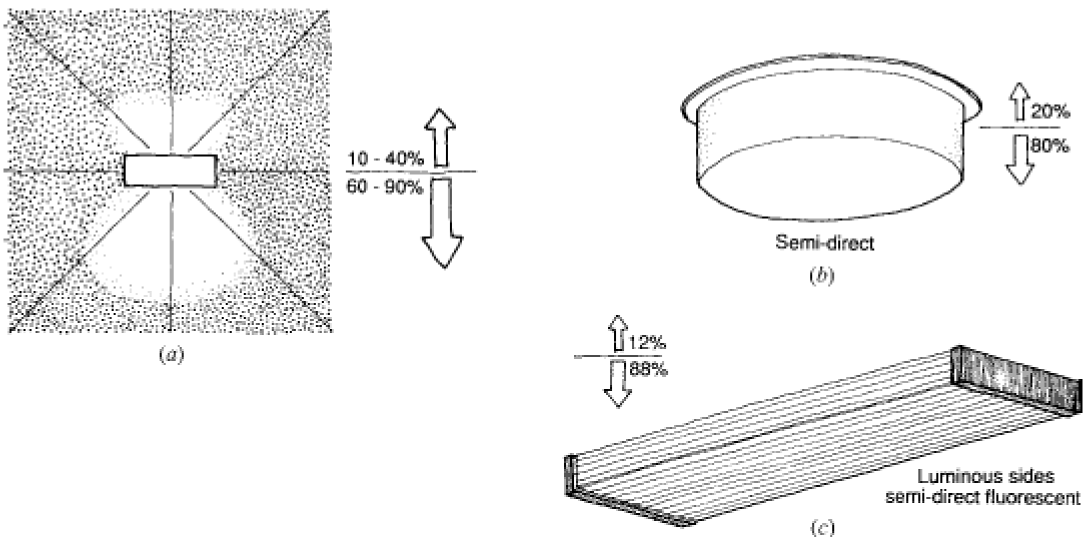


Fig. 13.8 Semi-direct lighting provides its own ceiling brightness (a), with surface-mounted fixtures (b) or pendant/surface units (c). Other characteristics are similar to those of direct lighting.

Figure 89 Semi-Direct lighting

c) General diffuse lighting: 40 - 60 %of the emitted light downlight and the 60-40 % up light.

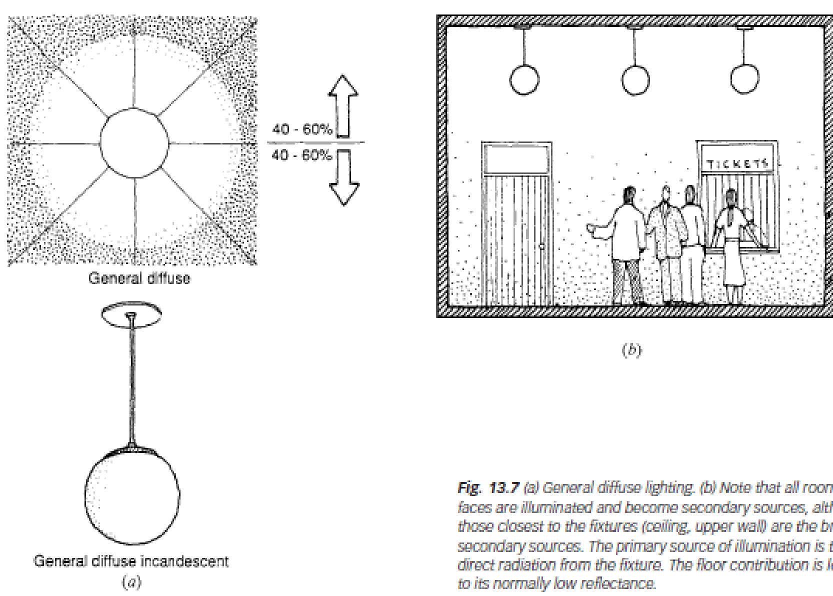


Fig. 13.7 (a) General diffuse lighting. (b) Note that all room surfaces are illuminated and become secondary sources, although those closest to the fixtures (ceiling, upper wall) are the brightest secondary sources. The primary source of illumination is the direct radiation from the fixture. The floor contribution is low due to its normally low reflectance.

Figure 90 General diffuse lighting

d) Direct-indirect lighting: general lighting gives a little light or no light at angles which is near the horizontal.

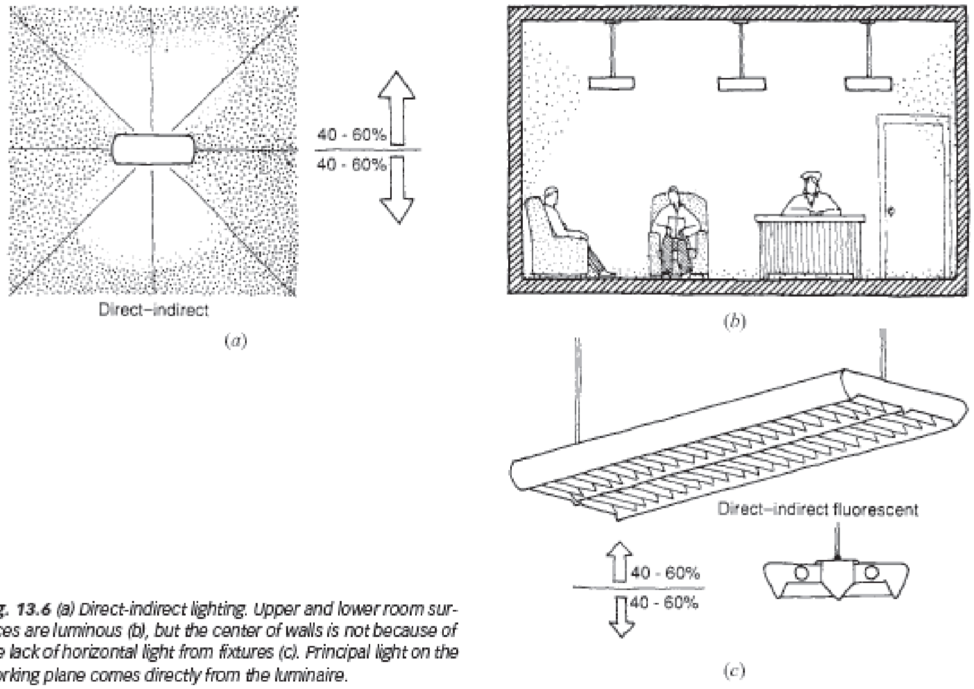


Fig. 13.6 (a) Direct-indirect lighting. Upper and lower room surfaces are luminous (b), but the center of walls is not because of the lack of horizontal light from fixtures (c). Principal light on the working plane comes directly from the luminaire.

Figure 91 Direct-Indirect lighting

e) Semi-indirect lighting: 10-40% of the emitted light is downlight and 90-60 % up light.

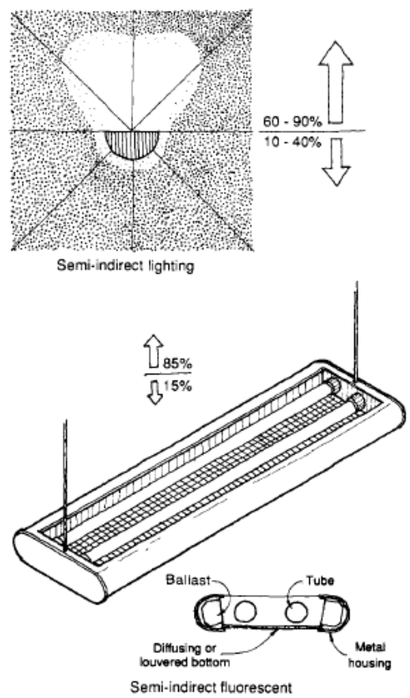


Figure 92 Semi indirect lighting

f) Indirect lighting: 90-100 of emitted lighting from the lamp is up light.

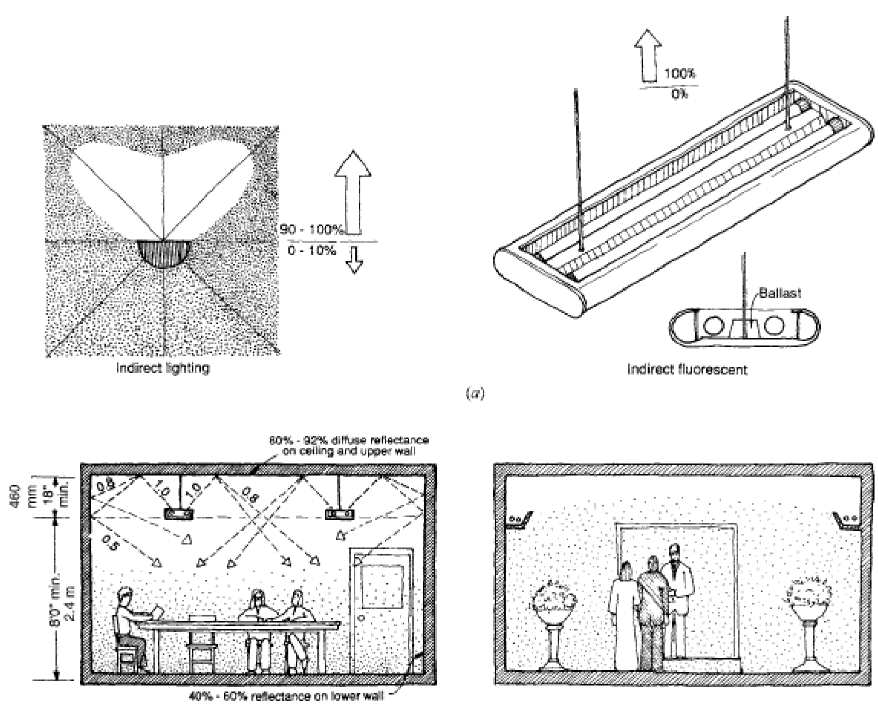


Figure 93 Indirect lighting

6.1.3 Artificial lighting using DIALux evo.

1. <u>Basketball yard</u>

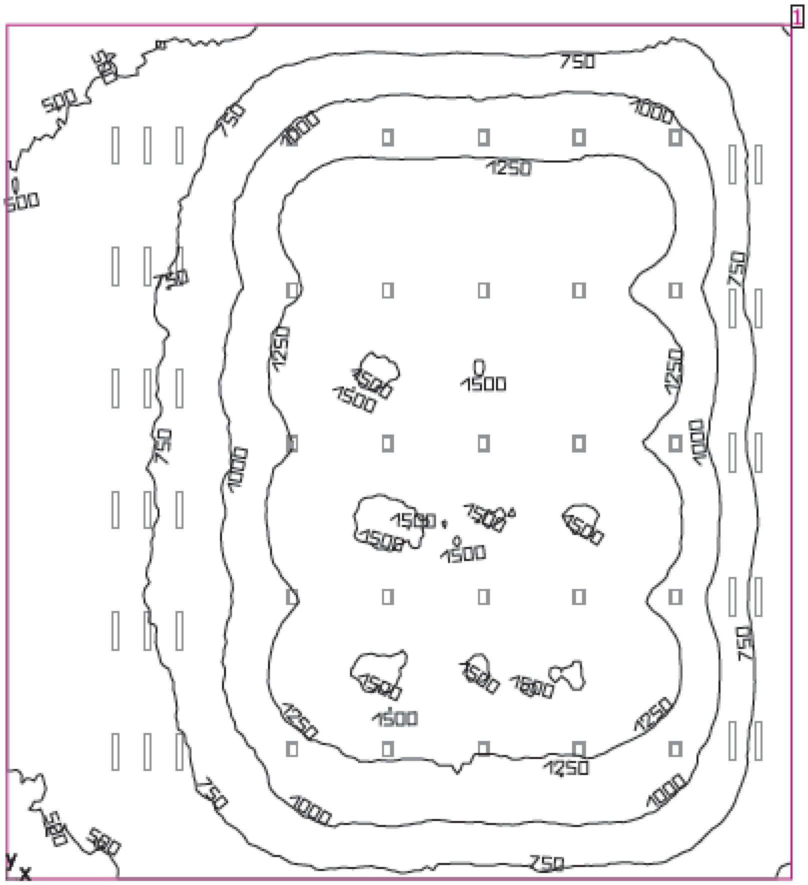


Figure 94 lighting Uniformity

Clearance height: 10.870 m, Reflection factors: Ceiling 83.3%, Walls 88.1%, Floor 51.3%, Light loss factor: 0.80

Workplane

	Surface	Result	Average (Target)	Min	Max	Mean/Min	Max/Min
1	Workplane (Room 1)	Perpendicular illuminance (adaptive) [lx] Height: 1.000 m, Wall zone: 0.000 m	1007 (≥ 1000)	405	1534	2.49	3.79

#	Luminaire	Φ(Luminaire) [lm]	Power [W]	Luminous efficacy [lm/W]
25	Philips - BY471P 1 xECO320S/865 NB GC	31862	218.0	146.2
28	Philips - TPS772 3xTL5-49W/865/827/865 HFD PC-MLO_865-827-865	8860	163.0	54.4
	Total via all luminaires	1044630	10014.0	104.3

Lighting power density: 8.50 W/m² = 0.84 W/m²/100 lx (Floor area of room 1177.75 m²)

Consumption: 29750 - 40550 kWh/a of maximum 41250 kWh/a

The energy consumption quantities do not take into account light scenes and their dimming levels

Figure 95 Work plan and luminaire

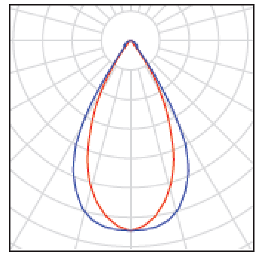
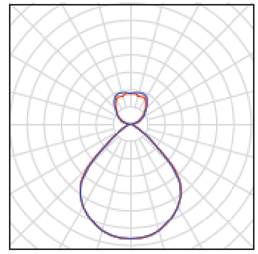
Quantity	Luminaire (Luminous emittance)		
25	Philips - BY471P 1 xECO320S/865 NB GC Luminous emittance 1 Fitting: 1xECO320S/865/- Light output ratio: 99.57% Lamp luminous flux: 32000 lm Luminaire luminous flux: 31862 lm Power: 218.0 W Luminous efficacy: 146.2 lm/W Colorimetric data 1xECO320S/865/-: CCT 3000 K, CRI 100	See our luminaire catalog for an image of the luminaire.	
28	Philips - TPS772 3xTL5-49W/865/827/865 HFD PC-MLO_865-827-865 Luminous emittance 1 Fitting: 3xTL5-49W/865/827/865/865-827-865 Light output ratio: 70.87% Lamp luminous flux: 12501 lm Luminaire luminous flux: 8860 lm Power: 163.0 W Luminous efficacy: 54.4 lm/W Colorimetric data 3xTL5-49W/865/827/865/865-827-865: CCT 3000 K, CRI 100		

Figure 96 Luminaire catalogue

2. Cafeteria

zone 1 (eating and sitting zone)

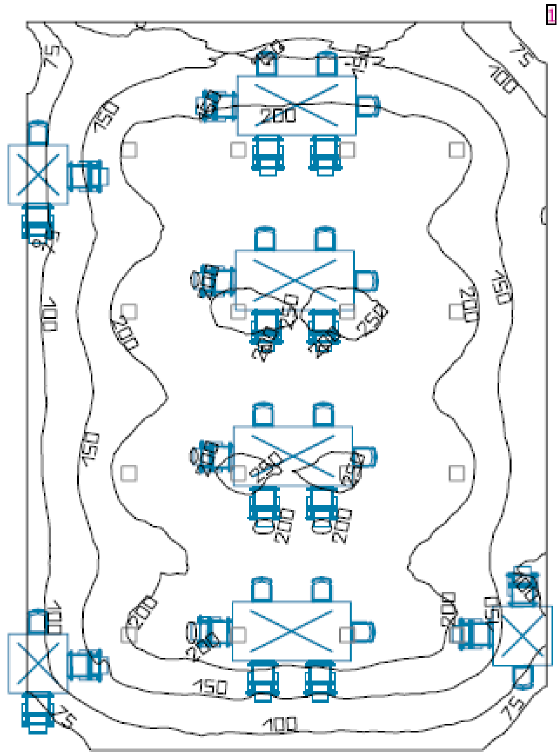
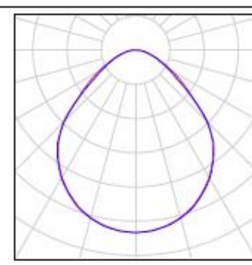


Figure 97 lighting uniformity for eating area in cafeteria

zone 1 (eating and sitting zone)

Quantity	Luminaire (Luminous emittance)		
16	Lightnet - EG2VSE-840H-Q290-KS Airtime-G2 Luminous emittance 1 Fitting: 1xLED High Power Absolute photometry Luminaire luminous flux: 1738 lm Power: 20.0 W Luminous efficacy: 86.9 lm/W Colorimetric data 1xLED High Power: CCT 4000 K, CRI 80		

Total lamp luminous flux: 27808 lm, Total luminaire luminous flux: 27808 lm, Total Load: 320.0 W, Luminous efficacy: 86.9 lm/W

Figure 98 Luminaire catalogue

Reflection factors: Ceiling 70.2%, Walls 0.0%, Floor 52.0%, Light loss factor: 0.80

Workplane

	Surface	Result	Average (Target)	Min	Max	Min/average	Min/max
1	Workplane (zone 1 (eating and sitting zone))	Perpendicular illuminance (adaptive) [lx] Height: 0.800 m, Wall zone: 0.000 m	179 (≥ 100)	52.4	261	0.29	0.20

#	Luminaire	Φ(Luminaire) [lm]	Power [W]	Luminous efficacy [lm/W]
16	Lightnet - EG2VSE-840H-Q290-KS Airtime-G2	1738	20.0	86.9
	Total via all luminaires	27808	320.0	86.9

Lighting power density: 2.06 W/m² = 1.15 W/m²/100 lx (Floor area of room 155.13 m²)

Consumption: 1250 kWh/a of maximum 5450 kWh/a

The energy consumption quantities do not take into account light scenes and their dimming levels.
The results are informative. The energy consumption of a building results from the sum of all consumptions in the rooms.

Figure 99 Work plan and luminaire

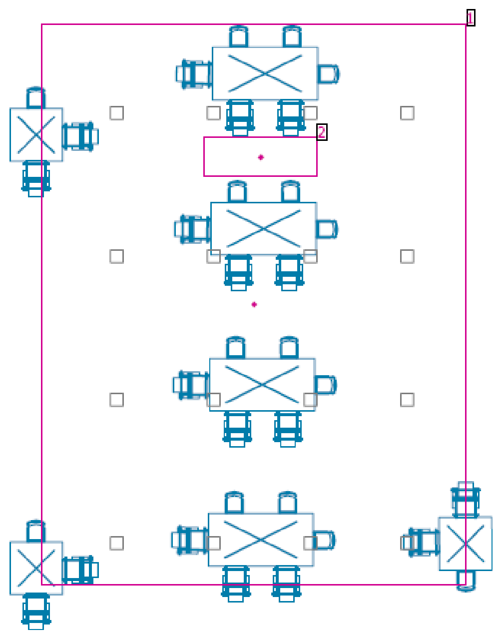


Figure 100 Work plan

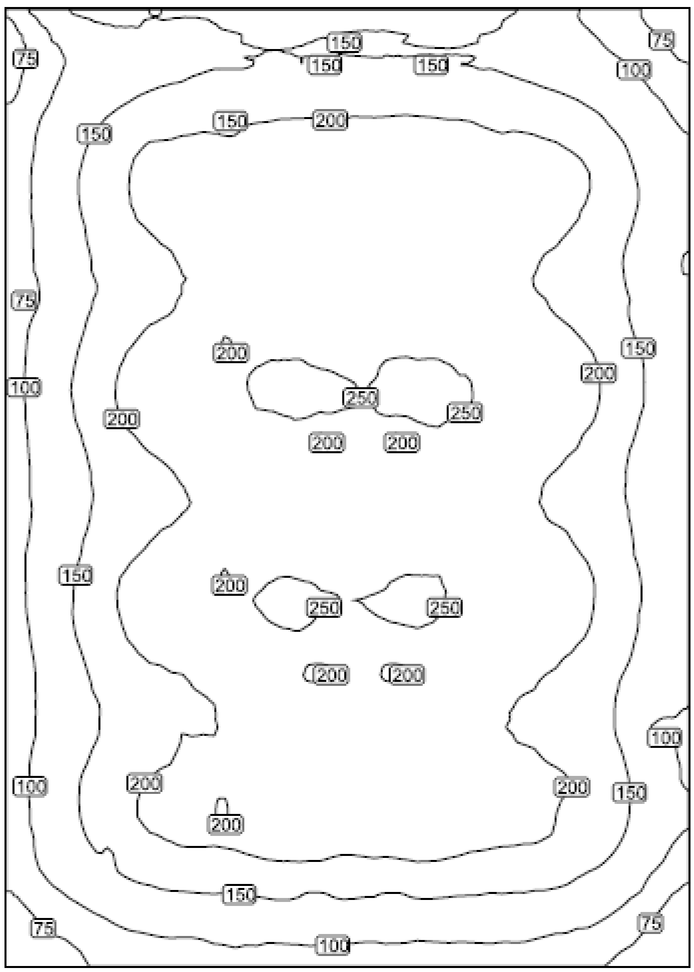
General

	Surface	Result	Average (Target)	Min	Max	Min/average	Min/max
1	Calculation surface (lunch zone)	Perpendicular illuminance [lx] Height: 0.800 m	227	227	227	1.00	1.00
		Perpendicular illuminance (adaptive) [lx]	196	83.4	261	0.43	0.32

Glare valuation

	Surface	Result	Min	Max	Threshold value
2	Glare in sitting room	UGR Height: 1.200 m	<10	16.1	≤19.0

Figure 101 Glare valuation and calculation surface



Scale: 1 : 100

Figure 102 Lux distribution

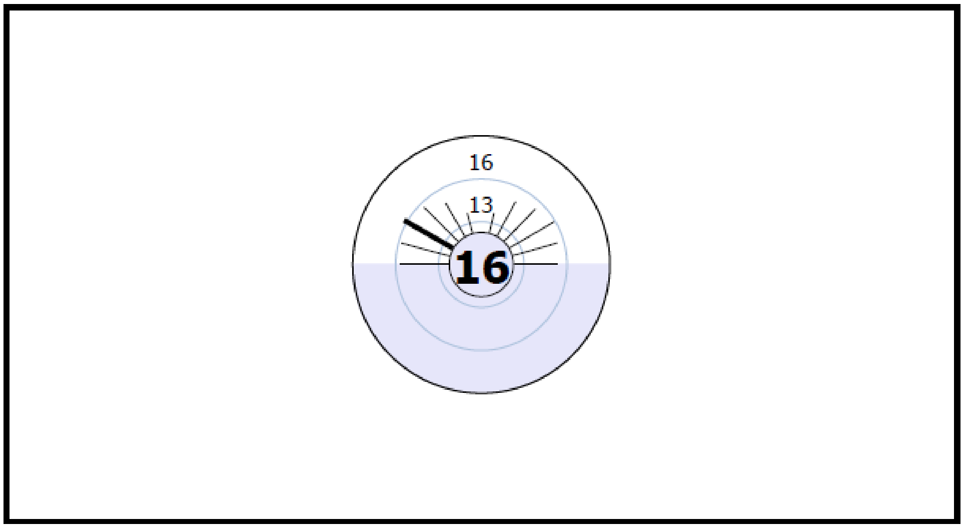
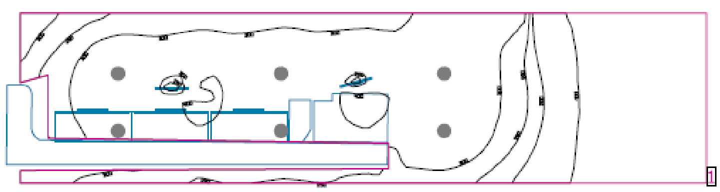


Figure 103 Glare check

zone 2 (cashier)



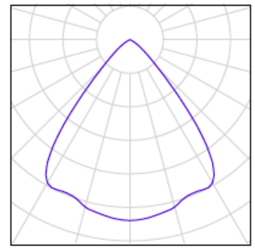
Reflection factors: Ceiling 70.2%, Walls 0.0%, Floor 52.0%, Light loss factor: 0.80

Workplane

	Surface	Result	Average (Target)	Min	Max	Min/average	Min/max
1	Workplane (zone 2 (cashier))	Perpendicular illuminance (adaptive) [lx] Height: 0.760 m, Wall zone: 0.000 m	252 (≥ 193)	45.2	426	0.18	0.11

Figure 104 Cashier work plan

zone 2 (cashier)

Quantity	Luminaire (Luminous emittance)		
6	SIMES - S.7320W LOBBY BASIC Luminous emittance 1 Fitting: 1x Absolute photometry Luminaire luminous flux: 1623 lm Power: 19.6 W Luminous efficacy: 82.8 lm/W Colorimetric data 1x: CCT 3224 K, CRI 91		

Total lamp luminous flux: 9738 lm, Total luminaire luminous flux: 9738 lm, Total Load: 117.6 W, Luminous efficacy: 82.8 lm/W

Figure 105 Luminaire catalogue

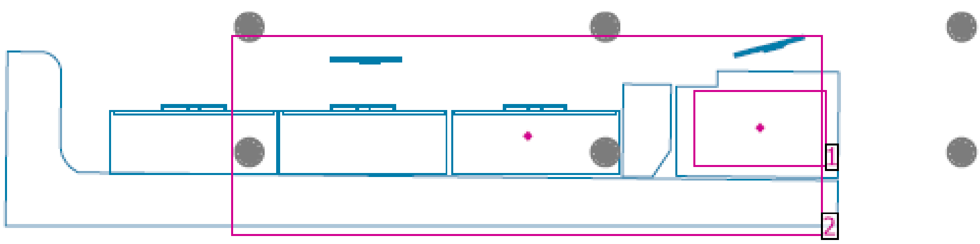


Figure 106 cashier calculation surface

General

	Surface	Result	Average (Target)	Min	Max	Min/average	Min/max
1	Calculation surface above cashier	Perpendicular illuminance [lx] Height: 0.750 m	406	406	406	1.00	1.00
		Perpendicular illuminance (adaptive) [lx]	394	354	424	0.90	0.83

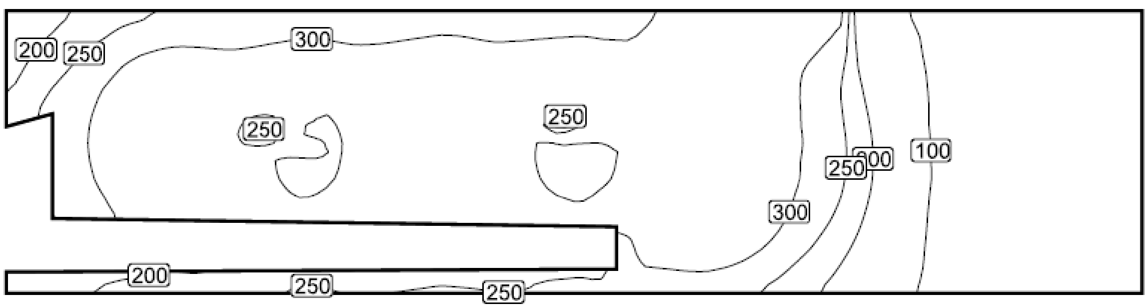
Glare valuation

	Surface	Result	Min	Max	Threshold value
2	Glare in cashier	UGR Height: 1.200 m	<10	<10	≤19.0

Figure 108 calculation surface

Workplane (zone 2 (cashier)): Perpendicular illuminance (adaptive) (Surface)
Light scene: artificial lighting only
Average: 252 lx (Target: ≥ 193 lx), Min: 45.2 lx, Max: 426 lx, Min/average: 0.18, Min/max: 0.11
Height: 0.760 m, Wall zone: 0.000 m

Isolines [lx]



Scale: 1 : 75

Figure 107 Lux distribution

Glare in cashier / UGR

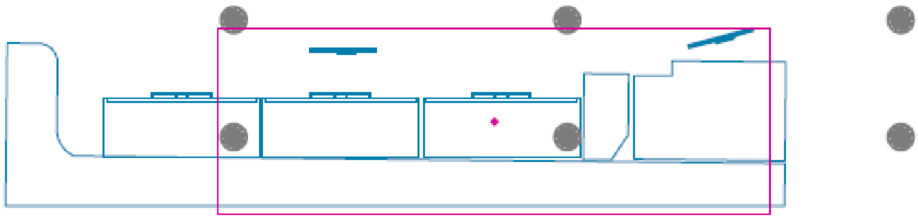


Figure 110 Glare in cashier surface

Glare in cashier: UGR (Grid)
Light scene: artificial lighting only
Strongest glare at: 380°, Max: <10, Threshold value: ≤19.0, Viewing sector: 320° - 20°, Step width: 15°, Height: 1.200 m

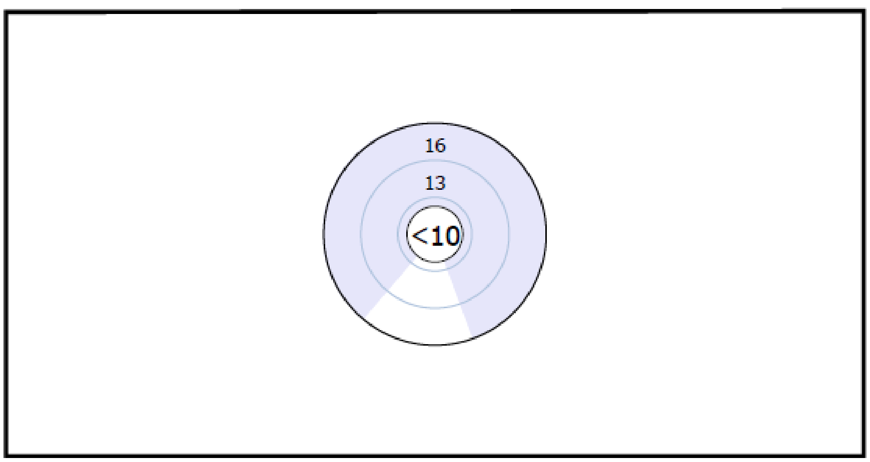


Figure 109 Glare check

zone 3 (kitchen in the restaurent)

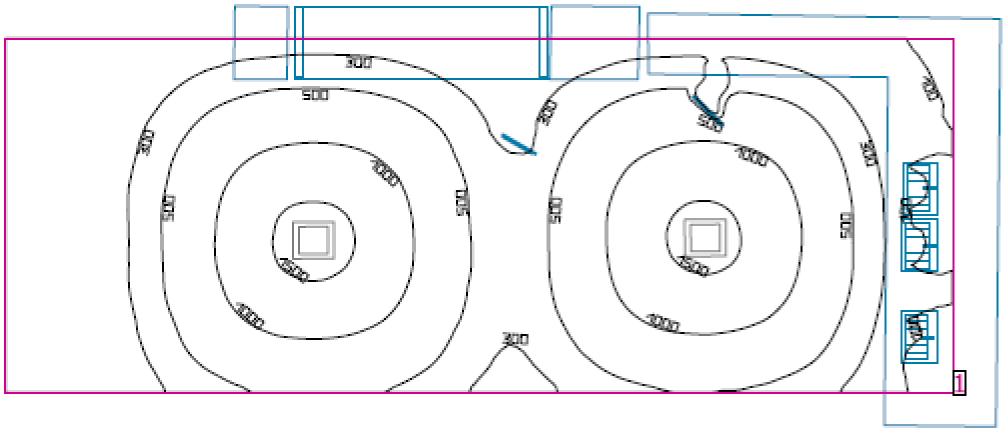
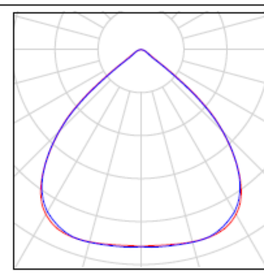


Figure 111 Kitchen zone

zone 3 (kitchen in the restaurent)

Quantity	Luminaire (Luminous emittance)		
2	Philips - BY480P PSD 1 xLED130S/840 WB Luminous emittance 1 Fitting: 1xLED130S/840/- Light output ratio: 99.96% Lamp luminous flux: 13000 lm Luminaire luminous flux: 12994 lm Power: 85.0 W Luminous efficacy: 152.9 lm/W Colorimetric data 1xLED130S/840/-: CCT 3000 K, CRI 100		

Total lamp luminous flux: 26000 lm, Total luminaire luminous flux: 25988 lm, Total Load: 170.0 W, Luminous efficacy: 152.9 lm/W

Figure 112 Luminaire catalogue

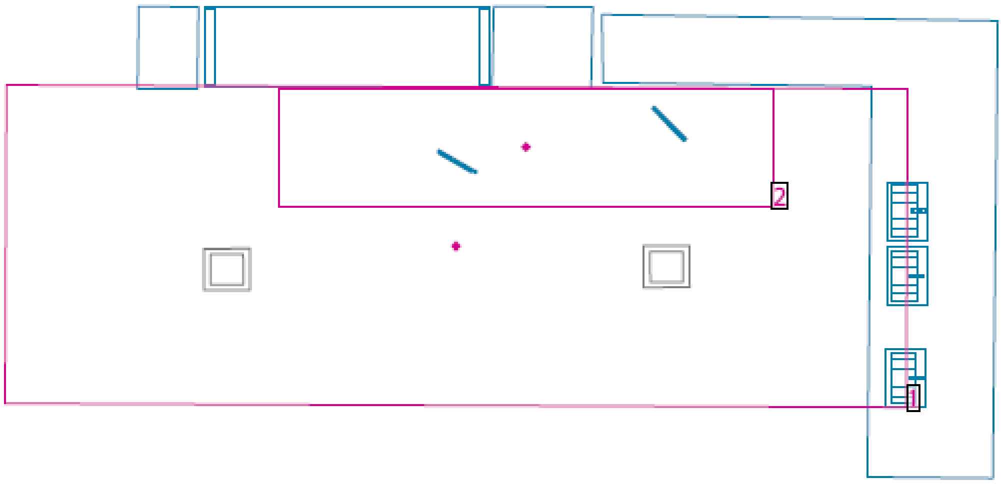


Figure 113 Kitchen work plan

General

	Surface	Result	Average (Target)	Min	Max	Min/average	Min/max
1	Calculation surface in the kitchen	Perpendicular illuminance [lx] Height: 1.200 m	452	452	452	1.00	1.00
		Perpendicular illuminance (adaptive) [lx]	733	48.5	1459	0.066	0.033

Glare valuation

	Surface	Result	Min	Max	Threshold value
2	Glare in the kitchen	UGR Height: 1.200 m	<10	<10	≤19.0

Figure 114 Calculation surface

Workplane (zone 3 (kitchen in the restaurent)): Perpendicular illuminance (adaptive) (Surface)
Light scene: artificial lighting only
Average: 587 lx (Target: ≥ 500 lx), Min: 61.0 lx, Max: 1611 lx, Min/average: 0.10, Min/max: 0.038
Height: 1.300 m, Wall zone: 0.000 m

Isolines [lx]

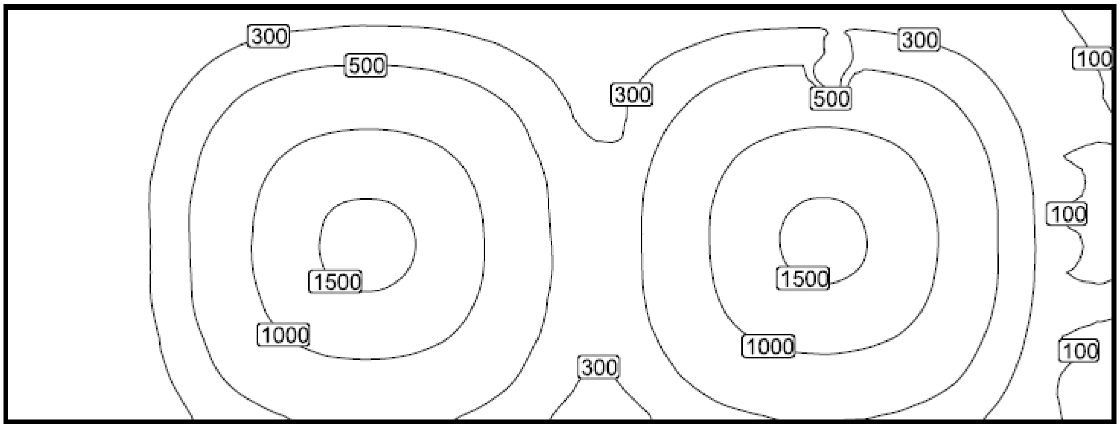


Figure 116 Lux Distribution

Glare in the kitchen / UGR

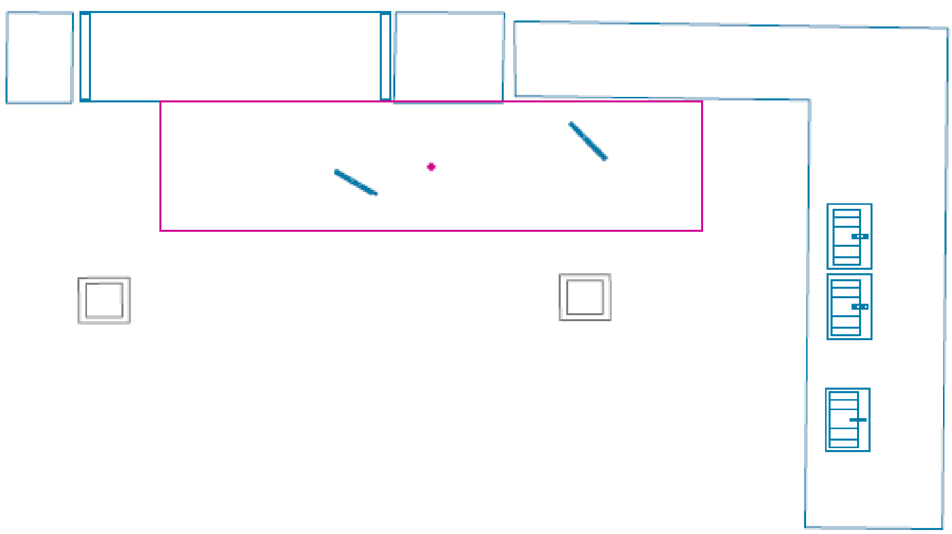


Figure 115 surface to check glare

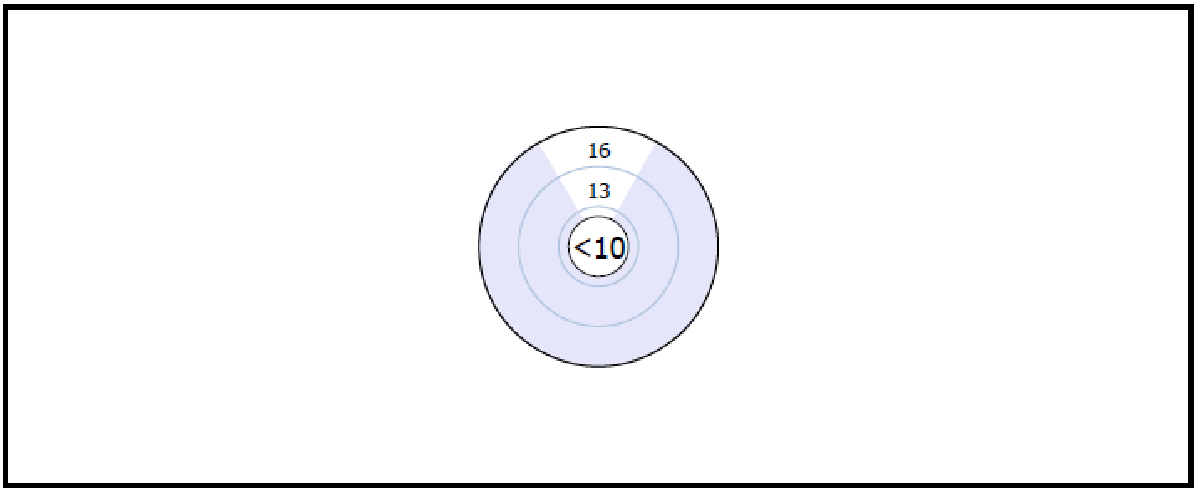


Figure 117 Glare check

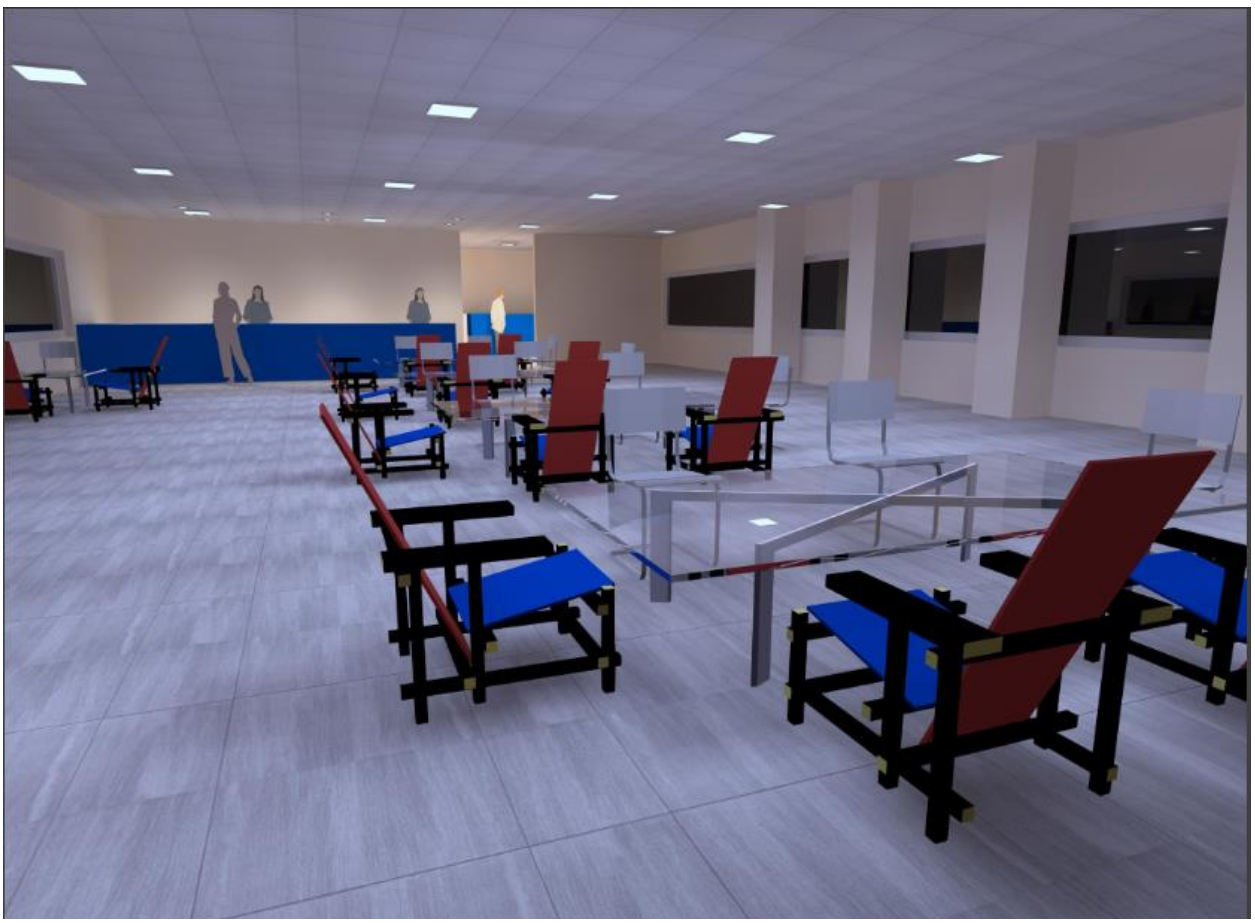


Figure 118 eating area by dialux

Figure 119 Cafeteria lighting design by dialux

3. ***Class room***

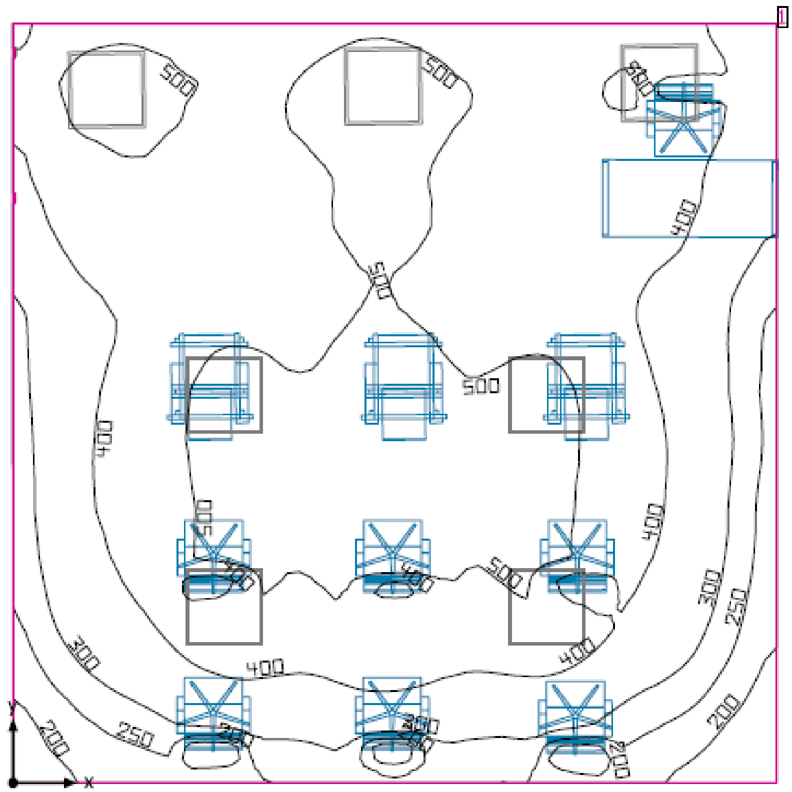


Figure 120 Class room

Clearance height: 2.470 m, Reflection factors: Ceiling 70.2%, Walls 89.8%, Floor 10.4%, Light loss factor: 0.80

Workplane

	Surface	Result	Average (Target)	Min	Max	Mean/Min	Max/Min
1	Workplane (class room)	Perpendicular illuminance (adaptive) [lx] Height: 0.760 m, Wall zone: 0.000 m	420 (≥ 400)	145	571	2.90	3.94

#	Luminaire	Φ(Luminaire) [lm]	Power [W]	Luminous efficacy [lm/W]
7	Petridis Lighting S.A. - 312193 LP2S 323x14W T16	2647	52.0	50.9
	Total via all luminaires	18529	364.0	50.9

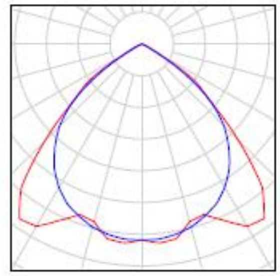
Lighting power density: 10.35 W/m² = 2.46 W/m²/100 lx (Floor area of room 35.16 m²)

Consumption: 400 - 480 kWh/a of maximum 1250 kWh/a

The energy consumption quantities do not take into account light scenes and their dimming levels.

