*An-Najah National University*
*Faculty of Engineering*
*Building Engineering*
*Department*
*Graduation Project 2*

# DESIGN OF MULTI-PURPOSE BUILDING

## WITH NEW CONSTRUCTION MATERIAL

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# "الحمد لله الذي انزل على عبده الكتاب و لم يجعل له عوجا"

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|---|---|
| "كم سهرنا من ليالي | للصباح لا ننم |
| كم عراقيل كسرنا | كم حفظنا من رزم |
| كم جسور قد عبرنا | كم ذرفنا من حمم |
| نبتغي صيد المعاني | نبتغي رأس الهرم |

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|---|---|
| نقضي ساعات طوال | نستقي علم العجم |
| نستهين كل غالي | كي نحقق الحلم |
| إن سأمنا لا نبالي | بل نسير للامام |
| إن قمة الجبال | تستحق لا جرم |

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| فضلكم يا والديا | عمي حبي اللجم |
| كل هم قد أصبنا | زادكم بالطبع هم |
| إن كل ما جنينا | من جهودكم نجم |
| والدي خير عون | كان لي عند المحن |

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| أنت يا من تملكين | جنةً تحث القدم |
| كل قول في لساني | كل شكراً قد رهن |
| إجمعو كل المعاني | من عراب او عجم |
| لا توافي شكركن | لا تجاوز العدم |

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|---|---|
| هذه فرحة الاهالي | لا يساويها رقم |
| حين يشهدون حالي | بالسرور ابتسم |
| إذ أقلد اللالي | والشهادة استلم |
| فرحتي وصرختي | تكاد تسمع الاصم |

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|---|---|
| يا نجوم السماء | يا عبائق النسم |
| يا سحائب الرجاء | يا طيور الحرم |
| يا رعود الشتاء | يا جميع الامم |
| اشهدوا هذا المساء | إنني قلت القسم" |

## Disclaimer:

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## Abstract:

Commercial center is the center in which economic, social, cultural, entertainment and administrative services, Common area is the total area within the commercial center that is designed for rental to investors, this project will contribute in bringing life to the region where our project will be construction and give new chance to businessmen to rental offices, markets, stores, etc. However, it gives that region new commercial life to take the economic benefits .The idea is to bring financial, business opportunities and to refresh the commercial business to that region.

On another hand the increasing of population in many societies, and the need to have a place that have complex function are the aim at this time.

This Multi-purpose Building will be designed typically and according to international building codes and as much as possible according to the shape and type closely reflect the city building system.

In this introduction we will take about multipurpose building as it is our project, this project will be design in Nablus city, and will give a support for economic situation in this city.

Multipurpose building in general is a building that contains many different functions such that stores, shops, restaurants and cafés, may have also cinema, offices and bowling lawn ,

The multi-purpose building is the perfect facility for all of human group's needs.  Whether you need a large facility for a business meeting, or need a facility for your youth group gathering, that what we need at the multi-purpose building.

Too many multi-purpose buildings are found since the beginning Renaissance of 1990s all over the world and this renaissance starts in our country in 2000s.

From the governmental buildings of ministers branches that helps people to continue their papers to some schools buildings that contains branches for kids, youth, and teens in their different needs, also commercial building that have shops center, restaurants, and café also a cinemas, more over the office buildings that contains clients, and laboratories at the sometime - which should have a special requirements- all these types are called multiparous buildings.

From engineering view multiparous building is our chance to get an experience in designing multi-function spaces with their needs and to face the problems that may face us.

These functions that we have in this project should be acceptable from architectural point of view by spacing separating and relationship in between, moreover the relation with site, also we should have the ability to solve the structural versus that may stand up.

Earthquakes is the rising problem that faces our society in general so as we design a construction for people we should keep them safe in the building as much as possible.

“We design the building for peoples if it doesn’t match with them, no need for design”. Full Architectural Comfortable Design , Safe and Economical Structural Design , Suitable and Operational Mechanical Design , Comfortable lighting design For Human , Good ventilation and infiltration for Areas , Acoustical Design with low noise , special design for handicap people , all these concepts and other are our target in designing the multiparous building .

# Table of Contents

## Chapter One: Introduction

# 1.1: Problem Statement:

This project is an integrative design of Multi-purpose building. The design involves architectural, structural, environmental, electrical, mechanical, and safety issues.

This project is designed following international standards, regulations and codes. All of these codes and standard will be mentioned in the next chapter.

# 1.2: Work objectives:

Architectural design: The architectural design considers the shape of the building, personnel circulation and the appropriate functionality for each space.

Structural design: It will be represented in a 3-D model which accounts for dynamic analysis and seismic design, the analysis and design of the structure will be carried out using computer software.

Mechanical design: in the mechanical, the HVAC, water, and sanitary systems in the project will be analyzed and designed.

Environmental design: It will include the orientation of the building, thermal insulation and shading techniques used in the building.

Electrical design: The electrical design will satisfy lighting and power system requirement.

Public safety design: In public safety design, emergency exits, fire protection systems and evacuation path will be designed.

Operation of the building : this mean solution for how we can clean whole the glazing area.

## 1.3: Scope of work:

Nablus needs a lot of facilities to satisfy the desire of tourists, like multi-purpose building, so it is proposed to design a highly class building in the middle of the city that meets the needs of these people.

The specific objectives of the proposed project are:

Architectural design.

Structural design.

Mechanical design.

Electrical design.

Environmental design

Architectural design we made this building from own ideas to make it suitable as much as possible.

In the structural design, there are two blocks; all of them are made of concrete and steel. All of the blocks were designed using SAP2000 V14.4 and all of them were detailed.

For the environmental design, a model done to calculate the heating and cooling loads and the daylight percentage for the whole structure.

In mechanical design, sewage system and H-VAC system were performed. In electrical design, Dialux program was used to build a model for distribution of lamps, also socket plans were made. In addition to that, the distribution panels and its relation to the main panel were detailed. Quantity surveying and cost estimation for the whole structure during the design process was made and calculated.

## 1.4: Work Significance:

Palestine is one of the few countries that attract the tourisms. The main reason for that is the historical and religious attraction. For example Jerusalem has many holy and spiritual places like Al Aqsa Mosques, and the Dome of the rock and the church of the holy sepulcher. Bethlehem also with the nativity church is a big source of tourism attraction. These numbers coming from various places of the globe improve the income and develop the economy in general. It creates job opportunities in all types of facilities and services.

From the previous discussion, it is concluded that the tourism industry is a big source of income and profit that we should use to the maximum level, from this aspect the idea of establishing multi-purpose building came.

Usually, most of the tourists come from a more developed countries and with a high educational background which leads to the demand of high and enhanced services.

## 1.5: Report Organization:

This report is divided into eleven chapters, starting with Chapter One which introduces the idea and the main objectives of this project. In Chapter two, the definition of constrains, the followed codes and requirements, the earlier course work. The literature review is discussed in Chapter Three. In Chapter Four, the architectural design of the project is discussed. In Chapter Five, the structural design is illustrated. In Chapters six, seven, eight, nine and ten environmental, mechanical, electrical, safety and operation for building are discussed. Finally, chapter eleven will discuss the quantity surveying and cost estimation.

# Chapter Two: Codes, Requirements and Earlier Coarse Work

## 2.1: Codes:

ACI -318-08 (American concrete institution) for reinforced concrete structural design.

UBC -97 (Uniform building code) for earthquake load computations.

ASCE (American society of civil engineers) for load computations.

ASME American Society of Mechanical Engineers.

NFPA National Fire Protection Association.

NPC National Plumbing Code.

SMACNA Sheet Metal and Air Conditioning Contractors National Association.

## 2.2: NFPA Codes:

The following NFPA (National Fire Protection Association) list of codes may be used for the systems:

1. NFPA 13 Standard for the Installation of Sprinkler Systems 2007 Edition
2. NFPA 14 Standard for the Installation of Standpipe and Hose Systems 2007 Edition
3. NFPA 2001 Standard on Clean Agent Fire Extinguishing Systems 2004 Edition.

## 2.3: Compliance Construction Codes:

The construction of the mechanical works shall be in accordance with international codes and regulations as listed below, and accepted by the local Authorities:

ASHRAE American Society of Heating, Refrigeration & Air Conditioning Engineers

ASME American Society of Mechanical Engineers

NFPA National Fire Protection Association

NPC National Plumbing Code

SMACNA Sheet Metal and Air Conditioning Contractors National Association

## 2.3: Earlier coarse work:

There are many courses that have been used to perform the analysis and the design progress such as:

***Concrete 1, 2 and 3.***

***Designing buildings using AUTOCAD and RIVET .***

***Solar system design.***

***H-VAC system design.***

***Lighting system design.***

***Acoustical design.***

***Integration of building engineering systems.***

***Seismic design.***

***Quantity surveying.***

***Building operation.***

## Chapter Three: Literature review.

# 3.1: Introduction

### 3.1.1: Definition of Multi-purpose building.

Commercial center is the center in which economic, social, cultural, entertainment and administrative services, Common area is the total area within the commercial center that is designed for rental to investors, this project will contribute in bringing life to the region where our project will be construction and give new chance to businessmen to rental offices, markets, stores, etc. However, it gives that region new commercial life to take the economic benefits .The idea is to bring financial, business opportunities and to refresh the commercial business to that region.

# 3.2: Architectural Design

In this part we will talk about

Commercial Part.

Business Part.

Entertainment Part.

Service Part.

### 3.2.1: Commercial Part:

Commercial part contains:

General shops

Superstore

General Shops

The normal shopping units hang becomes the feature of today's shopping unit, whether the project is in the suburbs or in the central business district. The shopping units usually divided to the major shopping path of the project, and one or more subsidiary approach shopping units connecting the main shopping units with the rest areas moreover units can be on one level or on two or more superimposed levels Shops as we know it's the main areas in commercial part. The design has to be comfort , good , and attracts buyers , the high of the shops in general is between 3-5m , and this connected with the floor area

The normal dimension of the general shops is about 4.5 W and 3-6 L and this area may become lager according to the costumer or business needs e.a the space of the electrical equipment shop is larger than the space needs for the shoo shops and also these two shops is larger than the accessory one.

Superstore

Superstore is a large area which contains many goods as food ,milk , cleaning materials and many daily needs for the people, Superstore includes mechanisms or means for determining price of the traded item, containing the price information , also some branches like meet branch may have service man to help customers.

### 3.2.2: Entertainment:

Entertainment part contains:

Cafeteria and café

Restaurant.

SPACE REQUIREMENTS:

- Space allowance may be strongly affected by the limitations of investment funds and available space.
- Requirements for cafés:

1. Toilet for customer.
2. Staff toilet.
3. Small office.
4. Food store including refrigerator .
5. Air conditioning if required.

- Calculated area requirements in terms of:

(1) Volume and type of service

(2) Amount and size of equipment to be used

(3) Number of workers required

(4) Space for needed supplies

(5) Suitable traffic area

### 3.2.3: Business:

Business part contains:

Offices

#### *3.2.3.1: Offices:*

In general, Offices are a variety of spaces, including meeting rooms, reception rooms, workrooms, storage rooms, manager rooms, and secretary room,

The office spaces are usually flexible environment so that integrates technology, comfort and safety, and energy efficiency for better productivity and cost-effective, Efficiency of an office building design is measured by the ratio of rentable space to total space.

The office unit must have an enough space for its use, and depend on the furniture and equipment contain. Thus, the furniture, equipment, movement areas, and the people, will control the space areas. In addition, we must take into consideration the flexibility of the spaces this principle fewer barriers to change, less distribution when change does occur, and lower costs in money and time can be accomplished by using open spaces and use flexible materials for construct portions.

We can break down the important types of space required in the typical office into five categories as office space, file space, special equipment, storage space and special rooms.

There is many special spaces should be provided but depending on the type of business such as receptions rooms, waiting rooms, conference rooms, exhibit rooms, examination rooms, interviewing rooms and small cafeteria.

### 3.2.4: Services:

In multi-purpose building there is  some special rooms for stuff ( like building general security, Cleaners , maintenance workers , etc…) , mechanical equipment's and electrical equipment's .

#### *3.2.4.1: Safety:*

Emergency exits:

An emergency exit in a structure is a special exit for emergencies such as a fire: the combined use of regular and special exits allows for faster evacuation, while it also provides an alternative if the route to the regular exit is blocked by fire or any any emergency case.

Fire protection:

Fire protection is the study and practice of mitigating the unwanted effects of destructive fires.

Once the construction of the structure is complete, a building must be maintained to have a level of protection from fire according to available fire codes.

Fire Detection:

Fire is detected either by locating the smoke, flame or heat, and an alarm is sounded to enable emergency evacuation as well as to dispatch the local fire department. Where a detection system is activated, it can be programmed to carry out other actions. A household smoke detector will typically be mounted in a disk shaped plastic enclosure about 150 mm in diameter and 25 mm thick. Because smoke rises, most detectors are mounted on the ceiling or on a wall near the ceiling. To avoid the nuisance of false alarms, most smoke detectors are mounted away from kitchens. To increase the chances of waking sleeping occupants, most homes have at least one smoke detector near any bedrooms.

## 3.3: Structural Design

### 3.3.1: Introduction:

Structural design is one of the important fields in structural engineering that deal with analysis and design of whole engineering structures (buildings and non-buildings),it can be defined as mixture of art and Science, combining the engineer's feeling for the behavior of a structure with a sound knowledge of the principles of statics, dynamic, mechanics of materials, and structural analysis, to produce a safe economic structure that will serve its intended purpose.

Structural design presents the conceptual and practical underpinnings of basic building design and technology. Engineering structural systems are of variety that they defy any attempt to enumerate them; any complete design requires the coordinated efforts of several branches of engineering.

Structural design can be divided into two systems:

Structural Analysis:

– Structural Analysis is the prediction of the performance of a given structure under prescribed loads and/or other effects ‹such as support movements and temperature change.

Structural Design:

Structural design is the art of utilizing principles of statics, dynamics, and mechanics of materials to determine the size and arrangement of structural elements under prescribed loads and/or other effects.

#### *3.3.1.1: Structural Construction material:*

There are several types of construction materials which include:

##### 1- Concrete:

Concrete is the common used locally. Concrete is a composite material composed of coarse granular material (the aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space among the aggregate particles and glues them together.

There are many types of concrete available, created by varying the proportions of the main ingredients below. In this way or by substitution for the cementations and aggregate phases, the finished product can be tailored to its application with varying strength, density, or chemical and thermal resistance properties.

##### 2- Steel:

Steel is an alloy of iron, with carbon being the primary alloying element, up to 2.1% by weight. Carbon, other elements, and inclusions within iron act as hardening agents that prevent the movement of dislocations that naturally exist in the iron atom crystal lattices. Varying the amount of alloying elements, their form in the steel either as solute elements, or a precipitated phase, retards the movement of those dislocations that make iron so ductile and so weak, and so it controls qualities such as the hardness, ductility, and tensile strength of the resulting steel. Steel can be made stronger than pure iron, but only by trading away ductility, of which iron has an excess.

### *3.3.1.2: Structural Systems:*

The best structural system is the one that fulfills most of the needs of the user while being serviceable, attractive, and economically cost efficient. Although most structures are designed for a life span of 50 years, the durability performance record indicates that properly proportioned concrete structures have generally had longer useful lives.

#### Slabs:

Slabs are the main horizontal elements in structure system, which transfer loads to the vertical framing support of the structure.

Slabs can be proportioned such that they act in one direction (one way slabs) or act in two perpendicular directions (two way slabs).

The choice of type of slab for a particular floor depends on many factors. Economy of

Construction is obviously an important consideration, but this is a qualitative argument until specific cases are discussed, and is a geographical variable.

The design loads, required spans, Serviceability requirements, and strength requirements are all important.

#### Beams:

A beam is a structural element that is capable of standing load primarily by resisting bending, and transmit the loads from floor slabs to vertical supporting columns.

Beams have several shapes as rectangular "L" shape for edge beams, & "T" shape for interior beams.

#### Columns:

Columns are the structural element that transmits, through compression, the weight of the structure above and the load of other structural elements below "footings".

Columns composed of concrete with an embedded steel frame to provide reinforcement.

For design purposes, the columns are separated into two categories: short columns and long columns (slender).

#### Walls:

A wall is a structure that defines an area, carries a load, or provides shelter or security. Walls of buildings are a fundamental part of the superstructure or which separate the spaces in buildings sections. Walls not necessary made from concrete it can be made from any material that structure system needs.

Foundations:

Foundations are the lowest and supporting layer of a structure, which receive the loads from all elements of structures (columns, walls, beams, floors) and transmit it to the soil.

Foundations are generally divided into two categories: shallow foundations and deep foundations.

Environmental Design:

Environmental design is the process of identifying surrounding environmental when studying plans, programs, techniques and buildings, or products.

Environmental design refers to the applied arts and sciences dealing with creating the human-designed environment that satisfies human comfort.

## 3.4: Building orientation:

Orientation simply refers to where the building is directed.

Orientation can be the most important step in providing a building with passive thermal and visual comfort. Orientation should be decided together with massing early in the design process.

Orientation is measured by the azimuth angle of a surface relative to true north. Successful orientation rotates the building to minimize energy loads and maximize free energy from the sun and wind.

### 3.4.1: Setback

The spaces around the building must be studied well in order to avoid shades that are formed from nearby buildings and trees. So solar system efficiency would not decrease.

### 3.4.2: Using green materials:

In order to consider a material as a green one, many conditions must be satisfied:

Low energy consumption in manufacturing process.

Follow the green code that recommends specific materials.

Materials that have bad side effects must not be used at all. Alternative must be used.

Must not assist indoor pollution.

Use natural construction materials.

Avoid using materials that emits organic compound gases.

### 3.4.3: Solar system:

The idea of solar system is to gain the largest possible energy in winter without losing it, and store the largest possible amount for night hours, and at the same time to earn less possible energy in summer and get rid of it.

Heating and cooling systems can be used as passive systems and active systems.

Passive solar system: it is the system that uses the sun's energy for the heating and cooling of living spaces, passive systems are simple, have few moving parts, and require minimal maintenance and require no mechanical systems.

Note: Passive solar system includes passive heating and passive cooling.

Active system: it is the system that doesn't work freely and it uses energy consumption.

### 3.4.4: Passive system:

Solar energy is a radiant heat source that causes natural processes upon which all life depends. Some of the natural processes can be managed through building design in a manner that helps heat and cool the building. The basic natural processes that are used in passive solar energy are the thermal energy flows associated with radiation, conduction, and natural convection. When sunlight strikes a building, the building materials can reflect, transmit, or absorb the solar radiation. Additionally, the heat produced by the sun causes air movement that can be predictable in designed spaces. These basic responses to solar heat lead to design elements, material choices and placements that can provide heating and cooling effects in a home.

### *Types of solar gain:*

#### a- Direct Gain:

Sunlight is admitted to the space (by south facing glass) and the storage mass (walls, floors) will conduct heat to their cores. At night, when outside temperatures drop and the interior space cools, the heat flow into the storage masses is reversed.

Direct gain design is simple in concept and can employ a wide variety of materials and combinations of ideas that will depend greatly upon the site and topography; building location and orientation; building shape (depth, length, and volume); and space use.

Note: In direct gain design remember to:

How much solar radiation you can get by orientation.

Minimize heat loss (U value).

Control the glare.

Control the heat in summer (shading).

Use thermal mass to store heat.

#### b) Indirect Gain:

In an indirect gain system, thermal mass is located between the sun and the space. The thermal mass absorbs the sunlight that strikes it and transfers it to the space by conduction. The indirect gain system will utilize 30 – 45% of the sun's energy striking the glass adjoining the thermal mass.

Thermal storage materials are placed between the interior habitable space and the sun so there is no direct heating.

Dark colored thermal storage wall is placed just behind a south facing glazing (windows)

Sunlight enters through the glass and is immediately absorbed at the surface of the storage wall where it is either stored or eventually conducted through the material mass to the inside space

Providing heat-distributing vents the top of the wall (where the heated air, rising upward due to less density, can flow into the interior space.

## 3.5: Acoustical Design:

Most Commercial centers are in the business of making people happy. This could be usually done by delivering good food, good service and an enjoyable experience that brings people back time and time again. When a structure is noisy, loud and when people have to strain to hear each other, the experience is diminished.

Some definitions about acoustics:

### 3.5.1: Measuring sound

Sound travels in waves. In solid building materials, it progresses as vibration. Building materials, such as stud walls, glass windows and concrete floors vibrate at a variety of frequencies when excited by sound or vibration. What we hear are fluctuations in air pressure produced by the vibrating surfaces.

Decibel (dB).

The decibel is commonly used in acoustics to quantify sound levels relative to a 0 dB reference, the typical threshold of perception of an average human

Reverberation time (RT60)

RT60 is the time required for reflections of a direct sound to decay 60 dB. Reverberation time is frequently stated as a single value; however, it can be measured as a wide band signal (20 Hz to 20 kHz).

### 3.5.2: Sound Transmission Class (or STC)

is an integer rating of how well a building partition attenuates airborne sound

***Acoustic insulation:***

It is worth clarifying what we mean by acoustic or sound insulation as opposed to sound absorption. Briefly put, sound absorption aims to reduce the amount of reverberation within a room to improve the overall sound quality and intelligibility, whereas sound insulation or soundproofing as it's commonly known, aims to reduce the overall level of sound that travels from one area to another within the building or structure.

### A) Sound insulation for ceilings:

Lightweight and easy to suspend from high, open ceilings using traditional hanging or innovative cable suspension systems baffles absorb sound from all directions to reduce reverberation in large interior spaces. Baffles are offered in a variety of standard and custom colors to complement or match color schemes. Fabric  wrapped wall panel absorbs up to 85% of the sound directed toward it. They are available in hundreds of fabrics to complement or match wall or ceiling.

### B) Sound insulation for floors:

Suspended wooden floors are likely to have an existing Rw rating of between 36 and 40dB for airborne sound and an Lwn rating of between 76 and 82dB for impact sound depending on the form of construction and ceiling type.

Increasing the dead weight of floors will not, on its own, significantly improve the impact sound insulation properties. A better solution is to provide a resilient layer that is isolated from and not fixed to the base structural floor and which incorporates a sound and shock absorbing material such as rubber composite or cellular foam.

A floating floor will improve both airborne and impact sound insulation qualities

Sound insulation measures may also increase the floor loads significantly.

### C) Sound insulation for walls:

The approach for improving sound insulation is to simply over-board internally to increase the overall wall thickness and weight of material.

The weakest part of external walls in terms of sound resistance will be the window units, Small enhancements can however be made quickly and easily to raise the sound insulation value by fitting a proprietary draught-proofing strip to the opening lights, and by providing beading or caulking to seal around the frame.

Weaknesses in party walls and separating compartment walls allowing indirect transmission of noise can be a major problem. Open cavities within the flanking walls and in roof spaces can be stopped off with an inert fibrous material such as Rockwool. This acts as an effective barrier to both sound and fire spread.

## 3.6: Lighting design:

Light and shade can render and give specification to space's function, Light also can change the human moods, brightness can make people feel happy and absence of light can cause sadness.

Generally there are three major aspects in lighting design: function, human health and aesthetic

There are two types of lighting (good and bad lighting)which can be defined as follows :

Good lighting:

Is an energy saver and also efficient.

Perception is limited on intended object.

Providing nighttime visibility.

Control the bright as much as needed.

Bad lighting:

Is the lights that waste the energy

Make light pollution

Create visual distortion and glare

There are two methods to get lighting for space:

### 3.6.1: Daylight and artificial lighting:

***a) Daylight design (natural lighting):***

Daylight needs to be considered at the outset of designing a building as day lighting strategies and architecture design strategies are inseparable. Daylight can not only replace artificial lighting, reduce lighting energy use, but also influence both heating and cooling loads. Planning for daylight therefore involves integrating the perspective and requirements of various specialties and professionals.

***b) Artificial lighting:***

Artificial lighting used when function or space need it. In almost when there is no daylight especially in night.

In Commercial centers which work in most days of the year and at night it is in need of an artificial lighting to light spaces. Artificial lighting is both science and art, because it is important to select type of lamps, color of lamps, temperature of color, and take in consideration human comfort.

There are three main sources for architectural lighting today: incandescent, electrical discharge, and LED. Incandescent lights work by heating a filament until it glows with black body radiation. Electrical discharge (or "gas discharge") lamps pass a current through a gas to split it into a glowing plasma. Fluorescent lamps are a kind of gas discharge lamp. Light-emitting diodes send a current through a semiconductor to cause photon emission.

### 3.6.2: Lighting Layouts:

Given the wide choice of different lamps and luminaries available, there is an almost infinite set of different arrangements of electric lights within a room that will provide a certain illumination level.

The primary concern in lighting layout is to avoid glare on activity surfaces. Such glare is a result of light bouncing directly into user's eyes, rather than diffusely.

### 3.6.3: Glare:

Glare is a visual sensation caused by excessive and uncontrolled brightness and there are many factors produces discomfort such as the luminance size and position of each light source in the space so reducing glare is an effective way to improve the lighting and we can get rid of glare by controlling the light source or by filtering it before it reaches your eyes

## 3.7: Mechanical Design:

The mechanical services installation must contain heating, ventilation, water, soils and wastes. The mechanical design services must take into consideration at the first place the site climate and the building orientation.

The criteria for the design and selection of the various mechanical systems shall be examined on an individual basis to provide as accurate results as possible.

The HVAC systems maintain a comfortable and healthy indoor environment by responding to the loads imposed by the building envelope design, lighting system design, and occupant activities.

### 3.7.1: Water:

#### *3.7.1.1: Water services:*

Water is one of the most vital services that should be considered in each building, water supply resources must be well known. Cold and hot water installations must be designed. Water distribution services depend on gravity systems or on pressurized system.

Cold and hot water piping shall be appropriate for use. Some problems must be solved in the design such as water hammering and air locking.

1. Cold Water Services:

Cold-water outlets must be shown on the room layout drawings. Cold-water must be stored in a well-insulated tank. There must be a comfort access for ease of maintenance. It must not be located in the boiler room.

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2. Hot Water Services:

In designing a water heating system, the key decisions the source of energy for water heating, whether to use a storage cylinder or continuous flow system, system layout, and system capacity (including delivery rate, recovery rate, actual and potential number of users, type and number of fixtures within a household).

The system must be designed to meet safety requirements, which largely concern controlling temperature and pressure to ensure there is minimal risk of scalding or of a storage cylinder exploding.

A well-designed system will also minimize energy and water use, for example by using an efficient heating source, ensuring the pipe runs are relatively short, and by using efficient fixtures and appliances.

#### *3.7.1.2: Water Source:*

There are many sources of water that supply our building in our region:

Wells:

Pumps:

Storm water

#### *3.7.1.3: Water Drainage:*

There are two types of drainage water:

Black water (Waste):

It is known as "waste water and sewage from toilets". This water can be treated from organic compounds by draining it to a septic tank

Grey water:

It defined as wastewater generated from wash hand basins, showers and baths, which can be recycled on-site for uses such as WC flushing and landscape irrigation. Reywater often includes discharge from laundry, dishwashers and kitchen sinks.

This water is connected to a sand filter in order to get rid of particles then to a tank to re use it again.

## 3.8: Electrical Design

Electrical design for multi-purpose building includes design lighting and power systems.

Power system in multi-purpose building usually needs a huge electric power for different equipment and machine. This system called three phase system.

Three phase system is the transmission system that carries the power from the generating centers to the load centers and the distribution system that feeds the power to nearby homes and industries. Smaller power systems are also found in industry, hospitals, commercial buildings and homes.

Before specific electric power sources and distribution systems can be considered, realistic preliminary load data must be compiled. The expected electric power demand on intermediate substations, and on the main electric power supply, shall be calculated from the connected load layout by applying appropriate factors. Determine these factors by load analysis and by combining loads progressively. To combine the loads, start at the ends of the smallest feeders and work back to the electric power source. Because all loads must be on a common kilowatt (kW) or. Preliminary electric power load estimates can be made by using the approximate value of one kilovolt-ampere of input per horsepower (hp) at full load. Preliminary estimates of lighting loads may be made by assuming watts per m2 of building area.

### 3.8.1: Artificial Lighting:

To eliminate lighting loads, divide a facility area into its significant components by function (for example, office, storage, mechanical, and corridor). Determine the average lighting level and type of light source for each area. Consider requirements for supplementary lighting (for example, floodlighting, security lighting, and special task lighting).

You should consider several criteria when choosing which light source to use. Note that these characteristics are often a function of the light source itself and the fixture housing it.

### 3.8.2: Earthling system:

In electricity supply systems, an earthling system or grounding system is circuitry which connects parts of the electric circuit with the ground, thus defining the potential of the conductors relative to the Earth's conductive surface. The choice of earthling system can affect the safety and electromagnetic compatibility of the power supply. In particular, it affects the magnitude and distribution of short circuit currents through the system, and the effects it creates on equipment and people in the proximity of the circuit. If a fault within an electrical device connects a live supply conductor to an exposed conductive surface, anyone touching it while electrically connected to the earth will complete a circuit back to the earthed supply conductor and receive an electric shock.

## 3.9: Safety:

in this part we will explain two main categories:

-Emergency exits (fire exits).

-Fire protection.

### 3.9.1: Emergency exits:

If it internal – must have a door – closed.

If it external – must have a door – can be open.

An emergency exit in a structure is a special exit for emergencies such as a fire: the combined use of regular and special exits allows for faster evacuation, while it also provides an alternative if the route to the regular exit is blocked by fire, etc.

It is usually a strategically located (e.g. in a stairwell, hallway, or other likely place) outward opening door with a crash bar on it and with exit leading to it. The name is a reference to when they are frequently used, however a fire exit can also be a main doorway in or out. A fire escape is a special kind of emergency exit, mounted to the outside of a building.

Some requirements about emergency exits:

1-It has very strong structure. For internal the walls must “shear walls” and fire rating very high.

2-The stairs must be uniform, wide, standard, rough, not slippery.

3-For metallic stairs make it open. If want to close you have to increase the width of stairs.

4-It has protected from falling by side fence.

5-It’s not allowed to put any type of obstacles.

6-All materials must be fire-proof.

7- All paints must be water-based not oil-based.

8-There are door between emergency exit and each floor.

9-For Internal type must be equipped emergency lighting system.

And there must put signs that attentions there are emergency exits.

Requirements for emergency exit doors:

1-Fire-proof and isolated.

2-It’s better to have small window with fire-proof glass and protection.

3-The lock must be long metallic bar “hand free lock”.

4-Must open to the stairs direction.

5-Must have automatic lock.

### 3.9.2: Fire Detectors:

Detectors respond as programmed with visual and audible signals to alert the occupants and the fire department.

Detector location in one of the key factors in determining the efficiency, performance and economics of a detector system installation.

Detector types:

1-Smoke detector.

2-Heat detectors.

3-Flame detectors.

### 3.9.3: Notification system (Fire alarm)

When a fire is detected, an alert is communicated to occupants via alarm systems, The type of alarm system is defined by the extent of communications,

-Local systems: alert only the occupants, who must contact the fire department.

-Proprietary systems: alert a central control panel, initiating action by building safety personnel.

-Central station system: alert the building occupants and a central control panel.

-Auxiliary system: alert the fire area by means direct line communication.

the recommended system that will be use in our project is auxiliary system because this system will call fire station directly and make visitors in all areas know to escape from building, so that this system is the most faster and safe system.

Fire extinguisher has many type according to the type of area:

1.Water type.

2. Carbon dioxide ($CO_2$) type.

3. Dry-powder pressure.

4. Foam extinguisher

## Chapter four: Architectural Design

# 4.1: General:

Architectural design a large part of the restructuring of modern cities in general, and then identify the architecture and preservation of cultural heritage of civilization, and the combination of heritage and contemporary formulation vision optics, and the role of architecture in this aspect, whether in the architectural planning of the building or the exterior design, which gives touch of aesthetic appearance on the outside.

Architectural work is the first step in any construction work, since the architectural design aims to provide creative and unique design. However, the creative architectural design may be incompatible with Environmental, Structural and Seismic design. So the best architectural design that satisfy the client's needs and requirements and at the same time does not conflict Environmental, Structural and Seismic design.

In our project, we tried to make a creative architectural design as much as we can. The Building consists of…. floors.

# 4.2: Site description:

The selected site is located in Palestine, Nablus city, in Hai Al-Basatin which located in Nablus near to Jamal Abd-Alnasser Park, about 494.13 m above sea level, it is to the west of Nablus. Land topography has specific contour lines that needs fill and cut in order to have a flat land. Site has a total area of 2700 $m^2$.

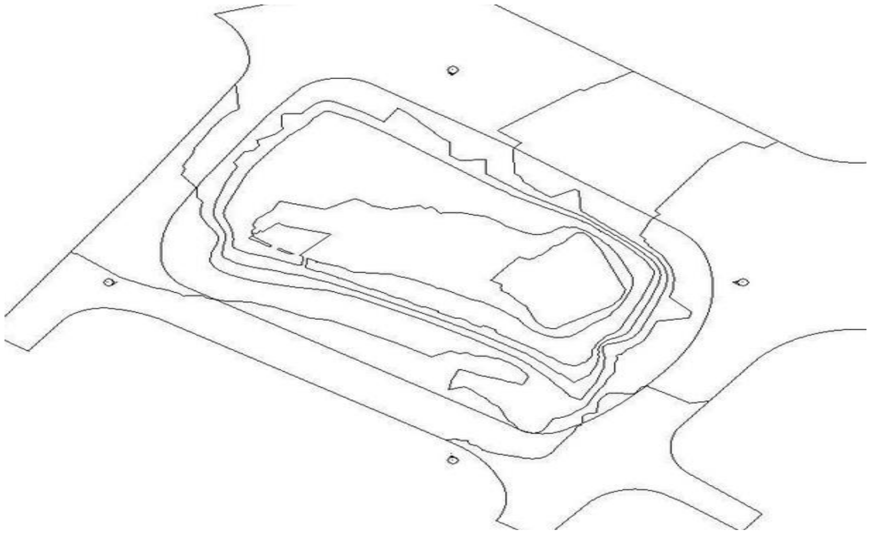


Figure 4: 1 Site layout

Figure 4: 2 Pictures for site

The site that was picked is located 627 m away from the city center.

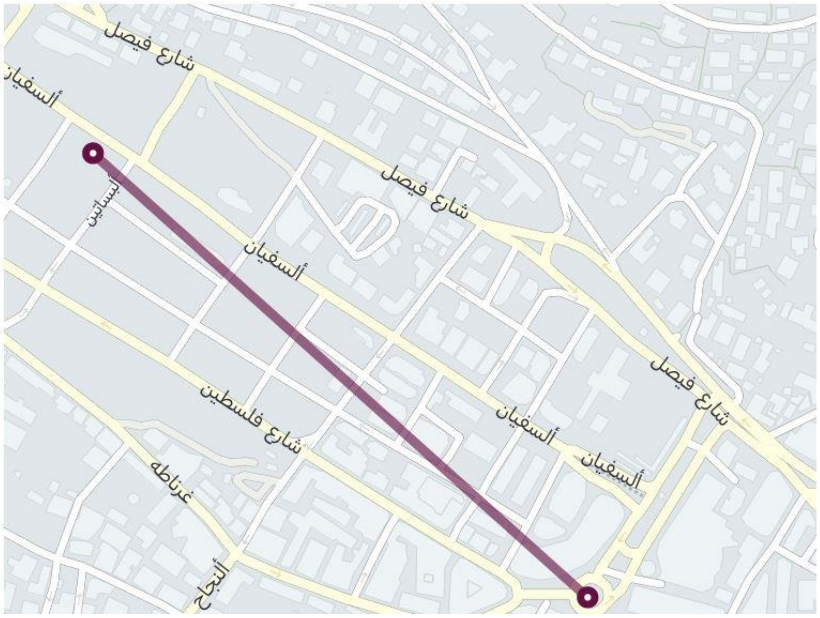



Figure 4: 3 Distances from city center

Figure 4: 4 Aerial photo

As it is shown the land in surrounded with 4 street, the northern street is described as one of the most vital commercial street in the downtown.

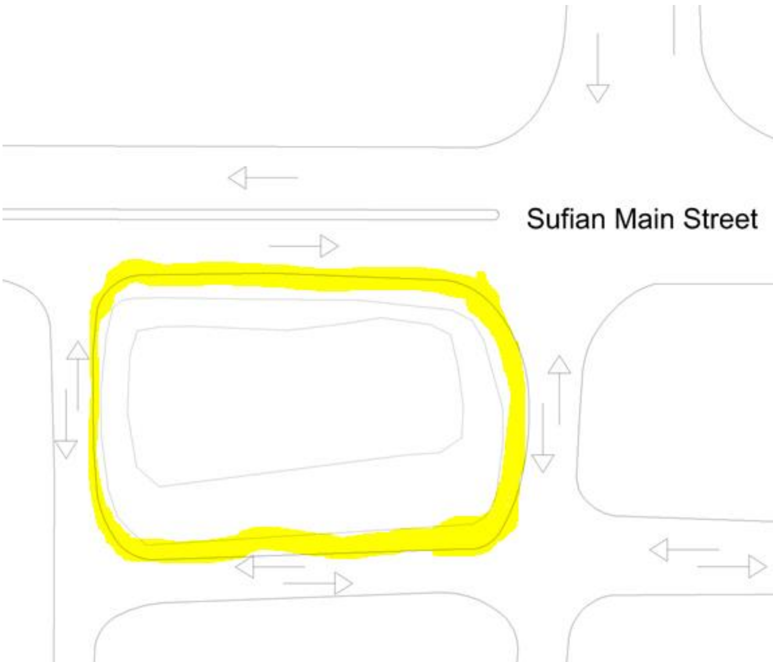



Figure 4: 5 Site layout

### 4.2.1: Nablus Climate:

The relatively temperate Mediterranean climate brings hot, dry summers and cool, rainy winters to Nablus. Spring arrives around March–April and the hottest months in Nablus are July and August with the average high being 28.9 °C (84 °F). The coldest month is January with temperatures usually at 3.9 °C (39 °F).

Table 4. 1 Nabulus Climate

| Climate data for Nabulus [hide] | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
| Average high °C (°F) | 11.7 (53) | 13.3 (56) | 16.1 (61) | 21.1 (70) | 25.0 (77) | 27.8 (82) | 28.9 (84) | 28.9 (84) | 27.8 (82) | 25.0 (77) | 18.9 (66) | 13.9 (57) | 21.53 (70.8) |
| Average low °C (°F) | 3.9 (39) | 4.4 (40) | 6.1 (43) | 9.4 (49) | 12.2 (54) | 15.0 (59) | 17.2 (63) | 17.2 (63) | 16.1 (61) | 13.9 (57) | 9.4 (49) | 5.6 (42) | 10.87 (51.6) |
| Precipitation mm (inches) | 142.2 (5.6) | 114.3 (4.5) | 99.1 (3.9) | 30.5 (1.2) | 2.5 (0.1) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 22.9 (0.9) | 68.6 (2.7) | 109.2 (4.3) | 589 (23.2) |
| Source: *The Weather Channel*[36] | | | | | | | | | | | | | |

### 4.2.2: Temperature

The geographical position of Nablus district in the northern part of the West Bank gives it a comparatively lower temperature range. The average maximum temperature reaches 26, and the average minimum temperature reaches 8c.

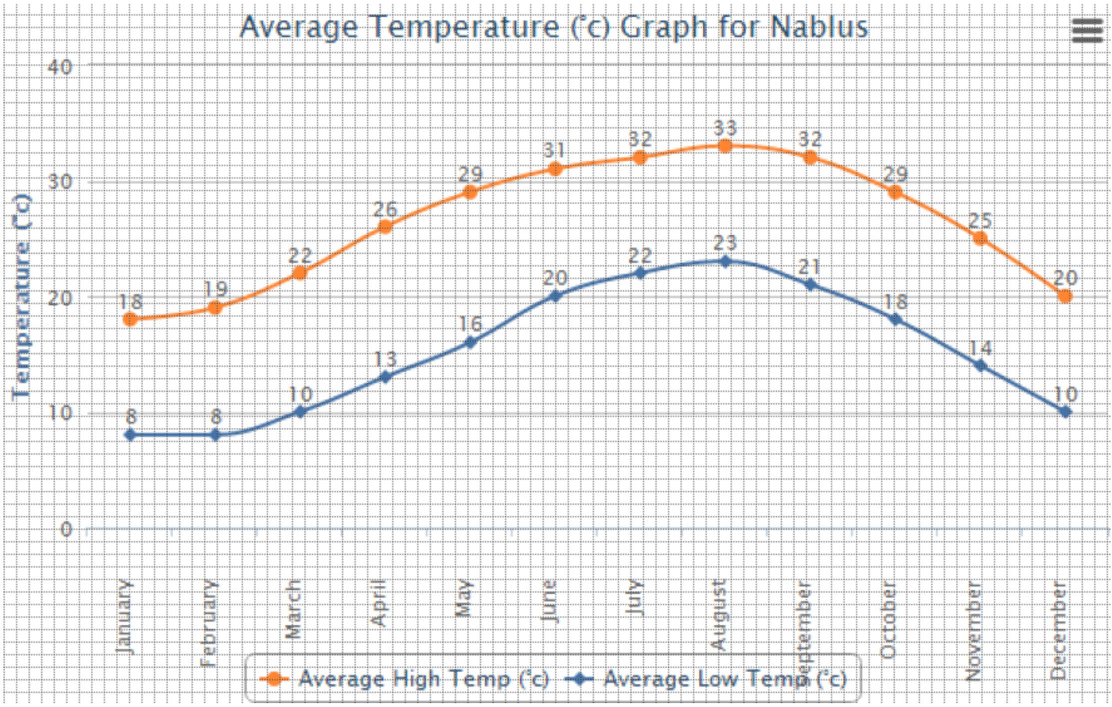



Figure 4: 6 Average temperature

### 4.2.3: Wind speed:

the wind blows the northern and north-western directions with annual mean speed of 6.4 Km/hours.

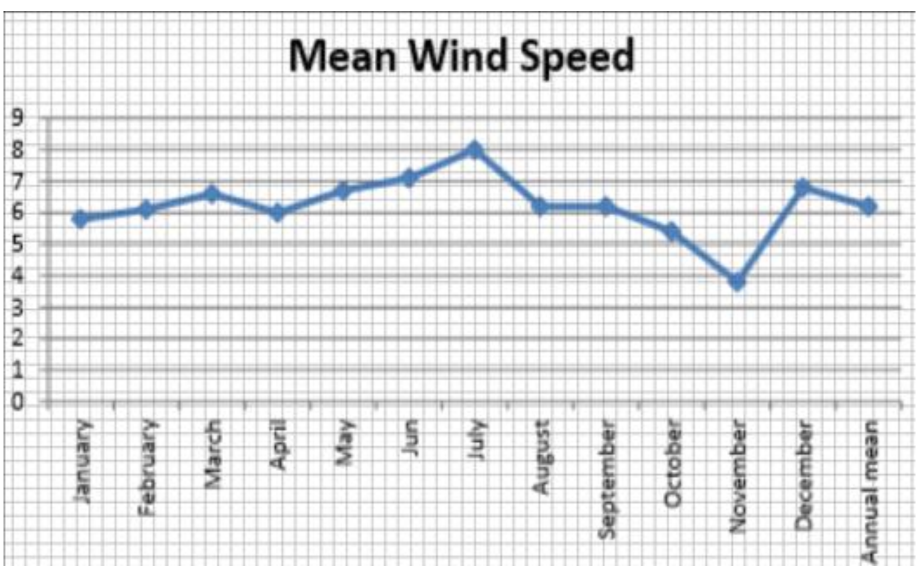



Figure 4: 7 Wind Speed

### 4.2.4: Relative Humidity:

The relative humidity reaches its minimum value in May because the high variation between the maximum and minimum daily temperature.

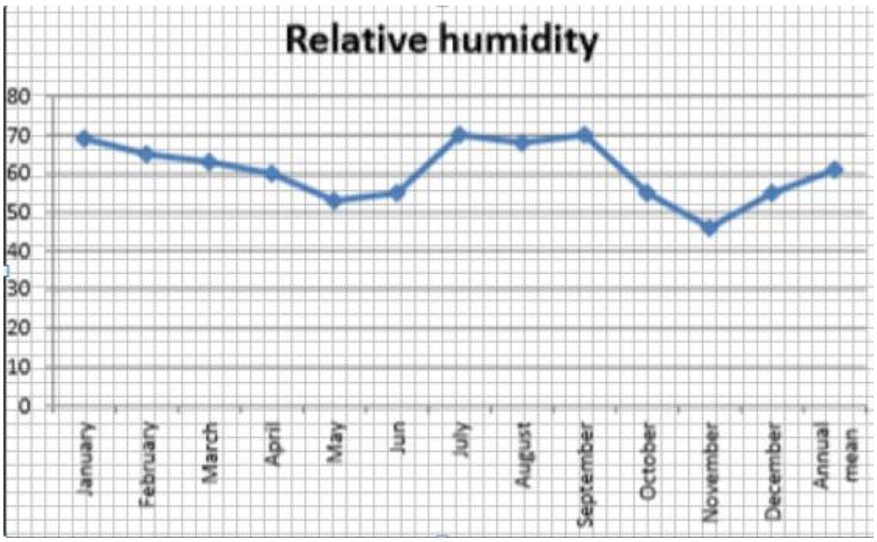



Figure 4: 8 Relative Humidity

### 4.2.5: Rainfall:

Rain generally falls between October and March, with annual precipitation rates being approximately 23.2 inches (589 mm).

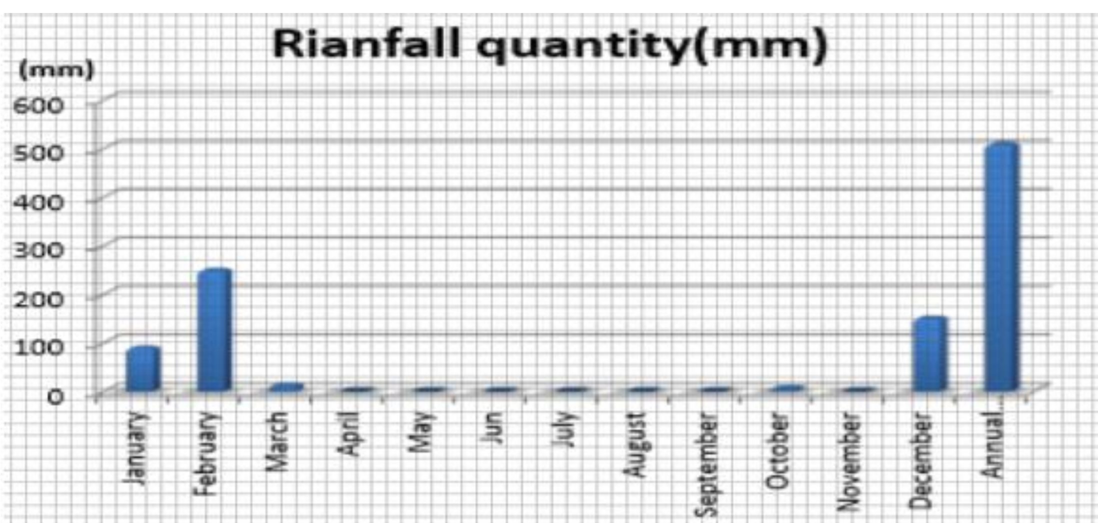



Figure 4: 9 Rainfall Quantity

### 4.2.6: Site Analysis:

1. Solar analysis.
2. Wind analysis.
3. Noise analysis.

***1. Solar analysis:***

A full solar analysis was obtained from Revit program in order to study the right design to the building. It was concentrated on the daylight design in order to minimize electrical usage.

***2.Wind analysis:***

As we will see in the figure below, the wind direction in general is always oriented to the north-west, so it was took in consideration in the site and function analysis in the building.

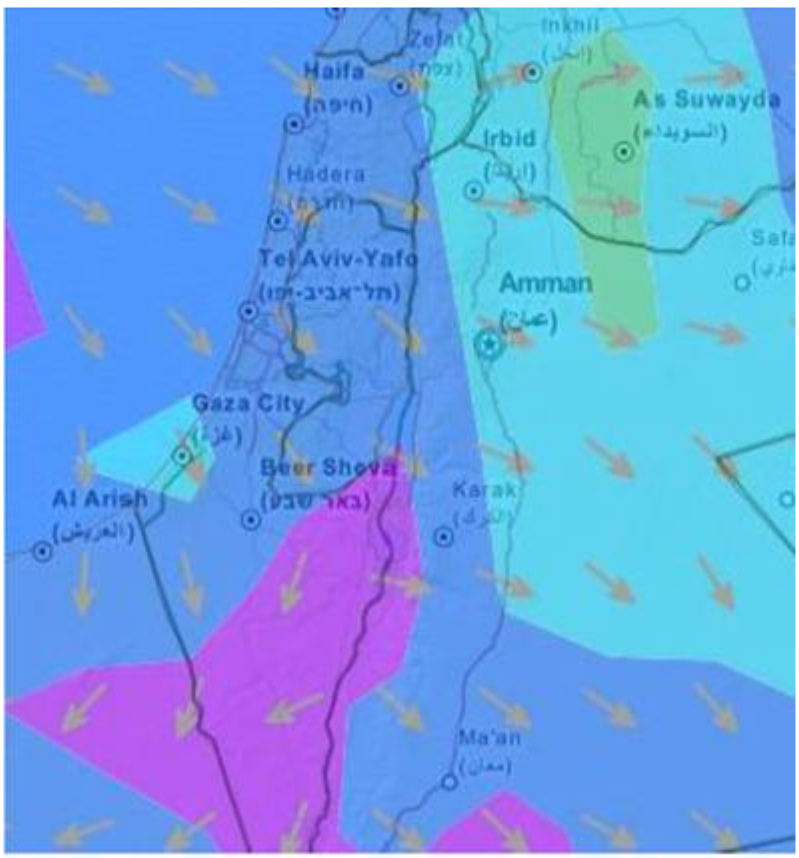



Figure 4: 10 Wind Direction

***3. Noise analysis:***

The main noise will come to the building from cars, people, buses, etc. From the streets. And another noise will come from the different activates the visitors will do in building, so in our future work we will solve this problem as much as possible.

## 4.2.7: Seasons Summary

***Summer Day:***

For the images below it's done on Revit program, this simulation shown the sun path during peak summer  days over year 21-06-year and 21-09-year.

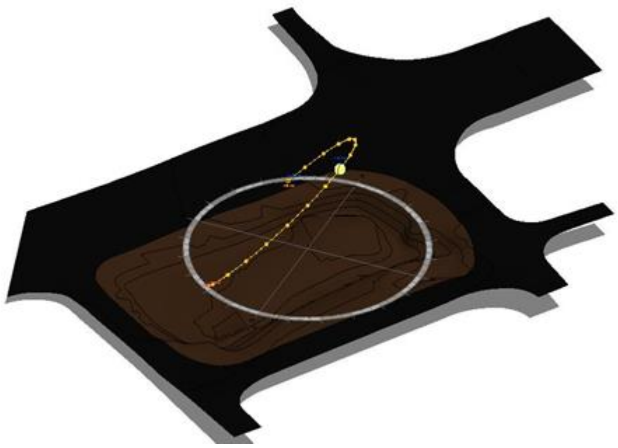


**Figure 4: 11 Sun Position 21-6**

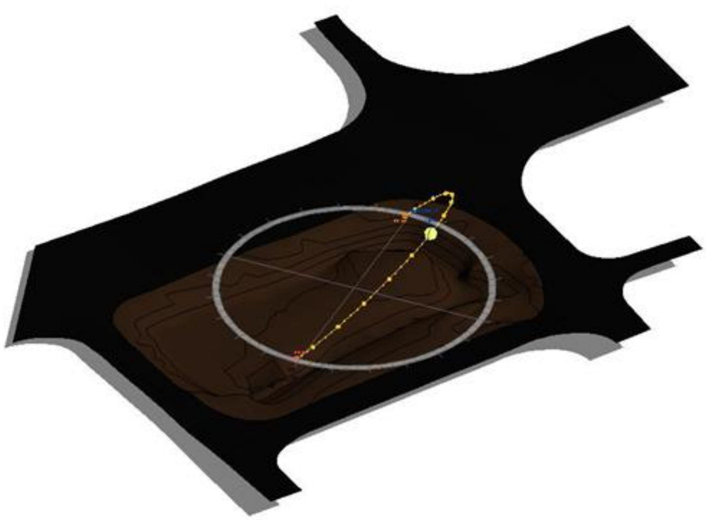


**Figure 4: 12 Sun Position 21-9**

*Winter Day:*

For the images below it's done on Revit program, this simulation shown the sun path during peak winter  days over year 21-01-year and 21-03-year.

