Graduation Project report- II

Faculty of Engineering & Information Technology

Department of Building Engineering

Integrative Design of a Hotel

By : Adham N. Mahamdeh

Alaa M. Mahroom

Fadi Z. Shaar

Osama M. Al-Hamouz

Supervisor : Eng. Fadi Fatayer

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Dedication

حمدا لله سبحانه وتعالى ...

الى الحبيب المصطفى محمد ﷺ ...

الى ثرى هذا الوطن وكل من عبر برفق وخدم ترابه

اليك فلسطين ...

الى القدس زهرة المدائن ...

الى شهداء هذا الوطن واسراه البواسل ...

إلى أبي الذي لم يبخل علي يوماً بشيء ...

وإلى أمي التي زودتني بالحنان والمحبة ...

إلى كل من علمني حرفاً أصبح سنا برقه يضيء الطريق أمامي ...

إلي كل من أضاء بعلمه عقل غيره

أو هدى بالجواب الصحيح حيرة سائليه ...

الى اهلي وعشيرتي ...

الى زملائي وزميلاتي ...

واهداء خاص الى استاذي المشرف فادي فطاير ...

أهدي هذا البحث المتواضع راجياً من المولى
عز وجل أن يجد القبول والنجاح

Acknowledgment

يقول تعالى: (يَا أَيُّهَا الَّذِينَ آَمَنُوا كُلُوا مِنْ طَيِّبَاتِ مَا رَزَقْنَاكُمْ وَاشْكُرُوا لِلَّهِ إِنْ كُنْتُمْ إِيَّاهُ تَعْبُدُونَ)

ويقول النبي ﷺ: (من لا يشكر الناس لا يشكر الله)

الحمد لله الّذي بعزّته وجلاله تتمّ الصالحات، الحمد لله الذي أنعم علينا بنعم كثيرة أعظمها أنه من علينا بالإسلام ....

شكرا الى احب الناس الى قلوبنا نبينا المصطفى الحبيب محمد ﷺ

اما بعد :

لابد لنا ونحن نخطو خطواتنا الأخيرة في الحياة الجامعية من وقفة نعود إلى أعوام قضيناها في رحاب الجامعة مع أساتذتنا الكرام الذين قدموا لنا الكثير باذلين بذلك جهودا كبيرة في بناء جيل الغد لتبعث الأمة من جديد...

وكذلك نشكر كل من ساعد على إتمام هذا البحث وقدم لنا العون ومد لنا يد المساعدة وزودنا بالمعلومات اللازمة لإتمام هذا البحث

الذين كانوا نورا يضيء الظلمة التي كانت تقف أحيانا في طريقنا...

كما نشكر الهيئة الإدارية والتدريسية في جامعة النجاح الوطنية ... ونخص بالذكر معلمنا

رئيس قسم هندسة البناء الدكتور منذر دويكات لك منا كل الثناء والتقدير

وأيضا وفاء وتقديرا وإعترافا منا بالجميل نتقدم بجزيل الشكر لأولئك المخلصين الذين لم يألوا جهداً في مساعدتنا في مجال البحث العلمي، وأخص بالذكر الأستاذ الفاضل : فادي فطاير ... الذي تفضل بالإشراف على هذا البحث فجزاه الله عنا كل خير فله منا كل التقدير والاحترام.

Disclaimer statement:

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ABSTRACT

The Historical and religious places will attract the tourists around the world.

Nablus City is considered as one of the most commercial and religious city in Palestine. Moreover, it has the second place in terms of area, it contains many entertainment places, associations and institutions.

Although Nablus city in counter many foreign people come from either tourists or business, still there is lack of one structural integrated hotel that contains all requirements and provide the best services, according to the last mentioned reason the hotel idea was emerged.

The hotel has been designed as a 4-stars hotel on the north mountain (Sama Nablus) to serve 60 bedroom in four bedrooms floors, for the environmental aspects hotel is mainly oriented to the south, cantilevers and louvers have been used for shading and all openings have been designed to get the best daylights, in the structural side two way ribbed and one way ribbed have been used with drop beams.

To get these results many programs and codes have been used like Uniform building Code (UBC97), International Building Code (IBC), Jordanian Building Code 2005, Arab Uniform Code 2006 and ACI 318-2008 the structural design have been built by Sap 2000 and Etabs, Revit have been used for 3-D models and AutoCAD for 2-D plans.

ASHRE standard for heating, ventilation and air conditioning have been used, In addition to that DIAlux, which used for lighting design depending on LEED specification.

Ecotect have been used for heating and cooling design, daylight factors and acoustics design.

CHAPTER

1. INTRODUCTORY

1.1. INTRODUCTION

This project presents an integrated and environmental design of Hotel to provide the best services**.** The hotel design has been focused primarily on functionality and operations and it has been designed with taken in the consideration many sides of architectural, structural, environmental mechanical, electrical and safety design strategies and aspects. This aims to apply practically, the various theories we have studied in last four years.

The selected location for the Hotel has been in North part of Nablus at North Mountain near Sama Nablus and Al-Najah hospital.

“The hotel is an establishment that provides lodging paid on a short-term basis. Facilities provided may range from a basic bed and storage for clothing, to luxury features like en-suite bathrooms. Larger hotels may provide additional guest facilities such as a swimming pool, business center, childcare, conference facilities and social function services. Hotel operations vary in size, function, and cost. Most hotels and major hospitality companies have set industry standards to classify hotel types”. (Wikipedia)

1.2. PROJECT PROBLEM

In the last years, the number of foreign that visit Nablus city is increasing rapidly. Therefore, the availability of hotels, motels, hostels and accommodation in Nablus city is necessary.

This project aims to create a hotel in the Nablus city in order to improve the economic situation of this city.

1.3. OBJECTIVES OF THE STUDY

The objective of this project is to design a fully integrated hotel facility in Nablus city and looking in deep to special requirement, which include architectural, structural, mechanical, electrical and environmental design.

1.4. METHODOLOGY

The study has been done in two phases:

1. Planning
2. Design

Planning phase include literature review, searching, site visit, etc. which formed the basis of the study .The Architectural species and recommended facilities area and the relationship between them have been studied and searched well .The structural information ,codes , methods, and concept have been collected .The mechanical ,electrical and environmental strategies have been considered in this phase .On the other wise Design phase has been considered as design , development and solve of architectural ,structural ,mechanical, electrical and environmental aspects .

The architectural designs in the project have been designed by using some software's like AutoCAD and Rivet. The structural designs have been done by using the codes of the construction such as ACI 318 and UBC97 and it has been analyzed and designed by using software's such as ETABs 2015 and SAP2000-16. The focuses have been on the environmental designs and it's done by analyzes the relationship of the building with the surrounding environment and the design process by using Ecotect and Dialux for solar design and acoustical and lighting system. The Mechanical HVAC and electrical system has been designed and calculated according to codes.

1.5. LIMITATIONS

The project is about a process that has been limited to the standards of 4 stars hotels, also due to the complexity and size of the project, manual analysis and design of the complete structure can't be done by the time for the whole hotel we have, so we have been designed a certain blocks with different aspects.

So the main constraint that we have been faced in the project is the time.

1.6. CODES & STANDARDS

Many programs and codes have been used like Uniform building Code (UBC97), International Building Code (IBC), ACI 318-2008 Code . The structural design has been built by ETABS15 and SAP2000-16 , Revit has been used for 3-D models and AutoCAD for 2-D plans.

ASHRE standard for heating, ventilation and air conditioning has been used, In addition to that DIAlux has been used for lighting design depending on LEED specification.

1.7. REPORT ARRANGEMENT

The report has been divided into many chapters to be easy flow and more understanding, so it become more interesting to readers and more organized, these chapters are:

Chapter One (Introductory) : Which include introduction about the project, with addition to problems the project faces and objectives the project targets to achieve .

Chapter Two (literature review) : its summery of report 1 which include an account of what has been published on the topic by accredited scholars and researchers or books about hotels design and standards that will be used for hotels design . These collected data has been used in design and analysis for the project and it is include a study about a real global hotel, these studies include architectural, structural, and environmental and sites analysis.

Chapter Three (Project design): This chapter Include designs, analysis, methods and calculations that have been done to construct a fully integrated 4 star hotel which include architectural, environmental, structural, electrical, mechanical designs and quantity survey and cost estimate.

Chapter Four (conclusion/summary): This chapter includes conclusion and summarization of what have been done on this project.

CHAPTER

2. LITERATURE REVIEW

2.1. ARCHITECTURAL ASPECTS

2.1.1. HOTEL CLASSIFICATION STAR SYSTEM

There are many criteria's that classify stars system of hotels and it's generally depends on service aspect. Therefore, the relation between spacing has been considered to meet this service requirement. The four stars system has been considered in the design.

Four Stars Requirements : ★★★★

1. Reception should be open 16 hours, 24 hours phone accessibility from inside and outside.
2. Lobby contains seats and beverage services, hotel bar.
3. Breakfast buffet or breakfast menu card via room service.
4. Minibar or 16 hours beverages via room service.
5. Upholstered couch with side table.
6. Slippers and bath robe on need.
7. Cosmetic products (e.g. nail file, shower cap, cotton swabs), vanity mirror, tray of a large scale in the bathroom, heating facility in the bathroom. (http://www.hotelstars.eu/index.php?id=criteria , 2016)

2.1.2. PLANNING AND STANDARD OF ARCHITECTURAL HOTEL COMPONENTS AND FACILITIES

Suites, rooms and others facilities dimensions are influenced by the shape of the site and buildings, aspect (maximizing the benefit of the view), function (type of accommodation provided) and costs (economic feasibility). (Lawson, 1976)

2.1.2.1. SUITES AND BEDROOMS

There are many types of suites and bedrooms (superior, master, Grand) that contains specific number of beds, bathrooms and others facilities. (Neufert et al ,2000)

Bedrooms specifications:

1. It should get benefit of the main view.
2. The door width shouldn't be less than 1m.

3. It should contain at least a bathroom.

4. Minimum area required 21 m^2 for the main room & 6m^2 for bathroom(min. width of 2.4m)

5. Gross area : 24m^2
6. Bed types :

   a. Single bed : (1*2) m^2
   b. Double bed : (1.35*2) m^2
   c. King bed : (2*2) m^2
   d. Queen bed : (1.5*2) m^2
   e. Twin bed : (1*2) m^2

Figure 1: Bed room double bed.

Figure 2: Bed room two individual bed.

2.1.2.2. KITCHEN

According to five stars hotels standard the kitchen has been opened 24 hours. So, it has been designed carefully and ventilation has been taken in consideration.

Kitchen specification: Size of kitchen determined by the workstations number, equipment's required space, ranges of meals and others extent of food preparation . So the number of seats or covers not a good guides.

Table (1) provides an approximate initial estimates for required space :

Table 1: Approximate basis for initial estimates of Space requirements.

Area per seat	High-grade hotels(m2)	Mid-grade hotels (m2)	Economy hotels (m2)
Main kitchen and stores	1.2	1	0.7
Satellite kitchen	0.3	-	-
Banquet kitchens	0.2	-	-

Or use gross area per room: 3.8m^2

Kitchen planning requires four stages of development:

1. Determine a process plan covering all major areas.
2. Check maximum and minimum personnel needs per area.
3. Determine the equipment needed for each area.
4. Space allocation.

Figure 3: Kitchen .

2.1.2.3. RECEPTION

The waiting area in a hotel has been close to the office that guests books the rooms or ask the staff questions. It represents the real face of hotel, Therefore it has been designed in a special, attractive & unique way. (collinsdictionary.com , 2016)

Most important in the design of the reception area is its location, especially if the area is intended to perform numerous functions .it has been in the center of activity so that users can easily identify it.

The reception area has been located in such a way that it guides users through the facility. A reception area by nature has the potential to cause lines to form. In certain recreation facilities such as amusement parks, users may have to wait a significant amount of time to access the product. adequate space to accommodate customer waiting has been incorporated into the design of any recreation facility .special consideration has been given to recreation facilities that attract large number of users and long lines with considerable waiting time. (Mull, Beggs and Renneisen, 2009)

Recommended Gross area per room: $0.4m^2$ (Neufert et al ,2000)

Figure 4: Reception.

2.1.2.4. ENTRANCE

The main entrance is important which defines the type of hotel by first impression .

Figure 5: Entrance.

The entrance forecourt has been at least 5.5m wide to allow two cars to pass. It must be always obvious and lead directly to reception.

2.1.2.5. RELATIONSHIP BETWEEN FACILITIES

The question that how will the guest or resident move from main external entrance to internal entrance then to reception and where they will go then ?

The bubble diagram shown below considers the relationship between hotel facilities:

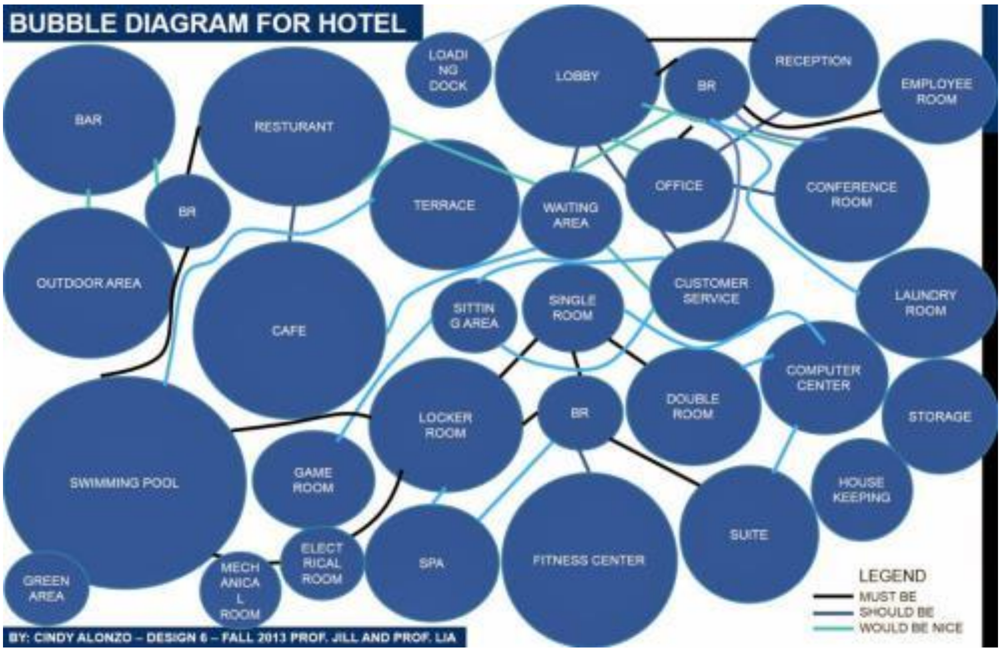


Figure 6: Relationship between facilities in hotels.

2.2. STRUCTURAL ASPECT

2.2.1. STRUCTURAL ANALYSIS

Structural analysis is important because it has been evaluated whether a specific structural design has been able to withstand external and internal stresses and forces expected for the design.

A primary reason that structural analysis is beneficial is to determine the cause of a structural failure. It has been important to perform complete structures components structural analysis and testing or more simplified tensile strength testing.

The analysis has been applied by the concepts of statics and provide the basis for solutions to the structure. Computer software has been used for the analysis and the calculation of forces, bending moment, stresses, strain, and deformation. (Braun)

2.2.2. STRUCTURAL DESIGN

There are two methods to design structures: (Washington)

1. Working stress design model.
2. The ultimate strength design method.

2.2.3. CONSTRUCTION MATERIALS

2.2.3.1. REINFORCED CONCRETE

Concrete is a building material made by mixing cement paste (Portland cement and water) with aggregate (sand and crushed stone). There are several properties such as, in tension its weak and 10% of compressive strength is average of the tensile strength of concrete. The concrete low tensile strength can be combining it with steel; Steel bars can be added to concrete to improve its strength, which are strong in tension. In concrete steel, combination (reinforced concrete) has been used in order to meet the needs of various structural engineering.

2.2.4. STRUCTURAL ELEMENTS

Structural elements are responsible of supporting the building
The structural elements include:

1. Slabs.
2. Beams.
3. Columns.
4. Walls.
5. Footings.

2.2.4.1. THE COMMON SLAB USED

2.2.4.1.1. RIBBED SLAB: (one way system, two way system).

Ribbed slabs has been used with small live loads, acoustical and thermal insulations, and to minimize the quantity of concrete which will decrease the dead load and decrease the cost.

In rib slab system anything can be used instead of blocks, because the zone of this volume not exposed to the stress, it is used just for filling the space.

Hollow blocks made of lightweight concrete or other materials are arranged between the ribs.

2.2.4.1.2. SOLID SLAB:

Solid slab has system practically used with large live loads, and long span.

1. One way slab:

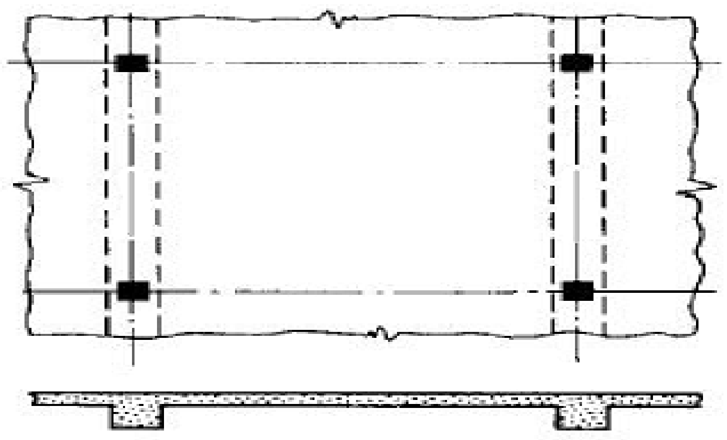


Figure 7: one way solid slab.

One way slab thickness can be determined according to ACI-318 by this table:

Table 2: Thickness equation for one way slab.

Support Conditions	Simply Support	Cantilever	One End Continuous	Tow End Continuous
Solid Slab	L/20	L/10	L/24	L/28
Ribbed Slab & Beam	L/16	L/8	L/18.5	L/21

Where: L is the longest span.

2.2.4.2. BEAMS

Beams are horizontal or inclined structural members spanning a distance between one or more supports, and carrying vertical loads across (transverse to) its longitudinal axis, as a girder, joist, purlin, or rafter.

The main function of the beam is to transfer the vertical loads and some horizontal loads (earthquake load, wind load). The beams transfer the loads that carry to the columns, wall, girders, which then transfer the force to the compression members of the structure (business dictionary).

Beams can be made from different materials like concrete, steel and wood.
The Beams are classified according to their depth into:

1. Hidden beams: have the same depth of the slab.
2. Dropped beams: have a depth more than the depth of the slab.
3. Inverted beams: have a depth more than the depth of the slab but it is dropped over the slab.

2.2.4.3. COLUMNS

Columns are defined as members that carry loads mainly in compression. Usually columns carry bending moments as well, about one or both axes of the cross section and the bending actions may produce forces over a part of the cross section. Even in such cases, columns are generally referred to as compression members, because the compression forces dominate their behavior (Nilson etal. 2008).

Columns are mainly used to carry vertical and resist axial compressive loads and transfer loads to the footing, and the column resist lateral loads if the effect loads was earth quake or wind load.

2.2.4.3.1. COLUMN TYPES AND CLASSIFICATIONS:

2.2.4.3.1.1. Classification according to cross section:

1. Rectangular and square cross sections: It is need at least bar in each corner.
2. Cylindrical section

2.2.4.3.1.2. Classification according to slenderness ratio:

This depend on ratio (Rule of thumb)

If L/B > 12, long column, (failure by buckling)

If L/B < 12, short column, (failure by crashing)

Where: L: column length

B: short diminution of cross section.

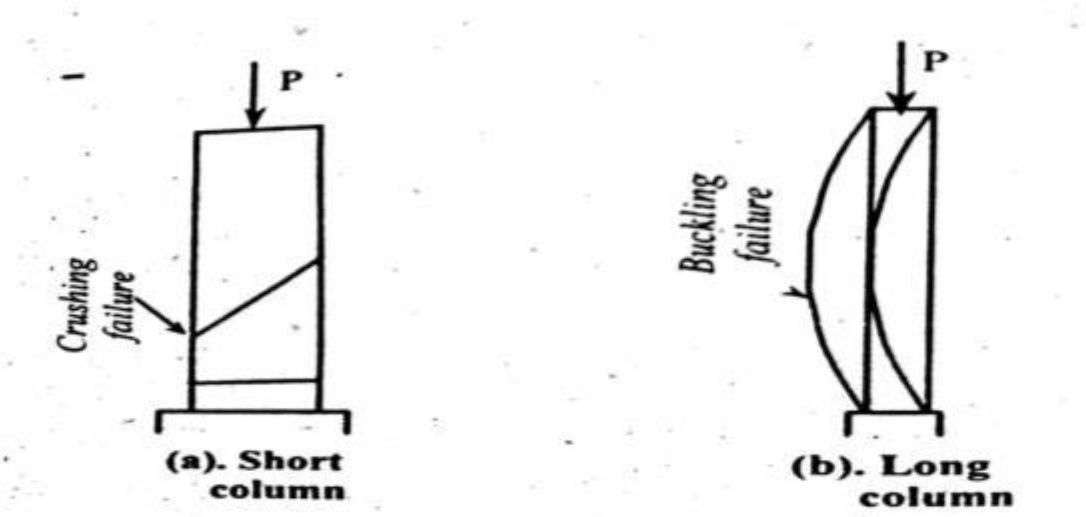


Figure: long column &short column

The reinforcement in a column is primarily to resist compressive forces, and they can resist moment.

2.2.4.4. WALLS

Walls are vertical elements, made of masonry or reinforced concrete, they are called bearing walls if their main structural function is to support gravity loads, and called shear walls if they are mainly required to resist lateral loads due to wind and earth quake, walls used also as nonstructural element.

An example of nonstructural wall (infill wall) shown in the following figure:

Figure 8: Non structural wall(infill wall).

An example of Shear wall shown in the following figure:

Figure: shear wall formwork

Concrete walls are commonly used in building as retaining walls, basement walls, shear walls, or load bearing walls. The essential difference between the reinforcement in a wall and a column is that ties are not required in a wall, unless the wall supports a large gravity load, the reinforcement in a wall consists as a mesh formed by vertical & horizontal bars, provided in one central layer. In wall 25cm or thicker, two layers of reinforcement are required close to each force of the wall, but separated from the face by minimum required cover.

2.2.4.5. FOUNDATIONS

The substructure, or foundation, is the part of structure that is usually placed below the surface of the ground and that transmits the loads to the underlying soil or rock. The essential requirement in the design of foundation is that the total settlement of the structure be limited to a tolerably small amount and that differential settlement of the various parts of the structure be eliminated as nearly as possible.

The common used footings:

1. Isolated footing

Isolated footings usually have a shape of square or rectangle; they are used as foundations for Columns. This type is the simplest, most economical type and most widely used footing

Figure 9: Isolated footing.

2. Wall footings:

Wall footing: it is used to carry a wall or retaining wall and distribute its weight to the soil.

Figure 10: Wall footing.

2.2.5. LOADS

2.2.5.1. LOADS TYPES

The structure has been designed to carry and resist the loads that are applied on the system and as per code requirements; the structure has been subjected to loads that have been categorized as follows:

Dead load ,live load , super imposed dead load , wind load , snow load, earthquake load.

2.2.5.1.1. DEAD LOADS

Dead loads are those that are constant in magnitude and fixed in location throughout the lifetime of the structure. Usually the major part of the dead load is the weight of the structure itself. This has been calculated with good accuracy from the design configuration, dimensions of the structure and density of the materials.

The dead loads consist of the weights of the various structural members for a building, the dead loads include the weights of the columns, beams, the floor slab, roofing, walls, windows, and partition, and any attached element.

2.2.5.1.2. LIVE LOADS

Live loads are consists of occupancy loads in building. They may be fully or partially in place or not present at all and may change its location. Live loads include human, furniture.

Live loads may change its present location, as they are not lifetime part of a structure. Therefore, in structural design, live load is provided with safety factor than the other loads.

2.2.5.1.3. EARTHQUAKE LOADS

Seismic load is a lateral external force applied on the building as a result of earthquake shock, and it is transfer to the structure by foundation.

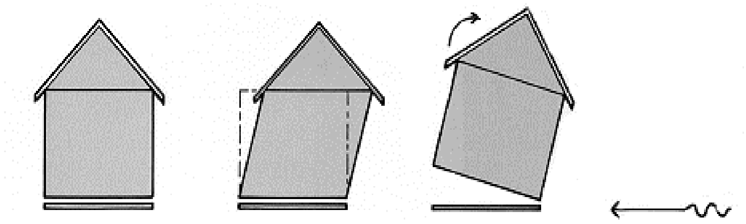


Figure 11: Earthquake loads.

2.2.5.1.4. WIND LOAD

The magnitude of wind load has been estimated according to height and region of the hotel (ASCE 2007).

2.2.5.1.5. SNOW LOAD

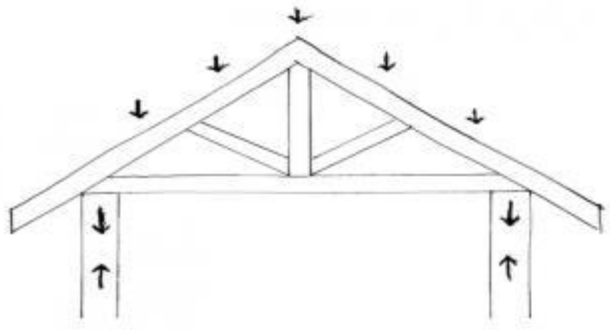


Figure 12: Snow load.

2.2.6. SEISMIC CONSIDERATIONS

An earthquake is a natural phenomenon that occurs as a result of the sudden release of some stored energies in the earth's crust. The Palestine region has a history of devastating earthquakes, the degree of that earthquakes lies between 1 and 6.5 on Richter scale. For example, Earthquakes in 1995 , 1954 , 1927 , 1903 , and other , The largest destructive recorded earthquake (Nablus Earthquake) occurred on 11 July 1927 north Jericho at the boundary between the Arabian and the Sinai plates and had a magnitude of about 6.3 (Richter scale).

Generally, local site effects play an important role in the intensity of earthquake-resistant design of new structures and evaluating the seismic vulnerability of existing buildings take into account their response to site ground motions.

2.2.6.1. SEISMIC FORCES- METHODS OF ANALYSIS:

1. **Equivalent static method.**

The seismic force effect on the structure can be translated to equivalent lateral force at the base of the structure which can be distributed to different stories and thus to the vertical structural elements (frames and/or shear walls).

2. **Dynamic analysis.**

The analysis shall be based on an appropriate ground motion Representation and shall be performed using accepted principles of dynamics.

3. **Response spectrum ANALYSIS: (the used method).**

4. **Time history analysis.**

An analysis of the dynamic response of a structure at each increment of time when the base is subjected to a specific ground motion time history.

2.3. ENVIRONMENTAL ASPECTS

Good environmental and eco-friendly design has many benefits, assists in energy conservation through the use of natural resources follows that reducing in the cost of construction and resources. The whole word should work hard to discover new solutions and alternative renewable energy resources, environmental design also contributes to providing a safe and comfortable urban environment.

2.3.1. STRATEGIES FOR DESIGN

The followings has been considered as strategies for design:

1. Building orientation

The method of orientating the hotel has been affected the gain a huge amount of light. As directing the hotel toward the south, synchronize with that prevents the excessive amount of light, which causes a glare or discomfort for guests.

Figure 13: Hotel orientation sketch.

2. Avoid excessive shading from nearby buildings or from different building wings.
3. Select the Suitable glazing size**.**

2.3.2. SHADING SYSTEM

This system has been used to avoid the directed sunlight that causes the discomfort in heat gain, and can be causes a high level of glare for guests .

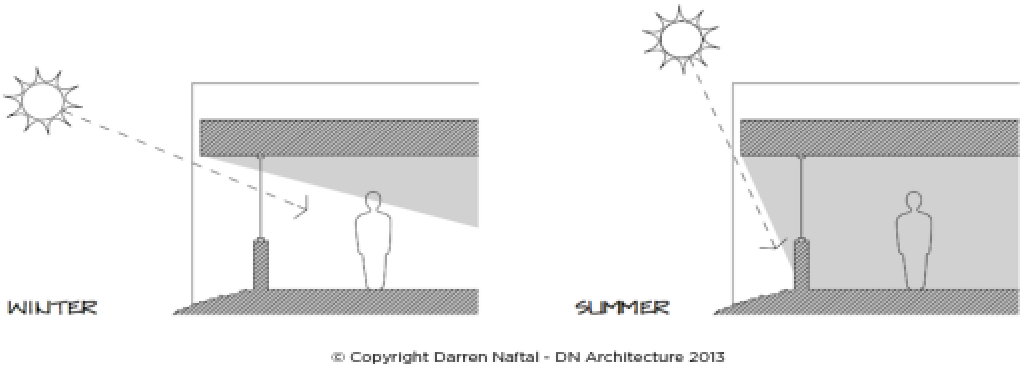


Figure 14: Shading system in summer & winter.

2.3.3. ARTIFICIAL LIGHTING

In the designing phase, the best goal from the architectural shape is to get the maximum amount of light that can be obtained from the daylight, in addition, the artificial lighting needed to get the suitable amount of light for the space.

The design of artificial lighting has been consider the illumination required , and the cost and energy efficiency , by using the different types of lamps inside the space of hotel and distribute it by the way that ensure the illumination in each pointed in the space reach to the amount of light required.

Figure 15: Artificial Lighting.

2.3.4. THERMAL COMFORT

The hotel guests need to feel comfortable and calm. The thermal environment parameters involved to affecting body heat gains and losses Air temperature, air velocity, air humidity and mean radiant temperature.

2.3.5. PASSIVE SOLAR DESIGN

2.3.5.1. THERMAL MASS

Thermal mass describes the ability of a material to store heat, it is crucial to good passive solar heating design. To be useful they have been able to absorb and release heat at a rate roughly in step with a building's daily heating and cooling cycle. Concrete and masonry products are good thermal mass and being dense materials can also store a lot of heat. Timber absorbs heat too slowly to offer much effective thermal mass and steel conducts heat too rapidly to be in agree with a building's natural heat flows over the day.

During summer thermal mass absorbs heat during the day and then release it by night to keeping the house comfortable and cooling breezes. In winter the same thermal mass can store the heat from the sun or heaters to release it at night, so it helping the home remains warmth is shows that the thermal mass acts as a thermal battery.

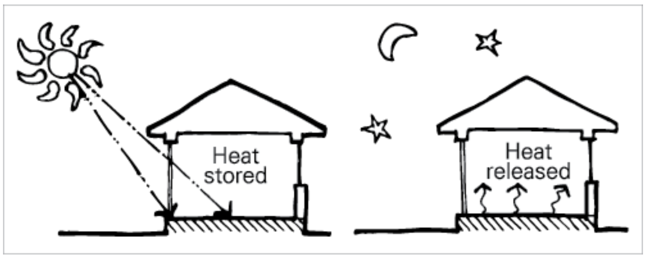


Figure 16: Thermal mass in winter.

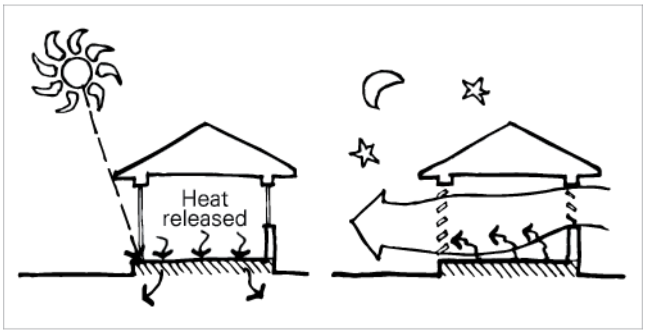


Figure 17: Thermal mass in summer.

Table 3: Thermal mass for various materials.

Material	Thermal mass (volumetric heat capacity, KJ/m³.k)
Water	4186
Concrete	2060
Sandstone	1800
Compressed earth blocks	1740
Rammed earth	1673
Fiber cement sheet (compressed)	1530
Brick	1360
Earth wall (adobe)	1300
Autoclaved aerated concrete	550

2.3.5.2. PASSIVE SOLAR HEATING

2.3.5.2.1. DIRECT GAIN

In this system, the actual living space is a solar collector, heat absorber and distribution system. South facing glass admits solar energy into the house where it strikes directly and indirectly thermal mass materials in the building such as masonry floors and walls. The direct gain system will utilize 60 – 75% of the sun's energy striking the windows.

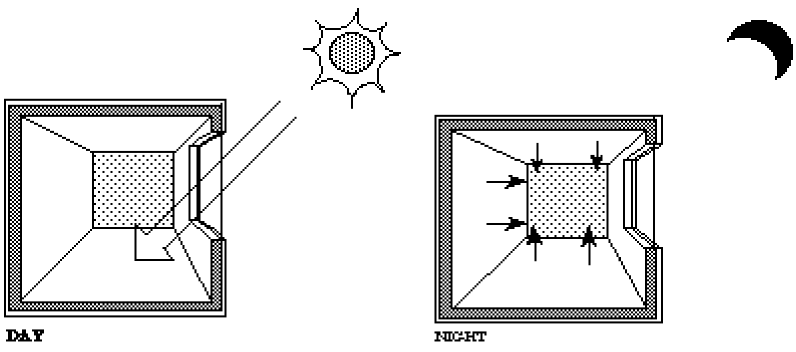


Figure 18: Direct gain at day and night.

In a direct gain system, the thermal mass floors and walls are functional parts of the house. It is also possible to use water containers inside the building to store heat.

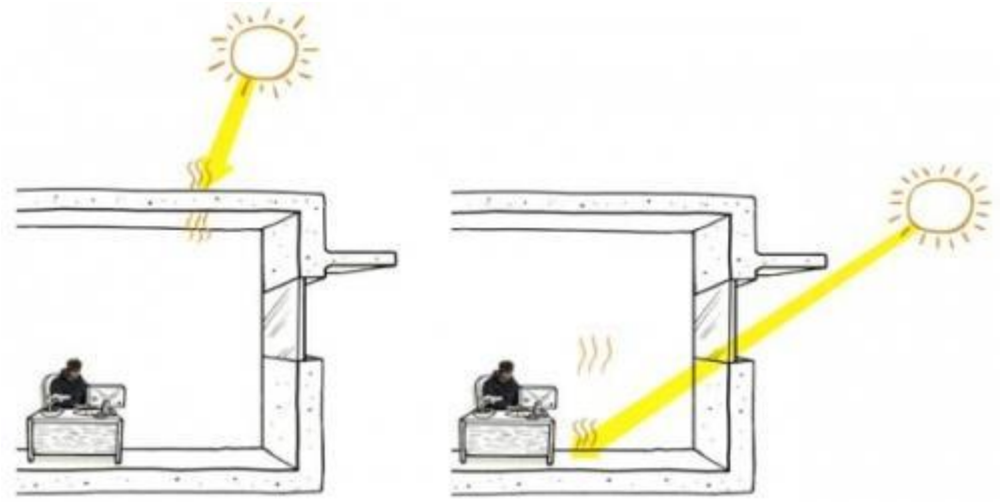


Figure 19: Direct gain through walls / roofs, and through glazing.

2.3.5.3. ACOUSTIC INSULATION

In buildings with concentrated high-level noise sources, such as certain types of machinery, it is always more desirable to reduce the noise at its source than to attempt to treat the larger enclosing space. This is most effectively accomplished by enclosing the noise source with materials that provide a combination of reverberant noise reduction by absorption and blocking of airborne sound with high transmission loss. These materials are available in the form of Curtains, panels, and prefabricated partial and full enclosures tailored to the specific characteristics of the noise source.

2.3.5.3.1. ABSORPTIVE MATERIALS AVAILABLE

1. Acoustic tiles.

Figure 20: Acoustic tiles.

2. Perforated metal-faced units.

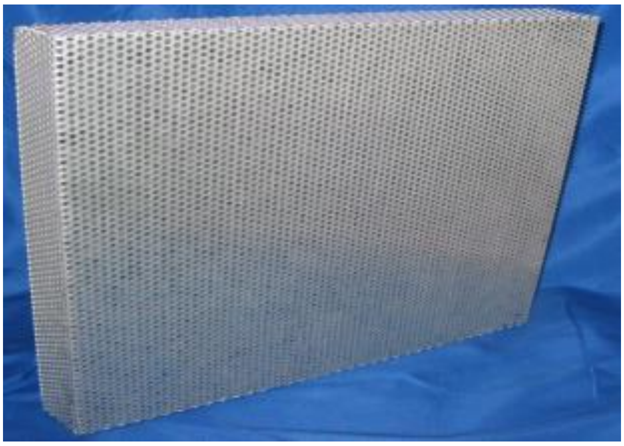


Figure 21: Perforated metal-faced units.

3. Acoustic panels.

Figure 22: Acoustic panels.

4. Carpeting and drapery.

Figure 23: Carpeting and drapery.

2.4. ELECTRO-MECHANICAL ASPECT

2.4.1. ELECTRICAL ASPECT:

2.4.1.1. POWER SYSTEM

Network of electrical components has been used to supply, transmit and use electric power.

2.4.1.2. ARTIFICIAL LIGHTING

Lighting is an important part in hotel design which take care of many several aspects such as decorative, comfortable and relaxation aspects by provide the appropriate lighting to ensure an integrated life for people in the hotel and provides a healthy environment for production in the workplace.

Figure 24: Artificial lighting in hotels.

2.4.1.2.1. ILLUMINANCE

"Is the total luminous flux incident on a surface, per unit area. It is a measure of how much the incident light illuminates the surface, wavelength-weighted by the luminosity function to correlate with human brightness perception. Illuminance Recommendations for General Lighting". (2010,جيلاني)

2.4.1.2.2. SELECTING A LAMP

We should consider several criteria when choosing light source to use. Correctly taking considerations will help you to choose the appropriate option in terms of effectiveness and price, these considerations are:

1. Efficacy, Life, Lumen Depreciation.
2. Amount of Diffusion.
3. Controllability.
4. Color Rendition.
5. Ambient Temperature and Humidity.
6. Cost.

2.4.2. MECHANICAL ASPECTS

2.4.2.1. VARIABLE REFRIGERANT SYSTEM (VRF SYSTEM)

Variable refrigerant flow (VRF) is an air-condition system where there is one outdoor condensing unit and multiple evaporators (indoor units).The system is able to control the amount of refrigerant flowing to the multiple indoor units, therefore system has the term variable.

The arrangement provides an individualized comfort control, simultaneous heating and cooling in different zones, and heat recovery from one zone to another. This refrigerant flow control is the heart of the VRF and is the main advantage of the VRF system.

The design of VRF systems is more complicated and requires additional work compared to designing a conventional direct expansion (DX) system. Through VRF system heat is transferred to or from the space directly by circulating refrigerant to evaporators located near or within the conditioned space**,** the system is comparable to direct expansion system. (seedenger.com)

2.4.2.2. WORKING PRINCIPLE

Through VRF system, one outdoor portion connects to several evaporators, that is similar to multi-split systems. However, VRF systems continually set the flow of refrigerant to each indoor evaporator, whereas multi-split systems turn OFF or ON completely in response to one master controller.

Pulse modulating valve (PMV) whose opening is determined by the microprocessor receiving information from the thermostat sensors in each indoor unit control the system continually varying the flow of refrigerant.

The indoor units are linked by a control wire to the outdoor unit, the compressor in outdoor unit change its speed to match the total cooling and/or heating requirements in the indoor units.

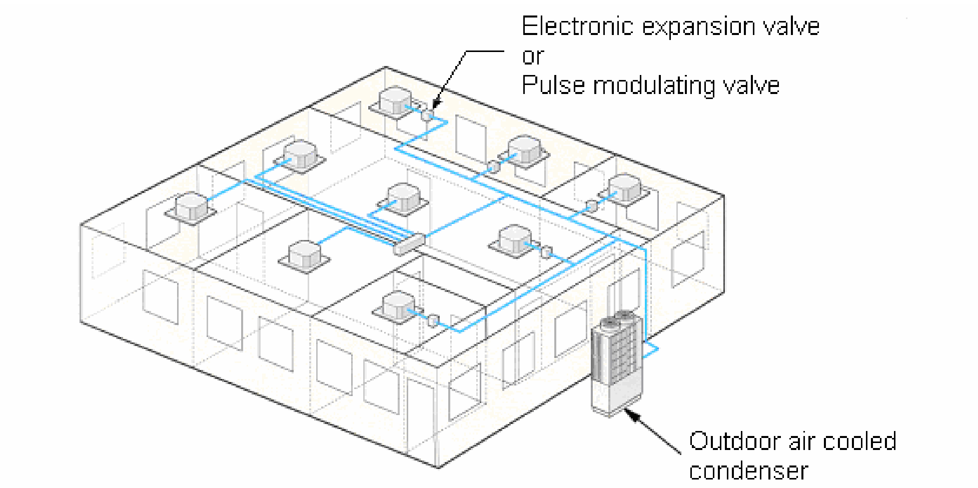


Figure 25: VRF System with Multiple Indoor Evaporator Units.

VRF modern technology uses an inverter-driven scroll compressor, it permits as many as 48 or more indoor units to operate from one outdoor unit Refrigerant. Piping runs of more than 200 ft are possible, and outdoor units are available in sizes up to 240,000 Btuh. A schematic VRF arrangement shown in Figure 26 .

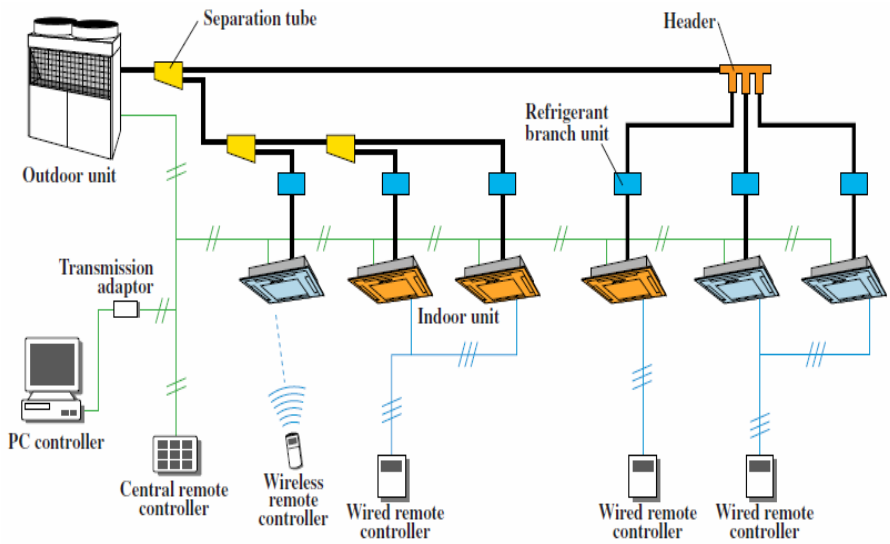


Figure 26: VRF modern technology.

VRF systems use a complex refrigerant and oil control circuitry. A separation tubes and/or headers are utilized in refrigerant pipe-work. A separation tube has 2 branches whereas a header has more than 2 branches. Either of the separation tube or header, or both, can be used for branches.

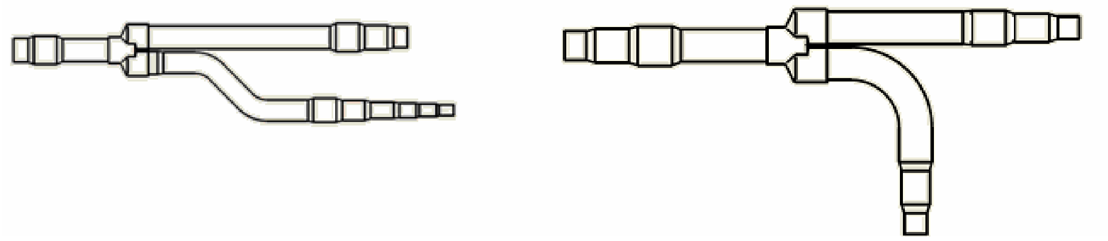
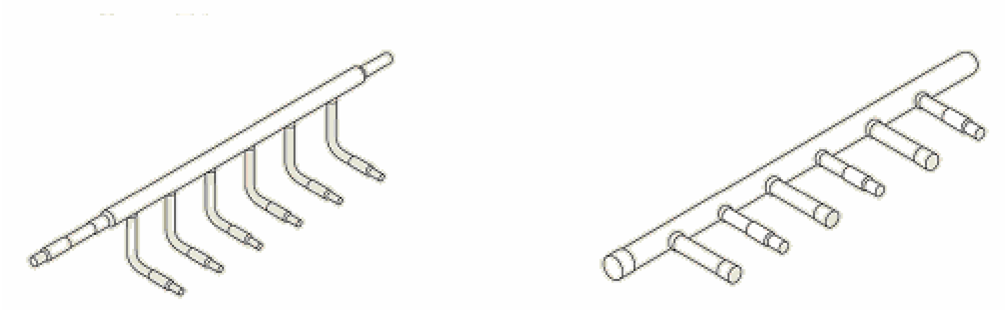


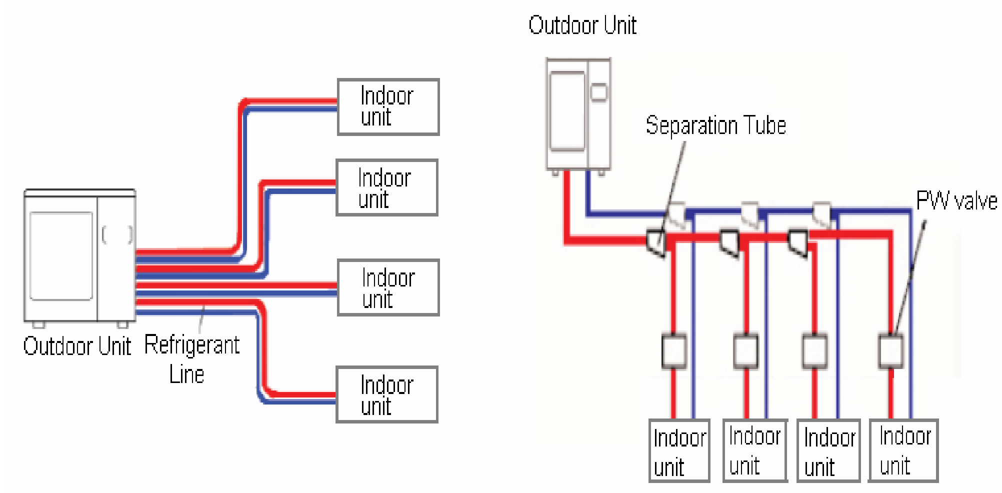
Figure 27: Separation tube.



(a) (b)

Figure 28: (a) Header Liquid Pipe. (b) Header Gas Pipe.

VRF systems minimize the refrigerant lines and use less copper tubing compared to multi-split systems. Minimizing the refrigerant lines allows for maximizing the efficiency of refrigerant work.



(a) (b)

Figure29 : (a) Refrigerant Piping in Multi-split System. (b) Refrigerant Piping in VRF System.

2.4.2.2.1. TYPES OF VRF SYSTEM

VRF system can be used for cooling only, heat recovery or heat pumping. In heat pump models there are two basic types of VRF system, heat pump system and energy recovery.

2.4.2.2.2. VRF HEAT PUMP SYSTEMS

VRF heat pump systems permit heating or cooling in all of the indoor units but not simultaneous heating and cooling. When the indoor units are in the cooling mode, they act as evaporators, when they are in the heating mode, they act as condensers.

VRF heat pump systems are effectively applied in areas that require cooling or heating during the same operational periods, such as open plan areas, retail stores, and cellular offices.

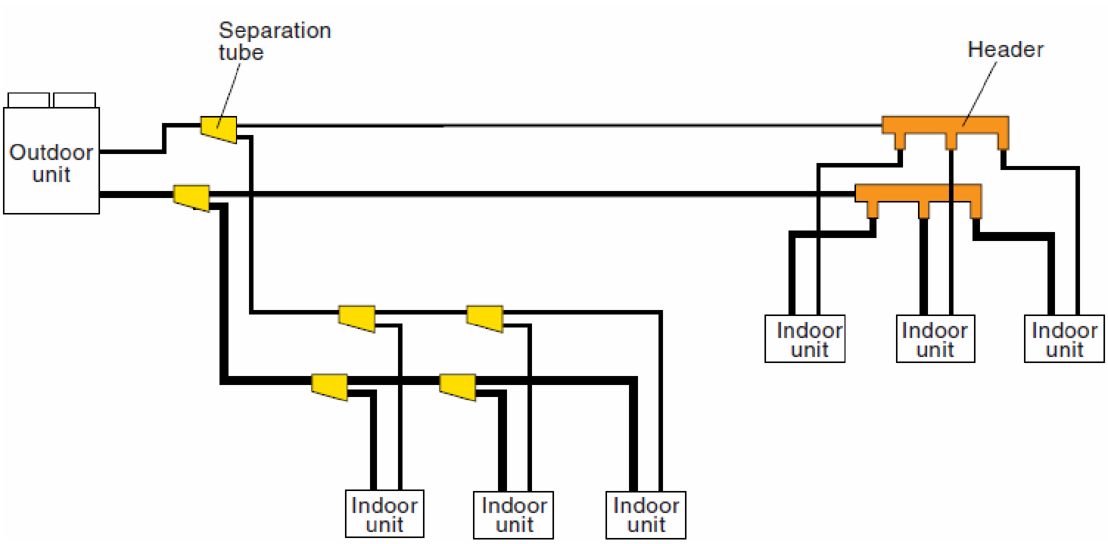


Figure 30: Cooling Type VRF System.

2.4.2.2.3. HEAT RECOVERY VRF SYSTEM

Variable refrigerant flow systems with heat recovery can operate simultaneously in heating and/or cooling mode. Enabling heat to be used rather than rejected as it would be in traditional heat pump systems. VRF-HR systems consist an inverter drives, pulse modulating electronic expansion valves and distributed controls that allow system to operate in net heating or net cooling mode, as needed by the space.

The system use two pipe or three pipe system, the most manufacturers use a three-pipe system which consists liquid line, a hot gas line ,a suction line, and special valves arrangements. Each indoor unit is branched off from the 3 pipes using solenoid valves. An indoor unit requiring cooling will open its liquid line and suction line valves and act as an evaporator. An indoor unit requiring heating will open its hot gas and liquid line valves and will act as a condenser.

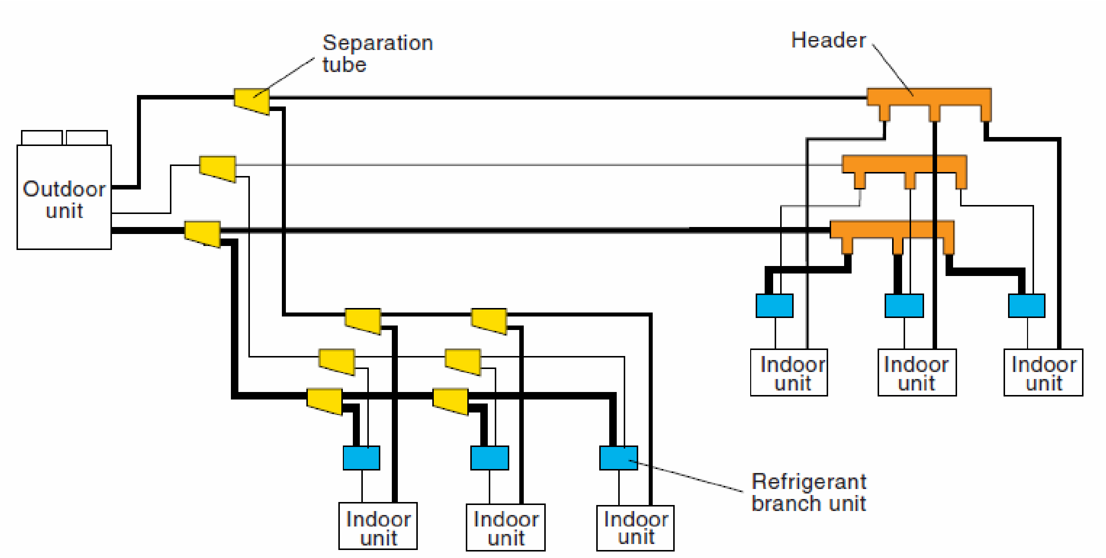


Figure 31: Heat Recovery Type VRF System.

VRF-HR systems work best when there is a need for some of the spaces to be cooled and some of them to be heated during the same period. This often occurs in the winter in medium-sized to large sized buildings or in the areas on the north and south sides of a building.

2.4.2.2.4. DESIGN CONSIDERATIONS FOR VRF SYSTEMS

Deciding what HVAC system will applied depend on several variables such as building characteristics, cooling and heating load requirements, simultaneous heating and cooling requirements, and minimum and maximum outdoor temperatures.

2.4.2.2.5. BUILDING CHARACTERISTICS

VRF systems are typically distributed systems, the outdoor unit is kept at a far off location like the top of the building, and all the evaporator units are installed at various locations inside the building. Typically the refrigerant pipe-work (liquid and suction lines) is very long, running in several hundreds of feet in length for large multi-story buildings. However, the long pipe lengths will increase pressure losses in the suction line. It is very important to make sure that the pipe sizing is done properly, both for the main header pipe as well as the feeder pipes that feed each indoor unit.

The maximum allowable length varies among different manufacturer; however the general guidelines are as follows:

1. The maximum allowable vertical distance between an outdoor unit and its farthest indoor unit is 164 feet (50m).
2. The maximum permissible vertical distance between two individual indoor units is 49 feet (15m).
3. The maximum overall refrigerant piping lengths between outdoor and the farthest indoor unit is up to 541 feet (165m)

The longer the lengths of refrigerant pipes, the more expensive the initial and operating cost.

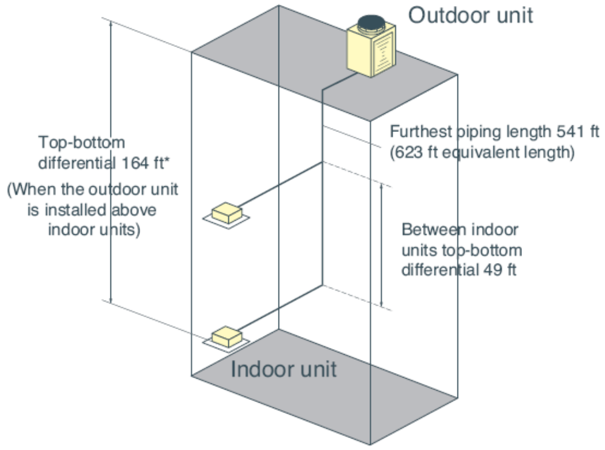


Figure32 : VRF Ducts distribution details.

2.4.2.2.6. SIMULTANEOUS HEATING AND COOLING

Simultaneous heating and cooling achieve through heat recovery feature. The cost of a VRF-HR is higher than that of a normal VRF heat pump unit and therefore its application should be carefully evaluated.

The areas that may require simultaneous heating and cooling are the parametric and interior zones. Parametric areas with lot of glazing and exposure especially towards west and south will have high load variations. A VRF heat pump type system can provide simultaneous heating and cooling exceeding 6 tons cooling requirement.

2.4.2.3. WATER SUPPLY SYSTEM

The water supply systems of most buildings make integrated use of 3 types of systems, namely:

1. The Direct Supply System.
2. Indirect Supply System.
3. Sump and Pump Supply System.

Under the direct supply system, fresh water is transmitted directly from the public water mains to households at lower floors by means of hydraulic pressure inside the mains.

Under the indirect supply system, a water pump is used to draw water from the storage tank installed at the ground level of the building, and fresh water drawn into the rooftop water tank is then transmitted to each household through a network of sub-mains.

Under the sump and pump supply system, water is transmitted to the receiving end by fitting a pressure pump to the supply: a fire main is one that functions in this way.

A water supply system comprises water pumps, risers, storage tanks, automatic float switches and sub-mains, all integral parts of the water supply system should be regularly checked and properly maintained, and all water storage tanks should be cleansed at regular times for quality control.

A good water supply system must have the following:

1. Good Pressure.
2. Good Water Flow.
3. Good Water Quantity.

2.4.2.3.1. EXPECTED WATER DEMANDS IN HOTELS

The following table illustrates the required water quantities per person per day for several functions:

Table 4: The required water quantities per person per day for several functions.

Function	Liters /person/day	US gallons /person/day
Hotel guests	135	35
Resident employees	90	24
Non Resident employees	45	12
Apartment , villas	90	24
Hostels	90	24
Restaurant	7-5 per meal	2

2.4.2.3.2. DRAINAGE SYSTEM

The design of the sanitation fittings has been compatible with the structural elements such as beams, columns and slabs.

Drainage systems contain many shapes of equipment and needs such as tubes, pipes and fittings which are shown in the figure:

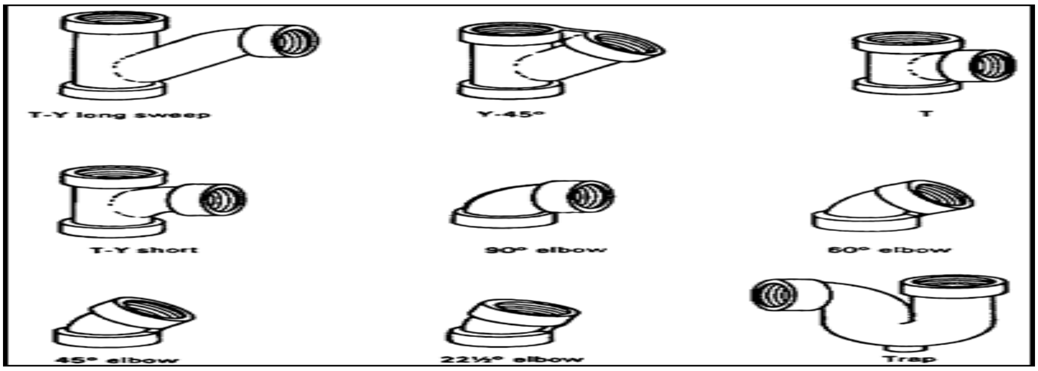


Figure 33: Fittings types.

2.4.2.3.3. TOILETS AND URINALS

1. Dual-mode flush Systems: while conventional flush systems use more than 11 liters of water per flush, modern dual-mode flush systems can reduce this amount to 4.5 liters per full flush and 3 liters per partial flush.

2. Urinals with on-demand sensors:

   These units use no more than 1 to 1.5 liters of water per flush, any defect in the sensor system may cause water wastage, and therefore it is important to fit the system with manual valve and continual maintenance.

2.4.2.3.4. ACCES

The actual method of providing access to drains is the construction of manholes; the size of manhole is dependent on the number of branches that are connected to it.

2.4.2.3.5. GUTTERS

A channel along the eaves (edges of the roof) or on the roof of a building, used to collect and carry away rainwater or other water resource.

2.4.2.3.6. VENT SYSTEM

The plumbing system shall be provided with a system of vent piping that will permit the admission or emission of air so that the seal of any fixture trap shall not be subjected to a pneumatic pressure differential of more than 1 inch of water column **.(** plumbingpros.com)

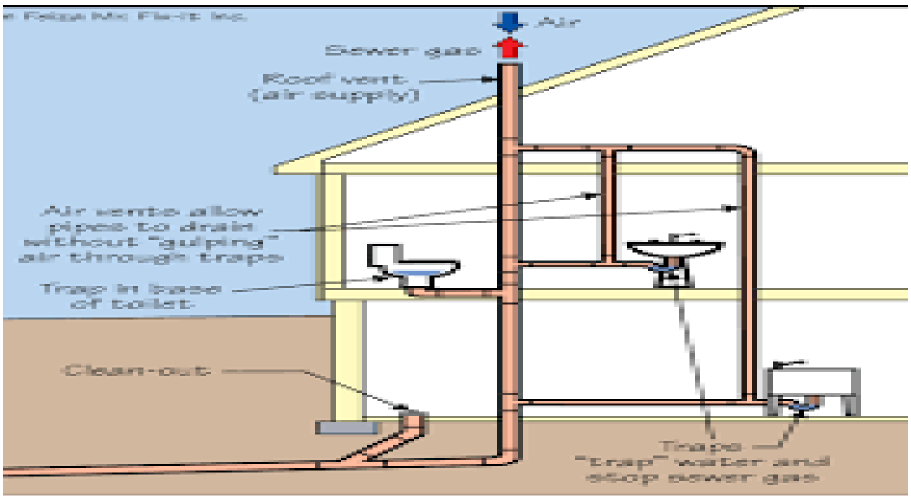


Figure 34: Drainage, Waste and Vent (DWV) System.

2.4.2.3.7. EXPECTED DISCHARGE AMOUNTS IN HOTELS

Table 5: Expected discharge amounts in hotels.

Discharge rates (taps, sprays ,and valves)	Liters /sec		Us gals / min	
	Hot	Cold	Hot	Cold
Bath	0.4	0.3	5	4
Lavatory basin	0.1	0.2	1.5	2
Shower spray	0.1	0.1	1.5	1.5
WC flushing cistern	-	0.1	-	1
Sink (domestic)	0.3	0.2	4	3

2.5. CASE STUDY

In this section, case study for existing hotel has been displayed and studied in several aspects. Our case study is ME hotel (5 stars hotel).

2.5.1. LOCATION AND SITE PLAN

"The hotel is located at the west London and it placed at the heart of all the action, near the River Thames, theatres, shopping areas, bars, restaurants and the city's lively nightlife, to the south of Covent Garden, between The Strand and Fleet Street, in the true global capital of culture and fashion. ME London offers impressive views of the city's historical landmarks, including the River Thames, London Eye and St. Paul's Cathedral."

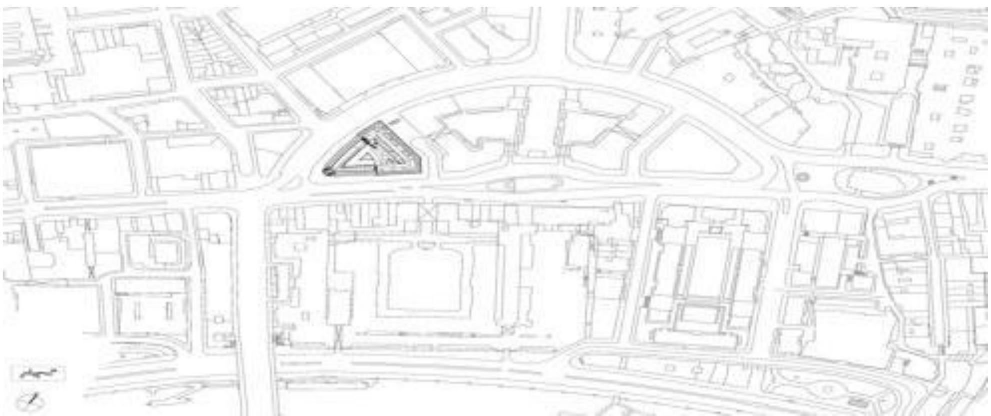


Figure 35: Location of ME Hotel.

The 157-bed hotel offers conference suites, a gym, and a 25-seat screening room in the basement.

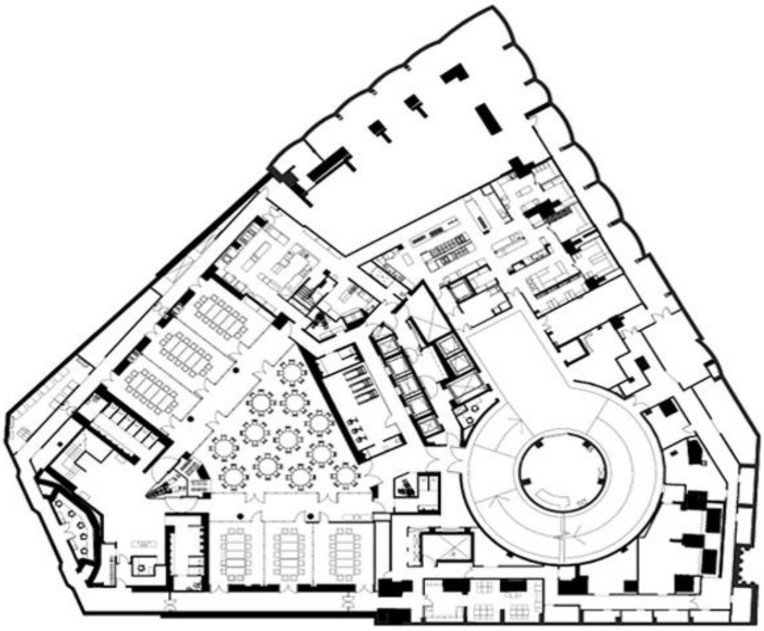


Figure 36: Basement plan.

Public restaurants, a bar, and lounge are located at entry level. With the hotel lobby, reception, and champagne bar on the first floor followed by nine stories of rooms and the rooftop radio bar offering breathtaking views of the city. It’s the first project of the internationally acclaimed firm to be entirely designed by them, from the overall structure to the graphics on the bathroom towels.

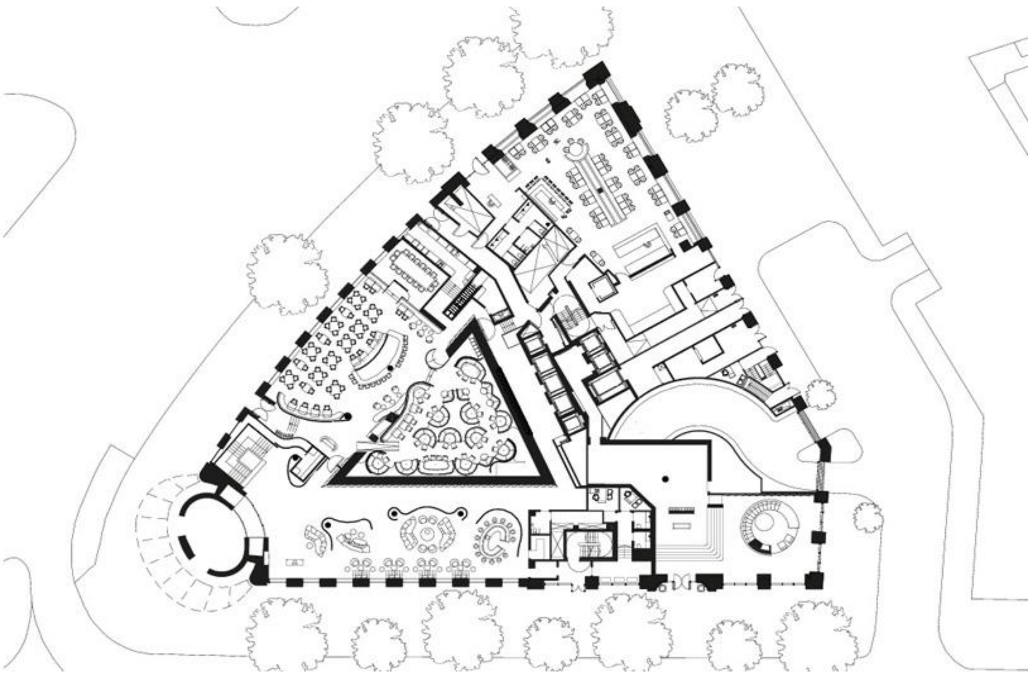


Figure 37: Ground floor plan.

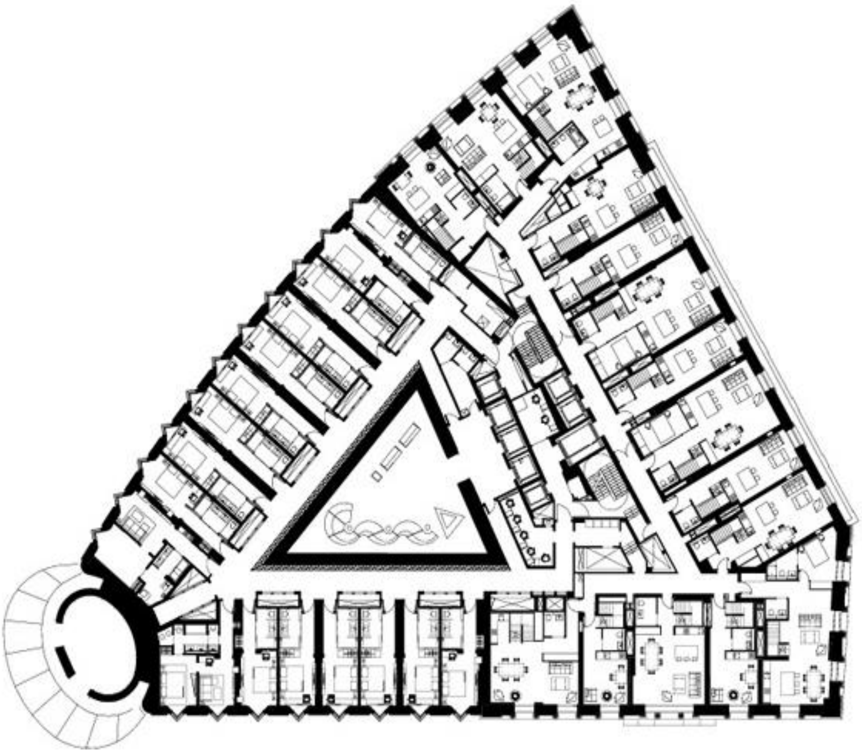


Figure 38: Level 1 plan.

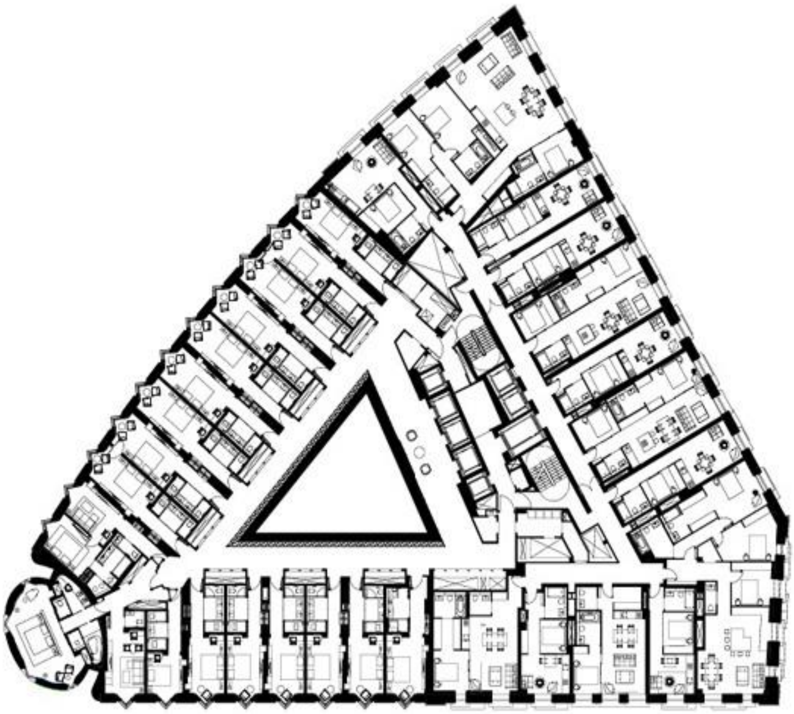


Figure 39: Level 3 plan.

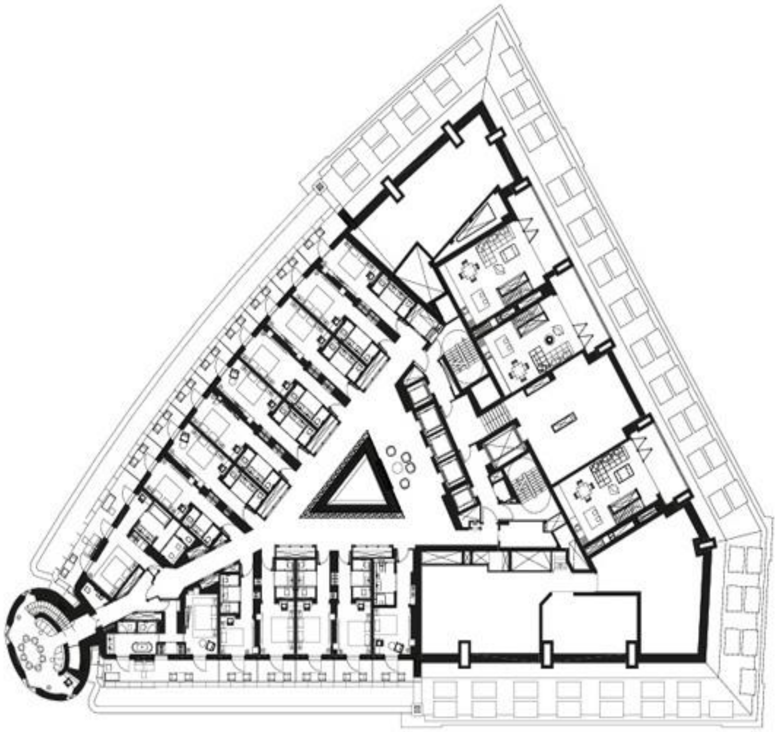


Figure 40: Level 9 plan.

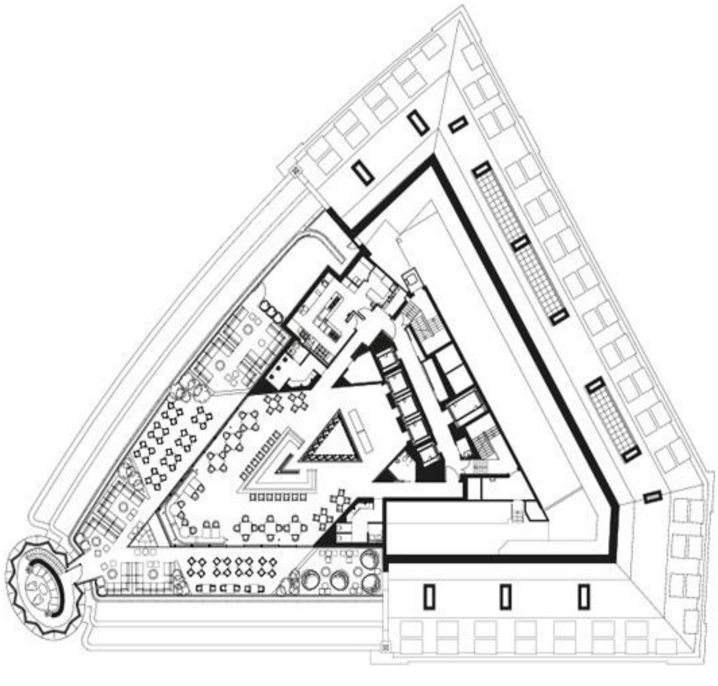


Figure 41: Roof plan.

