بسم الله الرحمن الرحيم

Palestine PolytechnicUniversity

College of Engineering & Technology
MechanicalEngineering Department

Graduation Project

Design of Mechanical system of residential villa
Hebron city

Project Team
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Project Supervisor
DrIshaq Seder

Hebron – Palestine

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جامعة بوليتكنك فلسطين
Palestine Polytechnic University
(PPU)
Hebron-Palestine

PROJECT NAME
Design of Mechanical system of residential villa
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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 ngineering and technology in partial fulfillment of therequirements of (B.SC) degree

Supervisor Signature

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Examine communitySignature

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Department Head Signature

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Dedication

I didicate this project to my family and my friends who beleived in me
Special dedication to Diaa al qemare , Mahmoud manasra , Slame rzeqat , ghada tarayra , Abed almnem al amle and Ahmed Bardwil

Acknowledgment

My thanks go first to my supervisor dr.Ishaq Seder for his dedication and support , and being such great guide and amazing person

Also I want to thank all my teachers specially mechanical ones.

Abstract:

Air conditioning water supply, drainage and sewage are the most important mechanical works that must be done during building construction. This can provide comfortable life for the customer and help him do his daily activities. Tha aim this project is to be familiar with the mechanical works done during any scheme and how to select the suitable mechanical system which have high economically and high performance.

Table of contents

REFERENCES

1) ASTRALPOOL, Swimming pools and SPAS ,Catalogue 2004-2005
2) JOHN DAWES, Design and planning of swimming pools,CPI publishing , London,1979.
3) Ashrae book
4) Fundamentals to HVAC systems (Robert mcdowall 2007)
5) Fluid mechanics (sie) (white)

Chapter one

Introduction

Chapter one

1- 1 Introduction

This project contains a full mechanical design for a villa and swimming pool under construction as it would be shown in the coming chapters, mechanical work includes (Air conditioning, water supply, and drainage).
The architectural drawings have been taken from the engineering office of Areen, main objective in this project is to be familiar with the mechanical works and new technology in mechanical systems to be ready for working in this field after graduation. Also doing such project during study has many benefits specially being under teachers supervision.

This project has been divided into eight chapters: the first chapter is to make introduction to the project contents, chapter two is to make a little introduction to air conditioning and a small look to its history and mechanical system used in this project including HVAC and plumbing systems, chapter three made a complete description for the building its location, and thermal, heating and cooling loads.

The fourth chapter is about the design condition especially in Palestine, The fifth chapter is about operating system. The sixth chapter made an introduction to plumbing systems and, chapter seven is calculating the capacity for the swimming pool and finally the conclusion in chapter eight.

1-2 Budget

Table (1-1) budgets

Task	Cost (Nis)
Using internet	١٥٠
Transportation and into the project	٠
Other Transportation	١٠٠
Printing papers	500
Printing drawing	٥٠
Total	800

1 – 3 Time planning

The project plan follows the following time schedule, which includes the related tasks of study and system analysis.

Table (1-2):project times – schedule for the first semester

Task/week	١	٢	٣	٤	٥	٦	٧	٨	٩	١٠	١١	١٢	١٣	١٤	١٥	١٦
Collection information about the project																
Study the mechanical draw																
Central heating system calculation and plumping system calculation																
Drawing planes and selection of equipment's																
Making bill of quantity BOQ																
Project documentation																

CHAPTER TWO

Design Conditions

Chapter two

٢.1 History of HVAC

An early method of cooling air as used in India was to put some quantity of wet grass over windows where they cooled incoming air by evaporation. Modern air-conditioning had its beginnings in the 19th-century, in which atomized sprays of water were used for simultaneous humidification and cooling.

In the early 20th century, Willis Carrier, discovered the “dew point control,” an air-conditioning unit based on the principle that cooled air reaches saturation and loses moisture through condensation. Carrier also discovered a system where in conditioned air was fed from the ceiling and exhausted at floor level. The first fully air-conditioned office building, the Milam Building in San Antonio, Texas, U.S., was constructed in the late 1920s.

In the early 1930s an important step was occurred, which is the development of highly-efficient refrigerant gases of low toxicity known as Freon’s (carbon compounds containing fluorine and chlorine or bromine). By the middle of that decade American railways had installed small air-conditioning units on their trains, and by 1950 compact units had become practical for use in single rooms. Since the late 1950s air conditioning has become more common in the modern world.

٢.2 Purposes of HVAC

The purpose of HVAC systems is to provide building occupants with thermal comfort, humidity control, ventilation and air filtration, however a poorly designed or constructed HVAC system may result in systems that are costly to operate, that cause discomfort, that are noisy, and that permit pollution to occur to the conditioned spaces.

٢.3 Human Comfort

In order for the body to feel comfortable, the surrounding environment must be of suitable temperature and humidity to transfer this excess heat. If the temperature of the air surrounding the body is too high, the body feels uncomfortably warm. The body responds by increasing the rate of perspiration in order to increase the heat loss through evaporation of body moisture. Additionally, if the surrounding air is too humid, the air is nearly saturated and it is more difficult to evaporate body moisture.

The term “comfort” is often used to define a set of conditions than just temperature and humidity. Air movement, adequate fresh air, cleanliness of the air, noise levels in the space, adequate lighting, and proper furniture and work surfaces, are just a few of the other variables that contribute to making a space comfortable for its occupants.

Thermal comfort depends on creating an environment of dry-bulb temperature, humidity, and air motion that is appropriate for the activity level of the people in the space. This environment allows the body’s rate of heat generation to balance with the body’s rate of heat loss.

So, heating and air conditioning systems use the principles of heat transfer to maintain comfortable indoor conditions for people.

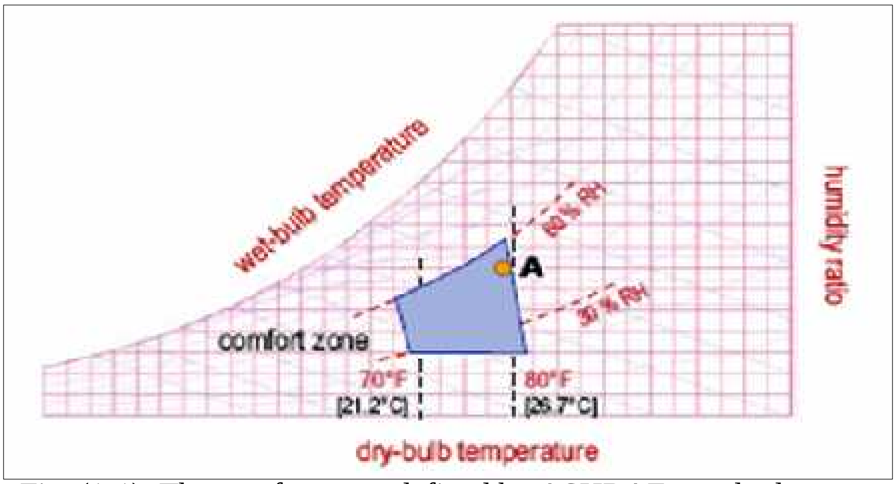


Fig. (1-1): The comfort zone defined by ASHRAE standard

٢.4 General Principles of heat transfer

Heat energy is transferred from one substance to another by one of three basic processes which are conduction, convection, or radiation. Conduction is the process of transferring heat through a solid. Convection is the process of transferring heat as the result of the movement of a fluid. Convection often occurs as the result of the natural movement of air caused by temperature differences. Radiation is the process of transferring heat by means of electromagnetic waves, emitted due to the temperature difference between two objects. An interesting thing about radiated heat is that it does not heat the air between the source and the object it contacts; it only heats the object itself.

So all these criteria will be considered in this project in order to increase the reliability and efficiency of the systems will be used in order to reduce the leakages.

2.5 Indoor Design Conditions (Cooling & Heating)

With a specific amount of air movement, thermal comfort can be produced with certain combinations of dry-bulb temperature and relative humidity. When plotted on a psychometric chart, these combinations form a range of conditions for delivering acceptable thermal comfort to the people in a space. Determining the desired condition of the space is the first step in estimating the cooling and heating loads for the space. We will choose 1.5m/s air velocity,20 ºC dry-bulb temperature and 45% relative humidity. Air entering the space must be filtered regardless being fresh outdoor or recalculated.

2.6 Outdoor Design Conditions (Cooling)

For estimating the cooling load of a space we have to determine the highest, frequently-occurring outdoor air temperature. In the summer, for example, when the temperature outside is high, heat transfers from outdoors to indoors, thus contributing to the heat gain of the space. Obviously, HVAC systems would be greatly oversized if cooling load calculations were based on the most extreme outdoor temperature ever recorded for the location. The cooling outdoor design conditions for Hebron area, 35ºC for 65% dry-bulb temperature.

