بسم الله الرحمن الرحيم

Palestine Polytechnic University

College of Engineering and Technology

Mechanical Engineering

Air Conditioning & Refrigeration Engineering

The use Of Building Information Modeling (BIM) To Model Building Services Of Residential Building.

Prepared by:

Sahir Amro

Supervised by:

Eng. Kazem Osaily

Submitted to the College of Engineering
In partial fulfillment of the requirements for the degree of
Bachelor degree in Building Engineering

May_ 2019

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Sahir Amro

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1.1 Introduction

With the global trends toward green or sustainable buildings the need for new technology (BIM) increases exponentially, where the less energy consumption and collaborative environment between various stakeholders such as Architects, Civil Engineers and structural Engineers and MEP system Engineers help increasing the efficiency of project construction and choosing the best mechanical systems which consume less energy (intuitively less carbon dioxide to the environment).

stakeholders such as Architects, Civil Engineers, Structural Engineers, MEP System Engineers, Builders, Manufacturers and Project Owners can extract and generate views and information according to their needs and standards all over the world means less time and better managing in project life cycle.

Traditional mechanical services design was reliant upon two-dimensional technical drawings (plans, elevations, sections, etc.), but now we use new technology that let us deal with three dimensions project in design and documentation to generate databases needed for every system at the same instant in project phase from construction to demolition.

This Building Information modeling technology extends our work beyond (3D) the three spatial dimensions (length ,width, height) with time as the fourth dimension, as long as the cost is the fifth (5^{th}) dimension where we will discuss in second semester when the project virtually finished.

There are also references to a sixth dimension (6D) representing building environmental and sustainability aspects, and a seventh dimension (7D) for through-life facility management.

BIM therefore covers more than just geometry. It also covers spatial relationships, light analysis, geographic information, and quantities and properties of building components (for example, manufacturers' specifications of systems and devices used specially in HVAC systems.

1.2 project overview

Due to universal development in technology and the use of computer aided design (CAD) software the project focusing on the use of Building Information Technology to model air conditioning system for residential building located virtually in Dura-Hebron.

As long as the job of mechanical engineers and HVAC designers is to maintain most comfortable conditions for the people, this technology will help us take the decision what system is better to use and see in the future of project life cycle the amount of energy that will be consumed.

modeling aims to design and model air conditioning system and plumbing with fire-fighting alarm system for residential building (home).

1.3 project scope

The scope of this project is to design, document and modeling the mechanical services systems for residential building by using Revit2019. This project can create a bridge between the mechanical engineering students and the architects engineers and civil engineers in good collaborative environment and networking which will improve our abilities in using modeling software extending our knowledge in different fields of engineering .

1.4 project objectives

The objectives of the project is to study and design the different mechanical systems needed inside the home and we have two main goals:

1- by using Revit2019 we design the mechanical systems used in the home and specially small residential building
2- we learn and improve our knowledge generally about building information modeling and green sustainable buildings.

1.5 project choice and justification

this project gives us sufficient experiences and increase the opportunity to get a job after graduation in designing and modeling mechanical systems at companies that adopt new technologies specially the device manufacturer of VRF and fire-fighting systems.

1.6 Time table

Table 1: first semester time table

week / Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Selection of the project															
Search about information															
Search for previous projects															
Learning Revit2019															
Heating &Cooling Load Calculations															
WSFU Calculations															
Project Documentation															
Project Printing															

Table 2: second semester time table

Activity / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Complete Design The Mechanical Services System for The Building															
Required drawings for the relevant systems on AutoCAD program and Revit															
Project Documentation															
Project Printing															

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chapter two

heating load calculations

2.1 Introduction
2.2 Human comfort
2.3 Overall heat transfer coefficient.
2.4 Design conditions (outdoor/indoor)

2.1 Introduction

The main objective of the air conditioning is to maintain comfortable and healthy conditions for the people in the home. This feeling of comfort is influenced by inside temperature, the relative humidity and the outside design condition.

- conditions that affect the human comfort.
  1. Air temperature of the rooms and spaces and its velocity.
  2. Humidity or the moisture contents of the air
  3. Purity and quality of the inside air.

2.2 Human comfort

Factors Affecting Human Comfort:

1. Dry Air: air that has no relative humidity.
2. Moist Air: air that is a mixture of dry air and any amount of water vapor generally.
3. Humidity: is the amount of water vapor in the air.
4. Dry Bulb Temperature: temperature that is usually thought of as air temperature.
5. Wet Bulb Temperature: is the temperature a parcel of air would have if it were cooled to saturation (100% relative humidity) by the evaporation of water into it.
6. Dew-Point Temperature: the temperature at which water vapor starts to condense out of the air (the temperature at which air becomes completely saturated). Above this temperature the moisture will stay in the air.
7. Relative Humidity: The ratio of the amount of water vapor in the air at a specific temperature.

2.3 Calculation of The overall heat transfer coefficient (U):

The overall heat transfer coefficient depends on the layers that the walls and roof consist of and the inside and outside convection heat transfer coefficients. So the overall heat transfer coefficient can be calculated by applying the following equation:

$$U=\frac{1}{\Sigma Rth}=\frac{1}{R\in+\Sigma\frac{\Delta x}{K}+Rout}$$

Where:

Δ X: the thickness of the wall.

R_{in}: inside film resistance.

R_{out}: Outside film resistance.

Calculation of overall heat transfer coefficient for walls,ceiling,floor, glass and door :

1- For external wall

Construction of external walls

Layers

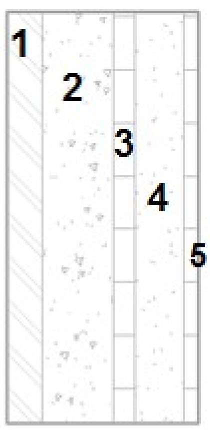
EXTERIOR SIDE

	Function	Material	Thickness	Wraps	Structural Material
1	**Core Boundary**	**Layers Above Wrap**	**0.00 cm**		
2	Structure [1]	ston	5.00 cm	☐	☐
3	Structure [1]	Concrete, Cast In Si	10.00 cm	☐	☑
4	Substrate [2]	Rigid insulation	3.00 cm	☐	☐
5	Structure [1]	cement brick	7.00 cm	☐	☐
6	Structure [1]	plaster	2.00 cm	☐	☐
7	**Core Boundary**	**Layers Below Wrap**	**0.00 cm**		