The triangle is a common element throughout the project that appears in many scales and for many functions. The overall footprint of the structure occupies a triangular lot. The main entrance is located under a Portland stone-clad elliptical tower at the westernmost extreme like a pivot from which the rest of the program radiates, with a glass rooftop dome enclosing the penthouse suite with 360-degree views.

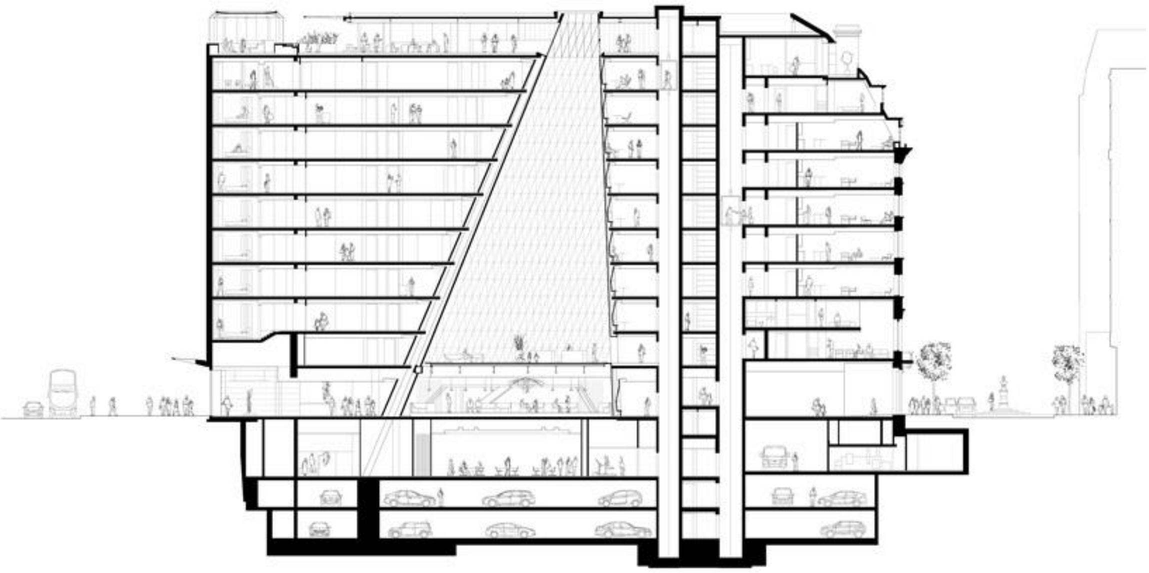


Figure 42: Section.

2.5.2. ARCHITECTURAL ASPECTS

ME London provides 157 exquisitely designed modern rooms, including 16 suites, Roof Bar with outdoor terrace and spectacular panoramic views of London (London Eye, Trafalgar Square, Tower Bridge, Covent Garden) and Marconi Lounge, two New York restaurants (Cucina Asellina and STK London); 7 meeting rooms measuring 500 m2 with capacity for up to 300 people and a separate reception area; a modern, fully equipped gym, open 24 hours a day and high speed Wi-Fi internet.

The 157-bed hotel offers conference suites, a gym, and a 25-seat screening room in the basement.

Public restaurants, a bar, and lounge are located at entry level. With the hotel lobby, reception, and champagne bar on the first floor followed by nine stories of rooms and the rooftop radio bar offering breathtaking views of the city. It's the first project of the internationally acclaimed firm to be entirely designed by them, from the overall structure to the graphics on the bathroom towels.

2.5.3. SUSTAINABILITY STRATEGIES

There are many criteria the ME hotel take in consideration to achieve sustainability concept.

1. **Accessibility:**

The hotel respects the needs of the disabled or persons with reduced mobility.

2. **Social Action:**

- The hotel is a “Friend of UNICEF” hotel and takes part in MHI's strategic partnership with UNICEF
- The hotel is participate in programs to promote the responsible conservation of the destination Biodiversity and the Environment
- The hotel applies initiatives for the maintenance, conservation and elimination of waste from the surrounding areas
- Hotel is involved with the protection and recovery of natural spaces of major environmental importance.

Architectural conservation and the responsible use of materials:

- The building is considered part of the city's cultural heritage.
- Environmentally-friendly materials were used in the construction of the hotel .
- Environmentally-friendly materials were used in any rehabilitation work that may have been carried out.
- Environmentally-friendly materials were used in any refurbishment work that may have been carried out in the hotel.

3. Energy and Climate Change:

- The hotel belongs to SAVE, Me Hotels International's Energy Efficiency Project (a corporate programmed).

4. Training:

- The collaborators receive training in environmental issues.

5. Local and Healthy Gastronomy:

- The collaborators receive training in environmental issues.
- The hotel hosts gastronomy events.
- Culinary offer includes organic produce.
- Culinary offer includes produce from ecological livestock farming and agriculture.
- The menus feature locally-sourced produce prepared in its kitchens.
- Special menus available for guests with specific dietary requirements or food intolerance.

6. Products:

- Hotel use eco-friendly products.

7. Cultural Resources:

- Cultural and social events are organized regularly.
- Guests are provided with details of cultural sites and activities in the surrounding area.
- Cultural events to promote local culture are organized at the hotel.
- Local arts and craft are promoted and supported.

- Conservation of local culture and identity are promoted through programs and actions.
- The hotel is involved in programs to promote the recovery of local and autochthonous traditions as well as architectural heritage.

8. Water Use Reduction:

- Treated water is reused for cisterns or garden irrigation systems
- The hotel is supplied with water from desalination plants
- The hotel is equipped with rainwater harvesting systems
- The hotel has its own water treatment system
- The hotel work to raise guests' awareness of the need for responsible water consumption during their stay.

CHAPTER

3. Project Design

3.1. ENVIRO-ARCHITECTURAL DESIGN

3.1.1. ARCHITECTURAL DESIGN

3.1.1.1. INTRODUCTION

According to little number of hotel in Nablus city such as AL-Qaser hotel and AL-yasmeneh hotel and others and availability of religious, historical and educational places there is a needed to have a fully integrated hotel. As a Palestinian city , Nablus is located at the north of Palestine as well as its concerned to be the widest city in the Palestine . The proposed site was chosen to be in Sama Nablus where it located at the north of Nablus on Aebal Mountain.

Figure 43: Site (1).

Figure 44: Site (2).

The land is 25000 m^2 with 15 m sloped located between two (10 m) sided streets which have been closed to have better views for hotel gardens and another two streets (20 m) have been opened which allow easy access to hotel and the best views .

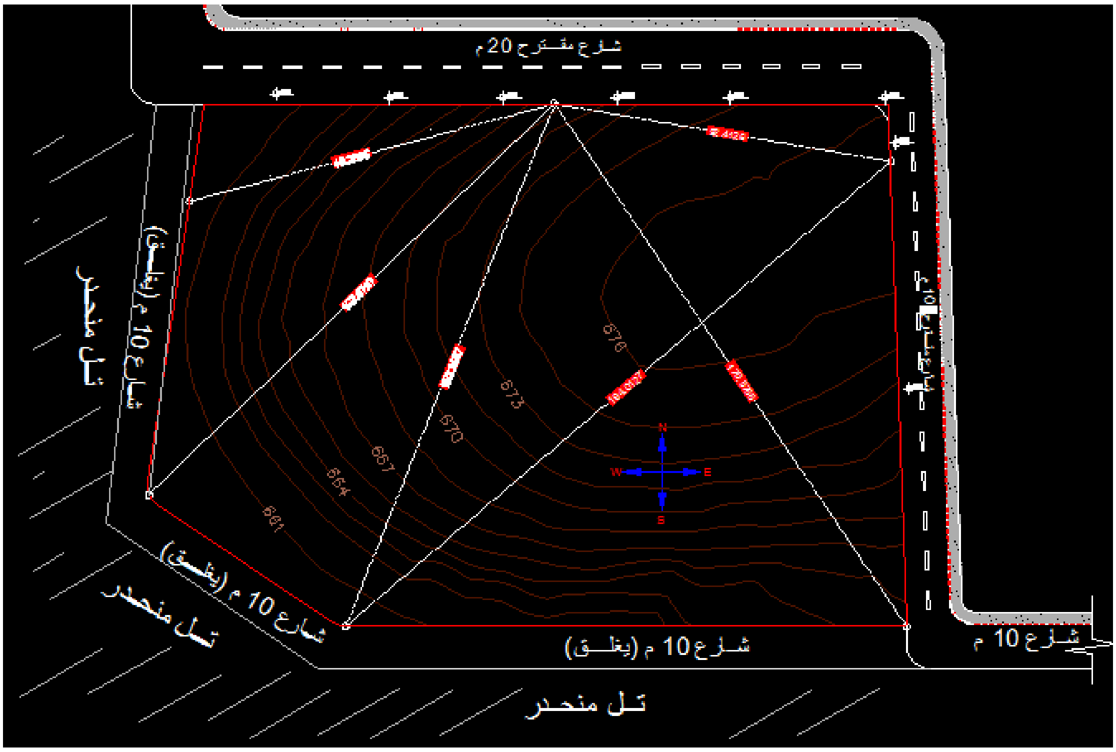


Figure 45: Site of the hotel.

3.1.1.2. CLIMATE OF NABLUS CITY

The climate in Nablus city has the common features like the other countries in the Mediterranean sea that have the perfect temperature in summer , its coldness and heavy rains in winter .

The average temperatures in Nablus city is between 9C as a lower limit in January and 24C in July , the relative humidity reaches 42% in April whereas in January 75% , and the average rainfall is about 630 mm3 yearly .

The rains mainly falls in the winter season where it reaches its peak in January ; the amount of rainfall varies in the city itself for example , the mountains there gain a big amount of rain rather than the plains.

Nablus city has two types of wind one is the eastern – south wind and is the eastern –north wind that they are warm in summer and cold in winter .The another is Western – north wind, it has full amount of moisture of approx. 46% yet in summer season it lowers temperature. (الادارة العامة للارصاد الجوية)

موقع المحطة								
الخليل	بيت لحم	أريحا	رام الله	نابلس	طولكرم	كرديه	جنين	الشهر
11.7	12.7	16.8	11.8	12.7	16.4	16.0	14.3	كانون ثاني
12.0	12.8	18.1	11.8	17.3	16.9	16.8	14.7	شباط
14.3	15.5	21.0	14.6	21.0	18.6	19.5	17.2	آذار
16.7	17.6	24.1	16.4	23.5	19.9	22.1	19.8	نيسان
19.7	20.8	27.8	19.8	27.1	22.5	25.2	23.1	أيار
22.0	24.2	31.1	22.4	29.9	26.0	29.0	26.1	حزيران
23.2	24.6	32.3	22.8	30.8	27.1	30.1	27.7	تموز
26.2	27.7	34.5	25.7	33.5	29.1	32.5	29.9	آب
22.7	24.2	31.8	23.0	30.6	27.4	30.0	27.9	أيلول
21.6	23.1	29.0	21.9	29.2	25.8	28.0	25.1	تشرين أول
19.2	19.5	23.5	19.7	26.7	22.5	24.1	21.1	تشرين ثاني
12.3	13.4	17.7	13.0	14.1	18.2	17.9	15.2	كانون أول
18.5	**19.7**	**25.6**	**18.6**	**24.7**	**22.5**	**24.3**	**21.8**	**المعدل السنوي**

المصدر : الادارة العامة للأرصاد الجوية

Figure 46: Air temperature rate in the West Bank 2010.

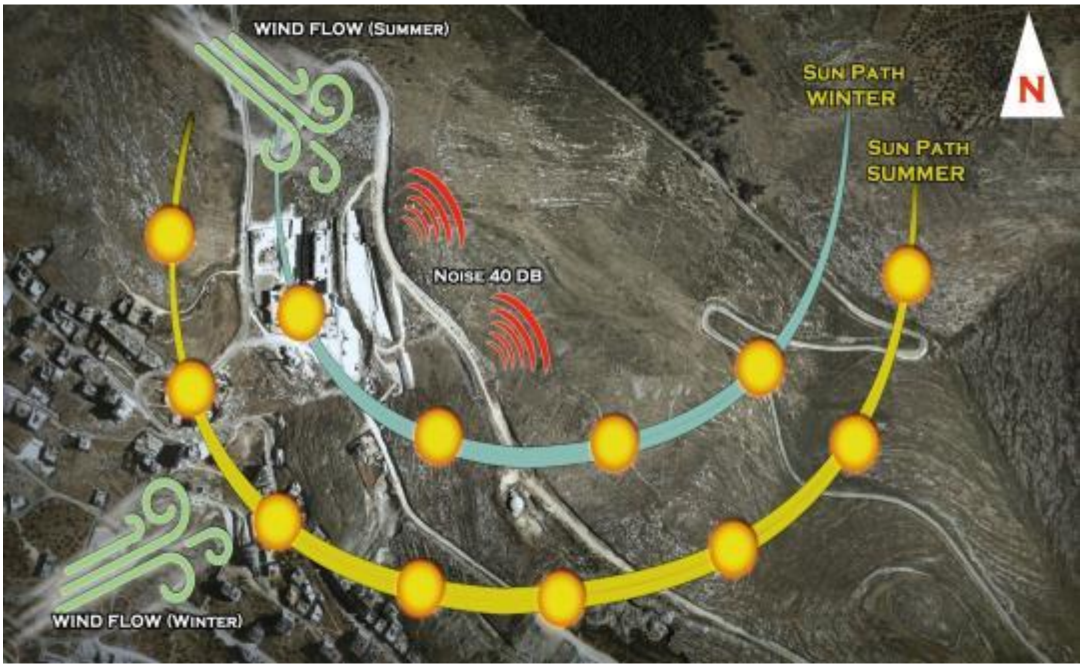


Figure 47: Site environmental analysis

3.1.1.3. ARCHITECTURAL SPACES AND FACILITIES

The design of a hotel have been balanced, layout functional, and aesthetic issues to develop simultaneously for the property that meets the needs of the guests, the staff, and the owner. First of all, user-friendly materials will be used , i.e. natural, biologically safe and not emitting harmful particles or radiation.

Disabled people have been considered in the design so ramps have been used and large elevators. Also, "Sliding doors systems that can be automatically or manually operated with the use of buttons, touch sensors or photocells will be used since disabled people are more comfortable with it instead of classically opening doors"

The relationship between facilities have been done using the bubble diagram shown below:

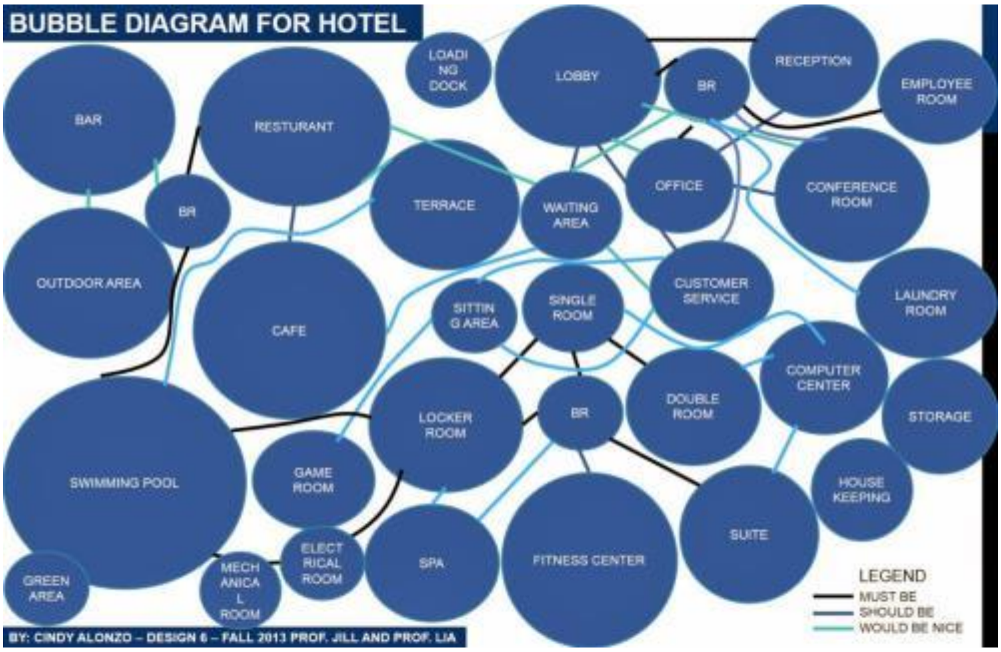


Figure 48: bubble diagram for the Hotel.

3.1.1.4. ANALYSIS FOR THE ARCHITECTURAL DESIGN

The hotel plans have been design considering the standard facilities, spaces and relationships for the five floors and basement to get the best design which integrated with the structural, environmental and electro-mechanical design for the 4-stars hotel.

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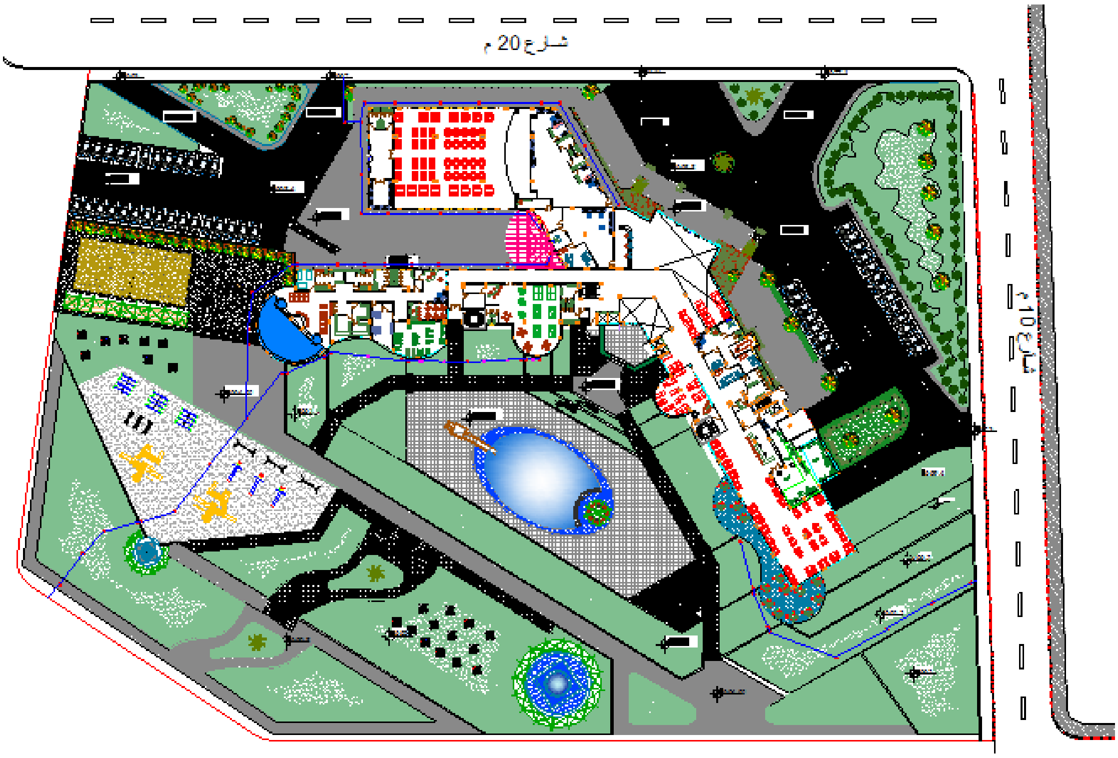


Figure 49: Master plan.

The hotel has main entrance for the hotel guests, separated entrance for the wedding hall and service entrance.

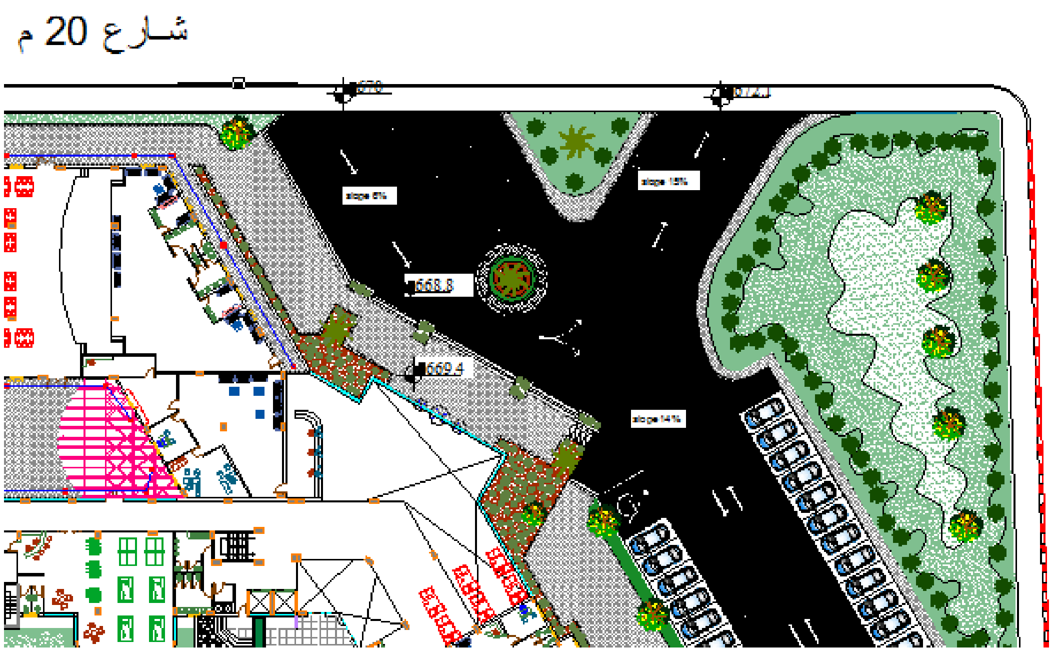


Figure 50: Main entrance.

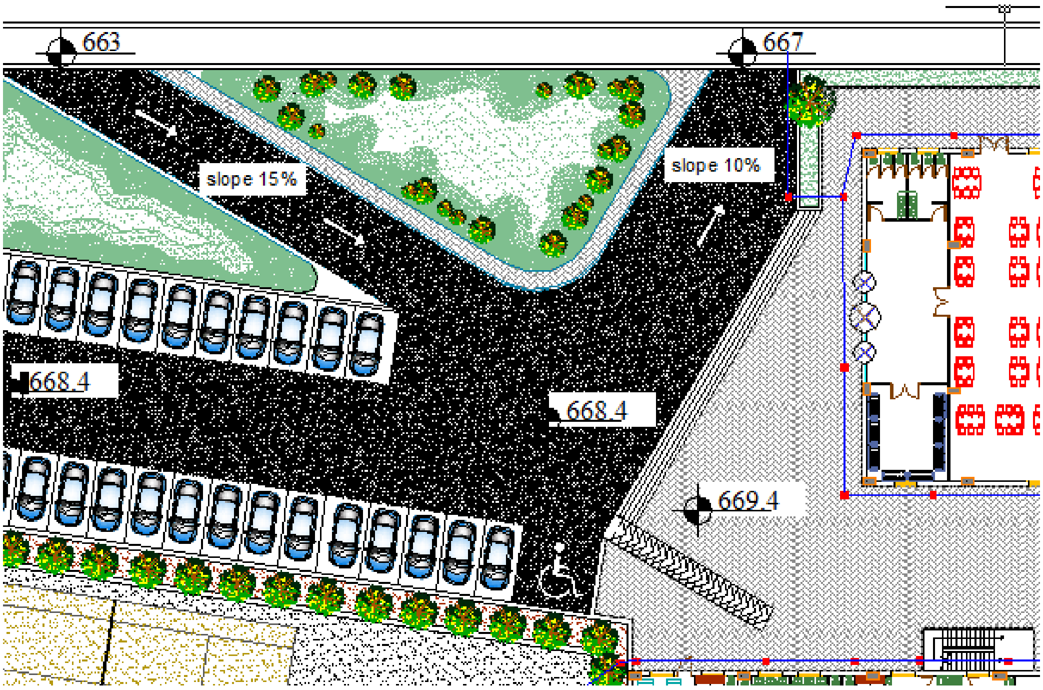


Figure 51: Wedding hall entrance.

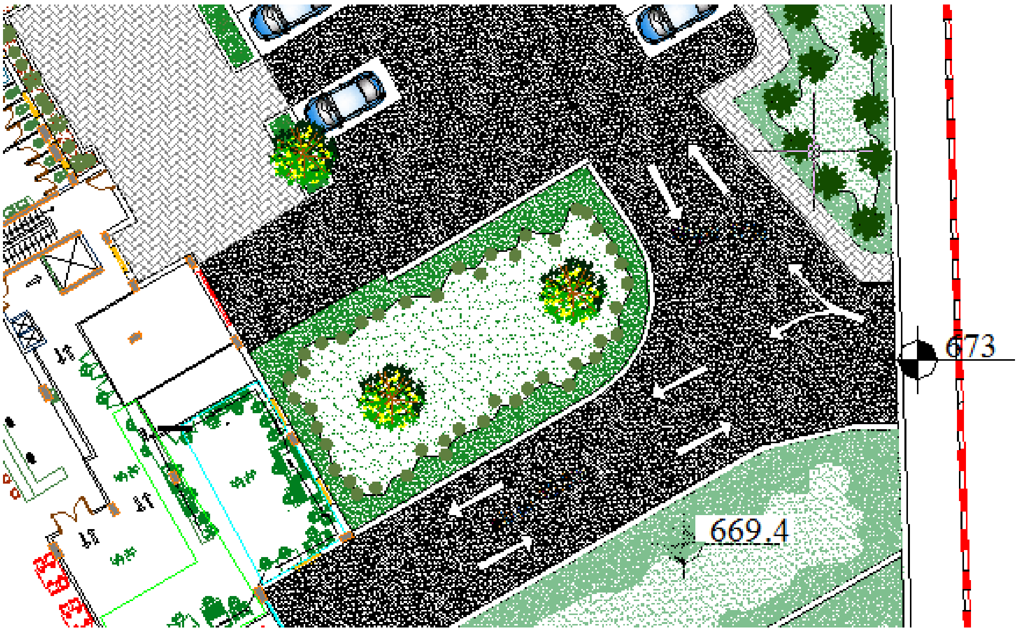


Figure 52: Service entrance.

Total area of the hotel 13925 m^2 (six stories included the basemen) consisted of :

1. **Basement** : 2651 m^2 which contains boiler room, electrical room, laundry room and parking .

Figure 53: Basement Floor.

2. Ground floor : 4312 m^2 which contains reception, restaurant, kitchen, store, waiting area, gym, pool, wedding hall, massage rooms.

Figure 54: Ground Floor.

3. First floor : 2410 m^2 contains coffee shop and bedrooms .

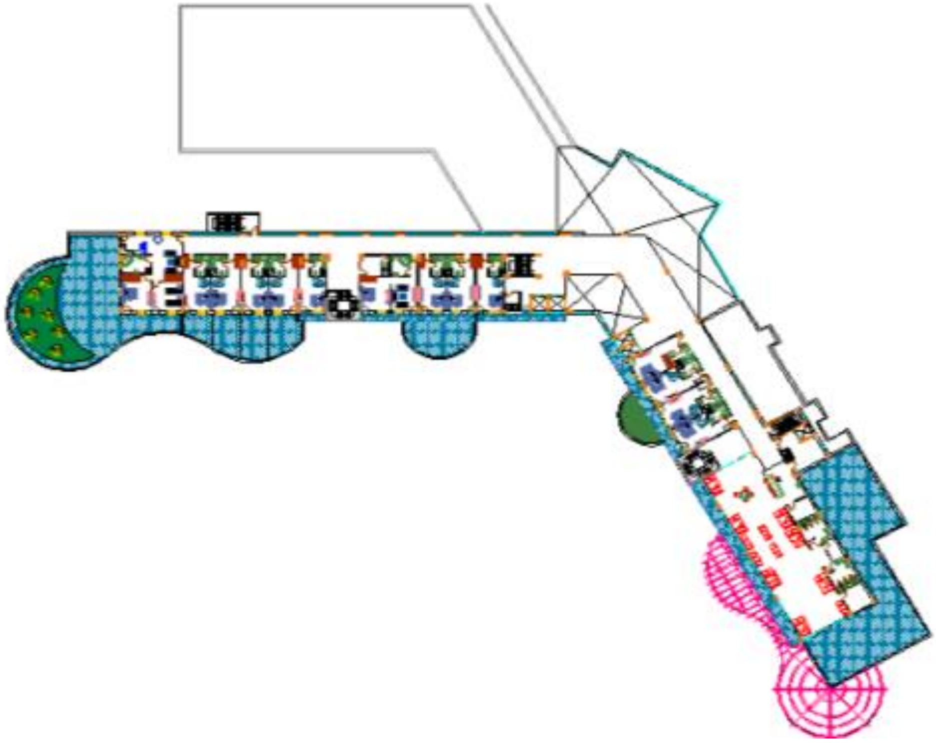


Figure 55: First Floor.

4. Rest floors (2.nd + 3.rd+ 4.th) contains bedrooms.

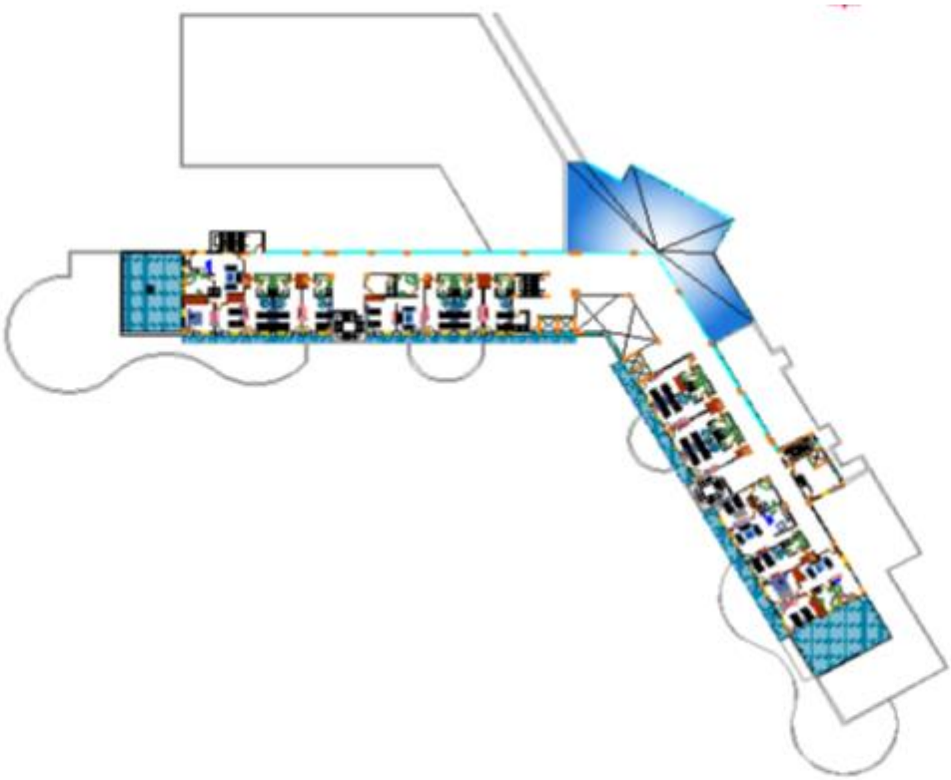


Figure 56: Rest Floor.

3.1.1.5. ELEVATIONS

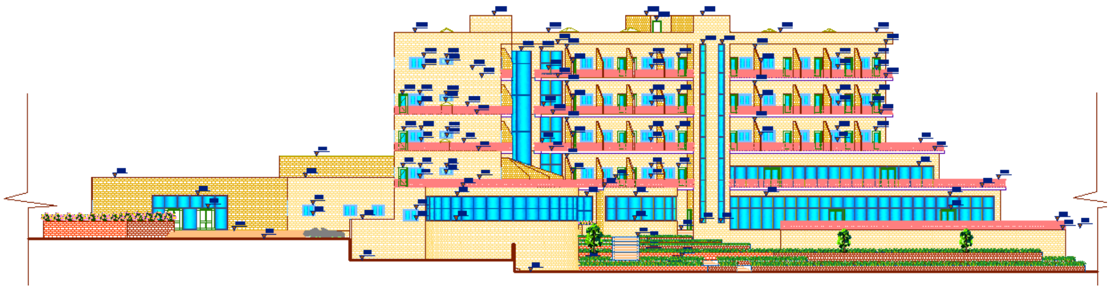


Figure 57: West Elevation.

Figure 58: South Elevation.

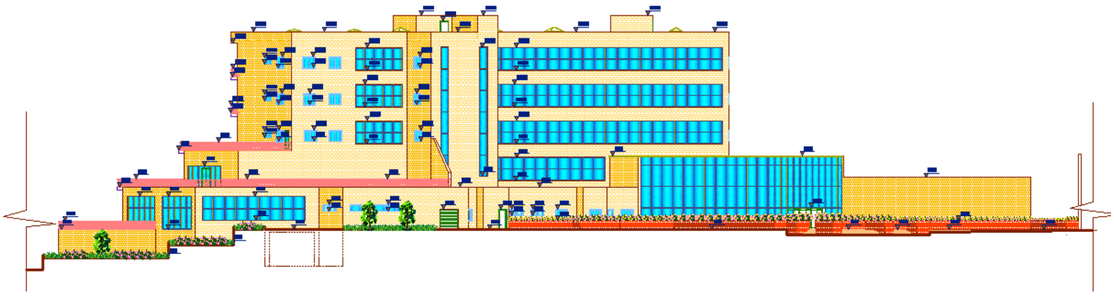


Figure 59: North Elevation.

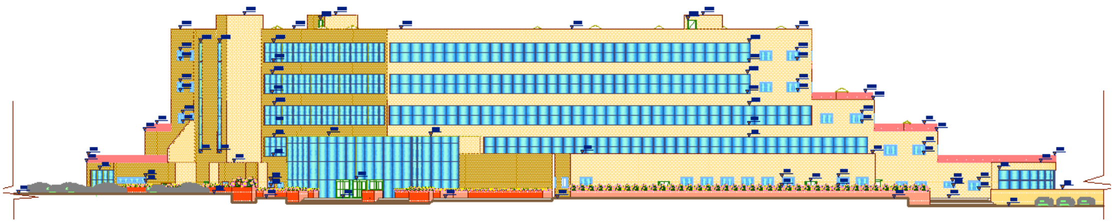


Figure 60: East Elevation.

Types of bedrooms:

1. Single bedroom : which contains one double bed or two single bed.

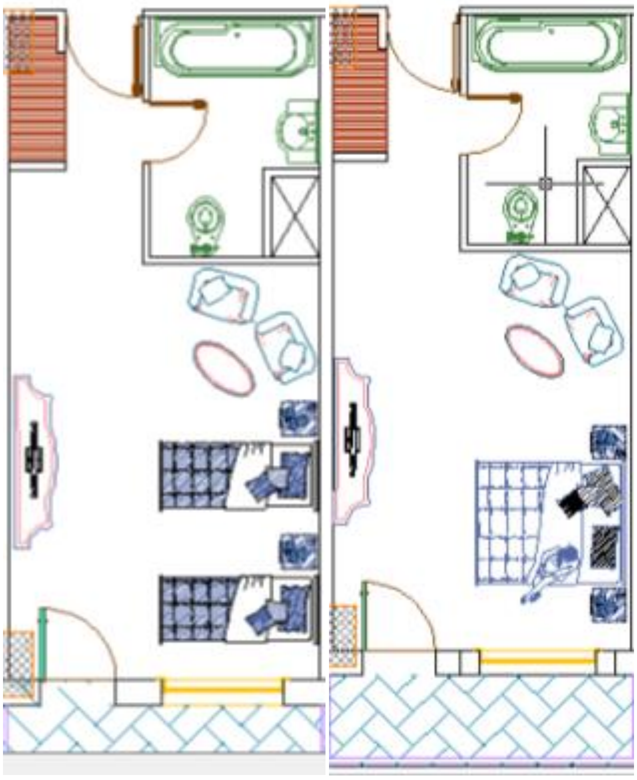


Figure 61: Single bedroom.

2. Suite bedroom

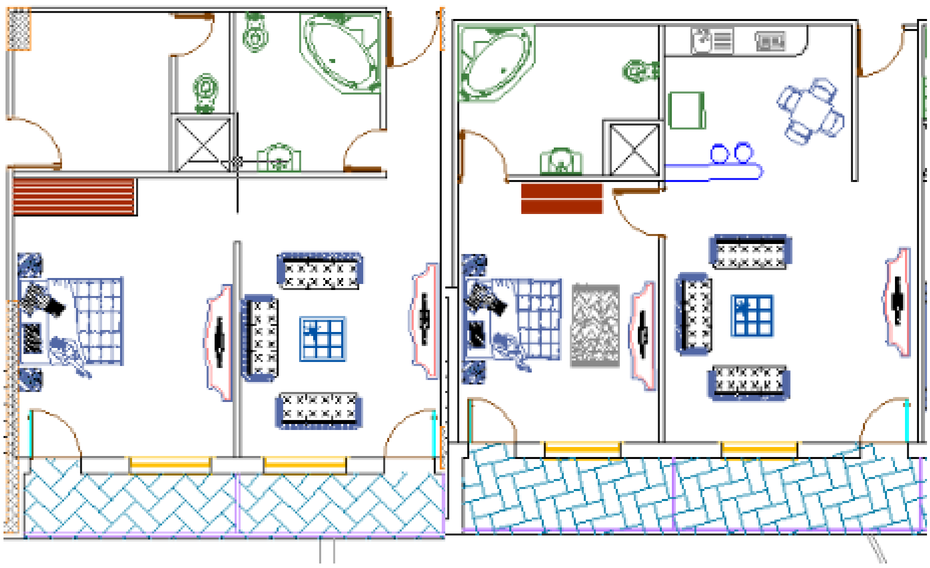


Figure 62: Suite bedroom.

3. Family room

Figure 63: Family bedroom.

3.1.1.6. SITE PROPERTIES :

1. The total number of available parking is 70 cars including the basement .

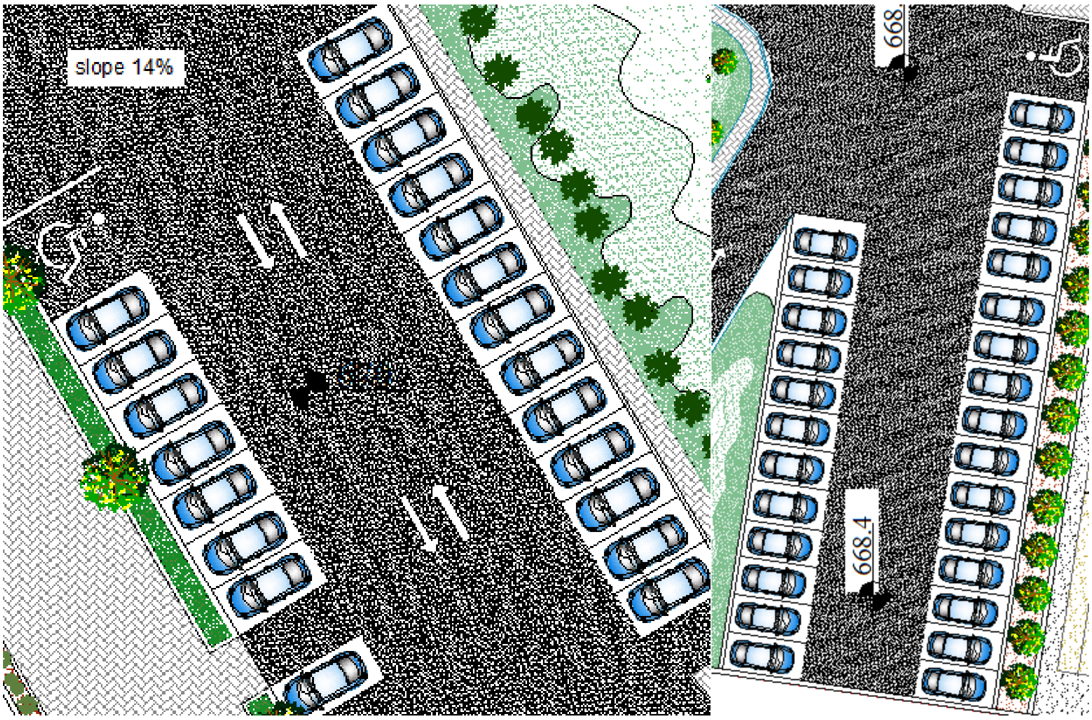


Figure 64: Parking.

2. Special needed accessibility: the ramp is added and special rooms with larger doors and large elevators, As shown in figure.

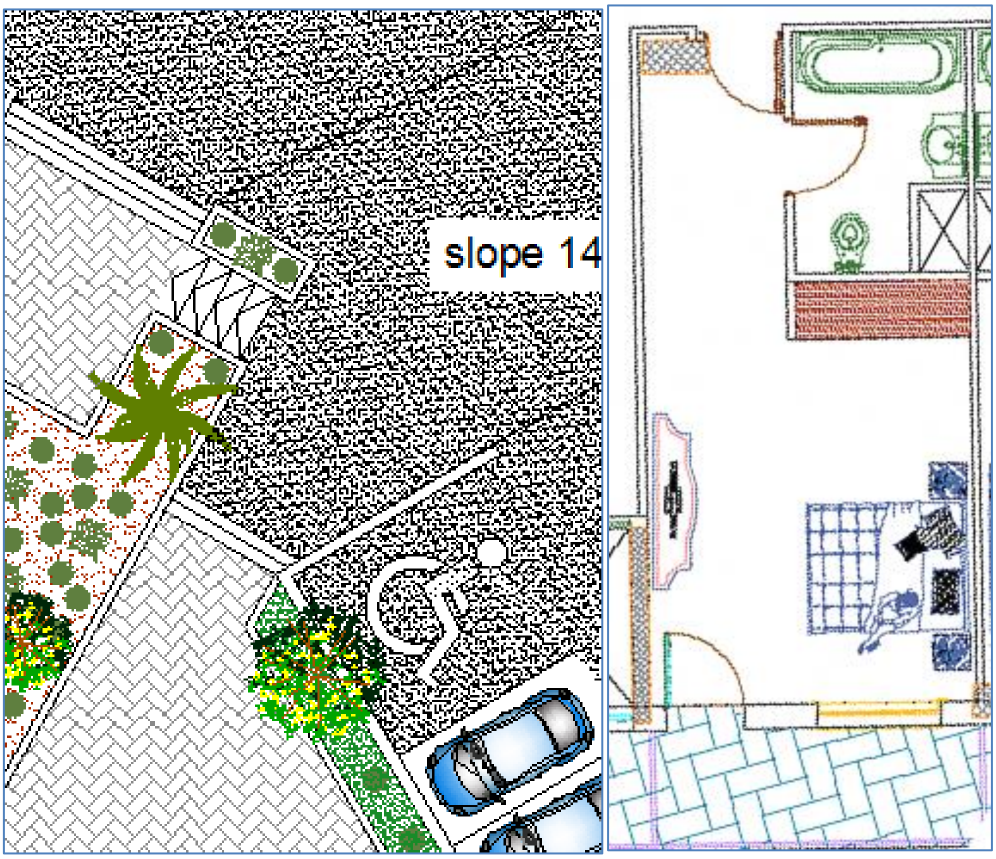


Figure 65: Special needed accessibility and Bedroom.

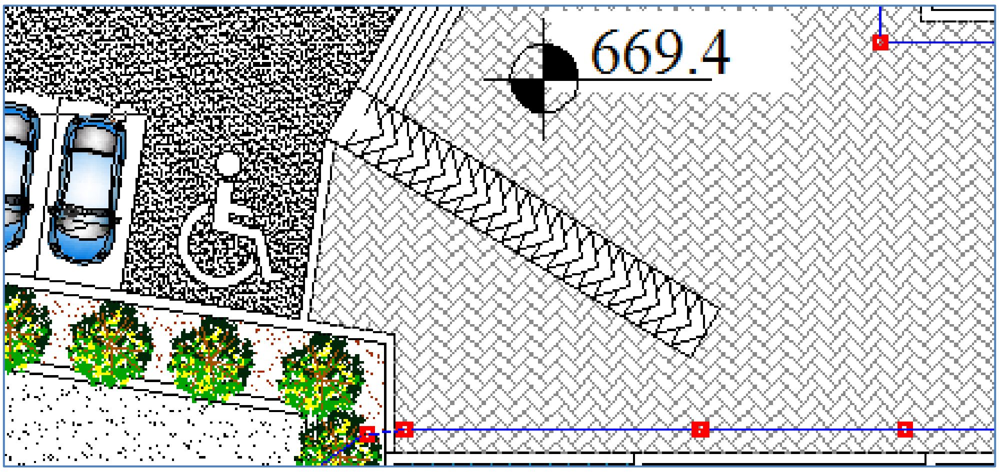


Figure 66: Special needed accessibility.

3. In case of fire, exit stairs is available and gathering areas and hoses.

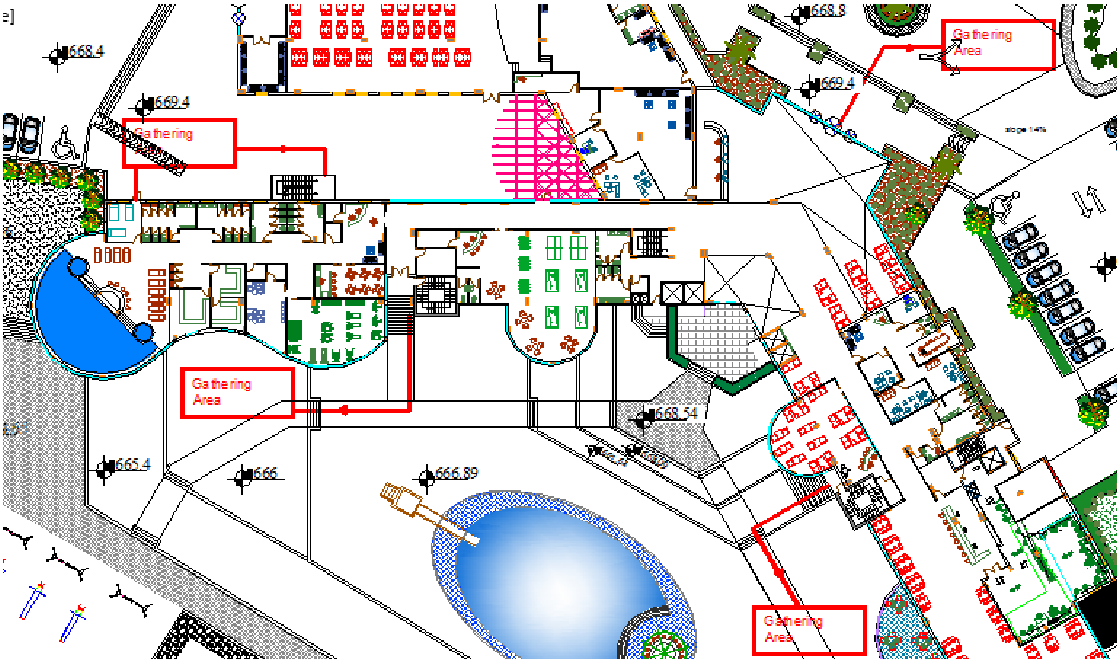


Figure 67: Gathering area plan.

3.1.1.7. ELEVETOR SYSTEM USED

<u>No. of Rooms = 62 room</u>

1. Population:

   For Hotels ➔ Normal = 62 *1.3 = 81 P

   Convention = 62*1.9 = 118 P

2. PHC :

   First Quality Hotels ➔ 12-15%

   HC = 118*15% = 18 Person/5min

3. Selection Option For Hotels :

   Car Capacity {2500 lb or 3000 lb}

   Elevation Rise = (6-1)*4.1 = 20.5 m ϵ (0-40m) ➔ speed 350-400 fpm

   Options {2500/350, 2500/400, 3000/350, 3000/400}

The following table gives different values of PHC:

Table 6: The different values of PHC.

Minimum Percent Handling Capacity (PHC)	
Facility	Percent of population to be carried in 5 minutes
Office building	
City center	12-14
Investment	11.5-13
Single - purpose	14-16
Residential	
Prestige	5-7
Other	6-8
Dormitories	10-11
Hotels - first quality	12-15
Hotels - second quality	10-12

The following table gives Population of typical buildings for estimating elevator and escalator requirements:

Table 7: Population of typical buildings for estimating elevator and escalator requirements.

Building Type	**Net Area**
Office Building	Ft^2 per person (m2/person)
Diversified (multiple tenancy)	
Normal	110-130(10-12)
Prestige	150-250(14-23)
Diversified (Single tenancy)	
Normal	90-110(8-10)
Prestige	130-200(12-19)
Hotels	Persons per sleeping Room
Normal use	1.3
Conventions	1.9

Table 8: Elevator options.

Elevator Equipment Recommendations						
Building Type	Car Capacity		Minimum Car speed		Rise	
	lb	Kg	ft	M	fpm	m/s
Office building	2500 3000 3500	1250 1250 1600	0-125 126-225 226-275 276-375 >375	0-40 41-70 71-85 86-115 >115	350-400 500-600 700 800 1000	2 2.5 3.15 4 5
Hotel	2500 3000	1250 1250	As above	As above	As above	As above

Table 9: Sellect Elevator.

	2500/350	2500/400	3000/350	3000/400
P	13	13	16	16
RT	104	101	116	112
hc	38	39	41	43
N	0.48	0.47	0.44	0.42
N'	1	1	1	1
PHC%	32	33	35	36
I (sec.)	104	101	116	112
State	Reject	Reject	Reject	Reject
N"	2	2	2	2
PHC%	64	65	70	73
I (sec.)	52.00	50.50	58.00	56.00
State	Reject	Reject	Reject	Reject
N"'	3	3	3	3
PHC%	8.0	7.8	7.3	7.0
I (sec.)	34.67	33.67	38.67	37.33
State	Accept	Accept	Accept	Accept

So, We choose 3 elevator (2500/350) cap 2500 lb with capacity 13 persons.

And because the building is hotel so we add 1 elevator.

The type of elevator is Motor driven elevator with two pulley and double wrapping around them.

3.1.2. ENVIRONMENTAL DESIGN

3.1.2.1. ANALYZE HOTEL IN ECOTECT PROGRAM

3.1.2.1.1. MATERIALS USED AND PROPERITIES

1. External walls Components and properties:

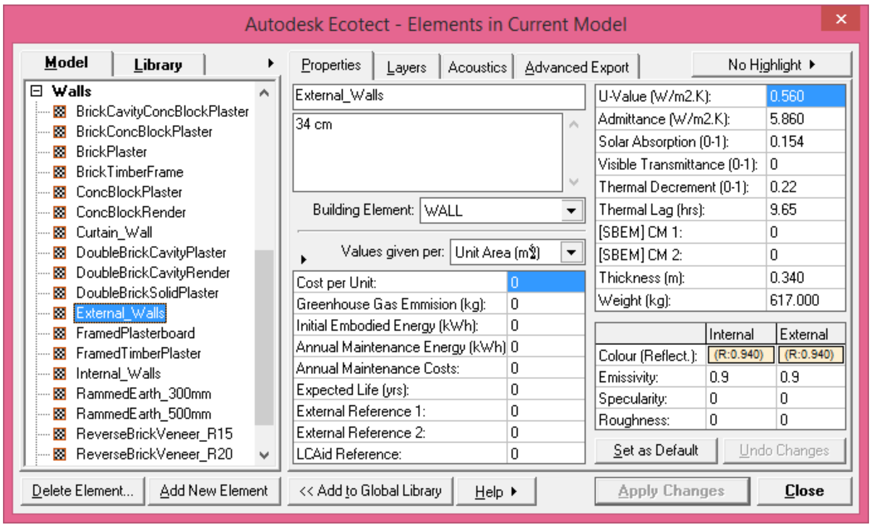


Figure 68: External walls properties.

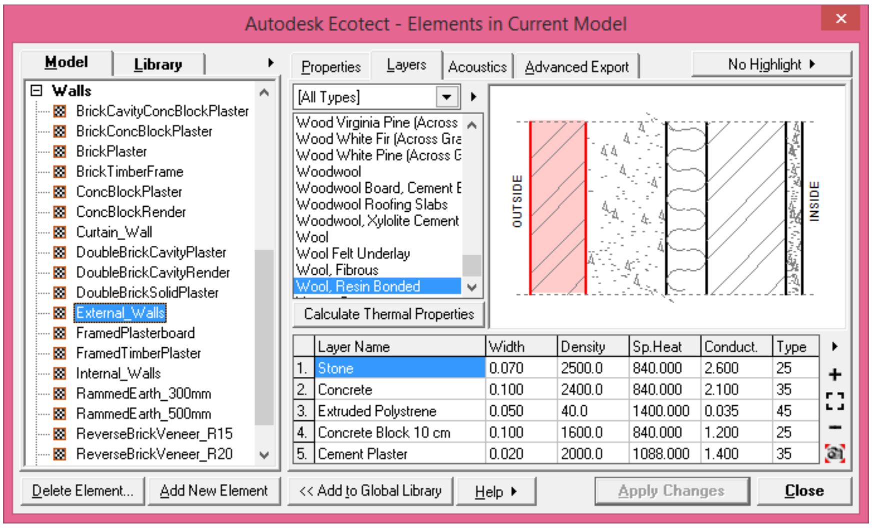


Figure 69: External walls Components.

2. Internal walls Components and properties:

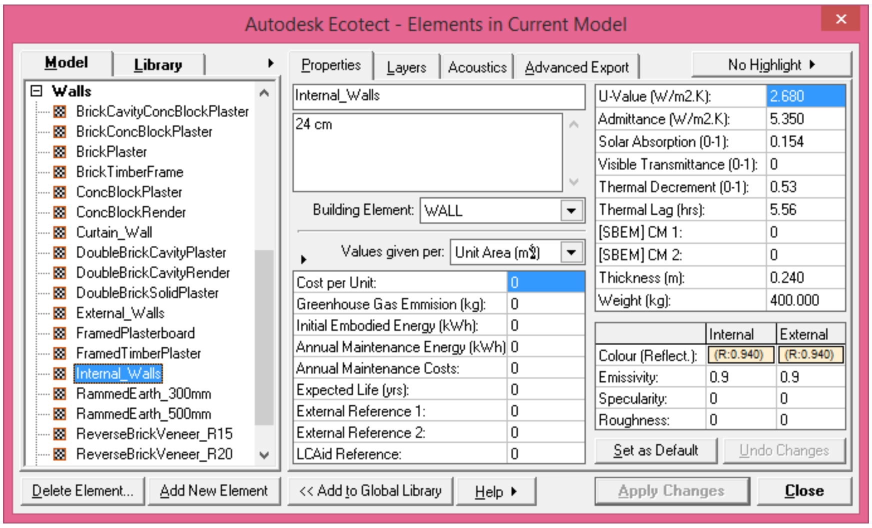


Figure 70: Internal walls properties.

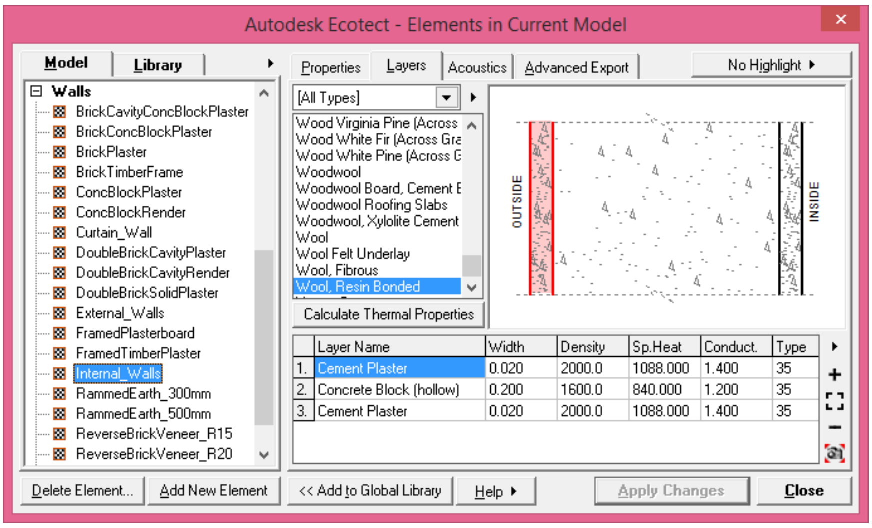


Figure 71: Internal walls Components.

3. Floor Components and properties:

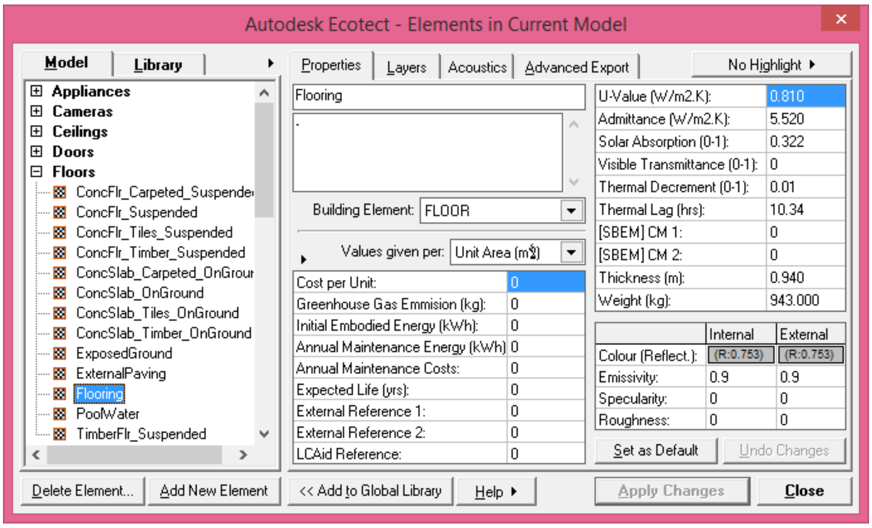


Figure 72: Floor properties.

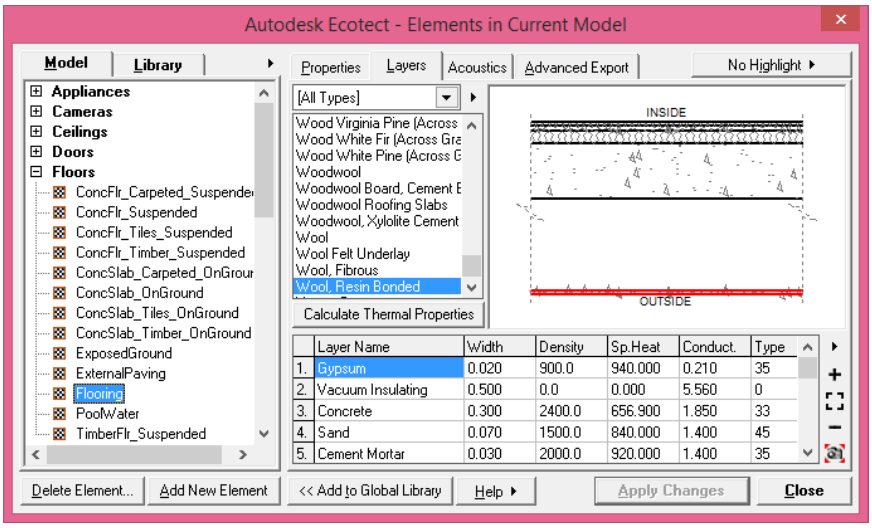


Figure 73: Floor Components.

4. Ceiling Components and properties:

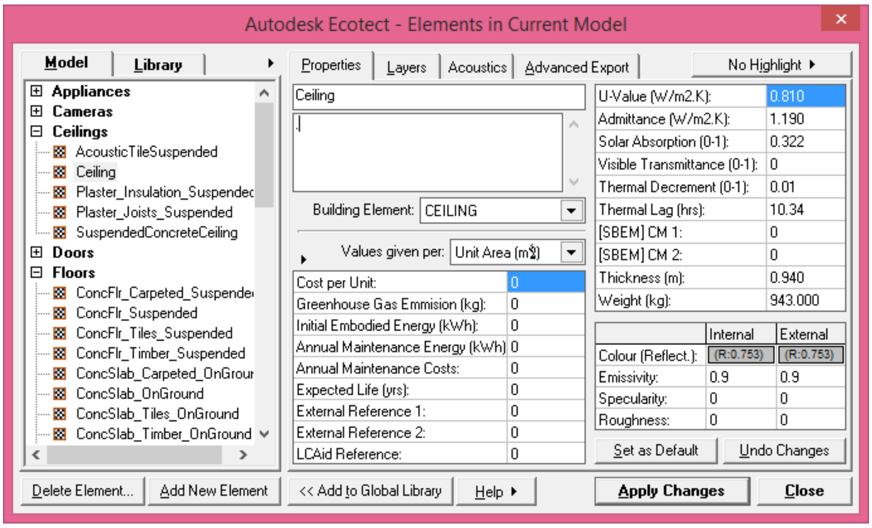


Figure 74: Ceiling properties.

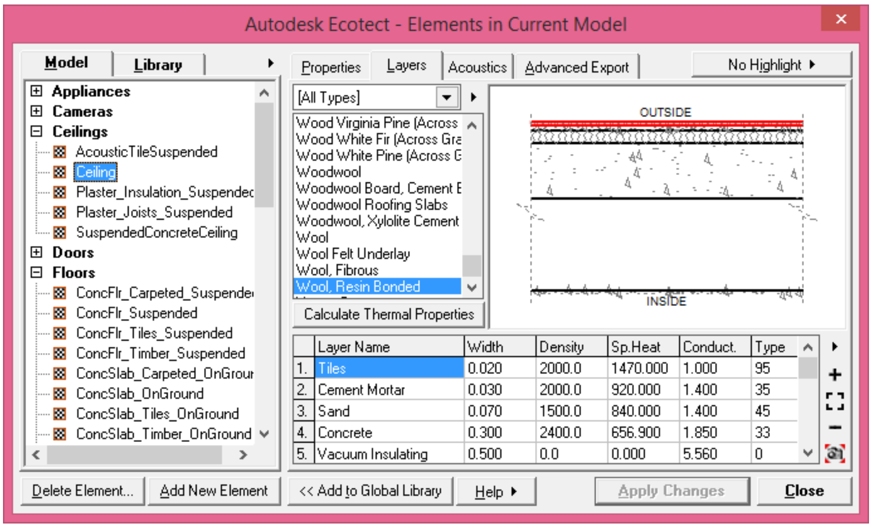


Figure 75: Ceiling Components.

5. Roof Components and properties:

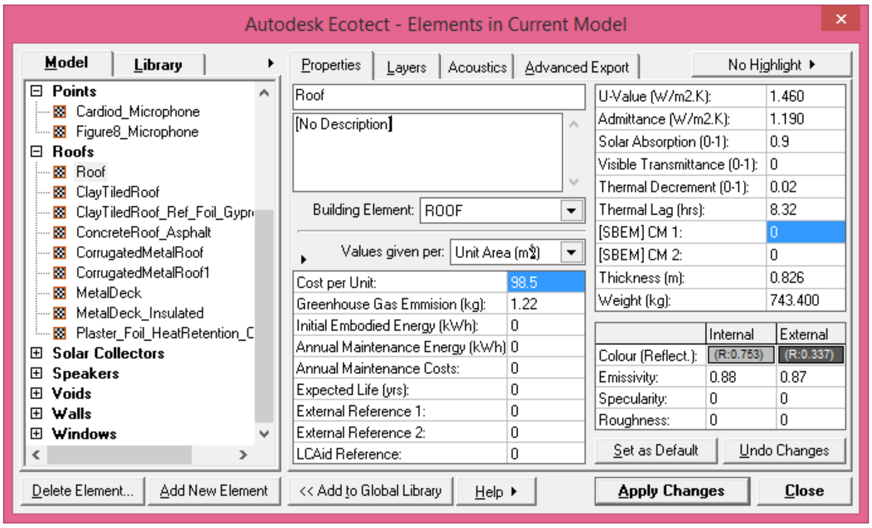


Figure 76: Roof properties.

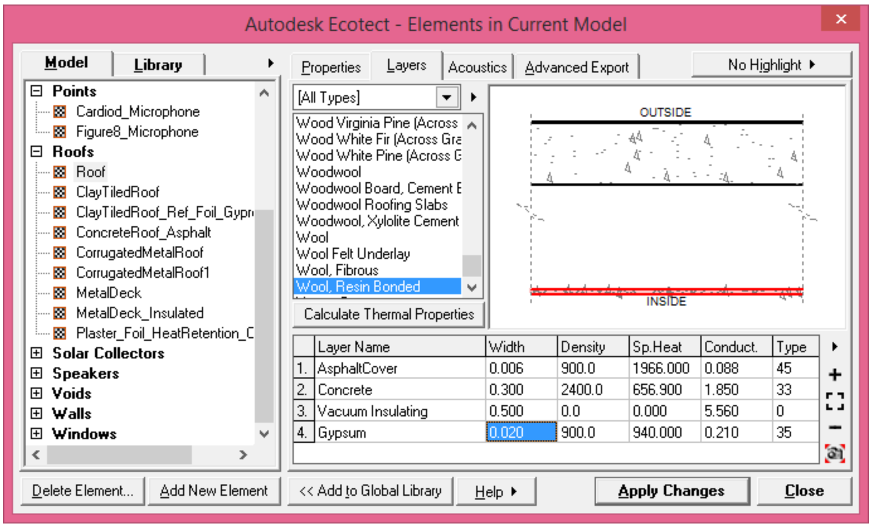


Figure 77: Roof Components.

6. Windows Components and properties:

PRODUCT	Light Transmittance LT (%)	Solar Factor g -value	Shading Coefficient SC	Selectivity LT/g	External Light Reflectance LRe (%)	Internal Light Reflectance LRi (%)	U-Value (EN 673) W/(m².K)	
							12mm air	16mm argon
NEUTRAL								
SGG COOL-LITE XTREME 60/28	60	0.27	0.31	2.22	14	17	1.5	1.0

Figure 78: Windows Glass Type from SAINT-GOBAIN Categories.

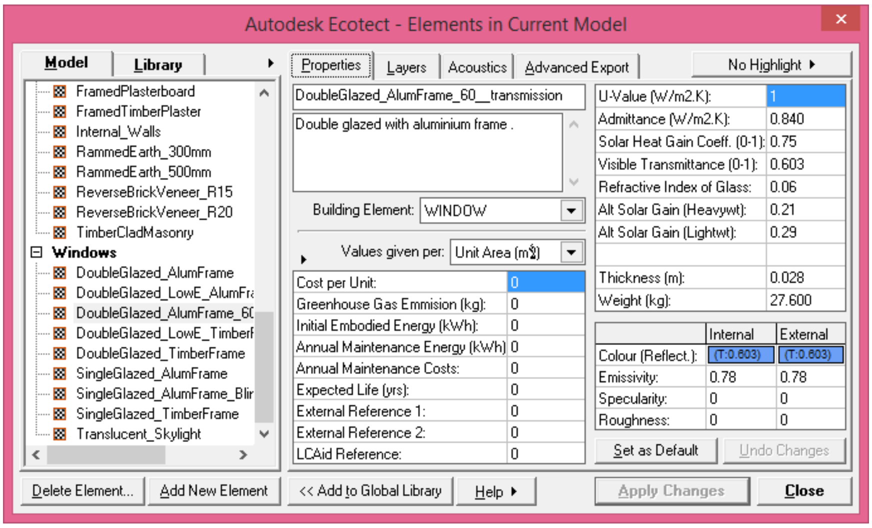


Figure 79: Windows Properties.

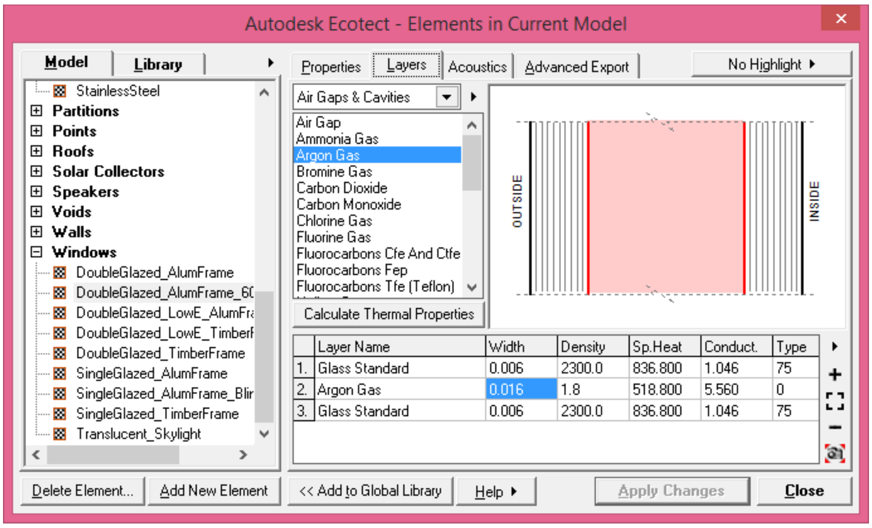


Figure 80: Windows Components.

Note: Glass type used for Glass Doors is same as type used for Windows and same properties.

7. Wood door Components and properties:

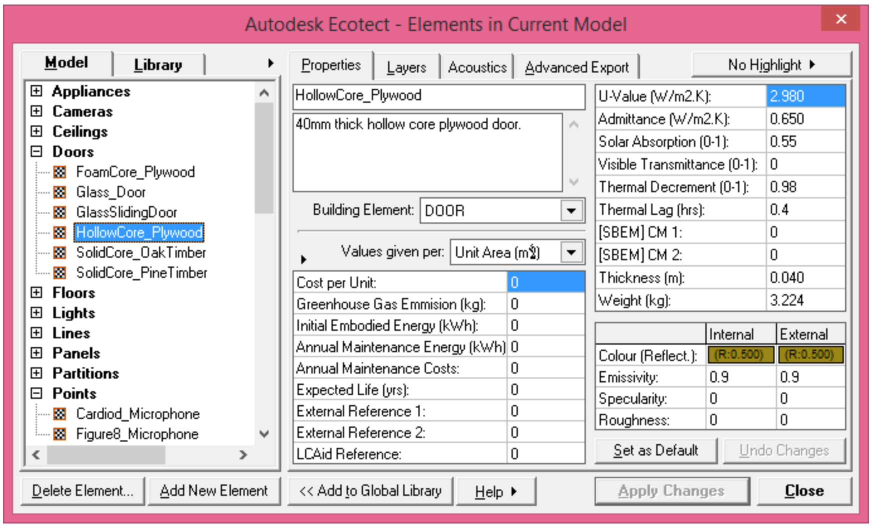


Figure 81: Wood door properties.

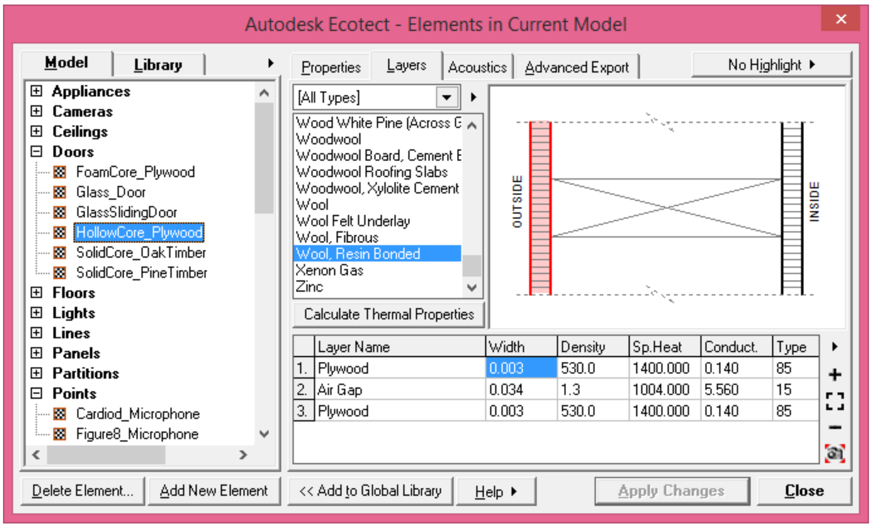


Figure 82: Wood door Components.

8. Glass Panels Components and properties:

PRODUCT	Light Transmittance LT (%)	Solar Factor g -value	Shading Coefficient SC	Selectivity LT/g	External Light Reflectance LRe (%)	Internal Light Reflectance LRi (%)	U-Value (EN 673) W/(m².K) 12mm air	16mm argon
BLUE								
SGG COOL-LITE ST 736	22	0.24	0.28	0.92	12	22	2.7	2.5

Figure 83: Panels Glass Type from SAINT-GOBAIN Categories.

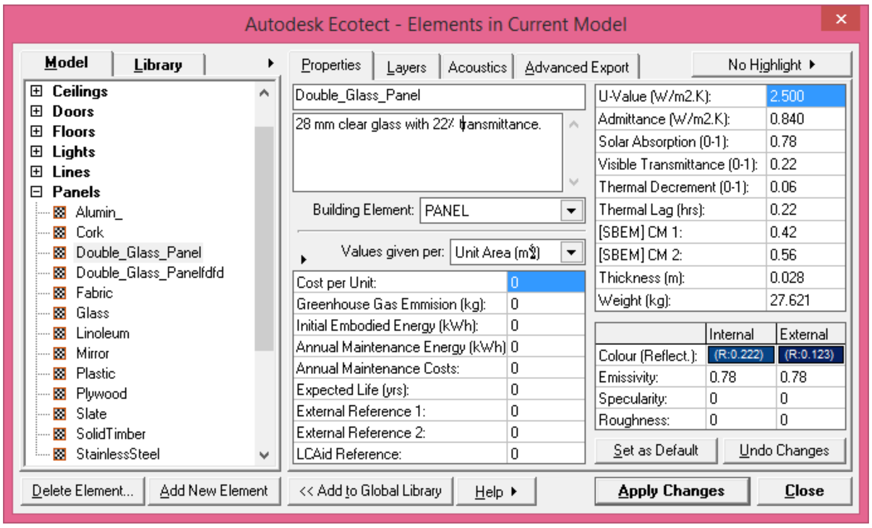


Figure 84: Glass Panels Properties.