2.7 Outdoor Design Conditions (Heating)

Similar to the cooling-design outdoor conditions, heating-design outdoor conditions in Hebron area since our heating routine is intermittent outdoor 45% dry-bulb temperature is 3ºC.

CHAPTER THREE

The designed building

3.1 Description and details building

The building is a 696 m^2located in Hebron city at 1005. m above sea level. Our level reference in the building floors is to be 0.00 m on the

The four directions of the building (North, south …) are shown on the layouts. The main entrance of the building is to the south.

The building is to be used for the residential purpose. It consists of the ground floor and one floor below the ground which is the basement in addition to the first floors above the ground and the roof floor.

The basement floor is 2.99 m height as one part shown in the layout and 2.73 m height at the other part because the slab is thickened, the floor area is 190m^2 to be used for service room, kitchen ,well , two bath rooms, besides to a large multi use area. It consists of fourteen outside double glass windows and four inside, outside doors detailed as follows.

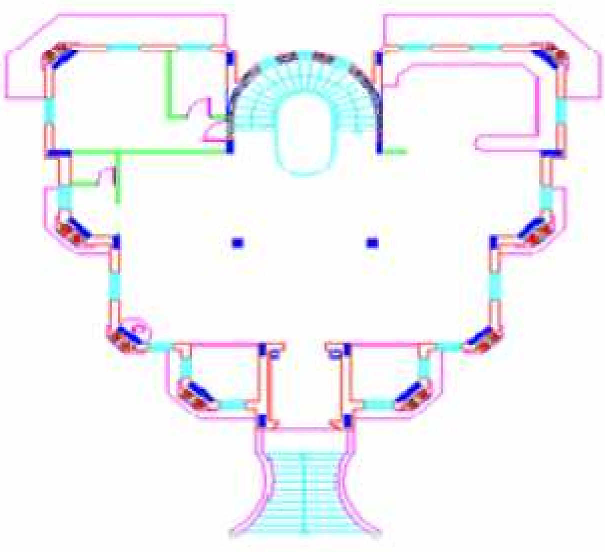


Figure 3.1: The basement floor

Table 3.1: The basement floor area description

Place	Floor Area (m^2)	Height (m)	External Wall Position	Wall's Section area(m^2)	Windows Section Area (m^2)
Space # 00 (well)	22.37	2.73	North	*	*
			East	*	*
Space # 01 (hall +kitchen)	123.61	2.73	North	25.2	5.59
			South	20.994	5.76
			East	23.75	4.96
			West	23.75	4.96
Space # 02 (service)	25.52	2.73	North	10.996	5.59
			East	3.6582	0
			West	9.639	0
Space # 03 (WC)	1.84	2.73	West	3.1395	0
Space # 04 (WC)	1.84	2.73	East	3.1395	0
Total floor area	191.94				

The ground floor is 3.78 m height as one part shown in the layout and 3.52 m height at the other part because the slab is thickened, the floor area is 190m^2 contains a kitchen, stairs, one bed room, one bath room, and a large hall to be used for two living rooms and two eating tables.

It consists of nineteen outside double glass windows and three inside and outside doors detailed as follows.

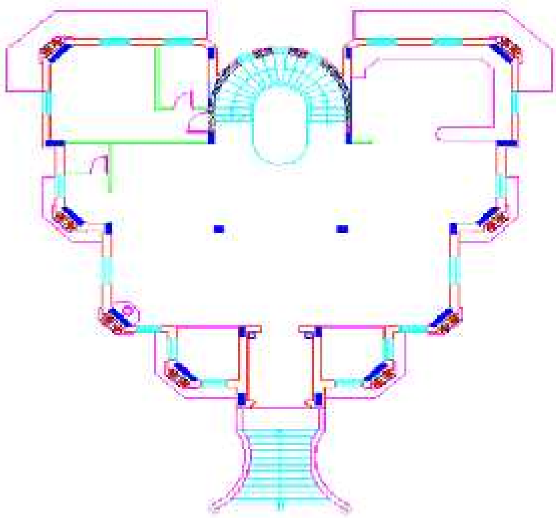


Figure 3.2: The ground floor area layout

Table 3.2: The ground floor area description

Place	Floor Area (m^2)	Height (m)	External Wall Position	Wall's Section area(m^2)	Windows Section Area (m^2)
Space #10 (kitchen)	24	3.52	North	20	3.2
			East	12.72	1.6
			West	4.7168	*
Space #11 (bedroom)	18.41	3.52	North	11.776	3.6
			East	4.541	1.6
			West	13.184	*
Space #12 (hall)	134.22	3.52	North	32.49	5.59
			South	27.07	6.08
			East	30.6227	4.96
			West	26.2227	4.96
Space #13 (W.C)	5.11	3.52	North	5.1	1.6
			East	3.18	0
Space #14 (W.C)	2	3.52	West	4.4	0
Total floor area	191.94				

The first floor is 3.15 m height as one part shown in the layout and 2.89 m height at the other part because the slab is thickened, the floor area is 151.83 m^2 to be used for three bed rooms, three WC, living room, Director Room, server room, and library. It consists of thirty eight outside double glass windows and seventeen inside doors detailed as follows.

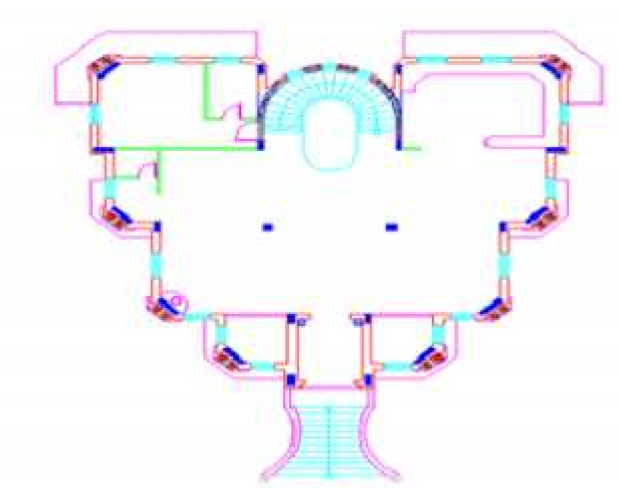


Figure 3.3: The first floor

Table 3.3: The first floor area calculation

Place	Height (m)	Floor Area (m^2)	External Wall Position	Wall's Section area(m^2)	Windows Section Area (m^2)
Space#20 (bed room)	2.89	19.07	North	9.96	1.6
			East	10.538	1.6
			south	9.537	*
Space#21 (Hall)	2.89	53.44	North	31	5.59
			East	8.173	*
			West	8.173	*
Space#22 (bed room)	2.89	19.07	North	10.538	*
			West	10.538	1.6
			south	9.537	*
Space#23 (bed room)	2.89	31.12	South	16.824	3.36
			West	8.773	1.92
Space#24 (WC)	2.89	19.4	East	10.22	1.92
			south	11.23	1.44
Space#25 (WC)	2.89	4.5	north	3.473	1.44
			East	3.18	0
Space#26 (WC)	2.89	4.5	north	3.473	1.44
			West	3.18	0
Total floor area	151.1				

The roof floor is 3.15 m height as one part shown in the layout and 2.89 m height at the other part because the slab is thickened, the floor area is 69.62 m^2 to be used for the boiler room, one WC, multi use area. It consists of ten outside double glass windows and four inside and inside doors detailed as follows

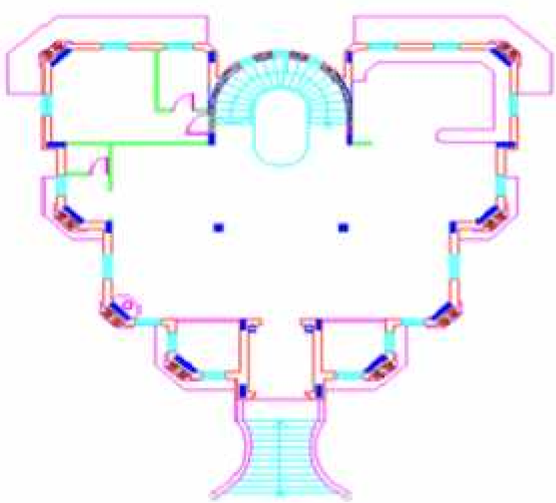


Figure 3.4 the roof floor

Table 3.4 : The roof floor area calculation

Place	Height (m)	Floor Area (m^2)	External Wall Position	Wall's Section area(m^2)	Windows Section Area (m^2)
Space #30 (WC)	2.89	6.12	North	5.336	1.6
			East	5.76	1.6
Space #31 (Hall)	2.89	55.92	North	31	26.325
			South	21.319	60.9
			East	8.173	
			West	8.173	
Space #32 (Boiler room)	2.89	6.12	North	5.336	1.6
			West	5.76	1.6
Total floor area	68.16				

3.2 Descriptions of the wall and floor sections and related Overall heat transfer coefficient (U)

There is much type of walls and floor sections exist in the structure of the building. Overall heat transfer coefficient calculated according to the thermal resistance R to the wall components such that

$U=1/(R_{total})$

R = L/ K ,Where

L: thickness of wall component.