INTERIOR SIDE

Insert Delete Up Down

Table3 construction of external walls

	Material	ΔX(m)	k(W/m.°C)	R(m^2.°C /W)	
1	**limestone**	0.05	2.2	0.022	
2	**Concrete**	0.1	1.75	0.057	
3	**Polyurethane**	0.03	0.04	0.750	
4	**Cement brick**	0.07	0.9	0.077	

5	**Plaster**	0.02	1.4	0.014	Figure 1 preview construction of external walls

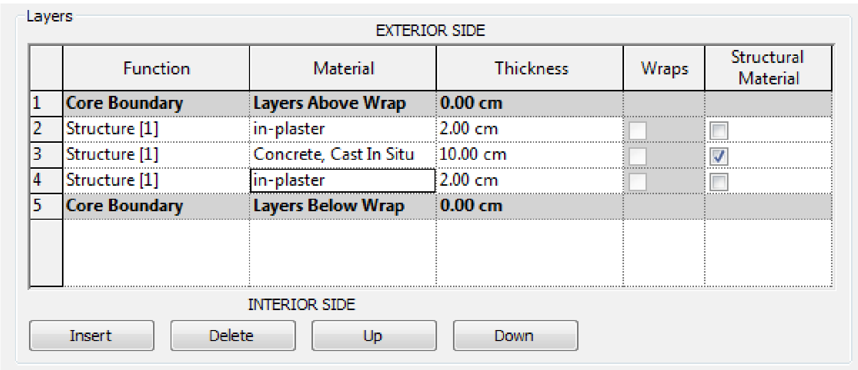
$R_{in}$and R_{out} for the external walls as 0.13 and 0.04 $(m^2/W.°C)$, respectively from the text book heating and air conditioning for residential buildings page 151.

$$Uout=\frac{1}{R\in+\frac{\Delta x_{st.}}{k_{st.}}+\frac{\Delta x_{con.}}{k_{con.}}+\frac{\Delta x_{poly.}}{k_{poly.}}+\frac{\Delta x_{Brick}}{k_{Brick}}+\frac{\Delta x_{plaster}}{k_{plaster}}+Rout}$$

$$=\frac{1}{0.13+\frac{0.05}{2.2}+\frac{0.1}{1.75}+\frac{0.03}{0.04}+\frac{0.07}{0.9}+\frac{0.02}{1.4}+0.04}$$

$=0.91 \ (W/m^2.°C)$.

2- For internal wall



Layers

EXTERIOR SIDE

	Function	Material	Thickness	Wraps	Structural Material
1	**Core Boundary**	**Layers Above Wrap**	**0.00 cm**		
2	Structure [1]	in-plaster	2.00 cm	☐	☐
3	Structure [1]	Concrete, Cast In Situ	10.00 cm	☐	☑
4	Structure [1]	in-plaster	2.00 cm	☐	☐
5	**Core Boundary**	**Layers Below Wrap**	**0.00 cm**		

INTERIOR SIDE

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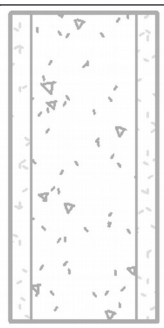
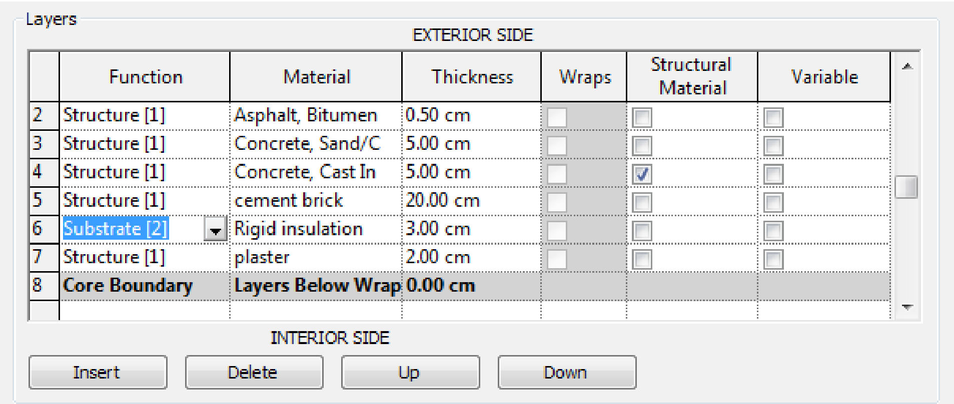
Table4: Internal wall construction

	Material	**ΔX(m)**	**k(W/m.°C)**	**R(m2.** $°C$ **/W)**	
1	**Plaster**	**0.02**	**1.4**	**0.014**	 Figure **2: internal wall construction**
2	**Brick**	**0.1**	**1**	**0.100**	
3	**Plaster**	**0.02**	**1.4**	**0.014**	

¿ 2.57 $(W/m^2.°C)$.

3- For ceiling



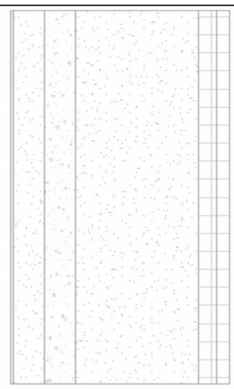
Layers

EXTERIOR SIDE

	Function	Material	Thickness	Wraps	Structural Material	Variable
2	Structure [1]	Asphalt, Bitumen	0.50 cm	☐	☐	☐
3	Structure [1]	Concrete, Sand/C	5.00 cm	☐	☐	☐
4	Structure [1]	Concrete, Cast In	5.00 cm	☐	☑	☐
5	Structure [1]	cement brick	20.00 cm	☐	☐	☐
6	Substrate [2]	Rigid insulation	3.00 cm	☐	☐	☐
7	Structure [1]	plaster	2.00 cm	☐	☐	☐
8	**Core Boundary**	**Layers Below Wrap**	**0.00 cm**			

INTERIOR SIDE

Table 5: Construction of ceiling

Material	ΔX(m)	k(W/m.°C)	R(m^2.°C /W)	
Asphalt mix	0.005	0.70	0.028	 Figure 3: Construction of ceiling
Concrete	0.05	1.75	0.028	
Reinforced concrete	0.05	1.75	0.028	
Plaster	0.02	1.4	0.014	
Hollow brick	0.2	0.95	0.210	
Polyurethane	0.03	0.04	0.750	

Because of its construction, the ceiling is divided into two overall heat transfer coefficient one with brick and the other without.