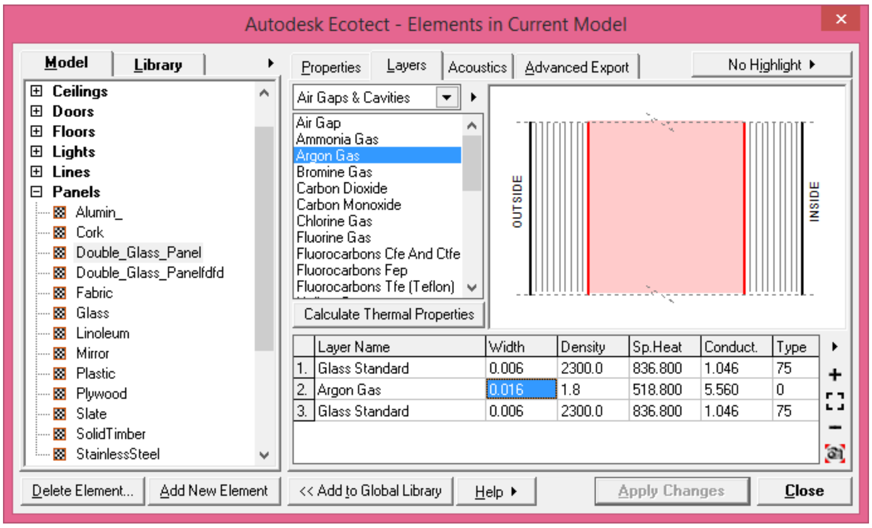


Figure 85: Glass Panels Components.

3.1.2.1.2. 3D MODEL IN ECOTECT PROGRAM

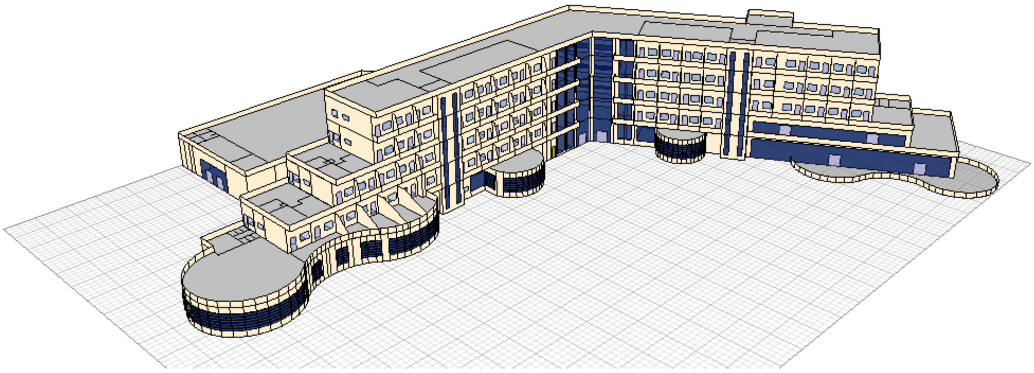


Figure 86: Ecotect 3D View (1).

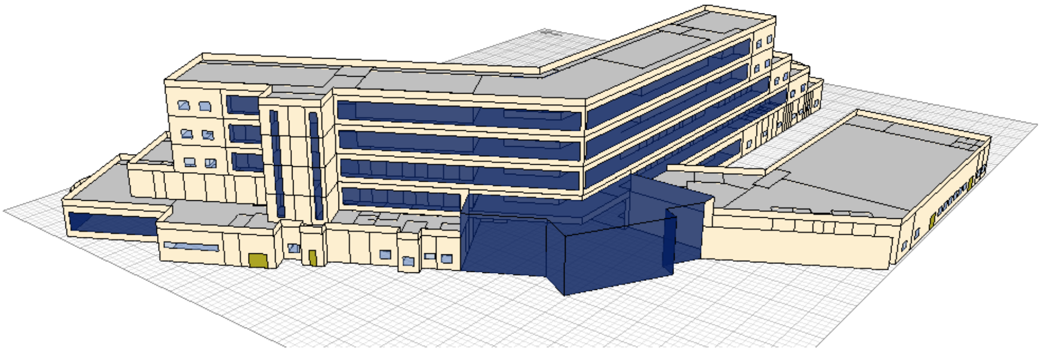


Figure 87: Ecotect 3D View (2).

3.1.2.1.3. DAILY AND ANNUAL SUN PATH

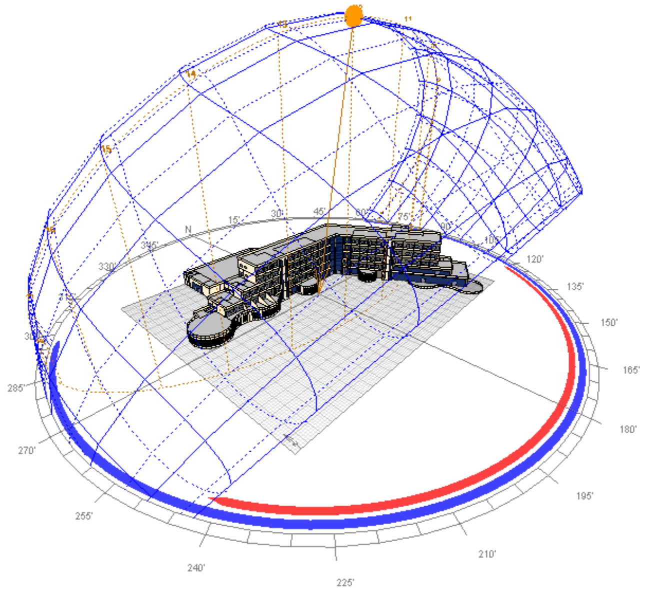


Figure 88: Annual and Dayly Sun Path.

3.1.2.1.4. SHADOWS ON THE BUILDING

1. On 15th may:

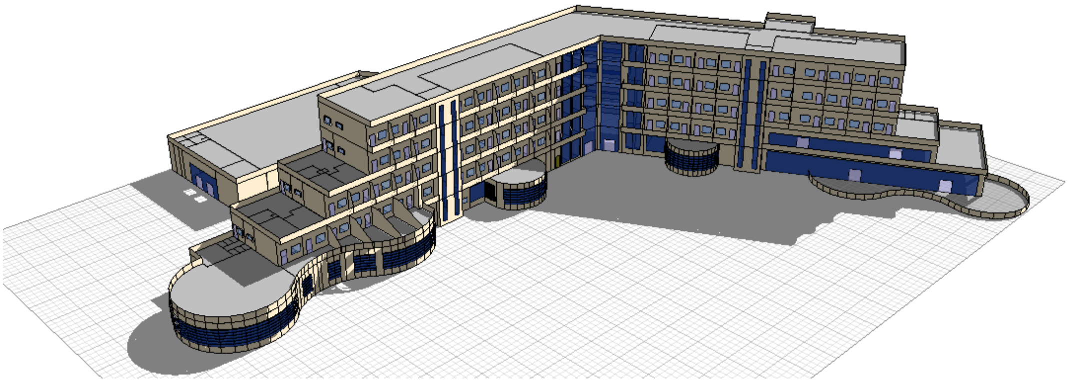


Figure 89: Building Shadow At 8:00 am On 15th May.

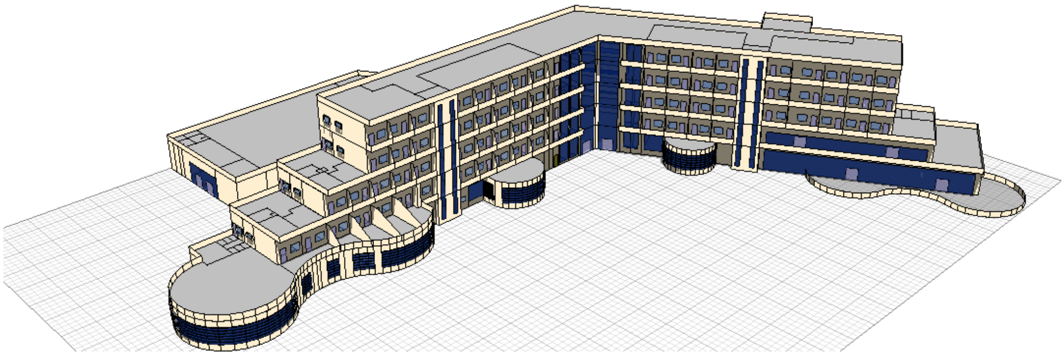


Figure 90: Building Shadow At 12:00 pm On 15th May.

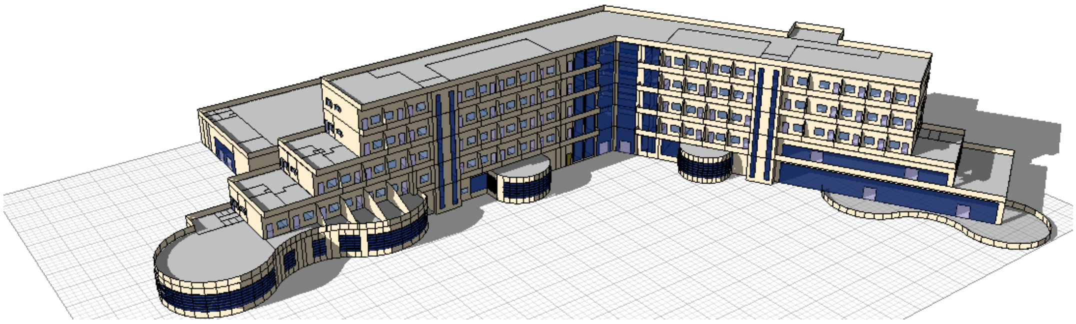


Figure 91: Building Shadow At 4:00 pm On 15th May.

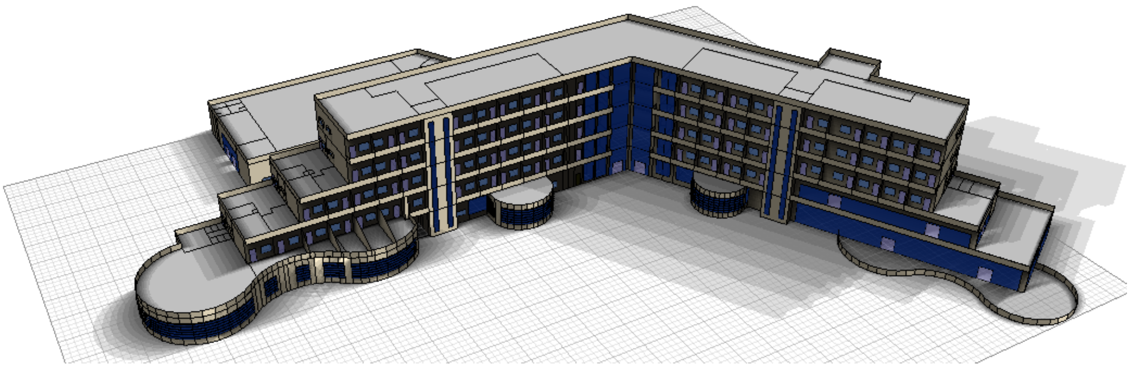


Figure 92: Shadow Range 8:00am-4:00pm on 15th May

2. On 15th Jan:

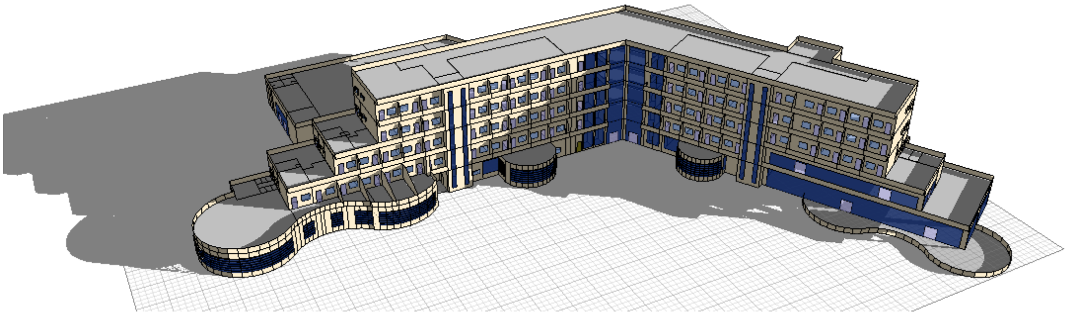


Figure 93: Building Shadow At 8:00 am On 15th Jan.

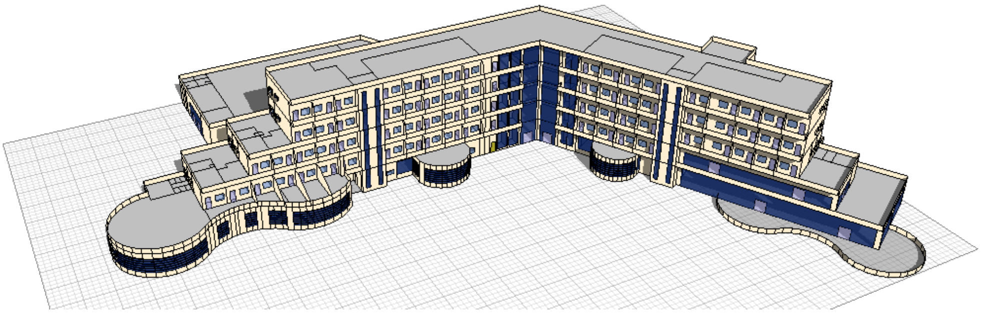


Figure 94: Building Shadow At 12:00 pm On 15th Jan.

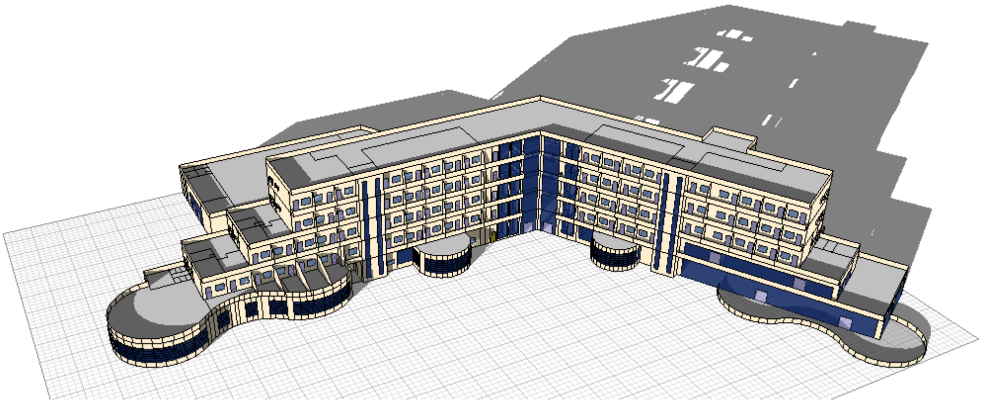


Figure 95: Building Shadow At 4:00 pm On 15th Jan.

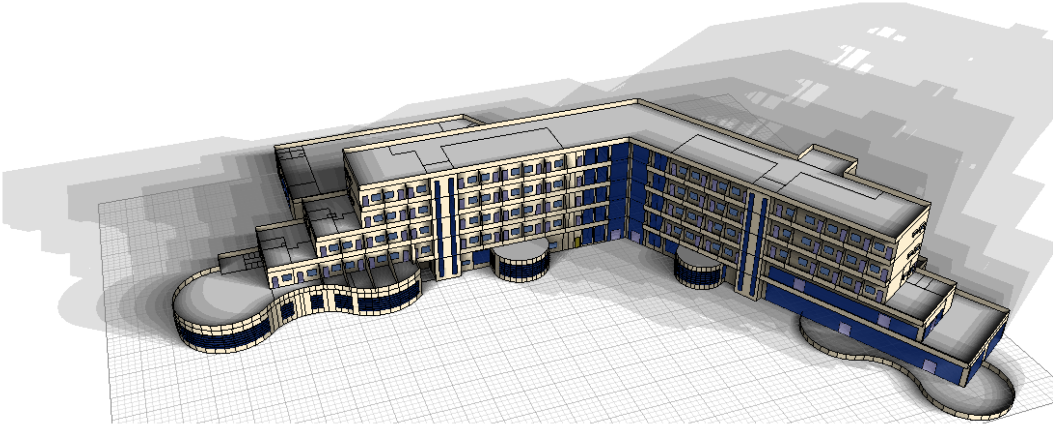


Figure 96: Shadow Range 8:00am-4:00pm on 15th Jan.

3.1.2.1.5. SHADING SYSTEM USED:

1. Shutters (Louvers):

   Horizontal Louvers for south glasses:

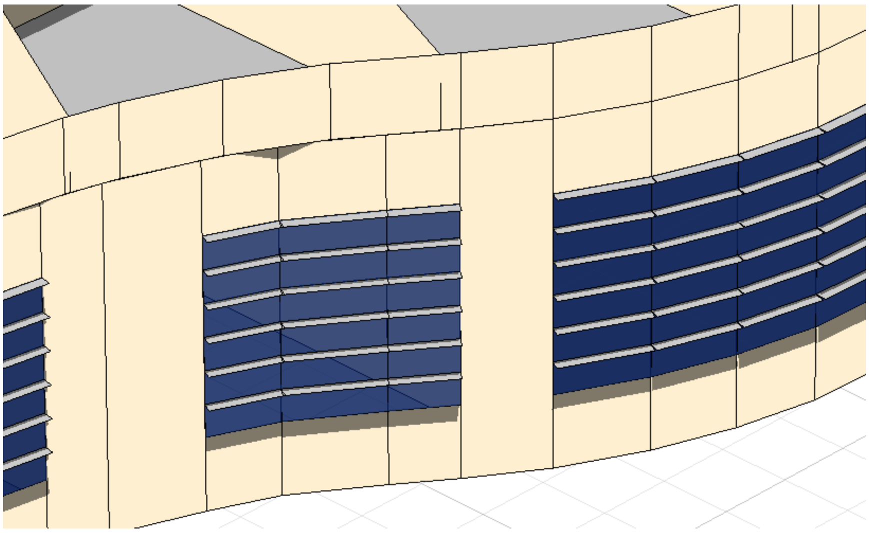


Figure 97: Horizontal Louvers for south glasses.

Vertical Louvers for east and west glasses:

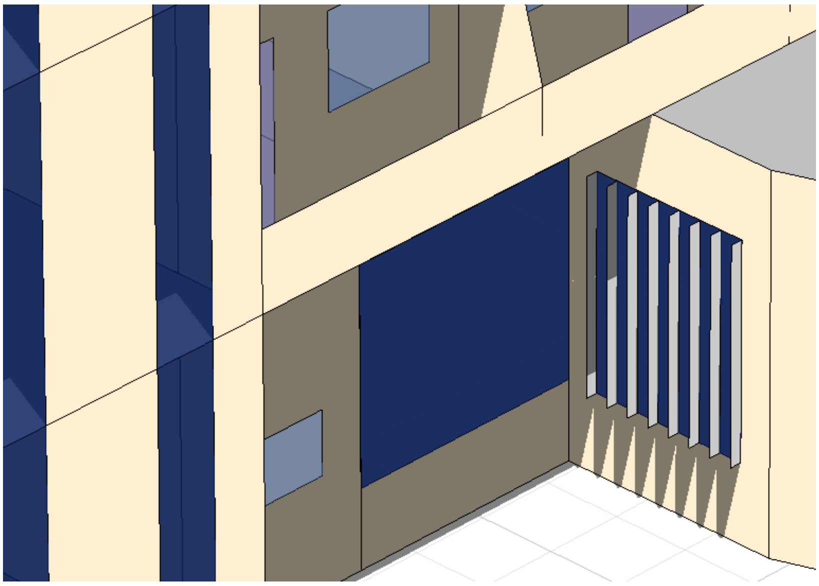


Figure 98: Vertical Louvers for east and west glasses.

Vertical and Horizontal Louvers for south-west glasses:

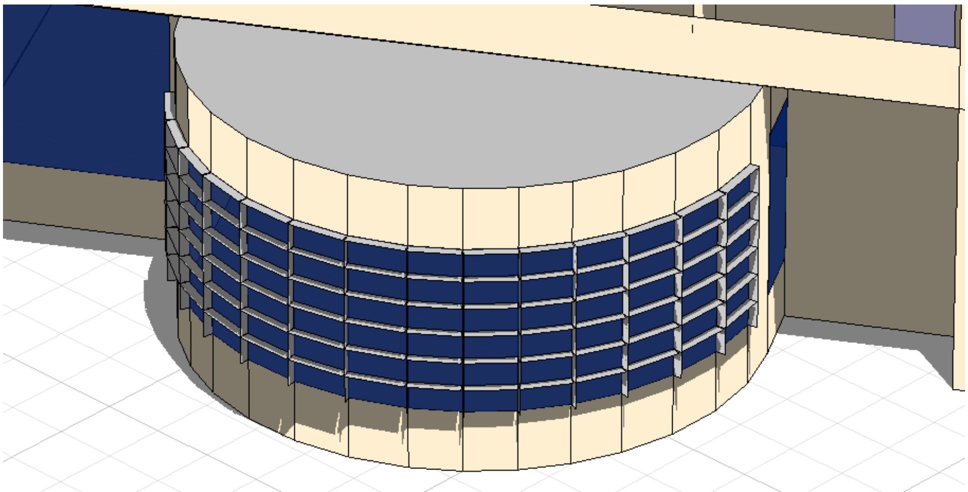


Figure 99: Vertical and Horizontal Louvers for south-west glasses.

2. Cantilever:

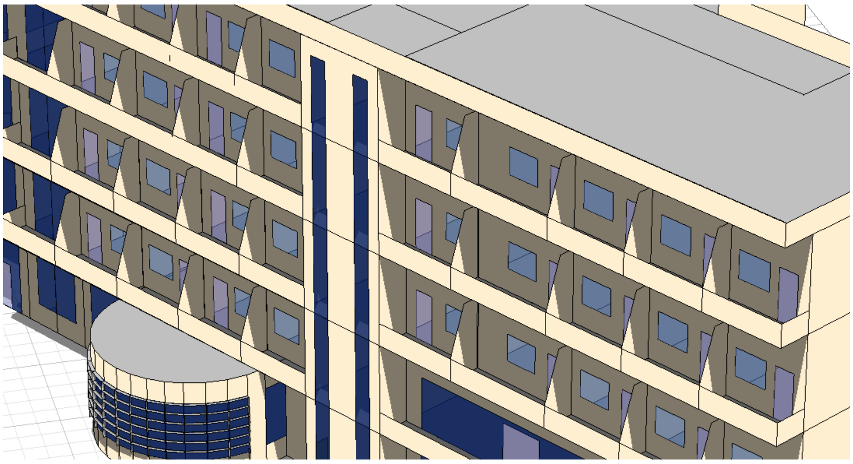


Figure 100: Cantilever Shading.

The effect of shading in summer and winter:

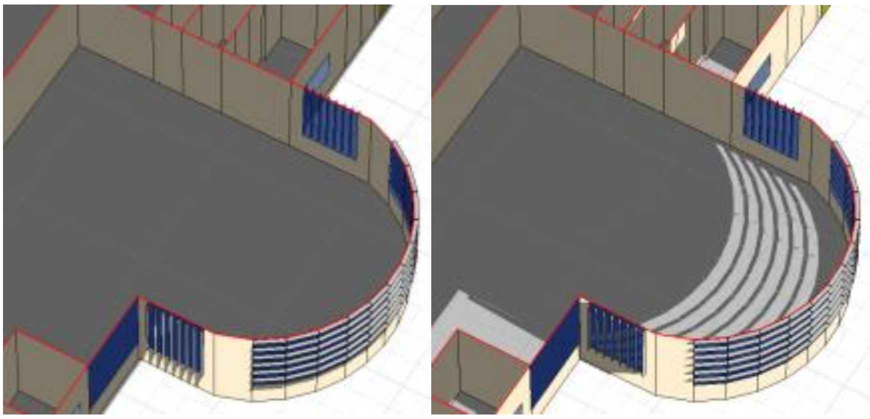


Figure 101: The effect of shading in summer and winter.

3.1.2.1.6. NATURAL LIGHTING

Recommended minimum and average daylight factor: (J&J,1993)

Table 10: Recommended Daylight factor.

Ambient	DF average (%)	DF minimum (%)
Offices	5	2
Classrooms	5	2
Living rooms	1.5	0.5
Bedrooms	1	0.3
Kitchens	2	0.6
Corridors	2	0.6
Stairs	2	0.6
Entrance halls	2	0.6
Assembly halls	2	0.6
Lounges	1.5	0.5

For Restaurant in Ground floor:

D.F avg = 3.08% and D.L = 261.82 Lux

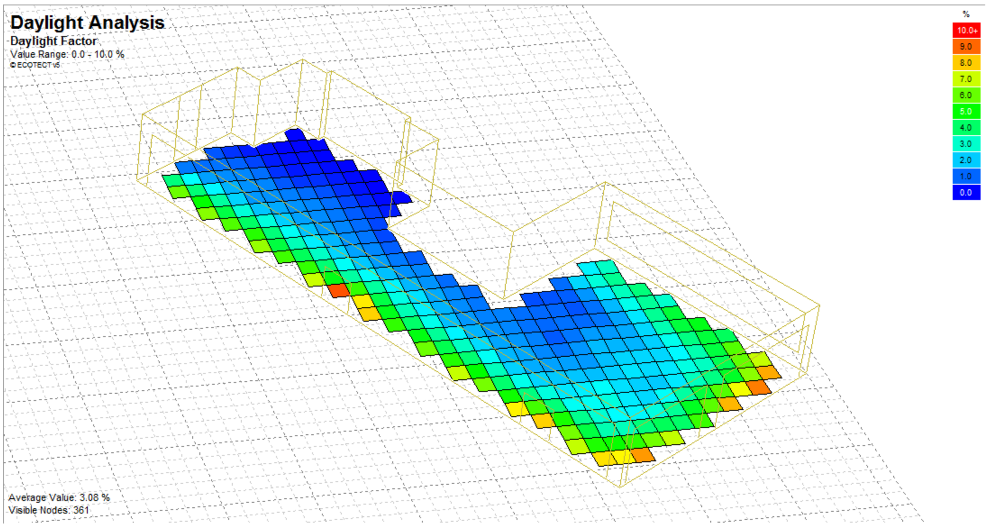


Figure 102: Restaurant Daylight Factor.

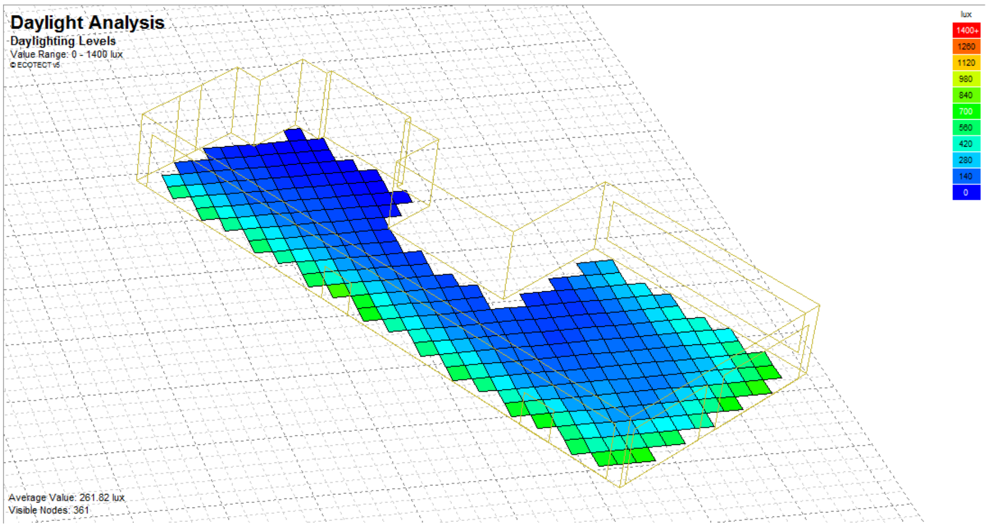


Figure 103: Restaurant Daylight Level.

For Restaurant in 1st floor:

D.F avg = 2.38% and D.L = 202.06 Lux

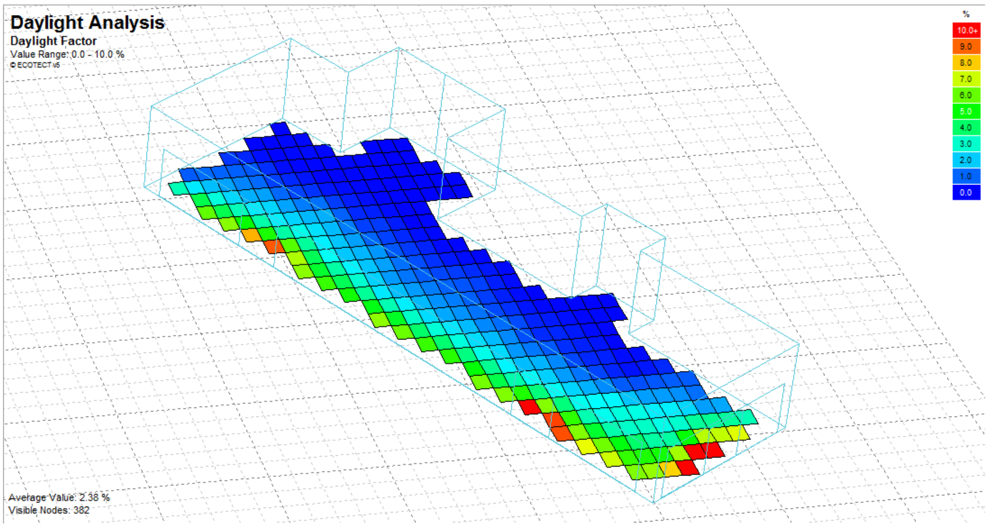


Figure 104: 1st floor Restaurant Daylight factor.

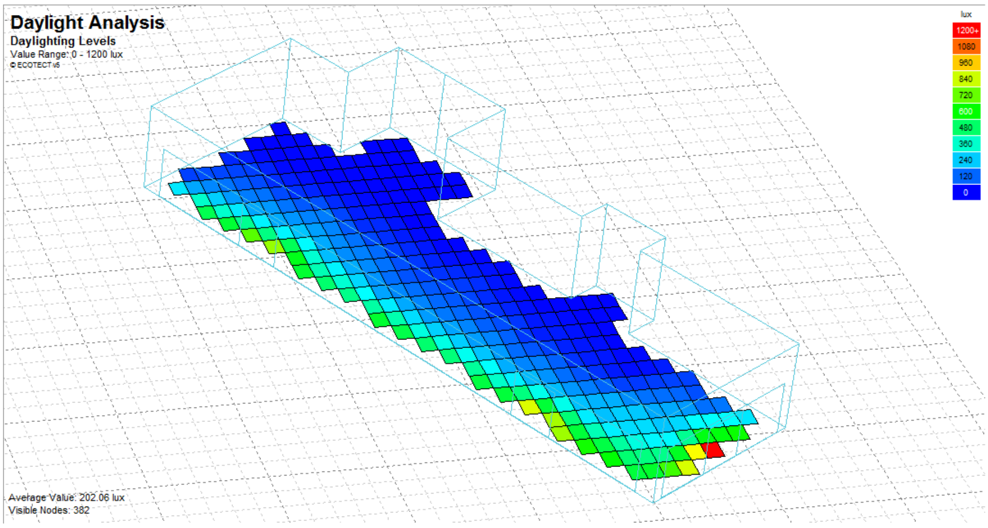


Figure 105: 1st floor Restaurant Daylight Level.

For Kitchen:

D.F avg = 3.26% and D.L = 277.33

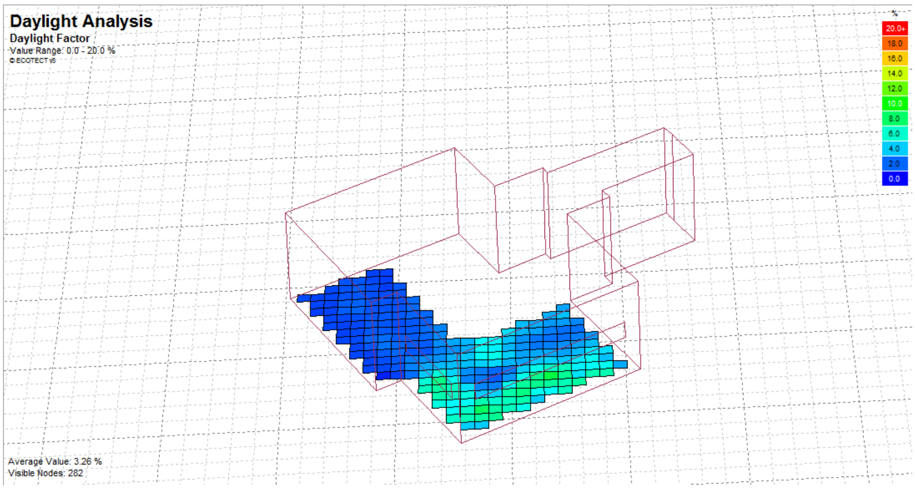


Figure 106: Kitchen Daylight factor.

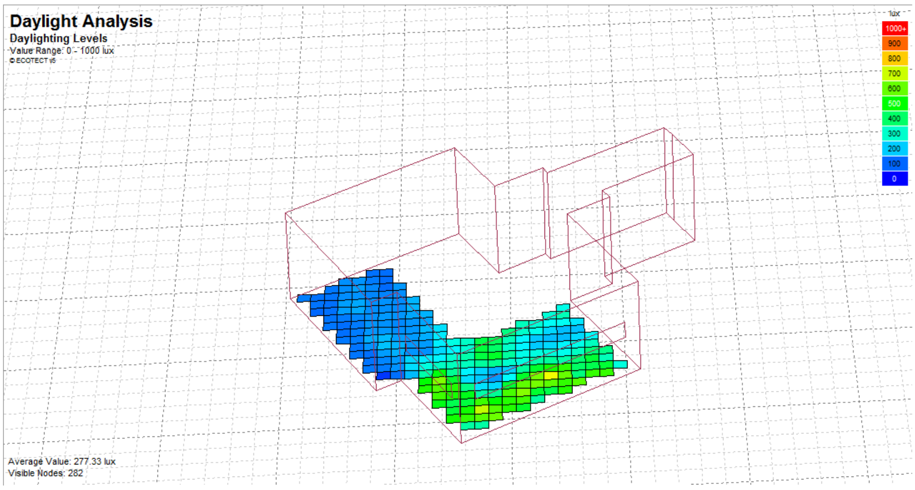


Figure 107: Kitchen Daylight Level.

For Single Bedroom:

D.F avg = 3.05% and D.L = 250 Lux

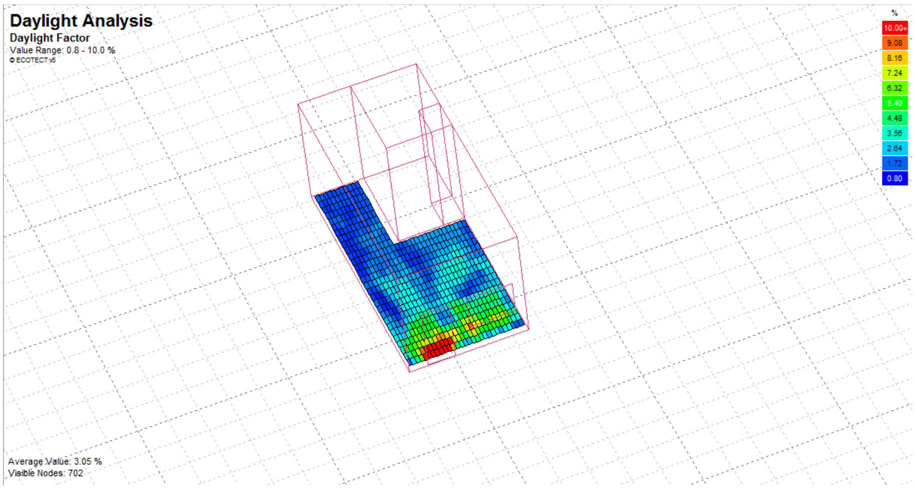


Figure 108: Single bedroom Daylight Factor.

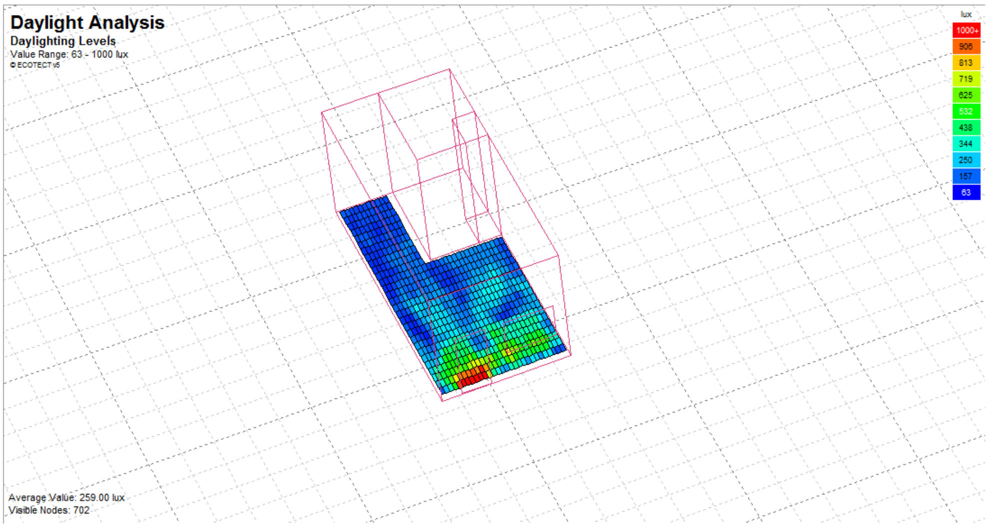


Figure 109: Single bedroom Daylight Level.

For Bedroom in Family Room:

D.F avg = 4.61% and D.L = 361.44 Lux

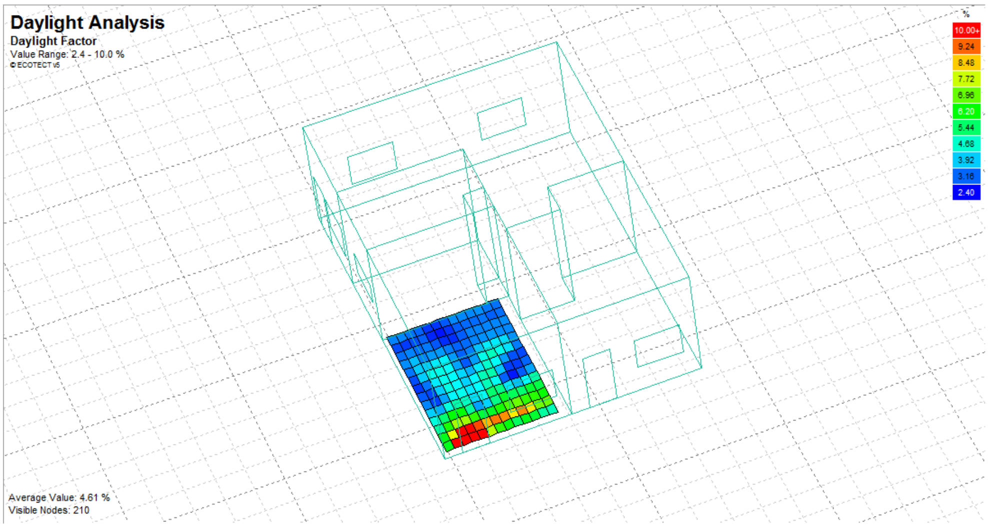


Figure 110: Bedroom in Family Room Daylight Factor.

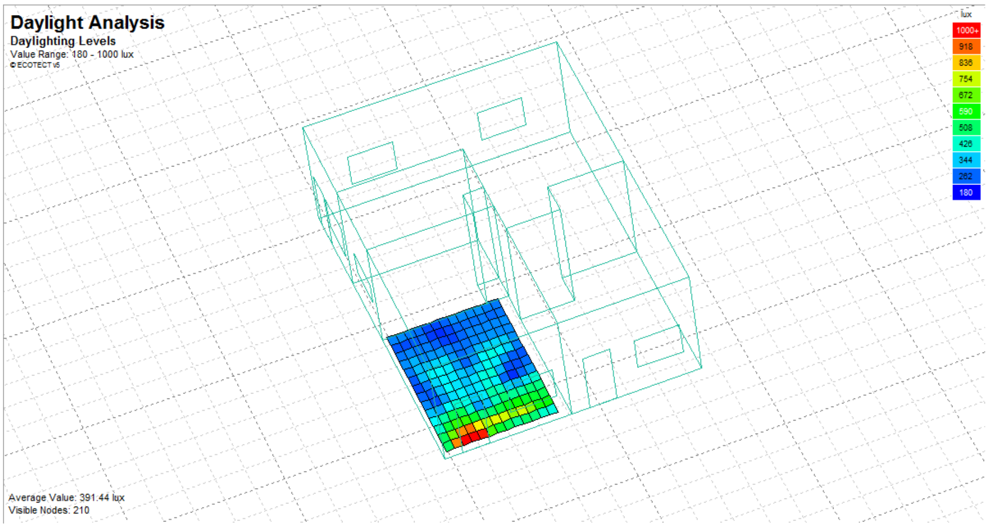


Figure 111: Bedroom in Family Room Daylight Level.

For Corridor between Bedrooms:

D.F avg = 2.64% and D.L = 224.18 Lux

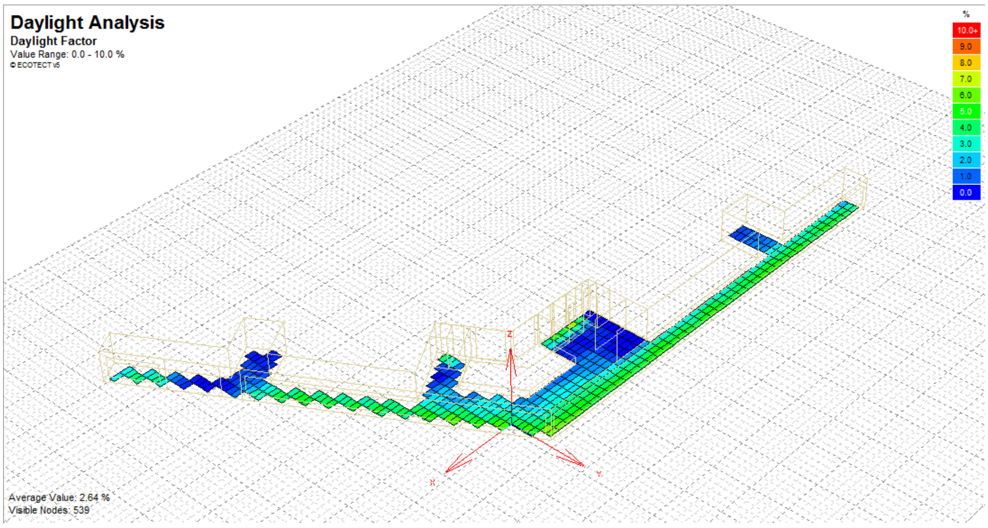


Figure 112: Corridor Daylight Factor.

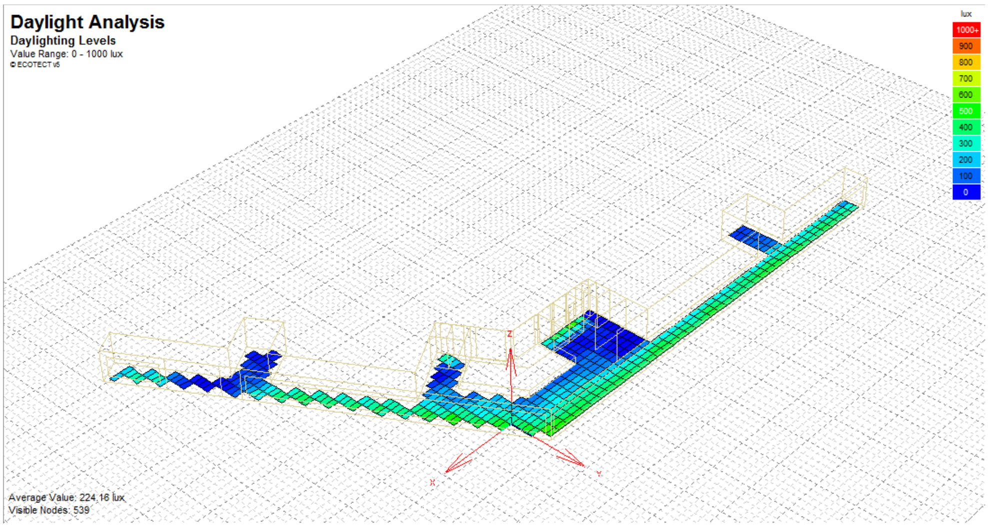


Figure 113: Corridor Daylight Level.

3.1.2.1.7. ACOUSTIC DESIGN:

3.1.2.1.7.1. The Reverberant time (RT_{60}):

The Reverberant time (RT_{60}) required for different rooms:

Table 11: Reverberant time adapted from (ASHRAE ,2007).

Room type	Application	T60 (sec), at 500 Hz, 1000 Hz, and 2000 Hz
Apartment and condominium	—	< 0.6
Hotel/motel	Individual room or suite	< 0.6
	Meeting or banquet room	< 0.8
Office building	Executive or private office	< 0.6
	Conference room	< 0.6
	Teleconference room	< 0.6
	Open-plan office without sound masking	< 0.8
	Open-plan office with sound masking	0.8
Courtroom	Unamplified speech	< 0.7
	Amplified speech	< 1.0
Performing arts space	Drama theaters, concert and recital halls	Varies by application
Laboratories	Testing or research with minimal speech communication	< 1.0
	Extensive phone use and speech communication	< 0.6
Church, mosque, synagogue	General assembly with critical music program	Varies by application
Library	—	< 1.0
Indoor stadium, gymnasium	Gymnasium and natatorium	< 2.0
	Large-capacity space with speech amplification	< 1.5
Classroom	—	< 0.6

	125 CPS	250 CPS	500 CPS	1000 CPS	2000 CPS	4000 CPS
Gypsum board 1/2"	.29	.10	.05	.04	.07	.09
Plaster	.013	.015	.02	.03	.04	.05
Concrete, terrazzo, marble or glazed tile	.01	.01	.015	.02	.02	.02

Figure 114: Acoustic Properties for material used (for wall, floor and Ceiling).

1. <u>For Restaurant:</u>

Before solution:

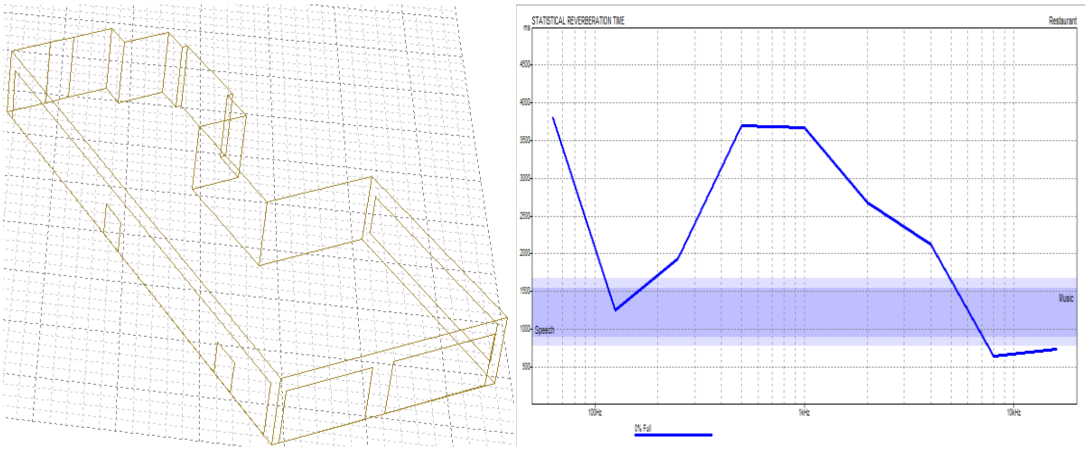


Figure 115: RT60 Curve for Restaurant Room.

Report:
STATISTICAL ACOUSTICS - Restaurant

Volume: 2116.320 m3
Surface Area: 1613.274 m2
Occupancy: 0 (120 x 0%)
Optimum RT (500Hz - Speech): 0.90 s
Optimum RT (500Hz - Music): 1.54 s

Volume per Seat: 17.636 m3
Minimum (Speech): 4.589 m3
Minimum (Music): 8.556 m3

FREQ.	TOTAL ABSPT.	EMPTY RT(60)	50% RT(60)	FULL RT(60)
63Hz:	83.939	3.99	3.81	3.64
125Hz:	268.417	1.27	1.25	1.23
250Hz:	161.510	2.08	1.94	1.82
500Hz:	77.497	4.15	3.69	3.32
1kHz:	68.214	3.99	3.67	3.38
2kHz:	87.137	2.85	2.68	2.51
4kHz:	98.848	2.16	2.12	2.07
8kHz:	23.063	0.54	0.64	0.74
16kHz:	30.168	0.66	0.73	0.79

After Solution:

To Reduce the RT60 we use Acoustic panels on walls and ceiling, and then:

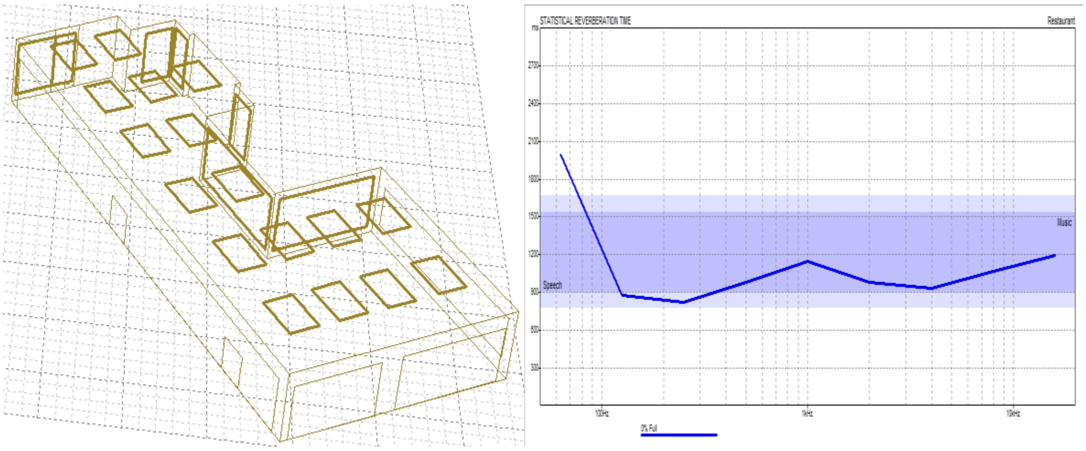


Figure 116: RT60 For Restaurant Room After Solution.

```
Report:
STATISTICAL ACOUSTICS - Restaurant

Volume:  2116.320 m3
Surface Area:  1807.545 m2
Occupancy:  0  (120 x 0%)
Optimum RT (500Hz - Speech):  0.90 s
Optimum RT (500Hz - Music):  1.54 s

Volume per Seat:  17.636 m3
Minimum (Speech):  4.589 m3
Minimum (Music):  8.556 m3
```

FREQ.	TOTAL ABSPT.	EMPTY RT(60)	50% RT(60)	FULL RT(60)
63Hz:	153.876	2.05	2.00	1.95
125Hz:	369.437	0.89	0.88	0.87
250Hz:	379.092	0.84	0.82	0.80
500Hz:	302.851	1.01	0.98	0.95
1kHz:	246.943	1.19	1.15	1.11
2kHz:	289.177	1.01	0.98	0.95
4kHz:	300.889	0.95	0.93	0.91
8kHz:	217.333	1.08	1.07	1.06
16kHz:	166.157	1.21	1.20	1.19

2. For Single Bedroom:

Before Solution:

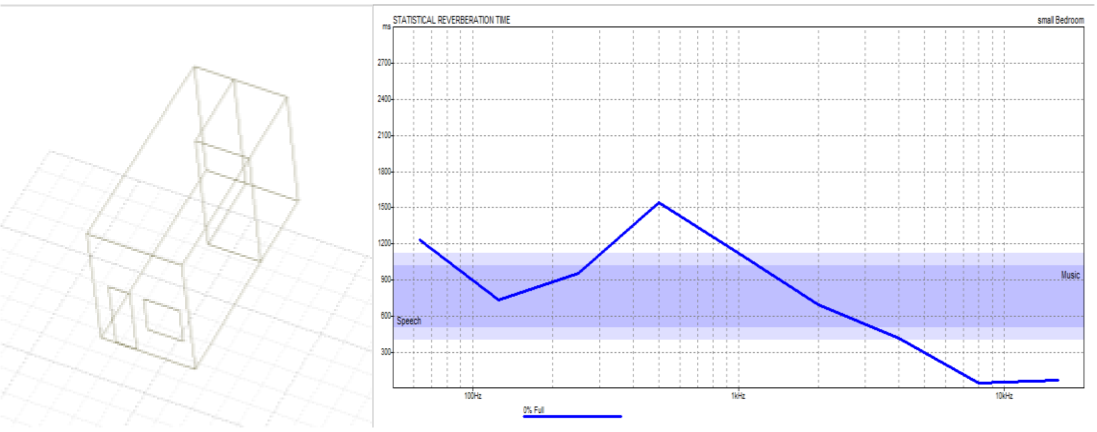


Figure 117: RT60 For Single Bedroom.

Report
STATISTICAL ACOUSTICS - small Bedroom

Volume: 108.140 m3
Surface Area: 158.124 m2
Occupancy: 0 (2 x 0%)
Optimum RT (500Hz - Speech): 0.50 s
Optimum RT (500Hz - Music): 1.02 s

Volume per Seat: 54.070 m3
Minimum (Speech): 3.703 m3
Minimum (Music): 7.359 m3

FREQ.	TOTAL ABSPT.	EMPTY RT(60)	50% RT(60)	FULL RT(60)
63Hz:	13.418	1.24	1.23	1.23
125Hz:	22.989	0.73	0.73	0.73
250Hz:	16.546	0.97	0.96	0.95
500Hz:	8.618	1.56	1.54	1.52
1kHz:	7.464	1.12	1.12	1.12
2kHz:	7.927	0.69	0.69	0.70
4kHz:	8.394	0.41	0.42	0.42
8kHz:	1.116	0.04	0.05	0.05
16kHz:	2.113	0.07	0.07	0.07

After Solution:

To Reduce the RT60 we use Acoustic panels on walls, and then:

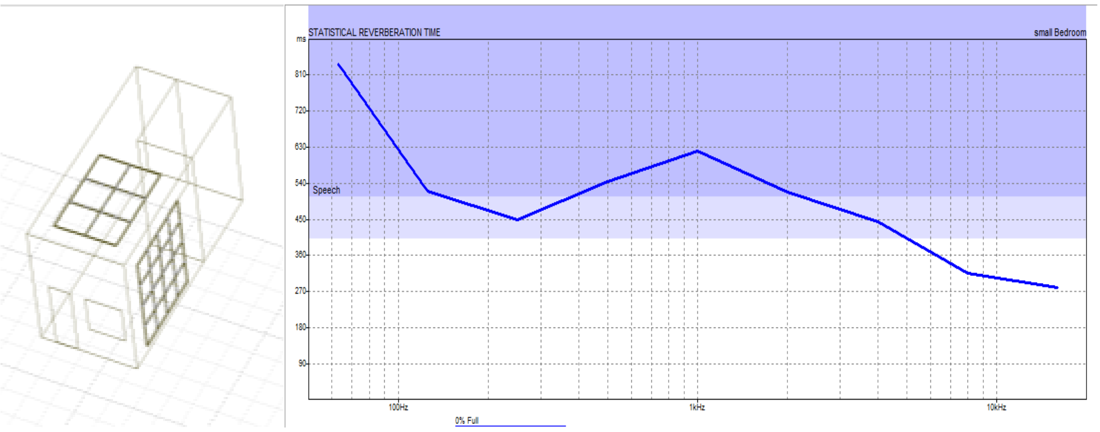


Figure 118: RT60 For Single Bedroom after Solution.

Report

STATISTICAL ACOUSTICS - small Bedroom

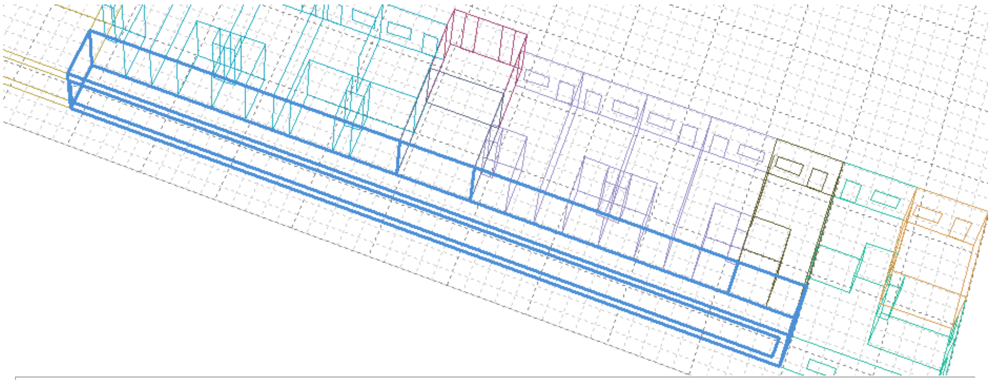
Volume: 108.140 m3
Surface Area: 177.116 m2
Occupancy: 0 (2 x 0%)
Optimum RT (500Hz - Speech): 0.50 s
Optimum RT (500Hz - Music): 1.02 s

Volume per Seat: 54.070 m3
Minimum (Speech): 3.703 m3
Minimum (Music): 7.359 m3

FREQ.	TOTAL ABSPT.	EMPTY RT(60)	50% RT(60)	FULL RT(60)
63Hz:	20.255	0.84	0.84	0.83
125Hz:	32.866	0.52	0.52	0.52
250Hz:	37.817	0.45	0.45	0.45
500Hz:	30.650	0.55	0.54	0.54
1kHz:	24.938	0.62	0.62	0.62
2kHz:	27.680	0.52	0.52	0.52
4kHz:	28.147	0.44	0.44	0.44
8kHz:	20.109	0.31	0.32	0.32
16kHz:	15.408	0.28	0.28	0.28

3. For Corridor:

Before Solution:



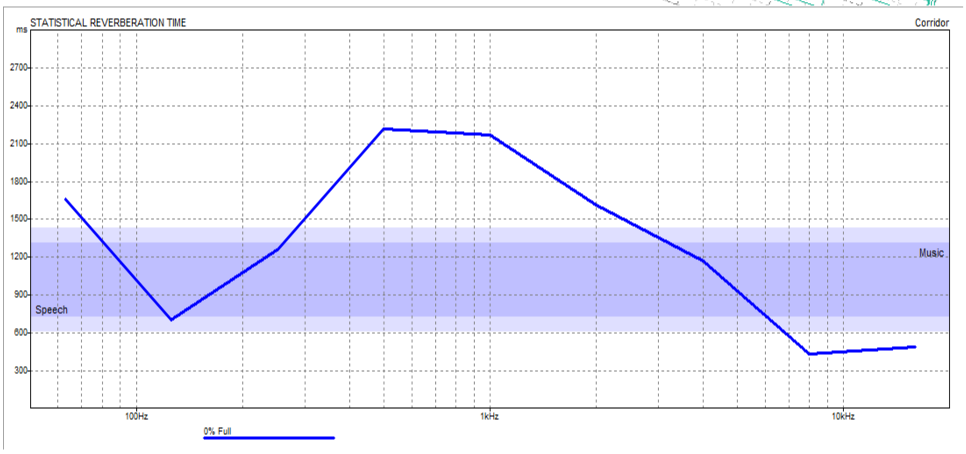


Figure 119: RT60 For Corridor.

Report
STATISTICAL ACOUSTICS - Corridor
Volume: 584.000 m3
Surface Area: 750.514 m2
Occupancy: 0 (15 x 0%)
Optimum RT (500Hz - Speech): 0.73 s
Optimum RT (500Hz - Music): 1.32 s
Volume per Seat: 38.933 m3
Minimum (Speech): 4.139 m3
Minimum (Music): 7.948 m3

FREQ.	TOTAL ABSPT.	EMPTY RT(60)	50% RT(60)	FULL RT(60)
63Hz:	55.390	1.68	1.66	1.65
125Hz:	133.642	0.70	0.70	0.70
250Hz:	72.120	1.28	1.25	1.23
500Hz:	38.580	2.29	2.22	2.16
1kHz:	32.499	2.22	2.17	2.13
2kHz:	36.389	1.63	1.61	1.59
4kHz:	42.086	1.17	1.17	1.17
8kHz:	18.914	0.42	0.43	0.44
16kHz:	23.571	0.48	0.49	0.50

After Solution:

To Reduce RT60 We use Acoustic Ceiling Tiles:

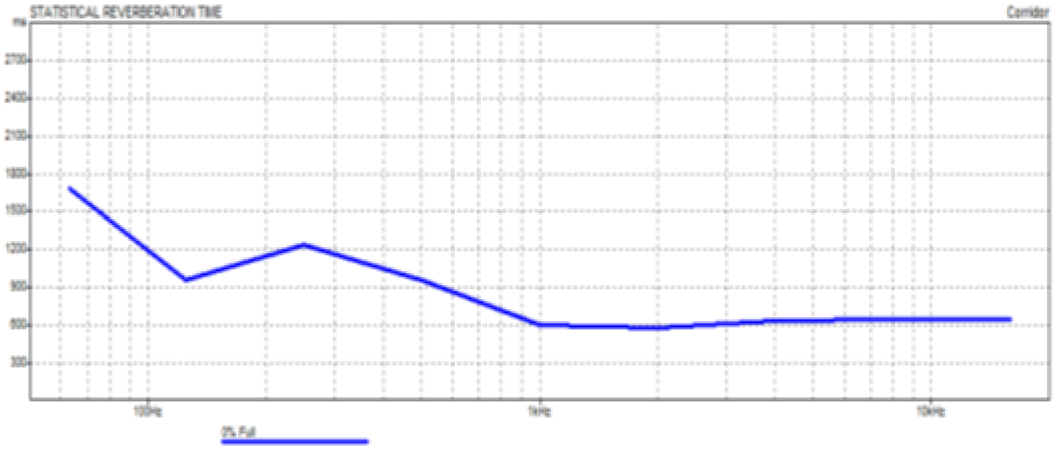


Figure 120: RT60 For Corridor after Solution.

```
Report
STATISTICAL ACOUSTICS - Corridor

Volume:  584.000 m3
Surface Area:  750.514 m2
Occupancy:  0  (15 x 0%)
Optimum RT (500Hz - Speech):  0.73 s
Optimum RT (500Hz - Music):  1.32 s

Volume per Seat:  38.933 m3
Minimum (Speech):  4.139 m3
Minimum (Music):  7.948 m3
```

FREQ.	TOTAL ABSPT.	EMPTY RT(60)	50% RT(60)	FULL RT(60)
63Hz:	55.390	1.64	1.62	1.61
125Hz:	98.033	0.94	0.93	0.93
250Hz:	74.969	1.19	1.17	1.14
500Hz:	96.979	0.92	0.91	0.90
1kHz:	156.419	0.58	0.57	0.57
2kHz:	158.885	0.56	0.55	0.55
4kHz:	137.519	0.61	0.61	0.60
8kHz:	110.074	0.63	0.63	0.63
16kHz:	107.609	0.63	0.63	0.63

Acoustic panels properties:

NRC : 0.8~1.1

Size: 1220 mm*2420 mm or Customized

Colors: More Than 44 Kinds of Colors

Thickness:9 mm, 12 mm or Customized

Polyester acoustic panel sound absorption coefficient:

Cavity/mm	0	50	100	150	200
Frequency/Hz	**1/3double frequency sound absorbing coefficient**				
100	0.02	0.12	0.24	0.36	0.52
125	0.04	0.16	0.36	0.52	0.64
160	0.02	0.20	0.48	0.72	0.84
200	0.04	0.32	0.68	0.96	1.08
250	0.08	0.44	0.88	1.12	1.12
315	0.08	0.52	0.80	0.96	0.96
400	0.08	0.60	0.96	1.12	1.28
500	0.12	0.80	1.08	1.16	1.12
630	0.20	0.96	1.12	1.08	0.96
800	0.28	1.00	1.04	1.04	0.80
1000	0.36	1.00	1.12	0.92	0.76
1250	0.48	1.12	1.00	0.72	0.96
1600	0.60	1.04	0.80	0.84	0.92
2000	0.72	1.16	0.92	1.04	1.00
2500	0.80	0.96	1.00	0.88	0.96
3150	0.88	0.92	0.96	0.96	1.00
4000	1.00	1.00	1.04	1.04	1.04
5000	1.08	1.00	1.00	0.96	1.00
NRC	0.30	0.85	0.95	1.00	1.00

Figure 121: Acoustic panels properties.

(http://euroyal.en.made-in-china.com/product/KSRJcONGfvhU/China-Formaldehyde-Free-Polyester-Anti-Sound-Acoustic-Wall-Panel.html **, 2016)**

Acoustic Ceiling tiles properties:

Typical acoustic absorptivity of different materials.
(Actual values will vary depending on the exact makeup of the material.)

	Frequency (Hz)					
Surface	125	250	500	1000	2000	4000
Acoustic tile, suspended	.5	.7	.6	.7	.7	.5

Sources: D. E. Hall, *Musical Acoustics*, 2002

Figure 122: Acoustic Ceiling tiles properties.

3.1.2.1.7.2. Sound Transmission Control for walls and floors:

Criteria for Airborne Sound Insulation of Partitions between Dwelling Units:

Table 12: Airborne Sound Insulation of Partitions between Dwelling Units. adapted from(Stein et al, 2010).

Assembly Function between Dwellings			Grade II STC
Apt. A		Apt. B	
Bedroom	to	Bedroom	52
Living room	to	Bedroom	54
Kitchen	to	Bedroom	55
Bathroom	to	Bedroom	56
Corridor	to	Bedroom	52
Living room	to	Living room	52
Kitchen	to	Living room	52
Bathroom	to	Living room	54
Corridor	to	Living room	52
Kitchen	to	Kitchen	50
Bathroom	to	Kitchen	52
Corridor	to	Kitchen	52
Bathroom	to	Bathroom	50
Corridor	to	Bathroom	48

Common Interior Walls:

Table 13: STC for Common Interior walls.

Layers	STC
Plaster	2
Dense Hollow Block 10 cm	38
Plaster	2
total	42

Wall insulation = 42 db < Required STC between Bedrooms = 52 db …. So, the insulation of wall not enough.

Interior Walls used:

Table 14: STC for used Interior walls

Layers	STC
Plaster 2 cm	2
Dense Hollow Block 20 cm	48
Plaster 2 cm	2
Total	52

The insulation of wall = 52 db, and this enough and achieve the requirement STC = 52 db between bedrooms.

For Floor and Ceiling:

Weight of floor or Ceiling from Ecotect = 943 Kg/m3

STC = $14.4*\text{Weight}^{0.23}$

= $14.4*943^{0.23}$ = 69.6 db , and this value is good for insulation.

Criteria for Airborne and Impact Sound Insulation of Floor-Ceiling Assemblies between Dwelling Units:

Table 15: Airborne and Impact Sound Insulation of Floor-Ceiling Assemblies between Dwelling Units. adapted from(Stein et al, 2010).

Assembly Function between Dwellings			**Grade II**	
Apt. A		Apt. B	STC	IIC
Bedroom	Above	Bedroom	52	52
Living room	Above	Bedroom	54	57
Kitchen	Above	Bedroom	55	62
Family room	Above	Bedroom	56	62
Corridor	Above	Bedroom	52	62
Bedroom	Above	Living room	54	52
Living room	Above	Living room	52	52
Kitchen	Above	Living room	52	57
Family room	Above	Living room	54	60
Corridor	Above	Living room	52	57
Bedroom	Above	Kitchen	55	50
Living room	Above	Kitchen	52	52
Kitchen	Above	Kitchen	50	52
Bathroom	Above	Kitchen	52	52
Family room	Above	Kitchen	52	58
Corridor	Above	Kitchen	48	52
Bedroom	Above	Family room	56	48
Living room	Above	Family room	54	50

3.1.2.1.7.3. Effect Of sound between Spacing:

1. Effect of sound from bedroom to bedroom:

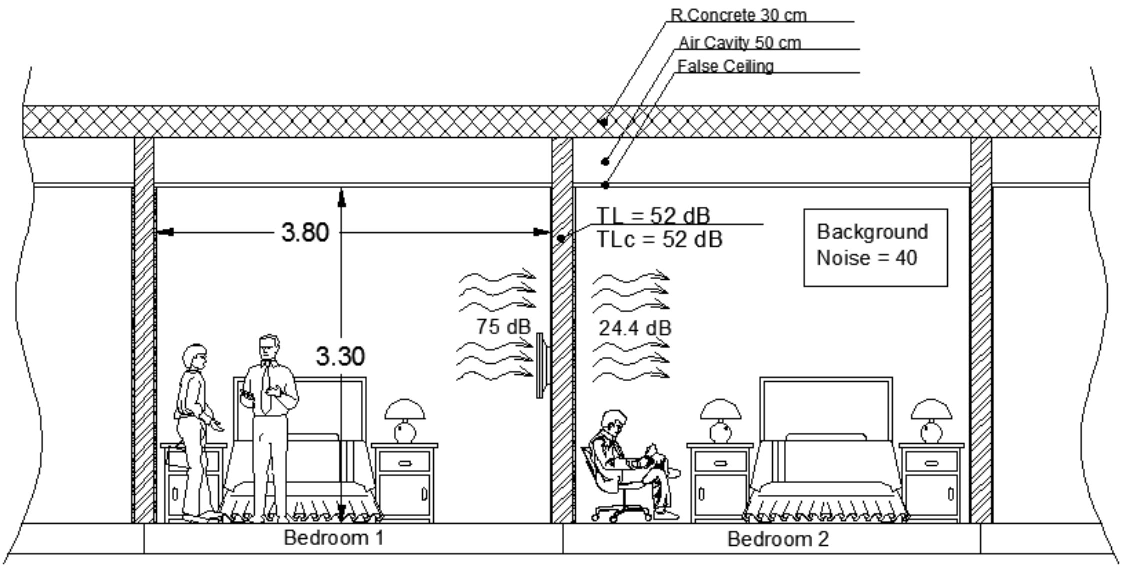


Figure 123: Effect of sound from bedroom to bedroom.

TL partition = 52 dB

Assume sound source = 75 dB in bedroom1

Partition Area = (4.1-0.9)*8.2 = 3.2*8.2 = 26.24 m2

To calculate the absorption for Receiving room (bedroom2):

Wall paint absorption coefficient = 0.1

Floor absorption coefficient (Tiles) = 0.02

Ceiling absorption coefficient (gypsum board) = 0.02

∑A = ∑surface area*absorption coefficient = (2*3.2*3.8)*0.1+(2*3.2*8.2)*0.1 +(3.2*8.2)*0.02+(3.2*8.2)*0.02 = 8.73 Sabine

NR = TL partition – 10 Log(Area partition/Total absorption)

= 52 – 10*Log(12.16/8.73) = 52 – 1.4 = 50.6 dB

IL in Bedroom2 = IL in bedroom1 – NR

= 75 – 50.6 = 24.4 dB

Background Noise In bedroom = 40 db > 24.4 , so it is good.

2. Effect Of sound between bedroom and Corridor:

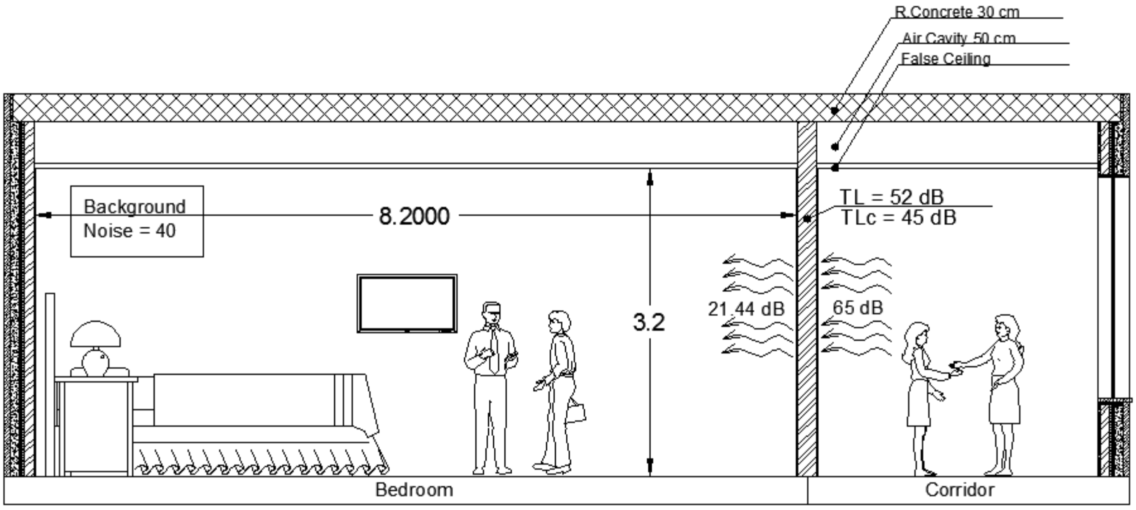


Figure 124: Effect Of sound between bedroom and Corridor.

