DESIGN OF MECHANICAL SYSTEMS FOR RESIDENTIAL BUILDING IN HEBRON

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Graduation Project Evaluation

According to the project supervisor and according to the agreement of the

Testing Committee Members, this project is submitted to the Department of Mechanical Engineering at College of Engineering and Technology in partial fulfillments of the requirements of (B.SC) degree.

Supervisor Signature

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Committee signature

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Department Headmaster Signature

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Dedication

To our parents who

Spend nights and days doing their best

To give us the best

To all students and our friends who

Wish to look

For the future

To who love the knowledge and

Looking for the new

In this world

Abstract

This project aims to design the mechanical services for residential building constructed in Hebron, where the area of the residential building is 1950 m^2 and consists of three flours and garage with area equal to 519.35 m^2. This building is constructed according to the general trend towards multi-layer construction in the city due to the scarcity of land in the light of the increasing population significantly.

الهدف من هذا المشروع هو تركيب الخدمات الميكانيكيه في المجمع السكني الذي سيتم انشاؤه في مدينة الخليل ، حيث تبلغ مساحة هذا المجمع السكني 1590 متر مربع ويتكون من ثلاثة طوابق بالاضافه لموقف سيارات ، حيث اقيم هذا المشروع بناء على التوجه العام نحو البناء متعدد الطبقات في المدينة نظرا لندرة الاراضي في ظل تزايد سكاني ملحوظ .

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CHAPTER ONE

Introduction

1.1 Introduction.

The residential buildings have a special important in Palestine, due to the increasing in the Population growth, and the lack of lands that owned by citizens as a result of the occupation authority policies that assimilate in confiscation of lands, and restrictions that prevent the ability of people from build freely in many lands; so that the phenomena of many floors residential building has become a familiar mean to end this suffering.

This project contains a full mechanical design for a residential building, and swimming pool as it would be shown in the coming chapters of the project.
The mechanical systems including Air conditioning system ,water supply system, drainage system ,and elevator.

The scope of the project is to study and design the different mechanical systems needed inside the residential building ,and swimming pool, this includes the following main topics:

1.Design the mechanical systems inside the residential building.
2.Theoretical calculations and design of HVAC system.
3.Theoretical calculations and design of plumping system.
4.Theoretical calculations and design of swimming pool system.
5. Theoretical calculations and design of elevator system.
5.To be familiar with the mechanical drawings for different mechanical systems.

Because of the human is the most variable thing that we have, the mechanical design should be complementary psychological and health comfort factors, which help him to complete his duties as required.

1.2 Building Description.

The building is located in AL-Mahawer region in Hebron city, it is planned to serve 45 people.
It consists from three flours with a total area of 1590 (m^2)and garage with a total area of 519.35(m^2), each floor consists of three departments, each department contains (3 bedrooms , kitchen , 2 bathrooms , Guest room) .

Table 1.1 :First floor rooms area.

Department NO	Type of room	NO. of rooms	Total area (m^2)
1	Living room	1	18
	Guest room	1	15
	Dining room	1	6.2
	Bed room	2	32.38
	Main bed room	1	16
	Bathroom	2	9.05
	Kitchen	1	16.86
	Corridors	1	13.9
	Balconies	2	10.56
2	Living room	1	29.03
	Guest room	1	18.26
	Dining room	1	5.87
	Bed room	2	31.84
	Main bed room	1	15.25
	Bathroom	2	9.25
	Kitchen	1	22.1
	Corridors	1	9.3
	Balconies	2	15
3	Living room	1	20.73
	Guest room	1	16.77
	Dining room	1	4
	Bed room	2	29.96
	Main bed room	1	15.6
	Bathroom	2	9.35
	Kitchen	1	22.1
	Corridors	1	15.52
	Balconies	2	9.47
Total area of the first floor rooms			437.35

The building also has the following facilities:

1.Private car parking.

2.Private garden.

3.Outside swimming pool.

4.Elevator.

1.3 Project benefits:

1- To be familiar with the different mechanical drawings.

2- To be familiar with all mechanical calculation and design of system installed in residential buildings.

1.4 Project objectives:

The main objectives of this project are study criteria for designing mechanical systems:

1- Design HVAC system for all floors.

2- Design plumping and drainage system.

3- Design firefighting system.

4- Design of the swimming pool.

5- Design of the elevator.

.

1.5 Time table.

Table 1.2: Time table of the of the first semester.

Week Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Choosing the project idea															
Study the building plane															
Writing the introduction															
Human comfort and load calculations															
Plumbing calculation															
Editing and printing final copy															

Table 1.3: Time table of the of the second semester.

Week / Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Editing the first semester copy															
Choosing HVAC system															
Complete plumbing and drainage															
Firefighting															
Swimming pool design															
Final editing and printing															

1.6 Project layout

Our project is to design a mechanical system in residential building , which consists of air conditioning system, plumbing and drainage system, firefighting system and swimming pool.

This proposal composed of sex chapters as follows:

- Chapter one: Introduction:

  Includes an overview about the project.
- Chapter two: Human comfort:

  Includes an overview about the appropriate conditions for human life in terms of temperature and humidity.
- Chapter three: Load Calculation:

  Includes an overview about the Thermal loads of the building account in the summer and winter.
- Chapter Four: Plumbing system:

  Includes an overview about the water supply, drainage system, plumbing materials, water distribution in buildings, water service sizing.
- Chapter Five: fire fighting system

  which explains the system that we use to fight the fire.
- Chapter Six: swimming pool and elevator design

1.7 Budget

Task	Cost (NIS)
Using Internet	120
Printing Papers	500
Reprinting Paper	100
Total	720

CHAPTER TWO

Human comfort

Heat and Human Comfort

Extreme temperatures (very cold and very hot) can affect on human, so the lack of controlling of the temperature of a hospital can lead to patient and employees dissatisfaction and increased incidence of stress.

The primary job of heating, ventilating and air conditioning system is usually to make people comfortable. The system helps people feel comfort and improves their efficiency. To meet people needs, the HVAC system will effectively manage only the temperature, humidity, air flow and manage the air equality of the exterior environment.

2.1 Human Comfort

People interaction is very complex with their environment; however defining comfort to everyone is difficult for three reasons. First, comfort means subjective feelings and feeling doesn't be measured. Second, comfort is different from one person to other, may be someone is comfort and the other is discomfort or the ideal temperature for each is too worm or too cold. Third, there are many variables that affect human comfort thermal, visual, acoustical and air quality.

2.2 Components of Comfort

1- Physical factors: include sound, light, area-volume, radiation, inspired gas, etc.

2- Reciprocities factors: include clothing, social, incentive and activity.

3- Organism factors: include body type, drive, age, sex, etc.

2.3 Heat and Temperature

Heat is a form of energy that flows from a point at one temperature to another point at a lower temperature and it has two types:

1- Sensible heat: is the heat which causes a change in temperature when it is added or removed.

2- Latent heat: is the heat which causes changes of phase in the substance while temperature remains constant. The two most common temperature scales is:

a. Fahrenheit scale: the most common throughout of united state.

b. Celsius scale: the most common used scientific thermometer throughout the world.

c.

2.4 Properties of Atmospheric Air

Air is a mixture of nitrogen, oxygen ,small amounts of some other gases, and water vapor. It plays an important role and affected the human comfort because the air all the time surrounds the human body at all times. The study of the physical properties and thermal processes of atmospheric air is called psychometrics, and the properties are:

2.4.1 Dry Bulb (db) Temperature

Dry bulb temperature is usually referred to the air temperature that is measured by thermometer. It is called dry bulb because the air temperature doesn't affected by the moisture of the air.

2.4.2 Specific and Relative Humidity

The amount of water vapor in the air can be specified in various ways. Probably the most logical way is to specify directly the mass of water vapor present in a unit mass of dry air. This is called absolute or specific humidity (*humidity ratio*) and is denoted by w.

The amount of moisture in the air has a definite effect on how comfortable we feel in an environment. However, the comfort level depends more on the amount of moisture air holds relative to the maximum amount of moisture air can hold at the same temperature. The ratio of these two quantities is called the relative humidity (Ø), also its value range from 0 for dry air to 1 for saturated air.

2.4.3 Wet Bulb Temperature

Wet bulb thermometer can be measured using a thermometer with the bulb wrapped in wet muslin. A wet bulb thermometer measures the extent of cooling as moisture dries from a surface (evaporative cooling). The wet bulb temperature is always lower than the dry bulb temperature except when there is 100% relative humidity, making the wet bulb temperature a more accurate measurement of product temperature.

2.5 Dew-Point Temperature

The dew point temperature is the temperature at which the air must become cooled in order to become completely saturated with water vapor. If the air is cooled to the dew point temperature, it will become saturated and condensation will begin to form.

2.6 ASHRAE Comfort Chart

ASHRAE is an abbreviation for the American Society of Heating Refrigerating and Air conditioning Engineers. Its Standard Thermal Environmental Conditions for Human Occupancy describes the combinations of indoor space conditions and personal factors necessary to provide comfort in the effective way. There are no static rules that indicate the best atmospheric condition for making all the individual comfortable because human comfort is affected by several factors such as health, age, clothing, etc.

Comfort condition is obtained as a result of tests for which people are subjected to air at various combinations of temperature and relative humilities. The result of such test indicates that a person will feel just about as cool at 24 ^{O}C and 60% RH as at 26 ^{O}C and 30% RH. Studies conducted by ASHRAE with relative humidity between (30%-70%) indicated that 98% of people feel comfort when the temperature and relative humidity combination fall in comfort zones.