R_{in} and R_{out} for the ceiling are 0.1 and 0.04 $(m^2/W.°C)$, respectively

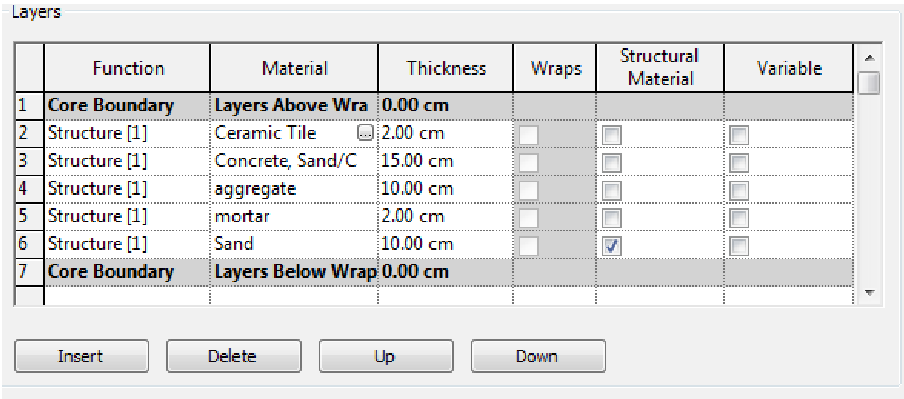
$$U_1 = \frac{1}{R_{in} + \frac{\Delta x_{asph.}}{k_{asph.}} + \frac{\Delta x_{conc.}}{k_{conc.}} + \frac{\Delta x_{poly.}}{k_{poly.}} + \frac{\Delta x_{conc.}}{k_{conc.}} + \frac{\Delta x_{Brick}}{k_{Brick}} + \frac{\Delta x_{Plaster}}{k_{Plaster}} + R_{out}}$$

$$= \frac{1}{0.1+\frac{0.005}{0.70}+\frac{0.05}{1.75}+\frac{0.03}{0.04}+\frac{0.05}{1.75}+\frac{0.2}{0.95}+\frac{0.02}{1.4}+0.04}$$

$$= 0.848\left(W/m^2.°C\right) .$$

Similarly, $U_2 = 1.032\left(W/m^2.°C\right)$

4- For floor



Layers

	Function	Material	Thickness	Wraps	Structural Material	Variable
1	**Core Boundary**	**Layers Above Wra**	**0.00 cm**			
2	Structure [1]	Ceramic Tile	2.00 cm	☐	☐	☐
3	Structure [1]	Concrete, Sand/C	15.00 cm	☐	☐	☐
4	Structure [1]	aggregate	10.00 cm	☐	☐	☐
5	Structure [1]	mortar	2.00 cm	☐	☐	☐
6	Structure [1]	Sand	10.00 cm	☐	☑	☐
7	**Core Boundary**	**Layers Below Wrap**	**0.00 cm**			

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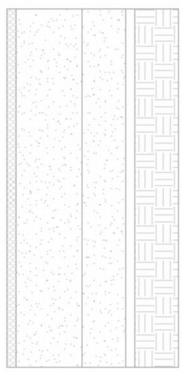
Table 6 Construction of floor

Material	**ΔX(m)**	**k(W/m.°C)**	**R(m^2.°C /W)**	
Reinforced concrete	0.15	1.75	0.085	
ceramic tiles	0.02	1.2	0.016	
Aggregates	0.10	1.05	0.095	
Mortar	0.02	0.16	0.125	
Sand layer	0.1	0.7	0.142	Figure 4 floor construction

R_{in}= 0.15 $\left(m^2/W.°C\right)$, from tables A (3.2)

$$U_f = \frac{1}{R\in \frac{+\Delta x_{ceramic}}{k_{ceramic}} + \frac{\Delta x_{mortar}}{k_{mortar}} + \frac{\Delta x_{aggregates}}{k_{aggregates}} + \frac{\Delta x_{con.}}{k_{con.}} + \frac{\Delta x_{sand.}}{k_{sand}}}$$

$$= \frac{1}{0.15+\frac{0.02}{1.2}+\frac{0.02}{0.16}+\frac{0.10}{1.05}+\frac{0.15}{1.75}+\frac{0.1}{0.7}} = 1.62\left(W/m^2.\circ C\right)$$

5- For glass

From table page152 of air conditioning book , $Ug = 3.2\left(W/m^2.\circ C\right)$ for double glass aluminum frame.

6- For door

From table page 153 of air conditioning book, $Ud = 3.6\left(W/m^2.\circ C\right)$ for wood door type.

2.4 Outdoor and Indoor design conditions

These conditions include the dry bulb temperature, relative humidity, and the average air speed. These values were obtained from the Palestinian code and the psychometric chart.

Table 7: Outdoors design condition

Property	Inside design condition		outside design condition	
	summer	winter	summer	winter
Temperature (˚C)	24	24	35	19
Relative humidity (%)	50	50	70	80
Wind speed (m/s)	….	….	2.3	3.5

2.4.1 Heat loss calculations:

The main resources of heat loss come from the walls, floor, ceiling, doors, windows and also comes from the infiltration. To calculate each one of them the following equations are to be use:

$$\dot{Q} = A \times U \times (T_i - T_o) \qquad (2.2)$$

Where:

$\dot{Q}$: Is the heat transfer rate. [kW]

A: Is the area of the layer which heat flow through it. [m^2]

ΔT : Is the difference between the inside and outside temperatures [$°C$]

U: Is the overall heat transfer coefficient. [$W/m^2.°C$]

2.4.2 Total heat load calculations

Total heat load calculations for the sample room:

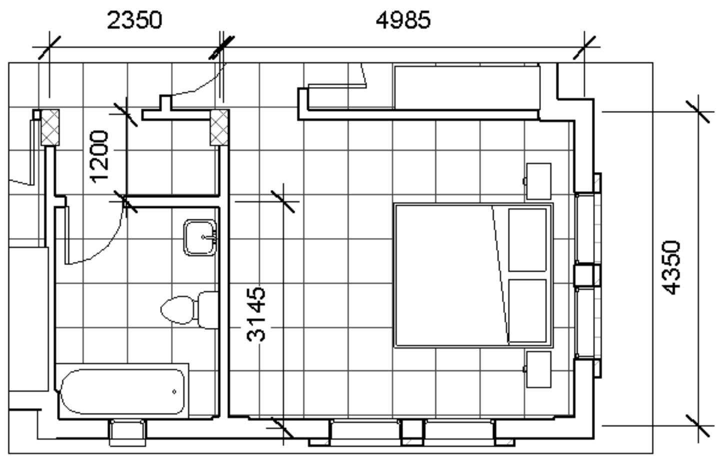


Figure 5 Sample room

Heat loss through ceiling ($\acute{Q}_c$):

Because of its construction, the ceiling is divided into two areas which are area A_1 and area A_2 as showing n Figure (2.5).