TL partition = 52 dB

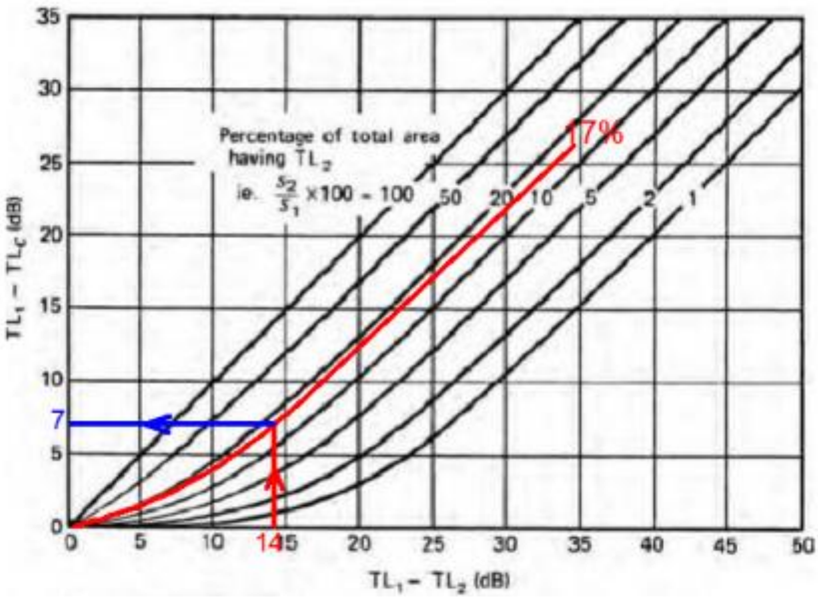
TL door (Side-Hinged Single Door System wood Flush door) = 38 dB

TL partition – TL door = 52-38 = 14 dB

Area Partition = (4.1-0.9)*3.8 = 3.2*3.8 = 12.16 m2

Area door = 0.9*2.25 = 2.03 m2

(A.door/A.wall)*100% = (2.03/12.16)*100% = 16.69% ≈ 17%



Title

From Curve: TL partition – TL combined = 7 ➔ TL combined = 52 – 7 = 45 dB

So, the new TL for Partition = 45 dB

To calculate the effect of sound from corridor to bedroom:

Assume sound source = 65 dB in corridor

Partition Area = (4.1-0.9)*3.8 = 3.2*3.8 = 12.16 m2

To calculate the absorption for Receiving room (bedroom) :

Wall paint absorption coefficient = 0.1

Floor absorption coefficient (Tiles) = 0.02

Ceiling absorption coefficient (gypsum board)= 0.02

∑A = ∑surface area*absorption coefficient = (2*3.2*3.8)*0.1+(2*3.2*8.2)*0.1 +(3.2*8.2)*0.02+(3.2*8.2)*0.02 = 8.73 Sabine

NR = TL partition – 10 Log(Area partition/Total absorption)

= 45 – 10*Log(12.16/8.73) = 45 – 1.44 = 43.56 dB

IL in Bedroom = IL in corridor – NR

= 65 – 43.56 = 21.44 dB

Background Noise In bedroom = 40 db > 21.44 , so it is good.

3. Effect Of sound between bedroom and outside ambient:

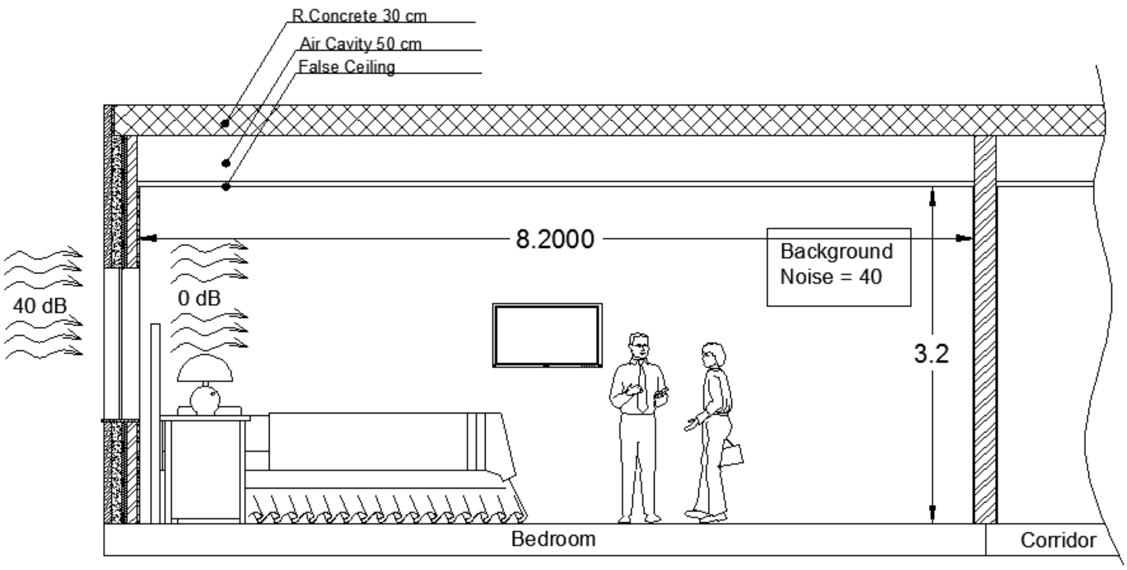


Figure 125: Effect Of sound between bedroom and outside ambient.

Weight of External walls from Ecotect = 617 Kg/m3

STC = $14.4*Weight^{0.23}$

= $14.4*617^{0.23}$ = 63.1 dB

TL Window (double glass) = 28 dB

TL glass door (double glass) = 28 dB

TL External wall – TL window+door = 63.1-28*2 = 7.1 dB

Area External wall = (4.1-0.9)*3.8 = 3.2*3.8 = 12.16 m2

Area window = 1.5*1.2 = 1.8 m2

Area door = 0.9*2.25 = 2.03 m2

(A.door+A.Win/A.wall)*100% = (1.8+2.03/12.16)*100% = 31.4% ≈ 32%

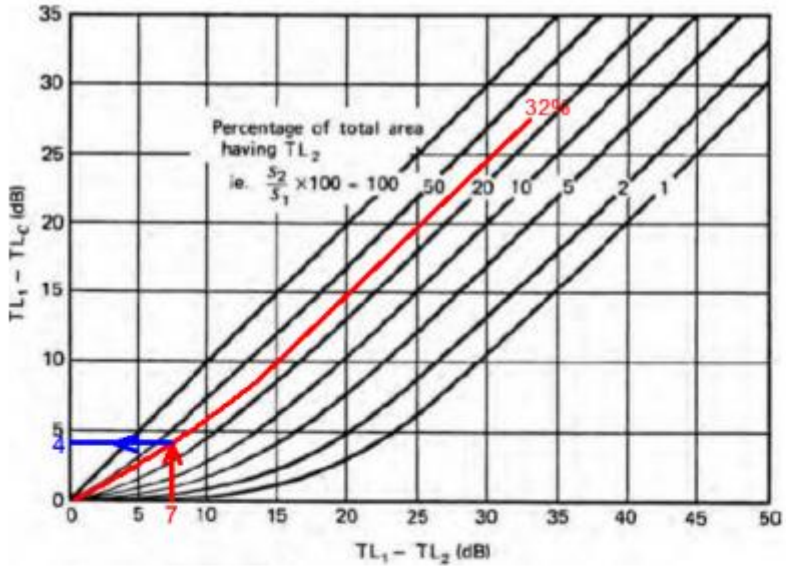


Figure 126:TL partition – TL combined Curve.

From Curve: TL partition – TL combined = 4 → TL combined = 63.1 – 4 = 59.1 dB

So, the new TL for Partition = 59.1 dB

To calculate the effect of sound from Outside to bedroom:

Assume outside sound = 40 dB

Partition Area = (4.1-0.9)*3.8 = 3.2*3.8 = 12.16 m2

To calculate the absorption for Receiving room (bedroom) :

Wall paint absorption coefficient = 0.1

Floor absorption coefficient (Tiles) = 0.02

Ceiling absorption coefficient (gypsum board)= 0.02

∑A = ∑surface area*absorption coefficient = (2*3.2*3.8)*0.1+(2*3.2*8.2)*0.1 +(3.2*8.2)*0.02+(3.2*8.2)*0.02 = 8.73 Sabine

NR = TL External wall – 10 Log(Area partition/Total absorption)

= 59.1 – 10*Log(12.16/8.73) = 59.1 – 1.44 = 58.56 dB

IL in Bedroom = IL Outside – NR

= 40 – 58.56 = -18.56 , so there is no noise from outside.

3.1.2.1.8. HEATING AND COOLING LOADS:

We calculate loads for the first two floors only:

1. <u>For Cooling Loads:</u>

The critical state to calculate the loads when the building in full occupancy and at comfort band 22-26 C.

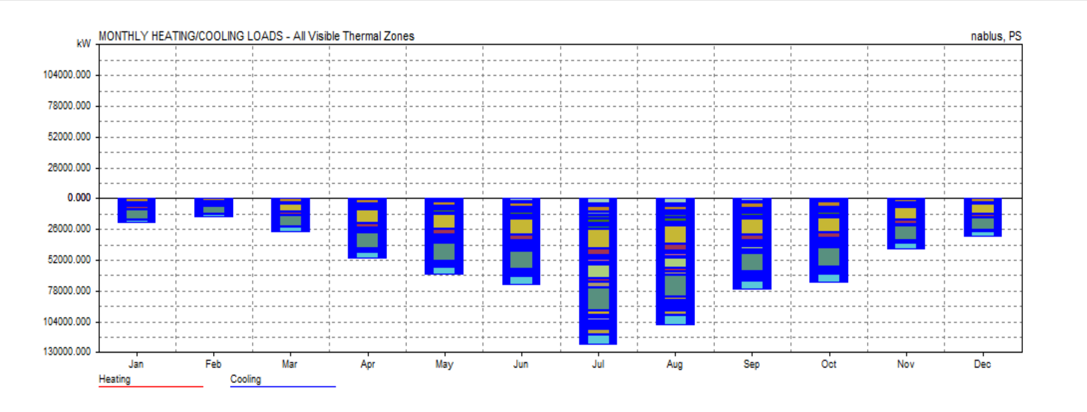


Figure 127: Cooling Load Diagram.

Report:
MONTHLY HEATING/COOLING LOADS
All Visible Thermal Zones
Comfort: Zonal Bands
Max Heating: 0.0 C - No Heating.
Max Cooling: 411.759 kW at 13:00 on 5th August

MONTH	HEATING (kWh)	COOLING (kWh)	TOTAL (kWh)
Jan	0.000	21167.072	21167.072
Feb	0.000	16249.122	16249.122
Mar	0.000	28823.488	28823.488
Apr	0.000	51475.285	51475.285
May	0.000	64932.973	64932.973
Jun	0.000	73204.938	73204.938
Jul	0.000	123945.867	123945.867
Aug	0.000	107086.398	107086.398
Sep	0.000	77384.555	77384.555
Oct	0.000	71234.055	71234.055
Nov	0.000	42769.531	42769.531
Dec	0.000	32318.973	32318.973
TOTAL	0.000	710592.250	710592.250
PER M²	0.000	139.538	139.538

Floor Area: 5092.457 m2

2. For Heating Loads:

The critical state to calculate the loads when the building is Empty and at comfort band 22-26 C.

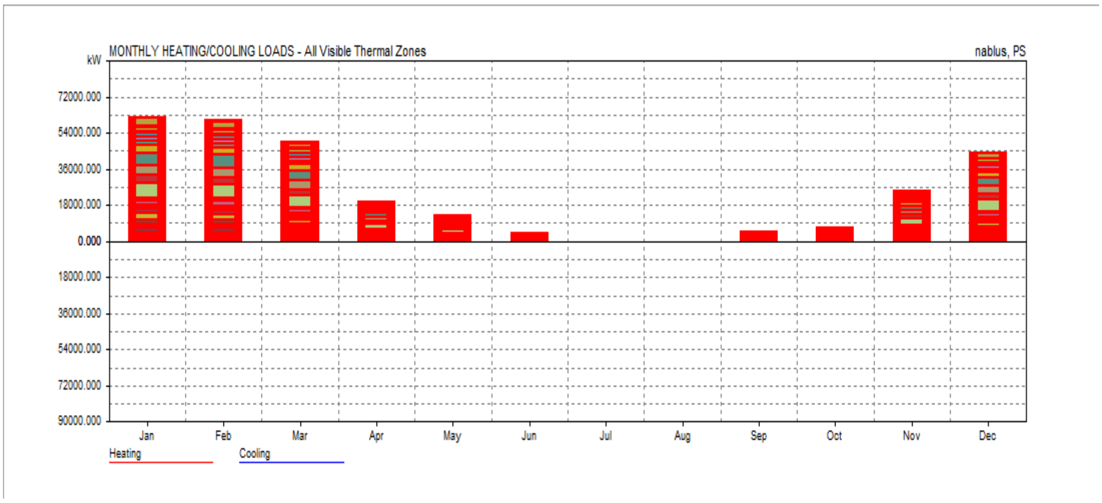


Figure 128: Heating load Diagram.

Report:
MONTHLY HEATING/COOLING LOADS
All Visible Thermal Zones
Comfort: Zonal Bands
Max Heating: 253.320 kW at 13:00 on 18th January
Max Cooling: 0.0 C - No Cooling.

MONTH	HEATING (kWh)	COOLING (kWh)	TOTAL (kWh)
Jan	62446.453	0.000	62446.453
Feb	60758.395	0.000	60758.395
Mar	49732.398	0.000	49732.398
Apr	20118.193	0.000	20118.193
May	13615.719	0.000	13615.719
Jun	4495.884	0.000	4495.884
Jul	8.163	0.000	8.163
Aug	154.856	0.000	154.856
Sep	5211.103	0.000	5211.103
Oct	7156.059	0.000	7156.059
Nov	25247.285	0.000	25247.285
Dec	44601.539	0.000	44601.539
TOTAL	293546.062	0.000	293546.062
PER M²	57.643	0.000	57.643

Floor Area: 5092.457 m2

3. For Full Air Conditioning :

We calculate Full Air Conditioning when 30% of occupancy in the building and at comfort band 22-26 C.

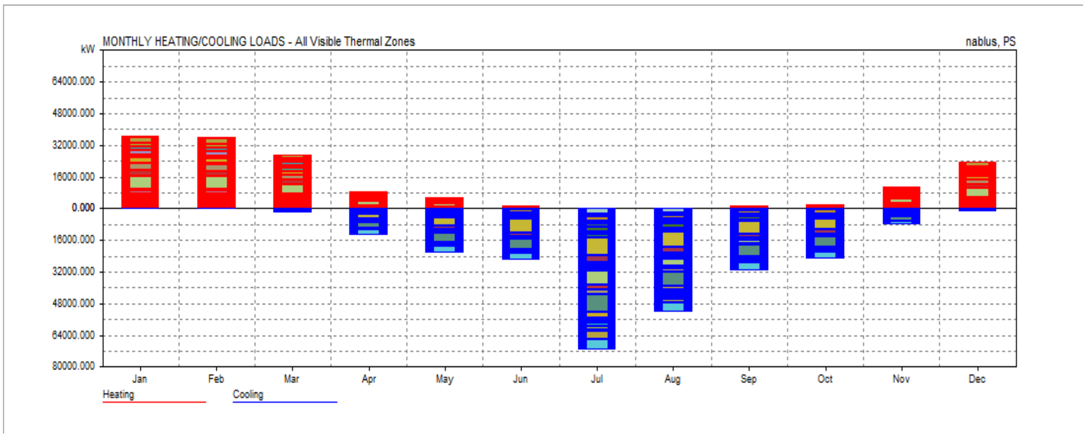


Figure 129: Full Air Conditioning.

Report:
MONTHLY HEATING/COOLING LOADS

All Visible Thermal Zones
Comfort: Zonal Bands

Max Heating: 147.120 kW at 13:00 on 18th January
Max Cooling: 309.728 kW at 13:00 on 5th August

MONTH	HEATING (kWh)	COOLING (kWh)	TOTAL (kWh)
Jan	34032.008	678.504	34710.512
Feb	33624.688	278.901	33903.590
Mar	25458.881	3060.963	28519.844
Apr	7801.546	17016.736	24818.281
May	4796.199	26189.824	30986.021
Jun	941.125	29630.082	30571.207
Jul	0.000	75910.773	75910.773
Aug	0.000	56787.039	56787.039
Sep	1079.009	35129.945	36208.953
Oct	1665.506	29680.795	31346.301
Nov	9520.776	11575.620	21096.396
Dec	21784.221	3013.998	24798.219
TOTAL	140703.953	288953.188	429657.156
PER M²	27.630	56.741	84.371

Floor Area: 5092.457 m2

Hotel Total Load = 139.538 + 57.643 = 197.181 KWh/m2

And According to Energy Stars Profitable Manager the Maximum Load for Hotels = 231.2 KWh/m2

So, the thermal system in the hotel is good.

3.2. STRUCTRAL DESIGN

The structural analysis and design of the hotel is considered as part of the design of integrative hotel.

The design done by using Etabs2015 for two blocks and sap2000 (V16) for water tank and stair cases.

This section shows all the steps that found to analysis and design structural blocks from the hotel that consist of sex floor (basement, ground and other four floors).

3.2.1. FIRST BLOCK ANALYSIS AND DESIGN.

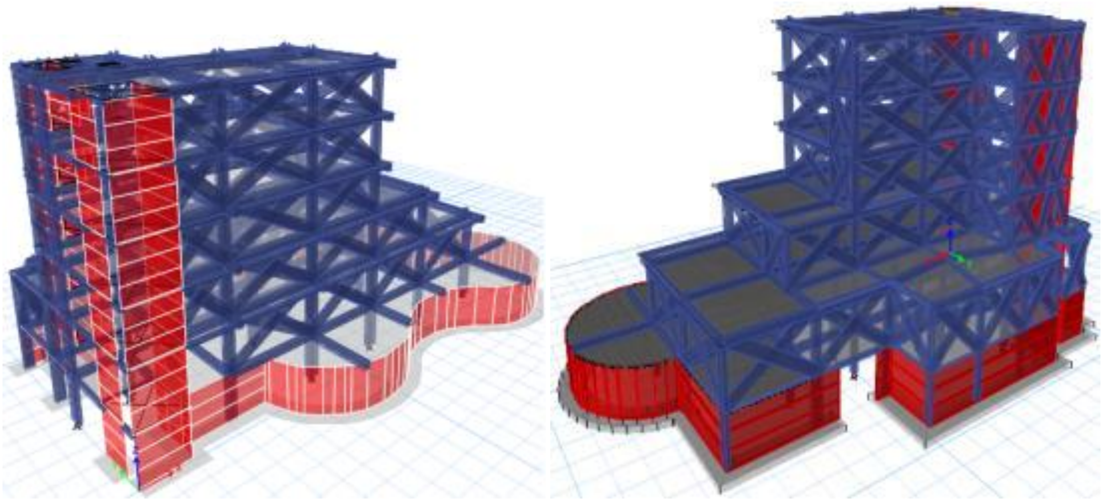


Figure 130: 3D view of Etab model for first block.

3.2.1.1. SITE AND GEOLOGY

The structure has been built on soil profile has a bearing capacity of 400 KN/m2.

3.2.1.2. DESIGN CODES

The project includes static and dynamic design for concrete slabs; the design is to be performed as follow:

1. ACI -318-14 for reinforced concrete structural design.
2. UBC -97 for earthquake load computations.

3.2.1.3. LOADS:

Loads that act on structures can be divided into three board categories: dead load, live loads, lateral loads.

1. Dead loads (D.L): the loads due to the own weight of the structure, which will remain constant during the life of the building.
2. Super Imposed dead load (SI): it is considered as dead load it result from the own weight of the backfill, the tile and mortar.
3. Live Load (L.L): The expected load that the structure will carry it, such as the people, machines, and all movable loads expected during the life of the structure.
4. Lateral loads consider earthquake load.

Load Case Name	Load Case Type
Dead	Linear Static
Live	Linear Static
SI	Linear Static
EQx	Response Spectrum
EQy	Response Spectrum

Figure 131: Load case name and type.

The building designed in order to carry live load 5 KN/m2 and 5.6 KN/m2 as super imposed load on ground floor and 3KN/m2 as live load and 5.6 KN/m2 as super imposed load on other floors.

Table16 : Type of load on slab.

Type of load	Load (KN/m2)
Super imposed(including block weight)	5.6
Live load	5KN/m2 for ground floor And 3KN/m2 for others floor

3.2.1.4. CLEAR COVERS: TO PROTECT STEEL FROM CORROSION AND FIRE:

1. Cover of footing = 6 cm.
2. Beam and column = 4 cm.
3. Cover of slab = 2 cm.

3.2.1.5. MATERIALS

The materials used in construction will have the following characteristics:

1. Compressive strength of Concrete “f′c”.

   It is the compressive strength of test cylinder 15cm in diameter and 30cm high Measured at an age of 28 days.

   1) For columns, shear walls, footing f′c = 28 MPa
   2) For slabs and beams f′c = 24 MPa
   3) For bracing f′c = 12 MPa

2. Yielding strength of steel fy = 420 MPa.

   The following table shows the densities for materials used in construction:

Table17 : Material used in construction.

Material	Unite weight (KN/m3)
Reinforced concrete	25
Block	12
Masonry stone	28
Sand and aggregate	18
Polystyrene	0.3
Tile	12
Mortar	2.3

3.2.1.6. PRELIMINARY DESIGN AND CONSTRUCT MODEL ON ETABS

3.2.1.6.1. DEFINE MATERIAL

Table18 : Compressive strength of concrete "f′c" for building element .

Type of frame or shells	Compressive strength of Concrete "f′c".
Slabs	24
Beams	24
Column	28
Wall	28
Footing	28
Bracing	12
Water tank	28
Stair case	28

3.2.1.6.2. DEFINE SHELLS AND FRAMES

3.2.1.6.2.1. Slab

According to ACI318, the approximate depth of the slab for one end continues in one way ribbed slab span:

h= L/18.5 = 5.6/18.5 = 30cm

Where the approximate depth of the slab for one end continues in two way ribbed slab span

h= L/27 = 8.5/27 = 30cm

Where

h: is the depth of the slab.

L: is the length of the span.

Then, slab thickness = h = 30cm.

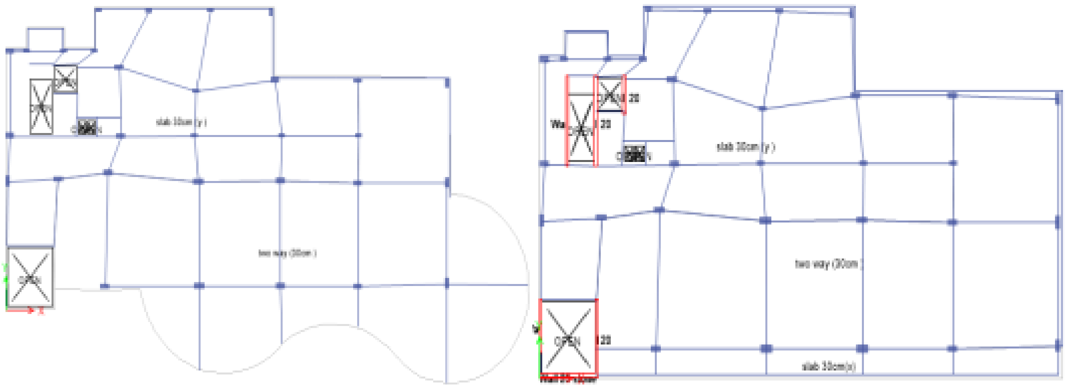


Figure 132: Ground floor and first floor plan .

Use ribbed slab Patten of 300mm thickness.

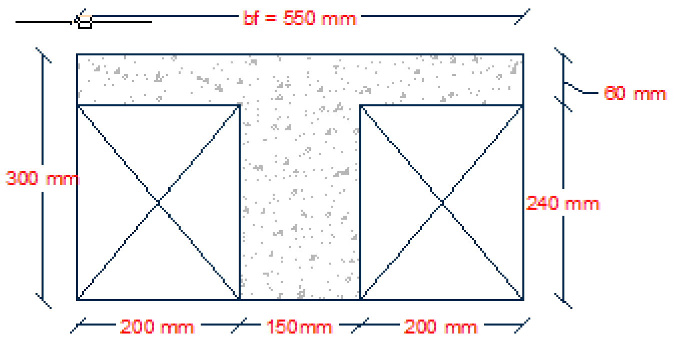
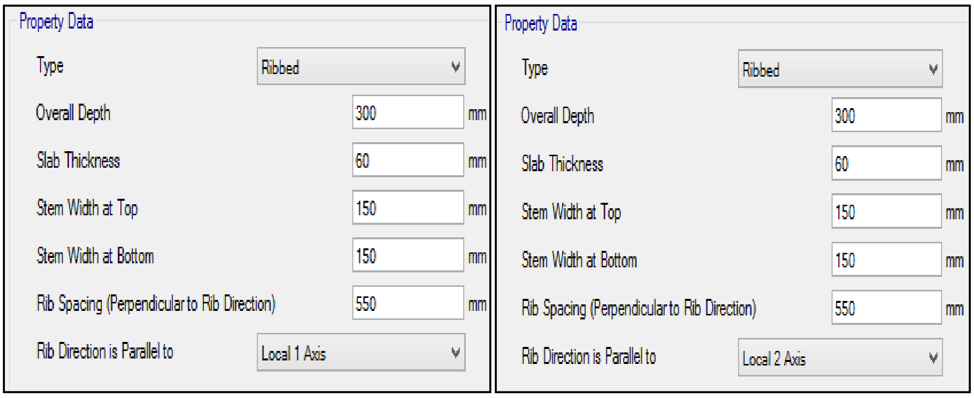


Figure 133: section in ribbid slab .

Define slab section on etabs as shown in the figure:



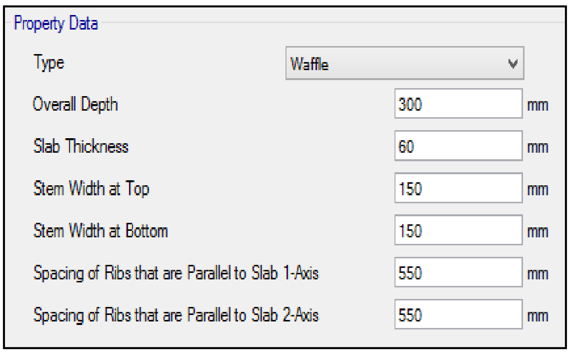
Property Data

Type	Ribbed	
Overall Depth	300	mm
Slab Thickness	60	mm
Stem Width at Top	150	mm
Stem Width at Bottom	150	mm
Rib Spacing (Perpendicular to Rib Direction)	550	mm
Rib Direction is Parallel to	Local 1 Axis	

Property Data

Type	Ribbed	
Overall Depth	300	mm
Slab Thickness	60	mm
Stem Width at Top	150	mm
Stem Width at Bottom	150	mm
Rib Spacing (Perpendicular to Rib Direction)	550	mm
Rib Direction is Parallel to	Local 2 Axis	

Figure 134: one way slab section define on ETABs (a-(with x-direction)b-(with y direction)).



Property Data

Type	Waffle	
Overall Depth	300	mm
Slab Thickness	60	mm
Stem Width at Top	150	mm
Stem Width at Bottom	150	mm
Spacing of Ribs that are Parallel to Slab 1-Axis	550	mm
Spacing of Ribs that are Parallel to Slab 2-Axis	550	mm

Figure 135: two way slab section define on ETABs..

The slab modifier is as shown here:

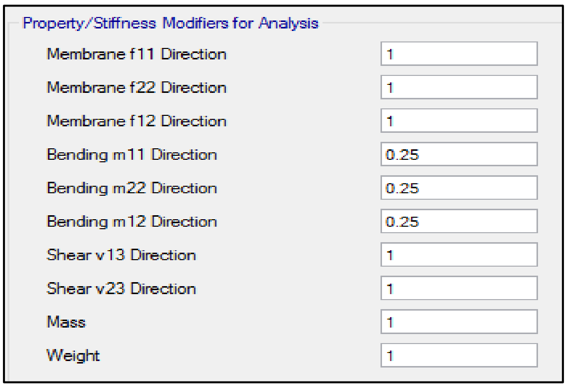


Figure 136: two way slab modifier.

3.2.1.6.2.2. Beams

Main beams (60*45): According to ACI318, the approximate depth of the beam for one end continues span.

h=depth of beam = L/18.5 = 8.6/18.5 = 0.46 use 60cm (dropped beam system will be used)

b=width of beam = 45 cm.

Secondary beams (30*30 cm).

Beams modifier is as shown here:

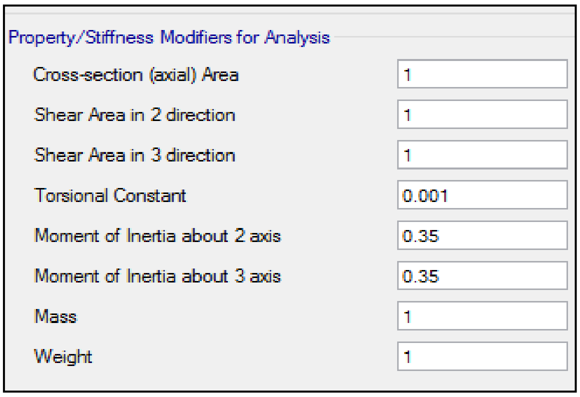


Figure 137: Beams modifier.

3.2.1.6.2.3. Columns

There are many types of Columns dimensions on plan 80*40 and column 60*30 as shown on column center in AutoCAD drawing.

Columns modifier is as shown here:

Property/Stiffness Modifiers for Analysis

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

Figure 138: Columns modifier.

3.2.1.6.2.4. Walls

Shear wall and retaining (basement) wall defined as thickness of 20 cm and Here the modifier for the shear walls.

Property/Stiffness Modifiers for Analysis

Membrane f11 Direction	1
Membrane f22 Direction	1
Membrane f12 Direction	1
Bending m11 Direction	0.7
Bending m22 Direction	0.7
Bending m12 Direction	0.7
Shear v13 Direction	1
Shear v23 Direction	1
Mass	1
Weight	1

Figure 139: walls modifier.

And the following is the modifier for the retaining wall (basment):

Property/Stiffness Modifiers for Analysis

Membrane f11 Direction	1
Membrane f22 Direction	1
Membrane f12 Direction	1
Bending m11 Direction	0.7
Bending m22 Direction	0.7
Bending m12 Direction	0.7
Shear v13 Direction	1
Shear v23 Direction	1
Mass	1.2
Weight	1.2

Figure 140: retaining modifier.

Here the mass and the weight edit to 1.2 because there is a stone on the walls.

3.2.1.6.2.5. Bracing

Bracing is constructed in model to simulate the reality of the stone and glass elevations. And its define as shown here:

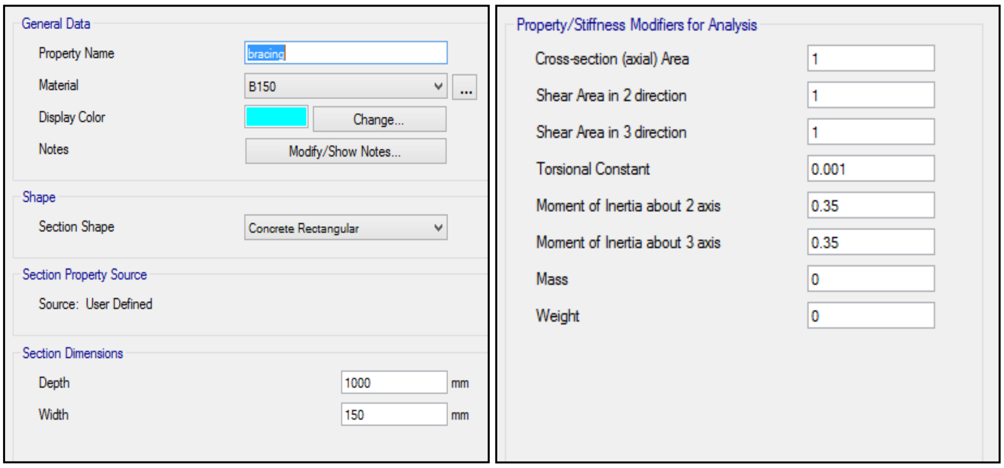


Figure 141: Bracing define and modifier .

3.2.1.6.2.6. Footing

Only wall footings are defined in ETABs, the other footing designed by using excel sheet and manual calculation.

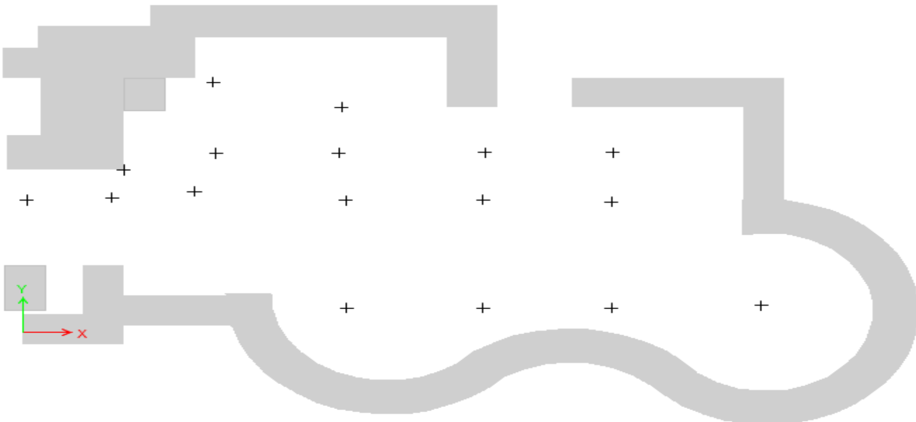


Figure 142: base story .

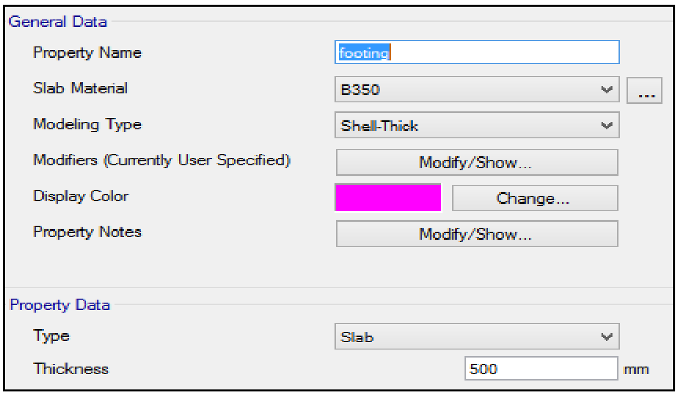


Figure 143: Footing definition.

3.2.1.6.3. DEFINE OF LOAD PATTERNS AND LOAD COMBINATION

Dead, live, Super imposed only defined and after make compatibility, equilibrium and stress-strain checks earthquake by load cases.

Two load combination defined by default and after ensure the model is built all combination will be defined and checked.

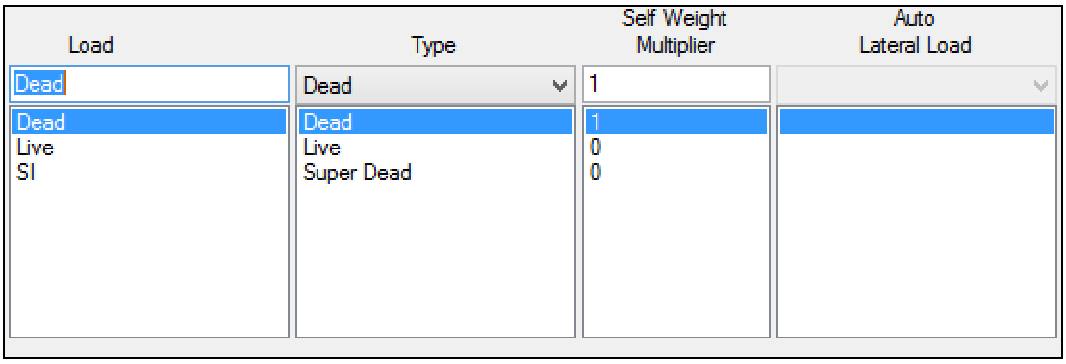


Figure 144: load pattern.

3.2.1.6.4. DRAW FRAMES/SHELLS/BRACING

3.2.1.6.5. ASSIGN LOAD ON MODEL

3.2.1.6.5.1. Loads on slab and Frames

Table19 : loads on slab and frames.

Type of load	Load on slab and frames
Super imposed on slab (including block weight)	5.6 KN/m2
Live load on slab	5KN/m2 for ground floor And 3KN/m2 for others floor
Load on beams from stone	28KN/m

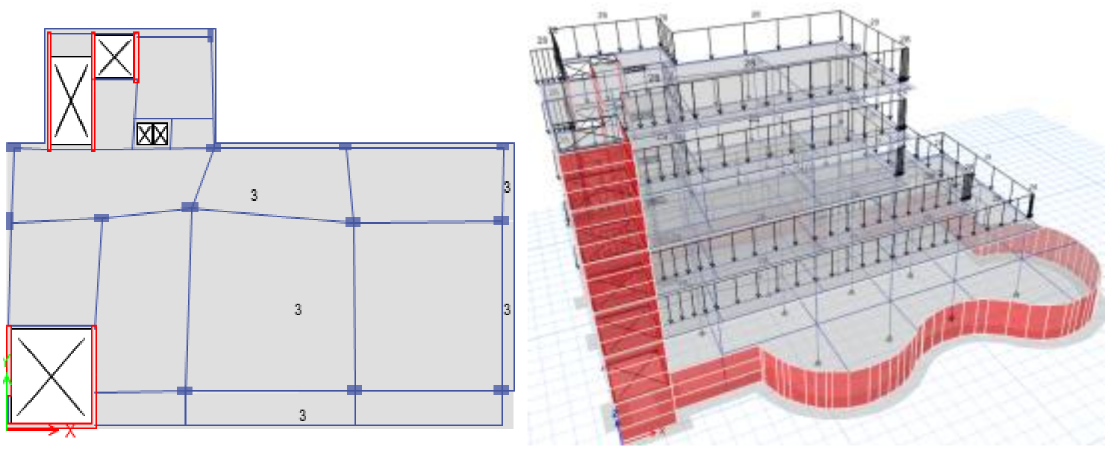


Figure 145: loads on slabs and frames.

3.2.1.6.5.2. Loads on retaining (basement) wall.

The retaining wall that available in basement to prevent the soil is calculated as following:

WL =20 KN/m2 because there is maybe huge vehicles

$\Phi=30^\circ$, H =4.1 m ,Ɣ soil=18KN/m3

Ka=1-sinΦ / 1+sin Φ = 1-sin 30°/1+sin 30° =0.333

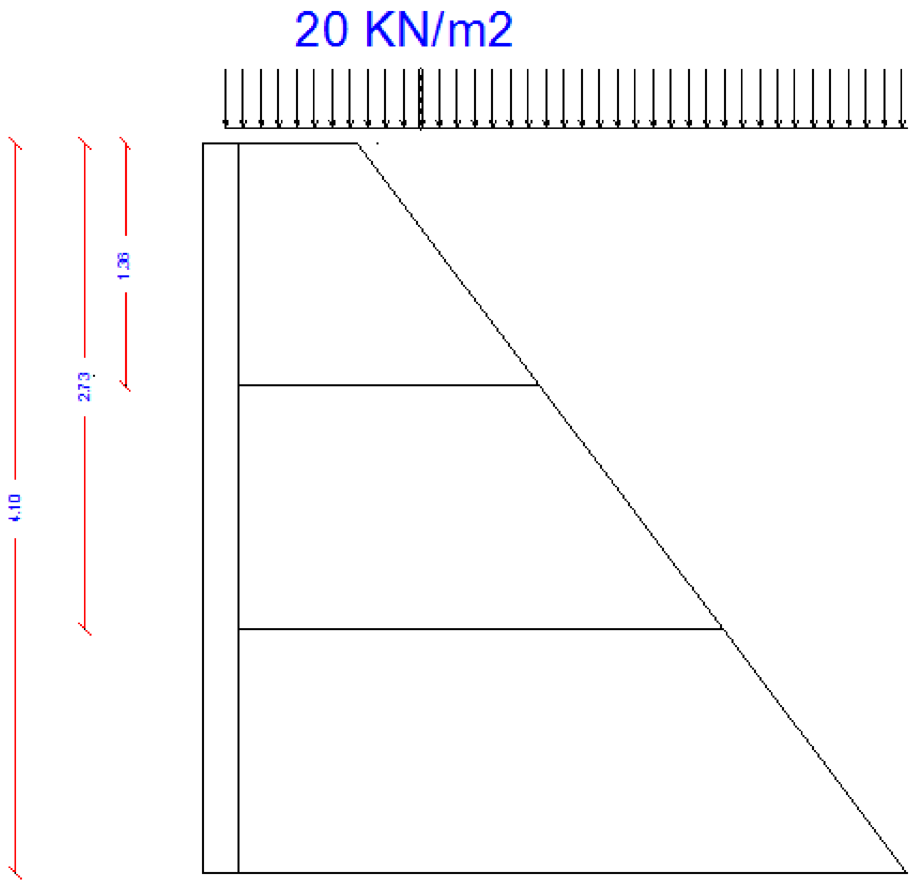


Figure 146: The pressure of soil on retaining walls.

Lateral pressure = Normal pressure * ka = 20*1/3 =6.7 at 0m height from top.

Lateral pressure = Normal pressure * ka = 20*1/3+1.36*18*1/3=14.8 at 1.36m height from top.

Lateral pressure = Normal pressure * ka = 20*1/3+1.36*18*1/3=23 at 2.73m height from top.

Lateral pressure = Normal pressure * ka = 20*1/3+4.1*18*1/3=31.3 at 4.1m height from top.

So the walls have been divided to three horizontal parts and assigned lateral load on it but the curved wall has been taken as one part and max lateral pressure was assigned on it as shown in the figure below.

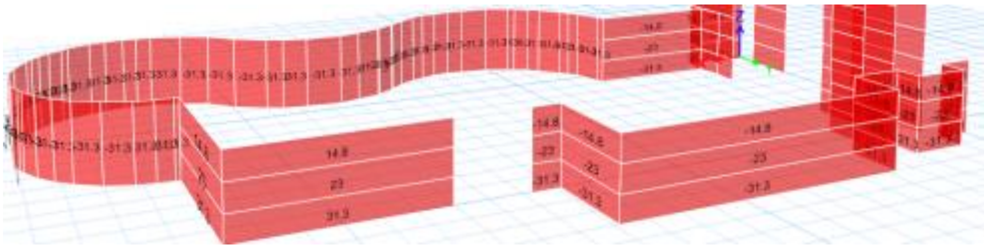


Figure 147: loads distribution on walls.

3.2.1.7. ANALYSIS THE MODEL AND CHECKS

The following checks are important to be taken in consideration :

3.2.1.7.1. COMPATIBILITY AND DEFORMATION CHECK.

1. Compatibility: To make sure that all the structural elements are compatible with each other. This can be achieved and approved by noticing and analyzing the deformed shape animation of the model from ETABs15.

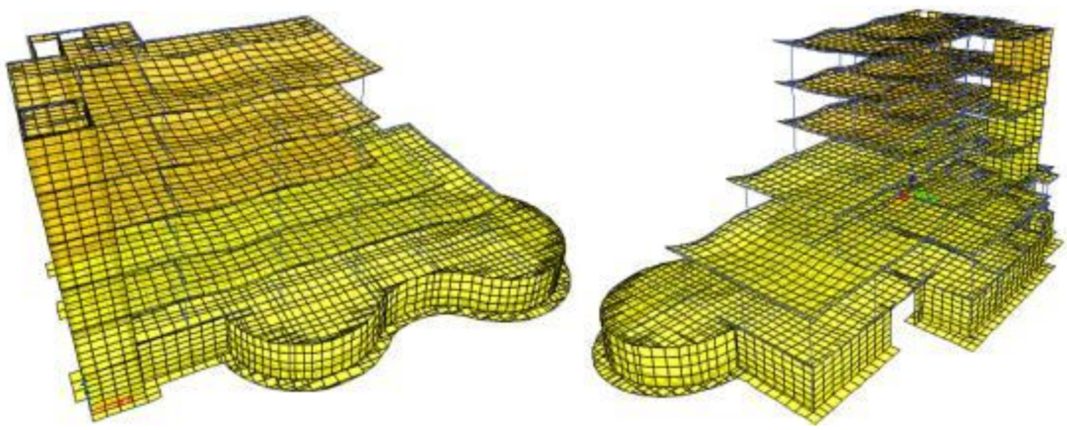


Figure 148: Deformed shape animation.

2. Deformation.

The following figure showed the maximum Deflection on slabs and walls.

The maximum deflection of slabs is Uz =36mm

Length of span = 8.75m

Deflection on slab = L/240 = 8750/240 =36.5

So it's ok.

For wall, The maximum deflection of walls is Uy =15mm

L of wall = L=4.1mm

Deflection on wall =L/240 =4100/240 = 17mm

So it's ok.

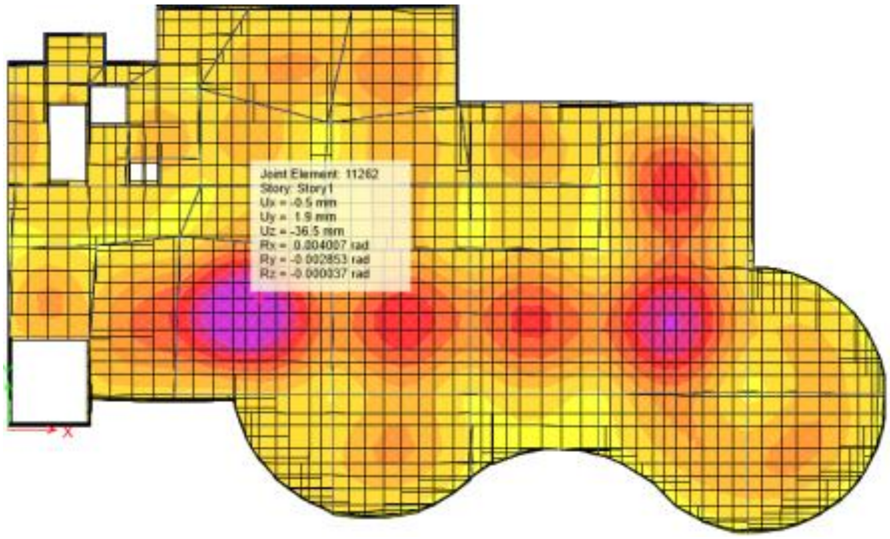


Figure 149: Deformation value of slab (Uz).

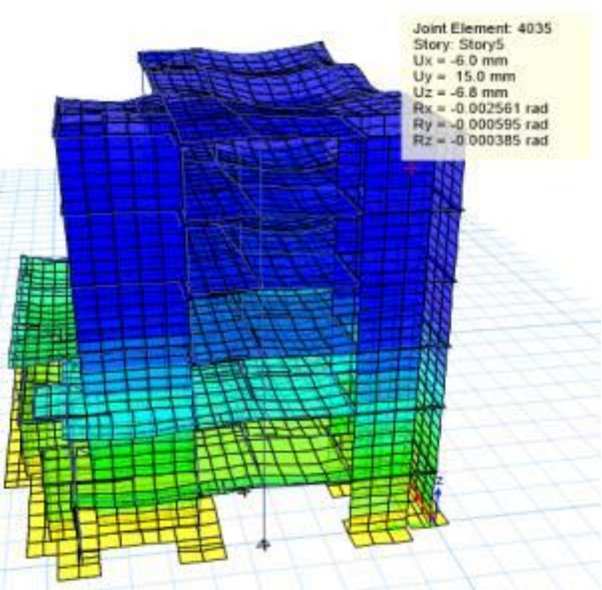


Figure 150: Deformation value of wall (Uy).

3.2.1.7.2. EQUILIBRIUM CHECKS

Table20 : Equilibrium checks.

Load type	Base reaction from ETABs	Base reaction from manual calculation	Percentage of Error (%)
Dead	33252.3	32513.5	2.27%
Live	11656.16	11661.8	0.048%
Super imposed	30338.6	30422.39	0.28%

The percentages of error are too small so the checks are acceptable.

Note that the manual calculation of base reaction is available in appendix.

3.2.1.7.3. STRESS –STRAIN RELATION (LOCAL EQUILIBRIUM) CHECKS

3.2.1.7.3.1. Beams

Check beams –from live load

Table21 : Equilibrium checks for beam .

Beams label	Manual Moment result (KN.m)	ETABs result	Percentage of error (%)
B47(First floor)	89.7	93.5	4.1%
B3(Ground floor)	39	42	7.1%
B32 (Ground floor)	135.6	150.2	9.6%

<u>Manual sample calculations:</u>

Checks beam (B47) on first floor slab - moment 3-3 from live load:

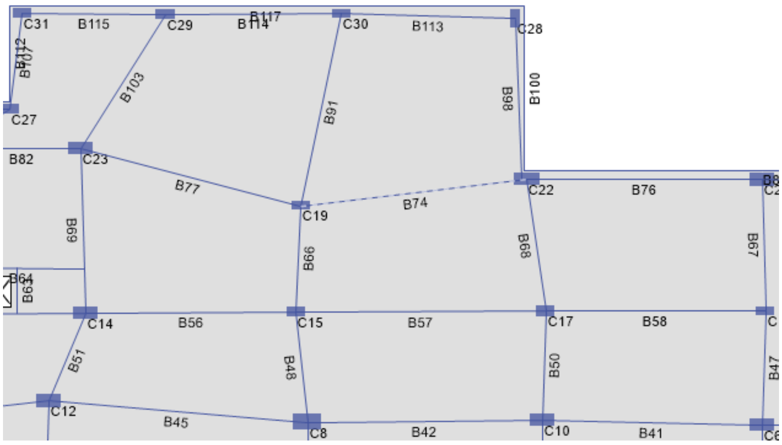


Figure 151: Beam (B47) to be check.

Manual calculation of moment:

Moment = WL on beam* L^2 /8 = 3*(5/2 + 4.2/2) * (7.21^2) /8 =89.7KN.m

Moment from ETABs = (61.44+49.19) /2   +38.183=93.5 KN.m

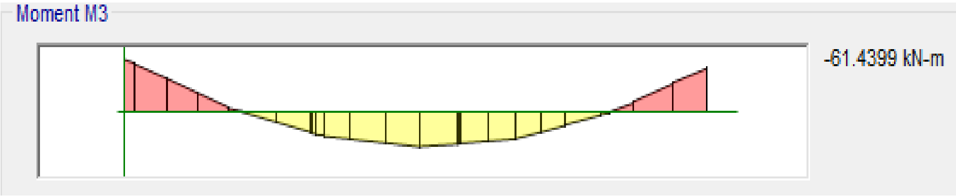


Figure 152: Moment 3-3 from ETABs at edge of beam (B47).

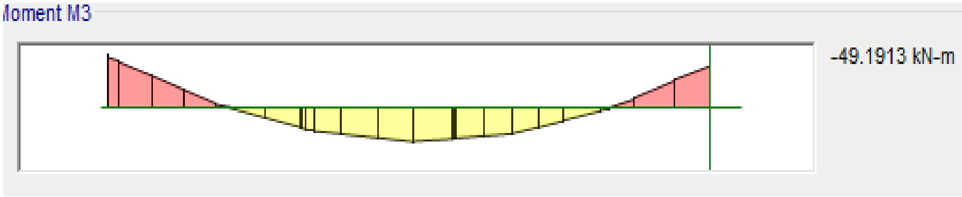


Figure 153: Moment 3-3 from ETABs at edge of beam (B47).

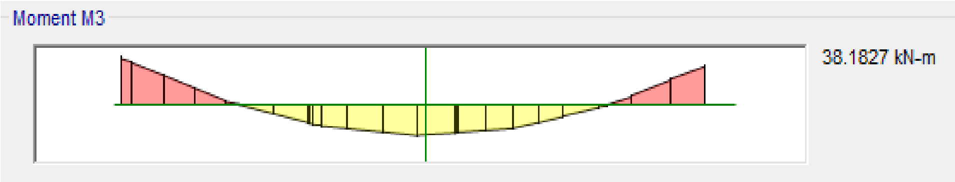


Figure 154: Moment 3-3 from ETABs at middle of beam (B47).

Percentage of Error = (93.5-89.7 /93.5) * 100% = 4.1%.

it's ok because the beam is connect between column which has different dimensions and deferent stiffness and it not strait 100% so there is percentage of error so it's acceptable.

3.2.1.7.3.2. Column

Check column –from live load.

Table22 : Equilibrium checks for columns .

Column label	Manual load calculation(KN)	ETABs Axial Result (KN)	Percentage of error (%)
C12	725	740.6	2.1%
C6	442	474	6.7%
C3	900	939	4.1%

Manual sample calculation for C12:

Live load on Ground floor = 5 KN/m2

Live load on others floor =3 KN/m2

Area of slabs around the column =99+46 =145 m2

Live load on column from ground floor = 5*145/4 =181.25 KN

Live load on column from others floors (5 stories) =5*3*145/4=543.75 KN

Total Live load on column =725 KN.

ETABs result =740 .6 KN (Axial from live load) as shown in the figure below:

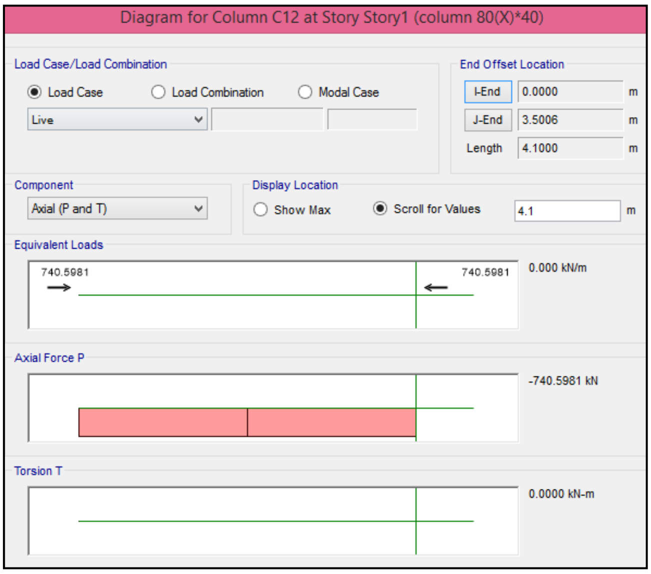


Figure 155: axial diagram for column (c12).

Percentage of Error = (740.6-725 /740.6) * 100% = 2.1%.... so it's ok.

3.2.1.7.3.3. Slab

To check slab we take this span which have L =3.45m as shown below and load from super imposed.

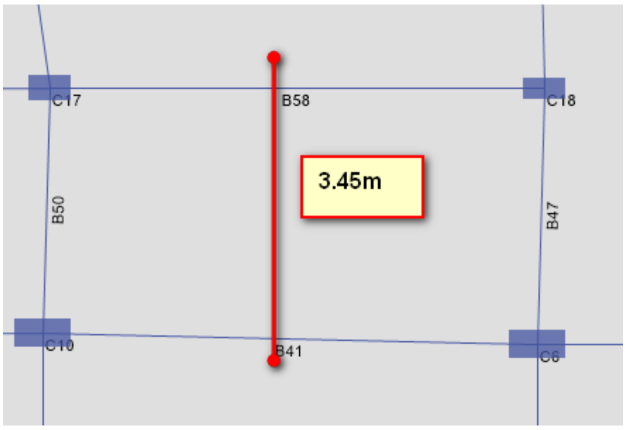


Figure 156: section on one way ribbed slab.

Manual calculation:

W super imposed =5.6 KN/m2.

Moment = WL^2/8 = 5.6*3.45*3.45/8=8.3 KN.m

ETABs result:

Here draw section cut has been done as shown below:

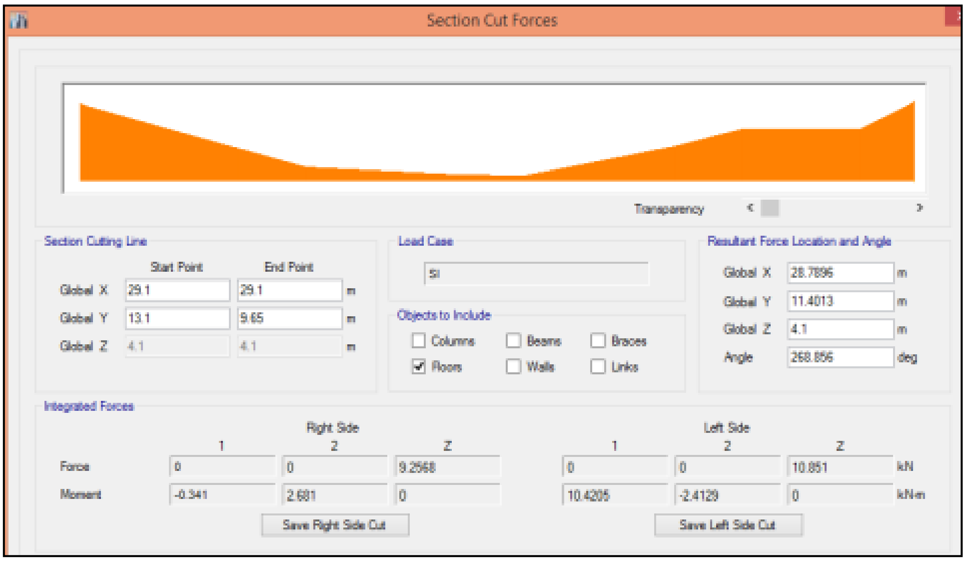


Figure157 : Draw section cut on one way ribbed slab.

So the moment from ETABs =10.42+0/2 + 2.41 =7.62 KN.m

Percentage of Error = (7.62-8.3/7.62) * 100% = 8.9% and its back to the real behavior of slab, its distribute the load on other direction not only y directions and the modifier M11 and m12 not zero its 0.25 so there is moment going to other direction so it’s ok.

3.2.1.7.4. MAKING SURE MODAL PARTICIPATION MASS RATIO > 90% IN BOTH X AND Y.

So as shown in table below, 22 modal cases needed to get 93.2% on x and 92.39% on y from the full mass of model:

Table 23: Modal Participating Mass Ratios.

Case	Mode	Period	UX	UY	UZ	Sum UX	Sum UY	Sum UZ
		sec						
Modal	1	0.767	0.0018	0.5551	0	0.0018	0.5551	0
Modal	2	0.378	0.5683	0.0002	0	0.5701	0.5553	0
Modal	3	0.294	0.011	0.0494	0	0.5811	0.6046	0
Modal	4	0.19	0.0002	0.1874	0	0.5814	0.792	0
Modal	5	0.137	0.1673	0.0002	0	0.7487	0.7922	0
Modal	6	0.122	0.0002	0.0007	0	0.7489	0.7929	0
Modal	7	0.094	0.0018	0.0367	0	0.7507	0.8296	0
Modal	8	0.075	0.0409	0.0033	0	0.7917	0.8329	0
Modal	9	0.068	0.0004	0.0031	0	0.7921	0.8359	0
Modal	10	0.064	0.0016	0.0604	0	0.7937	0.8964	0
Modal	11	0.059	0.0002	0.00004091	0	0.7938	0.8964	0
Modal	12	0.058	0.0001	0.0002	0	0.7939	0.8966	0
Modal	13	0.055	0.0004	0.0015	0	0.7943	0.8981	0
Modal	14	0.055	0.0072	0	0	0.8015	0.8981	0
Modal	15	0.054	0.0038	0.0006	0	0.8053	0.8987	0
Modal	16	0.053	0.0499	0.0032	0	0.8552	0.9019	0
Modal	17	0.051	0.001	0.0186	0	0.8562	0.9205	0
Modal	18	0.05	0.0003	0.0024	0	0.8565	0.9229	0
Modal	19	0.05	0.00002078	0.0005	0	0.8565	0.9235	0
Modal	20	0.049	0.024	0.0003	0	0.8805	0.9238	0
Modal	21	0.047	0.0498	0.0001	0	0.9303	0.9239	0
Modal	22	0.046	0.0017	0	0	0.932	0.9239	0

3.2.1.7.5. CHECK PERIOD OF MODE OF MAXIMUM MODAL PARTICIPATION MASS RATIO.

So here check done on T on first mode in y =T etabs =0.767 sec.

T method A from UBC 97 Code = Ct * (hn) ^3/4

Where Ct:

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

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

Ct = (0.0488) for all other buildings.

So Ct =0.0488 (other building) because the only shear wall will take the lateral load of earthquake.

Where hn is building height =25.2

So, T method A =0.0488*(25.2) ^3/4 = 0.549sec

The value of *T* from Method B shall not exceed a value 30 percent greater than the value of *T* obtained from Method A in Seismic Zone 4, and 40 percent in Seismic Zones 1, 2 and 3.

So T etabs should be < 1.4 T method A

Then 0.767 <0.77 so it's ok.

3.2.1.8. DYNAMIC ANALYSIS AND DESIGN.

3.2.1.8.1. DEFINE RESPONSE SPECTRUM FUNCTION AND RESPONSE SPECTRUM CASES.

3.2.1.8.1.1. Define - mass source as shown below

Take the 100% dead and super imposed and 25% of live load as mass sources of building.

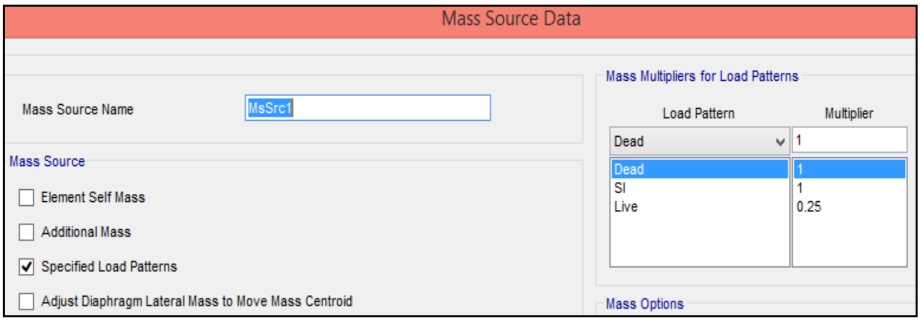


Figure 158: Define mass source.

3.2.1.8.1.2. Define function –response spectrum according to ubc97

The seismic zone of Nablus is 2B which have factor Z = 0.20 as shown in the following figure:

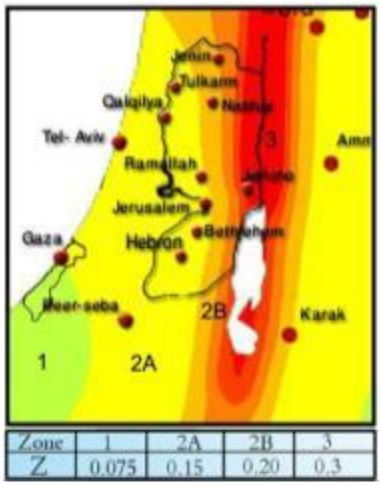


Figure 159: Map of seismic zone factor .

The soil profile type in the site is classify as rock so the soil profile is SB.

SOIL PROFILE TYPE	SOIL PROFILE NAME/GENERIC DESCRIPTION
S_A	Hard Rock
S_B	Rock
S_C	Very Dense Soil and Soft Rock
S_D	Stiff Soil Profile
S_E [1]	Soft Soil Profile
S_F	

Figure 160: Table of soil profile type.

Sesmic coefficient Cv has been founded and its equal 0.2 as shown in table below:

TABLE 16-R—SEISMIC COEFFICIENT C_v

SOIL PROFILE TYPE	SEISMIC ZONE FACTOR, Z				
	$Z = 0.075$	$Z = 0.15$	$Z = 0.2$	$Z = 0.3$	$Z = 0.4$
S_A	0.06	0.12	0.16	0.24	$0.32N_v$
S_B	0.08	0.15	0.20	0.30	$0.40N_v$
S_C	0.13	0.25	0.32	0.45	$0.56N_v$
S_D	0.18	0.32	0.40	0.54	$0.64N_v$
S_E	0.26	0.50	0.64	0.84	$0.96N_v$
S_F	See Footnote 1				

Figure 161: Table of Seismic coefficient Cv.

Sesmic coefficient Ca has been founded and its equal 0.2 as shown in table below:

TABLE 16-Q—SEISMIC COEFFICIENT C_a

SOIL PROFILE TYPE	SEISMIC ZONE FACTOR, Z				
	$Z = 0.075$	$Z = 0.15$	$Z = 0.2$	$Z = 0.3$	$Z = 0.4$
S_A	0.06	0.12	0.16	0.24	$0.32N_a$
S_B	0.08	0.15	0.20	0.30	$0.40N_a$
S_C	0.09	0.18	0.24	0.33	$0.40N_a$
S_D	0.12	0.22	0.28	0.36	$0.44N_a$
S_E	0.19	0.30	0.34	0.36	$0.36N_a$
S_F	See Footnote 1				

Figure 162: Table of Seismic coefficient Ca.

So the response spectrum function defined as shown in the following picture:

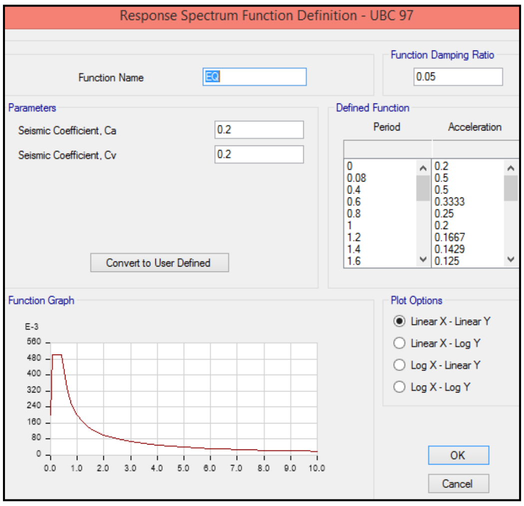


Figure 163: Define of response spectrum function.

3.2.1.8.1.3. Define load cases

Vmode=m *a/g *(g *I/R)

Scale factore =g *I/R

I : Importance factor =1 from ubc code

R =5.5 as shown in tabel below. because the basic structre system in building is building frame that mean the frame as column dosnt take the lateral load only reseste by shear walls so its 5.5 .

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

Figure 164: Table used to find R .

Scale factor = 9810 *1 /5.5 =1784

Other scale factor in same defintion = 0.3*1784 =535

So the load cases of earthquake response spectrum in x diriction and y driction is define as shown below :

Note that : the scale factor shown in table not 1784 because the base shear of EQx and EQy from respounse spectrum < base shear from equivalent static . (disscused below by calculation) .

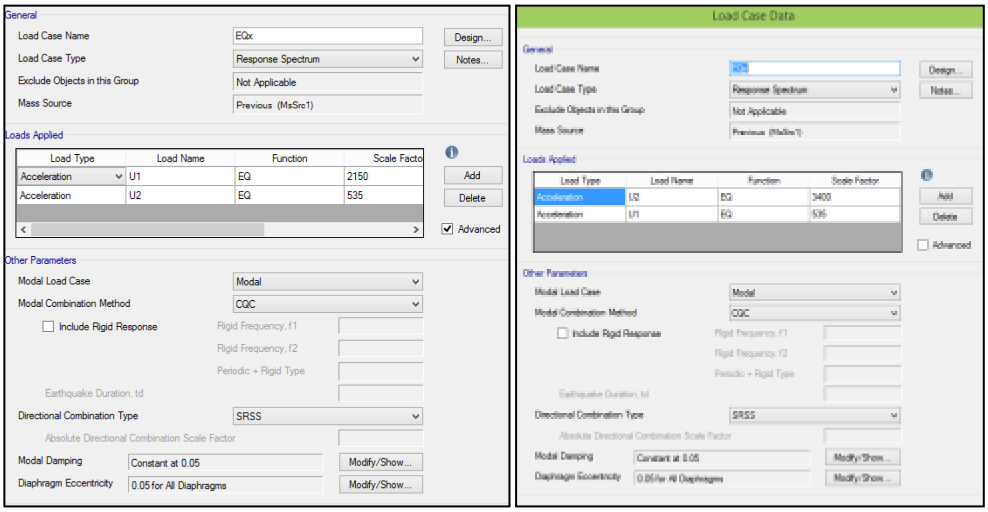


Figure 165: Load case data.

3.2.1.8.2. DEFINE LOAD COMBINATIONS

The following are the load combinations and factors of safety in design according to ACI 318 and UBC97:

3.2.1.8.2.1. Service combinations.

1. W service = 1.D.L+1.S.I +1.L.L.
2. W service = 0.9 D.L+0.9S.I +0.71EQx.
3. W service = 0.9 D.L+0.9S.I +0.71EQy.
4. W service = 0.9 D.L+0.9S.I +0.75L.L+0.54EQx.
5. W service = 0.9 D.L+0.9S.I +0.75L.L+0.54EQy.

$$D + L + (L_r \text{ or } S) \qquad (12\text{-}12)$$

$$D + L + \left(W \text{ or } \frac{E}{1.4}\right) \qquad (12\text{-}13)$$

$$D + L + W + \frac{S}{2} \qquad (12\text{-}14)$$

$$D + L + S + \frac{W}{2} \qquad (12\text{-}15)$$

$$D + L + S + \frac{E}{1.4} \qquad (12\text{-}16)$$

$$0.9D \pm \frac{E}{1.4} \qquad (12\text{-}16\text{-}1)$$

Figure 166: service load combination as discussed in ubc97 code.

Note that E =pEh+EV and p=1-1.5 so take it 1, Ev=zero in allowable combination ,Eh=EQx +0.3EQy .

3.2.1.8.2.2. Ultimate Combinations

1. Wu= 1.2D.L+1.2S.I+ 1.6L.L.
2. Wu= 1.4D.L+1.4S.I.
3. Wu= 1.3D.L+1.3S.I+ 1L.L± 1EQx.
4. Wu= 1.3D.L+1.3S.I+ 1L.L± 1EQy.
5. Wu= 0.8D.L+0.8S.I ±1EQx.
6. Wu= 0.8D.L+0.8S.I± 1EQy.

1612.2.1 Basic load combinations. Where Load and Resistance Factor Design (Strength Design) is used, structures and all portions thereof shall resist the most critical effects from the following combinations of factored loads:

$$1.4D \quad (12\text{-}1)$$
$$1.2D + 1.6L + 0.5\,(L_r \text{ or } S) \quad (12\text{-}2)$$
$$1.2D + 1.6\,(L_r \text{ or } S) + (f_1L \text{ or } 0.8W) \quad (12\text{-}3)$$
$$1.2D + 1.3W + f_1L + 0.5\,(L_r \text{ or } S) \quad (12\text{-}4)$$
$$1.2D + 1.0E + (f_1L + f_2S) \quad (12\text{-}5)$$
$$0.9D \pm (1.0E \text{ or } 1.3W) \quad (12\text{-}6)$$

Figure 167: Ultimate load combination as discussed in ubc97 code.

Where D.L =Dead load , S.I = super imposed load , L.L =live load ,

EQx = earthquake with x diriction ,EQy =earthquake with y diriction.

Note that E =pEh+EV and p =1-1.5 so take it 1, Ev=0.5*Ca*I*D =0.5*0.2*1* D = 0.1D, Eh=EQx +0.3EQy.

3.2.1.8.3. CHECK BASE SHEAR

The base shear of EQx and EQy from respounse spectrum Should be larger than base shear from equivalent static.

V base = min of (cv/t or 2.5ca)*W*I/R

W= Fz of (dead+ S.I +0.25 L.L) = 33252+ 30331+ (0.25) 11655=66470 KN

= (0.2/0.549)* 66470*1/5.5=4394.5 KN

When the scale factor was 1740 the respunse spectrum base shear was smaller than base shear from equivalent static , so the scale factor has been changed as shown befor .

The base shear from etabs is as shown below :

Load Case/Combo	FX kN	FY kN	FZ kN
Dead	-10.2532	0.4517	33252.3089
Live	2074.9241	-1325.8772	11655.5921
SI	-8.1644	0.8902	30331.1625
EQx Max	4412.813	702.8008	0.1779
EQy Max	1174.0892	4396.5511	0.9602

Figure 168: base shear value from etabs .

So the base shear from EQx and EQy is larger than equ.static . so the check is ok .

3.2.1.8.4. CHECK STORY DRIFT

T metohd A = 0.549 < 0.7 so Check if $\Delta m < L/40$

L /40= 4100/40 =102.5mm.

$\Delta m = 0.7\ R * \Delta S = 0.7*5.5*\Delta S$.

Table24 : Story drift check (ux).

Srory	Ux	ΔS	Δm
6	7	1.1	4.23
5	5.9	3.1	11.93
4	2.8	1.2	4.62
3	1.6	1.1	4.23
2	0.5	0.5	1.93
1	0	0	0

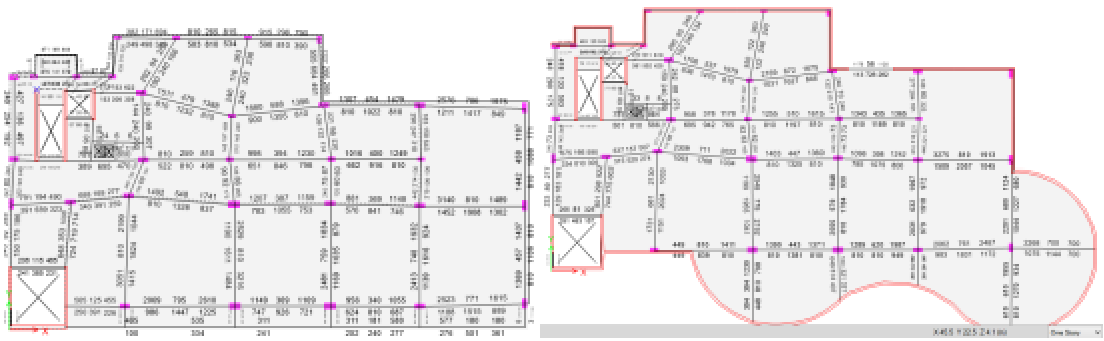
Table25 : Story drift check (uy).

Srory	Uy	ΔS	Δm
6	21.3	3.8	14.63
5	17.5	8	30.8
4	9.5	3.5	13.5
3	6	4.2	16.17
2	1.8	1.8	6.93
1	0	0	0

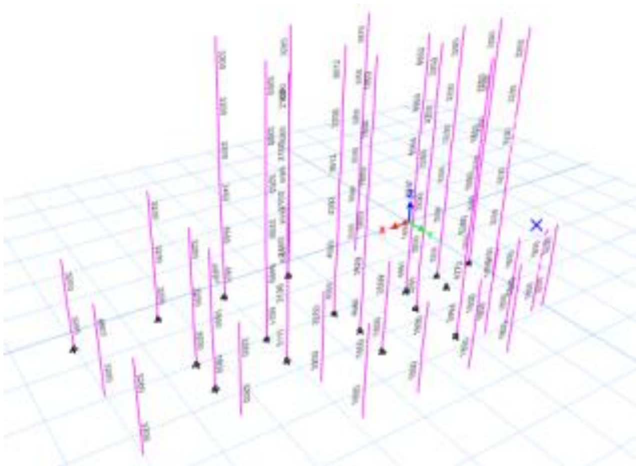
So , as shown in the previous table all $\Delta m < 102.5$mm so the check of drift is ok .

3.2.1.9. CHECK DESIGNED MEMBER

After all previous steps the design done and all members are ok as shown in following pictures .