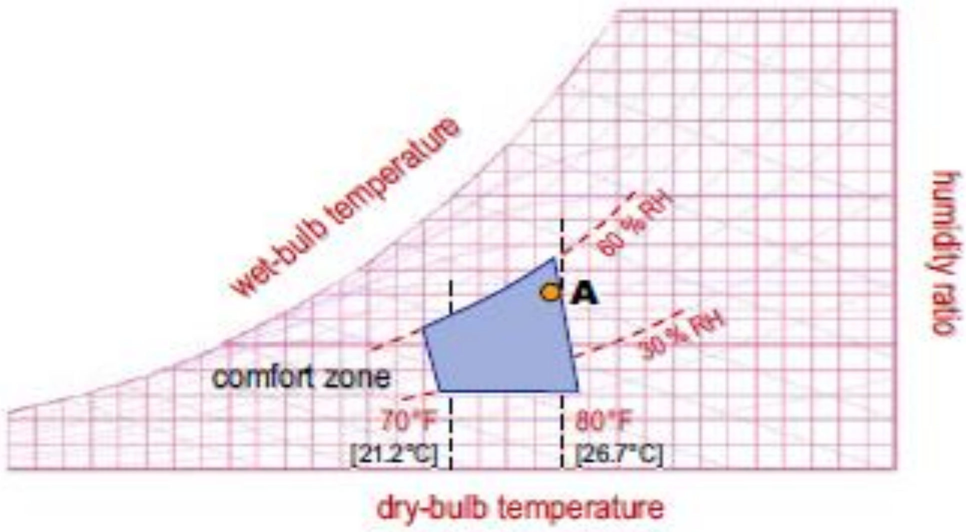

Figure 2.1 The comfort zone defined by ASHRAE standard

CHAPTER THREE

Load Calculation

Heating System

A heating system is combination of equipment that is used to raise the temperature in any location. This can be accomplished by several ways, using energy sources such as: solar, oil, wood, electricity and gas.

3.1 Heating load

The heating load of building consists of the following components:

1) Heat loss through the exposed areas which consist of the walls, the roofs, windows, doors, and walls between the space and unheated spaces.
2) Heat required to warm air infiltrated through cracks of windows and doors, and by opening and closing of doors and windows or to warm mechanical ventilation air to the temperature of the space.
3) Domestic hot water load.
4) Miscellaneous heat load required such as emergency heating loads and safety factor heating load.

3.2 Air conditioning system

Air-conditioning: it's a process that simultaneously conditions air, distributes it, combined with the outdoor air to the conditioned space and controls and maintains the required space's temperature, humidity, air movement, air cleanliness, sound level, and pressure differential within predetermined limits for the health and comfort of the occupants, for product processing or both.

3.2.1 Cooling Load

Cooling load: it is in summer and it is the rate at which heat must be removed from a space in order to maintain the desired conditions in the space. Generally a dry-bulb Temperature and relative humidity.

3.2.2 Cooling load sources

The cooling loads for a given space consist of the following heat gains:

(1) Heat gains that transmitted through building structures such as walls, floors and roof that are adjacent to unconditioned spaces .The heat transmitted is caused by temperature difference that exists on both sides of structures

(2) Heat gain due to solar effect which include:

- Solar radiation transmitted through the glass and absorbed by inside surfaces and furniture.
- Solar radiation absorbed by walls, glass windows, glass doors and roofs that are exposed to solar radiation.

(3) Sensible and latent heat gains brought into the space as a result of infiltration of air through windows and doors

(4) Sensible heat produced in space by lights, appliances, motors and other miscellaneous heat gains.

(5) Latent heat produced from cooking, hot baths, or any other moisture producing equipment.

(6) Sensible and latent heat produced by occupants.

The latent portion of the cooling load is evaluated separately. While the entire structure may be considered as a single zone, equipment selection and system design should be based on a room-by-room calculation. For proper design, the amount of conditioned air required by each room must be known.

3.3 Cooling load calculation

Table 3. 1 Design conditions:

Table Season location	summer	
	Db Degrees (°C)	RH (%)
Inside design condition	22	65
outside design condition	32	50

values taken from palastaiain code in 2011.

Table 3.2 total area for first floor departments:

NO. of department	NO.ROOM	INSIDE WALL AREA $[m^2]$	OUSIDE WALL AREA $[m^2]$	CELLING AREA $[m^2]$	GROUND AREA $[m^2]$	WINDOWS AREA $[m^2]$	DOORS AREA $[m^2]$
1	**1**	**19.70**	**21.05**	**12**	**12**	**3**	**1.8**
	2	**19.70**	**20.20**	**16**	**16**	**3**	**3.6**
	3	**32.17**	**2.75**	**29**	**29**	**15.69**	**6.2**
	4	**19.70**	**20.20**	**16**	**16**	**3**	**1.8**
	5	**31.91**	**11.2**	**16**	**16**	**3**	**3.6**
	6	**18.63**	**20.29**	**16**	**16**	**2.5**	**1.8**
2	**1**	**19.92**	**21.75**	**12**	**12**	**3**	**1.8**
	2	**19.92**	**10.17**	**15.7**	**15.7**	**1.5**	**1.8**
	3	**41.37**	**13.09**	**22.2**	**22.2**	**1.5**	**3.6**
	4	**51.62**	**21.58**	**49.44**	**49.44**	**1.5**	**5.65**
	5	**30.37**	**8.92**	**16**	**16**	**1.5**	**1.8**
3	**1**	**19.92**	**21.75**	**12**	**12**	**3**	**1.8**
	2	**19.92**	**10.17**	**15.7**	**15.7**	**1.5**	**1.8**
	3	**41.37**	**3.09**	**22.2**	**22.2**	**1.5**	**3.6**
	4	**51.62**	**21.58**	**49.44**	**49.44**	**1.5**	**5.65**
	5	**30.37**	**8.92**	**16**	**16**	**1.5**	**1.8**

3.4 Over All Heat Transfer Coefficient (U)

$$U = \frac{1}{R_{th}} = \frac{1}{\frac{1}{h_i} + \frac{\Delta x_1}{k_1} + \frac{\Delta x_2}{k_2} + \cdots + 1/h_0} \qquad \textbf{[3.1]}$$

h_i : Convection coefficient (surface conductance) of inside wall, floor, or ceiling from the Palestinian code for Hebron City.

h_i=9.37 W/m^2 .^{o}C

h_0 : Convection coefficient (surface conductance) of outside wall, floor, or roof from the Palestinian code for Hebron City.

h_0= 22.7 W/m^2 .C^o

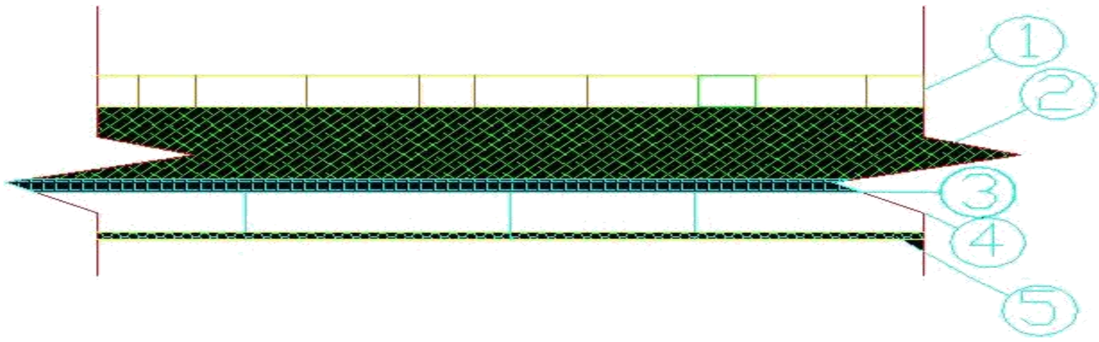

Figure 3. 1 outside wall construction

Table 3. 3 the thermal conductivity & thickness (x) for the outside walls

Construction	material	Material thickness (m)	Rth(W/m. °C)
1	Stone	0.07	1.7
2	Concrete	0. 2	1.75
3	Polyurethane	0.03	0.04
4	Block	0.01	0.95
5	Plaster	0.03	1.2

U = 0.92 W/m^2 . ^{o}C

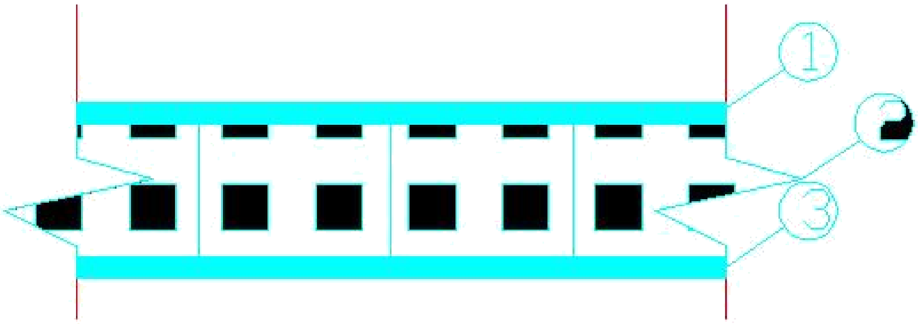

Figure 3. 2 inside wall construction

Table 3. 4 Construction of inside wall

Construction	Material	Material thickness (m)	Rth(W/m. °C)
1	Plaster	0.02	1.2
2	Block	0.1	0.95
3	Plaster	0.02	1.2

U =3.4 $W/m^2 . ^oC$

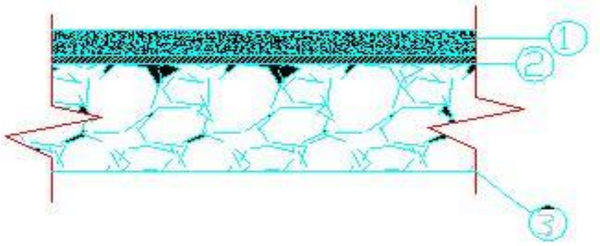

Figure 3. 3 ground construction

Table 3. 5 construction of ground

Construction#	Material	Material thickness(m)	Rth(W/m. °C)
_	tiles	0.02	1.1
1	sand	0.1	0.7
2	mortar	0.02	1.2
3	rock	0.5	1.05