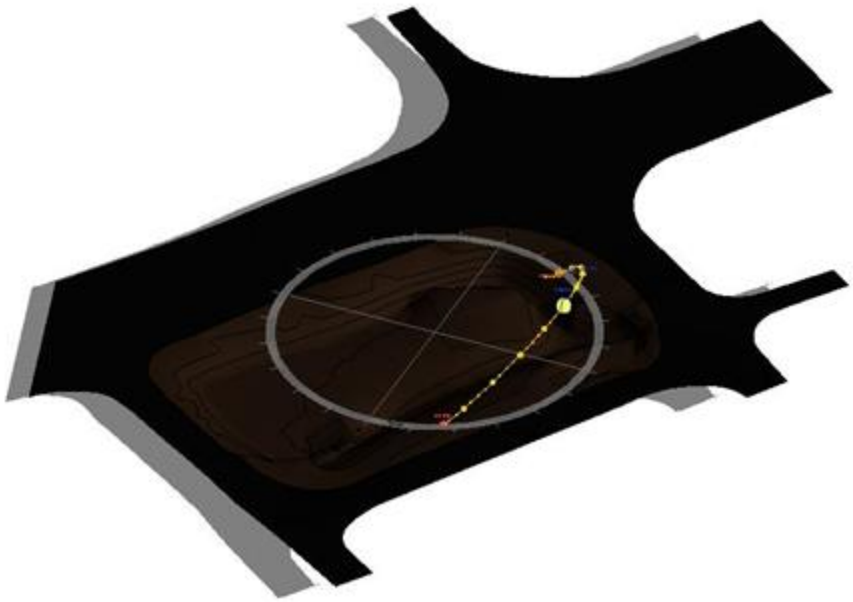


Figure 4: 13 Sun Position 21-1

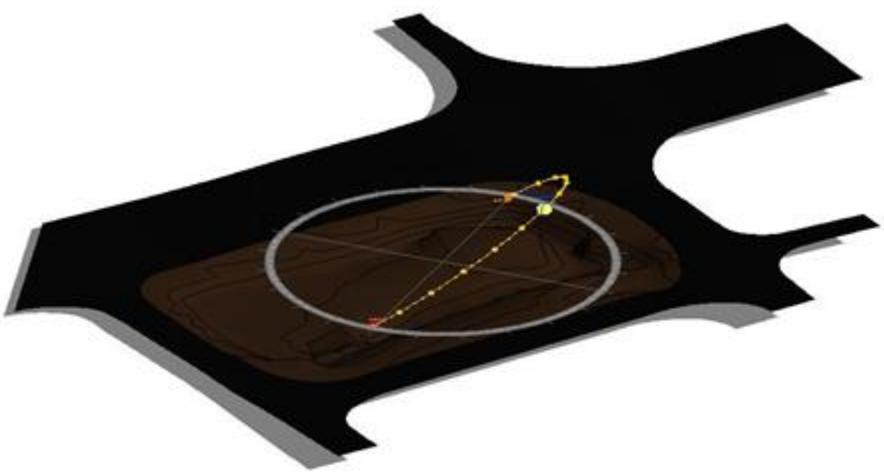


Figure 4: 14 Sun Position  21-3

## 4.3: Project Description:

Multi-purpose building is the center in which economic, social, cultural, entertainment and administrative services, Common area is the total area within the commercial center that is designed for rental to investors, this project will contribute in bringing life to the region where our project will be construction and give new chance to businessmen to rental offices, markets, stores, etc. However, it gives that region new commercial life to take the economic benefits .The idea is to bring financial, business opportunities and to refresh the commercial business to that region. On another hand the increasing of population in many societies, and the need to have a place that have complex function are the aim at this time.

The Architect structure 14$^{th}$ floors that will contains:

The forth Basement floor with an area of 2540 $m^2$ consists Parking.

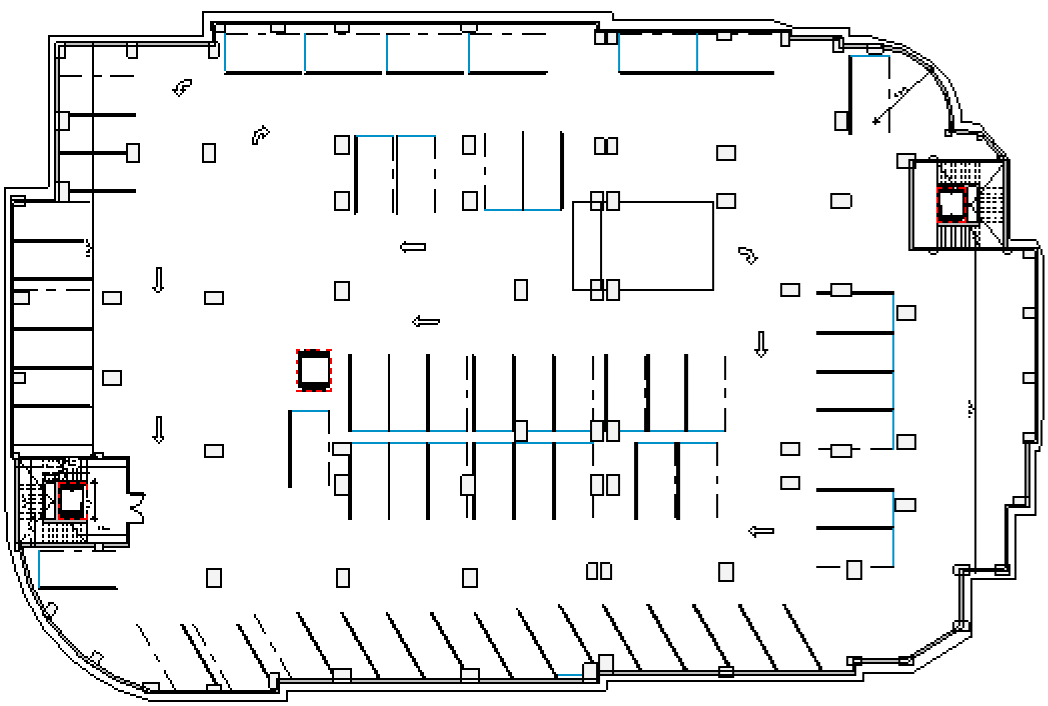


Figure 4: 15 The forth Basement floor

The Third Basement floor with an area of 2540 $m^2$ consists Parking.

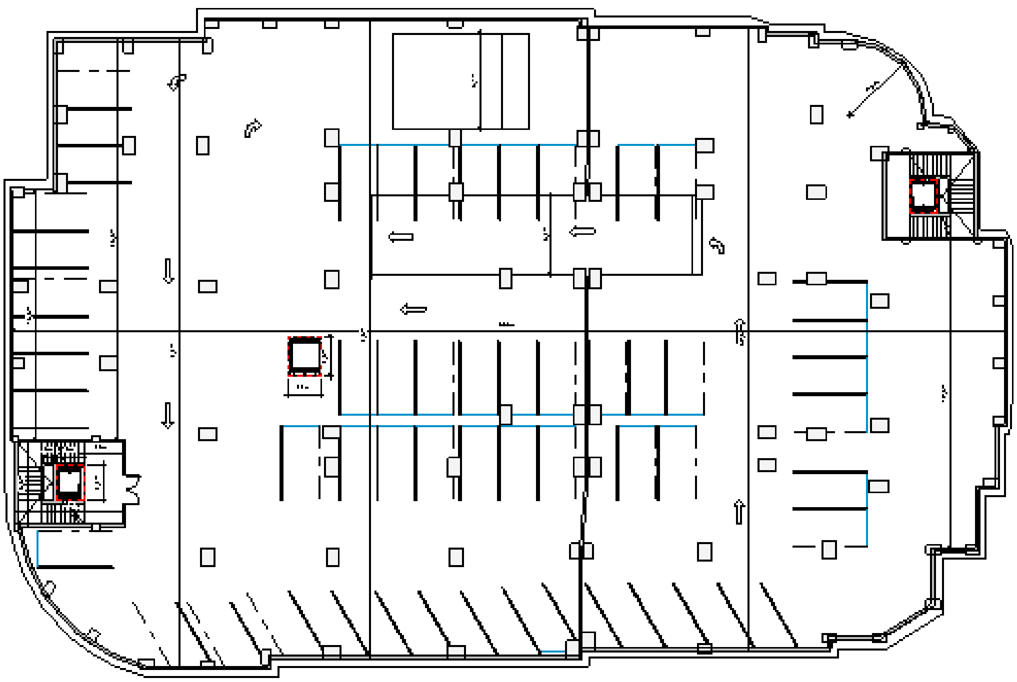


Figure 4: 16 The Third Basement floor

The Second Basement floor with an area of 2540 $m^2$ consists Parking.

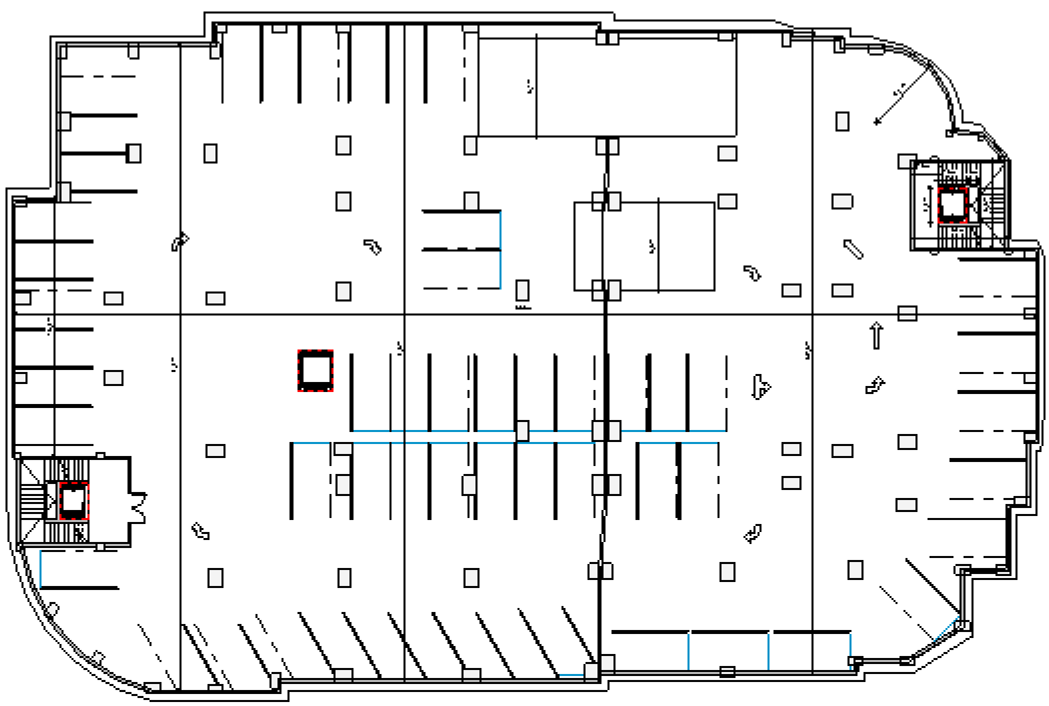


Figure 4: 17 The Second Basement floor

The First Basement floor with an area 2540 $m^2$ consists show rooms.

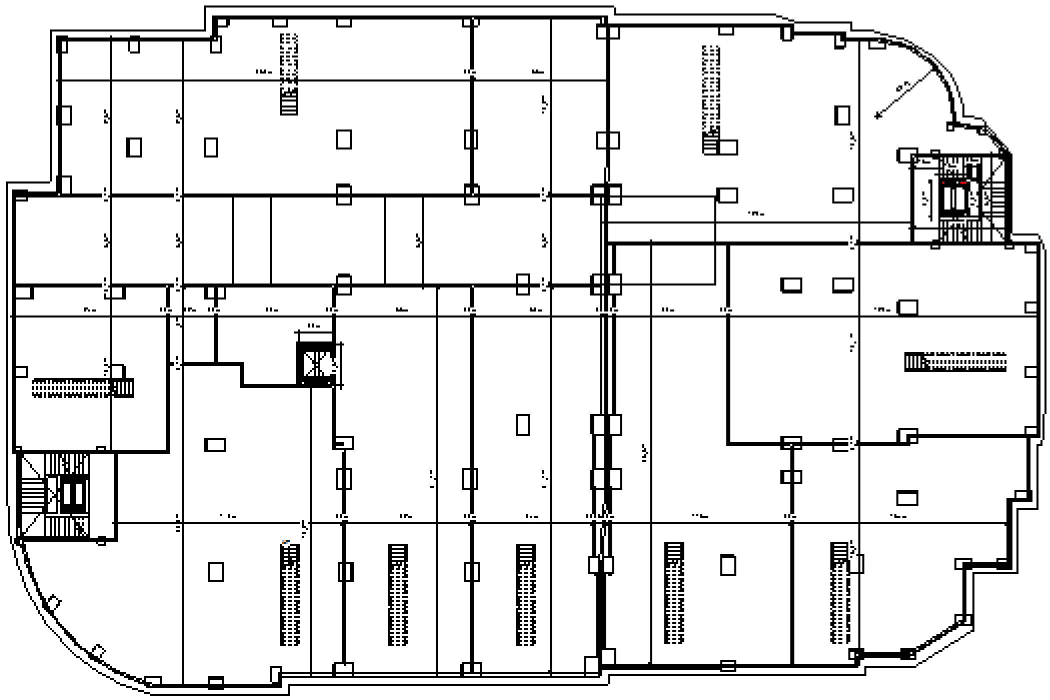


**Figure 4: 18 The First Basement floor**

The Ground floor with an area of 2430 $m^2$ consists lobby , courtyard, shops, staircase.

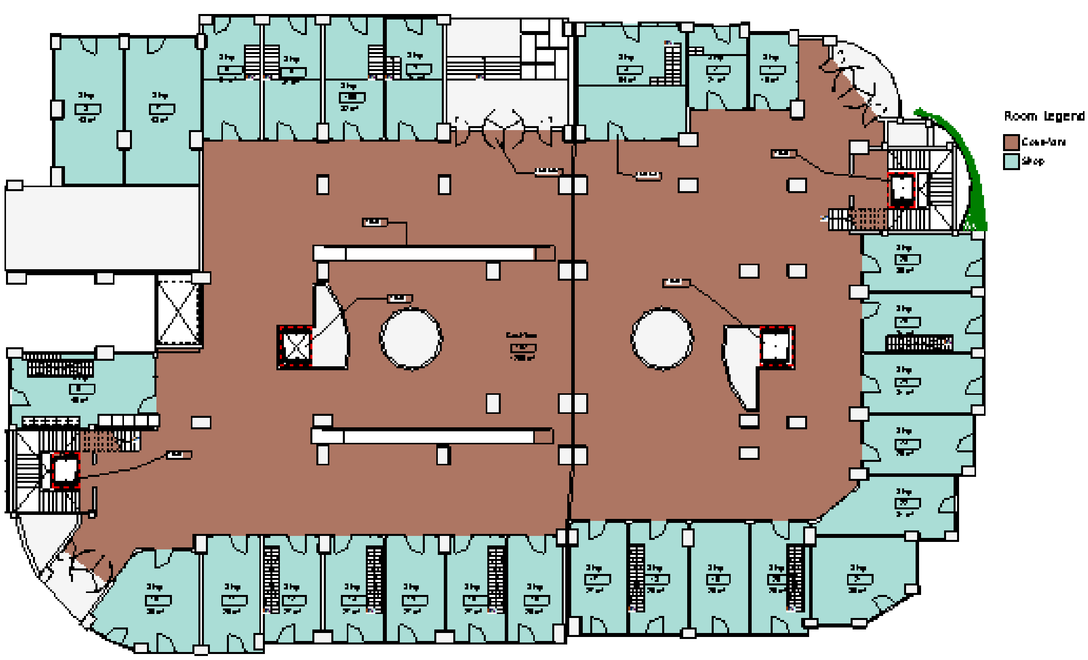



**Figure 4: 19 The Ground floor**

The First floor with an area of 2110 $m^2$ consists of Supermarket, Staircase , courtyard, shops, W.c's .

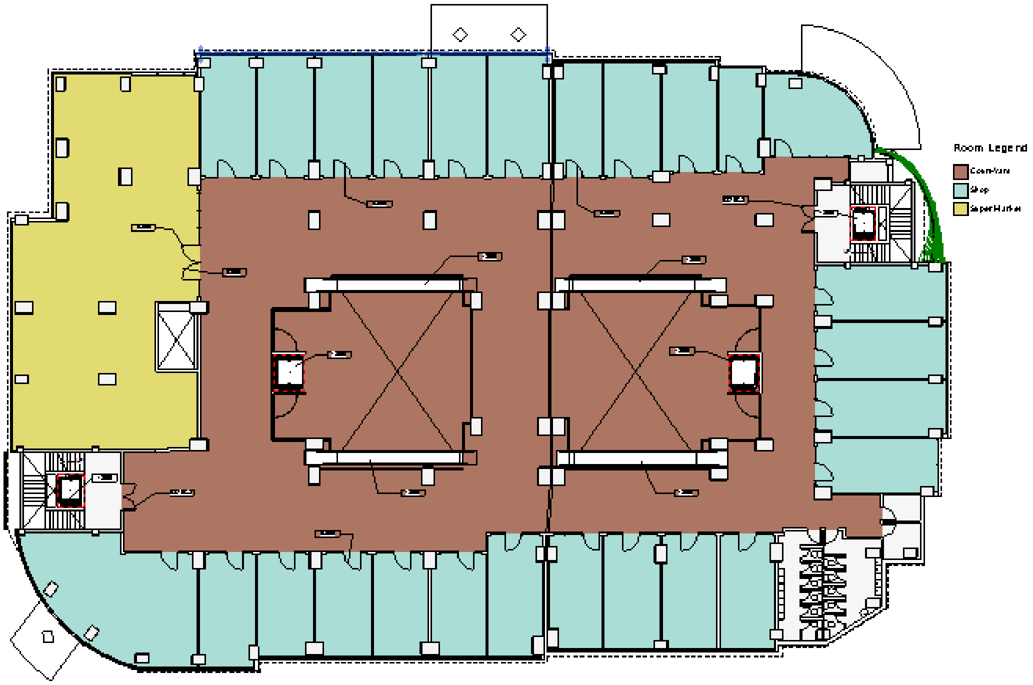



Figure 4: 20 The First floor

The Second floor with an area of 2110 $m^2$ consists of Supermarket, Staircase , courtyard, shops, W.c's .

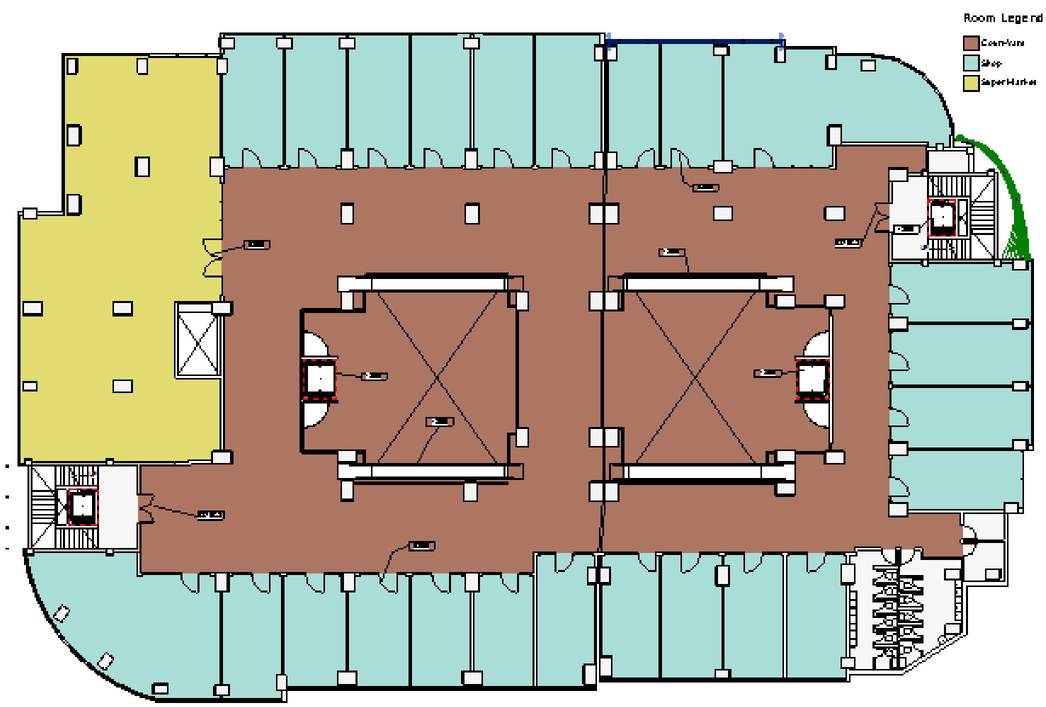



Figure 4: 21  The Second floor

The Third floor with an area of 2110 $m^2$ consists of Cafeteria, Staircase , courtyard, showrooms, W.c's .

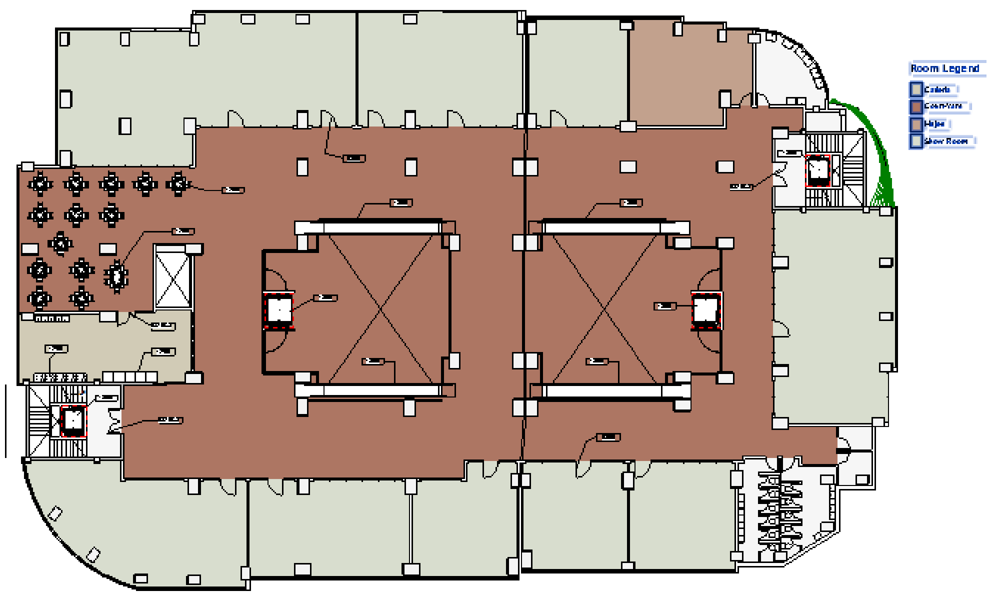



**Figure 4: 22 The Third floor**

The Fourth floor with an area of 2110 $m^2$ consists of Cafeteria, Staircase , courtyard, showrooms, W.c's .

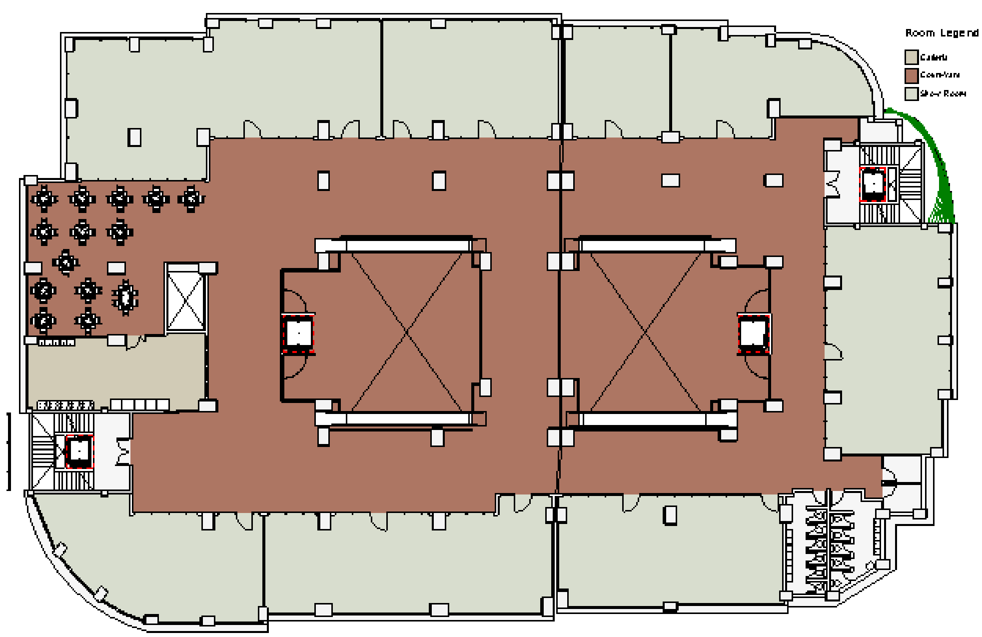



**Figure 4: 23 The Fourth floor**

The Fifth floor with an area of 2110m$^2$ consists of Cafeteria, Staircase , courtyard, showrooms, W.c's .

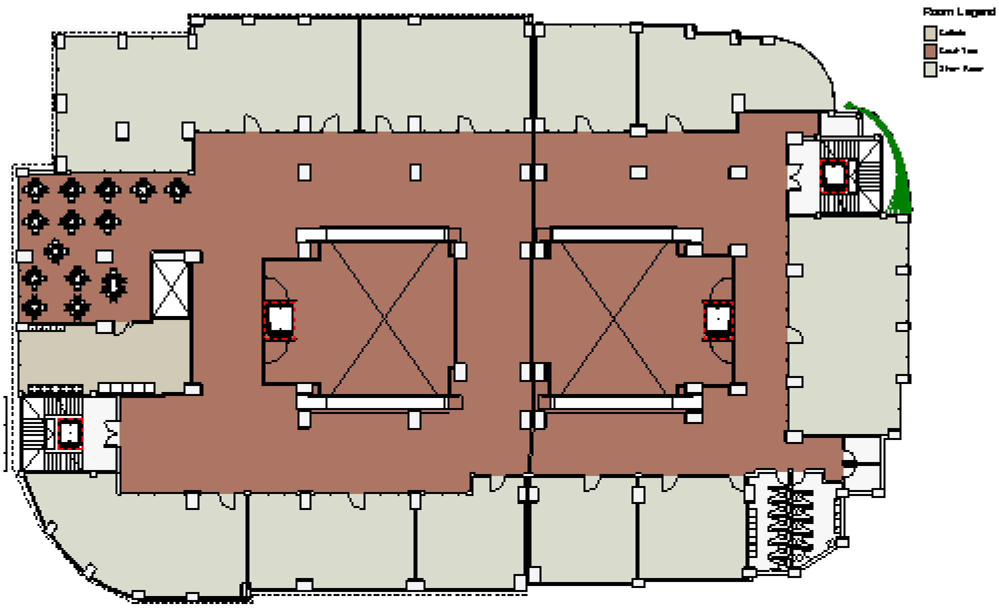


Figure 4: 24 The Fifth floor

The Sixth floor with an area of 2110 m$^2$ consists of Multipurpose area, Staircase , courtyard.

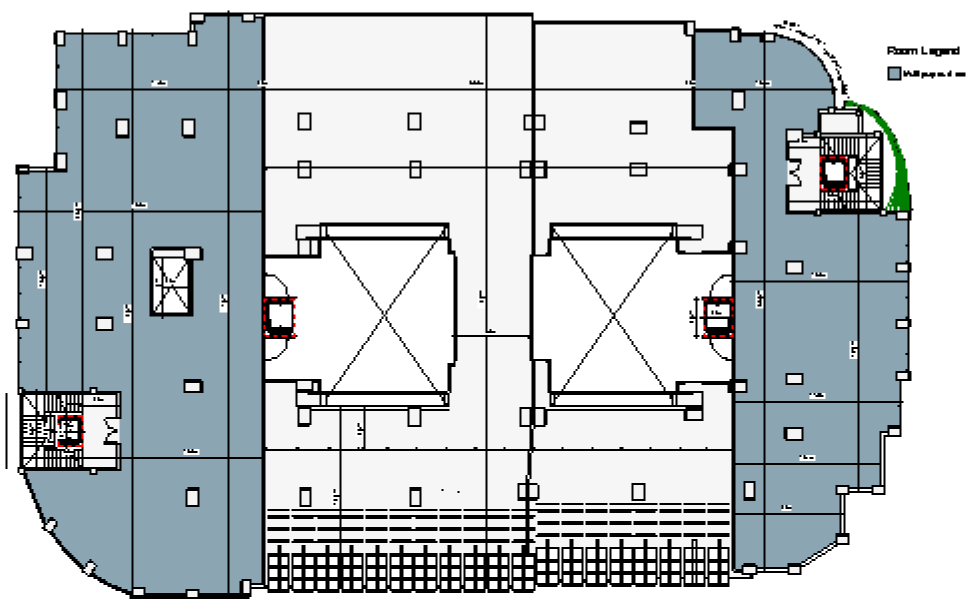


Figure 4: 25 The Sixth floor

The Seventh floor with an area of 2000 $m^2$ consists of Restaurants Kitchens, Dining Area, Staircase , courtyard, W.C's .

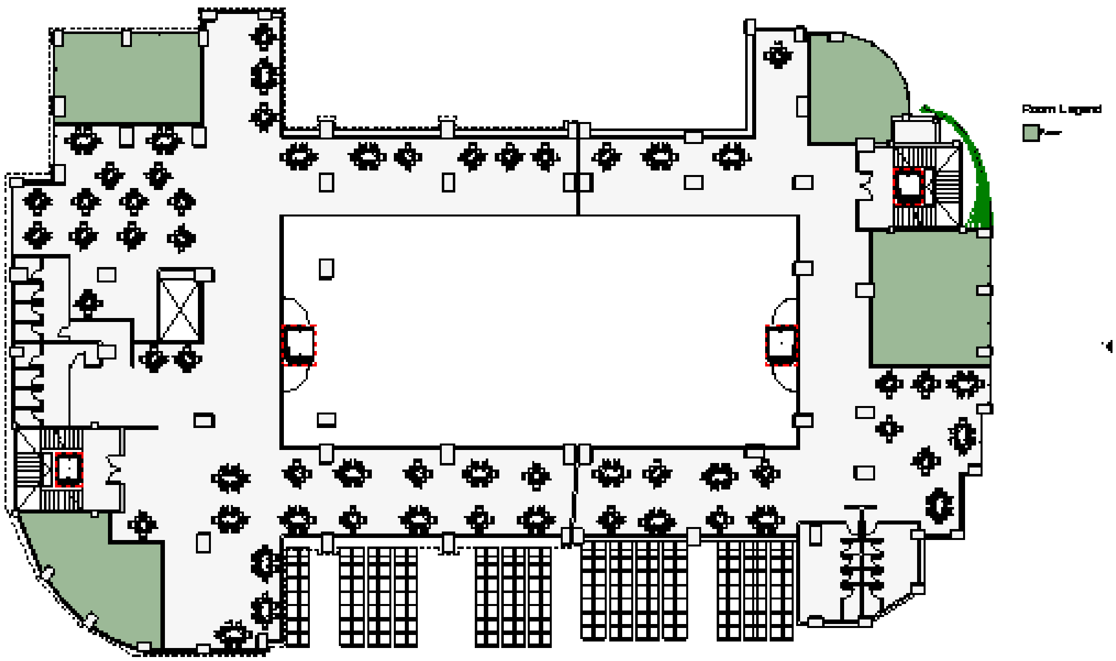


Figure 4: 26 The Seventh floor

The Eighth floor with an area of 2020 $m^2$ consists of Office rooms, Offices Kitchens, , Staircase , courtyard, W.c's .

.

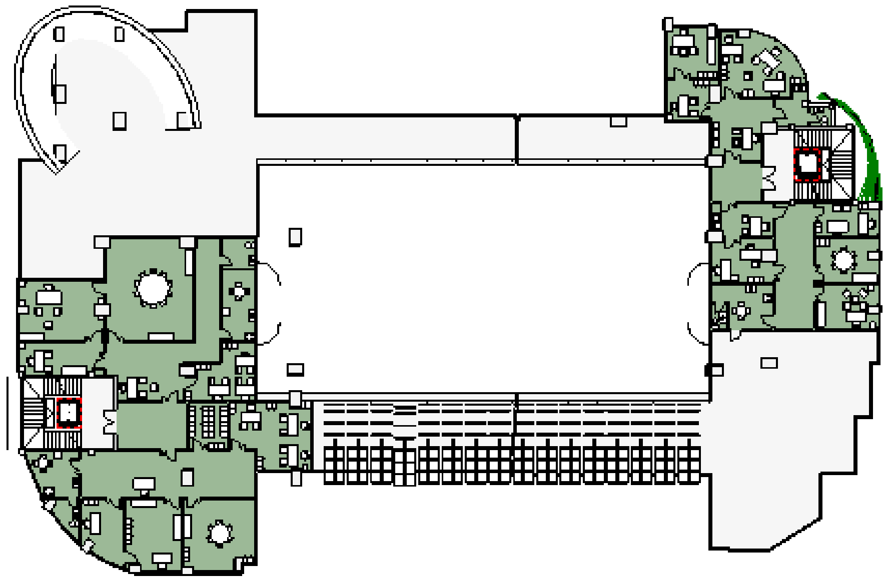


Figure 4: 27 The Eighth floor

The Ninth floor with an area of 880 $m^2$ consists of Office rooms, Offices Kitchens, , Staircase , courtyard, W.c's .

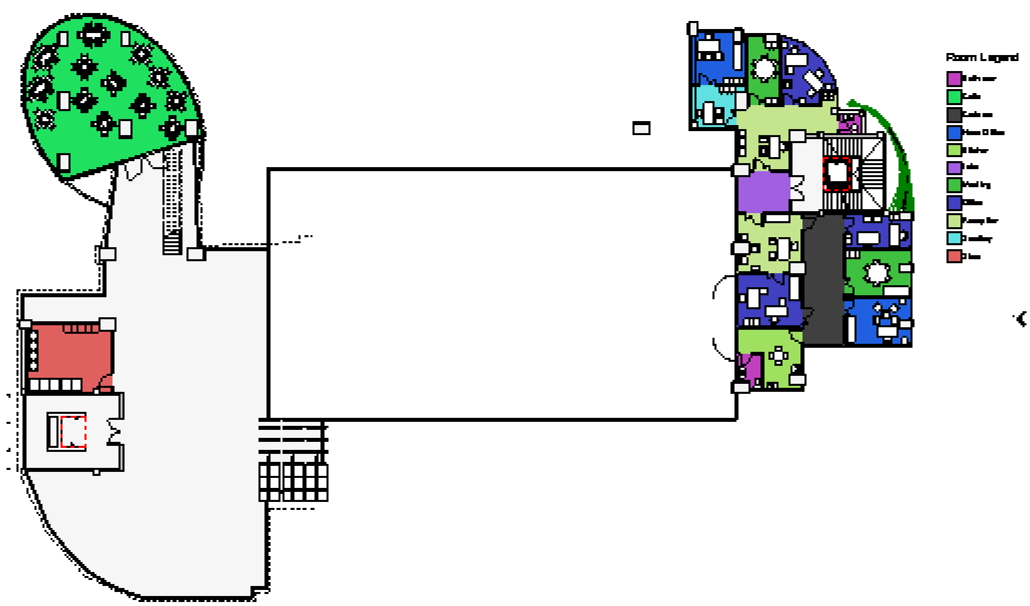



Figure 4: 28 The Ninth floor

And Last floor with an area 120 $m^2$ , contain second floor for cafeteria.

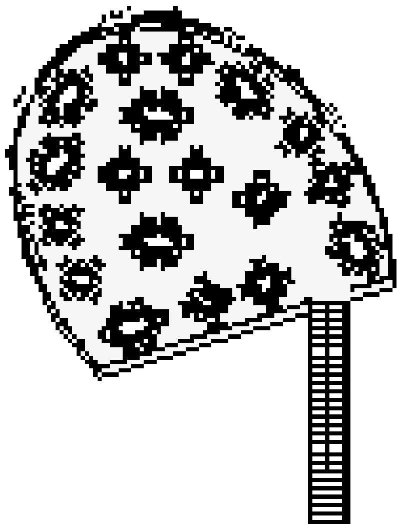


Figure 4: 29 The Last floor

The spaces each area is:

Table 4. 2 Space Areas

| Space type | Area in $m^2$ | Number |
|---|---|---|
| **Shops** | Range (11-87) $m^2$ | 77 |
| **Courtyard** | Range (1107-1224) $m^2$ | 1 |
| **supermarket** | 284 $m^2$ | 2 |
| **Water closet space** | Range (5-14) $m^2$ | 30 |
| **Stare case** | 36 $m^2$ | 2 |
| **showrooms** | Range (56-195) $m^2$ | 28 |
| **Mini Cafeteria** | 65 $m^2$ | 3 |
| **Multipurpose area** | Range (353-588) $m^2$ | 2 |
| **Manager rooms for cafeterias** | Range (44-53) $m^2$ | 2 |
| **Cafeterias Kitchens** | Range (55-66) $m^2$ | 2 |
| **Dining area** | 1431 $m^2$ | 1 |
| **Offices** | Range (8-48) $m^2$ | 37 |
| **Offices Kitchen** | Range (6-12) $m^2$ | 4 |

Final Design :

Figure 4: 30 Rendered Photos

Figure 4: 31  Rendered Photos

Figure 4: 32  Rendered Photos

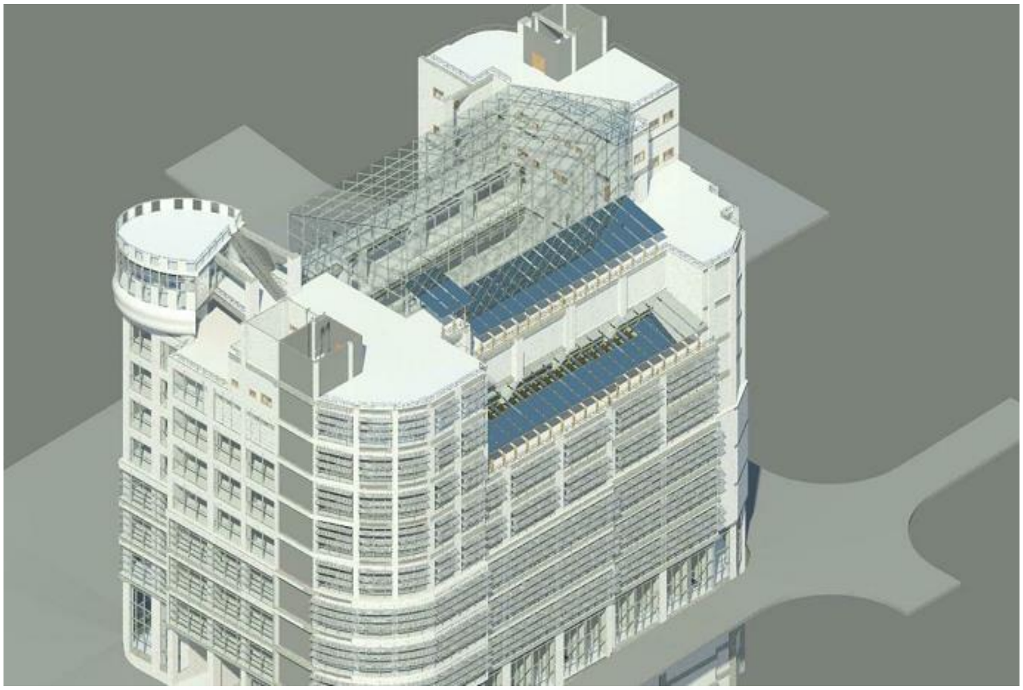


Figure 4: 33  Rendered Photos

Figure 4: 34  Rendered Photos

**Figure 4: 35 Rendered Photos**

## 4.4: Parking:

Table 4. 3 Parking Lot's

| Item | #of parking lot |
|---|---|
| **Shops + show rooms + multipurpose area** | 106 |
| **supermarkets** | 16 |
| **Restaurants and cafe** | 28 |
| **offices** | 12 |
| **total** | 162 |

Available parking lots in the project are 170.

## 4.5: Elevator:

Number of elevator calculation:

Number of floors above ground floor = 10-1= 9 floors.
Building height “elevator travel” = 9*4.9= 44.1 m.
#= 2000*9= 18000.
PHC%= (11.5-13) %.

Diversified (multi-purpose) “prestige” (14-23) .
Population = $\frac{M^2}{person}$ = $\frac{18000}{14}$= 1285.7.
HC= 13%*1285.7= 167.141
choices, speed
2500 500
3000 600
3500

Table 4. 4 Elevator Tables

| Item | 2500/500 | 2500/600 | 3000/500 | 3000/600 | 3500/500 | 3500/600 |
|---|---|---|---|---|---|---|
| **RT** | 116 | 110 | 119 | 116 | 129 | 126 |
| **P normal** | 13 | 13 | 16 | 16 | 19 | 19 |
| **hc=(300/Rt)*Pn** | 33.6 | 35.5 | 40.3 | 41.4 | 44.2 | 45.2 |
| **N=Hc/hc** | 5.0 | 4.7 | 4.1 | 4.0 | 3.8 | 3.7 |
| **N'** | 5 | 4 | 4 | 4 | 3 | 3 |

Then we choose 5 elevator from (2500/500) (lb/fpm) type.
But we have two staircases and many escalator for the structure so we use **4** elevator.

# Chapter Five : Structural Design

## 5.1: Site and geology:

The structure will be built on a clay Soil, therefore the soil allowable bearing capacity is 150 KN/m2 but after treatment the soil by put base corse with three layers the bearing capacity will up to 200 KN/m2.

### 5.1.1: Design codes:

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

ACI -318-08 (American Concrete Institution) for reinforced concrete structural design.

UBC -97 (Uniform Building Code) for earthquake load computations.

ASCE (American Society Of Civil Engineers) for load combinations.

### 5.1.2: Project description:

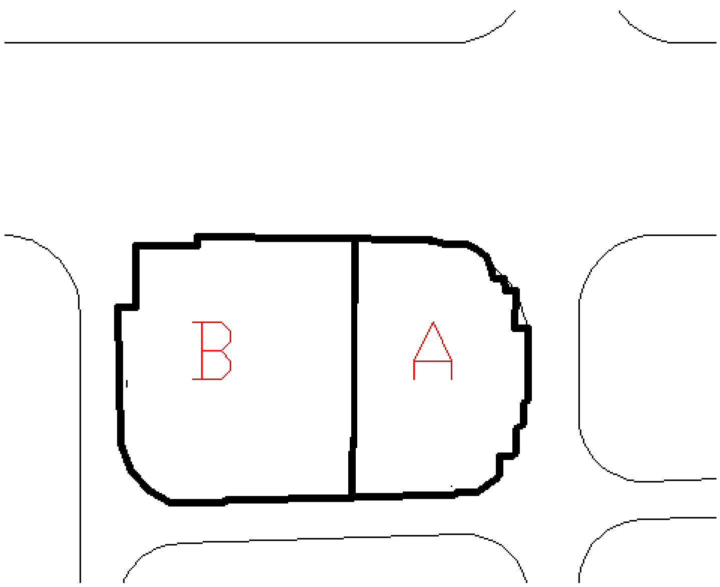



Figure 5. 1 Building Blocks

As its shown above, The structure is divided into two blocks (A and B ) of concrete.

## 5.2: Materials:

The materials used in construction have the following characteristics:

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.

For columns f'c= 32 MPa.

For beams f'c= 28 MPa.

Yielding strength of steel fy= 420 MPa.

## 5.3: Methodology:

**The first step:**

Finishing the architectural design. After that, the layout of the columns is made and making sure that the columns would not change in the architectural design.

**The second step:**

Choosing the structural system that is going to be used. In our design we have one type of structures which is reinforced concrete structure, beam-girder system is used because we have to make large spans in order to make it easy for circulation of cars in the parking.

**The third step:**

3D SAP model have been done according to these loads:

Table 5. 1 Loades Used iIn SAP Model

| Type of load | Load $KN/m^2$ |
|---|---|
| Live load | 5 $KN/m^2$ |
| Super imposed dead load | 4 $KN/m^2$ |

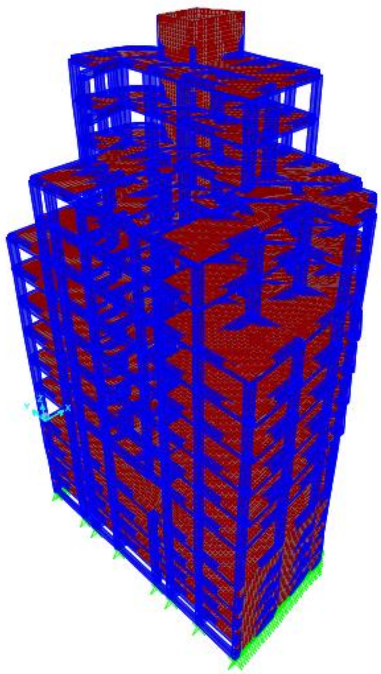


Figure 5. 2 The figure shows the sap model of Block A

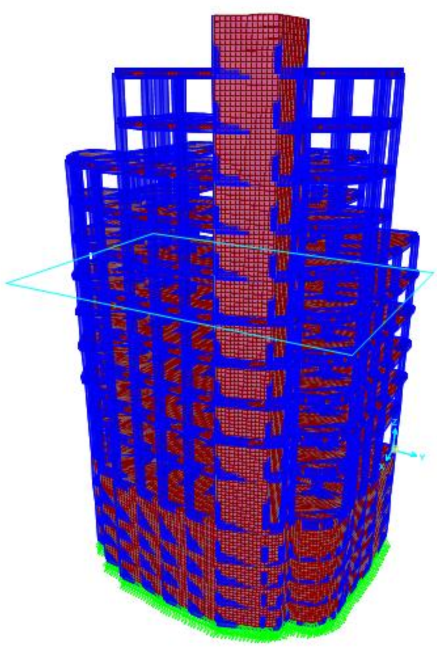


Figure 5. 3 The figure shows the sap model of Block A

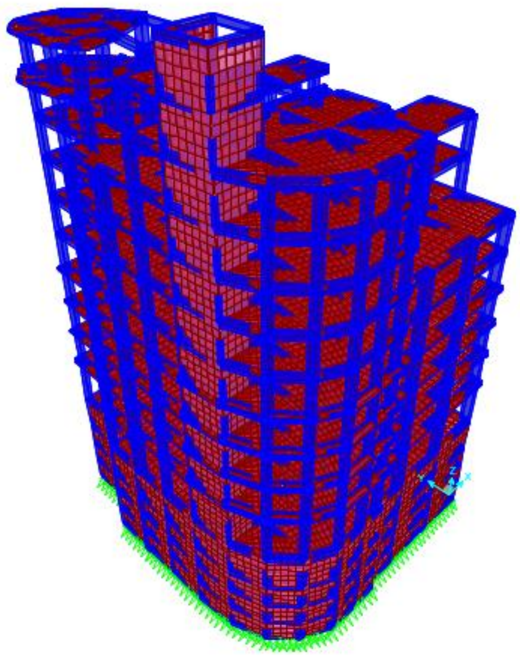


Figure 5. 4  SAP model of Block B

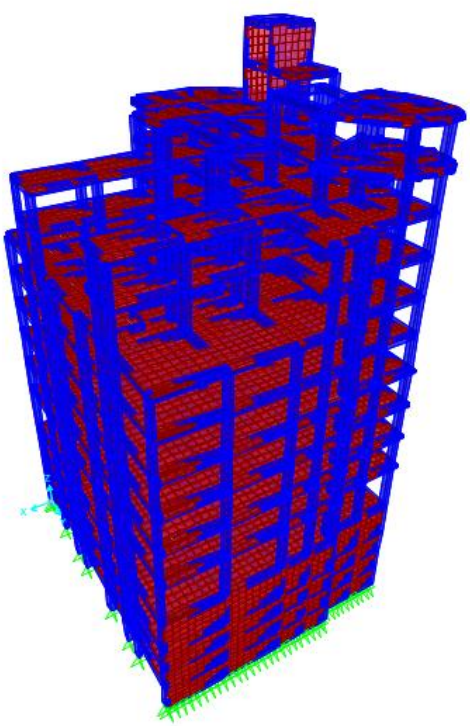


Figure 5. 5 sap model of Block B

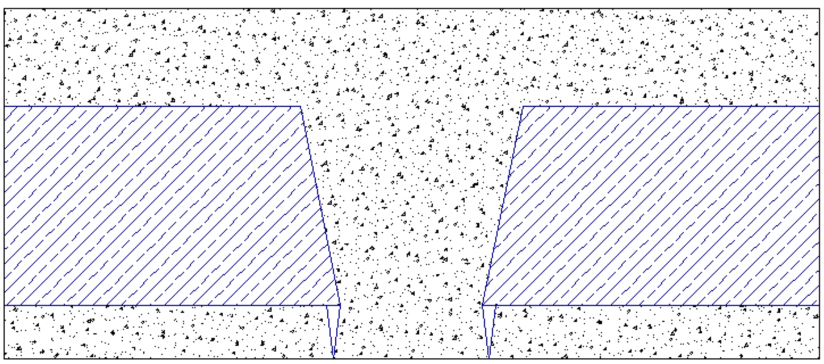
According to **ACI318-08**, the minimum depth for the slabs and column was as follow:

The maximum simply supported beam was $7_m$ --->$\frac{7}{16} = 0.43\ m$

The maximum one end continues beam was $8.8_m$ --->$\frac{8.8}{18.5} = 0.47\ m$

The maximum two end continues beam was$8_m$ --->$\frac{8}{21} = 0.38\ m$

**The system of the slab is one way ribbed slab(30 cm thickness) with Drop beams.**



The dimensions of the slab is match the specifications from **ACI 318-08** Code such that :

The width of the rib = $120_{mm}$ >$100_{mm}$ .

The height of the flange = $60_{mm}$>$50_{mm}$ .

The width of the block = $400_{mm}$ <$750_{mm}$ .

The height of the slab = 300mm < 3.5* width of the rib .

**Input for sap:**

The **load combination** according to **ACI 318-08**:

1) Wu= 1.4D.L

2) Wu= 1.2D.L+ 1.6L.L + 0.5(Lr or S or R)

3) Wu= 1.2D.L +1.6(Lr or S or R) + (1.0L or 0.8W)

4) Wu= 1.2D.L+ 1.6W + 1.0L + 0.5(Lr or S or R)

5) Wu= 1.2D.L ± 1.0E + 1.0L + 0.2S

6) Wu= 0.9D.L ± (1.6W or 1.0E)

**Where:**

D.L: Dead load

L.L: live load

E: Earthquake load

S: Snow load

W: Wind load

Lr: Roof live load

R: Rain load

**2.Beam and slab sections:** As mentioned before.

**3.Beams modifiers:**

The modifiers for the beams for bending moment 1 &2 and for torsion are as follows:

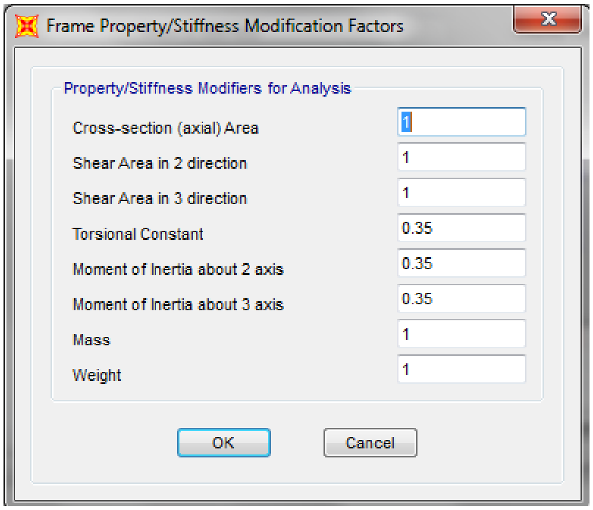



Figure 5. 6 SAP modification Factors

**Slab modifiers:**

The slab used was one way beton slab reinforced in x direction, and the modifiers were as follows:

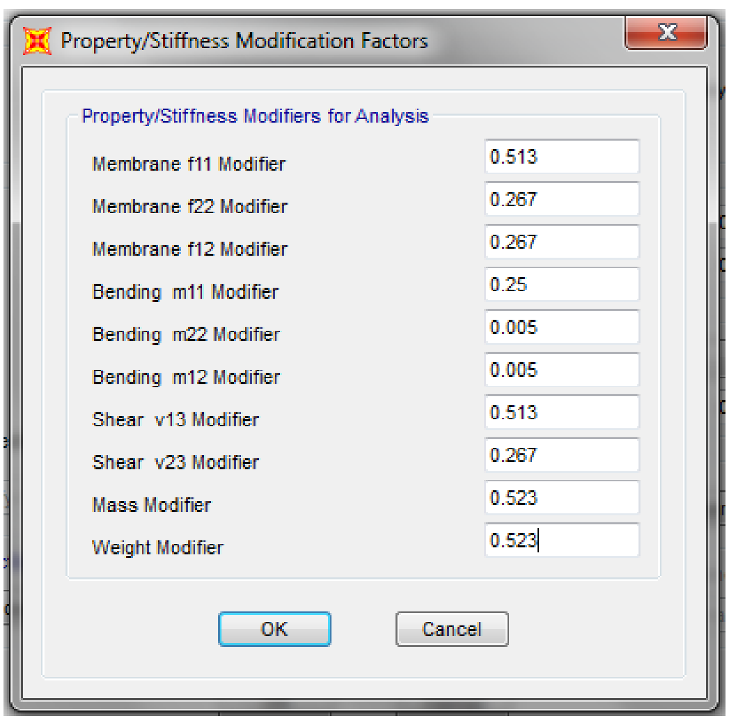



Figure 5. 7 SAP modification Factors

and for the Parking we use solid slab (one way) and the modifiers as follows:

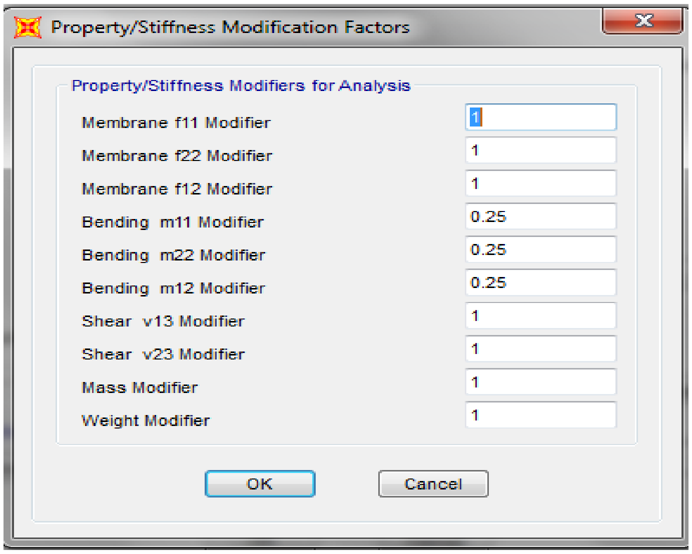



Figure 5. 8 SAP modification Factors

4.**Columns and Shear Walls modifiers:**

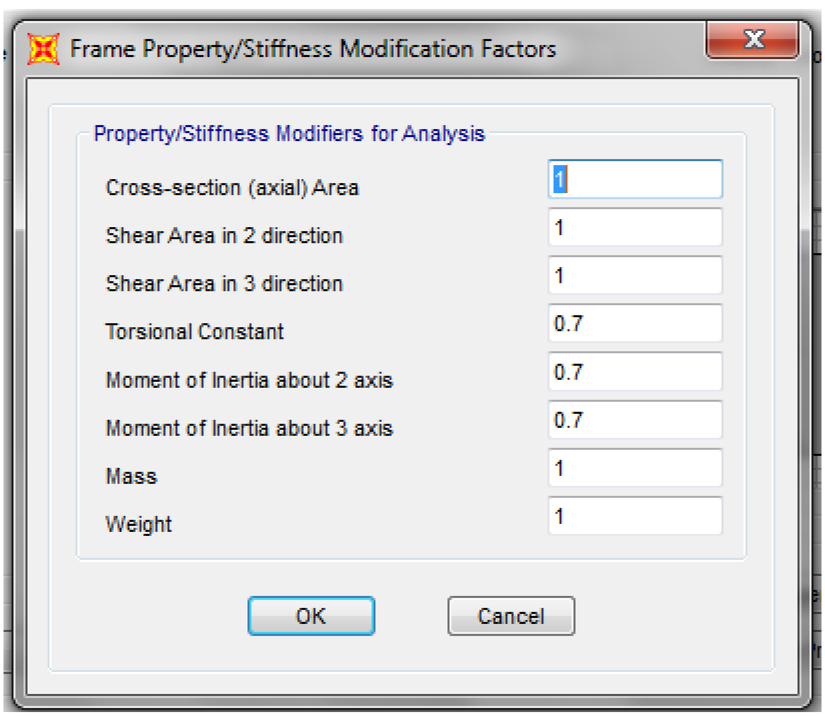



Figure 5. 9 SAP modification Factors

**5.Loads on slabs and beams as we mentioned before according to ASCE.**

**NOTE:**

After analyzing the model on sap, The output shows that the shear and torsion in some of beams exceeds the maximum allowable, so the thickness of the beams was made in order to be able to carry the maximum shear and torsion.