(a)



(b)

Figure 169: a) beams check after designed , b) column checks after designed.

3.2.1.10. DESIGN AND REINFORCEMENT

3.2.1.10.1. SLAB DESIGN

In this block, there is two type of slab there is two- way ribbed slabs and there is one-way ribbed slab.

To design the slab, moment will be taken from ETABs.

First of all, As min should be calculated.

As min (ribbed slab) = Pmin*bw*d.

bw=150mm ,h=300mm, d =h-30 =270mm .

=0.0033*150*270 =134mm2 so use 2 ϕ 12 if slab need minimum reinforcing.

As used in minimum case when 2 ϕ 12 is used =226.2mm2.

ϕMn=0.9*226.2*420*(270-226.2*420/1.7*24*150) = 21.75 KN.m/rib.

ϕMn = 21.75/0.55=39.6 KN.m/m.

so by using ETABs and as shown in the following figure , the value of moment 39.6 KN.m/m was made as a boundary of moment value so any value that exceed this value ETAbs give it a dark tone of blue color .

and here sample of how the slab have been designed .

From the following table -select properties of shell forces that we want to see - m11 and m22 in max. That mean the bottom reinforcing and in min. the top reinforcing.

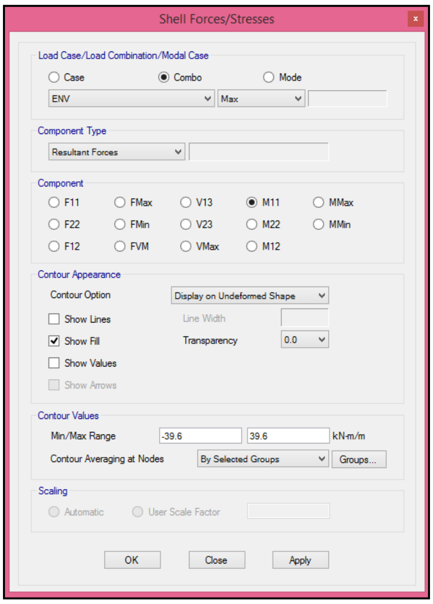


Figure 170: Shell forces stress command.

As shown in the following figure m11 for bottom bar (reinforcing in x-diricrtion) has been checked there is one panel only need more than minmum reinforcing and the moment on it 45 KN.m/m so 2 ϕ 14 will be used in this panel has been used as shown in detailing.

Note that the pure yellow color means approximately zero moment and that back to type of slab in these panels (one way ribbed slab in y direction).

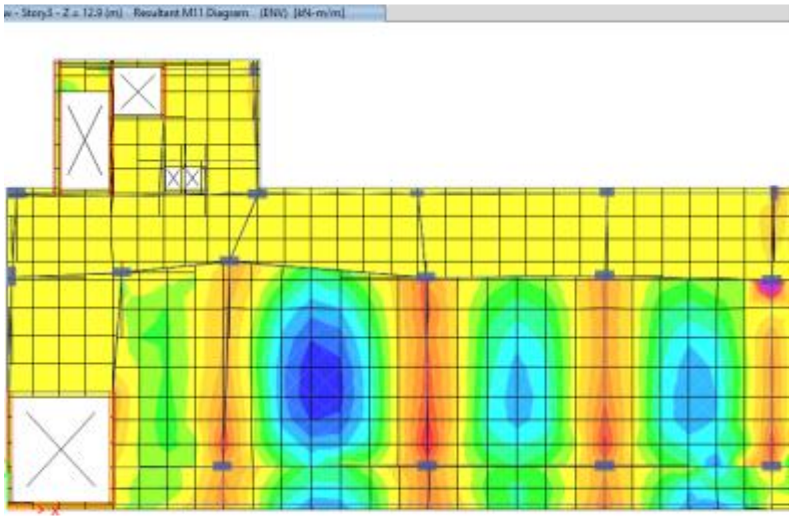


Figure 171: M11 –envelope -max.

As shown in the following figure m11 for top bar (reinforcing in x-diricrtion) has been checked .here all panel has been designed on min. reinforcing 2 ϕ12 as shown in detailing. Note that around beam exceeds the min value so the design will be shown in beams design.

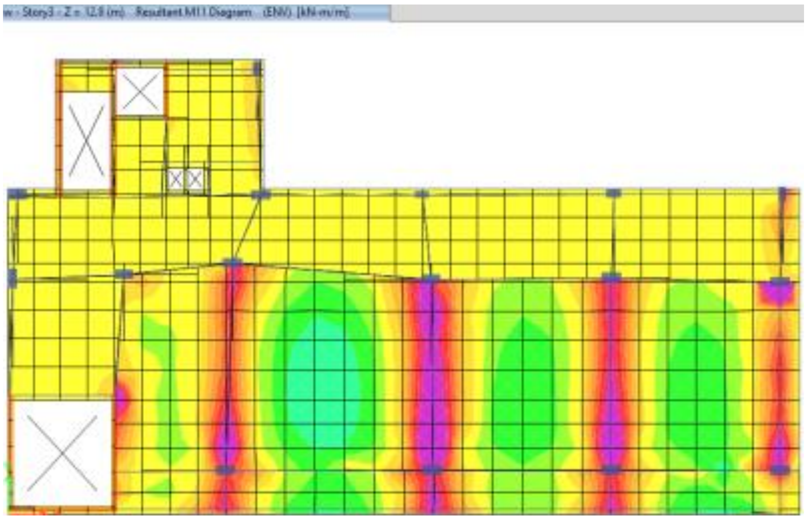


Figure 172: M11 – envelope -min.

As shown in the following figure m22 for bottom bar (reinforcing in y-diricrtion) has been checked there is one panel only need more than minmum reinforcing and the moment on it 48 KN.m/m so 2 ϕ 14 will be used in this panel has been used as shown in detailing.

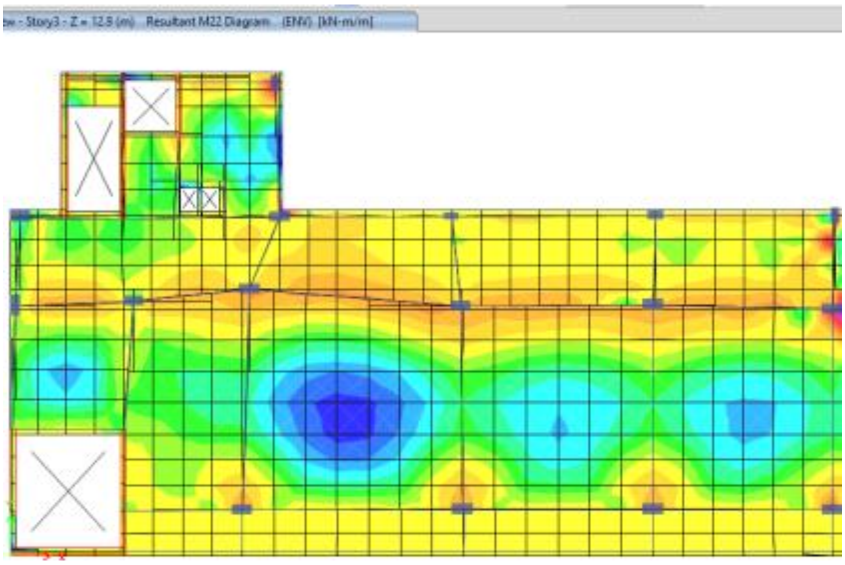


Figure 173: M22 –envelope -max.

As shown in the following figure m22 for top bar (reinforcing in y-diricrtion) has been checked .here all panel has been designed on min. reinforcing 2 ϕ12 as shown in detailing. Note that around beam exceeds the min value so the design will be shown in beams design.

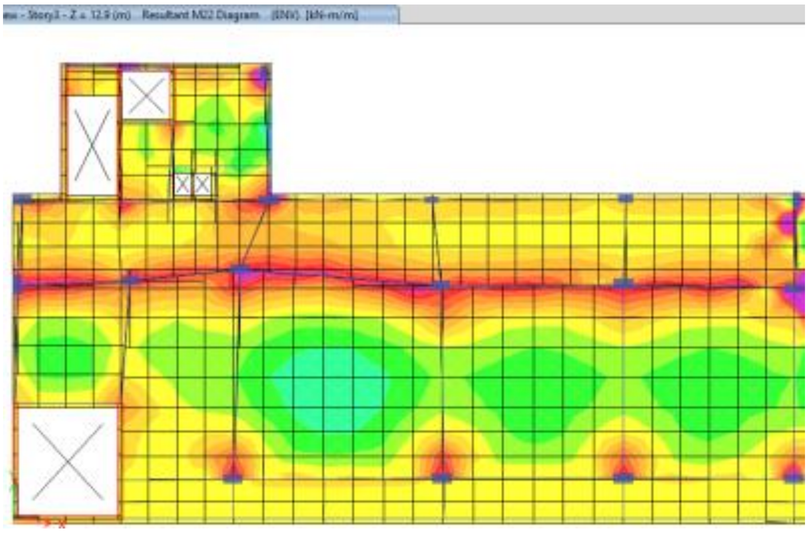


Figure 174: M22 – envelope -min.

Mesh (grade) will be 3 ϕ 8mm/1m in each way as shown in the detailing below: $As_{shrinkage}$=.0018*30*1000=54mm^2/m ➔ use3Ø8 /m.

Detailing of slabs: here sample of detailing and others detailing are available in drawing sheets.

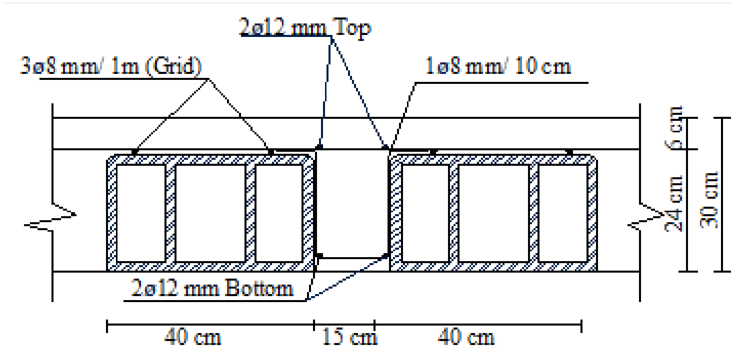


Figure 175: section in one way ribbed slab.

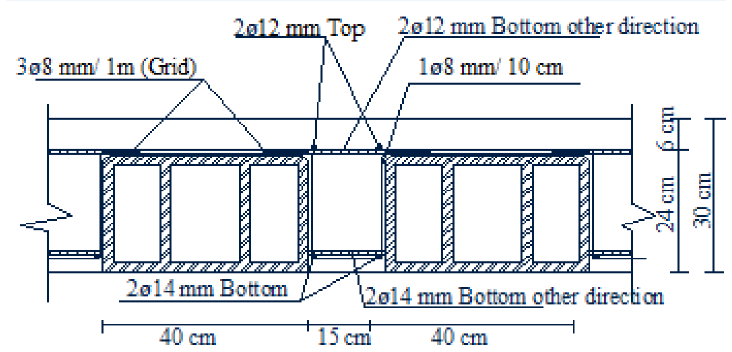


Figure 176: section in two way ribbed slab.

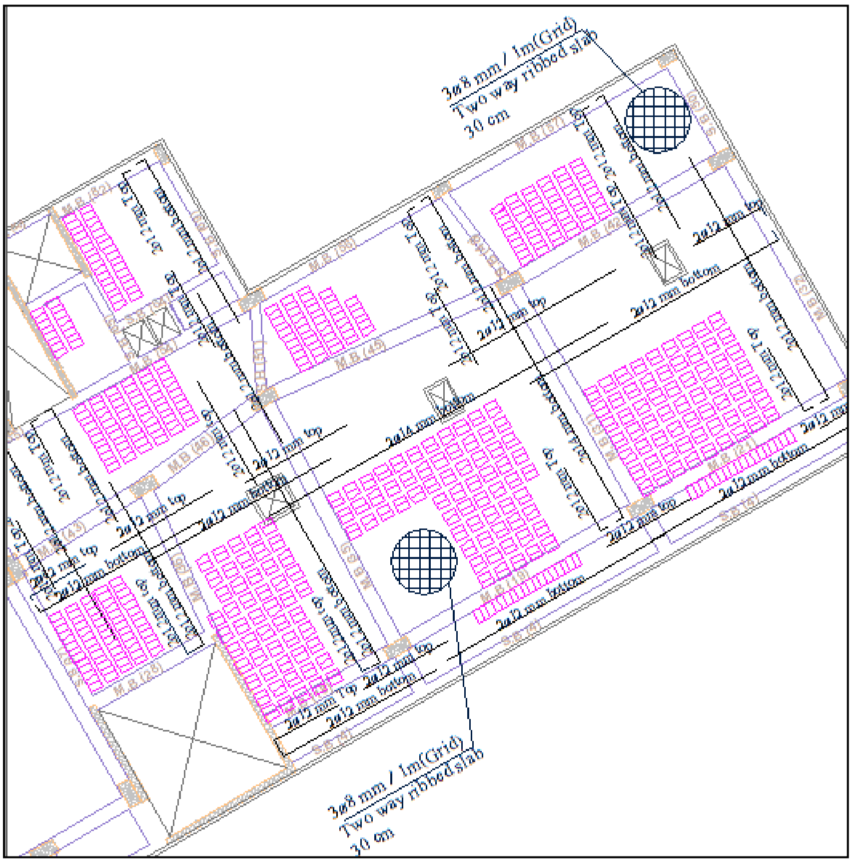


Figure 177: detailing of slab.

3.2.1.10.2. BEAMS DESIGN

All longitudinal reinforcing and shear reinforcing has been taken from ETABs.

Here sample for calculation and number of bars needed on top and bottom of the beam and checks it with As min.

Note that : As min =p min *b *d

p min = max of { 1.4 /Fy or 0.25√ f'c/Fy} =0.0033

The same things has been done for shear reinforcing and check the maximum spacing between confinement (Smax) = min of {d/2 or 600mm}).

Beams Weight for story 1 floor (ground floor at h=4.4m)												
Beam	story	Section	Length	Area	Top	Check	Bars	Bottom	check	Bars	NO.conf	spacing
M.B (B1)	story 1	60*45	7.517	0.27	1757	ok	7 ϕ 18mm	1229	ok	7 ϕ 16mm	2	150
M.B (B7)	story 1	60*45	3	0.27	896	ok	6 ϕ 14mm	810	ok	6 ϕ 14mm	2	150
M.B (B3)	story 1	60*45	4.42	0.27	965	ok	6 ϕ 16mm	810	ok	6 ϕ 14mm	2	150
M.B (B2)	story 1	60*45	6.325	0.27	1303	ok	6 ϕ 18mm	810	ok	6 ϕ 14mm	2	150
M.B (B26)	story1	60*45	7.323	0.27	2174	ok	7 ϕ 20mm	1110	ok	7 ϕ 16mm	2	150
M.B (B25)	story1	60*45	8.133	0.27	2440	ok	8 ϕ 20mm	1789	ok	8 ϕ 18mm	2	150
M.B (B22)	story1	60*45	6.967	0.27	1955	ok	7 ϕ 20mm	934	ok	7 ϕ 14mm	2	150
M.B (B21)	story1	60*45	7.392	0.27	1445	ok	6 ϕ 18mm	1391	ok	6 ϕ 18mm	2	150
M.B (B19)	story 1	60*45	8.543	0.27	1378	ok	8 ϕ 16mm	810	ok	6 ϕ 14mm	2	150
M.B (B33)	story 1	60*45	7.592	0.27	2081	ok	7 ϕ 20mm	1172	ok	7 ϕ 16mm	2	150
M.B (B30)	story 1	60*45	7.771	0.27	2037	ok	7 ϕ 20mm	1938	ok	7 ϕ 20mm	2	150
M.B (B32)	story 1	60*45	7.934	0.27	2437	ok	8 ϕ 20mm	1812	ok	8 ϕ 18mm	2	150
M.B (B31)	story1	60*45	7.866	0.27	2273	ok	8 ϕ 20mm	1994	ok	8 ϕ 18mm	2	150
M.B (B35)	story1	60*45	8.565	0.27	2500	ok	8 ϕ 20mm	1989	ok	8 ϕ 18mm	2	150
M.B (B36)	story1	60*45	5.169	0.27	938	ok	7 ϕ 14mm	1777	ok	7 ϕ 18mm	2	150
M.B (B40)	story1	60*45	8.134	0.27	3188	ok	7 ϕ 25mm	1961	ok	7 ϕ 20mm	2	150
M.B (B41)	story 1	60*45	6.969	0.27	1240	ok	7 ϕ 16mm	1081	ok	7 ϕ 14mm	2	150
M.B (B42)	story 1	60*45	7.455	0.27	1496	ok	6 ϕ 18mm	1348	ok	6 ϕ 18mm	2	150
M.B (B45)	story 1	60*45	8.228	0.27	2334	ok	8 ϕ 20mm	1768	ok	8 ϕ 18mm	2	150
M.B (B46)	story 1	60*45	4.518	0.27	810	ok	6 ϕ 14mm	810	ok	6 ϕ 14mm	2	150
M.B (B43)	story1	60*45	4.603	0.27	810	ok	6 ϕ 14mm	810	ok	6 ϕ 14mm	2	150
M.B (B47)	story1	60*45	3.616	0.27	810	ok	6 ϕ 14mm	810	ok	6 ϕ 14mm	2	150
M.B (B67)	story1	60*45	4.17	0.27	810	ok	6 ϕ 14mm	810	ok	6 ϕ 14mm	2	150
M.B (B63)	story1	60*45	1.438	0.27	810	ok	6 ϕ 14mm	810	ok	6 ϕ 14mm	2	150
M.B (B58)	story 1	60*45	6.967	0.27	1334	ok	7 ϕ 16mm	1150	ok	7 ϕ 16mm	2	150

Figure 178: sample of beams design sheet.

Note that: all beams of this block has been designed and at appendix there is a full excel sheet for all beams reinforcing .

Detailing of beams: here sample of detailing and the others detailing are available in drawing sheets.

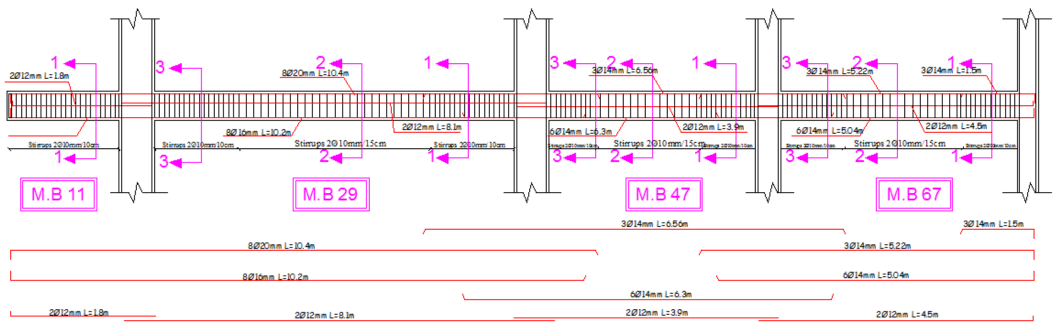


Figure 179: detailing of frames available in first floor (story 2 on etabs).

Note that the bars devlopment extended length = Lmax/3 .

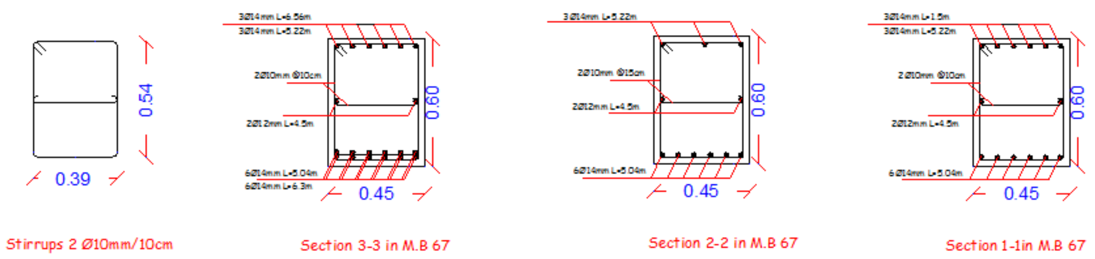


Figure 180: section in main beams.

3.2.1.10.3. COLUMN DESIGN

All longitudinal reinforcing and shear reinforcing has been taken from ETABs.

Here sample for calculation and number of bars needed beam and checks it with As min.

Note that : As min =p min *b *d

p min = max of { 1.4 /Fy or 0.25√ f'c/Fy} =0.0033

The same things has been done for shear reinforcing and checke the maximum spacing between confinement (Smax) = min of {d/2 or 600mm}).

column story 1 and 2 (basment slab and ground slab)										
column	Section	Length	Area	LON.renf.	Bars	CONFIMENT (AV/S)		AV=4 LEGS*AREA	Spacing	Spacing
C1	80*40	25.2	0.32	3200	14φ18mm	14φ18mm	1956	314	160.53	150
C3	90*50	25.2	0.45	8180	18φ25mm	14φ20mm	818	314	383.86	150
C4	90*50	25.2	0.45	4500	14φ20mm	14φ18mm	750	314	418.67	150
C2	80*40	12.9	0.32	3200	14φ18mm	14φ18mm	667	314	470.76	150
C5	40*80	8.8	0.32	3200	14φ18mm	14φ18mm	318	314	987.42	150
C9	40*80	25.2	0.32	3200	14φ18mm	14φ18mm	704	314	446.02	150
C11	80*40	25.2	0.32	3200	14φ18mm	14φ18mm	1065	314	294.84	150
C12	80*40	25.2	0.32	6793	14φ25mm	14φ25mm	2257	314	139.12	150
C8	90*50	25.2	0.45	4500	14φ20mm	14φ20mm	667	314	470.76	150
C10	80*40	25.2	0.32	6215	14φ25mm	14φ25mm	667	314	470.76	150
C6	80*40	12.9	0.32	3200	14φ18mm	14φ18mm	550	314	570.91	150
C7	40*80	8.8	0.32	3200	14φ18mm	14φ18mm	1500	314	209.33	150
C16	80*40	25.2	0.32	3200	14φ18mm	14φ18mm	260	314	1207.7	150
C14	80*40	25.2	0.32	3200	14φ18mm	14φ18mm	807	314	389.1	150
C15	60*30	25.2	0.18	4787	16φ20mm	12φ25mm	951	314	330.18	120
C17	60*35	25.2	0.21	4918	16φ20mm	12φ25mm	648	314	484.57	120
C18	60*30	12.9	0.18	1800	12φ14mm	12φ14mm	444	314	707.21	120
C24	80*40	8.8	0.32	3200	14φ18mm	14φ18mm	126	314	2492.1	150
C25	60*30	8.8	0.18	1800	12φ14mm	12φ14mm	188	314	1670.2	120
C26	60*30	8.8	0.18	1800	12φ14mm	12φ14mm	633	314	496.05	120
C27	60*30	8.8	0.18	1800	12φ14mm	12φ14mm	329	314	954.41	120
C23	80*40	25.2	0.32	5700	12φ25mm	12φ25mm	623	314	504.01	150
C19	60*30	8.8	0.18	1800	12φ14mm	12φ14mm	500	314	628	120
C22	80*40	8.8	0.32	3200	14φ18mm	14φ18mm	1072	314	292.91	150
C21	80*40	8.8	0.32	3200	14φ18mm	14φ18mm	1432	314	219.27	150
C20	40*80	8.8	0.32	3200	14φ18mm	14φ18mm	1500	314	209.33	150
C31	60*30	8.8	0.18	1800	12φ14mm	12φ14mm	267	314	1176	120
C29	60*30	8.8	0.18	1800	12φ14mm	12φ14mm	811	314	387.18	120
C30	60*30	8.8	0.18	1800	12φ14mm	12φ14mm	807	314	389.1	120
C28	30*60	8.8	0.18	1800	12φ14mm	12φ14mm	849	314	369.85	120

Figure 181: sample of columns design sheet.

Note that: all column of this block has been designed and at appendix there is a full excel sheet for all column reinforcing .

Detailing of Columns: here sample of detailing and the others detailing are available in drawing sheets.

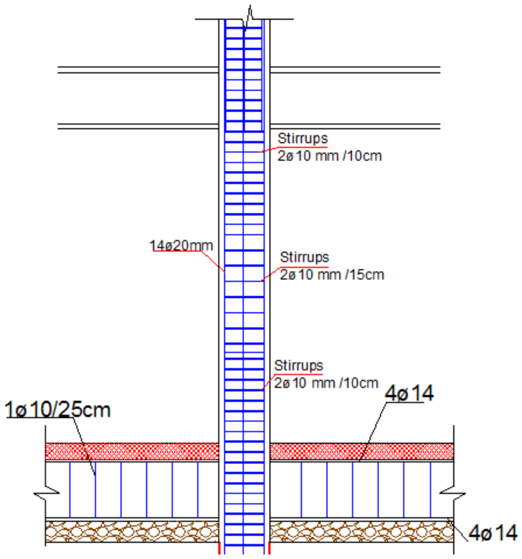


Figure 182: detailing of column.

3.2.1.10.4. FOOTING DESIGN

In this project many type of footing are define so it designed by using ETABs except isolated footing designed by manual method.

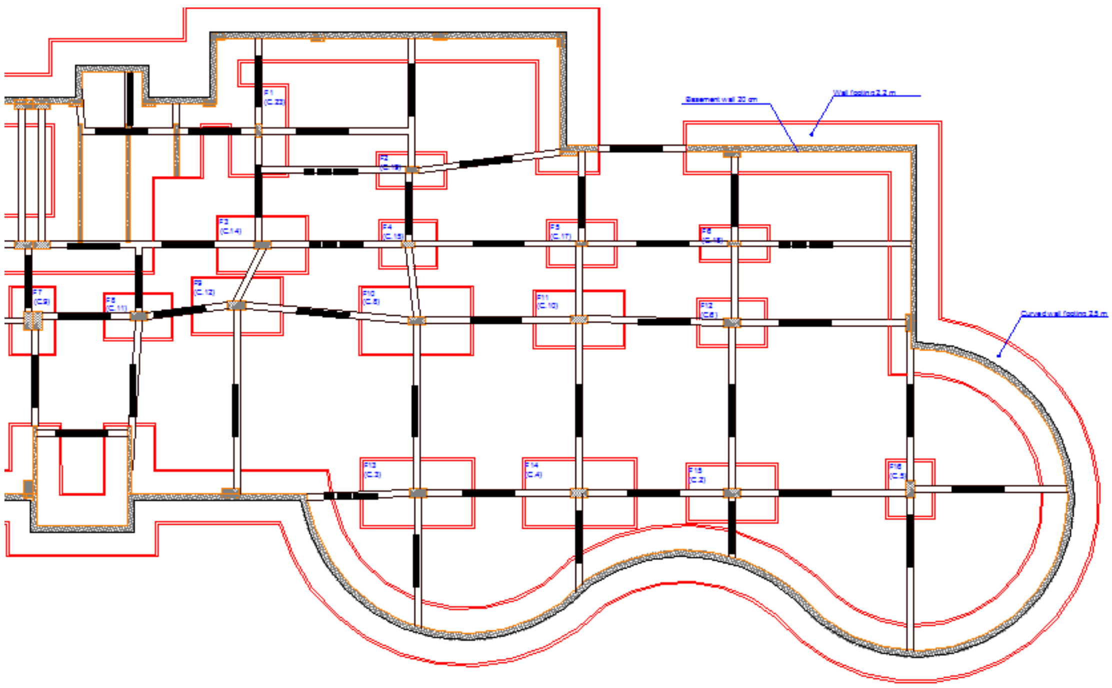


Figure 183: plan view of footing and tie beams.

3.2.1.10.4.1. Walls footing and combined

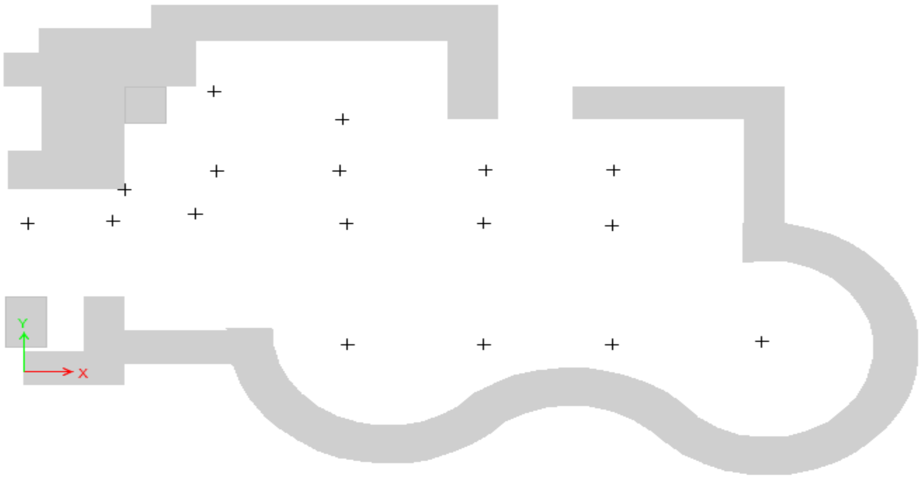


Figure 184: plan view of footing that checked by Etabs.

To design the slab, moment will be taken from ETABs.

First of all, As min should be calculated.

As min = AS shrinking= 0.0018 *b *h

Footing thickness =h =500mm

As min = 0.0018*1000*500 =900mm2/m.

So use 6 ϕ 14 if slab need minimum reinforcing.

As used in minimum case when 6 ϕ 14 is used =924 mm2/m.

Mu= 145 KN.m when As =As shrinking=924 mm2.

So by using ETABs and as shown in the following figures , the value of moment 145 KN.m/m was made as a boundary of moment value so any value that exceed this value ETAbs give it a dark tone of blue color .

As shown in the following figure m11 (reinforcing in x-diricrtion) has been checked there is some regon that have dark tone of blue color so its only more than minmum reinforcing and the moment on it have been Checked its about 160KN.m/m so 7 ϕ 14 will be used in this region has been used as shown in detailing.

Note that: the distribution of reinforcement is available in drawing sheets.

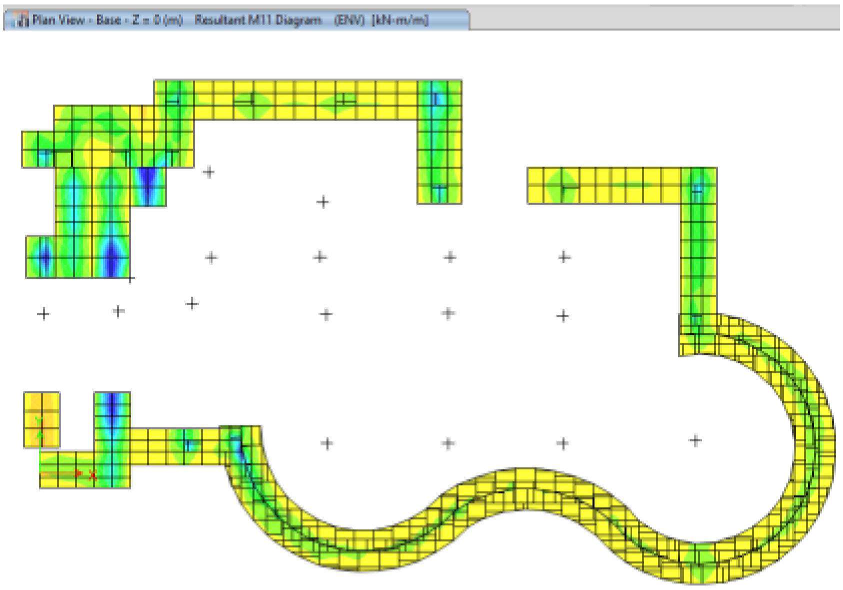


Figure 185: plan view of M11 result –env.

As shown in the following figure m22 (reinforcing in y-diricrtion) has been checked and all of moment in this dirction is lower than the minmum of area of steel reinforcing so using 6 ϕ 14 for the whole of this footing .

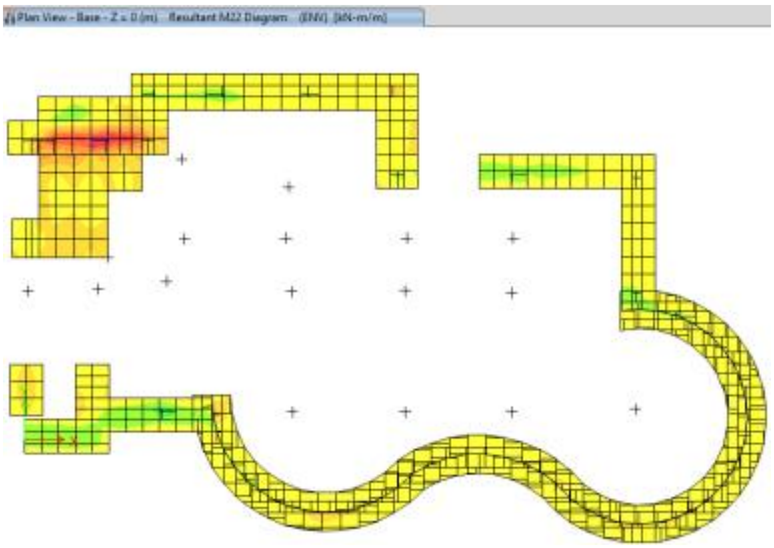


Figure 186: plan view of M22 result –env.

Note that shear for this wall footing should be checked.

$\phi Vc=0.75\ (1/6)*\sqrt{f'c}*b*d$

$\phi Vc=0.75\ (1/6)*\sqrt{28}*1000*430/1000=284.4KN/m$

Check, V13 and V23 both of it should be smaller than ϕVc.

As shown in the following figures V13 and V23 have been checked and all its ok its all < ϕVc=284.4 KN/m.

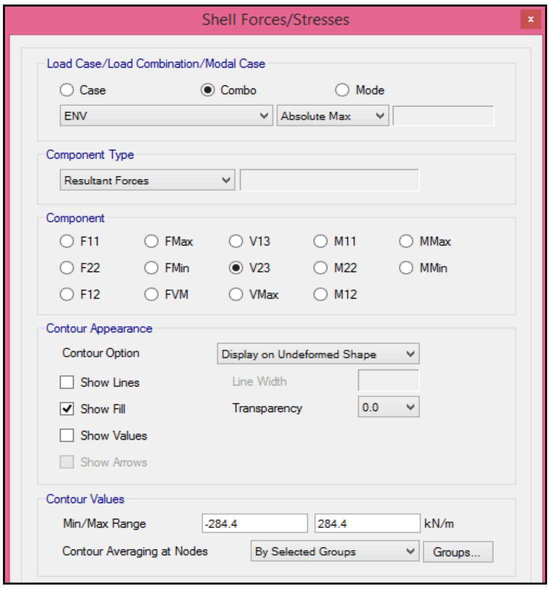


Figure 187: shear contour value - min and max range .

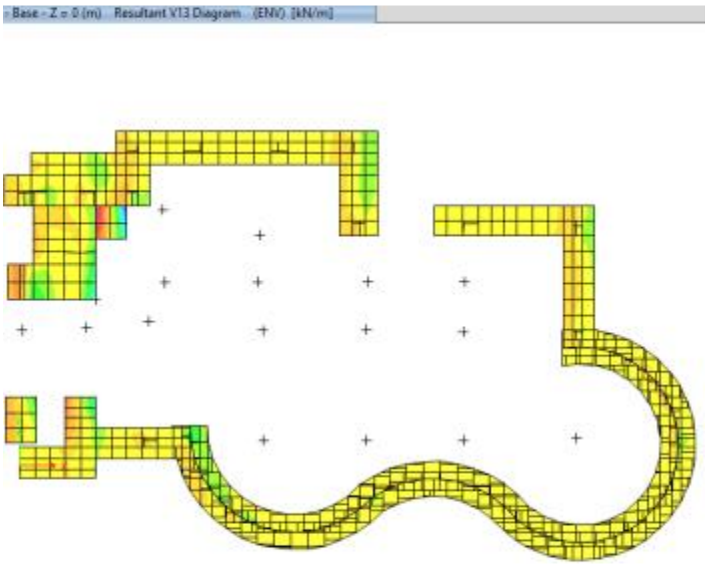


Figure 188: V13-env.

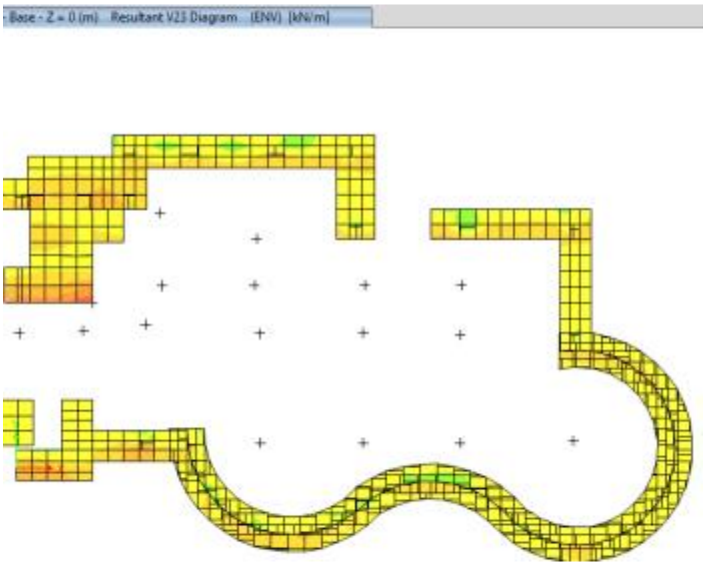


Figure 189: V23-env.

3.2.1.10.4.2. Footing design of isolated footing by calculates it manually

To design the isolated footing P ultimate and p service have been taken from ETABs as shown in the table below.

Column	footing name.	Pu	Pserv.	COLUMN WEDTH	COLUMN LENGTH
23	1	4906.5	3436.92	40	80
19	2	1410.0	1086.60	30	60
14	3	4301.0	3130.00	40	80
15	4	2428.5	1865.00	30	60
17	5	3228.1	2364.00	35	60
18	6	1953.0	1396.43	30	60
9	7	1656.8	1262.56	40	80
11	8	2896.4	2262.40	40	80
12	9	4542.1	3539.70	40	80
8	10	5978.2	4645.02	50	90
10	11	4701.9	3553.30	40	80
6	12	2941.0	2264.20	40	80
3	13	7170.3	5578.75	50	90
4	14	6342.9	4709.46	50	90
2	15	3548.8	2609.56	40	80
5	16	2636.4	1910.17	40	80

Figure 190: Table of Pu and Pservice value.

After that excel sheet has been created to solve, check and reinforce the footing as shown below.

Note that these entire tables are available in appendix.

Column	footing name.	Pu	Pserv.	COLUMN WEDTH	COLUMN LENGTH	footing area	h used (cm)	d(mm)	footing width	footing length
23	1	4906.5	3436.92	40	80	8.59	75	690	2.5	4.0
19	2	1410.0	1086.60	30	60	2.72	45	390	1.5	3.0
14	3	4301.0	3130.00	40	80	7.83	70	640	2.5	4.0
15	4	2428.5	1865.00	30	60	4.66	50	440	2	2.5
17	5	3228.1	2364.00	35	60	5.91	60	540	2	3.0
18	6	1953.0	1396.43	30	60	3.49	55	490	1.5	3.0
9	7	1656.8	1262.56	40	80	3.16	55	490	1.5	3.0
11	8	2896.4	2262.40	40	80	5.66	55	490	2	3.0
12	9	4542.1	3539.70	40	80	8.85	75	690	2.5	4.0
8	10	5978.2	4645.02	50	90	11.61	85	790	3	5
10	11	4701.9	3553.30	40	80	8.88	75	690	2.5	4
6	12	2941.0	2264.20	40	80	5.66	60	540	2	3
3	13	7170.3	5578.75	50	90	13.95	95	890	3	5
4	14	6342.9	4709.46	50	90	11.77	95	890	3	5
2	15	3548.8	2609.56	40	80	6.52	70	640	2.5	4
5	16	2636.4	1910.17	40	80	4.78	50	440	2	2.5

Figure 191: excel sheet of isolated footing design.

b₀	6u	Vu punch	ØVc(punch.)	punching check	Vu Transverse	Vu in Longitudinal	ØVc	check wide shear in Transverse	check wide shear in Longitudinal
5160.0	490.6	4109.6	4710.0	ok	176.6	446.5	456.4	ok	ok
3360.0	313.3	1196.0	1733.5	ok	65.8	253.8	258.0	ok	ok
4960.0	430.1	3656.9	4199.3	ok	176.3	412.9	423.3	ok	ok
3560.0	485.7	2054.7	2072.2	ok	199.1	247.7	291.0	ok	ok
4060.0	538.0	2682.2	2900.3	ok	153.3	355.1	357.2	ok	ok
3760.0	434.0	1579.3	2437.3	ok	47.7	308.1	324.1	ok	ok
4360.0	368.2	1234.1	2826.2	ok	22.1	224.6	324.1	ok	ok
4360.0	482.7	2342.2	2826.2	ok	149.6	294.5	324.1	ok	ok
5160.0	454.2	3804.4	4710.0	ok	163.5	413.3	456.4	ok	ok
5960.0	398.5	5109.3	6228.6	ok	183.3	502.2	522.5	ok	ok
5160.0	470.2	3938.3	4710.0	ok	169.3	427.9	456.4	ok	ok
4560.0	490.2	2323.6	3257.4	ok	127.4	274.5	357.2	ok	ok
6360.0	478.0	5980.9	7488.0	ok	172.1	554.5	588.7	ok	ok
6360.0	422.9	5290.7	7488.0	ok	152.2	490.5	588.7	ok	ok
4960.0	354.9	3017.3	4199.3	ok	145.5	340.7	423.3	ok	ok
4160.0	527.3	2087.2	2421.4	ok	189.8	216.2	291.0	ok	ok

Figure 192: excel sheet of isolated footing design.

Mu Transverse	Mu Longitudinal	ρ Transverse	ρ Longitudinal	As shrinkage /m	As in Long. /m	As in Trans./m	As Transverse mm2	As Longitudinal mm2	# of bars in Transverse	# of bars in Longitudinal
270.5	628.0	0.00152	0.00360	1350.0	2482.7	1350.0	5400.0	6206.7	22 ϕ 18mm	20 ϕ 20mm
56.4	225.6	0.00099	0.00406	810.0	1584.6	810.0	2430.0	2376.8	16ϕ 14mm	16 ϕ 14mm
237.1	550.5	0.00155	0.00367	1260.0	2347.8	1260.0	5040.0	5869.6	20 ϕ 18mm	20 ϕ 20mm
175.5	219.2	0.00245	0.00307	900.0	1352.2	1076.4	2691.0	2704.5	14 ϕ 16mm	14 ϕ 16mm
183.1	387.4	0.00168	0.00362	1080.0	1957.2	1080.0	3240.0	3914.3	17 ϕ 16mm	20 ϕ 16mm
78.1	312.5	0.00087	0.00355	990.0	1738.7	990.0	2970.0	2608.0	15 ϕ 16mm	13 ϕ 16mm
55.7	222.7	0.00062	0.00251	990.0	1227.7	990.0	2970.0	1841.6	15 ϕ 16mm	12 ϕ 14mm
154.5	292.1	0.00173	0.00331	990.0	1621.5	990.0	2970.0	3243.0	15 ϕ 16mm	17 ϕ 16mm
250.4	581.4	0.00141	0.00332	1350.0	2292.5	1350.0	5400.0	5731.4	18 ϕ 20mm	19 ϕ 20mm
311.4	837.4	0.00133	0.00366	1530.0	2893.2	1530.0	7650.0	8679.5	25 ϕ 20mm	18 ϕ 25mm
259.2	601.8	0.00146	0.00344	1350.0	2375.8	1350.0	5400.0	5939.6	18 ϕ 20mm	19 ϕ 20mm
156.9	296.6	0.00144	0.00275	1080.0	1486.5	1080.0	3240.0	2973.0	17 ϕ 16mm	15 ϕ 16mm
373.5	1004.4	0.00126	0.00345	1710.0	3074.4	1710.0	8550.0	9223.1	28 ϕ 20mm	20 ϕ 25mm
330.4	888.5	0.00111	0.00304	1710.0	2709.5	1710.0	8550.0	8128.5	28 ϕ 20mm	17 ϕ 25mm
195.6	454.2	0.00128	0.00301	1260.0	1925.7	1260.0	5040.0	4814.2	20 ϕ 18mm	16 ϕ 20mm
168.7	190.5	0.00235	0.00266	900.0	1170.8	1034.2	2585.6	2341.7	17 ϕ 14mm	16 ϕ 14mm

Figure 193: excel sheet of isolated footing design.

Sample calculation of isolated footing:

Footing name (4) and column label (15).

Column dimension (30*60) cm.

Q all = 400 KN/m^2 , f'_c = 28 MPa and Fy= 420 MPa.

P service =1865KN

Area dimensions:

Max=Qall =400= P service /B*L

400=1865/B*L

Guess B :

√p/qall=√1865/400 =2.16m

Assume B=2m

Then L= 2.33 m use L=2.5m.

Thickness:

Column dimension (30*60) cm.

Pu=2428.5 KN

σu= Pu/B*L=2428.5/2*2.5=485.7KN/m2

Guess d : 10√pu =492.7mm

Assume h=500mm, d=440mm

Note that, footing not directly exposed to the soil.

Check Pu punching:

ΦVcp=0.75*1/3*√28*((2*1040+2*740)/1000) *440

ΦVcp=2072.2 KN

Vup=Pu-stress*area

=2428.5 – 485.7(1.04*0.74)

=2054.7KN Vup

ΦVcp>Vup so check is ok.

Check wide beam shear :

Critical shear failure path check:

ΦVc=0.75*1/6*√28*1000*440/1000

ΦVc=291KN/m

Vu=485.7(0.95-0.85)=48.6KN/m

ΦVc>Vu

Check is ok .

Reinforcement:

Mu(longitudinal)=(485.7*0.95^2)/2=219.17KN.m/m

Mu(transverse)=(485.7*0.95^2)/2=175.5KN.m/m

Compute steel ratio (Ƥ) :

(Mu=219.17KN.m/m ,d=440mm,b=1000)

Ƥ=0.00307

As= Ƥbd=1350mm^2 /m

As min=0.0018*1000*450=810 mm^2 /mm

Use As , Use 14Φ16.

(Mu=175.5KN.m/m ,d=440mm,b=1000)

Ƥ=0.00245

As= Ƥbd =1078mm^2 /mm

Use As , Use 14Φ16.

Detailing of footing:

All detailing are available on drawing sheets , the following figure are examples of the detailing .

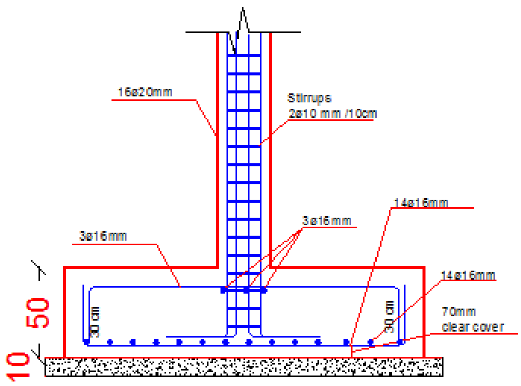


Figure 194: longitudinal section in footing.

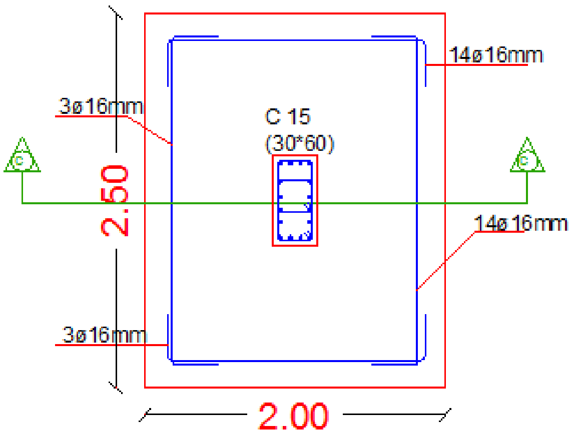


Figure 195: plan view in footing.

3.2.1.10.5. BASEMENT (RETAINING WALLS) DESIGN

The retaining wall that has been designed is available on basement floor which have 4.4m height and 0.2m thickness.

WL =20 KN/m2 because there is maybe huge vehicles

Φ=30◦ , H =4.1 m ,Ɣ soil=18KN/m3

Ka=1-sinΦ / 1+sin Φ = 1-sin 30◦/1+sin 30◦ =0.333

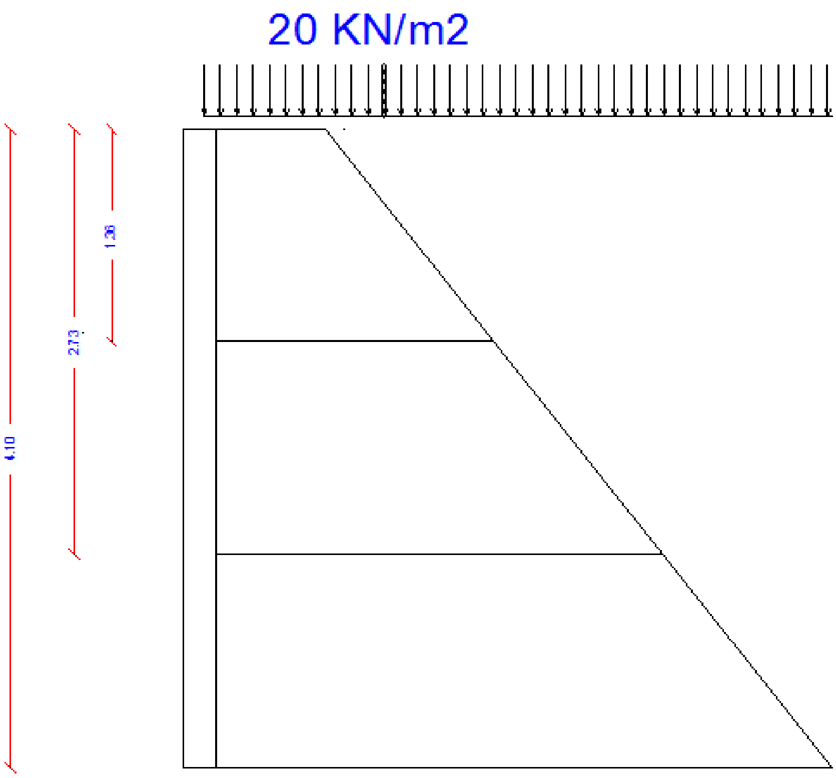


Figure 196: the pressure of soil on retaining walls.

Lateral pressure = Normal pressure * ka = 20*1/3 =6.7 at 0m height from top.

Lateral pressure = Normal pressure * ka = 20*1/3+1.36*18*1/3=14.8 at 1.36m height from top.

Lateral pressure = Normal pressure * ka = 20*1/3+1.36*18*1/3=23 at 2.73m height from top.

Lateral pressure = Normal pressure * ka = 20*1/3+4.1*18*1/3=31.3 at 4.1m height from top.

There are two retaining wall in basement floor:

1. Curved walls.

Stem design:

<u>Vertical reinforcing:</u>

The max, moment from etabs =92KN.m/m

Mu=92KN.m/m. h=200m,d=150mm,b=1000

P=0.01179.

As =Pbd =1770 mm2/m, so it's about 7 Φ18/m.

As min =0.0015 bh =0.0015*1000*200=300mm2/m

Then use As.

Other face reinforcing: As=1/2 As min =150mm2/m, so its need 2 Φ10 /m.

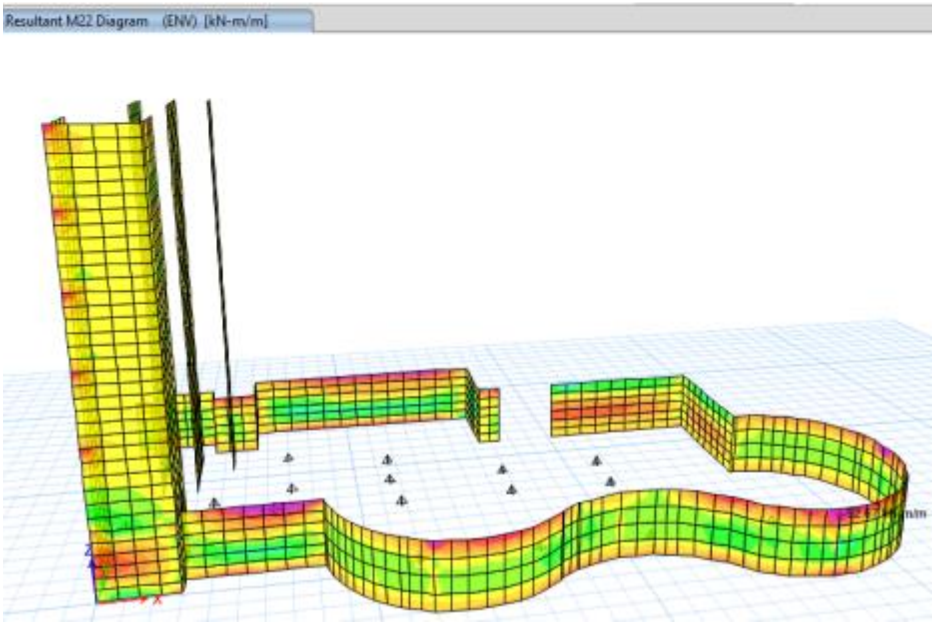


Figure 197: value of max moment.

<u>horizantal reinforcing:</u>

As=AS sh.=0.0025bh =0.0025 =500mm2/m.

7 Φ10mm on two layer so use 4 Φ10mm on each layer.

Footing design: the bottom bar as discussed in footing design and the top bar is

Long. Reinforcement = AS =ASmin =0.0018*1000*500=900mm2/m so its need 6 Φ14mm/m.

Transverse = As min =0.0018*1000*500=900mm2/m so its need 6 Φ14mm/m.

Here the sample of detailing on curved wall.

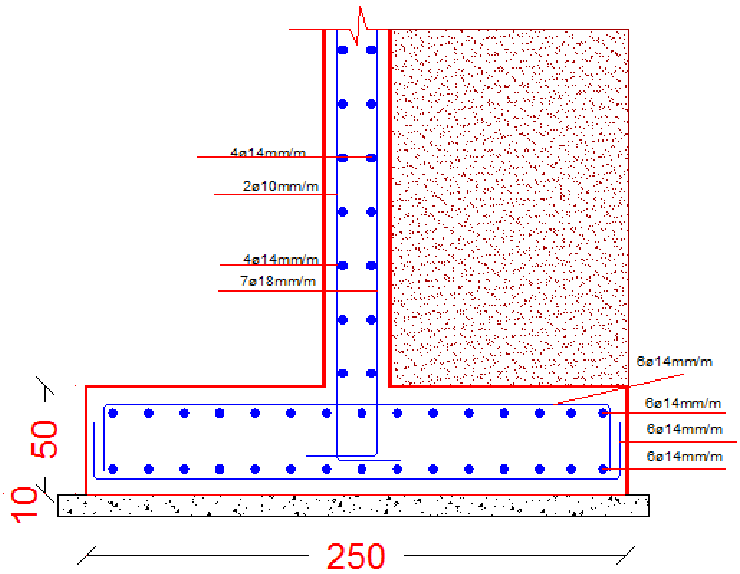


Figure 198: longitudinal section in retaining wall(curved) and its footing .

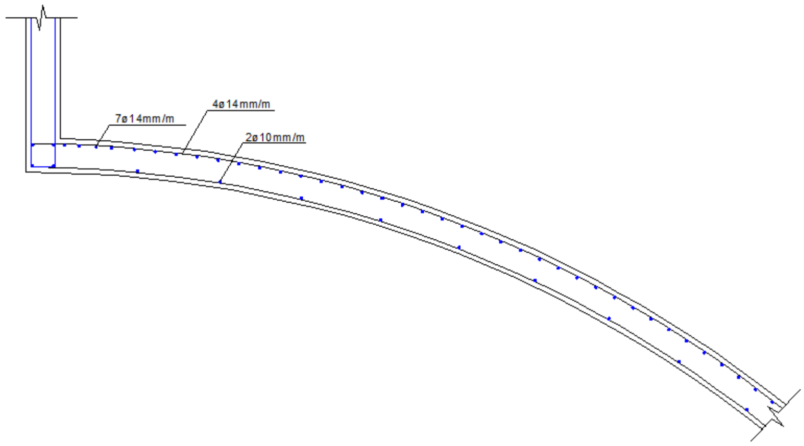


Figure 199: section in curved wall.

2. Typical(strait) retaining wall.

Stem design:

Vertical reinforcing:

The max, moment from etabs =59KN.m/m

Mu=59KN.m/m. h=200m,d=150mm,b=1000

P=7.14*10-3.

As =Pbd =1070 mm2/m, so it's about 7 Φ14/m.

As min =0.0015 bh =0.0015*1000*200=300mm2/m

Then use As.

Other face reinforcing As=1/2 As min =150mm2/m, so its need 2 Φ10 /m.

horizantal reinforcing:

As=AS sh.=0.0025bh =0.0025 =500mm2/m.

7 Φ10mm on two layer so use 4 Φ10mm on each layer.

Footing design: the bottom bar as discussed in footing design and the top bar is Long. Reinforcement = AS =ASmin =0.0018*1000*500=900mm2/m so its need 6 Φ14mm/m.

Transverse = As min =0.0018*1000*500=900mm2/m so its need 6 Φ14mm/m.

Here the sample of detailing on curved wall.

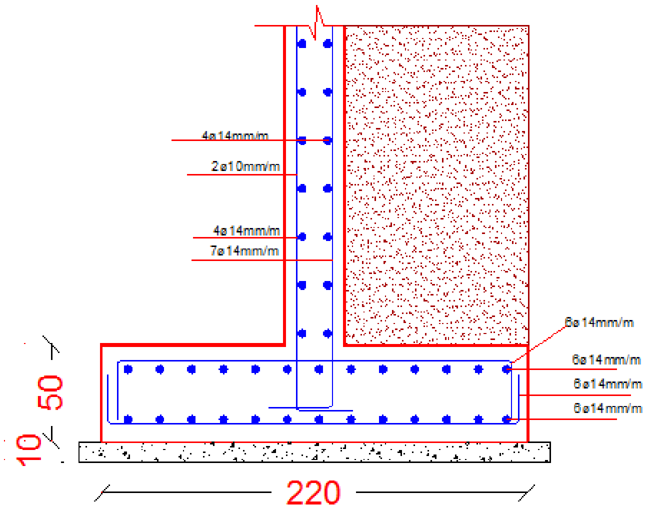


Figure 200: longitudinal section in retaining wall and its footing.

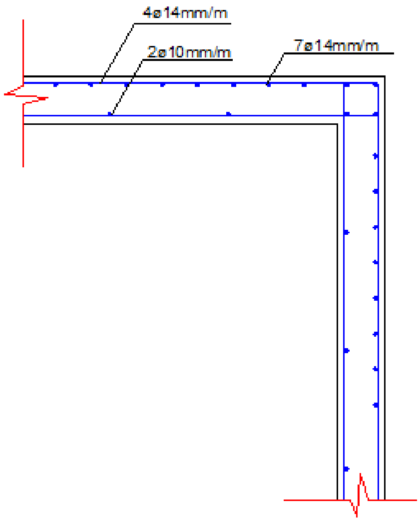


Figure 201: section in retaining wall.

3.2.1.10.6. SHEAR WALL DESIGN

For boundary:

b = 0.1 * 4.5 ˜ 0.45m.

h=200mm.

ρ = 1% ➔ As = ρ b h ➔ As = 8Ø12

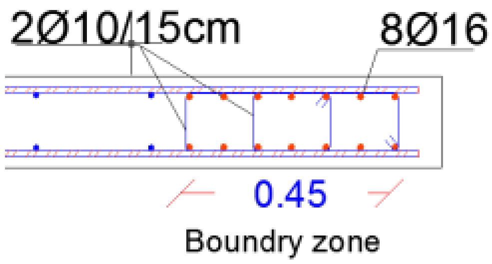


Figure 202: section in boundary zone of shear wall .

For web:

For horizontal steel:

ρ = 0.25%

As = ρ b h → As = 5Φ12/m for each layer (8Φ12).

For vertical steel:

ρ = 0.25%

As = ρ b h → As = 5Φ12/m for each layer(8Φ12).

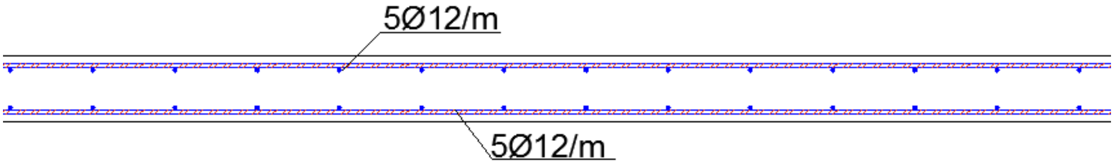


Figure 203: section in shear wall .

The following tables show the reinforcement of shear walls:

Table 26 : shear wall design (1).

shear wall	length	flange 1	flange 2	web	ρ Vertical	ρ Horizontal	ρ flange	h wall
1	4500	450	450	3600	0.0025	0.0025	0.01	200
2	3300	330	330	2640	0.0025	0.0025	0.01	200
3	4700	470	470	3760	0.0025	0.0025	0.01	200
4	5570	557	557	4456	0.0025	0.0025	0.01	200
5	5570	557	557	4456	0.0025	0.0025	0.01	200
6	2385	238.5	238.5	1908	0.0025	0.0025	0.01	200

Table 27 : shear wall design (2).

					Φ12	Φ 12	Φ 12	Φ12
shear wall	As horizontal	As Vertical	As flange 1	As flange 2	bars horizontal	bars vertical	bars flange1	bars flange2
1	1800	1800	900	900	16	16	8	8
2	1320	1320	660	660	12	12	6	6
3	1880	1880	940	940	16	16	8	8
4	2228	2228	1114	1114	20	20	10	10
5	2228	2228	1114	1114	20	20	10	10
6	954	954	477	477	8	8	4	4

3.2.1.10.7. TIE BEAMS DESIGN

The tie beams are 60cm depth with 30cm width for Hotel.

All ground beams has been reinforced with minimum steel.

ρ=1.4/Fy=0.0033

b=0.3m, h=0.60m

As=0.0033*30*54=5.35cm^2

Use 4Ø14 for top and 4Ø14 for bottom

Shear reinforcement:

For Av/s=0.025

S=Av/(Av/S)=1.57/0.025=62 cm

Use 1Ø10mm/25cm.

3.2.1.10.8. STAIR CASES DESIGN

Use SAP program to design the stair case:

Live load = 4.8KN/m^2

SID = 4KN/m^2

Thickness = 0.2m

Figure 204: stair cases design.

SAP moment results (1.2D+1.6L) combination:

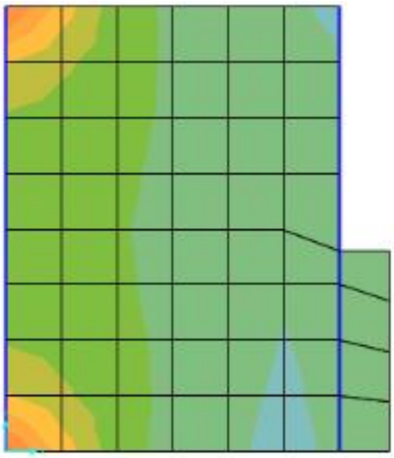


Figure 205: M11-Landing1 design.

Use an average moment (M11) = 60KN.m/m

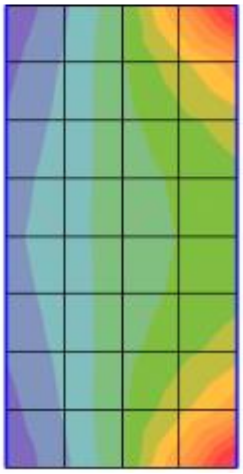


Figure 206: M11-Landing2 design.

Use an average moment(M11) = 60KN.m/m .

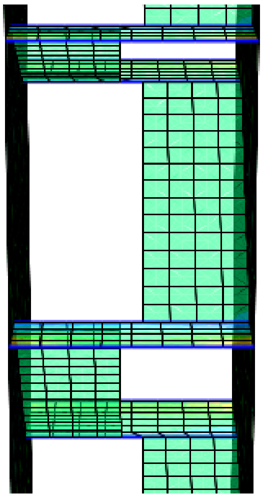


Figure 207: M11-stair case-inclined part.

Use an average moment(M11)= 16KN.m/m

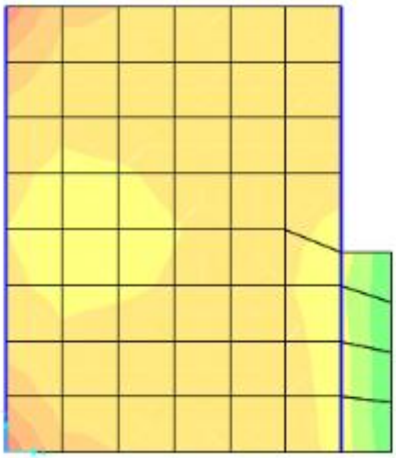


Figure 208: M22-Landing1 design.

Use an average moment(M22)= 24KN.m/m.

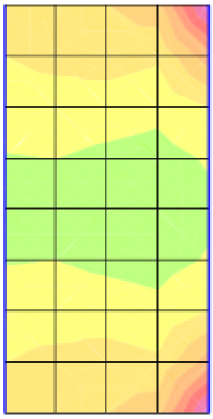


Figure 209: M22-Landing2 design.

Use an average moment(M22)= 24KN.m/m

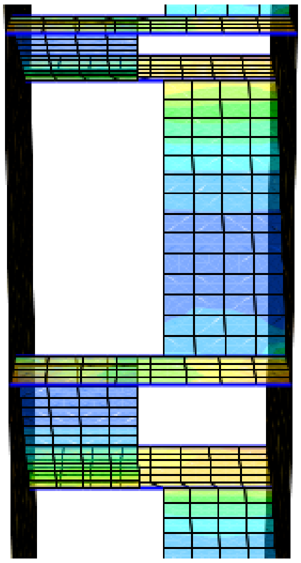


Figure 210: M22-stair case-inclined part.

Use an average moment (M22) = 48KN.m/m .

Table 28: Stair cases design.

Moments	ρ	As	As min	As required	# of bars
24	2.24e-3	381	360	381	4Φ12
24	2.24e-3	381	360	381	4Φ12
16	1.48e-3	253	360	360	4Φ12
48	4.6e-3	783	360	783	4Φ16
60	5.83e-3	991	360	991	5Φ16

3.2.2. SECOND BLOCK ANALYSIS AND DESIGN

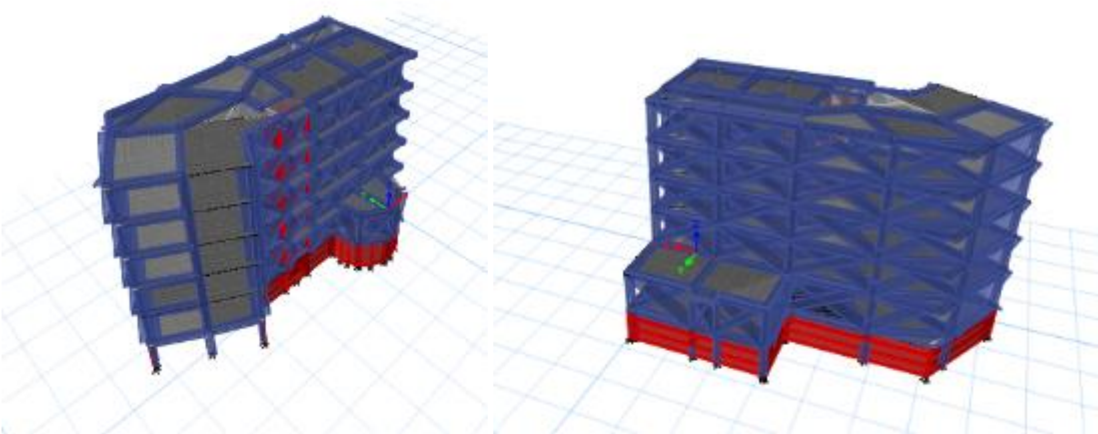


Figure 211: 3D view of Etab model for Second block.

Analysis the model and checks:

The following checks are important to be taken in consideration:

3.2.2.1. COMPATIBILITY

To make sure that all the structural elements are compatible with each other. This can be achieved and approved by noticing and analyzing the deformed shape animation of the model from ETABs15.

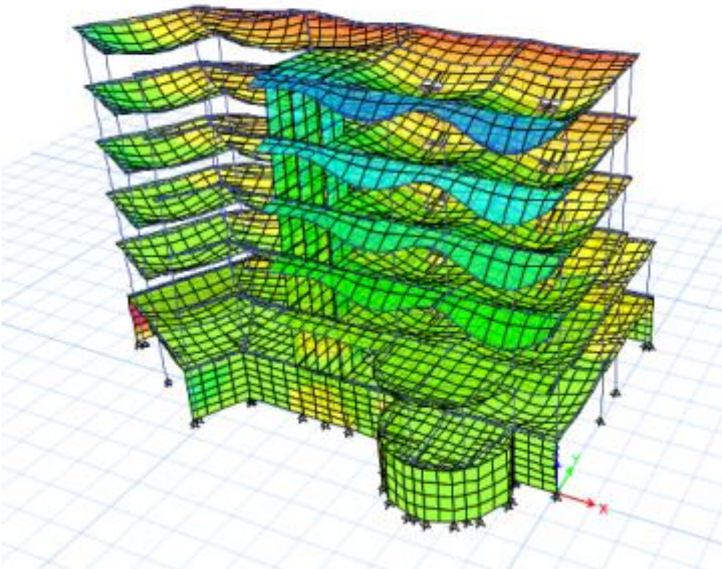


Figure 212: Compatibility check (1).

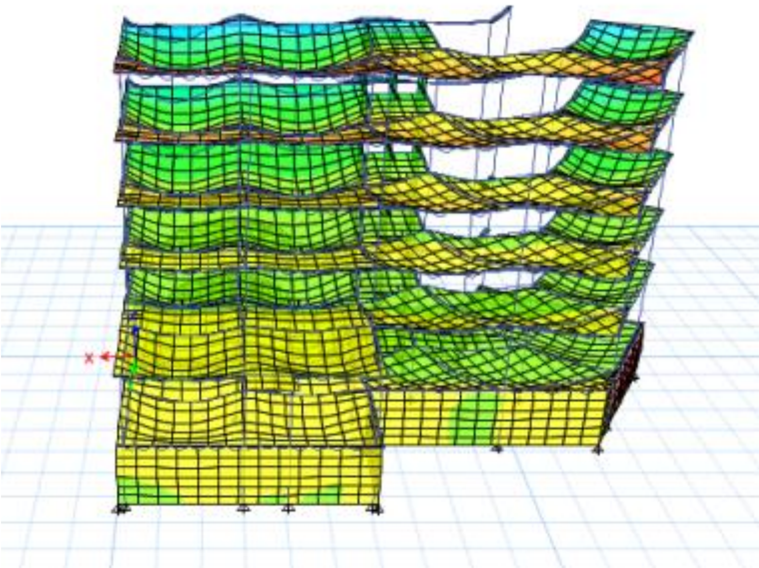


Figure 213: Compatibility check (2).

3.2.2.2. EQUILIBRIUM CHECKS.

Table29 : Percentage of Error In Equilibrium Checks.

Load type	Base reaction from manual calculations	Base reaction from ETABs	Percentage of Error (%)
Dead	27707.2	27309.5	1.43
SID	24701	24189.6	2.11
Live Z	8675.07	8714	0.44
Live X	1139.5	1166.3	2.3
Live Y	599.2	684.5	14.22

The percentages of error are too small so the checks are acceptable; the 14.22% error is due to geometry errors.

Note that the manual calculation of base reaction is available in appendix.

3.2.2.3. STRESS –STRAIN RELATION (LOCAL EQUILIBRIUM) CHECKS

3.2.2.3.1. BEAMS

Check beams –from live load:

Table30 : Equilibrium checks for beams.

Beams label	Manual Moment result (KN.m)	ETABs result	Percentage of error (%)
B14(Story 2)	67.37	67.25	0.178%
B9 (Story 2)	23.8	26.6	10.5%
B36 (Story 6)	67.5	74.2	9%

<u>Manual sample calculations:</u>

Checks beam (B14) on story 2 - moment 3-3 from live load:

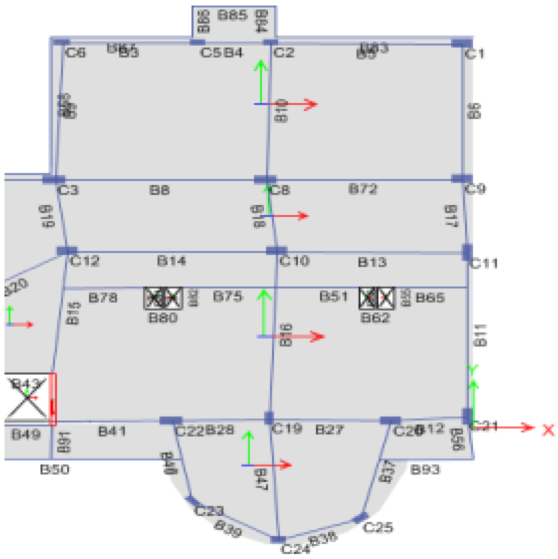


Figure 214: beam B (14) to be check.

<u>Manual calculation of moment:</u>

W_{Live} on beam, using tributary area by using AUTOCAD program

A = 28.4m2.

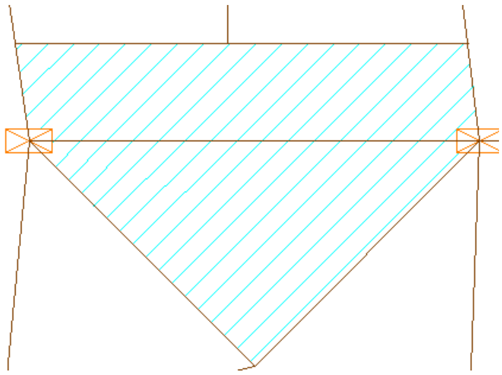


Figure 215: Tributary area on beam 14.

W_l/m(Manual) = (28.4*3)/7.8 = 10.9KN/m.