U =1.27 W/m^2 . ^{o}C

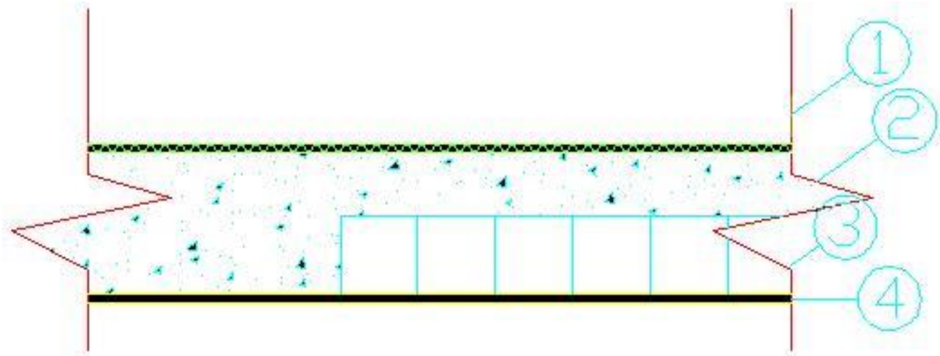

Figure 3.4 ceiling construction (roof)

Table 3. 6 Construction of ceiling (roof)

Construction #	Material	Material thickness (m)	Rth(W/m. °C)
1	Asphalt	0.02	0.81
2	Concrete	0.15	1.75
3	Cement block	0.1	0.95
4	Plaster	0.02	1.2

U = 2.61 $W/m^2 . ^oC$

Table 3. 7 Over all heat transfer coefficient for each section in the building

NO of construction	Type of section	Over all heat transfer coefficient [$W/m^2 . ^oC$]
1	Outside wall	0.92
2	Inside wall	3.4
3	Ground	1.27
4	Ceiling (roof)	2.61
5	Wood door	3.6
6	Glass window	5

3.5 Heat Gain through Sunlit Walls and Roofs

Direct and diffused solar radiation that is absorbed by walls and roof result in rising the temperature of these surface , amount of radiation absorbed by walls and roofs depends upon time of the day, building orientation, types of wall construction and presence of shading.

The calculation of this type of heat gain be obtain by using the following relation for heat transmission through walls.

$$Q = U * A * CLTDcorr \qquad \textbf{[3.2]}$$

the magnitude of heat transfer through inside walls can be calculated by :

$$Q = U * A * \Delta T$$

Where:

$$Q = U*A*(CLTD)_{corr} \qquad \textbf{[3.3]}$$

CLTD: is called cooling load temperature difference for sunlit roofs and walls

$$(CLTD)corr = (CLTD + LM)\ K + (25.5 - Ti) + (To, m - 29.4)\ f$$

$$T_{out.m} = (T\ max + T\ min) / 2 \qquad \textbf{[3.5]}$$

$$= (35 + 17) / 2 = 28.5\ ^{o}C$$

$$* Ti = 22\ ^{o}C$$

(CLTD) $_{corr}$ for windows

LM: Latitude correction factor for horizontal and vertical surfaces (Appendix A) Table (1) K: colors adjustment factor such that k=1.0 for dark colored roofs, & k=0. 5 for Permanently Light colored walls.

(25.5-Ti): a correction factor for indoor design temperature where Ti is the room design temperature 22 °c.

(To, m -29.4): a correction factor for outdoor mean temperature $T_{out.m}$, f: attic or roof fan factor such that f=1 if there is no attic or roof fan & f = 0.75 if there is an attic or roof fan.

Q: Heat flow through the walls by conduction.

(Watt) U: Over all heat transfer coefficient

(W/m².K).

A: Outdoor Area of heat conduction. (m²).

ΔT : The temperature differential across the wall in Celsius .

Table 3 .8 Estimation of Cooling Load for each Region.

NO	Direction	CLTD	LM	(CLTD)$_{corr}$
1	N	1	0.5	2.075
2	E	10	0.0	7.6
3	S	11	-1.6	7.2
4	W	6	-0.5	-
5	Roof	5	0.5	-

CLTD) corr for walls and roof:

(CLTD) corr = (CLTD+ LM) K + (25.5-Ti) + (To, m -29.4) f

(CLTD) corr for north walls = (1+0.5)*0.65 + (25.5-22) + (27-29.4)*1= 2.075°C (CLTD) corr for east walls = (10+0.0)*0.65 + (25.5-22) + (27-29.4)*1=7.6C (CLTD) corr for south walls = (11+ -1.6)*0. 65+ (25.5-22) + (27-29.4)*1=7.2 °C

3.6 Heat Transmitted through glass

$Q_{TOTAL} = Q_{convection} + Q_{transmission}$ **[3.6]**

$Q_{convection}$: Heat flow through the windows, by conviction. (Watt)

$Q_{transmission}$: Heat gain due to solar transmission through glass windows (Watt)

Solar radiation which falls on glass has three components which are:

- Transmitted component: it represents the largest component, which is transmitted directly into the interior of the building or the space. This component represents about 42% to 87% of incident solar radiation, depending on the glass transmissibility value.

- Absorbed component: this component is absorbed by the glass itself and raises its temperature. About 5 to 50% of solar radiation it absorbed by the glass, depending on the absorptive value of the glass.

- Reflected component: this component is reflected by the glass to the outside of the building. About 8% of the solar energy is reflected back by the glass.

The amount of solar radiation depends upon the following factors:

1- Type of glass (single, double or insulation glass) and availability of inside shading. 2- Hour of the day, day of the month, and month of the year.
3- Orientation of glass area. (North, northeast, east orientation, etc). 4- Solar radiation intensity and solar incident angle.
5- Latitude angle of the location.

Q CONV = U*A*(CLTD) corr

Q CONV: Heat flow through the windows, by convection. (Watt)

U: Over all heat transfer coefficient ($W/m^2.K$).

$$U = \frac{1}{R_{th}} = \frac{1}{\frac{1}{h_i} + \frac{\Delta x_1}{k_1} + \frac{\Delta x_2}{k_2} + \cdots + 1/h_0}$$

A: Out windows Area of heat conduction. (m^2)

K: conduction heat transfer coefficient in regular glass

(W/m.K). ΔX: wall component thickness (m).

hi: Indoor convection heat transfer coefficient (W/m^2.K).

ho: Outdoor convection heat transfer coefficient (W/m^2.K).

(CLTD) corr: is the temperature difference determined by equation:

(CLTD) corr = (CLTD+ LM) K + (25.5-Ti) + (To, m -

29.4) f Q TR. = A (SHG)*(SC)*(CLF)

Q TR: Heat gain due to solar transmission through glass windows (Watt)

SHC: Solar heat gain factor: this factor represents the amount of solar energy that would be received by floor, furniture and the inside walls of the room and can be extracted from (Appendix B) Table(10).

SC: Shading coefficient: this factor accounts for different shading effects of the glass wall or window and can be extracted from (Appendix B) Table (4) for single and double glass without interior shading or from (Appendix B) Table(5) for single and double glass as well as for insulating glass with internal shading.

CLF: Cooling load factor: this represent the effects of the internal walls, floor, and furniture on the instantaneous cooling load, and can be extracted from (Appendix B) Table (6)

SHG: in July

SHG NORTH = 126 w/ m^2. SHG SOUTH = 227w/ m^2. SHG WEST = 678 w/ m^2.

SHG EAST = 678 w/ m^2.

SC: Shading coefficient for glass windows with interior shading (dark –double glass) = 0.6 W/ m^2.K

CLF: with interior shading at solar time 14 hours.

CLF NORTH = 0.86, CLF SOUTH = 0.68, CLF WEST = 0.22, CLF EAST = 0.22

3.7 Sample Calculations for Cooling & Heating Load

room #1 in the first floor is taken as a sample of our load calculation.

3.7.1 Sample of cooling load

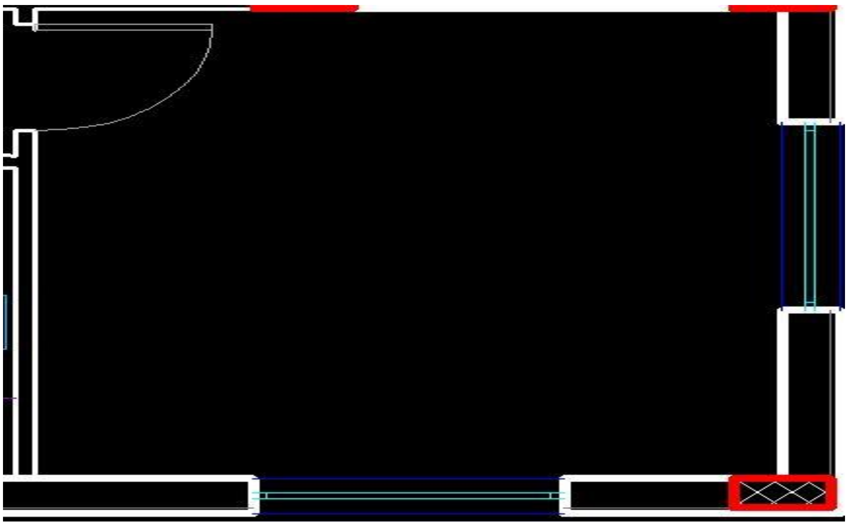

Figure 3.5 sample calculation for cooling load

- **For walls**

Q= U*A*(CLTD) corr

Q: Heat flow through the walls by conduction. (Watt)

U: Over all heat transfer coefficient (W/m².C).

A: Outdoor Area of heat conduction. (m²).

Q north wall = U*A*(CLTD) corr

=3.4*(3.82*2.75)*2.075

= 74.1 W

Qwest .in= U*A* ΔT

= 3.4*(2.97*2.75)*5

= 138.84 W.

Q_{south}= U*A*(CLTD) corr

= 0.92*(4.82*2.75)*7.2

= 87.8 W.

Q_{east}= U*A*(CLTD) corr

=3.4*(4.6*2.75)*7.6

= 326.87 W

- **For floor**

Q= U*A*ΔT

= 1.27*(3.82*4) * (5)

= 97.02 W.

- **For ceiling**

Q= U*A*(CLTD) corr

= 2.61 * (4*3.82) *7.2

= 287.14 W

- **For glass**

Q TR. = A (SHG)*(SC)*(CLF) **[3.7]**

SHG: in July

SHG NORTH= 126 w/ m².

SHG SOUTH = 227w/ m².

SHG WEST = 678 w/ m².

SHG EAST = 678 w/ m².