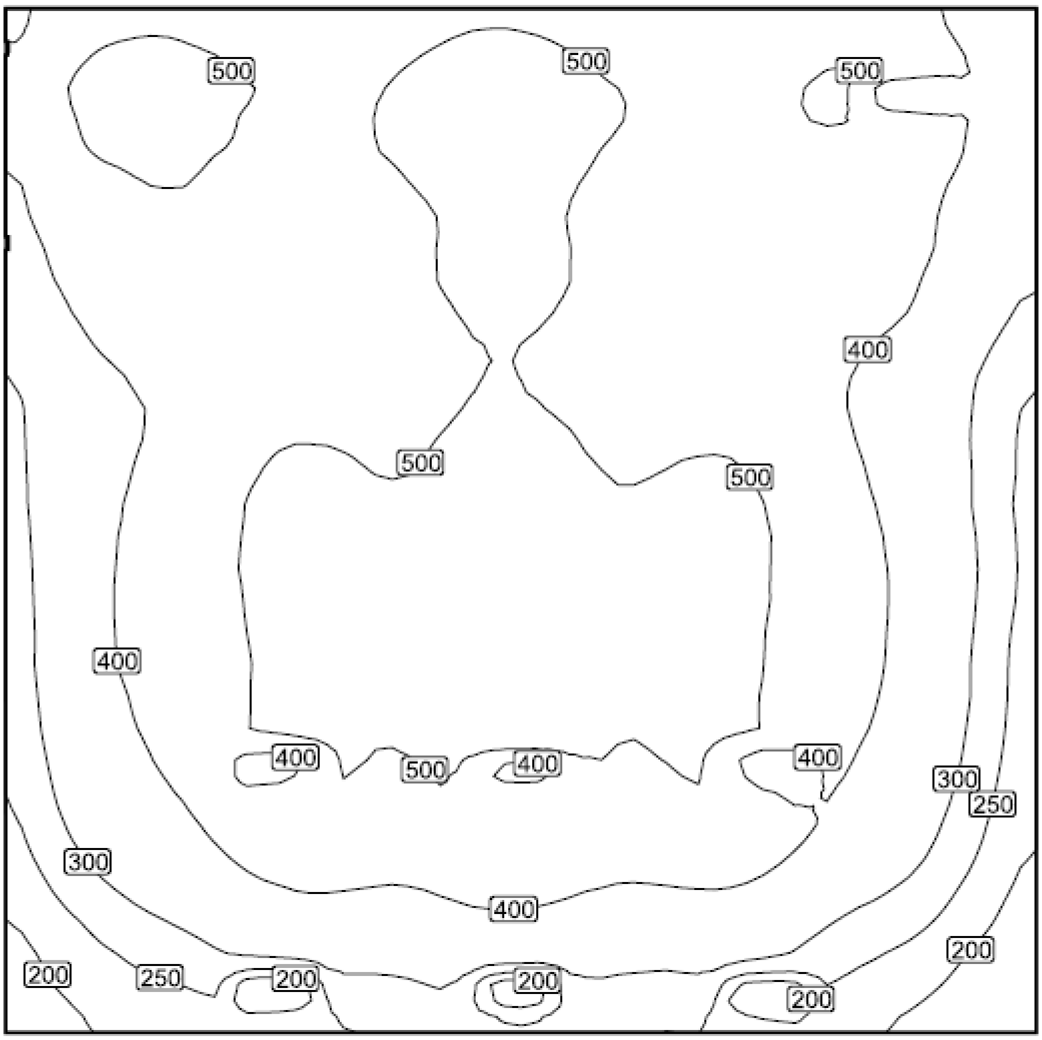
Figure 121 Work plane

class room

Quantity	Luminaire (Luminous emittance)		
7	Petridis Lighting S.A. - 312193 LP2S 323x14W T16 Luminous emittance 1 Fitting: 3xT16 14W/840 Light output ratio: 70.58% Lamp luminous flux: 3750 lm Luminaire luminous flux: 2647 lm Power: 52.0 W Luminous efficacy: 50.9 lm/W Colorimetric data 3xT16 14W/840: CCT 4000 K, CRI 85		

Total lamp luminous flux: 26250 lm, Total luminaire luminous flux: 18529 lm, Total Load: 364.0 W, Luminous efficacy: 50.9 lm/W

Figure 123 Luminaire catalogue



Scale: 1 : 50

Figure 122 Lux distribution

glare 1 / UGR

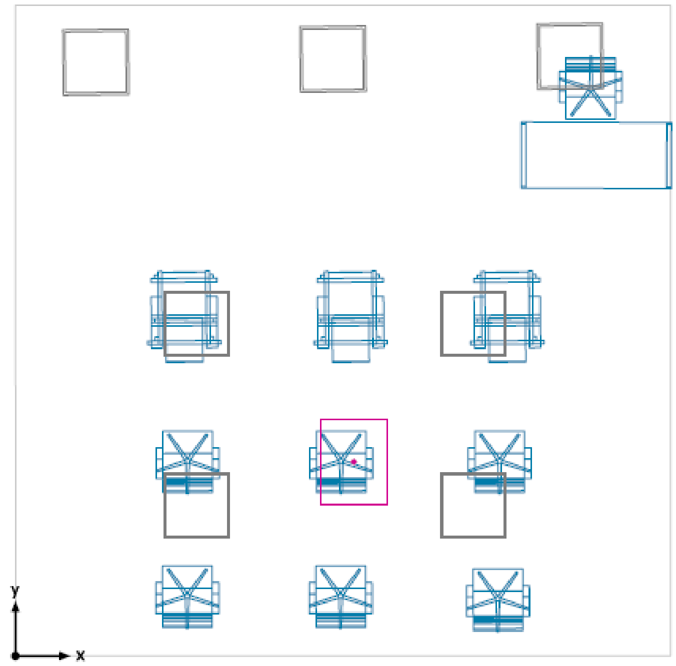


Figure 124 glare checking zone

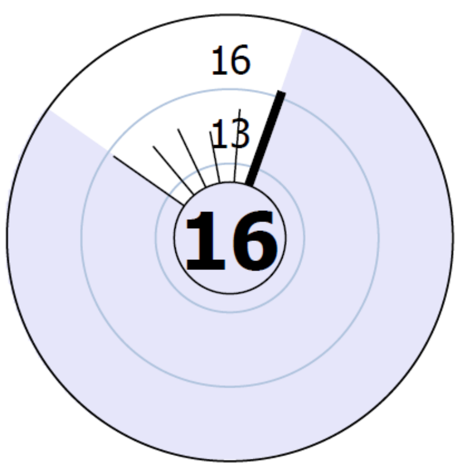


Figure 125 Glare check

Figure 126 Class room by dialux

4. Clinic room

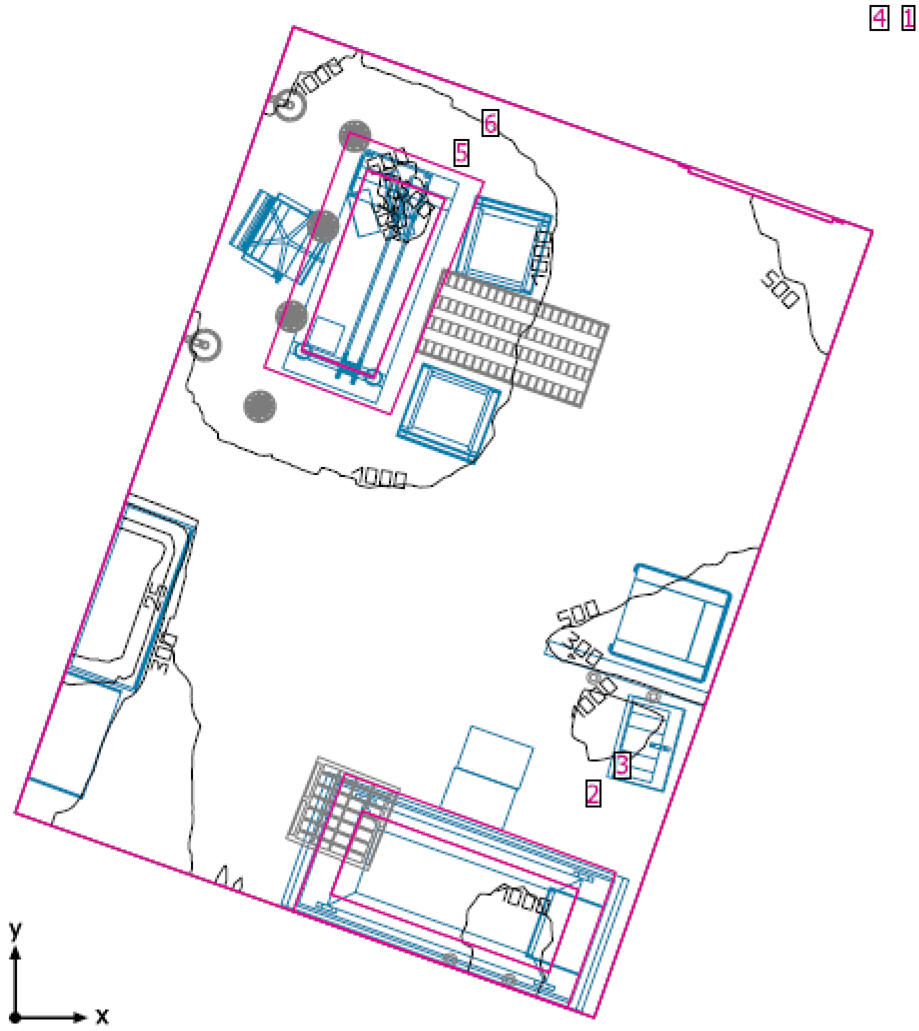


Figure 127 Clinic room plan

Clearance height: 3.170 m, Reflection factors: Ceiling 70.2%, Walls 88.2%, Floor 73.6%, Light loss factor: 0.80

Workplane

	Surface	Result	Average (Target)	Min	Max	Min/average	Min/max
1	Workplane (clinic room)	Perpendicular illuminance (adaptive) [lx] Height: 0.915 m, Wall zone: 0.000 m	794 (≥ 500)	0.47	1823	0.001	0.000

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	Surface	Result	Average (Target)	Min	Max	Min/average	Min/max
2	visiual+surrounding+background (Above the bed)	Perpendicular illuminance (adaptive) [lx] Surrounding area: 0.200 m	878 (≥ 500)	689	994	0.78	0.69
3	Surrounding area 1	Perpendicular illuminance (adaptive) [lx]	806 (≥ 0.00)	589	961	0.73	0.61
4	Background area 1	Perpendicular illuminance (adaptive) [lx] Wall zone: 0.500 m	753 (≥ 0.00)	1.34	1213	0.002	0.001
5	Visual task area (on the table)	Perpendicular illuminance (adaptive) [lx] Surrounding area: 0.200 m	1133 (≥ 500)	655	1241	0.58	0.53
6	Surrounding area 2	Perpendicular illuminance (adaptive) [lx]	1196 (≥ 0.00)	1020	1364	0.85	0.75
4	Background area 1	Perpendicular illuminance (adaptive) [lx] Wall zone: 0.500 m	744 (≥ 0.00)	1.34	1213	0.002	0.001

Figure 129 Work plan in clinic

#	Luminaire	Φ(Luminaire) [lm]	Power [W]	Luminous efficacy [lm/W]
2	LEDS-C4 - 05-1941-81-81 HALL	454	63.1	7.2
4	Luxiona - 06IL947800GR3402 Beryl CR 75 MLM 20W 4000K gs 1-10v grey	1525	20.3	75.0
4	SIMES - S.7320W LOBBY BASIC	1623	19.6	82.8
1	Saudi Lighting - 5718A/414QF.59.E3 Recess "Laid-in" Mounted on Modular Ceiling Indoor Air Handling Luminaire with Diffuser or Louver and with or without Air Supply and/or Return	2534	56.0	45.3
1	Saudi Lighting - 6746A/428QF.76 Recess"Laid-in" Mounted on Modular Ceilling Indoor Commercial / Residential Luminaire with Partially Perforated Sheet Steel Spacer and Deep Side Parabolic Louver	6304	112.0	56.3
	Total via all luminaires	22338	453.8	49.2

Lighting power density: 18.94 W/m² = 2.39 W/m²/100 lx (Floor area of room 23.96 m²)

Consumption: 1350 - 1650 kWh/a of maximum 850 kWh/a

The energy consumption quantities do not take into account light scenes and their dimming levels.

Figure 128 Luminaire detailing

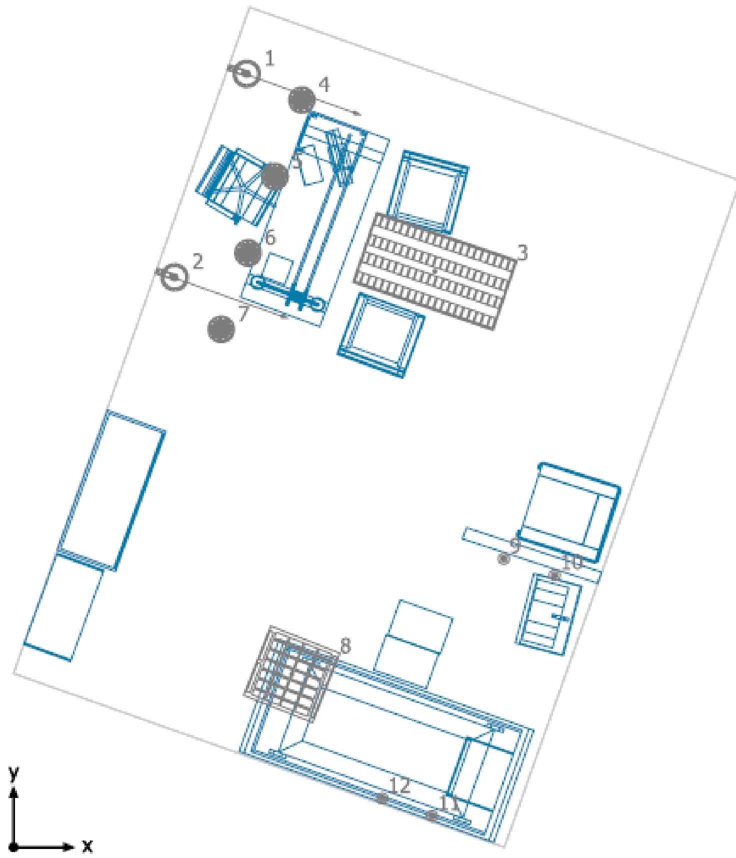


Figure 130 lighting design in clinic

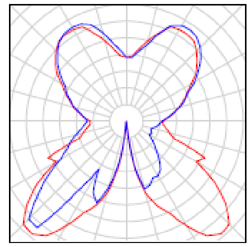
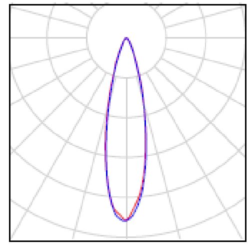
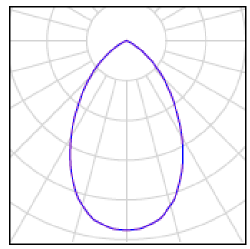
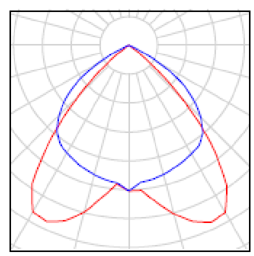
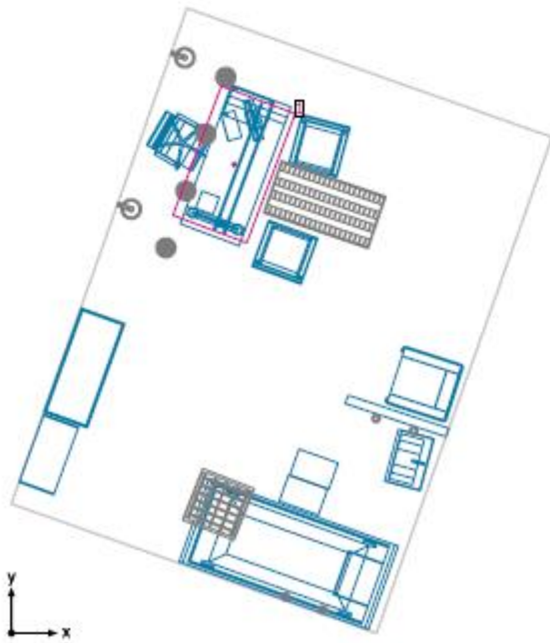
Quantity	Luminaire (Luminous emittance)		
2	LEDS-C4 - 05-1941-81-81 HALL Luminous emittance 1 Fitting: 1xE27 Led 7W Light output ratio: 60.86% Lamp luminous flux: 567 lm Luminaire luminous flux: 345 lm Power: 60.0 W Luminous efficacy: 5.8 lm/W Colorimetric data 1xE27 Led 7W: CCT 3000 K, CRI 91		
	Luminous emittance 2 Fitting: 1xLED HALL 3W Light output ratio: 100% Lamp luminous flux: 109 lm Luminaire luminous flux: 109 lm Power: 3.1 W Luminous efficacy: 35.0 lm/W Colorimetric data 1xLED HALL 3W: CCT 3000 K, CRI 91		
4	Luxiona - 06IL947800GR3402 Beryl CR 75 MLM 20W 4000K gs 1-10v grey Luminous emittance 1 Fitting: 1xLED Light output ratio: 100.35% Lamp luminous flux: 1520 lm Luminaire luminous flux: 1525 lm Power: 20.3 W Luminous efficacy: 75.0 lm/W Colorimetric data 1xLED: CCT 4144 K, CRI 72		

Figure 131 Luminaire catalogue

Quantity	Luminaire (Luminous emittance)		
1	Saudi Lighting - 6746A/428QF.76 Recess"Laid-in" Mounted on Modular Ceilling Indoor Commercial / Residential Luminaire with Partially Perforated Sheet Steel Spacer and Deep Side Parabolic Louver Luminous emittance 1 Fitting: 4xMASTER TL5 HE 28W/840 Light output ratio: 60.04% Lamp luminous flux: 10500 lm Luminaire luminous flux: 6304 lm Power: 112.0 W Luminous efficacy: 56.3 lm/W Colorimetric data 4xMASTER TL5 HE 28W/840: CCT 4000 K, CRI 80		

Total lamp luminous flux: 29224 lm, Total luminaire luminous flux: 22338 lm, Total Load: 453.8 W, Luminous efficacy: 49.2 lm/W

Figure 132 luminaire catalogue



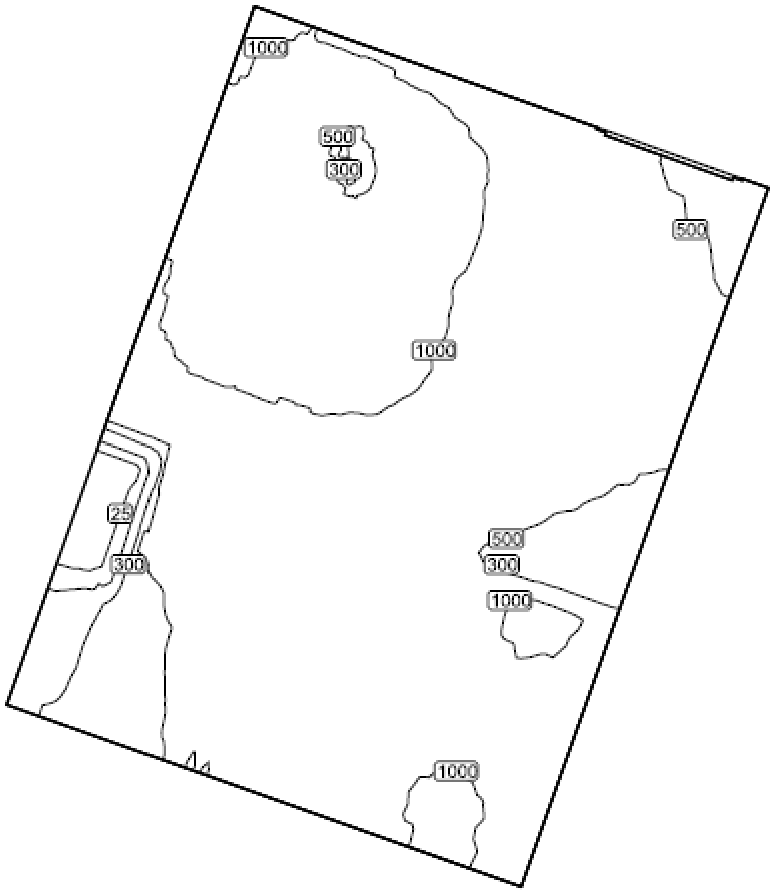
Clearance height: 3.170 m, Reflection factors: Ceiling 70.2%, Walls 88.2%, Floor 73.6%, Light loss factor: 0.80

Glare valuation

	Surface	Result	Min	Max	Threshold value
1	Glare Check	UGR Height: 1.200 m	<10	<10	≤0.00

Figure 133 Glare valuation in clinic room

Isolines [lx]



Scale: 1 : 50

Figure 134 Lux distribution

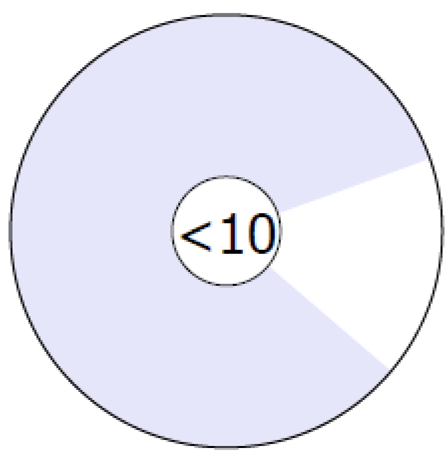


Figure 135 Glare check in clinic room

Figure 136 artificial lighting design in clinic by dialux

5. Gym

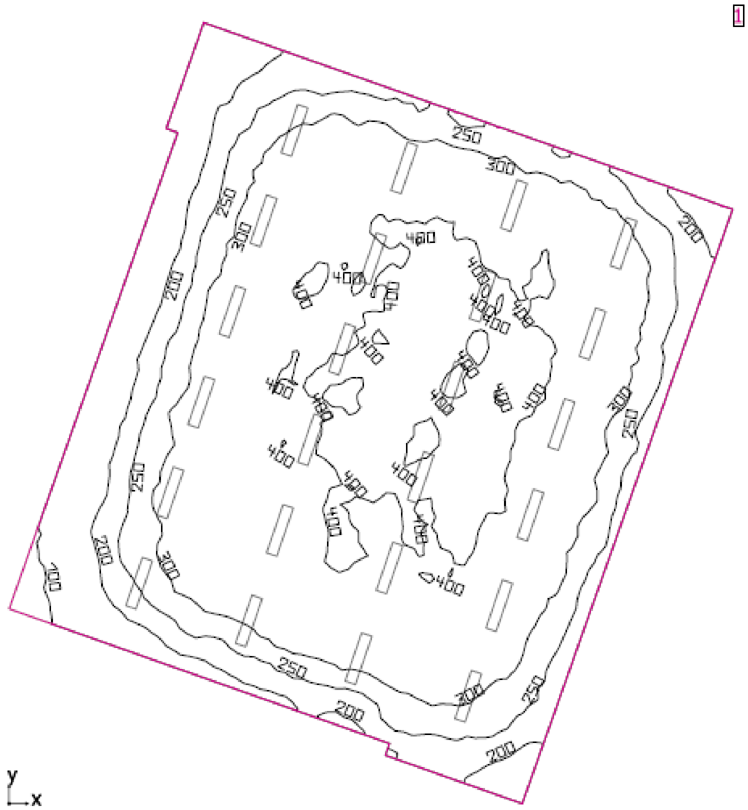


Figure 137 Gym Lighting

Workplane

	Surface	Result	Average (Target)	Min	Max	Min/average	Min/max
1	Workplane (Room 1)	Perpendicular illuminance (adaptive) [lx] Height: 1.200 m, Wall zone: 0.000 m	315 (≥ 300)	71.2	429	0.23	0.17

#	Luminaire	Φ(Luminaire) [lm]	Power [W]	Luminous efficacy [lm/W]
24	Philips - TPS764 2xTL5-28W HFP ND AC-MLO_827	4511	61.0	73.9
	Total via all luminaires	108264	1464.0	74.0

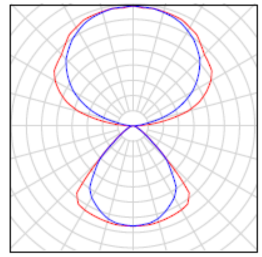
Lighting power density: 7.00 W/m² = 2.22 W/m²/100 lx (Floor area of room 209.18 m²)

Consumption: 4350 - 5950 kWh/a of maximum 7350 kWh/a

The energy consumption quantities do not take into account light scenes and their dimming levels.

Figure 138 Work plan

Room 1

Quantity	Luminaire (Luminous emittance)		
24	Philips - TPS764 2xTL5-28W HFP ND AC-MLO_827 Luminous emittance 1 Fitting: 2xTL5-28W/827 Light output ratio: 85.91% Lamp luminous flux: 5250 lm Luminaire luminous flux: 4511 lm Power: 61.0 W Luminous efficacy: 73.9 lm/W Colorimetric data 2xTL5-28W/827: CCT 3000 K, CRI 100		

Total lamp luminous flux: 126000 lm, Total luminaire luminous flux: 108264 lm, Total Load: 1464.0 W, Luminous efficacy: 74.0 lm/W

Figure 139 Luminaire catalogue

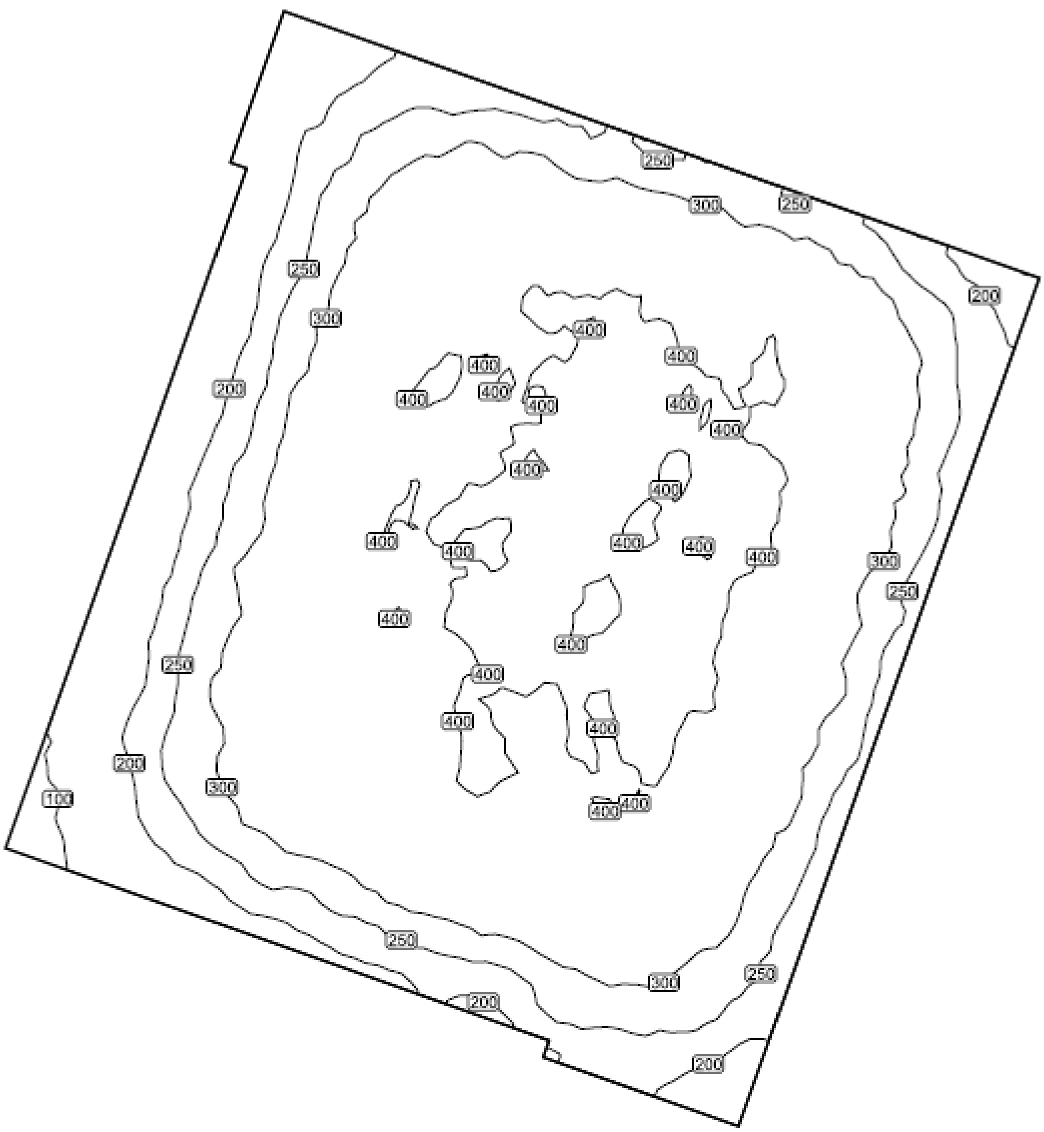


Figure 140 Lux distribution

Glare valuation

	Surface	Result	Min	Max	Threshold value
1	glare 1	UGR Height: 1.200 m	<10	<10	≤22.0
2	glare 2	UGR Height: 1.200 m	<10	<10	≤22.0

Figure 141 Glare

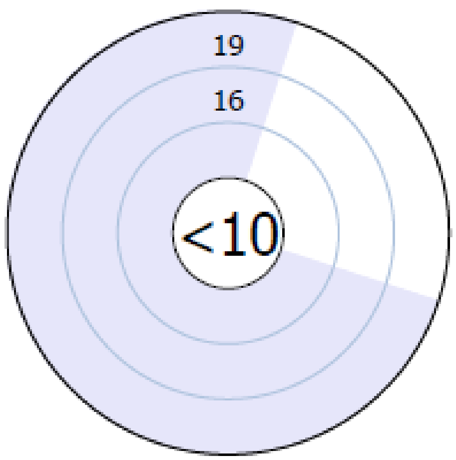


Figure 142 Glare check 1

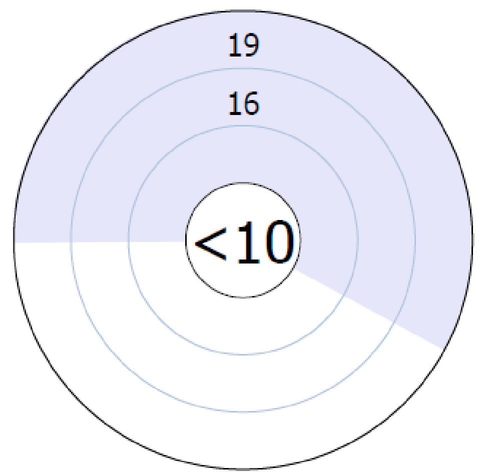


Figure 143 Glare check 2

6. ***Massage room***

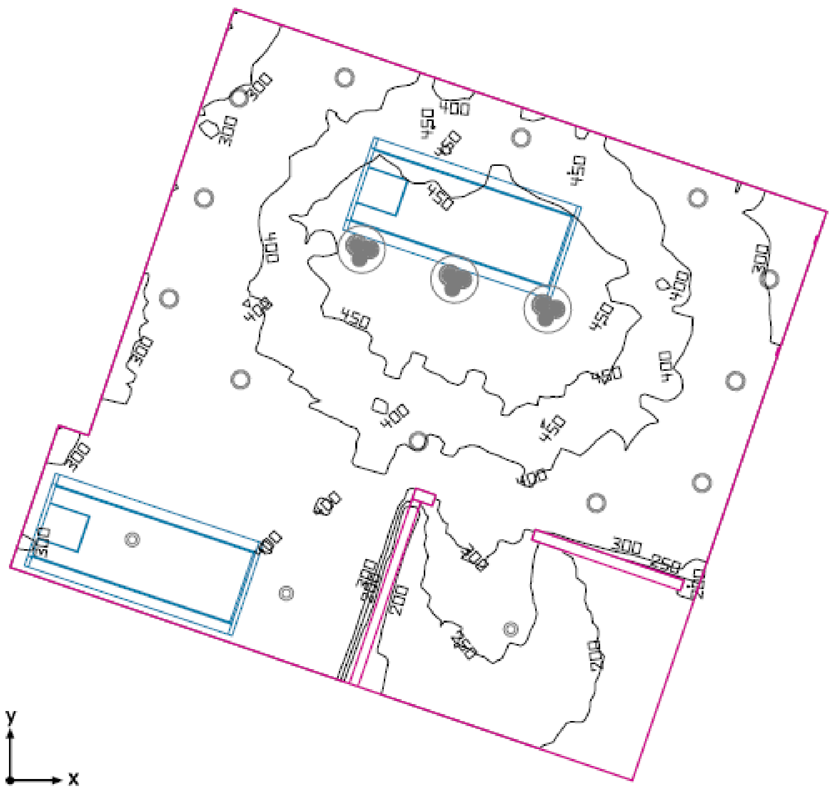


Figure 144 Massage room layout

Workplane

	Surface	Result	Average (Target)	Min	Max	Min/average	Min/max
1	Workplane (Room 1)	Perpendicular illuminance (adaptive) [lx] * Height: 0.800 m, Wall zone: 0.000 m	363 (≥ 300)	158	499	0.44	0.32

Figure 146 Work plane

#	Luminaire	Φ(Luminaire) [lm]	Power [W]	Luminous efficacy [lm/W]
3	LEDS-C4 - 15-4968-06-14 STRATA	2009	39.0	51.5
12	LEDS-C4 - 55-9667-CA-CMV1 GEA	1221	18.0	67.8
3	LEDS-C4 - 90-3926-14-M3 VOL	676	10.0	67.6
	Total via all luminaires	22707	363.0	62.6

Lighting power density: 10.57 W/m² = 2.91 W/m²/100 lx (Floor area of room 34.33 m²)

Consumption: 910 - 1300 kWh/a of maximum 1250 kWh/a

Figure 145 Luminaire

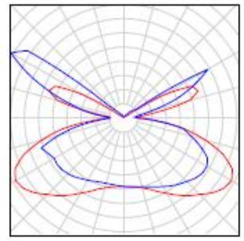
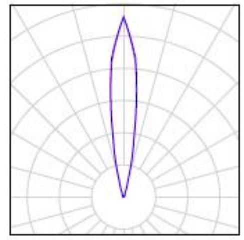
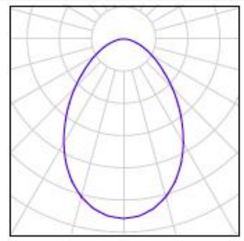
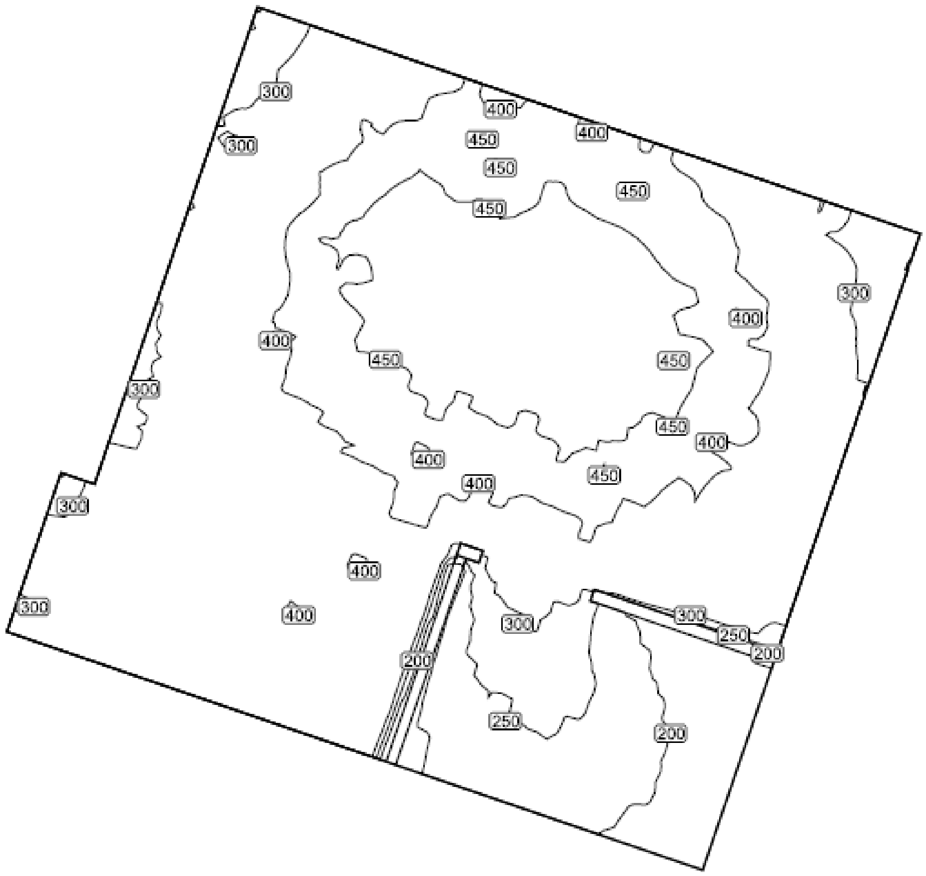
Quantity	Luminaire (Luminous emittance)		
3	LEDS-C4 - 15-4968-06-14 STRATA Luminous emittance 1 Fitting: 1xLED STRATA 39W Light output ratio: 100.04% Lamp luminous flux: 2008 lm Luminaire luminous flux: 2009 lm Power: 39.0 W Luminous efficacy: 51.5 lm/W Colorimetric data 1xLED STRATA 39W: CCT 3000 K, CRI 80		
12	LEDS-C4 - 55-9667-CA-CMV1 GEA Luminous emittance 1 Fitting: 1xLED GEA 55-9667 4000K Light output ratio: 95.08% Lamp luminous flux: 1284 lm Luminaire luminous flux: 1221 lm Power: 18.0 W Luminous efficacy: 67.8 lm/W Colorimetric data 1xLED GEA 55-9667 4000K: CCT 4000 K, CRI 79		
3	LEDS-C4 - 90-3926-14-M3 VOL Luminous emittance 1 Fitting: 1xLED VOL 9,6W 4000K Light output ratio: 99.77% Lamp luminous flux: 678 lm Luminaire luminous flux: 676 lm Power: 10.0 W Luminous efficacy: 67.6 lm/W Colorimetric data 1xLED VOL 9,6W 4000K: CCT 4000 K, CRI 84		

Figure 147 Luminaire catalogue

Total lamp luminous flux: 23466 lm, Total luminaire luminous flux: 22707 lm, Total Load: 363.0 W, Luminous efficacy: 62.6 lm/W

Isolines [lx]



Scale: 1 : 50

Figure 148 Lux distribution

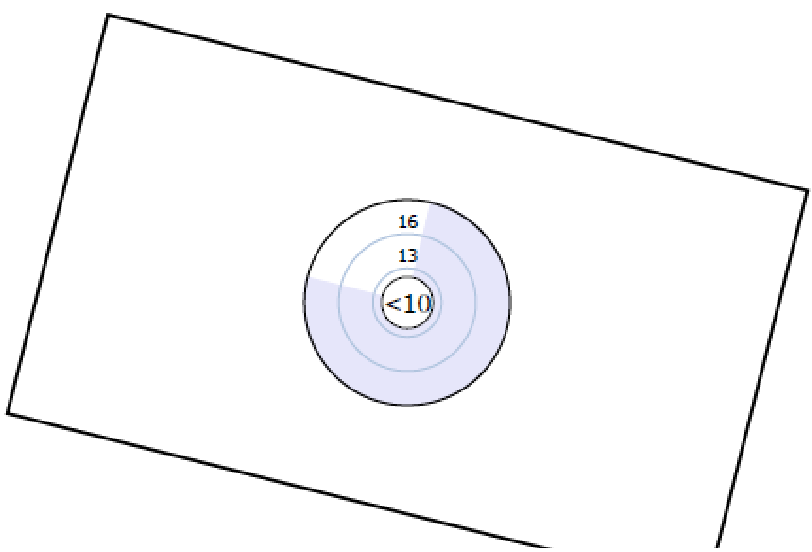


Figure 149 Glare check

Figure 150 Massage room lighting by dialux

Figure 151 massage room lighting by dialux

7. ***Multipurpose room***

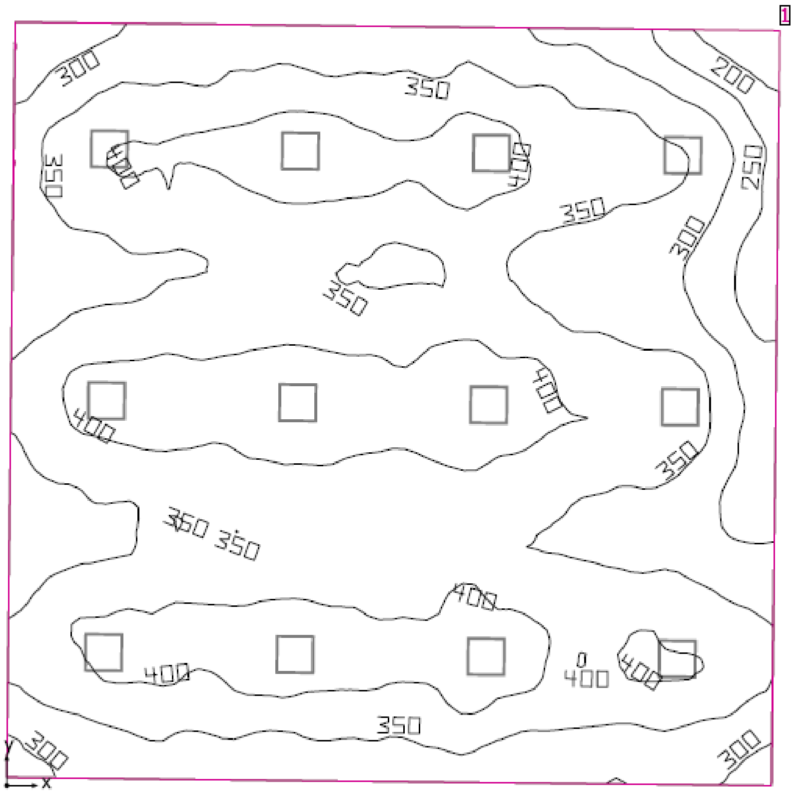


Figure 152 Multipurpose room

Workplane

	Surface	Result	Average (Target)	Min	Max	Mean/Min	Max/Min
1	multipurpose room **	Perpendicular illuminance (adaptive) [lx] Height: 0.760 m, Wall zone: 0.000 m	362 (≥ 300)	171	446	2.12	2.61

#	Luminaire	Φ(Luminaire) [lm]	Power [W]	Luminous efficacy [lm/W]
12	Philips - RC125B W60L60 1 xLED34S/830 NOC	3396	36.0	94.3
	Total via all luminaires	40752	432.0	94.3

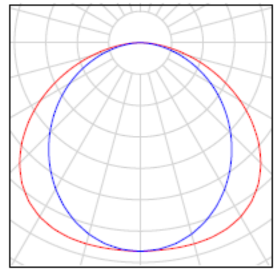
Lighting power density: 2.97 W/m² = 0.82 W/m²/100 lx (Floor area of room 145.30 m²)

Consumption: 290 - 410 kWh/a of maximum 5100 kWh/a

The energy consumption quantities do not take into account light scenes and their dimming levels.