## 5.4: Analysis and design for block B:

***Model Validation:***

To be confident that SAP model works properly and gives correct results, three checks on the model and the obtained results should be made. The checks are:

Compatibility of structural elements in the model.

Global Equilibrium.

Local Equilibrium (internal-forces equilibrium).

### 5.4.1: Compatibility and deflection check:

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 SAP.

The compatibility of the model was checked and it was found to be OK, The Figures below shows the deformed shape of the model.

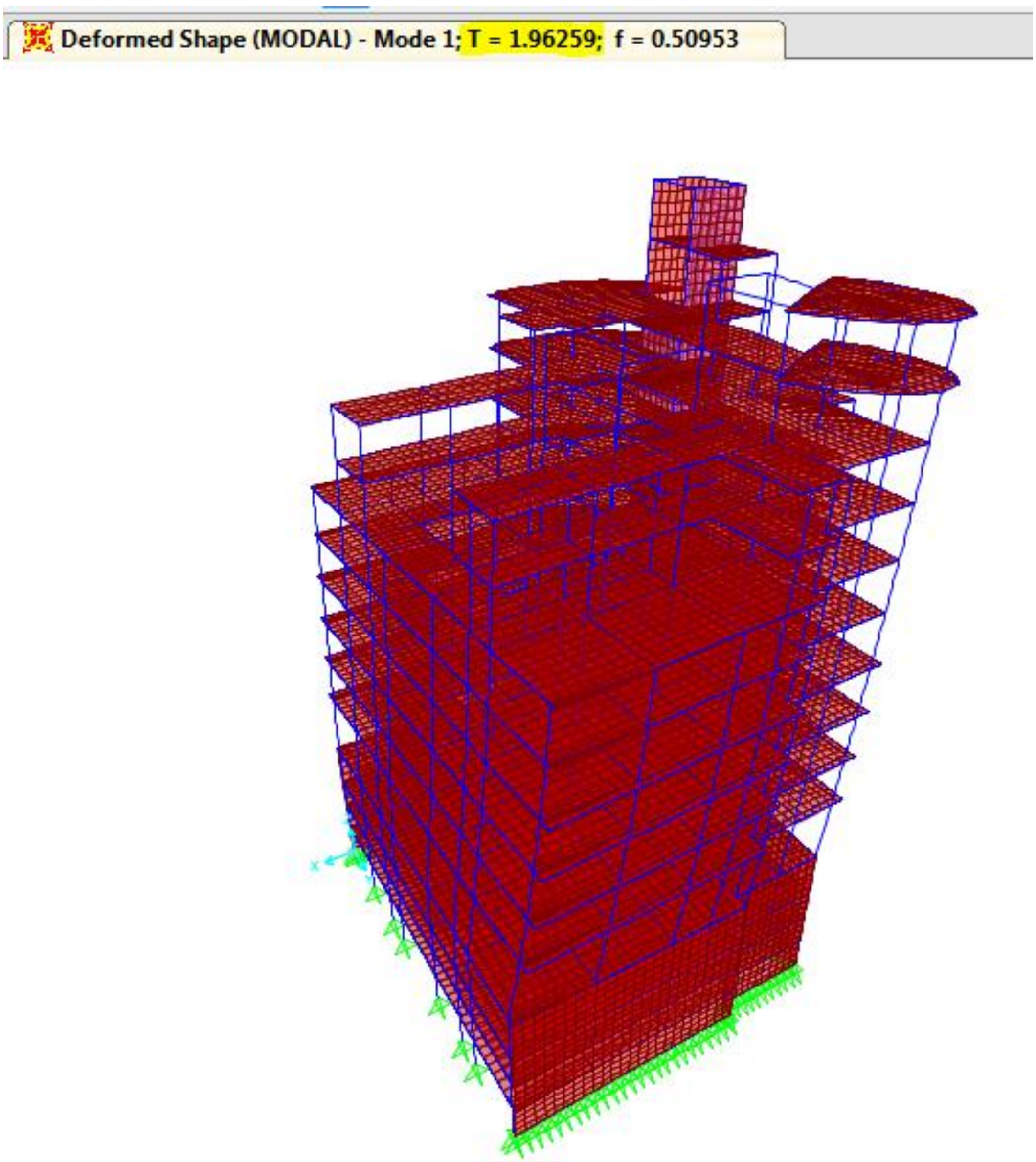



Figure 5. 10 Deformed Shape SAP

The period for the building from Sap was 1.96 as shown above.

The calculated period:

$T_b = Ct * hn^{3/4}$

**Where:**

Ct = 0.0488, for the building that classified as others in UPC97

hn= Total height of the building = 76.5m.

$\mathbf{Tb = 0.0488 * (76.5)^{3/4} = 1.3}$

**Deflection Check:**

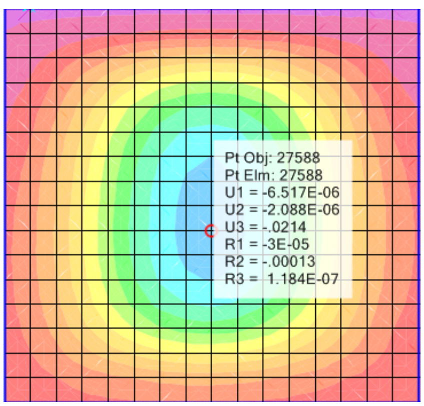



Figure 5. 11 Deflection Check

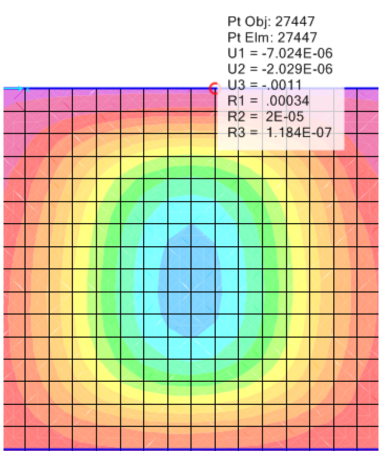



Figure 5. 12 Deflection Check

As its shown above, the deflection in the beam equals to 1 cm.

Length of the beam = 8m.

Allowable deflection = $\frac{8}{240}$ = 3.3 cm > 1 cm ---> ok.

And the deflection in the slab equals to 2.14 - 1= 1.14cm.

Length of the slab = 6.8 m.

Allowable deflection = $\frac{6.8}{240}$ = 2.83 cm > 1.14 cm ---> ok.

### 5.4.2: Equilibrium check:

For the static bodies, the summation of forces in any direction must equal to zero. Thus, for the model, the total reactions in columns must equal the total loads applied. However, because of the difference resulting from area modeling and weight computation, the allowable difference must be less than 5%.

**For Dead load:**

Total weight of basement two ceiling = 20374.26 KN

Total weight of the other floor ceiling = 36244.27 KN
Total SIDL=69381.76

Total weight of All columns = 86437.9 KN.

Total weight of beams = 58764.53 KN

**Total weight of the building = 271202.72 KN.**

**Total Dead load from sap = 267530.157KN**

Base Reactions

File View Format-Filter-Sort Select Options

Units: As Noted    Base Reactions

| OutputCase | CaseType Text | GlobalFX KN | GlobalFY KN | GlobalFZ KN | GlobalMX KN-m | GlobalMY KN-m | GlobalMZ KN-m | GlobalX m | GlobalY m | GlobalZ m |
|---|---|---|---|---|---|---|---|---|---|---|
| DEAD | LinStatic | -2.705 | 10.25 | 267530.157 | 5289012.44 | 5145351.02 | -9.4729 | 0 | 0 | |
| LIVE | LinStatic | 0.218 | 0.28 | 71748.068 | 1434883.17 | 1321781.479 | 94.9413 | 0 | 0 | |

Figure 5. 13 Total Dead Load

**The percentage of difference =** $\frac{271202.72-267530.15}{271202.72}$ *** 100% = 1.37 % < 5% ---> OK**

**For Live load:**

Total Area of basement s = 4311 $m^2$

Total Area of the nine floor =522.2 $m^2$

Total Area of the las two floor = 191 $m^2$

Total Area of other ceiling = 11457.94$m^2$

Total Area of basement s*live load = 4311 $m^2$ *5=21555

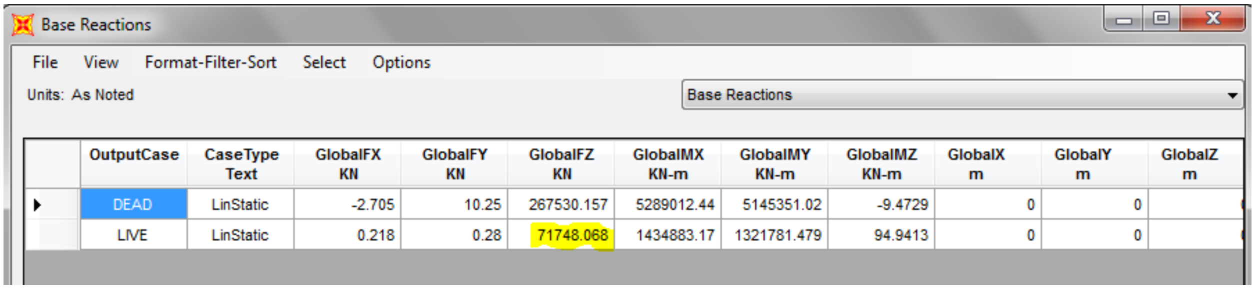
Total Area of the nine floor*live load =522.2 $m^2$ * 3=1566.6

Total Area of the las two floor *live load = 191 $m^2$ * 4=49284.96

Total Area of other ceiling*live load = 11457.94$m^2$* 4=1566.6

**Total live load of the building =21555+1566.6+49284.96+1566.6=73170.56**

**Total live load from sap = 71748.1 KN.**


Base Reactions

File View Format-Filter-Sort Select Options

Units: As Noted

Base Reactions

| | OutputCase | CaseType Text | GlobalFX KN | GlobalFY KN | GlobalFZ KN | GlobalMX KN-m | GlobalMY KN-m | GlobalMZ KN-m | GlobalX m | GlobalY m | GlobalZ m |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ▶ | DEAD | LinStatic | -2.705 | 10.25 | 267530.157 | 5289012.44 | 5145351.02 | -9.4729 | 0 | 0 | |
| | LIVE | LinStatic | 0.218 | 0.28 | 71748.068 | 1434883.17 | 1321781.479 | 94.9413 | 0 | 0 | |

Figure 5. 14 Total Live Load

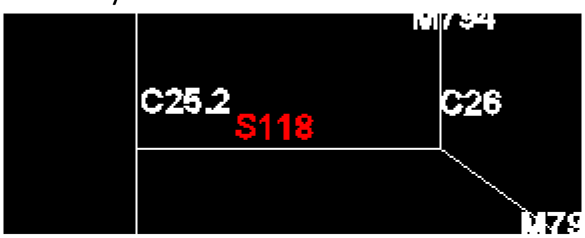
**The percentage of difference =** $\frac{73170.56-71748.1}{73170.56}$ *** 100% = 1.94% < 5% ---> OK**

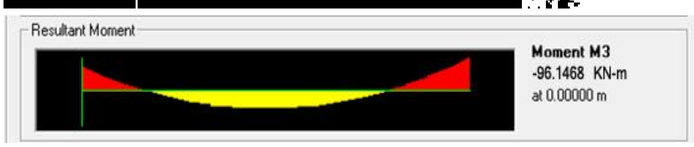
***Internal forces check:***

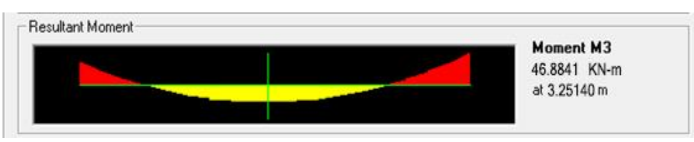
**Check Beams: Beam S118**

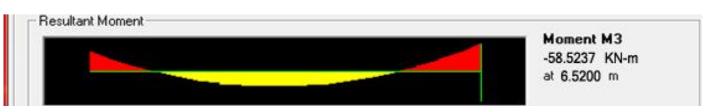
-From dead load:

Tributary width for the beam = 5.2 m.




Ultimate dead load of the beam =((0.2236*25*0.523)*5.2)+(0.8*0.4*25)=23.2

Mu = $\frac{23.2*6.5*6.5}{8}$ = **122.5 KN.m**

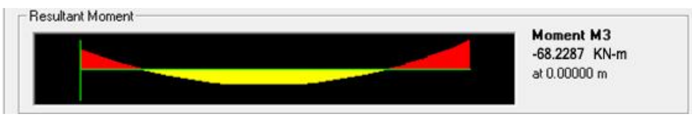
Mu from SAP = $\frac{96.1+58.8}{2}$ + 46.9 = 124.35 **KN.m**

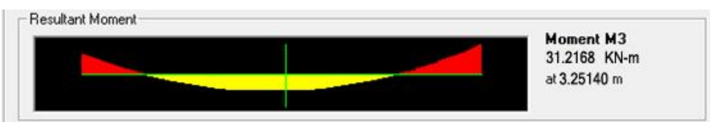
**So**

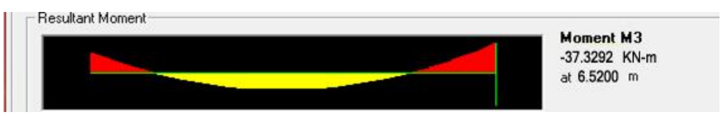
**The percentage of difference = $\frac{124.35-122.5}{124.35}$ * 100% = 1.47% < 5% ---> OK**

-From Live load:

Ultimate dead load of the beam = 5.2*3= 15.6 KN/m.




Mu = $\frac{15.6*6.5*6.5}{8}$ = **82.3 KN.m**

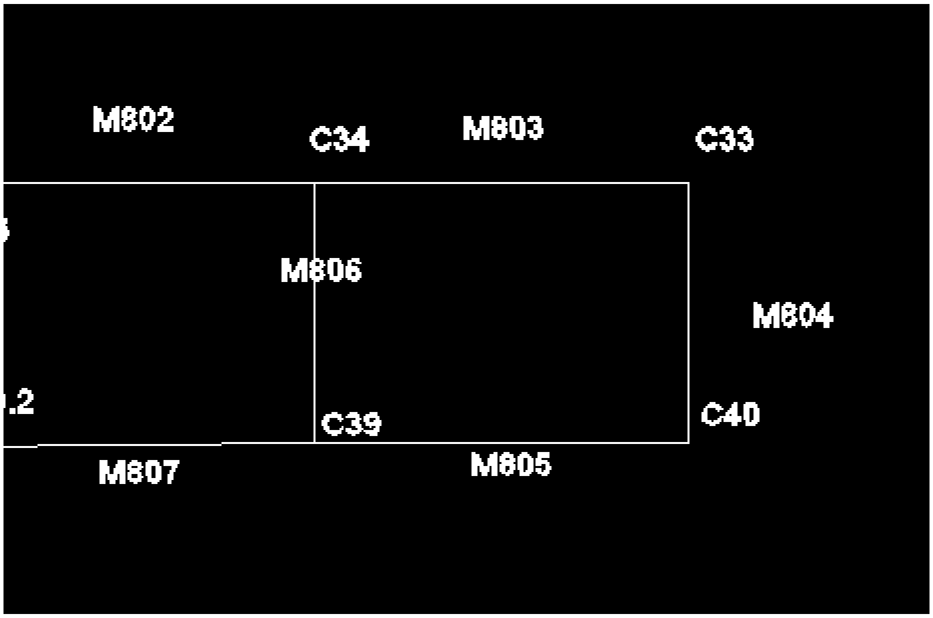
Mu from SAP = $\frac{68.2+37.3}{2}$ + 31.2 = **83.9 KN.m**

**The percentage of difference = $\frac{83.9-82.3}{83.9}$ * 100% = 1.9% < 5% --->OK.**

**Check columns: column 93 (LEVEL 8)**

**From Ultimate load (1.2D.L + 1.6 L.L)**

Tributary Area for the column = 22 $m^2$.

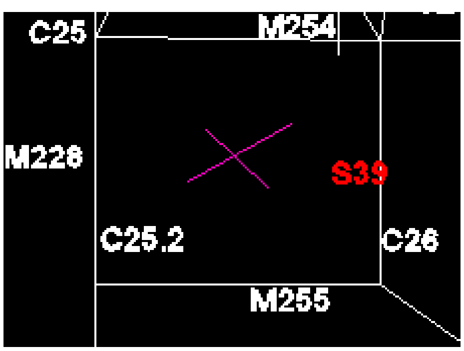




Wu slab (from ultimate) =(((0.2236*25*0.523+4)*1.2)+(1.6*3))=13.1
Wu * trb.area=22*31.1=288.38

Pu=((288.38)+(((1.2*0.6*4.9*25*1.2)+((1.2*(0.8*0.4*25*(9.7)*(3)))))))=673.5
Pu From SAP = 647.6
**The percentage of difference =** $\frac{673.5-647.6}{673.5}$ *** 100% = 3.9 < 5% OK.**

**Check Slabs:**




From dead load:

The weight of the slab = 2.92 $KN/m^2$.

Mu = $\frac{2.92*6*6}{8}$ = **13.1**KN.m/m

Mu from SAP = $\frac{3.2+10}{2}$ + 5.3 = **13.5**KN.m/m

**The percentage of difference = $\frac{13.5-13}{13.5}$ * 100% = 2.6 %.< 5% ok.**

From live load:

The live load of the slab = 5 KN/m$^2$.

Mu = $\frac{5*6*6}{8}$ = **22.5**KN.m/m

Mu from SAP = $\frac{5.6+8.8}{2}$ + 11.6 = **21.6**KN.m/m

**The percentage of difference = $\frac{22.5-21.6}{22.5}$ * 100% = 4% < 5% ok.**

**Note: For other more checks see checks sheet attached with this report.**

Dynamic Analysis (Response spectrum analysis):

Response spectrum analysis has been done on the building to perform the dynamic analysis and design using UBC97 design code.

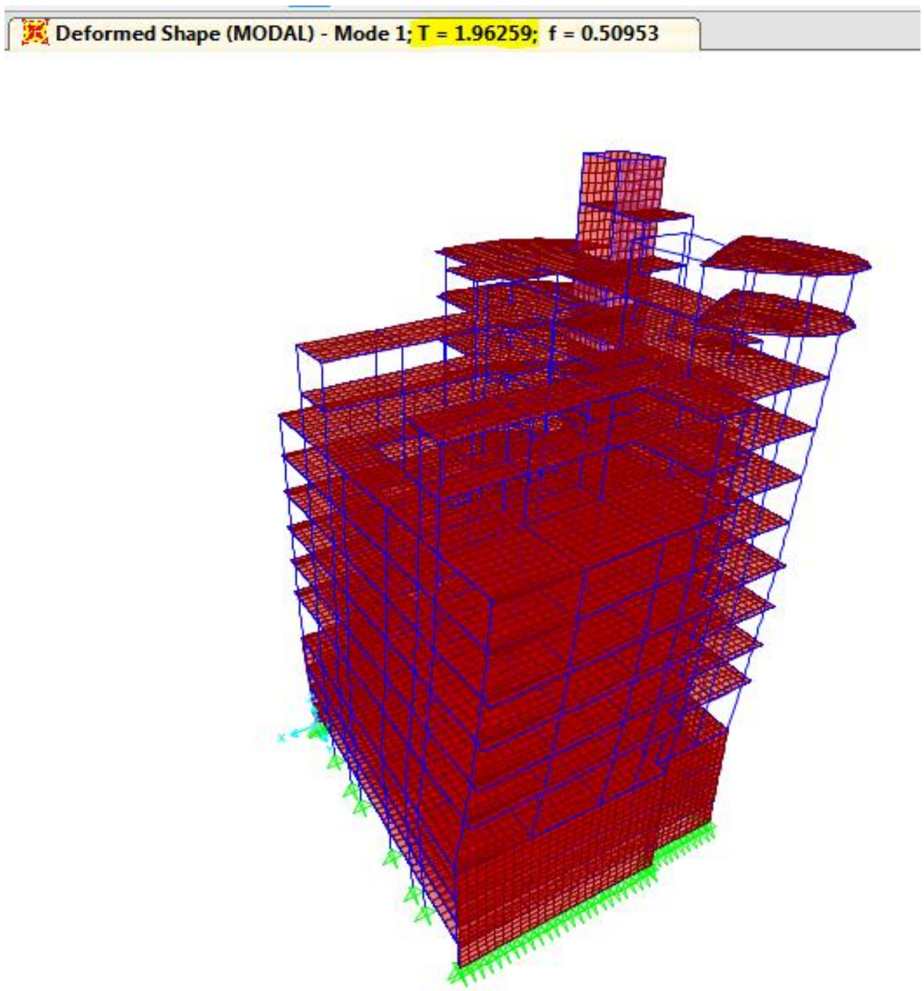



Figure 5. 15 Deformed Shape

**Our structure will work as FRAME SYSTEM.**

### 5.4.3: Needed information:

**1. Importance factor:** I =1

**2. Peak Ground Acceleration (PGA):** the value of PGA = 0.2g, since the building is located in Nablus city according to Palestine seismic map.

**3. Soil profile** in the project region (Sd).

**4. Seismic coefficient (Cv)**= 0.4

**5. Seismic coefficient (Ca)**= 0.28

**6. The structural system** to be designed is assumed to be Sway Intermediate.

**Response modification factor (R):**

Since we have a shear walls oriented in y-direction and shear walls in x-direction the building classification will not differ in each direction. Thus: R is assumed to be 5.5 for both directions by assuming the building is (moment resisting frame intermediate).

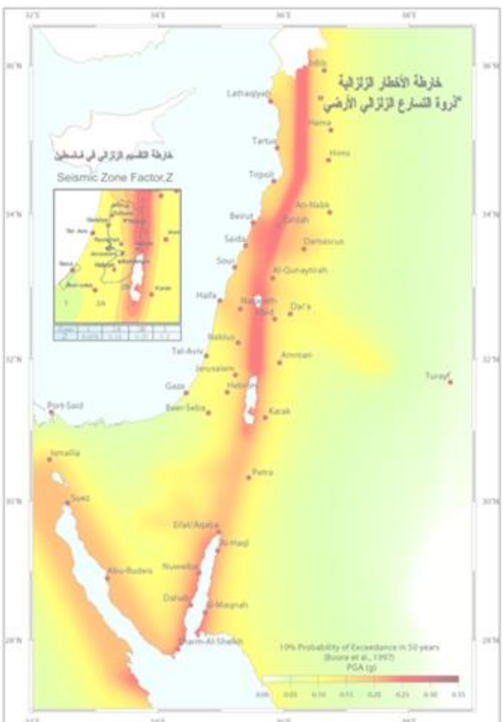



Figure 5. 16 Seismic Zones

Check Dynamic Analysis Results ( Response spectrum analysis):

in order to make the results correct, the base shear from response spectrum function have to be made close to the base shear from the equivalent static method (manual).

**Manual Base shear:**

Weight of the building = dead load + 0.25 live load

= 271202.7 + 0.25 * 73171.56 = **289495.6 KN**.

Base shear (V) = $\frac{Cv*I}{R*T}$* weight = $\frac{0.4*1}{5.5*1.9} * 289495.6$ = **11081.17 KN.**

Base Reactions

File View Format-Filter-Sort Select Options

Units: As Noted — Base Reactions

| OutputCase | CaseType Text | StepType Text | GlobalFX KN | GlobalFY KN | GlobalFZ KN | GlobalMX KN-m | GlobalMY KN-m | GlobalMZ KN-m | GlobalX m | GlobalY m |
|---|---|---|---|---|---|---|---|---|---|---|
| Retz X | LinRespSpec | Max | 10808.797 | 3247.371 | 142.242 | 95367.256 | 264396.1368 | 239438.7911 | 0 | |
| Retz Y | LinRespSpec | Max | 3157.395 | 10310.878 | 65.704 | 271037.7238 | 91579.4243 | 239466.8723 | 0 | |

Figure 5. 17 Base Shear Check

Design of slabs:

**First starting with check shear** in the slab to make sure that the slab doesn't need for shear reinforcement.

The ultimate shear the slab can carry is:

ØVc = $\frac{0.75}{6} * \sqrt{f'c}$ * bw * d

**Where:**

**bw = 150 mm.**

**depth ( d) = 270 mm.**

ØVc = $\frac{0.75}{6} * \sqrt{28} * 150 * 270$ =26.78 KN/ rib ---->38.78 KN/m.

By showing the ultimate shear acting on the slab by SAP program, its clear that there is no shear force (at the face of support ) more than 39 KN/m, so the slab thickness is suitable and it doesn't need for shear reinforcement.

**Second with flexural reinforcement** in the slab:

Slab reinforcement was done by assuming that there is a minimum reinforcement in the rib which is:

$As_{min} = \frac{1.4}{Fy} * b_w * d$ ----> 0.0033*150*270 = 133 $mm^2$ -----> 2Ø10 mm/rib which have an area of 157 $mm^{2.}$

**Note:** See slab reinforcement in the AUTOCAD sheets attached with this report.

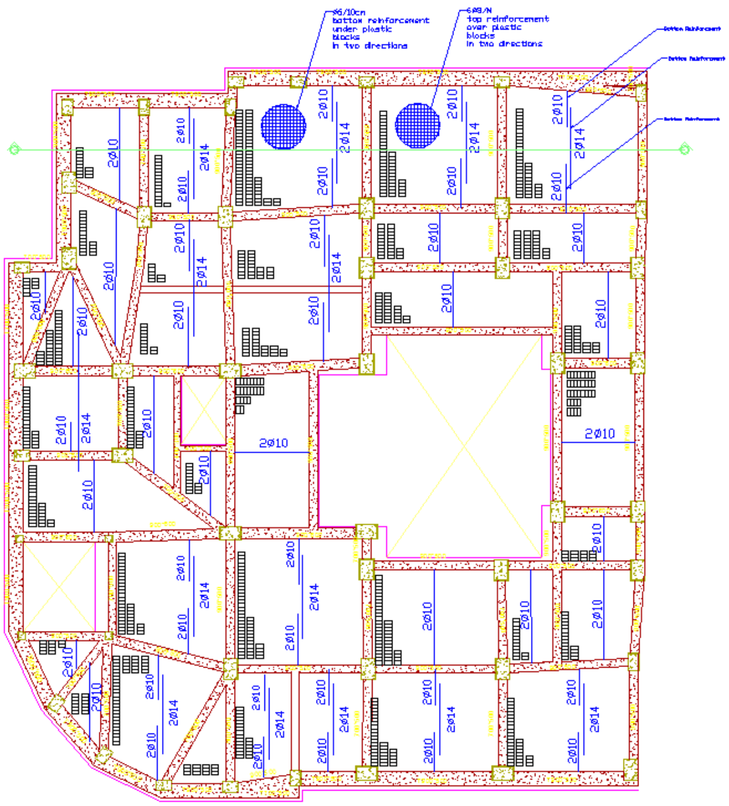



Figure 5. 18 Slab Layout

## 5.5: Design of Beams:

Design of beams have been done using SAP results for shear, moment, torsion, here is a sample of results that obtained from SAP:

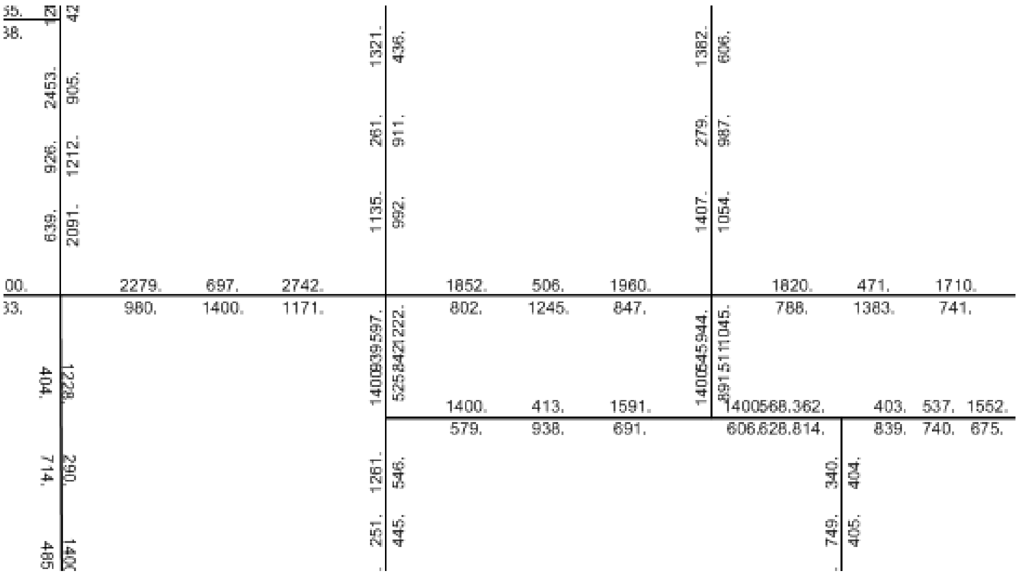



Figure 5. 19 Longitunal Steel SAP

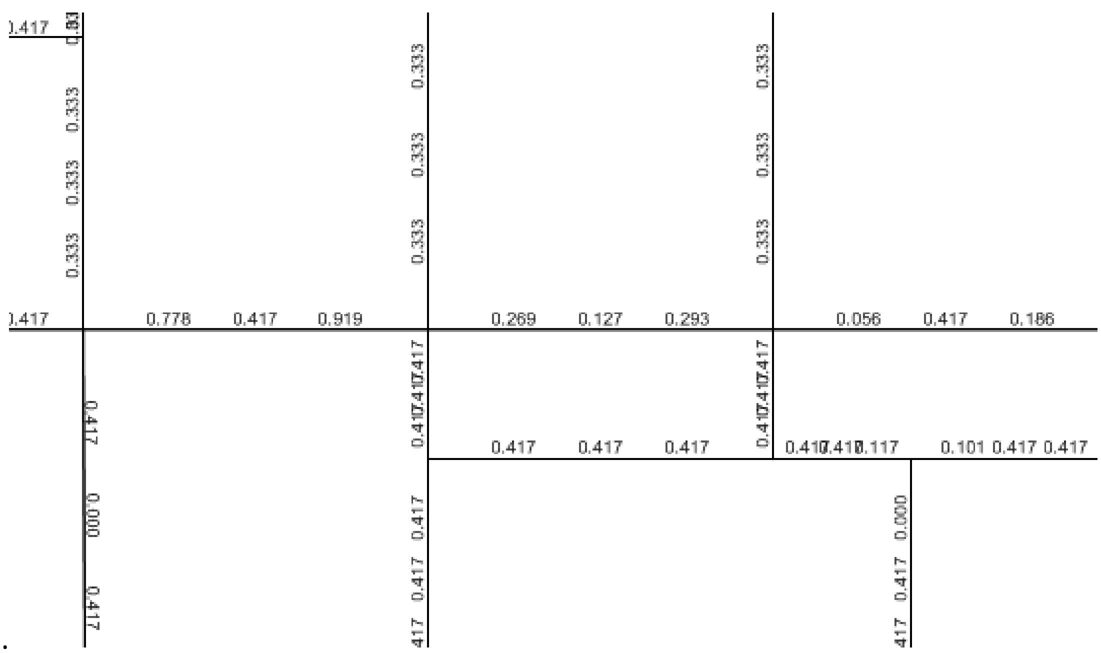



Figure 5. 20 Shear Reinforcement SAP

**Design of the beams was done as follow:**

Compute longitudinal flexural steel for top right and top left and bottom steel.

Compute the longitudinal torsion steel.

divide the longitudinal torsion steel into 3 parts, and distribute it on three layers, one on the bottom of the beam and one on the middle and one on the top of the beam.

Compute the spacing between stirrups for shear and torsion by adding shear reinforcement to torsional reinforcement obtained from sap, figure below shows a sample of beam detailing, for more detailing see the attached AUTOCAD sheets.

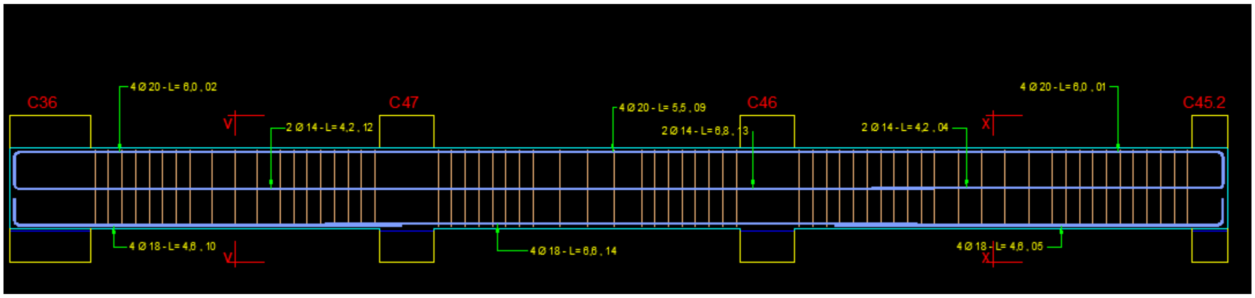



Figure 5. 21 Final Layout Design

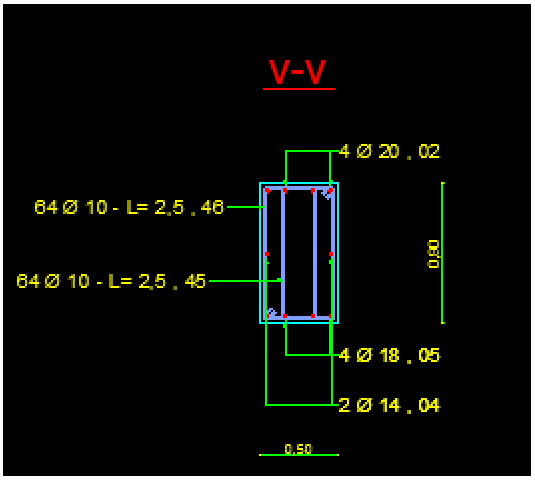



Figure 5. 22 Final Section Design

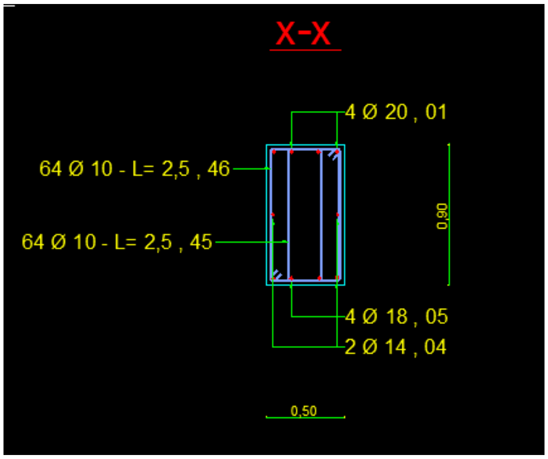



Figure 5. 23 Final Section Design

## 5.6: Design of Columns:

Design of column have been done according to sap results, as its shown below, the rebar percentage is 1.00% which is acceptable by the code, from column neck to the top of the last floor column.

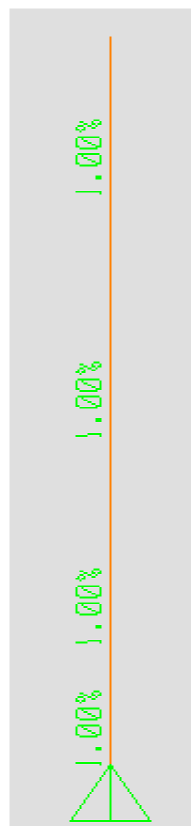



Figure 5. 24 Steel Percentage SAP

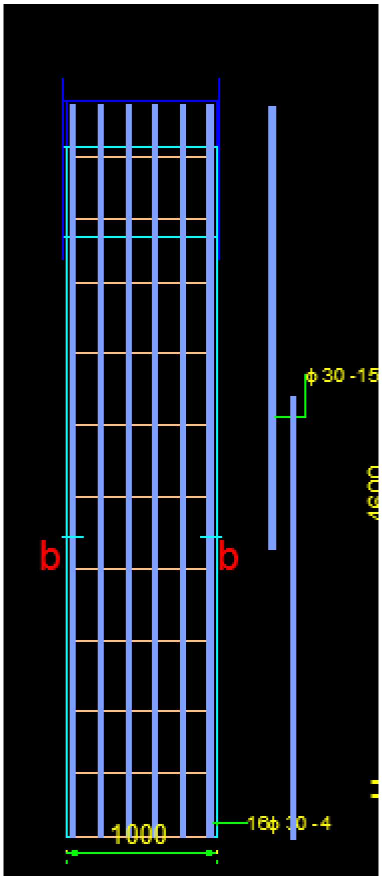



Figure 5. 25 Final Column Design

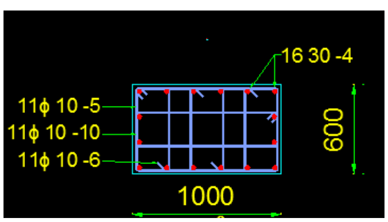



Figure 5. 26 Final Column Section

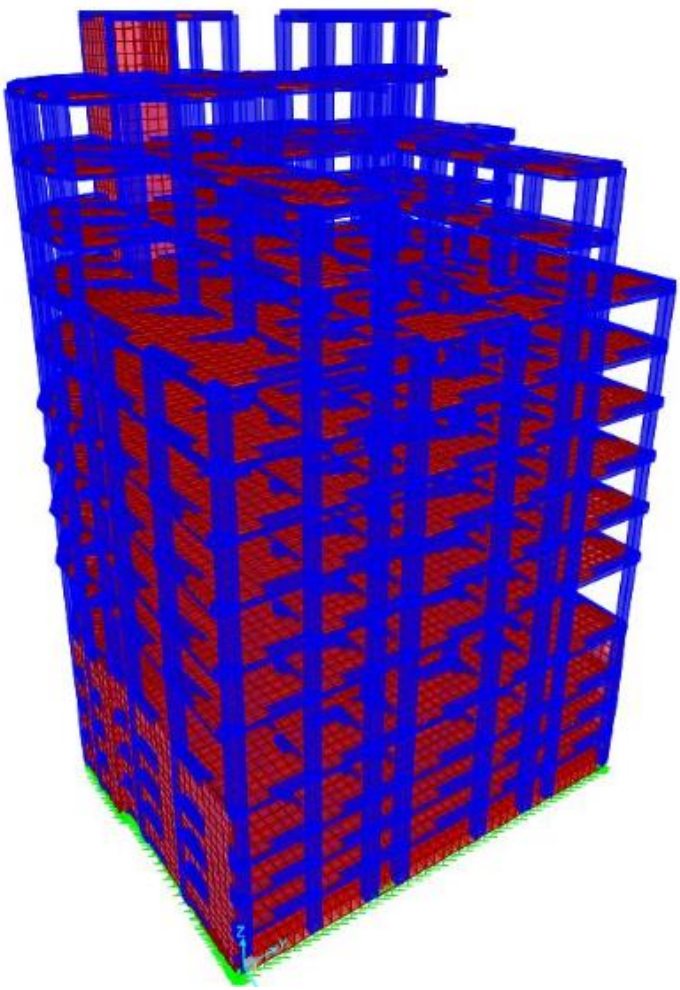
**NOTE:** See attached AUTOCAD sheets that shows More details including splice length and development length with spacing between stirrups.

## 5.7: Design of Footing:

MAT Foundation

Dead load=270781.3
Live Load=73338.6

Bearing capacity (Qall )for soil=250 KN/m3.



sum loads=Dead load+ Live Load = 270781.3+73338.6= 344119.9

sum loads/Qall= $^{344119.9}/_{250}$= 1377 m2
Area required is 1377 m2
Actual area is 1510m2
since 1377<1510 then its ok .

We check the thickness in many positions , the most critical check behind the column
Pu=9128.9 Kn

$ØVc=0.75*\frac{1}{3}*\frac{\sqrt{fc'}(4000+4d)d}{1000}=0.75*\frac{1}{3}*\frac{\sqrt{32}(4000+4d)d}{1000}$

d=1056.02mm then use **d as 1500mm**

**After check**

Dead load=270781.3
Live Load=73338.6

Matt load = 27135.7

Bearing capacity (Qall )for soil=250 KN/m3.

sum loads=Dead load+ Live Load+Matt laod = 270781.3+73338.6+27135.7= 371255.7

sum loads/Qall= $371255.7/_{250}$= 1485 m2
Area required is 1485 m2
Actual area is 1510m2
since 1485<1510 then its ok .

From Sap

**In Y direction**

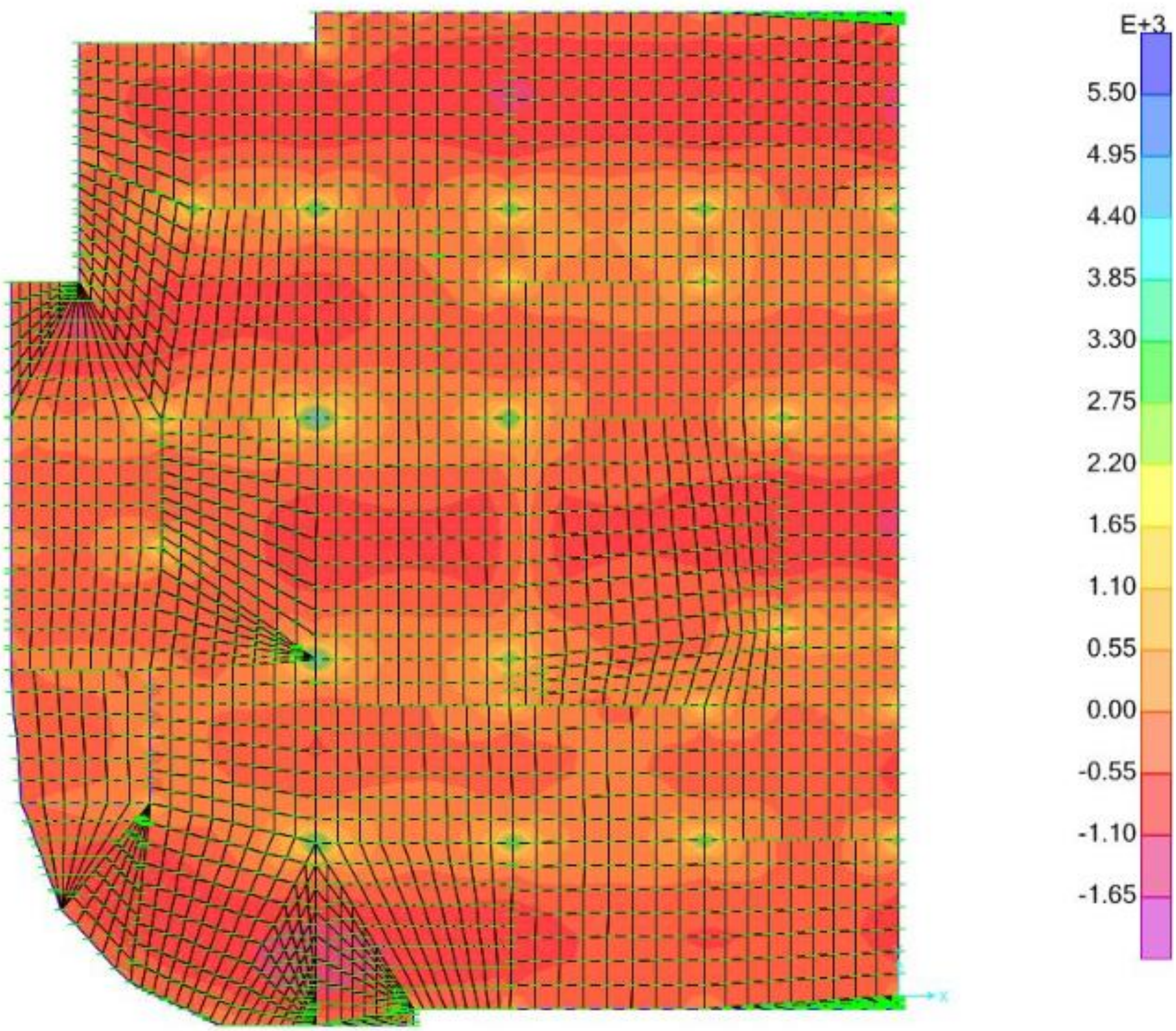



Figure 5. 27 Maximum Bottom Moment

M=0.9*fy*As*(1450-$\frac{As*fy}{1.7*fc*1000}$)

3382=0.9*420*As*(1450-$\frac{As*420}{1.7*32*1000}$) =

As=6387.65

=1Ø25 /15 cm.

Max Top

M=0.9*fy*As*(1450-$\frac{As*fy}{1.7*fc*1000}$)

1649=0.9*420*As*(1450-$\frac{As*420}{1.7*32*1000}$) =

As=3060.26

=1Ø18 /15 cm.

**In X direction**

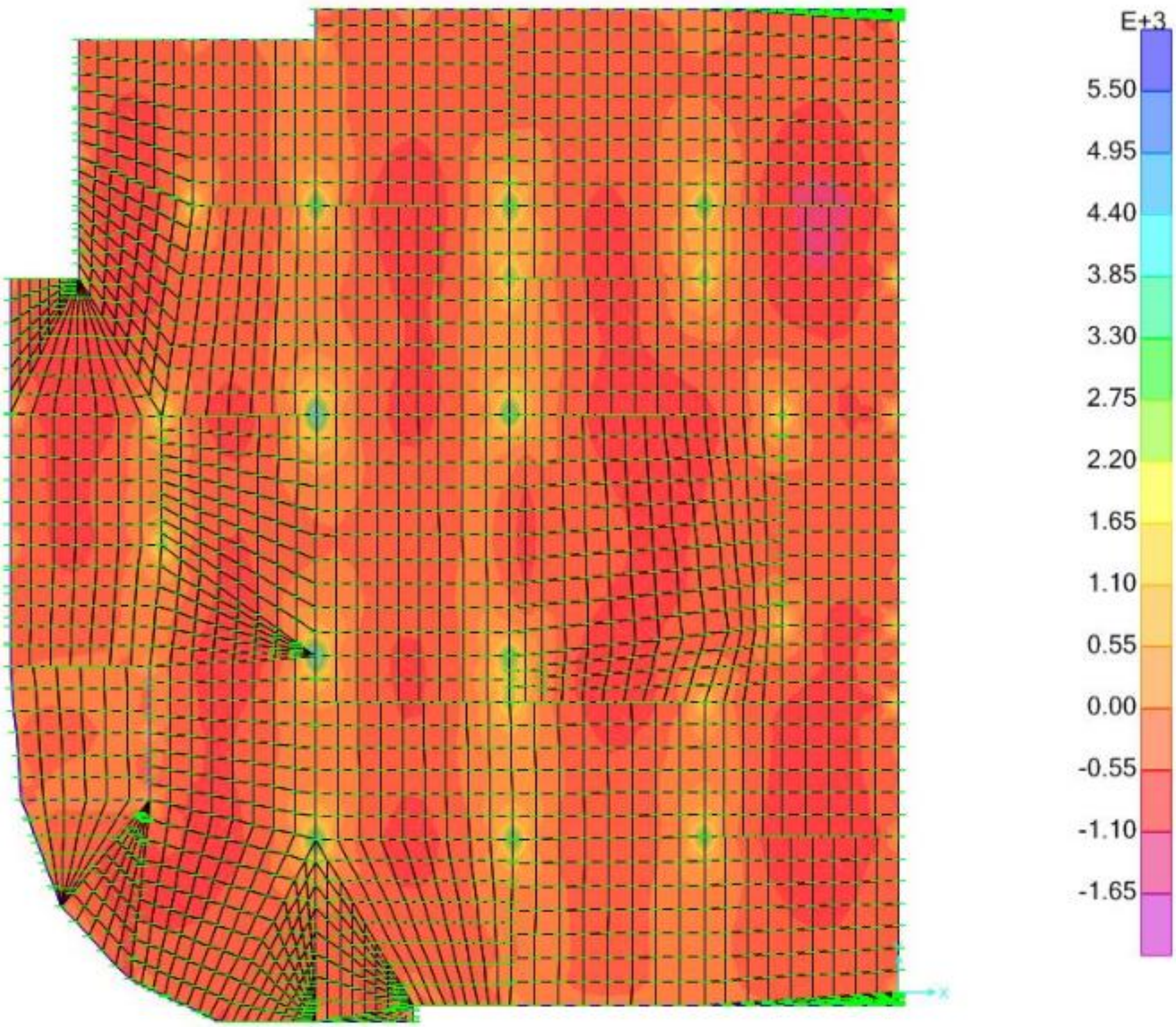



Figure 5. 28 Maximum Bottom Moment

$M=0.9*fy*As*(1450-\frac{As*fy}{1.7*fc*1000})$

$3819.28=0.9*420*As*(1450-\frac{As*420}{1.7*32*1000})$ =

As=7249.35

=1Ø25 /15 cm.

Max Top

$M=0.9*fy*As*(1450-\frac{As*fy}{1.7*fc*1000})$

$2925.2=0.9*420*As*(1450-\frac{As*420}{1.7*32*1000})$ =

As=2925.2

=1Ø18 /15 cm

## 5.8: Design of shear wall:

Once shear wall is analyzed, 5 internal ultimate forces can be computed; namely, $P$, $V_x$, $V_y$, $M_x$ and $M_y$. The design for these forces can be performed as follows:

Proportion the wall such that $V_x \leq \phi V_c$.

Design for $V_y$ in a way similar to beams.

Design for $M_y$ can be carried out by assuming two equal areas of steel on both faces of the wall working as a couple (one is in tension and the other is in compression).

Design for $P$ and $M_x$ in a way similar to columns.

$P_u$ = 8795 kN

$M_{uy}$ = 74 kN.m

$M_{ux}$ = 30439 kN.m

$V_{uy}$ = 9280 kN

$V_{ux}$ = 161 kN

$f'_c$ = 24 MPa, $F_y$ = 420 MPa, wall thickness = 200 mm, wall length = 19 m.

**Check shear in X direction:**

$V_{ux}$ = 161 kN

$\phi V_c = 0.75 \times \frac{1}{6} \times \sqrt{24} \times (200 - 40) \times 19000 \times 10^{-3} = 1861$ kN $> V_{ux}$ OK

**Design for shear in Y direction:**

$V_{uy}$= 9280kN

$\phi V_c = 0.75 * \frac{1}{6} \times \sqrt{24} \times 200 \times (0.8 \times 19000) \times 10^{-3} = 1861$ kN

$V_s$ = 9280 - 1861 = 7419 KN.

$$\frac{A_v}{s} = \frac{7419000}{420 \times (0.8 \times 1500)} = 1.1 \text{ mm} > \frac{A_v}{s} min$$

Assume 2ϕ12 mm Av = 226 mm s = 200 mm

Use 2ϕ12 mm @ 200 mm C/C

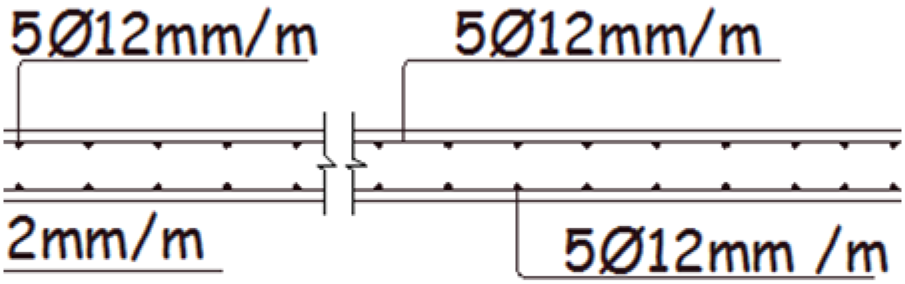
**Design for moment around Y axis:**

$M_{uy}$ = 74kN.m $M_{uy=}$ 4KN.m/m

$\rho = \frac{0.85*24}{420} * 1 - \sqrt{1 - \frac{2.61*4}{1000*160*160*24}}$ = 0.0004

$\rho_{min}$ = 0.0025.

As= 400 mm$^2$/m.   use 4Ø12 mm/m for two faces.




**Design for moment around x axis and Pu:**

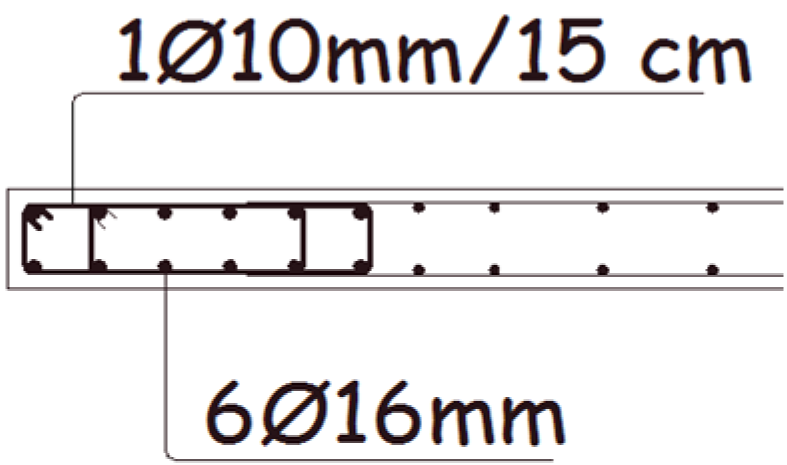
Design for moment around x direction and Pu is done as a column, so its required to reinforce boundaries by 1% steel ratio.