SC: Shading coefficient for glass windows with interior shading (dark –double glass) = 0.6 W/ m².K

CLF: with interior shading at solar time 14 hours.

CLF NORTH = 0.86

CLF SOUTH = 0.68

CLF WEST = 0.22

CLF EAST = 0.22

Qtransmitted.east = A (SHG)*(SC)*(CLF) = (1*1.5)*678*0.6*0.22

=134.2 W

Qtransmitted.south = A (SHG)*(SC)*(CLF) = (1*1.5)*277*0.6*0.22

=54.84 W

- **For Inner door**

U= 3.6(W/m².C)

$Q_{door}= U_{door}$ A (To-Ti)

Q_{door} = 3.6 * 0.9*1.8*(5) = 29.16 W

- **Heating gain due to occupants:**

Q total for occupant = Q sensible + Q latent

[3.8]

Q latent = heat gain latent * No. of people* Diversity

Factor Q latent = 57*2 * 0.5 =57 W

Q sensible = heat gain sensible * No. of people* CLF* Diversity

Factor Q sensible = 71.5*2 * 0.5 * 0.5 = 35.75 W

Q total due to occupant

92.75W

Q total= 1274.97 W

3.8 Heating Load

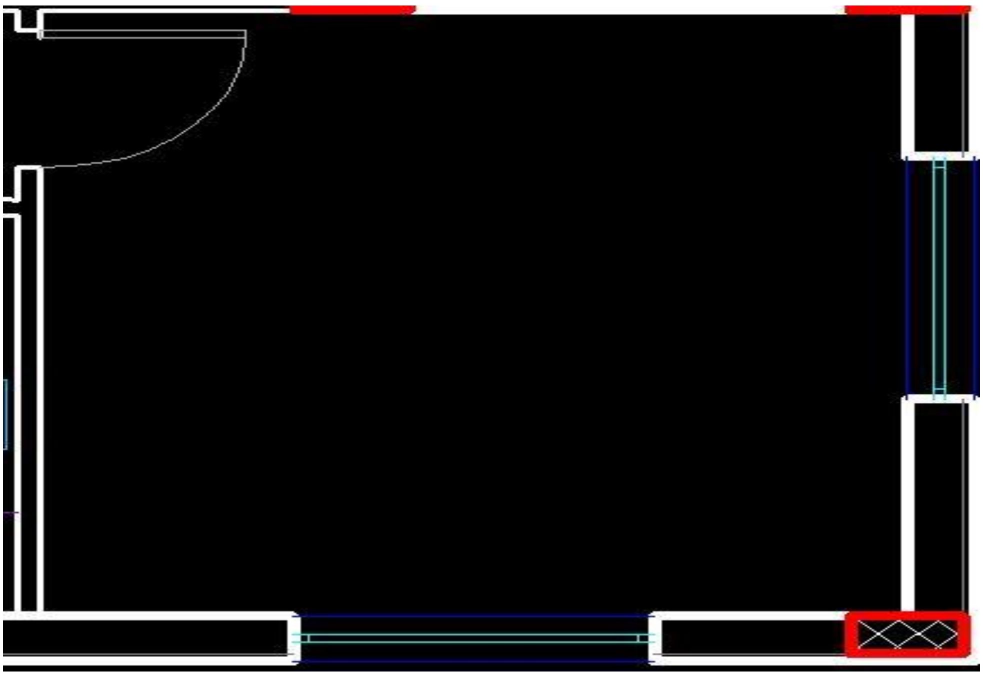

Figure 3.6 sample calculation for heating load

$$Q_T = Q_{inside\ walls} + Q_{outside\ walls} + Q_{windows} + Q_{doors} + Q_{groud} + Q_{celling} \quad \textbf{[3.9]}$$

$Q_{inside} = U * A * \Delta T$ = 3.4 *19.70*5 = 334.9 W

= 0.92 *21.05*16 = 309.85 W$Q_{outside} = U * A * \Delta T$

$Q_{windows} = U * A * \Delta T$ = 5 *3 *16 = 240 W

$Q_{doors} = U * A * \Delta T$ = 3.6 *(0.9*2)*5 = 32.4 W

$Q_{celling} = U * A * \Delta T$ = 2.61*12*16 = 501.12 W

$Q_{ground} = U * A * \Delta T$ = 1.27*12*16 = 243.84 W

Qtotal = 1662.1 W

Total cooling and heating loads for the first floor

Table 3. 9 Total cooling and heating load for the first floor.

NO of department	NO of room	Heating load (W)	Cooling load (W)
1	1	1662.1	1274.97
	2	1680.5	1400.4
	3	2030.37	1619.9
	4	1672.38	1393.7
	5	1736.17	1446.8
	6	1597.76	1331.4
2	1	1680.14	1400.1
	2	1490.89	1242.41
	3	1720.88	1433.4
	4	2213.65	1844.71
	5	925.13	770.9
	1	1680.14	1100.9
	2	1490.89	862.9

3	3	1720.88	1165.6
	4	2213.65	1876.8
	5	925.13	688.6
Total load for first floor		26440.7	22033.9

3.8.1 Selection of HVAC system

Outdoor unit: Panasonic/AQUAREA1 12Kw /WH-ADC1216G6E5.
Indoor unit: Panasonic/wall mounted Etherea Inverter + Silver /KIT-XE7-QKE

3.8..1.1 Advantages of VRF system

1) Cooling and heating load in different rooms.
2) Flexible.
3) More efficient and comfort.
4) Small space required.
5) Reliable.

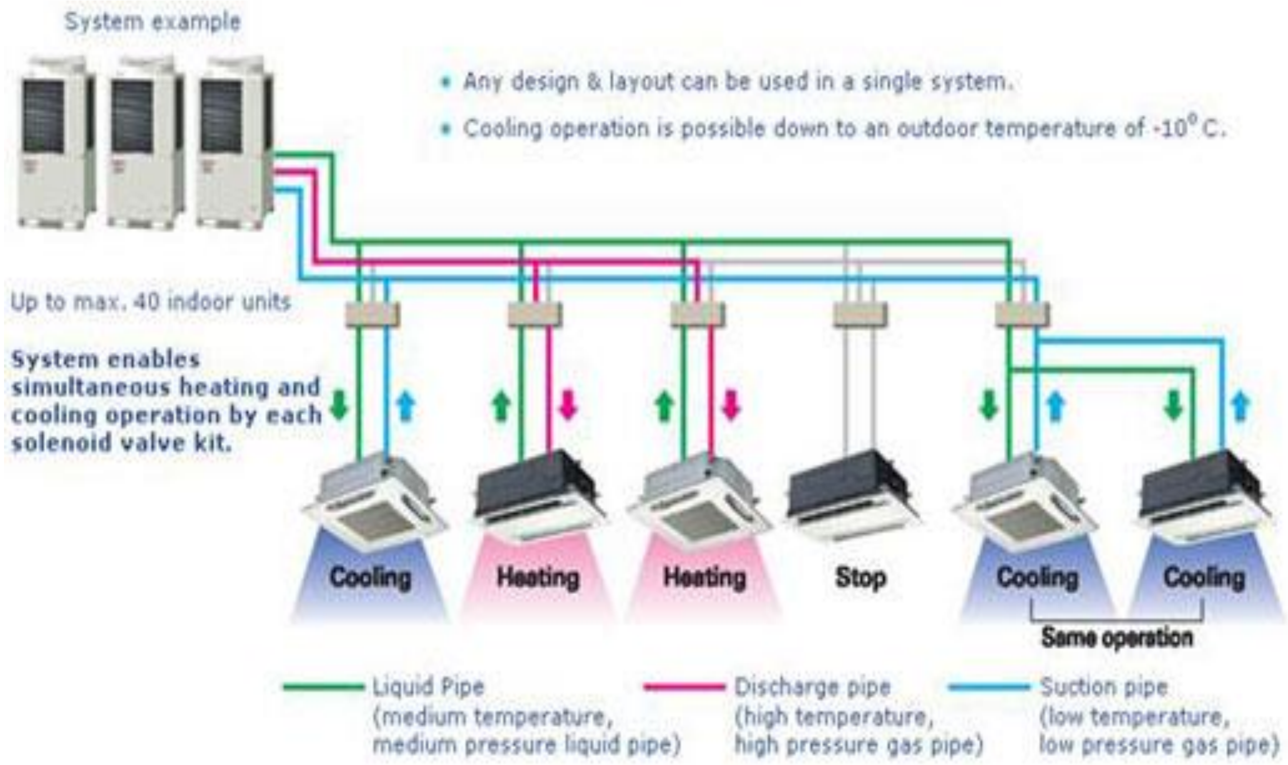

Figure 3.7 VRF components

3.8.2 calculation of ventilation fan

Ventilation is used in the places where there is a possibility for odors and bad smiles to happen .

3.8.2.1 Sample calculation for kitchen :

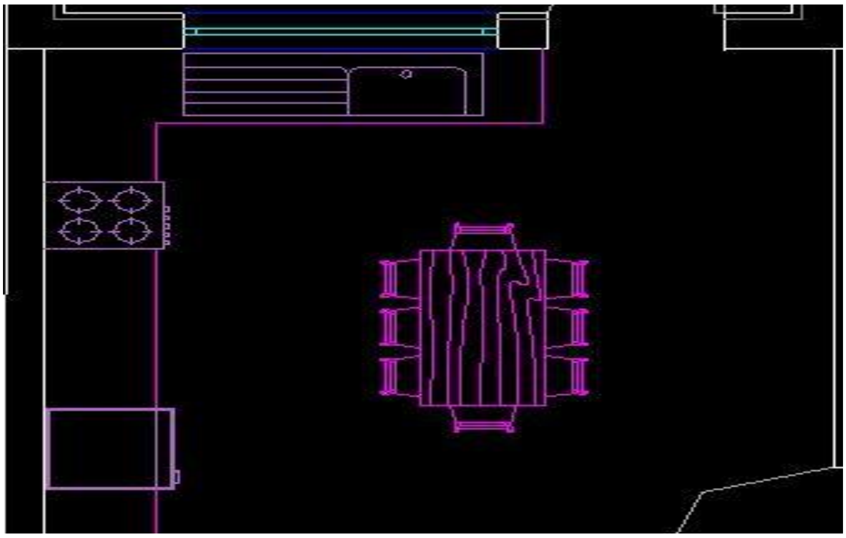

Figure 3.8 sample calculation for ventilation

Length = 4.26m = (4.26/0.305) = 13.96 ft

Width = 4.21m = 13.80 ft

Height =2.75m = 9ft

Total volume of the kitchen = L*W*H =13.96 *13.8*9 =1736.9 ft^3

Volume * NO..air change per hour = 1736.9 * 15 = 26054.85 CFH

=26054.85/60 =434.24 CFM

Table 3.10: ventilation calculation.