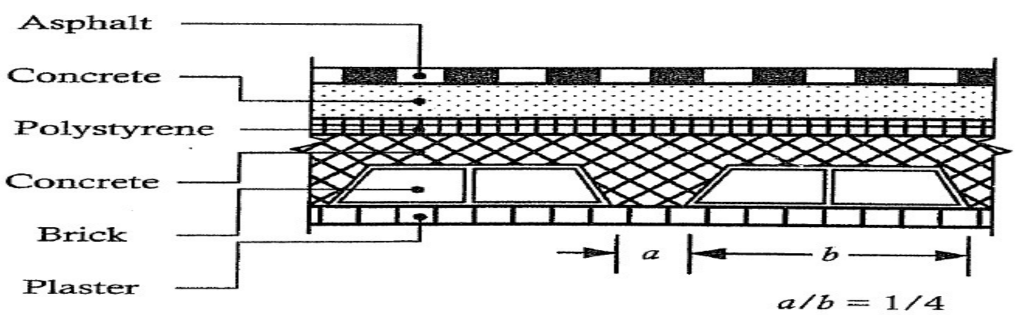


Figure 6 Ceiling construction

The area A_1 is equal to:

$A_c = 4.985*4.35 = 21.7$ and $A_1 = \frac{4}{5} A_c = \frac{4}{5}(21.7) = 17.36\ m^2$

And the area A_2 is equal to: $A_2 = \frac{1}{5} A_c = \frac{1}{5}(21.7) = 4.34\ m^2$

$\acute{Q}_c = U_c A_c (T_i - T_o) = (U_1 A_1 + U_2 A_2)(T_i - T_{unc})$

$\acute{Q}_c = (0.848 \times 17.36 + 1.032 \times 4.34)(24 - 19) = 96.0008\ W$

Heat loss through walls ($\acute{Q}_w$):

The heat loss from internal is :

$Q_{wall,in1} = U_w A_w (T_i - T_{un}) = 2.57*21.7*0 = 0W$

$Q_{wall,in2} = U_w A_w (T_i - T_{un}) = 2.57*(21.7 - 2*1.8)*5 = 232.58\ W$

$Q_{wall,in3} = 232.58W$

$Q_{wall,in4} =$ 2.57*(21.7)*(24-21) = 152.658W

Heat loss through floor (Q_f):

Af= 4.35*4.985 = 21.7

$Q_f = U_f A_f (T_i - T_{un}) = 1.62*21.7*5 = 175.8\ W$

Heat loss through windows ($\acute{Q}_g$):

$\acute{Q}_g = U_g A_g (T_i - T_o)$

$Ag = (4*1)*(1.8) = 7.2\, m2$

$\acute{Q}_g = (3.2)(7.2)(24-14) = 230.4\ W$

Heat loss through external door ($\acute{Q}_d$):

$\acute{Q}_d = U_d A_d (T_i - T_{un.}) = (3.6)(2 \times 0.9)(24-19) = 34\ W$

Heat loss through infiltration ($\acute{Q}_{inf}$):

Infiltration is the leakage of outside air through cracks and clearances around the windows and doors. The amount of infiltration depends mainly on the tightness of the windows and doors on the outside wind velocity or the pressure difference between the outside and inside of the room.

The total heat load due to infiltration is given by the equation

$$\dot{Q}_{inf.,g} = \frac{1250}{3600} \dot{V}f \quad (T_i - T_o) \qquad (2.4)$$

Where:

T_{in}: inside design temperature ($°C$¿ .

T_{out}: outside design temperature($°C$¿

$\dot{V}f$: The volumetric flow rate of infiltrated air in (m^3/h)

$$\dot{V}f = K \times L\,[0.613\,(S_1 \times S_2 \times V_O)^2\,]^{2/3} \qquad (2.5)$$

Where:

K: the infiltration air coefficient.

L: the crack length in meter.

S_1 : Factor that depends on the topography of the location of the building

S_2 : Coefficient that depends on the height of the building.

V_O : measured wind speed (m/s)

The value of K, S_1 and S_2 is obtained from Appendix A.

K =0.43, S_1 =1, S_2 =0.94,

V_O = 1.4 (m/s) from Palestinian code

L = [4* 2(1.8+1)] = 22.4 m

Therefore;

$$\dot{V}f = (0.43)\,(22.4)\,[0.613(1 \times 0.65 \times 1.4)^2\,]^{2/3} = 6.13\ m^3/h$$

The total heat loss due to infiltration is calculated as follows:

Through window

$$\acute{Q}_{inf.,g} = \frac{1250}{3600} \acute{V}f \quad (T_i - T_o)$$

$$= \frac{1250}{3600} \quad (6.13)\ (24 - 19)$$

$= 10.64W$

Through door

$$\acute{Q}_{inf.,d} = \frac{1250}{3600} \acute{V}f \quad (T_i - T_o)$$

$$\acute{V}f = K \times L\ [0.613\ (\ S_1 \times S_2 \times v_\circ\ )^2\ ]^{2/3}$$

$L = [(2\times0.9) + (2\times2)] = 5.8$ m

Therefore;

$$\acute{V}f = (0.43)\ (5.8)\ [0.613(1 \times 0.94 \times 1.4)^2\ ]^{2/3}$$

$= 2.59\ m^3/h$

$$\acute{Q}_{inf.,d} = \frac{1250}{3600} \acute{V}f \quad (T_i - T_o)$$

$$= \frac{1250}{3600} \quad (2.59)\ (24 - 19) = 5.12W$$

$$\acute{Q}_{inf.,tot} = \acute{Q}_{inf.,g} + \acute{Q}_{inf.,d}$$

$= 10.64 + 5.12$

$= 15.76$ W

Heat gain due to ventilation

The ventilation is used for maintaining a healthy indoor air by introducing a fresh air from outside of the building. And this kind of heat gain can be calculated by using the following equations:

$$Q_{vent.} = \acute{m} \times C_{pair} \times (T_o - T_{¿})$$

Where:

$\acute{m}$: mass flow rate of ventilation air (kg/s).

$$\acute{m} = \frac{Rate\ of\ ventilation\ air}{v_o}$$

Rate of ventilation = Room Area × Requirement outside ventilation air

= 4.985*4.35×2 = 43.4 L/s = 0.0434 m^3 /s.

v_o = 0.791 m^3 /kg.