K: thermal conductivity W/m.k

Table 3.5: thermal resistance calculation for external wall

Material Type	**Thick. (m)**	**K (W/m.k)**	**Area (m^2)**	**R (m^2.k/W)**
Inside Air Film	*	*	1	0.13
Stone	0.05	2.3	1	0.021
Concrete	0.15	1.74	1	0.086
Thermal insulation	0.03	0.04	1	0.75
Brick	0.7	0.9	1	0.777
plaster	0.02	1.4	1	0.014
Outside Air film	*	*	1	0.04
Total Resistance	1.820009519			
Overall Heat Transfer Coefficient	0.549447531			

Table 3.6: thermal resistance calculation For internal wall

Material Type	Thick. (m)	K (W/m.k)	Area (m^2)	R (m^2.k/W)
Inside Air Film	*	*	1	0.13
Concrete	0.2	1.74	1	0.114942529
plaster	0.02	1.4	1	0.014285714
plaster	0.02	1.4	1	0.014285714
Inside Air Film	*	*	1	0.13
Total Resistance	0 0.406174			
Overall Heat Transfer Coefficient	2.48			

Table 3.7: thermal **resistance** calculation for ceiling

Material Type	Thick. (m)	K (W/m.k)	Area (m^2)	R (m^2.k/W)
Inside Air Film	*	*	1	0.1
Tiles	0.03	1.3	1	0.023
mortar	0.03	1.4	1	0.021
Sand	0.07	0.6	1	0.116
insulation	0.01	0.15	1	0.066
Thermal resistance	0.03	0.04	1	0.75
concrete	0.08	0.9	1	0.088
brick	0.24	1.7	1	0.141
plaster	0.02	1.4	1	0.014
Outside Air film	*	*	1	0.04
Σ R	1.3624			
Overall Heat Transfer Coefficient	U =0.734			

Table 3.8 : thermal resistance calculation for floor

Material Type	Thick. (m)	K (W/m.k)	Area (m^2)	R (m^2.k/W)
Inside Air Film	*	*	1	0.17
tiles	0.03	1.1	1	0.027
mortar	0.03	1.4	1	0.021
sand	0.07	0.6	1	1.17
concrete	0.08	0.9	1	0.088
Base course	0.2	1.2	1	0.166
Σ R	1.644257			
Overall Heat Transfer Coefficient	U =0.608177			

For windows

Double glass , aluminum frame wind speed (0.5 - 5)
U=3.2 W/m^2.K

For doors
External doors: steel without storm door
Internal doors: 45mm-wood without storm door

Heating load calculations was done for space number20 as a sample as shown in table 3.9

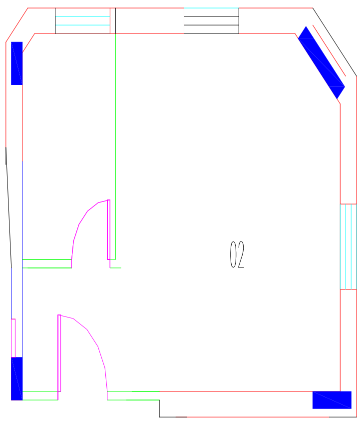


Figure 3.5: space number 20

Table 3.9: Heating load calculations for space number 20

$\mathbf{Q_{loss} = U_{ov.} * Area * (T_i - T_0)}$

$\mathbf{Q_{Room}}$ = 0.998 kW

Heating load calculations for all the building are shown in tables(3.9),(3.10),(3.11)

Table 3.10: Heating load calculation for Basement floor

Surface	Space			
	٠١ Kitchen+ hall	**٠٢ Service**	**٠٣ W.C**	**٠٤ W.C**
	Q(kW)			
External wall	١.٦١	٠.٤٣٥	٠.٠٥٦	٠.٠٥٦
Internal wall	٠.١٢٤	٠.١٩٧	٠	٠
External (well)	٠.١١٦	٠.٠٣٦	٠	٠.٠٣٨
Ceiling	٠	٠	٠	٠
Floor	٤.٢٧٢	٠.٤٦٥	٠.٠٠٣	٠.٠٠٣
Windows	١.٢٩٣	٠.١٤٩	٠	٠
Doors	٠.٤٠٥	٠.١٧٧	٠	٠
Ventilation	٤.٨	٠.١٥٧	٠.٠٦٩٦	٠.٠٦٩٦
Total	١٢.٦٢	١.٥٨	0.1286	0.1666
Total heating load for the floor		14.49 kW .		

Table 3.11: Heating load calculation for Ground floor

Surface	Space				
	١٠ Kitchen	**١١ Bedroom**	**١٢ Hall**	**١٣ W.C**	**١٤ W.C**
	Q(kW)				
External wall	٠.٦٢١	٠.٤١٩	٢.١	٠.٠٨	٠.١٦٢
Internal wall	٠	٠.٢٩٣	٠	٠	٠
Ceiling	٠	٠	٠	٠	٠
Floor	٠	٠	٠	٠	٠
Windows	٠.٢٩٢	٠.١٥	١.٣	٠.١٠٧	٠
Doors	٠	٠	٠.٤١	٠	٠
Ventilation	١.٠٦	٠.٣١٢	٦.١٥	٠.٠٩٧٥	٠.٢٥
Total	٢.٦١	١.١٧٤	٩.٩٦	١.٠٠٤٥	0.412
Total heating load for the floor			15.16 kW		

Table 3.12: Heating load calculation for First floor

surface	Space						
	٢٠ Bedroom	٢١ hall	٢٢ Bedroom	٢٣ bedroom	٢٤ W.C	٢٥ W.C	٢٦ W.C
	Q(kW)						
External wall	٠.٤٢٥	٠.٦٨	٠.٤٢٥	٠.٤٥	٠.٤	٠.١٢٢	٠.١٢٢
Internal wall	-٠.٠٥٧	٠	-٠.٠٥٧	٠	٠.٠٦	٠.٠٥٤	٠.٠٥٤
Ceiling	0.522	٠	٠.١٨	0	0	٠	0.476
Floor	٠	٠	٠	٠	٠	٠	٠
Windows	٠.٠٩٧	٠.٣٤	٠.٠٩٧	٠.٣٢	٠.٢٥٦	٠.١١	٠.١١
Doors	٠.٢٣١	٠.٤١٥	٠.٢٣١	٠.٩٦	٠	٠.٠١	٠.٠١
Ventilation	٠.١٢٢	١.٤٦٢	٠.١٢٢	٠.٧٥		٠.١٨	٠.١٨
Total	٠.٩٩٨	٢.٨٩٧	٠.٩٨	٢.٤٨	٠.٧١٦	٠.٤٧٦	٠.٤٧٦
Total heating load for the floor				9.023 kW			

Table 3.13: Heating load calculation for Roof floor

Surface	Space		
	٣٠ W.C	٣١ hall	٣٢ boiler room
	Q(kW)		
External wall	٠.٢	١.٠٥	٠.١٣٩
Internal wall	٠	٠	٠
Ceiling	0.085	0.779	0.085
Floor	٠	٠	٠
Windows	٠.٢١٥	٠.٨٦٥	٠.١٤٨
Doors	٠	٠.٤٨	٠
Ventilation	٠.٢٤٥	١.٥	٠.١٧
Total	0.745	4.674	0.542
Total heating load for the floor		5.961 kW	

water heater capacity

$Q_w = m * cp * \Delta T$, Where

m = ((65 ltr/day/ person * 1 * 1000) * 8) / (24 * 3600)
= 6.1 m^3/sec
Q_w = 6.1 * 4.19 * 60
= 1.5 kW.

Q_{total} =46.134+10%=50.74kW
Heating system will be selected for this project is water heating system
All systems components and details will be selected in next semester

3.3 Cooling load calculation

The Cooling load Consists of the following heat gains :

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

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

(a) solar radiation transmitted through the glass and absorbed by inside space surfaces and furniture.

(b) 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 spaces as a result of infiltration of air through windows and doors.

(4) sensible heat produced in the space by lights, appliance, 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.

Heat gain from solar effect depends heavily on tabular data for calculation the tables needed for the calculations are included.

3.4 Heat Gain Through Sunlit Walls And Roofs:

Direct and diffused solar radiation that is absorbed by walls and roofs result in raising the temperature of these surfaces. 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 can be obtained by using the following for heat transmission through walls.

$Q = UA\,(CLTD)_{corr}$

$(CLTD)_{corr} = (CLTD + LM)k + (25.5 - T_i) + (T_{o,m} - 29.4)f$

Where:

LM is latitude correction factor, which can be obtained from table s

CLTD cooling load temperature differences can be obtained from table according to the wall orientation.

k: color adjustment factor such that k=0.65 for permanent light colour walls.

f: attic or roof fan factor such that f =1.0, if there is no attic or roof fan; f = 0.75, if there is an attic or roof fan.