NO. of floor	Room Name	Volume (ft^3)	Total CFM
First floor	Kitchen	1736.9	434.24
	Bathroom	431.4	57.52
Second floor	Kitchen	1755.1	438.7
	Bathroom	431.4	57.52
Third floor	Kitchen	1755.1	438.7
	Bathroom	431.4	57.52

Type of suction fan is TOSHEPA WALL VENTILATOR VRH-30S1which have the following specifications :

* AC 220 V/ 50 Hz
* Plastic body and blades
* 2 directions
* Easy for cleaning
* Safety back window
*More than 5000 working hours

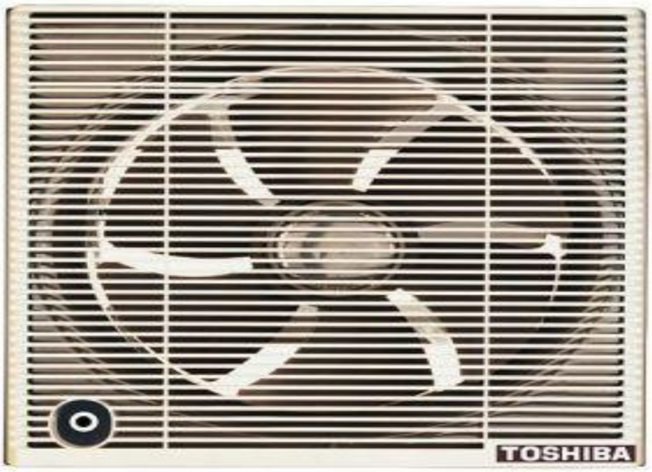

Figure 3.9 Toshiba suction fan

CHAPTER FOUR

Plumbing system

4.1 Introduction

One of the two basic functions of building plumbing system is supply of water .The other is drainage in the majority of building ,only potable water is supplied ,regardless of its eventual use .The source of water is almost a water utility pipeline in the street . wells are used in isolated areas . it's the plumbing technologists responsibility to design the entire water service and distribution system for all uses ,recognizing the pressure and flow limitations .

The goal of modern plumbing design for buildings is to provide the necessary quantity of water for daily uses, such as drinking, cooking, washing and flushing, drinking ,fire fighting, bathing, and irrigation .

4.2 Water Quantity and Sources

Water covers approximately 70% of the earth's surface in oceans ,lakes ,rivers, and glaciers. Over 97% of this water is inaccessible (not suitable for direct use) because it is salty or frozen in the polar ice caps .

The water sources can be divided into surface water and ground water sources . the primary source of a water supply is rainfall. Water constantly circulates ,powered by the earth's solar energy .

Distilled water, which is very expensive due to price increase of fuel ,has a limited application for water supply .

4.3 Water kinds

a) Potable water: which is tested and treated to be suitable for human drinking, cooking and bathing.
b) Non-potable water: surface water, ground water, or collected water that contains some degree of impurity. This water can be used for any purpose except human drinking, cooking and bathing.
c) Gray water: water discharged from dishwasher, washing machines, bathtubs, sinks and other fixture except waste water from toilets or urinals.
d) Black water: water containing toilets and urinals wastes.
e) Distilled water: pure water by using distillation, its commonly used in laboratories, and is not economical for the use in water supply because of its high price.

Basic principles of plumbing:

The main goal of plumping design for buildings provide domestic water, and removing sanitary wastes.

4.4 Water Supply

4.4.1 Water Supply calculation

To determine the pipe size for cold and hot water we must calculate the water supply fixture unit (WSFU) for each fixture and fixture unit total on each piping run out and determine the minimum flow pressure required at the most remote outlet.

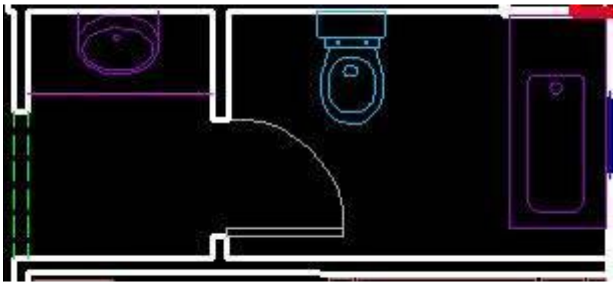

Figure 4.1 sample calculation for water supply .

Table 4.1: Sample calculation for water supply :

Name of Fixture Unit	NO.FU	Demand per fixture unit	Cold water demand (WSFU)	Hot water Demand (WSFU)
Lavatory (private)	1	1*3/4	0..75	0.75
Water closet	1	5*3/4	3	0.0
Bathtub	1	2*3/4	1.5	1.5
Total load (WSFU)			5.25	

Table 4.2 Plumbing calculation for the first floor:

FU department(1)	#NO of FU	Demand per fixture unit	Total demand for cold water	Total demand for hot water(WSFU)
Kitchen sink (private)	1	4*(3/4)	3	3
Lavatory(private)	2	1*(3/4)	1.5	1.5
Water closet	2	5*(3/4)	6	0.0
Bathtub	2	1*(3/4)	1.5	1.5
FU department(2)	#NO of FU	LOAD/FU	Total demand for cold water	Total demand for hot water
Kitchen sink (private)	1	4*(3/4)	3	3
Lavatory(private)	2	1*(3/4)	1.5	1.5
Water closet	2	5*(3/4)	6	0.0
Bathtub	2	1*(3/4)	1.5	1.5
FU department(3)	#NO of FU	LOAD/FU	Total demand for cold water	Total demand for hot water
Kitchen sink (private)	1	4*(3/4)	3	3
Lavatory(private)	2	1*(3/4)	1.5	1.5
Water closet	2	5*(3/4)	6	0.0
Bathtub	2	1*(3/4)	1.5	1.5
Total demand of water for the first floor				36

Total demand water for the building (WSFU) = 36 *3 =108 WSFU.

Total demand water for the building (gpm) = 70.4 gpm

4.4.2 Design of the well

Daily domestic water consumption = 153 m^3/day

Daily irrigation water consumption = 1 m^3/day

Total daily water consumption for the building = 154 m^3/day

Multiple by 10% safety factor = 169.4 m^3/day

assuming 9 families in the the building ,and the consumption of each family is 20-25 meter cubic / month

for 15 days , the storage capacity for underground tank = 338.8 m^3

Dimension of the well :

length = 8 m

width = 7

Depth = 6.5 m

for firefighting uses, the needed amount of water = 1/3 * 338.8 = 112.9 m^3

4.5 calculations for supply water pipes diameter

The maximum instantaneous water depend on :

1. The amount of total water demand for cold water = 70.4 gpm

2.The amount of total water demand for hot water = 18 gpm So, the total demand for cold and hot water = 88.4 gpm

3.The available main pressure at the level outlet is :

Main pressure = Static head pressure + Friction head pressure + Main flow pressure

Static head = (Height of floors +Height of water tank + Height of stairs well + Height of FU)

height of floors = 12 m

height of stairs well = 4m

height of water tank = 2m

height of FU = 1.05 m

Static head = (12+2+4+1.05) = 19.05 m = 62.5 ft

Static head pressure = 62.5* 0.433 = 27.1 psi

Total equivalent length (TEL): the distance from water tanks to the collector in ground floor + distance from collector to fixture unit

TEL = longest run * 1.5 TEL= 101.71 * 1.5 = 151.5 ft

Min flow pressure of the critical fixture = 8 psi

Friction head = static pressure – min flow pressure = 27.1 – 8 =19.1 psi

Uniform friction loss = friction head / TEL = 19.1 / 151.5 = 12.60 psi/100ft

from APPENDIX A fig 9.7 the main diameter = 2 inch, and the branch diameter for each floor = 1.5 inch

Table 4.3: water pipe diameters.

NO .floor	NO .collector	Total HW demand (WSFU)	Total CW demand (WSFU)	D.HW(in)	D.CW(in)
First floor	Collector 1	22.5	40.5	3/4"	3/4"
	Collector 2	22.5	40.5	3/4"	3/4"
	Collector 3	22.5	40.5	3/4"	3/4"
Second floor	Collector 1	22.5	40.5	3/4"	3/4"
	Collector 2	22.5	40.5	3/4"	3/4"
	Collector 3	22.5	40.5	3/4"	3/4"
Third floor	Collector 1	22.5	40.5	3/4"	3/4"
	Collector 2	22.5	40.5	3/4"	3/4"
	Collector 3	22.5	40.5	3/4"	3/4"

4.6 Selection the diameter and the slope of the drainage pipe system

1. Branches from fixture unit to the floor drainage (F.D.) with diameter (2") for lavatory and shower and with slope(1%).
2. Building Drains from fixture unit to the manhole with diameter (4") for water closet with flush valve and with slope (1% - 2%).
3. Sewage Pipes between manholes with diameter (6") and with slope (1.5%), and the waste water will transfer between manholes until it reach the main Manhole.
4. Floor trap (F.T.) at the end of the branches as a collection box for this pipes and in order to provide a water seal to prevent odors, sewage gases and vermin's from entering building.
5. Clean out (C.O) at the end of the branches in order to clean the pipes from any things that can blockage and close the pipes.
6. Stack with diameter (4") in order to drain the waste water to the manholes.

4.4.1 Manholes calculations

Depth of the first manhole is (50 cm) and the second manhole is calculated according to the following equations.