Figure 153 Work plane

Multipurpose room

Quantity	Luminaire (Luminous emittance)		
12	Philips - RC125B W60L60 1 xLED34S/830 NOC Luminous emittance 1 Fitting: 1xLED34S/830/- Light output ratio: 99.89% Lamp luminous flux: 3400 lm Luminaire luminous flux: 3396 lm Power: 36.0 W Luminous efficacy: 94.3 lm/W Colorimetric data 1xLED34S/830/-: CCT 3000 K, CRI 100		

Total lamp luminous flux: 40800 lm, Total luminaire luminous flux: 40752 lm, Total Load: 432.0 W, Luminous efficacy: 94.3 lm/W

Figure 154 Lighting catalogue

Glare valuation

	Surface	Result	Min	Max	Threshold value
1	Glare in multipurpose room	UGR Height: 1.200 m	13.1	14.2	≤22.0

Figure 155 Glare

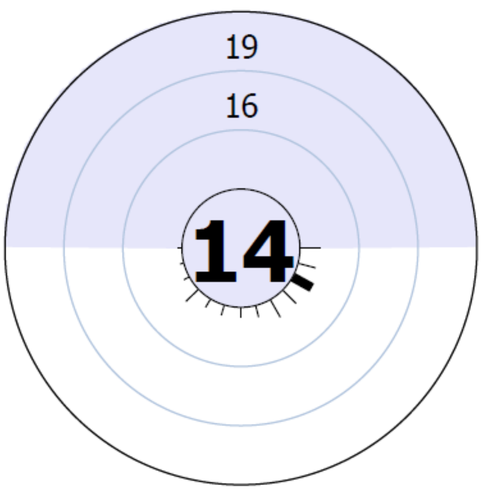


Figure 156 Glare check

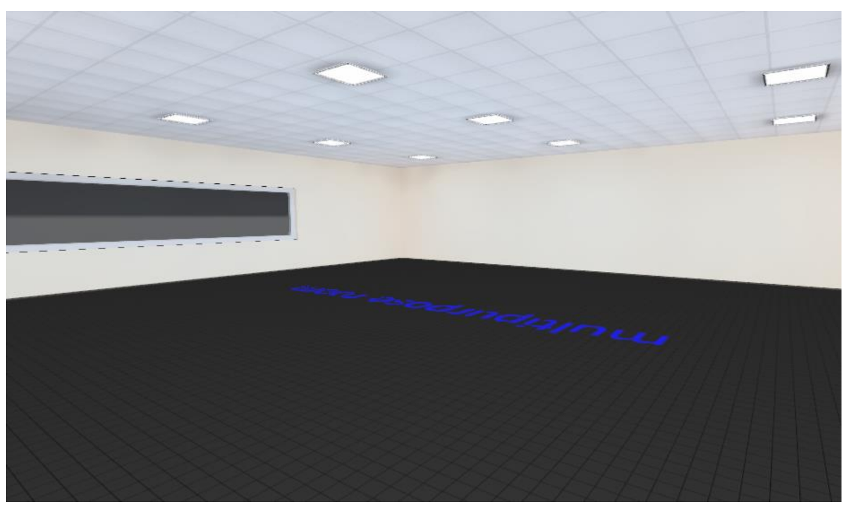


Figure 157 Multipurpose lighting by dialux

8. <u>Radiology room</u>

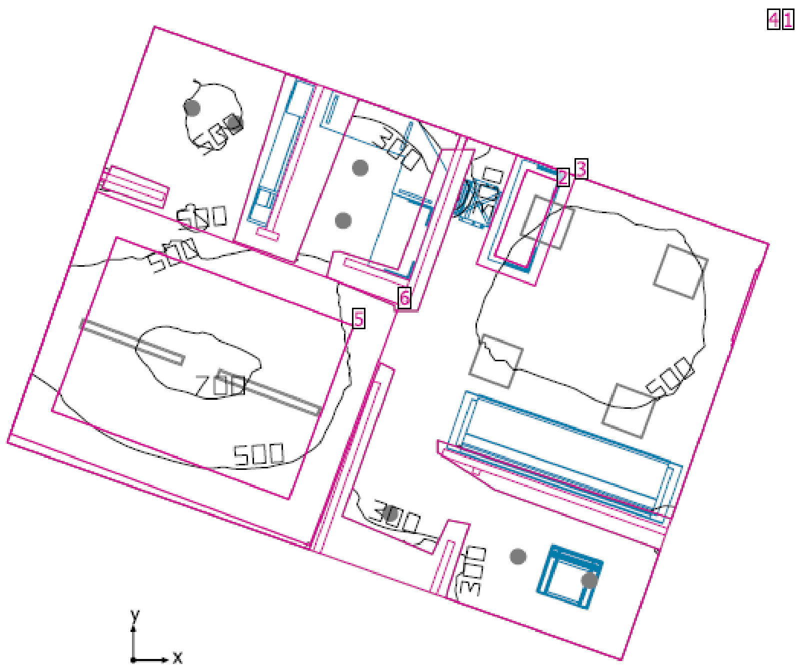


Figure 158 Radiology room

#	Luminaire	Φ(Luminaire) [lm]	Power [W]	Luminous efficacy [lm/W]
4	Philips - TBS165 G 4xTL5-14W HFS M2_865	2696	61.0	44.2
2	Philips - TCS165 2xTL5-49W HFP C3_865	5043	108.0	46.7

Figure 159 Luminaire 1

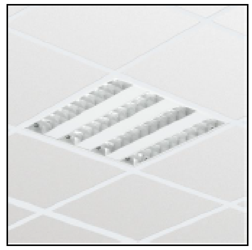
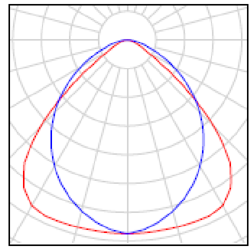
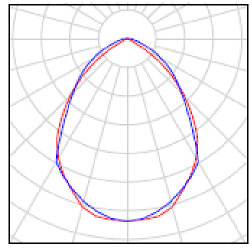
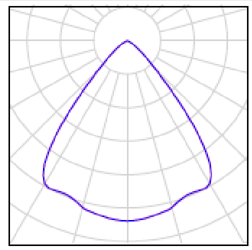
#	Luminaire	Φ(Luminaire) [lm]	Power [W]	Luminous efficacy [lm/W]
7	SIMES - S.7320W LOBBY BASIC	1623	19.6	82.8
	Total via all luminaires	32231	597.2	54.0

Lighting power density: 10.65 W/m² (Floor area of room 56.09 m²),
Lighting power density: 12.24 W/m² = 2.58 W/m²/100 lx (Area of working plane 48.80 m²)

Consumption: 1850 kWh/a of maximum 3050 kWh/a

The energy consumption quantities do not take into account light scenes and their dimming levels.

Figure 160 Luminaire 2

Quantity	Luminaire (Luminous emittance)		
4	Philips - TBS165 G 4xTL5-14W HFS M2_865 Luminous emittance 1 Fitting: 4xTL5-14W/865 Light output ratio: 59.90% Lamp luminous flux: 4500 lm Luminaire luminous flux: 2696 lm Power: 61.0 W Luminous efficacy: 44.2 lm/W Colorimetric data 4xTL5-14W/865: CCT 3000 K, CRI 100		
2	Philips - TCS165 2xTL5-49W HFP C3_865 Luminous emittance 1 Fitting: 2xTL5-49W/865 Light output ratio: 61.87% Lamp luminous flux: 8150 lm Luminaire luminous flux: 5043 lm Power: 108.0 W Luminous efficacy: 46.7 lm/W Colorimetric data 2xTL5-49W/865: CCT 3000 K, CRI 100		
7	SIMES - S.7320W LOBBY BASIC Luminous emittance 1 Fitting: 1x Absolute photometry Luminaire luminous flux: 1623 lm Power: 19.6 W Luminous efficacy: 82.8 lm/W Colorimetric data 1x: CCT 3224 K, CRI 91		

Total lamp luminous flux: 45661 lm, Total luminaire luminous flux: 32231 lm, Total Load: 597.2 W, Luminous efficacy: 54.0 lm/W

Figure 162 Lighting catalogue

General

	Surface	Result	Average (Target)	Min	Max	Min/average	Min/max
1	Calculation surface (radiology zone)	Perpendicular illuminance [lx] Height: 1.700 m	1032	1032	1032	1.00	1.00
		Perpendicular illuminance (adaptive) [lx]	639	451	726	0.71	0.62

Glare valuation

	Surface	Result	Min	Max	Threshold value
2	Glare on the reception+waiting area	UGR Height: 1.200 m	<10	<10	≤22.0
3	Glare on development room	UGR Height: 1.200 m	<10	<10	≤22.0
4	Glare (X-ray room)	UGR Height: 1.200 m	<10	<10	≤22.0

Figure 161 Calculation surface

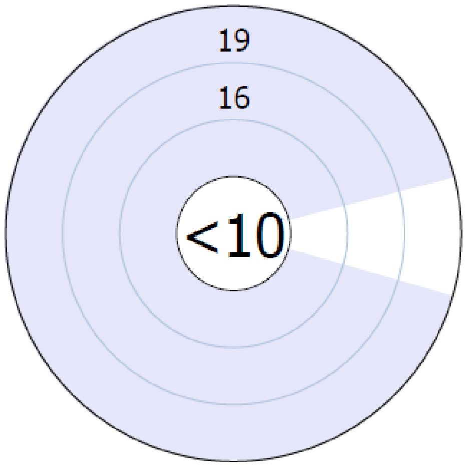


Figure 163 Glare check

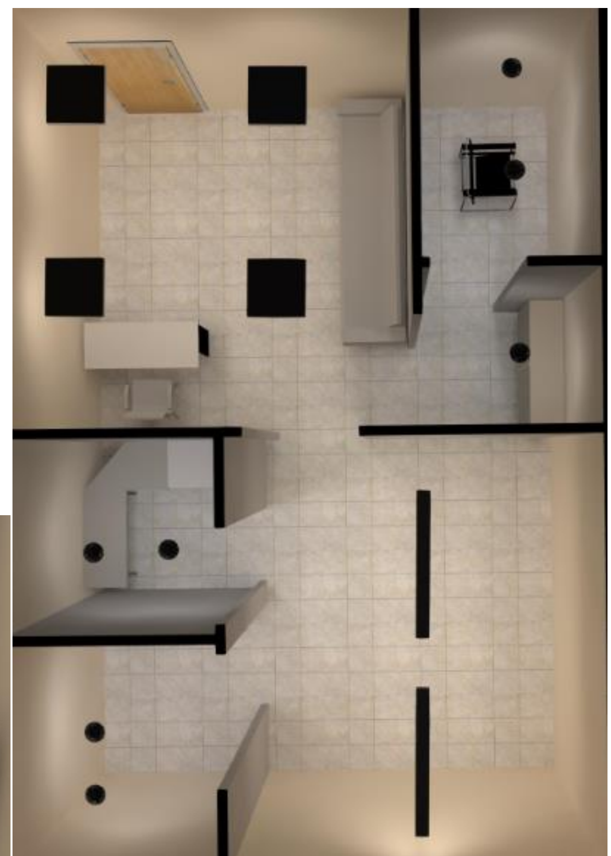


Figure 164 radiology room artificial lighting by dialux

9. WC's

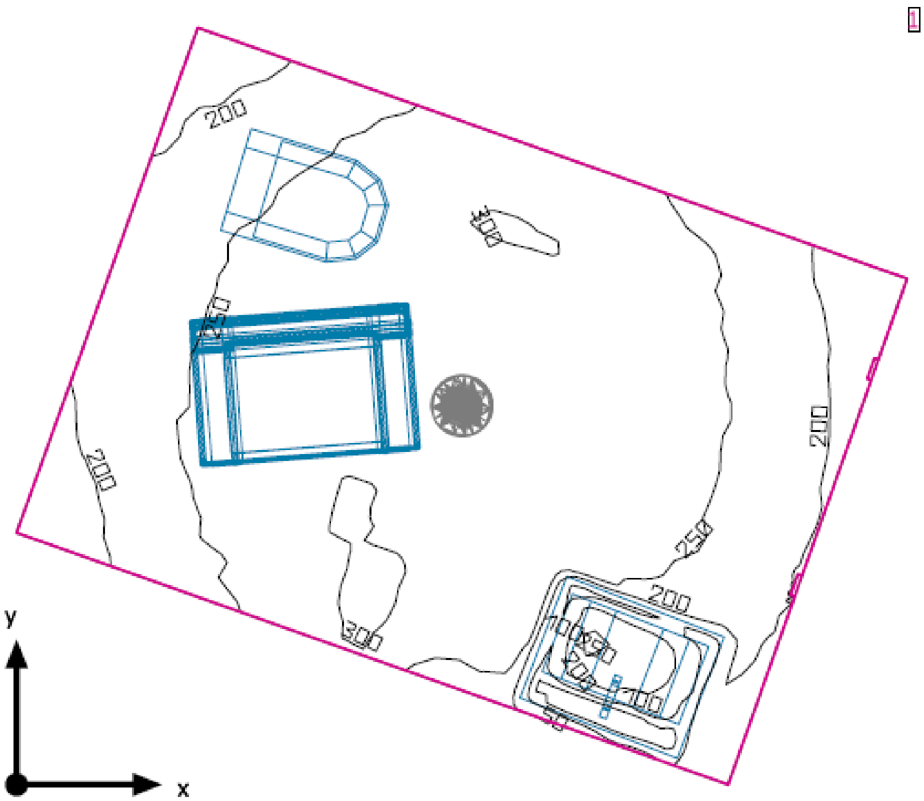


Figure 165 WC

Cl

Workplane

	Surface	Result	Average (Target)	Min	Max	Min/average	Min/max
1	Workplane (W.C)	Perpendicular illuminance (adaptive) [lx] Height: 0.800 m, Wall zone: 0.000 m	248 (≥ 200)	39.1	312	0.16	0.13

#	Luminaire	Φ(Luminaire) [lm]	Power [W]	Luminous efficacy [lm/W]
1	SIMES - S.7360W.19 LOBBY PROFESSIONAL	1884	28.0	67.3
	Total via all luminaires	1884	28.0	67.3

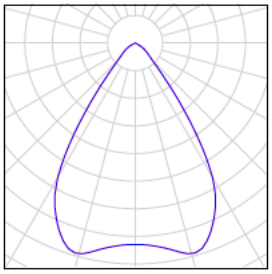
Lighting power density: 5.84 W/m² = 2.36 W/m²/100 lx (Floor area of room 4.79 m²)

Consumption: 3 - 5 kWh/a of maximum 200 kWh/a

The energy consumption quantities do not take into account light scenes and their dimming levels.

Figure 166 Work plane

W.C

Quantity	Luminaire (Luminous emittance)		
1	SIMES - S.7360W.19 LOBBY PROFESSIONAL Luminous emittance 1 Fitting: 1xLED Citizen CLU038 1206C4 303 H5 K2 Warm White Absolute photometry Luminaire luminous flux: 1884 lm Power: 28.0 W Luminous efficacy: 67.3 lm/W Colorimetric data 1xLED Citizen CLU038 1206C4 303 H5 K2 Warm White: CCT 3224 K, CRI 91		

Total lamp luminous flux: 1884 lm, Total luminaire luminous flux: 1884 lm, Total Load: 28.0 W, Luminous efficacy: 67.3 lm/W

Figure 167 Luminaire catalogue

General

	Surface	Result	Average (Target)	Min	Max	Min/average	Min/max
1	Calculation surface (W.C)	Perpendicular illuminance (adaptive) [lx]	230	70.1	281	0.30	0.25

Glare valuation

	Surface	Result	Min	Max	Threshold value
2	Glare Check	UGR Height: 1.200 m	<10	<10	≤25.0

Figure 168 Calculation surface

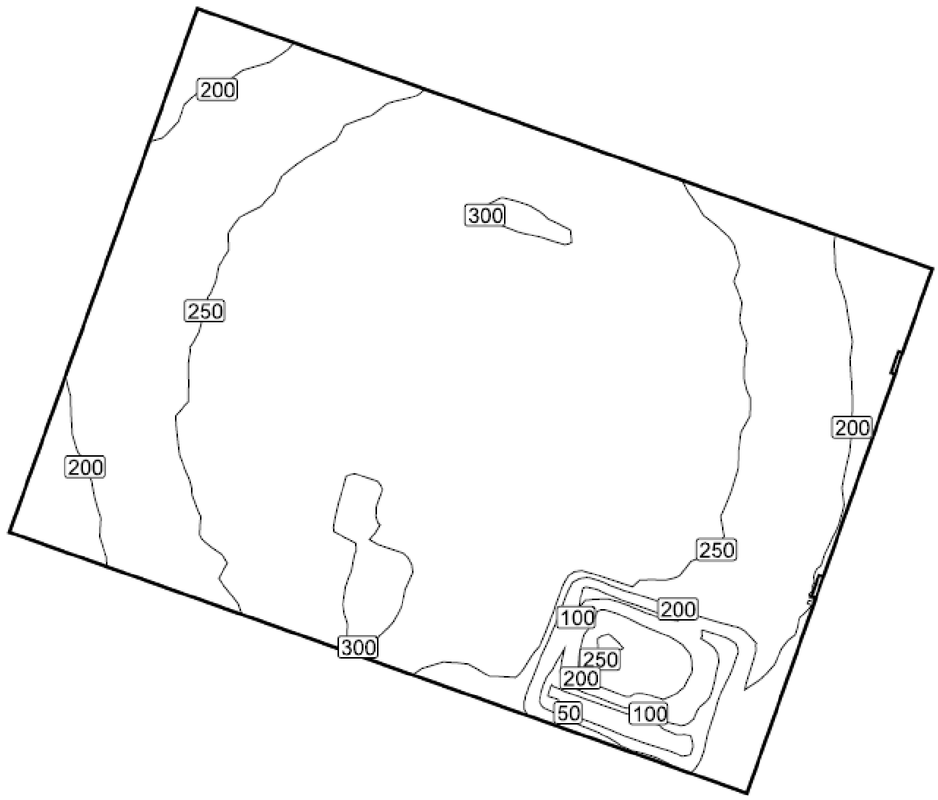


Figure 169 lux distribution

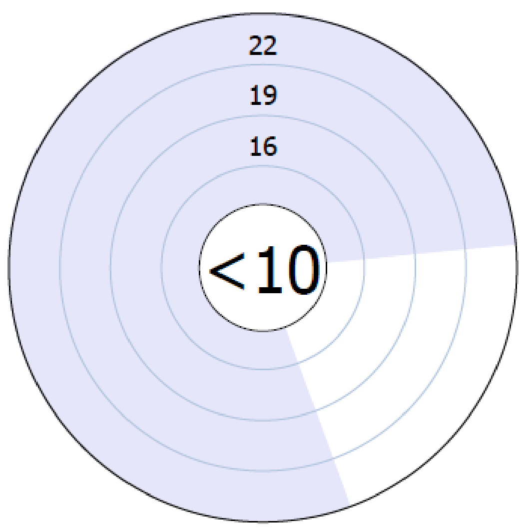


Figure 170 Glare check

10. Workshop

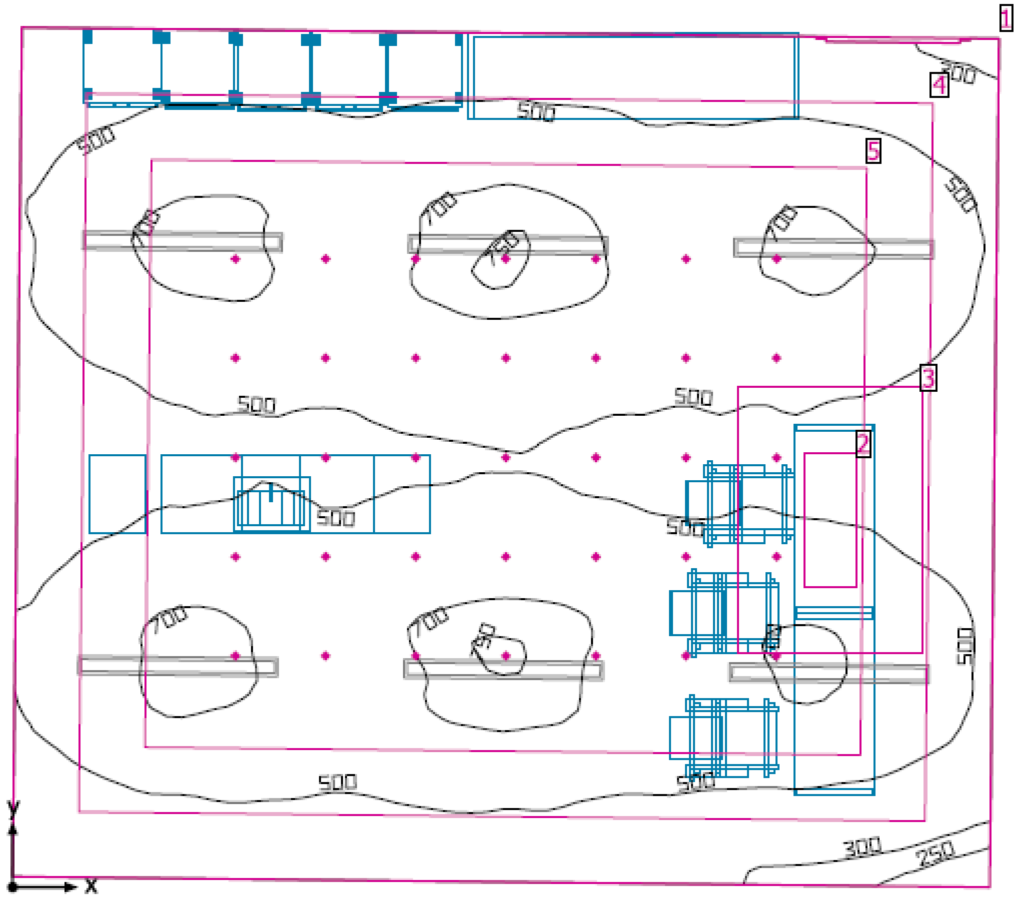


Figure 171 Workshop plan

Workplane

	Surface	Result	Average (Target)	Min	Max	Min/average	Min/max
1	Workplane (workshop room)	Perpendicular illuminance (adaptive) [lx] Height: 1.200 m, Wall zone: 0.000 m	550 (≥ 500)	204	760	0.37	0.27

EN 12464-1

2	Visual task+surrounding+back fround area	Perpendicular illuminance (adaptive) [lx] Surrounding area: 0.500 m	515 (≥ 500)	451	612	0.88	0.74
3	Surrounding area 1	Perpendicular illuminance (adaptive) [lx]	541 (≥ 300)	416	712	0.77	0.58
4	Background area 1	Perpendicular illuminance (adaptive) [lx] Wall zone: 0.500 m	563 (≥ 100)	433	644	0.77	0.67

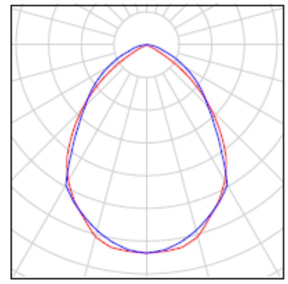
#	Luminaire	Φ(Luminaire) [lm]	Power [W]	Luminous efficacy [lm/W]
6	Philips - TCS165 2xTL5-49W HFP C3_865	5043	108.0	46.7
	Total via all luminaires	30258	648.0	46.7

Lighting power density: 13.39 W/m² = 2.43 W/m²/100 lx (Floor area of room 48.39 m²)

Consumption: 750 - 860 kWh/a of maximum 1700 kWh/a

Figure 172 Work plane

Quantity	Luminaire (Luminous emittance)
6	Philips - TCS165 2xTL5-49W HFP C3_865 Luminous emittance 1 Fitting: 2xTL5-49W/865 Light output ratio: 61.87% Lamp luminous flux: 8150 lm Luminaire luminous flux: 5043 lm Power: 108.0 W Luminous efficacy: 46.7 lm/W Colorimetric data 2xTL5-49W/865: CCT 3000 K, CRI 100



Total lamp luminous flux: 48900 lm, Total luminaire luminous flux: 30258 lm, Total Load: 648.0 W, Luminous efficacy: 46.7 lm/W

Figure 173 Luminaire catalogue

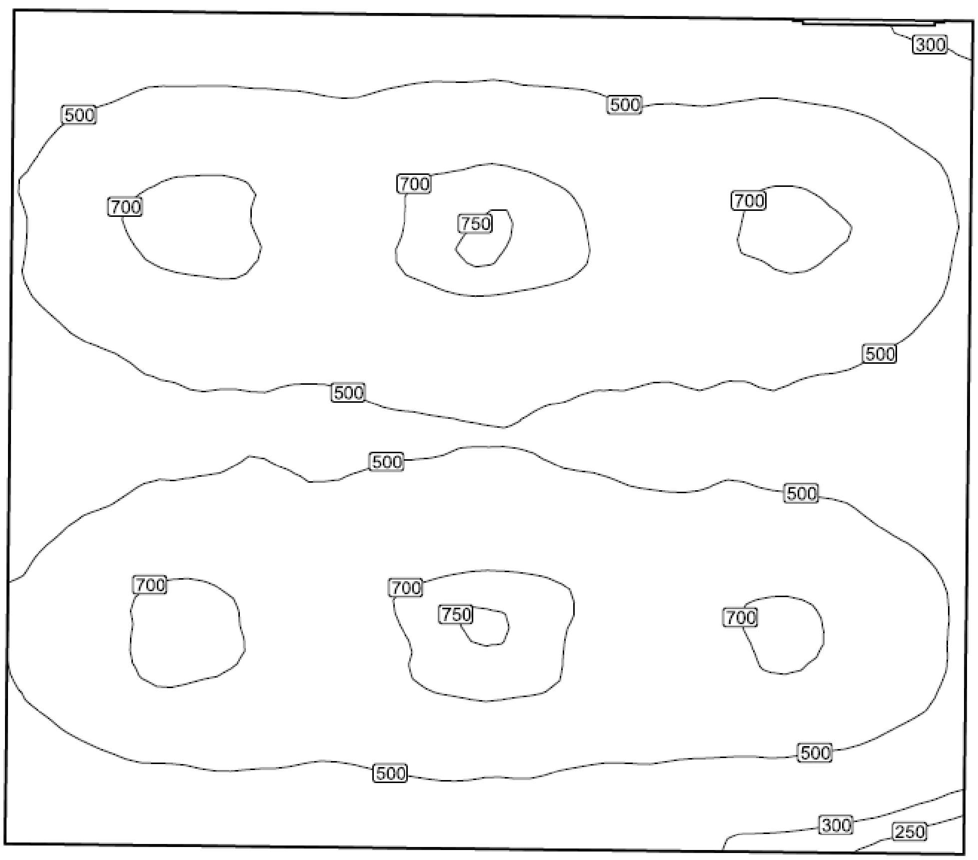


Figure 174 Lux distribution

Surface	Result	Average (Target)	Min	Max	Min/average	Min/max
Visual task+surrounding+back fround area	Perpendicular illuminance (adaptive) [lx] Surrounding area: 0.500 m	515 (≥ 500)	451	612	0.88	0.74
Surrounding area 1	Perpendicular illuminance (adaptive) [lx]	541 (≥ 300)	416	712	0.77	0.58
Background area 1	Perpendicular illuminance (adaptive) [lx] Wall zone: 0.500 m	563 (≥ 100)	433	644	0.77	0.67

Figure 175 Calculation surface

Glare Check: UGR (Grid)
Light scene: Light scene (artificial lighting without natural lighting)
Strongest glare at: 155°, Max: 18.2, Threshold value: ≤19.0, Viewing sector: 140° - 240°, Step width: 15°, Height: 1.200 m

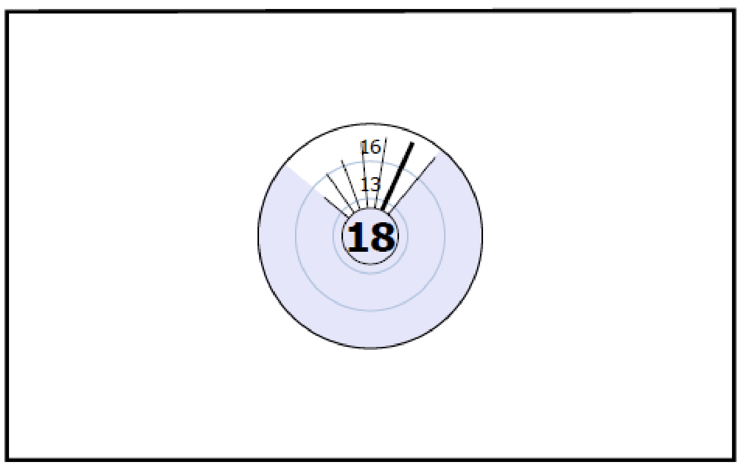


Figure 176 Glare check

Figure 177 Workshop lighting design by dialux

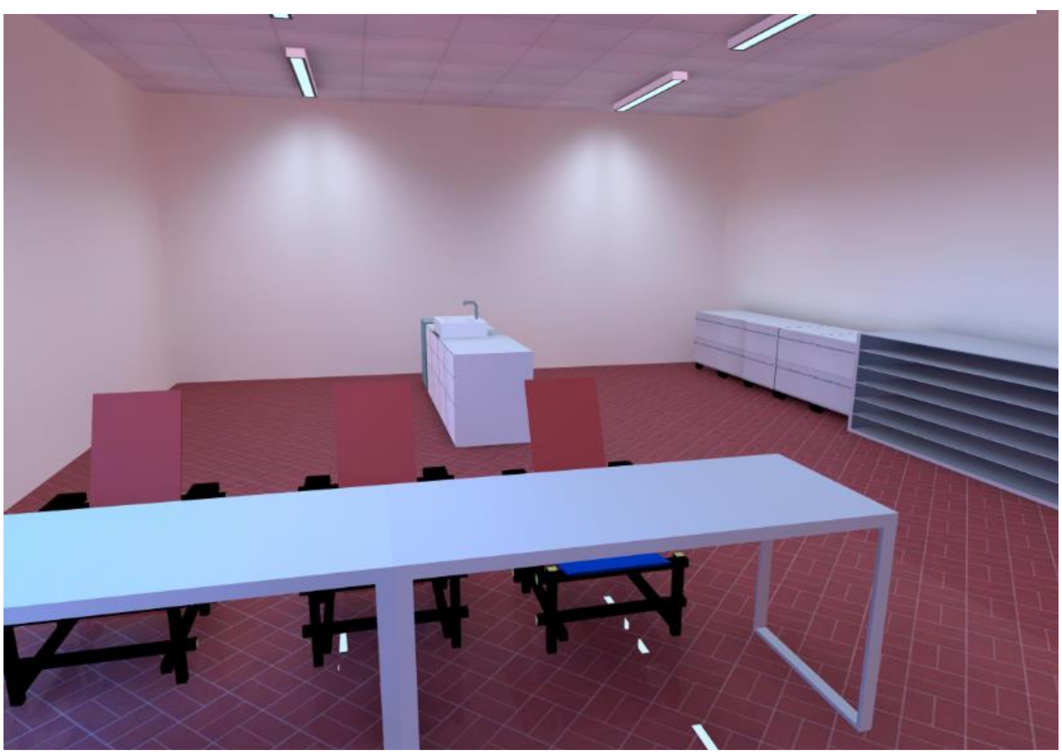


Figure 178 Workshop lighting design by dialux

11. ***Swimming Pool zone***
a. Corridor

Workplane

	Surface	Result	Average (Target)	Min	Max	Mean/Min	Max/Min
1	Workplane (corridor)	Perpendicular illuminance (adaptive) [lx] Height: 0.000 m, Wall zone: 0.000 m	18.4 (≥ 50.0)	1.30	215	14.2	165

Lighting power density: 0.00 W/m² = 0.00 W/m²/100 lx (Floor area of room 27.20 m²)

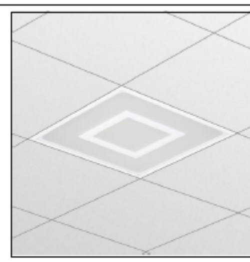
Consumption: 39 kWh/a of maximum 1000 kWh/a

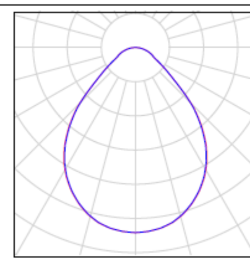
The energy consumption quantities do not take into account light scenes and their dimming levels.
The results are informative. The energy consumption of a building results from the sum of all consumptions in the rooms.

Figure 179 Work plane

corridor

Quantity	Luminaire (Luminous emittance)
1	Philips - RC482B W62L62 CPC 1xLED35S/840 MK AC-MLO-R Luminous emittance 1 Fitting: 1xLED35S/840/- Light output ratio: 99.90% Lamp luminous flux: 3600 lm Luminaire luminous flux: 3596 lm Power: 35.5 W Luminous efficacy: 101.3 lm/W Colorimetric data 1xLED35S/840/-: CCT 3000 K, CRI 100





Total lamp luminous flux: 3600 lm, Total luminaire luminous flux: 3596 lm, Total Load: 35.5 W, Luminous efficacy: 101.3 lm/W

Figure 180 Luminaire catalogue

Glare valuation

	Surface	Result	Min	Max	Threshold value
1	glare in corridor	UGR Height: 1.200 m	<10	<10	≤19.0

Figure 181 Glare valuation

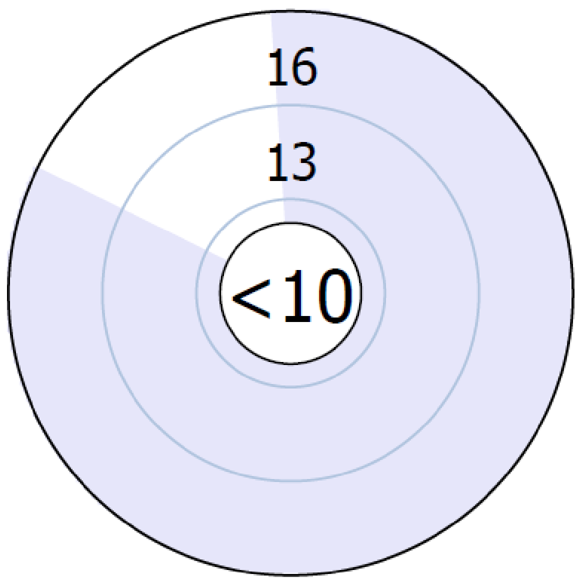


Figure 182 Glare check

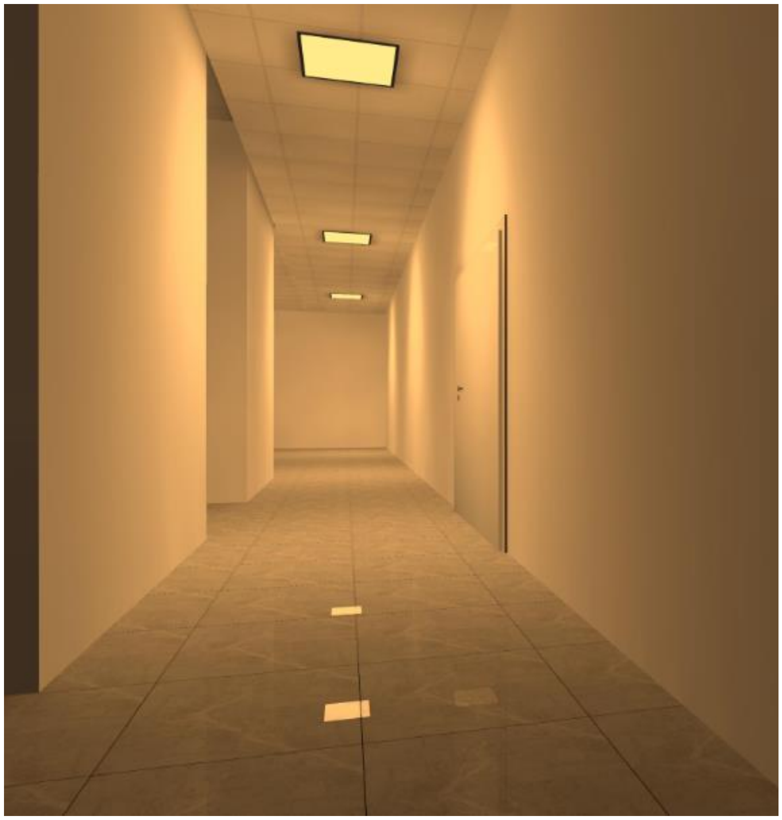


Figure 183 Corridore lighting from dialux

b. Reception

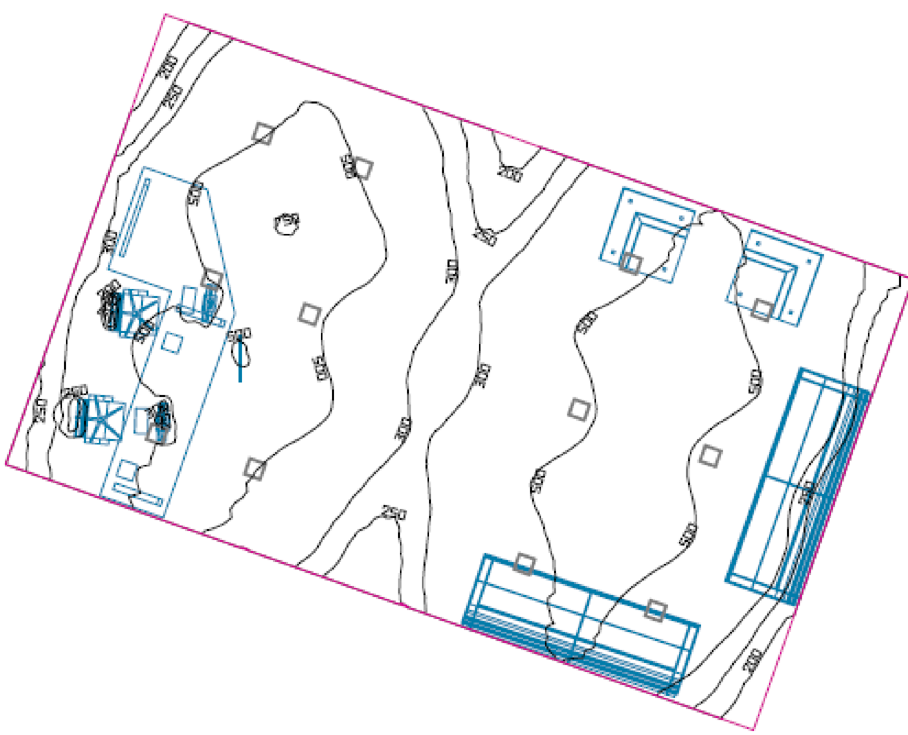


Figure 184 Reception plan

Workplane

	Surface	Result	Average (Target)	Min	Max	Mean/Min	Max/Min
1	Workplane (reception)	Perpendicular illuminance (adaptive) [lx] Height: 0.750 m, Wall zone: 0.000 m	428 (≥ 400)	147	756	2.91	5.14

#	Luminaire	Φ(Luminaire) [lm]	Power [W]	Luminous efficacy [lm/W]
12	Philips - DN572B PSE-E 1xLED20S/830 C	2000	17.8	112.4
	Total via all luminaires	24000	213.6	112.4

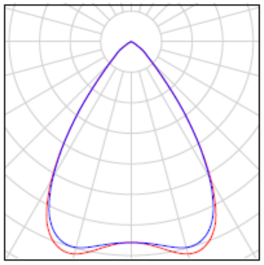
Lighting power density: 3.98 W/m² = 0.93 W/m²/100 lx (Floor area of room 53.69 m²)

Consumption: 260 - 410 kWh/a of maximum 1900 kWh/a

The energy consumption quantities do not take into account light scenes and their dimming levels.
The results are informative. The energy consumption of a building results from the sum of all consumptions in the rooms.

Figure 185 Work plane

reception

Quantity	Luminaire (Luminous emittance)		
12	Philips - DN572B PSE-E 1xLED20S/830 C Luminous emittance 1 Fitting: 1xLED20S/830/- Light output ratio: 100% Lamp luminous flux: 2000 lm Luminaire luminous flux: 2000 lm Power: 17.8 W Luminous efficacy: 112.4 lm/W Colorimetric data 1xLED20S/830/-: CCT 3000 K, CRI 100		

Total lamp luminous flux: 24000 lm, Total luminaire luminous flux: 24000 lm, Total Load: 213.6 W, Luminous efficacy: 112.4 lm/W

Figure 186 luminaire catalogue

Glare valuation

	Surface	Result	Min	Max	Threshold value
1	Glare on waiting area(reception)	UGR Height: 1.200 m	12.8	14.6	≤19.0
2	Glare on reception chair	UGR Height: 1.672 m	11.6	13.7	≤22.0

Figure 187 Glare valuation

reception

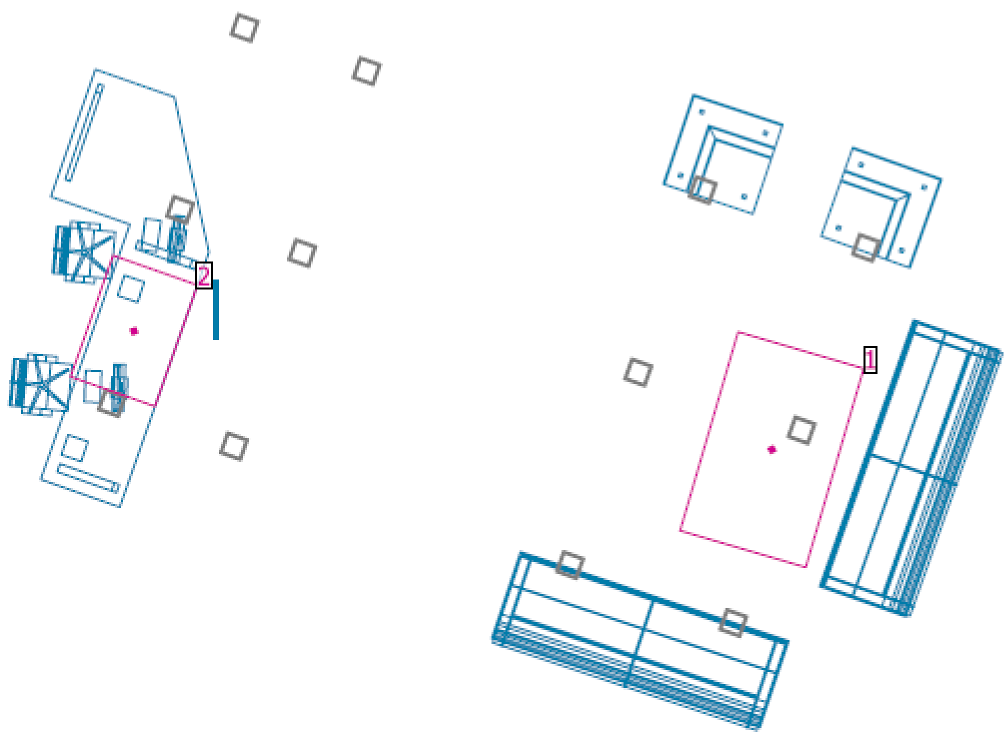


Figure 188 Glare surface check

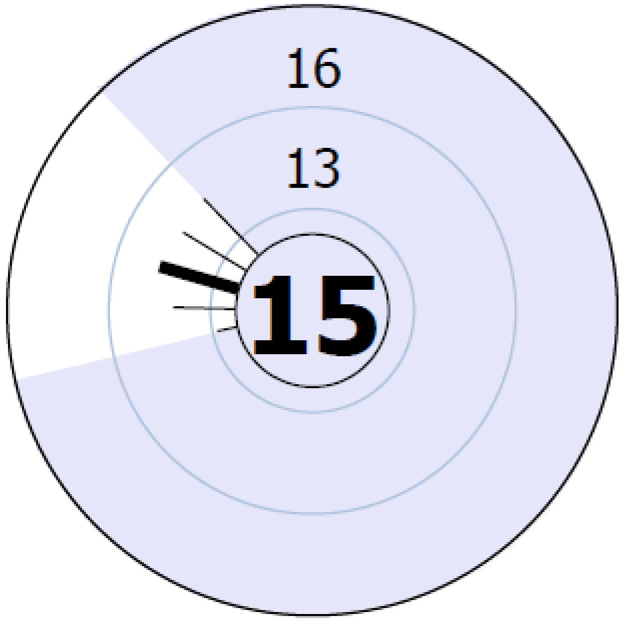


Figure 189 Glare check in waiting area

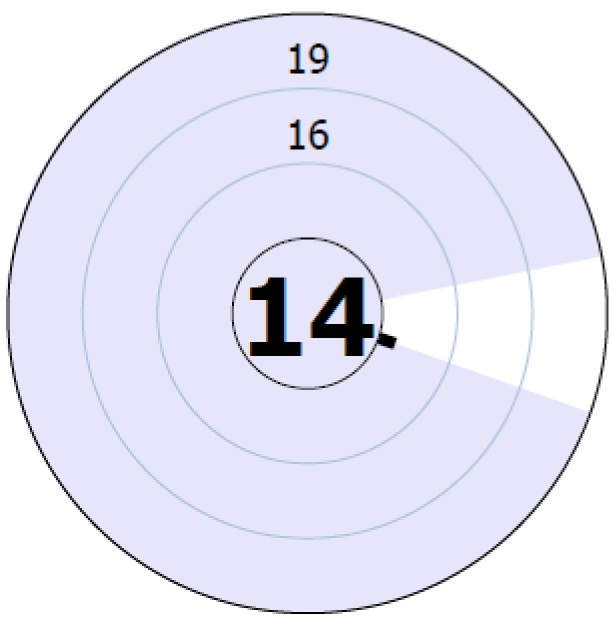
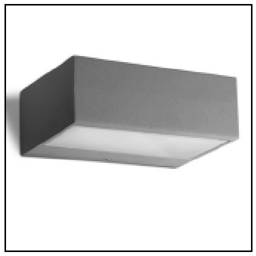
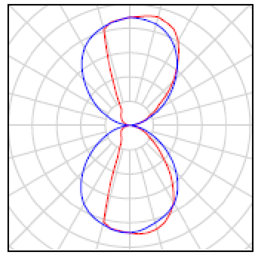


Figure 190 Glare check on reception table

Figure 191 lighting in reception by dialux

c. Steam room

Sauna

Quantity	Luminaire (Luminous emittance)		
5	LEDS-C4 - 05-9629-CA-CL NEMESIS Luminous emittance 1 Fitting: 1xQFDE 150/930 Light output ratio: 39.95% Lamp luminous flux: 900 lm Luminaire luminous flux: 360 lm Power: 13.0 W Luminous efficacy: 27.7 lm/W Colorimetric data 1xQFDE 150/930: CCT 2821 K, CRI 99		

Total lamp luminous flux: 4500 lm, Total luminaire luminous flux: 1800 lm, Total Load: 65.0 W, Luminous efficacy: 27.7 lm/W

Figure 192 Luminaire catalogue

Glare valuation

	Surface	Result	Min	Max	Threshold value
2	Glare Sauna	UGR Height: 2.300 m	<10	<10	≤19.0