The length of the boundary is 0.8 m and thickness is 0.2m

ρ = 1%, As = 0.01*800*200 = 1600 mm$^2$.

Use 800 mm$^2$ on each face and add this to the flexural reinforcement.

**Use 6Ø16mm each face.**




Design of Basement retaining wall:

**Check shear in X direction:**

$V_{ux}$ = 5638kN

$\phi V_c$ =$0.75 \times \frac{1}{6} \times \sqrt{28} \times 210 \ * 41000 \times 10^{-3} = 5695$ kN >$V_{ux}$      OK

**Check shear in y direction:**

$V_{uy}$ = 7891kN

$\phi V_c$ =$0.75 \times \frac{1}{6} \times \sqrt{28} \times 250 \ * 0.8 * \ 41000 \times 10^{-3} = 5423$ kN.

$V_s$ = 7891 - 5423 = 2467.2KN.

$$\frac{A_v}{s} = \frac{2467000}{420 \times (0.8 \times 41000)} = 0.18 \text{ mm.}$$

In this case the area of steel minimum for flexural in the horizontal direction is more than the area of steel from shear reinforcement, so use area of steel minimum for horizontal direction.

**Use 2Ø12 mm/m two layers.**

**Flexural reinforcement:**

Maximum positive moment = 187 KN.m/m

Maximum negative moment = 170 KN.m/m

**For positive moment ( 187KN.m/m ):**

ρ = $\frac{0.85*28}{420} * 1 - \sqrt{1 - \frac{2.61*187}{1000*200*200*28}}$ = 0.014

As = 2800 $mm^2$.

**Use 9Ø20 mm/m**

**For negative moment ( 170KN.m/m ):**

ρ = $\frac{0.85*28}{420} * 1 - \sqrt{1 - \frac{2.61*170}{1000*200*200*28}}$ = 0.0135

As = 2800 $mm^2$.

**Use 9Ø20 mm/m**

**For positive moment ( 36KN.m/m ) & negative ( 42 KN.m/m ):**

$$\rho = \frac{0.85*28}{420} * 1 - \sqrt{1 - \frac{2.61*42}{1000*200*200*28}} = 0.0024$$

Use $As_{min}$= 0.0033 * 1000 * 250 = 660 $mm^2$.

**Use 5Ø14 mm/m**

## 5.9: Design of Stair

Design of stairs has been done according to these loads:

Table 5. 2 Stairs Loads

| Type | Load |
|---|---|
| Dead load | 6.25 $KN/m^2$ |
| Super imposed | 6 $KN/m^2$ |
| Live load | 5 $KN/m^2$ |

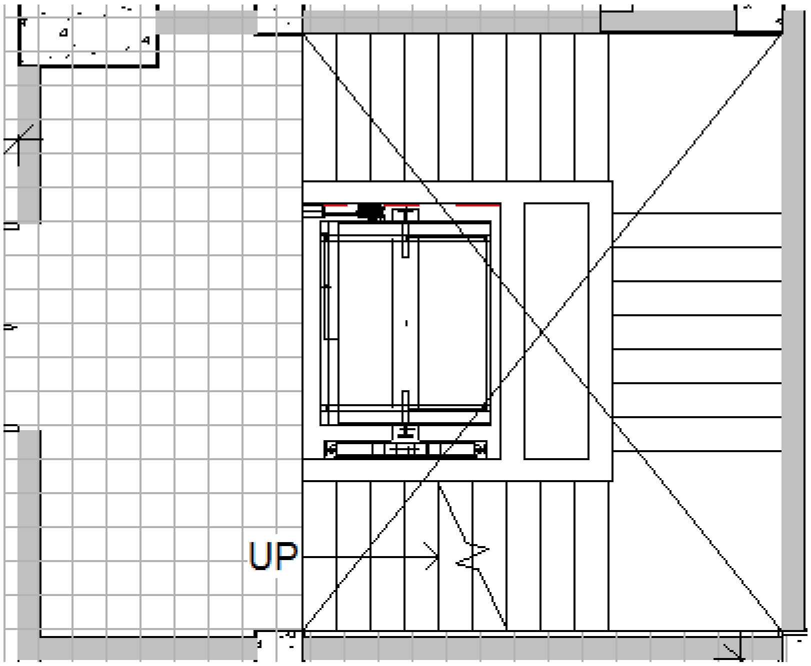



Figure 5. 29 Stairs layout

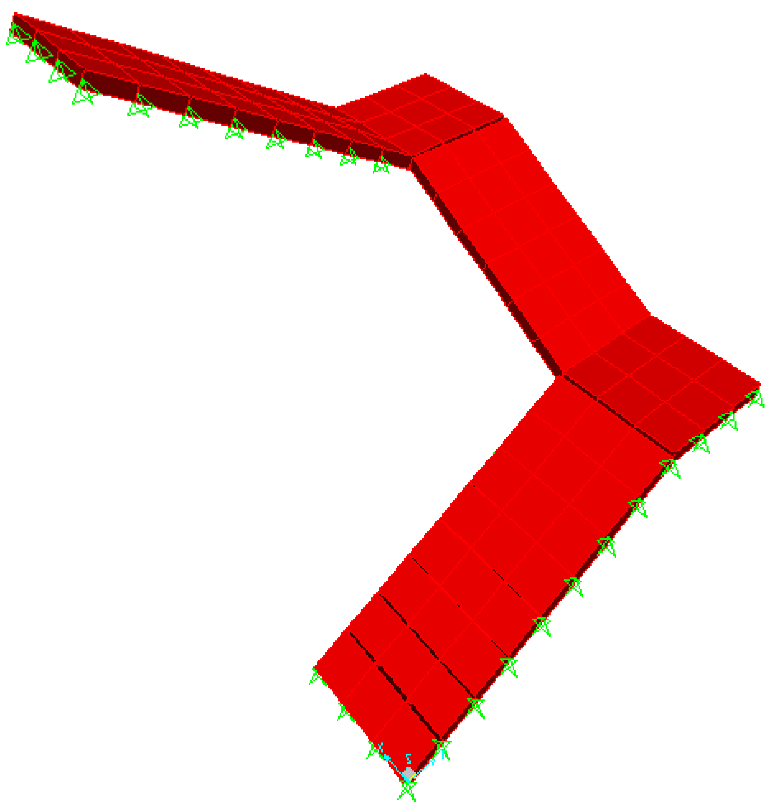


Figure 5. 30 Stairs structural modeling

From results of SAP analysis, All the forces are less than minimum reinforcement for the stairs, so use minimum vertical and horizontal reinforcement.

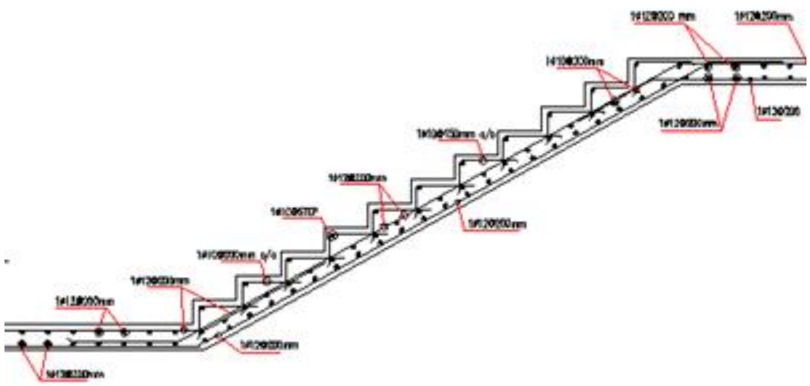


Figure 5. 31  Stairs Reinforcement

## 5.10: Steel Design

### 5.10.1: Member capacity

Pu-section

ϕpn for chosen section

ϕpn=0.9AgFy less or equal pu

Slenderness check

Kl/r min < 300

### 5.10.2: Welded connections

#### *5.10.2.1: Weld Failure*

ϕRn/L = ϕ ( 0.707 a) fw

fw = 0.6 Fexx ( 1 + 0.5 (sinɵ^(1.5)))

such that:

ɵ: angle between load and weld line

Fexx : tensile strength of weld metal

Note : Conservatively assume ɵ= zero

So fw=0.6*Fexx

#### *5.10.2.2: Base Metal Failure*

ϕRn = ϕ ( L t ) ( Shear Strength of metal )

ϕRn = 0.6 L t * min (Fy , 0.75 Fu )

### 5.10.3: Bolted connection

By assuming bolts type and diameter according to our market

Calculate the shear failure that governs ϕRn

ϕRn=ϕRn for shear

ϕRn= 0.75 Ab Fnv

| Bolt type | Fnt | Fnv |
|---|---|---|
| A325 – N | 620 | 330 |
| A325 – X | 620 | 414 |

ϕRn = Fv

Finding N

Weld failure

| | | Fw (Mpa) | | 0.6 | Fexx ( E90xx) (Mpa) | 1+(0.5* (sin ɵ^(1.5)) |
|---|---|---|---|---|---|---|
| 1 | 100*100*5 | 367.2 | | 0.6 | 612 | 1 |
| 2 | 80*80*5 | 367.2 | | 0.6 | 612 | 1 |
| 3 | 70*70*4 | 367.2 | | 0.6 | 612 | 1 |

| | ϕ | Rn (N/mm) | L (mm) |
|---|---|---|---|
| 1 | 0.75 | 81 | 0.1 |
| 2 | 0.75 | 130.1 | 0.1 |
| 3 | 0.75 | 137.4 | 0.1 |

| ϕ | 45 ° | a (mm) | Fw (Mpa) |
|---|---|---|---|
| 0.75 | 0.707 | 6 | 367.2 |
| 0.75 | 0.707 | 6 | 367.2 |
| 0.75 | 0.707 | 6 | 367.2 |

| | minimum available L | Check |
|---|---|---|
| 1 | 400 | OK |
| 2 | 320 | OK |
| 3 | 210 | OK |

Base Metal Failure

| | | |
|---|---|---|
| min of | Fy (Mpa) | 379.2 |
| | 0.75 Fu (Mpa) | 369.675 |

| | ϕ | Rn (N/mm) | L (mm) | 0.6 | t (mm) | min |
|---|---|---|---|---|---|---|
| 1 | 0.75 | 81 | 0.1 | 0.6 | 5 | 369.675 |
| 2 | 0.75 | 130.1 | 0.1 | 0.6 | 5 | 369.675 |
| 3 | 0.75 | 137.4 | 0.2 | 0.6 | 4 | 369.675 |

| | minimum available L | Check |
|---|---|---|
| 1 | 400 | OK |
| 2 | 320 | OK |
| 3 | 280 | OK |

# Chapter Six: Environmental Design

## 6.1 Solar:

Solar panels (spaces) A configure, modern solar solution

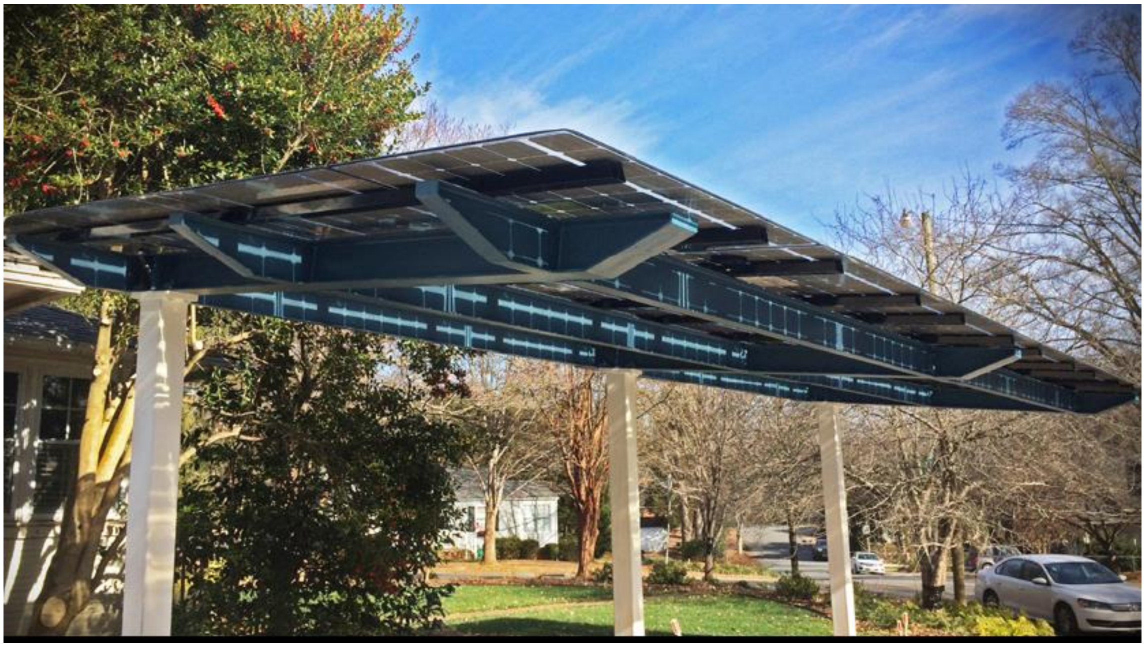


Figure 6. 1 Solar Panels

Table 6. 1 Solar panel discribtion

| Features | Benefits |
|---|---|
| **Frameless Module** | PID Free<br>Lower profile |
| **No Module Grounding** | No ground lugs<br>No continuous module equipment ground |
| **Constrained Module Positioning** | Perfect alignment<br>Speeds installation time |
| **Unique Through-Bolt Mounting** | Innovation design options<br>Tamper resistant mounting<br>Effortless weatherproof integration |
| **Available with black or clear back sheet** | Aesthetic options for different applications |

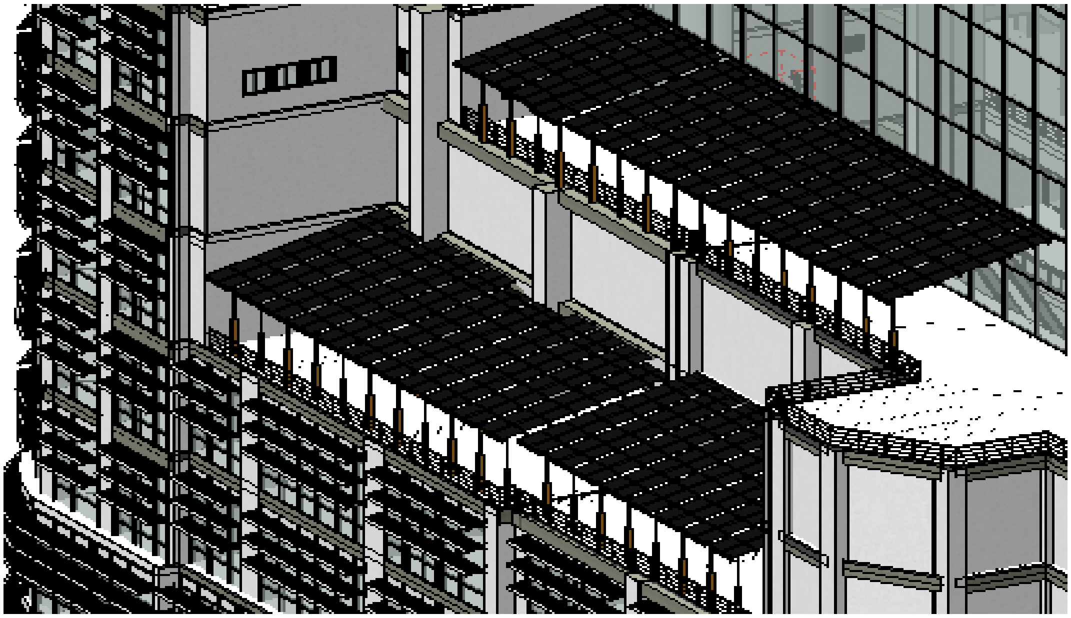


Figure 6. 2 Solar panel on building

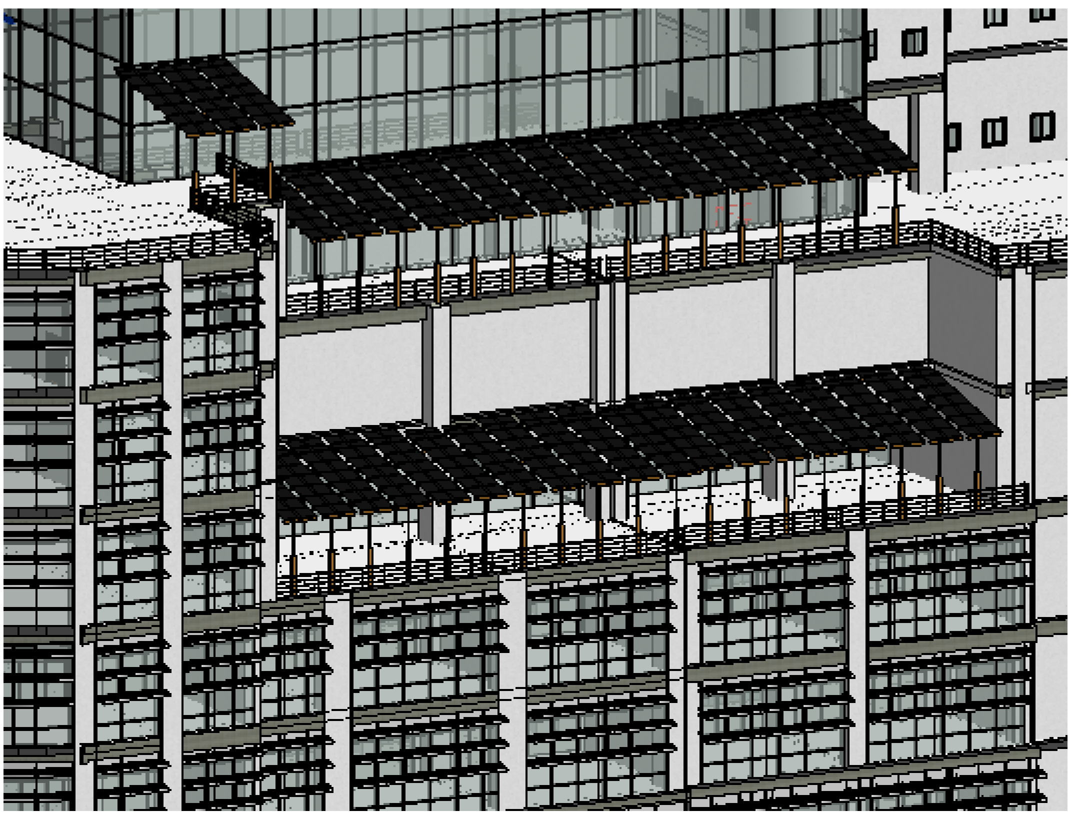


Figure 6. 3 Solar panel on building

This solar spaces was plotted on south façade to take maximum sunlight and heat, to generate electricity.

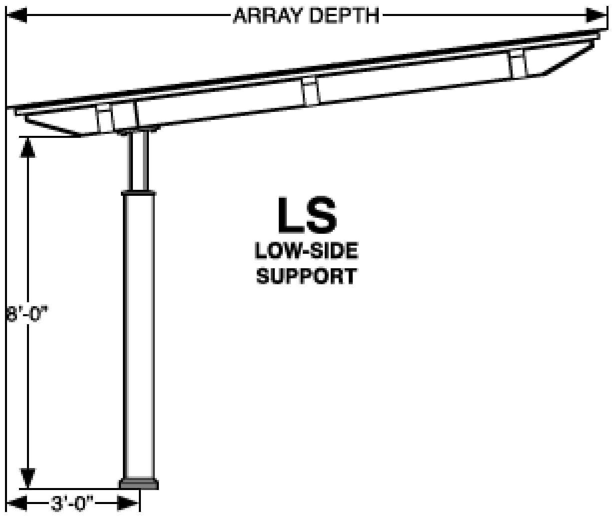



Figure 6. 4  Solar Panel Single Support

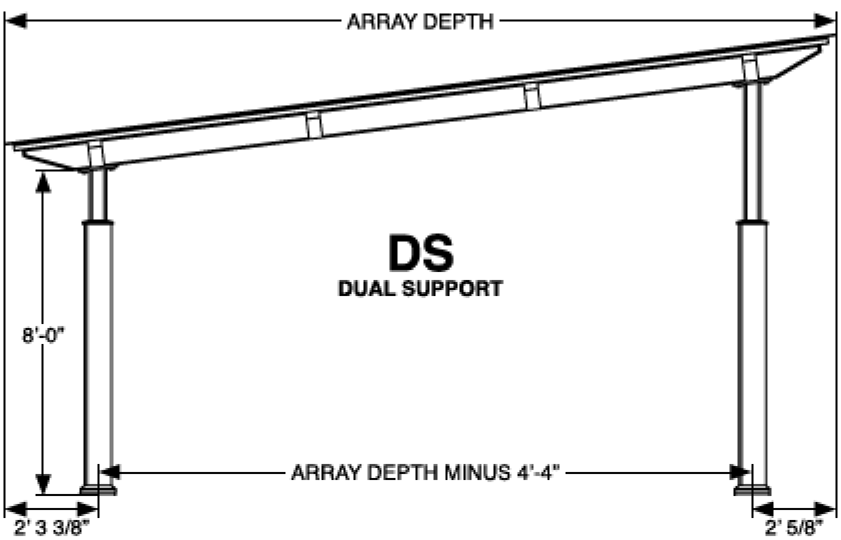



Figure 6. 5  Solar Panel Dual Support

**Note: See concept sheets for this technic attached with this report.**

**Shading with Solar technic:**

This solar spaces was built also to shade part of the courtyard.

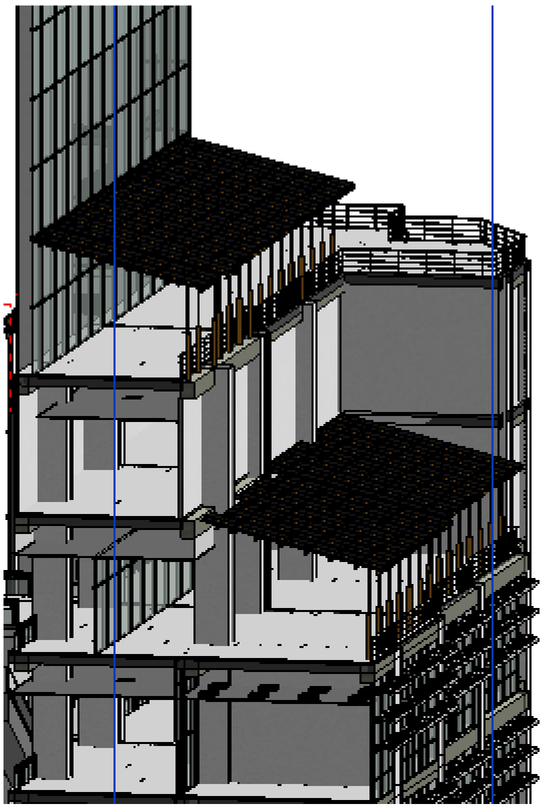


Figure 6. 6 Shading with Solar Technic

The peak Power voltage is 30.3 volt for each panel

## 6.2: Shading

Shading is a very important technique to minimize cooling loads needed in summer days.

Sun path will be studied well in order to control the solar gain entering the opening to minimize the cooling load.

The use of shading device is very important in the design of building. It has been proved that the use of shading device could improve building energy performance, prevent glare, increase useful daylight availability and create a sense of security. To realize these benefits, a varied of shading configurations have been invented and put in the market, such as fixed, manual and automatic movable, internal and external shading device.

Solar shading is an effective energy saver all year round. In summer, it can cut the amount of heat entering a building and in winter it can decrease heat loss.

In winter, solar shadings will remain open to let free solar energy into the building during the day, to reduce energy requirements for heating. When the sun has set, these will close, to reduce heat loss and thus continuing to save on the energy required for heating.

**South elevation:**

Is the elevation that was sun direct to it in summer .

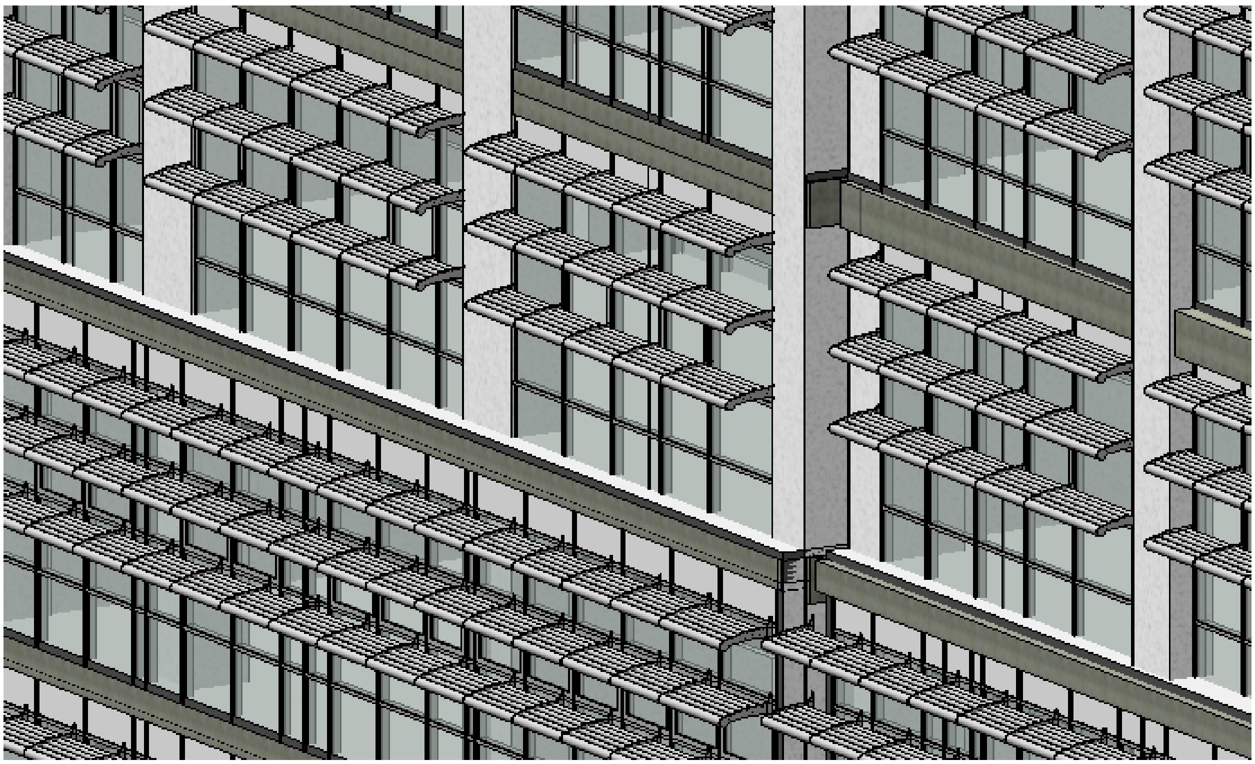


Figure 6. 7 South Elevation

**Solution:**

Fixed horizontal cantilevers are used to protect south elevation from sunray. The dimensions of the cantilevers can be calculated by the equation below.

The dimensions of the shutters were calculated depending on the altitude angle of the Sun.

Calculation of the cantilever was made at 11am 21th of May.

Where α is the angle that can be obtained from tables.

X is the cantilever length.

Y is the distance between the cantilever and the heading of the window.

ALT is the altitude angle of the Sun.

Altitude angle = 72°

When the height of the glass = 1 m

X=$\frac{H}{TanAlt-.067}$=$\frac{1}{Tan75-.067}$= 0.4 m

amd the height of glass = 2.9 m

X=$\frac{H}{TanAlt-.067}$=$\frac{2.9}{Tan75-.067}$= 1.2 m

So we use 0.7m cantilever shading to make some sunlight enter and to make good view for people.

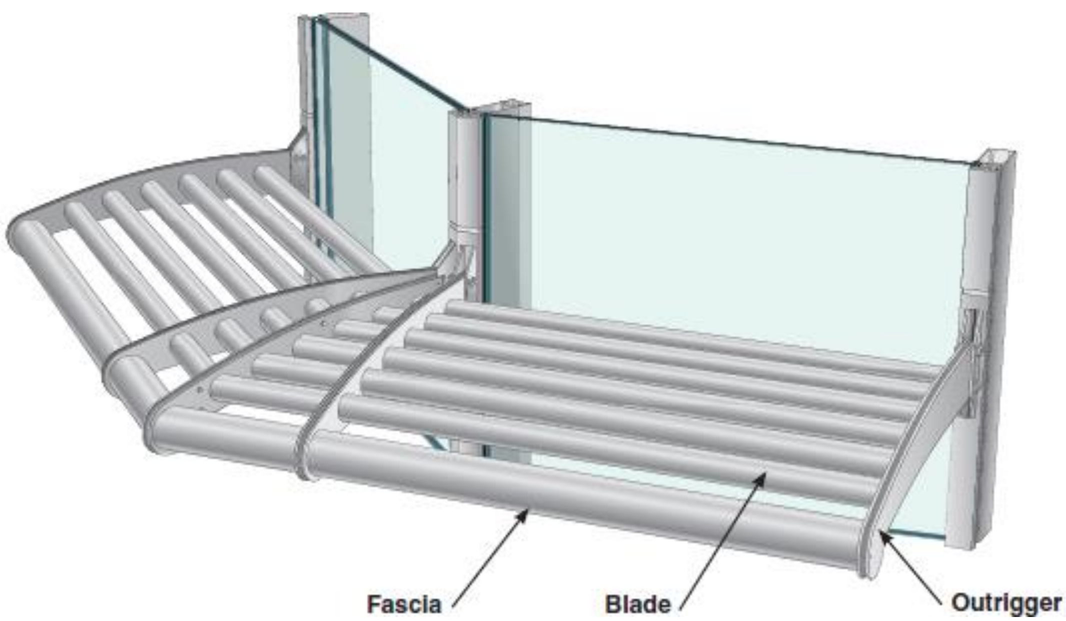



Figure 6. 8 Shading Device

**Features**

• Standardized solution for seamless integration with 1600 Wall SystemTM1,

1600 Wall SystemTM2, 1600UT SystemTM1, 1600 Wall SystemTM5, 1600 SS, 1600 SS SSG and 1630 SS IR.

• Tested for combined wind, snow and dead loads

• 30" (762 mm) and 36" (914.4 mm) deep Outriggers are standard

• Fully pre-engineered 90° and 135° inside and outside corners

• Thermally broken attachment method for 1600 Wall SystemTM1, 1600UT SystemTM1, 1600 SS, 1600 SS SSG and 1630 SS IR.

1600 Wall SystemTM2 and 1600 SS SSG allow 2 sided SSG.

• Attachment bracket designed to accept shallow and deep covers

• Easy to use Load Charts quicken design process

• Refreshing new blade options, with tubular profiles for spanning wider openings

• 44 different combinations of outrigger and blade styles allow aesthetic & shading performance flexibility

• Qualified for up to 3 different LEED Certification criteria

• PermanodicTM anodized finishes in seven standard choices

• Painted finishes in standard and custom choices

• Shading performance can be analyzed by SolectorTM Sun Shading Estimator Tool

**Product Application**

• Curtain Wall Facades

• Interior aesthetical application

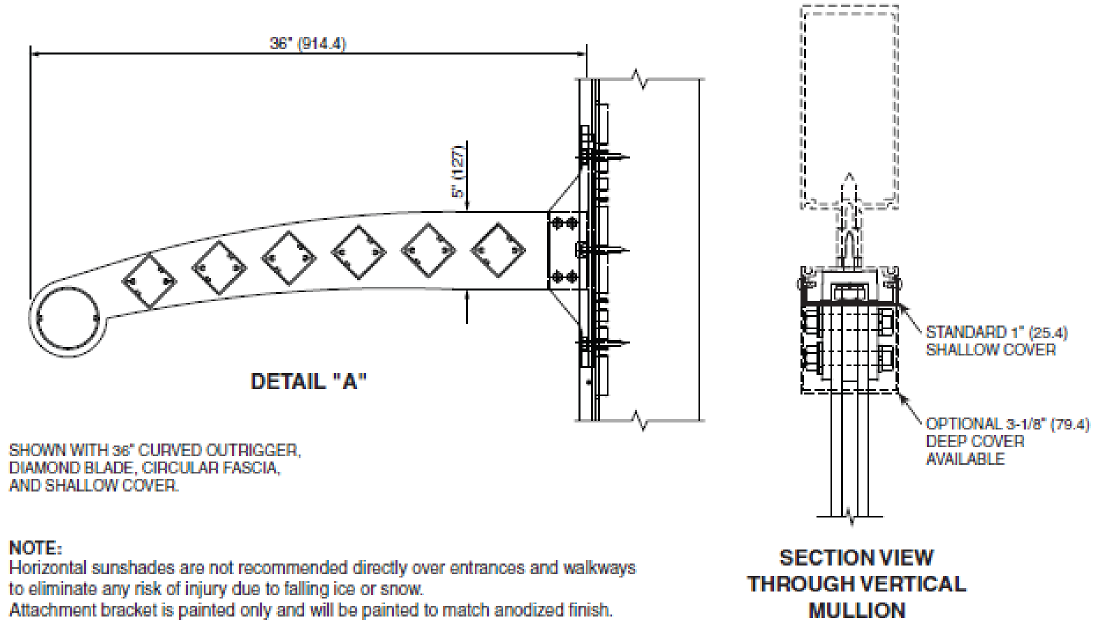



Figure 6. 9 Shading Detail

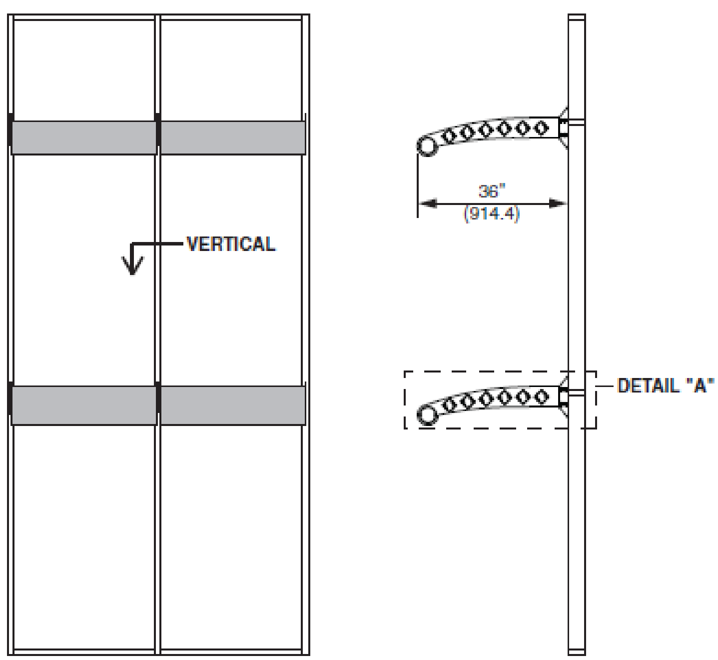



Figure 6. 10 Shading Detail

**Note: See Concept sheets for this technic attached with this report.**

**East and West elevations :**

huge glazing areas for these two elevation so good shading must be take in considered .

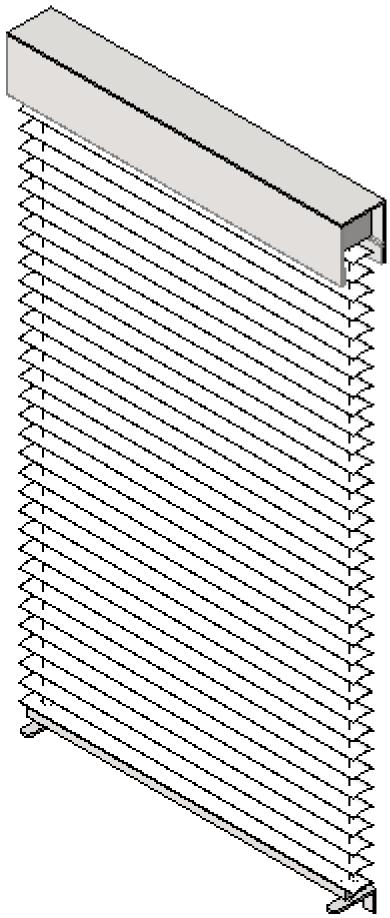


Figure 6. 11 Shading Detail

**Solution:** Using vertical louvers to block sun exposure, in order to reduce heat gain.

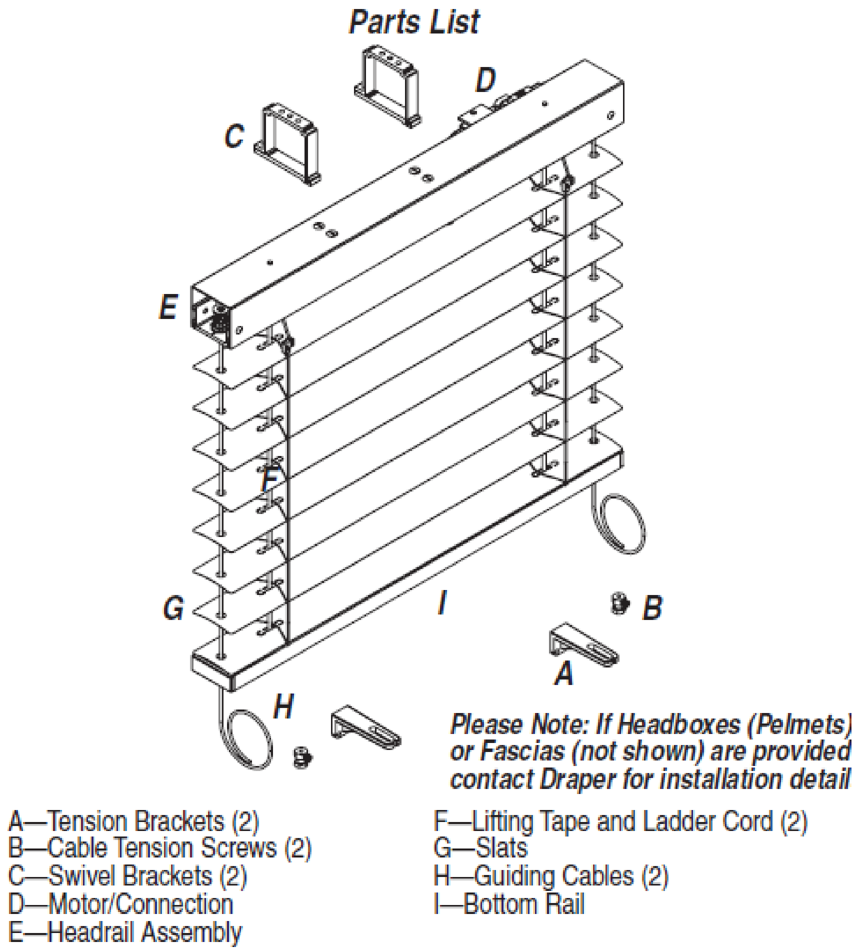



Figure 6. 12 Shading Detail

### *For Crank Operation*

If this unit is to be located outside the window, then you will need to make provisions for the unit to be operated from the inside. See Fig. 2 for an example of how to provide crank access from the inside.

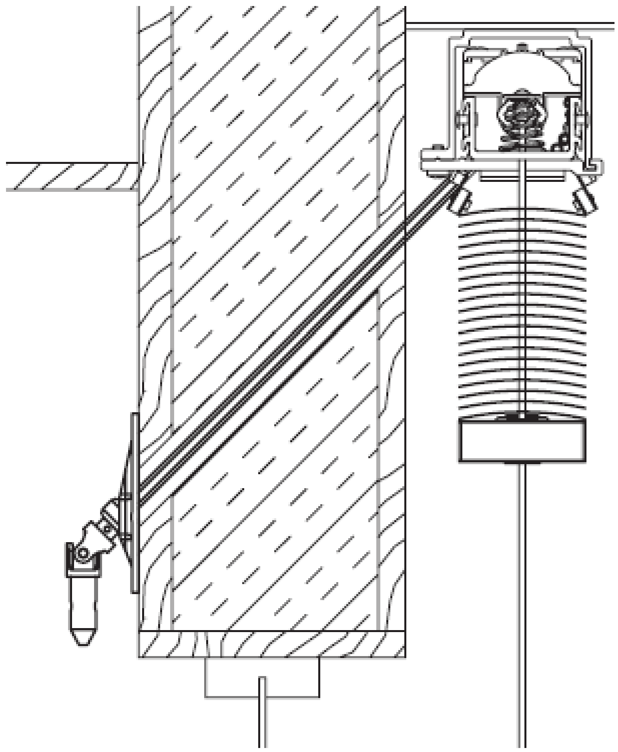


*Figure 2*

Figure 6. 13 Shading Detail

**Note: See Concept sheets for this technic attached with this report.**

## 6.3: Acoustical Design:

The acoustical design had a great interest from ancient time, such as the Greek theatre and Romanian theatre, and at the Islamic period the acoustical design have more attention especially in Mosques design.

In commercial building, theatres, restaurant, or public spaces the acoustical design is very important to ensure the comfortable and Privacy, and to make an ideal building acoustics you have to consider many factors such as

1- Absorption coefficient or reflection coefficient for material that used for building.
2- Dimension of the rooms.
3- The value of articulation loss.
4- Sound to noise ratio.
5- Reverberation (RT).
6- Sound Insulation level.
7- The value of sound transmission class (STC) in the adjacent or linked rooms, this value is determined from special tables that will be shown later.

The noise transmission to the building by two ways:

1- Structural Borne: water pumping and elevator motor.
2- Air Borne.

And to reduce that noise there are many ways as follow:

1- Use vibration damping material on all surface.
2- Seal enclosure or surrounding room.
3- Use lining for surrounding rooms.
4- Fixed on the heaviest part of the machine.
5- For piping use flexible pipes.

### 6.3.1: STC design:

In commercial buildings built near a highway or train tracks, the exterior building walls should have at least an STC of 50. .Windows and doors should have at least an STC of 40 or 45 depending on the amount of window or door area.

The tables below show the recommendation value for STC for partition:

Table 6. 2 Criteria for Airborne Sound Insulation of Partitions between spaces

| Apt. A | Apt. B | STC |
|---|---|---|
| **Offices** | Offices | 52 |
| **Offices** | Kitchen | 52 |
| **Kitchen** | Dining room | 50 |
| **Dining room** | offices | 38 |

Table 6 . 3 STC Ratings of Masonry Walls

| Description | STC |
|---|---|
| 4-in. Lightweight hollow block | 36 |
| 4-in. Dense hollow block | 38 |
| 6-in. Lightweight hollow block | 41 |
| 6-in. Dense hollow block | 43 |
| 8-in. Lightweight hollow block | 46 |
| 8-in. Dense hollow block | 48 |
| 12-in. Lightweight hollow block | 51 |
| 12-in. Dense hollow block | 53 |
| | |
| 4-in. Brick | 41 |
| 6-in. Brick | 45 |
| 8-in. Brick | 49 |
| 12-in. Brick | 54 |
| | |

| | |
|---|---|
| 6-in. Solid concrete | 47 |
| 8-in. Solid concrete | 50 |
| 10-in. Solid concrete | 53 |
| 12-in. Solid concrete | 56 |

**Table 6 . 4 Modifications for STC Ratings of Masonry Walls**

| Modifications | Extra STC |
|---|---|
| Add sand to cores of hollow blocks | Plus 3 |
| Add plaster to one side | Plus 2 |
| Add plaster to both sides | Plus 4 |
| Add furring strips, lath and plaster to one side | Plus 6 |
| Add furring strips, lath and plaster to both sides | Plus 10 |
| Add plaster via resilient mounting to one side | Plus 10 |
| Add plaster via resilient mounting to both sides | Plus 15 |

## Walls acoustical Design:

### Office to Office:

Wall type: Hollow Blocks (10 cm):

The value of airborne sound insulation between Office and Office room shall be 52 or more:

**Table 6 . 5 STC For Office Wall**

| Layers | STC |
|---|---|
| 4-in. Dense hollow block | 38 |
| Add plaster to both sides | Plus 4 |
| Add furring strips, lath and plaster to both sides | Plus 10 |

| | |
|---|---|
| Total | 52 |

STC for walls between office and office with respect to these layers equal to 52 which is equal to the recommended STC, so it is good for airborne sound insulation.

### Office to Kitchen:

Wall type: Hollow Blocks (10 cm):

The value of airborne sound insulation between Office and Kitchen shall be 52 or more:

**Table 6 . 6 STC for office to Kitchen wall**

| Layers | STC |
|---|---|
| 4-in. Dense hollow block | 38 |
| Add plaster to both sides | Plus 4 |
| Add furring strips, lath and plaster to both sides | Plus 10 |
| Total | 52 |

STC for walls between office and Kitchen with respect to these layers equal to 52 which is equal to the recommended STC, so it is good for airborne sound insulation.

### Office to Dining room:

Wall type: Hollow Blocks (10 cm):

The value of airborne sound insulation between Office and Dining room shall be 38 or more:

**Table 6 . 7 STC for Office to Dining**

| Layers | STC |
|---|---|
| 4-in. Dense hollow block | 38 |
| Add plaster to both sides | Plus 4 |
| Total | 42 |

STC for walls between office and office with respect to these layers equal to 42 which is greater than the recommended STC = 38, so it is very good for airborne sound insulation.

### Dining room to Kitchen :

Wall type: Hollow Blocks (10 cm):

The value of airborne sound insulation between Kitchen and Dining room shall be 50 or more:

**Table 6 . 8 STC Dining to Kitchen wall**

| Layers | STC |
|---|---|
| 4-in. Dense hollow block | 38 |
| Add plaster to both sides | Plus 4 |
| Add furring strips, lath and plaster to both sides | Plus 10 |
| Total | 52 |

STC for walls between office and office with respect to these layers equal to 52 which is greater than the recommended STC=50, so it is good for airborne sound insulation.

## 6.4: Reverberant time:

Calculation and analysis was done on the courtyard in the ground floor at the building:

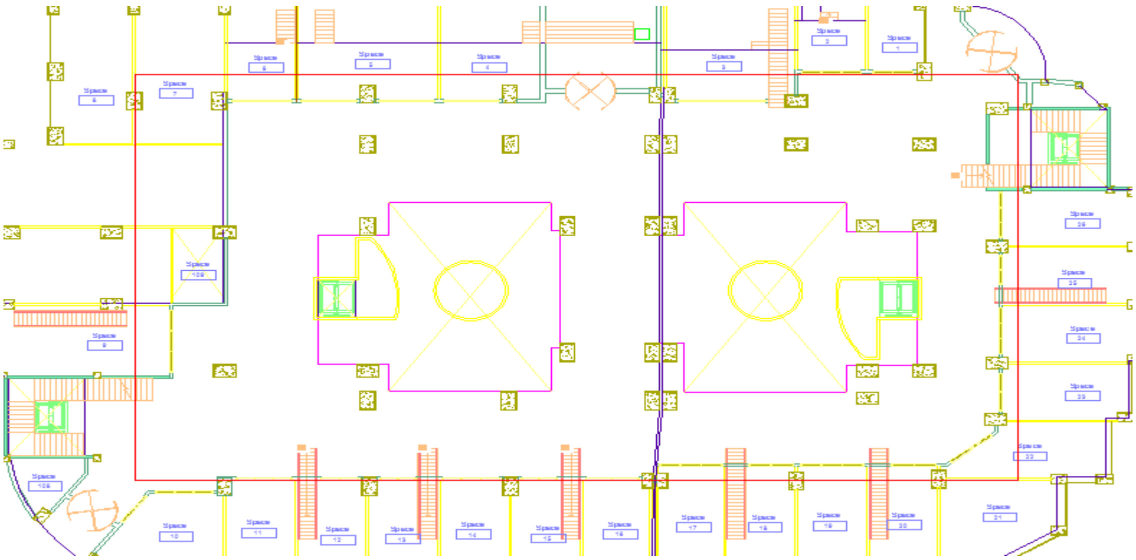


Figure 6. 14 Calculated Area

Note: The height of the floor is 4.9 m.

The walls are made of glass with α = 0.04

The walls are made of plaster with α = 0.03

The Floors are made of Tile with α = 0.01

The ceilings are made of solid gypsum lime panels with α = 0.05

The ceilings are made of glass panels with α = 0.04

The calculation:

Table 6 . 9 Sabine area for courtyard

| Materials | Area | α | A* α |
|---|---|---|---|
| Tiles | 1300 | 0.01 | **13** |

| | | | |
|---|---|---|---|
| Wall glass | 466 | 0.04 | **18.64** |
| Wall plaster | 1251.2 | 0.03 | **37.53** |
| Ceiling panels | 985 | 0.05 | **49.25** |
| Ceiling glass | 315 | 0.04 | **12.6** |
| SUM | 4317 | | **131.02** |

$RT_{60} = \frac{0.16*V}{As} = \frac{0.16*19571.5}{131.02} = 23.9$ s

As it is shown in the standards, the reverberant time inside the Courtyard does not match the specifications that is (1-1.8) s, a modification have to be done by changing the material for one or more elements inside the room to reach the desired and suitable reverberation time.

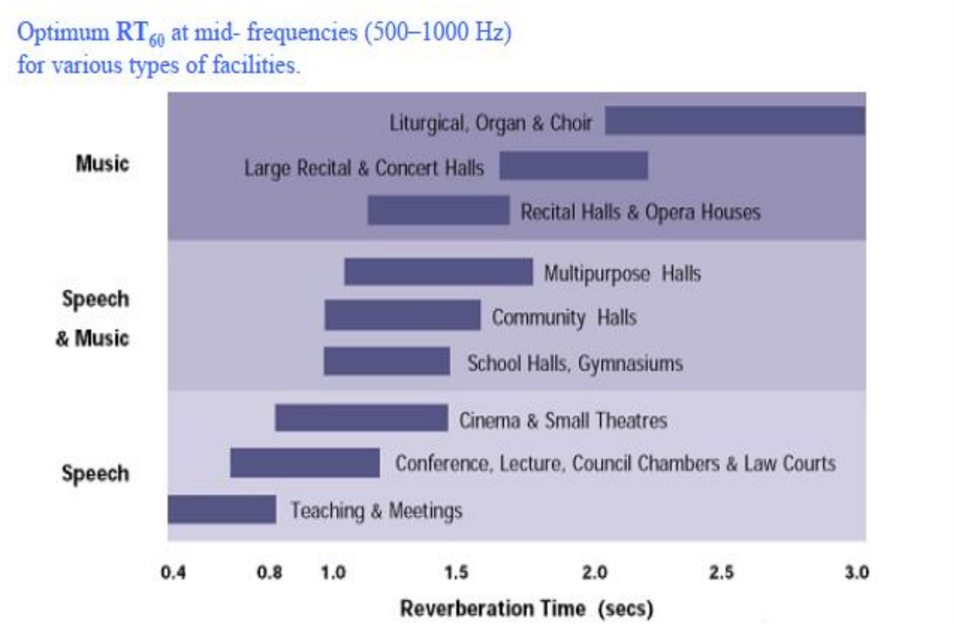



**Figure 6. 15 The optimum RT60 at (500-100 Hz) for various types of facilities**

Therefore, to meet the standards of the $RT_{60}$ we will modify the material of the ceiling:

From the tables of absorption factor for the materials, (perforated gypsum boards) that has absorption factor of 0.6 was selected and it is suitable to be installed on the unglazed ceiling.


Figure 6. 16 Ceiling with perforated gypsum board.

Table 610 . Sabine area for courtyard after modification.

| Materials | Area | α | A* α |
|---|---|---|---|
| Tiles | 1300 | 0.01 | **13** |
| Wall glass | 466 | 0.04 | **18.46** |
| Wall plaster | 1251.2 | 0.03 | **37.5** |
| Ceiling panels | 985 | 0.6 | **591** |
| Ceiling glass | 315 | 0.04 | **12.6** |
| SUM | 4317 | | **672.77** |

$RT_{60} = \frac{0.16*V}{As} = \frac{0.16*19571.5}{972.77} = 3.22$ s

The reverberant time inside the Courtyard still does not match the specifications that is (1-1.8) s, so we need to make a modification to another element also,

Therefore, to meet the standards of the $RT_{60}$ we will modify the material of the columns finish:

From the tables of absorption factor for the materials, (fiberglass board 50 mm) that has absorption factor of 0.99 was selected and it is suitable to be installed on the columns and walls finish.

| Materials | area | α | A* α |
|---|---|---|---|
| Tiles | 1300 | 0.01 | **13** |
| Wall glass | 466 | 0.04 | **18.46** |
| Wall with fiber glass board 50 mm | 1251.2 | 0.99 | **1238.49** |
| Ceiling panels | 985 | 0.6 | **591** |
| Ceiling ( glass) | 315 | 0.04 | **12.6** |
| SUM | 4317 | | **1873.73** |

$RT_{60} = \frac{0.16*V}{As} = \frac{0.16*19571.5}{1873.73} = 1.67$ s OK

## Chapter Seven: Mechanical Design

Mechanical design of a building involves many aspects including:

1. HVAC system.
2. Water Supply Systems.
3. Drainage Water Systems Design.

# 7.1: H-VAC Design.

Revit program have been used to calculate heating and cooling load.

Using HVAC system for cooling in our project “multi-purpose building” is the suitable choose.

***System components:***

1-Diffuser: a diffuser is the mechanical device that is designed to control the characteristics of a fluid at the entrance to a thermodynamic open system. Diffusers are used to slow the fluid's velocity and to enhance its mixing into the surrounding fluid.

Figure 7. 1 HVAC System

2-Fan coil: (FCU) is a simple device consisting of a heating or cooling coil and fan. Typically a fan coil unit is not connected to ductwork.

Figure 7. 2 HVAC System

3-Chiller: A chiller is a machine that removes heat from a liquid via a vapor- compression or absorption refrigeration cycle. This liquid can then be circulated through a heat exchanger to cool air or equipment as required.

Figure 7. 3 HVAC System

4-Ducts: it's the medium of air condition.

Figure 7. 4 HVAC System

5-Fans or blowers: mechanical device in system to move air.

Figure 7. 5  HVAC System

6-Exhausts: used to kick air out.