$\acute{m}$ = 0.055 kg/s.

C_{pair} : Specific heat of air, C_{pair} = 1.005 kJ/kg.°C.

$Q_{vent.}$ = 0.055×1.005 × (24- 19) = 0.553KW.

The total heat loss from the sample room is

$\acute{Q}_{tot} = \acute{Q}_{w,tot} + \acute{Q}_{c} + Qf + \acute{Q}_{g} + \acute{Q}_{d} + \acute{Q}_{inf.,tot} + \acute{Q}_{vn}$

= 617 + 96.0008 + 175.8+ 230.4 + 34 + 15.76 + 553

= 1722W

By using Revit2019 this table shows heating and cooling loads calculated using the software packages specified.

Default Spaces

Space Name	Area (m^2)	Volume (m^3)	Peak Cooling Load (W)	Cooling Airflow (L/s)	Peak Heating Load (W)	Heating Airflow (L/s)
18 guest bathroom	4	11.43	92	4.5	171	12.7
17 garage	24	62.19	2,736	132.9	151	39.5
19 guest room	50	157.81	6,645	322.7	374	82.3
20 bathroom	6	17.41	589	28.6	779	57.9
21 Room	8	24.90	690	33.5	499	37.1
24 master bedroom	22	57.05	1,886	91.6	1,602	119.2
23 masterbathroom	7	19.87	553	26.9	422	31.4
27 bedroom	14	41.62	1,180	57.3	842	62.6
26 bathroom-s	4	11.09	347	16.8	271	20.2
25 boys-bedroom	14	42.62	1,132	55.0	1,083	80.5
22 stair	13	48.96	663	32.2	1,131	84.1
34 caridor	20	58.72	1,358	66.0	1,260	93.7
29 balcony	12	39.40	502	24.4	1,001	74.4
30 kitchen	23	56.81	2,057	99.9	2,092	155.6
32 living room	19	56.08	2,523	122.5	1,273	94.7
33 main entrance	11	31.72	2,732	132.7	539	40.1

Chapter three

cooling load calculations

3.1 Introduction

The cooling load is defined as the rate at which heat energy must be removed from a space in order to maintain a given inside design condition.

To achieve the human comfort conditions it is needed to do some calculation to select the proper equipment to have the conditions that it is needed and the cooling load is the most important load that can helps in selecting the equipment's that needed correctly.

3.2 Cooling load

- The total cooling load of a structure involves:
- Sensible heat gain through walls, floors and roof.
- Sensible heat gain through windows.
- Sensible heat and latent heat gain from ventilation.
- Sensible and latent heat due occupancy.
- Sensible heat gain from the equipment.

3.2.1 Cooling load calculations:

Total cooling load calculations for the sample room:

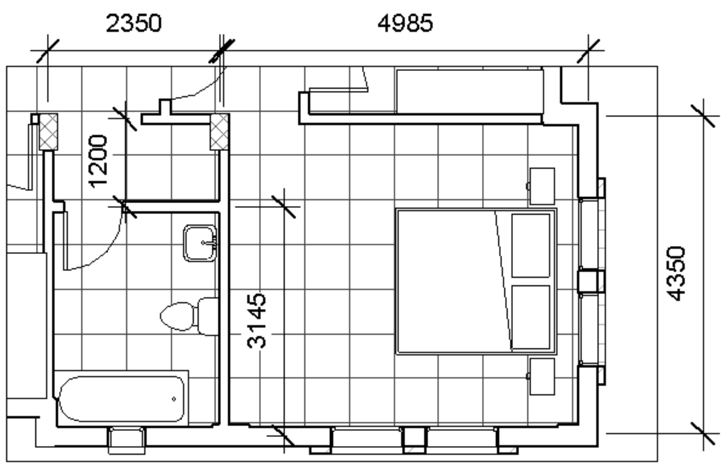


Figure 7 Sample Room

Direct and diffused solar radiation that 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 heat transfer rate through sunlit walls or sunlit roofs is calculated from the following equation:

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

Where:

$(CLTD)_{corr.}$: corrected cooling load temperature difference, ˚C

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

Where:

CLTD: cooling load temperature difference, ˚C
LM: latitude correction factor.
k: color adjustment factor.
T_{in}: inside comfort design temperature, ˚C
f: attic or roof fan factor.
$T_{o,m}$: outdoor mean temperature, ˚C

$T_{o,m} = (T_{max}+T_{min}) /2$

Where:

T_{max}: maximum average daily temperature, ˚C
T_{min}: minimum average daily temperature, ˚C

T_{max} = 35 ˚C and T_{min} = 20˚C are obtained from Palestinian Code.

Applying these values to obtain the outdoor mean temperature $T_{o,m}$ 27.5 ˚C.

3.3 Sample Calculation:

Calculation the heat gain from the Guest room in the last floor as a sample :

Heat gain through sunlit roof (Q_{Roof}):

CLTD = 14 ˚C from Appendix A

LM = 0.5 from Appendix A

k = 0.83 for permanently light colored roofs.

f = 1 there is no attic or roof fan.

$(CLTD)_{corr.} = (14 + 0.5)\ 0.83 + (25.5 - 24) + (27.5 - 29.4)\ 1$

$= 11.635^{\circ}C$

$\acute{Q}_{Roof} = (U_1 A_1 + U_2 A_2)\ (CLTD)_{corr}$

$\acute{Q}_{Roof} = (0.832 \times 17.36 + 4.34 \times 1.01)\ (11.635)$

$= 219.05\ W$

Heat gain through sunlit walls (Q_{Wall}):

CLTD at 14:00 o'clock … from Appendix A.

CLTD =15 c

LM =0

N = 0.0

k = 0.83 for permanent medium color walls.

$A_E = 8.7 + 9.97 = 18.64\ m^2$

$(CLTD)_{corr., E} = (15+0)\ 0.83 + (25.5-24) + (27.5-29.4) \times 1$

$= 12.05\ ^{\circ}C$

$Q^{\cdot}_{Wall} = Q^{\cdot}_{E} = 2.57 * 18.64 * 12.05$

$= 577.25\ W \quad = 0.57725 kW$

Heat gain due to glass (Q_{Glass}):

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

1- 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.

2- 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.

3- 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.