Figure 193 Glare valuation

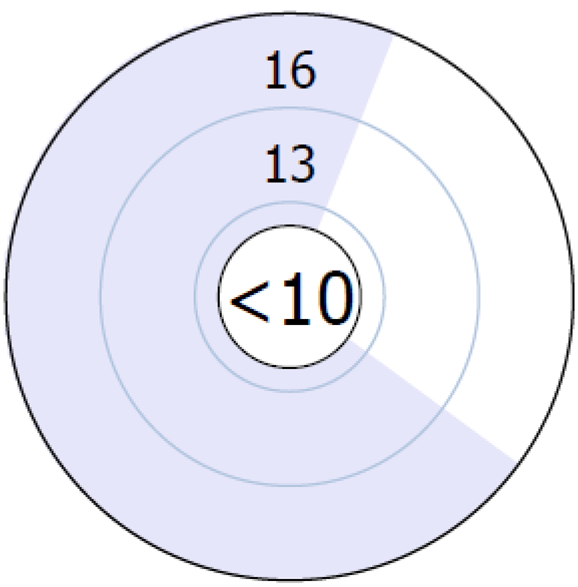


Figure 194 Glare check

Figure 195 Steam room lighting from dialux

d. Swimming pool

Therapeutic pool for group

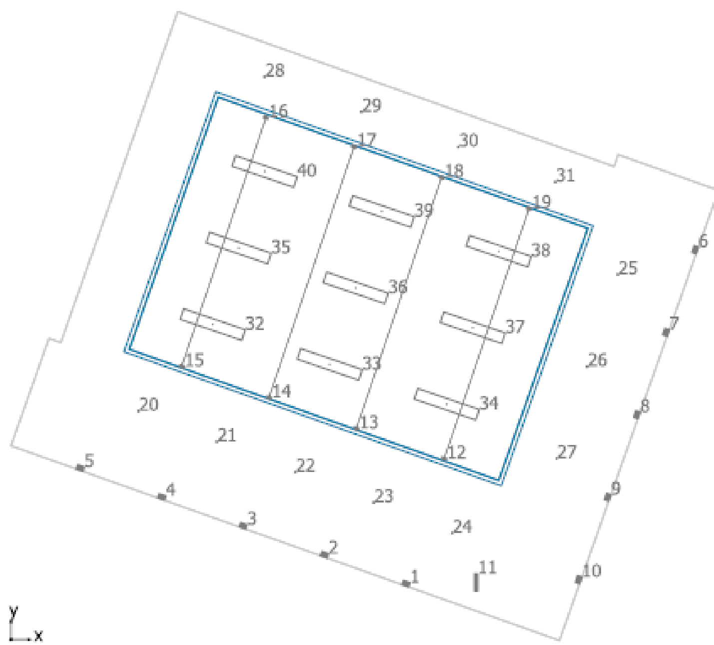
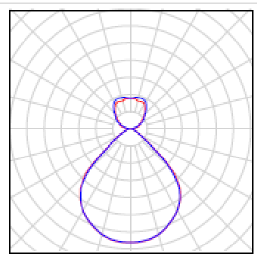
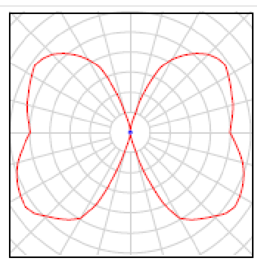


Figure 196 Therapeutic pool

9	Philips - TPS772 3xTL5-49W/865/827/865 HFD PC-MLO_865-827-865 Luminous emittance 1 Fitting: 3xTL5-49W/865/827/865/865-827-865 Light output ratio: 70.87% Lamp luminous flux: 12501 lm Luminaire luminous flux: 8860 lm Power: 163.0 W Luminous efficacy: 54.4 lm/W Colorimetric data 3xTL5-49W/865/827/865/865-827-865: CCT 3000 K, CRI 100		
1	Saudi Lighting - 7071DP/108BF.E3 Pendant Mounted Exit Sign/Directional Indoor Luminaire Luminous emittance 1 Fitting: 1xL 8W/840 Light output ratio: 74.13% Lamp luminous flux: 450 lm Luminaire luminous flux: 334 lm Power: 11.0 W Luminous efficacy: 30.3 lm/W Colorimetric data 1xL 8W/840: CCT 4000 K, CRI 85		

Total lamp luminous flux: 127643 lm, Total luminaire luminous flux: 88218 lm, Total Load: 1659.6 W, Luminous efficacy: 53.2 lm/W

Figure 197 Luminaire catalogue

Therapeutic pool for group

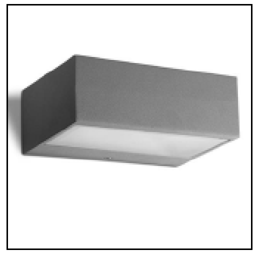
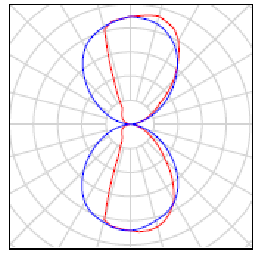
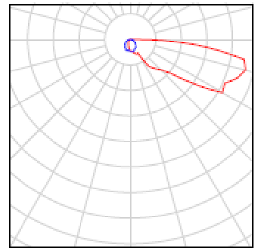
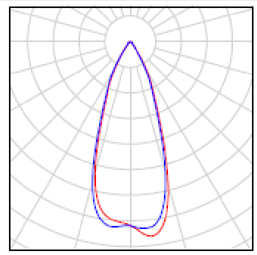
Quantity	Luminaire (Luminous emittance)		
10	LEDS-C4 - 05-9629-CA-CL NEMESIS Luminous emittance 1 Fitting: 1xQFDE 150/930 Light output ratio: 39.95% Lamp luminous flux: 900 lm Luminaire luminous flux: 360 lm Power: 13.0 W Luminous efficacy: 27.7 lm/W Colorimetric data 1xQFDE 150/930: CCT 2821 K, CRI 99		
8	LEDS-C4 - 05-9771-34-M2 MICENAS path Luminous emittance 1 Fitting: 1xLED MICENAS 1,5W 4000K Light output ratio: 100% Lamp luminous flux: 154 lm Luminaire luminous flux: 154 lm Power: 1.5 W Luminous efficacy: 102.8 lm/W Colorimetric data 1xLED MICENAS 1,5W 4000K: CCT 4000 K, CRI 70		
12	LEDS-C4 - 71-3817-14-M2 MINI PLAY Luminous emittance 1 Fitting: 1xLED MINIPLAY 3W 3000K Light output ratio: 74.27% Lamp luminous flux: 371 lm Luminaire luminous flux: 276 lm Power: 3.3 W Luminous efficacy: 83.5 lm/W Colorimetric data 1xLED MINIPLAY 3W 3000K: CCT 3000 K, CRI 79		

Figure 198 Luminaire catalogue

Glare valuation

	Surface	Result	Min	Max	Threshold value
1	glare in the pool	UGR Height: 0.500 m	<10	<10	≤0.00
2	glare around the pool	UGR Height: 1.200 m	<10	<10	≤0.00

Figure 199 Glare valuation

glare in the pool / UGR

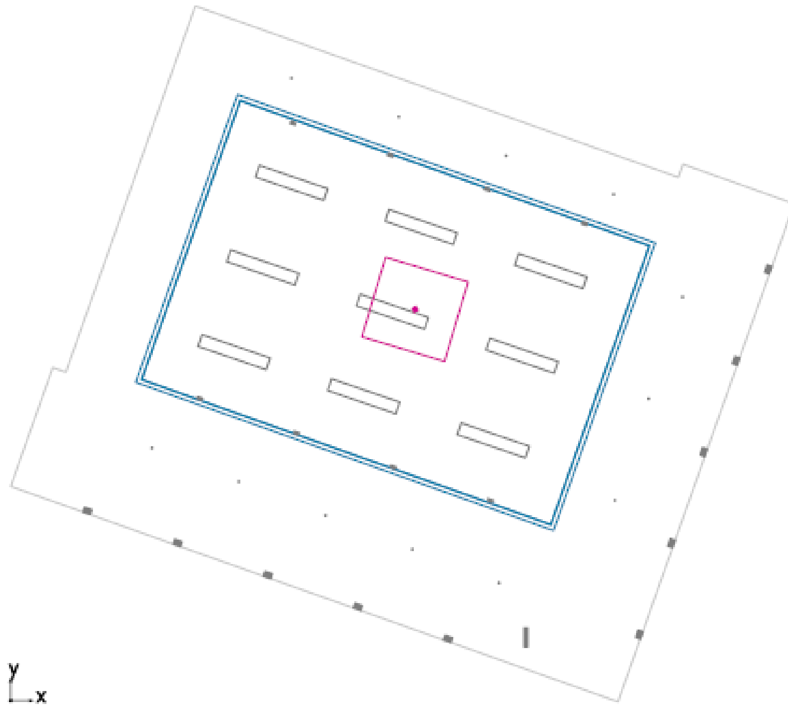


Figure 200 Glare check point

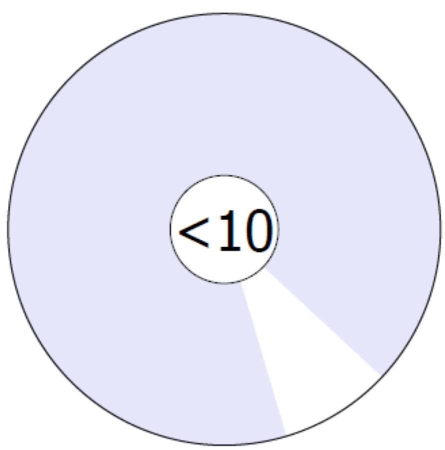


Figure 201 Sample glare check

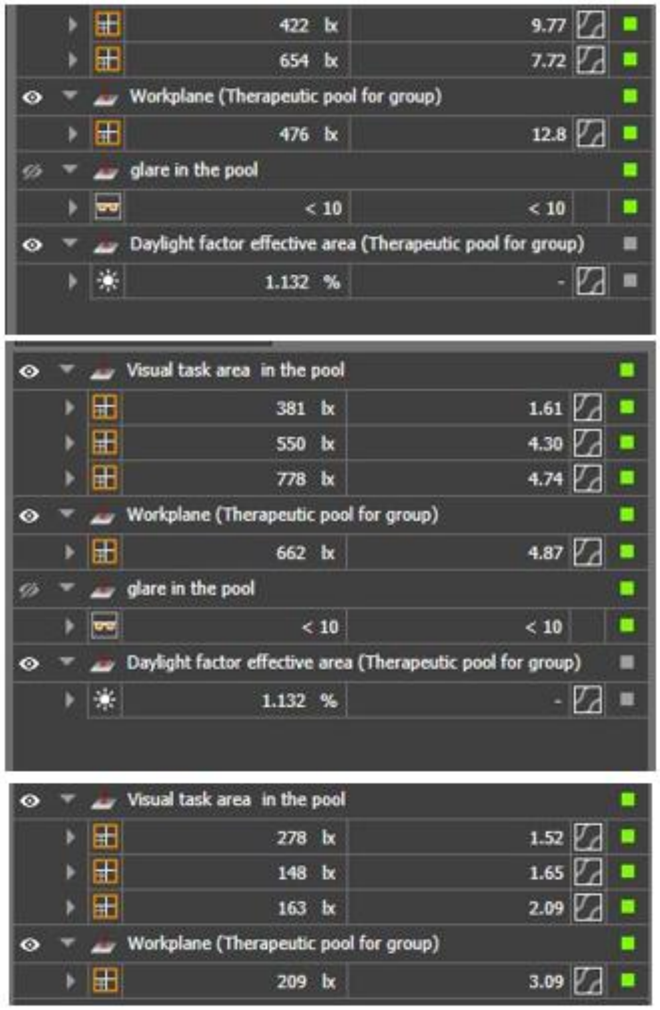


Figure 202 Dialux results for swimming pool

Figure 203 Calculation surface in dialux for swimming pool

Figure 204 lighting for swimming pool by dialux

6.1.4 list of used luminaires

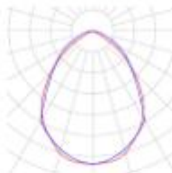
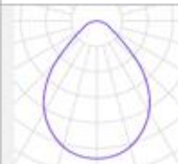
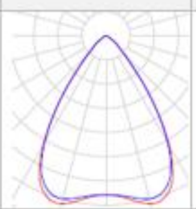
symbol	Image	Luminaire emittance	CCT	Power	Flux	CRI	Efficacy
			3224 k	28 w	18841 lm	90	67.3 Lm/W
			3000 K	108 W	8150 Lm	100	46.7 Lm/W
			3000 K	35.5 W	3600 Lm	100	101.3 Lm/W
			3000 K	17.8 W	2000 Lm	100	112.4 Lm/W

Figure 205 luminaires types used in the project

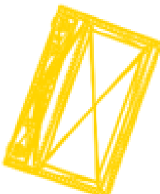
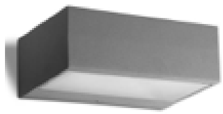
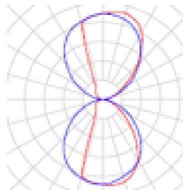
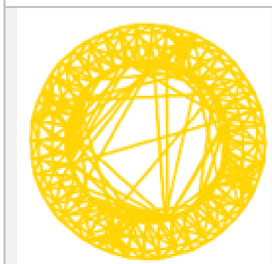
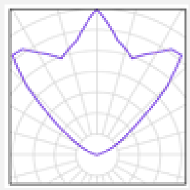
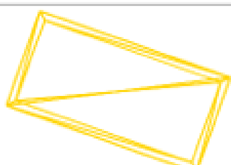
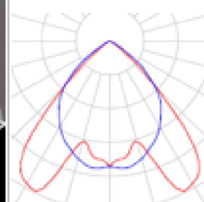
symbol	Image	Luminaire emittance	CCT	Power	Flux	CRI	Efficacy
			2821 K	13.0 W	900 Lm	99	27.7 Lm/W
			3000 K	70 W	6400 Lm	84	51.7 Lm/W
			4000 K	230 W	20000 Lm	80	69.8 Lm/W

Figure 206 luminaires types used in the project

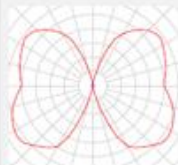
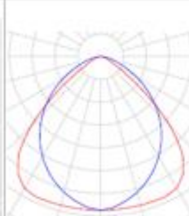
symbol	Image	Luminaire emittance	CCT	Power	Flux	CRI	Efficacy
			4000 K	11 W	450 Lm	85	30.3 Lm/W
			3000 K	61 W	4500 Lm	100	44.2 Lm/W
			3224 K	19.6 W	1623 Lm	91	82.8 Lm/W

Figure 207 luminaires types used in the project

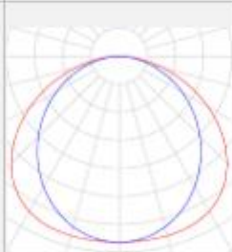
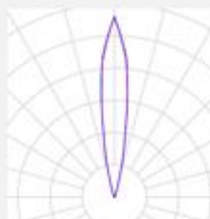
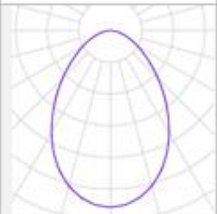
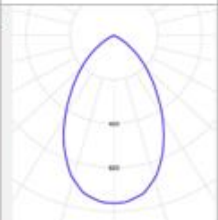
symbol	Image	Luminaire emittance	CCT	Power	Flux	CRI	Efficacy
			3000 K	36 W	3400 Lm	100	94.3 Lm/W
			3000 K	39 W	2008 Lm	80	51.5 Lm/W
			4000 K	18 W	1284 Lm	79	67.8 Lm/W

Figure 208 luminaires types used in the project

symbol	Image	Luminaire emittance	CCT	Power	Flux	CRI	Efficacy
			4000 K	10 W	678 Lm	84	67.6 Lm/W
			3000 K	60 W	567 Lm	91	5.8 Lm/W
			4144 K	20.3 W	1520 Lm	72	75 Lm/W

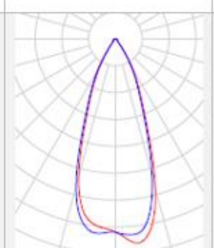
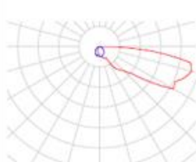
symbol	Image	Luminaire emittance	CCT	Power	Flux	CRI	Efficacy
			3000 K	3.3 W	371 Lm	79	83.5 Lm/W
			4000 K	1.5 W	154 Lm	70	102.8 Lm/W

Figure 209 luminaires types used in the project

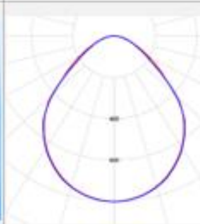
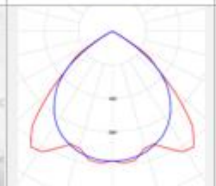
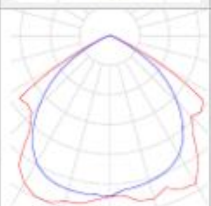
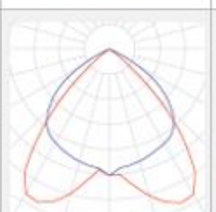
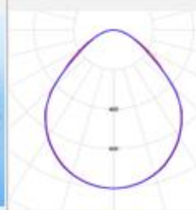
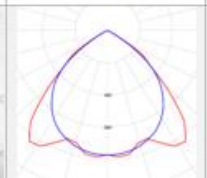
symbol	Image	Luminaire emittance	CCT	Power	Flux	CRI	Efficacy
			4000 K	20 W	1738 Lm	80	86.9 Lm/W
			3000 K	85 W	13000 Lm	100	152.9 Lm/W
			4000 K	52 W	3750 Lm	85	50.9 Lm/W
			3224 K	19.6 W	1623 Lm	91	82.8 Lm/W
			4000 K	56 W	4800 Lm	80	45.3 Lm/W
			4000 K	112 W	10500 Lm	80	56.3 Lm/W

Figure 210 luminaires types used in the project

symbol	Image	Luminaire emittance	CCT	Power	Flux	CRI	Efficacy
			4000 K	20 W	1738 Lm	80	86.9 Lm/W
			3000 K	85 W	13000 Lm	100	152.9 Lm/W
			4000 K	52 W	3750 Lm	85	50.9 Lm/W

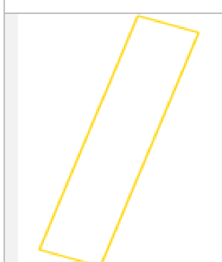
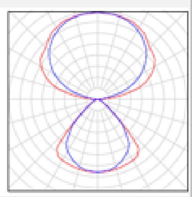
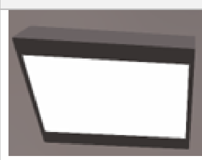
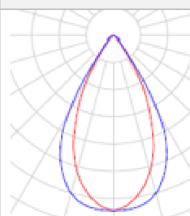
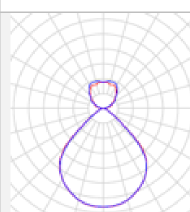
symbol	Image	Luminaire emittance	CCT	Power	Flux	CRI	Efficacy
			3000 K	61 W	5250 Lm	100	73.9 Lm/W
			3000 K	218 W	32000 Lm	100	146.2 Lm/W
			3000 K	163 W	12501 Lm	100	54.4 Lm/W

Figure 211 luminaires types used in the project

No.	Space name	Lamp Name	Number of luminair	Luminaire Power W	Total power W
30	W.C	SIMES LOBBY PROFESSIONAL	30	28	840
22	Changing room	SIMES LOBBY PROFESSIONAL	25	28	700
2	Electric Workshop	Philips TCS165 2xTL5-49W HFP C3_865	12	108	1296
2	Carpentry workshop	Philips TCS165 2xTL5-49W HFP C3_865	12	108	1296
2	Food workshop	Philips TCS165 2xTL5-49W HFP C3_865	12	108	1296
2	Sewing Workshop	Philips TCS165 2xTL5-49W HFP C3_865	15	108	1620
2	Study room	Petridis Lighting S.A. LP2S 323x14W T16	14	52	728
6	Offices	Petridis Lighting S.A. LP2S 323x14W T16	72	52	3744
5	Receptions	Philips DN572B PSE-E 1xLED20S/830 C	47	17.8	836.6
3	Waiting areas	Philips RC125B W60L60 1 xLED34S/830 NOC	39	36	1404
1	Multipurpose room	Philips RC125B W60L60 1 xLED34S/830 NOC	12	36	432
1	Exhibition	Philips RC125B W60L60 1 xLED34S/830 NOC	12	36	432
1	refugee room	Philips RC125B W60L60 1 xLED34S/830 NOC	12	36	432
1	Swimming Pool room	LEDS-C4 NEMESIS	10	13	130
		LEDS-C4 MINI PLAY	12	3.3	39.6
		Philips TPS772 3xTL5-49W/865/827/865 HFD PC-MLO_865-827-865	9	163	1467
		LEDS-C4 MICENAS path	8	1.5	12
2	Sauna	LEDS-C4 NEMESIS	10	13	130
3	Individual theraeutic basins	LEDS-C4 NEMESIS	17	13	221
	Corridor	Philips RC482B W62L62 CPC 1xLED35S/840 MK AC-MLO-R	44	35.5	1562
1	Radiology Room	SIMES LOBBY BASIC	7	19.6	137.2
		Philips TCS165 2xTL5-49W HFP C3_865	2	108	216
		Philips TBS165 G 4xTL5-14W HFS M2_865	4	61	244
2	Massage Room	LEDS-C4 GEA	24	18	432
		LEDS-C4 STRATA	6	39	234
		LEDS-C4 VOL	6	10	60
2	Dry therapy	LEDS-C4 GEA	28	18	504
		LEDS-C4 VOL	14	10	140
		LEDS-C4 STRATA	12	39	468
5	clinic room	SIMES LOBBY BASIC	4	19.6	78.4
		Saudi Lighting Recess"Laid-in" Mounted on Modular Ceilling Indoor Commercial / Residential Luminaire with Partially Perforated Sheet Steel Spacer and Deep Side Parabolic Louver	1	112	112
		Saudi Lighting Recess "Laid-in" Mounted on Modular Ceiling Indoor Air Handling Luminaire with Diffuser or Louver and with or without Air Supply and/or Return	1	56	56
1	Clinic of prostheses	SIMES LOBBY BASIC	6	19.6	117.6
		Saudi Lighting Recess"Laid-in" Mounted on Modular Ceilling Indoor Commercial / Residential Luminaire with Partially Perforated Sheet Steel Spacer and Deep Side Parabolic Louver	1	112	112
		Saudi Lighting Recess "Laid-in" Mounted on Modular Ceiling Indoor Air Handling Luminaire with Diffuser or Louver and with or without Air Supply and/or Return	1	56	56
		Philips DN572B PSE-E 1xLED20S/830 C	4	17.8	71.2
1	GYM	Philips TPS764 2xTL5-28W HFP ND AC-MLO_827	24	61	1464
2	Cafeteria	Lightnet Airtime-G2	66	20	1320
		SIMES LOBBY BASIC	10	19.6	196
		Philips BY480P PSD 1 xLED130S/840 WB	4	85	340
20	Emergency Lighting	Saudi Lighting Pendant Mounted Exit Sign/Directional Indoor Luminaire	20	11	220
3	Stair case	LEDS-C4 VOL	6	10	60
1	Basketball court	Philips BY471P 1 xECO320S/865 NB GC	25	218	5450
		Philips TPS772 3xTL5-49W/865/827/865 HFD PC-MLO_865-827-865	18	163	2934
TOTAL POWER FOR LIGHTING (WATT)					33640.6

Figure 212 Total lighting power

6.2 Electric Design

6.2.1 Electric load calculation

After calculating lighting power for each room according to the type of the luminaire, also finding number of normal load power for each room and assuming that the power of the normal load sockets 250 W, and calculation number of special loads in each room supposing that the power of each special load socket 3000 W, each zone separated according to its load and according to the function of its rooms, taking into the consider the farthest distance the distribution board, finally the total power will equal the following equation:

- $Total\ power = Ns * 3000\ W + 0.4\ (Nn * 250)W + 0.8\ (lighting\ power)W$

Such that, Ns: number of special load.

Nn: number of normal load.

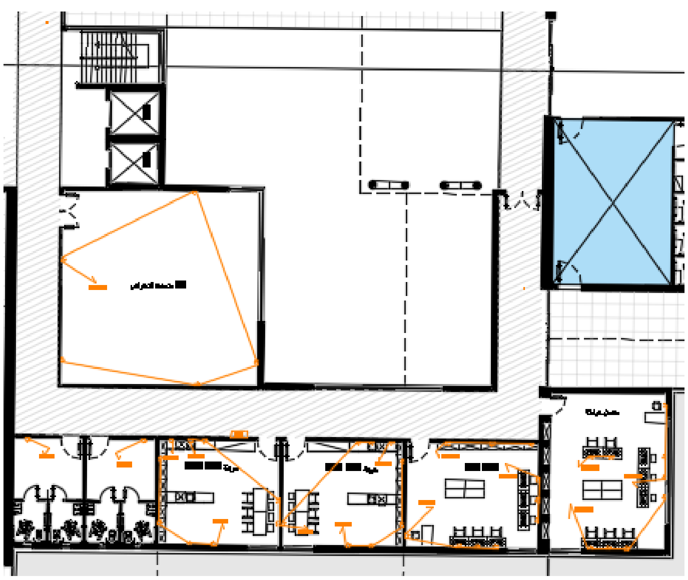


Figure 214 Power sockets plan

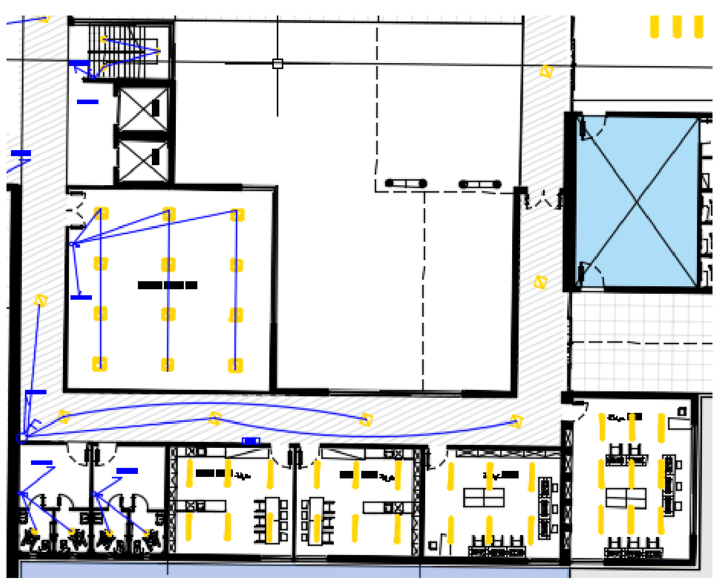


Figure 213 lighting switches plan

➢ <u>Sample calculation for distribution board 1</u>

Rooms that connected to the distribution board 1 (DB-1)

Space name	Number of normal load	Number of special load
kitchen workshop	8	1
kitchen workshop	8	1
Sewing workshop	9	
Sewing workshop	9	
Multipurpose room	5	
WC's	1	
WC's	1	
Corridor	0	
Stair	0	

Table 38 Electric load

1. Total number of special load (Ns) = 2
2. Total number of normal load (Nn) = 41
3. Total power for lighting in this zone =3503 W.

Calculate total power according to the previous equation:

- $Total\ power = Ns * 3000\ W + 0.4\ (Nn * 250)W + 0.8\ (lighting\ power)W$
- $Total\ power = 2 * 3000\ W + 0.4\ (41 * 250)W + 0.8\ (3503)W$
- $Total\ power = 12902.4$ W
- I load = Total load (W) / Voltage (V)
- $I\ load = \frac{12902.4W}{220\ V}$ = 58.64 Amp > 50 Amp, use 3 phase for this distribution board.
- 3 phase equation: I load = Total power / (400 * 1.732 * 0.9)
- I load 3 phase = 20.69 Amp < 50 Amp, OK
- I circuit breaker (CB) = 1.15 * I load
- I CB = 1.15 * 20.69 = 23.79 Amp

- I cable = 1.15 * I CB
- I cable = 1.15 * 23.79 Amp = 27.36 Amp.

Choosing suitable cross section area from the following table:

conductor	Burned and enclosed in conducting مدفونtrunk		Clipped direct to the surface and (معلق في الهواء) unclosed	
Nominal cross sectional area (mm2)	Single phase Current rating (Amp)	Three phase Current rating (Amp)	Single phase Current rating (Amp)	Three phase Current rating (Amp)
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

Table 39 sectional area for cables

- Calculation voltage drop according to the maximum length = 20 m

material	ρ wire	A lighting	L	R wire	power	v	Pf	I load	V drop	% drop
copper	1.75E-08	1.50E-06	20	0.14	140	220	0.9	0.572727	0.080181818	0.036446281

Table 40 Voltage drop check

In this project, 10 distribution board uses, 6 DB in the ground floor and 4 DB in the first floor.

- Use 3 phase for elevators (4 elevators)

6.2.2 Distribution boards

GROUND FLOOR									
LOADS Distribution boards	Normal load (Amp)	Special load (Amp)	Lighting power (Watt)	Total power (Watt)	I single Phase (Amp)	I 3 phase (Amp)	I Circuit Breaker(Amp)	I cable (Amp)	Cross section area mm^2
DB1	10250	6000	3503	12902.4	58.64727273	20.69284	23.79676674	27.36628	6
DB2	6500	0	2625	4700	21.36363636	*****	24.56818182	28.25341	6
DB3	5750	0	4963	6270.4	28.50181818	*****	32.77709091	37.69365	10
DB4	4000	0	1954	3163.2	14.37818182	*****	16.53490909	19.01515	4
DB5	1250	0	8929	7643.2	34.74181818	*****	39.95309091	45.94605	16
DB6	3250	9000	809	10947.2	49.76	17.5571	20.19065948	23.21926	6
Total Amp	137.2353904								

Table 41 Ground floor DB

FIRST FLOOR									
LOADS Distribution boards	Normal load (Amp)	Special load (Amp)	Lighting power (Watt)	Total power (Watt)	I single Phase (Amp)	I 3 phase (Amp)	I Circuit Breaker(Amp)	I cable (Amp)	Cross section area mm^2
DB7	6750	0	2751	4900.8	22.27636364	******	25.61781818	29.46049	6
DB8	7250	0	3376	5600.8	25.45818182	******	29.27690909	33.66845	10
DB9	8000	0	3149	5719.2	25.99636364	******	29.89581818	34.38019	10
DB10	8250	6000	3940	12452	56.6	19.97049	22.96606364	26.41097	6
Total Amp	93.70139921								

Table 42 First floor DB

Space	Ground Floor	First Floor
I (Amp)	137.2353904	93.70139921
Total Amp	231	

Table 43 Total Load need for the building

- One main distribution board, and 10 distribution boards with a total load = 231 Amp.

In addition of using 3 phase for four elevators.

6.3 Photovoltaic design

6.3.1 PV syst.

The project is in Nablus; it is good to make a pergola for cars also sued as a PV system to reduce the active resources by using passive methods to minimize the cost of operating the building.

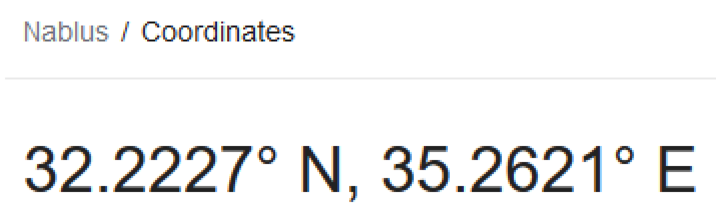


Figure 215 Nablus coordinates "PVsyst software"

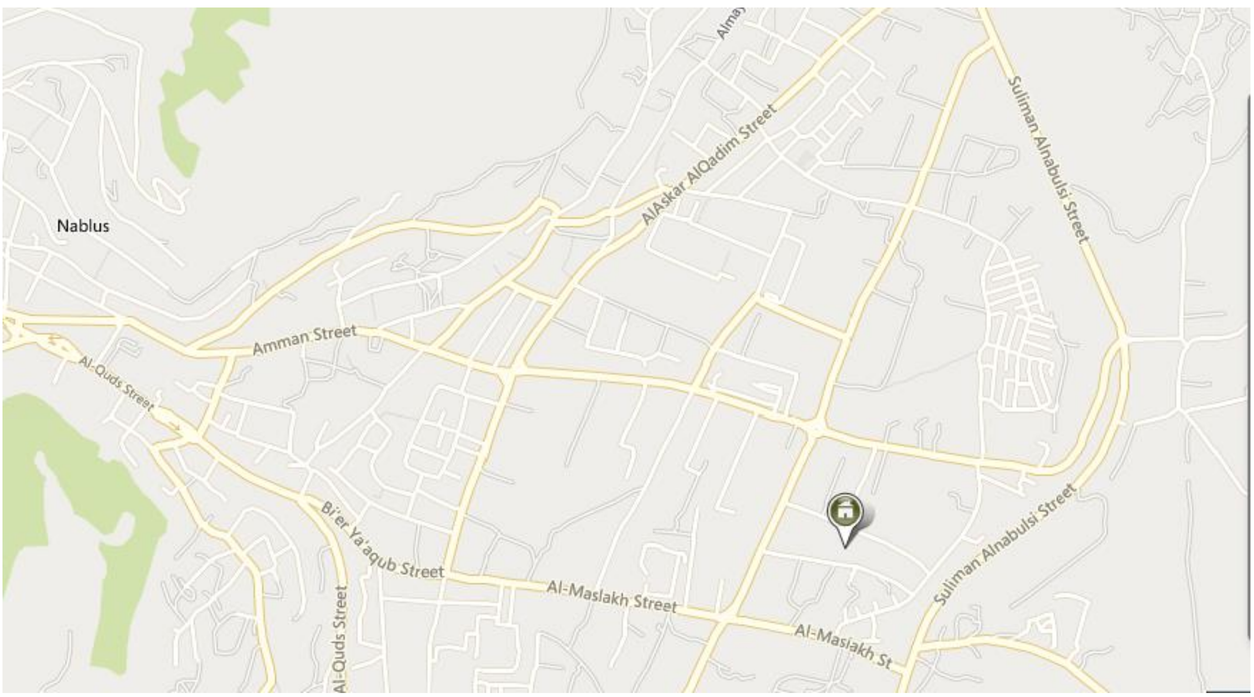


Figure 216 Project area by PVsyst software

The latitude angle is 32.22 and the longitude angle is 35.26 degree, also it is 802 m above the sea level

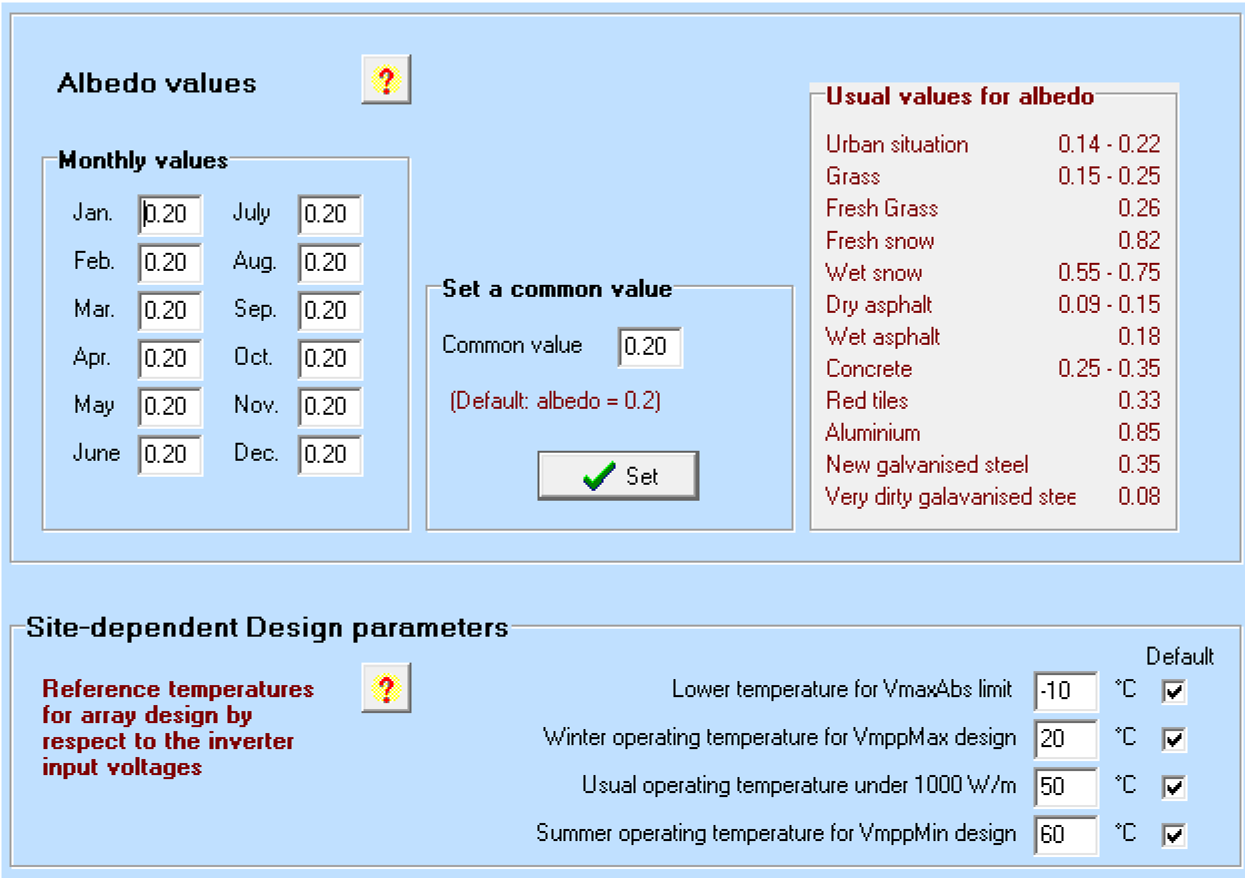


Figure 217 Data in PVsyst software

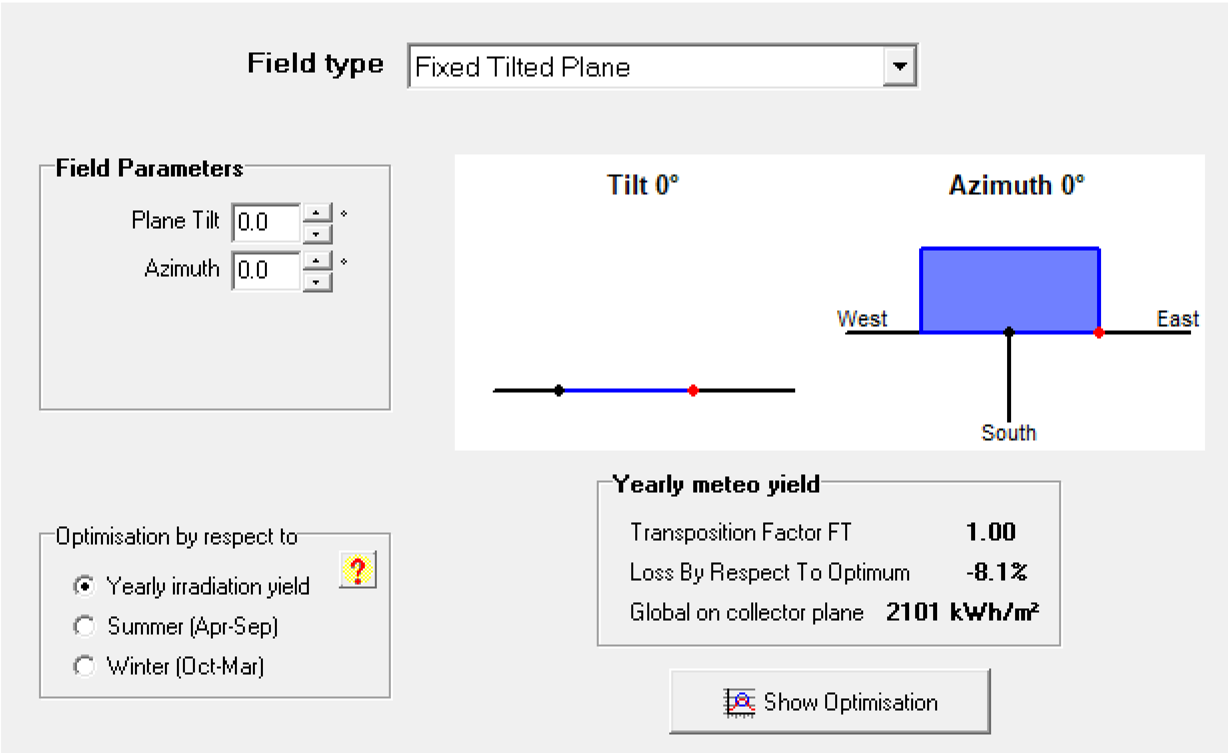


Figure 219 Azimuth and tilt angle

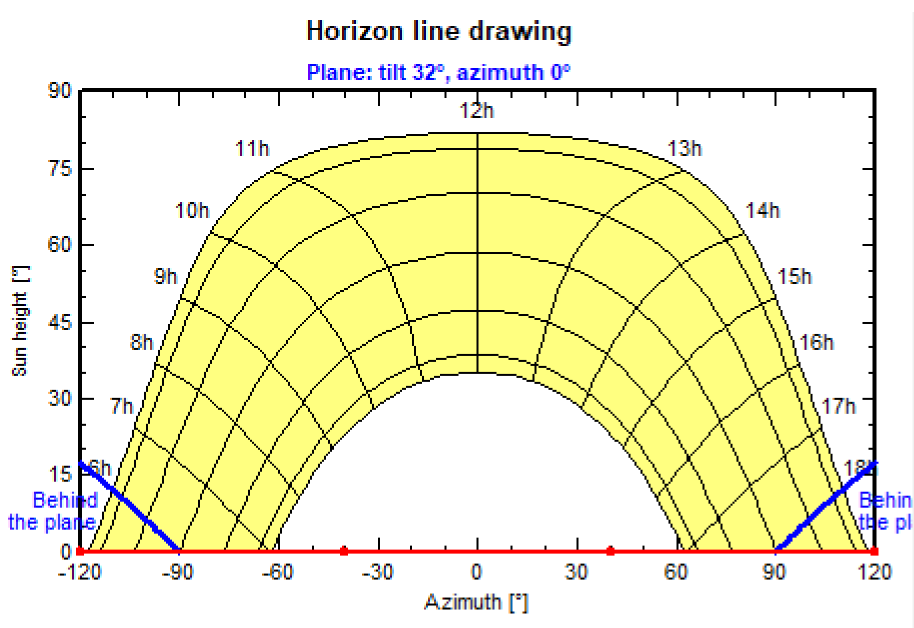


Figure 218 Horizon line drawing

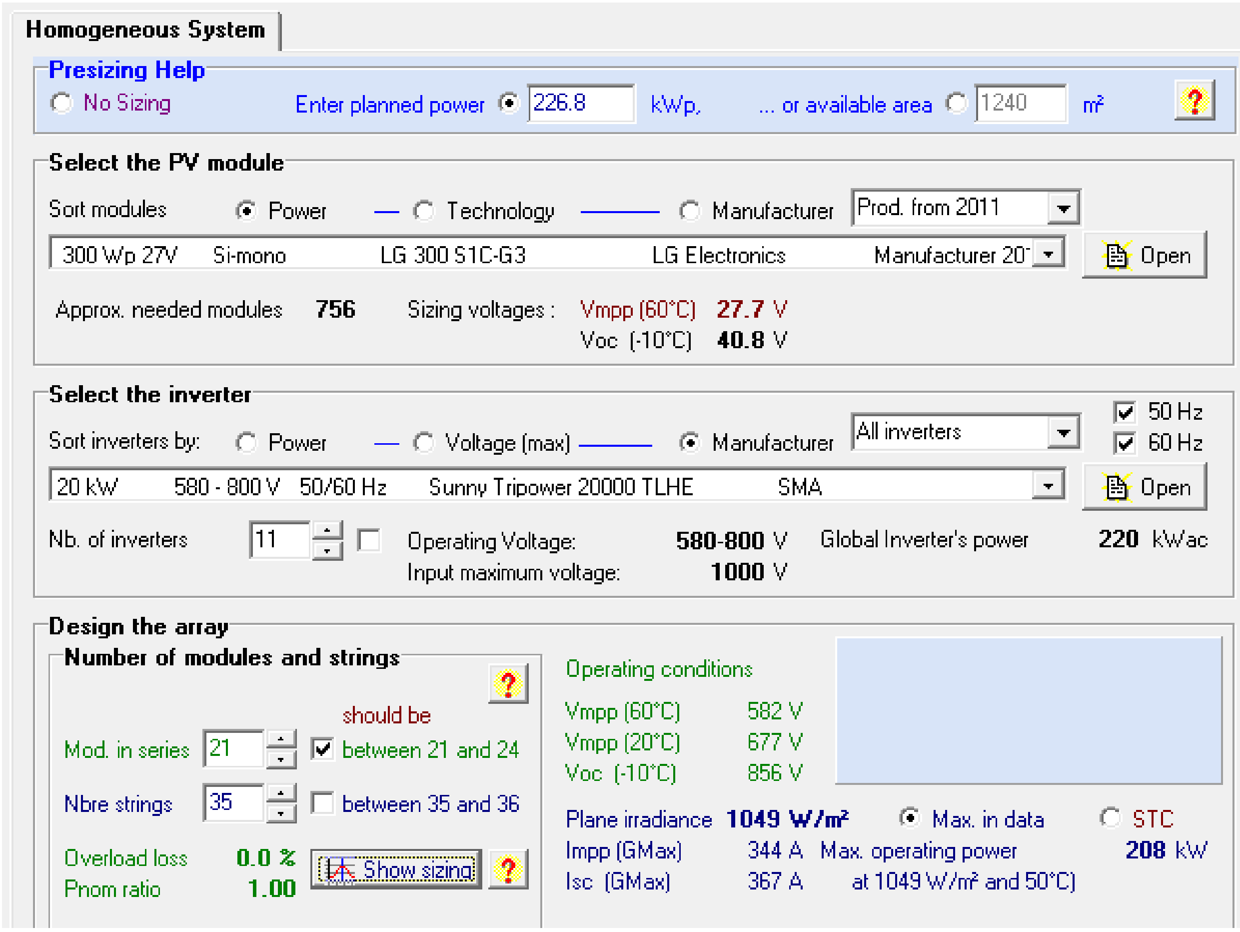


Figure 220 data in PV syst software

After choosing the PV module from catalogue, and by calculating the number of modules according to the area that it will be installed, it found that the 756 modules need.