$(25.5 - T_i)$:correction value for indoor design temperature where T_i is the room design temperature C^o.

$(T_{o,m} - 29.4)$ correction factor for outdoor mean temperature $T_{o,m}$. it is related to the outdoor design temperature T_o , according to the relation.

$$T_{o,m} = T_o - \frac{DR}{2}$$

Where DR is the daily rang temperature which equals to the difference between the average maximum and average minimum temperature for the warmest month of the summer season.

Cooling load calculations for space #20

1- heat gain through external walls

$Q_{cooling} = \text{area} * U_{ov} * CLTD_{corr}$

Table 3.14: Cooling load calculation for space # 20

surface	Area (m^2)	U_{ov}	CLTD	$CLTD_{corr}$	LM	$Q_{cooling}$
North wall	25.2	0.68	6	8.235	-1.1	55.77401
South wall	20.994	0.68	7	9.925	0.5	64.36521
East wall	23.75	0.68	13	13.5	0	96.73884
West wall	0	0.68	10	11.25	0	0
glass	20.59	3.2	7	11.9	*	121.856
Total						338.7341

2- heat gain through windows

a. by transmission

$Q_{transmission} = \text{area} * SHG * SC * CLF$

Table 3.15: heat gain through windows by transmission

glass	SHG	SC	CLF	area	Q_{tr}
North	١١٧	٠.٣	٠.٧٥	1.6	42.12
South	٣٥٠	٠.٣	٠.٥٨	0	0
East	٦٩١	٠.٣	٠.٣١	1.6	102.8208
West	٦٩١	٠.٣	٠.٢١	0	0

b. by convection:

$Q_{convection}$= Area * U_{ov} * $CLTD_{corr}$

$CLTD_{cor=}$ CLTD+(25.5-T_i)+($T_{o,m}$-29.4)
=7+5.5-.6
=11.9C^o

$Q_{convection}$= 19.07 * 3.2 * 11.9
= 0.726kW

Table 3.16: heat gain through windows by convection

floor	Q cooling									
	External wall	Internal wall	Occupants (sensible)	Occupants (latent)	Glass (transmission)	Glass (convection)	light	Equipments(sen)	Equipment (lat)	ventilation
basement	2.9072	0.3943			1.05	0.27	٣.٧4			
ground	2.35	٠.٣٧٦			1.54	0.35	٤.٤			
first	3.54	0.1195	61.62	0.078	.723	0.26	٣.٦	4.4	1.4	16
roof	8.45	.0996			1.5	1.1	1.6			
total	12.3	١.٤٥٧			4.8	٢.٤٢	١٣.٣			

Total sensible cooling load = 21.48kw

Total latent cooling load = 17.48kw

Total cooling load= 38.96kW

Central cooling system will be used in this project with 25% fresh air and 75%

Chapter Four

Operating Systems

Chapter Four

4.1 System selected

The designer have to recommend one system from various systems that will perform as desired. The designer and the owner have to decide with each other the criteria that may be considered as:

1- Performance requirements

2- Capacity requirements

3- Spatial requirements

4- First cost as:

a- System cost b- Cost to add zones c- Ability to increase capacity d- Contribution to life safety needs e- Air quality control

5- Operating cost as:

a- Energy costs b- Gas c- Oil d- Electricity e- Water costs f- Chemical costs g- Manpower costs

6- Reliability

7- Flexibility

8- Maintainability as: a- Labor costs b- Licensing for operators c- Material costs

4.1.1 System selection inquiries

1- If the system fit in the available space, or does it require some architectural modification.

2- If the system use more floor space than others considered, or require construction of additional space for mechanical rooms or shafts.

3- If the system deliver the desired uniform temperature under varying weather and solar conditions.

4- Cost of the system to own compared to others considered.

5- The recovery time of the initial investment, interest on investment system life, and the future cost of replacement equipment.

6- The operating costs—for energy, maintenance, labor, and supplies of this system compared to others.

7- The reliability can the owner expects compared to other systems.

8- Component failures affect the entire building, or affect only limited areas.

9- The easiest of the system to be serviced.

10- The time can the system be restored to operation after various equipment failures.

11- The system flexibility to meet changes in the owner's needs.

12- Ability of the system to meet the increased capacity requirements of a space when equipment is added.

4.2 air conditioning system (heating & cooling)

4.2.1 Operating system

Operating system used in this project the VRV system which has many criteria that make it suitable for the project

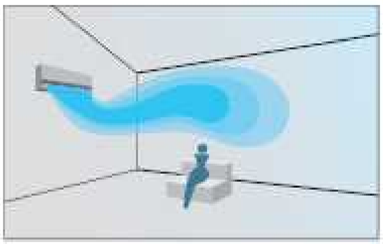
The VRV system is:

4.2.1.1 Stylish and compact Design

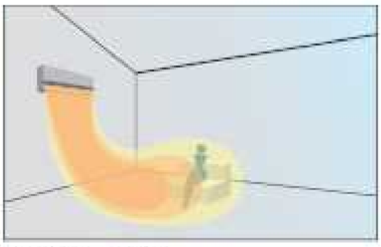
Indoor unit with such a sleek profile is an air conditioning unit.In standby mode, the discharge opening is closed, resulting in a compact depth of only 15cm. When starting the unit up, the entire front panel slides smoothly open

4.2.1.2 Clean and comfortable air flow

For the first time in history, a titanium apatite photocatalyticair purification filter is integrated in an air conitioningunit. This to increase the active surface area for effective purification and deodorization, even when a high volume of air is required. Super quiet: The indoor/outdoor unit silent operation function brings us comfort by offering an industry top-level quiet operation of 22 dB(A) for the indoor unit and 43dB(A) for the outdoor
Unit.



Cooling mode



Heating mode

4.2.1.3 Sensational thinning technology

• High efficiency slit fin heat exchanger
• Miniature cross flow fan
The blade configuration has been optimized to achieve quiet operation and powerful air flow, while reducing the fan’s diameter by 20% compared to conventional models.

4.2.1.4 Superb energy efficiency

the energy efficiency is improved. At the same time the substantial energy savings compared is realized to conventional models by achieving an industrial top class EER of 4.03 and COP of 4.15. These top of the class values are achieved by the following 3 technologies:
• PAM Inverter control
• Reluctance DC motor + DC Fan motor
• Swing compressor

4.2.1.5 Comfort mode

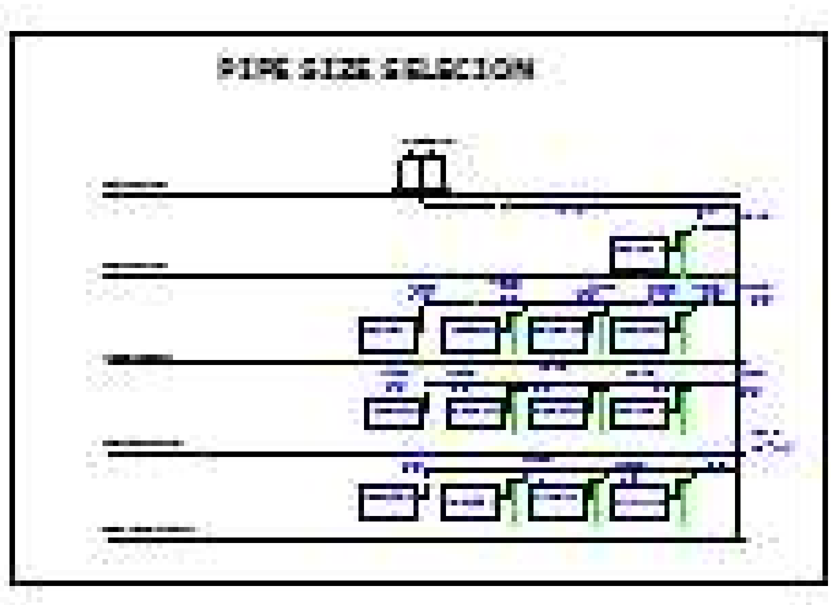
a wide-angle distribution flap reassures draught free operation. During cooling operation the flap angle turns horizontally to prevent cold air blowing directly on the body, while during heating operation it turns downward vertically to send the warm air directly to the feet.