Moment = WL on beam* L^2 /8 = 10.9*$(7)^2$/8 =67.37KN.m

Moment from ETABs = (38.4+39.5) /2 +28.3 =67.25 KN.m

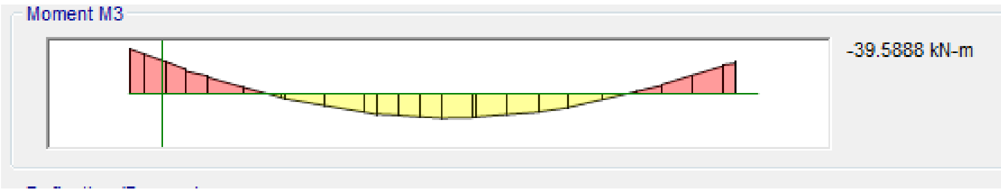


Figure 216: Moment 3-3 from ETABs at edge of beam (B14).

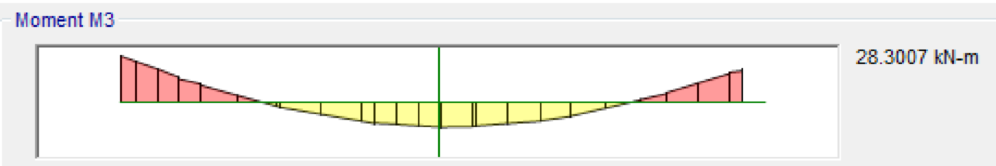


Figure 217: Moment 3-3 from ETABs at middle of beam (B14).

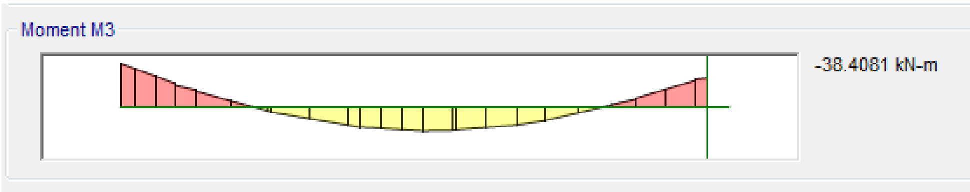


Figure 218: Moment 3-3 from ETABs at edge of beam (B14).

Percentage of Error = (67.25-67.37 /67.25) * 100% = 0.178%.

it's ok because the beam is connect between column which has different dimensions and deferent stiffness and it not strait 100% so there is percentage of error so it's acceptable.

3.2.2.3.2. COLUMN

Check column –from live load:

Table31 : Equilibrium checks for beams.

Column label	Manual load calculation (KN)	ETABs Axial Result (KN)	Percentage of error (%)
C10	862	889.64	3.1%
C11	380	401.73	5.41%
C1	91.44	93	1.67%

<u>Manual sample calculation for C10:</u>

Live load on Ground floor = 5 KN/m2

Live load on others floor =3 KN/m2

Tributary area around column 10 = 43.1m^2.

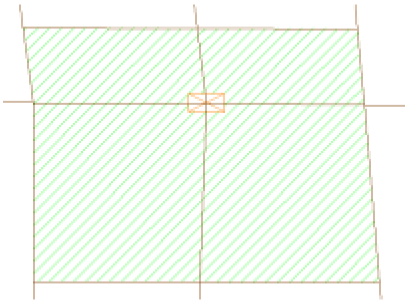


Figure 219: Tributary area on column.

Live load on column from ground floor = 5*43.1 =215.5 KN

Live load on column from others floor(5 stories) =5*3*43.1=646.5KN

Total Live load on column =862 KN.

ETABs result =889.46KN (Axial from live load) as shown in the figure below:

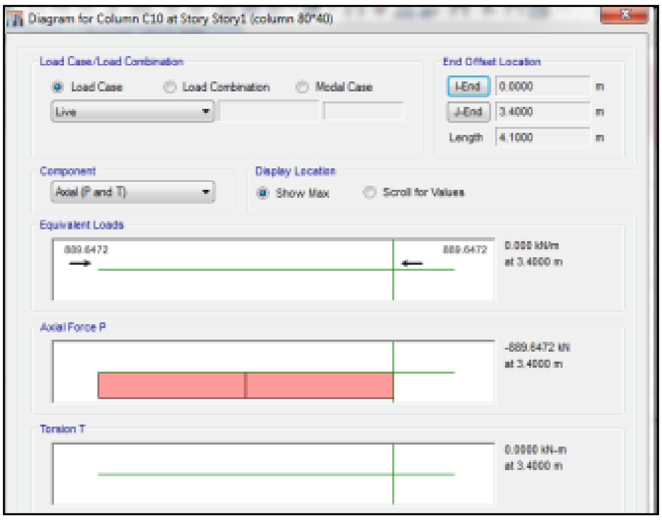


Figure 220: Axial load from ETABs.

Percentage of Error = (889.64-862 /889.64) * 100% = 3.1%. So it's ok.

3.2.2.4. MAKING SURE MODAL PARTICIPATION MASS RATIO > 90% IN BOTH X AND Y.

So as shown in table below, 23 modal cases needed to get 90.4 in x-direction and 98.93 in y-direction from the full mass of model.

Table32 : Modal Participating Mass Ratios.

Modal Participating Mass Ratios.								
Case	**Mode**	**Period**	**UX**	**UY**	**UZ**	**Sum UX**	**Sum UY**	**Sum UZ**
		sec						
Modal	1	0.786	0.0051	0.5087	0	0.0051	0.5087	0
Modal	2	0.328	0.0372	0.0213	0	0.0424	0.5301	0
Modal	3	0.22	0.6783	0.0035	0	0.7207	0.5336	0
Modal	4	0.203	0.002	0.216	0	0.7227	0.7496	0
Modal	5	0.113	0.0068	0.112	0	0.7295	0.8616	0
Modal	6	0.098	0.0017	0.0076	0	0.7312	0.8692	0
Modal	7	0.078	0.0025	0.0273	0	0.7337	0.8965	0
Modal	8	0.074	0.1592	0.014	0	0.8929	0.9105	0
Modal	9	0.059	0.0008	0.0346	0	0.8938	0.9451	0
Modal	10	0.057	0.0002	0.0037	0	0.8939	0.9488	0
Modal	11	0.057	0.0003	0.000004871	0	0.8942	0.9488	0
Modal	12	0.056	0.0002	0.0017	0	0.8944	0.9504	0
Modal	13	0.056	0.0009	0.001	0	0.8953	0.9514	0
Modal	14	0.055	0.0003	0.0003	0	0.8956	0.9518	0
Modal	15	0.054	0.00001021	0.0001	0	0.8956	0.9518	0
Modal	16	0.054	0.0003	0.0004	0	0.8959	0.9522	0
Modal	17	0.053	0.0006	0.0002	0	0.8965	0.9524	0
Modal	18	0.05	0.00004983	0.0004	0	0.8965	0.9528	0
Modal	19	0.049	0.0003	0.0002	0	0.8969	0.953	0
Modal	20	0.048	0.0023	0.0324	0	0.8992	0.9854	0
Modal	21	0.048	0.0001	0.0038	0	0.8993	0.9892	0
Modal	22	0.046	0.0005	0.00003795	0	0.8997	0.9892	0
Modal	23	0.045	0.0042	0.00004751	0	0.9039	0.9893	0
Modal	24	0.044	0.0062	0.000009003	0	0.9101	0.9893	0
Modal	25	0.043	0.0007	0.00000619	0	0.9108	0.9893	0
Modal	26	0.043	0.01	0.0001	0	0.9208	0.9894	0

3.2.2.5. CHECK PERIOD OF MODE OF MAXIMUM MODAL PARTICIPATION MASS RATIO.

So here check done on T on first mode in y =T etabs =0.78 sec.

T method A from UBC 97 Code = Ct * (hn) ^3/4

Where Ct:

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

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

Ct = (0.0488) for all other buildings.

So Ct =0.0488 (other building) because the only shear wall will take the lateral load of earthquake.

Where hn is building height =25.2

So, T method A =0.0488*(25.2) ^3/4 = 0.549sec

The value of *T* from Method B shall not exceed a value 30 percent greater than the value of *T* obtained from Method A in Seismic Zone 4, and 40 percent in Seismic Zones 1, 2 and 3.

So T etabs should be < 1.4 T method A

Then 0.7 <=0.77 so it's ok.

3.2.2.6. CHECK BASE SHEAR

The base shear of EQx and EQy from respounse spectrum Should be larger than base shear from equivalent static.

V base = min of (cv/t or 2.5ca)*W*I/R

W= Fz of (dead+ S.I + 0.25L.L) = 27309.5+24701 +(0.25*8714)=54189 KN

V= (0.2/0.549)* 54189*1/5.5=3590.11 KN

The scale factor has been changed, in EQx scale factor become as following:

Load Type	Load Name	Function	Scale Factor
Acceleration	U1	EQ	1870
Acceleration	U2	EQ	1000

Figure 221: define of EQx and scale factor.

The scale factor has been changed, in EQx scale factor become as following:

Load Type	Load Name	Function	Scale Factor
Acceleration	U2	EQ	3560
Acceleration	U1	EQ	535

Figure 222: define of EQy and scale factor .

The base shear from etabs is as shown below:

Load Case/Combo	FX	FY
	kN	kN
Dead	0.0009	-0.0239
Live	-1166.29	684.573
SID	0.0004	-0.029
EQx Max	3596.085	1104.61
EQy Max	1328.133	3605.1133
DCon1	0.0018	-0.0742
DCon2	-1866.05	1095.2532

Figure 223: Table of base shear value .

So, the base shear from EQx and EQy is larger than equ.static . so the check is ok .

3.2.2.7. CHECK STORY DRIFT

T metohd A = 0.549 < 0.7 so Check if Δm < L/40

L /40= 4100/40 =102.5mm.

Δm = 0.7 R *ΔS =0.7*5.5*ΔS.

Table33 : Story drift in y-direction.

Story	Uy	ΔS	Δm
6	26.4	6.5	25.025
5	19.9	6.6	25.41
4	13.3	6.2	23.87
3	7.1	5	19.25
2	2.1	1.7	6.545
1	0.4	0	0

Table34 : Story drift in y-direction.

Story	Ux	ΔS	Δm
6	2.63	0.57	2.19
5	2.06	0.593	2.3
4	1.467	0.6	2.31
3	0.867	0.367	1.412
2	0.5	0.37	1.4
1	0.13	0	0

So , as shown in the previous table all Δm < 102.5mm so the check of drift is ok.

3.2.2.8. DEFLECTION OF THE SLABS AND WALLS BEAMS.

For slab with a 7.3 m length at story 6.

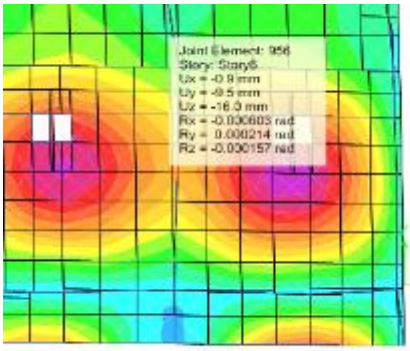


Figure 224: Deflection on slab (1).

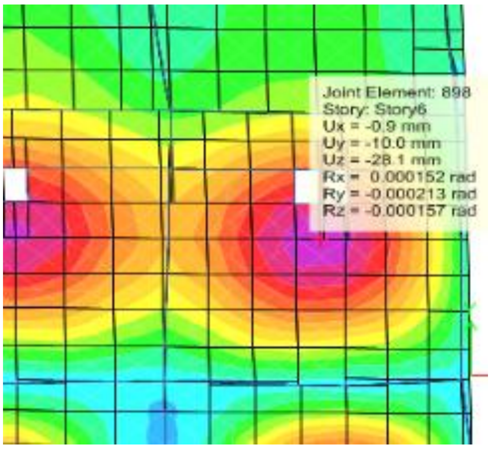


Figure 225: Deflection on slab (2).

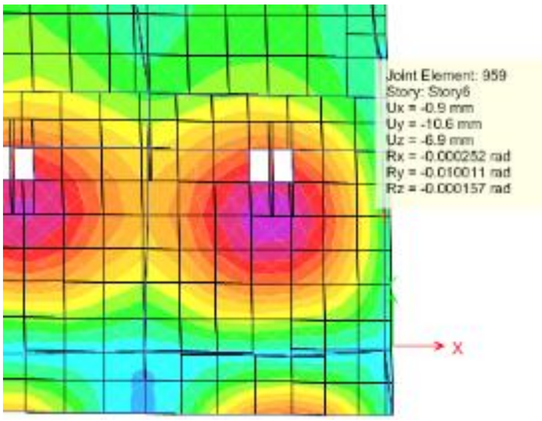


Figure 226: Deflection on slab (3).

Deflection =28.1-((16+7)/2)=16.6mm < 7.3/240 = 30.4 OK .

For beam with a 7.06 m length at story 6.

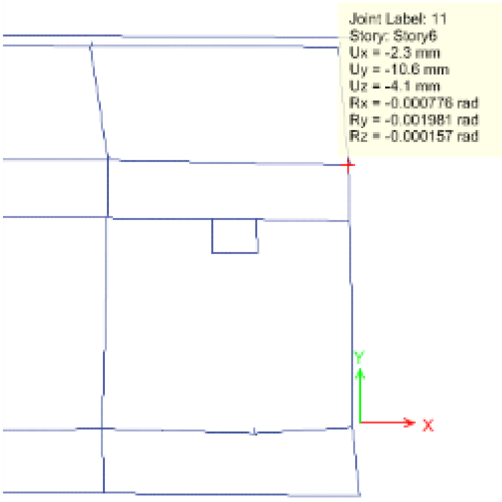


Figure 227: Deflection on beam (1).

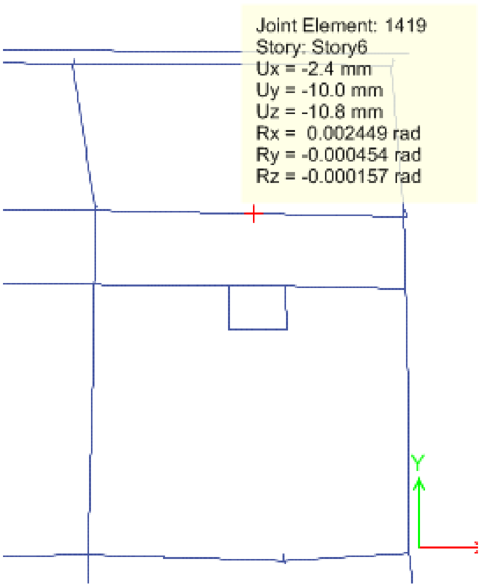


Figure 228: Deflection on beam (2).

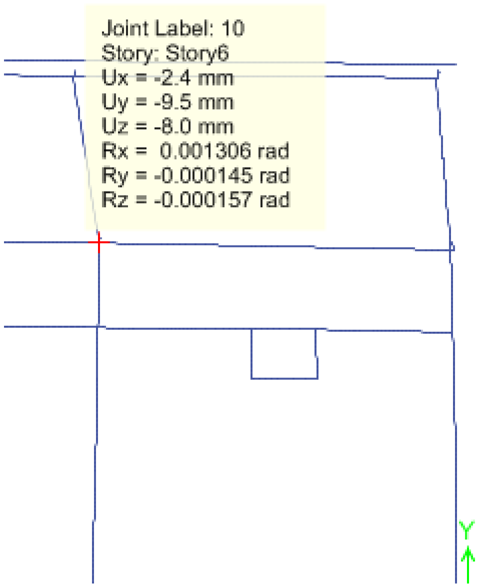


Figure 229: Deflection on beam(3).

Deflection = 10.8 - ((4.1+8)/2)=4.75mm < 7.06/360 = 19.6 OK .

<u>For wall with a 4.1 m height at story6:</u>

1. Deflection in X direction

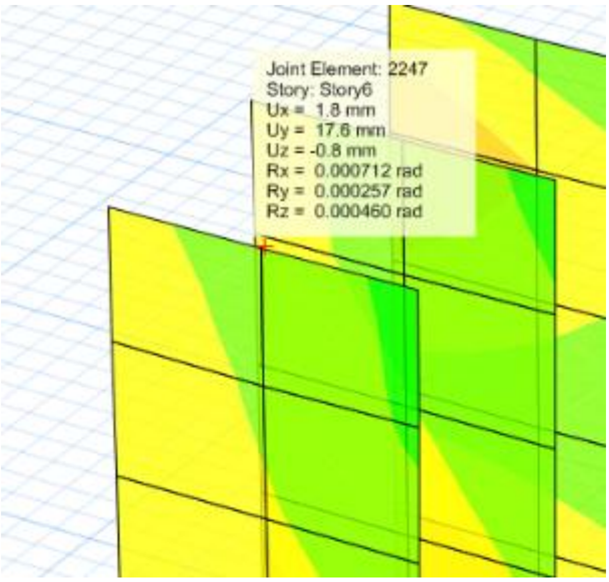


Figure 230: Deflection on walls (1).

Deflection =1.8 < 4.1/240 = 17.08 Ok.

2. Deflection in y direction

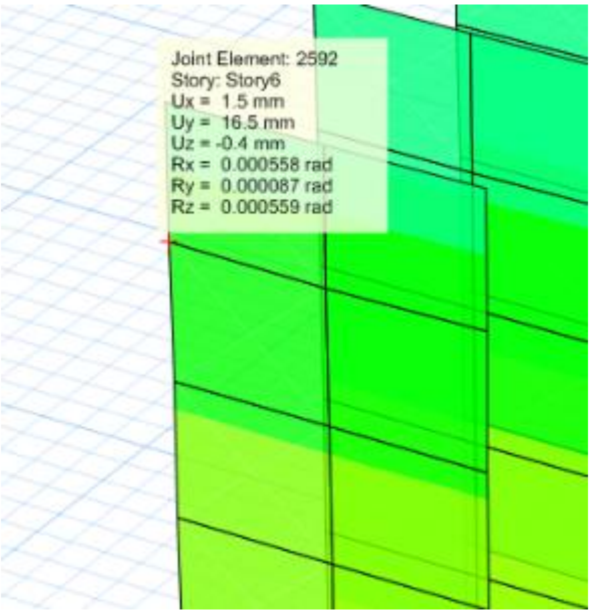


Figure 231: Deflection on walls (2).

Deflection = 16.5 < 4.1/240 = 17.08 Ok.

3.2.3. WATER TANK DESIGN

Water tank will take a rectangular shape without supporting roof; therefore, the roof will be considered as a cover.

Dimensions:

Base has an exterior dimension of $11*6*0.4m^3$, roof has a $10*5*0.25m^3$, walls have a thickness of 0.3m.

Materials: F_y =420 Mpa, f'c = 28Mpa (B350).

This tank will be underground; thus, it has two cases of Loading:

Full liquid without soil exposed.

Empty Case with soil exposed.

Design steps:

If L/H>4 ➔One way

L/H = 10/5 = 2<4; ➔ Two way model.

Case1 : Full with liquid without soil, not backfilled.

Vertical direction:

$V_V = 0.5* ɣ*h^2 = 0.5*10*25=125$ KN/m.

$M_V=0.166* ɣ*h^3 = 0.166*10*125=208.3$ KN.m /m.

Horizontal direction:

$T_h = V_h = ɣh^2/4 = 10*25/4=62.5$ KN/m.

$M_h = ɣh^3/8 =10*125/8= 156.25$ KN.m/m.

Case2: Empty Case with soil pressure after backfilled

Vertical direction:

$V_V = 0.5* ɣ*h^2*k= 0.5*10*25*0.333=41.625$ KN/m.

$M_V=0.166* ɣ*h^3*k= 0.166*10*125*0.333=69.3$ KN.m /m.

Horizontal direction:

$T_h = V_h = k*ɣh^2/4 = 0.333*10*25/4=20.8$ KN/m.

$M_h = k*ɣh^3/8 =0.333*10*125/8= 52.03$ KN.m/m.

Note that the critical case is case (1) and all dimensions of all parts of tank will be design based on liquid stresses.

<u>Thickness of Walls:</u>

$V_{V(ult)} = 1.4*125 = 175$ KN.

$175 = 0.75(1/6)*28^{0.5} * d1*1000/1000$

d= 265 mm

Use h =300mm.

<u>Tension force in Walls:</u>

T_h =62.5 KN

Tu =1.4*62.5= 87.5KN/m.

$Sd = \Phi f_y/ɣfs_{max} =0.9*420/1.4*138 =1.96$

$T_{u-design} =1.96*87.5 =172$KN/m

$As_{tension}=T_{u-design}/0.9f_y =172*1000/0.9*420 =453mm^2/m$

Check for thickness:

T_{ser} +60/nAs+A_g <= ($f'_c{}^{0.5}$)/3

[(62.5*1000) +60*453]/ [8*453+ (300*1000)] =0.29<1.76 ……ok.

Moments:

M_v = 208 KN.m/m

$M_{v\ ult}$ = 1.4*208 =291KN.m/m.

Sd = 0.9*420/1.4*210 =1.29

$M_{u\text{-}design}$ =ψ*Sd*Mu

$M_{u\text{-}design}$ = 1.06*1.29**291 = 397.5KN.m/m

ρ=0.016

As = 1000*270*0.016 = 4320mm^2

As min (V) = 0.003bh = 0.003*1000*300 = 900mm^2 /m. <As (Use As)

Use9Φ25/m for the interior face

Use As min (V) for exterior face = 900/2 = 450mm^2/m. Use 4Φ12/m

As min(Tension) = 0.005*b*h =0.005*1000*300=1500m^2 /m.

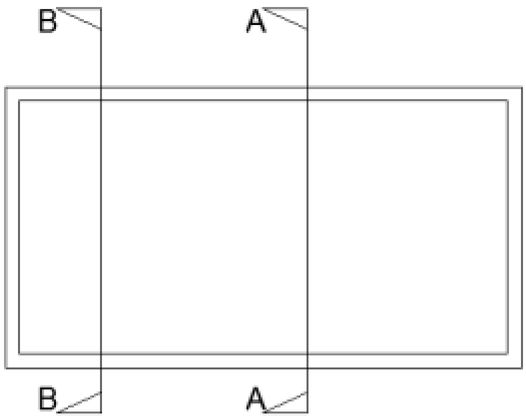


Figure 232: section in water tank to design it .

At section A-A, walls exposed to tension only.

As (Tension) = 453mm^2/m. <As min = 1500mm^2/m. (Use As min).

Use 5Φ14 for each face.

At section B-B, walls exposed to tension and moment.

Interior face has As(tension) / 2 + As from horizontal moment

M_H =218.75KN.m/m

$M_{H\ design\ =}$ 1.29*218.75 = 298.125KN.m/m.

ρ = 0.012 , b = 1000 , d = 270

$As_H = \rho * b * d = 0.012 * 1000 * 270 = 3240 mm^2/m$.

$453/2 + 3240 = 3466 mm^2/m$, Use 8Φ25/m.

Exterior face has As min (tension) /2

$As\ min = 1500/2 = 750 mm^2/m$. Use 5Φ14/m.

Hook length in base of tank $=16 * d_b * (As_{req}/As_{used})$

<u>Base design:</u>

Use SAP program to design the base.

Base has an exterior dimension of $11*6*0.4 m^3$

Figure 233: water tank modeling by SAP2000.

SAP moments results:

Top face has $As\ 1 = 0.496 mm^2/mm$

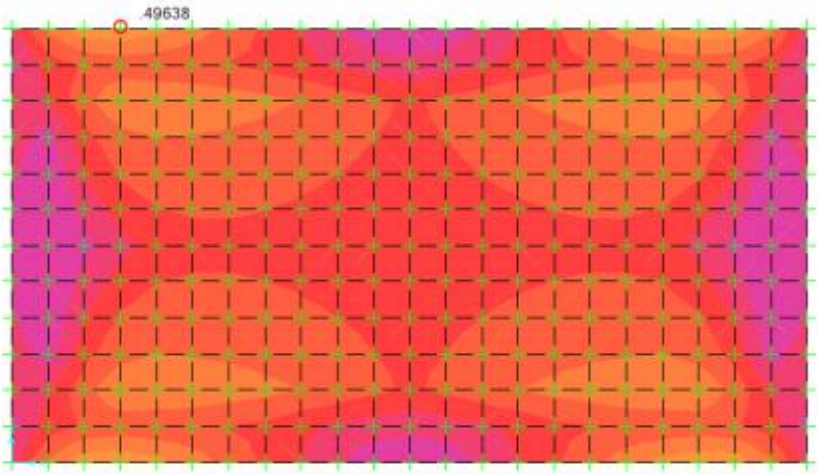


Figure 234: Top face -AS1 (In x- directions).

As = 496mm^2/m

As min = 0.0018*b*h

= 0.0018 * 1000*400 = 720mm^2/m >As Use As min

As = 720*6 = 4320mm$^{2.}$

Use 14Φ20.

Top face has As2 = 0.912mm^2/mm

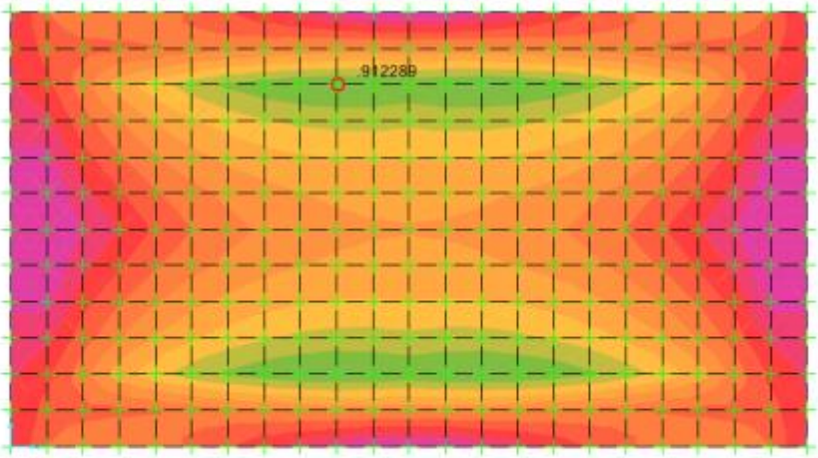


Figure 235: Top face - AS2 (In x- directions).

As 2 = 912mm^2/m >As min

As = 912 * 11 = 10032mm^2 .

Use 21Φ25.

Bottom face has As1 = 0.408mm^2/mm.

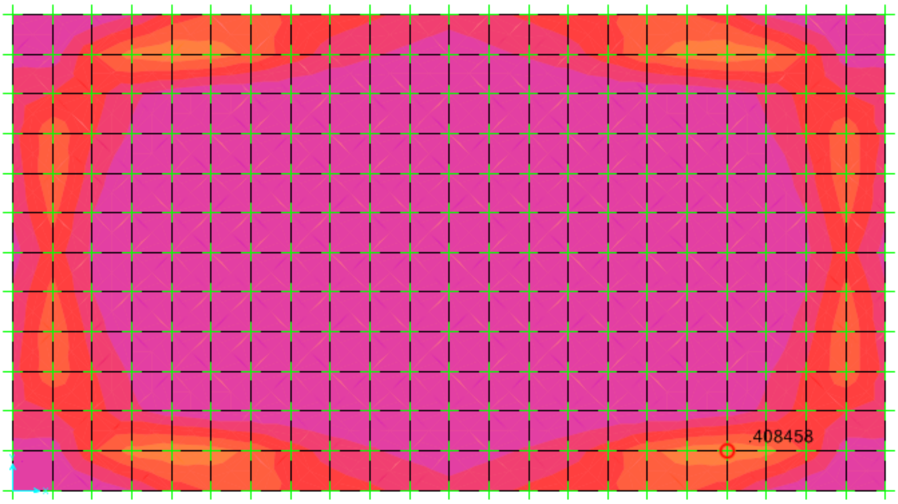


Figure 236: bottom face -AS1 (In x- directions).

As1 = 408mm^2/m <As min (Use As min) Use 14Φ20

Bottom face has As2 = 0.36mm^2/mm

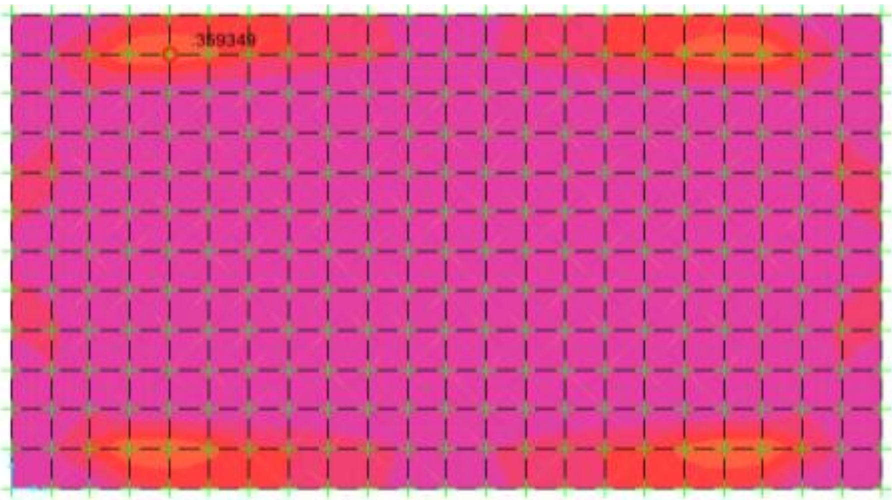


Figure 237: bottom face -AS (In x- directions).

As2 = 360mm^2/m <As min (Use As min) Use 17Φ25

<u>Check shear:</u>

ΦVc = 0.75 * (1/6) * f'c$^{0.5}$ * b*d = 224.8KN/m

V23 = 57.7KN/m <ΦVc.

V13 = 49.7KN/m < ΦVc.

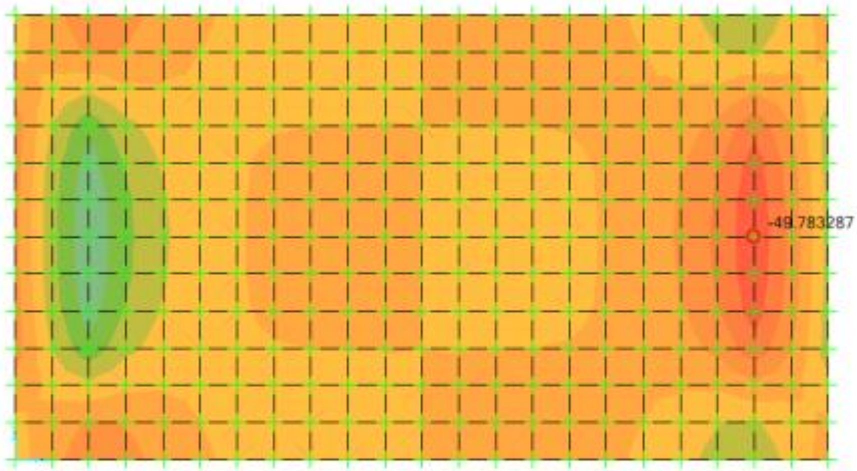


Figure 238: V13 result.

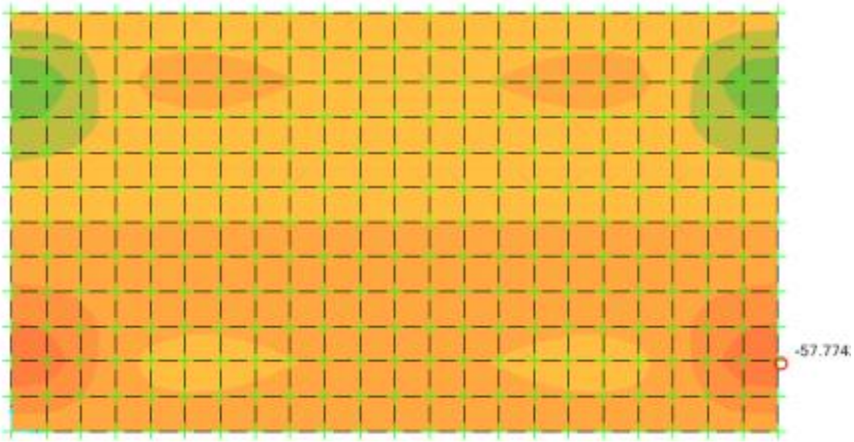


Figure 239: V23 result.

Roof slab design:

Roof has $10*5*0.25m^3$.

Live load = $12KN/m^2$.

h = 5/20 = 0.25m

W_{dead} = 0.25*25 = $6.25KN/m^2$

W_{ult} = 1.2D+1.6L = $26.7KN/m^2$.

$M_{ult} = 26.7*(5^2) / 8$ = 83.4KN.m/m

ρ= 0.00523

As = 0.00523*1000*210 = 1098.3 mm^2/m.

As min = 0.0018*1000*250 =450mm^2/m.<As (Use 5Φ20)

Secondary direction.

Use As min = 450mm^2/m .(Use 4Φ12/m).

Shear design:

Vmax = 26.7*5 /2 = 66.75 KN

V_{ult} = 66.75 - (26.7*0.21) = 61.143 KN

ΦVc = 0.75 * (1/6) * $f'c^{0.5}$ * b*d = 138.9KN > V_{ult} .

3.2.4. STRUCTURAL SEPARATIONS

Every structure shall be separated from adjoining structures and this project has been separate on many regions.

Adjacent buildings on the same property shall be separated by at least ΔM where $\Delta M = \sqrt{((\Delta M1)^2+(\Delta M2)^2)}$

Where $\Delta m1$ and $\Delta m1$ are the displacements of the adjacent buildings.

For $\Delta m1$ *(First block)*

Three value of ux are taken from etabs as shown in the following figure:

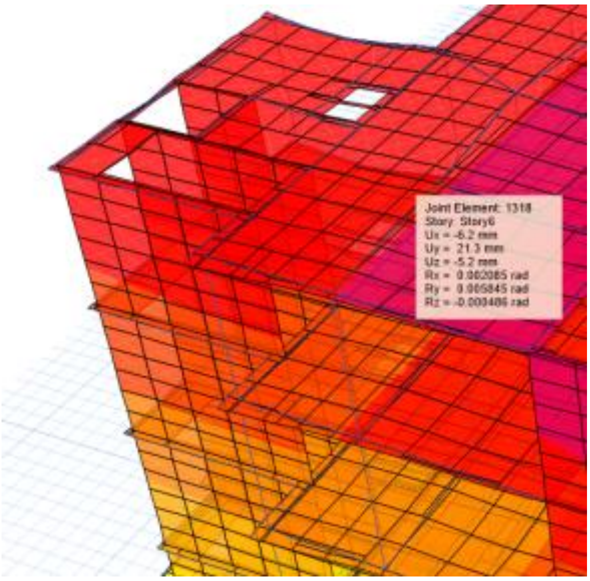


Figure 240: ux result From Etabs for first block (1).

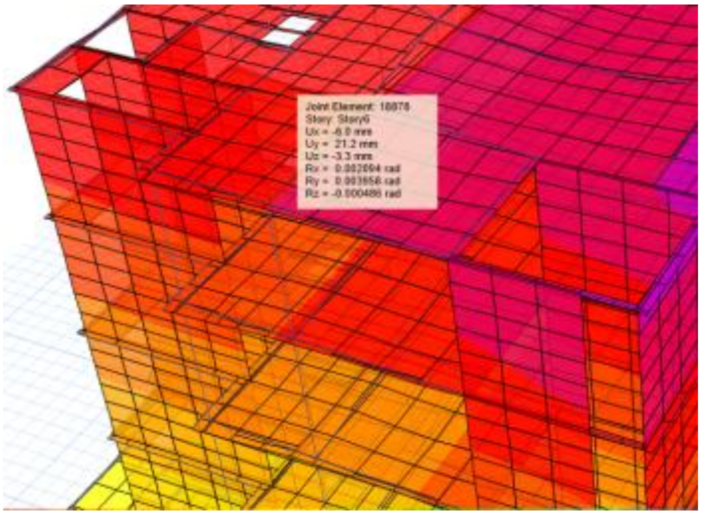


Figure 241: ux result From Etabs for first block (2).

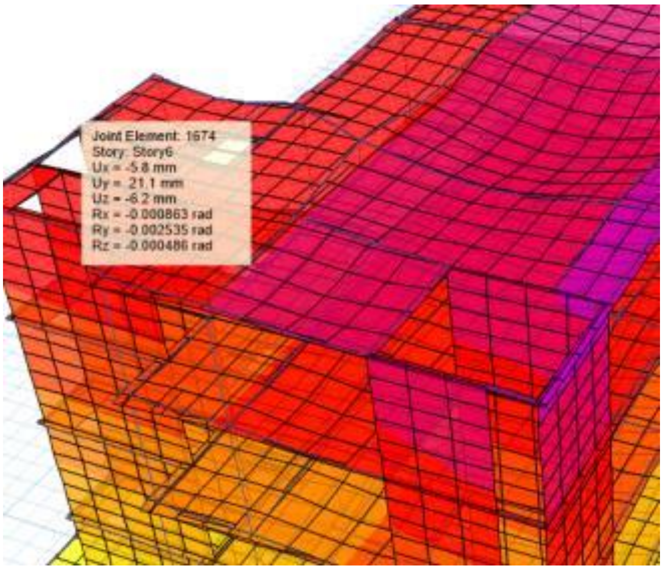


Figure 242: ux result From Etabs for first block (3) .

So as shown in previous figure:

The Value of ux is 6.2, 6, and 5.8.

Ux from block 1 = (5.8+6.2+6)/3 = 6

ΔM1 = Ux*R*0.7 = 6*5.5*0.7 = 23.1

For Δm2 (Second block):

Three value of ux are taken from etabs as shown in the following figure:

From Block 2 the displacement in X direction.

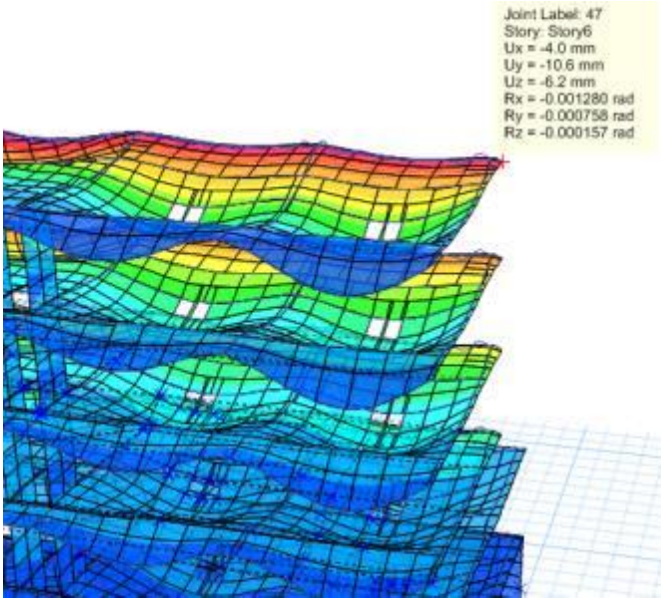


Figure 243: ux result From Etabs for second block (1).

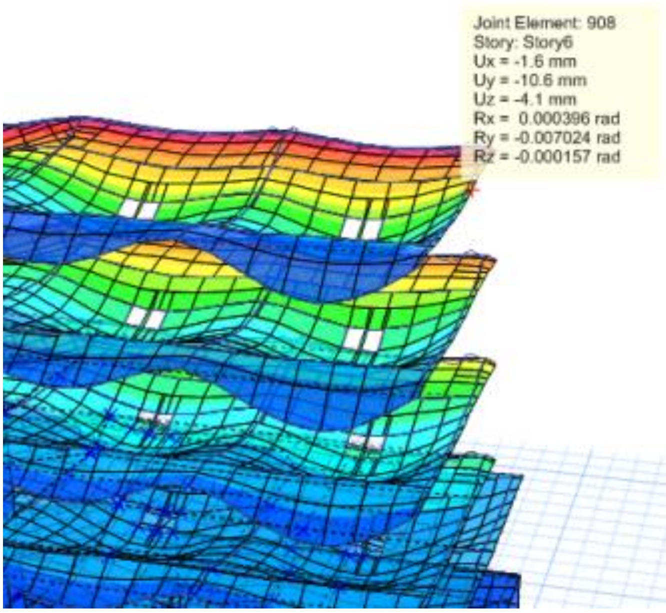


Figure 244: ux result From Etabs for second block (2).

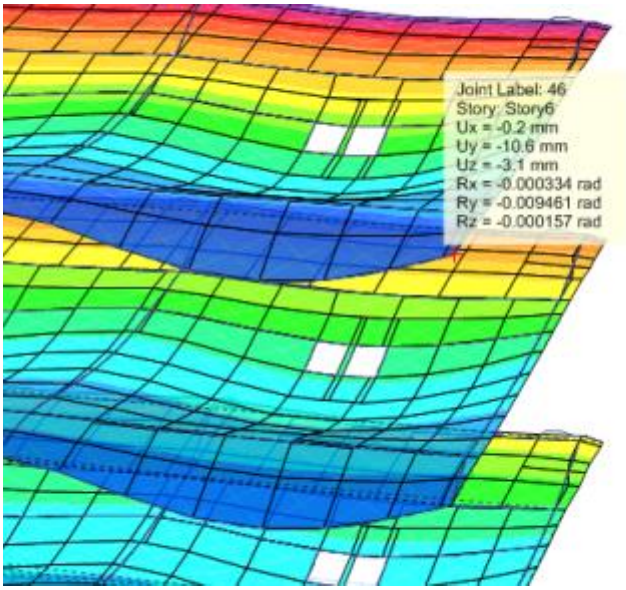


Figure 245: ux result From Etabs for second block (3).

So as shown in previous figure:

Ux from block 2= (4+1.6+0.2)/3 = 1.93.

ΔM2 = Ux*R*0.7= 1.93*5.5*0.7 = 7.44.

So, ΔM= $\sqrt{(7.44)^2+(23.1)^2}$ = 24.2mm . Use **30mm** building separation.

3.3. ELECTRO-MECHANICAL DESIGN

3.3.1. ELECTRICAL DESIGN

3.3.1.1. ARTIFICIAL LIGHTING DESIGN

Lighting is an important part in hotel design which take care of many several aspects such as decorative, comfortable and relaxation aspects by provide the appropriate lighting to ensure an integrated life for people in the hotel and provides a healthy environment for production in the workplace.

Illuminance Recommendations according to general building area and facilities type:

Table 35: Illuminance Recommendations for general buildin adapted from (Ies.org).

General building areas	IES standards illumination level
Receptions	300
Restaurant	200
Laundry	400
Service room	400
corridors	100
Entrance hall	150
bars	100
Security area	200
lift	150
Stairs	150
Escalator	150
Gate	300
lobbies, waiting rooms, halls	150
Kitchen Foods stores	100
Kitchen General work place	500
Dining room	200
Stores	50
Casual reading	150
Bedroom sleep	50
Bedrooms general	150
Bathroom	100
Shops	500
Living room	150
Pumps	300
Garages	100
Parking area	50

Illuminance Recommendations for Specific Residential Visual Tasks:

Table 36: Average Illuminance for specific residential tasks adapted from (acuitybrandslighting.com).

Activity or Area	Average Lux
Conversation and relaxation	50-100
Kitchen (food preparing involving difficult seeing tasks)	500-1000
Area other than kitchen (services and non critical tasks)	200-500
Dining	100-200
Laundry	200-500
Books ,reading ,magazine	200-500
Table games	200-500
Ordinary tasks	200-500
Difficult tasks	500-1000
Critical tasks	1000-2000

3.3.1.1.1. LIGHTING SOURCES

There are three main sources, discharge , incandescent, and LED.” Incandescent lamps work by heating wire filament until it glares with black body radiation. Electrical discharges or gases discharges lights flow a current through a gas to split it into a glowing plasma”.

“Fluorescent lamps is a type of gases discharging lamps. Light-emitting diodes (LED) transfer a current by a semiconductor to create photon emission”.

3.3.1.1.2. LIGHTING DESIGN

Artificial lighting have been designed for bedrooms, restaurant and meetings room considering standards illumination and uniformity more than (0.6) .

1. Bedroom design

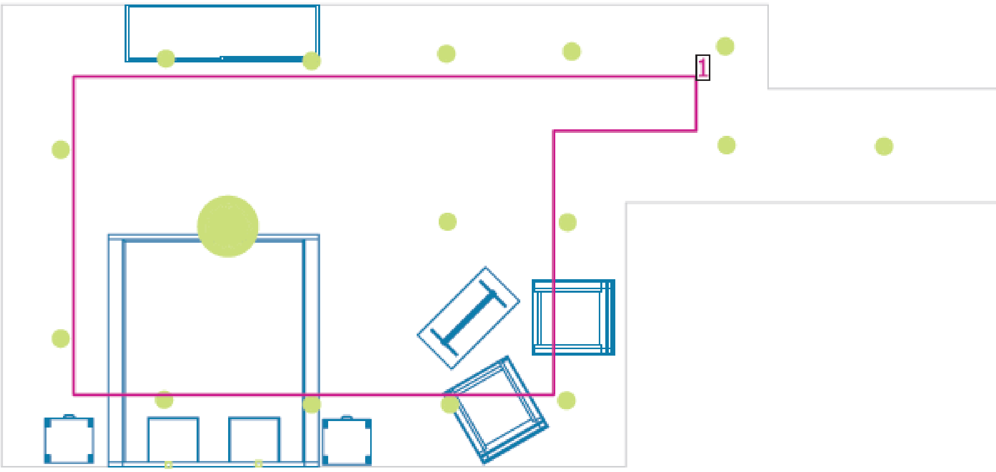


Figure 246: Bedroom Lamps Distribution.

Height of room: 4.100 m, Height of working plane: 0.800 m, Wall zone: 0.600 m

Reflection factors: Ceiling 70.0%, Walls 53.0%, Floor 4.5%, Light loss factor: 0.80

Results:

Workplane

	Surface	Result	Mean (target)	Min	Max	Min/average	Min/max
1	Workplane 5	Perpendicular illuminance [lx]	169 (150)	107	262	0.633	0.408

Figure 247: Bedroom Lights Results (1).

Luminaire parts list :

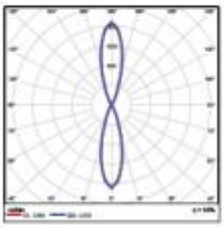
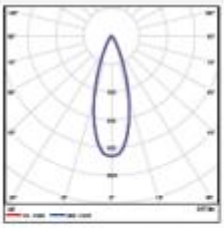
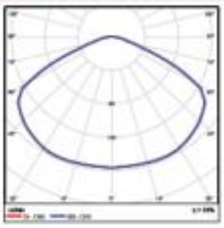
No.	Quantity			
1	2	Ares 507111 delta led Light output ratio: 98.08% Lamp luminous flux: 260 lm Luminaire Luminous Flux: 255 lm Power: 6.8 W Light yield: 37.5 lm/W		
2	15	SIMES S.5882N.19 MINIZIP DOWNLIGHT Absolute photometry Luminaire Luminous Flux: 317 lm Power: 6.0 W Light yield: 52.8 lm/W		
3	1	SLV 155521 FORCHINI PD-1 Light output ratio: 57.64% Lamp luminous flux: 1445 lm Luminaire Luminous Flux: 833 lm Power: 24.0 W Light yield: 34.7 lm/W		

Figure 248: Bedroom Lights Results (2).

Total lamp luminous flux: 6720 lm, Total luminaire luminous flux: 6098 lm, Total Load: 127.6 W, Light yield: 47.8 lm/W

Lighting power density: 5.37 W/m^2 = 3.19 W/m^2/100 lx (Ground area 23.77 m^2)

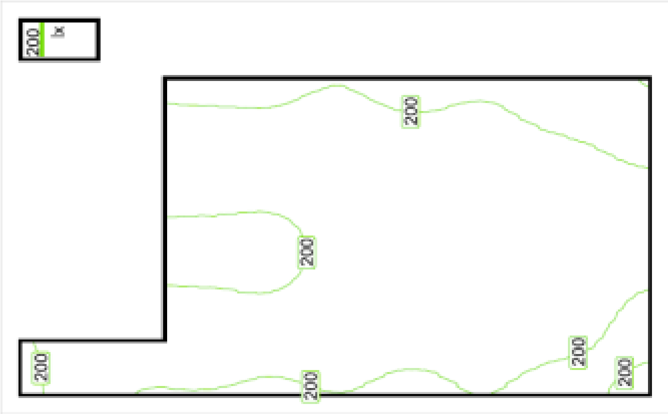


Figure 249: Bedroom Lights Results (3).

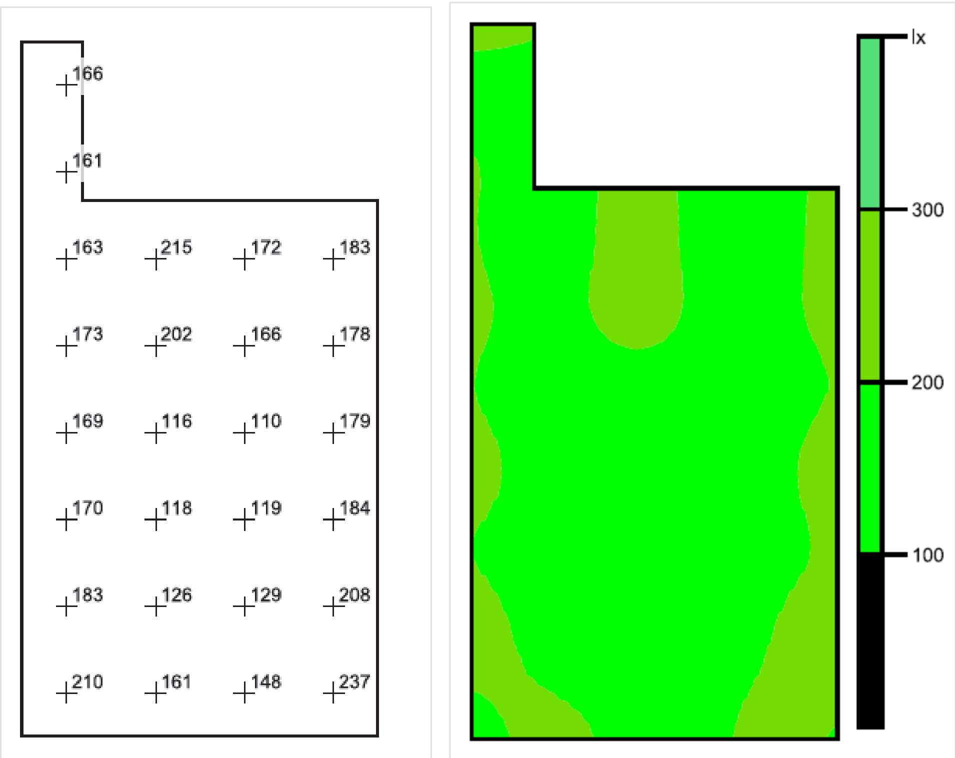


Figure 250: Bedroom Lights Results (4).

Bedroom views:

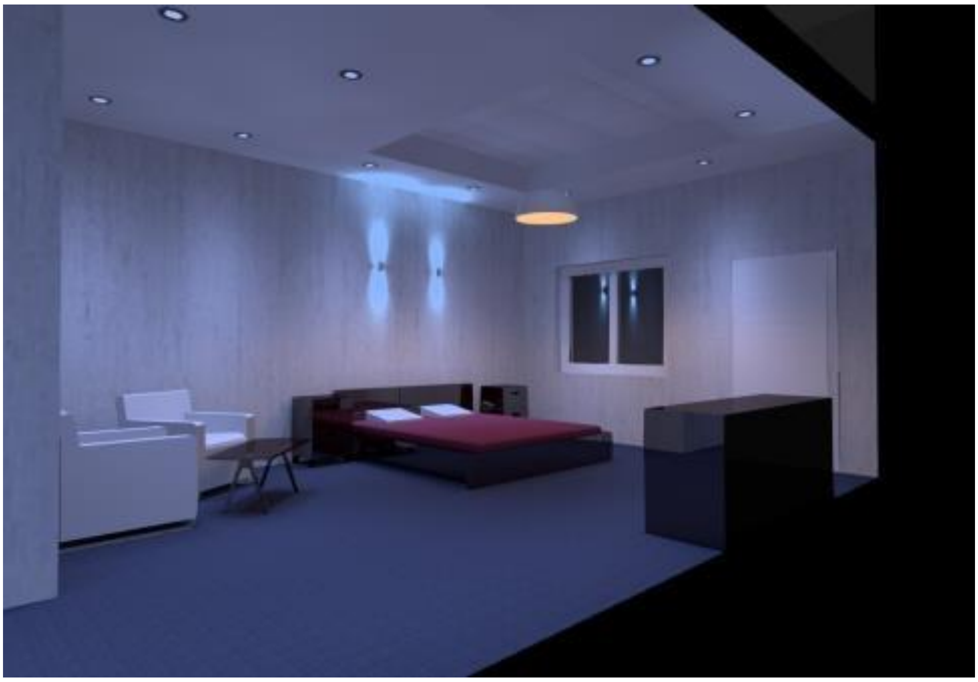


Figure 251: Bedroom View 1.

Figure 252: Bedroom View 2.

Figure 253: Bedroom View 3.

2. Restaurant Design :

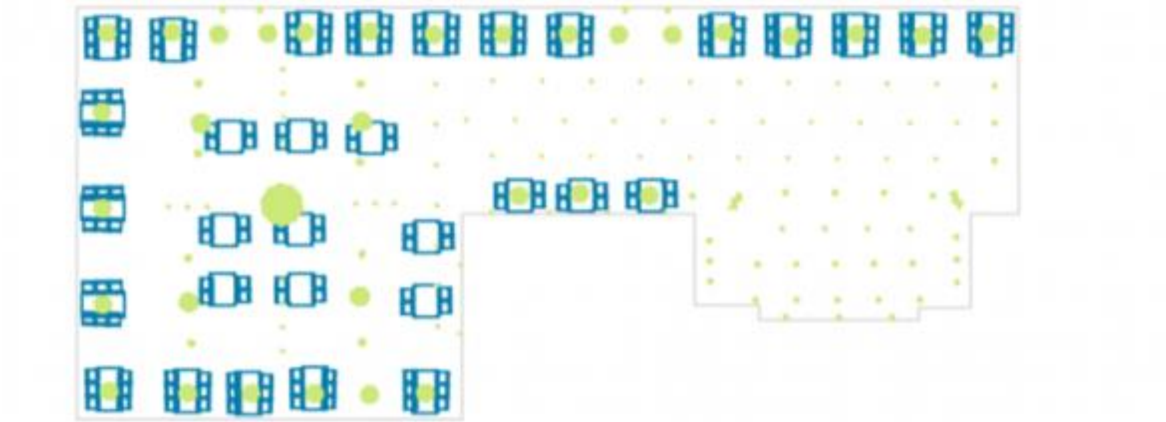


Figure 254: Restaurant Lamps Distribution.

Height of room: 4.700 m Reflection factors: Ceiling 66.5%, Walls 51.1%, Floor 10.4%, Light loss factor: 0.80 , Height of working plane: 0.800 m .

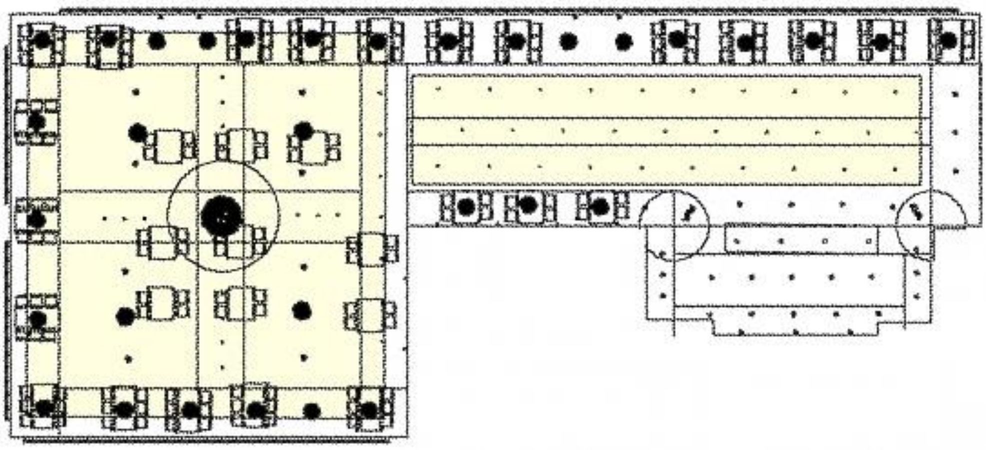


Figure 255: Restaurant Workplans.

Results:

1. For tables :

Result	Mean (target)	Min	Max	Min/average	Min/max
Perpendicular illuminance [lx]	308	169	506	0.549	0.334

Figure 256: Restaurant Lights Results (1).

277	176	326	235	173	332	192	193	336	204	342
214	212	260	243	196	198	178	208	237	216	265
313	331	407	387	293	352	266	363	380	332	415
339	357	426	397	316	384	333	442	506	405	445
308	237	245	251	260	301	319	345	332	303	400
295	234	234	256	285	467	397	316	292	302	434
292	253	260	280	299	463	398	319	291	293	418
342	274	309	328	319	326	343	360	359	310	169
388	353	426	449	357	387	359	452	493	388	395
314	263	285	290	242	293	251	302	315	279	276
319	173	195	209	194	181	179	202	226	253	324

Figure 257: Restaurant Lights Results (2).

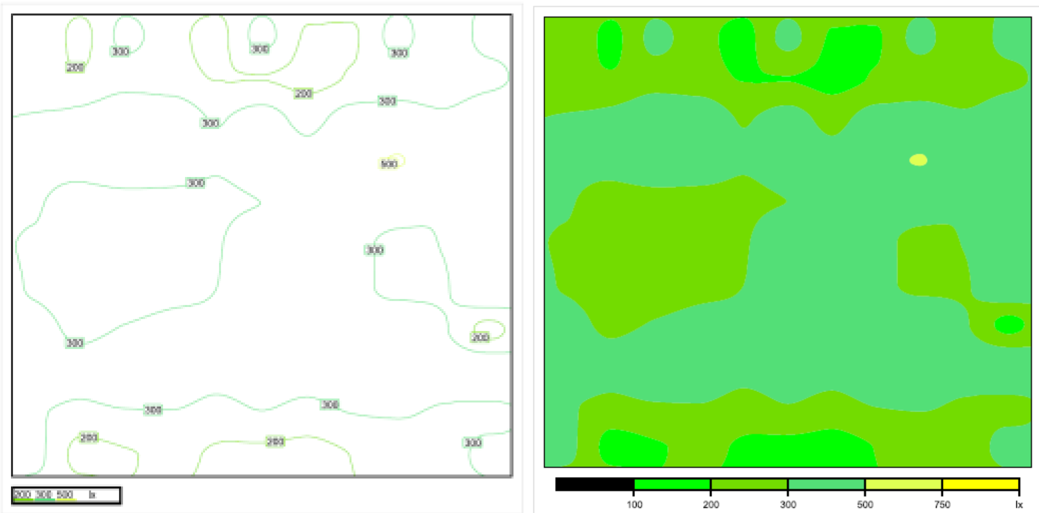


Figure 258: Restaurant Lights Results (3).

2. For corridor :

Result	Mean (target)	Min	Max	Min/average	Min/max
Perpendicular illuminance [lx]	187	141	249	0.754	0.566

Figure 259: Corridor Lights Results (1).

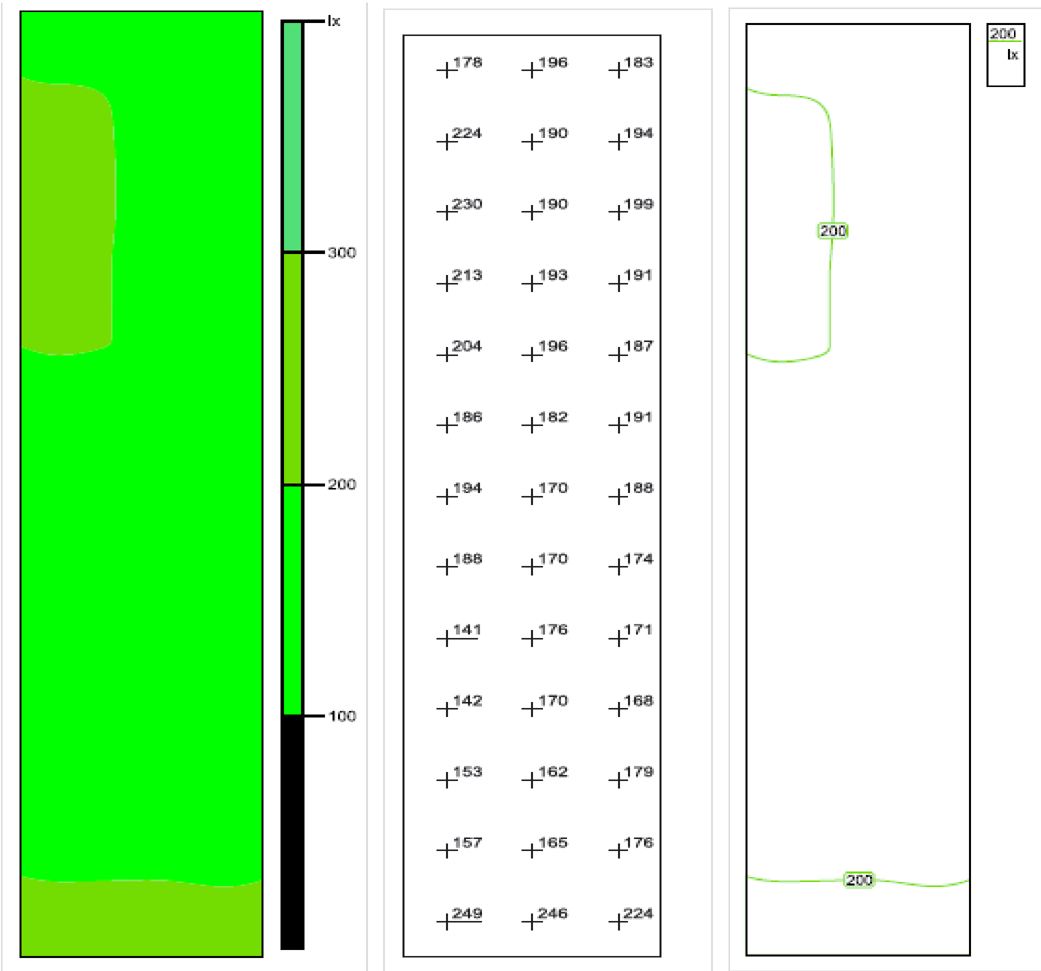
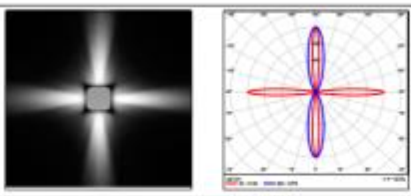


Figure 260: Corridor Lights Results (2).

Luminaire parts list :

No.	Quantity	
1	6	Ares 1079145 marco led Light output ratio: 100% Lamp luminous flux: 336 lm Luminaire Luminous Flux: 336 lm Power: 7.0 W Light yield: 48.0 lm/W
2	7	Ares 12316554 Leo 120 led Light output ratio: 100% Lamp luminous flux: 121 lm Luminaire Luminous Flux: 121 lm Power: 9.0 W Light yield: 13.4 lm/W



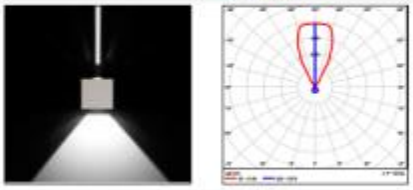
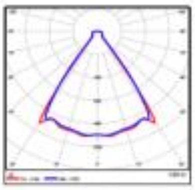
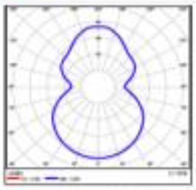
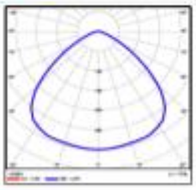
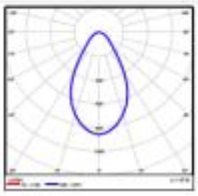
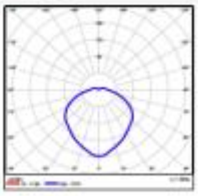


Figure 261: Corridor Lights Results (3).

No.	Quantity			
3	2	Artemide - Artemide Group 1590050A Led NET 66 Lineare Soffitto Absolute photometry Luminaire Luminous Flux: 1265 lm Power: 23.0 W Light yield: 55.0 lm/W		
4	1	Artemide - Artemide Group 1708010A NUBOLI SOSPENSIONE 6X55W Light output ratio: 53.86% Lamp luminous flux: 28800 lm Luminaire Luminous Flux: 15513 lm Power: 322.0 W Light yield: 48.2 lm/W		
5	8	Castaldi Lighting D29/E27 micrososia halo Light output ratio: 73.65% Lamp luminous flux: 2100 lm Luminaire Luminous Flux: 1547 lm Power: 150.0 W Light yield: 10.3 lm/W		
6	4	Endo Lighting Corp. ERP7021W_RA606FA Pendant Light output ratio: 96.93% Lamp luminous flux: 456 lm Luminaire Luminous Flux: 442 lm Power: 5.2 W Light yield: 85.0 lm/W		
7	4	Louis Poulsen Lighting A/S 5741085897 PH 6 ½ - 6 white, 1x150W HIT G12 Light output ratio: 55.56% Lamp luminous flux: 14000 lm Luminaire Luminous Flux: 7778 lm Power: 163.0 W Light yield: 47.7 lm/W		

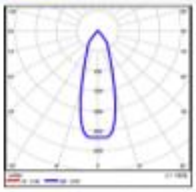
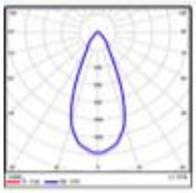
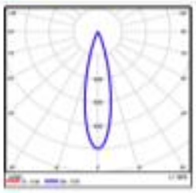
No.	Quantity			
8	28	Louis Poulsen Lighting A/S 5741096268 PH Artichoke LED stainles steel Ø600, 96W / 2700K Light output ratio: 99.96% Lamp luminous flux: 2151 lm Luminaire Luminous Flux: 2150 lm Power: 96.0 W Light yield: 22.4 lm/W		
9	24	LTS Licht & Leuchten CSARLP 72.3027.35 CSARLP 72.3027.35 35° Light output ratio: 100.14% Lamp luminous flux: 2775 lm Luminaire Luminous Flux: 2779 lm Power: 36.0 W Light yield: 77.2 lm/W		
10	31	Modular Lighting Instruments 108813XX_50W 50° Lotis adjustable E550 Light output ratio: 90.54% Lamp luminous flux: 525 lm Luminaire Luminous Flux: 475 lm Power: 50.0 W Light yield: 9.5 lm/W		
11	21	SLV 111171 PIKA ADJUSTABLE Light output ratio: 98.40% Lamp luminous flux: 220 lm Luminaire Luminous Flux: 216 lm Power: 4.0 W Light yield: 54.1 lm/W		

Figure 262: Corridor Lights Results (4).

Total lamp luminous flux: 256540 lm, Total luminaire luminous flux: 212319 lm, Total Load: 7531.8 W, Light yield: 28.2 lm/W

Lighting power density: 17.76 W/m^2 (Ground area 424.19 m^2)

Views :

Figure 263: Restaurant View 1.

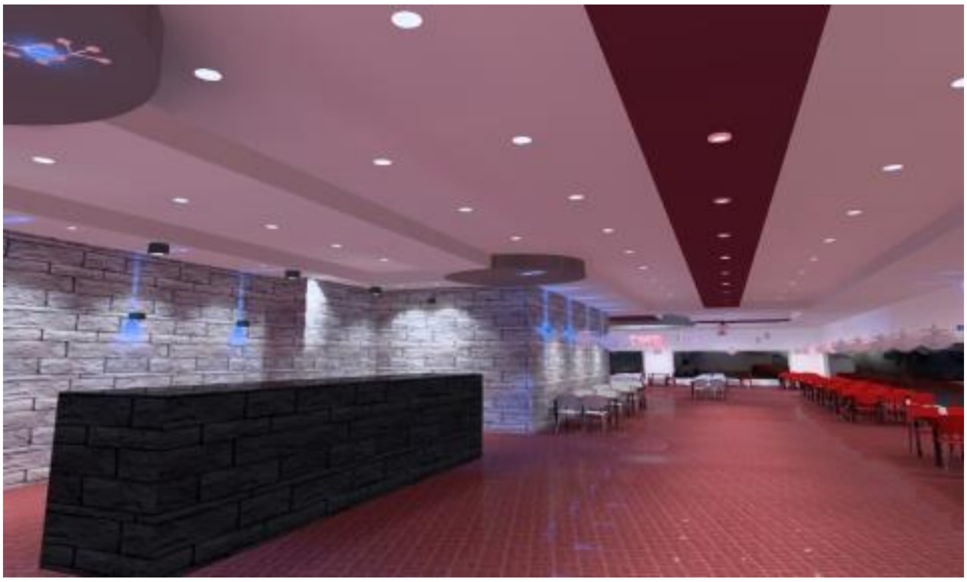


Figure 264: Restaurant View 2.

Figure 265: Restaurant View 3.

3. Meetings room Design :

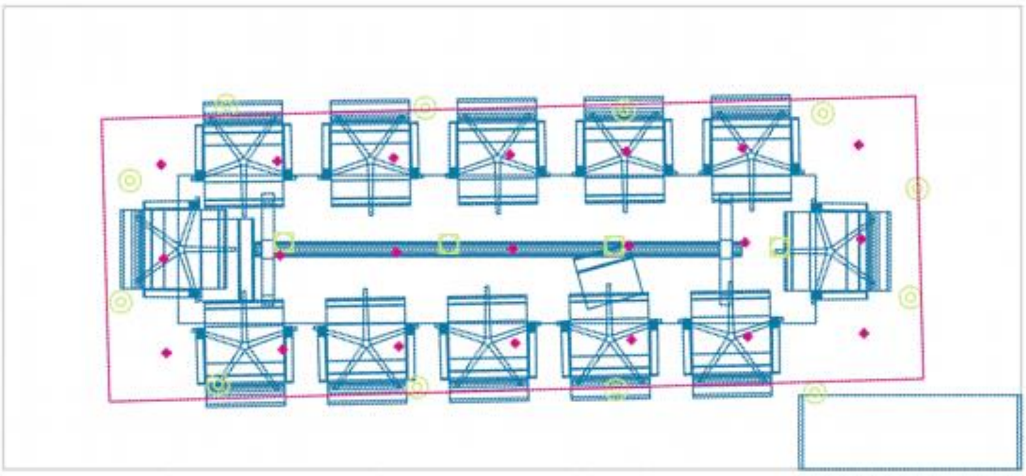


Figure 266: Meetings Room Lamps Distribution.

Height of room: 4.700 m

Reflection factors: Ceiling 74.3%, Walls 78.2%, Floor 4.4%, Light loss factor: 0.80

Results:

Result	Mean (target)	Min	Max	Min/average	Min/max
Perpendicular illuminance [lx]	556	400	654	0.719	0.612

Figure 267: Meeting Room Lighting Results (1).

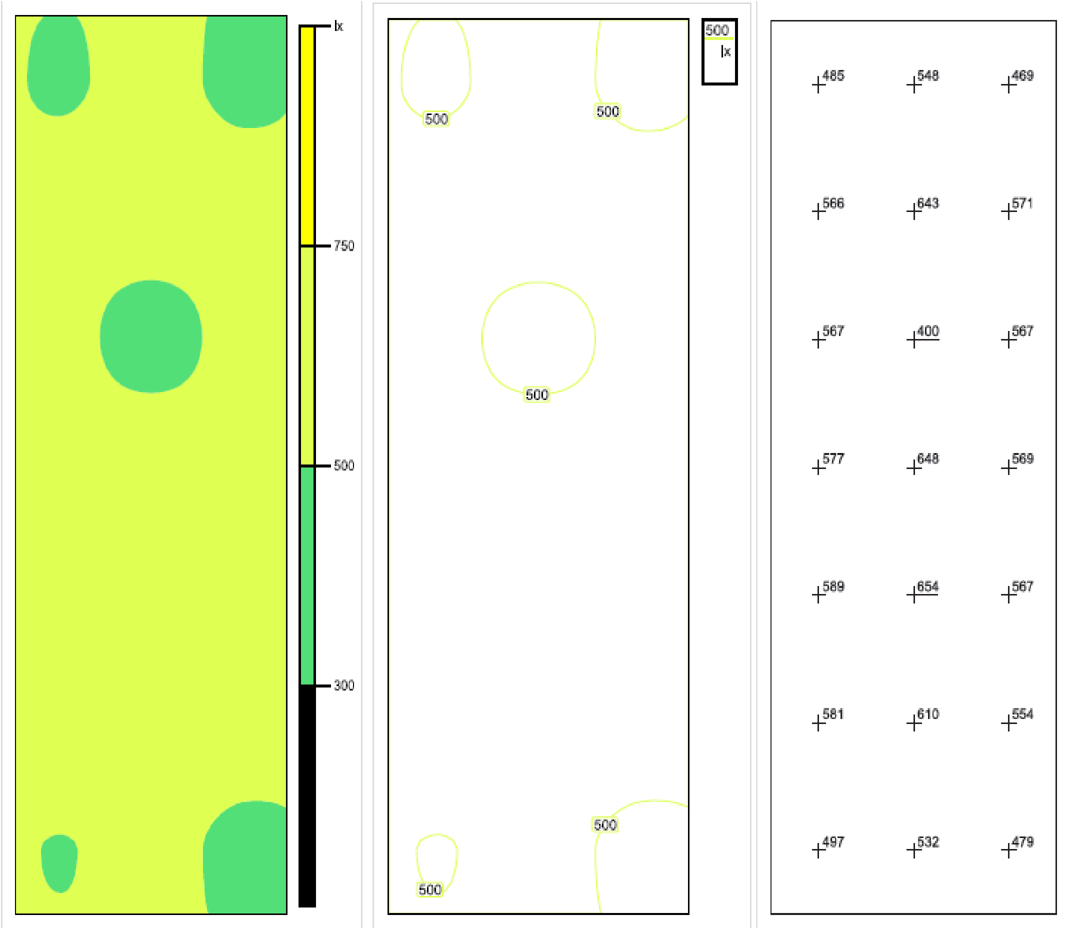


Figure 268: Meeting Room Lighting Results (2).