300 W of LG modules was selected.

Planned power = $\frac{756*300}{1000}$ = 226.8 KWp.

Global system summary

Nb. of modules	735	Nominal PV Power	221 kWp
Module area	1205 m²	Maximum PV Power	208 kWdc
Nb. of inverters	11	Nominal AC Power	220 kWac

Figure 222 PV syst summary

Figure 221 300 Watt Pv module

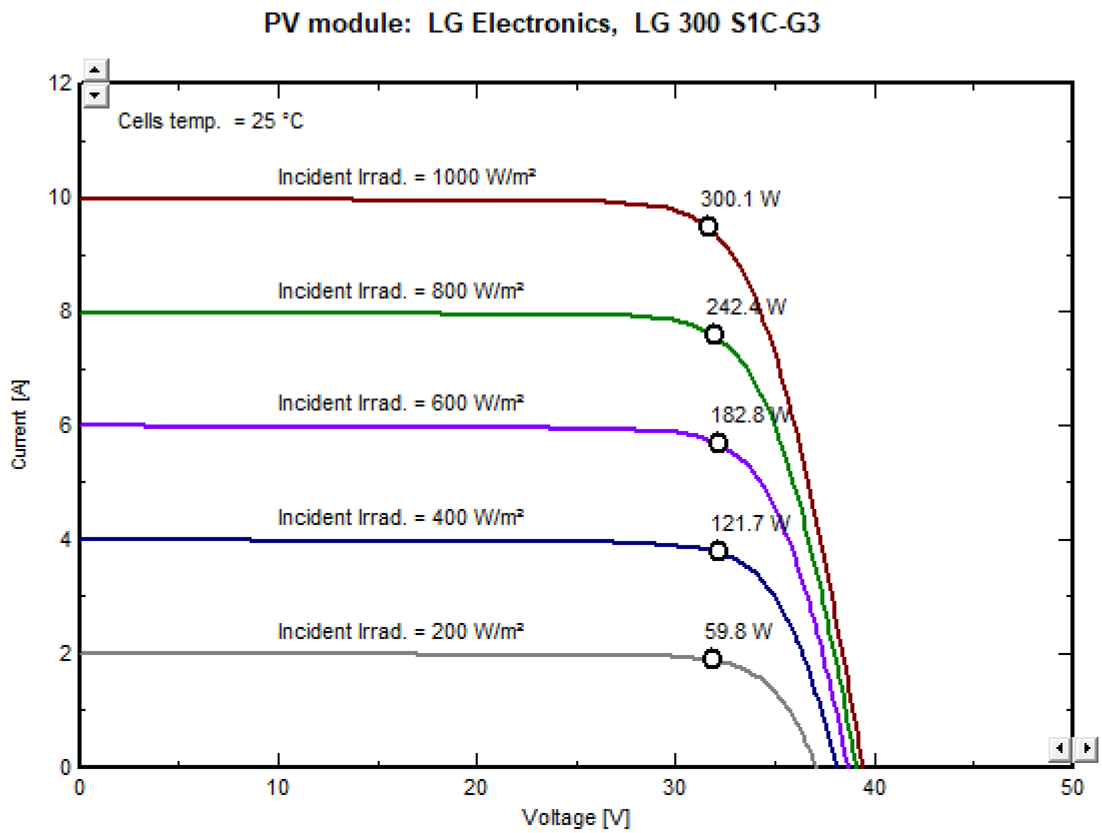


Figure 224 module description

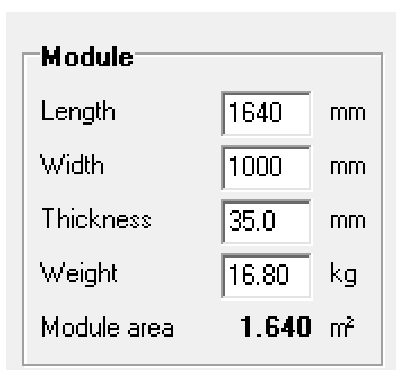


Figure 223 Module size

6.3.1.1 Simulation results and report from PV syst. software

Grid-Connected System: Simulation parameters

Project :	**Graduation project**			
Geographical Site	**Jerusalem**		**Country**	**Israel**
Situation	Latitude	31.4°N	Longitude	35.1°E
Time defined as	Legal Time	Time zone UT+2	Altitude	790 m
	Albedo	0.20		
Meteo data :	Jerusalem, Synthetic Hourly data			

Simulation variant :	**New simulation variant**	
	Simulation date	01/11/19 09h36

Simulation parameters

Collector Plane Orientation	Tilt	0°	Azimuth	0°
Horizon	Free Horizon			
Near Shadings	No Shadings			

PV Array Characteristics

PV module Si-mono	Model	**LG 300 S1C-G3**		
	Manufacturer	LG Electronics		
Number of PV modules	In series	21 modules	In parallel	35 strings
Total number of PV modules	Nb. modules	735	Unit Nom. Power	300 Wp
Array global power	Nominal (STC)	**221 kWp**	At operating cond.	199 kWp (50°C)
Array operating characteristics (50°C)	U mpp	607 V	I mpp	328 A
Total area	Module area	**1205 m²**	Cell area	1054 m²

Inverter	Model	**Sunny Tripower 20000 TLHE**		
	Manufacturer	SMA		
Characteristics	Operating Voltage	580-800 V	Unit Nom. Power	20.0 kW AC
Inverter pack	Number of Inverter	11 units	Total Power	220.0 kW AC

PV Array loss factors

Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
=> Nominal Oper. Coll. Temp. (G=800 W/m², Tamb=20°C, Wind=1 m/s.)			NOCT	56 °C
Wiring Ohmic Loss	Global array res.	30 mOhm	Loss Fraction	1.5 % at STC
Module Quality Loss			Loss Fraction	0.1 %
Module Mismatch Losses			Loss Fraction	2.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i -	'bo Parameter	0.05

Figure 225 Result and simulation

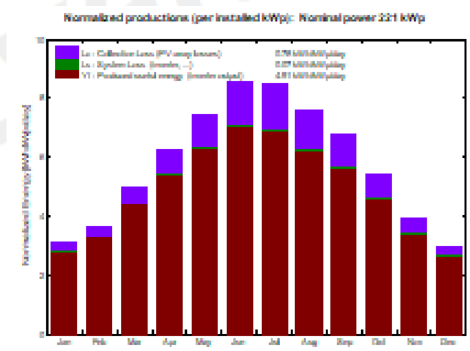
Grid-Connected System: Main results

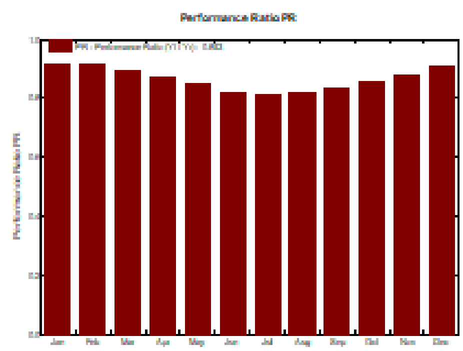
Project : **Graduation project**

Simulation variant : **New simulation variant**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	0°	azimuth	0°
PV modules	Model	LG 300 S1C-G3	Pnom	300 Wp
PV Array	Nb. of modules	735	Pnom total	**221 kWp**
Inverter	Model	Sunny Tripower 20000 TLHE	Pnom	20.00 kW ac
Inverter pack	Nb. of units	11.0	Pnom total	**220 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**395.1 MWh/year**	Specific prod.	1792 kWh/kWp/year
	Performance Ratio PR	85.3 %		





New simulation variant

Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	EffArrR %	EffSysR %
January	96.0	7.90	96.0	90.5	19.65	19.37	16.98	16.74
February	101.0	8.40	101.0	96.4	20.72	20.43	17.02	16.78
March	153.0	10.70	153.0	146.9	30.61	30.19	16.60	16.37
April	187.0	15.10	187.0	180.8	36.28	35.80	16.09	15.88
May	231.0	19.00	231.0	224.3	43.71	43.15	15.70	15.50
June	257.0	21.20	257.0	249.9	47.24	46.58	15.25	15.04
July	263.0	22.90	263.0	255.5	47.89	47.22	15.10	14.90
August	236.0	23.40	236.0	228.8	43.33	42.74	15.23	15.03
September	202.0	22.30	202.0	195.1	37.66	37.16	15.47	15.27
October	167.0	19.00	167.0	159.5	31.93	31.54	15.86	15.67
November	117.0	14.50	117.0	110.4	23.02	22.71	16.33	16.10
December	91.0	9.50	91.0	85.6	18.46	18.20	16.83	16.59
Year	2101.0	16.20	2101.0	2023.7	400.49	395.12	15.81	15.60

Legends:

GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
T Amb	Ambient Temperature	E_Grid	Energy injected into grid
GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

Figure 226 simulation results

Grid-Connected System: Loss diagram

Project : **Graduation project**

Simulation variant : **New simulation variant**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	0°	azimuth	0°
PV modules	Model	LG 300 S1C-G3	Pnom	300 Wp
PV Array	Nb. of modules	735	Pnom total	**221 kWp**
Inverter	Model	Sunny Tripower 20000 TLHE	Pnom	20.00 kW ac
Inverter pack	Nb. of units	11.0	Pnom total	**220 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year

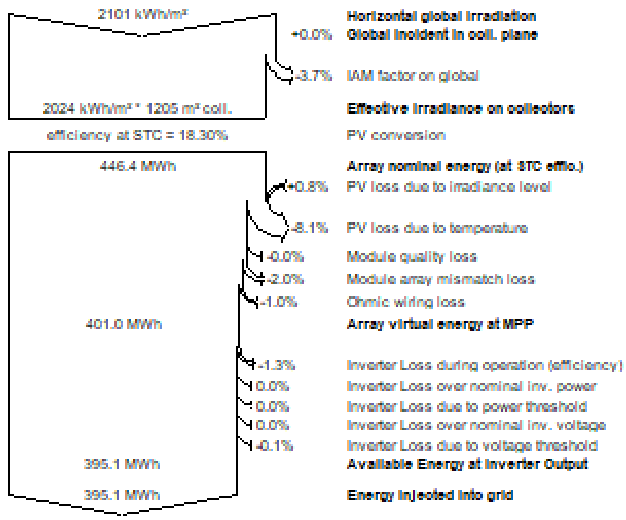


Figure 227 Simulation results

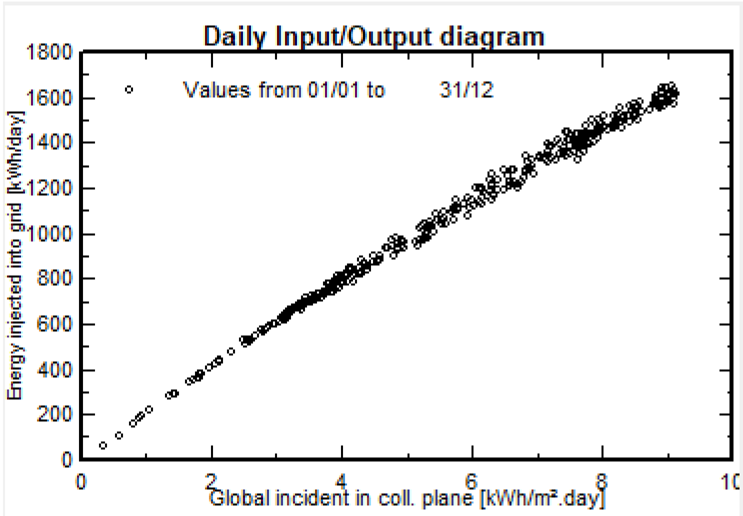


Figure 228 Daily input/ Output diagram

New simulation variant

Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	EffArrR %	EffSysR %
January	96.0	7.90	96.0	90.5	19649	19369	16.98	16.74
February	101.0	8.40	101.0	96.4	20717	20431	17.02	16.78
March	153.0	10.70	153.0	146.9	30608	30188	16.60	16.37
April	187.0	15.10	187.0	180.8	36278	35804	16.09	15.88
May	231.0	19.00	231.0	224.3	43714	43152	15.70	15.50
June	257.0	21.20	257.0	249.9	47235	46582	15.25	15.04
July	263.0	22.90	263.0	255.5	47887	47225	15.10	14.90
August	236.0	23.40	236.0	228.8	43327	42744	15.23	15.03
September	202.0	22.30	202.0	195.1	37661	37179	15.47	15.27
October	167.0	19.00	167.0	159.5	31931	31536	15.86	15.67
November	117.0	14.50	117.0	110.4	23023	22711	16.33	16.10
December	91.0	9.50	91.0	85.6	18458	18201	16.83	16.59
Year	2101.0	16.20	2101.0	2023.7	400487	395122	15.81	15.60

Figure 229 monthly simulation

6.3.2 Life cycle cost and payback period

Using RET screen software for environment analysis:

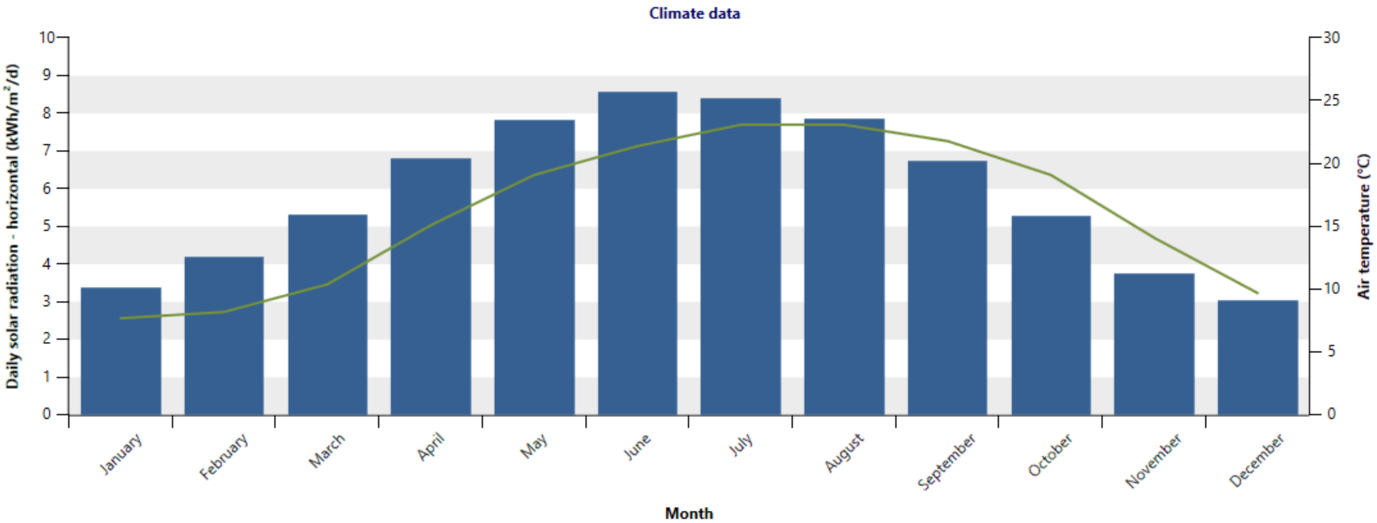


Figure 230 Climate data by RET screen software

From PV syst. Software results that is 735 design in the project, and the system is fixed and Mono-Si, and the capacity per unit equal 300 W, so the total capacity as the following equation

$$Total\ capacity = Capacity\ for\ the\ unit * Number\ of\ modules$$

$$Total\ capacity = 0.3\ KW * 735$$

$$Total\ capacity = 220.5\ KW$$

- Assuming that unit cost for KW is 1200 $

Total initial cost = 1200$ * 220.5 KW = 264.600 $

- Assuming operating and maintenance = 40 $/KW-year

Total operating and maintenance cost = 40 $* 220.5 KW = 8820 $

- Assuming electricity cost per KW = 0.19 $

Electricity exported = 404157 KWh (Calculated from the software according to the catalogue)

- Electricity export revenue = 404157 KWh * 0.19 $ = 76790 $
- Additional costs: (Assuming the following)
    1. Feasibility study = 500$
    2. Development = 500 $
    3. Engineering = 1000 $
- Total cost = 26400$+500$+500$+100$ = 26600$

- Periodic cost: from year 1-8 = 2000$

  And from year 8-16 = 2000 $, these costs will have added in year 8 and year 16.
- Assuming the sun rise 5 hours per day:

Sun hour/ year	**KWh**	**KWY**	**Revenue**
1800	220.5	396900	75411

- Assuming discount rate = 5%
- $PV = CF\ (1 + i)^n$ Such that n is number of year.
- Accurate method to calculate Payback period:
- =Year + (balance / PV CF)
  = 3 - (-40367 / 6703.64)
  = 3.02 year.

- Table below, shows that the payback period is 3.02 years.

Year	initial cost	maintinance cost	Periodic cost	Total cost	Cash flow Total cost	Revenue	PV CF	Balance
0	266600			266600	($266,600)	$0	($266,600)	($266,600)
1				0	$0	$75,411	$0.00	($191,189)
2				0	$0	$75,411	$0.00	($115,778)
3				0	$0	$75,411	$0.00	($40,367)
4		8820		8820	($7,256)	$75,411	($6,703.64)	$35,044
5				0	$0	$75,411	$0.00	$110,455
6				0	$0	$75,411	$0.00	$185,866
7				0	$0	$75,411	$0.00	$261,277
8		8820	2000	10820	($7,323)	$75,411	($6,250.45)	$336,688
9				0	$0	$75,411	$0.00	$412,099
10				0	$0	$75,411	$0.00	$487,510
11				0	$0	$75,411	$0.00	$562,921
12		8820		8820	($4,911)	$75,411	($3,872.53)	$638,332
13				0	$0	$75,411	$0.00	$713,743
14				0	$0	$75,411	$0.00	$789,154
15				0	$0	$75,411	$0.00	$864,565
16		8820	2000	10820	($4,957)	$75,411	($3,610.74)	$939,976
17				0	$0	$75,411	$0.00	$1,015,387
18				0	$0	$75,411	$0.00	$1,090,798
19				0	$0	$75,411	$0.00	$1,166,209
20		8820		8820	($3,324)	$75,411	($2,237.07)	$1,241,620
21				0	$0	$75,411	$0.00	$1,317,031
22				0	$0	$75,411	$0.00	$1,392,442
23				0	$0	$75,411	$0.00	$1,467,853
24		8820		8820	($2,735)	$75,411	($1,700.28)	$1,543,264
25				0	$0	$75,411	$0.00	$1,618,675
PB						3.02		Year

Figure 232 Excel sheet for life cycle and payback period

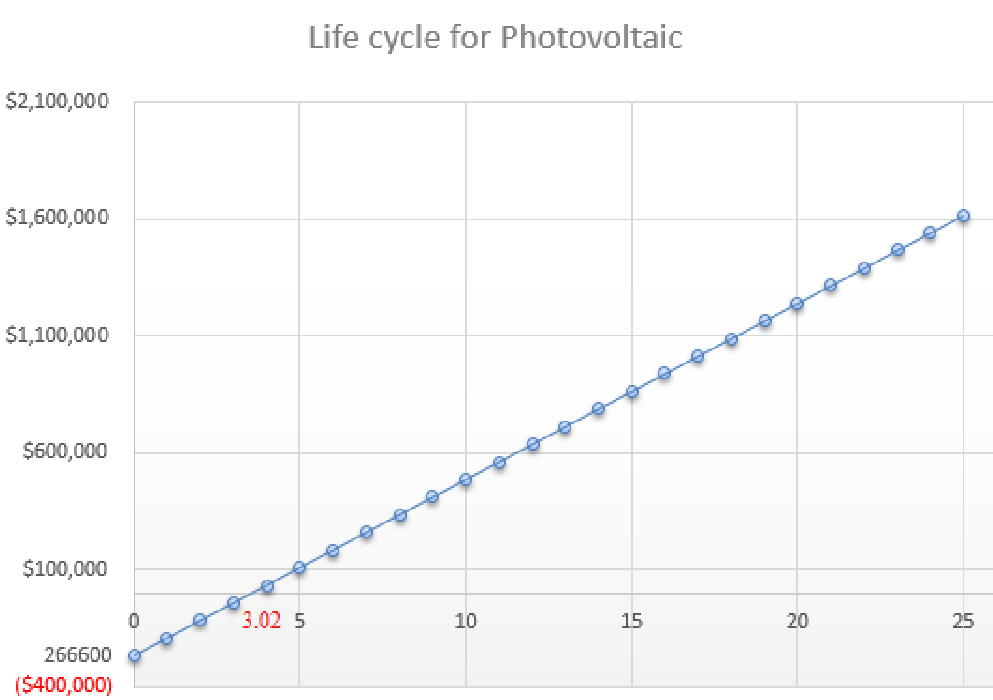


Figure 231 cycle and payback period

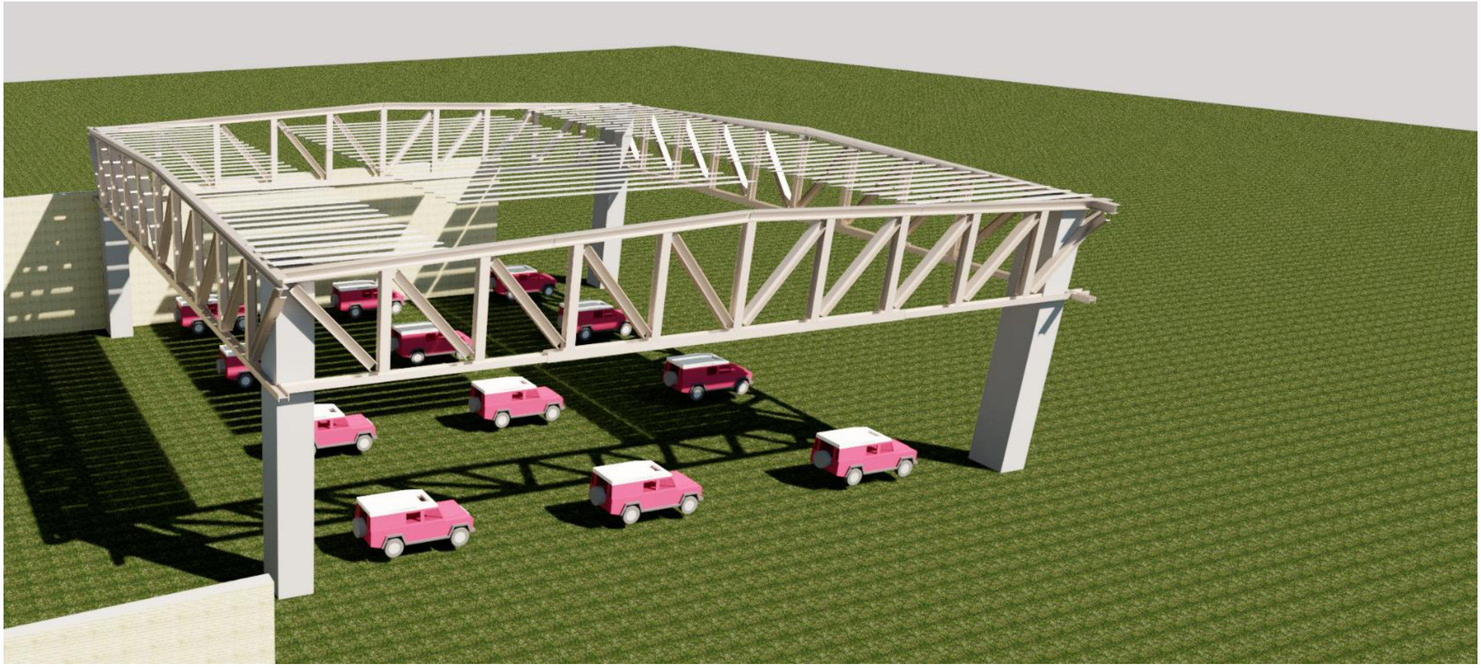


Figure 233 PV modules (REVIT)

CHAPTER 7

7.0 Environmental

7.1 Geothermal

Geothermal ventilation systems are a technique used to reduce energy consumption in the buildings, because of the provision conditioned air in summer and winter for the space.

Geothermal system is considered as an environmentally friendly field and is the best method of safe money as well as environment.

Geothermal energy process can be summarized as a system consist of a group of pipe buried underground that transfers heat to the ground in summer, and from the ground in winter, taking benefits from the stability of temperature at (3-5 m) depth, the value of this temperature in Palestine is (14-17 C°).

(Renweable energy world, 2016)

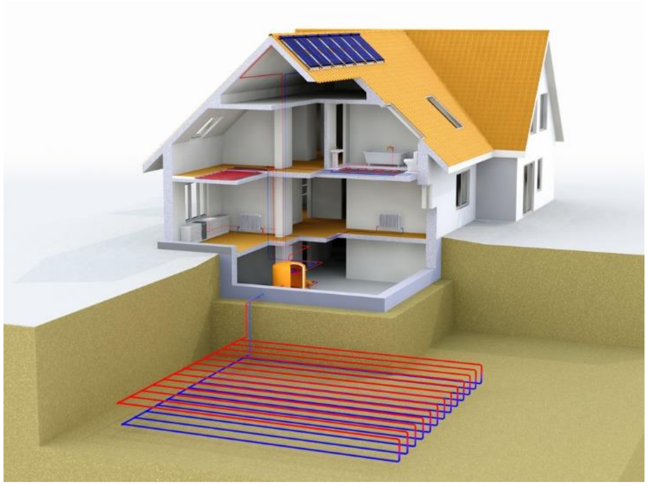


Figure 234 Geothermal

- Geothermal energy in cooling and heating can be obtained by using one of two common systems, the first uses water and the second uses air.
- To get an efficient system, a good thermal insulation must be provided for tubes, in order to avoid thermal bridge.

7.1.1 Geothermal operating principles

Geothermal cooling and heating system works based on transfer heat. In the winter, heat is gained from the soil and transferred to the building. In the summer, heat is released in to the soil.

(Renweable energy world, 2016)

Figure 235 Geothermal system

7.1.2 Executing methods

- **<u>Horizontal loops:</u>**

This system is preferred when sufficient land area is available. Here pipes are buried in tranches .it is allowed to buried more than one pipe in the same trenches with minimum distance equal foot between pipes. And the distance between tranches it must be ten to fifteen feet. (Wolf, Apr.20,1982)

- **<u>Vertical loops:</u>**

This system is preferred when the horizontal land is unavailable, for example commercial building and school. here u-tubes are installed in 100-400 feet deep. The depth and number determined by the estimated cooling and heating load.

(Wolf, Apr.20,1982)

- **Pond loops**

This system contains a group of pond or stream with enough depth and flow, then the fluid pumped in the same way its pumped in closed loop ground system.

Figure shows loop systems. (Wolf, Apr.20,1982)

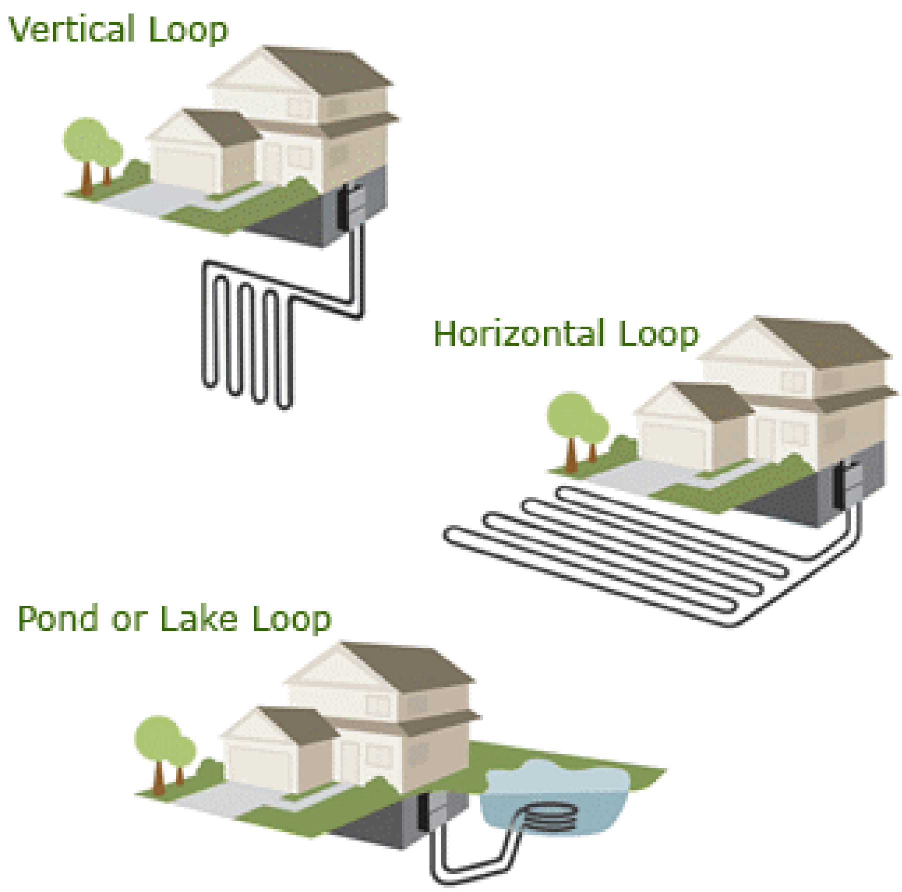


Figure 236 Geothermal executing methods

(S.Al-Zyoud, February 2014)

7.1.3 Design consideration

There are a group of standards that should be noticed while designing which are:

1) Tube material: The pipes material should be able to resist the compression when these pipe buried.

Figure 237 Geothermal tube

(Wolf, Apr.20,1982)

2) Diameter: The best option of diameters ranges from value equal 10 to value equal 30 cm; in general, it preferred to use smaller diameter. But also, in the same flow rates the smaller diameters could give a larger loss because of friction. In some cases, diameter could be equal1 meter as in large buildings. (Wolf, Apr.20,1982)
3) Length: generally, the pipes length ranged from 10m to 100 m. The longer tube causes extra efficiency in system. (Wolf, Apr.20,1982)

4) Spacing: It preferred to make thermally independent, as a result the spacing should be enough. generally, 1-meter distance is acceptable distance.

- The conditions that determined the numbers of the tube are: (Hashimoto, Sep. 25, 2001)
  - Tubes length.
  - The required air flow.
  - The required thermal performance.

5) Depth: The deeper positioning is better performance. Acceptable depth for this system range from 1.5m to 3 m.
   (Wolf, Apr.20,1982)
6) Type of soil: heat conductivity is better in the wet soil than in dry soil. A compacted soil also gives good thermal conductivity between the pipes and earth.

(Wolf, Apr.20,1982)

7) Flow rate: it should be proportionality between the diameter of pipe, and the flow rate. The required thermal performance based on that the lower flow rate are more suitable to gives higher or lower temperature. (Wolf, Apr.20,1982)

7.1.4 System description

All zones in the center contains two vent, the first one is linked with the (fresh air) out let air. And this vent is linked to a damper device to monitoring the quantity of air which enter and out the spaces. The vent for inlet air is located at 0.30 meter on top of the level floor, and it is linked with a group of PVC horizontal pipe which located beneath the layer of tiles in all stories. Then 90° elbow is used to connect it with vertical pipe that connected between stories then by using elbow with 90° they will be linked to U-shaped trench. (S.Al-Zyoud, February 2014)

The trench consists of a group of pipe that are existing 4 m under the ground, which is connected with inlet air called air tower that is provides the system with fresh air. The filter provided to the fan in order to guarantee the air quality which entering the pipes. (S.Al-Zyoud, February 2014)

The second one is vent that rises about 2.75meter from the floor level linked with another horizontal PVC pipes that pass through the floor. The horizontal pipes are connected with vertical pipes which passes in all the stories, finally it is connected with the underground trenches. That is buried 4 m underground. (S.Al-Zyoud, February 2014)

The two trenches are connected by controlled valves, that open and close according to the spaces usage. (S.Al-Zyoud, February 2014) (Wolf, Apr.20,1982)

The following figure shows the air tower

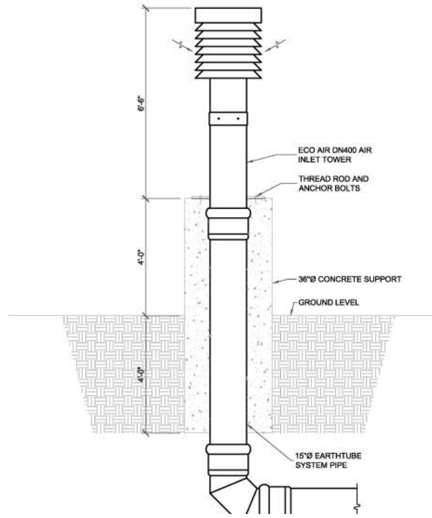


Figure 238 Air tower

The

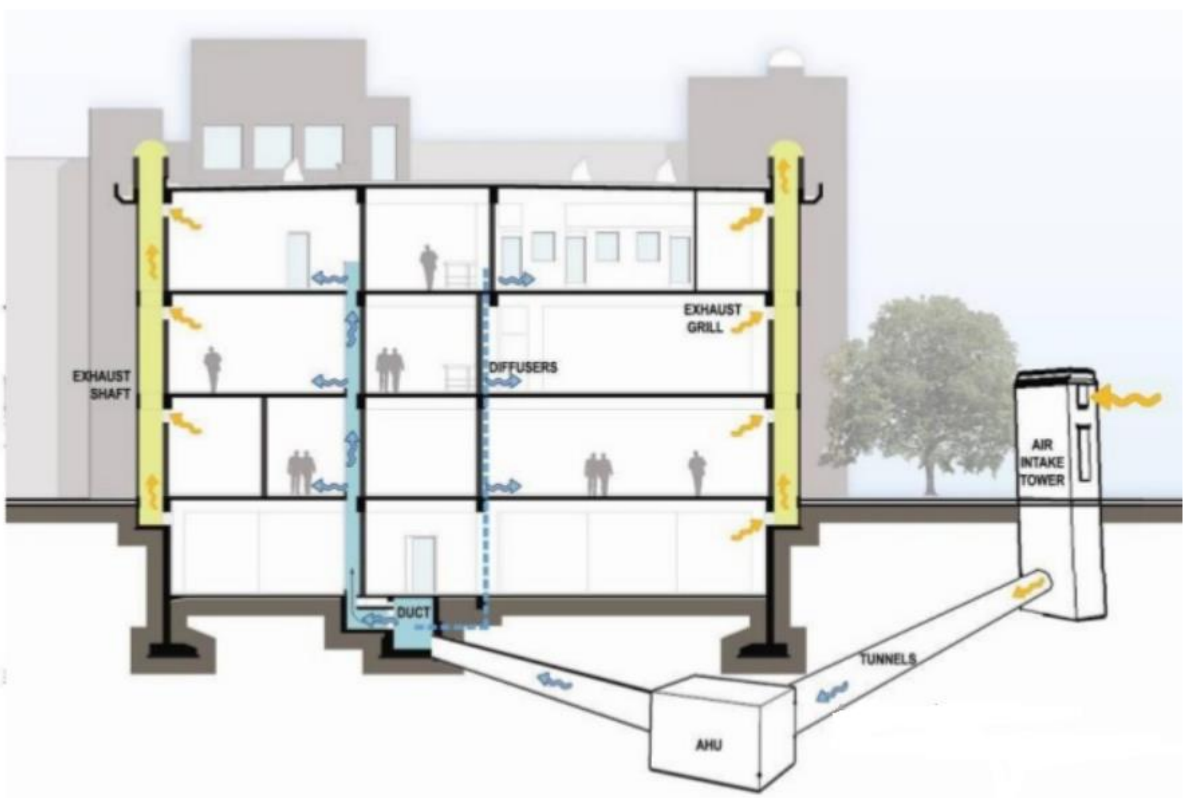


Figure 239 Geothermal system

7.1.5 Maintenance

The required maintenance of the geothermal system is considered low, this system considered durable system if compared with traditional systems which contains outside units. This system has low mechanical units compared with other system, also the majority of system units are buried underground or located in door the building, protected from the effect of weather. underground pipes that used in this system are warranted to last more than 25 years and may arrive 50 years or more. The inside units are easy to access for the purpose of maintenance. as in forced air systems, cool air and warm air in geothermal are distributed by using duct. Also, geothermal systems are less annoying because of there is no outside condensing device like traditional air conditioning systems.

The environmental aspect is very important due to its contribution in cost saving, achieving thermal comfortable and reducing global warming. Therefore, the environmental aspect must be considered during the architectural design stage. (S.Al-Zyoud, February 2014) (Hashimoto, Sep. 25, 2001)

Geothermal System in physiotherapy and rehabilitation center

- Horizontal tubes system is used in this center.
- The experimental system consists of two tranches used for inlet and outlet air.
- The system contains a dampers and an ardweno controlled sensors.
- Depending on to the similar case studies which uses the earth tubes, the tranches number assumed to be 27 horizontal pipes.
- The tubes will be buried 4 meters under the ground level.

7.1.6 Cost analysis for system installation

Material and labor	365920
Excavation	260000
Total	**625920**

Table 44 Cost analysis for Geothermal

	Geothermal	VRF
Initial cost	625920	350000
Maintenance cost/year	-	25000
Operation cost/year	6000	13680

Table 45 Comparison between Geothermal and VRF

- The previous calculations are based on theoretical studies and checked by the simulations. After the installation of the real system, the results will configure whether the system is efficient or not.

7.1.7 Life cycle for Geothermal and VRF systems

Year	initial cost	maintinance cost	Operation cost	Total cost	Cash flow Total cost
0	500000	0	0	500000	-500000.00
1		0	3000	3000	-2857.14
2		0	3000	3000	-2721.09
3		0	3000	3000	-2591.51
4		0	3000	3000	-2468.11
5		0	3000	3000	-2350.58
6		0	3000	3000	-2238.65
7		0	3000	3000	-2132.04
8		0	3000	3000	-2030.52
9		0	3000	3000	-1933.83
10		0	3000	3000	-1841.74
11		0	3000	3000	-1754.04
12		0	3000	3000	-1670.51
13		0	3000	3000	-1590.96
14		0	3000	3000	-1515.20
15		0	3000	3000	-1443.05
16		0	3000	3000	-1374.33
17		0	3000	3000	-1308.89
18		0	3000	3000	-1246.56
19		0	3000	3000	-1187.20
20		0	3000	3000	-1130.67
21		0	3000	3000	-1076.83
22		0	3000	3000	-1025.55
23		0	3000	3000	-976.71
24		0	3000	3000	-930.20
25		0	3000	3000	-885.91
				Total	-542281.83

Figure 240 Geothermal system life cycle

Year	initial cost	maintinance cost	Operation cost	Total cost	Cash flow Total cost
0	500000	0	0	500000	-500000.00
1		0	3000	3000	-2857.14
2		0	3000	3000	-2721.09
3		0	3000	3000	-2591.51
4		0	3000	3000	-2468.11
5		0	3000	3000	-2350.58
6		0	3000	3000	-2238.65
7		0	3000	3000	-2132.04
8		0	3000	3000	-2030.52
9		0	3000	3000	-1933.83
10		0	3000	3000	-1841.74
11		0	3000	3000	-1754.04
12		0	3000	3000	-1670.51
13		0	3000	3000	-1590.96
14		0	3000	3000	-1515.20
15		0	3000	3000	-1443.05
16		0	3000	3000	-1374.33
17		0	3000	3000	-1308.89
18		0	3000	3000	-1246.56
19		0	3000	3000	-1187.20
20		0	3000	3000	-1130.67
21		0	3000	3000	-1076.83
22		0	3000	3000	-1025.55
23		0	3000	3000	-976.71
24		0	3000	3000	-930.20
25		0	3000	3000	-885.91
				Total	-542281.83

Figure 241 Life cycle for VRF

7.2 Envelop analysis

7.2.1 Materials properties

Material existing in the building construction.

1. External walls: with a total thickness 30 cm and these walls contain five layers, stone (5cm), cast concrete (10cm), polystyrene (4cm), block (10cm) and cement plaster (1cm). Figure shows the layers of wall and Figure shows the material properties for external wall.

Figure 242 External wall layers

Inner surface	
Convective heat transfer coefficient (W/m2-K)	2.152
Radiative heat transfer coefficient (W/m2-K)	5.540
Surface resistance (m2-K/W)	0.130
Outer surface	
Convective heat transfer coefficient (W/m2-K)	19.870
Radiative heat transfer coefficient (W/m2-K)	5.130
Surface resistance (m2-K/W)	0.040
No Bridging	
U-Value surface to surface (W/m2-K)	0.549
R-Value (m2-K/W)	1.992
U-Value (W/m2-K)	**0.502**
With Bridging (BS EN ISO 6946)	
Thickness (m)	0.3000
Km - Internal heat capacity (KJ/m2-K)	61.9800
Upper resistance limit (m2-K/W)	1.992
Lower resistance limit (m2-K/W)	1.992
U-Value surface to surface (W/m2-K)	0.549
R-Value (m2-K/W)	1.992
U-Value (W/m2-K)	**0.502**

Figure 243 Material properties of external wall layers

2. Internal walls

a) Internal walls with total thickness 23 cm and these walls consist of three layers, plaster (1.5cm), concrete (20cm), plaster (1.5cm). Figure shows internal wall layers and Figure shows the properties of concrete internal wall layers.

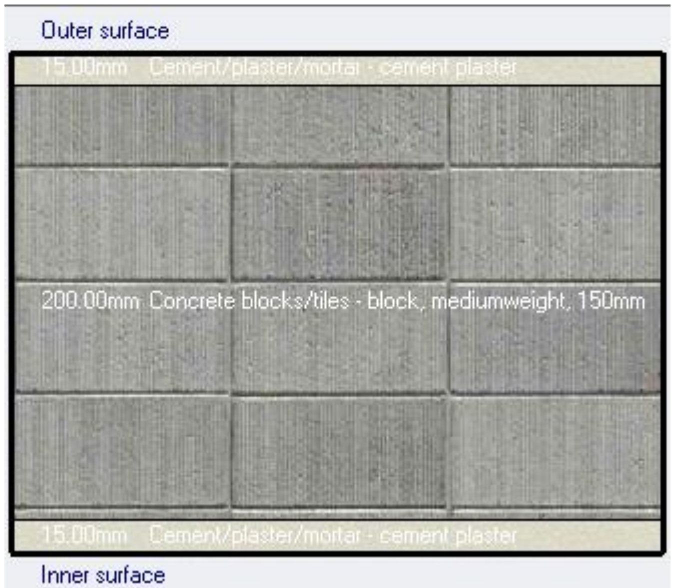
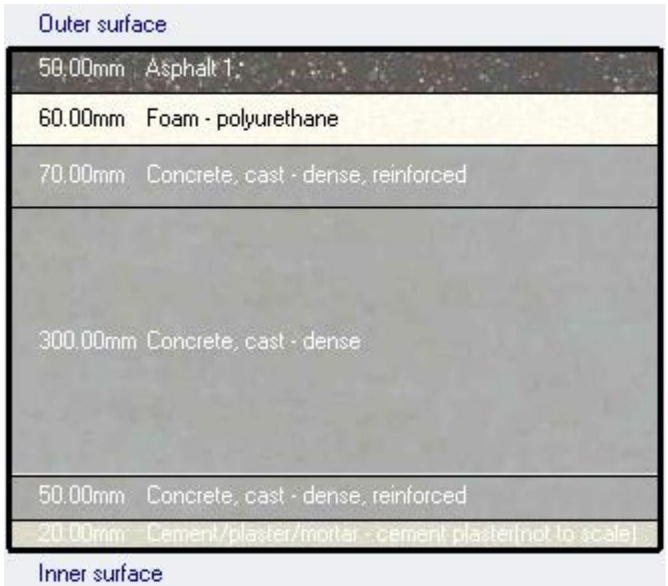


Figure 244 Internal wall layers

Inner surface	
Convective heat transfer coefficient (W/m2-K)	2.152
Radiative heat transfer coefficient (W/m2-K)	5.540
Surface resistance (m2-K/W)	0.130
Outer surface	
Convective heat transfer coefficient (W/m2-K)	2.152
Radiative heat transfer coefficient (W/m2-K)	5.540
Surface resistance (m2-K/W)	0.130
No Bridging	
U-Value surface to surface (W/m2-K)	3.318
R-Value (m2-K/W)	0.561
U-Value (W/m2-K)	**1.781**
With Bridging (BS EN ISO 6946)	
Thickness (m)	0.2300
Km - Internal heat capacity (KJ/m2-K)	157.8360
Upper resistance limit (m2-K/W)	0.561
Lower resistance limit (m2-K/W)	0.561
U-Value surface to surface (W/m2-K)	3.318
R-Value (m2-K/W)	0.561
U-Value (W/m2-K)	**1.781**

Figure 245 Figure: material properties of internal wall layers.

b) Roof floor has a thickness 55 cm and it consists of six layers, Asphalt (5cm), polystyrene (6) cm, reinforced concrete (7cm), concrete (30cm), reinforced concrete (5cm), plaster. (2cm).



Inner surface	
Convective heat transfer coefficient (W/m2-K)	4.460
Radiative heat transfer coefficient (W/m2-K)	5.540
Surface resistance (m2-K/W)	0.100
Outer surface	
Convective heat transfer coefficient (W/m2-K)	19.870
Radiative heat transfer coefficient (W/m2-K)	5.130
Surface resistance (m2-K/W)	0.040
No Bridging	
U-Value surface to surface (W/m2-K)	0.403
R-Value (m2-K/W)	2.622
U-Value (W/m2-K)	**0.381**
With Bridging (BS EN ISO 6946)	
Thickness (m)	0.5500
Km - Internal heat capacity (KJ/m2-K)	181.6080
Upper resistance limit (m2-K/W)	3.898
Lower resistance limit (m2-K/W)	2.736
U-Value surface to surface (W/m2-K)	0.317
R-Value (m2-K/W)	3.317
U-Value (W/m2-K)	**0.301**

Figure 247 material properties of roof layers.