7-Pipes

### *7.1.1: Duct sizing:*

For duct sizing Revit program was used depending on specified air flow.
Table shows the Area space, air flow, friction, duct height , duct width , duct length, Keynote and velocity for whole courtyard in project.

**Table7. 1 Duct Schedule**

| Duct Schedule | | | | | | | |
|---|---|---|---|---|---|---|---|
| Area<br>$m^2$ | Flow<br>L/s | Friction<br>Pa/m | Height<br>mm | Width<br>mm | Length<br>mm | Keynote<br>- | Velocity<br>m/s |
| 11.712 $m^2$ | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 6890 | 15800 | 5 m/s |
| 10.334 $m^2$ | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 6890 | 15800 | 5 m/s |
| 5.837 $m^2$ | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 4490 | 15800 | 5 m/s |
| 6.259 $m^2$ | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 5690 | 15800 | 5 m/s |
| 4.388 $m^2$ | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 5484 | 15800 | 5 m/s |
| 1.824 $m^2$ | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 960 | 15800 | 5 m/s |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.333 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 175 | 15800 | 5 m/s |
| 0.712 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 375 | 15800 | 5 m/s |
| 0.097 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 51 | 15800 | 5 m/s |
| 17.411 m² | 1575.0 L/s | 0.33 Pa/m | 600 | 600 | 7255 | 15800 | 5 m/s |
| 4.394 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 2929 | 15800 | 5 m/s |
| 0.411 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 316 | 15800 | 5 m/s |
| 0.365 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 457 | 15800 | 5 m/s |
| 2.207 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 1162 | 15800 | 5 m/s |
| 0.709 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 645 | 15800 | 5 m/s |
| 0.118 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 147 | 15800 | 5 m/s |
| 1.736 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2169 | 15800 | 5 m/s |
| 0.803 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1004 | 15800 | 5 m/s |
| 1.760 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2200 | 15800 | 5 m/s |
| 7.218 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 6562 | 15800 | 5 m/s |
| 2.643 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2403 | 15800 | 5 m/s |
| 0.027 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 33 | 15800 | 5 m/s |
| 4.124 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 5155 | 15800 | 5 m/s |
| 0.200 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 249 | 15800 | 5 m/s |
| 4.437 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 3413 | 15800 | 5 m/s |
| 0.209 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 262 | 15800 | 5 m/s |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4.281 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 3892 | 15800 | 5 m/s |
| 0.438 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 547 | 15800 | 5 m/s |
| 5.348 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 6684 | 15800 | 5 m/s |
| 0.400 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 500 | 15800 | 5 m/s |
| 0.372 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 196 | 15800 | 5 m/s |
| 3.705 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 1950 | 15800 | 5 m/s |
| 10.974 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 6455 | 15800 | 5 m/s |
| 0.233 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 291 | 15800 | 5 m/s |
| 6.734 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 4490 | 15800 | 5 m/s |
| 0.301 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 376 | 15800 | 5 m/s |
| 6.048 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 4652 | 15800 | 5 m/s |
| 8.781 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 6755 | 15800 | 5 m/s |
| 0.209 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 262 | 15800 | 5 m/s |
| 3.621 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 3292 | 15800 | 5 m/s |
| 0.278 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 347 | 15800 | 5 m/s |
| 3.426 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 4282 | 15800 | 5 m/s |
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 0.962 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1202 | 15800 | 5 m/s |
| 0.480 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 600 | 15800 | 5 m/s |
| 5.139 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 3426 | 15800 | 5 m/s |
| 0.522 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 474 | 15800 | 5 m/s |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.779 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 1617 | 15800 | 5 m/s |
| 0.182 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 227 | 15800 | 5 m/s |
| 2.468 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 3084 | 15800 | 5 m/s |
| 0.144 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 180 | 15800 | 5 m/s |
| 3.882 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 3529 | 15800 | 5 m/s |
| 3.067 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2788 | 15800 | 5 m/s |
| 3.318 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 4147 | 15800 | 5 m/s |
| 0.218 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 272 | 15800 | 5 m/s |
| 1.987 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 1046 | 15800 | 5 m/s |
| 0.331 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 301 | 15800 | 5 m/s |
| 1.830 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2287 | 15800 | 5 m/s |
| 1.146 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1432 | 15800 | 5 m/s |
| 9.321 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 6214 | 15800 | 5 m/s |
| 2.251 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 1732 | 15800 | 5 m/s |
| 0.369 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 462 | 15800 | 5 m/s |
| 3.612 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 4516 | 15800 | 5 m/s |
| 0.080 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 100 | 15800 | 5 m/s |
| 1.570 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 1427 | 15800 | 5 m/s |
| 0.604 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 549 | 15800 | 5 m/s |
| 2.461 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2238 | 15800 | 5 m/s |
| 0.438 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 547 | 15800 | 5 m/s |
| 4.388 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 5484 | 15800 | 5 m/s |
| 0.400 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 500 | 15800 | 5 m/s |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3.122 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 1643 | 15800 | 5 m/s |
| 0.480 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 600 | 15800 | 5 m/s |
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 0.693 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 408 | 15800 | 5 m/s |
| 1.931 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 1136 | 15800 | 5 m/s |
| 1.974 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 1161 | 15800 | 5 m/s |
| 0.171 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 214 | 15800 | 5 m/s |
| 7.634 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 5090 | 15800 | 5 m/s |
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 6.958 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 5352 | 15800 | 5 m/s |
| 7.164 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 5511 | 15800 | 5 m/s |
| 0.209 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 262 | 15800 | 5 m/s |
| 3.619 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 3290 | 15800 | 5 m/s |
| 0.278 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 347 | 15800 | 5 m/s |
| 2.948 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 3684 | 15800 | 5 m/s |
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 5.626 m² | 1225.0 L/s | 0.50 Pa/m | 500 | 500 | 2813 | 15800 | 5 m/s |
| 0.608 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 760 | 15800 | 5 m/s |
| 1.051 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1313 | 15800 | 5 m/s |
| 0.242 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 302 | 15800 | 5 m/s |
| 10.084 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 5307 | 15800 | 5 m/s |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.854 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2595 | 15800 | 5 m/s |
| 0.598 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 747 | 15800 | 5 m/s |
| 1.988 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2484 | 15800 | 5 m/s |
| 1.120 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1400 | 15800 | 5 m/s |
| 1.603 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 1068 | 15800 | 5 m/s |
| 0.668 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 835 | 15800 | 5 m/s |
| 6.617 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 5090 | 15800 | 5 m/s |
| 0.369 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 462 | 15800 | 5 m/s |
| 5.599 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 5090 | 15800 | 5 m/s |
| 0.438 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 547 | 15800 | 5 m/s |
| 1.608 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2009 | 15800 | 5 m/s |
| 1.007 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1258 | 15800 | 5 m/s |
| 0.880 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1100 | 15800 | 5 m/s |
| 1.706 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 1003 | 15800 | 5 m/s |
| 0.008 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 10 | 15800 | 5 m/s |
| 3.360 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 4200 | 15800 | 5 m/s |
| 1.128 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 752 | 15800 | 5 m/s |
| 2.317 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 1783 | 15800 | 5 m/s |
| 0.769 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 962 | 15800 | 5 m/s |
| 0.257 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 321 | 15800 | 5 m/s |
| 0.082 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 103 | 15800 | 5 m/s |
| 6.259 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 5690 | 15800 | 5 m/s |
| 0.278 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 347 | 15800 | 5 m/s |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7.268 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 9084 | 15800 | 5 m/s |
| 0.112 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 140 | 15800 | 5 m/s |
| 1.987 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 1046 | 15800 | 5 m/s |
| 0.331 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 301 | 15800 | 5 m/s |
| 1.830 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2287 | 15800 | 5 m/s |
| 1.146 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1432 | 15800 | 5 m/s |
| 9.321 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 6214 | 15800 | 5 m/s |
| 2.251 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 1732 | 15800 | 5 m/s |
| 0.369 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 462 | 15800 | 5 m/s |
| 3.612 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 4516 | 15800 | 5 m/s |
| 0.080 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 100 | 15800 | 5 m/s |
| 1.570 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 1427 | 15800 | 5 m/s |
| 0.604 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 549 | 15800 | 5 m/s |
| 2.461 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2238 | 15800 | 5 m/s |
| 0.438 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 547 | 15800 | 5 m/s |
| 4.388 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 5484 | 15800 | 5 m/s |
| 0.400 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 500 | 15800 | 5 m/s |
| 3.122 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 1643 | 15800 | 5 m/s |
| 0.480 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 600 | 15800 | 5 m/s |
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 0.693 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 408 | 15800 | 5 m/s |
| 1.931 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 1136 | 15800 | 5 m/s |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.974 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 1161 | 15800 | 5 m/s |
| 0.171 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 214 | 15800 | 5 m/s |
| 7.634 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 5090 | 15800 | 5 m/s |
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 6.958 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 5352 | 15800 | 5 m/s |
| 7.164 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 5511 | 15800 | 5 m/s |
| 0.209 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 262 | 15800 | 5 m/s |
| 3.619 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 3290 | 15800 | 5 m/s |
| 0.278 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 347 | 15800 | 5 m/s |
| 2.948 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 3684 | 15800 | 5 m/s |
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 5.626 m² | 1225.0 L/s | 0.50 Pa/m | 500 | 500 | 2813 | 15800 | 5 m/s |
| 0.562 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 703 | 15800 | 5 m/s |
| 1.051 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1313 | 15800 | 5 m/s |
| 0.242 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 302 | 15800 | 5 m/s |
| 10.084 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 5307 | 15800 | 5 m/s |
| 2.791 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2538 | 15800 | 5 m/s |
| 0.598 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 747 | 15800 | 5 m/s |
| 1.988 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2484 | 15800 | 5 m/s |
| 1.120 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1400 | 15800 | 5 m/s |
| 1.688 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 1125 | 15800 | 5 m/s |
| 0.668 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 835 | 15800 | 5 m/s |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6.617 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 5090 | 15800 | 5 m/s |
| 0.369 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 462 | 15800 | 5 m/s |
| 5.599 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 5090 | 15800 | 5 m/s |
| 0.438 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 547 | 15800 | 5 m/s |
| 1.608 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2009 | 15800 | 5 m/s |
| 1.007 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1258 | 15800 | 5 m/s |
| 0.880 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1100 | 15800 | 5 m/s |
| 1.706 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 1003 | 15800 | 5 m/s |
| 0.342 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 427 | 15800 | 5 m/s |
| 3.360 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 4200 | 15800 | 5 m/s |
| 1.128 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 752 | 15800 | 5 m/s |
| 2.399 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 1846 | 15800 | 5 m/s |
| 0.769 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 962 | 15800 | 5 m/s |
| 0.257 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 321 | 15800 | 5 m/s |
| 0.032 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 40 | 15800 | 5 m/s |
| 6.259 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 5690 | 15800 | 5 m/s |
| 0.278 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 347 | 15800 | 5 m/s |
| 7.268 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 9084 | 15800 | 5 m/s |
| 0.112 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 140 | 15800 | 5 m/s |
| 1.987 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 1046 | 15800 | 5 m/s |
| 0.331 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 301 | 15800 | 5 m/s |
| 1.830 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2287 | 15800 | 5 m/s |
| 1.146 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1432 | 15800 | 5 m/s |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 9.321 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 6214 | 15800 | 5 m/s |
| 2.251 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 1732 | 15800 | 5 m/s |
| 0.369 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 462 | 15800 | 5 m/s |
| 3.612 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 4516 | 15800 | 5 m/s |
| 0.080 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 100 | 15800 | 5 m/s |
| 1.570 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 1427 | 15800 | 5 m/s |
| 0.604 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 549 | 15800 | 5 m/s |
| 2.461 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2238 | 15800 | 5 m/s |
| 0.438 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 547 | 15800 | 5 m/s |
| 4.388 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 5484 | 15800 | 5 m/s |
| 0.400 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 500 | 15800 | 5 m/s |
| 3.122 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 1643 | 15800 | 5 m/s |
| 0.480 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 600 | 15800 | 5 m/s |
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 0.693 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 408 | 15800 | 5 m/s |
| 1.931 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 1136 | 15800 | 5 m/s |
| 1.974 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 1161 | 15800 | 5 m/s |
| 0.171 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 214 | 15800 | 5 m/s |
| 7.634 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 5090 | 15800 | 5 m/s |
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 6.958 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 5352 | 15800 | 5 m/s |
| 7.164 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 5511 | 15800 | 5 m/s |
| 0.209 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 262 | 15800 | 5 m/s |

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|---|---|---|---|---|---|---|---|
| 3.619 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 3290 | 15800 | 5 m/s |
| 0.278 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 347 | 15800 | 5 m/s |
| 2.948 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 3684 | 15800 | 5 m/s |
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 5.626 m² | 1225.0 L/s | 0.50 Pa/m | 500 | 500 | 2813 | 15800 | 5 m/s |
| 0.610 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 763 | 15800 | 5 m/s |
| 1.051 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1313 | 15800 | 5 m/s |
| 0.242 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 302 | 15800 | 5 m/s |
| 10.084 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 5307 | 15800 | 5 m/s |
| 2.857 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2598 | 15800 | 5 m/s |
| 0.598 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 747 | 15800 | 5 m/s |
| 1.988 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2484 | 15800 | 5 m/s |
| 1.120 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1400 | 15800 | 5 m/s |
| 1.598 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 1065 | 15800 | 5 m/s |
| 0.668 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 835 | 15800 | 5 m/s |
| 6.617 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 5090 | 15800 | 5 m/s |
| 0.369 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 462 | 15800 | 5 m/s |
| 5.599 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 5090 | 15800 | 5 m/s |
| 0.438 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 547 | 15800 | 5 m/s |
| 1.608 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2009 | 15800 | 5 m/s |
| 1.007 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1258 | 15800 | 5 m/s |
| 0.880 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1100 | 15800 | 5 m/s |

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|---|---|---|---|---|---|---|---|
| 1.706 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 1003 | 15800 | 5 m/s |
| 0.006 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 7 | 15800 | 5 m/s |
| 3.360 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 4200 | 15800 | 5 m/s |
| 1.128 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 752 | 15800 | 5 m/s |
| 2.321 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 1786 | 15800 | 5 m/s |
| 0.769 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 962 | 15800 | 5 m/s |
| 0.257 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 321 | 15800 | 5 m/s |
| 0.080 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 100 | 15800 | 5 m/s |
| 6.259 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 5690 | 15800 | 5 m/s |
| 0.278 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 347 | 15800 | 5 m/s |
| 7.268 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 9084 | 15800 | 5 m/s |
| 0.112 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 140 | 15800 | 5 m/s |
| 1.987 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 1046 | 15800 | 5 m/s |
| 0.331 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 301 | 15800 | 5 m/s |
| 1.830 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2287 | 15800 | 5 m/s |
| 1.146 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1432 | 15800 | 5 m/s |
| 9.321 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 6214 | 15800 | 5 m/s |
| 2.251 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 1732 | 15800 | 5 m/s |
| 0.369 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 462 | 15800 | 5 m/s |
| 3.612 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 4516 | 15800 | 5 m/s |
| 0.080 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 100 | 15800 | 5 m/s |
| 1.570 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 1427 | 15800 | 5 m/s |
| 0.604 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 549 | 15800 | 5 m/s |

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|---|---|---|---|---|---|---|---|
| 2.461 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2238 | 15800 | 5 m/s |
| 0.438 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 547 | 15800 | 5 m/s |
| 4.388 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 5484 | 15800 | 5 m/s |
| 0.400 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 500 | 15800 | 5 m/s |
| 3.122 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 1643 | 15800 | 5 m/s |
| 0.480 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 600 | 15800 | 5 m/s |
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 0.693 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 408 | 15800 | 5 m/s |
| 1.931 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 1136 | 15800 | 5 m/s |
| 1.974 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 1161 | 15800 | 5 m/s |
| 0.171 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 214 | 15800 | 5 m/s |
| 7.634 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 5090 | 15800 | 5 m/s |
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 6.958 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 5352 | 15800 | 5 m/s |
| 7.164 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 5511 | 15800 | 5 m/s |
| 0.209 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 262 | 15800 | 5 m/s |
| 3.619 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 3290 | 15800 | 5 m/s |
| 0.278 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 347 | 15800 | 5 m/s |
| 2.948 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 3684 | 15800 | 5 m/s |
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 5.626 m² | 1225.0 L/s | 0.50 Pa/m | 500 | 500 | 2813 | 15800 | 5 m/s |
| 0.610 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 763 | 15800 | 5 m/s |

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|---|---|---|---|---|---|---|---|
| 1.051 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1313 | 15800 | 5 m/s |
| 0.242 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 302 | 15800 | 5 m/s |
| 10.084 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 5307 | 15800 | 5 m/s |
| 2.857 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2598 | 15800 | 5 m/s |
| 0.598 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 747 | 15800 | 5 m/s |
| 1.988 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2484 | 15800 | 5 m/s |
| 1.120 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1400 | 15800 | 5 m/s |
| 1.598 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 1065 | 15800 | 5 m/s |
| 0.668 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 835 | 15800 | 5 m/s |
| 6.617 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 5090 | 15800 | 5 m/s |
| 0.369 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 462 | 15800 | 5 m/s |
| 5.599 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 5090 | 15800 | 5 m/s |
| 0.438 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 547 | 15800 | 5 m/s |
| 1.608 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2009 | 15800 | 5 m/s |
| 1.007 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1258 | 15800 | 5 m/s |
| 0.880 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1100 | 15800 | 5 m/s |
| 1.706 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 1003 | 15800 | 5 m/s |
| 0.006 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 7 | 15800 | 5 m/s |
| 3.360 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 4200 | 15800 | 5 m/s |
| 1.128 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 752 | 15800 | 5 m/s |
| 2.321 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 1786 | 15800 | 5 m/s |
| 0.769 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 962 | 15800 | 5 m/s |
| 0.257 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 321 | 15800 | 5 m/s |

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|---|---|---|---|---|---|---|---|
| 0.080 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 100 | 15800 | 5 m/s |
| 6.259 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 5690 | 15800 | 5 m/s |
| 0.278 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 347 | 15800 | 5 m/s |
| 7.268 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 9084 | 15800 | 5 m/s |
| 0.112 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 140 | 15800 | 5 m/s |
| 1.987 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 1046 | 15800 | 5 m/s |
| 0.331 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 301 | 15800 | 5 m/s |
| 1.830 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2287 | 15800 | 5 m/s |
| 1.146 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1432 | 15800 | 5 m/s |
| 9.321 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 6214 | 15800 | 5 m/s |
| 2.251 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 1732 | 15800 | 5 m/s |
| 0.369 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 462 | 15800 | 5 m/s |
| 3.612 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 4516 | 15800 | 5 m/s |
| 0.080 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 100 | 15800 | 5 m/s |
| 1.570 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 1427 | 15800 | 5 m/s |
| 0.604 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 549 | 15800 | 5 m/s |
| 2.461 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2238 | 15800 | 5 m/s |
| 0.438 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 547 | 15800 | 5 m/s |
| 4.388 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 5484 | 15800 | 5 m/s |
| 0.400 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 500 | 15800 | 5 m/s |
| 3.122 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 1643 | 15800 | 5 m/s |
| 0.480 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 600 | 15800 | 5 m/s |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 0.693 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 408 | 15800 | 5 m/s |
| 1.931 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 1136 | 15800 | 5 m/s |
| 1.974 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 1161 | 15800 | 5 m/s |
| 0.171 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 214 | 15800 | 5 m/s |
| 7.634 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 5090 | 15800 | 5 m/s |
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 6.958 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 5352 | 15800 | 5 m/s |
| 7.164 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 5511 | 15800 | 5 m/s |
| 0.209 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 262 | 15800 | 5 m/s |
| 3.619 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 3290 | 15800 | 5 m/s |
| 0.278 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 347 | 15800 | 5 m/s |
| 2.948 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 3684 | 15800 | 5 m/s |
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 5.626 m² | 1225.0 L/s | 0.50 Pa/m | 500 | 500 | 2813 | 15800 | 5 m/s |
| 0.610 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 763 | 15800 | 5 m/s |
| 1.051 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1313 | 15800 | 5 m/s |
| 0.242 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 302 | 15800 | 5 m/s |
| 10.084 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 5307 | 15800 | 5 m/s |
| 2.857 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2598 | 15800 | 5 m/s |
| 0.598 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 747 | 15800 | 5 m/s |
| 1.988 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2484 | 15800 | 5 m/s |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.120 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1400 | 15800 | 5 m/s |
| 1.598 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 1065 | 15800 | 5 m/s |
| 0.668 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 835 | 15800 | 5 m/s |
| 6.617 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 5090 | 15800 | 5 m/s |
| 0.369 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 462 | 15800 | 5 m/s |
| 5.599 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 5090 | 15800 | 5 m/s |
| 0.438 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 547 | 15800 | 5 m/s |
| 1.608 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2009 | 15800 | 5 m/s |
| 1.007 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1258 | 15800 | 5 m/s |
| 0.880 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1100 | 15800 | 5 m/s |
| 1.706 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 1003 | 15800 | 5 m/s |
| 0.006 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 7 | 15800 | 5 m/s |
| 3.360 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 4200 | 15800 | 5 m/s |
| 1.128 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 752 | 15800 | 5 m/s |
| 2.321 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 1786 | 15800 | 5 m/s |
| 0.769 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 962 | 15800 | 5 m/s |
| 0.257 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 321 | 15800 | 5 m/s |
| 0.080 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 100 | 15800 | 5 m/s |
| 6.259 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 5690 | 15800 | 5 m/s |
| 0.278 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 347 | 15800 | 5 m/s |
| 7.268 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 9084 | 15800 | 5 m/s |
| 0.112 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 140 | 15800 | 5 m/s |
| 5.385 m² | 5081.0 L/s | 0.56 Pa/m | 600 | 1200 | 1496 | 15800 | 5 m/s |

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|---|---|---|---|---|---|---|---|
| 4.172 m² | 2380.0 L/s | 0.33 Pa/m | 700 | 700 | 1490 | 15800 | 5 m/s |
| 0.018 m² | 595.0 L/s | 0.76 Pa/m | 350 | 350 | 13 | 15800 | 5 m/s |
| 5.590 m² | 1785.0 L/s | 0.41 Pa/m | 600 | 600 | 2329 | 15800 | 5 m/s |
| 8.208 m² | 1785.0 L/s | 0.41 Pa/m | 600 | 600 | 3420 | 15800 | 5 m/s |
| 18.756 m² | 1785.0 L/s | 0.41 Pa/m | 600 | 600 | 7815 | 15800 | 5 m/s |
| 0.082 m² | 595.0 L/s | 0.76 Pa/m | 350 | 350 | 58 | 15800 | 5 m/s |
| 5.959 m² | 1190.0 L/s | 0.48 Pa/m | 500 | 500 | 2979 | 15800 | 5 m/s |
| 3.440 m² | 1190.0 L/s | 0.48 Pa/m | 500 | 500 | 1720 | 15800 | 5 m/s |
| 18.480 m² | 1190.0 L/s | 0.48 Pa/m | 500 | 500 | 9240 | 15800 | 5 m/s |
| 1.492 m² | 1190.0 L/s | 0.48 Pa/m | 500 | 500 | 746 | 15800 | 5 m/s |
| 1.238 m² | 595.0 L/s | 0.76 Pa/m | 350 | 350 | 884 | 15800 | 5 m/s |
| 2.554 m² | 595.0 L/s | 0.76 Pa/m | 350 | 350 | 1824 | 15800 | 5 m/s |
| 7.210 m² | 595.0 L/s | 0.76 Pa/m | 350 | 350 | 5150 | 15800 | 5 m/s |
| 12.258 m² | 595.0 L/s | 0.76 Pa/m | 350 | 350 | 8756 | 15800 | 5 m/s |
| 8.635 m² | 595.0 L/s | 0.76 Pa/m | 350 | 350 | 6168 | 15800 | 5 m/s |
| 0.161 m² | 595.0 L/s | 0.76 Pa/m | 350 | 350 | 115 | 15800 | 5 m/s |
| 2.393 m² | 1575.0 L/s | 0.33 Pa/m | 600 | 600 | 997 | 15800 | 5 m/s |

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|---|---|---|---|---|---|---|---|
| 0.538 m² | 1575.0 L/s | 0.33 Pa/m | 600 | 600 | 224 | 15800 | 5 m/s |
| 1.790 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2237 | 15800 | 5 m/s |
| 0.238 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 297 | 15800 | 5 m/s |
| 2.949 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2681 | 15800 | 5 m/s |
| 0.726 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 907 | 15800 | 5 m/s |
| 9.434 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 6290 | 15800 | 5 m/s |
| 0.733 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 916 | 15800 | 5 m/s |
| 2.313 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2891 | 15800 | 5 m/s |
| 4.033 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 3667 | 15800 | 5 m/s |
| 0.413 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 375 | 15800 | 5 m/s |
| 1.251 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 1138 | 15800 | 5 m/s |
| 0.550 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 687 | 15800 | 5 m/s |
| 1.208 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1509 | 15800 | 5 m/s |
| 0.714 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 893 | 15800 | 5 m/s |
| 3.344 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 4180 | 15800 | 5 m/s |
| 1.512 m² | 2380.0 L/s | 0.33 Pa/m | 700 | 700 | 540 | 15800 | 5 m/s |
| 0.980 m² | 2380.0 L/s | 0.33 Pa/m | 700 | 700 | 350 | 15800 | 5 m/s |
| 0.147 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 184 | 15800 | 5 m/s |
| 1.520 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1900 | 15800 | 5 m/s |
| 3.908 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 4884 | 15800 | 5 m/s |
| 0.592 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 740 | 15800 | 5 m/s |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.644 m² | 1225.0 L/s | 0.50 Pa/m | 500 | 500 | 822 | 15800 | 5 m/s |
| 11.433 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 6725 | 15800 | 5 m/s |
| 0.675 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 843 | 15800 | 5 m/s |
| 3.579 m² | 5081.0 L/s | 0.56 Pa/m | 600 | 1200 | 994 | 15800 | 5 m/s |
| 2.809 m² | 1050.0 L/s | 0.49 Pa/m | 475 | 475 | 1479 | 15800 | 5 m/s |
| 4.067 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 3698 | 15800 | 5 m/s |
| 2.724 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2477 | 15800 | 5 m/s |
| 1.158 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1447 | 15800 | 5 m/s |
| 1.978 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2472 | 15800 | 5 m/s |
| 1.946 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 1297 | 15800 | 5 m/s |
| 2.776 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 1851 | 15800 | 5 m/s |
| 2.221 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 1481 | 15800 | 5 m/s |
| 0.221 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 276 | 15800 | 5 m/s |
| 8.957 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 6890 | 15800 | 5 m/s |
| 0.289 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 362 | 15800 | 5 m/s |
| 11.539 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 10490 | 15800 | 5 m/s |
| 0.438 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 547 | 15800 | 5 m/s |
| 5.828 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 7284 | 15800 | 5 m/s |
| 0.400 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 500 | 15800 | 5 m/s |
| 1.378 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 811 | 15800 | 5 m/s |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.639 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 964 | 15800 | 5 m/s |
| 2.079 m² | 875.0 L/s | 0.60 Pa/m | 425 | 425 | 1223 | 15800 | 5 m/s |
| 0.233 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 291 | 15800 | 5 m/s |
| 9.506 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 6337 | 15800 | 5 m/s |
| 5.443 m² | 700.0 L/s | 0.73 Pa/m | 375 | 375 | 3629 | 15800 | 5 m/s |
| 0.733 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 916 | 15800 | 5 m/s |
| 10.517 m² | 525.0 L/s | 0.87 Pa/m | 325 | 325 | 8090 | 15800 | 5 m/s |
| 0.021 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 27 | 15800 | 5 m/s |
| 2.824 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2567 | 15800 | 5 m/s |
| 0.495 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 450 | 15800 | 5 m/s |
| 2.965 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2695 | 15800 | 5 m/s |
| 0.919 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 835 | 15800 | 5 m/s |
| 3.275 m² | 350.0 L/s | 0.95 Pa/m | 275 | 275 | 2978 | 15800 | 5 m/s |
| 0.282 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 352 | 15800 | 5 m/s |
| 1.432 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1789 | 15800 | 5 m/s |
| 0.400 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 500 | 15800 | 5 m/s |
| 0.896 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 1120 | 15800 | 5 m/s |
| 0.380 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 475 | 15800 | 5 m/s |
| 2.060 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 2575 | 15800 | 5 m/s |
| 0.240 m² | 175.0 L/s | 1.27 Pa/m | 200 | 200 | 300 | 15800 | 5 m/s |
| 1.091 m² | 2000.0 L/s | 0.51 Pa/m | 600 | 600 | 454 | 15800 | 5 m/s |
| 1.125 m² | 5081.0 | 18.32 Pa/m | 300 | 600 | 625 | 15800 | 5 m/s |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | L/s | | | | | | |
| 1.415 m² | 5081.0 L/s | 2.96 Pa/m | 600 | 600 | 589 | 15800 | 5 m/s |
| 0.879 m² | 5081.0 L/s | 2.96 Pa/m | 600 | 600 | 366 | 15800 | 5 m/s |
| 1.383 m² | 5081.0 L/s | 2.96 Pa/m | 600 | 600 | 576 | 15800 | 5 m/s |
| 1.433 m² | 5081.0 L/s | 2.96 Pa/m | 600 | 600 | 597 | 15800 | 5 m/s |
| 2.563 m² | 5081.0 L/s | 2.96 Pa/m | 600 | 600 | 1068 | 15800 | 5 m/s |
| 2.525 m² | 5081.0 L/s | 2.96 Pa/m | 600 | 600 | 1052 | 15800 | 5 m/s |
| 2.715 m² | 5081.0 L/s | 2.96 Pa/m | 600 | 600 | 1131 | 15800 | 5 m/s |
| 2.671 m² | 5081.0 L/s | 2.96 Pa/m | 600 | 600 | 1113 | 15800 | 5 m/s |
| 2.747 m² | 5081.0 L/s | 2.96 Pa/m | 600 | 600 | 1145 | 15800 | 5 m/s |
| 1.333 m² | 5081.0 L/s | 2.96 Pa/m | 600 | 600 | 555 | 15800 | 5 m/s |
| 11.856 m² | 1160.0 L/s | 0.05 Pa/m | 780 | 780 | 3800 | 15800 | 5 m/s |
| 5.616 m² | 1160.0 L/s | 0.05 Pa/m | 780 | 780 | 1800 | 15800 | 5 m/s |

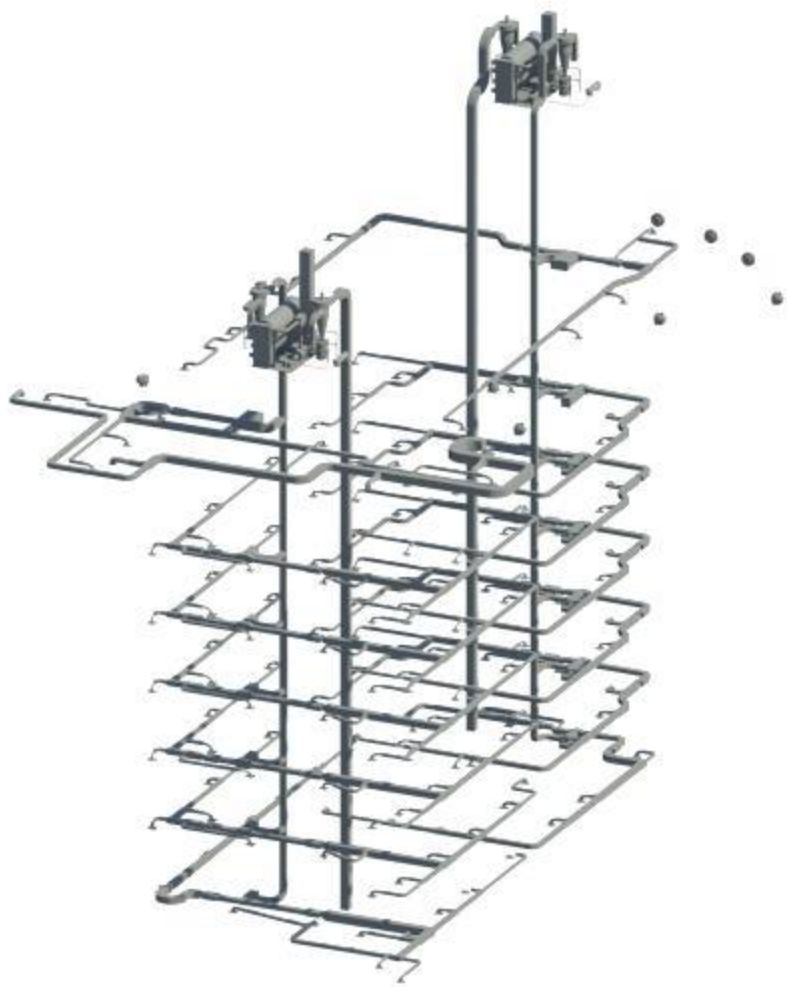


Figure 7. 6 HVAC System

## 7.2: Water Supply System:

The network supplies all the units with water for cleaning, drinking, feed fire systems, and even chiller systems.

Size of the tank:

Individual demand in the multipurpose building from water is 15 liter/day.

The size of the tank will be computed over three days.

30% of the tank size for firefighting and cleaning.

(0.3*1800*15+15*1800))*3=105300 liter(

The size of the tanks will be used 110 m$^{3.}$

First floor:

**Table7. 2 Fixture units for first floor- zone C**

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **W.C** | public | Flush tank | 7 | cold | 5 | 35 |
| **lavatories** | public | faucet | 5 | cold | 1.5 | 7.5 |
| | public | faucet | 5 | hot | 1.5 | 7.5 |
| | | | | | | **50** |

**Table7. 3 Fixture units for first floor- zone D**

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **W.C** | public | Flush tank | 6 | cold | 5 | 30 |
| **lavatories** | public | faucet | 4 | cold | 1.5 | 6 |
| | public | faucet | 4 | hot | 1.5 | 6 |
| | | | | | | **42** |

Second floor:

**Table7. 4 Fixture units for second floor- zone C**

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **W.C** | public | Flush tank | 7 | cold | 5 | 35 |
| **lavatories** | public | faucet | 5 | cold | 1.5 | 7.5 |
| | public | faucet | 5 | hot | 1.5 | 7.5 |
| | | | | | | **50** |

**Table7. 5 Fixture units for second floor- zone D**

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **W.C** | public | Flush tank | 6 | cold | 5 | 30 |
| **lavatories** | public | faucet | 4 | cold | 1.5 | 6 |
| | public | faucet | 4 | hot | 1.5 | 6 |
| | | | | | | **42** |

Third floor:

**Table7. 6 Fixture units for third floor-zone A**

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **Kitchen sink** | public | faucet | 2 | cold | 3 | 6 |
| | public | faucet | 2 | hot | 3 | 6 |
| | | | | | | **12** |

**Table7. 7 Fixture units for third floor-zone C**

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **W.C** | public | Flush tank | 7 | cold | 5 | 35 |
| **lavatories** | public | faucet | 5 | cold | 1.5 | 7.5 |
| | public | faucet | 5 | hot | 1.5 | 7.5 |
| | | | | | | **50** |

**Table7. 8 Fixture units for third floor-zone D**

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **W.C** | public | Flush tank | 6 | cold | 5 | 30 |
| **Lavatories** | public | faucet | 4 | cold | 1.5 | 6 |
| | public | faucet | 4 | hot | 1.5 | 6 |
| **lavatories** | public | faucet | 5 | cold | 1.5 | 7.5 |
| | public | faucet | 5 | hot | 1.5 | 7.5 |
| | | | | | | **57** |

fourth floor:

Table7. 9 Fixture units for third floor-zone A

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **Kitchen sink** | public | faucet | 2 | cold | 3 | 6 |
| | public | faucet | 2 | hot | 3 | 6 |
| | | | | | | **12** |

Table7. 10 Fixture units for third floor-zone C

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **W.C** | public | Flush tank | 7 | cold | 5 | 35 |
| **lavatories** | public | faucet | 5 | cold | 1.5 | 7.5 |
| | public | faucet | 5 | hot | 1.5 | 7.5 |
| | | | | | | **50** |

Table7. 11 Fixture units for fourth floor- zone D

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **W.C** | public | Flush tank | 6 | cold | 5 | 30 |
| **lavatories** | public | faucet | 4 | cold | 1.5 | 6 |
| | public | faucet | 4 | hot | 1.5 | 6 |
| | | | | | | **42** |

Fifth floor:

Table7. 12 Fixture units for third floor-zone A

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **Kitchen sink** | public | faucet | 2 | cold | 3 | 6 |
| | public | faucet | 2 | hot | 3 | 6 |
| | | | | | | **12** |

Table7. 13 Fixture units for fifth floor zone C

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **W.C** | public | Flush tank | 7 | cold | 5 | 35 |
| **lavatories** | public | faucet | 5 | cold | 1.5 | 7.5 |
| | public | faucet | 5 | hot | 1.5 | 7.5 |
| | | | | | | **50** |

Table7. 14 Fixture units for fifth floor- zone D

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **W.C** | public | Flush tank | 6 | cold | 5 | 30 |
| **lavatories** | public | faucet | 4 | cold | 1.5 | 6 |
| | public | faucet | 4 | hot | 1.5 | 6 |
| | | | | | | **42** |

seventh floor zone A:

Table7. 15 Fixture units for seventh floor Zone A

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **W.C** | public | Flush tank | 8 | cold | 5 | 40 |
| **lavatories** | public | faucet | 6 | cold | 1.5 | 9 |
| | public | faucet | 6 | hot | 1.5 | 9 |
| **Kitchen sink** | public | faucet | 2 | cold | 3 | 6 |
| | public | faucet | 2 | hot | 3 | 6 |
| | | | | | | **70** |

Table7. 16 Fixture units for seventh floor Zone B

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **W.C** | public | Flush tank | 8 | cold | 5 | 40 |
| **lavatories** | public | faucet | 6 | cold | 1.5 | 9 |
| | public | faucet | 6 | hot | 1.5 | 9 |
| **Kitchen sink** | public | faucet | 2 | cold | 3 | 6 |
| | public | faucet | 2 | hot | 3 | 6 |
| | | | | | | **70** |

eighth floor:

Table7. 17 Fixture units for eighth floor Zone A

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **W.C** | public | Flush tank | 2 | cold | 5 | 10 |
| **lavatories** | public | faucet | 2 | cold | 1.5 | 3 |
| | public | faucet | 2 | hot | 1.5 | 3 |
| **Kitchen sink** | public | faucet | 2 | cold | 3 | 6 |
| | public | faucet | 2 | hot | 3 | 6 |
| | | | | | | **28** |

Table7. 18 Fixture units for eighth floor Zone B

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **W.C** | public | Flush tank | 2 | cold | 5 | 10 |
| **lavatories** | public | faucet | 2 | cold | 1.5 | 3 |
| | public | faucet | 2 | hot | 1.5 | 3 |
| **Kitchen sink** | public | faucet | 2 | cold | 3 | 6 |
| | public | faucet | 2 | hot | 3 | 6 |
| | | | | | | **28** |

Ninth floor:

Table7. 19 Fixture units for ninth floor Zone B

| Type | occupancy | Type of supply control | Number of function | Hot or cold | WUFU | total |
|---|---|---|---|---|---|---|
| **W.C** | public | Flush tank | 2 | cold | 5 | 10 |
| **lavatories** | public | faucet | 2 | cold | 1.5 | 3 |
| | public | faucet | 2 | hot | 1.5 | 3 |
| **Kitchen sink** | public | faucet | 2 | cold | 3 | 6 |
| | public | faucet | 2 | hot | 3 | 6 |
| | | | | | | **28** |

Now to compute pipes sizes for the main vertical feeder in each zone, we need to compute water demand for each zone by using the following figure:

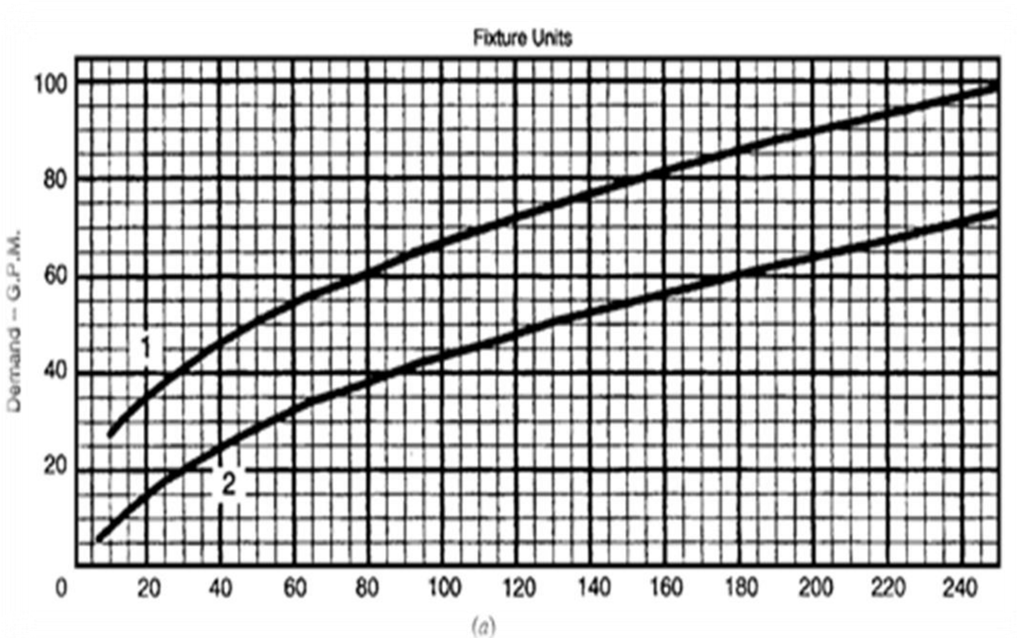



Figure 7. 7 Curve for demand load with relation of F.U

Table7 . 20 Water demand for Zone A

| Zone A | Type of supply control | Number of F.U | Water demand (gpm) |
|---|---|---|---|
| third floor | Flush Tank | 12 | **11** |
| fourth floor | Flush Tank | 12 | **11** |
| seventh floor | Flush Tank | 70 | **35** |
| eighth floor | Flush Tank | 28 | **19** |

Table7 . 21 Water demand for Zone B

| Zone B | Type of supply control | Number of F.U | Water demand (gpm) |
|---|---|---|---|
| third floor | Flush Tank | 15 | **13** |
| seventh floor | Flush Tank | 70 | **35** |
| eighth floor | Flush Tank | 28 | **19** |
| ninth floor | Flush Tank | 28 | **19** |

Table7 . 22 Water demand for Zone C

| Zone C | Type of supply control | Number of F.U | Water demand (gpm) |
|---|---|---|---|
| first floor | Flush Tank | 50 | **28** |
| second floor | Flush Tank | 50 | **28** |
| third floor | Flush Tank | 50 | **28** |
| fourth floor | Flush Tank | 50 | **28** |
| fifth floor | Flush Tank | 50 | **28** |

Table7 . 23 Water demand for Zone D

| Zone D | Type of supply control | Number of F.U | Water demand (gpm) |
|---|---|---|---|
| first floor | Flush Tank | 42 | **24** |
| second floor | Flush Tank | 42 | **24** |
| third floor | Flush Tank | 57 | **31** |
| fourth floor | Flush Tank | 42 | **24** |
| fifth floor | Flush Tank | 42 | **24** |

Table7 . 24 Water demand for main feeder

| Zone | Type of supply control | Number of F.U | Water demand (gpm) |
|---|---|---|---|
| Zone A | Flush Tank | 122 | **52** |
| Zone B | Flush Tank | 141 | **55** |
| Zone C | Flush Tank | 250 | **75** |
| Zone D | Flush Tank | 225 | **69** |

## Pipes diameters for zone C:

h =14.7 ft. for each floor

Number of floors = 10, Flush tank

### First Floor:

Possible diameter of the galvanized steel vertical feeder :-

$P_{first}$ = (10*14.7+ (6/2) -4) *0.433 =63.22 psi

Height of main feeder =10*14.7 = 147 ft.

Galvanized steel h = 1.5*132.3 = 220.5 ft. , F.U= 250 , demand water = 75 gpm

By using the following figure, we will select the diameter pipe & friction losses:

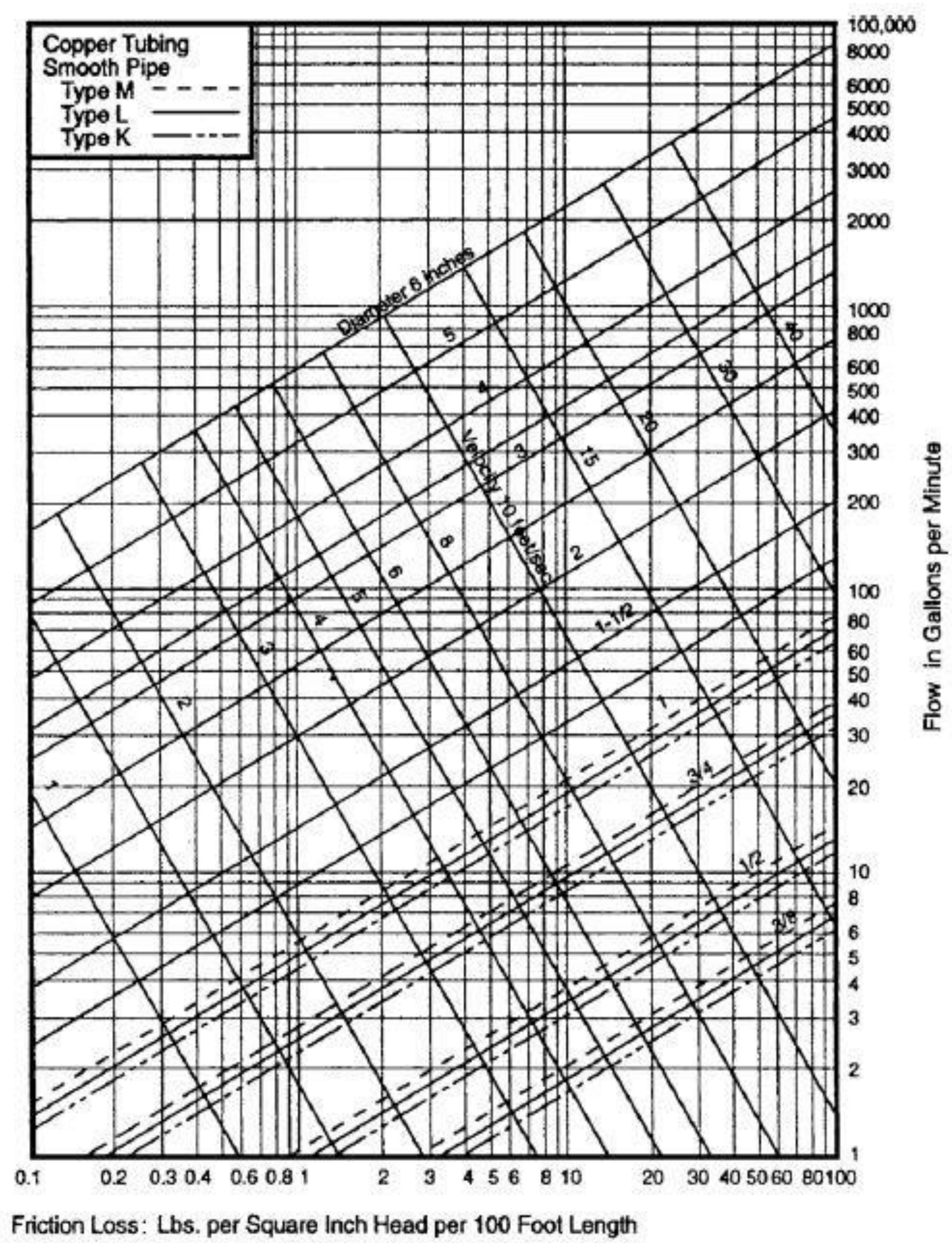



**Figure 7. 8 Flow chart for rough pipe**

Table7 . 25 Possible diameter for main feeder zone C

| possible diameter | 4" | 3.5" | 3" | 2.5" | 2" |
|---|---|---|---|---|---|
| losses /100 ft | 0.21 | 0.45 | 0.68 | 1.9 | 4.8 |
| losses /220.5 ft | 0.46 | 0.99 | 1.499 | 4.19 | 10.6 |

Possible diameter of the of the PVC horizontal feeder :-(collector C)

F.U= 50 , demand water = 28 gpm

Length = 15.6 m

L = (1.2*15.6/0.3048) =61.4ft

Table7 . 26 Possible diameter for horizontal feeder first– zone C

| possible diameter | 3" | 2.5" | 2" | 1.5" | 1.25" |
|---|---|---|---|---|---|
| losses /100 ft | 0.13 | 0.32 | 0.8 | 3.1 | 7.1 |
| losses /61.4 ft | 0.0798 | 0.20 | 0.49 | 1.90 | 4.36 |

Possible diameter of the PVC upper branch :-

F.U= 5 , demand water = 5 gpm , C.F = 12 psi (W.C Flush Tank)

Length = 6.7 m

L = (1.2*6.7/0.3048) =26.8 ft

Table7 . 27 Possible diameter of the branch F.F– zone C

| possible diameter | 1.5" | 1.25" | 1" | (3/4)" | (1/2)" |
|---|---|---|---|---|---|
| losses /100 ft | 0.18 | 0.39 | 1.2 | 3.1 | 19 |
| losses /26.8 ft | 0.048 | 0.104 | 0.322 | 0.83 | 5.1 |

Suitable diameter for vertical feeder (2") & horizontal feeder (1.25") &branches (0.5")

Total losses = 10.6+4.36+5.1=20.1 psi

Available pressure = 63.22-20.1 = 43.16 > 12 … OK

## Pipes diameters for zone A:

h =14.7 ft. for each floor

Number of floors = 7,    Flush tank

### Third Floor:

Possible diameter of the galvanized steel vertical feeder :-

$P_{Third}$ = (7*14.7+ (6/2) -4) *0.433 =44.1 psi

Height of main feeder =7*14.7 = 102.9 ft.

Galvanized steel h = 1.5*102.9 = 145.35 ft.    ,   F.U= 122   , demand water = 52 gpm

the diameter pipe & friction losses

**Table7 . 28 Possible diameter for main feeder zone C**

| possible diameter | 4" | 3.5" | 3" | 2.5" | 2" |
|---|---|---|---|---|---|
| losses /100 ft | 0.12 | 0.21 | 0.35 | 0.8 | 2.8 |
| losses /145.3 ft | 0.174 | 0.304 | 0.507 | 1.16 | 4.06 |

Possible diameter of the of the PVC horizontal feeder :-(collector A)

F.U= 12   , demand water = 11 gpm

Length = 7.9 m

L = (1.2*7.9/0.3048) =31.1 ft

Table7 . 29 Possible diameter for horizontal feeder first– zone A

| possible diameter | 3" | 2.5" | 2" | 1.5" | 1.25" |
|---|---|---|---|---|---|
| losses /100 ft | 0.17 | 0.58 | 1.2 | 3.1 | 12 |
| losses /31.1 ft | 0.05 | 0.18 | 0.373 | 0.96 | 3.73 |

Possible diameter of the PVC upper branch :-

F.U= 4 , demand water = 4 gpm , C.F = 8 psi (Kitchen sink)

Length = 6.9 m

L = (1.2*6.9/0.3048) =27.16 ft

Table7 . 30 Possible diameter of the branch F.F– zone A

| possible diameter | 1.25" | 1 " | (3/4)" | (1/2)" | (3/8)" |
|---|---|---|---|---|---|
| losses /100 ft | 2.3 | 6.8 | 2.2 | 14 | 38 |
| losses /27.16 ft | 0.623 | 1.84 | 0.596 | 3.79 | 10.29 |

Suitable diameter for vertical feeder (2") & horizontal feeder (1.25") &branches (0.5")

Total losses = 4.06+3.73+3.79=11.58 psi

Available pressure = 44.1-11.58 = 32.52 > 8 … OK

## 7.3: Drainage System Design:

In our project, the drainage system is divided into two groups black and gray water. The pipes of the black water will be connected with Sewerage and sanitation of municipality, but the grey water will be collected, and use for toilet or for irrigation.

**Table7. 31 Drainage fixture units (DFU's)**

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

**Table7. 32 Horizontal fixture branches and stacks**

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

1

**Table7. 33 Size and length of vent**

| Diameter of Soil or Waste Stack in. (mm)[b] | Total Fixture Units Being Vented (dfu) | Maximum Developed Length[a] of Vent, Feet (m)[b] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Diameter of Vent, In. (mm)[b] | | | | | | | | | |
| | | 1¼ (32) | 1½ (38) | 2 (51) | 2½ (64) | 3 (76) | 4 (102) | 5 (127) | 6 (152) | 8 (203) | 10 (254) |
| 1¼ (32) | 2 | 30 (9.1) | | | | | | | | | |
| 1½ (38) | 8 | 50 (15.2) | 150 (45.7) | | | | | | | | |
| 1½ (38) | 10 | 30 (9.1) | 100 (30.5) | | | | | | | | |
| 2 (51) | 12 | 30 (9.1) | 75 (22.9) | 200 (61.0) | | | | | | | |
| 2 (51) | 20 | 26 (7.9) | 50 (15.2) | 150 (45.7) | | | | | | | |
| 2 1/2 (64) | 42 | | 30 (9.1) | 100 (30.5) | | | | | | | |
| 3 (76) | 10 | | 42 (12.8) | 150 (45.7) | 360 (109.7) | 1040 (317) | | | | | |
| 3 (76) | 21 | | 32 (9.8) | 110 (33.5) | 270 (82.3) | 810 (246.9) | | | | | |
| 3 (76) | 53 | | 27 (8.2) | 94 (28.7) | 230 (70.1) | 680 (207.3) | | | | | |
| 3 (76) | 102 | | 25 (7.6) | 86 (26.6) | 210 (64.0) | 620 (189.0) | | | | | |
| 4 (102) | 43 | | | 35 (10.7) | 85 (25.9) | 250 (76.2) | 980 (298.7) | | | | |
| 4 (102) | 140 | | | 27 (8.2) | 65 (19.8) | 200 (61.0) | 750 (228.6) | | | | |
| 4 (102) | 320 | | | 23 (7.0) | 55 (16.8) | 170 (51.8) | 640 (195.0) | | | | |
| 4 (102) | 540 | | | 21 (6.4) | 50 (15.2) | 150 (45.7) | 580 (176.8) | | | | |
| 5 (127) | 190 | | | | 28 (8.5) | 82 (25.0) | 320 (97.5) | 990 (301.8) | | | |
| 5 (127) | 490 | | | | 21 (6.4) | 63 (19.2) | 250 (76.2) | 760 (231.6) | | | |
| 5 (127) | 940 | | | | 18 (5.5) | 53 (16.2) | 210 (64.0) | 670 (204.2) | | | |
| 5 (127) | 1400 | | | | 16 (4.9) | 49 (14.9) | 190 (57.9) | 590 (179.8) | | | |
| 6 (152) | 500 | | | | | 33 (10.1) | 130 (39.6) | 400 (121.9) | 1000 (304.8) | | |
| 6 (152) | 1100 | | | | | 26 (7.9) | 100 (30.5) | 310 (94.5) | 780 (237.7) | | |
| 6 (152) | 2000 | | | | | 22 (6.7) | 84 (25.6) | 260 (79.2) | 660 (201.2) | | |

**Table7. 34 horizontal Drainage calculation**

| Fixture type | DFU. | size | Fall/foot |
|---|---|---|---|
| **W.C** | 4 | 4" | 1/8" |
| **Lavatory** | 1 | 2" | 1/4" |
| **Kitchen sink** | 2 | 2" | 1/4" |
| **Floor drain** | 3 | 2" | 1/4" |

### *7.3.1: Drainage Calculations for main stack:*

In our project, we need for two types of stack one for black water and one for gray water now will calculate the number and diameter of stacks that required for the Building.