The maximum cooling load due to the glass window $Q_{Glass,}$ consists of transmitted ($Q_{tr.}$) and convicted ($Q_{conv.}$) cooling loads as follows:

$$Q_{Glass} = Q_{tr.} + Q_{conv.}$$

Where:

$Q_{tr.}$: transmission heat gain, W

$Q_{conv.}$: convection heat gain, W

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 A.

SC: Shading coefficient: this factor accounts for different shading effects of the glass wall or window and can be extracted from tables Appendix A for single and double glass without interior shading 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 table for glass without interior shading or from for glass with interior shading.

The transmitted cooling load is calculated as follows:

$Q_{tr.}$ = A (SHG) (SC) (CLF)

SHG in W/m^2 … from Appendix A

A = 7.2 m^2

SHG = 691 W/m m, SC = 0.57… reflective double ,

CLF = 0.31 at 14:00 o'clock ,

$Q_{tr.\,N}$ = 7.2×691× 0.57× 0.31= 879.12 W

$Q_{conv.} = UA\,(CLTD)_{corr.}$

Where:

U: Over all heat transfer coefficient of glass (W/m².K).

A: Out windows Area of heat conduction. (m²).

$(CLTD)_{corr.}$: is calculated as the same of walls and roofs and the CLTD value for glass is obtained from Appendix A.

CLTD = 7 ˚C at 14:00 o'clock

k = 1 for glass

f = 1 for glass

$Q_{conv.\,N}$ = 170.24 W

Q_{Glass} = 879.12 + 170.24

= 1049.36 W

Heat gain due to lights ($Q^{\cdot}_{Lt.}$):

Heat gains due to lights are sensible loads and are calculated by the following equation: $Q^{\cdot}_{Lt.}$ = light intensity × A × $(CLF)_{Lt.}$

Where:

light intensity = 10-30 W/m^2 for apartment, so we will take 30W/m^2

A: floor area = 21.7 m^2

$(CLF)_{Lt.}$: cooling load factor for lights.

$(CLF)_{Lt.}$ = 0.82

$Q_{Lt.}$ = 30 ×21.7× 0.82

= 533.82 W

= 0.534 kW

Heat gain due to infiltration (Q_f):

As the same way in heating load

$$\acute{Q}_{inf.,g} = \frac{1250}{3600} \acute{V}f \quad (T_i - T_o)$$

Where:

$\acute{V}f$: The volumetric flow rate of infiltrated air in (m^3/s)

$\acute{V}f$ = K × L [0.613 (S_1 × S_2 × V_O)^2]$^{2/3}$

Where:

K: the infiltration air coefficient.

L: the crack length in meter.

S_1 : Factor that depends on the topography of the location of the building

S_2 : Coefficient that depends on the height of the building.

V_O : measured wind speed (m/s)

The value of K, S_1 and S_2 is obtained from Appendix A

K =0.43 , S_1 =1 , S_2 =0.65, V_O = 1.4 (m/s) from Palestinian code

And the window is sliding then: L = [4* 2(1.8+1)] = 22.4 m

Therefore;

$\acute{V}f$ = (0.43) (22.4) [0.613(1 × 0.65 × 1.4)^2] $^{2/3}$ = 6.13 m^3/h

$$\acute{Q}_{inf.,g} = \frac{1250}{3600} \acute{V}f \quad (T_i - T_o)$$

$$= \frac{1250}{3600} (6.13)(35–24)$$

=23.413 W

Through door

$$\acute{Q}_{inf.,d} = \frac{1250}{3600} \acute{V}f \quad (T_i - T_o)$$

$\acute{V}f = K \times L\ [0.613\ (\ S_1 \times S_2 \times v_{\circ}\ )^2\ ]^{2/3}$

L = [2 (2+0.9)] = 5.8 m

Therefore;

$\acute{V}f = (0.43)\ (5.8)\ [0.613(\ 1 \times 0.65 \times 1.4)^2\ ]^{2/3} = 1.59\ m^3/h$

$$\acute{Q}_{inf.,d} = \frac{1250}{3600} \acute{V}f \quad (T_i - T_o)$$

$$= \frac{1250}{3600} \quad (\ 1.59\ )(35- 24)$$

= 6.1W

$\acute{Q}_{inf.,tot} = \acute{Q}_{inf.,g} + \acute{Q}_{inf.,d}$

= 23.4 + 6.1

= 29.5 W

Heat gain due to occupants ($Q_{oc.}$):

Sensible and latent heat gains from occupants must be removed from the conditioned space. The heat gain due to occupants is the following:

$Q_{oc.} = Q_{sensible} + Q_{latent}$

$Q_{sensible}$ = heat gain sensible × No. of people × $(CLF)_{oc.}$

Where:$(CLF)_{oc.}$: cooling load factor due to occupants.

heat gain sensible = 70 very light work

No. of people = 2

$(CLF)_{oc.}$ = 0.84 at 9 hours after each entry into space is obtained from Appendix A.

$Q_{sensible}$ = 70 ×2× 0.84

= 117.6 W

Q_{latent} = heat gain latent × No. of people

heat gain latent = 44… very light work

$Q_{latent} = 44 \times 2 = 88W$

$Q_{oc.} = 117.6 + 88 = 205.6$ W

Heat gain due to ventilation ($Q_{vn.}$):

Mechanical ventilation is required for places in which the inside air is polluted due to activities that place in these spaces as factories, restaurants, closed parking areas, etc. The amount of outside fresh air recommended for mechanical ventilation for different applications is listed Appendix and The sensible and total cooling loads required to cool the ventilated air to the inside room temperature is calculating by the following equation:

$$Q_{vn.} = \acute{m} \times Cp_{air} \times (T_{out} - T_{in})$$

Where: $\acute{m}$: mass flow rate of ventilation air, kg/s

Cp_{air}: specific heat of air = 1.005 kJ/kg .k

$$\acute{m} = \frac{rate\ of\ ventilation\ air}{v\,o}$$

rate of ventilation air = $A_{room} \times$ requirement outside ventilation air

$A_{room} = 21.7\ m^2$

requirement outside ventilation air = 2 $L/s/m^2$ from the Appendix

rate of ventilation air = 21.7×2= 43.4 L/s = 0.0434 m^3/s

$v_o = 0.879 m^3/kg$,

$\acute{m} = 0.0434/0.879 = 0.0494$ kg/s

$Q_{vn.} = 0.0494 \times 1.005 \times (35 - 24) = 0.543$ kW

The total heat loss from Sample Room is:

$Q_{Tot} = Q_{Roof} + Q_{Wall} + Q_{Glass} + Q_{Lt} + Q_f + Q_{oc.} + Q_{vn.}$

$Q_{Tot=}$

=3229.58W

3.4 Variable Refrigerant Flow System

3.4.1 Overview

The primary function of all air-conditioning systems is to provide thermal comfort for building occupants. There are a wide range of air conditioning systems available, starting from the basic window-fitted units to the small split systems, to the medium scale package units, to the large chilled water systems, and currently to the variable refrigerant flow (VRF) systems.