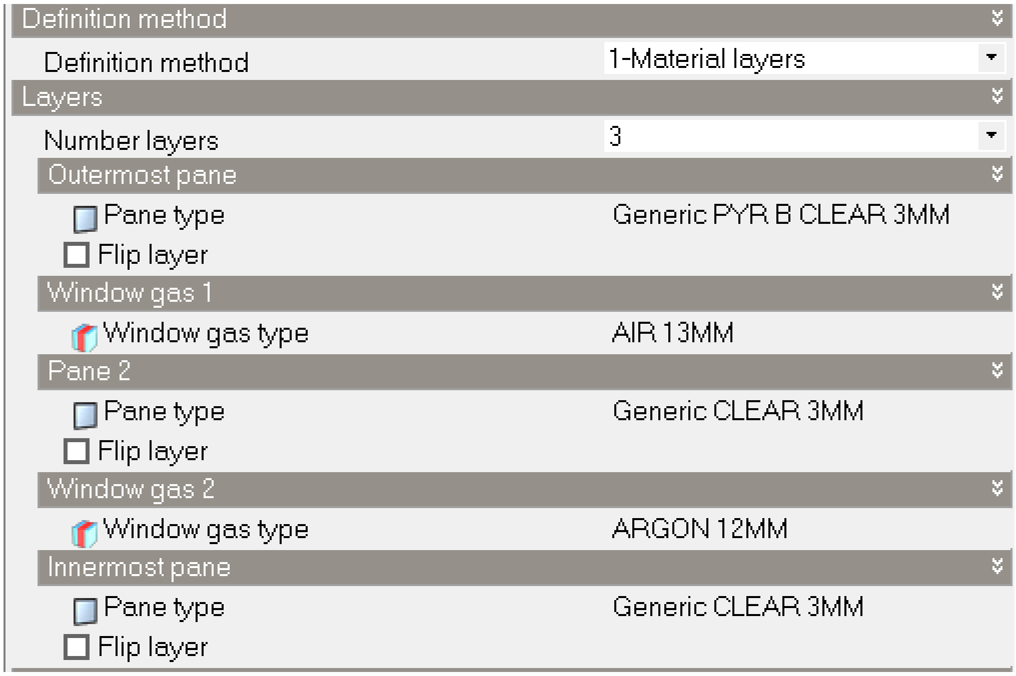
c) Floors with total thickness equal20 cm and it consists of two layers. concrete (15) cm, mortar (5cm) Figure below shows internal floor layers and Figure 104 shows material properties of internal floor.

Figure 248 Internal floor layers

Inner surface	
Convective heat transfer coefficient (W/m2-K)	0.342
Radiative heat transfer coefficient (W/m2-K)	5.540
Surface resistance (m2-K/W)	0.170
Outer surface	
Convective heat transfer coefficient (W/m2-K)	19.870
Radiative heat transfer coefficient (W/m2-K)	5.130
Surface resistance (m2-K/W)	0.040
No Bridging	
U-Value surface to surface (W/m2-K)	8.721
R-Value (m2-K/W)	0.325
U-Value (W/m2-K)	**3.080**
With Bridging (BS EN ISO 6946)	
Thickness (m)	0.2000
Km - Internal heat capacity (KJ/m2-K)	193.2000
Upper resistance limit (m2-K/W)	0.325
Lower resistance limit (m2-K/W)	0.325
U-Value surface to surface (W/m2-K)	8.721
R-Value (m2-K/W)	0.325
U-Value (W/m2-K)	**3.080**

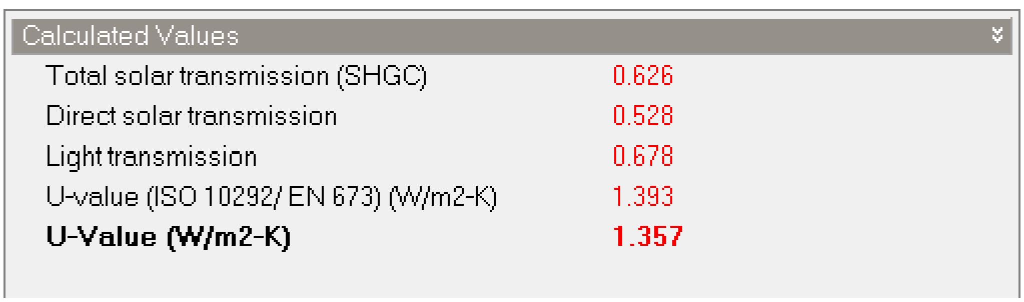
Figure 249 Material properties of floor layers

3. Windows material is triple glass low emissivity glass. Figures below, shows windows material and properties.



Definition method	
Definition method	1-Material layers
Layers	
Number layers	3
Outermost pane	
Pane type	Generic PYR B CLEAR 3MM
Flip layer	
Window gas 1	
Window gas type	AIR 13MM
Pane 2	
Pane type	Generic CLEAR 3MM
Flip layer	
Window gas 2	
Window gas type	ARGON 12MM
Innermost pane	
Pane type	Generic CLEAR 3MM
Flip layer	

Figure 250 Windows material



Calculated Values	
Total solar transmission (SHGC)	0.626
Direct solar transmission	0.528
Light transmission	0.678
U-value (ISO 10292/ EN 673) (W/m2-K)	1.393
U-Value (W/m2-K)	**1.357**

Figure 251 Material properties for windows.

- The following table, summarize the final results of U-values for the whole construction elements

Construction Element	U-value (W/m_2. k)
External Wall	0.502
Internal Partitions	1.78
Floor	3.08
Roof	0.301
Glazing	1.357

Table 46 U- values for whole construction

7.2.2 Design builder results

- The location used in Design Builder software is JERUSALEM AIRPORT.

- <u>Heating and cooling parameters for swimming pool:</u>

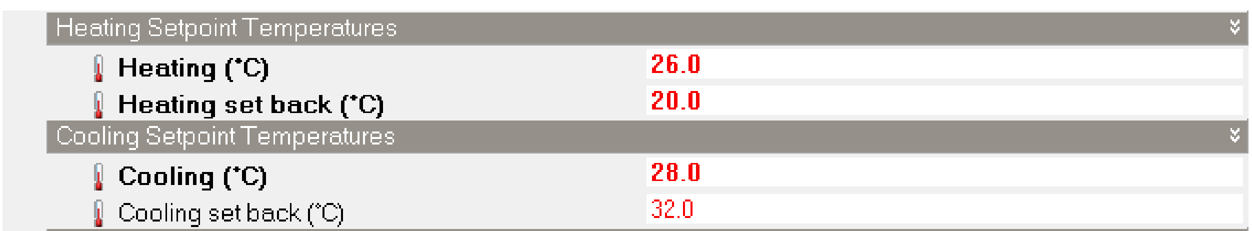


Figure 252 heating and cooling set point temperature for swimming pool

- <u>Heating and cooling parameters for the rest of the zones</u>:

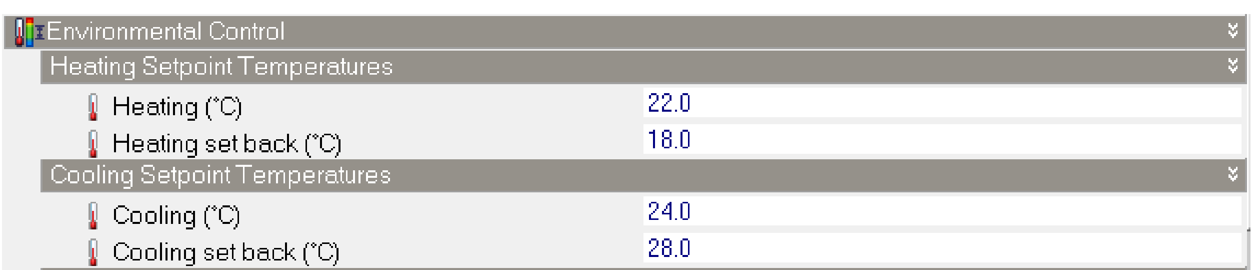


Figure 253 heating and cooling set point temperature for other zones

- Fresh air is different from zone to zone by its standard.

- Illuminance are varying from zone to zone by its standard, there are some examples in the following figure.

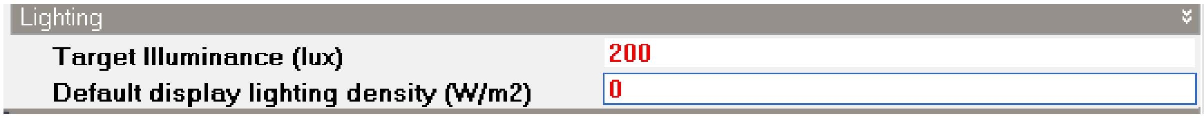


Figure 254 Target illuminance in the reception

Figure 255 Target illuminance in the clinic.

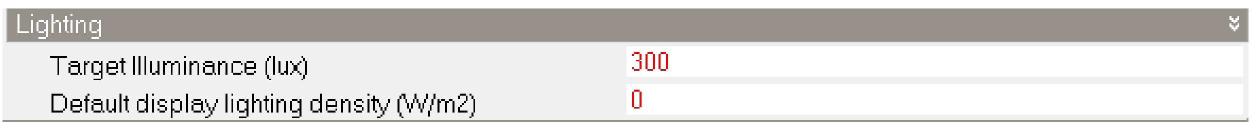


Figure 256 Target illuminance in the gym

The schedule that used in the building occupancy, and lighting.

General

Name	physiotherapy and rehabilitation center
Description	
Source	UK NCM
Category	Hospitals/Care Homes
Region	General
Schedule type	1-7/12 Schedule

Design Days

Design day definition method	1-End use defaults
Use end-use default	2-Occupancy

Profiles

Month	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Jan	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	Off	Off	9:00 - 16:00
Feb	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	Off	Off	9:00 - 16:00
Mar	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	Off	Off	9:00 - 16:00
Apr	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	Off	Off	9:00 - 16:00
May	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	Off	Off	9:00 - 16:00
Jun	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	Off	Off	9:00 - 16:00
Jul	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	Off	Off	9:00 - 16:00
Aug	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	Off	Off	9:00 - 16:00
Sep	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	Off	Off	9:00 - 16:00
Oct	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	Off	Off	9:00 - 16:00
Nov	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	Off	Off	9:00 - 16:00
Dec	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	9:00 - 16:00	Off	Off	9:00 - 16:00

Figure 257 building schedule

7.2.3 Simulation phases and comparison

- The simulation has been done three times, by changing many parameters in each time, to choose the most suitable way for reducing the cooling load.

1. The simulation has been done, firstly without the usage of insulation material, the following results were obtained for the number of dis-comfort hours and the comfort figures:

Comfort and Setpoint Not Met Summary

	Facility [Hours]
Time Setpoint Not Met During Occupied Heating	29.00
Time Setpoint Not Met During Occupied Cooling	219.50
Time Not Comfortable Based on Simple ASHRAE 55-2004	1174.50

Figure 258 Comfort set point results

Figure 259 design builder result without using insulation

2. secondly the simulation done without usage of earth tubes system, the following results were obtained for the number of dis-comfort hours and the comfort figures.

Comfort and Setpoint Not Met Summary

	Facility [Hours]
Time Setpoint Not Met During Occupied Heating	0.00
Time Setpoint Not Met During Occupied Cooling	0.00
Time Not Comfortable Based on Simple ASHRAE 55-2004	2689.50

Figure 260 Comfort set point results

Figure 261 design builder result without using earth tubes

3. Thirdly the simulation has been done, when the earth tubes system are active.

The following table shows the number of hours of dis comfort .

Comfort and Setpoint Not Met Summary

	Facility [Hours]
Time Setpoint Not Met During Occupied Heating	93.00
Time Setpoint Not Met During Occupied Cooling	53.50
Time Not Comfortable Based on Simple ASHRAE 55-2004	882.50

Figure 262 Comfort set point results

The following diagrams shows the comfort figures for the physiotherapy and rehabilitation center after the earth tubes were turned on in the Design Builder software:

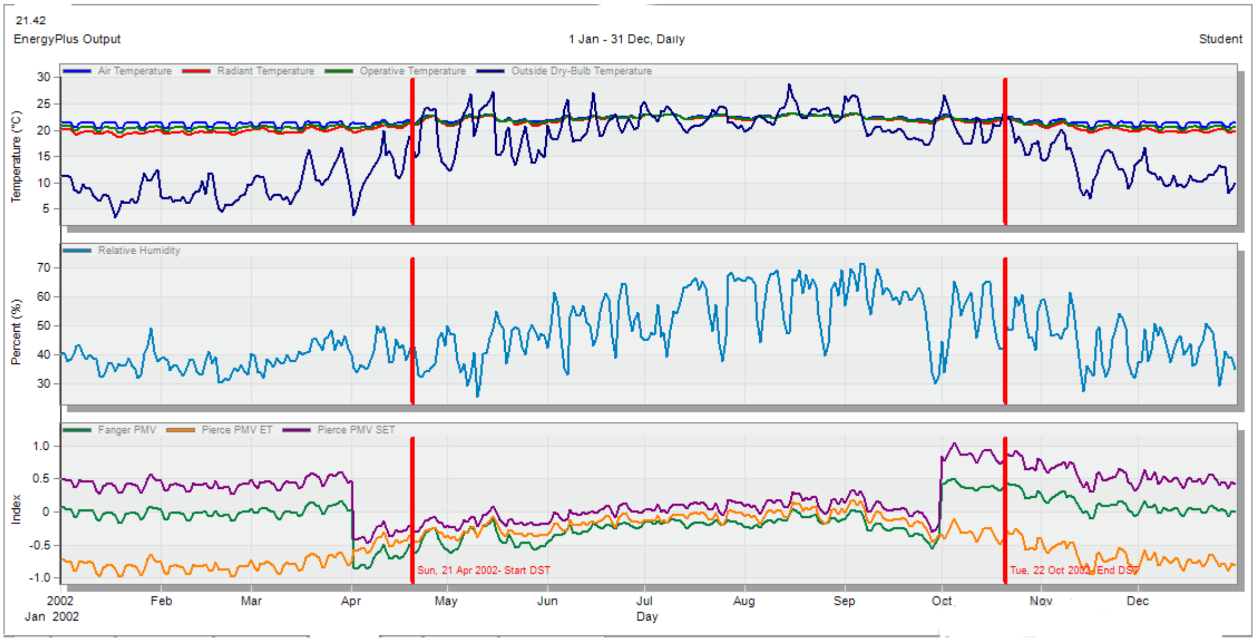


Figure 263 design builder results using earth tubes

- According to the results above, changing materials U value and using geothermal system gives the best result.

7.2.4 Shading analysis

Design builder software is used to show shadow effects on building in winter and summer at several times shown in following figures.

1) *On 21st July at 9.00 am.*

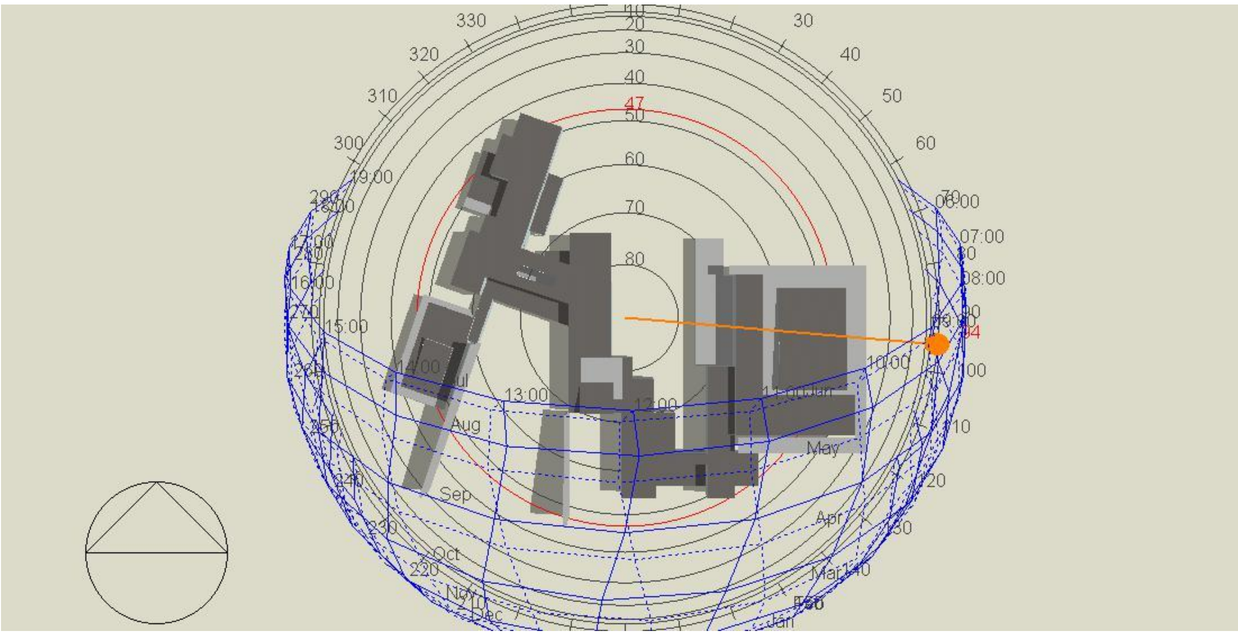


Figure 264 21st July at 9.00 am.

2) On 21st July at 12.00 pm.

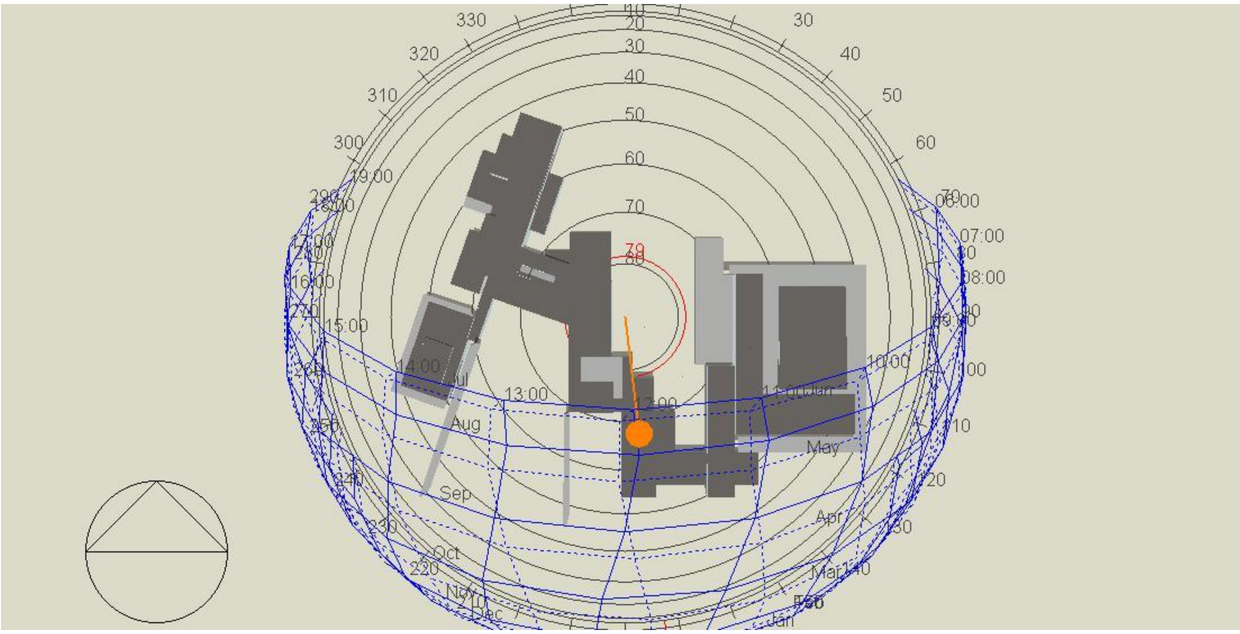


Figure 265 21st July at 12.00 pm.

3) On 21st Jan at 9.00 am

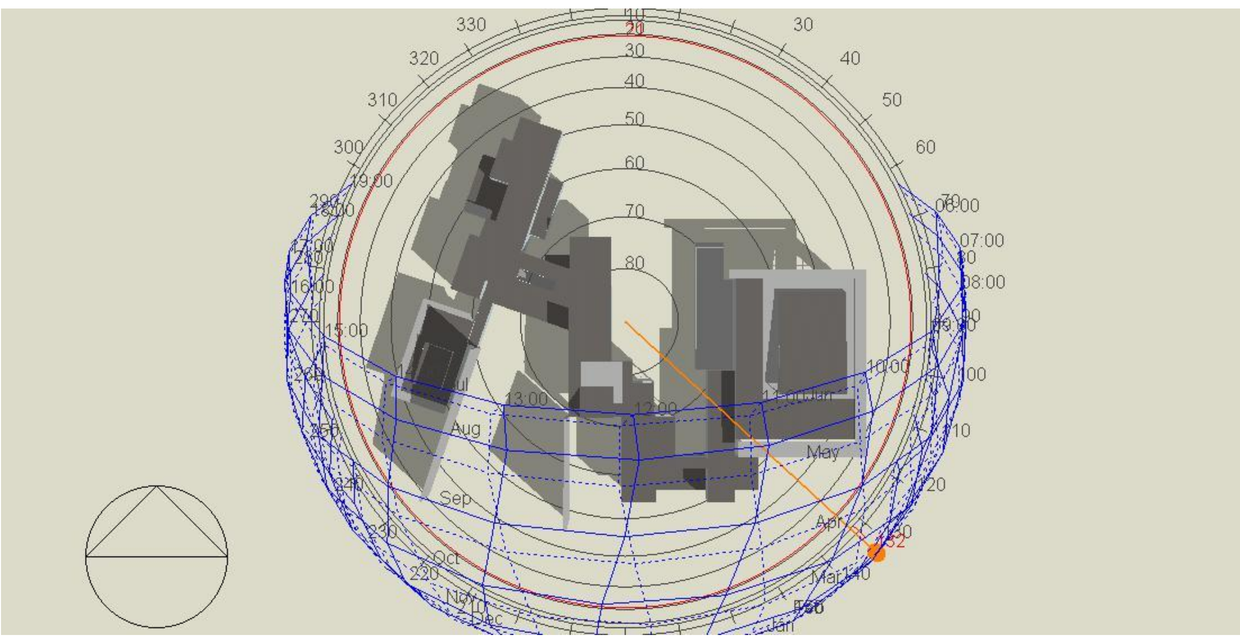


Figure 266 21st Jan at 9.00 am

4) *On 21st Jan at 12.00 pm.*

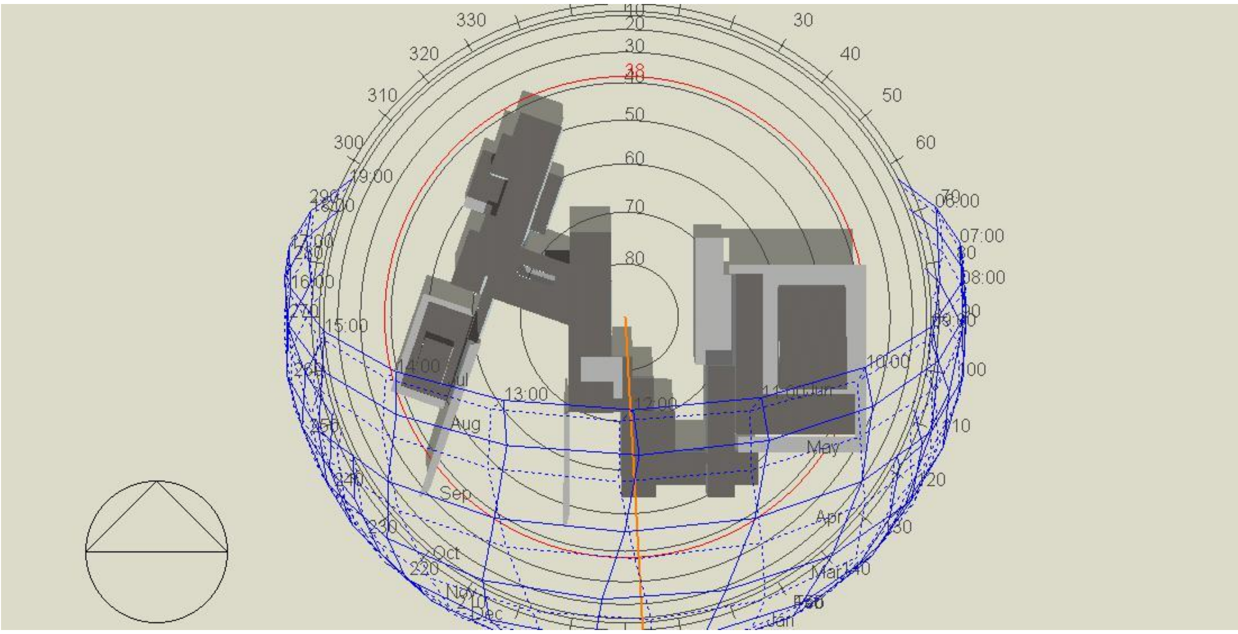


Figure 267 21st Jan at 12.00 pm.

7.2.5 shading system

Shading system are used, to reduce the amount of solar gain in the building and to prevent glare from day lighting.

- The building has a 2.5m cantilever above the curtain wall.
- CNC patterned panels on skylight.
- louvers in southern façade.

7.2.6 Thermal performances analysis

Design builder software used to show the value of cooling load, heating load value and energy consumption for the physio therapy and rehabilitation center, Figure shows 3D models.

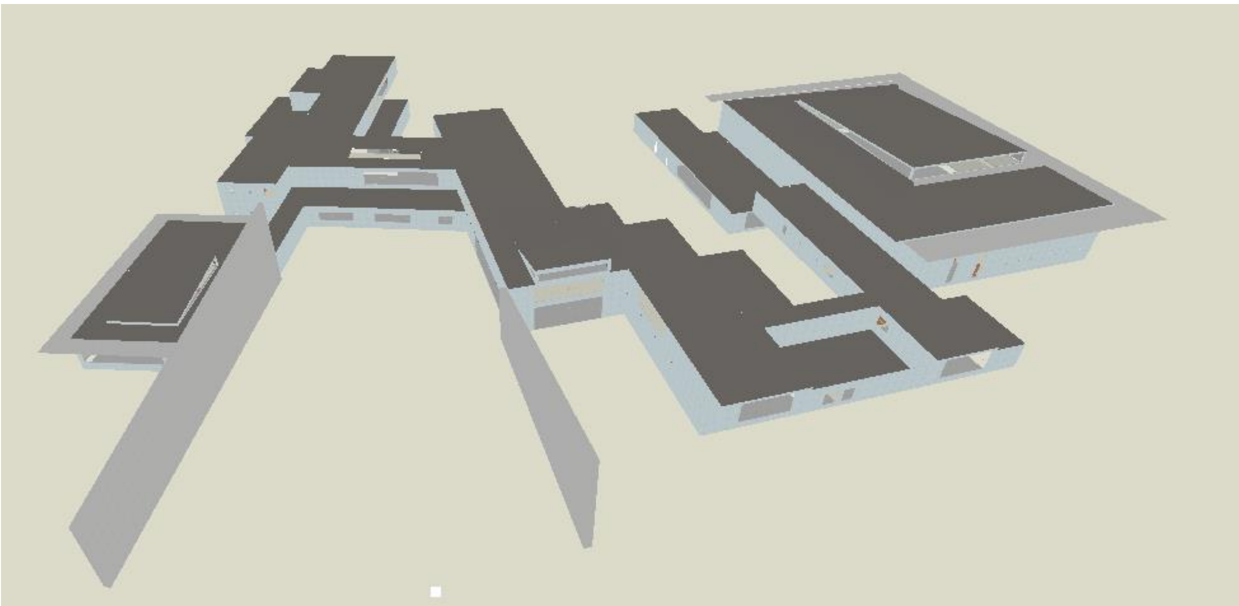


Figure 268 3D using design builder

7.2.7 Daylight factor

Daylight factor can be calculated as the ratio between the value of light inside the building and the light outside the building.

$$DF=\left(\frac{E\ indoor}{E\ outdoor}\right) \times 100\ \%$$

Where:

DF: daylight factor.

E: illuminance value.

The daylight factor, analyzed by using design builder software. The value of factor depends on two factor first the area second the type of windows that used.

- The recommended value is in the range (2-6) %. Daylight distributed in each floor shown in the following figures.

  (The building is divided into the parts as shown in the following drawing)

A. Daylight factor for ground floor (zone A).

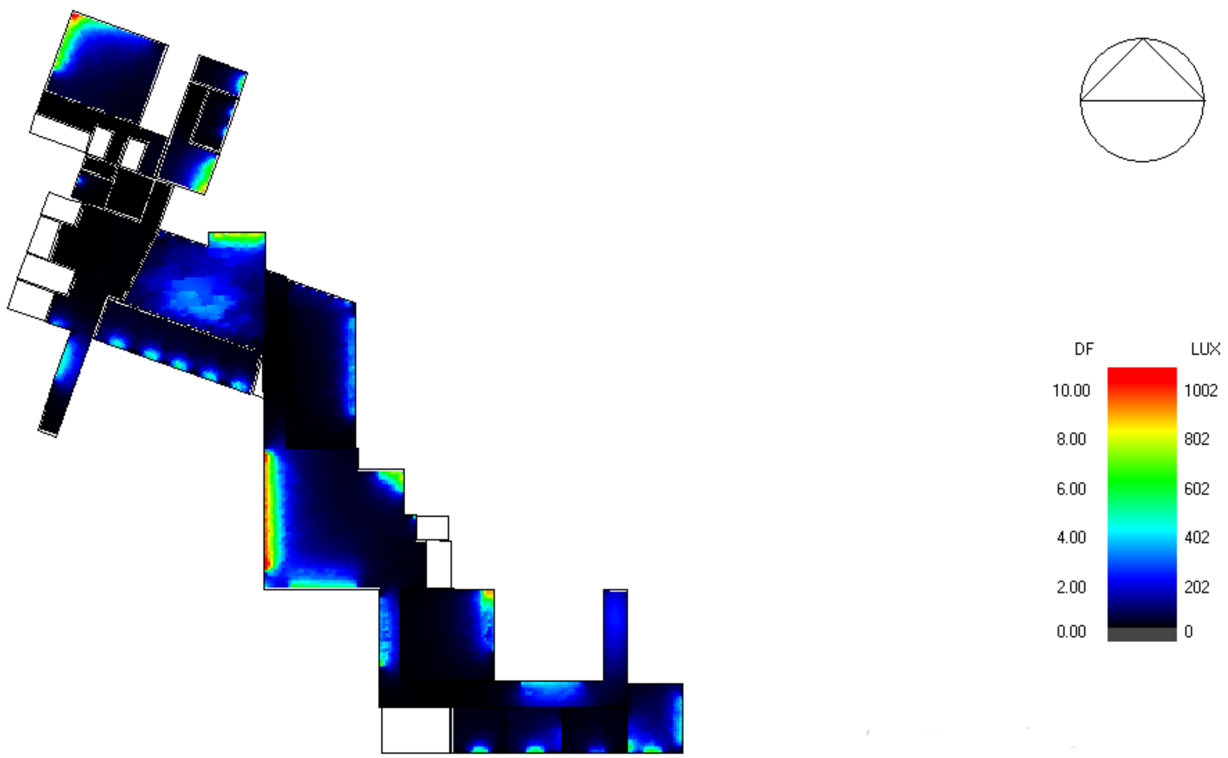
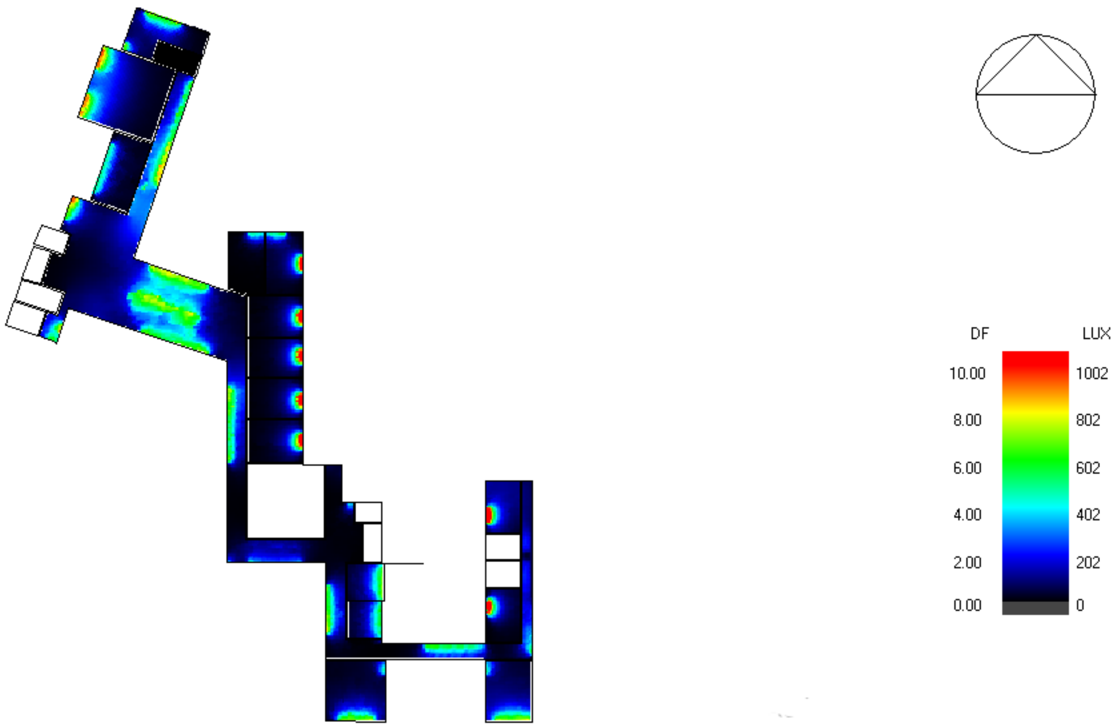


Figure 269 Daylight factor for ground floor (zone A).

B. Daylight factor for first floor (zone A).



C. Daylight factor for ground floor (zone B).

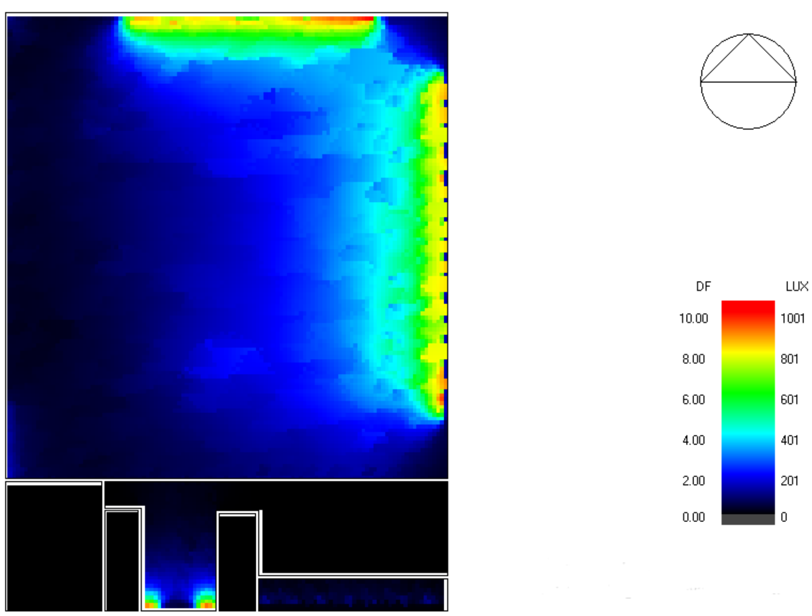


Figure 270 Daylight factor for ground floor (zone B)

D. Daylight factor for first floor (zone B).

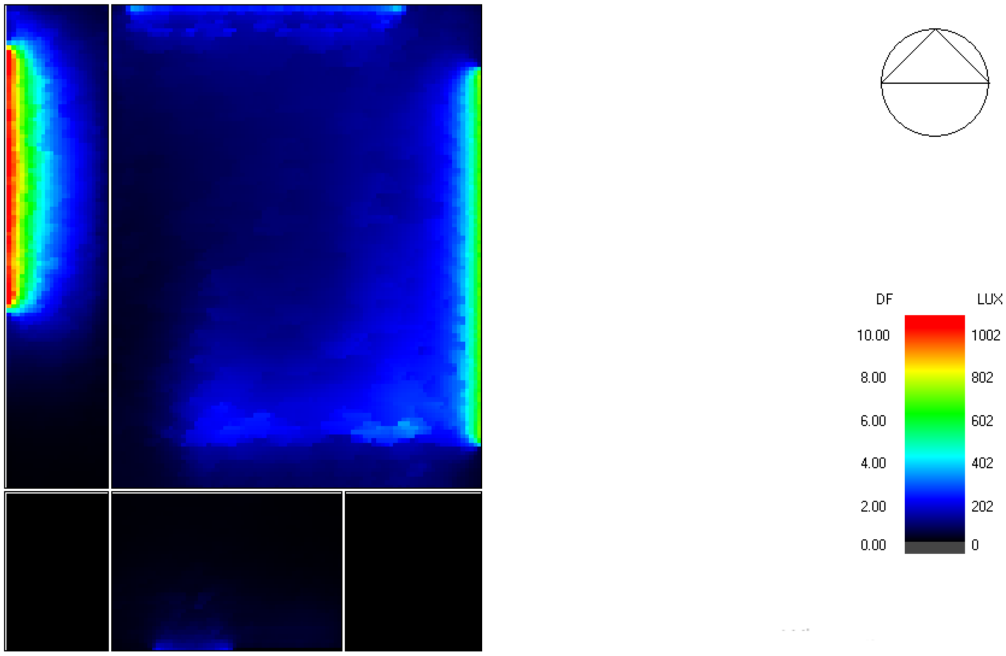


Figure 271 Daylight factor for first floor (zone B)

E. Daylight factor for ground floor (zone C).

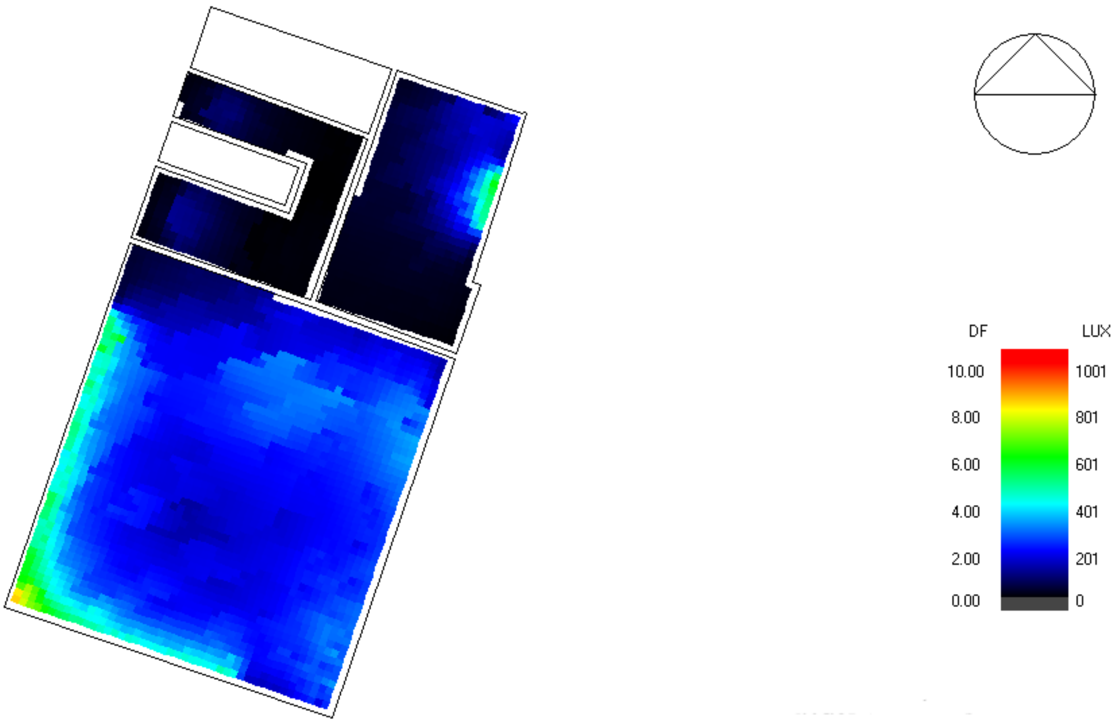


Figure 272 Daylight factor for ground floor (zone C).

F. Daylight factor for ground floor (zone D).

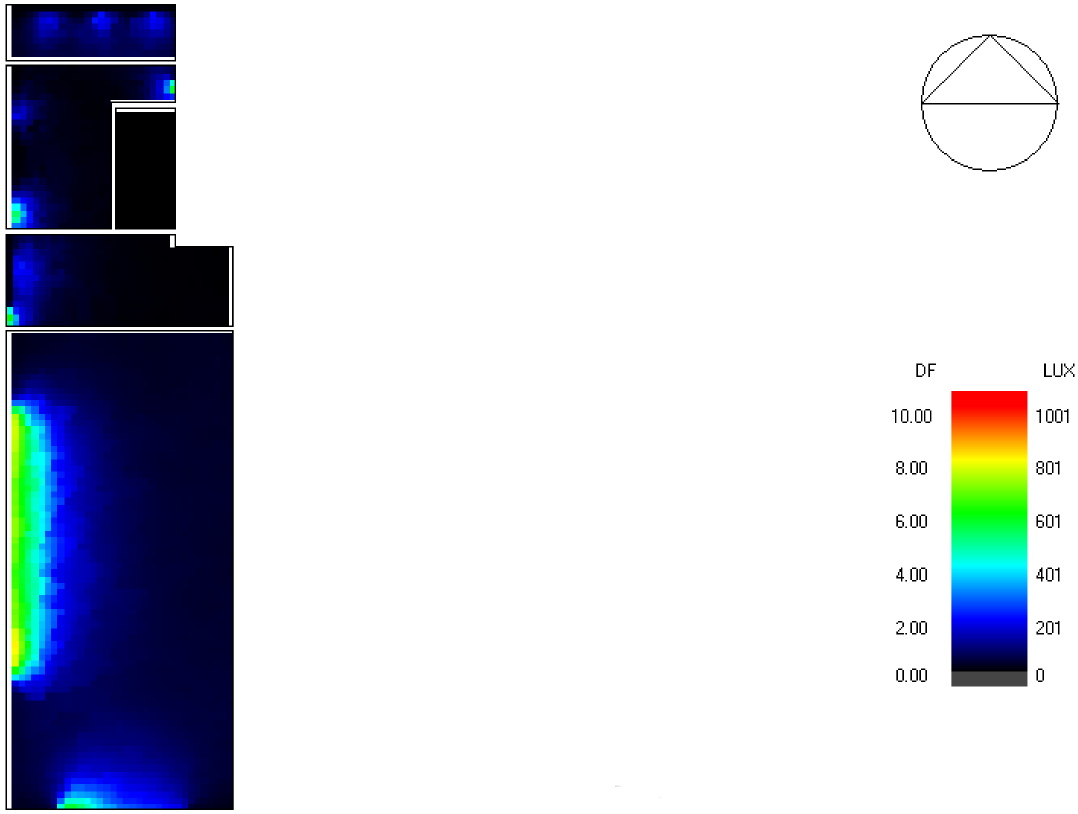


Figure 273 Daylight factor for ground floor (zone D).

7.3 Acoustic Design

7.3.1 Introduction

Building acoustics is the science of controlling noise in buildings. This includes the minimization of noise transmission from one space to another and the control of the characteristics of sound within spaces themselves.

Building acoustics are an important consideration in the design, operation and construction of most buildings, and can have a significant impact on health and wellbeing, communication and productivity. They can be particularly significant in spaces such as concert halls, recording studios, lecture theatres, and so on, where the quality of sound and its intelligibility are very important.

<u>Factors to consider</u>

- Reverberation time (RT60): is the time required for the sound to fade away or decay in a closed space.
- Sound transmission class (STC): is an integer rating of how well a building partition attenuates airborne sound.
- Impact insulation class (IIC): is an integer-number rating of how well a building floor attenuates impact sounds, such as footsteps.

- Two program were used to make simulation and that two program is Ecotect to design RT60 based on the finishing layer of each room and the second program is Insul to design (STC) and (IIC).

7.3.2 Simulation

- The simulation done on the following spaces: class room, multipurpose hall, cafeteria, Gym, office room and reception.

Space	Reverberation time (RT60)	Sound transmission class (STC)
Classroom	0.6 – 0.9	45
Multipurpose hall	1.5-1.9	40
Cafeteria	0.9-1.4	50
Gym	2	-
Offices room	0.75	45
Reception	1	55

Table 47 RT60 and STC

- **Reverberation time (RT60):**

Component	Finishing layer	Absorption coefficient(α)					
		125HZ	250HZ	500HZ	1000HZ	2000HZ	4000HZ
Wall	Plaster	0.09	0.07	0.01	0.01	0.01	0.02
Ceiling	plaster	0.28	0.1	0.05	0.03	0.07	0.09
Floor	Tile on concrete	0.01	0.01	0.01	0.02	0.03	0.07
Door	Hollow core plywood	0.41	0.35	0.25	0.2	0.15	0.14
Window	Double glass	0.1	0.06	0.04	0.03	0.03	0.03
	Curtain wall	0.3	0.35	0.55	0.72	0.7	0.65

Table 48 Absorption coefficient

1) Class room

Required reverberation time in classroom is 0.6-0.9 second. Using framed plasterboard in wall to achieve the required reverberation time.