** We will use two stacks for the W.C's one for black and one for gray water.

In the building, each floor have the following fixture:

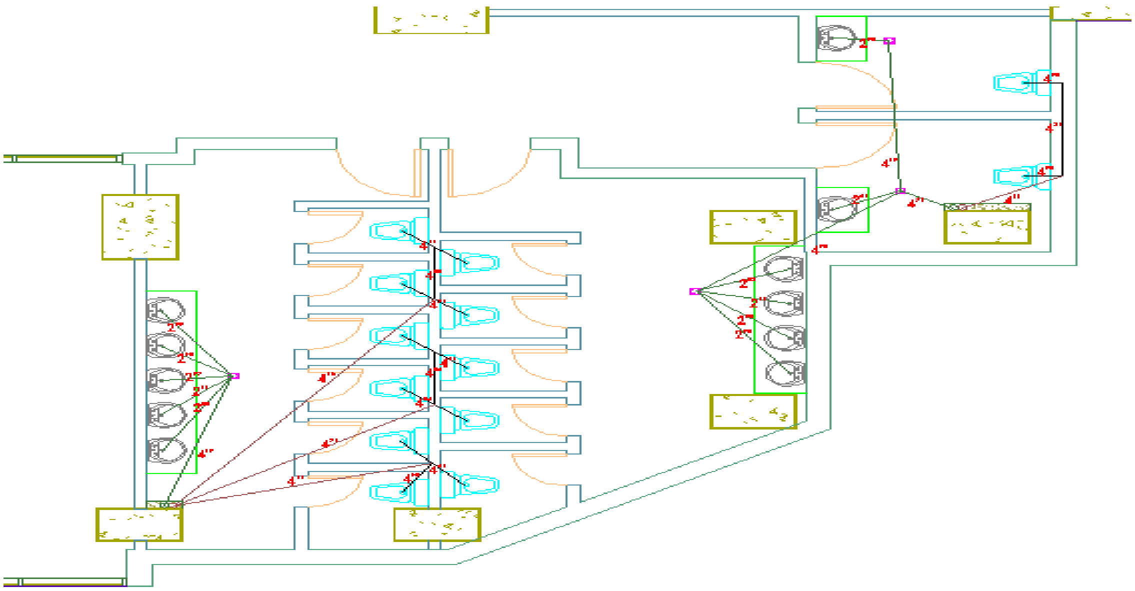


Figure 7. 9 Drainage Layout

13 W.C 5 lavatory 5-floor drain

No. of DFUs. For black water = 4*13=52

No. of DFUs. For gray water = 1*5=5

Total No. of fixture for black water =5*52=260 DFUs.

Total No. of fixture for gray water =5*5=25 DFUs.

In the sixth, floor the fixture:

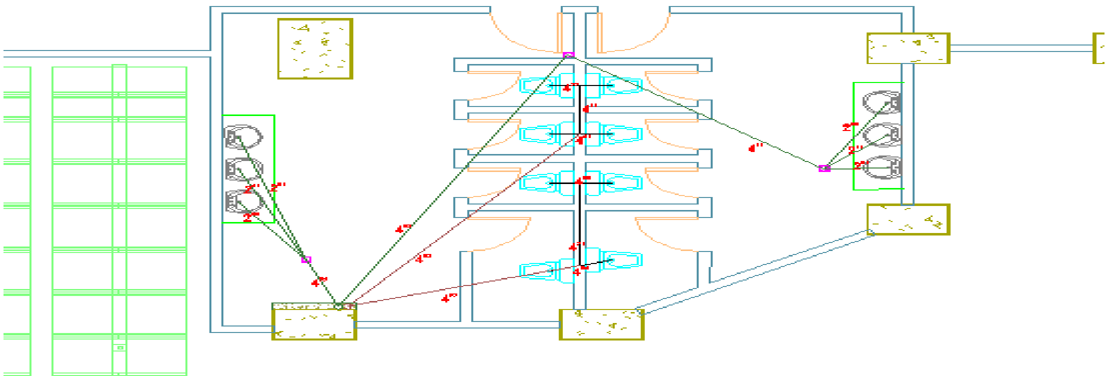


Figure 7. 10 Drainage Layout

8 W.C 6 lavatory 1-floor drain

No. of DFUs. For black water = 4*8=32

No. of DFUs. For gray water = 1*6=6

Total No. of fixture for black water =5*52 +32 =292 DFUs.

Total No. of fixture for gray water =5*5+ 6=31 DFUs.

For the bath rooms use one stack (4") for black water and one stack( 4") for gray water.

## Chapter Eight: Electrical Design

## 8.1: General

Electrical design for buildings is a very important issue because without lighting, the life will be very difficult; also, lighting design is very essential. Therefore, in this chapter we design the lighting for the building using DIALUX program.

## 8.2: Electrical sockets

Sockets should be located so as to allow the most appropriate positioning of equipment and lighting using the shortest possible cable length. Wiring cables of connected devices will be discretely and neatly arranged. Some easily accessible sockets should be available permanently for use by guests

Figure 8. 1 socket

## 8.3: Electrical switches

Control consisting of a mechanical or electrical or electronic device for making or breaking or changing the connections in a circuit

Used types:

1- Single switch: Switch that open and close circuit from one point only

Figure 8. 2 Single switch

2- Double switch: Switch than open and close circuit from two different points.

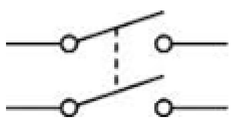


Figure 8. 3 Double switch

## 8.4: lighting Design

The lighting design depends on two types of lighting as follows:

1- Day light.

2- Artificial lighting.

The intensity of light falling at unit area (luminance in lux) in the day light depends on the direction of the building. And we can use computer programs such as (Ecotect Analysis, Dialux) for help us to compute this value.

But in the artificial lighting we determine the value of (lux) that we need from specialized tables that will shows later, and there are many factors that affect the artificial lighting design such as:

1- Room dimension.

2- The function of the room, and that used for what.

3- Selection of the luminaries.

4- Maintenance factor for lamps.

5- Reflection factors for ceiling, walls, and floors.

The tables below show the luminance (E) for various areas buildings in accordance with CIE recommendations:

Table-1::

**Table 8. 1 Recommended luminance level for different areas**

| Space/ activity | Recommended min. luminance E (lux) | Glare index | Suitable lamp |
|---|---|---|---|
| **Office** | 300 | 19 | C,D,E,F,H,I,K,L |
| **Team office** | 500 | | |
| **Deep- plan office** | 750 | 19 | C,D,E,F,H,I,K,L |
| **Technical drawing office** | 750 | 16 | A,C,D,E,F,H,I,K,L |

| | | | |
|---|---|---|---|
| **Control room** | 300 | 16 | C,D,E,F,H,I,K,L |
| **Corridor** | 150 | | D,E,H,L,K,L,P,Q |
| **Staircase** | 150 | | C,D,E,F,H,I,J,L,M,Q |
| **Waiting areas** | 150 | 19 | D,E,F,H,I,K,J ,Q |
| **Bathroom, WC** | 100 | | D,E,F,G,I,J,Q |
| **Reception** | 300 | 19 | D,E,K,L,Q |
| **Restaurant** | 200 | 22 | D,E,F,H,I,J,Q |
| **Laboratory** | 500 | 19 | A,C,D,E,F,H,I,Q |
| **Art ROOM** | 500 | 19 | A,B,D,E |
| **Meeting room** | 300 | | |

Table 8. 2Types of lamps

| Lamp type | Lamp reference latter | Lamp designation and code |
|---|---|---|
| **Tubular fluorescent (MCF)** | A | North light color matching |
| | B | Artificial daylight |
| | C | Daylight |
| | D | Natural |
| | E | Color – rite Trucolor37 |

| | | |
|---|---|---|
| | F | Color 84 Plus-White |
| | G | De lux natural |
| | H | White |
| | I | Warm White |
| | J | Deluxe Warm White<br>Softened 32 |
| **High pressure discharge** | K | Mercury halide (MBI)<br>Mercury halide (MBIL)<br>Mercury halide Fluorescent(MBIF) |
| | L | Mercury (MBF) Fluorescent<br>Mercury Fluorescent REFLECTOR(MBIF)<br>Mercury – tungsten Fluorescent(MBTF)(blended) |
| **High pressure discharge continued** | M | High- pressure sodium (SON)<br>High- pressure sodium (SONT)<br>High pressure sodium (SONL)<br>High pressure sodium |

| | | |
|---|---|---|
| | | (SONR) |
| **Low pressure discharge (excluding tubular Fluorescent)** | N | Low pressure sodium(SOX)<br>Low pressure sodium(SOXL) |
| **Incandescent lamp** | P | Tungsten halogen (T/H) |
| | Q | Tungsten – general lighting service (GLS)<br>Tungsten reflector |

Table 8. 3 Spaces with lighting and power loads

| Space Schedule 4 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Name | No. | Level | Area | Lighting Calculation Workplane | Lighting Load | Lighting Load per area | Power Load | Power Load per area |
| | | | m2 | m | W | W/m2 | W | W/m2 |
| Space | 1 | Level 1 | 15 | 0.8 | 338 | 22.6 | 161 | 10.76 |
| Space | 2 | Level 1 | 21 | 0.8 | 466 | 22.6 | 222 | 10.76 |
| Space | 3 | Level 1 | 53 | 0.8 | 1200 | 22.6 | 571 | 10.76 |
| Space | 4 | Level 1 | 30 | 0.8 | 673 | 22.6 | 320 | 10.76 |
| Space | 5 | Level 1 | 31 | 0.8 | 694 | 22.6 | 331 | 10.76 |
| Space | 6 | Level 1 | 30 | 0.8 | 686 | 22.6 | 327 | 10.76 |
| Space | 7 | Level 1 | 46 | 0.8 | 1048 | 22.6 | 499 | 10.76 |
| Space | 8 | Level 1 | 42 | 0.8 | 948 | 22.6 | 451 | 10.76 |
| Space | 9 | Level 1 | 44 | 0.8 | 1002 | 22.6 | 477 | 10.76 |
| Space | 10 | Level 1 | 38 | 0.8 | 858 | 22.6 | 408 | 10.76 |
| Space | 11 | Level 1 | 28 | 0.8 | 640 | 22.6 | 305 | 10.76 |
| Space | 12 | Level 1 | 26 | 0.8 | 582 | 22.6 | 277 | 10.76 |
| Space | 13 | Level 1 | 26 | 0.8 | 577 | 22.6 | 275 | 10.76 |
| Space | 14 | Level 1 | 26 | 0.8 | 580 | 22.6 | 276 | 10.76 |
| Space | 15 | Level 1 | 26 | 0.8 | 580 | 22.6 | 276 | 10.76 |
| Space | 16 | Level 1 | 25 | 0.8 | 554 | 22.6 | 264 | 10.76 |
| Space | 17 | Level 1 | 25 | 0.8 | 571 | 22.6 | 272 | 10.76 |
| Space | 18 | Level 1 | 28 | 0.8 | 622 | 22.6 | 296 | 10.76 |
| Space | 19 | Level 1 | 28 | 0.8 | 622 | 22.6 | 296 | 10.76 |
| Space | 20 | Level 1 | 27 | 0.8 | 617 | 22.6 | 294 | 10.76 |
| Space | 21 | Level 1 | 32 | 0.8 | 717 | 22.6 | 341 | 10.76 |
| Space | 22 | Level 1 | 29 | 0.8 | 656 | 22.6 | 312 | 10.76 |
| Space | 23 | Level 1 | 27 | 0.8 | 614 | 22.6 | 293 | 10.76 |
| Space | 24 | Level 1 | 29 | 0.8 | 666 | 22.6 | 317 | 10.76 |
| Space | 25 | Level 1 | 30 | 0.8 | 668 | 22.6 | 318 | 10.76 |
| Space | 26 | Level 1 | 29 | 0.8 | 650 | 22.6 | 310 | 10.76 |
| Space | 27 | Level 2 | 31 | 0.8 | 710 | 22.6 | 338 | 10.76 |
| Space | 28 | Level 2 | 284 | 0.8 | 6422 | 22.6 | 3058 | 10.76 |
| Space | 29 | Level 2 | 32 | 0.8 | 720 | 22.6 | 343 | 10.76 |
| Space | 30 | Level 2 | 32 | 0.8 | 726 | 22.6 | 346 | 10.76 |
| Space | 31 | Level 2 | 32 | 0.8 | 724 | 22.6 | 345 | 10.76 |
| Space | 32 | Level 2 | 32 | 0.8 | 728 | 22.6 | 347 | 10.76 |
| Space | 33 | Level 2 | 35 | 0.8 | 787 | 22.6 | 375 | 10.76 |
| Space | 34 | Level 2 | 25 | 0.8 | 557 | 22.6 | 265 | 10.76 |
| Space | 35 | Level 2 | 30 | 0.8 | 685 | 22.6 | 326 | 10.76 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Space | 36 | Level 2 | 28 | 0.8 | 639 | 22.6 | 304 | 10.76 |
| Space | 37 | Level 2 | 21 | 0.8 | 480 | 22.6 | 228 | 10.76 |
| Space | 38 | Level 2 | 36 | 0.8 | 815 | 22.6 | 388 | 10.76 |
| Space | 39 | Level 2 | 84 | 0.8 | 1909 | 22.6 | 909 | 10.76 |
| Space | 40 | Level 2 | 30 | 0.8 | 678 | 22.6 | 323 | 10.76 |
| Space | 41 | Level 2 | 27 | 0.8 | 618 | 22.6 | 294 | 10.76 |
| Space | 42 | Level 2 | 27 | 0.8 | 614 | 22.6 | 292 | 10.76 |
| Space | 43 | Level 2 | 27 | 0.8 | 616 | 22.6 | 293 | 10.76 |
| Space | 44 | Level 2 | 27 | 0.8 | 616 | 22.6 | 293 | 10.76 |
| Space | 45 | Level 2 | 31 | 0.8 | 694 | 22.6 | 330 | 10.76 |
| Space | 46 | Level 2 | 28 | 0.8 | 633 | 22.6 | 301 | 10.76 |
| Space | 47 | Level 2 | 30 | 0.8 | 687 | 22.6 | 327 | 10.76 |
| Space | 48 | Level 2 | 30 | 0.8 | 687 | 22.6 | 327 | 10.76 |
| Space | 49 | Level 2 | 30 | 0.8 | 686 | 22.6 | 327 | 10.76 |
| Space | 50 | Level 2 | 31 | 0.8 | 693 | 22.6 | 330 | 10.76 |
| Space | 51 | Level 2 | 34 | 0.8 | 762 | 22.6 | 363 | 10.76 |
| Space | 52 | Level 2 | 34 | 0.8 | 768 | 22.6 | 366 | 10.76 |
| Space | 53 | Level 2 | 33 | 0.8 | 745 | 22.6 | 355 | 10.76 |
| Space | 54 | Level 3 | 284 | 0.8 | 6408 | 22.6 | 3051 | 10.76 |
| Space | 55 | Level 3 | 32 | 0.8 | 719 | 22.6 | 342 | 10.76 |
| Space | 56 | Level 3 | 32 | 0.8 | 720 | 22.6 | 343 | 10.76 |
| Space | 57 | Level 3 | 32 | 0.8 | 726 | 22.6 | 346 | 10.76 |
| Space | 58 | Level 3 | 32 | 0.8 | 724 | 22.6 | 345 | 10.76 |
| Space | 59 | Level 3 | 32 | 0.8 | 728 | 22.6 | 347 | 10.76 |
| Space | 60 | Level 3 | 35 | 0.8 | 787 | 22.6 | 375 | 10.76 |
| Space | 61 | Level 3 | 25 | 0.8 | 556 | 22.6 | 265 | 10.76 |
| Space | 62 | Level 3 | 30 | 0.8 | 685 | 22.6 | 326 | 10.76 |
| Space | 63 | Level 3 | 88 | 0.8 | 1994 | 22.6 | 949 | 10.76 |
| Space | 64 | Level 3 | 33 | 0.8 | 745 | 22.6 | 355 | 10.76 |
| Space | 65 | Level 3 | 34 | 0.8 | 768 | 22.6 | 366 | 10.76 |
| Space | 66 | Level 3 | 34 | 0.8 | 762 | 22.6 | 363 | 10.76 |
| Space | 67 | Level 3 | 31 | 0.8 | 705 | 22.6 | 336 | 10.76 |
| Space | 68 | Level 3 | 30 | 0.8 | 686 | 22.6 | 327 | 10.76 |
| Space | 69 | Level 3 | 30 | 0.8 | 687 | 22.6 | 327 | 10.76 |
| Space | 70 | Level 3 | 30 | 0.8 | 687 | 22.6 | 327 | 10.76 |
| Space | 71 | Level 3 | 28 | 0.8 | 633 | 22.6 | 301 | 10.76 |
| Space | 72 | Level 3 | 31 | 0.8 | 692 | 22.6 | 329 | 10.76 |
| Space | 73 | Level 3 | 27 | 0.8 | 619 | 22.6 | 295 | 10.76 |
| Space | 74 | Level 3 | 27 | 0.8 | 617 | 22.6 | 294 | 10.76 |
| Space | 75 | Level 3 | 27 | 0.8 | 614 | 22.6 | 292 | 10.76 |
| Space | 76 | Level 3 | 28 | 0.8 | 630 | 22.6 | 300 | 10.76 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Space | 77 | Level 3 | 29 | 0.8 | 666 | 22.6 | 317 | 10.76 |
| Space | 78 | Level 3 | 84 | 0.8 | 1909 | 22.6 | 909 | 10.76 |
| Space | 79 | Level 4 | 195 | 0.8 | 4413 | 22.6 | 2101 | 10.76 |
| Space | 80 | Level 4 | 101 | 0.8 | 2282 | 22.6 | 1087 | 10.76 |
| Space | 81 | Level 4 | 56 | 0.8 | 1268 | 22.6 | 604 | 10.76 |
| Space | 82 | Level 4 | 63 | 0.8 | 1433 | 22.6 | 682 | 10.76 |
| Space | 83 | Level 4 | 135 | 0.8 | 3048 | 22.6 | 1451 | 10.76 |
| Space | 84 | Level 4 | 62 | 0.8 | 1399 | 22.6 | 666 | 10.76 |
| Space | 85 | Level 4 | 60 | 0.8 | 1346 | 22.6 | 641 | 10.76 |
| Space | 86 | Level 4 | 59 | 0.8 | 1333 | 22.6 | 634 | 10.76 |
| Space | 87 | Level 4 | 84 | 0.8 | 1888 | 22.6 | 899 | 10.76 |
| Space | 88 | Level 4 | 115 | 0.8 | 2607 | 22.6 | 1241 | 10.76 |
| Space | 89 | Level 5 | 80 | 0.8 | 1803 | 22.6 | 859 | 10.76 |
| Space | 90 | Level 5 | 53 | 0.8 | 1206 | 22.6 | 574 | 10.76 |
| Space | 91 | Level 5 | 96 | 0.8 | 2180 | 22.6 | 1038 | 10.76 |
| Space | 92 | Level 5 | 184 | 0.8 | 4147 | 22.6 | 1975 | 10.76 |
| Space | 93 | Level 5 | 62 | 0.8 | 798 | 12.92 | 997 | 16.15 |
| Space | 94 | Level 5 | 104 | 0.8 | 2357 | 22.6 | 1122 | 10.76 |
| Space | 95 | Level 5 | 138 | 0.8 | 3110 | 22.6 | 1481 | 10.76 |
| Space | 96 | Level 5 | 116 | 0.8 | 2623 | 22.6 | 1249 | 10.76 |
| Space | 97 | Level 5 | 129 | 0.8 | 2910 | 22.6 | 1385 | 10.76 |
| Space | 98 | Level 6 | 80 | 0.8 | 1803 | 22.6 | 859 | 10.76 |
| Space | 99 | Level 6 | 54 | 0.8 | 1210 | 22.6 | 576 | 10.76 |
| Space | 100 | Level 6 | 97 | 0.8 | 2188 | 22.6 | 1042 | 10.76 |
| Space | 101 | Level 6 | 184 | 0.8 | 4155 | 22.6 | 1978 | 10.76 |
| Space | 102 | Level 6 | 104 | 0.8 | 2358 | 22.6 | 1122 | 10.76 |
| Space | 103 | Level 6 | 80 | 0.8 | 1818 | 22.6 | 866 | 10.76 |
| Space | 104 | Level 6 | 56 | 0.8 | 1276 | 22.6 | 608 | 10.76 |
| Space | 105 | Level 6 | 57 | 0.8 | 1295 | 22.6 | 616 | 10.76 |
| Space | 106 | Level 6 | 58 | 0.8 | 1309 | 22.6 | 623 | 10.76 |
| Space | 107 | Level 6 | 128 | 0.8 | 2903 | 22.6 | 1382 | 10.76 |
| Space | 112 | Level 4 | 64 | 0.8 | 830 | 12.92 | 1037 | 16.15 |
| Space | 116 | Level 7 | 588 | 0.8 | 8233 | 13.99 | 6332 | 10.76 |
| Space | 117 | Level 7 | 347 | 0.8 | 4854 | 13.99 | 3733 | 10.76 |
| Space | 118 | Level 7 | 12 | 0.8 | 167 | 13.99 | 128 | 10.76 |
| Space | 119 | Level 8 | 12 | 0.8 | 167 | 13.99 | 128 | 10.76 |
| Space | 120 | Level 8 | 55 | 0.8 | 704 | 12.92 | 880 | 16.15 |
| Space | 121 | Level 8 | 66 | 0.8 | 857 | 12.92 | 1072 | 16.15 |
| Space | 122 | Level 8 | 38 | 0.8 | 455 | 11.84 | 621 | 16.15 |
| Space | 123 | Level 8 | 53 | 0.8 | 631 | 11.84 | 860 | 16.15 |
| Space | 124 | Level 8 | 978 | 0.8 | 9480 | 9.69 | 5684 | 5.81 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Space | 125 | Level 4 | 24 | 0.8 | 228 | 9.69 | 137 | 5.81 |
| Space | 126 | Level 1 | 1120 | 0.8 | 6027 | 5.38 | 3619 | 3.23 |
| Space | 127 | Level 2 | 785 | 0.8 | 4222 | 5.38 | 2535 | 3.23 |
| Space | 128 | Level 3 | 782 | 0.8 | 4206 | 5.38 | 2525 | 3.23 |
| Space | 129 | Level 4 | 905 | 0.8 | 4867 | 5.38 | 2922 | 3.23 |
| Space | 130 | Level 5 | 898 | 0.8 | 4831 | 5.38 | 2901 | 3.23 |
| Space | 131 | Level 6 | 898 | 0.8 | 4830 | 5.38 | 2900 | 3.23 |
| Space | 132 | Level 7 | 657 | 0.8 | 3533 | 5.38 | 2121 | 3.23 |
| Space | 133 | Level 8 | 506 | 0.8 | 2721 | 5.38 | 1634 | 3.23 |
| Space | 134 | Level 9 | 600 | 0.8 | 3228 | 5.38 | 1938 | 3.23 |
| Space | 135 | Level 9 | 14 | 0.8 | 169 | 11.84 | 231 | 16.15 |
| Space | 136 | Level 9 | 25 | 0.8 | 298 | 11.84 | 406 | 16.15 |
| Space | 137 | Level 9 | 10 | 0.8 | 115 | 11.84 | 157 | 16.15 |
| Space | 138 | Level 9 | 18 | 0.8 | 209 | 11.84 | 285 | 16.15 |
| Space | 139 | Level 9 | 6 | 0.8 | 70 | 11.84 | 95 | 16.15 |
| Space | 140 | Level 9 | 11 | 0.8 | 135 | 11.84 | 184 | 16.15 |
| Space | 141 | Level 9 | 15 | 0.8 | 177 | 11.84 | 242 | 16.15 |
| Space | 142 | Level 9 | 15 | 0.8 | 177 | 11.84 | 242 | 16.15 |
| Space | 143 | Level 9 | 26 | 0.8 | 311 | 11.84 | 424 | 16.15 |
| Space | 144 | Level 9 | 11 | 0.8 | 131 | 11.84 | 179 | 16.15 |
| Space | 145 | Level 9 | 14 | 0.8 | 163 | 11.84 | 222 | 16.15 |
| Space | 146 | Level 9 | 12 | 0.8 | 145 | 11.84 | 198 | 16.15 |
| Space | 147 | Level 9 | 48 | 0.8 | 566 | 11.84 | 772 | 16.15 |
| Space | 148 | Level 9 | 27 | 0.8 | 323 | 11.84 | 441 | 16.15 |
| Space | 149 | Level 9 | 15 | 0.8 | 175 | 11.84 | 239 | 16.15 |
| Space | 150 | Level 9 | 41 | 0.8 | 487 | 11.84 | 665 | 16.15 |
| Space | 151 | Level 9 | 13 | 0.8 | 156 | 11.84 | 213 | 16.15 |
| Space | 152 | Level 9 | 5 | 0.8 | 65 | 11.84 | 89 | 16.15 |
| Space | 153 | Level 9 | 18 | 0.8 | 211 | 11.84 | 287 | 16.15 |
| Space | 154 | Level 9 | 27 | 0.8 | 324 | 11.84 | 442 | 16.15 |
| Space | 155 | Level 9 | 10 | 0.8 | 116 | 11.84 | 158 | 16.15 |
| Space | 156 | Level 9 | 43 | 0.8 | 505 | 11.84 | 689 | 16.15 |
| Space | 157 | Level 9 | 28 | 0.8 | 329 | 11.84 | 449 | 16.15 |
| Space | 158 | Level 9 | 22 | 0.8 | 263 | 11.84 | 359 | 16.15 |
| Space | 159 | Level 9 | 14 | 0.8 | 161 | 11.84 | 220 | 16.15 |
| Space | 160 | Level 9 | 12 | 0.8 | 140 | 11.84 | 190 | 16.15 |
| Space | 161 | Level 9 | 5 | 0.8 | 55 | 11.84 | 75 | 16.15 |
| Space | 162 | Level 9 | 2 | 0.8 | 27 | 11.84 | 37 | 16.15 |
| Space | 163 | Level 10 | 2 | 0.8 | 27 | 11.84 | 37 | 16.15 |
| Space | 164 | Level | 4 | 0.8 | 43 | 11.84 | 59 | 16.15 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 10 | | | | | | |
| Space | 165 | Level 10 | 14 | 0.8 | 169 | 11.84 | 231 | 16.15 |
| Space | 166 | Level 10 | 11 | 0.8 | 130 | 11.84 | 177 | 16.15 |
| Space | 167 | Level 10 | 14 | 0.8 | 160 | 11.84 | 218 | 16.15 |
| Space | 168 | Level 10 | 10 | 0.8 | 115 | 11.84 | 157 | 16.15 |
| Space | 169 | Level 10 | 24 | 0.8 | 282 | 11.84 | 384 | 16.15 |
| Space | 170 | Level 10 | 11 | 0.8 | 135 | 11.84 | 184 | 16.15 |
| Space | 171 | Level 10 | 15 | 0.8 | 177 | 11.84 | 242 | 16.15 |
| Space | 172 | Level 10 | 15 | 0.8 | 177 | 11.84 | 242 | 16.15 |
| Space | 173 | Level 10 | 26 | 0.8 | 311 | 11.84 | 424 | 16.15 |
| Space | 174 | Level 10 | 17 | 0.8 | 205 | 11.84 | 280 | 16.15 |
| Space | 175 | Level 10 | 17 | 0.8 | 198 | 11.84 | 270 | 16.15 |
| Space | 176 | Level 10 | 14 | 0.8 | 170 | 11.84 | 232 | 16.15 |
| Space | 177 | Level 10 | 29 | 0.8 | 370 | 12.92 | 463 | 16.15 |
| Space | 178 | Level 10 | 102 | 0.8 | 991 | 9.69 | 594 | 5.81 |
| Space | 179 | Level 6 | 62 | 0.8 | 798 | 12.92 | 997 | 16.15 |
| Space | 182 | Level 2 | 32 | 0.8 | 195 | 6.03 | 69 | 2.15 |
| Space | 183 | Level 2 | 31 | 0.8 | 188 | 6.03 | 67 | 2.15 |
| Space | 184 | Level 3 | 32 | 0.8 | 195 | 6.03 | 69 | 2.15 |
| Space | 185 | Level 3 | 31 | 0.8 | 188 | 6.03 | 67 | 2.15 |
| Space | 186 | Level 4 | 32 | 0.8 | 195 | 6.03 | 69 | 2.15 |
| Space | 187 | Level 4 | 1 | 0.8 | 8 | 6.03 | 3 | 2.15 |
| Space | 188 | Level 5 | 31 | 0.8 | 188 | 6.03 | 67 | 2.15 |
| Space | 189 | Level 5 | 32 | 0.8 | 195 | 6.03 | 69 | 2.15 |
| Space | 190 | Level 6 | 31 | 0.8 | 188 | 6.03 | 67 | 2.15 |
| Space | 191 | Level 6 | 32 | 0.8 | 195 | 6.03 | 69 | 2.15 |
| Space | 192 | Level 7 | 31 | 0.8 | 188 | 6.03 | 67 | 2.15 |
| Space | 193 | Level 7 | 32 | 0.8 | 195 | 6.03 | 69 | 2.15 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Space | 194 | Level 8 | 31 | 0.8 | 188 | 6.03 | 67 | 2.15 |
| Space | 195 | Level 8 | 32 | 0.8 | 195 | 6.03 | 69 | 2.15 |
| Space | 196 | Level 9 | 31 | 0.8 | 188 | 6.03 | 67 | 2.15 |
| Space | 197 | Level 9 | 32 | 0.8 | 195 | 6.03 | 69 | 2.15 |
| Space | 198 | Level 10 | 31 | 0.8 | 188 | 6.03 | 67 | 2.15 |
| Space | 200 | Level 2 | 5 | 0.8 | 45 | 9.69 | 15 | 3.23 |
| Space | 201 | Level 2 | 6 | 0.8 | 56 | 9.69 | 19 | 3.23 |
| Space | 202 | Level 2 | 14 | 0.8 | 139 | 9.69 | 46 | 3.23 |
| Space | 203 | Level 2 | 12 | 0.8 | 121 | 9.69 | 40 | 3.23 |
| Space | 204 | Level 2 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 205 | Level 2 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 206 | Level 2 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 207 | Level 2 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 208 | Level 2 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 209 | Level 2 | 2 | 0.8 | 18 | 9.69 | 6 | 3.23 |
| Space | 210 | Level 2 | 2 | 0.8 | 17 | 9.69 | 6 | 3.23 |
| Space | 211 | Level 2 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 212 | Level 2 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 213 | Level 2 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 214 | Level 2 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 215 | Level 3 | 4 | 0.8 | 44 | 9.69 | 15 | 3.23 |
| Space | 216 | Level 3 | 6 | 0.8 | 57 | 9.69 | 19 | 3.23 |
| Space | 217 | Level 3 | 14 | 0.8 | 139 | 9.69 | 46 | 3.23 |
| Space | 218 | Level 3 | 13 | 0.8 | 123 | 9.69 | 41 | 3.23 |
| Space | 219 | Level 3 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 220 | Level 3 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 221 | Level 3 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 222 | Level 3 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 223 | Level 3 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 224 | Level 3 | 2 | 0.8 | 17 | 9.69 | 6 | 3.23 |
| Space | 225 | Level 3 | 2 | 0.8 | 17 | 9.69 | 6 | 3.23 |
| Space | 226 | Level 3 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 227 | Level 3 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 228 | Level 3 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 229 | Level 3 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 230 | Level 4 | 4 | 0.8 | 42 | 9.69 | 14 | 3.23 |
| Space | 231 | Level 4 | 6 | 0.8 | 54 | 9.69 | 18 | 3.23 |
| Space | 232 | Level 4 | 15 | 0.8 | 143 | 9.69 | 48 | 3.23 |
| Space | 233 | Level 4 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 234 | Level 4 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Space | 235 | Level 4 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 236 | Level 4 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 237 | Level 4 | 2 | 0.8 | 17 | 9.69 | 6 | 3.23 |
| Space | 238 | Level 4 | 2 | 0.8 | 18 | 9.69 | 6 | 3.23 |
| Space | 239 | Level 4 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 240 | Level 4 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 241 | Level 4 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 242 | Level 4 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 243 | Level 4 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 244 | Level 4 | 12 | 0.8 | 121 | 9.69 | 40 | 3.23 |
| Space | 245 | Level 5 | 5 | 0.8 | 46 | 9.69 | 15 | 3.23 |
| Space | 246 | Level 5 | 5 | 0.8 | 46 | 9.69 | 15 | 3.23 |
| Space | 247 | Level 5 | 12 | 0.8 | 112 | 9.69 | 37 | 3.23 |
| Space | 248 | Level 5 | 1 | 0.8 | 13 | 9.69 | 4 | 3.23 |
| Space | 249 | Level 5 | 1 | 0.8 | 13 | 9.69 | 4 | 3.23 |
| Space | 250 | Level 5 | 1 | 0.8 | 13 | 9.69 | 4 | 3.23 |
| Space | 251 | Level 5 | 1 | 0.8 | 13 | 9.69 | 4 | 3.23 |
| Space | 252 | Level 5 | 2 | 0.8 | 17 | 9.69 | 6 | 3.23 |
| Space | 253 | Level 5 | 11 | 0.8 | 102 | 9.69 | 34 | 3.23 |
| Space | 254 | Level 5 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 255 | Level 5 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 256 | Level 5 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 257 | Level 5 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 258 | Level 5 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 259 | Level 5 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 260 | Level 6 | 5 | 0.8 | 47 | 9.69 | 16 | 3.23 |
| Space | 261 | Level 6 | 5 | 0.8 | 46 | 9.69 | 15 | 3.23 |
| Space | 262 | Level 6 | 12 | 0.8 | 117 | 9.69 | 39 | 3.23 |
| Space | 263 | Level 6 | 11 | 0.8 | 104 | 9.69 | 35 | 3.23 |
| Space | 264 | Level 6 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 265 | Level 6 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 266 | Level 6 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 267 | Level 6 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 268 | Level 6 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 269 | Level 6 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 270 | Level 6 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 271 | Level 6 | 1 | 0.8 | 12 | 9.69 | 4 | 3.23 |
| Space | 272 | Level 6 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 273 | Level 6 | 2 | 0.8 | 16 | 9.69 | 5 | 3.23 |
| Space | 274 | Level 6 | 1 | 0.8 | 11 | 9.69 | 4 | 3.23 |
| Space | 275 | Level 8 | 12 | 0.8 | 115 | 9.69 | 38 | 3.23 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Space | 276 | Level 8 | 17 | 0.8 | 163 | 9.69 | 54 | 3.23 |
| Space | 277 | Level 8 | 1 | 0.8 | 10 | 9.69 | 3 | 3.23 |
| Space | 278 | Level 8 | 1 | 0.8 | 10 | 9.69 | 3 | 3.23 |
| Space | 279 | Level 8 | 1 | 0.8 | 10 | 9.69 | 3 | 3.23 |
| Space | 280 | Level 8 | 3 | 0.8 | 25 | 9.69 | 8 | 3.23 |
| Space | 281 | Level 8 | 2 | 0.8 | 22 | 9.69 | 7 | 3.23 |
| Space | 282 | Level 8 | 1 | 0.8 | 10 | 9.69 | 3 | 3.23 |
| Space | 283 | Level 8 | 1 | 0.8 | 10 | 9.69 | 3 | 3.23 |
| Space | 284 | Level 8 | 1 | 0.8 | 10 | 9.69 | 3 | 3.23 |
| Space | 285 | Level 8 | 9 | 0.8 | 89 | 9.69 | 30 | 3.23 |
| Space | 286 | Level 8 | 12 | 0.8 | 114 | 9.69 | 38 | 3.23 |
| Space | 287 | Level 8 | 2 | 0.8 | 19 | 9.69 | 6 | 3.23 |
| Space | 288 | Level 8 | 2 | 0.8 | 20 | 9.69 | 7 | 3.23 |
| Space | 289 | Level 8 | 2 | 0.8 | 20 | 9.69 | 7 | 3.23 |
| Space | 290 | Level 8 | 2 | 0.8 | 20 | 9.69 | 7 | 3.23 |
| Space | 291 | Level 8 | 2 | 0.8 | 22 | 9.69 | 7 | 3.23 |
| Space | 292 | Level 8 | 2 | 0.8 | 20 | 9.69 | 7 | 3.23 |
| Space | 293 | Level 8 | 2 | 0.8 | 20 | 9.69 | 7 | 3.23 |
| Space | 294 | Level 8 | 2 | 0.8 | 19 | 9.69 | 6 | 3.23 |
| Space | 295 | Level B1 | 227 | 0.8 | 1953 | 8.61 | 733 | 3.23 |
| Space | 296 | Level B1 | 159 | 0.8 | 1373 | 8.61 | 515 | 3.23 |
| Space | 297 | Level B1 | 239 | 0.8 | 2062 | 8.61 | 773 | 3.23 |
| Space | 298 | Level B1 | 181 | 0.8 | 1559 | 8.61 | 585 | 3.23 |
| Space | 299 | Level B1 | 192 | 0.8 | 1651 | 8.61 | 619 | 3.23 |
| Space | 300 | Level B1 | 270 | 0.8 | 2322 | 8.61 | 871 | 3.23 |
| Space | 301 | Level B1 | 92 | 0.8 | 789 | 8.61 | 296 | 3.23 |
| Space | 302 | Level B1 | 259 | 0.8 | 2228 | 8.61 | 836 | 3.23 |
| Space | 304 | Level 1 | 31 | 0.8 | 264 | 8.61 | 99 | 3.23 |
| Sum | | | | | 227102 | | 127622 | |

## 8.5: Artificial lighting

Artificial lighting is computed without any sunlight resource. Artificial lighting is the light which is made by human, such as fluorescent, tungsten, mercury vapor, sodium vapor, halogen, compact fluorescent, et.

When designing lighting system there are several factors need to be take in consideration for suitable and comfortable lighting, which are:

* Function of space.

* Dimension and detail of space.

* Style and decor.

* Lighting budget.

>> Dilaux was used in artificial designing.

**Designing criteria:**

1- Define the function of the space
2- Use a suitable lux level that satisfies the function.
3- Use a suitable light unit that the function needs.
4- Distribute the lighting units.
5- Define the working place height.
6- Run the calculation
7- Check the lighting luminance
8- Check the light uniformity which is recommended to be larger than 60%.
9- Check the average lux that is distributed.

### 8.4.1: Shop artificial lighting

Shop general

Figure 8. 4 Renderd View From Dialux

Figure 8. 5 Renderd View From Dialux

**Room 1 / Room summary**

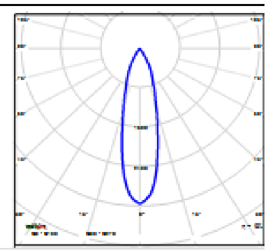
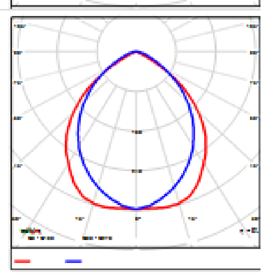
Figure 8. 6 Dialux Room Summary

Height of room: 3.200 m, Height of working plane: 0.000 m, Wall zone: 0.000 m

Reflection factors: Ceiling 52.0%, Walls 29.2%, Floor 75.6%, Light loss factor: 0.80

Workplane

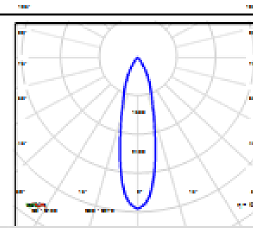
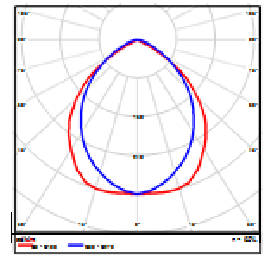
| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 1 | Perpendicular illuminance [lx] | 327 (100) | 0.55 | 761 | 0.002 | 0.001 |

| No. | Quantity | | | |
|---|---|---|---|---|
| 1 | 4 | OSRAM AG LUNIS SL-T LED 2700-830-24deg<br>Light output ratio: 100% Lamp luminous flux: 2730 lm Luminaire Luminous Flux: 2730 lm Power: 33.4 W<br>Light yield: 81.7 lm/W | See our luminaire catalog for an image of the luminaire. |  |
| 2 | 8 | Siteco Beleuchtungstechnik GmbH 5LQ11673A<br>Siteco® louvre luminaire<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 42120 lm, Total luminaire luminous flux: 31160 lm, Total Load: 573.6 W, Light yield: 54.3 lm/W

Specific connection value: 17.69 W/m² = 5.41 W/m²/100 lx (Groundarea 32.42 m²)

## Room 1 / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) | | |
|---|---|---|---|
| 4 | OSRAM AG LUNIS SL-T LED 2700-830-24deg<br>Luminous emittance 1<br>Fitting: 1xLED - PrevaLED Core C Z2 830<br>Light output ratio: 100% Lamp luminous flux: 2730 lm Luminaire Luminous Flux: 2730 lm Power: 33.4 W<br>Light yield: 81.7 lm/W | See our luminaire catalog for an image of the luminaire. |  |
| 8 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 42120 lm, Total luminaire luminous flux: 31160 lm, Total Load: 573.6 W, Light yield: 54.3 lm/W

Figure 8. 7 Luminaire Part List

Storey 1 (1), Illuminance values in [lx]

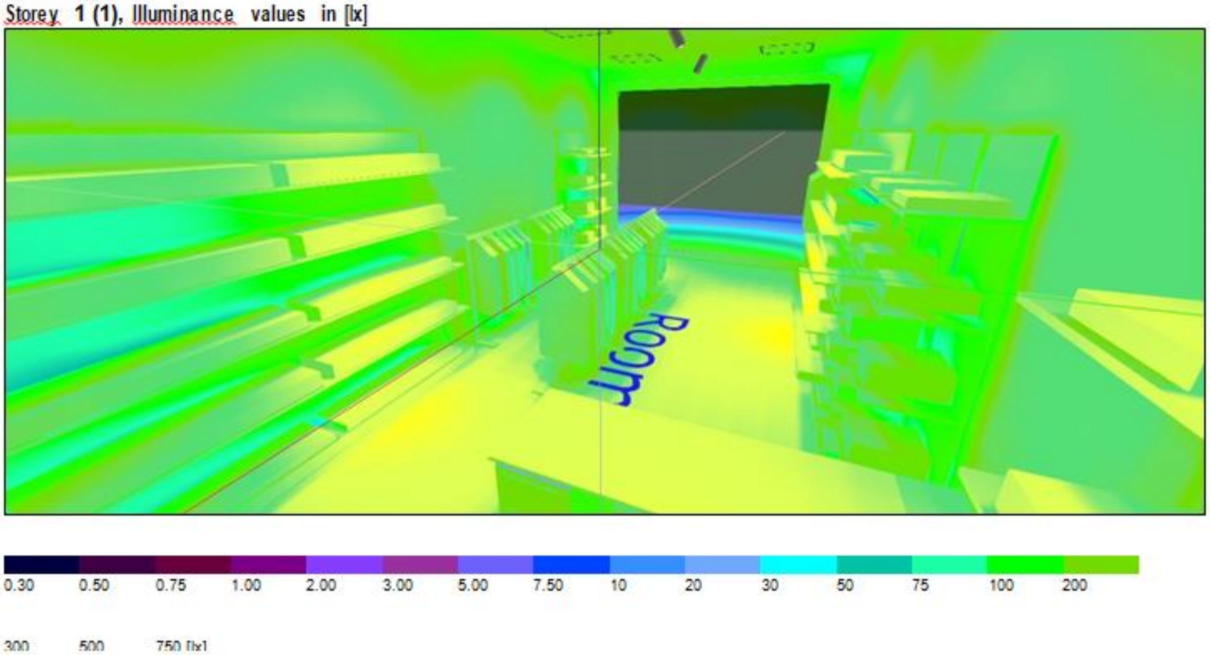



Figure 8. 8 Illuminance Values

## South shop daylight:

Figure 8. 9 Renderd View From Dialux

Figure 8. 10  Renderd View From Dialux

## Room 1 / Room summary

Figure 8. 11 Room Summary

Height of room: 3.200 m, Height of working plane: 0.000 m, Wall zone: 0.000 m

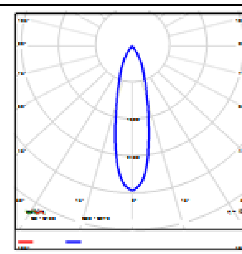
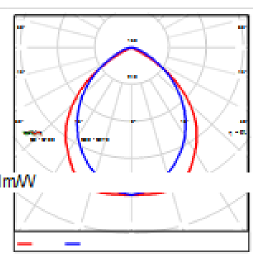
Reflection factors: Ceiling 52.0%, Walls 29.2%, Floor 75.6%, Light loss factor: 0.80

Workplane

| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 1 | Perpendicular illuminance [lx] | 1232 (100) | 1.00 | 7185 | 0.001 | 0.000 |

Daylight

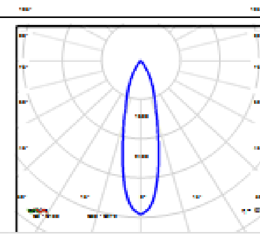
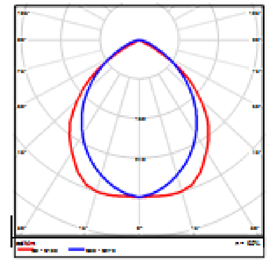
| | | | | | | |
|---|---|---|---|---|---|---|
| Daylight quotient effective area 1 | Daylight factor<br>Rotation: X:0.0°, Y:0.0°, Z:0.0° | 3.51 | 0.00 | 14 | / | / |

| No. | Quantity | | | |
|---|---|---|---|---|
| 1 | 4 | OSRAM AG LUNIS SL-T LED 2700-830-24deg<br>Light output ratio: 100% Lamp luminous flux: 2730 lm Luminaire Luminous Flux: 2730 lm Power: 33.4 W<br>Light yield: 81.7 lm/W | See our luminaire catalog for an image of the luminaire. |  |
| 2 | 8 | Siteco Beleuchtungstechnik GmbH 5LQ11673A<br>Siteco® louvre luminaire<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 42120 lm, Total luminaire luminous flux: 31160 lm, Total Load: 573.6 W, Light yield: 54.3 lm/W

Specific connection value: 17.69 W/m² = 1.44 W/m²/100 lx (Groundarea 32.42 m²)

## Room 1 / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) | | |
|---|---|---|---|
| 4 | OSRAM AG LUNIS SL-T LED 2700-830-24deg<br>Luminous emittance 1<br>Fitting: 1xLED - PrevaLED Core C Z2 830<br>Light output ratio: 100% Lamp luminous flux: 2730 lm Luminaire Luminous Flux: 2730 lm Power: 33.4 W<br>Light yield: 81.7 lm/W | See our luminaire catalog for an image of the luminaire. |  |
| 8 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 42120 lm, Total luminaire luminous flux: 31160 lm, Total Load: 573.6 W, Light yield: 54.3 lm/W

Figure 8. 12 Luminaire Part List

**Room 1 / Views**

Storey 1 (1), Illuminance values in [lx]

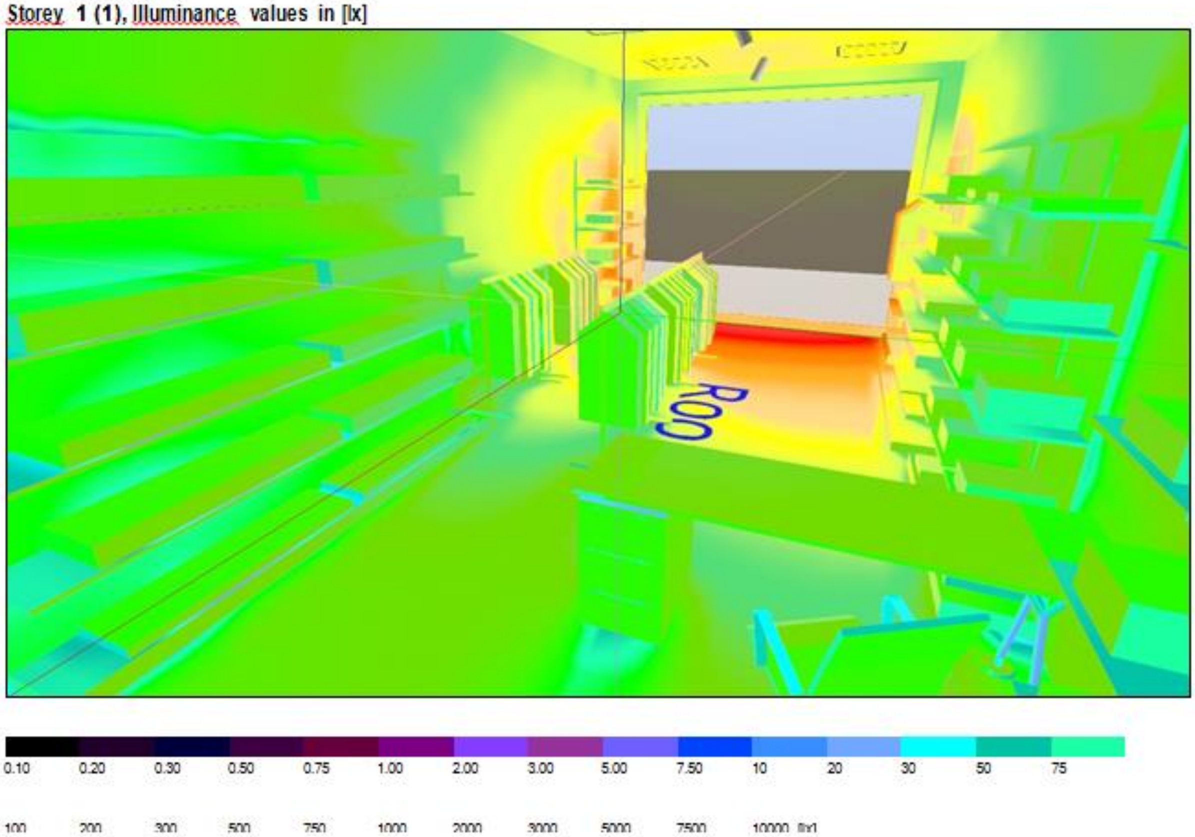



Figure 8. 13 Illuminance Values

## North shop daylight:

Figure 8. 14 Renderd View From Dialux

Figure 8. 15  Renderd View From Dialux

## Room 1 / Room summary

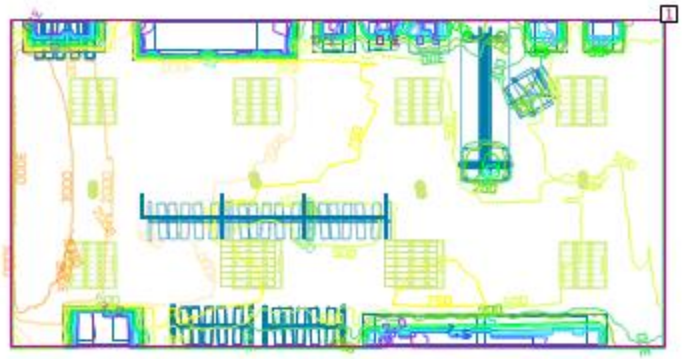


Figure 8. 16 Room Summary

Height of room: 3.200 m, Height of working plane: 0.000 m, Wall zone: 0.000 m

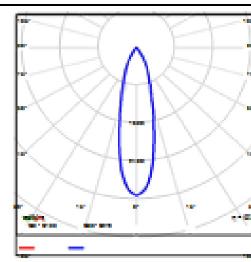
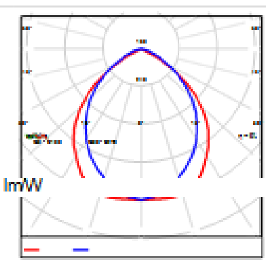
Reflection factors: Ceiling 52.0%, Walls 29.3%, Floor 75.6%, Light loss factor: 0.80

Workplane

| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 1 | Perpendicular illuminance [lx] | 948 (100) | 1.23 | 4622 | 0.001 | 0.000 |

Daylight

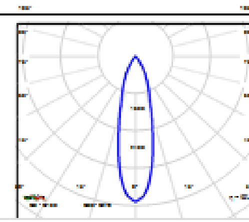
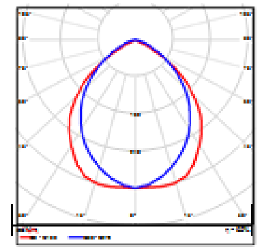
| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| Daylight quotient effective area 1 | Daylight factor Rotation: X:0.0°, Y:0.0°, Z:0.0° | 1.92 | 0.00 | 6.05 | / | / |

| No. | Quantity | | | |
|---|---|---|---|---|
| 1 | 4 | OSRAM AG LUNIS SL-T LED 2700-830-24deg Light output ratio: 100% Lamp luminous flux: 2730 lm Luminaire Luminous Flux: 2730 lm Power: 33.4 W Light yield: 81.7 lm/W | See our luminaire catalog for an image of the luminaire. |  |
| 2 | 8 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 42120 lm, Total luminaire luminous flux: 31160 lm, Total Load: 573.6 W, Light yield: 54.3 lm/W