For Manhole.1:

Top level = 0.0 m

Depth = 0.5 m

Outlet level = Top level – Depth

= 0.0- 0.5

= -0.5 m

For Manhole 2:

The distance between Manhole 1 &Manhole 2 is 3.22 m.

Depth of Manhole 2 is:

Depth = ((distance*Slope) + depth Manhole1 +5 cm) = 60 cm

Outlet level Manhole.2 =Top level-Depth Manhole.2= 0.0- 0.60 = -0.60m

The slope is 1.5% .

Invert level of Manhole.2 = Outlet Level of Manhole.2 + 5 cm= -0.65 m

The following table shows calculations and dimensions of all manholes that used in our project:

Table 4.4 Manholes Calculations.

Manhole NO.	Top Level (m)	Invert Level (m)	Outlet Level (m)	Depth (cm)	Diameter (cm)	Cover	Type
Manhole 1	0.0	- 0.55	- 0.5	50	60	Medium	8 Ton
Manhole 2	0.0	- 0.65	- 0.60	60	60	Medium	8 Ton
Manhole 3	0.0	-0. 85	-0.8	80	60	Medium	8 Ton
Manhole 4	0.0	-1.05	-1.00	100	80	Medium	8 Ton
Manhole 5	0.0	- 1.15	-1.10	110	80	Medium	8 Ton
Manhole 6	0.0	- 1.20	- 1.15	115	80	Medium	8 Ton
Manhole 7	0.0	-1.25	-1.20	120	80	Medium	8 Ton
Manhole 8	0.0	-1.37	-1.32	132	100	Medium	8 Ton

Manhole 9	0.0	-1.45	-1.40	140	100	Medium	8 Ton
Manhole 10	0.0	-0.55	-0.5	50	80	Medium	8 Ton
Manhole 11	0.0	-0.72	-0.68	68	80	Medium	8 Ton
Manhole 12	0.0	-0.88	-0.83	83	80	Medium	8 Ton
Manhole 13	0.0	-1.00	-0.95	95	80	Medium	8 Ton
Manhole 14	0.0	-1.15	-1.10	110	80	Medium	8 Ton

CHAPTER FIVE

Firefighting system

5.1 Firefighting system

Fire Definition:

a process in which substances combine chemically with oxygen from the air and typically give out bright light, heat, and smoke; combustion or burning.

Fire protection definition:

Fire protection is the study and practice of mitigating the unwanted effects of potentially destructive fires it involves the study of the behavior, compartmentalization, suppression and investigation of fire and its related emergencies.

5.2 Fire Classification

Classes of Fire - A, B, C, D, and K

Fires are classified by the types of fuel they burn.

Class A

Class A Fires consist of ordinary combustibles such as wood, paper, trash or anything else that leaves an ash. Water works best to extinguish a Class A fire.

Class B

Class B Fires are fueled by flammable or combustible liquids, which include oil, gasoline, and other similar materials. Smothering effects which deplete the oxygen supply work best to extinguish Class B fires.

Class C

Class C Fires. Energized Electrical Fires are known as Class C fires. Always de-energize the circuit then use a non-conductive extinguishing agent. Such as Carbon dioxide.

Class D

Class D Fires are combustible metal fires. Magnesium and Titanium are the most common types of metal fires. Once a metal ignites do not use water in an attempt to extinguish it. Only use a Dry Powder extinguishing agent. Dry powder agents work by smothering and heat absorption.

Class K

Class K Fires are fires that involve cooking oils, grease or animal fat and can be extinguished using Purple K, the typical agent found in kitchen or galley extinguishers.

5.3 Firefighting objectives

The objective is always to save lives and property. But innovative fire protection does more. It combines science and economics. A superior, environmentally friendly fire suppressant. Easier and more cost-effective installations. Advanced methods for protecting more challenging applications.

5.4 Types of Firefighting Systems

Fire systems are classified as follows:

5.4.1 Portable Fire Extinguishers

Portable fire extinguishers can contain a wide variety of extinguishing agents; the portable fire extinguishers enable an individual with minimal training to extinguish an incipient fire.

A portable fire extinguisher should not be considered as the sole solution to fire protection analysis of a building but, rather only one of many components of a total fire protection plan.

5.4.1.1 Types of Portable Firefighting Extinguishers

1) Foam: fire extinguishers extinguish the fire by taking away the heat element of the fire triangle. Foam agents also separate the oxygen element from the other elements.

   Water extinguishers are for Class A fires only - they should not be used on Class B or C fires. The discharge stream could spread the flammable liquid in a Class B fire or could create a shock hazard on a class C fire.

   Foam extinguishers can be used on Class A & B fires only. They are not for use on Class C fires due to the shock hazard.
2) Carbon Dioxide: Carbon dioxide fire extinguishers extinguish the fire by taking away the oxygen element of the fire triangle and also by removing the heat with a

very cold discharge. Carbon dioxide can be used on Class B & C fires. They are usually ineffective on Class A fires.

3) Clean agent extinguishers: Halogenated or Clean Agent extinguishers include the halon agents as well as the newer and less ozone depleting halocarbon agents. They extinguish the fire by interrupting the chemical reaction of the fire triangle.
4) Dry chemical extinguishers, hand and wheeled: fire extinguishers extinguish the fire primarily by interrupting the chemical reaction of the fire triangle
5) Wet chemical extinguishers: Wet Chemical is a new agent that extinguishes the fire by removing the heat of the fire triangle and prevents reigniting by creating a barrier between the oxygen and fuel elements and use in kitchen.
6) Dry Powder: extinguishers are similar to dry chemical except that they extinguish the fire by separating the fuel from the oxygen element or by removing the heat element of the fire triangle. .

Building featuring more than one occupancy may be protected on a room or area basis, with extinguishers appropriately placed for the occupancy. An example is a school, which would be expected to be protected with extinguishers rated for class hazards and light hazard occupancy, but also may contain a laboratory with a significant quantity of flammable liquid hazard, which would be protected by extinguishers rated for class B hazards and ordinary hazard occupancy

5.5 Fire Hose cabinet:

Fire hose cabinet categorized into of three classes:

A) Class I Systems:

1) At each intermediate landing between floor levels in every required exit stairway

2) On each side of the wall adjacent to the exit openings of horizontal exits.

3) At the entrance to each exit passageway or exit corridor, and at exterior public entrances to the mall.

4) Travel distance =46 m (with throw) – general design at 35 m.

B) Class II Systems:

1) Travel distance =36 m (with throw) – general design at 30 m.

C) Class III Systems: combined of class I and class II.

Fire house cabinet includes two types:

a) Hose Reel :

Figure 5.1 Hose Reel

b) Hose Rack:

Figure 5.2 Hose Rack

Fire Hose cabinet should be installed according to NPFA 14 and shown in drawings:

1-Near escape stairs

2- 30 m(100ft) length of the pipe which is the distance traveled by the pipeline passing

barriers and walls until it reaches the fire place .

3- Next to the main door of the building.

4- Fire house cabinet height above the ground (90-150)cm.

5- The Pipe that enters the cabinet diameter is 1’’or 1.25’’ and the flow should be 100gpm at pressure 4.5 bar.

5.5.1 Fire hose reel.

A **fire hose** is a high-pressure hose that carries water or other fire retardant (such as foam to a fire to extinguish it. Outdoors, it attaches either to a fire engine or a fire hydrant.

Indoors, it can permanently attach to building's stand pipe or plumbing system.

Hero invented it and based it on double action piston pump.

Consist of tow type:

- Hose reel a pipe which consists of rubber rolled on pulley having an arm witch use by regular people.

Figure 5.3 fire hose

- Hose rack: a pipe which consists of Cloth-reinforced which usually used by Civil Defense Company.

5.5.2 Fire hose calculation and pump selection

The pipe is manufacturing from the steel.

- **Friction Loss In Fire Hose:**

Friction loss (FL) :is the most important variable to be considered in fire ground hydraulics. Each appliance, fitting, coupling, section of hose and everything else through which water flows will impede the flow through friction.

Friction loss can be calculated by :

$FL = C\ Q^2 L$ **[5.1]**

where :

FL = friction loss in psi.

C = friction loss coefficient.

Q = quantity of water flowing or flow rate in gpm.

L = hose length in hundreds of feet.

2.5 pipe inch is to be for house diameter, so the value of C = 2

Hose Diameter and Type (inches)	Coefficient (C)
3/4 inch booster	1100
1" booster	150
1 1/4 "booster	80
1 1/2 "rubber lined	24
1 3/4 with 1 1/2" couplings	15.5
2 1/2" rubber lined with 1 1/2" couplings	8
2 1/2 rubber lined	2
2 3/4" with 3" couplings	1.5
3" with 2 1/2" couplings	0.8
3" with 3" couplings	0.677
3 1/2"	0.34
4"	0.2
4 1/2"	0.1
5"	0.08
6"	0.05
4" standpipe	0.374
5" standpipe	0.126
6" standpipe	0.052

Fig 5.4 Hose cabin Coefficient (C)

In hose cabin there are two ports one of them for un trained people and its 1.5 inch and give flow of 100 gpm, the other is for firefighting men its 2.5 inch with 250 gpm flow and 4.5 bar .

FL =C Q^2L

= 2 * (100^2) * 30/100 = 0.6 psi

5.4.2 hand fire extinguishers :

Fire extinguishers are 'rated' on their ability to extinguish test fires. In the case of class A, (which is paper, cardboard carbonaceous material a wooden crib of specific size and length is ignited, and the amount of burning crib that can be extinguished is measured.

British Standard 5306 contains formulae for calculating the number of class A extinguishers as follows: floor area (m^2) x 0.065 divided by the extinguisher rating, however this is sometimes impractical particularly in large or complex buildings.

To simplify things, as a rule of thumb in factories, offices and shops was adopted, one 13A extinguisher covers 200 square meters of floor area.

the number of fire extinguishers needed for the first department

= Area of floor /200 **[5.3]**

= 138.04/200 = 0.69 round up to1

but there should be a minimum of 2 extinguishers per floor, unless the upper floor area is very small i.e. below 100m2.