Variable refrigerant flow (VRF) is an air-conditioning system configuration where there isone outdoor condensing unit and multiple indoor units. The term variable refrigerant flow refers to the ability of the system to control the amount of refrigerant flowing to the multiple evaporators (indoor units), enabling the use of many evaporators of differing capacities and configurations connected to a single condensing unit. The arrangement provides an individualized comfort control, and simultaneous heating and cooling indifferent zones.

Currently widely applied in large buildings especially in Japan and Europe, these systems are just starting to be introduced in the U.S. The VRF technology/system was developed and designed by Daikin Industries, Japan who named and protected the term variable refrigerant volume (VRV) system so other manufacturers use the term VRF "variable refrigerant flow". In essence both are same.

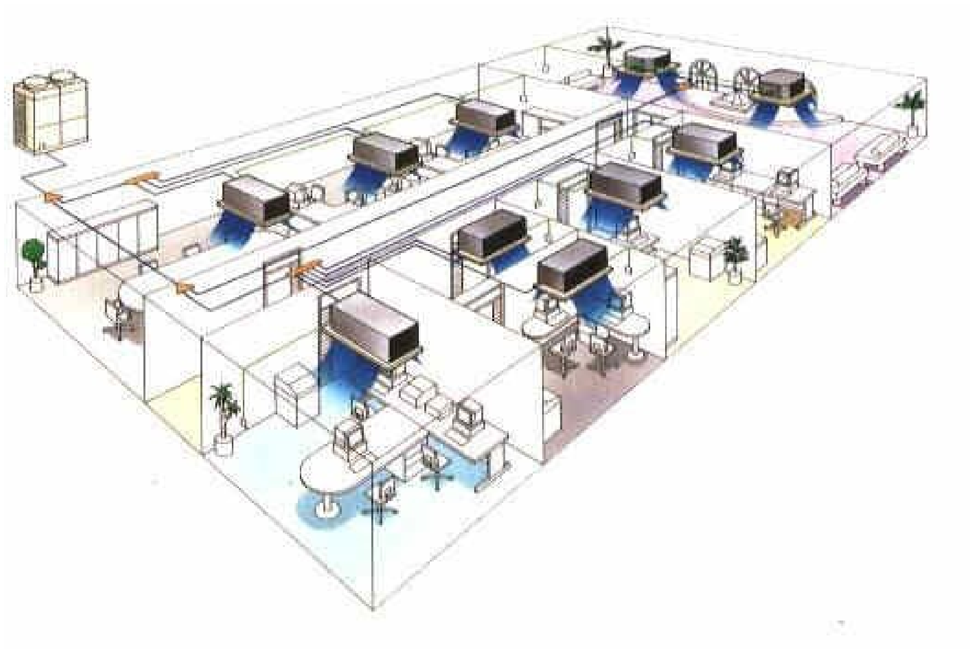


Figure 8:sample for VRF system

3.4.2 Refrigerant modulation in a VRF system

VRV/VRF technology is based on the simple vapour compression cycle (same as conventional split air conditioning systems) but gives you the ability to continuously control and adjust the flow of refrigerant to different internal units, depending on the heating and cooling needs of each area of the building. The refrigerant flow to each evaporator is adjusted precisely through a pulse wave electronic expansion valve in conjunction with an inverter and multiple compressors of varying capacity, in response to changes in the cooling or heating requirement within the air conditioned space.

VRF systems are engineered systems and use complex refrigerant and oil control circuitry. The refrigerant pipe-work uses a number of separation tubes and/or headers.

A separation tube has 2 branches whereas a header has more than 2 branches. Either of the separation tube or header, or both, can be used for branches. However, the separation tube is never provided after the header because of balancing issues.

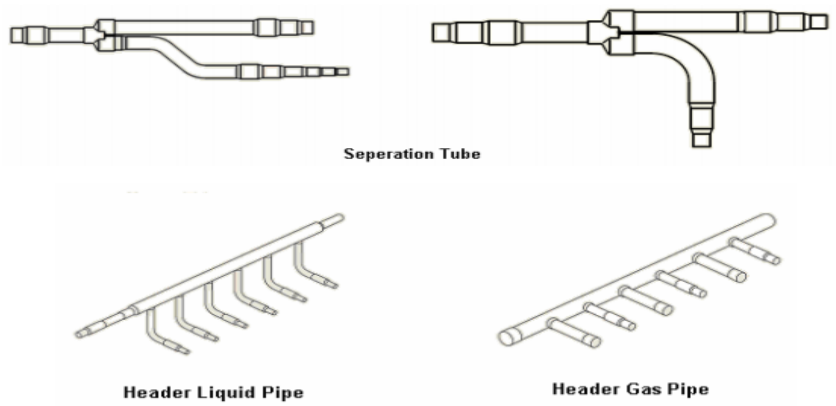


Figure 9 Separation and header tubes

3.4.3 Building Load Profile

When selecting a VRF system for a new or retrofit application, the following assessment tasks should be carried out:

- Determine the functional and operational requirements by assessing the cooling load and load profiles including location, hours of operation, number/type of occupants, equipment being used, etc.
- Determine the required system configuration in terms of the number of indoor units and the outdoor condensing unit capacity by taking into account the total capacity and operational requirements, reliability and maintenance considerations

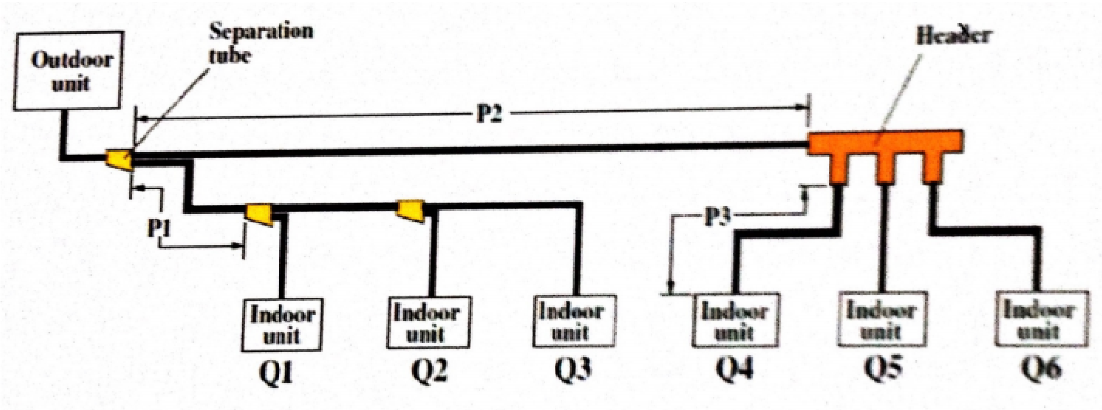


Figure 10:indoor and out door capacity

- Size of P1: Depends on the total capacity of (Q1+Q2+Q3)
- Size of P2: Depends on the total capacity of (Q4+Q5+Q6)
- Size of P3: Depends on the total capacity of (Q4)