Specific connection value: 17.69 W/m² = 1.87 W/m²/100 lx (Ground area 32.42 m²)

## Room 1 / Luminaire parts list

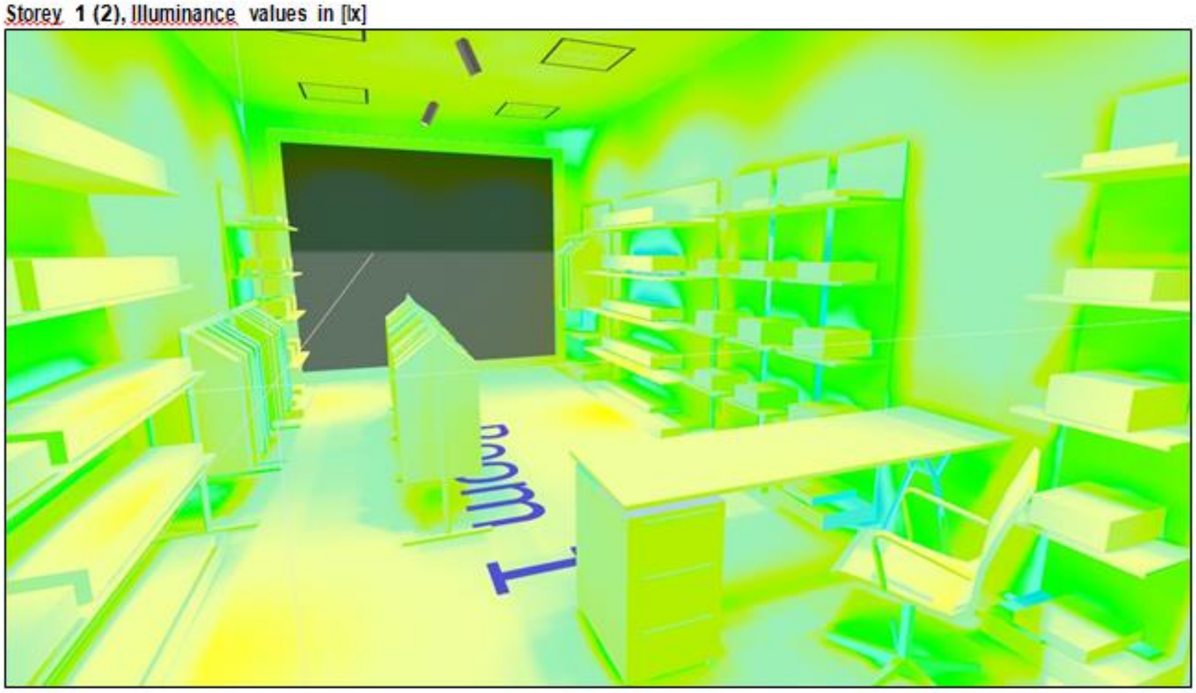
| Quantity | Luminaire (Luminous emittance) | | |
|---|---|---|---|
| 4 | OSRAM AG LUNIS SL-T LED 2700-830-24deg<br>Luminous emittance 1<br>Fitting: 1xLED - PrevaLED Core C Z2 830<br>Light output ratio: 100% Lamp luminous flux: 2730 lm Luminaire Luminous Flux: 2730 lm Power: 33.4 W<br>Light yield: 81.7 lm/W | See our luminaire catalog for an image of the luminaire. |  |
| 8 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 42120 lm, Total luminaire luminous flux: 31160 lm, Total Load: 573.6 W, Light yield: 54.3 lm/W

Figure 8. 17 Luminaire Part List

## Room 1 / Views

Storey 1 (2), Illuminance values in [lx]



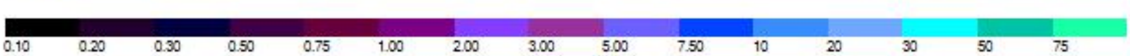



Figure 8. 18 Illuminance Values

Office light:

Figure 8. 19 Renderd View From Dialux

Figure 8. 20 Renderd View From Dialux

## Office 1 / Room summary

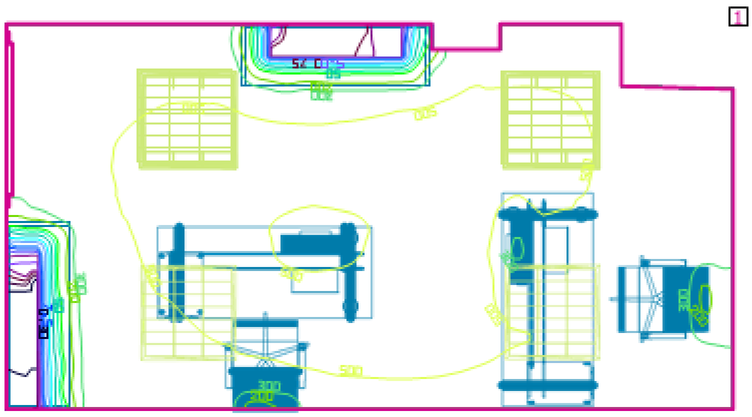
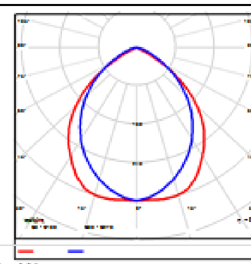


Figure 8. 21 Room Summary

Height of room: 3.200 m, Height of working plane: 0.800 m, Wall zone: 0.000 m
Reflection factors: Ceiling 77.0%, Walls 77.0%, Floor 75.6%, Light loss factor: 0.80

### Workplane

| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 1 | Perpendicular illuminance [lx] | 431 (500) | 0.25 | 574 | 0.001 | 0.000 |

| No. | Quantity | | | |
|---|---|---|---|---|
| 1 | 4 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 15600 lm, Total luminaire luminous flux: 10120 lm, Total Load: 220.0 W, Light yield: 46.0 lm/W

Specific connection value: 19.36 W/m² = 4.49 W/m²/100 lx (Groundarea 11.36 m²)

## Office 1 / Description

Storey 1 (1), Illuminance values in [lx]

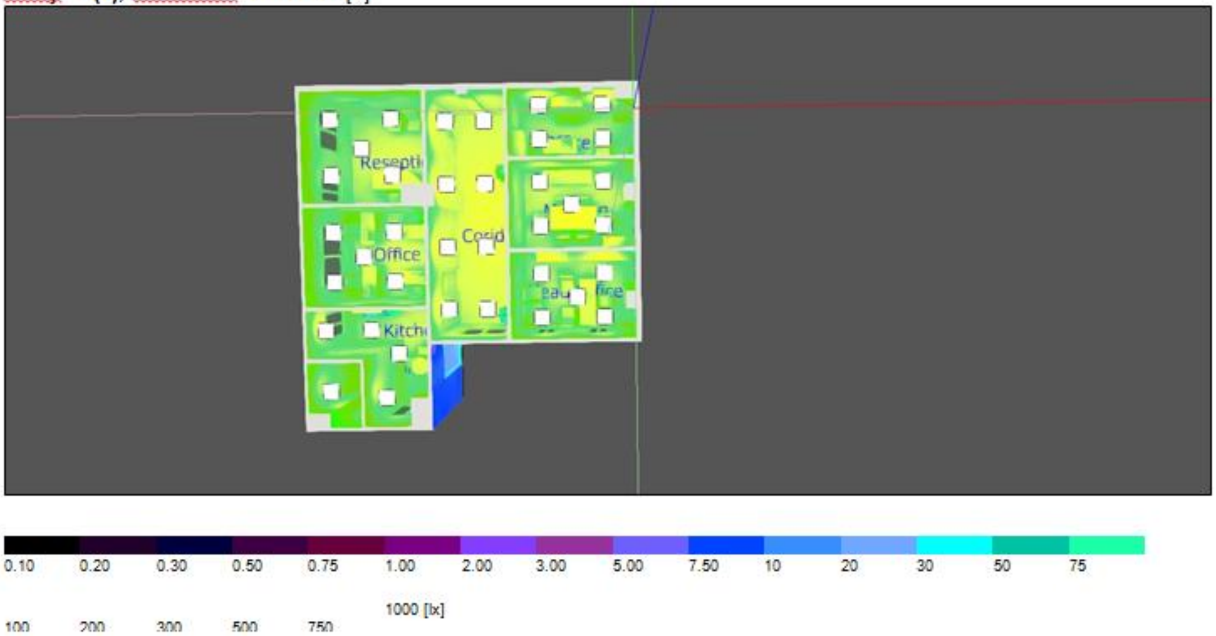
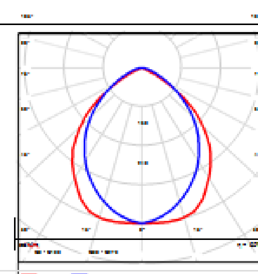



Figure 8. 22 Illuminance Values

## Office 1 / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) |
|---|---|
| 4 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |



Total lamp luminous flux: 15600 lm, Total luminaire luminous flux: 10120 lm, Total Load: 220.0 W, Light yield: 46.0 lm/W

Figure 8. 23 Luminaire Part List

## Meeting / Room summary

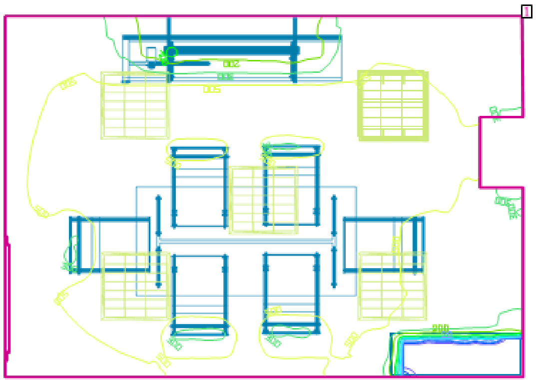
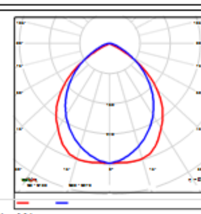


Figure 8. 24 Room Summary

Height of room: 3.200 m, Height of working plane: 0.800 m, Wall zone: 0.000 m
Reflection factors: Ceiling 70.0%, Walls 77.0%, Floor 75.4%, Light loss factor: 0.80

Workplane

| | Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|---|
| 1 | Workplane 2 | Perpendicular illuminance [lx] | 489 (500) | 3.09 | 728 | 0.006 | 0.004 |

| No. | Quantity | | | |
|---|---|---|---|---|
| 1 | 5 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 19500 lm, Total luminaire luminous flux: 12650 lm, Total Load: 275.0 W, Light yield: 46.0 lm/W

Specific connection value: 18.14 W/m² = 3.71 W/m²/100 lx (Ground area 15.16 m²)

## Meating / Description

Storey 1 (1), Illuminance values in [lx]

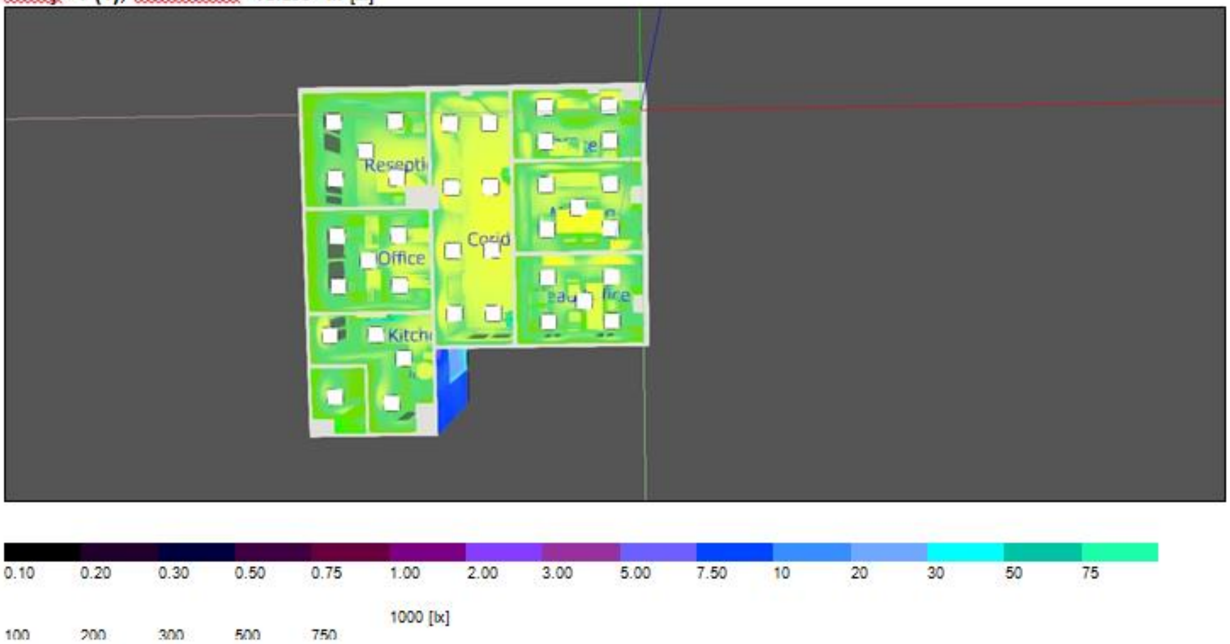
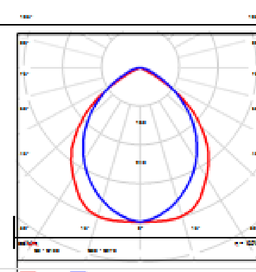



Figure 8. 25 Illuminance Values

## Meating / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) |
|---|---|
| 5 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |



Total lamp luminous flux: 19500 lm, Total luminaire luminous flux: 12650 lm, Total Load: 275.0 W, Light yield: 46.0 lm/W

Figure 8. 26 Luminaire Part List

## Meating / Views

Figure 8. 27 Renderd View From Dialux

## Head Office / Room summary

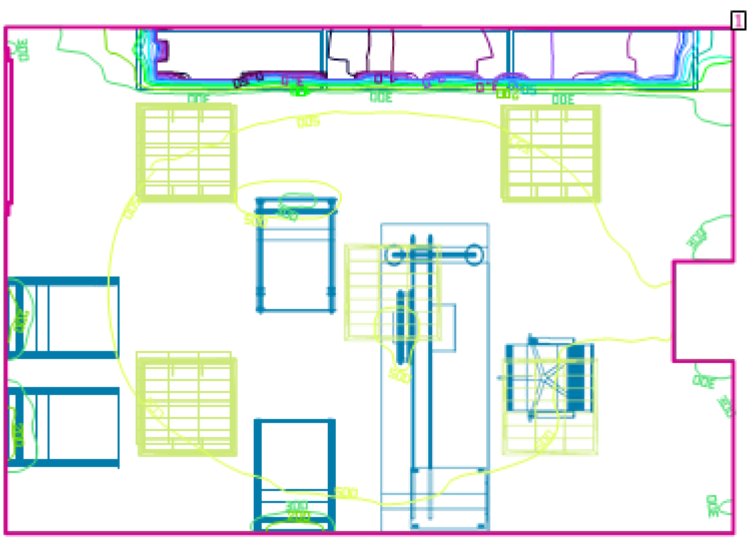
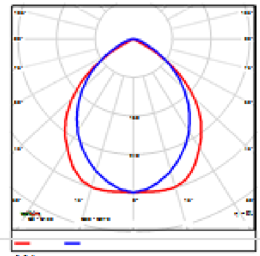


Figure 8. 28 Room Summary

Height of room: 3.200 m, Height of working plane: 0.800 m, Wall zone: 0.000 m
Reflection factors: Ceiling 70.0%, Walls 76.8%, Floor 75.4%, Light loss factor: 0.80

### Workplane

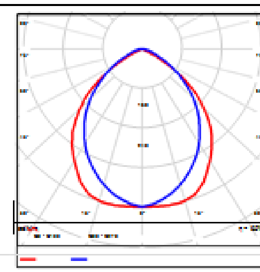
| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 3 | Perpendicular illuminance [lx] | 435 (500) | 0.22 | 645 | 0.001 | 0.000 |

| No. | Quantity | | | |
|---|---|---|---|---|
| 1 | 5 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 19500 lm, Total luminaire luminous flux: 12650 lm, Total Load: 275.0 W, Light yield: 46.0 lm/W

Specific connection value: 18.15 W/m² = 4.17 W/m²/100 lx (Ground area 15.15 m²)

## Head Office / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) | | |
|---|---|---|---|
| 5 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire Luminous emittance 1 Fitting: 3xT26 18W/840 Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 19500 lm, Total luminaire luminous flux: 12650 lm, Total Load: 275.0 W, Light yield: 46.0 lm/W

Figure 8. 29 Luminaire Part List

## Head Office / Views

Figure 8. 30  Renderd View From Dialux

## BathRoom / Room summary

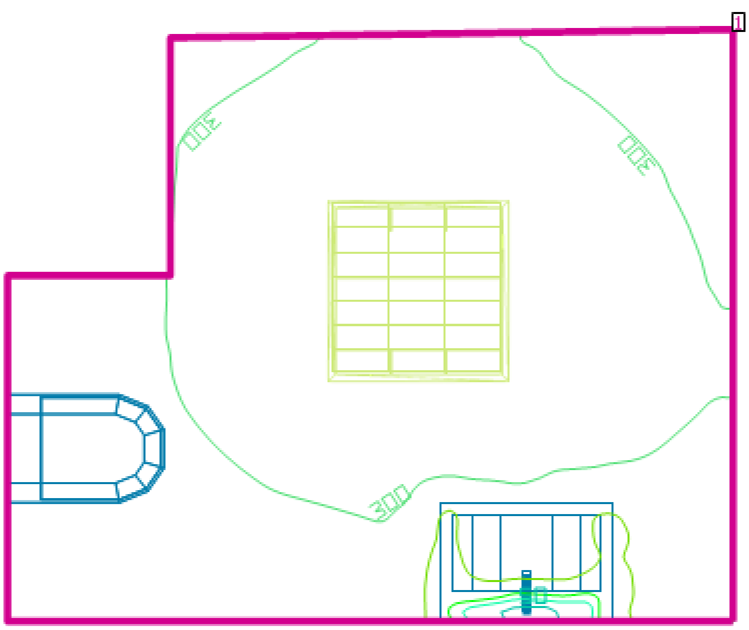
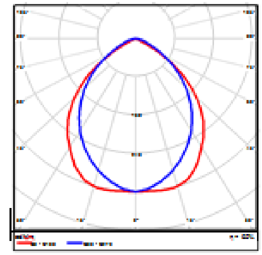



Figure 8. 31  Room Summary

Height of room: 3.200 m, Height of working plane: 0.800 m, Wall zone: 0.000 m
Reflection factors: Ceiling 70.0%, Walls 77.0%, Floor 75.6%, Light loss factor: 0.80

Workplane

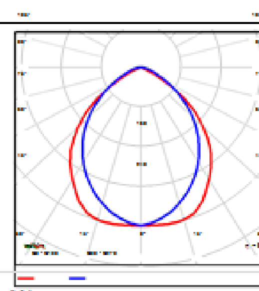
| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 4 | Perpendicular illuminance [lx] | 295 (500) | 41 | 349 | 0.139 | 0.117 |

| No. | Quantity | | | |
|---|---|---|---|---|
| 1 | 1 | Siteco Beleuchtungstechnik GmbH 5LQ11673A<br>Siteco® louvre luminaire<br>Light output ratio: 64.87% Lamp<br>luminous flux: 3900 lm Luminaire<br>Luminous Flux: 2530 lm Power:<br>55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 3900 lm, Total luminaire luminous flux: 2530 lm, Total Load: 55.0 W, Light yield: 46.0 lm/W

Specific connection value: 12.24 W/m² = 4.15 W/m²/100 lx (Groundarea 4.49 m²)

## BathRoom / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) | | |
|---|---|---|---|
| 1 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco®<br>louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp<br>luminous flux: 3900 lm Luminaire<br>Luminous Flux: 2530 lm Power:<br>55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 3900 lm, Total luminaire luminous flux: 2530 lm, Total Load: 55.0 W, Light yield: 46.0 lm/W

Figure 8. 32 Luminaire Part List

## Kitchen / Room summary

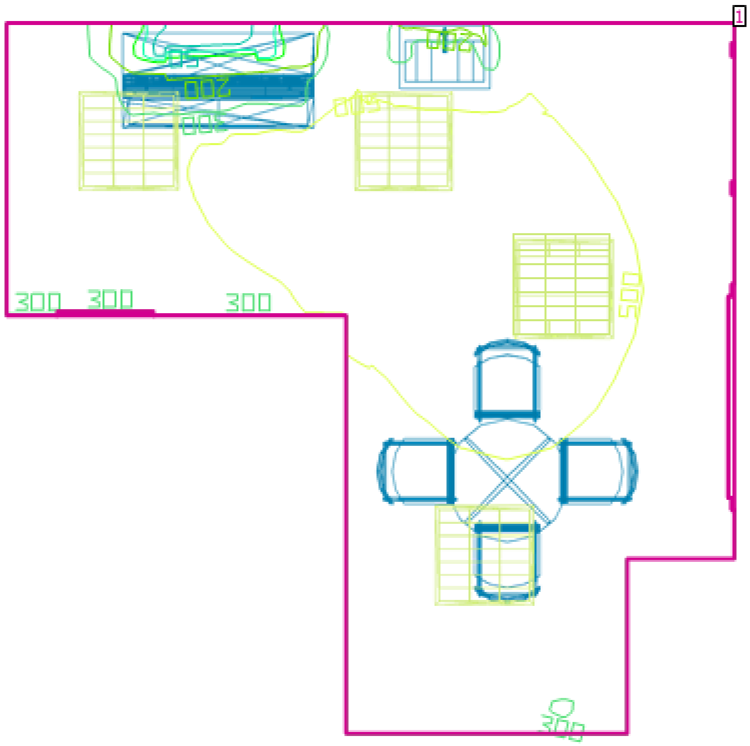
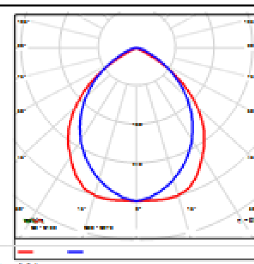



Figure 8. 33 Room Summary

Height of room: 3.200 m, Height of working plane: 0.800 m, Wall zone: 0.000 m
Reflection factors: Ceiling 70.0%, Walls 76.8%, Floor 75.3%, Light loss factor: 0.80

### Workplane

| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 5 | Perpendicular illuminance [lx] | 444 (500) | 39 | 588 | 0.088 | 0.066 |

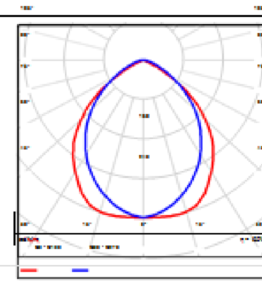
| No. | Quantity | | | |
|---|---|---|---|---|
| 1 | 4 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 15600 lm, Total luminaire luminous flux: 10120 lm, Total Load: 220.0 W, Light yield: 46.0 lm/W

Specific connection value: 16.00 W/m² = 3.60 W/m²/100 lx (Groundarea 13.75 m²)

## Kitchen / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) |
|---|---|
| 4 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |



Total lamp luminous flux: 15600 lm, Total luminaire luminous flux: 10120 lm, Total Load: 220.0 W, Light yield: 46.0 lm/W

Figure 8. 34 Luminaire Part List

## Office 2 / Room summary

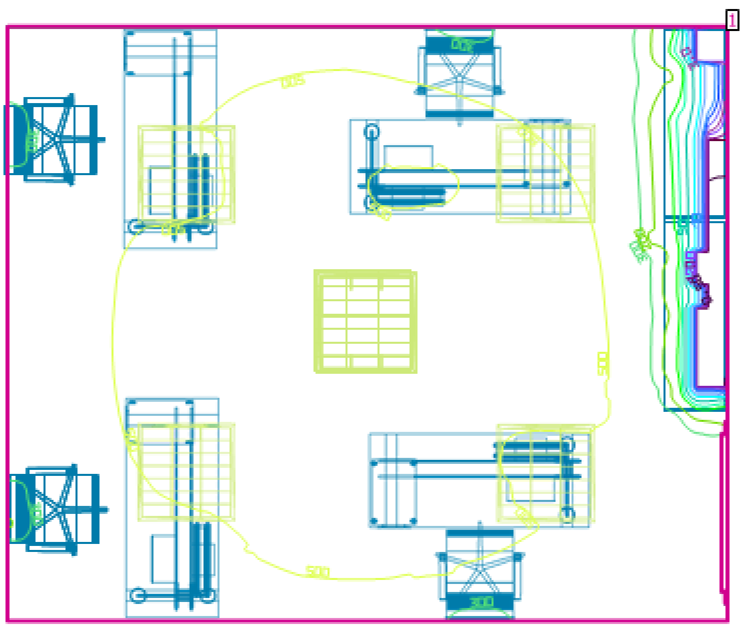
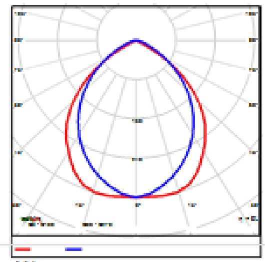


Figure 8. 35 Room Summary

Height of room: 3.200 m, Height of working plane: 0.800 m, Wall zone: 0.000 m
Reflection factors: Ceiling 70.0%, Walls 76.9%, Floor 75.4%, Light loss factor: 0.80

Workplane

| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 6 | Perpendicular illuminance [lx] | 468 (500) | 0.38 | 673 | 0.001 | 0.001 |

| No. | Quantity | | | |
|---|---|---|---|---|
| 1 | 5 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 19500 lm, Total luminaire luminous flux: 12650 lm, Total Load: 275.0 W, Light yield: 46.0 lm/W

Specific connection value: 16.46 W/m² = 3.52 W/m²/100 lx (Groundarea 16.70 m²)

## Office 2 / Description

Storey 1 (1), Illuminance values in [lx]

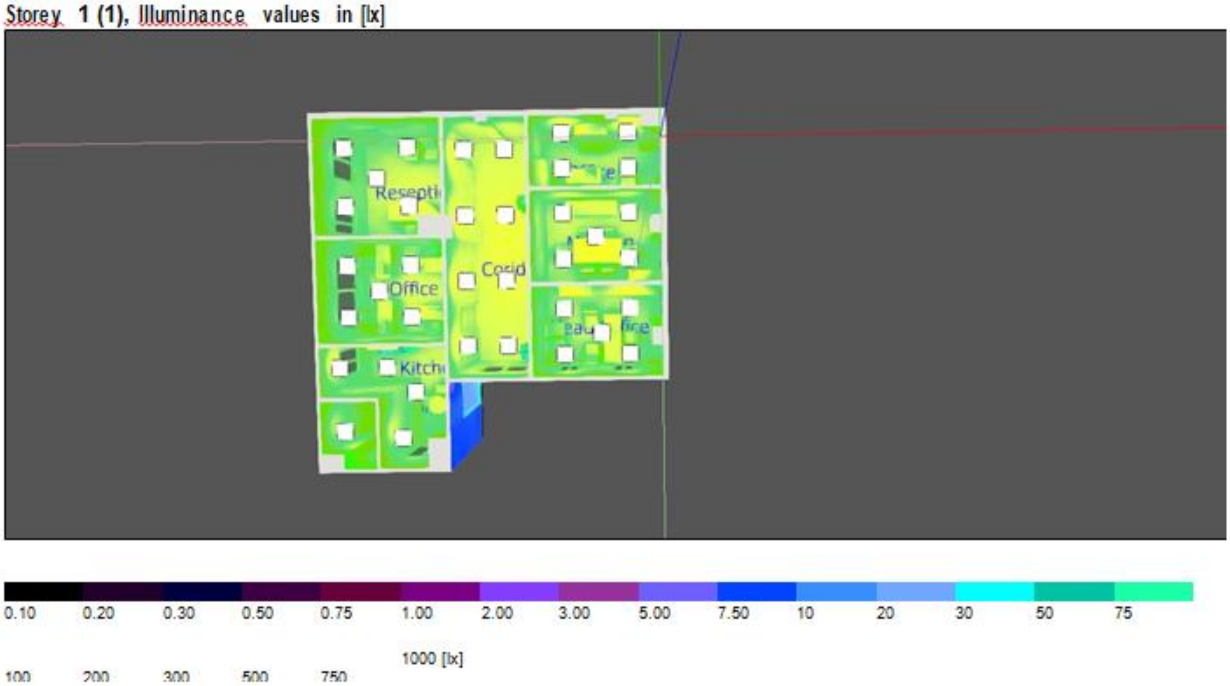
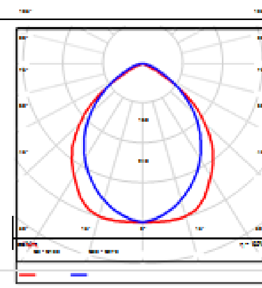



Figure 8. 36 Illuminance Values

## Office 2 / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) |
| --- | --- |
| 5 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |



Total lamp luminous flux: 19500 lm, Total luminaire luminous flux: 12650 lm, Total Load: 275.0 W, Light yield: 46.0 lm/W

Figure 8. 37  Luminaire Part List

## Office 2 / Views

Figure 8. 38  Renderd View From Dialux

## Reseption / Room summary

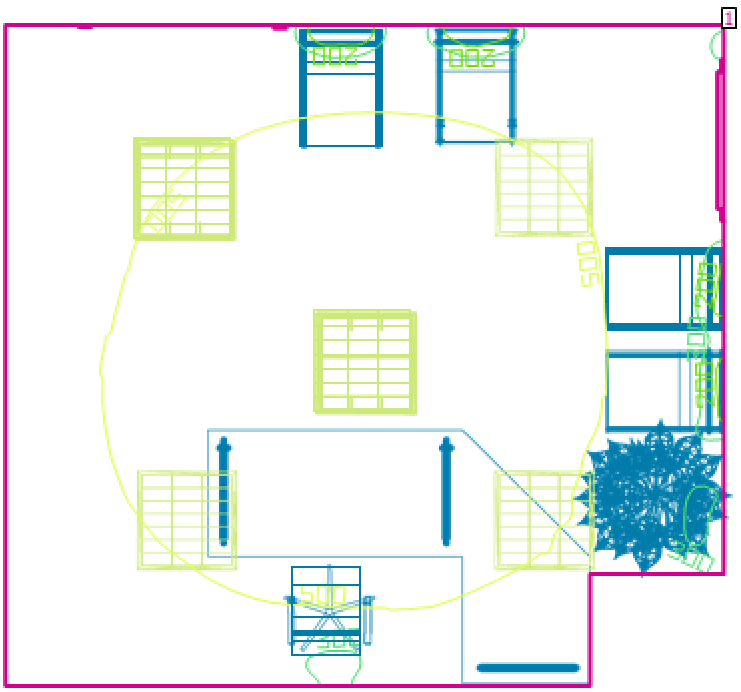
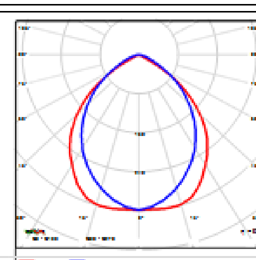


Figure 8. 39 Room Summary

Height of room: 3.200 m, Height of working plane: 0.800 m, Wall zone: 0.000 m
Reflection factors: Ceiling 70.0%, Walls 69.7%, Floor 75.5%, Light loss factor: 0.80

### Workplane

| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 7 | Perpendicular illuminance [lx] | 485 (500) | 105 | 655 | 0.216 | 0.160 |

| No. | Quantity | | | |
|---|---|---|---|---|
| 1 | 5 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 19500 lm, Total luminaire luminous flux: 12650 lm, Total Load: 275.0 W, Light yield: 46.0 lm/W

Specific connection value: 15.12 W/m² = 3.12 W/m²/100 lx (Groundarea 18.18 m²)

## Reseption / Description

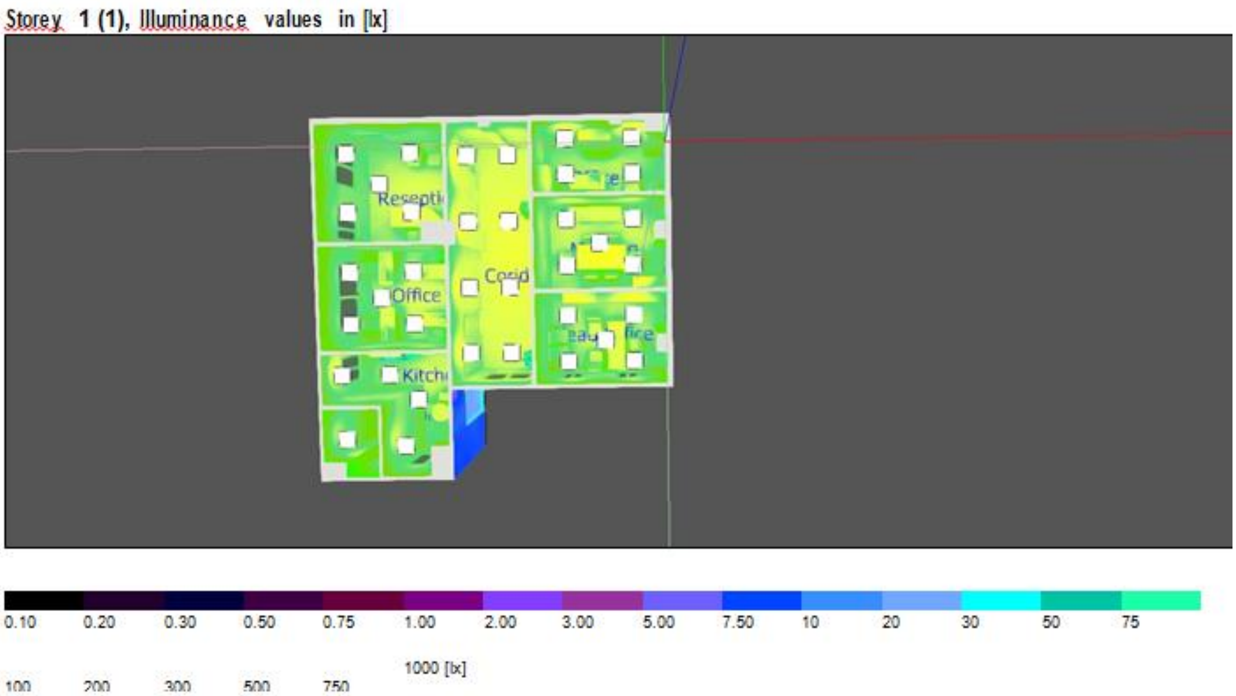
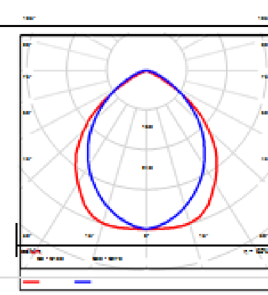



Figure 8. 40 Illuminance Values

## Reseption / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) |
|---|---|
| 5 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |



Total lamp luminous flux: 19500 lm, Total luminaire luminous flux: 12650 lm, Total Load: 275.0 W, Light yield: 46.0 lm/W

Figure 8. 41 Luminaire Part List

## Reseption / Views

Figure 8. 42 Renderd View From Dialux

## Coridor / Room summary

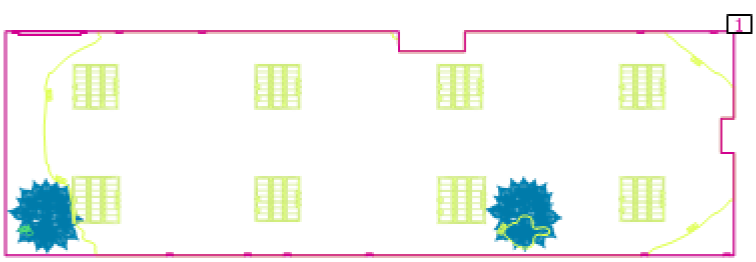
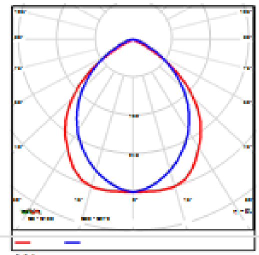


Figure 8. 43 Room Summary

Height of room: 3.200 m, Height of working plane: 0.800 m, Wall zone: 0.000 m
Reflection factors: Ceiling 70.0%, Walls 76.7%, Floor 75.5%, Light loss factor: 0.80

### Workplane

| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 8 | Perpendicular illuminance [lx] | 606 (500) | 296 | 713 | 0.488 | 0.415 |

| No. | Quantity | | | |
|---|---|---|---|---|
| 1 | 8 | Siteco Beleuchtungstechnik GmbH 5LQ11673A<br>Siteco® louvre luminaire<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 31200 lm, Total luminaire luminous flux: 20240 lm, Total Load: 440.0 W, Light yield: 46.0 lm/W

Specific connection value: 16.37 W/m² = 2.70 W/m²/100 lx (Groundarea 26.88 m²)

## Coridor / Description

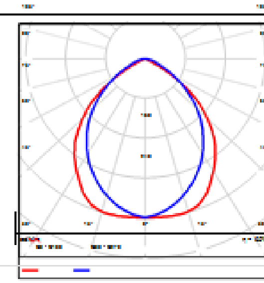
Storey 1 (1), Illuminance values in [lx]



Figure 8. 44 Illuminance Values

## Coridor / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) |
|---|---|
| 8 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |



Total lamp luminous flux: 31200 lm, Total luminaire luminous flux: 20240 lm, Total Load: 440.0 W, Light yield: 46.0 lm/W

## Coridor / Views

Figure 8. 45 Renderd View From Dialux

Office daylight :

Figure 8. 46  Renderd View From Dialux

Figure 8. 47  Renderd View From Dialux

## Office 1 / Room summary

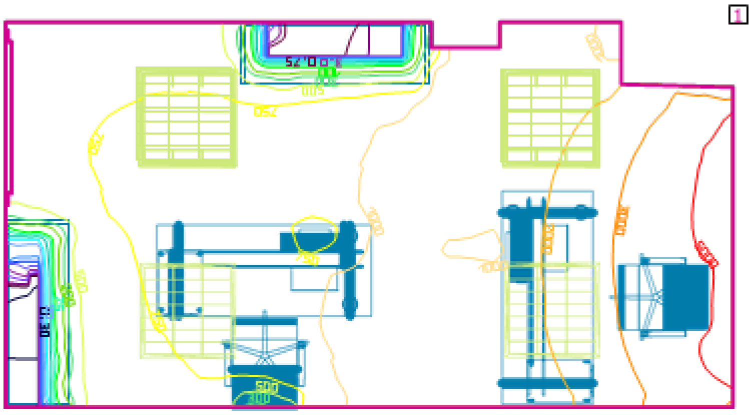


Figure 8. 48 Room Summary

Height of room: 3.200 m, Height of working plane: 0.800 m, Wall zone: 0.000 m
Reflection factors: Ceiling 77.0%, Walls 77.0%, Floor 75.6%, Light loss factor: 0.80

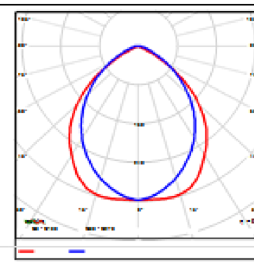
Location: Jerusalem (31.80° N 35.20° O)
Reference sky type: Average sky (Direct sunlight)
Date and time: 6/21/2015 12:00 PM (Jerusalem Standard Time)
Zenith luminance: 21382 cd/m²

### Workplane

| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 1 | Perpendicular illuminance [lx] | 1425 (500) | 0.26 | 7148 | 0.000 | 0.000 |

### Daylight

| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| Daylight quotient effective area 1 | Daylight factor<br>Rotation: X:0.0°, Y:0.0°, Z:0.0° | 3.60 | 2.25 | 4.65 | / | / |

| No. | Quantity | | | |
|---|---|---|---|---|
| 1 | 4 | Siteco Beleuchtungstechnik GmbH 5LQ11673A<br>Siteco® louvre luminaire<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 15600 lm, Total luminaire luminous flux: 10120 lm, Total Load: 220.0 W, Light yield: 46.0 lm/W

Specific connection value: 19.36 W/m² = 1.36 W/m²/100 lx (Groundarea 11.36 m²)

## Office 1 / Description

Storey 1 (1), Illuminance values in [lx]

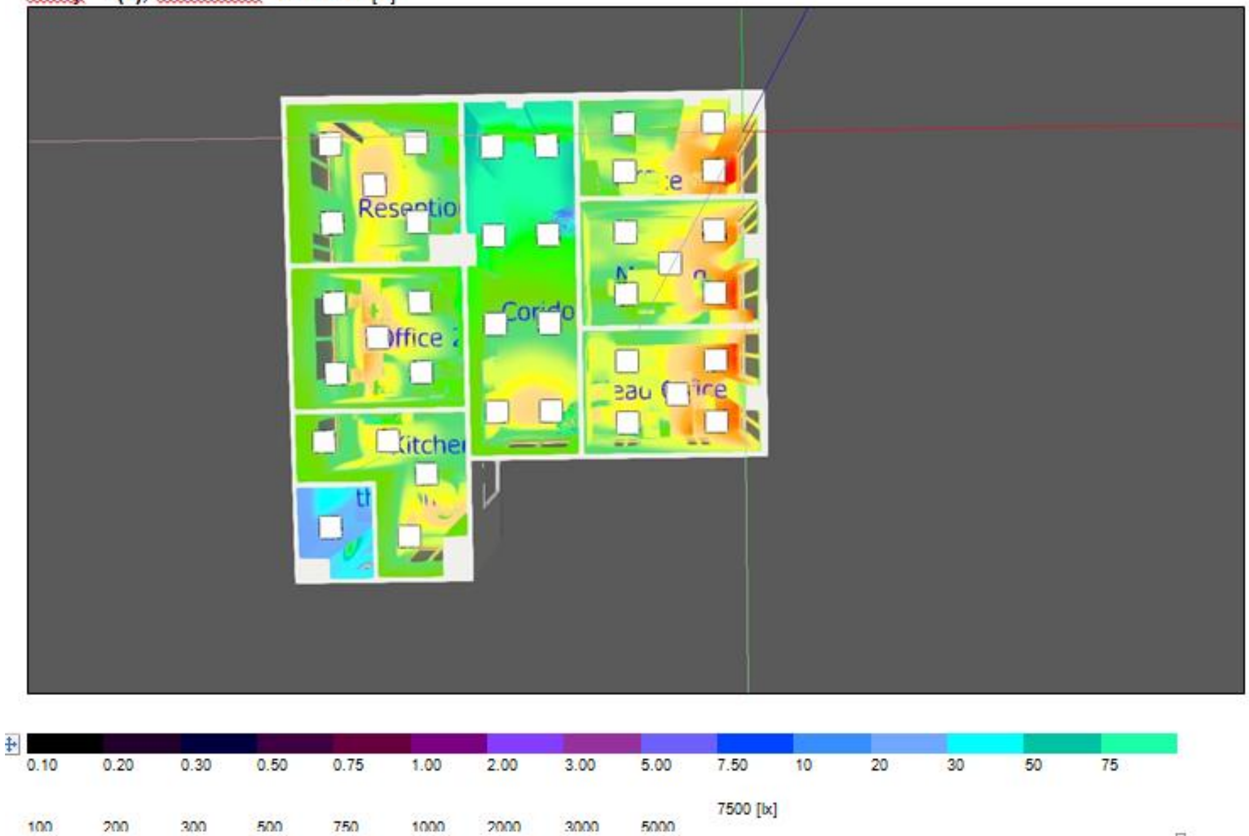
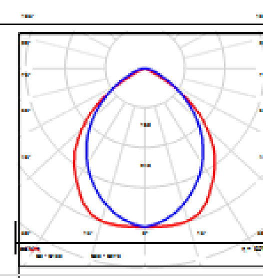



Figure 8. 49 Illuminance Values

## Office 1 / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) |
|---|---|
| 4 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |



Total lamp luminous flux: 15600 lm, Total luminaire luminous flux: 10120 lm, Total Load: 220.0 W, Light yield: 46.0 lm/W

Figure 8. 50 Luminaire Part List

## Meating / Room summary

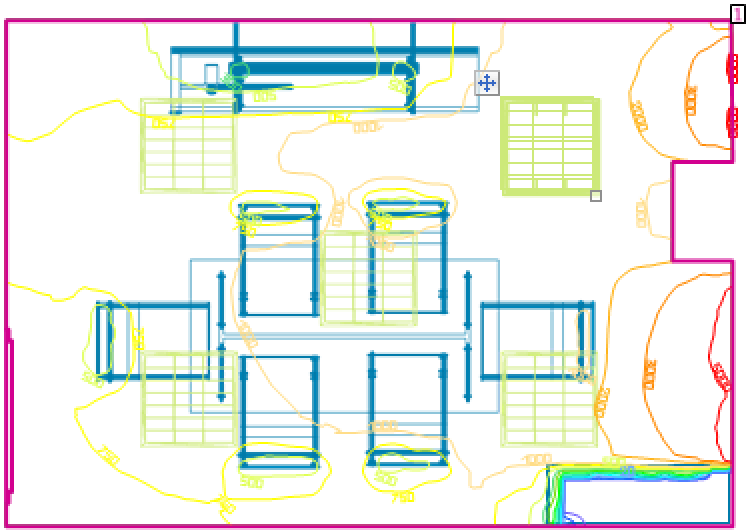


Figure 8. 51 Room Summary

Height of room: 3.200 m, Height of working plane: 0.800 m, Wall zone: 0.000 m
Reflection factors: Ceiling 70.0%, Walls 77.0%, Floor 75.4%, Light loss factor: 0.80

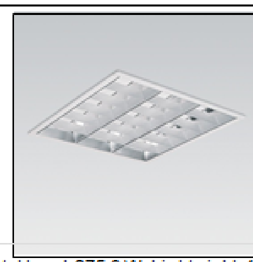
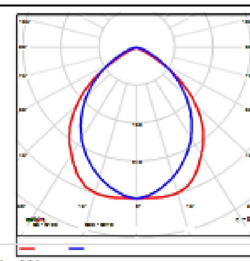
Location: Jerusalem (31.80° N 35.20° O)
Reference sky type: Average sky (Direct sunlight)
Date and time: 6/21/2015 12:00 PM (Jerusalem Standard Time)
Zenith luminance: 21382 cd/m²

### Workplane

| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 2 | Perpendicular illuminance [lx] | 1181 (500) | 3.09 | 7129 | 0.003 | 0.000 |

### Daylight

| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| Daylight quotient effective area 2 | Daylight factor<br>Rotation: X:0.0°, Y:0.0°, Z:0.0° | 3.31 | 0.00 | 6.63 | / | / |

| No. | Quantity | Luminaire | | |
|---|---|---|---|---|
| 1 | 5 | Siteco Beleuchtungstechnik GmbH 5LQ11673A<br>Siteco® louvre luminaire<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 19500 lm, Total luminaire luminous flux: 12650 lm, Total Load: 275.0 W, Light yield: 46.0 lm/W

Specific connection value: 18.14 W/m² = 1.54 W/m²/100 lx (Groundarea 15.16 m²)

## Meating / Description

Storey 1 (1), Illuminance values in [lx]

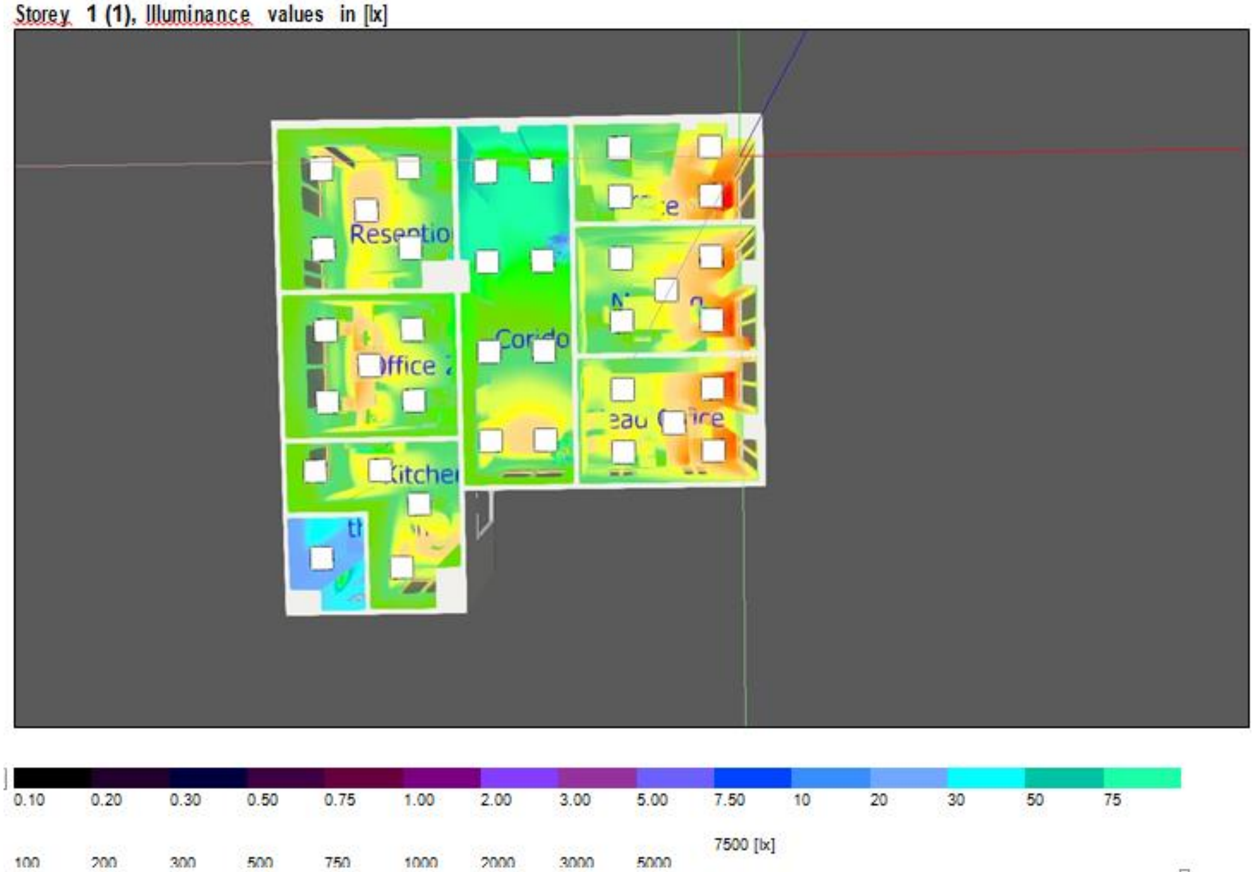
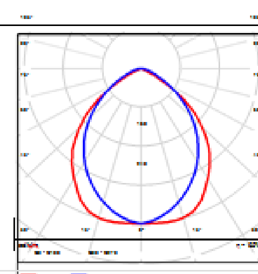



Figure 8. 52 Illuminance Values

## Meating / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) |
|---|---|
| 5 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |



Total lamp luminous flux: 19500 lm, Total luminaire luminous flux: 12650 lm, Total Load: 275.0 W, Light yield: 46.0 lm/W

Figure 8. 53 Luminaire Part List

## Meating / Views

Figure 8. 54  Renderd View From Dialux

## Head Office / Room summary

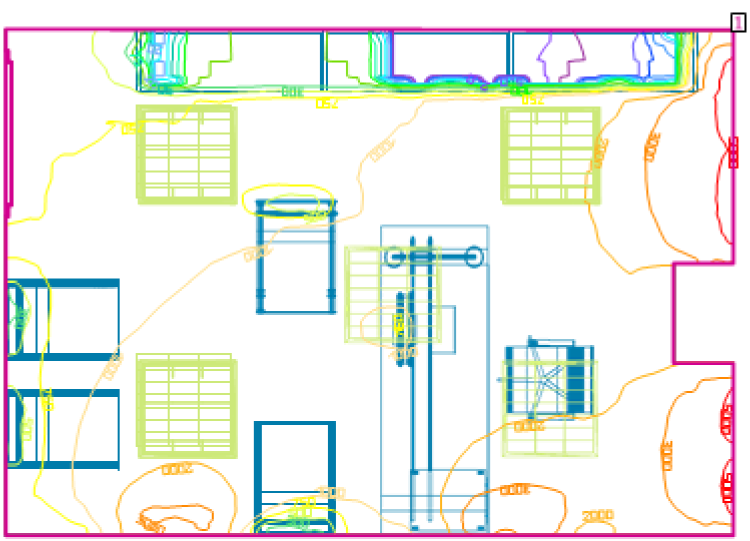


Figure 8. 55   Room Summary

Height of room: 3.200 m, Height of working plane: 0.800 m, Wall zone: 0.000 m
Reflection factors: Ceiling 70.0%, Walls 76.8%, Floor 75.4%, Light loss factor: 0.80

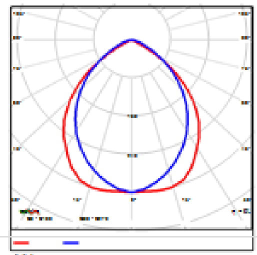
Location: Jerusalem (31.80° N 35.20° O)
Reference sky type: Average sky (Direct sunlight)
Date and time: 6/21/2015 12:00 PM (Jerusalem Standard Time)
Zenith luminance: 21382 cd/m²

### Workplane

| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 3 | Perpendicular illuminance [lx] | 1404 (500) | 1.08 | 6919 | 0.001 | 0.000 |

### Daylight

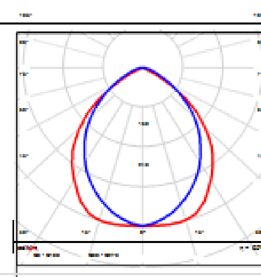
| | | | | | | |
|---|---|---|---|---|---|---|
| Daylight quotient effective area 3 | Daylight factor<br>Rotation: X:0.0°, Y:0.0°, Z:0.0° | 5.05 | 3.11 | 8.80 | / | / |

| No. | Quantity | | | |
|---|---|---|---|---|
| 1 | 5 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 19500 lm, Total luminaire luminous flux: 12650 lm, Total Load: 275.0 W, Light yield: 46.0 lm/W