This function combines Vertical and Horizontal auto-swing to circulate a stream of cool/warm air right to the corners of even large spaces. Why VRV is suitable for this project l State of the art design: sleek, compact and stylish outlook
l Available in 2 color variations: mat crystal white and mat crystal silver
l Lightweight and compact l Easy to clean flat suction grille l Superb energy efficiency l Movement sensor saves power consumption in unoccupied rooms 1

Comfort mode reassures draught free operation thanks to the new wide angle distribution flap l The new titanium apatite photo catalytic air purification filter increases the active surface area for effective purification and deodorization l Horizontal and vertical auto-swing 3D-air flow ensure efficient air and temperature distribution. l Powerful mode can be selected for rapid cooling or heating l Indoor / outdoor unit silent operation

4.22 Air conditioning system design:

In order to determine the number of HVAC units many steps where done , first dividing the floors into zones , and determining the loads for each zone , the type of the indoor units using the charts and the catalogue of the company , after that connects the outdoor units with the indoor ones All the details are shown in the next figure



Air conditioning were done for the four floors , in each one the indoor units were either ducted or wall mounted which needs no ducts , the duct design for the ducted units were done by the following way:
Using velocity method
Determine the velocity and the volumetric flow rate for air supply:
Air velocity = 0.02 m^3 (table -10-1)

By the eq
$V=(\Pi/4)*d^2*velocity$
D= 0.2/1.96=.10 m
The duct size is 10 cm circular cross section
Using the chart 10-5 the pressure drop per equivalent length = 1 pa/m

Chapter five

Plumbing system

Chapter five

5 -1 Introduction

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

5 – 2 Plumbing

The goal of modern plumbing design for buildings as it will be discussed in the book, is to safely and reliably provide domestic water, cooking gas and water for firefighting and to remove sanitary wastes. The word safely is emphasized because; although it would not appear so at first glance plumbing systems can be very dangerous if improperly designed. Dangers from coking/heating gas are obvious. Less obvious is the explosive potential of hot water system and pressurized cold water system.

The nauseating effect of improperly vented sanitary drainage system and the disease causing potential of inadequate sanitary drainage. System reliability is of primary importance to the beneficial occupancy of a building. Think for a minute about the disruption of normal building use that can be caused by loss of water supple or stoppage of the drainage system. The image is sufficient to confirm the importance of plumping system reliability. Moreover, reliability means not only long periods of trouble-free service but also a design that permits easy, rapid, economical and effective repairs to be made.

Table 5.1 : plumbing calculation for basement floor

Fixture unit	No. of Unit	WSFU from table ( )	Total no. WSFU for cold water	Total no. WSFU for hot water	Total no. WSFU for hot and cold water
Sink	١	¾*٢	١.٥	١.٥	٢
W.C	٢	¾*٦	٩	٠	١٢
lavatory	٢	¾*١	١.٥	١.٥	٢
Total WSFU			١٢	٣	١٦
Total gal/min			٢٩.٧	٢٧	٣١.٨

The number ¾ is taken from table 9.3 which a factor for private use

Table 5.2: plumbing calculation for Ground floor

Fixture unit	No. of Unit	WSFU from table ( )	Total no. WSFU for cold water	Total no. WSFU for hot water	Total no. WSFU for hot and cold water
Sink	1	¾*٢	١.٥	١.٥	٢
dishwasher	1	¾*١	٠.٧٥	٠.٧٥	١.٢
Bathtupe	١	¾*٢	١.٥	١.٥	٢
W.C	٢	¾*٦	٩	٠	١٢
lavatory	٢	¾*١	١.٥	٢	٢
Total WSFU			١٤.٢٥	٥.٢٥	١٩
Total gal/min			٣٠.٤	٢٧	٣٤.٢

Table 5.3: plumbing calculation for First floor

Fixture unit	No. of Unit	WSFU from table ( )	Total no. WSFU for cold water	Total no. WSFU for hot water	Total no. WSFU for hot and cold water
Urinal	1	¾*٥	3.75	٠	٥
Bath tube	٣	¾*٢	٤.٥	٤.٥	٦
W.C	٣	¾*٦	١٣.٥	٠	١٨
lavatory	٤	¾*٢	٦	٦	٨
Total WSFU			٢٧.٧٣	١٠.٥	*
Total gal/min			٣٩.٦	٢٧.٧	*

Table 5.4: plumbing calculation for Roof

Fixture unit	**No. of Unit**	**WSFU from table ( )**	**Total no. WSFU for cold water**	**Total no. WSFU for hot water**	**Total no. WSFU for hot and cold water**
W.C	1	¾*٦	٤.٥	٠	٦
lavatory	١	¾*٢	١.٥	١.٥	٢
Cloth washer	١	¾*١	٠.٧٥	٠.٧٥	١
Total WSFU			٦.٧٥	٢.٢٥	٩
Total gal/min			٢٧	٢٧	٢٧

1- Design Of Well:

- The total area of the building service = 696 m^2
- The amount of water fall in Palestine every year is 420 mm
- The volume of well required

= area of building service × amount of water fall yearly

= 696 × 0.42 = 292.32 m^3

This volume of the well is required or sufficient for the building consumption and store of water.

The selected well is with following data:

- The dimensions of well are (9m×11m)
- The depth of the well is 3m
- The total volume available of well = 9 × 11 × 3 = 297 m^3

Well details shown in figure (A-1)

2- Design a reservoir for the building:

we well design the tanks separately for each apartment (floor) so that we will have 8 tanks for each apartment one for hot water and other for cold water.

1. Cold water tank design :

For cold water tank there are available many different size of cold water tank but the most peripheral one is the tank with dimension of (1m×1m×2m) with total volume $2m^3$ and this volume is sufficient for normally family.

2. Hot water design:

For hot water tanks there are available two standard volume tank that is 150 litter and 200 litter. Because of that we will design the tank storage capacity and heating capacity that we needed and then we select the tank.

1- the water consumption for each floor:

number of person = 8 person

water consumption = 50 × 2 + 6 × 30 = 280 litter/ hour

2- maximum hourly demand:

= (1/7) × total hot water

= (1/7) × 280 = 40 litter/hour

3- maximum water demand in peak hour

= maximum hourly demand ×number of peak hour

= 4 ×40 = 160 litter

4- storage capacity

= (1/5) × total hot water demand

= (1/5) × 40 = 8 litter

5- heating capacity:

= (1/7) × total hot water demand (9.10)

= (1/7) × 40 = 5.714 litter.h

6- heat recovery rate

= (total daily demand-storage capacity)/peak hour

= (40-8)/4 = 8 litter/hour

3- Design Of Cold Water System:

We will design the cold water pipe in this project by down feed system according 4 lines, we use line for each floor.

How the cold water will reach from the well to cold tank?

we will need one line in order to connect the water from the well to two cold tanks and we will put pump for the line.

We select for the line:

- pipe with diameter 1"
- pump with hours power which have:
  1. delivery head :- (25 – 33)m = (82 – 108.24)ft
  2. water flow :- (80-20)L/min
  3. suction head :- 7m
- water meter before the tank with friction = 2 Psi = 4.6 ft
- float tank friction is = 4 Psi = 9.2 ft

Chick if this pump able to connect the water from well to the tank or no?

The hight of the building is = 18m = 59.04 ft

The hight of the water tank base is = 2m = 6.56 ft

Length from pump to tank

= building hight + horizontal distance + tank intrance hight

= 59.04 + 32.8 + 9.51 = 101.35 ft

static head = 59.04 + 6.56 = 65.6 ft

equivalent length = 101.35 × 1.5 =152.025 ft

Main pressure =

static head + friction head + minimum flow(friction water meter + friction of float)

108.24 ft = 65.6 + friction head (available by the pump) + (4.6 + 9.2)

Friction head (available by the pump) = 28.84 ft = 12.35 Psi

= 12.35/(152.025/100) =8.125 (Psi/100ft) friction haed required from figure steel pipe (9.5) for :

- flow = 20 L/min= 0.33 l/s

  0.33*15.85 = 5.3 gpm

- diameter = 1"

friction required=6.2(Psi/100ft)<friction available =8.125 (Psi/100ft)

From previous calculation we prove that the diameter and the pump selected are satisfy

Water supply system

Cold water

1- Roof floor

A – Minimium flow pressure = 4 psi
B – Main pressure = height of the tank from the faucet of fixture
= 3.36 + 1.25 – 0.55 = 4.6 m
= 15.08 ft
= 6.5 Psi
Main pressure = height of the tank from the faucet of fixture
= 6.5 Psi
Main pressure = friction loss + minimum flow pressure
6.5 Psi = friction loss + 4 Psi
Friction loss = 2.5 Psi
C – The total length of cold water = 3.75 + 3.36 + 1.25
= 8.36 m
= 27.41 ft
The total equivalent length = total length * 1.5
= 41.11 ft
D – Friction (Psi / 100ft) = (net friction loss in pipe) / (total equivalent length)
= (2.5 * 100) / 41.11 = 6.08 (Psi / 100ft)
E – Select the pipe diameter: from chart (9.5) for iron or steel pipe

Table (5.5): of cold water pipe

Pipe section	E.L(ft)	Size (inch)	Velocity (fps)	Fiction (Psi/100ft)	Section friction (Psi)
From the tank to fourth floor fixture	41.11	1	2.4	1.3	1.14

2 –first floor:

A – Minimum flow pressure = 8 Psi
B – Main pressure = height of the tank from the faucet of fixture
= 3.15 + 3.36 + 1.25 – 0.55

= 7.21 m

= 23.64 ft

= 10.26 Psi

Main pressure = height of the tank from the faucet of fixture
= 10.26 Psi

Main pressure = friction loss + minimum flow pressure
10.26 Psi = friction loss + 8 Psi

Friction loss = 2.26 Psi

C – The total length = 9.8 + 3.15 + 3.36 + 1.25

= 16.96 m

= 55.61 ft

The total equivalent length = total length * 1.5

= 55.61 * 1.5 = 83.47 ft

D -Friction (Psi / 100ft) = (net friction loss in pipe) / (total equivalent length)
= (2.26 * 100) / 83.41 = 2.7 (Psi / 100ft)
E – Select the pipe diameter : from chart (9.5) for iron or steel pipe

Table (5.6): of cold water pipe

Pipe section	E.L(ft)	Size (inch)	Velocity (fps)	Fiction (Psi/100ft)	Section friction (Psi)
From the tank to fourth floor fixture	83.41	1	2.4	1.3	1.34

3 –ground floor :

A – Minimum flow pressure = 15 Psi
B – Main pressure = height of the tank from the faucet of fixture
= 3.52 + 3.15 + 3.36 +1.5

= 11.53 m

= 37.8 ft

= 16.4 Psi

Main pressure = height of the tank from the faucet of fixture
= 16.4 Psi

Main pressure = friction loss + minimum flow pressure
16.4 Psi = friction loss + 15 Psi

Friction loss = 1.4 Psi

C – The total length = 10.6 + 11.53

= 22.13 m

= 72.56 ft

The total equivalent length = total length * 1.5

= 72.56 * 1.5 = 108.8 ft

D -Friction (Psi / 100ft) = (net friction loss in pipe) / (total equivalent length)
= (1.4 * 100) / 108.8 = 1.286 (Psi / 100ft)
E – Select the pipe diameter : from chart (9.5) for iron or steel pipe

Table (5.7): of cold water pipe

Pipe section	E.L(ft)	Size (inch)	Velocity (fps)	Fiction (Psi/100ft)	Section friction (Psi)
From the tank to fourth floor fixture	108.8	3/4	3.9	4.2	5.01

4 –floor number one:

A – Minimum flow pressure = 15 Psi
B – Main pressure = height of the tank from the faucet of fixture
= 2.73 + 3.52 + 3.15 + 3.36 + 1.5

= 14.26 m

= 46.75 ft

= 20.3 Psi

Main pressure = height of the tank from the faucet of fixture
= 20.3 Psi

Main pressure = friction loss + minimum flow pressure
20.3 Psi = friction loss + 15 Psi

Friction loss = 5.2 Psi

C – The total length = 25.12

= 82.4 ft

The total equivalent length = total length * 1.5

= 82.4 * 1.5 = 123.6 ft

D -Friction (Psi / 100ft) = (net friction loss in pipe) / (total equivalent length)
= (5.2 * 100) / 123.6 = 4.2 (Psi / 100ft)

E – Select the pipe diameter : from chart (9.5) for iron or steel pipe

Table (5.8): of cold water pipe

Pipe section	E.L(ft)	Size (inch)	Velocity (fps)	Fiction (Psi/100ft)	Section friction (Psi)
From the tank to fourth floor fixture	123.6	3/4	3.9	4.2	5.68

Hot water design

For 200 liter of hot water tank we need a sun collector with
3 mirrors and nine polyurethane insulation rows are needed from nairokh factory an electrical water heater is needed as well , that can be installed anywhere the family wants .

Sewage calculations:

Table (5.9) Total DFU for basement floor

FU	#DFU		
lavatory	3	2	6
Kitchen sink	3	1	3
W.C (private)	4	2	8
Total dfu	17		

Table (5.9) Total DFU for Firstt floor

FU	# DFU		
Kitchen sink	1	1	1
lavatory	1	2	2
W.C (private)	2	4	8
Bath tube	2	3	6
Dish washer	1	2	2
Total dfu	19		

Table (5.9) Total DFU for Second floor

FU	#DFU		
lavatory	4	3	12
W.C (private)	3	2	6

Bath tube	3	2	6
urinal	1	4	4
Total dfu	28		

Table (5.9) Total DFU for Roof floor

FU	# DFU		
lavatory	1	2	2
W.C (private)	1	3	3
Cloth washer	1	3	3
Total dfu	8		

Total dfu for the house = 8+28+19+17= 72
From table 10 – 4
Stak diameter =3 inches
From table 10 – 5
Slope =1 %

= 1/8
inches
From table 10
Velocity = 1.93m/s low
It must be at least 3 m/s so we increase the slope to be 1/4 inch
Velocity = 2.73 m/s

Man holes
We increase diameter to be 6 inches and decrease the slope
Slope = 1.5 %

Capacity of septic tank
From table 10-11
Capacity = 1200 gal for 8 persons
From table 10-12
Quantity = 150 gal/day/person
Required absorption area = 150 *8 = 1200 gal/day
Porosity of 2
Area = 40 ft^2 / 100 gal
For 1200
1200 *40)/100 = 480 ft^2 .

Chapter six

Swimming pool calculation

6 – 1 Swimming pool

The pool water is filtered due to:-

1) biological contamination ; due to micro-organisms may be air bore or introduced by bather.
2) Wind and rain introduced dust , seeds , leaves…ext which is muddy and pollute the water.

Swimming pools owners seeking for absolute hygiene , crystal clear water , which can be achieved by:

1) Mechanical filtering system using pump and filters to remove suspended particle from pool water.

2) Chemical treatment:- to combat micro-organisms.

i) { chlorine, bromine, oxygen} ⟷ bactericide

ii) chloric acid

iii) aluminum sulphat

iv) algaecide

v) soda ash.

6 – 2 Level of alkalinity and acidity { PH }

PH = 7 neutral

PH > 7 – 14 alanine

PH < 0 – 7 acid

If PH is larger than 7.6

1) the calcium will precipate into acleudy form giving pool water milky appearance.
2) Deposits will form on pool walls and equipments.
3) The chlorine will not act as bactericide

IF **PH is lower-than 7.2**

1) Water-becomes corrosive
2) Cause eye irritation
3) Affect mucous membranes.

7 – 3 Swimming pool calculation

Pool capacity = surface area * average depth

= 40 * ((1.7 + 0.8) / 2)

= 50 m^3 water

Turn over time = pool capacity / filter flow rate

= 50/4 = 12.5 m^3 / hr.

filter surface area = filter flow rate / filtration velocity

= 12.5/30 = 0.4 m^2

suction devices :

for skimmers = 1/3 * 12.5 = 4.16 m^3/hr.

for main draining = 2/3 * 12.5 = 8.3 m^3/hr.

one main draining 12 m^3/hr.

one skimmer 5 m^3/hr.

return inlet 4.5 m^3/hr.

filter diameter 750 mm

1 hp pump flow rate 12.5 m^3/hr.

Head 10 m

See appendix (a-12)

Discharge lines pipe sizing:

The discharge line from the pump to the various return inlets.

Information of main discharge lines
* Flow rate = 55 gpm.
* Maximum velocity acceptable = 10 ft/sec.
* Maximum friction loss =
* Length = (from AutoCAD drawing by measurement)

From PVC table in Appendix A, and by interpolation at the following values :

Table (6.1) Fraction head VS Velocity

Flow rate (gpm)	Fraction head (ft/100ft)	Velocity (ft/sec)
50	4.2	4.9
55	f	v
60	5.8	5.9

By interpolation we find :
* Friction head = 5.5 ft/100ft.
* Velocity = 5.4 ft/sec
* Diameter = 2 inch = 63 mm.

Return inlets

symbol	Flow rate (gpm)	Diameter (mm)	Friction head (ft/100ft)	Velocity (ft/sec)
a	45.838	2	1.9	6.23
b	36.676	1.5	8.07	5.968
c	27.514	1.5	4.75	4.45
d	18.352	1	4.84	4.03
e	18.352	1	4.84	4.03

For each return inlet:-

* Flow rate = 12.5/ number of return inlets = 12.5/6 = 2.0833m^3 /hr = 9.1622 gpm.
* Maximum velocity acceptable = 10 ft/sec.
* Maximum friction loss = 12 ft/100ft.
* Friction head = 5.11 ft/100ft.
* Velocity = 3.52 ft/sec
* Diameter = 1 inch = 30 mm.

Suction lines pipe sizing:

The suction line from the main drains and skimmers to the pump.