Table 5.1: extinguishers needed in the building

floor NO floor	NO of department	Total Area (m^2)	NO of extinguishers needed
1	Department 1	138.04	2
	Department 2	155.81	2
	Department 3	143.50	2
2	Department 1	138.04	2
	Department 2	155.81	2
	Department 3	143.50	2
3	Department 1	138.04	2
	Department 2	155.81	2
	Department 3	143.50	2
Ground floor		519.35	3

Where it is desirable to have smaller, lighter extinguishers, foam, or water with additives, can be used to reduce weight whilst maintaining fire fighting capability. e.g. 6 Liter AFFF foam spray extinguishers are usually rated at 13A, but are approximately 30% lighter than 9 liter water.
Specialized extinguishers should also be provided to cover classes B (Liquids), and E (fires involving electrical apparatus) and F (cooking oils and fats), e.g. foam, carbon dioxide or powder.
the intention is to encourage people to move towards the exit, rather than go further into danger. It is usual to locate extinguishers adjacent to fire alarm call points, so people can actuate the fire alarm before picking up an extinguisher.

Sitting of Fire Extinguishers :
a) Normally, extinguishers should be permanently mounted on brackets or stands in conspicuous positions where persons following an escape route can easily see them, e.g. close to exits .
b) Extinguishers provided for special fire risks should be sited near to the risk, but not so near as to be inaccessible or place the operator in undue danger from fire. e.g In a boiler room, next to the door rather than next to the boiler.
Mounting Fire Extinguishers:
Small extinguishers weighing up to 4 kg should be mounted with the carrying handle about 1.5m from the floor, whilst larger, heavier extinguishers should be mounted with their handles at about 1m.

5.6 Firefighting pump room components

In any fire fighting system we need water to be pumped until it reaches the desired fire place
1- Gate valve
2- check valve : It prevents back flow, and allows only flow in on direction, and is installed in pump discharge line directly to prevent pumps from starting at a load or at the system pressure.
3- Suction header, it prevents vortex.
4- Discharge header.

5- Diesel pump: It’s a 100% stand-by pump, operates in case of power failure with the failure of pressure make up process by the electric pump, or to even with the present of power if failure of pressure make up
process.

6- Jockey pump

It’s the first pump to start in case of fire, It operates as a pressure maintenance pump so in case of a leakage in the system pressure it will makes the system pressure as recommended, and A jockey pump should be sized to make up the allowable leakage rate within10 minutes or 1GPM (3.8 L/min), whichever is larger, and is used for this job instead-off starting the electric pump to protect it from starting until a serious problem occurs.

7- Electric pumps

It’s the second pump to start in case of fire; it's the 100% duty pump

8- Pressure relief valve

A valve being set at a pressure higher than the system pressure or shut off pressure of the diesel pump to protect the system from the very high pressure generated by the diesel pump in case of sudden acceleration.

The relief valve shall be located between the pump and the pump discharge check valve and shall be so attached that it can be readily removed for repairs without disturbing the piping.

Note: - locations of all gate valves in the pump room are mainly for make ease maintenance for each component in the room and without loss water in pipes as possible as we can and for make maintenance which stops the system 100 % is very not possible as we can.

5.7 Selections of other firefighting system components

1. Fire hose :

We need a hose length of 30 meter.

Selection : kiddeModel 3SWA/230.

2. Pump:

Bangpu Modle xbc Electric+diesel+jockey fire fighting pump

3. Fire Extinguishers:

BUCKEYE 5.5 STD V/B 2.5 Kg

CHAPTER SIX

Swimming pool and elevator

6.1 introduction

Swimming pools consider as one of the most places that attract human to reduce the daily work pressure, and daily troubles.

Swimming pools in general must have appropriate design for all ages and different level of swimming skills, also it must have a clean ,good water quality.

6.2 swimming pool components

1- Skimmer : machine that separates a liquid from particles floating on it or from another liquid.

Fig 6.1 swimming pool skimmer

2- main drain : are usually located on the lowest point in the pool, Most of the dirt and debris that sinks exits the pool through these drains, he drains are almost always covered with grates or antivortex covers (a cover that diverts the flow of water to prevent a dangerous vortex from forming).

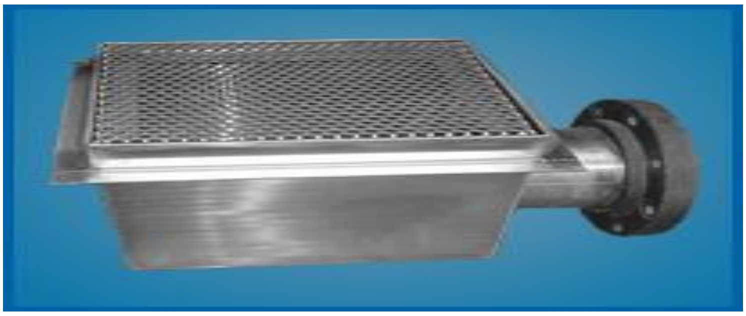

Fig 6.2 swimming pool main drain

3- Pump : pulls water from one or more suction ports (i.e., skimmer & main drain), and then pushes it through the filter & heater**.**

Fig 6.3 swimming pool pump

4- Return inlet : Pool water returns are places in the pool where water comes back in from the circulation system**.**

Fig 6.4 swimming pool return inlet

5- Filter : Pool water comes from the circulation pump into the filter where small debris particles are removed**.**

Fig 6.5 swimming pool filters

6- Suction inlet : used primarily as a suction port for vacuuming the pool

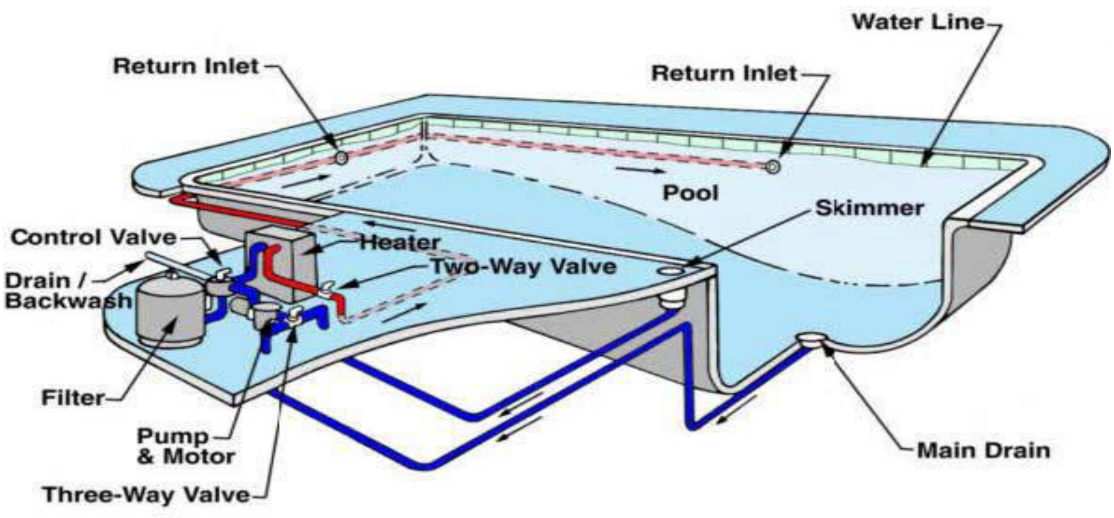

Fig 6.6 general swimming pool components

7- swimming pool (led lights) :

Used as aesthetic appearance and to light the area of the swimming pool

Fig 6.7 swimming pool (led light)

8- swimming pool chlorinator

used for sterilization of the water in the swimming pool.

Fig 6.8 swimming pool chlorinator

6.3 Pool Capacity Calculations

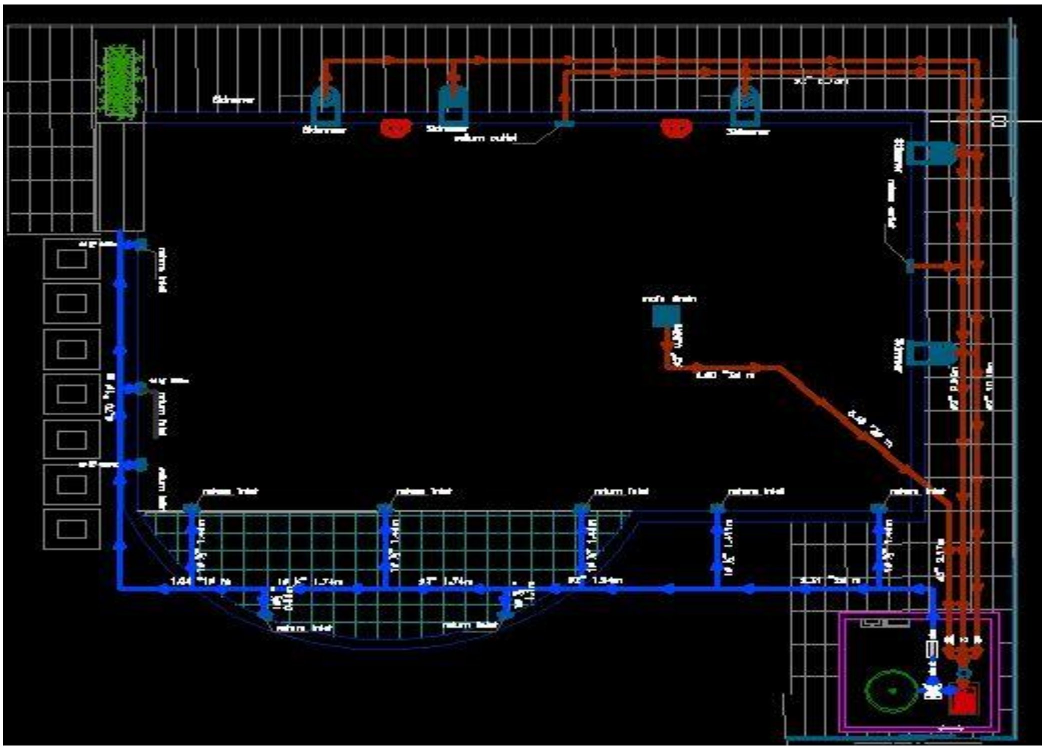

Fig 6.9swimming pool top view

Average depth = (Shallow end depth + deep end depth)/2 **[6.1]**

= (3 + 1)/2 = 2 m.