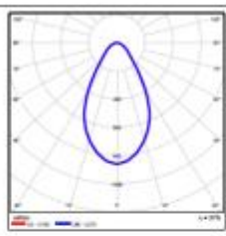
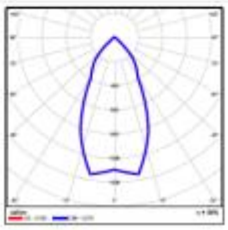
No.	Quantity			
1	4	Endo Lighting Corp. ERP7021W_RA606FA Pendant Light output ratio: 96.93% Lamp luminous flux: 456 lm Luminaire Luminous Flux: 442 lm Power: 5.2 W Light yield: 85.0 lm/W		
2	12	Modular Lighting Instruments 11024909 Mini thub metal LED<900lm warm white medium GE white struc Light output ratio: 97.75% Lamp luminous flux: 673 lm Luminaire Luminous Flux: 658 lm Power: 10.5 W Light yield: 62.7 lm/W		

Figure 269: Meeting Room Lighting Results (3).

Total lamp luminous flux: 9900 lm, Total luminaire luminous flux: 9664 lm, Total Load: 146.8 W, Light yield: 65.8 lm/W

Lighting power density: 10.64 W/m^2 (Ground area 13.79 m^2)

Views:

Figure 270: Meetings Room Views.

3.3.1.2. LOUDSPEAKERS DESIGN

1. Loudspeakers design and its distribution: In the hotel, loudspeakers should be design and distributed to create comfort background noise especially in public spacing so in this section shows the design of loudspeakers and its distributions for the restaurant that available in ground floor.

Selection of loudspeaker type:

1) F-121 C/M - by TOA Electronics Speaker.

(http://www.toacanada.com/assets/files/TOA_Speaker_Guide.pdf , 2016)

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Figure 271: sample of F-121 C/M - by TOA Electronics loudspeaker.

F-121C/M Specifications	
Coverage Angle	hemispherical
Frequency Response	80 Hz – 18 kHz
Sensitivity (1 W / 1 m)	90 dB
Power Handling	F-121CM: 20 W transformer F-121C: 40 W pink noise
Transformer Tap (F-121CM only)	70.7/100 V: 1, 3, 5, 10, 20 W
Components	4.7" driver with diffuser cone
Installation Accessories (optional)	TBF-100 Tile Bridge, BBF-100 Back Box
900 Series Equalizer Module	E-03R module or AC-120 stand-alone EQ

Figure 272: specifications of F-121 C/M loudspeaker.

F-121C/M Coverage And Spacing						
Height Above Listener h-l (ft)	Coverage Area (sq. ft)	Spacing (ft)				
		Edge to Center Overlap	Min. Overlap (square)	Min. Overlap (hex)	No Overlap	Max. On-Axis SPL
2	38	3	5	6	7	107
3	85	5	7	9	10	104
4	151	7	10	12	14	101
5	236	9	12	15	17	99
6	339	10	15	18	21	98
8	603	14	20	24	28	95
10	942	17	24	30	35	93
12	1357	21	29	36	42	92
14	1847	24	34	42	48	90
16	2413	28	39	48	55	89
18	3054	31	44	54	62	88
20	3770	35	49	60	69	87

Figure 273: Specification of F-121 C/M loudspeaker (all unit in (ft)).

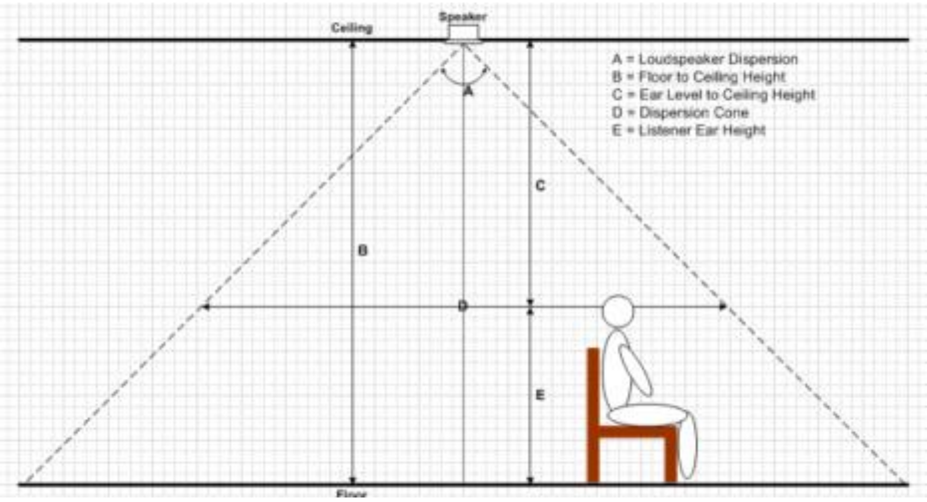


Figure 274: speaker coverage area of F-121 C/M.

Floor height is 4.7, Ceiling height is 3.9m and the person set on 1.2m from ground.

So at 2.7m (8.9 ft) from ceiling and as shown in previous table the converge area by loudspeaker is 942sq.ft at 10ft and 603sq.ft at 8 ft so at 8.9 ft the coverage area is 760 sq ft and min overlap square distribution spacing = 6.7m.

Figure 275: Sound reinforcement system.

Figure 276: Distribution of loudspeakers: Square with minimum overlap.

2) Wall moment speaker (BS-1030B/W)- by TOA Electronics Speaker (http://www.toacanada.com/assets/files/TOA_Speaker_Guide.pdf , 2016)

That will be used where terraces are available as shown in the AutoCAD drawing.

Wall-mount Speakers

BS-1030B/W

BS-1030B/W Specifications	
Coverage Angle	100° H x 100° V
Frequency Response	80 Hz – 20 kHz
Sensitivity (1 W / 1 m)	90 dB
Power Handling	Transformer: 30 W 8 Ω Direct: 30 W pink noise
Transformer Taps	70.7/100 V: 5, 10, 15, 20, 30 W
Components	LF: 4.7" cone HF: 1" balanced-dome
Installation Accessories	Mounting bracket included WCB-12/W swivel bracket (optional)

Figure 277: sample of (BS-1030B/W and its specifications.

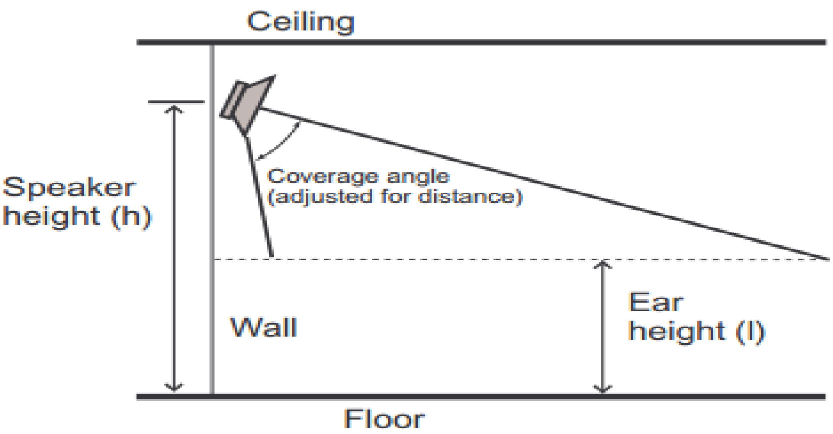


Figure 278: speaker coverage area.

BS-1030B/W 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)
2	10	103	11	19	94
3	10	231	17	29	90
4	10	410	23	39	88
5	10	641	28	48	86
4	20	101	11	20	94
5	20	158	14	25	92
6	20	227	16	29	90
8	20	404	22	39	88
10	20	631	27	49	86
8	30	186	14	27	91
10	30	291	17	34	89
12	30	419	21	40	87

Figure 279: Wall moment speaker (BS-1030B/W) - specifications.

Loudspeaker height is 3.9m, person set on 1.2m from ground.

So at 2.7m (8.9 ft) from ceiling and as shown in previous table the converge area by loudspeaker is 631sq.ft at 10ft and 404sq.ft at 8 ft so at 8.9 ft the coverage area is 500 sq ft and coverage depth is 24.5 ft = 7.5m.

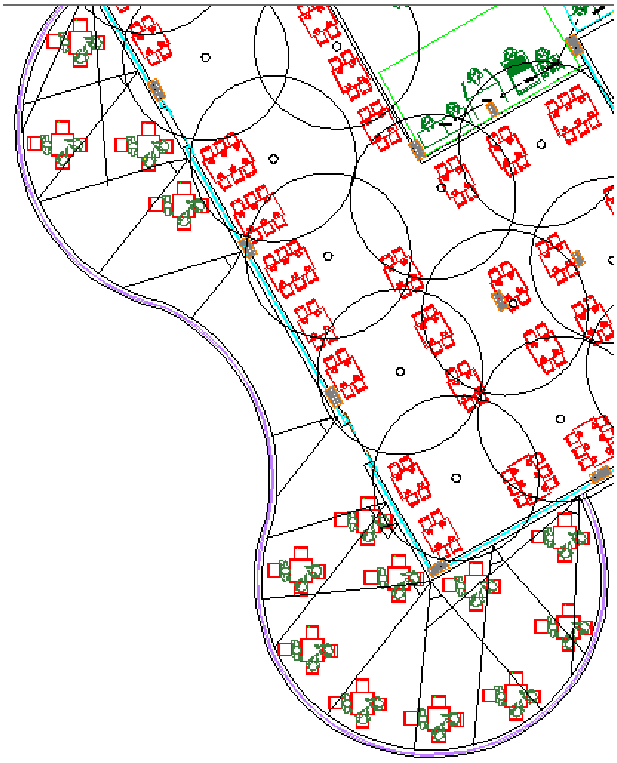


Figure 280: Wall moment speaker distribution.

3.3.1.3. ELECTRICAL DESIGN

The design have been done for ground floor and drawings for all floors .

Table 37: Electrical Design For Ground Floor.

Room	area	Em	type	watt	n	Fl	Hm	l+w	Km	Kr	Ku	N	power
waiting room	96	250	F.L 28w	28	2	2900	2.5	20.6	0.8	1.86	0.68	8	448
kitchen	204	450	F.L 28w	28	2	2900	2.5	29.6	0.8	2.76	0.78	26	1456
store	14	200	F.L 28w	28	2	2900	2.5	7	0.8	0.8	0.37	2	112
bathrooms	14	150	F.L 28w	28	1	2900	2.5	7	0.8	0.8	0.7	2	56
corridor	117	150	F.L 28w	28	1	2900	2.5	22.6	0.8	2.07	0.73	11	308
office	19	300	F.L 28w	28	2	2900	2.5	9.72	0.8	0.78	0.41	3	168
office	14.3	300	F.L 28w	28	2	2900	2.5	8.56	0.8	0.67	0.37	3	168
office	12	300	F.L 28w	28	2	2900	2.5	7.93	0.8	0.61	0.35	3	168
office	16.4	300	F.L 28w	28	2	2900	2.5	9.1	0.8	0.72	0.4	3	168
meeting room	14.5	300	F.L 28w	28	2	2900	2.5	8.62	0.8	0.67	0.38	3	168
corridor	21	200	F.L 28w	28	1	2900	2.5	10.2	0.8	0.83	0.44	5	140
Gaming room	175	300	F.L 28w	28	2	2900	2.5	27.5	0.8	2.55	0.74	16	896
store	13.6	150	F.L 28w	28	1	2900	2.5	8.38	0.8	0.65	0.37	3	84
store	8	150	F.L 28w	28	1	2900	2.5	6.66	0.8	0.48	0.49	2	56
Gym	80	300	F.L 28w	28	2	2900	2.5	18.9	0.8	1.69	0.7	8	448
cafteria	30	250	F.L 28w	28	2	2900	2.5	12	0.8	1	0.51	4	224
sawna	23	50	I.75W	75	1	935	2.5	10.6	0.8	0.87	0.44	4	300
salon	31	250	F.L 28w	28	2	2900	2.5	12.1	0.8	1.02	0.51	4	224
corridor	310	160	F.L 28w	28	1	2900	2.5	36.2	0.8	3.42	0.85	26	728
pool	210	300	F.L 28w	28	2	2900	2.5	30	0.8	2.8	0.79	18	1008
corridor	150	150	F.L 28w	28	1	2900	2.5	25.5	0.8	2.35	0.74	14	392
wedding hall	600	300	F.L 28w	28	2	2900	2.7	50	0.8	4.45	0.89	44	2464
wedding wating	32	200	F.L 28w	28	2	2900	2.5	12.3	0.8	1.04	0.51	3	168
massage room	18.2	200	F.L 28w	28	2	2900	2.5	9.53	0.8	0.76	0.4	2	112
wedding 2	165	150	F.L 28w	28	1	2900	2.5	26.7	0.8	2.47	0.83	13	364
Room	10	200	F.L 28w	28	2	2900	2.5	7.32	0.8	0.55	0.44	1	56
corridor	54	150	F.L 28w	28	1	2900	2.5	15.7	0.8	1.38	0.54	2	56
restaurant	424		from dialux					42.2					7500
							Total						18440

To find Number of branches for circuit breakers :

Rated current for circuit breaker (lighting) : 10 Amp

Rated current for circuit breaker (sockets) : 16 Amp

$$\text{\# of branch for lighting} = \frac{\textbf{Total lighting power}}{\textbf{220} * \textbf{Rated circuit breaker lighting}}$$

# of branch for 2Amp sockets (4-5) socket on each branch for 16Amp C.B

for 5Amp sockets (3) socket on each branch for 16Amp C.B

Rated current for main circuit breaker = [(I lighting * lighting D.F) + (I sockets * sockets D.F) + (special load * special load D.F)] * Safty Factor

where :

Lighting D.F = 0.8 Safty Factor = 1.2 Power Factor =1

Sockets D.F = 0.3 Special load D.F = 1

For Ground Floor:

Area = 4312 m^2 Total power = 18440 watt

Table 38: Number of Socket needed.

	#of 2Amp sockets	#of 5Amp sockets	#of 15 Amp sockets
No.	**90**	**15**	**10**

# of branches for lighting = 18440 / (220*10) = 8.3 = 9 but that's not practical .

We have to use circuit breaker for each $50m^2$.

So 4312 / 50 = 86.24 use 87 branch for lighting .(3ф1.5mm2)

# of branches for sockets = 90/4 = 22.5 use 23 branch for sockets .(3ф2.5 mm2)

Add 5 branches for 5Amp sockets & 10 branch for special load .

Total branches = 87+23+5+10 = 115 branch

To find I rated D.B.1 :

I lighting = total power / V *P.F = 18440 / 220*1 = 83.8 Amp

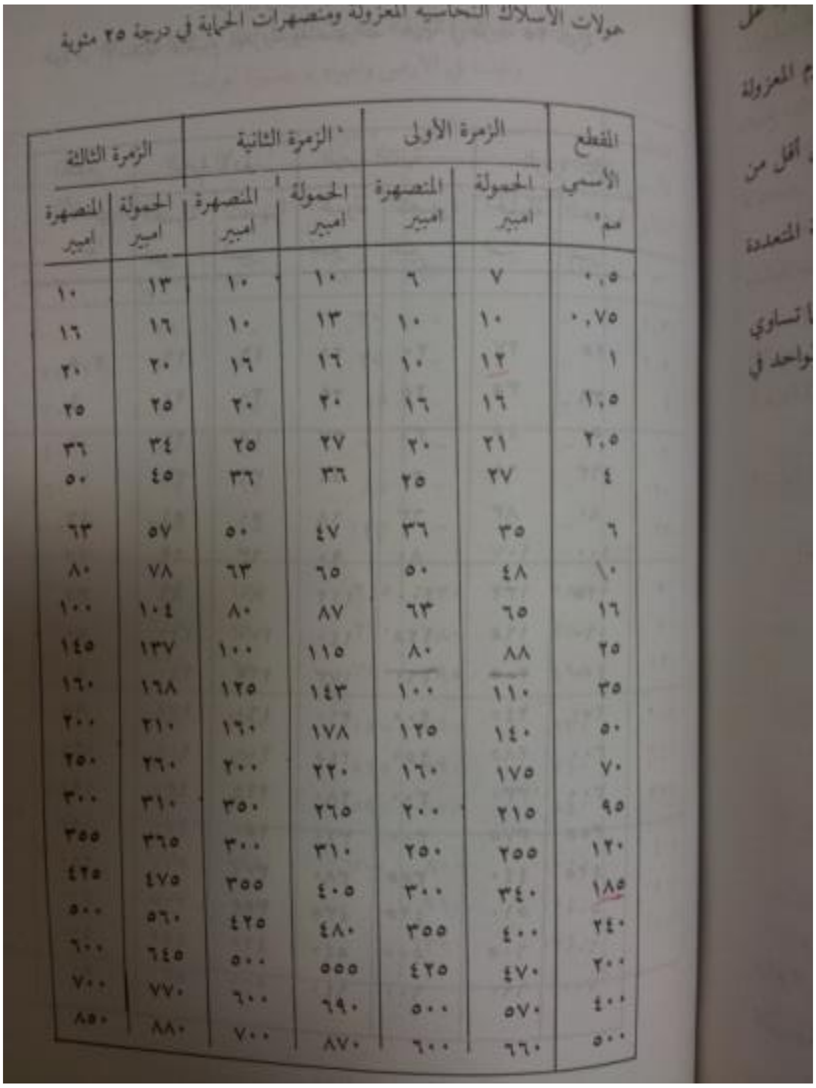
I sockets = 90*2 + 15*5 = 255 Amp

I special load = 10* 15 Amp = 150 Amp

Rated current for D.B circuit breaker .1 = [(83.8*0.8)+(255*0.3)+(150*1)]*1.2

= 352.2 Amp

Use standard 3ϕ200 Amp



حولات الأسلاك النحاسية المعزولة ومنصهرات الحماية في درجة ٢٥ مئوية

المقطع الأسمي مم²	الزمرة الأولى		الزمرة الثانية		الزمرة الثالثة	
	الحمولة امبير	المنصهرة امبير	الحمولة امبير	المنصهرة امبير	الحمولة امبير	المنصهرة امبير
٠,٥	٧	٦	١٠	١٠	١٣	١٠
٠,٧٥	١٠	١٠	١٣	١٠	١٦	١٦
١	١٢	١٠	١٦	١٦	٢٠	٢٠
١,٥	١٦	١٦	٢٠	٢٠	٢٥	٢٥
٢,٥	٢١	٢٠	٢٧	٢٥	٣٤	٣٦
٤	٢٧	٢٥	٣٦	٣٦	٤٥	٥٠
٦	٣٥	٣٦	٤٧	٥٠	٥٧	٦٣
١٠	٤٨	٥٠	٦٥	٦٣	٧٨	٨٠
١٦	٦٥	٦٣	٨٧	٨٠	١٠٤	١٠٠
٢٥	٨٨	٨٠	١١٥	١٠٠	١٣٧	١٤٥
٣٥	١١٠	١٠٠	١٤٣	١٢٥	١٦٨	١٦٠
٥٠	١٤٠	١٢٥	١٧٨	١٦٠	٢١٠	٢٠٠
٧٠	١٧٥	١٦٠	٢٢٠	٢٠٠	٢٦٠	٢٥٠
٩٥	٢١٥	٢٠٠	٢٦٥	٢٥٠	٣١٠	٣٠٠
١٢٠	٢٥٥	٢٥٠	٣١٠	٣٠٠	٣٦٥	٣٥٥
١٨٥	٣٤٠	٣٠٠	٤٠٥	٣٥٥	٤٧٥	٤٢٥
٢٤٠	٤٠٠	٣٥٥	٤٨٠	٤٢٥	٥٦٠	٥٠٠
٣٠٠	٤٧٠	٤٢٥	٥٥٥	٥٠٠	٦٤٥	٦٠٠
٤٠٠	٥٧٠	٥٠٠	٦٩٠	٦٠٠	٧٧٠	٧٠٠
٥٠٠	٦٦٠	٦٠٠	٨٧٠	٧٠٠	٨٨٠	٨٥٠

Figure 281: Area of Electrical Wires.

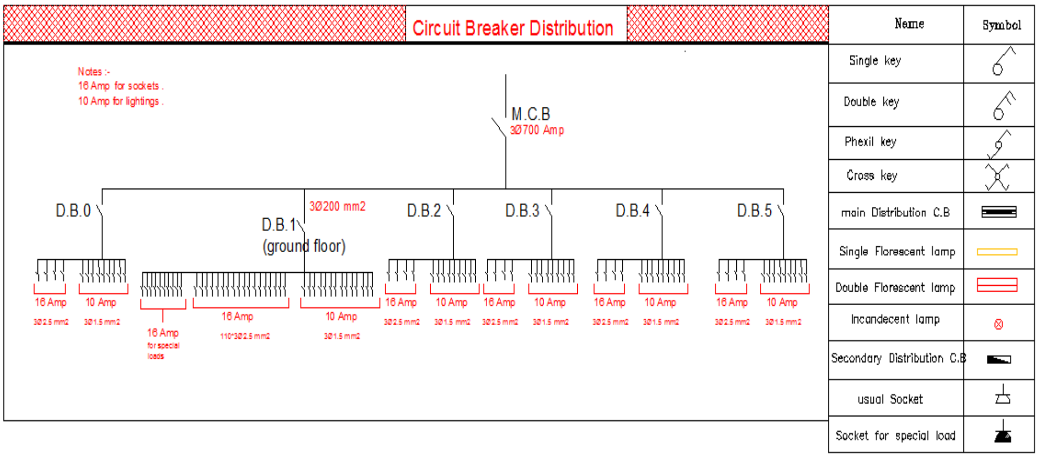


Figure 282: Circuit Breaker Distribution.

Rooms design depending on dialux design for lighting and for other electrical devices these design is considered (lighting control and AC thermostat control) :

Figure 283: Single Bedroom Mechanical Switches.

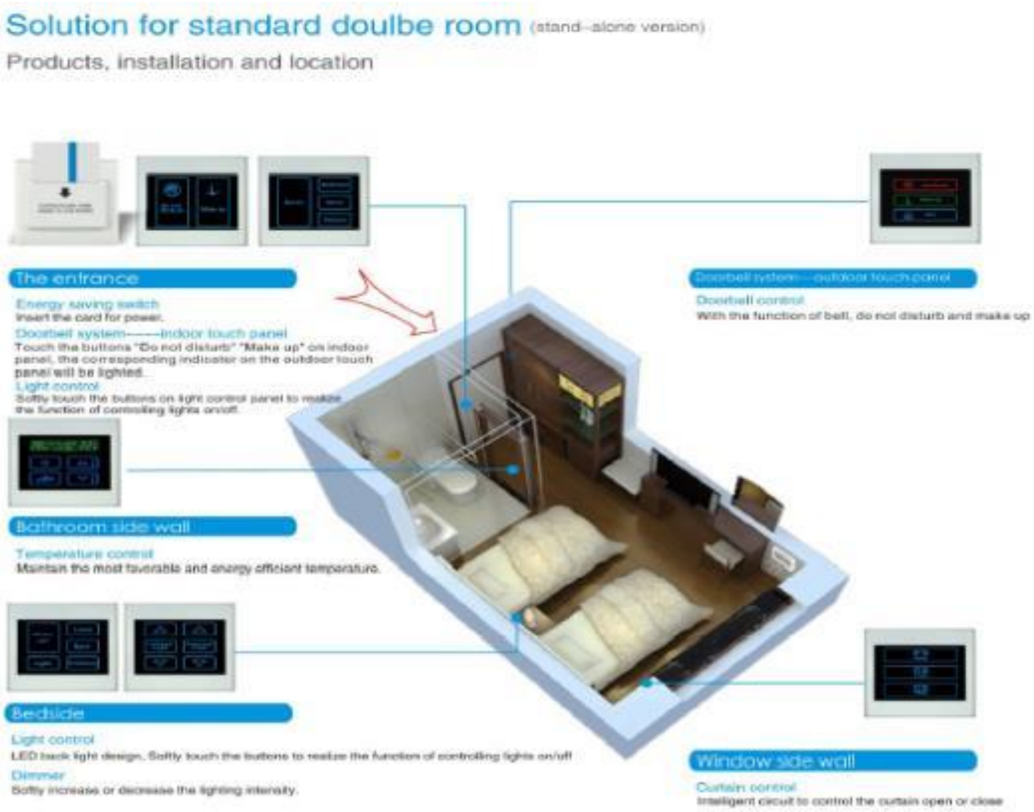


Figure 284: Double room (Stand-alone version).

Figure 285: Luxury Business Suite.

3.3.2. MECHANICAL DESIGN

3.3.2.1. DRAINAGE DESIGN

Most of drainage pass through shafts and some through walls and due to some architectural reasons like restaurant the pipes pass through ceilings to direct it to the walls pipes.

The pipes ends in the basement and some in the ground floor, some of manholes in the basement and direct the sewage to another manholes out of building.

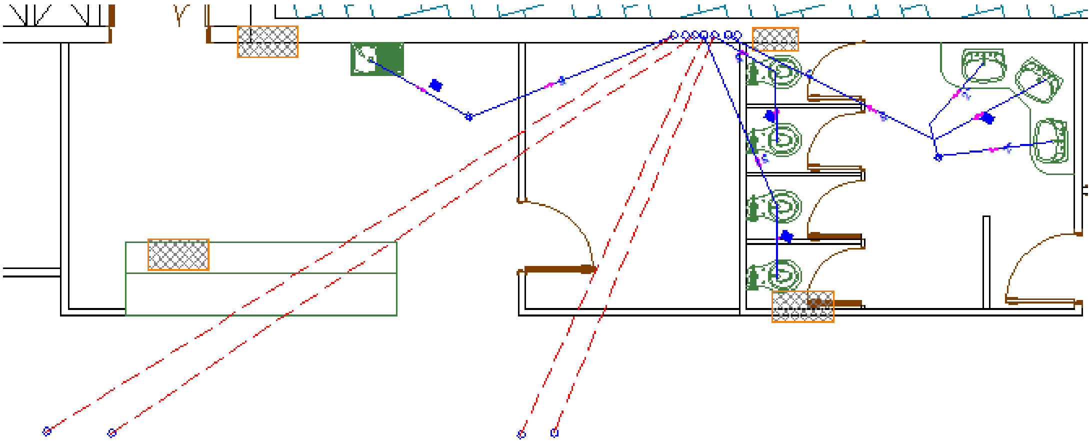


Figure 286: Drainage pipes through ceilings.

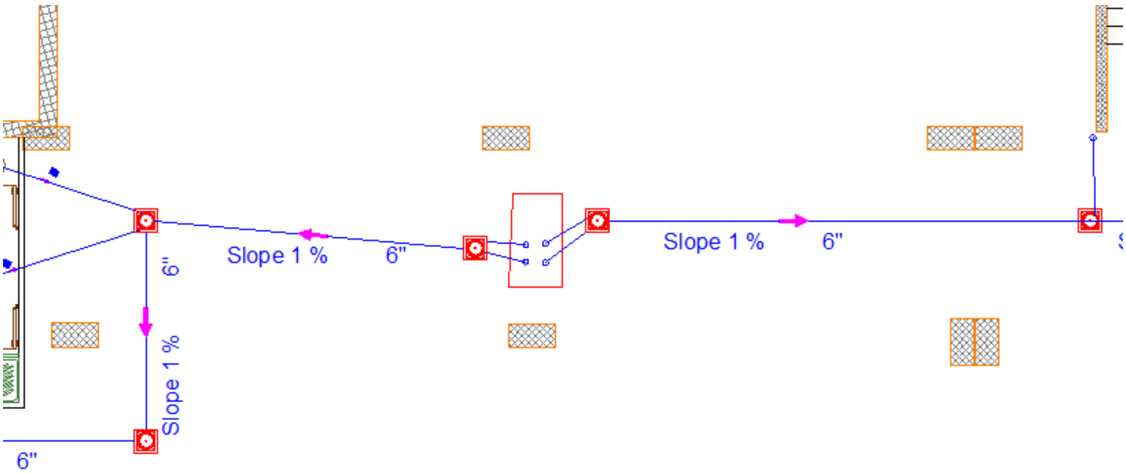


Figure 287: Pipes wardrobe in the basement.

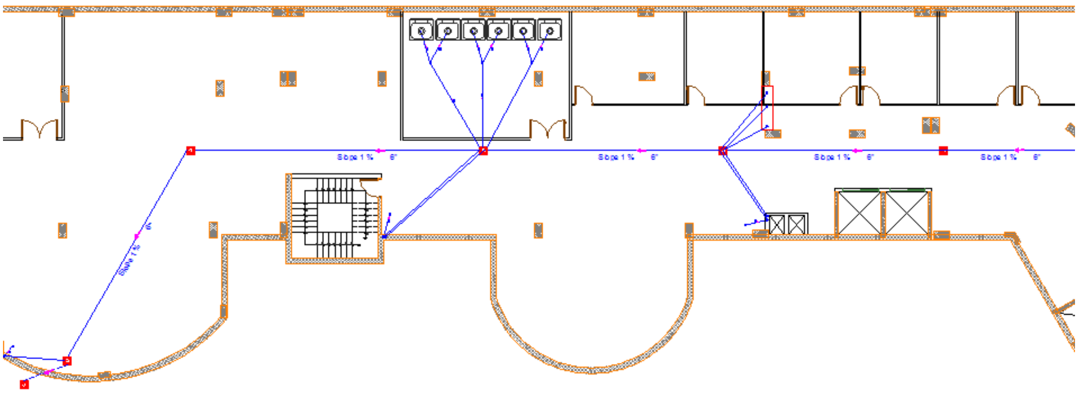


Figure 288: Manholes in the basement.

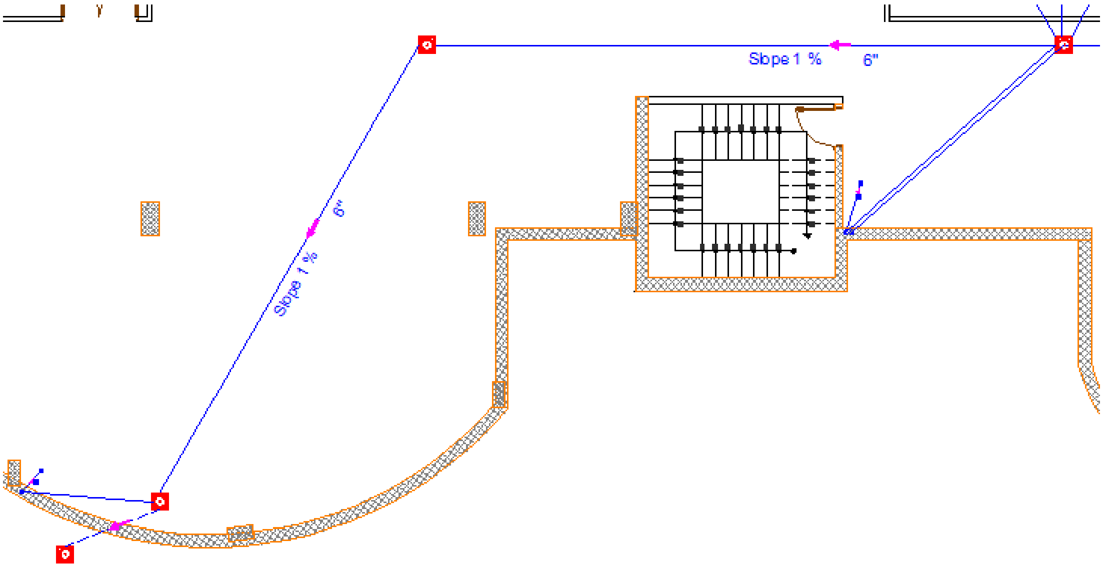


Figure 289: Manholes in the basement to out manholes.

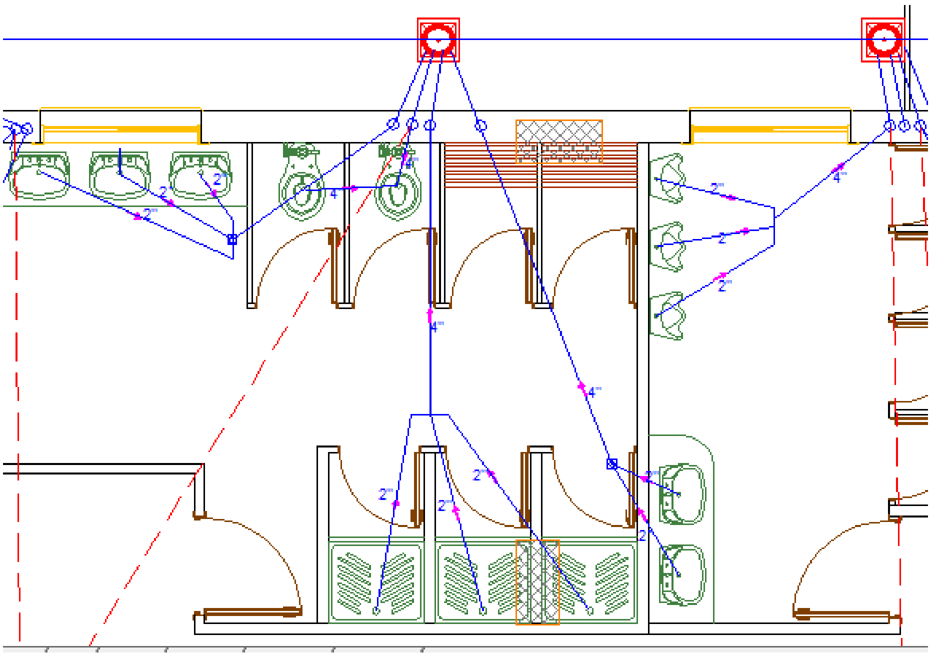


Figure 290: Pipes connections.

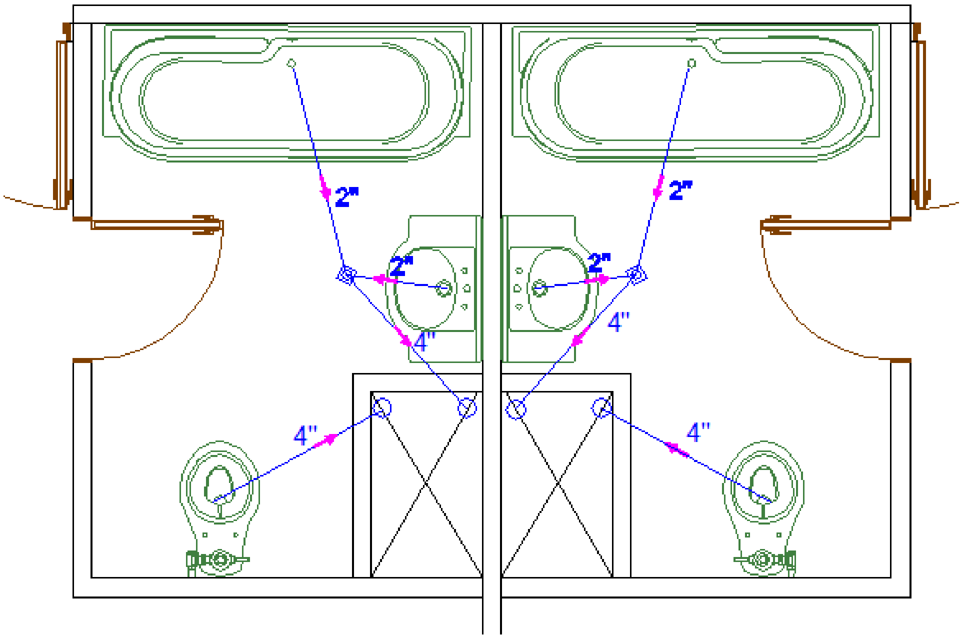


Figure 291: Bathrooms drainage.

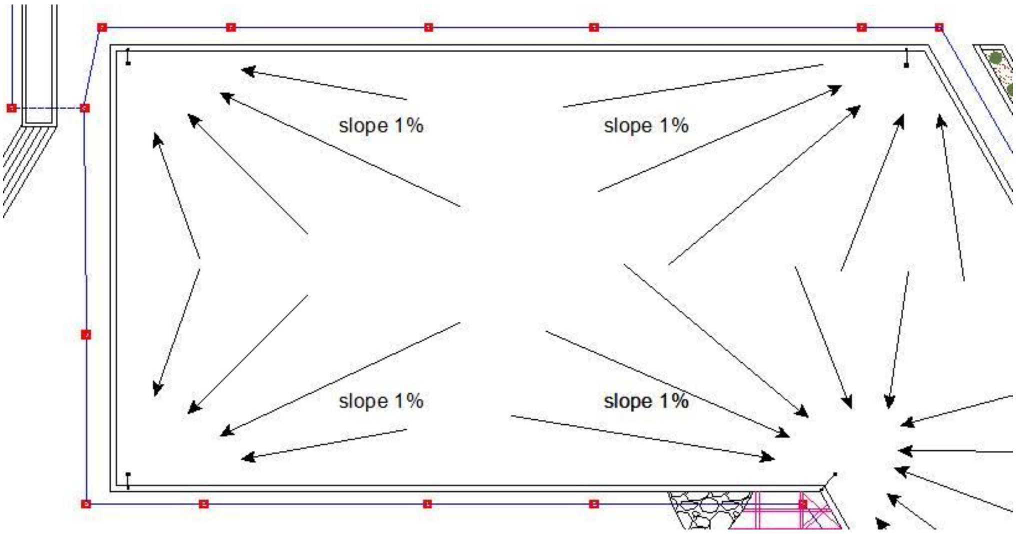


Figure 292: Site drainage (1).

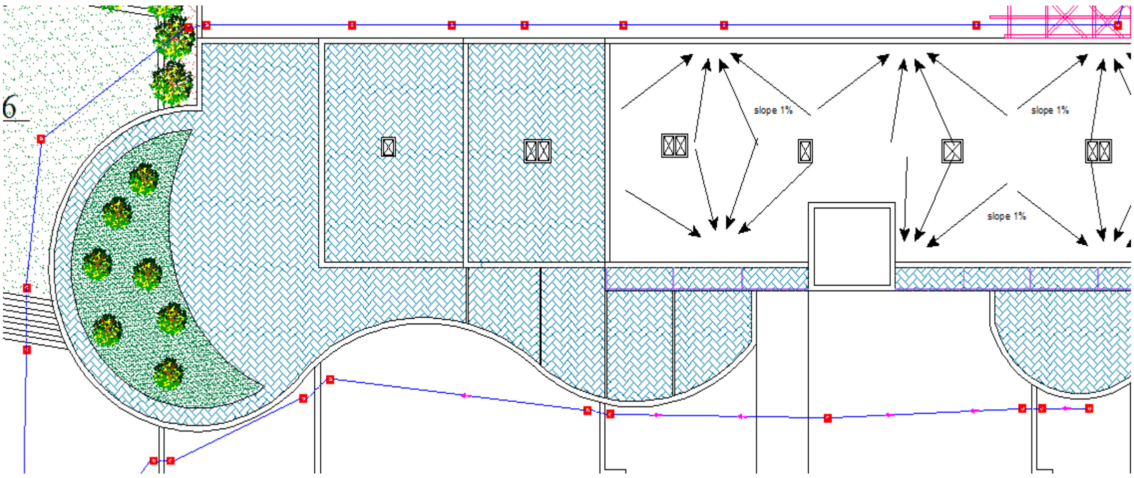


Figure 293: Site drainage (2)

3.3.2.2. WATER SUPPLY DISTRIBUTION

The water supply designed as main pipe from the source connected to main water tank underground and to the tanks over the building which they also connected to the main water tank.

The over building tanks connected to collectors in the building through shafts and due to some architectural reasons like restaurant some pipes pass through the ceiling.

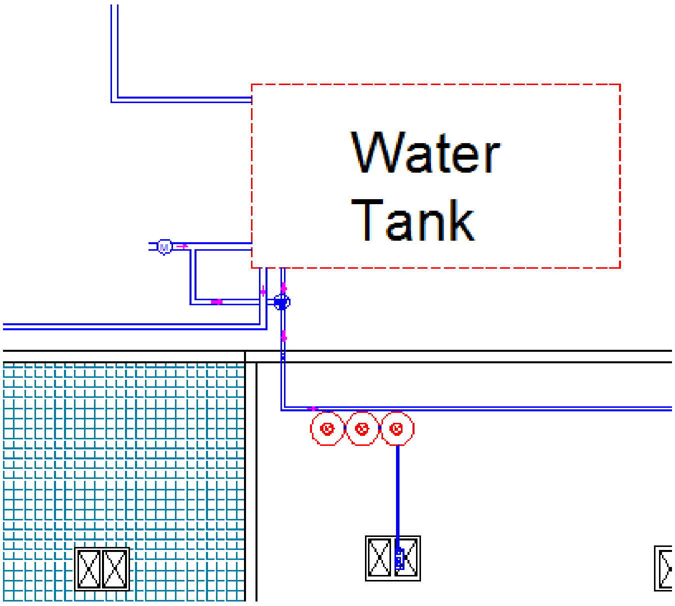


Figure 294: From supply to tanks.

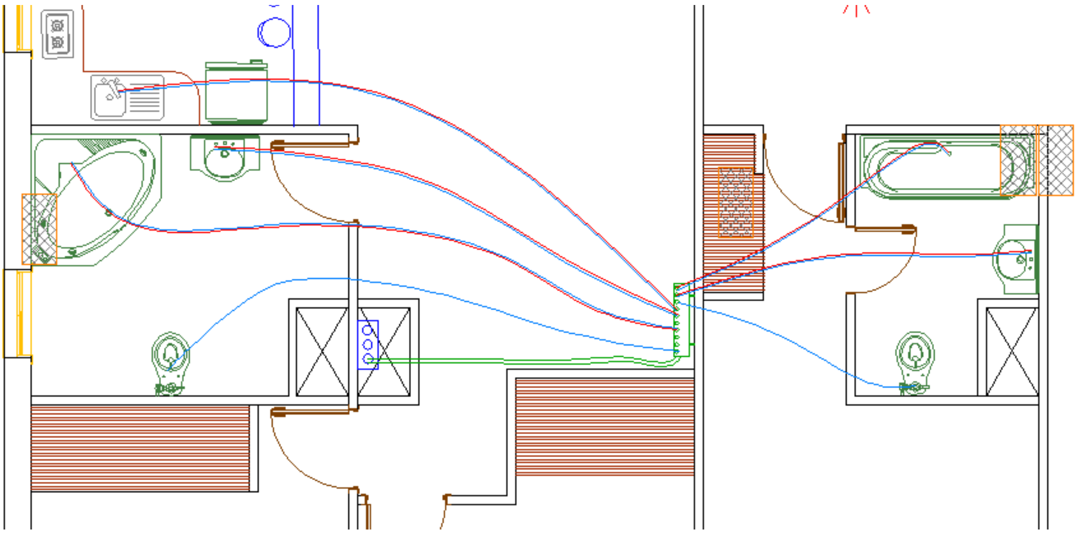


Figure 295: Distribution from controller (1).

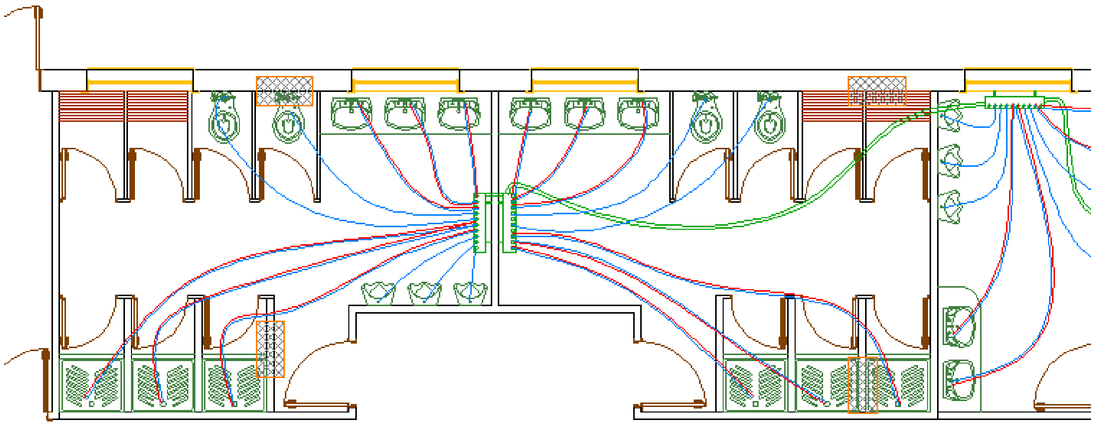


Figure 296: Distribution from controller (2).

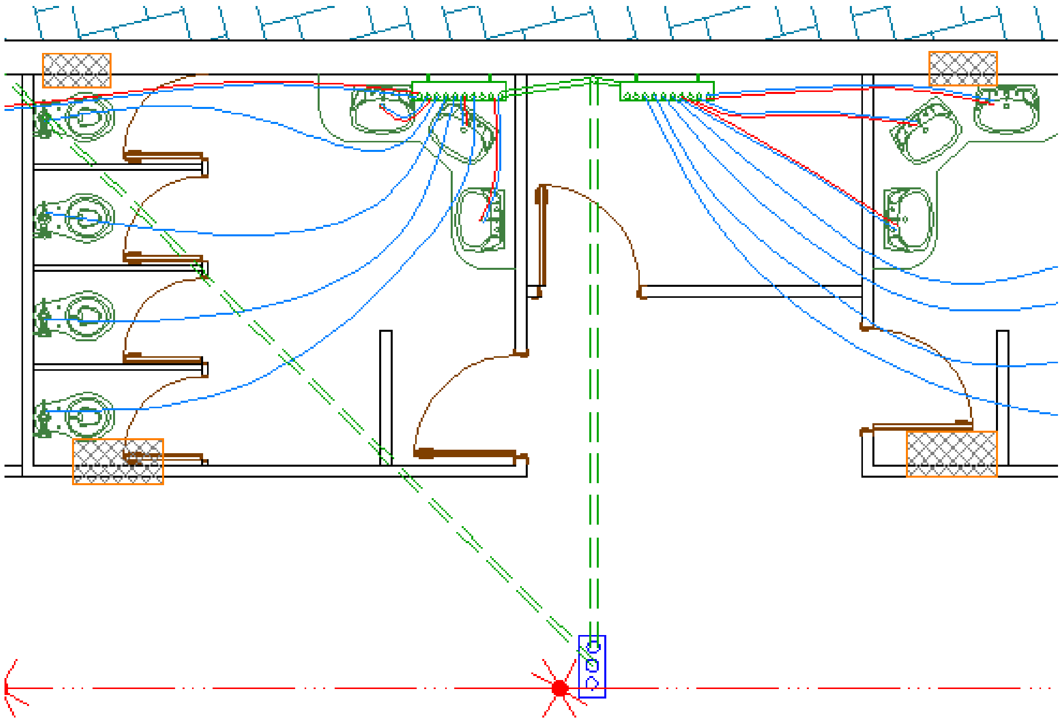


Figure 297: Pipes through ceilings.

3.3.2.3. DESIGN WATER SUPPLY SYSTEM

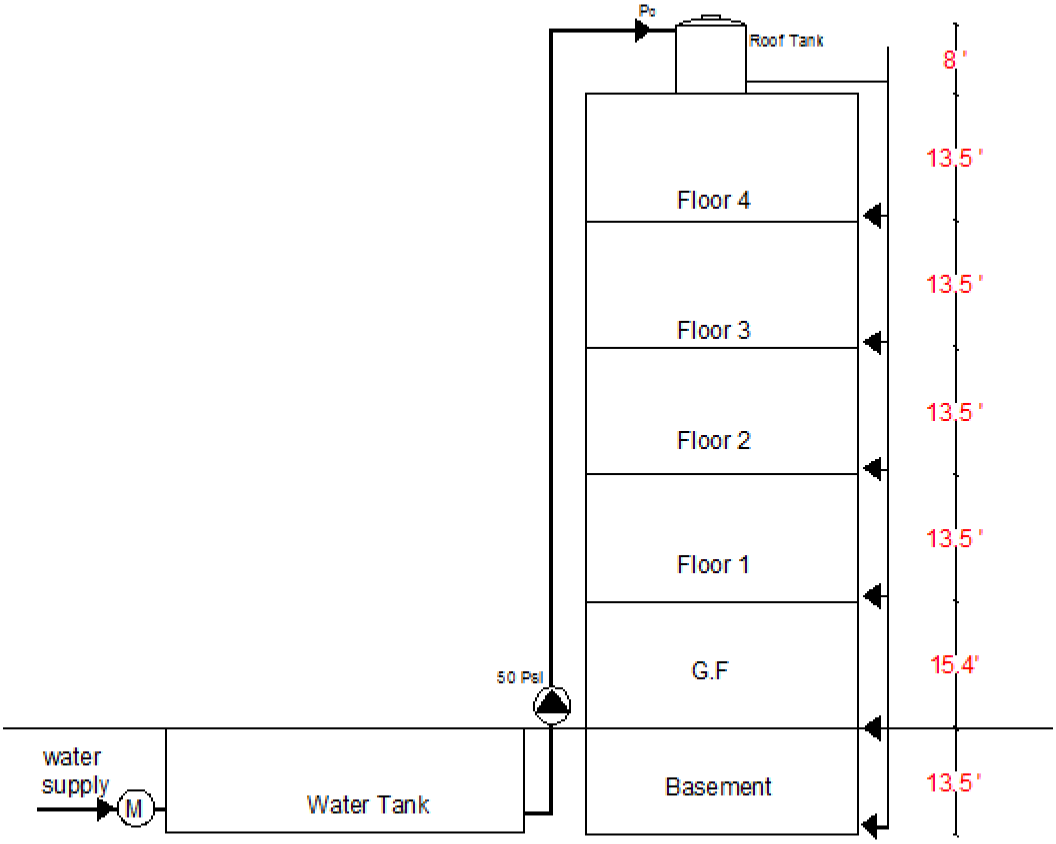


Figure 298: Water Supply System.

we use pump to deliver the water from the water tank to roof tank = 50 psi

The pressure when the water reaches the Roof tank:

P0 = 50-(0.433*(69.4)+8) = 16.5 psi

To provide the water for floors the minimum pressure should be more than 12 psi for critical point (shower) .

The pressure reach for each floor :

P = 0.433 * h

P(GF) = 0.433*(69.4+8-4-4) = 30.1 psi

P(floor 1) = 0.433((54)+4-4) = 23.4 psi

P(floor 2) = 0.433((40.5)+4-4) = 17.5 psi

P(floor 3) = 0.433((27)+4-4) =11.7 psi

P(floor4) = 0.433((13.5)+4-4) =5.98 psi

Design the water supply system for the (**Basement**):

The vertical length = 82.9 ’

The Horizontal length = 120.7’

The Branch length = 17.8’

The Approx. Equivalent length :

Approx. eq. vertical length = 1.5*82.9 = 124.35’

Approx. eq. Horizontal length = 120.7*1.2 = 144.84’

Approx. eq. Branch length = 17.8*1.2 = 21.3 ’

Table 39: Number of FU's for Basement.

Basement				
collector	type	No.	FU's	Total FU's
1	Lavatory	2	1	2
	Shower	3	1.5	4.5
	Sink	3	2.5	7.5
2	Lavatory	2	1	2
	Shower	3	1.5	4.5
	Sink	3	2.5	7.5
	Total			28

Design the water supply system for the (**Floor GF**):

The vertical length = 69.4 ’

The Horizontal length = 89.4’

The Branch length = 24.67’

The Approx. Equivalent length :

Approx. eq. vertical length = 1.5*69.4 = 104.1’

Approx. eq. Horizontal length = 89.4*1.2 = 107.28’

Approx. eq. Branch length = 24.67*1.2 = 29.6 ’

Table 40: Number of FU's for Ground Floor.

Ground Floor				
collector	type	No.	FU's	Total FU's
1	Sink	5	2.5	12.5
2	Sink	3	2.5	7.5
	Bathtub	2	1	2
3	Sink	4	2.5	10.0
	Bathtub	4	1	4
4	Sink	2	2.5	5
	Bathtub	2	1	2
	Total			43

Design the water supply system for the (**Rest floors**):

The vertical length = 54 ’

The Horizontal length = 49.34’

The Branch length = 12.1’

The Approx. Equivalent length : `

Approx. eq. vertical length = 1.5*54 = 81’

Approx. eq. Horizontal length = 49.34*1.2 = 59.2’

Approx. eq. Branch length = 12.1*1.2 = 14.5 ’

Table 41: Number of FU's for other floor.

Rest Floor				
collector	**type**	**No.**	**FU's**	**Total FU's**
1	**sink**	**1**	**2.5**	**2.5**
	bathtub	**1**	**1**	**1**
	Shower	**1**	**1.5**	**1.5**
2	**sink**	**2**	**1**	**2**
	bathtub	**2**	**2.5**	**5**
	Shower	**2**	**1.5**	**3**
3	**sink**	**2**	**1**	**2**
	bathtub	**1**	**2.5**	**2.5**
	Shower	**1**	**1.5**	**1.5**
	Total			**21**

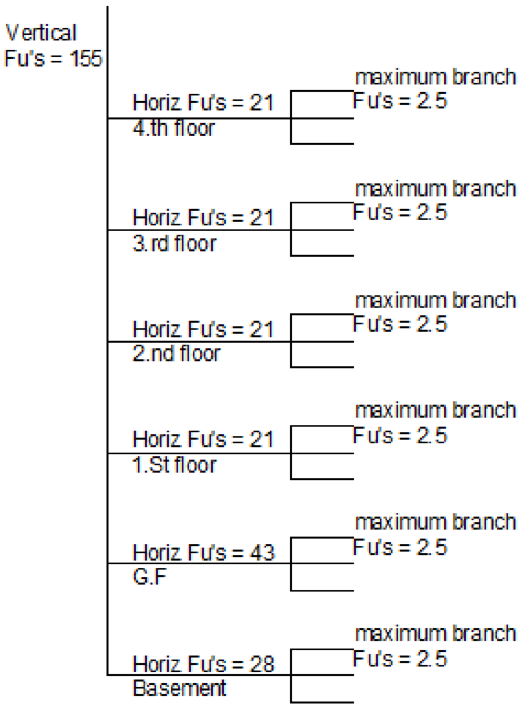


Figure 299: FU's Distribution graph.

By using the following figure we can get water demand for each Fu's :

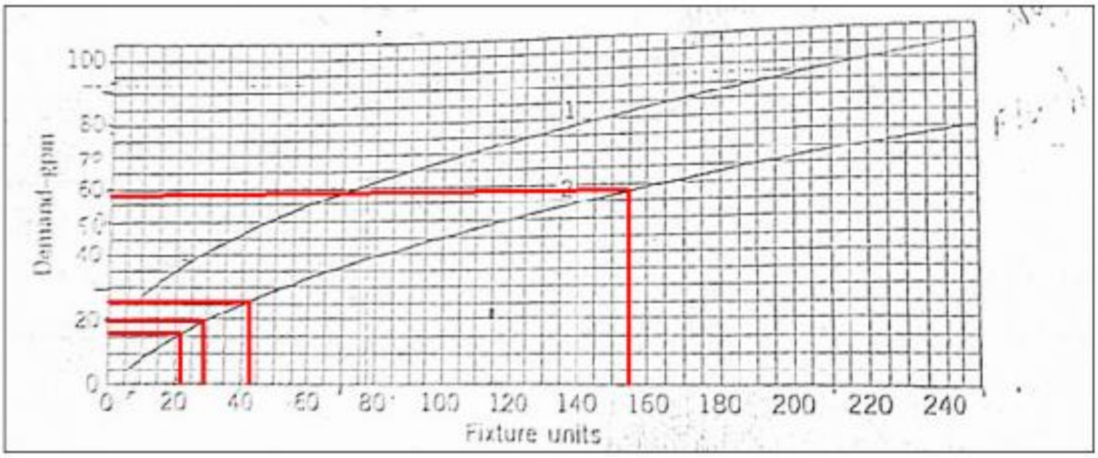


Figure 300: water demand for each Fu's.

Using the figure bellow to get the loss in pipes/100 m:

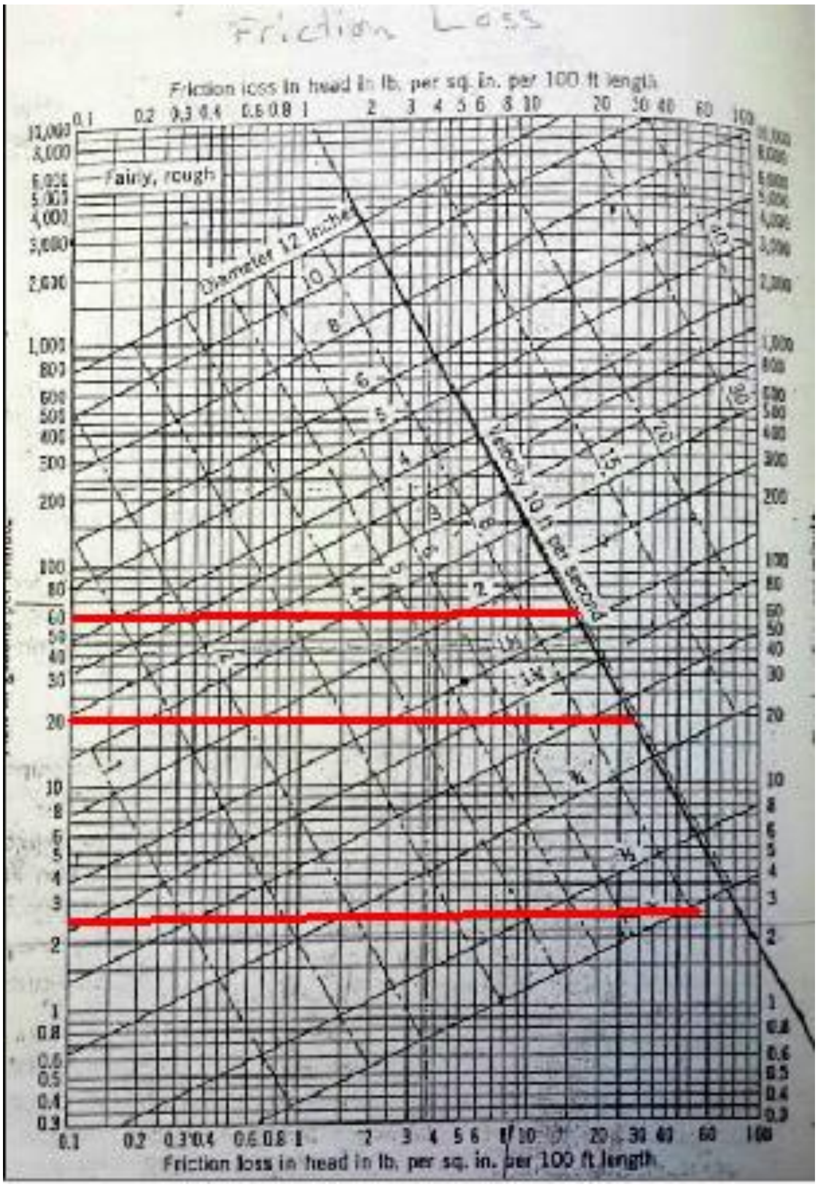


Figure 301: the loss in pipes/100.

The pipe diameter for the Vertical steel pipe :

Eq. length = 124.35’ water demand = 58 gpm

Table 42: Diameter of Vertical Steel Pipe.

Diameter	3 ‘’	2.5 ‘’	2 ‘’
Loss/100	0.7	1.6	6
Loss/124.35	0.87	1.98	7.44

The pipe diameter for the Horizontal PVC pipe :

Eq. length critical for basement = 144’ water demand = 23 gpm

Table 43: Diameter of Horizontal PVC Pipe.

Diameter	3 ‘’	2.5 ‘’	2 ‘’	1.5 ‘’	1.25 ‘’
Loss/100	0.14	0.3	0.9	3.5	9
Loss/144	0.2	0.432	1.3	5.04	12.96

The pipe diameter for the branch PVC pipe :

Eq. length = 29.6 water demand = 2.5 gpm

Table 44: Diameter of Branch PVC Pipe.

Diameter	1.5 ‘’	1.25 ‘’	1 ‘’	3/4 ‘’
Loss/100	-	0.12	0.35	1.5
Loss/29.6	-	0.036	0.11	0.44

Table 45: Pressure Loss.

	Pipe	Loss
Vertical	2.5	1.98
Horizontal	2	1.3
Branch	1.25	0.036
		3.316

Minimum Available Pressure – Pressure Loss = 11.7- 3.316 = 8.38 psi

So, use pump more than 6 psi for 3rd floor , and 12 psi for 4th floor.

3.3.2.4. FIRE SAFETY DESIGN

For the fire design sprinkler system has been used in addition to hoses distributed in the building and connected to separate fire tanks and escape stairs round building .

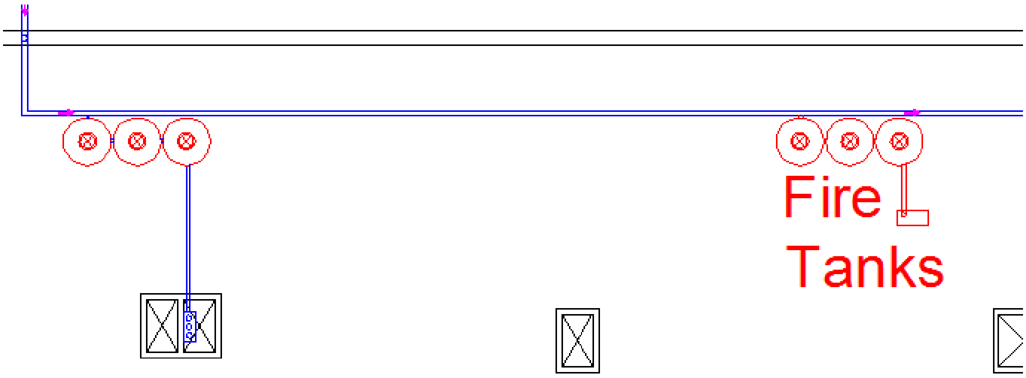


Figure 302: Fire tanks on the roof.

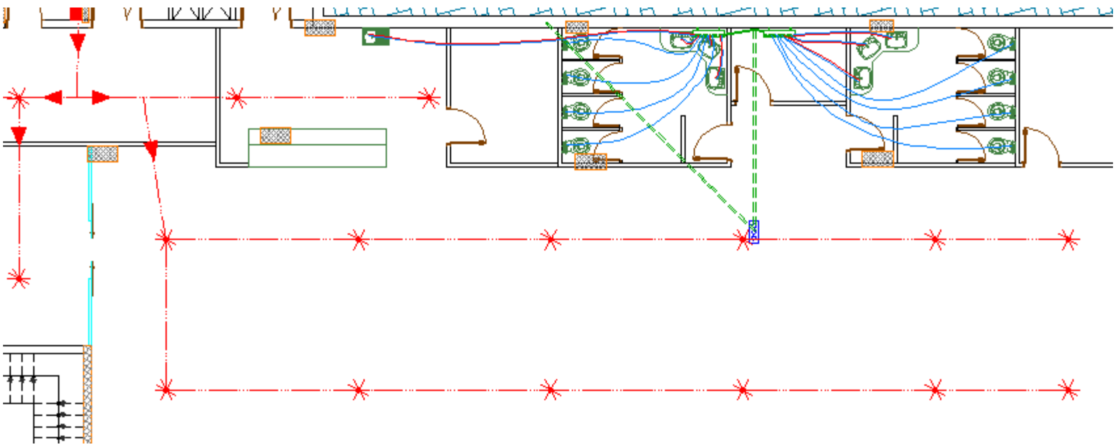


Figure 303: Sprinkler distribution in the restaurant.

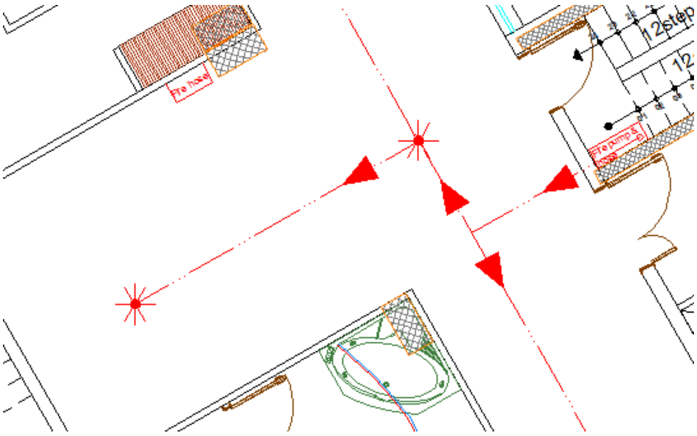


Figure 304: Fire pump and hose.

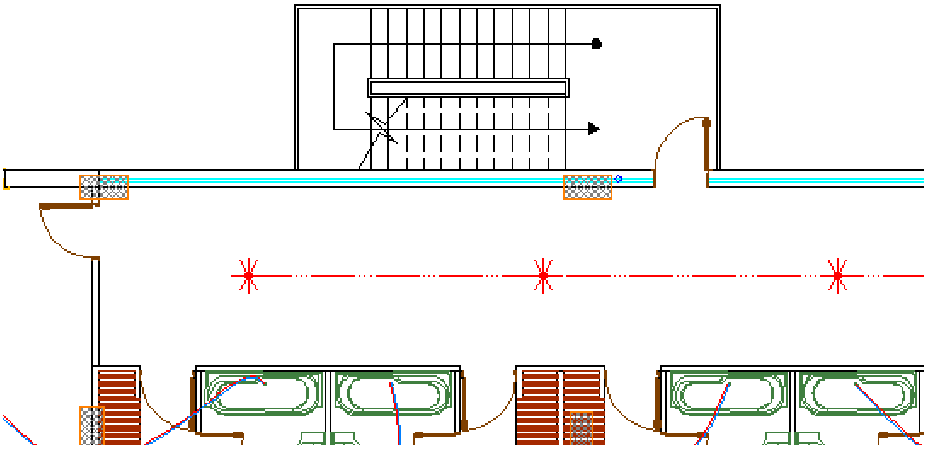


Figure 305: Emergency stair.

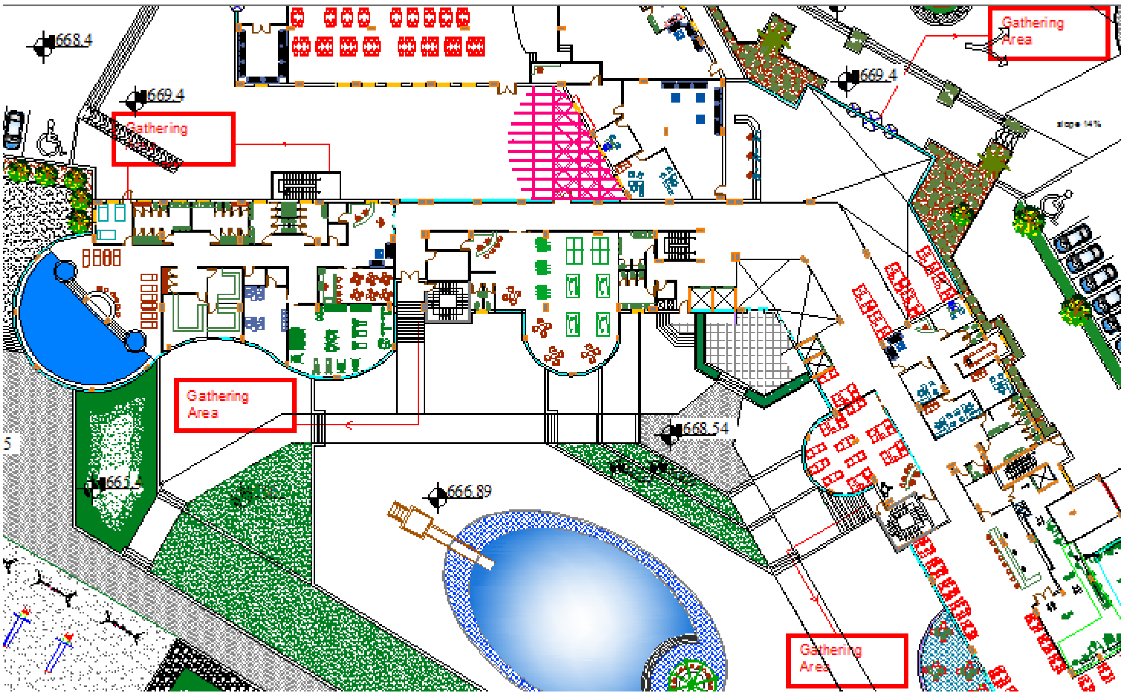


Figure 306: Gathering area .

3.3.2.5. H-VAC DESIGN

HVAC system has been designed using heating and cooling loads which calculated in Ecotect. Variable refrigerant flow (VRF) system have been used, The system is able to control the amount of refrigerant flowing to the multiple indoor units and provides an individualized comfort control, simultaneous heating and cooling in different zones, and heat recovery from one zone to another .

For the bedrooms VRF without fresh air have been used and with fresh air for the public spaces like restaurants, gym and corridors …etc.

We used main unit and controller from (MITSUBISHI).

1. **Main unit :**

The L-Generation Air Source VRF Outdoor Units represent the latest in a long line of innovations from Mitsubishi Electric Cooling & Heating. Featuring HexiCoil™ aluminum flat tube heat exchanger technology, the L-Generation offers best-in-class efficiency ratings across all categories improving on the already highly efficient variable refrigerant flow technology. With single modules up to 14 tons and an optimized footprint, the L-Generation Air Source Outdoor Unit is the perfect fit for any commercial application.

- Best-in-class efficiency ratings.
- Single modules up to 14 tons with the ability to combine modules for systems up to 28 tons.
- HexiCoil™ aluminum flat tube, zinc-coated heat exchanger technology eliminates copper tubing from the condenser coil. Featuring turbulated tube walls and a unique fin shape for water shedding capability, the HexiCoil™ condenser coil ensures maximum heat transfer through an optimized cross section.
- Up to 50% less refrigerant charge required than previous generations.
- Floating/adjustable evaporation temperature in swing seasons, saving energy while maintaining exceptional performance.
- Automated and dynamic refrigerant temperature control.
- Optimized refrigerant circuit and component design for improved flow distribution, allowing maximum energy transfer with minimal power input.

- Superior high-ambient cooling performance with guaranteed operation to 126°F.
- Extended 10-year parts and compressor warranty available.

Figure 307: Outdoor unit.

2. Controllers :

Figure 308: Controller.

The BC Controller works in unison with the outdoor unit to provide simultaneous cooling and heating. The single BC Controller is connected to the outdoor unit by two refrigerant pipes, and to each indoor unit by a series of two pipes, depending on the indoor unit count.

- Each set of ports supports up to 54,000 Btu/h (15.8KW) of capacity
- Single BC Controller: used when only one BC controller is required, available in up to 16 ports (up to 120,000 (35.1KW) Btu/h nominal cooling capacity).

- Main BC Controller: for large systems, available in up to 16 ports (up to 288,000 Btu/h (48.4 KW) nominal cooling capacity) and when use of Sub BC Controllers is desired.
- Sub BC Controller: used with a Main BC controller to connect additional indoor units, available in up to 16 ports.
- A maximum of two Sub BC controllers can be connected to one Main BC Controller per system.

Bedrooms Design:

The heating and cooling loads for the bedrooms ranges between 5800 Btu (1.7 KW) for single bedroom to 14000 Btu (4.1 KW) for Family rooms .

We used ceiling-concealed, ducted indoor unit from (MITSUBISHI) 1-3 units

- External static pressure settings are adjustable to meet different application conditions.
- Extremely quiet, with sound ratings as low as 26 dB(A).
- Auto-fan feature to adjust fan speed based on temperature differentials between space and set point.
- Capacities range from 6,000 to 24,000 Btu/h (1.75 -7 KW).
- Side access to control panel.
- Integrated condensate lift mechanism to provide up to 21 11/16" of lift.

Figure 309: indoor unit.

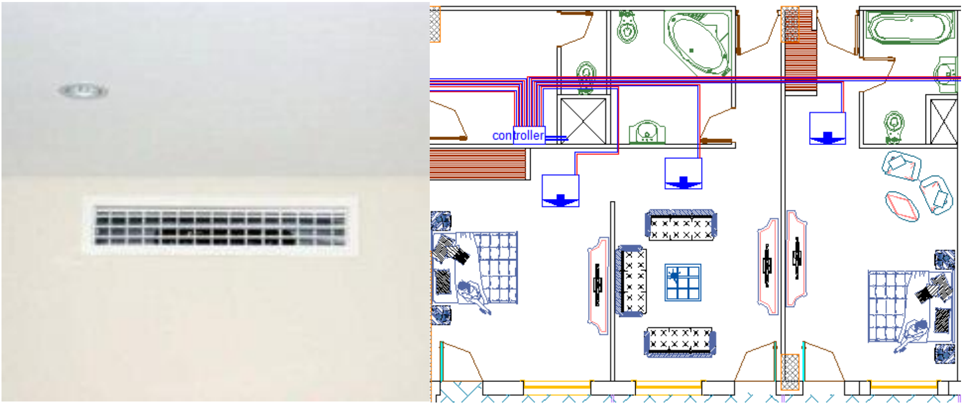


Figure 310: Indoor Unit Distribution.

Table 46: Number of units for each zone.

Area	load (KWh)	CFM	CMH	No. of units
pool	16.98	354.98	603.47	4.79
massage	2.08	43.58	74.09	0.59
baths	7.33	153.24	260.51	2.07
staff rooms1	1.55	32.43	55.14	0.44
Gym room	14.81	309.77	526.61	4.18
cafeteria	5.40	112.86	191.87	1.52
staff rooms2	4.23	88.35	150.20	1.19
corridor1	13.24	276.94	470.79	3.74
Games room	12.87	269.07	457.43	3.63
clean room	1.67	34.88	59.30	0.47
corridor2	9.29	194.27	330.26	2.62
Main restaurant	42.62	891.23	1515.09	12.02
Main Kitchen	11.41	238.69	405.77	3.22
baths2	1.91	39.84	67.72	0.54
baths1	2.55	53.37	90.72	0.72
waiting room	8.31	173.67	295.25	2.34
Administration rooms	7.90	165.16	280.78	2.23
corridor3	7.62	159.37	270.93	7.53
Entrance + Reception	48.49	1013.92	1723.66	13.68
Administration rooms2	8.82	184.49	313.63	2.49
Baths3	11.98	250.59	426.00	3.38
wedding room	57.55	1203.38	2045.75	16.24
entrance + baths for wedding room	15.73	328.90	559.14	4.44
West(large bed room) 1st floor	5.62	117.46	199.69	1.58
Bedrooms1	6.58	137.52	233.78	1.86
Bedrooms2	8.48	177.29	301.40	2.39
West(Small Bedroom) 1st floor	1.62	33.90	57.63	0.46
Bedrooms3	7.45	155.79	264.85	2.10
Restaurant 1st floor Baths	4.90	102.53	174.30	1.38
Corridor 1st floor	26.45	553.02	940.13	7.46
Restaurant 1st floor	21.11	441.39	750.36	5.96

Maximum Heating and Cooling Load for the first two floors only using Ecotect Program:

1. For Cooling Loads:

The critical state to calculate the loads when the building in full occupancy and at comfort band 22-26 C.