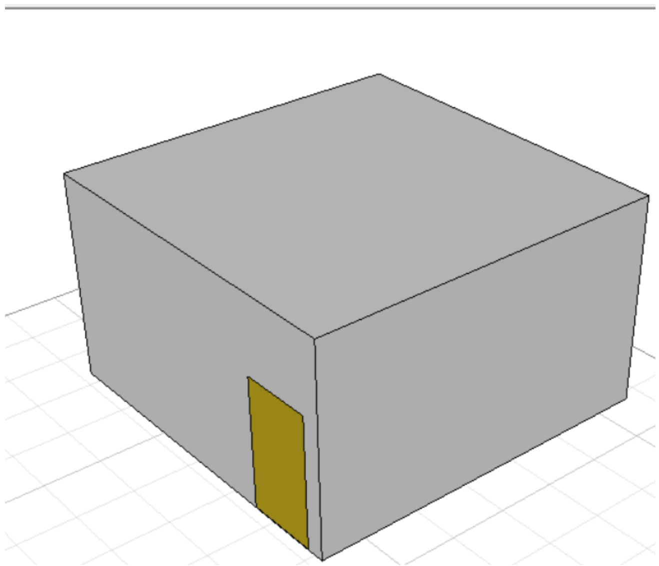


Figure 274 Class room

Surface area of the room is $36m^2$ and the volume of room is 126 m^3 most suitable is (Sabine) distribution.

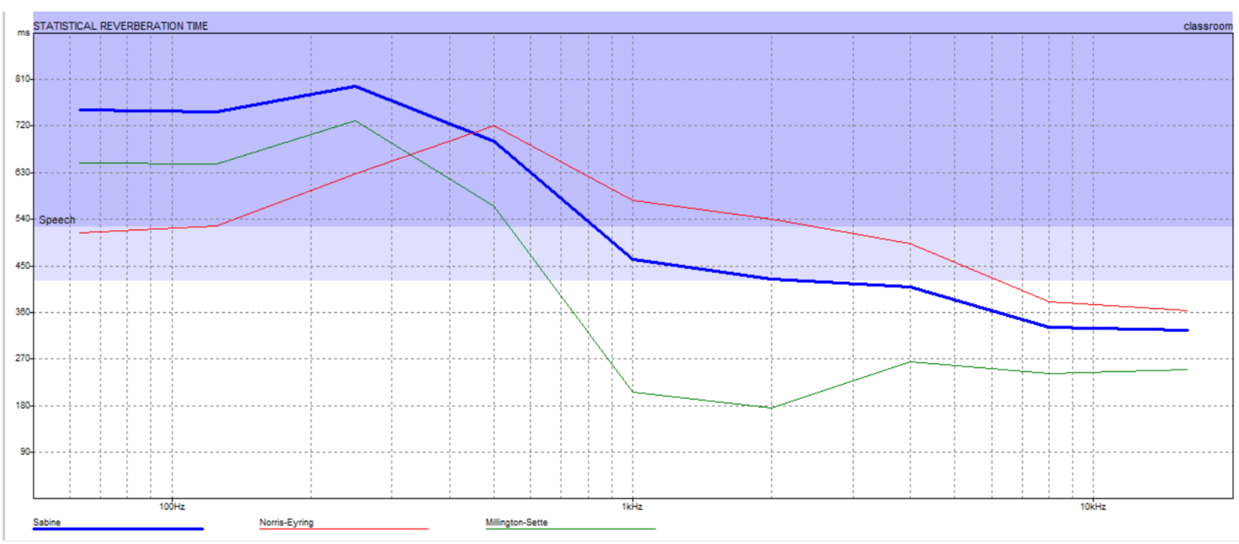


Figure 275 class room analysis results

- Table below, shows the reverberation time when it is empty, half and full room capacity.

Frequency	Total ABSPT	Empty	Half	Full
		RT60	RT60	RT60
63Hz	25.746	0.77	0.76	0.75
125Hz	25.622	0.76	0.76	0.75
250Hz	21.921	0.86	0.83	0.8
500Hz	25.941	0.73	0.71	0.69
1kHz	39.613	0.48	0.47	0.46
2kHz	40.921	0.44	0.43	0.43
4kHz	38.948	0.42	0.41	0.41
8kHz	38.295	0.33	0.33	0.33
16kHz	38.913	0.33	0.33	0.33

Figure 276 Reverberation time

- Reverberation time at 500HZ 0.73 and it's in range (0.6-0.9) which is acceptable

2) ***Multipurpose hall***: Required reverberation time in Multipurpose hall is 1.5-1.9 second.

- Using framed plasterboard in wall to achieve the required reverberation time

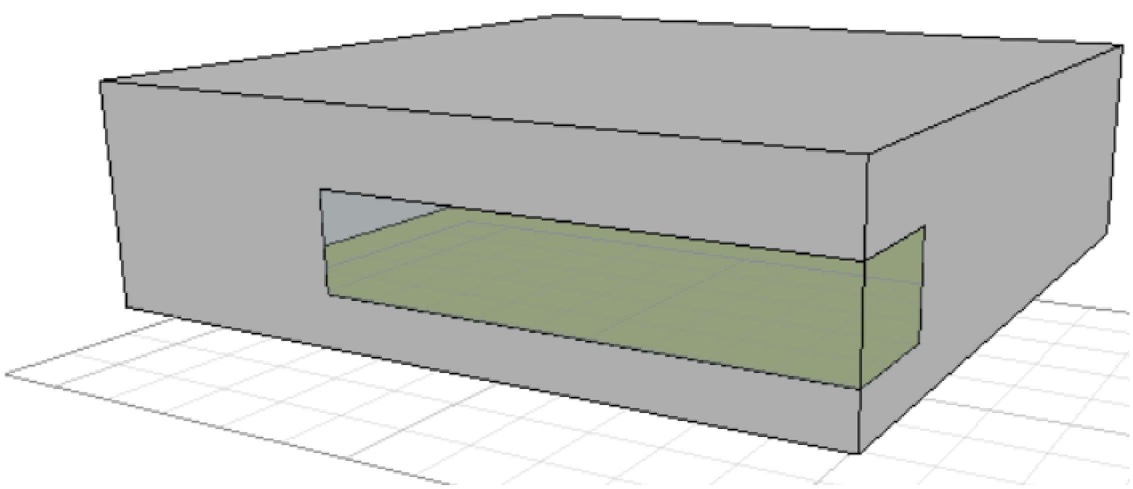


Figure 277 Multipurpose room

- Surface area of the room is146m^2 and the volume of room is 512 m^3 most suitable is (sabine) distribution .

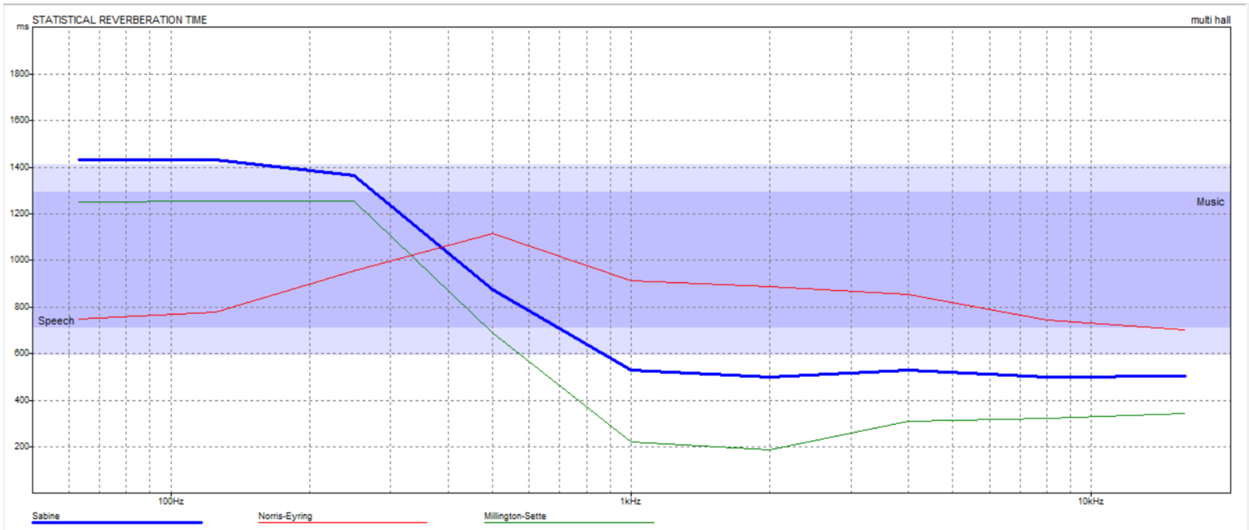


Figure 278 multipurpose room analysis results

- Table below, shows the reverberation time in empty, half and full room capacity.

Frequency	Total ABSPT	Empty	Half	Full
		RT60	RT60	RT60
63Hz	54.629	1.47	1.45	1.43
125Hz	54.187	1.46	1.45	1.43
250Hz	53.023	1.46	1.41	1.36
500Hz	87.047	0.91	0.89	0.87
1kHz	148.045	0.54	0.53	0.53
2kHz	153.659	0.51	0.51	0.5
4kHz	140.534	0.54	0.53	0.53
8kHz	136.275	0.5	0.5	0.5
16kHz	131.967	0.51	0.51	0.51

Figure 279 Reverberation time

- Reverberation time at 500HZ 0.91 and it’s in range (1.5-1.9) which is acceptable .

3) Cafeteria

Required reverberation time in cafeteria is 0.9-1.4second.

Using framed plasterboard in wall to achieve the required reverberation time.

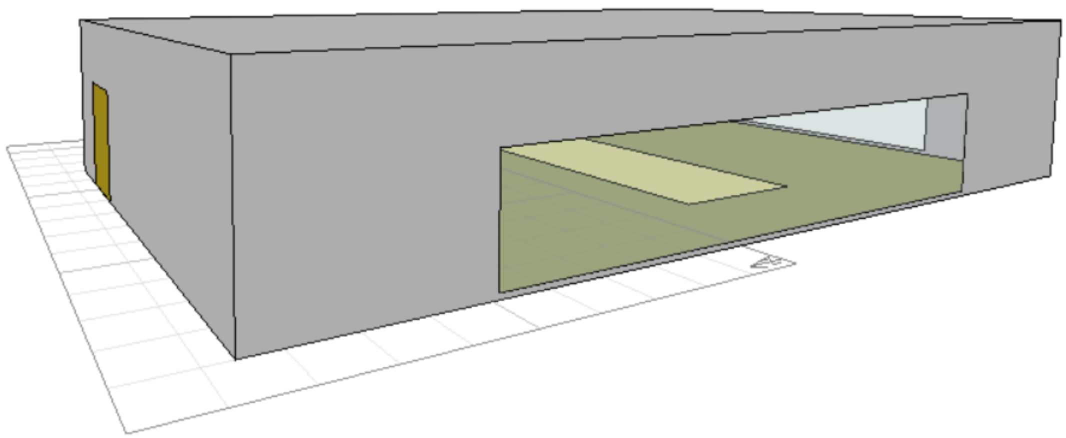


Figure 280 Cafeteria

Surface area of the room is188m^2 and the volume of room is 731 m^3 most suitable is (sabine) distribution .

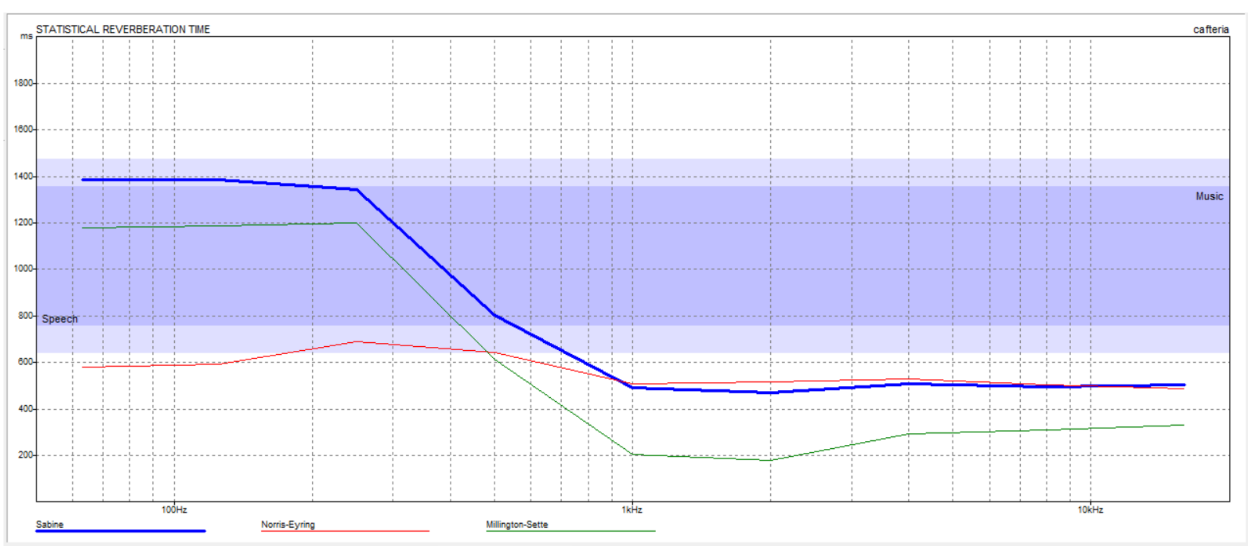


Figure 281 cafeteria analysis results

- Table below, shows the reverberation time in empty, half and full room capacity.

Frequency	**Total ABSPT**	**Empty**	**Half**	**Full**
		RT60	RT60	RT60
63Hz	83.395	1.39	1.37	1.35
125Hz	82.653	1.39	1.37	1.36
250Hz	83.911	1.35	1.3	1.25
500Hz	142.401	0.8	0.79	0.77
1kHz	235.486	0.49	0.48	0.48
2kHz	241.921	0.47	0.47	0.46
4kHz	219.19	0.51	0.5	0.5
8kHz	212.091	0.49	0.49	0.49
16kHz	204.718	0.5	0.5	0.5

Figure 282 reverberation time

- Reverberation time at 500HZ 0.8 and it's in range (0.9-1.4) which is acceptable.

7.3.3 STC & IIC

- Sound transmission class (STC):

❖ ***Class room***

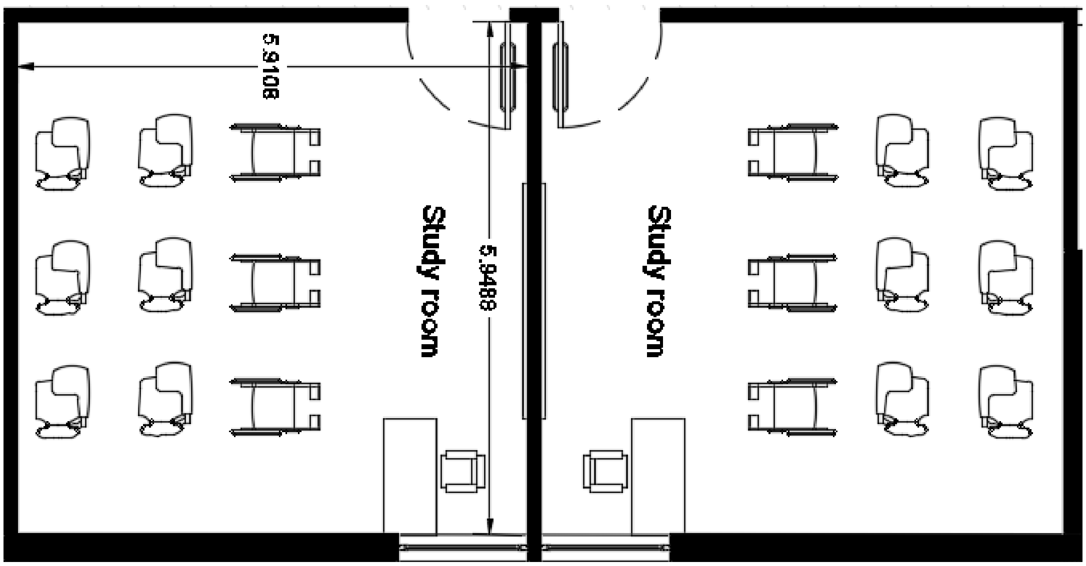


Figure 283 Class room

SOURCE ROOM	RECEIVING ROOM	RECOMMENDED MINIMUM STC
SCHOOL CLASSROOM	Adjacent classroom	
	Speech use only	STC 42
	Speech + audiovisual	STC 48
	Corridor, public area	STC 42
	Recreational area	STC 52+

Figure 284 detailing

- For portion between classroom and adjacent classroom STC = 42

Sound Insulation Prediction (v8.0.4)

Program copyright Marshall Day Acoustics 2014

- Key No. 0283

Margin of error is generally within STC +/- 3 dB

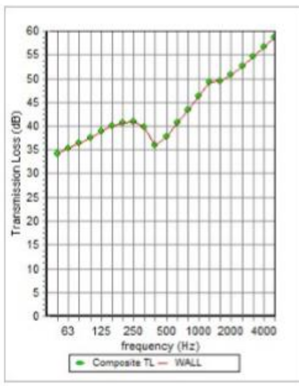
Job Name:

Job No.: Page No.: Notes:

Date: 9 Dec 19 Initials:student

File Name: insul

Composite Transmission Loss Calculation



STC 45 dB

OITC 41

Composite TL per Frequency(Hz))						
63	125	250	500	1k	2k	4k
35	39	40	38	46	51	56

Element	Area	Third Octave Band Centre Frequency (Hz)																						
		50	63	80	100	125	160	200	250	315	400	500	630	800	1k	1k25	1k6	2k	2k5	3k15	4k	5k	STC	OITC
WALL	20.8	34	35	36	38	39	40	41	41	40	36	38	41	43	46	49	49	51	53	55	57	59	45	41
	20.8	34	35	36	38	39	40	41	41	40	36	38	41	43	46	49	49	51	53	55	57	59	45	41

Figure 285 INSUL results for class room

- Area of partition 5.95*3.5 = 20.8 so STC from INSUL 45 which is grater of 42.

- **<u>it’s acceptable</u>**

External wall of classroom to outside

Sound Insulation Prediction (v8.0.4)

Program copyright Marshall Day Acoustics 2014

- Key No. 0283

Margin of error is generally within STC +/- 3 dB

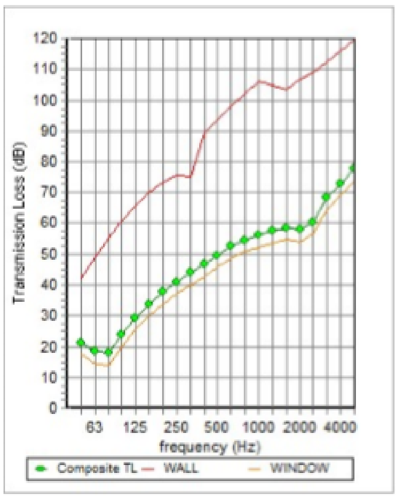
Job Name:

Job No.: Page No.: Notes:

Date: 9 Dec 19 Initials:student

File Name: insul

Composite Transmission Loss Calculation



STC 52 dB

OITC 35

Composite TL per Frequency(Hz))						
63	125	250	500	1k	2k	4k
19	27	40	49	56	59	71

Element	Area	Third Octave Band Centre Frequency (Hz)																						
		50	63	80	100	125	160	200	250	315	400	500	630	800	1k	1k25	1k6	2k	2k5	3k15	4k	5k	STC	OITC
WALL	12.5	42	49	55	61	66	70	73	75	75	89	94	98	102	106	105	103	107	109	112	116	120	87	72
WINDOW	8.8	17	15	14	20	25	30	34	37	40	43	46	49	51	52	54	55	54	57	64	69	74	48	31
	21.3	21	18	18	24	29	34	38	41	44	47	49	53	54	56	58	58	58	60	68	73	78	52	35

Figure 286 External wall STC

- Area of wall = 3.47*3.5= 12.5 and area of window = 2.5*3.5 = 8.75 so STC value from INSUL 52 dB more than 50db which is acceptable.

- **IIC for class room and multipurpose hall**

Impact Sound Prediction (v8.0.4)

Program copyright Marshall Day Acoustics 2014

INSUL

- Key No. 0283

Margin of error for Impact Sound Prediction is generally within IIC +/- 5 dB

Job Name:

Job No.: Page No.: Notes:

Date: 9 Dec 19 Initials:

File Name: insul

IIC 30

System description

Floor Cover: None (Measured)

Panel 1 : 1 x 40.0 mm mm Plasterboard (ρ:710 kg/m3,E:2GPa,η:0.01) + 1 x 150.0 mm Concrete (ρ:2340 kg/m3,E:11GPa,η:0.04)

frequency (Hz)	Ln(dB)	Ln(dB)
50	61	
63	64	69
80	66	
100	68	
125	71	76
160	73	
200	72	
250	69	78
315	77	
400	79	
500	80	84
630	80	
800	79	
1000	78	83
1250	77	
1600	76	
2000	74	79
2500	71	
3150	67	
4000	63	69
5000	59	

Panel Size 2.4x2.4 m; Mass 379.4 kg/m2

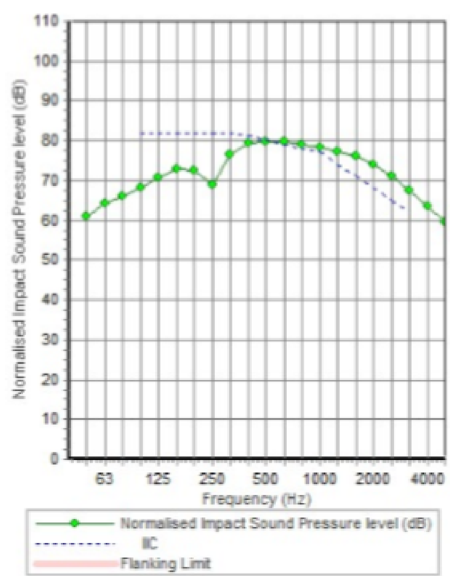


Figure 287 IIC FOR CLASS ROM AND MULTIPURPOSE ROOM

➢ IIC value from INSUL 30 which is less than 55 so not acceptable.

- **STC roof for classroom**

Rainfall Noise Prediction (v8.0.4)

Program copyright Marshall Day Acoustics 2014

- Key No. 0283

Margin of error for Rainfall Noise Prediction is generally within +/- 5 dBA

Job Name:

Job No.: Page No.: Notes:

Date: 9 Dec 19 Initials:

File Name: insul

LpA 28dB

System description

Natural Rain: Rainfall 40 mm/hr

Panel 1 : 1 x 10.0 mm Asphaltestrich (ρ:2000 kg/m3,E:15GPa,η:0.38) + 1 x 10.0 mm mm Plasterboard (ρ:710 kg/m3,E:2GPa,η:0.01)

[illegible] Youngs Modulus =5(GPa), Damping=0.04)

Panel 2 + 1 x 13.0 mm mm Plasterboard (ρ:710 kg/m3,E:2GPa,η:0.01)

Mass-air-mass resonant frequency =61 Hz

Panel Size 2.4x2.4 m

Room volume 50 m3, Reveberation time 0.5 s

frequency (Hz)	(dB)	(dB)
50	22	
63	22	26
80	20	
100	22	
125	24	28
160	24	
200	21	
250	21	26
315	22	
400	21	
500	19	24
630	18	
800	17	
1000	18	22
1250	18	
1600	16	
2000	16	23
2500	20	
3150	16	
4000	10	17
5000	9	

Figure 288 STC roof for class room

➢ STC for roof from INSUL 28db.

7.3.4 Loudspeaker design

7.3.4.1 ceiling loudspeaker

Figure 289 Loudspeaker

Details | Certificates (1) | Documents (3) | Software Downloads (1)

Frequency Range (-10 db):	50 Hz – 20 kHz
Nominal Coverage (Conical):	100°
Power Handling:	200 W Program, 100 W Pink Noise
Sensitivity (SPL 1 W/1 m):	87 dB
Max Calculated SPL:	107 dB Avg, 113 dB Peak
Impedance:	10 ohms
LF Transducer:	165 mm (6.5 in)
HF Transducer:	35 mm Compression Driver
Transformer Taps:	70V: 60W, 30W, 15W, 7.5W, 8 ohm100V: 60W, 30W, 15W, 8 ohm
Connectors:	Removable locking 4-pin (Phoenix) 2.5 mm (12 AWG) max wire size
Enclosure:	ABS Plastic (UL94V-O) Baffle, steel back can
Grille:	Color matched steel grille with fabric
Dimensions (H x Dia):	260 mm x 280 mm (10.2 in x 11.0 in)
Cutout Size:	248 mm (9.76 in)
Net Weight:	7.0 kg (15.4 lb)

Figure 290 loudspeaker detailing

- Converge angle 100
- Ear height 1.2 m
- Covered area from one speaker

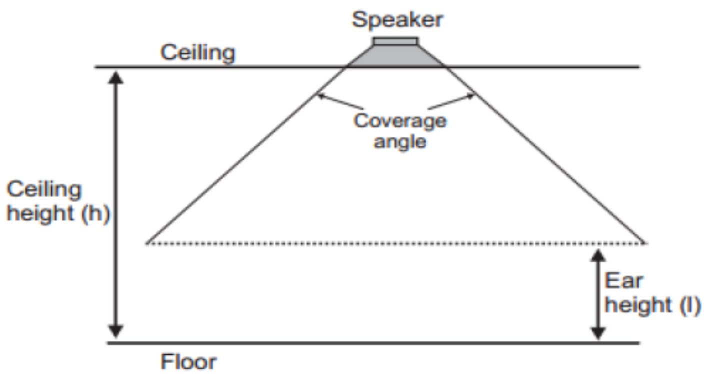


Figure 291 speaker

- **<u>Cafeteria</u>**

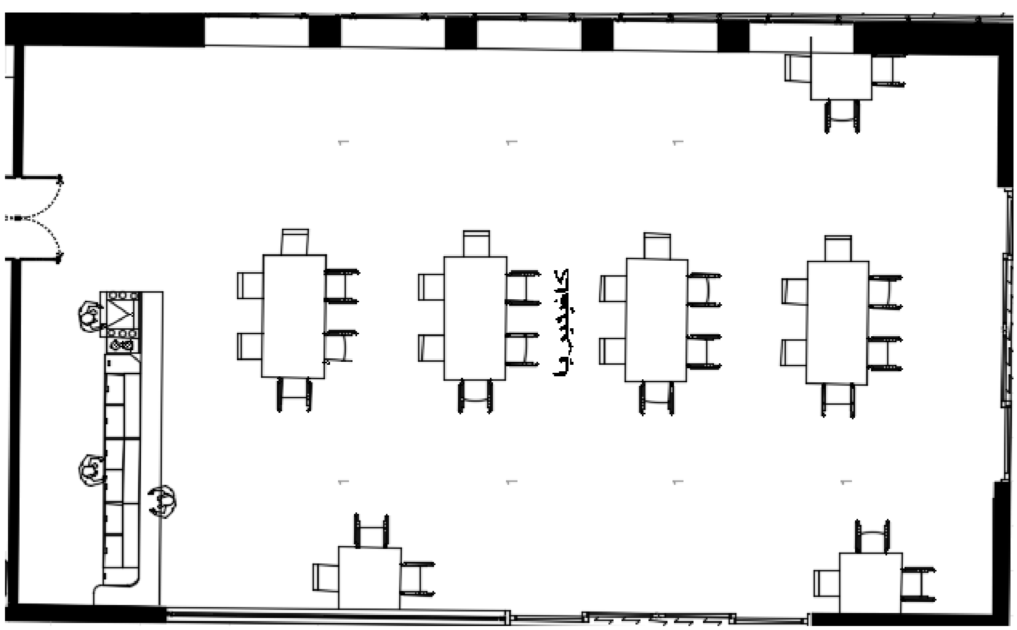


Figure 292 cafeteria

➢ **<u>Calculate coverage area</u>**

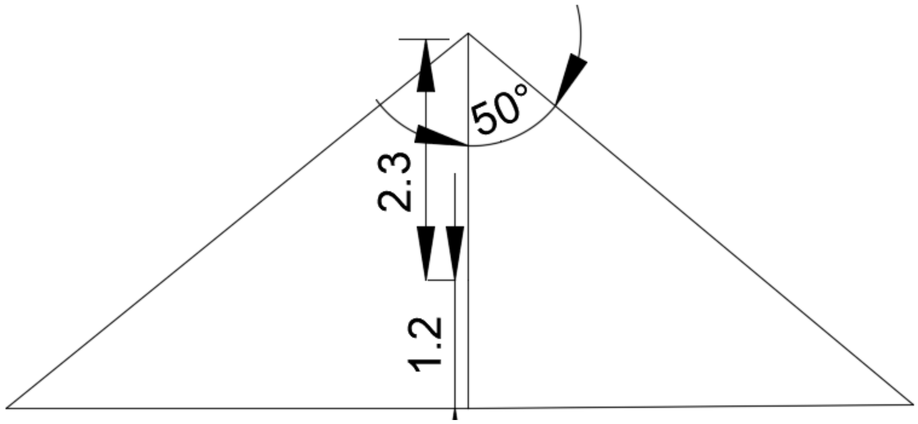


Figure 293 angel

Tan (50) = $\frac{d}{2.3}$ = 2.74m

Coverage area = πd^2 = $\pi(2.74)^2$ = 23.7

Area of cafeteria =188

➢ Number of speaker = $\frac{total\ area}{covarge\ area}$ = $\frac{188}{23.7}$ = 8 speaker

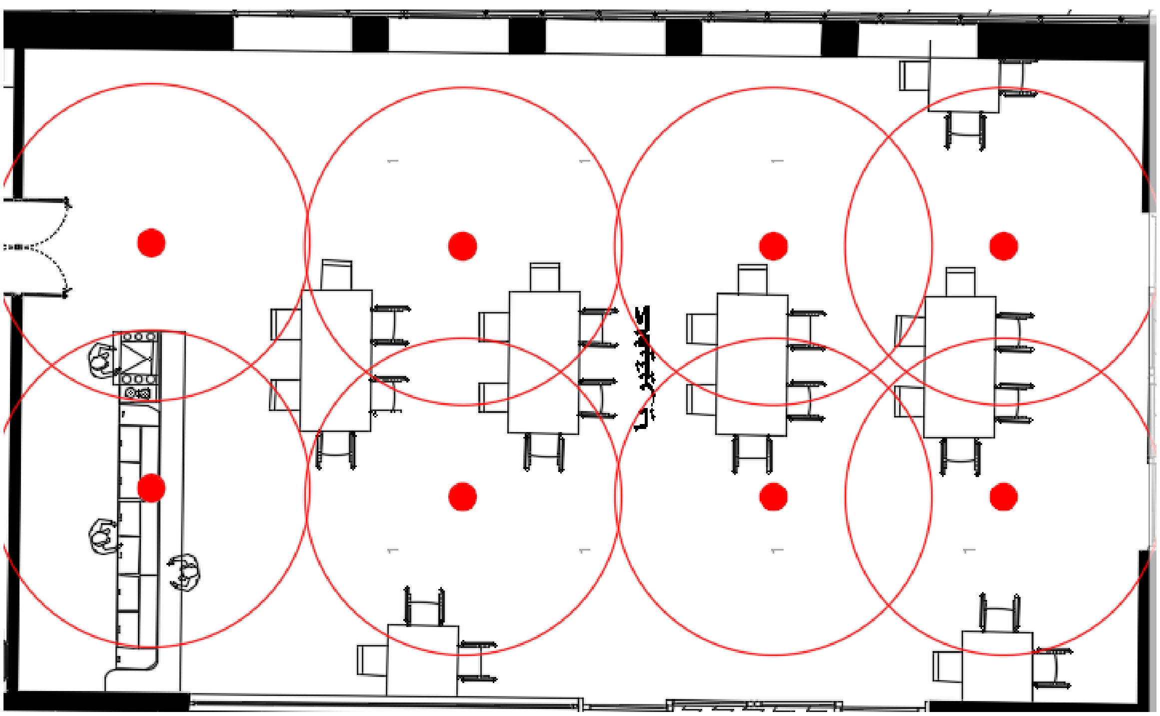


Figure 294 Loudspeaker distribution

7.3.4.2 Wall mounted speaker

F-160/F-240 Specifications		
	F-160	F-240
Coverage Angle	90º H x 90º V	90º H x 90º V
Frequency Response	100 Hz – 20 kHz (1/2- or 1/4-space)	65 Hz – 20 kHz (1/2- or 1/4-space)
Sensitivity (1 W / 1 m)	91 dB	92 dB

Coverage area:

F-160/F-240 Coverage and Spacing					
Height Above Listener h-l (ft)	Downward Tilt (degrees)	Coverage Area (sq. ft)	Coverage Depth (ft)	Maximum Spacing for Rated Coverage Depth (ft)	Max. SPL for Farthest On-Axis Listener (dB) F-160/F-240
2	10	113	11	21	95 / 96
3	10	254	17	32	92 / 93
4	10	452	23	42	89 / 90
5	10	707	28	53	87 / 88
4	20	112	11	21	95 / 96
5	20	175	14	27	93 / 94
6	20	252	16	32	91 / 92
8	20	449	22	43	89 / 90
10	20	701	27	54	87 / 88
8	30	208	14	29	92 / 93
10	30	325	17	37	90 / 91
12	30	469	21	44	89 / 90

Figure 296 Coverage and spacing

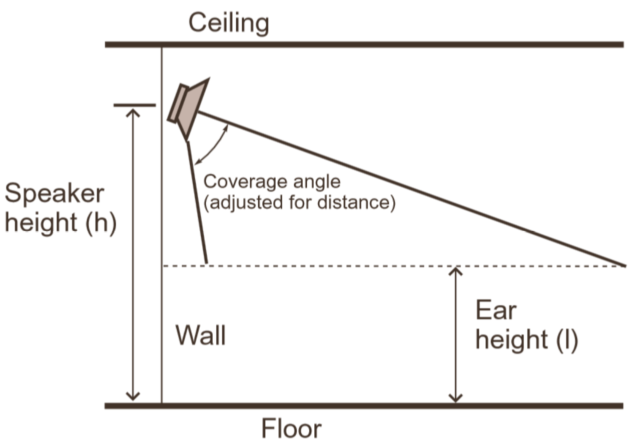


Figure 297 wall mounted loudspeaker

- **Multiparous hall:**

Speaker height 3m

Ear height 1.2m

At 1.8 m coverage area = 23.4

Multi hall area = 145

➢ Number of speaker = $\frac{total\ area}{covarge\ area}$ = $\frac{145}{23.4}$ =6 speaker

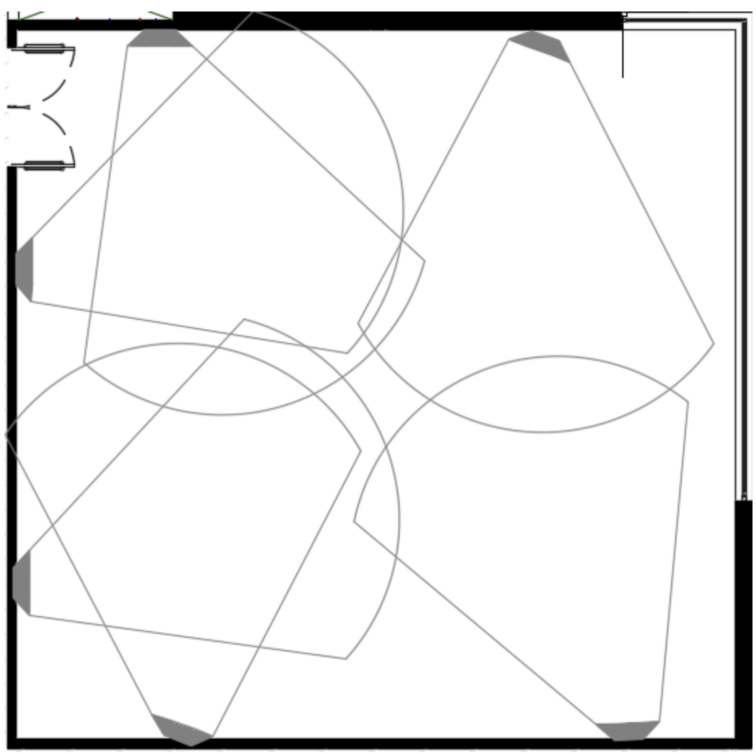


Figure 298 loudspeaker in multipurpose hall

CHAPTER 8

8.0 Firefighting and emergency exit

8.1 Firefighting

Fire protection is one of the important issues that should take to consider to save lives and to reduce the consequences that happen when fire occurs in the building according to specifications.

there are many types of fire protection system:

- Fire extinguishers.
- Hose station.
- Sprinkler.

Fire extinguisher:

It is a manual fire extinguishing device used to control fires and extinguish it.

In our building a carbon dioxide fire extinguisher is used.

There are two types of it:

- Limited discharge time: (its range between 29 to 40 seconds).
- Restricted range: (it's range between 1.22m to 1.83 m).

Figure 299 fire extinguisher

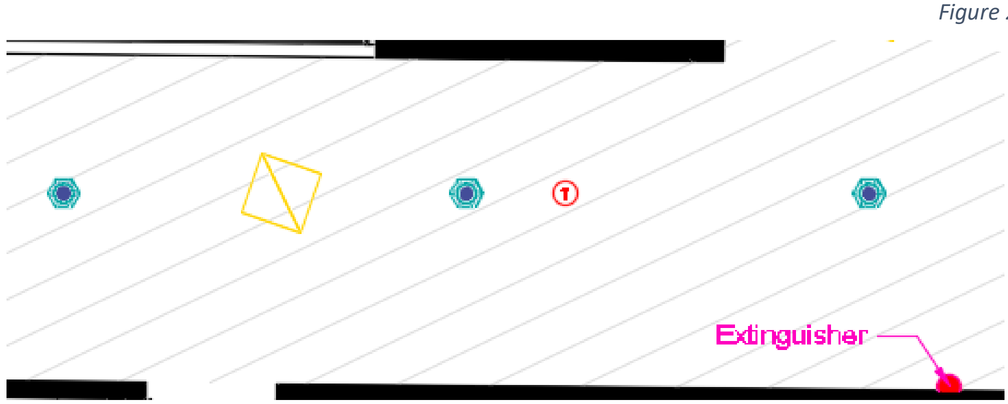


Figure 300 fire extinguisher plan

Types of extinguishers used in this project:

	Name	**Detailing**	**Space to use**
	ABC Dry Chemical	• Dry chemical. • A, B and C fire class. • Consists of 2.3 to 9.1 Kilo-gram of mono-ammonium phosphate. • have a range of about 4.6 m.	• Corridors • Labs
	Carbon Dioxide (CO_2)	• Filled with either 2.3 or 4.5 Kilo-gram of CO_2 liquid. • used only on electrical fires or flammable liquid. • Have a range of about 1.2 m to 1.8 m.	• Mechanical rooms • Labs
	Halon	• A, B and C fire class, it is also affective in A class. • Have a range of about 4.6 m. • Extremely clean agent that doesn't leave any residue.	• Computers room
	Class K Extinguisher	• rated to combat Class K (grease) and A, B, or C fires. • Have a range of is 3 m to 3.6 m.	• kitchens

Figure 301 fire extinguisher used in the building

Hose station:

Hose station should be located in every floor of building

this system used in corridors and staircase in addition of fire extinguisher system.

Figure 302 Hose station

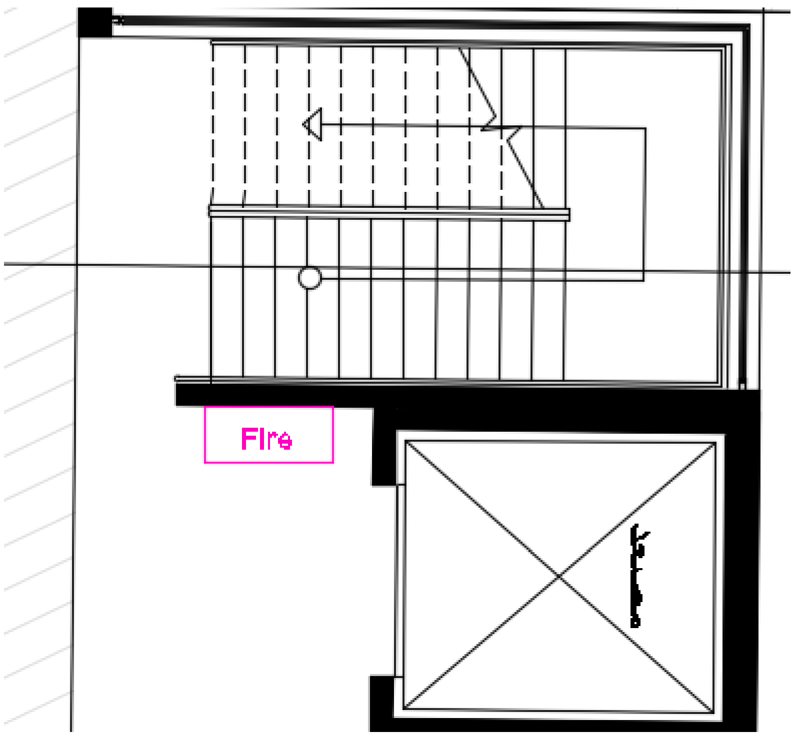


Figure 303 Hose station plan

Sprinkler:

The sprinkler a glass tube with a special fluid and a small amount of air. When the temperature increase, the fluid.

If the temperature increases, the fluid extend in the glass tube. and the fluid remains to expand until it explodes, and the fluid fall on the fire source.

the temperature that the sprinkler explode depends on the type of the sprinkler.

- Types of sprinkler:

Standard sprinklers

- These types can be installed standing or suspended.
- It is designed so that the areas both below and above the sprinkler are sprayed.
- This type of sprinkler is suitable for flammable ceilings.

Figure 304 Standard sprinkler

Suspended and standing spray sprinklers

- It is the most common type of sprinkler.
- Standing sprinklers are used when the pipework is visible.
- Suspended sprinklers are always used when they pipework is hidden.

Figure 305 Standing sprinkler

Fast Response Sprinkler

this type has an extremely short response time that enables a fire to be detected in a short time and fire-fighting to start quickly.

The table below, shows the suitable area and distance of sprinklers according to the hazard in the building.

Hazard	Low	Moderate	High
Area	21 m^2	12 m^2	9.3 m^2
Distance	4.6 m	3.6 m	3.6 m

Figure 306 Fast response sprinkler

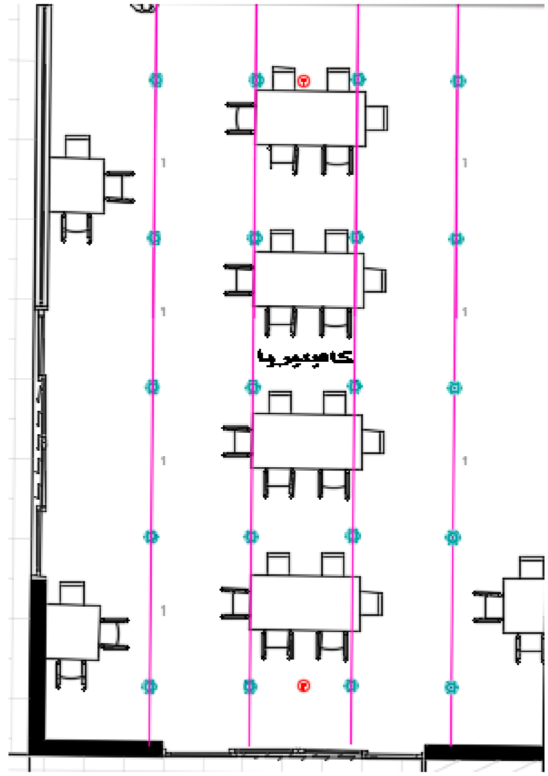
Sprinklers are used in many rooms in project, take an example multipurpose room, in this situation it is a high hazard room.

According to the previous table, it should cover area that equal 9.3 m^2 and the distance between each sprinkler less than 3.6 m.

Sample calculation:

area =179.52 m^2

$$\text{Number of sprinklers} = \frac{179.52}{9.3} = 19.3$$



- Number of sprinklers = 20 (4*5)
- Maximum distance < 3.6 m OK.

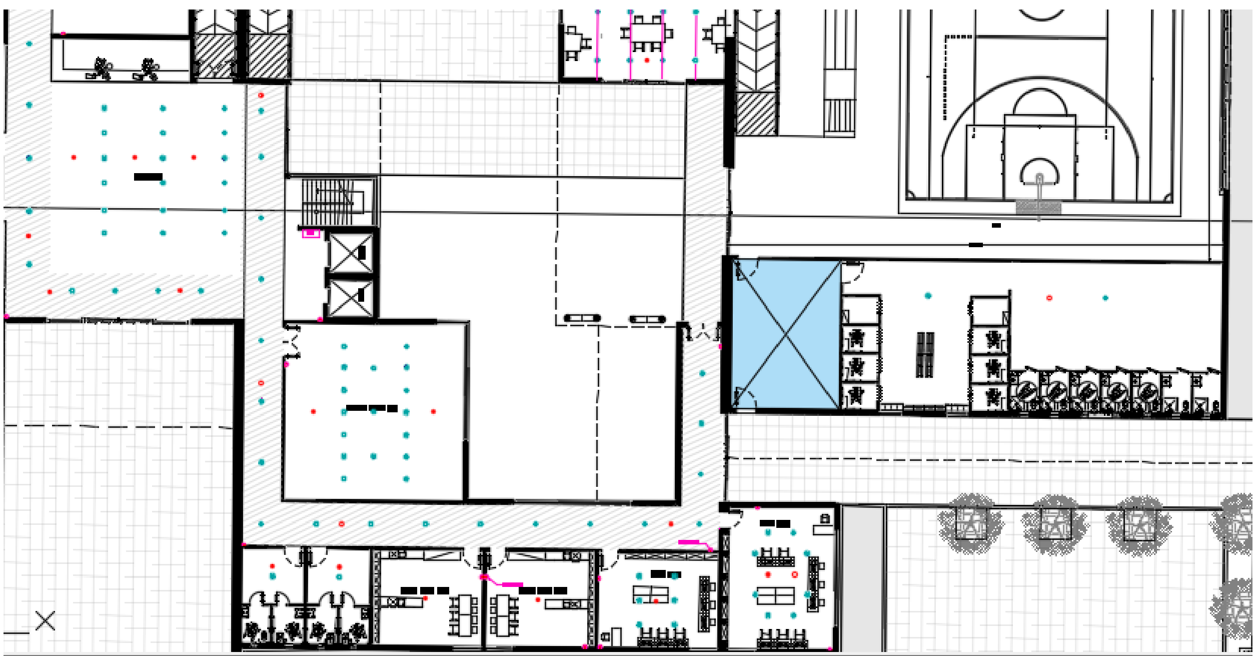


Figure 307 Sprinklers plan

- **Fire detectors**

Fire detector device works as a sensor for fire, to know that there is fire in the building and to start the fire fighting system.