Information of main suction lines

* Flow rate = 55 gpm.
* Maximum velocity acceptable = 3.3 ft/sec.
* Maximum friction loss =   ft/100ft.
* Length =   (from AutoCAD drawing by measurement)

Flow rate (gpm)	**Fraction head (ft/100ft)**	**Velocity (ft/sec)**
50	0.6	2.2
55	f	v
60	0.9	2.7

By interpolation we find :
* Friction head = 0.75 ft/100ft.
* Velocity = 2.45 ft/sec
* Diameter = 3 inch = 75 mm.

Information of main drain lines
* Flow rate = 36.784 gpm.
* Maximum velocity acceptable = 3.3 ft/sec.
* Maximum friction loss = 6 ft/100ft.
* Length =   (from AutoCAD drawing by measurement)

From PVC table in Appendix A, and by interpolation at the following values :

Flow rate (gpm)	**Fraction head (ft/100ft)**	**Velocity (ft/sec)**
35	0.9	2.4
36.78	f	v
40	1.2	2.7

By interpolation we find :
* Friction head = 1 ft/100ft.
* Velocity = 2.5 ft/sec
* Diameter = 2.5 inch = 75 mm.

For skimmers:

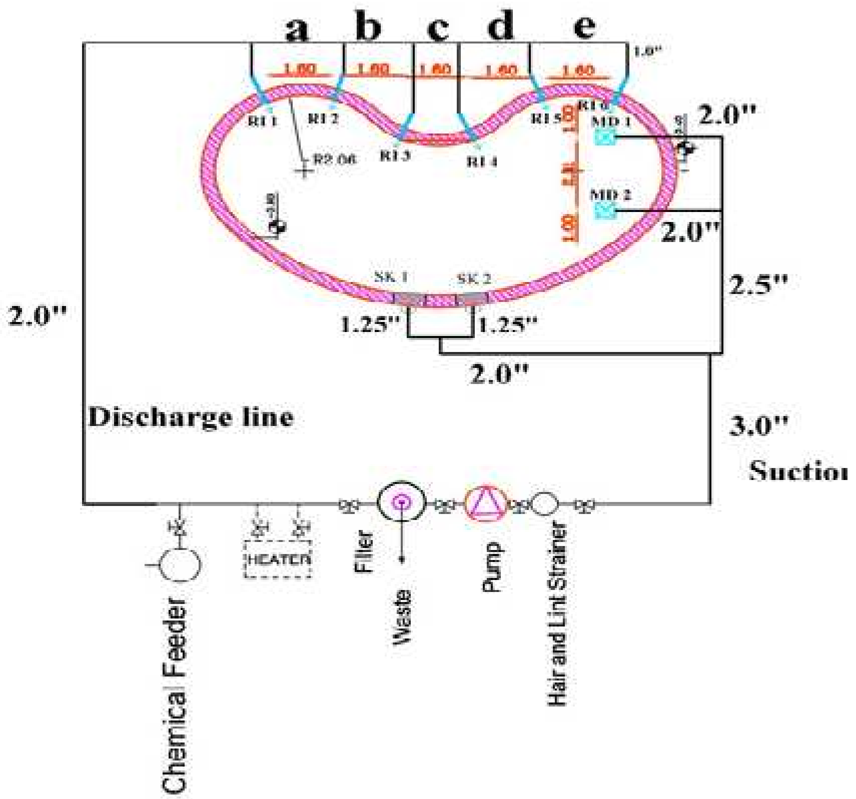
Information of main discharge lines
* Flow rate = 4.16 m^3/hr = 18.304 gpm.
* Maximum velocity acceptable = 3.3 ft/sec.
* Maximum friction loss = ft/100ft.
* Length =   (from AutoCAD drawing by measurement)

From PVC table in Appendix A, and by interpolation at the following values:

Flow rate (gpm)	**Fraction head (ft/100ft)**	**Velocity (ft/sec)**
15	0.5	1.5
18.304	f	v
20	0.8	2

By interpolation we find :
* Friction head = 0.6982 ft/100ft.
* Velocity = 1.8034 ft/sec
* Diameter = 2 inch = 63 mm.

For each skimmer
* flow rate = 9.152 gpm.
* velocity = 2.028 ft/sec.
* friction head = 5 ft/100ft.
* diameter = 1.25 inch.



\+ Figure 6.1 : swimming pool

Quantity tables

ITEM No.	DESCRIPTION	UNIT	QUANTITY	RATE ILS	AMOUNT ILS
	MECHANICAL WORKS				
	Plumbing				
14.1	Storm water Drain System				
14.1.1	Roof Storm Water Drain				
	Supply, install, testing and commissioning of Polypropylene (PP) Roof rain water drain size 4" with cover of 30x30 plastic mesh (REDI make or E.A) to be connected to rain water vertical pipes with required accessories, as per drawings, specifications and related codes.	No.	6		
14.2	UPVC pipe				
	Supply, install, testing and commissioning of SN8 Ø4" UPVC pipes and fittings for roof and building storm water drainage system. The rate shall include all related civil works and all necessary accessories, as per drawings, specifications and related codes.				
	Ø2"	M.L	30		
	Ø4"	M.L	105		
14.3	Supply, install, testing and commissioning of Ø11/4" UCPVC pipes and fittings air conditioning compensated water drainage system. The rate shall include all related civil works and all necessary accessories, as per drawings, specifications and related codes.	M.L	60		
14.4	Floor Drains				

	Supply, install, testing and commissioning of (FT), 4"chrome plated threaded 15x15cm cast brass cover, multi inlet adjustable with 4"/2" trap UPVC floor drain. Including, floor clean out plug and necessary accessories, connections with fixtures and drainage system. as per drawings, specifications and related codes.	No.	14		
	FD 4"/2"	No.	2		
14.5	<u>Clean Outs</u>				
	Supply, install, testing and commissioning of the following, UPVC, nonadjustable 15x15 cm 304 stainless steel screwed cover floor clean out with gas and water tightness ABS plug and necessary accessories as per drawings, specifications and related codes.				
14.5.1	a- Ø4" clean out	No	7		
14.6	<u>EXTERNAL WORKS</u>				
	<u>Waste Water Drainage System:</u>				
	Supply, install, testing and commissioning of the following waste water drainage system consisting of SN8 6" UPVC pipes, pipe fittings, excavation and back fill with sand, connection to drainage system manholes, required sleeves, wall penetration fill and all necessary accessories as per drawings, specifications and related codes.	M.L	35		
14.7	<u>Manholes</u>				

	Supply, install, testing and commissioning of the, 15cm thick for walls and base, pre-casted concrete manholes, with medium duty cast iron covers and frames, excavation, back filling (1/2" steps of galvanized steel for depth=80cm and above), benching, plastering and connection to existing drainage system as per drawings, specifications and related codes.				
14.7.1	a- Ø 60 cm (inner diameter) manhole	No.	2		
14.7.2	b- Ø 80 cm (inner diameter) manhole	No.	1		
	Totals				
	TOTAL CARRIED TO NEXT PAGE.				

BILL No. (14)
MECHANICAL WORKS

ITEM No.	DESCRIPTION	UNIT	QUANTITY	RATE ILS	AMOUNT ILS
	MECHANICAL WORKS				
	FORWARDED TOTAL				
14.7.3	c- Ø 100 cm (inner diameter) manhole	No.	3		
14.8	Domestic Hot and Cold Water systems:				
	Supply, install, testing and commissioning of; GI schedule 40 class A PSI approved, not welded water pipes the price to include, valves, water taps, reducers, tees, plugs for different pipe diameters, including excavation, backfilling with sand, insulating pipes with fine insulation of 6mm for cold and 13mm for hot water, wrapping with 10cm pvc tape and connecting from water				

	source to collectors and fire cabinets from main water system the barrier parts of pipes to be installed in 2" pvc protection pipe at 50cm below grade the price includes installing of water meter and its cabinet as per drawings, specifications and related codes.				
14.8.1	Ø 3/4"	M.L	45		
14.8.2	Ø 1"	M.L	55		
14.8.3	Ø 11/4"	M.L	25		
14.9	<u>Cold and Hot water PEX. Pipes</u>				
	Supply, install, testing and commissioning of, the following PEX. pipes from hot/cold water collectors to related fixtures. The rate to include; copper elbows, angle stop valves (type GIACOMINI or E.A.), 1/2" male and female adaptors as per drawings, specifications and related codes.	M.L	200		
14.10	20mm PEX pipe in 32mm PVC sleeve.	M.L	50		
14.11	25mm PEX pipe in 32mmPVC sleeve	M.L	120		
14.12	<u>Hot and Cold Water Collectors</u>				
	Supply, install, connect, testing and commissioning of, hot and cold water collectors (GIACOMINI or E.A.), Inlets/ Outlets quick shut-off valves, record valves, nipples, nuts, unions, brass fitting adapters, price to include; cabinet made of 1.5mm galvanized steel with 1.5 mm 304 stainless steel hinged lockable door, and all necessary accessories. as per drawings, specifications and related codes.				