Volume of water = area * average depth **[6.2]**

= (112.7)*2 = 225.3 m^3.

Turn Over Time**:**

In Hebron the turn over time is 4 hr in residential pools.

6.4 Filter Sizing and Selection

Filter flow rate = Total Water Circulation rate (m^3/hr)

$$= \left[\frac{Pool\ water\ volume\ (m^3)}{Pool\ turn\ over\ period\ (hr)}\right]$$ **[6.3]**

= [225.3/4]

= 56.3 (m^3/hr)

For a filtration velocity of 20 m/hr, the efficiency is 100%.

For a filtration velocity of 30m/hr, the efficiency is 70%.

For a filtration velocity of 40 m/hr, the efficiency is 50%.

The filter efficiency between 70-100%, so a 25 m/hr filtration velocity.

Filter surface area = $\left[\frac{Filtration\ flow\ rate}{Filtration\ velocity}\right]$ **[6.4]**

$$= \left[\frac{56.3}{25}\right]$$

= 2.25 m^2

6.5 Skimmers and main drain selection

- Number of skimmers =(50% X Total flow rate)/capacity of each skimmer

= pool surface area / 25 **[6.5]**

= 112.7/25

= 5 skimmers are required .

Flow rate of each skimmer = (50% $\times$ flow rate)/number of skimmers **[6.6]**

= (50% $\times$ 56.3) / 5

= 5.63 m^3/hr = 24.8 gpm.

Flow rate of main drain = 50% $\times$ flow rate **[6.7]**

= 50% $\times$ 56.3

= 28.15 m^3/hr = 123.94 gpm.

Number of main drains = (flow rate $\times$ 50%)/ flow rate of main drain **[6.8]**

= (56.3 $\times$ 50%)/28.15

= 1 main drain required.

6.6 Selection of return inlets:

Number of required return inlets = $\left[\frac{Filtration\ flow\ rate}{Flow\ rate\ of\ each\ inlet}\right]$ **[6.9]**

= pool perimeter / 5

= 50.35 /5

= 10 return inlets.

$Flow\ rate\ of\ each\ return\ inlet = \left[\frac{Filtration\ flow\ rate}{\text{Number of required return inlets}}\right]$ **[6.10]**

= $\left[\frac{46.7}{8}\right]$

= 5.8 m^3/hr

= 25.5 gpm.

6.7 swimming pool control room components:

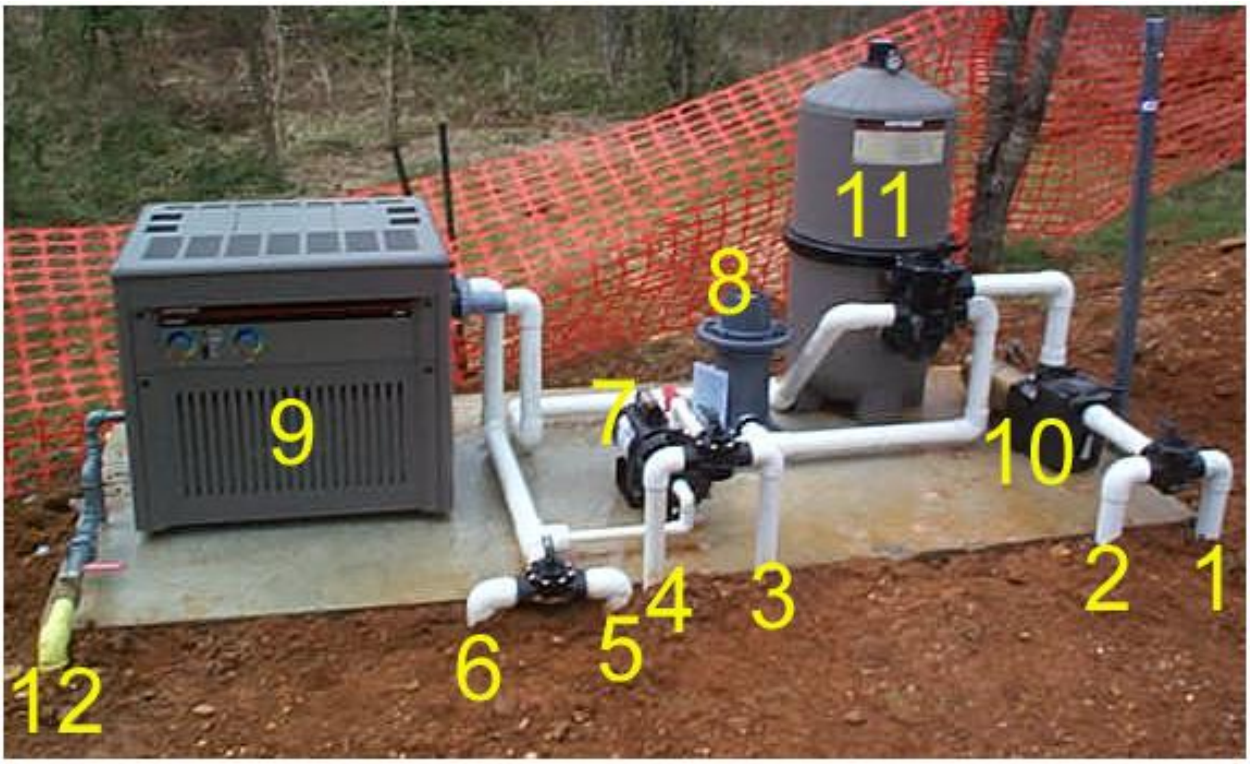

Fig 6.10 swimming pool control room main components

1. Swimming Pool Skimmer Line
2. Swimming Pool Main Drain Line
3. Swimming Pool Slide Line
4. Automatic Pool Cleaner Line
5. Swimming Pool Return Line
6. Swimming Pool Return Line
7. Automatic Pool Cleaner Motor
8. Auto Sanitizer
9. Swimming Pool Heater
10. Swimming Pool Pump
11. D.E. Pool Filter
12. Pool Heater Gas Supply Line

6.8 Elevator design

fig 6.11 Residential building elevator

6.8.1 Introduction

Due to the increasing in the population growth and the lack of lands that allowed for buildings ; it was necessary for the vertical increasing, which made the many floors building to be used.

The need for vertical components to travel between different level of floors became necessary to make the travel easy for persons .

The elevators were the most appropriate solution .

6.8.2 Elevator definition

A machine for movement that carries people and goods from a floor to another in the building , it travels upward and downward within a vertical bath.

6.8.3 Elevator components

- The machine

the machine of the elevator moves the cabinet of the elevator upward and downward, the power of the machine depends on capacity of the elevator , the velocity, and the building height .

fig 6.12 Elevator machine

- The controller

It consists from electrical control board that make a control for all elevator devices, placed in the machine room .

fig 6.13 Elevator controller

- Emergency brake system

It consists from a speed regulator device which built with cabin , that means , if the cabinet speed is higher than the programmable speed it stops the elevator immediately

- U.P.S

It is a three phase electrical charger works automatically to drive the elevator to the nearest floor when the electricity turns off .

- Motion paths

It is made from cast iron used as guide for the cabin movement which make comfortable movement .

fig 6.14 Elevator cabin motion path

- Cabin

Used to carry people or goods made from iron covered with décor

fig 6.15 Cabins

- Elevator shaft

It is used only four the elevator equipments and parts , so it is not allowed any other pieces to be in .

- ✓ The elevator shaft ground must end with strong , fixed ground that have at least a resistant equals to 500 Kg / m^2.
- ✓ The depth under the elevator shaft ground 1.5 m from the level of the lowest entry for the elevator and it increases with the increasing in velocity and capacity.
- ✓ The elevator shaft height must be at least 4 m and it increases with the increasing in velocity and capacity.

- Machines room .

It placed at the top of the elevator shaft and it must have the following conditions .

a. The height of the room is not less than 2 m.
b. Good filtration
c. Enough space for distribution for room components , and make safety entry for the maintenance men if the machines need maintenance .
d. Make sure there is no dust and water enter the room
e. To be will locked .

Machine room consists from :

- Elevator machine .
- Controller .
- Speed regulator .

6.8.4 Design calculations of the elevator

There are many properties control the design of the elevator includes the following :

- Type of building .
- The location of main and secondary entrance in the building.
- The location of the elevator comparing with building entries .
- Number , volume , and shape of the elevator cabin .

The building consists from 3 floors and garage with a total area 1590 m^2.

Number of people served = 45

For residential building , ability of lift = 12% .

availability of lift = 12 * Number of people / 100 **[6.11]**

= 5.4 for every 5 minuets

stroke travelling for the elevator = floor height * number of floors **[6.12]**

= 3 * 4 = 12 m

The travelling stroke (upward + downward) = 12 second for building height + 30 second for filling and empty [assume speed = 1m/second] **[6.13]**

= 12 + (30 * 3)

= 102 second

The travelling stroke in five minuets will be equal (5*60) / 102 = 3 travels

finally , load of the elevator = availability of lift / number of travels **[6.14]**

5.4/ 3 = 2 person per travel .

أبعاد غرفة المكن				أبعاد بئر المصعد						أبعاد الباب		أبعاد العربة			سرعة	حمولة	أشخاص
الباب	ارتفاع	عمق	عرض	ارتفاع السقف	عمق الحفرة	كتف	كتف	عمق	عرض	ارتفاع	عرض	ارتفاع	عمق	عرض	m/s	KG	العدد
90	200	300	200	400	150	13	27	150	140	200	70	210	100	90	1.0	320	4
90	200	300	200	400	150	15	35	170	160	200	80	210	120	110	1.0	450	6
90	200	300	200	400	150	20 15	40 45	180 180	170 170	200 200	80 90	210	140	110	1.0	630	8
90	200	350	240	400	150	35 30	55 50	200 200	200 200	200 200	80 90	220	140	135	1.0	800	10
90	200	350	280	400	150	45 40	85 85	200 200	240 240	200 200	80 90	220	140	160	1.0	100 0	12

fig 6.16 Elevator dimension selection