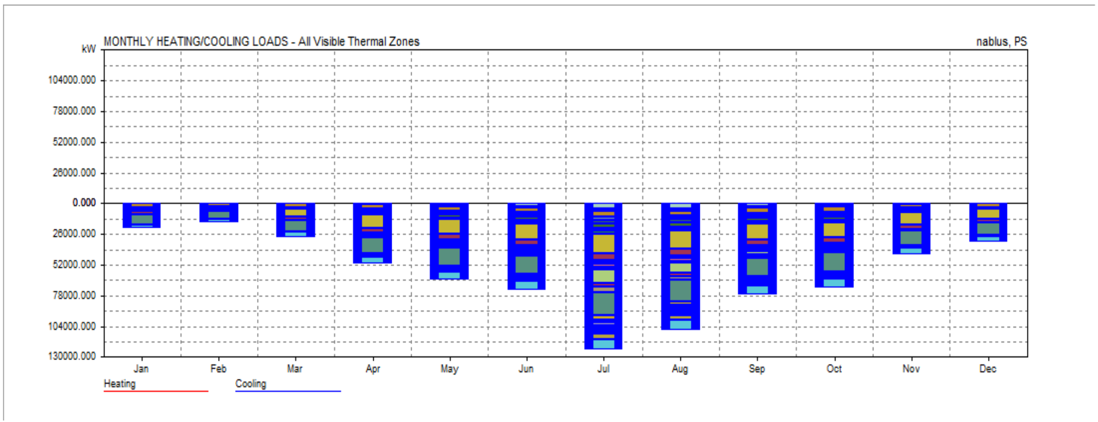


Figure 311: Cooling Load Diagram.

Report:
MONTHLY HEATING/COOLING LOADS
All Visible Thermal Zones
Comfort: Zonal Bands
Max Heating: 0.0 C - No Heating.
Max Cooling: 411.759 kW at 13:00 on 5th August

MONTH	HEATING (kWh)	COOLING (kWh)	TOTAL (kWh)
Jan	0.000	21167.072	21167.072
Feb	0.000	16249.122	16249.122
Mar	0.000	28823.488	28823.488
Apr	0.000	51475.285	51475.285
May	0.000	64932.973	64932.973
Jun	0.000	73204.938	73204.938
Jul	0.000	123945.867	123945.867
Aug	0.000	107086.398	107086.398
Sep	0.000	77384.555	77384.555
Oct	0.000	71234.055	71234.055
Nov	0.000	42769.531	42769.531
Dec	0.000	32318.973	32318.973
TOTAL	0.000	710592.250	710592.250
PER M²	0.000	139.538	139.538

Floor Area: 5092.457 m2

2. For Heating Loads:

The critical state to calculate the loads when the building is Empty and at comfort band 22-26 C.

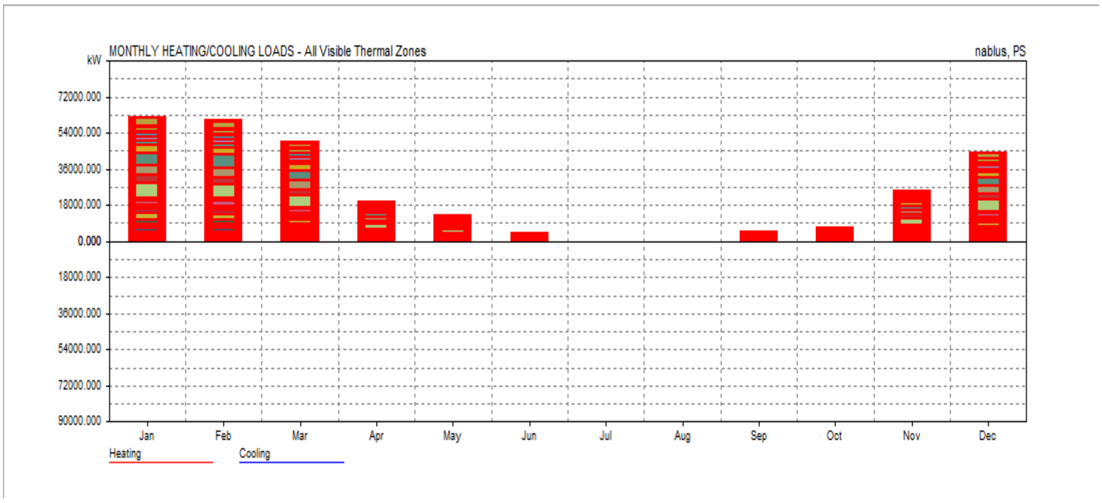


Figure 312: Heating load Diagram.

Report:
MONTHLY HEATING/COOLING LOADS
All Visible Thermal Zones
Comfort: Zonal Bands
Max Heating: 253.320 kW at 13:00 on 18th January
Max Cooling: 0.0 C - No Cooling.

MONTH	HEATING (kWh)	COOLING (kWh)	TOTAL (kWh)
Jan	62446.453	0.000	62446.453
Feb	60758.395	0.000	60758.395
Mar	49732.398	0.000	49732.398
Apr	20118.193	0.000	20118.193
May	13615.719	0.000	13615.719
Jun	4495.884	0.000	4495.884
Jul	8.163	0.000	8.163
Aug	154.856	0.000	154.856
Sep	5211.103	0.000	5211.103
Oct	7156.059	0.000	7156.059
Nov	25247.285	0.000	25247.285
Dec	44601.539	0.000	44601.539
TOTAL	293546.062	0.000	293546.062
PER M²	57.643	0.000	57.643

Floor Area: 5092.457 m2

3. For Full Air Conditioning :

We calculate Full Air Conditioning when 30% of occupancy in the building and at comfort band 22-26 C.

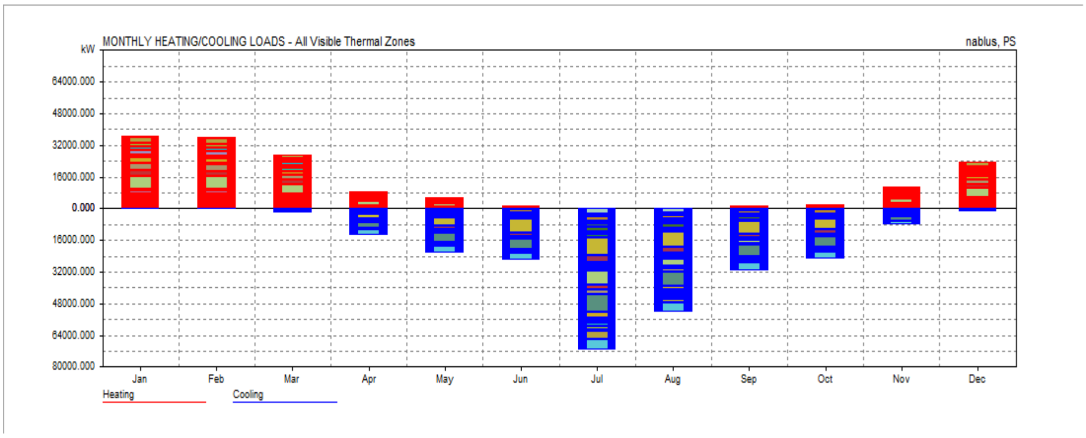


Figure 313: Full Air Conditioning.

Report:
MONTHLY HEATING/COOLING LOADS

All Visible Thermal Zones
Comfort: Zonal Bands

Max Heating: 147.120 kW at 13:00 on 18th January
Max Cooling: 309.728 kW at 13:00 on 5th August

MONTH	HEATING (kWh)	COOLING (kWh)	TOTAL (kWh)
Jan	34032.008	678.504	34710.512
Feb	33624.688	278.901	33903.590
Mar	25458.881	3060.963	28519.844
Apr	7801.546	17016.736	24818.281
May	4796.199	26189.824	30986.021
Jun	941.125	29630.082	30571.207
Jul	0.000	75910.773	75910.773
Aug	0.000	56787.039	56787.039
Sep	1079.009	35129.945	36208.953
Oct	1665.506	29680.795	31346.301
Nov	9520.776	11575.620	21096.396
Dec	21784.221	3013.998	24798.219
TOTAL	140703.953	288953.188	429657.156
PER M²	27.630	56.741	84.371

Floor Area: 5092.457 m2

For the VRF with fresh air we used TROX slot type (VSD35-3-AZ):

- Nominal length from 600 to 1200 mm, 3 slots
- Volume flow rate range 8 – 40 l/s or 30 – 144 m³/h
- Diffuser face made of extruded aluminum sections
- For variable and constant volume flows
- High induction results in a rapid reduction of the temperature difference and airflow velocity
- Individually adjustable air control elements to meet individual local requirements

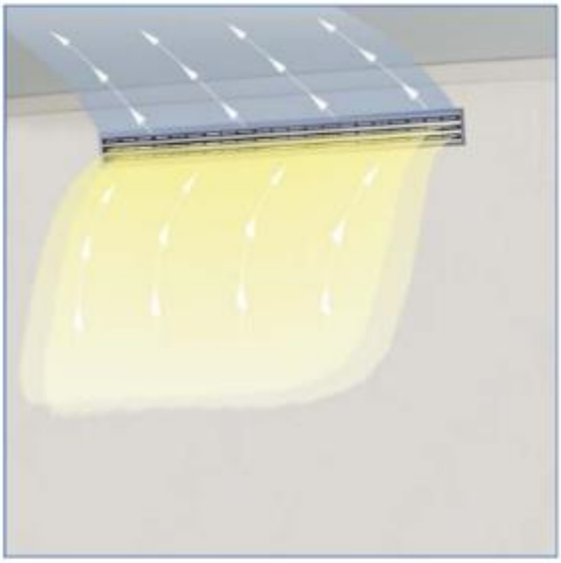


Figure 314: Slot diffuser unit(1).

Figure 315: Slot diffuser unit (2).

Sample calculation for Main Restaurant:

The maximum cooling load = 42.6 Kwh we need to convert the unit to cube meter per hour (CMH)

CMF = 42.62*20.9 = 891.23

CMH = 891.23*1.7 = 1515.09 m^3/h

We used side slots 1050 mm with V' = 126 m^3/h so we need 12 units which connected to air handling unit.

Nominal length	V̇		Damper blade position								
			0°			45°			90°		
			$\Delta p_{t\ supply\ air}$	$\Delta p_{t\ extract\ air}$	L_{WA}	$\Delta p_{t\ supply\ air}$	$\Delta p_{t\ extract\ air}$	L_{WA}	$\Delta p_{t\ supply\ air}$	$\Delta p_{t\ extract\ air}$	L_{WA}
	l/s	m^3/h	Pa		dB(A)	Pa		dB(A)	Pa		dB(A)
600	8	30	6	3	15	9	5	17	26	13	24
600	15	54	19	9	31	31	16	34	85	43	40
600	25	90	54	26	45	86	45	47	237	120	54
600	30	108	77	37	50	124	65	52	341	173	59
750	10	37	7	4	21	12	8	23	28	19	31
750	20	72	28	15	38	44	31	40	107	74	47
750	25	90	44	24	44	68	48	46	167	116	53
750	30	108	64	35	48	98	70	51	241	167	57
900	12	44	9	6	23	14	10	26	37	28	29
900	20	72	24	15	36	37	27	39	97	74	44
900	30	108	55	33	46	82	60	50	217	167	55
900	35	126	74	45	51	112	82	54	296	228	60
1050	15	54	12	8	28	17	15	30	58	39	38
1050	25	90	34	22	40	48	41	44	161	110	51
1050	35	126	66	43	49	95	80	53	316	215	60
1050	40	144	86	56	52	124	104	56	413	281	63
1200	15	54	11	8	26	20	13	29	55	41	38
1200	30	108	44	30	44	79	52	47	218	165	56
1200	35	126	60	41	48	107	71	52	297	225	60
1200	40	144	79	54	51	140	92	55	388	293	63

Figure 316: Unit specifications.

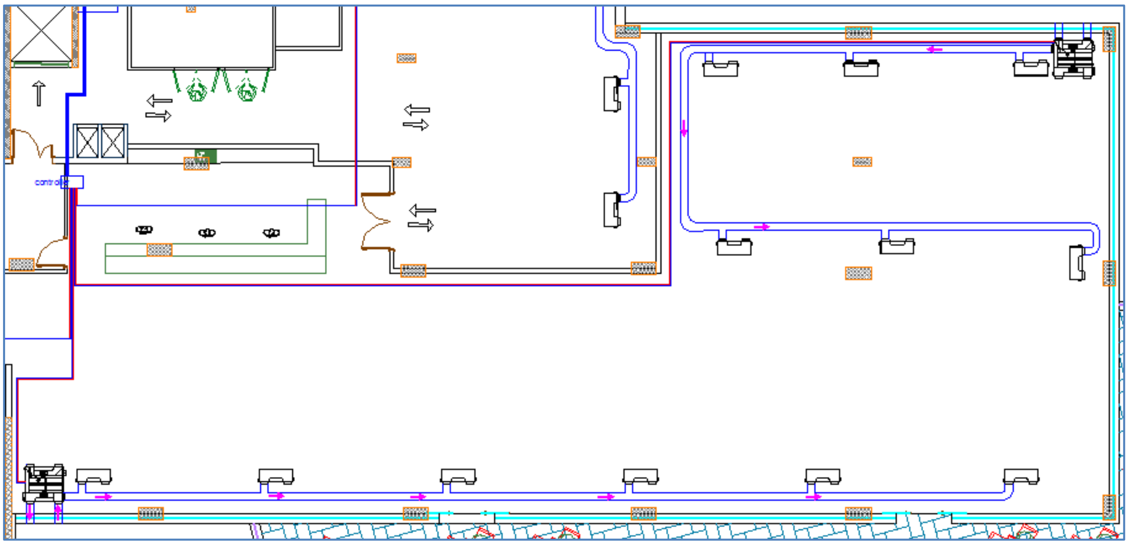


Figure 317: Distribution inside ceiling.

And normal slot for decorated rooms:

Figure 318: slot diffuser unit.

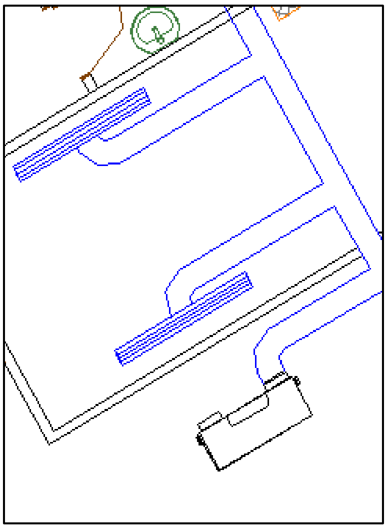


Figure 319: Distribution of Slot Units.

Figure 320: Distribution inside ceiling.

MITSUBISHI Energy Recovery Ventilator type (LGH-F300RX5-E) has been used:

Table 47: Prosperities of “MITSUBISHI” Energy Recovery Ventilator.

Power Source	Voltage, Phase, Cycle	208-230V, 1 Phase, 60Hz
Capacity		1,200 ft³/min (34 m³/min)
Power Consumption		0.810-1.290 kW
Current		3.6-5.7 Ampere
Minimum Circuit Ampacity	MCA	6.9 Ampere
Maximum fuse size (time delay)	MOCP	15 Ampere
Sound Level	(fan speed low-high-extra high) (230V)	32-39-41 dB (A)
Fan Speed	(230V)	Extra High - High - Low
Dimensions H x W x D	Height	65-7/16 Inches (1662 mm)
	Width	48-7/16 Inches (1230 mm)
	Depth	31-1/2 Inches (800 mm)

Figure 321: energy ventilation recovery unit.

3.4. QUANTITY SURVEY AND COST

3.4.1. INTRODUCTION

One of the most important works in a building engineering field is the ability to evaluate and calculate the economic activities in the projects.

The skills, knowledge and science are needed to describe and estimate every item and activity in any project.

3.4.2. CALCULATIONS

Note that all calculation was done on one block, which was designed as full structural design and detailing.

The total area of this is block as shown in the following table:

Table 48: Area of block.

Floor	Area of block
Basement	942
Ground	802
First	455
second	351
third	351
fourth	351
Total	3252

3.4.2.1. EARTH WORKS

From AutoCAD drawing of site and contour analysis the Earth works was done, the following table shows the calculation of excavation, backfilling and disposal of the soil.

Table 49: Earth works.

Excavation, Backfilling & Disposal					
	Excavation		Backfilling		Disposal
	Bank volume m3	loose volume m3	Compacted volume m3	Loose volume m3	Loose volume m3
for ground	63876.70	71531.47	14468	16638.2	-
for footings	1850.00	2071.70	1623	1866.45	-
Total	65726.70	98590.05	16091	18504.65	80085.40

3.4.2.2. CIVIL WORKS

3.4.2.2.1. FOUNDATIONS

3.4.2.2.1.1. Blinding concrete

As shown in the following table the volume of concrete needed for blinding concrete under footing is calculated.

Table 50: Blinding concrete under footings B200.

Footing	Area	Depth	Iteration	Volume of con.
F1	11	0.1	1	1.1
F2	5.5	0.1	1	0.55
F3	11	0.1	1	1.1
F4	6	0.1	1	0.6
F5	7	0.1	1	0.7
F6	5.5	0.1	1	0.55
F7	5.5	0.1	1	0.55
F8	7	0.1	1	0.7
F9	11	0.1	1	1.1
F10	16	0.1	1	1.6
F11	11	0.1	1	1.1
F12	7	0.1	1	0.7
F13	16	0.1	1	1.6
F14	16	0.1	1	1.6
F15	11	0.1	1	1.1
F16	6	0.1	1	0.6
F17	385	0.1	1	38.5
			Total	53.75

Sample calculation for footing (1):

Volume of blinding concrete = 11*0.1 = 1.1 m^3 .

3.4.2.2.1.2. Concrete of footing

As shown in the following table the volume needed of concrete for footing is calculated:

Table 51: Concrete of footing m3.

Footing	length	width	depth	area	volume
F1	4.0	2.5	0.75	10	7.5
F2	3.0	1.5	0.45	4.5	2.025
F3	4.0	2.5	0.7	10	7
F4	2.5	2	0.5	5	2.5
F5	3.0	2	0.6	6	3.6
F6	3.0	1.5	0.55	4.5	2.475

F7	3.0	1.5	0.55	4.5	2.475
F8	3.0	2	0.55	6	3.3
F9	4.0	2.5	0.75	10	7.5
F10	5	3	0.85	15	12.75
F11	4	2.5	0.75	10	7.5
F12	3	2	0.6	6	3.6
F13	5	3	0.95	15	14.25
F14	5	3	0.95	15	14.25
F15	4	2.5	0.7	10	7
F16	2.5	2	0.5	5	2.5
wall.F	_	_	0.5	365.95	182.975
				Total	283.2

Sample calculation for footing (1):

Volume of concrete =4*2.5*0.75 = 7.5 $m^{3.}$

3.4.2.2.1.3. Formwork of footing

As shown in the following table the area needed of formwork for footing is calculated.

Table 52: Formwork of footings.

Footing	Perimeter	depth	No. of footings	Area of Formwork m2
F1	13	0.75	1	9.75
F2	9	0.45	1	4.05
F3	13	0.7	1	9.1
F4	9	0.5	1	4.5
F5	10	0.6	1	6
F6	9	0.55	1	4.95
F7	9	0.55	1	4.95
F8	10	0.55	1	5.5
F9	13	0.75	1	9.75
F10	16	0.85	1	13.6
F11	13	0.75	1	9.75
F12	10	0.6	1	6
F13	16	0.95	1	15.2
F14	16	0.95	1	15.2
F15	13	0.7	1	9.1
F16	9	0.5	1	4.5
wall.F	275	0.5	1	137.5
			Total	269.4

Sample calculation for formwork area of footing (1):

Area = perimeter * depth = 13 * 0.75= 9.75 m^2

3.4.2.2.1.4. Reinforcement steel of footings.

As shown in the following table the weight needed of steel for footing is calculated:

Table 53: Reinforcement steel for footings.

Footing	No. of bars	Length of bar m	ø	Quantity Needed kg
F1	22	2.9	18	127.60
	20	4.4	20	217.28
F2	16	1.9	14	36.78
	16	3.4	14	65.82
F3	20	2.9	18	116.00
	20	4.4	20	217.28
F4	14	2.4	16	53.10
	14	2.9	16	64.16
F5	17	2.4	16	64.47
	20	3.4	16	107.46
F6	15	1.9	16	45.04
	13	3.4	16	69.85
F7	15	1.9	16	45.04
	12	3.4	14	49.36
F8	15	2.4	16	56.89
	17	3.4	16	91.34
F9	18	2.9	20	128.89
	19	4.4	20	206.42
F10	25	3.4	20	209.88
	18	5.4	25	375.00
F11	18	2.9	20	128.89
	19	4.4	20	206.42
F12	17	2.4	16	64.47
	15	3.4	16	80.59
F13	28	3.4	20	235.06
	20	5.4	25	416.67
F14	28	3.4	20	235.06
	17	5.4	25	354.17
F15	20	2.9	18	116.00
	16	4.4	20	173.83
F16	17	2.4	14	49.36
	16	2.9	14	56.14
wall.F	1620	2.75	14	5390.00
	252	6	14	1829.33
			Total	11683.64

Sample calculation for footing (1) reinforcement:

Longitudinal bar (22Ø18) = 22*18^2*2.9 /162 = 127.6 Kg.

Transverse bar (20Ø20) = 20*20^2*4.4 /162 = 217.28 Kg.

3.4.2.2.2. COLUMNS NECKS (C.N)

3.4.2.2.2.1. Formwork of C.N.

As shown in the following table the area needed of formwork for C.N. is calculated:

Table 54: Formwork of Column Nick.

Column nick				
High of C.N	Perimeter of Column neck	No. of columns neck	Area of Formwork m2	
1.2	2.4	16	46.08	
1.2	1.8	10	21.6	
1.2	2.8	3	10.08	
1.2	1.9	1	2.28	
		Total	80.04	m2

Sample calculation for formwork:

Area = height of column neck* #of columns neck * perimeter of col. neck

= 1.2*16*2.4 = 46.08 m^2

3.4.2.2.2.2. Concrete of C.N.

Table 55: Concrete of Column Nick m3.

Height of C.N	Area of Column	No. of columns	Volume of concrete m3	
1.2	0.32	16	6.144	
1.2	0.18	10	2.16	
1.2	0.45	3	1.62	
1.2	0.21	1	0.252	
		Total	10.176	m3

Sample calculation for formwork:

Volume = height of column neck* #of columns neck * area of col. neck

= 1.2*16*0.32 = 6.14m^3

3.4.2.2.2.3. Reinforcement of C.N.

Table 56: Reinforcement and Stirrups of Column Nick.

Reinforcement of C.N				
No. of columns	No. of bars	Length of bar m	ø	Quantity Needed kg
1	60	2.6	20	385.2
1	58	2.6	25	581.8
			Total	6683.5
Stirrups of of C.N				
stirrups no.	ø	No. of columns	Length of stirrups m	Quantity Needed kg
12	10	16	2.2	260.7
12	10	10	1.6	118.5
12	10	3	2.6	57.8
12	10	1	1.7	12.6
			Total	449.6

Sample calculation for C.N reinforcement:

Longitudinal bar for all C.N which have the same specification (60Ø20) = $60*20^2*2.6/162$ = 385.2Kg.

Stirrups =$12*10^2*2.2/162$ = 260.7Kg.

3.4.2.2.3. TIE BEAMS

3.4.2.2.3.1. Formwork and concrete of T.B.

Table 57: Formwork and Concrete for T.B.

Formwork and concrete for T.B						
Beam	Total length	No. of beams	depth	width	concrete m3	Formwork m2
1	263	1	0.6	0.3	47.34	473.4
				Total	47.34	473.4

Sample calculation for tie beam (1) formwork & concrete volume:

Total length = 263 m

Total concrete volume = 263*0.6*0.3 = 47.34 m^3

Total formwork area =1*263*(2*0.6+2*0.3)= 473.4 m^3

3.4.2.2.3.2. Reinforcement of T.B.

Table 58: Reinforcement for Tie Beams.

Reinforcement for Tie Beams				
Beam	No. of bars	ø	Length of bars m	Quantity Needed kg
Beam Top	4	14	295	1427.65
Beam bottom	4	14	295	1427.65
Stirrups	1052	10	1.56	1013.04
			Total	3868.35

<u>Tie beam (1) reinforcement:</u>

Length of all bars with splicing = 295m

No. of top bar = 4 ø14 .

Weight of top bar =295* 14^2 * 4/162.

No. of bottom bar = 4 ø14.

Weight of top bar =295* 14^2 * 4/162.

Stirrups = 21m * 5 / m = 105.

Length of stirrups = 1.56m

No. of stirrups =1052 Ø 10mm.

Weight for stirrups = 1.56*1052* 10^2 /162 = 1013.04Kg.

3.4.2.2.4. SLAB ON GRADE.

3.4.2.2.4.1. Formwork of slab on grade .

Table 59: Slab on grade Formwork

Formwork		
Perimeter	depth	Area m2
135	0.1	13.5

Area of formwork = 135*0.1 =13.5m2.

3.4.2.2.4.2. Concrete of slab on grade.

Table 60: Concrete of slab on grade .

Concrete		
Area	depth	volume m3
942	0.1	94.2

The volume of concrete = area *depth =942*0.1 =94.2 m3.

3.4.2.2.4.3. Reinforcement of slab on grade

Table 61: 3.4.2.2.4.3. Reinforcement of slab on grade.

Reinforcement				
Direction	No. of bars	Length of bar m	ø	Quantity Needed kg
Long Dir.	148	26	8	1520.198
Short Dir.	77	49	8	1490.568
			Total	3010.766

Sample calculation:

1Ø8 mm / 20 cm .So,

No of bars for longitudinal = 148 bar.

No of bars for short =77 bar.

Quantity needed = 77*26* 8^2 /162 = 1520.2Kg.

3.4.2.2.5. COLUMN

3.4.2.2.5.1. Concrete of column

Table 62: Concrete of column.

Concrete				
column	Section	Length	Area	volume m3
C1	80*40	25.2	0.32	8.1
C3	90*50	8.8	0.45	4.0
C4	90*50	8.8	0.45	4.0
C2	80*40	12.9	0.32	4.1
C5	40*80	8.8	0.32	2.8
C9	40*80	25.2	0.32	8.1
C11	80*40	25.2	0.32	8.1
C12	80*40	25.2	0.32	8.1
C8	90*50	25.2	0.45	11.3
C10	80*40	25.2	0.32	8.1
C6	80*40	12.9	0.32	4.1
C7	40*80	8.8	0.32	2.8
C16	80*40	25.2	0.32	8.1
C14	80*40	25.2	0.32	8.1
C15	60*30	25.2	0.18	4.5
C17	60*35	25.2	0.21	5.3
C18	60*30	12.9	0.18	2.3
C24	80*40	8.8	0.32	2.8
C25	60*30	8.8	0.18	1.6
C26	60*30	8.8	0.18	1.6
C27	60*30	8.8	0.18	1.6
C23	80*40	8.8	0.32	2.8
C19	60*30	8.8	0.18	1.6

C22	80*40	8.8	0.32	2.8
C21	80*40	8.8	0.32	2.8
C20	40*80	8.8	0.32	2.8
C31	60*30	8.8	0.18	1.6
C29	60*30	8.8	0.18	1.6
C30	60*30	8.8	0.18	1.6
C28	30*60	8.8	0.18	1.6
C3(after first floor)	80*40	16.4	0.32	5.2
C4(after first floor)	80*40	16.4	0.32	5.2
C23(after first floor)	60*30	16.4	0.18	3.0
			Total	141.9

The volume of concrete (c28) =0.3*0.6*8.8=1.6 m3.

3.4.2.2.5.2. Formwork of column.

Table 63: Formwork of column.

Formwork	
Perimeter of Column	Area of column m2
2.4	60.48
2.8	24.64
2.8	24.64
2.4	30.96
2.4	21.12
2.4	60.48
2.4	60.48
2.4	60.48
2.8	70.56
2.4	60.48
2.4	30.96
2.4	21.12
2.4	60.48
2.4	60.48
1.8	45.36
1.9	47.88
1.8	23.22
2.4	21.12
1.8	15.84
1.8	15.84
1.8	15.84
2.4	21.12
1.8	15.84
2.4	21.12
2.4	21.12
2.4	21.12
1.8	15.84

1.8	15.84
1.8	15.84
1.8	15.84
2.4	39.36
2.4	39.36
1.8	29.52
Total	1104.38

Area of formwork =perimeter *length =1.8*8.8=15.84m2

3.4.2.2.5.3. Reinforcement of column.

1. Longitudinal reinforcement:

Table 64: Longitudinal Reinforcement of column

Longitudinal reinforcement				
column	No. of bars	Length of bar m	ø	Quantity Needed kg
C1	14	32.2	18	901.6
C3	18	11.8	25	819.4
C4	14	11.8	20	407.9
C2	14	16.9	18	473.2
C5	14	11.8	18	330.4
C9	14	32.2	18	901.6
C11	14	32.2	18	901.6
C12	14	32.2	25	1739.2
C8	14	32.2	20	1113.1
C10	14	32.2	25	1739.2
C6	14	16.9	18	473.2
C7	14	11.8	18	330.4
C16	14	32.2	18	901.6
C14	14	32.2	18	901.6
C15	16	32.2	20	1272.1
C17	12	32.2	20	954.1
C18	14	16.9	14	286.3
C24	12	11.8	18	283.2
C25	12	11.8	14	171.3
C26	12	11.8	14	171.3
C27	12	11.8	14	171.3
C23	12	32.2	25	1490.7
C19	12	11.8	14	171.3
C22	14	11.8	18	330.4
C21	14	11.8	18	330.4
C20	14	11.8	18	330.4
C31	12	11.8	18	283.2
C29	12	11.8	14	171.3

C30	12	11.8	14	171.3
C28	12	11.8	14	171.3
C3(after first floor)	18	20.4	25	1416.7
C4(after first floor)	14	20.4	20	705.2
C23(after first floor)	12	20.4	25	944.4
			Total	21760.3

Sample calculation (C15):

Length of bar =32.2m (with taken in consecration the splicing of bar

Quantity needed = 16*32.2* 20^2 /162 = 1272Kg.

2. Stirrups reinforcement.

Table 65: Columns Stirrups Reinforcement.

Stirrups Reinforcement			
stirrups no.	ø	Length of stirrups m	Quantity Needed kg
180	10	3.4	377.8
71	10	4	175.3
71	10	4	175.3
98	10	3.4	205.7
71	10	3.4	149.0
180	10	3.4	377.8
180	10	3.4	377.8
180	10	3.4	377.8
180	10	4	444.4
180	10	3.4	377.8
98	10	3.4	205.7
71	10	3.4	149.0
180	10	3.4	377.8
180	10	3.4	377.8
222	10	2.58	353.6
222	10	2.74	375.5
120	10	2.58	191.1
71	10	3.4	149.0
86	10	2.58	137.0
86	10	2.58	137.0
86	10	2.58	137.0
71	10	3.4	149.0
86	10	2.58	137.0
71	10	3.4	149.0
71	10	3.4	149.0
71	10	3.4	149.0
86	10	2.58	137.0
86	10	2.58	137.0
86	10	2.58	137.0
86	10	2.58	137.0

122	10	3.4	256.0
122	10	3.4	256.0
122	10	2.58	194.3
		Total	7616.2

Sample calculation (C15):

1 ø10 /15 cm and 1 ø10/10 cm on confinement zone.

Length of stirrups =2.58m.

No. of stirrups = 222 ø10.

Quantity needed = 222*2.58* 10^2 /162 = 353.6Kg.

3.4.2.2.6. SLABS AND BEAMS.

Note that:

Slab thickness =30cm

Main beam dimensions = 60*45 cm.

Secondary dimensions = 30*30 cm.

3.4.2.2.6.1. Concrete of slabs with beams.

Table 66: Concrete of slabs with beams.

ground floor and beams(the slab of basement)		first floor and beams (the slab of G.F)		second floor and beams (the slab of FIRST)		3rd,4th,5th floor and beams(the slab ofsec,3rd,4th)	
length of beam	volu me	length of beam	volu me	length of beam	volu me	length of beam	volu me
7.517	1.0	8.137	1.1	7.4	1.00	7.4	1.00
3	0.4	6.967	0.9	8.55	1.15	8.55	1.15
4.42	0.6	7.392	1.0	4.613	0.62	4.613	0.62
6.325	0.9	8.543	1.2	7.934	1.07	7.934	1.07
7.323	1.0	4.613	0.6	7.866	1.06	7.866	1.06
8.133	1.1	7.584	1.0	8.57	1.16	8.57	1.16
6.967	0.9	7.785	1.1	5.17	0.70	5.17	0.70
7.392	1.0	7.934	1.1	4.3	0.58	4.3	0.58
8.543	1.2	7.866	1.1	7.455	1.01	7.455	1.01
7.592	1.0	8.565	1.2	8.228	1.11	8.228	1.11
7.771	1.0	5.169	0.7	4.518	0.61	4.518	0.61
7.934	1.1	4.3	0.6	4.603	0.62	4.603	0.62
7.866	1.1	8.134	1.1	7.919	1.07	7.919	1.07
8.565	1.2	6.969	0.9	6.669	0.90	6.669	0.90
5.169	0.7	7.455	1.0	6.109	0.82	6.109	0.82
8.134	1.1	8.228	1.1	1.75	0.24	1.75	0.24
6.969	0.9	4.518	0.6	2.2	0.30	2.2	0.30

7.455	1.0	4.603	0.6	2.2	0.30	2.2	0.30
8.228	1.1	3.616	0.5	3.75	0.51	3.75	0.51
4.518	0.6	4.17	0.6	1.438	0.19	1.438	0.19
4.603	0.6	1.438	0.2	1.6	0.22	1.6	0.22
3.616	0.5	7.584	1.0	1.615	0.22	1.615	0.22
4.17	0.6	6.967	0.9	4.4	0.59	4.4	0.59
1.438	0.2	7.919	1.1	1.615	0.22	1.615	0.22
6.967	0.9	6.669	0.9	slab +sec.beam area	volume	slab area	volume
7.919	1.1	6.109	0.8	375.92	112.78	289.93	86.98
6.669	0.9	1.75	0.2	Total	126.89	total for 3 stories	309.73
6.109	0.8	2.2	0.3				
3.9	0.5	2.2	0.3				
2.2	0.3	2.2	0.3				
4.3	0.6	8.137	1.1				
2.2	0.3	7.464	1.0				
7.202	1.0	7.207	1.0				
7.22	1.0	7.224	1.0				
3.75	0.5	3.75	0.5				
3.275	0.4	2.747	0.4				
1.621	0.2	3.275	0.4				
1.621	0.2	1.621	0.2				
slab +sec.beam area	volume	5.534	0.7				
783	234.9	5.577	0.8				
Total	264.4	1.8	0.2				
		1.6	0.2				
		1.62	0.2				
		1.62	0.2				
		1.6	0.2				
		4.541	0.6				
		slab +sec.beam area	volume				
		662	198.6				
		Total	231.4				
Total concrete volume for all story =933							

Area of basement slab with secondary beam =783m2.

Thickness =0.3 m.

Volume =0.3*783=234.9m3.

Total Volume of main beams = Total length for every beam *(0.6-0.3)*0.45=29.5m3.

Total Volume of concrete =264.4m3.

3.4.2.2.6.2. Formwork of slabs with beams.

Table 67: ground floor and beams (the slab of basement).

Formwork beams			Formwork slab	Total
Perimeter	depth	Area m2	Area	
217	0.3	65.1	942	1007.1

Table 68: first floor and beams (the slab of G.F).

Formwork beams			Formwork slab	Total
Perimeter	depth	Area m2	Area	
243	0.3	72.9	802	874.9

Table 69: second floor and beams (the slab of FIRST).

Formwork beams			Formwork slab	Total
Perimeter	depth	Area m2	Area	
156	0.3	46.8	455	501.8

Table 70: 3rd,4th,5th floor and beams(the slab ofsec,3rd,4th).

Formwork beams			Formwork slab	Total
Perimeter	dept9h	Area m2	Area	
120	0.3	36	351	387

Sample calculation:

Basement floor:

Area of formwork =Perimeter of all main beams *(its own depth- slab depth) +area of slab and secondary beam = 243*0.3*(0.6-0.3) +942 =1007m2.0

3.4.2.2.6.3. Block used on slabs.

Blocks dimension =0.2*0.4*0.24m

Table (): No. and volume of block in each story		
Story no.	No.	volume
Story 1	8276	159
Story 2	7290	140
Story 3	4095	79
Story 4	3177	61
Story 5	3177	61
Story 6	3177	61
Total	29192	560

Note that: the number of blocks was estimated as shown in previous table by using AutoCAD drawing.

3.4.2.2.6.4. Reinforcement of slabs.

1. Slab mesh:

Table 71: Slabs mesh reinforcement.

grade (mesh)reinforcement .				
Story number	**no. Of bar**	**length**	**ϕ**	**Quantity Needed kg**
STORY1	9	44	8	156
	15	28	8	166
STORY2	8	39	8	123
	13	23	8	118
STORY3	5	34	8	67
	11	16	8	70
STORY4	5	27	8	53
	9	14	8	50
STORY5	5	27	8	53
	9	14	8	50
STORY6	5	27	8	53
	9	14	8	50
			Total	1010

2. Slab top bar, bottom bar and stirrups:

Table 72: Slab top bar, bottom bar and stirrups.

Story number	Quantity of TOP BAR(kg)	Quantity of bottom bar (kg)	Quantity of STIRUPPS(kg)
Story 1	5074.3	5381.9	2602.7
Story 2	3834.0	3860.0	2389.0
Story 3	2717.0	2260.0	2133.0
Story 4	1800.1	1114.0	1792.0
Story 5	1800.1	1114.0	1792.0
Story 6	1800.1	1114.0	1792.0
Total	17025.6	14843.8	12500.7

Note that the number and diameter of bar are available in slab drawing.

3.4.2.2.6.5. Reinforcement of beams

The following table shows the Total Top, bottom, mid and stirrups reinforcement quantity (kg):

Table 73: Reinforcement of beam.

Story number	BOTTOM BAR(kg)	TOP BAR(kg)	MID.BAR(kg)	STIRUPPS(kg).
Story 1	4227.3	1336.0	465.0	2967.0
Story 2	4712.5	1605.0	550.0	3500.0
Story 3	2690.0	991.0	197.5	2200.2
Story 4	7805.9	1720.0	531.6	1718.5
Story 5	7805.9	1720.0	531.6	1718.5
Story 6	7805.9	1720.0	531.6	1718.5
Total	35047.5	9092.0	2807.4	13822.6

The following tables shown below the method that used to calculate the previous bar weight and quantity:

<u>Sample of top bar reinforcement for 3rd floor:</u>

Table 74: Top Bar Reinforcement for 3rd floor.

3rd =4th=5th floor beams(the beams of second slab)					
Reinforcement top					
NO. of extended Top bar	NO. of edge Top bar	length of extended bar	length of edge top bar	ф	Quantity Needed kg
3	3	9.9	4.4	14	51.82
3	3	4.8	0.0	16	22.52
3	3	2.6	0.0	14	9.30
3	5	4.4	0.0	16	20.90
3	5	4.4	0.0	18	26.22
3	5	4.8	0.0	18	28.57
3	3	2.9	0.0	14	10.43
3	3	2.4	0.0	14	8.67
3	4	4.1	0.0	16	19.63
3	4	4.6	0.0	16	21.67
3	3	2.5	0.0	14	9.11
3	3	6.1	1.8	14	28.93
3	4	10.6	2.9	14	52.55
3	3	3.7	0.0	14	13.45
3	3	3.4	0.0	14	12.32
3	3	2.3	0.7	14	10.97
3	3	1.2	0.0	14	4.44
3	3	1.2	0.0	14	4.44
3	3	5.0	1.6	14	23.77
3	3	0.8	0.0	14	2.90

3	3	0.9	0.0	14	3.23
3	3	0.9	0.0	14	3.26
3	3	2.4	0.0	14	8.87
3	3	0.9	0.0	14	3.26
3	1	27.4	7.1	12	79.41
3	1	0.7	0.0	12	1.96
3	1	6.4	0.8	12	17.84
3	1	4.6	0.7	12	12.88
3	1	2.0	0.3	12	5.47
3	1	1.7	0.0	12	4.48
3	1	4.6	0.7	12	12.86
3	1	6.9	0.9	14	26.27
3	1	2.2	0.0	12	5.89
3	1	1.8	0.0	12	4.89
			Total	To tal	573.18

Sample of bottom bar reinforcement for 3rd floor:

Table 75: bottom bar reinforcement for 3rd floor.

3rd =4th=5th floor beams(the beams of second slab)				
Reinforcement bottom				
beam label	NO. of Bottom bar	length of bar	ϕ	Quantity Needed kg
M.B (21)	6	10	14	71.62
M.B (19)	6	14.3	18	171.00
M.B (16)	6	7.7	14	55.81
M.B (32)	8	13.2	20	261.20
M.B (31)	8	13.1	20	258.96
M.B (35)	8	14.3	20	282.14
M.B (36)	6	8.6	16	81.70
M.B (28)	6	7.2	14	52.02
M.B (42)	7	12.4	18	173.95
M.B (45)	7	13.7	18	191.99
M.B (46)	6	7.5	14	54.66
M.B (43)	6	6.1	14	44.55
M.B (57)	7	10.6	18	147.82
M.B (56)	6	11.1	16	105.39
M.B (54)	6	10.2	14	73.91
M.B (55)	6	2.3	14	16.94
M.B (53)	6	3.7	14	26.62
M.B (73)	6	3.7	14	26.62
M.B (82)	6	5.0	14	36.30
M.B (63)	6	2.4	14	17.40
M.B (10)	6	2.7	16	25.28

M.B (13)	6	2.7	16	25.52
M.B(83)	6	7.3	14	53.23
M.B (14)	6	2.7	14	19.54
S.B (4)	4	27.4	14	132.59
S.B (8)	4	2.2	16	13.96
S.B (37)	4	6.4	12	22.80
S.B (50)	4	4.6	12	16.36
S.B (48)	4	5.9	12	20.81
S.B (51)	4	5.0	12	17.92
S.B (49)	4	4.6	12	16.34
S.B (69)	4	6.9	16	43.90
S.B (64)	4	6.6	12	23.57
S.B (65)	4	5.5	12	19.54
			Total	2601.98

Sample of mid.bar reinforcement for 3rd floor:

Table 76: Mid.bar Reinforcement .

Table (): reinforcement mid.bar			
No bar	length	ϕ	Quantity Needed kg
2	6.8	12	7.77
2	7.6	12	8.99
2	7.6	12	10.14
2	9.6	12	6.21
2	9.6	12	8.59
2	9.6	12	9.53
2	7.6	12	9.47
2	7.6	12	10.17
2	8.6	12	6.77
2	8.6	12	5.10
2	7.6	12	7.77
2	6.8	12	9.06
2	7.8	12	9.83
2	7.6	12	6.12
2	7.6	12	5.40
2	6.8	12	7.77
2	7.6	12	9.52
2	7.6	12	8.27
2	6.8	12	7.71
2	7.6	12	3.35
2	7.6	12	3.80
2	7.6	12	3.80
2	7.6	12	6.00
2	7.6	12	6.00
		Total	177.12

Sample of stirrups reinforcement for 3rd floor:

Table 77: Stirrups Reinforcement for 3rd floor.

3rd =4th=5th floor beams(the beams of second slab)			
Stirupps			
stirrups no.	ø	Length of stirrups(m)	Quantity Needed kg
57	10	2.55	89.60
66	10	2.55	103.53
35	10	2.55	55.86
61	10	2.55	96.07
61	10	2.55	95.24
66	10	2.55	103.77
40	10	2.55	62.60
33	10	2.55	52.07
57	10	2.55	90.27
63	10	2.55	99.63
35	10	2.55	54.71
35	10	2.55	55.73
61	10	2.55	95.89
51	10	2.55	80.75
47	10	2.55	73.97
13	10	2.55	21.19
17	10	2.55	26.64
17	10	2.55	26.64
29	10	2.55	45.41
11	10	2.55	17.41
12	10	2.55	19.37
12	10	2.55	19.55
34	10	2.55	53.28
12	10	2.55	19.55
158	10	1.04	101.47
10	10	1.04	6.54
37	10	1.04	23.75
27	10	1.04	17.04
27	10	1.04	17.34
23	10	1.04	14.93
27	10	1.04	17.02
40	10	1.04	25.72
31	10	1.04	19.64
25	10	1.04	16.29
		Total	1718.46

3.4.2.2.7. STAIRS.

3.4.2.2.7.1. Square Stairs.

Table 78: Concrete, Formwork and Reinforcement for Square Stairs.

Concrete				
Area of stair	length	No. of stairs	Volume of بسطة	Volume of concrete m3
0.048	1.3	159	6.4896	22.9008
Formwork m2				
طوبار المراي	طوبار الشاحط	طوبار البسطة	مجموع الطوبار	كامل
5	8.5	4.5	36	360
reinforcement				
No. of bars	ø	L	weight kg	For all story
5	16	6.5	51.358	
11	12	0.8	7.822	
5	12	1.9	8.444	
28	8	1.2	13.274	
1	8	0.8	0.316	
6	16	1.9	18.015	
8	12	1.2	8.533	
		Total	107.763	1724.207

3.4.2.2.7.2. Rectangular Stairs.

Table 79: Concrete, Formwork and Reinforcement for Rectangular Stairs.

Concrete				
Area of stair	length	No. of stairs	Volume of بسطة	Volume of concrete m3
0.048	0.9	141	5.76	17.6112
Formwork m2				
طوبار المراي	طوبار الشاحط	طوبار البسطة	مجموع الطوبار	
5	8.2	4	34.4	481.6
reinforcement				
No. of bars	ø	L	weight kg	For all story
5	16	5	39.506	
11	12	1.2	11.733	
5	12	1.2	5.333	
28	8	1.2	13.274	
1	8	1.2	0.474	
6	16	1.2	11.378	
8	12	1.2	8.533	
		Total	81.699	1960.77037

3.4.2.2.8. WALLS

3.4.2.2.8.1. Concrete and formwork

Table 80: Walls Concrete and formwork.

concrete					formwork
length of wall	height of wall	thickness	Volume		area
77	4.1	0.2	63.14		315.7
44.5	25.2	0.2	224.28		1121.4
75	4.1	0.2	61.5		307.5
		Total	349	Total	1744.6

3.4.2.2.8.2. Reinforcement of walls

Table 81: Walls Reinforcement.

horizontal bar				Vertical reinforcement .					
Length of bar	no.of bar	ø	Quantity Needed kg	length of wall	height of wall	length of bar	no.of bar	ø	Quantity Needed kg
77	16	14	1490.57	77	4.1	6	7	18	6468
75	16	14	1451.85	77	4.1	6	2	10	570
		To tal	2942.42	36	25.2	32.2	10	12	10304
				75	4.1	6	7	14	3811
				75	4.1	6	2	10	556
				3.5	25.2	32.2	2	12	200
				4	25.2	32.2	14	16	2850
				1	25.2	32.2	14	16	712
							Total		25471

3.4.2.3. ARCHITECTURAL WORKS.

3.4.2.3.1. INTERNAL PARTITIONS BLOCKS AND THE VOLUME OF MORTAR NEEDED.

Table 82: Internal partitions blocks(20cm) & mortar for Ground floor.

Ground floor									
Internal partitons blocks(20cm) & mortar									
Wall	length	area walls	# doors	area of door	# of wind	window area	total area	#of blocks	volume of mortar
w1	7.3	34.31	0	0	0	0	34.31	412	0.50
w2	7.6	35.72	0	0	0	0	35.72	429	0.52
w3	3.4	15.98	1	4.05	0	0	11.93	143	0.17
w4	9.174	43.1178	1	1.76	0	0	41.3578	496	0.61

w5	5.7	26.79	1	4.05	0	0	22.74	273	0.33
w6	2.15	10.105	0	0	0	0	10.105	121	0.15
w7	6.4	30.08	0	0	0	0	30.08	361	0.44
w8	4.7	22.09	2	3.15	0	0	15.79	189	0.23
w9	3.3	15.51	0	0	0	0	15.51	186	0.23
w10	3.55	16.685	1	2	0	0	14.685	176	0.21
w11	3.2	15.04	0	0	0	0	15.04	180	0.22
w12	2.3	10.81	0	0	0	0	10.81	130	0.16
w13	3.45	16.215	0	0	0	0	16.215	195	0.24
w14	1.8	8.46	0	0	0	0	8.46	102	0.12
w15	1.65	7.755	0	0	0	0	7.755	93	0.11
w16	3.8	17.86	0	0	0	0	17.86	214	0.26
w17	1.75	8.225	1	2	0	0	6.225	75	0.09
w18	4.1	19.27	0	0	0	0	19.27	231	0.28
w19	3.6	16.92	2	2	0	0	12.92	155	0.19
w20	1.95	9.165	2	1.76	0	0	5.645	68	0.08
w21	1.5	7.05	0	0	0	0	7.05	85	0.10
							Total	4314	5.26

Table 83: Internal partitions blocks (20cm) & mortar for First floor.

First floor									
Internal partitons blocks(20cm) & mortar									
Wall	length	area walls	# doors	area of door	# of wind	window area	total area	#of blocks	volume of mortar
w1	6.7	27.47	1	2	0	0	25.47	306	0.37
w2	3.5	14.35	0	0	0	0	14.35	172	0.21
w3	4.5	18.45	0	0	0	0	18.45	221	0.27
w4	3.4	13.94	4	1.76	0	0	6.9	83	0.10
w5	1.2	4.92	0	0	0	0	4.92	59	0.07
w6	3.5	14.35	1	2	0	0	12.35	148	0.18
w7	3	12.3	1	2	0	0	10.3	124	0.15
w8	3.5	14.35	1	2	0	0	12.35	148	0.18
w9	1.2	4.92	0	0	0	0	4.92	59	0.07
w10	3.8	15.58	0	2	0	0	15.58	187	0.23
w11	3.5	14.35	0	0	0	0	14.35	172	0.21
w12	4.5	18.45	0	0	0	0	18.45	221	0.27
w13	3.5	14.35	0	0	0	0	14.35	172	0.21
w14	2.8	11.48	1	2	0	0	9.48	114	0.14
w15	3.5	14.35	0	0	0	0	14.35	172	0.21
w16	0.75	3.075	0	0	0	0	3.075	37	0.05
w17	3.5	14.35	0	0	0	0	14.35	172	0.21
w18	2	8.2	1	2.76	0	0	5.44	65	0.08
w19	2.3	9.43	1	2	0	0	7.43	89	0.11
w20	7.5	30.75	0	0	0	0	30.75	369	0.45
w21	4.37	17.917	0	0	0	0	17.917	215	0.26
							Total	3306	2.02

Table 84: Internal partitions blocks (20cm) & mortar for 2nd,3rd and 4th floor.

second,3rd,4th floor									
Internal partitions blocks(20cm) & mortar									
Wall	length	area walls	# doors	area of door	# of wind	window area	total area	#of blocks	volume of mortar
w1	3.65	14.97	0	0	0	0	14.965	180	0.22
w2	3.65	14.97	0	0	0	0	14.965	180	0.22
w3	0.9	3.69	0	0	0	0	3.69	44	0.05
w4	5.5	22.55	1	2	0	0	20.55	247	0.30
w5	1.75	7.18	1	2	0	0	5.175	62	0.08
w6	1.13	4.63	0	0	0	0	4.633	56	0.07
w7	2.15	8.82	0	0	0	0	8.815	106	0.13
w8	11.2	45.92	1	2	0	0	43.92	527	0.64
w9	3.11	12.75	1	2	0	0	10.751	129	0.16
w10	1.25	5.13	0	0	0	0	5.125	62	0.08
w11	2.2	9.02	0	0	0	0	9.02	108	0.13
w12	5.2	21.32	0	0	0	0	21.32	256	0.31
w13	1.8	7.38	0	0	0	0	7.38	89	0.11
w14	3.95	16.20	1	2	0	0	14.195	170	0.21
w15	3.1	12.71	0	0	0	0	12.71	153	0.19
w16	1.2	4.92	1	2	0	0	2.92	35	0.04
w17	3.15	12.92	0	0	0	0	12.915	155	0.19
w18	8.2	33.62	1	2	0	0	31.62	379	0.46
w19	4.12	16.89	1	2	0	0	14.892	179	0.22
w20	8	32.80	0	0	0	0	32.8	394	0.48
w21	2.3	9.43	0	0	0	0	9.43	113	0.14
w22	4.85	19.89	0	0	0	0	19.885	239	0.29
w23	5	20.50	0	0	0	0	20.5	246	0.30
w24	5.72	23.45	1	2.76	0	0	20.692	248	0.30
w25	6.7	27.47	1	2	0	0	25.47	306	0.37
w26	2.61	10.70	0	0	0	0	10.701	128	0.16
							Total	4788	5.84
						Total 3 stories		14365	17.53

3.4.2.3.2. EXTERNAL PARTITIONS BLOCKS AND THE VOLUME OF MORTAR NEEDED.

Table 85: External blocks & mortar for all floors.

Wall	Length	Area walls	# doors	area door	# of wind	area of windows	Total area	# of blocks	Vol. of mort
Ground floor									
WE1	5.5	25.85	0	0	1	1.8	24.05	289	0.3
WE2	13.3	62.51	0	0	2	1.8	58.91	707	0.4
WE3	3	14.1	0	0	0	0	14.1	169	0.1
WE4	2.75	12.93	0	0	1	1.8	11.13	134	0.1
WE5	1.43	6.721	0	0	0	0	6.721	81	0.0
WE6	3.3	15.51	1	2	0	0	13.51	162	0.1
WE7	3.1	14.57	0	0	0	0	14.57	175	0.1
WE8	2	9.4	0	0	0	0	9.4	113	0.1
First floor									
WE9	24	98.4	0	0	0	0	98.4	1181	0.7
WE10	16	65.6	0	0	0	0	65.6	787	0.7
WE11	3.9	15.99	0	0	0	0	15.99	192	0.1
WE12	5.2	21.32	0	0	0	0	21.32	256	0.2
WE13	13.9	56.99	0	0	0	0	56.99	684	0.4
WE14	21.9	89.79	0	0	0	0	89.79	1077	0.7
WE15	9.4	38.54	0	0	0	0	38.54	462	0.3
WE16	2.5	10.25	0	0	0	0	10.25	123	0.1
WE17	3	12.3	0	0	0	0	12.3	148	0.1
WE18	2.7	11.07	0	0	0	0	11.07	133	0.1
WE19	1.5	6.15	0	0	0	0	6.15	74	0.1
WE20	5.5	22.55	0	0	0	0	22.55	271	0.2
WE21	2.1	8.61	0	0	0	0	8.61	103	0.1
WE22	8.6	35.26	0	0	2	1.2	32.86	394	0.2
Second ,3rd,4th floor									
WE23	16.2	66.42	0	0	0	0	66.42	797	0.5
WE24	14.9	61.09	0	0	0	0	61.09	733	0.4
WE25	16	65.6	0	0	0	0	65.6	787	0.5
WE26	12	49.2	0	0	0	0	49.2	590	0.4
WE27	22.2	91.02	0	0	1	1.8	89.22	1071	0.7
WE28	5.2	21.32	0	0	0	0	21.32	256	0.2
WE29	16.3	66.83	0	0	0	0	66.83	802	0.5
WE30	3	12.3	0	0	0	0	12.3	148	0.1
WE31	8.7	35.67	0	0	2	1.2	33.27	399	0.2
WE32	1.5	6.15	0	0	0	0	6.15	74	0.0
WE33	1.5	6.15	0	0	0	0	6.15	74	0.0
WE34	3.4	13.94	0	0	0	0	13.94	167	0.1
WE35	2.5	10.25	0	0	0	0	10.25	123	0.1
WE36	5.2	21.32	0	0	1	1.8	19.52	234	0.1
						Total for all story	2206.586	26479.032	16.7

3.4.2.3.3. PLASTERING AND PAINTING.

Table 86: Plastering and Painting for Basement floor.

Basement floor							
Wall	length	area walls	# doors	area of door	# of wind	window area	total area
WB1	77	315.7	0	0	0	0	315.7
WB2	75	307.5	0	0	0	0	307.5
						Total	623.2

Table 87: Plastering and Painting for Ground floor.

Ground floor							
Wall	length	area walls	# doors	area of door	# of wind	window area	total area
w1	7.3	68.62	0	0	0	0	68.62
w2	7.6	71.44	0	0	0	0	71.44
w3	3.4	31.96	1	4.05	0	0	27.91
w4	9.174	86.2356	1	1.76	0	0	84.4756
w5	5.7	53.58	1	4.05	0	0	49.53
w6	2.15	20.21	0	0	0	0	20.21
w7	6.4	60.16	0	0	0	0	60.16
w8	4.7	44.18	2	3.15	0	0	37.88
w9	3.3	31.02	0	0	0	0	31.02
w10	3.55	33.37	1	2	0	0	31.37
w11	3.2	30.08	0	0	0	0	30.08
w12	2.3	21.62	0	0	0	0	21.62
w13	3.45	32.43	0	0	0	0	32.43
w14	1.8	16.92	0	0	0	0	16.92
w15	1.65	15.51	0	0	0	0	15.51
w16	3.8	35.72	0	0	0	0	35.72
w17	1.75	16.45	1	2	0	0	14.45
w18	4.1	38.54	0	0	0	0	38.54
w19	3.6	33.84	2	2	0	0	29.84
w20	1.95	18.33	2	1.76	0	0	14.81
w21	1.5	14.1	0	0	0	0	14.1
WE1	5.5	25.85	0	0	1	1.8	24.05
WE2	13.3	62.51	0	0	2	1.8	58.91
WE3	3	14.1	0	0	0	0	14.1
WE4	2.75	12.925	0	0	1	1.8	11.125
WE5	1.43	6.721	0	0	0	0	6.721
WE6	3.3	15.51	1	2	0	0	13.51
WE7	3.1	14.57	0	0	0	0	14.57
WE8	2	9.4	0	0	0	0	9.4
ceiling	0	0	0	0	0	0	802

Table 88: Plastering and Painting for First floor.

First floor							
Wall	length	area walls	# doors	area of door	# of wind	window area	total area
w1	6.7	54.94	1	2	0	0	52.94
w2	3.5	28.7	0	0	0	0	28.7
w3	4.5	36.9	0	0	0	0	36.9
w4	3.4	27.88	4	1.76	0	0	20.84
w5	1.2	9.84	0	0	0	0	9.84
w6	3.5	28.7	1	2	0	0	26.7
w7	3	24.6	1	2	0	0	22.6
w8	3.5	28.7	1	2	0	0	26.7
w9	1.2	9.84	0	0	0	0	9.84
w10	3.8	31.16	0	2	0	0	31.16
w11	3.5	28.7	0	0	0	0	28.7
w12	4.5	36.9	0	0	0	0	36.9
w13	3.5	28.7	0	0	0	0	28.7
w14	2.8	22.96	1	2	0	0	20.96
w15	3.5	28.7	0	0	0	0	28.7
w16	0.75	6.15	0	0	0	0	6.15
w17	3.5	28.7	0	0	0	0	28.7
w18	2	16.4	1	2.76	0	0	13.64
w19	2.3	18.86	1	2	0	0	16.86
w20	7.5	61.5	0	0	0	0	61.5
w21	4.37	35.834	0	0	0	0	35.834
WE9	24	98.4	0	0	0	0	98.4
WE10	16	65.6	0	0	0	0	65.6
WE11	3.9	15.99	0	0	0	0	15.99
WE12	5.2	21.32	0	0	0	0	21.32
WE13	13.9	56.99	0	0	0	0	56.99
WE14	21.9	89.79	0	0	0	0	89.79
WE15	9.4	38.54	0	0	0	0	38.54
WE16	2.5	10.25	0	0	0	0	10.25
WE17	3	12.3	0	0	0	0	12.3
WE18	2.7	11.07	0	0	0	0	11.07
WE19	1.5	6.15	0	0	0	0	6.15
WE20	5.5	22.55	0	0	0	0	22.55
WE21	2.1	8.61	0	0	0	0	8.61
WE22	8.6	35.26	0	0	2	1.2	32.86
ceiling	0	0	0	0	0	0	455

Table 89: Plastering and Painting for 2nd, 3rd and 4th floor.

second ,3rd,4th floor							
Wall	length	area walls	# doors	area door	# of wind	window area	total area
w1	3.65	29.93	0	0	0	0	29.93
w2	3.65	29.93	0	0	0	0	29.93
w3	0.9	7.38	0	0	0	0	7.38
w4	5.5	45.10	1	2	0	0	43.1
w5	1.75	14.35	1	2	0	0	12.35
w6	1.13	9.27	0	0	0	0	9.266
w7	2.15	17.63	0	0	0	0	17.63
w8	11.2	91.84	1	2	0	0	89.84
w9	3.11	25.50	1	2	0	0	23.502
w10	1.25	10.25	0	0	0	0	10.25
w11	2.2	18.04	0	0	0	0	18.04
w12	5.2	42.64	0	0	0	0	42.64
w13	1.8	14.76	0	0	0	0	14.76
w14	3.95	32.39	1	2	0	0	30.39
w15	3.1	25.42	0	0	0	0	25.42
w16	1.2	9.84	1	2	0	0	7.84
w17	3.15	25.83	0	0	0	0	25.83
w18	8.2	67.24	1	2	0	0	65.24
w19	4.12	33.78	1	2	0	0	31.784
w20	8	65.60	0	0	0	0	65.6
w21	2.3	18.86	0	0	0	0	18.86
w22	4.85	39.77	0	0	0	0	39.77
w23	5	41.00	0	0	0	0	41
w24	5.72	46.90	1	2.76	0	0	44.144
w25	6.7	54.94	1	2	0	0	52.94
w26	2.61	21.40	0	0	0	0	21.402
WE23	16.2	66.42	0	0	0	0	66.42
WE24	14.9	61.09	0	0	0	0	61.09
WE25	16	65.60	0	0	0	0	65.6
WE26	12	49.20	0	0	0	0	49.2
WE27	22.2	91.02	0	0	1	1.8	89.22
WE28	5.2	21.32	0	0	0	0	21.32
WE29	16.3	66.83	0	0	0	0	66.83
WE30	3	12.30	0	0	0	0	12.3
WE31	8.7	35.67	0	0	2	1.2	33.27
WE32	1.5	6.15	0	0	0	0	6.15
WE33	1.5	6.15	0	0	0	0	6.15
WE34	3.4	13.94	0	0	0	0	13.94
WE35	2.5	10.25	0	0	0	0	10.25
WE36	5.2	21.32	0	0	1	1.8	19.52
ceiling	0	0	0	0	0	0	351
						Total	1691.098
						total for 3 stories	5073.294

3.4.2.3.4. TILING

By using AutoCAD drawing area of tiling has been calculated.

Table 90: Tiling for all floors.

Floor	Area of floor	Area of wall (W.c)
Basement floor	942	0
Ground floor	802	0
First floor	455	192.7
Second floor	351	135.3
Third floor	351	135.3
Fourth floor	351	135.3
		ceramic tile
Total	2310	598.6

3.4.2.3.5. DOORS AND WINDOWS

Table 91: Doors and Windows.

doors type	Height (m)	width (m)	N	parameterحلق (m)	area door (m^2)
(1) wood	2.25	2	2	13	9
(2) wood	2.25	0.8	7	37.1	12.6
(3) wood	2.25	1.8	2	12.6	8.1
(4) wood	2.25	0.9	35	189	70.875
(5) wood	2.25	1.2	4	22.8	10.8
(6) wood	2.25	1.4	2	11.8	6.3
(7) steel	2.7	4	1	9.4	10.8
				Total	128.475

doors type	عدد حلوق	سعر الحلق $	∑ $
(1) wood	52	45	2340
(2) steel	1	70	70

براطيش شبابيك m^2 /$40				
window type	width (m)	n	width*n (m)	area (m^2)
1	1.5	10	15	5.25
2	1	8	8	2.8
3	-	-	-	40
			∑ area	48

3.4.3. COST ESTIMATE

The following table shows the cost and the quantity for each activity.

Note that: civil and architectural works has been calculated for one block, which has total area 3252 m2 and the other work activities done for the whole building which has 13925m2 as full area.

Table 92: The Total cost and final quantity used in building.

ID	Item	Unit	material			Labor		Total cost ($)
			Final Quantity	unit cost ($)	Total cost ($)	unit cost	Total cost ($)	
1	Earth works							
	Excavation	m^3	65726.70	13.2	867592.4		0.0	867592.4
	Backfill works	m^3	18504.65	9.5	175794.2		0.0	175794.2
	Disposing works	m^3	80085.40	2	160170.8		0.0	160170.8
	Total							1203557.4
2	Civil Works							
	Foundations							
	Footings							
	Blinding concrete under footings B200	m^3	53.75	60	3225.0		0.0	3225.0
	Formwork of footings	m^2	269.40		0.0	12	3232.8	3232.8
	Steel reinforcement of footings	ton	11.68	760	8876.8		0.0	8876.8
	Concrete for footing	m^3	283.20	100	28320.0		0.0	28320.0
	Column's Necks (C.N)							
	Formwork	m^2	80.04		0.0	12.	960.5	960.5

	of C.N					0		
	Steel reinforcement of C.N	ton	7.13	760	5418.8		0.0	5418.8
	Concrete for C.N	m^3	10.18	100	1017.6		0.0	1017.6
	Tie Beams (T.B)							
	Formwork of T.B	m^2	473.00		0.0	12	5676.0	5676.0
	Steel reinforcement of T.B	ton	3.87	760	2941.2		0.0	2941.2
	Concrete for T.B	m^3	94.20	100	9420.0		0.0	9420.0
	Slab on grade (S.G)							
	Formwork of S.G	m^2	13.50		0.0	12	162.0	162.0
	Steel reinforcement of S.G	ton	3.00	760	2280.0		0.0	2280.0
	Concrete for S.G	m^3	24.40	100	2440.0		0.0	2440.0
	G.F stair							
	Formwork of stairs	m^2	840.00		0.0	12	10080.0	10080.0
	Reinforcement of stairs	Ton	3.68	760	2796.8		0.0	2796.8
	Concrete for stairs	m^3	1.64	100	164.2		0.0	164.2
	Formwork of columns	m^2	1105.00		0.0	12	13260.0	13260.0
	Steel reinforcement of columns	ton	29.40	760	22344.0		0.0	22344.0
	Concrete for columns	m^3	142.00	100	14200.0		0.0	14200.0
	slab +beams							
	Formwork of slab +beams	m^2	3545.00		0.0	12	42540.0	42540.0
	Steel	ton	40.66	760	30901.6		0.0	30901.6

	reinforcement of beams							
	Steel reinforcement of slab	ton	45.38	760	34488.8		0.0	34488.8
	Blocks 24cm for slab	No.	29192.00	0.5	14596.0		0.0	14596.0
	Concrete placing for slab	m^3	935.00	100	93500.0		0.0	93500.0
	Walls							
	Formwork of slab +beams	m^2	1745.00		0.0	12	20940.0	20940.0
	Steel reinforcement of beams	ton	28.40	760	21584.0		0.0	21584.0
	Concrete placing for slab	m^3	349.00	100	34900.0		0.0	34900.0
	Total for one block							430266.1
3	Architectural works							
	Ground floor							
	Plastering works							
	Internal plaster	m^2	8292.00	3	24876.0	3.0	24876.0	49752.0
	walls				0.0		0.0	0.0
	15 cm block works (external)	Piece	26479.00	0.4	10591.6		0.0	10591.6
	20 cm block works (internal)	Piece	21986.00	0.6	13191.6		0.0	13191.6
	Stones	m^2	1340.00	150	201000.0		0.0	201000.0
	mortar external partitions	m^3	16.70	50	835.0	3.5	58.5	893.5
	mortar internal partitions	m^3	24.81	50	1240.5	3.5	86.8	1327.3

	concrete for external walls	m^3	19.14	60	1148.4		0.0	1148.4
	Glass	m^2	1640.00	200	328000.0		0.0	328000.0
	tile works							
	Basement floor	m^2	942.00	60	56520.0	8.0	7536.0	64056.0
	tiles works	m^2	2310.00	50	115500.0	6.0	13860.0	129360.0
	tiles works	m^2	598.00	50	29900.0	7.0	4186.0	34086.0
	Painting works							
	internal painting works	m^2	26479.00	5	132395.0		0.0	132395.0
	شبابيك براطيش	m^2	48.00	40	1920.0		0.0	1920.0
	ابواب حلوق حديد	No.	2.00	70	140.0		0.0	140.0
	ابواب حلوق خشب	No.	52.00	50	2600.0		0.0	2600.0
	خشب ابواب	m^2	118.00	700	82600.0		0.0	82600.0
	حديد ابواب	m^2	10.80	800	8640.0		0.0	8640.0
	Total for one block							1061701.4
4	Mechanical works for whole building	m2	13925.00	110	1531750		0.0	1531750
5	Electrical work for whole building	m2	13925.00	60	835500		0.0	835500
6	safety	m2	13925.00	30	417750		0.0	417750

The following table below summarized the total cost of building:

Table 93: Summarization of the total cost of the building.

Type of work	unit	area	total cost for specific area	unit cost	Total cost ($)
Excavation works	m^2	13925.00	1203557.4	86.4	1203557.4
civil works	m^2	3252.00	430266	132.3	1842390.5
architectural works	m^2	3252.00	1061701	326.5	4546182.8
mechanical work	m^2	13925.00	1531750	110.0	1531750
Electrical works	m^2	13925.00	835500	60.0	835500
safety work	m2	13925.00	417750	30.0	417750
Total cost	m^2	13925.00	_	745.2	10377130.7

The total cost of the building is 10,377,130.7$ = 39245789.45 NIS.

The cost of the 1 meter square = 745.2 $ /m2.

Note that the decorative works and landscape (gardens) works did not calculate.

So, there is a range between this number (745.2$/m2) and the stander number which is about (1000-1200$/m2) for the four Stars hotel.

(http://www.turnerandtownsend.com/construction-cost-2012/TT_ICC_Report_Single_Pages_j98ul.pdf.file , 2016)

CHAPTER

4. Conclusion

Conclusion

The hotel is designed as a 4-stars hotel to serve 60 bedroom in four bedrooms floors and aground floor in addition to the basement and a separated wedding hall up to 240 person with its own parking. The hotel can afford up to 70 car parking.

The requirements for the people with special needs were included in terms of ramp for easy access and special rooms which have bigger entrance.

The hotel is mainly oriented to the south to the main view Nablus city and the main entrance on the north.

Environmental systems were designed in the hotel such as shading system (louvers). However the total heating and cooling loads per one meter square in the hotel is 190 KW without domestic hot water which is acceptable. On the other hand, 20cm blocks have been used to minimize the sound transition between spaces and acoustical panels have been used to minimize reverberation as needed.

The structural system is one way ribbed slab and two way ribbed slab with dropped beams, and the columns dimension and shape are selected according to their loads and function. However some columns are added or enlarged for seismic aspect or to improve drop beams layout.

Wall footing and isolated footing have been used sizes were relatively high due the large spans and areas. On the other hand all parts of the hotel are designed to resist earthquakes.

The used HVAQ system was VRF system (variable refrigerant flow) which gives better control in the temperature but without fresh air so ventilators recovery system have been added in areas which need ventilation like restaurant, gym and other spaces .

And finally the quantity survey and cost estimate are leads to the following results:

Table 94: The total cost of the building.

Type of work	unit	area	total cost for specific area	unit cost	Total cost ($)
Excavation works	m^2	13925.00	1203557.4	86.4	1203557.4
civil works	m^2	3252.00	430266	132.3	1842390.5
architectural works	m^2	3252.00	1061701	326.5	4546182.8
mechanical work	m^2	13925.00	1531750	110.0	1531750
Electrical works	m^2	13925.00	835500	60.0	835500
safety work	m2	13925.00	417750	30.0	417750
Total cost	m^2	13925.00	_	745.2	10377130.7

The total cost of the building is 10,377,130.7$ = 39245789.45 NIS.

The cost of the 1 meter square = 745.2 $ /m2.

Note that the decorative works and landscape (gardens) works did not calculate.

So, there is a range between this number (745.2$/m2) and the stander number which is about (1000-1200$/m2) for the four Stars hotel.

(http://www.turnerandtownsend.com/construction-cost-2012/TT_ICC_Report_Single_Pages_j98ul.pdf.file , 2016)

References:

- محمود جيلاني. المرجع في التركيبات والتصميمات الكهربائية (2010)
- Arthur Nilson , David Darwin , Charles Dolan .” Design of concrete structures” 2008. McGraw-Hill.
- ASHRAE (2007d) American society. 2007 ASHRAE Handbook-HVAC Applications .
- Collinsdictionary.com (November 2015) available at : http://www.collinsdictionary.com/dictionary/english/reception-area
- Ernst Neufert, Peter Neufert, Johannes Kister , “Architects' Data. Oxford: Blackwell Science”, 2000.
- Eugene Washington, Introduction to reinforced concrete structural design (Oct. 2015) available at : http://www.pdhonline.org/courses/s131/s131.htm
- Fred R. Lawson, “Hotels, Motels and Condominiums: Design, Planning and Maintenance” (1976) .
- Hotelstars.eu (September 2015) available at : http://www.hotelstars.eu
- Plumbingpros.com (Oct.2015) available at: http://www.plumbingpros.com/pdf/dwvents.pdf\
- Richard F. Mull, Brent A. Beggs, Mick Renneisen. “Recreation Facility Management: Design, Development, Operations, and Utilization”, IL: Human Kinetics, 2009.
- Seedengr.com (Oct.2015) available at : http://www.seedengr.com
- Shannon Braun,"strucural design" (Oct.2010)
- Walter T. Grondzik, Alison G. Kwok, Benjamin Stein, John S. Reynolds, “Mechanical and Electrical Equipment for Buildings”,10th edition (2006) .