14.12.1	Ø3/4"	Eye	10		
14.12.2	Ø11/4"	Eye	38		
14.13	Water pumps				
	Domestic Water Supply pump Set				
	Supply, install, test and commission of; End suction Domestic water pump, of 2900 rpm, class-F insulation, IP-55 to operate at 415 V, 50 Hz. coupled motor, 20cn concrete base mounted on common bed plate with drip lip, casings to be epoxy coated cast iron, high grade properly balanced cast brass impeller, including; pressure regulating valves, control, check valves, pressure transducers, vibration pads, bypass loop with appropriate check valves, low pressure cut off switches, hydro pneumatic tank as per drawings, specifications, and related codes.				
	Q=3m³/hr @ H305m head (P3)	Set	1		
	Totals				
	TOTAL CARRIED TO NEXT PAGE.				

ITEM No.	**DESCRIPTION**	UNIT	QUANTITY	RATE ILS	AMOUNT ILS
	MECHANICAL WORKS				
	FORWARDED TOTAL				
14.14	**Domestic Water Supply pump Set**				

	Supply, install, test and commission of; Horizontal split casing centrifugal, multi stage Domestic water pump set (one duty one standby), with close 2900 rpm, class-F insulation, IP-55 to operate at 415 V, 50 Hz. coupled motors, set to be floor mounted on common bed plate with drip lip, casings to be epoxy coated cast iron, high grade properly balanced cast brass impeller, including; VFD drive, pressure regulating valves, control, check valves, pressure transducers, vibration pads, duplex flow switches, alternatively operation logic controller with features mentioned in specs to be contained in NEMA 3R W.P enclosure, bypass loop with appropriate check valves, low pressure cut off switches, hydro pneumatic tank (all components to be from single manufacturer) as per drawings, specifications, and related codes.				
	Q=70m³/hr @ H=30m (P1&P2)	Set	1		
14.15	**Sanitary Fixture and Their Accessories:**				
	Water Closet				
	Supply, install, testing and commissioning of, floor mounted, white color Porcelain, siphon jet water closet/toilet (Twiford) or approved equal with an elongated bowl, top spud flush valve, seat with open front and check hinge, and carrier. including hanging brackets and accessories, 9-lt capacity cistern, valves,	No.	8		

	fittings, 13mm stop angle valves, chrome plated 13mm hose, and accessories, heavy duty side l m length 13mm Chrome plated hand shower, connection to drainage and water systems as per drawings, specifications and related codes.				
14.16	As above but for handicapped with 1 1/4" stainless steel grab bar for handicapped.	No.	1		
14.17	**Lavatory**				
	Supply, install, testing and commissioning of, slab type, white vitreous china, lavatory (approximate bowl size 56x42cm) (Twiford) or approved equal with: faucet holes on 4" centers, foucet to be of, Solid cast brass construction, Chrome plated, washer less ceramic disc mixing cartridge, laminar flow, gooseneck spout with gear blade handles, hanging accessories, connection to hot/cold water and drainage system. as per specifications, drawings and related codes.	No.	8		
14.18	As above but for handicaped	No.	1		
14.19	**Pathtup**				
	Supply, install, testing and commissioning of, 80x80cm porcelain coate3d steel pathtup including, Solid cast brass construction, Chrome plated, washer less ceramic disc mixing cartridge, laminar flow, shower gear blade handles, connection to dranage system and all necessary accesorries as per drawings, specifications and related codes.	No.	4		
	Totals				

	TOTAL CARRIED TO NEXT PAGE.				
BILL No. (14) **MECHANICAL WORKS**					
ITEM No.	**DESCRIPTION**	UNIT	QUANTITY	RATE ILS	AMOUNT ILS
	MECHANICAL WORKS				
	FORWARDED TOTAL				
14.20	**HAND DRAYERS**				
	Supply, install, connect, test and commission Automatic, robots, vandal resistant, IP 54, Hand Dryer constructed of solid steel frame and painted dia cast aluminum front including thermal cut-out, infrared sensor, adjustable hot air nozzle, conduits, boxes, Double pole switch with pilot lamp and 3*2.5mm2 cable with all accessories. as per specifications, drawings and related standards.	No.	3		
14.21	**Sinks**				
	Supply, install, testing and commissioning of, Single compartment stainless steel sink, drop-in, self-rimming, ledge-type, connected with a drain. with pre-punched fixture center hole, foucet of, Solid cast brass construction, Chrome plated, washer less ceramic disc mixing cartridge, laminar flow, gooseneck spout with gear blade handles integral back ledge to accommodate deck-mounted fixtures, brushed interior and top surfaces, sound deadened. Recommended for use in suspended or counter top. including Coordinate actual outside sink dimensions with the actual clear dimension of				

	cabinet specified to ensure that they are compatible. as per specifications, drawings and related codes.				
	Counter top Kitchen sink	No.	1		
14.22	**Water Storage Tank**				
	Supply, install, testing and commissioning of the following PVC water tanks, each of 1500L capacity, the rate shall include; valves, nipples, shut off valves, vent pipes, non return valves, unions, flowt valve and steel painted stand made of 50x50x5mm angle and all necessary accessories for connections to main watersupply pipes as per drawings, specifications and related codes.	No.	4		
14.23	**Solar Water Heating System**				
	Supply, install, testing and commissioning of, solar water heating system with 45 degrees tilt angle, freezing ambient conditions, using of the following solar water heating system consisting of 2 numbers 90x190x10cm flat solar panels , 1500 ltr cold water storage tank with 2.5KW heater, 160 liter water storage with heat exchange coil , valves and steel painted stand made of 50x50x5mm angle as per drawing specification and related codes .	JOB	2		

14.24	**<u>Fire fighting systems:</u>**				
	Supply, install, testing and commissioning of; GI schedual 40 class A PSI approved, not welded water pipes the price to include, valves, water taps, reducers, tees, plugs for diffirent pipe diameters, including excavation, backfilling as per drawings, specifications and related codes.				
	Ø 11/4"	M.L	34		
	Ø 11/2"	M.L	15		
	Ø 3"	M.L	55		
	Totals				
	TOTAL CARRIED TO NEXT PAGE.				

ITEM No.	**DESCRIPTION**	UNIT	QUANTITY	RATE ILS	AMOUNT ILS
	MECHANICAL WORKS				
	FORWARDED TOTAL				
14.31	**<u>Exhaust Air Fans</u>**				
	Supply and install testing and commissioning of: SWSI exhaust air inline ducted fans of industrial construction, galvanized steel housing with duct adapter, connection to electrical system, vibration absorbers and prefabricated top roof mount. as per specifications, drawings and related codes.				
14.31.1	Exhaust:200 CFM window type	No.	1		
14.31.2	Exhaust:100 CFM window type	No.	10		
14.32	**<u>LPG system</u>**				

	Supply and install testing and commissioning of: 48 kg. liquid petroliym gas cylinder including; lockable painted steel cabinet, gas valves, gas collector, 8mm Cu PE coated pipes, gas leak detectors, shut off valve for each kitchen as per drawings, specifications and related codes.	JOB	1		
14.33	**Air Conditioning**				
	Split units				
	Supply, install, connect, test and commissioning of the following decorative split units heat pump (indoor and outdoor units) complying with ASHAE/USGBC/IES 189.1-2009 requirements including; room thermostats, fittings, 6mm vidoflex insulated Cu pipes wrapped with pvc tape, indoor units brackets, electrical cables and 5/5 cm galvanized steel stands/ brackets with vibration absorbers. As per drawings, specifications, and related codes. Note: Refrigerant gas to be of zero Ozone depletion potential (ODP) as R410A.				
	:Units must iclude the following				
	1- Electronic control system with wireless control remote				
	2- Hermebic piston type compressor of Copland or equal.				
	3- Sound pressure level of indoor unit must not exceed than 40 dBA at 3 m				
	4- Indoor unit of double swing				
	5- Heavy duty outdoor painted galvanized steel cover				

	6- Defrost self contained unit				
	7- Suction accumulator				
	8- Remote control with the following features :				
	a. On - Off				
	b. Three speed fan				
	c. Four operating modes				
	d. Timer bottons				
	The price includes supply and install of flexible joints , painted metal base for outdoor unit , all gas and electrical piping and wiring works as required by manufacturer , electrical connection to power supply and isolation system to all pipes				
14.33.1	a-Cooling capacity 1 TR	No.	6		
14.33.2	b-Cooling capacity 11/2 TR	No.	1		
14.33.3	c-Cooling capacity 2 TR	No.	1		
	Totals				
	TOTAL CARRIED TO NEXT PAGE.				

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Chapter seven

Appendix

REFERENCES

1) ASTRALPOOL, Swimming pools and SPAS ,Catalogue 2004-2005
2) JOHN DAWES, Design and planning of swimming pools,CPI publishing , London,1979.
3) Ashrae book
4) Fundamentals to HVAC systems (Robert mcdowall 2007)
5) Fluid mechanics (sie) (white)