Figure 308 Fire detector

- **Fire alarm**

it is a device to alert all the occupants in the building that there is a fire.

Figure 309 Fire alarm

8.2 Emergency exit

Readiness and planning for emergency such as fire occurs, earthquake, wars etc. is one of the terms that the building will not get its license from the civil defense, so the designer should provide a clear plan for emergency, escape outlet according to their specifications.

In this project, escape outlet is planned according to civil defend specification and according to the situation of the project.

One of the standard that is the maximum length of escaping bath should not exceed 30 m. So, it is important to change some interior design, for example, instead of using W. C's as its high number, put an emergency staircase for disabled, and selected the outside ramps as an emergency exit after editing its slope.

The new additional for this project, is an elevator with one hydraulic standing that it is allowed the elevator to go upward and downward, but the special aspect is the expansion and compression properties.

This idea is taking from a system is already used but we change some of its work principle to be appreciate with this project.

It is a platform provides with a grid net and rails to make it safe for disabled. When fire occurs the emergency exit door open and let the people go inside this platform with a helping by a special team, then when the elevator goes downward by an outdoor railway on the exterior wall that allow the elevator to transfer through it there is a small ramp open to make the movement easy with no obstacles.

There is battery outside the building with a motor that is design as a different part from the building to make sure that it is works even there is no electricity in the building and to make it as safe as possible.

All the weight, loads, hanging weight, hydraulic parts and all electrical issues should be designed perfectly.

(escape and rescue system, n.d.)

The pictures below, it is the elevator system that is the idea supposed to be.

Figure 310 emergency elevator (escape and rescue system, n.d.)

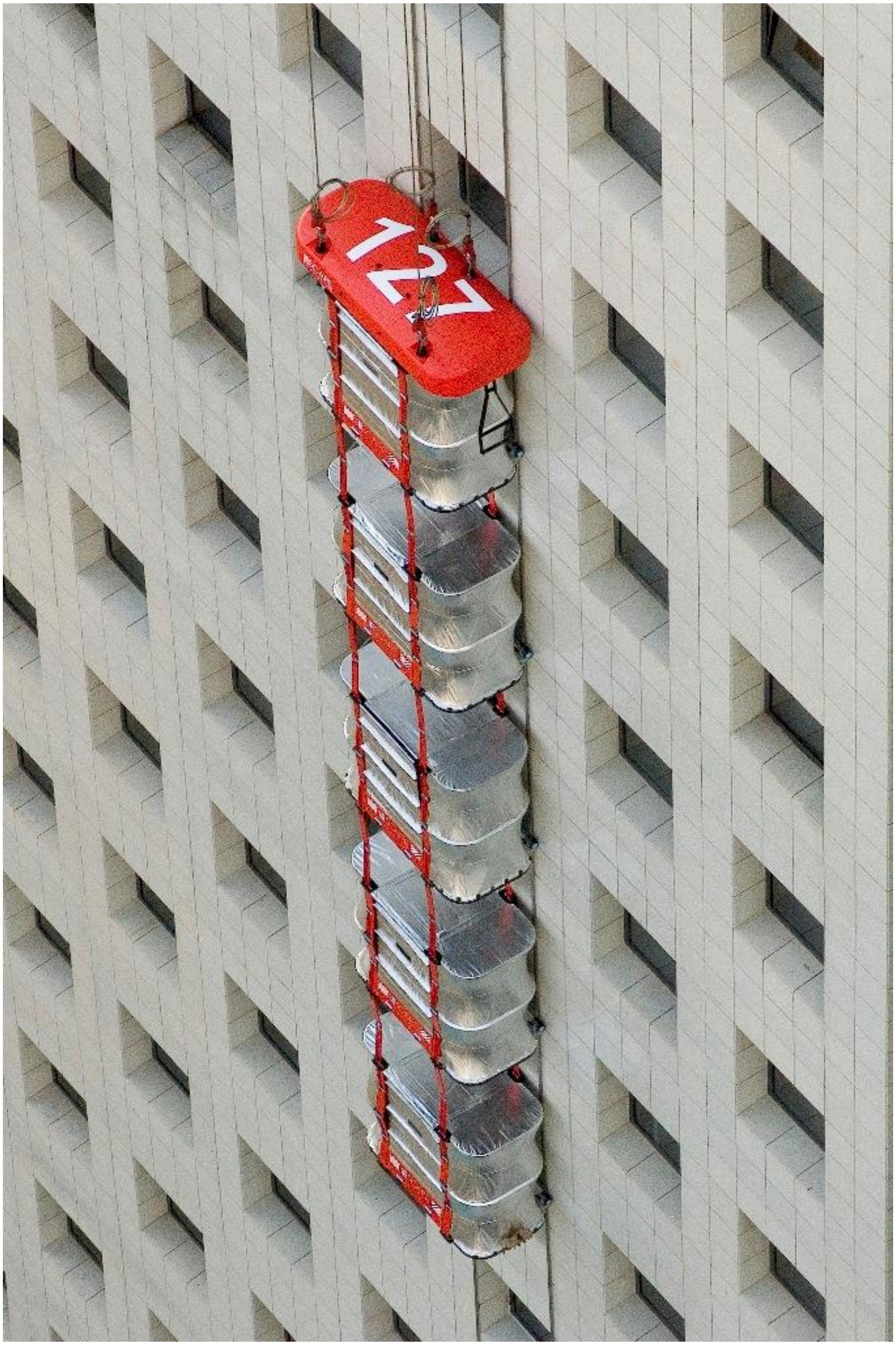


Figure 311 emergency elevator (escape and rescue system, n.d.)

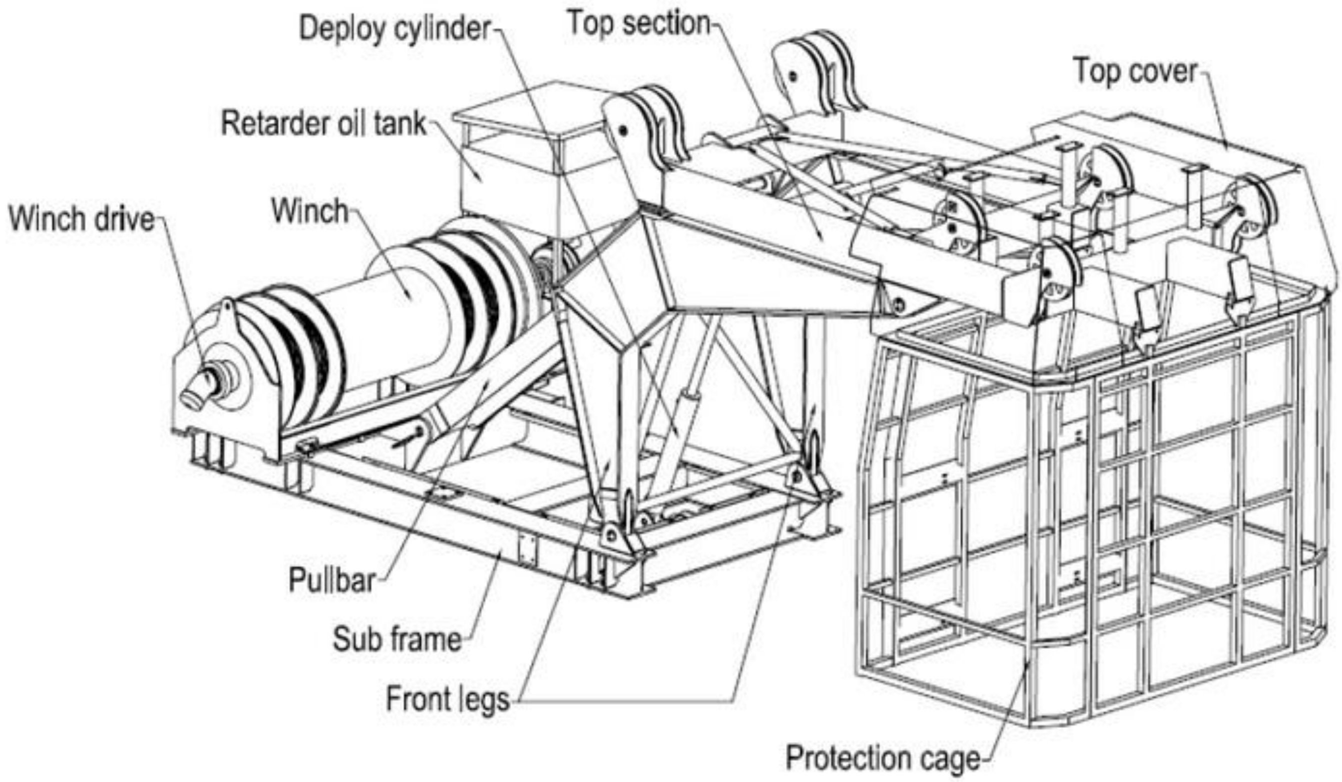


Figure 313 emergency elevator parts (escape and rescue system, n.d.)

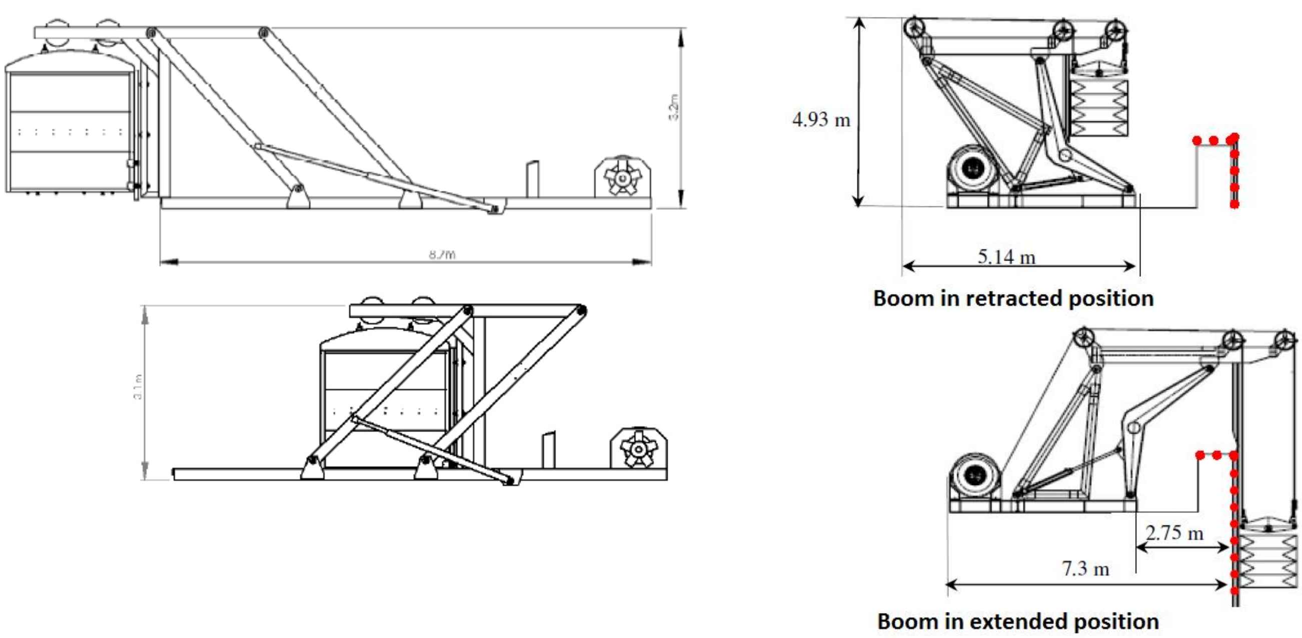


Figure 312 emergency elevator parts

Solutions for emergency exit

1. Mattress sheets and slip mats: These can be used for people who are bound to bed and people who have a problems and difficulties in movement.
   Mats or evacuation pads, looks like a thin mattress with clamps which The person being tied with it while evacuated to the safety zone.
   mats and sheets can be used through the stairs and corridors.
   (Marsden fire safety, 2017-2019)

Figure 314 slip mats

2. Evacuation chairs: Moving people downstairs and upstairs makes it relatively easy. They come in different sizes and form different capacities and functions.
   The use of an evacuation chair reduces the risk of manual handling and associated hurts, which could occur if a person is carried from the building.

(Marsden fire safety, 2017-2019)

Figure 315 Evacuation chairs

3. Bariatric equipment: it is a device to move disabled people or bariatric if it is impossible to use electric systems, it securely keeps the person in place and allow rescuers to evacuate them safely along stairs and corridors.
(Marsden fire safety, 2017-2019)

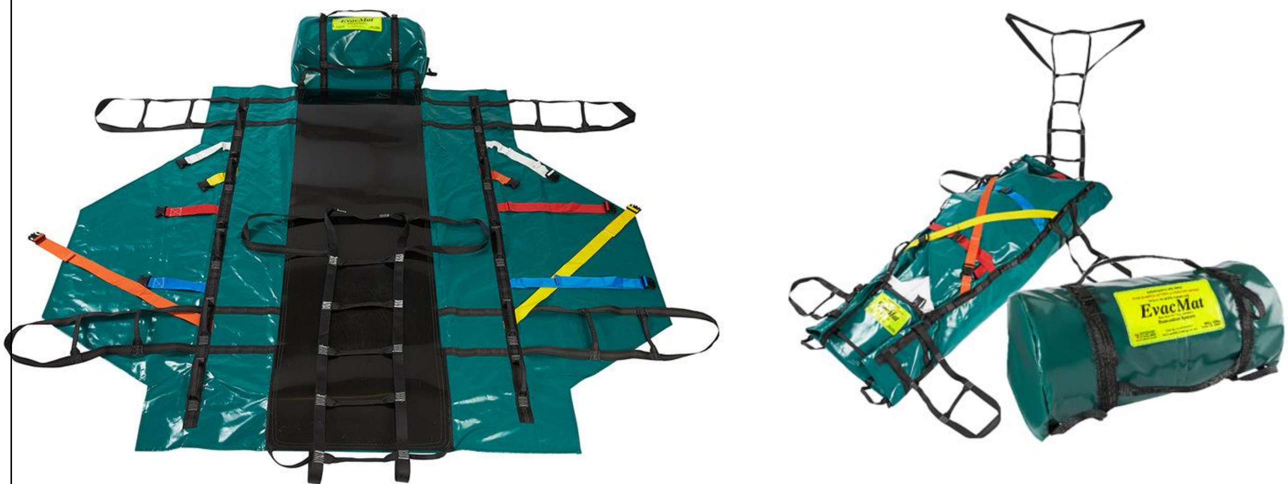
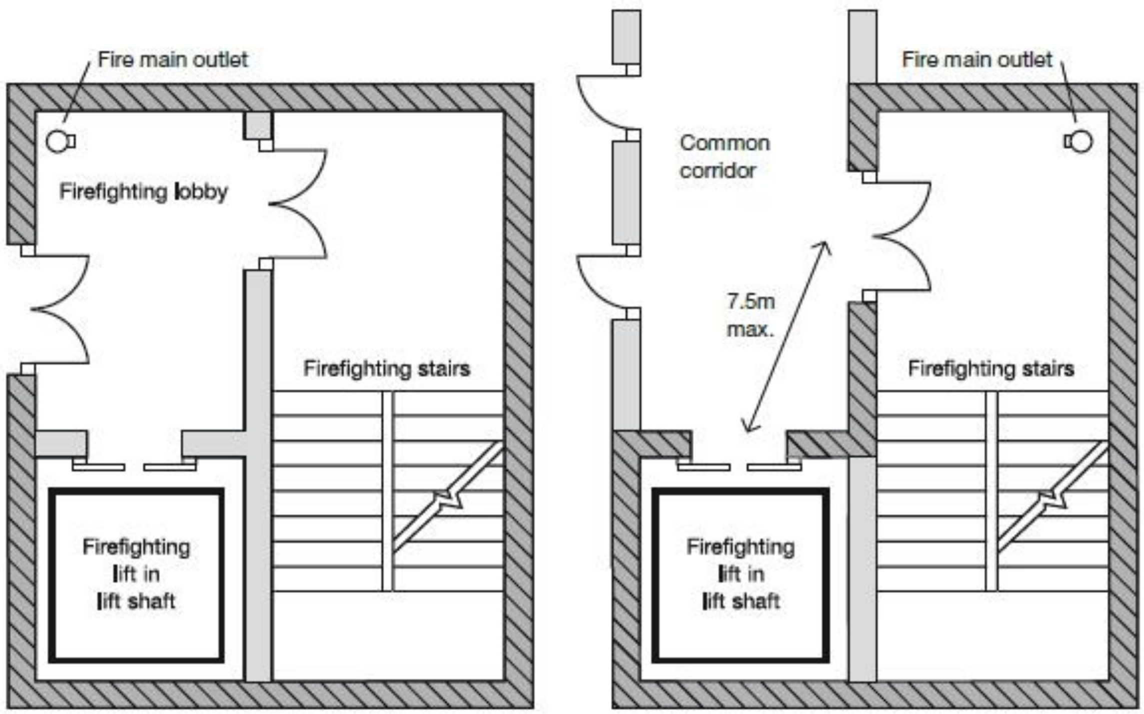


Figure 316 Bariatric equipment (Marsden fire safety, 2017-2019)

- Using stairs for escaping

a. Any building

b. Shafts serving flats



Minimum fire resistance 60 minutes from both sides with 30 minute fire doors

Minimum fire resistance 120 minutes from accommodation side and 60 minutes from inside the shaft with 60 minute fire doors

Notes:

1. Outlets from a fire main should be located in the firefighting lobby or, in the case of a shaft serving flats, in the firefighting stairway (see Diagram b).
2. Smoke control should be provided in accordance with BS 5588-5:2004 or, where the shaft only serves flats, the provisions for smoke control given in paragraph 2.25 may be followed instead.
3. A firefighting lift is required if the building has a floor more than 18m above, or more than 10m below, fire service vehicle access level.
4. This Diagram is only to illustrate the basic components and is not meant to represent the only acceptable layout. The shaft should be constructed generally in accordance with clauses 7 and 8 of BS 5588-5:2004.

Figure 317 Emergency stairs (designingbuildings, 2004)

Types of disabled and methods for rescue

1. Wheelchairs users: wheelchairs users should stay in the place or move to refuge area when the alarm starts. then the evacuation assistant should help disabled to evacuate them outside the building to refuge point. this process should be conducted by professionals.
2. Hearing Impaired: they must be alerted by * strobe fire alarm lights. if it is not available, they should be alerted by writing a clear short note to evacuate or by hand gestures.

* A strobe light is a device used to produce uniform flashes of light. The source of the light is commonly xenon flash lamp, the color temperature of approximately 5,600 kelvins.

3. Visually Impaired: they can hear the alarm when starts but they need a help from professional assistance to evacuate from the right path to reach refuge zone.

(Disabilities) (escape and rescue system, n.d.)

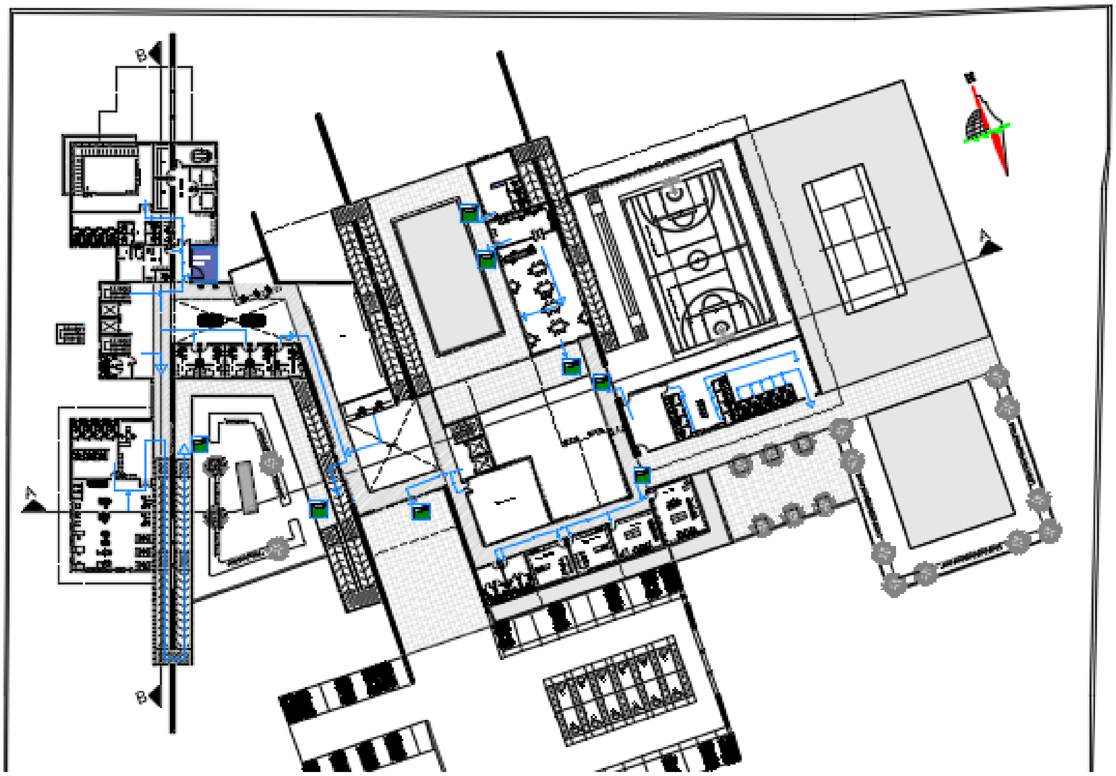


Figure 319 ground floor emergency plan

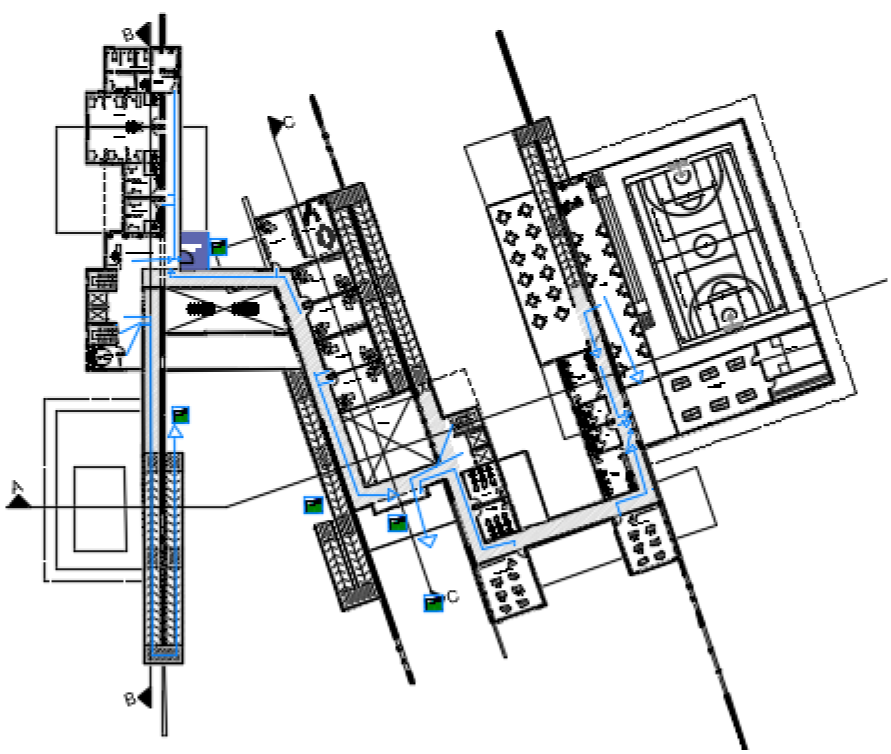


Figure 318 First floor emergency plan

CHAPTER 9

9.0 Quantity and serving cost

9.1 Quantity calculations

Note that calculation was done on two block which were design as full structural design and detailing

- First block: gym
- Total area of gym

Store	Area(m^2)
Ground floor	256
First floor	121

Table 49 area in the block

Earth work:

From AUTOCAD drawing earth work was done

Excavation , backfilling & disposal					
	excavation		backfilling		disposal
	Bank volume	Loose volume	Compacted volume	Loose volume	Loose volume
ground	1635.2	2044	1635.2	-	-
footing	98.04	122.55	73.35	-	-
total		2166.55	1708.55		458

Table 50 Earth work quantity

Civil work

- Foundation

1. Blinding concrete

This table show the volume of concrete need for blinding under footing

footing	area(m^2)	depth(m)	iteration	Volume((m^3)
F1	2.21	0.1	2	0.442
F2	0.7	0.1	2	0.14
F3	5.76	0.1	2	1.152
F4	5.28	0.1	6	3.168
			Total	4.902

Table 51 concrete volume for blinding

- <u>Sample calculation for footing 1 for blinding</u>

Volume of concrete = 2.21*0.1*2 = 0.442m^3

1. Concrete of footing:

Table show the needed concrete volume for footing

footing	Length(m)	Width(m)	Depth(m)	Iteration	volume(m^3)
F1	1.7	1.3	0.5	2	2.21
F2	1	0.7	0.5	2	0.7
F3	2.4	2.4	0.5	2	5.76
F4	2.4	2.2	0.5	6	15.84
				Total	24.51

Table 52 concrete volume for footing

- <u>Sample calculation for footing 1:</u>

Volume = area * depth * #no. = (1.7*1.3)*0.5*2 = 2.21(m^3)

2. Formwork of footing:

Footing	Parameter(m)	Depth(m)	No. of footing	Area of formwork(m^2)
F1	6.8	0.5	2	6.8
F2	4.2	0.5	2	4.2
F3	10.4	0.5	2	10.4
F4	10	0.5	6	30
			Total	51.4

Table 53 formwork for footing

- <u>Sample calculation for footing 1</u>

Area of formwork = parameter * depth * no. = (1.9*2+1.5*2)*0.5*2 = 6.8(m^2)

2. <u>Reinforcement steel for footing:</u>

No.of bars	diameter	Steel bar length	Total length vertical (m)	Weight (kg/m)	Total weight
9	12	2.7	24.3	0.888	43.16
7	12	2.3	16.1	0.888	28.59
4	14	1.7	6.8	1.209	16.44
3	14	2	6	1.209	14.51
16	14	3.4	54.4	1.209	131.54
16	14	3.4	54.4	1.209	131.54
13	14	3.4	44.2	1.209	320.63
14	14	3.2	44.8	1.209	324.98
				Total	1011.39

Table 54 Reinforcement steel for footing

- Column neck:

1. Formwork of column neck:

Column neck			
High of column neck(m)	Parameter of column neck(m)	No.of column neck	Area of formwork(m^2)
0.95	3.6	4	13.68
0.95	2.4	2	4.56
0.95	2.8	5	13.3
		Total	31.54

Table 55 Column neck

Sample calculation:

Area of formwork= parameter * no. * high = (1.1*2+0.7*2)*4*0.95 = 13.68(m^2)

1. Concrete for column neck:

High of column neck(m)	Area of column neck(m^2)	No. of column	Volume(m^3)
0.95	0.6	4	2.28
0.95	0.25	2	0.475
0.95	0.35	5	1.6625
		Total	4.4175

Table 56 concrete for column neck

Sample calculation:

Volume of concrete = area * high * No. = 0.6*0.95*4 = 2.28**(m^3)**

- Reinforcement of column neck Steel bar

No.of bars	diameter	Steel bar length(m)	Total length vertical (m)	Weight (kg/m)	Total weight
40	20	2	80	2.466	197.28
72	20	2	144	2.466	355.10
24	20	2	48	2.466	118.37
40	20	2	80	2.466	197.28
				Total	868.03

Table 57 Reinforcement of column neck

- <u>Stirrups</u>

Stirrups length	No of stirrups	Weight (kg/ml)	Total weight
19.2	10	0.616	118.27
10.8	10	0.616	66.53
8.4	10	0.616	51.74
8.4	10	0.616	51.74
		Total	288.29

Table 58 Stirrups

- Tie beams

1. Formwork and concrete of tie beams

Formwork and concrete for tie beam						
beam	Total length(m)	No	Depth(m)	Width(m)	concrete(m^3)	formwork(m^2)
1	121	1	0.6	0.3	21.78	217.8

Table 59 formwork and concrete for tie beams

Sample calculation:

Total concrete volume = 121 *0.6*0.3 =21.78

Total formwork= 121*(2*0.6+2*0.3) =217.8

- Slab on grade

1. Formwork of slab on grade:

Formwork for slab on grade		
Parameter(m)	Depth(m)	Area of formwork(m^2)
82	0.1	8.2

Table 60 formwork for slab on grade

Sample calculation:

Area of formwork = parameter * depth = 82*0.1 = 8.2(m^2)

2. Concrete of slab on grade

Concrete for slab on ground		
Area(m^2)	Depth(m)	Volume(m^3)
380	0.1	38

Table 61 concrete for slab on ground

Sample calculation:

Volume of concrete = area * depth = 380*0.1 = 38$(\boldsymbol{m^3})$

- Column

1. Concrete of column:

Concrete for column					
column	section	area$(\boldsymbol{m^2})$	Length(m)	NO.	volume$(\boldsymbol{m^3})$
C1	100*60	0.6	5.1	4	12.24
C2	50*50	0.25	5.7	2	2.85
C3	70*50	0.35	5.1	3	5.355
C4	70*50	0.35	5.7	2	3.99
				Total	24.435

Table 62 Concrete for column

Sample calculation of column 1:

Volume = area* length * NO. = (1*0.6)*5.1*4 = 12.24$(\boldsymbol{m^3})$

2. Formwork for column:

Column	Parameter(m)	Area of formwork$(\boldsymbol{m^2})$
C1	3.6	73.44
C2	2.4	27.36
C3	2.8	42.84
C4	2.8	31.92
	Total	175.56

Table 63 formwork for columns

Sample calculation:

Area of formwork = parameter * length * NO =3.6*5.1*4 = 73.44$(\boldsymbol{m^2})$

3. Reinforcement steel of column

	No. of bars	diameter	Steel bar length	Total length vertical (m)	Weight (kg/m)	Total weight
C1	40	20	5	200	2.466	493.20
C2	72	20	5	360	2.466	887.76
C3	24	20	5	120	2.466	295.92
C4	40	20	5	200	2.466	493.20
C4	24	20	2	48	2.466	118.37
					Total	2288.45

Table 64 Reinforcement steel for column

- <u>beams:</u>

1. beams concrete

Beam	Length(m)	Width(m)	Depth(m)	Volume of concrete(m^3)
B1	143.4	0.8	1	114.72
B2	27.2	0.53	0.5	7.208
			Total	121.928

Table 65 beam concrete

- <u>Sample calculation of beam 1</u>

Volume of concrete = area of beam * length = (1*0.8)*143.4 = 114.72(m^3)

2. Formwork of beams:

Beam	Parameter(m)	Length(m)	Area of formwork(m^2)
B1	4	143.4	573.6
B2	5.46	27.2	148.512
		Total	722.112

Table 66 Beams formwork

Sample calculation:

Area of formwork = parameter * length = 4*143.4 = 573.6(m^2)

- <u>slab</u>

1. Slab concrete:

Slab type	volume(m^3)
U-boot slab	35.9
Solid slab	42.35
Total	78.25

Table 67 Slab concrete

2. Slab formwork:

	Formwork area(m^2)
Ground floor	119
First floor	121
Total	140

Table 68 Slab formwork

- Reinforcement steel for slab

No.of bars	diameter	Steel bar length	Total length vertical (m)	Weight (kg/m)	Total weight
56	14	3	168	1.209	203.11
56	14	2.8	156.8	1.209	189.57
48	14	14.6	700.8	1.209	847.27
24	14	29	696	1.209	841.46
32	14	3.5	112	1.209	135.41
32	14	9.8	313.6	1.209	379.14
2	8	29	58	0.202	11.72
3	8	9.8	29.4	0.202	5.94
3	8	3.5	10.5	0.202	2.12
6	8	14.6	87.6	0.202	17.70
8	8	6	48	0.202	9.70
				Total	2643.13

Table 69 Reinforcement steel for slab

- Walls:

1. Concrete and formwork for walls:

		Concrete			
Length of wall(m)	Height of wall(m)	Thickness(m)	volume(m^3)		Formwork (m^2)
13	4.65	0.2	12.09		60.45
15.6	4.65	0.2	14.508		72.54
		Total	26.598	Total	132.99

Table 70 concrete and formwork for walls

➢ Architectural work

Internal partition blocks and volume of mortar needed:

Ground floor blocks(20cm) &mortar(1cm)								
wall	Area walls(m^2)	#doors	Area of door(m^2)	#of window	Window area(m^2)	Total area(m^2)	#of blocks	Volume of mortar(m^3)
W1	64.17	2	6.06	0	0	58.11	697.32	0.87165
W2	46.5	0	0	0	0	46.5	558	0.6975
W3	29.76	0	0	0	0	29.76	357.12	0.4464
W4	25.11	0	0	0	0	25.11	301.32	0.37665
W5	2.9	0	0	0	0	2.9	34.8	0.0435
W6	39.06	0	0	0	0	39.06	468.72	0.5859
W7	17.84	0	0	0	0	17.84	214.08	0.2676
					Total	219.28	2631.36	3.2892

Table 71 internal work

External wall blocks and volume of mortar:

Ground floor								
wall	Area walls(m^2)	#doors	Area of door(m^2)	#of window	Window area(m^2)	Total area	#of blocks	Volume of mortar(m^3)
W1	60.45	0	0	0	0	60.45	726	.85
W2	72.54	0	0	0	0	72.54	871	1
					Total	133	1597	1.85

Table 72 External walls

Plastering and painting: wall	Area walls(m^2)
Int .wall	219.28
Ex.wall	133

Table 73 Plaster and painting

- <u>Tiling</u>

Using AUTOCAD to find total floor area:

Floor	Area (m^2)
	377

Table 74 Tiling area

- <u>Doors and window</u>

door type	Height(m)	Width(m)	N	parameter	door area(m^2)
باب سحاب	2.8	4.4	1		12.32
باب زوجي	2.8	2	1		5.6
باب فردي	2.8	1.2	1		3.36
باب حمام	2	1	4		8
				Tot	29.28

Table 75 Doors and windows

- <u>Curtain wall</u>

Curtain wall	**Area**(m^2)
Total	83.95

Table 76 Curtain wall

9.2 Cost calculation

9.2.1 Gym block

Activity Name	Unit	Quantity (Unit)	Unit Cost (NIS/Unit)	Total Cost (NIS)	Labor Unit Cost (NIS/Unit)	Total Labor Cost (NIS)	Unit Cost (NIS/Unit)	Total Cost (NIS)
Structure Work								
Sub-Structure								
Earthworks								
Excavation	CM	2166.55	0	0	50	108327.5	50.00	108,328
Disposal For Excavation	CM	458	0	0	80	36640	80.00	36,640
Concrete Work								
Blinding	CM	393.53	350	137735.5	50	19676.5	400.00	157,412
Foundations	CM	24.51	350	8578.5	150	3676.5	500.00	12,255
Insulation	SM	131.2	6	787.2	10	1312	16.00	2,099
Super-Structure								
Concrete Work								
Columns	CM	24.4	350	8540	150	3660	500.00	12,200
Beams	CM	122	350	42700	150	18300	500.00	61,000
Stairs	CM	0	350	0	100	0	#DIV/0!	0
Slabs	CM	78.25	350	27387.5	150	11737.5	500.00	39,125
Block Work								
External Block	SM	133	30	3990	15	1995	45.00	5,985
Internal Block	SM	219.28	30	6578.4	15	3289.2	45.00	9,868
U-boot	unit	530	25	13250	15	7950	40.00	21,200
Block Work	unit	4228	2	8456	10	42280	12.00	50,736
Steel Work								
Foundations	Ton	1.01	3000	3030	500	505	3500.00	3,535
Columns	Ton	0.298	3000	894	500	149	3500.00	1,043
Beams	Ton	4.5	3000	13500	500	2250	3500.00	15,750
Slabs	Ton	4	3000	12000	500	2000	3500.00	14,000

Figure 320 Cost for Gym block

Activity Name	Unit	Quantity (Unit)	Unit Cost (NIS/Unit)	Total Cost (NIS)	Labor Unit Cost (NIS/Unit)	Total Labor Cost (NIS)	Unit Cost (NIS/Unit)	Total Cost (NIS)
Stone Work								
Stone Work	SM	1911	160	305760	25	47775	185.00	353,535
concrete Work	CM	191.1	350	66885	15	2866.5	365.00	69,752
Stone cural	SM	1911	10	19110	20	38220	30.00	57,330
Finishing								
Plastering	SM	352.28	20	7045.6	25	8807	45.00	15,853
Tiling	SM	377	50	18850	20	7540	70.00	26,390
Painting	SM	352.28	15	5284.2	10	3522.8	25.00	8,807
False Ceiling	SM	377	150	56550	10	3770	160.00	60,320
Curtain Walls	SM	84	600	50400	300	25200	900.00	75,600
Doors Installation (Metal)	No	1	3200	3200	300	300	3500.00	3,500
Doors Installation (Wood)	No	7	1500	10500	300	2100	1800.00	12,600
Mechanical Work								
Drainage Work								
2 Inch Drainage Pipe	LM	8.5	15	127.5	5.36	45.56	20.36	173.06
4 Inch Drainage Pipe	LM	14.27	35	499.45	18.19	259.5713	53.19	759
6 Inch Drainage Pipe	LM	13.5	45	607.5	100	1350	145.00	1,958

Figure 321 cost for Gym block

Activity Name	Unit	Quantity (Unit)	Unit Cost (NIS/Unit)	Total Cost (NIS)	Labor Unit Cost (NIS/Unit)	Total Labor Cost (NIS)	Unit Cost (NIS/Unit)	Total Cost (NIS)
Water Supply Piping System								
Sink	No	50	955	47750	70	3500	1025.00	51,250
Water Closet (W.C)	No	1	1400	1400	300	300	1700.00	1,700
Manholes	No	2	200	400	300	600	500.00	1,000
Steel Pipes Water Supply	LM	91	85	7735	133.34	12133.94	218.34	19,869
Collector	No	1	350	350	300	300	650.00	650
Water Tanks Installation	No	1	600	600	25	25	625.00	625
Boiler	No	1	30000	30000	0	0	30000.00	30,000
Safety Works								
Fire Extinguisher	No	2	100	200	10	20	110.00	220
Automatic Sprinklers	No	33	190	6270	10	330	200.00	6,600
Heat Detector	No	4	20	80	20	80	40.00	160
Electrical Work								
Wires								
1.5 mm Wire	LM	102	1.5	153	8	816	9.50	969
2.5 mm Wire	LM	37	0.9	33.3	8	296	8.90	329
Sockets								
2 Amp	No.	15	9	135	20	300	29.00	435
LAmp	No.	43	120	5160	15	645	135.00	5,805
Switches	No.	12	10	120	10	120	20.00	240

Figure 322 cost for Gym block

Activity Name	Unit	Quantity (Unit)	Unit Cost (NIS/Unit)	Total Cost (NIS)	Labor Unit Cost (NIS/Unit)	Total Labor Cost (NIS)	Unit Cost (NIS/Unit)	Total Cost (NIS)
Circuit Breakers								
10 Amp C.B	No.	2	15	30	15	30	30.00	60
16 Amp C.B	No.	3	15	45	15	45	30.00	90
40 Amp C.B	No.	50	40	2000	15	750	55.00	2750
DB	No.	1	250	250	15	15	265.00	265
MDB	No.	1	400	400	15	15	415.00	415
Total cost for Gym block								937,897

Figure 323 Total cost for Gym block

- Total block cost = 937.897 NIS
- UNIT COST (NIS/M^2) = 937.897/256 = 3663 NIS/M^2

9.2.2 Stadium block

Activity Name	Unit	Quantity (Unit)	Unit Cost (NIS/Unit)	Total Cost (NIS)	Labor Unit Cost (NIS/Unit)	Total Labor Cost (NIS)	Unit Cost (NIS/Unit)	Total Cost (NIS)
Structure Work								
Sub-Structure								
Earthworks								
Excavation	CM	460	0	0	50	23000	50.00	23,000
Disposal For Excavation	CM	344.8	0	0	80	27584	80.00	27,584
Concrete Work								
Blinding	CM	30.1	350	10535	50	1505	400.00	12,040
Foundations	CM	84.32	350	29512	150	12648	500.00	42,160
Insulation	SM	1106	6	6636	10	11060	16.00	17,696
Super-Structure								
Concrete Work								
Columns	CM	50	350	17500	150	7500	500.00	25,000
Slabs	CM	110.6	350	38710	150	16590	500.00	55,300
Block Work								
External Block	SM	237.28	30	7118.4	15	3559.2	45.00	10,678
Internal Block	SM	308.9	30	9267	15	4633.5	45.00	13,901
Insulation	SM	542	6	3252	10	5420	16.00	8,672
Steel Work								
Foundations	Ton	2.079	3000	6237	500	1039.5	3500.00	7,277
Columns	Ton	7.56	3000	22680	500	3780	3500.00	26,460
Steel beam	SM	1106	500	553000	500	553000	1000.00	1,106,000
Slabs	Ton	3.5	3000	10500	500	1750	3500.00	12,250

Figure 324 Cost for stadium block

Activity Name	Unit	Quantity (Unit)	Unit Cost (NIS/Unit)	Total Cost (NIS)	Labor Unit Cost (NIS/Unit)	Total Labor Cost (NIS)	Unit Cost (NIS/Unit)	Total Cost (NIS)
Stone Work								
Stone Work	SM	137.2	160	21952	25	3430	185.00	25,382
concrete Work	CM	137.2	350	48020	15	2058	365.00	50,078
Stone cural	SM	137.2	10	1372	20	2744	30.00	4,116
Finishing								
Plastering	SM	546.18	20	10923.6	25	13654.5	45.00	24,578
Tiling	SM	1106	50	55300	20	22120	70.00	77,420
Painting	SM	546.18	15	8192.7	10	5461.8	25.00	13,655
False Ceiling	SM	1106	150	165900	10	11060	160.00	176,960
Curtain Walls	SM	291	600	174600	300	87300	900.00	261,900
Doors Installation (Metal)	No	1	3200	3200	300	300	3500.00	3,500

Figure 325 cost for stadium block

Activity Name	Unit	Quantity (Unit)	Unit Cost (NIS/Unit)	Total Cost (NIS)	Labor Unit Cost (NIS/Unit)	Total Labor Cost (NIS)	Unit Cost (NIS/Unit)	Total Cost (NIS)
Safety Works								
Fire Extinguisher	No	2	100	200	10	20	110.00	220
Automatic Sprinklers	No	10	190	1900	10	100	200.00	2,000
Hose Station	No	1	300	300	50	50	350.00	350
Heat Detector	No	12	20	240	20	240	40.00	480
Electrical Work								
Wires								
1.5 mm Wire	LM	318	1.5	477	8	2544	9.50	3,021
2.5 mm Wire	LM	42	0.9	37.8	8	336	8.90	374
Sockets								
sockets	No.	10	9	90	20	200	29.00	290
LAmp	No.	59	120	7080	15	885	135.00	7,965
Switches	No.	4	10	40	10	40	20.00	80
Circuit Breakers								
10 Amp C.B	No.	5	15	75	15	75	30.00	150
16 Amp C.B	No.	3	15	45	15	45	30.00	90
40 Amp C.B	No.	2	40	80	15	30	55.00	110
DB	No.	2	250	500	15	30	265.00	530
MDB	No.	1	400	400	15	15	415.00	415
Total cost for stadium block								1,966,220

Figure 326 Total cost for stadium block

➢ References

- (n.d.). Retrieved from escape and rescue system: http://www.escaperescue.com/products/general-specifications
- (2004). Retrieved from designingbuildings: https://www.designingbuildings.co.uk/w/images/c/c6/Firefighting_shaft.jpg?fbclid=IwAR2uIrXlHmLE43QbyNXLWYHjztofbtEpXBngQN-8JWdcvpZkbq-O_O_XIb8
- (n.d.). *area of refuge.* North America.
- Disabilities, P. w. (n.d.).
- Hashimoto, T. (Sep. 25, 2001). UILDING AIR CONDITIONING SYSTEM USING GEOTHERMAL ENERGY . *United States Patent*.
- *Marsden fire safety*. (2017-2019). Retrieved from https://www.marsden-fire-safety.co.uk/resources/disabled-evacuation?fbclid=IwAR13GpFaVmnF7NbxGRBBLukRo_zq8GXejKM7BvLWy1m53KY8K6w-Vkx3FGk
- Nathanson, J. A. (2019, Nov 8). *Britannica*. Retrieved from www.britannica.com/technology/water-supply-system
- *Renweable energy world*. (2016, 2 24). Retrieved from The Hidden Genius of Geothermal HVAC Systems: https://www.renewableenergyworld.com/2016/02/24/the-hidden-genius-of-geothermal-hvac-systems/#gref
- S.Al-Zyoud. (February 2014). Dynamic numerical modeling of the usage of groundwater for cooling in north east Jordan – A geothermal case study. *science direct*, 63-72.
- the thermal insulation desigh for refuge champer. (2013). *article preview*, 805-806.
- *Wikipedia*. (2016, january 9). Retrieved from https://en.wikipedia.org/wiki/Area_of_refuge
- Wolf. (Apr.20,1982). EOTHERMAL HEATING AND COOLING SYSTEM. *United States Patent* .