Specific connection value: 18.15 W/m² = 1.29 W/m²/100 lx (Ground area 15.15 m²)

## Head Office / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) | | |
|---|---|---|---|
| 5 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 19500 lm, Total luminaire luminous flux: 12650 lm, Total Load: 275.0 W, Light yield: 46.0 lm/W

**Figure 8. 56 Luminaire Part List**

## Head Office / Views

Figure 8. 57  Renderd View From Dialux

## BathRoom / Room summary

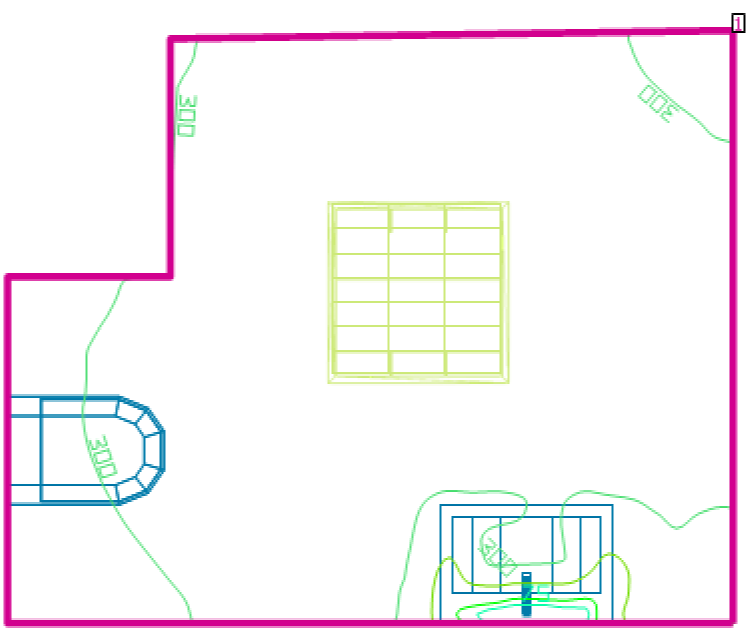


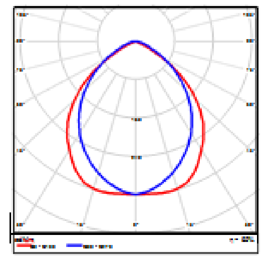

Figure 8. 58   Room Summary

Height of room: 3.200 m, Height of working plane: 0.800 m, Wall zone: 0.000 m
Reflection factors: Ceiling 70.0%, Walls 77.0%, Floor 75.6%, Light loss factor: 0.80

Location: Jerusalem (31.80° N 35.20° O)
Reference sky type: Average sky (Direct sunlight)
Date and time: 6/21/2015 12:00 PM (Jerusalem Standard Time)
Zenith luminance: 21382 cd/m²

### Workplane

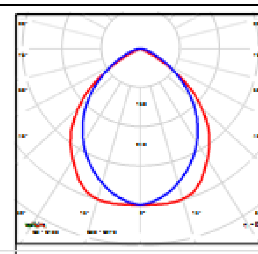
| | Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|---|
| 1 | Workplane 4 | Perpendicular illuminance [lx] | 324 (500) | 52 | 381 | 0.160 | 0.136 |

| No. | Quantity | | | |
|---|---|---|---|---|
| 1 | 1 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 3900 lm, Total luminaire luminous flux: 2530 lm, Total Load: 55.0 W, Light yield: 46.0 lm/W

Specific connection value: 12.24 W/m² = 3.78 W/m²/100 lx (Ground area 4.49 m²)

## BathRoom / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) | | |
|---|---|---|---|
| 1 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire Luminous emittance 1 Fitting: 3xT26 18W/840 Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 3900 lm, Total luminaire luminous flux: 2530 lm, Total Load: 55.0 W, Light yield: 46.0 lm/W

Figure 8. 59 Luminaire Part List

## Kitchen / Room summary


Figure 8. 60 Room Summary

Height of room: 3.200 m, Height of working plane: 0.800 m, Wall zone: 0.000 m
Reflection factors: Ceiling 70.0%, Walls 76.8%, Floor 75.3%, Light loss factor: 0.80

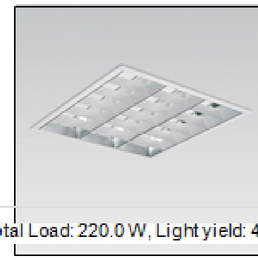
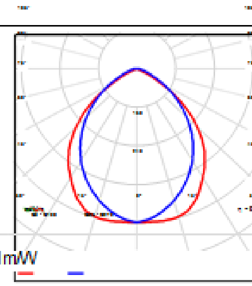
Location: Jerusalem (31.80° N 35.20° O)
Reference sky type: Average sky (Direct sunlight)
Date and time: 6/21/2015 12:00 PM (Jerusalem Standard Time)
Zenith luminance: 21382 cd/m²

### Workplane

| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 5 | Perpendicular illuminance [lx] | 1407 (500) | 178 | 41422 | 0.127 | 0.004 |

### Daylight

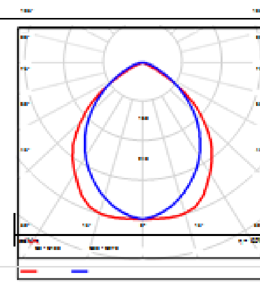
| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| Daylight quotient effective area 5 | Daylight factor<br>Rotation: X:0.0°, Y:0.0°, Z:0.0° | 1.77 | 1.55 | 2.08 | / | / |

| No. | Quantity | | | |
|---|---|---|---|---|
| 1 | 4 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 15600 lm, Total luminaire luminous flux: 10120 lm, Total Load: 220.0 W, Light yield: 46.0 lm/W

Specific connection value: 16.00 W/m² = 1.14 W/m²/100 lx (Groundarea 13.75 m²)

## Kitchen / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) | | |
|---|---|---|---|
| 4 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 15600 lm, Total luminaire luminous flux: 10120 lm, Total Load: 220.0 W, Light yield: 46.0 lm/W

Figure 8. 61 Luminaire Part List

## Office 2 / Room summary

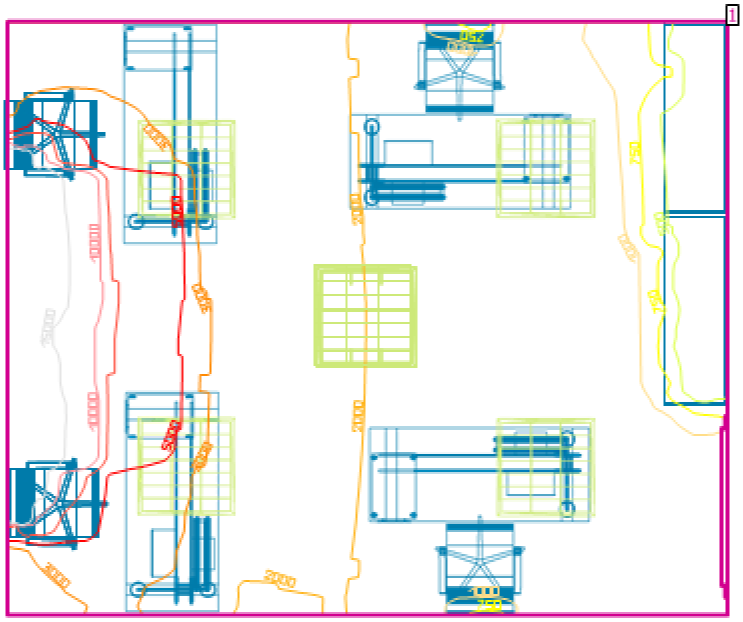


Figure 8. 62 Room Summary

Height of room: 3.200 m, Height of working plane: 0.800 m, Wall zone: 0.000 m
Reflection factors: Ceiling 70.0%, Walls 76.9%, Floor 75.4%, Light loss factor: 0.80

Location: Jerusalem (31.80° N 35.20° O)
Reference sky type: Average sky (Direct sunlight)
Date and time: 6/21/2015 12:00 PM (Jerusalem Standard Time)
Zenith luminance: 21382 cd/m²

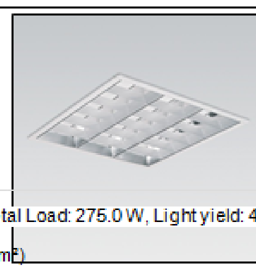
### Workplane

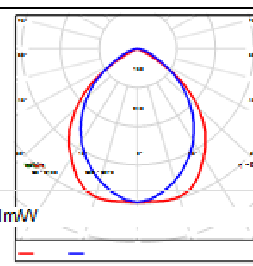
| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 6 | Perpendicular illuminance [lx] | 4813 (500) | 373 | 158448 | 0.077 | 0.002 |

### Daylight

| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| Daylight quotient effective area 6 | Daylight factor<br>Rotation: X:0.0°, Y:0.0°, Z:0.0° | 3.02 | 1.19 | 7.35 | / | / |

| No. | Quantity | Luminaire |
|---|---|---|
| 1 | 5 | Siteco Beleuchtungstechnik GmbH 5LQ11673A<br>Siteco® louvre luminaire<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |





Total lamp luminous flux: 19500 lm, Total luminaire luminous flux: 12650 lm, Total Load: 275.0 W, Light yield: 46.0 lm/W

Specific connection value: 16.46 W/m² = 0.34 W/m²/100 lx (Groundarea 16.70 m²)

## Office 2 / Description

Storey 1 (1), Illuminance values in [lx]

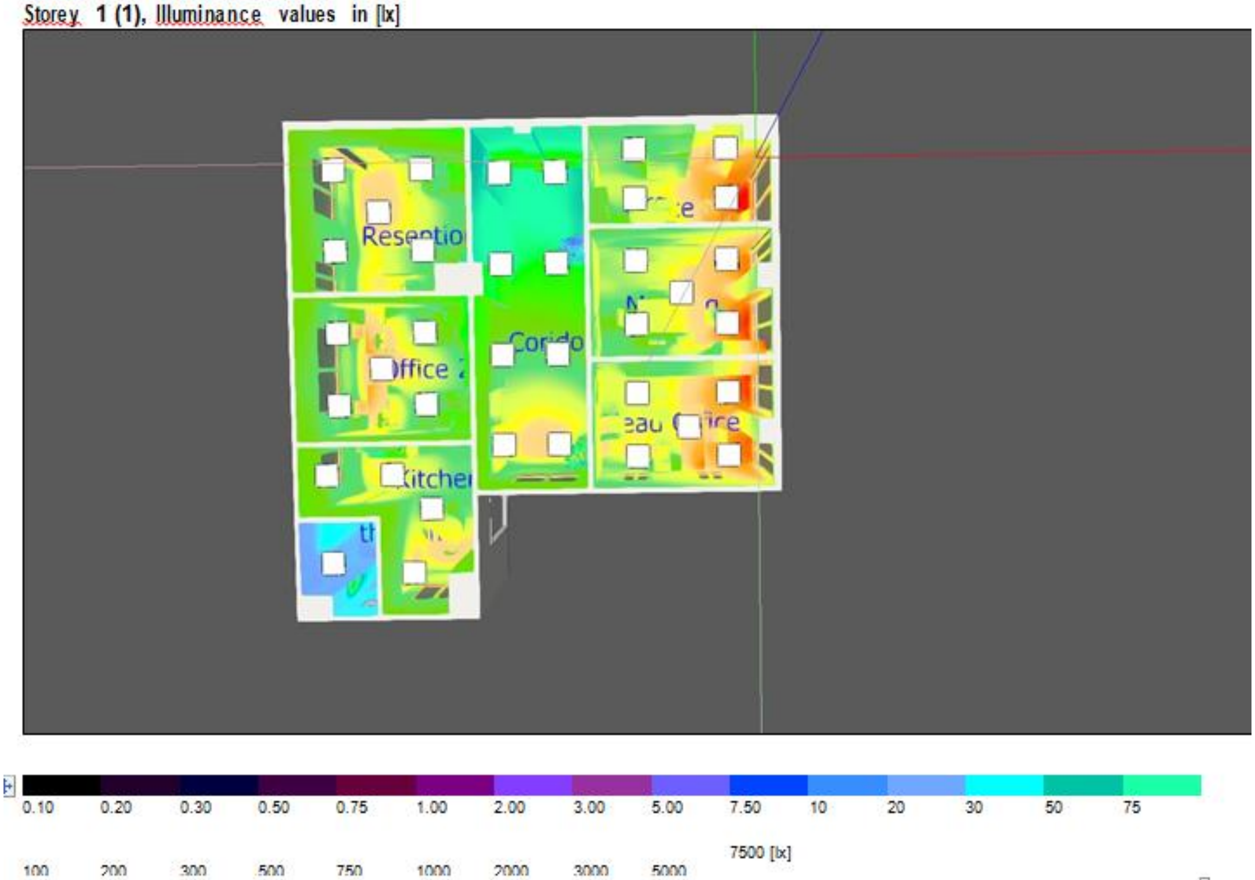
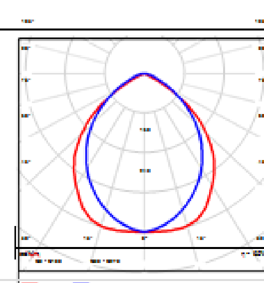



Figure 8. 63 Illuminance Values

## Office 2 / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) |
|---|---|
| 5 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |



Total lamp luminous flux: 19500 lm, Total luminaire luminous flux: 12650 lm, Total Load: 275.0 W, Light yield: 46.0 lm/W

Figure 8. 64 Luminaire Part List

## Office 2 / Views

Figure 8. 65  Renderd View From Dialux

## Reseption / Room summary

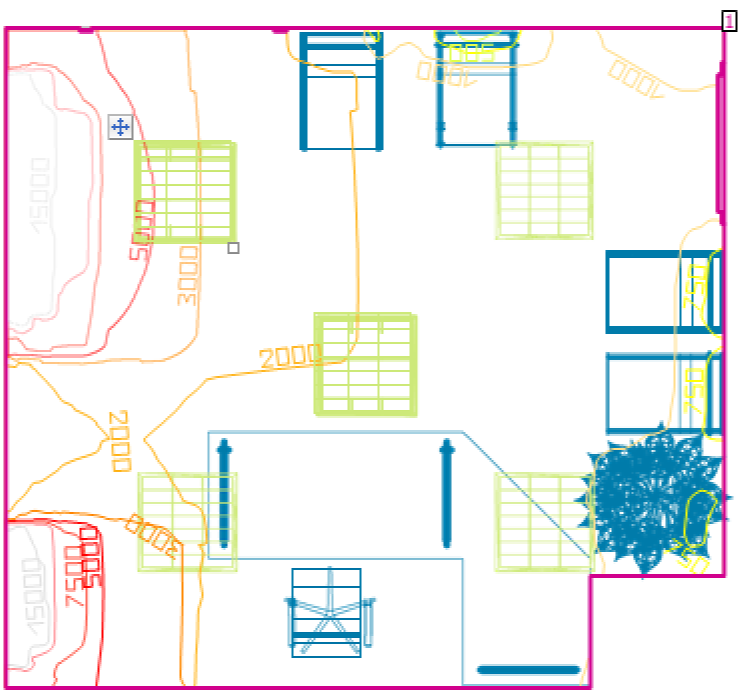



Figure 8. 66  Room Summary

Height of room: 3.200 m, Height of working plane: 0.800 m, Wall zone: 0.000 m
Reflection factors: Ceiling 70.0%, Walls 69.7%, Floor 75.5%, Light loss factor: 0.80

Location: Jerusalem (31.80° N 35.20° O)
Reference sky type: Average sky (Direct sunlight)
Date and time: 6/21/2015 12:00 PM (Jerusalem Standard Time)
Zenith luminance: 21382 cd/m²

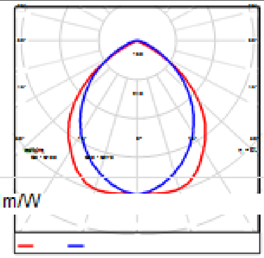
## Workplane

| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 7 | Perpendicular illuminance [lx] | 4131 (500) | 448 | 153293 | 0.108 | 0.003 |

## Daylight

| | | | | | | |
|---|---|---|---|---|---|---|
| Daylight quotient effective area 7 | Daylight factor<br>Rotation: X:0.0°, Y:0.0°, Z:0.0° | 2.32 | 1.16 | 5.55 | / | / |

| No. | Quantity | |
|---|---|---|
| 1 | 5 | Siteco Beleuchtungstechnik GmbH 5LQ11673A<br>Siteco® louvre luminaire<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |



Total lamp luminous flux: 19500 lm, Total luminaire luminous flux: 12650 lm, Total Load: 275.0 W, Light yield: 46.0 lm/W

Specific connection value: 15.12 W/m² = 0.37 W/m²/100 lx (Ground area 18.18 m²)

## Reseption / Description

Storey 1 (1), Illuminance values in [lx]

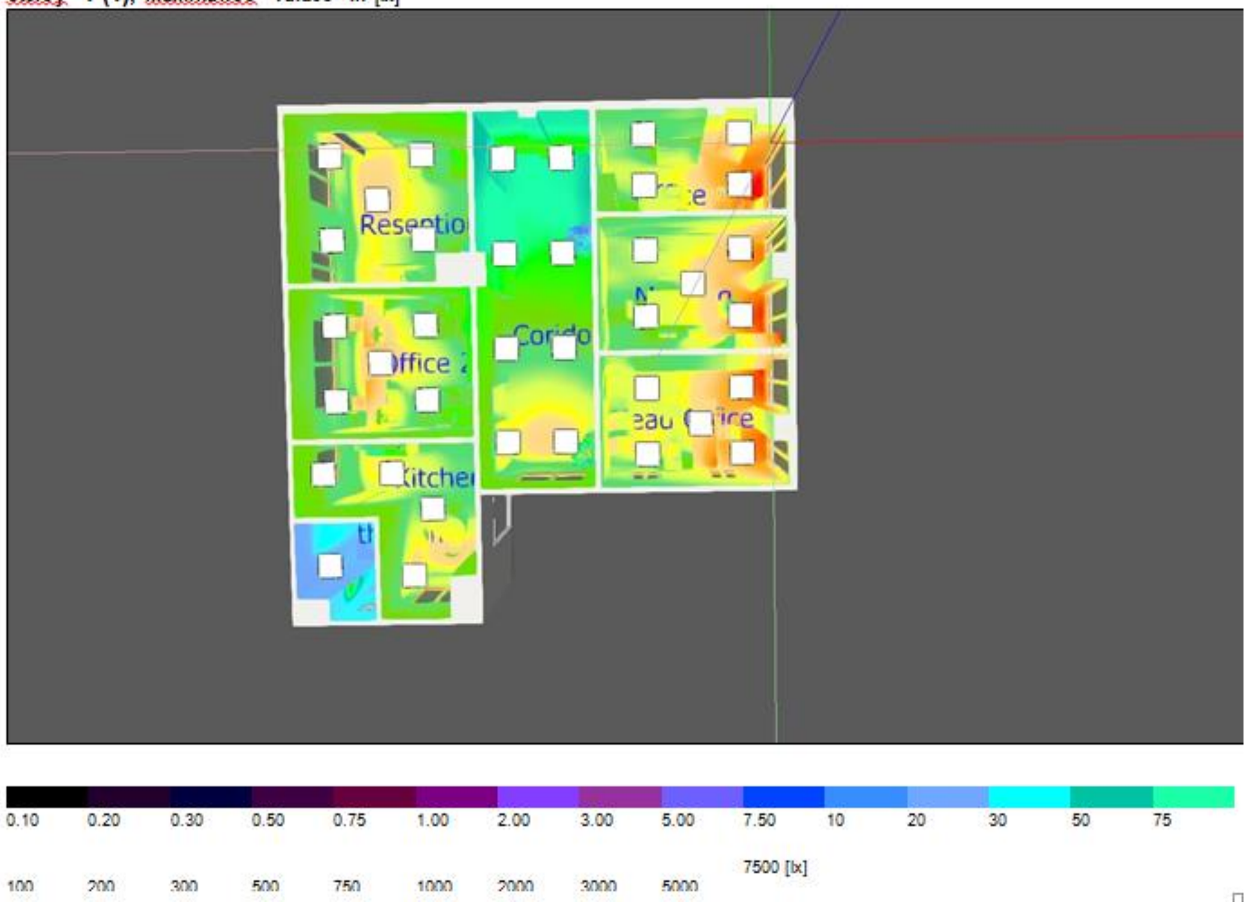
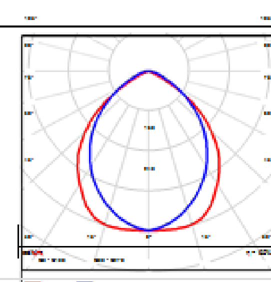



Figure 8. 67 Illuminance Values

## Reseption / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) | | |
|---|---|---|---|
| 5 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 19500 lm, Total luminaire luminous flux: 12650 lm, Total Load: 275.0 W, Light yield: 46.0 lm/W

Figure 8. 68 Luminaire Part List

## Reseption / Views

Figure 8. 69 Renderd View From Dialux

## Coridor / Room summary


Figure 8. 70 Room Summary

Height of room: 3.200 m, Height of working plane: 0.800 m, Wall zone: 0.000 m
Reflection factors: Ceiling 70.0%, Walls 76.7%, Floor 75.5%, Light loss factor: 0.80

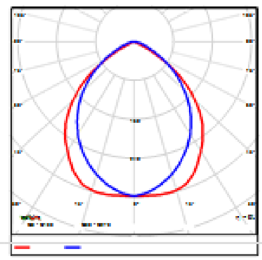
Location: Jerusalem (31.80° N 35.20° O)
Reference sky type: Average sky (Direct sunlight)
Date and time: 6/21/2015 12:00 PM (Jerusalem Standard Time)
Zenith luminance: 21382 cd/m²

## Workplane

| Surface | Result | Mean (target) | Min | Max | Min/average | Min/max |
|---|---|---|---|---|---|---|
| 1 Workplane 8 | Perpendicular illuminance [lx] | 868 (500) | 482 | 4133 | 0.555 | 0.117 |

## Daylight

| | | | | | | |
|---|---|---|---|---|---|---|
| Daylight quotient effective area 8 | Daylight factor<br>Rotation: X:0.0°, Y:0.0°, Z:0.0° | 1.18 | 0.35 | 3.88 | / | / |

| No. | Quantity | | | |
|---|---|---|---|---|
| 1 | 8 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 31200 lm, Total luminaire luminous flux: 20240 lm, Total Load: 440.0 W, Light yield: 46.0 lm/W

Specific connection value: 16.37 W/m² = 1.89 W/m²/100 lx (Groundarea 26.88 m²)

## Coridor / Description

Storey 1 (1), Illuminance values in [lx]

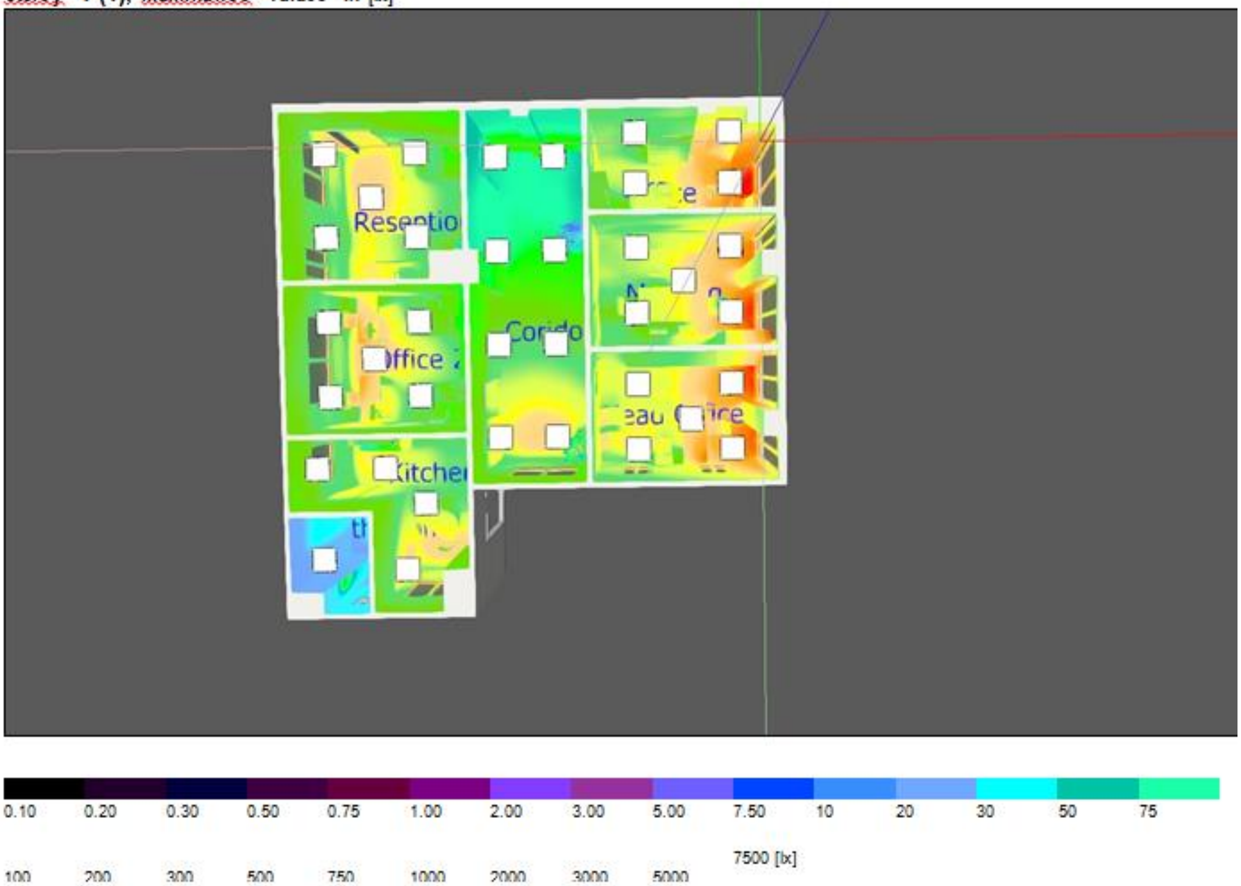
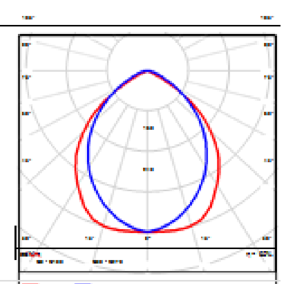



Figure 8. 71 Illuminance Values

## Coridor / Luminaire parts list

| Quantity | Luminaire (Luminous emittance) | | |
|---|---|---|---|
| 8 | Siteco Beleuchtungstechnik GmbH 5LQ11673A Siteco® louvre luminaire<br>Luminous emittance 1<br>Fitting: 3xT26 18W/840<br>Light output ratio: 64.87% Lamp luminous flux: 3900 lm Luminaire Luminous Flux: 2530 lm Power: 55.0 W<br>Light yield: 46.0 lm/W |  |  |

Total lamp luminous flux: 31200 lm, Total luminaire luminous flux: 20240 lm, Total Load: 440.0 W, Light yield: 46.0 lm/W

Figure 8. 72 Luminaire Part List

**Coridor / Views**

Figure 8. 73 Renderd View From Dialux

## 8.5: Electrical Box

Box in the wall where electrical connections are made to fixtures and that supports fixtures.

### 8.5.1: Electrical wires

In general refers to insulated conductors used to carry electricity, and associated devices. This article describes general aspects of electrical wiring as used to provide power in buildings and structures, commonly referred to as building wiring. This article is intended to describe common features of electrical wiring that may apply worldwide.

It contains three types:-

- Neutral
- Phase
- Earth

### 8.5.2: Circuit breaker

A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and interrupt current flow.

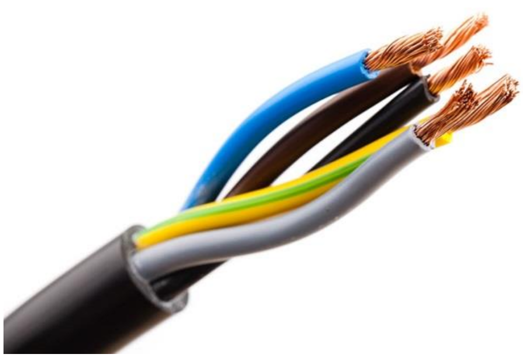


Figure 8. 74 Electrical wires

Two types are used:

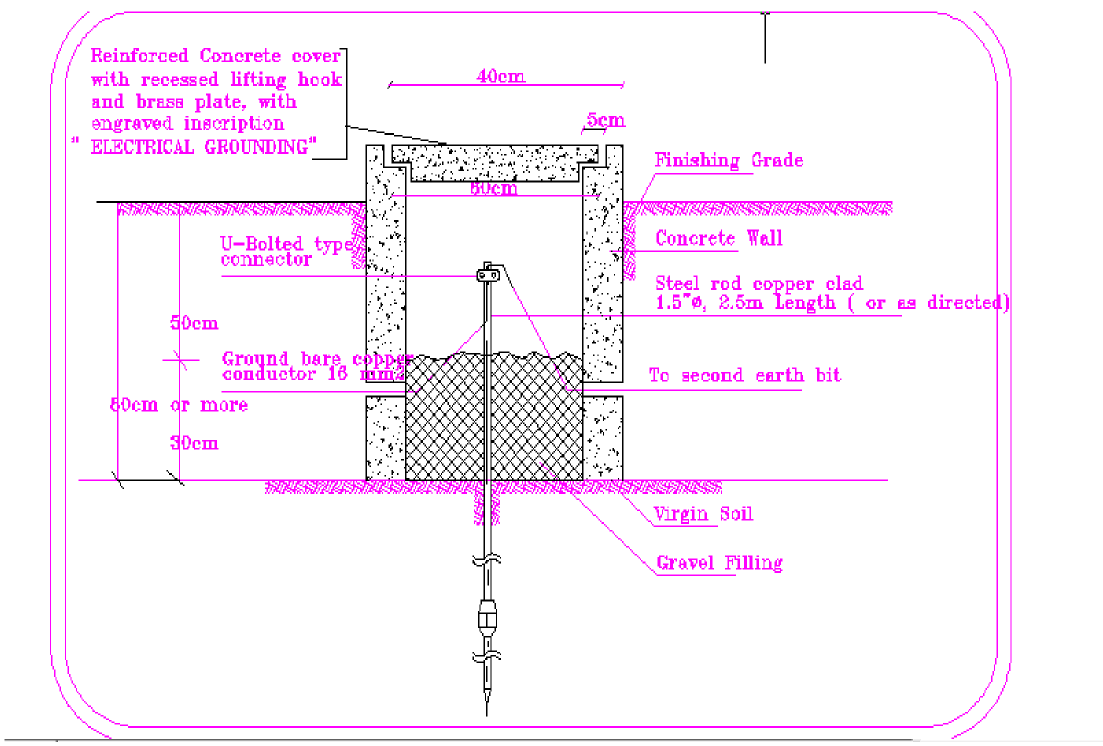
1- 10 amp circuit breaker for lighting.

16 amp circuit breaker for outlets

Figure 8. 75 circuit breaker

## 8.6: Earthling system

In electrical supply systems, an earthling system or grounding system is circuitry which connects parts of the electric circuit with the ground, thus defining the potential of the conductors relative to the Earth's conductive surface. The choice of earthling system can affect the safety and electromagnetic compatibility of the power supply. In particular, it affects the magnitude and distribution of short circuit currents through the system, and the effects it creates on equipment and people in the proximity of the circuit. If a fault within an electrical device connects a live supply conductor to an exposed conductive surface, anyone touching it while electrically connected to the earth will complete a circuit back to the earthed supply conductor and receive an electric shock.



# Chapter Nine: Safety Design

## 9.1: General

The safety systems is a major part must be taken into consideration when designing any buildings, because it's very important to preserve the lives of people, whether they are residents or workers or even visitors.

The primary goal of safety engineering is to manage risk, eliminating or reducing it to the lowest levels. Risk is the combination of the probability of a failure event, and the severity resulting from the failure. For instance, the severity of a particular failure may result in fatalities, injuries, property damage, or nothing more than annoyance. It may be a frequent, occasional, or rare occurrence. The acceptability of the failure depends on the combination of the two. Probability is often more difficult to predict than severity due to the many factors that could lead to a failure, such as mechanical failure, environmental effects, and operator error. Safety engineering attempts to reduce the frequency of failures, and ensure that when failures do occur, the consequences are not life threatening.

## 9.2: Safety Design

Design safety in Commercial Building addresses many of the important points that cannot be dispensed with. The first point in the design of safety is stairs and distribute it in the Building; in our project, we have distributed two stairs at the edges of the Building to reduce the large gatherings of people for each stair and to rapid evacuation of the Building in emergencies such as earthquakes, fires and any other dangers.

The following figures shown the distributed of stairs on the building:

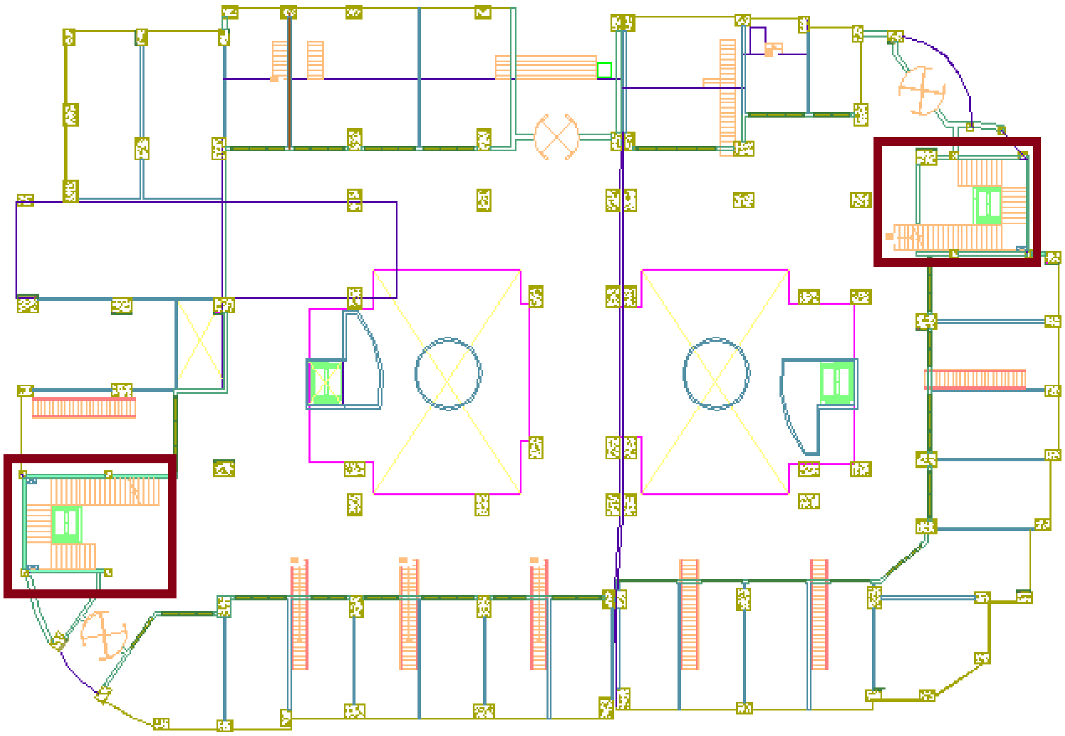


Figure 9. 1  AutoCAD drawing for distribution of stairs in Ground floor

The second point in the design of safety is, safety signs and distribute it  in the Building to help people to  evacuate the building in any case of emergency quickly and easily , and these signs are as follows:

**Evacuation route:** It indicates to the direction of evacuation route in the hotel (left or right).


Figure 9. 2 Evacuation route Sign


Figure 9. 3 Fire Exit Sign


Figure 9. 4 Exit Sign

**Exit:** It indicates to  exit door or outlet in the building .


Figure 9. 6  Exit Sign


Figure 9. 5  Exit Sign

**Output stairs:** It indicates to the direction of output stairs (up or down).


Figure 9. 7 Stair Sign


Figure 9. 8 Stair Sign

**Elevators should not use in case of fire or earthquake:** This refers to not use elevators during a fire or earthquake:


Figure 9. 10 Stair Sign


Figure 9. 9 Stair Sign

**Safe area in case of earthquake:** Refers to the safe areas in the event of earthquakes.


Figure 9. 11 Safe area in case of earthquake Sign

There are also signs on the whereabouts of safety and security tools in the building where these tools can be used in emergency situations, the following offer tools that we used in our project:

**Fire Proof Doors:**

It used for stairs and for restaurants kitchens to prevent fire from spreading.

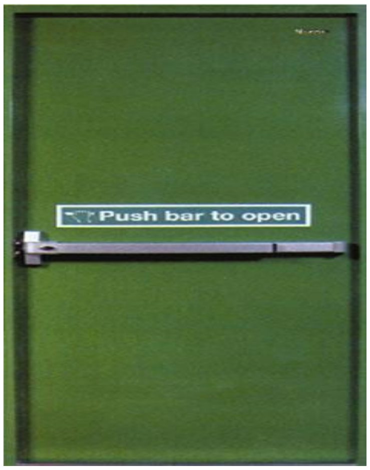



Figure 9. 12 Fire Proof Doors

**Extinguishers:** It indicates for the location of the Extinguishers in the building.

Two types of fire extinguisher are used:

Type K: It is located in the cooking zone, which is specialized in kitchen hazards.

Type A: It is located in the dining areas, corridors and the offices.


Figure 9. 13 Extinguishers Signs

**Fire alarm:** It indicates to the location of the fire :

Figure 9. 14 Fire alarm

Figure 9. 15  Fire alarm

**Smoke detectors:** It indicates for the location of smoke detectors :

Figure 9. 16  Smoke detectors

Figure 9. 17 Smoke detectors

The third point in the design of safety is a way to evacuate the building in emergencies. Each person must go to the nearest exit to evacuate the building easily, rapidly, and not causing overcrowding.

The following figures shown the way of evacuation of the building:

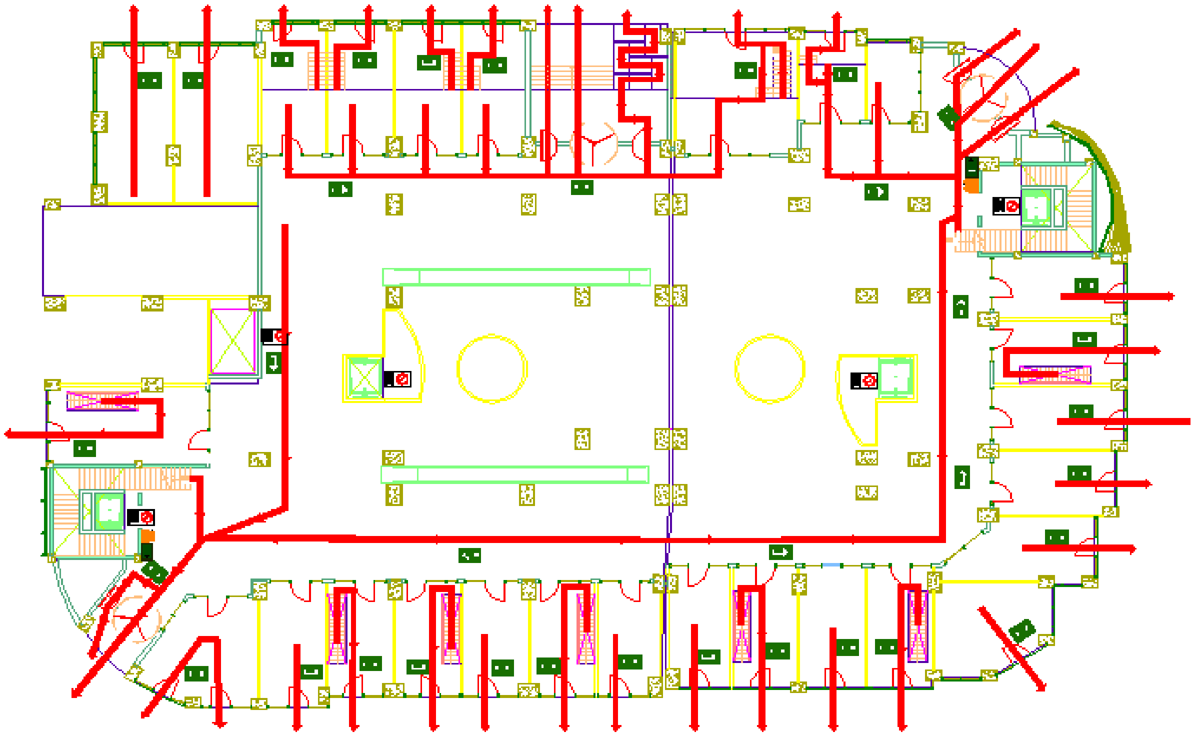


Figure 9. 18 AutoCAD drawing for the way of evacuate the G.F.

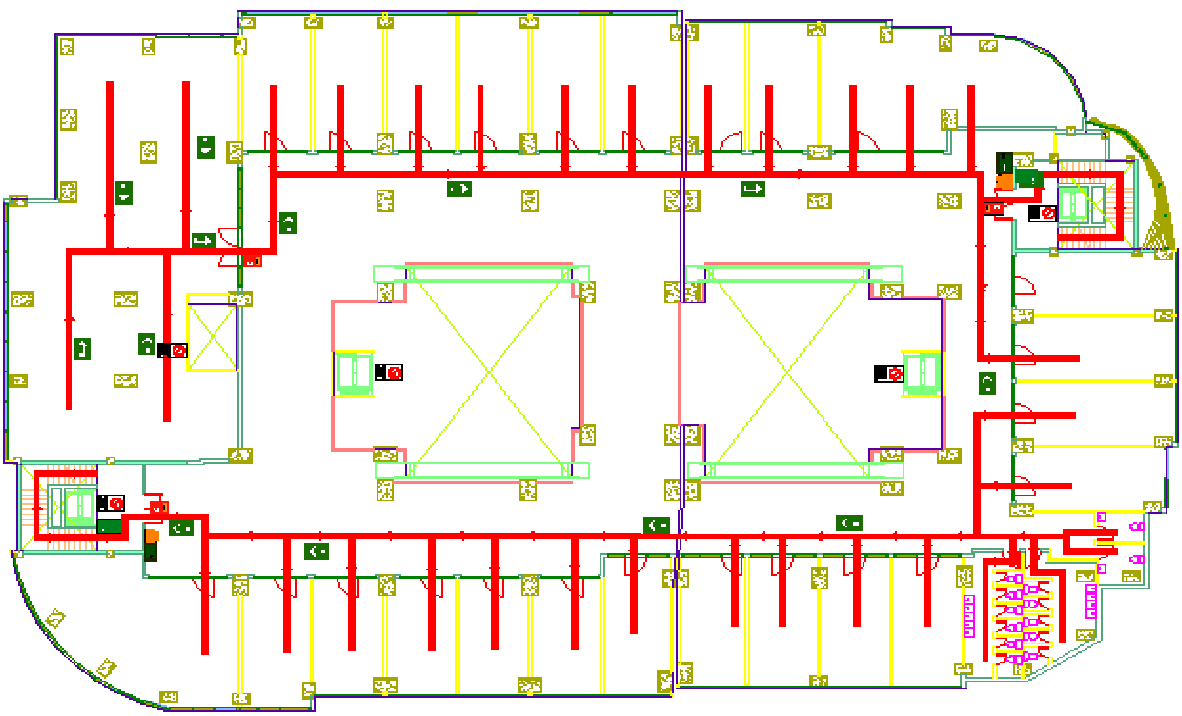


Figure 9. 19 AutoCAD drawing for the way of evacuate the third .F.

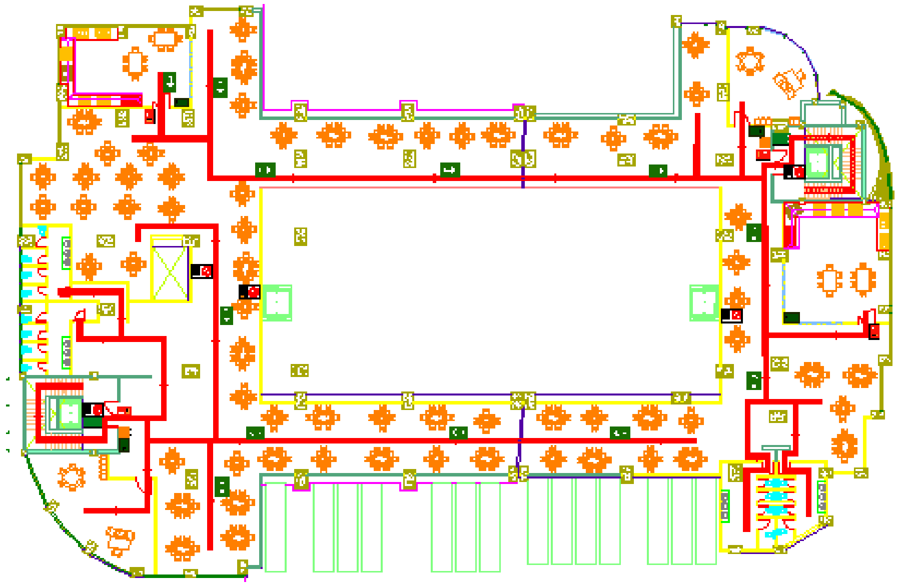


Figure 9. 20  AutoCAD drawing for the way of evacuate the seventh .F.

The fourth point in the design of safety is put out the fire in case the incident occurred and for this case, we have used automatic sprinkler, which is a device for automatically distributing water on a fire in sufficient quantity. For designing automatic sprinkler system

The distance between sprinklers and the area that covers by each sprinkler depend on the type of the building.

The buildings are classified depend on sprinklers as following:

a) Low hazard: the spread of fire from place to another is very low.

b) Medium hazard: the spread of fire from place to another is medium.

c) High hazard: the spread of fire from place to another is high.

The following table shows the maximum spacing and area for each sprinkler:

Table: spacing and area for sprinkler.

| *Type of building* | *Low hazard* | *Medium hazard* | *High hazard* |
|---|---|---|---|
| *Max spacing (m)* | 4.6 | 4.6 | 3.7 |
| *Area/ sprinkler ($m^2$)* | 20 | 12 | 9 |

The Building are classified as Medium hazard, so the max distance from sprinkler to another Should not be more than 4.6 m, and the area that covers by each sprinkler Should not be more than 12 $m^2$.

In Figure below, one of the offices rooms in the building was taken to make a sample of calculation for the distribution of sprinklers.

Area of office = 15.6 $m^2$.

Number of sprinkler = $\frac{15.6}{12}$ = 2 sprinkler

Max distance= 4.6 m

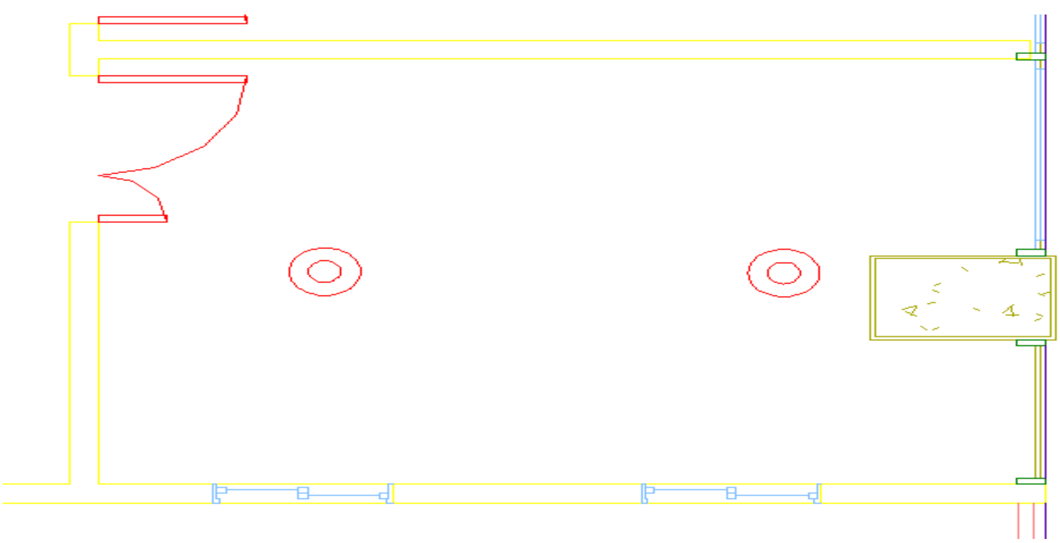


Figure 9. 21 AutoCAD drawing for the sprinklers distribution.

Figure below shows the distances between sprinklers and all the distances are less than 4.6 m

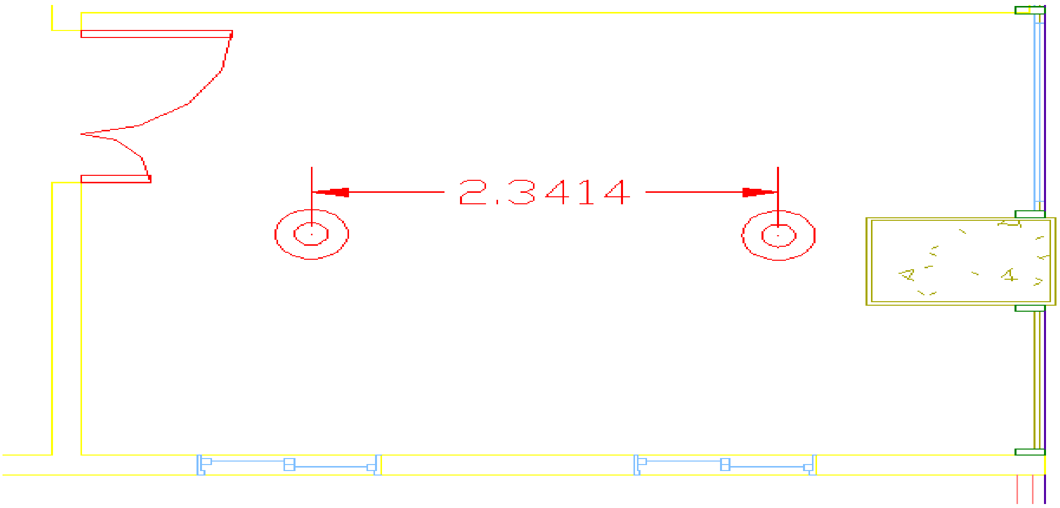



Figure 9. 22  AutoCAD drawing for the sprinklers distribution and distance between them.

# Chapter Ten: Building operation

Main problem that most of building confronts is hard to clean or maintenance them after construct , this problem summarized by inability to entirely reach and maintain the fenestration due to the architectural form of the building.

Architects should aim to minimize irregular architectural forms in the design of building fenestrations. These irregularities provide for difficulty in reaching and maintaining the fenestrations where collections of moisture, dust or water take place

Simi-movable Trolley (**DAVIT YSTEM**) was used when operate this building to make maintenance and to clean all the glazing areas.

According to **TRACMOD** company this davit system are used in our structure.
this davits include three parts bolts tightened on ground, arms and the davits unit.

NOTE: See concept sheets for this features attached with this report.

Figure 10. 1 Picture of Davits

**Figure 10. 2 Picture of Davits**


**Figure 10. 3 Picture of Davits**

# Chapter Eleven: Quantity Surveying

The quantities for the current design were computed and the total price of the project is computed as shown in table below:

Table 11. 1 Table Of Quantities

| Number | Name | Unit | Total Cost |
|---|---|---|---|
| | | | |
| **1** | Earth work | | |
| **1.1** | Sub Base | m3 | 370033 |
| **1.2** | Base Course | m3 | 400501.3 |
| **1.3** | Excavation | m3 | 2530200 |
| **1.4** | Insulation | m2 | 240090 |
| **2** | Concrete and steel | | |
| **2.1** | Footing | m3 | 2906922.3 |
| **2.2** | Columns | m3 | 6372368 |
| **2.3** | Stair Cases | m3 | 311704 |
| **2.4** | Slabs | m2 | 9986882 |
| **2.5** | Retaining Walls | m | 5286290 |
| **2.6** | Shear Wall | m3 | 1349700 |
| **3** | Partitions | | |
| **3.1** | Partition | m2 | 22090 |
| **4** | Finishes | | |
| **4.1** | Stucco | m2 | 698413 |
| **4.2** | Tiles | m2 | 6789632 |
| **4.3** | False Ceiling | m2 | 8816000 |
| **4.4** | Paint | m2 | 867020 |
| **4.5** | Elevator | number | 3840000 |
| **4.6** | Panorama Elevator | number | 4160000 |
| **4.7** | Escalator | number | 48000 |
| **4.8** | Curtain Wall | m2 | 7413250 |
| **4.9** | Rail | m | 108063 |
| **4.11** | Solar Panels | number | 12500 |
| **4.12** | Doors | number | 600000 |

| | | | |
|---|---|---|---|
| **5** | Mechanical | | |
| **5.1** | Sinks | number | 694000 |
| **5.2** | WC units | number | 484256 |
| **5.3** | Diffusers | number | 853210 |
| **5.4** | Sprinkler | m2 | 1225000 |
| **5.5** | collectors | number | 52000 |
| **5.6** | pipes | m | 2623900 |
| **5.7** | grill | number | 88100 |
| **5.8** | fan coil | number | 96500 |
| **5.9** | chiller | number | 824220 |
| **5.11** | shading cantilever | number | 95360 |
| **5.22** | shading shutters | number | 338360 |
| **6** | Electrical | | |
| **6.1** | Electrical points | number | 32100 |
| **6.2** | Lighting | number | 698041 |
| **6.3** | Sockets | number | 60700 |
| **6.4** | Switches | number | 26940 |
| **6.5** | Circuit Parker | number | 18660 |
| **6.6** | Operation for Building | | |
| **6.7** | Simi Movable Davits | number | 40000 |
| **7** | Labor | | 950000 |
| | Total project cost | | 72331005.6 |

- The total cost of the multi-purpose building is about 72.33 million shekels.
- The total cost of the multi-purpose building is about 14.46 million JD.
- The total cost of the multi-purpose building is about 18.54 million dollars.
- The total cost per meter square for the multipurpose building is about 2315 shekels.
- The total cost per meter square for the multipurpose building is about 465 JD.
- The total cost per meter square for the multipurpose building is about 594$ dollars.

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# Appendix