VRF systems have several key benefits, including:

1. Installation Advantages.
   VRF systems are lightweight and modular. Each module can be transported easily and fits into a standard elevator.
2. Design Flexibility.
   A single condensing unit can be connected to many indoor units of varying capacity (e.g., 0.5 to 4 tons [1.75 to 14 kW]) and configurations (e.g., ceiling recessed, wall mounted, floor console). Current products enable up to 20 indoor units to be supplied by a single condensing unit. Modularity also makes it easy to adapt the HVAC system to expansion or reconfiguration of the space, which may require additional capacity or different terminal units.
3. Maintenance and Commissioning**.**
   VRF systems with their standardized configurations and sophisticated electronic controls are aiming toward near plug-and-play commissioning.
4. Comfort.
   Many zones are possible, each with individual set point control. Because VRF systems use variable speed compressors with wide capacity modulation capabilities, they can maintain precise temperature control, generally within ±1°F (±0.6°C), according to manufacturers' literature.
5. Energy Efficiency.
   The energy efficiency of VRF systems derives from several factors. The VRF essentially eliminates duct losses, which are often estimated to bebetween (10-20) percent of total airflow in a ducted system.VRF systems typically include two to three compressors, one of which is variable speed, in each condensing unit, enabling wide capacity modulation. This approach yields high part-load efficiency, which translates into high seasonal energy efficiency, because HVAC systems typically spend most of their operating hours in the range of 40% to 80% of maximum capacity.

6. Refrigerant piping runs of more than 200 feet (60.96 m) are possible and outdoor units are available in sizes up to 240,000 Btu/ h (60478.98 kW).

3.4.4 Selection units

This section talks about selection of outdoor and indoor units of VRF system, depending on the “Samsung VRF catalogue”, since this company product exists in Hebron.

Outdoor and indoor units are selected according to the thermal load of the building

Outdoor unit

We are chosen compact package outdoor units

Figure 11Out Door Unit

Table8:outdoor unit details

Unit	Cooling Load (HP)	Cooling load (kW)	Outdoor Unit Name
Unit 1	24	16.8	RVXVHT240GE

Indoor unit

In this project there are two types of indoor units selected, which are split and cassette units. The split unit is used for bedrooms, and the cassette units are used for meeting room and Buffy.

The figure below shows the two types of selected units:

Figure 12:indoor unit

The selected indoor units for the basement and ground floor are listed in the tables below:

Table9:indoor unit details

Indoor Unit Type	Cooling Load (kW)	Indoor Unit Name	Number	Dimension (Mm)
Split (Neoforte)	2.8	AVXWNH028EE	4	825×285×189
Split (Neoforte)	5.6	AVXWNH056EE	1	825×285×189

To see all VRF systems go to drawings from (M09-M10).

CHAPTER FOUR

PLUMBING SYSTEM

4.1 Introductions

4.2 Water system

4.3 Pipe size calculations

4.4 Sanitary Drainage System

4.5 Storm Drainage System

4.1 Introduction

The goal of modern plumbing design for building is to safely and reliable, provide domestic water, cold water and remove sanitary waste.

In this chapter the designs of the water supply and sanitary drainage system will be discuss as following:

4.2 Water supply system

4.2.1 Calculations of hot and cold water supply systems

To determine the pipe size for cold and hot water supply system the water supply fixture unit (WSFU) for each fixture unite must be determined and total fixture unit on each piping run out be calculated, the minimum floor pressure required at the critical fixture unit must be determined.

Example: calculation of water supply unit (WSFU) in the Sample Bathroom.

There was three fixtures (lavatory, bathtub, and water closet with flush valve) each have (WSFU) as follow:

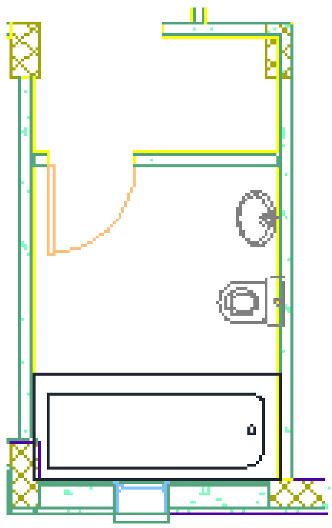


Figure 13 Sample Bathroom

1- Lavatory: is a fixture unit needs cold and hot water supplies as shown in table (30) the demand of the lavatory for private use is 1WSFU (for both cold and hot water), while if cold or hot water only was needed then this value should be multiplied by (3/4), so the demand of the lavatory will be as follow:

   a. 2 WSFU for both hot and cold water demand.
   b. (3/4)*1 WSFU for hot or cold water only.

2- Water closet: is a fixture unit needs cold and hot water supplies as shown in table (30) the demand of the water closet for private use is 3 WSFU (for both cold and hot water), while if cold or hot water only was needed then this value should be multiplied by (3/4), so the demand of the water closet will be as follow :

a. 3 WSFU for both hot and cold water demand.
b. (3/4)*3 WSFU for hot or cold water only.

3- Bath tub: is a fixture unit needs cold and hot water supplies as shown in table (30) the demand of the bathtub for privet use is 2 WSFU (for both cold and hot water), while if cold or hot water only was needed then this value should be multiplied by (3/4), so the demand of the bath tub will be as follow:

a. 2 WSFU for both hot and cold water demand.
b. (3/4)*2 WSFU for hot or cold water only

Based on the above information the following table can performed:

Table 10 : The WSFU for the sample Bathroom

Fixture unit	No. of Units	WSFU	Total no. of WSFU for cold water	Total no. of WSFU for hot water	Total no. of WSFU for hot & cold water
Lavatory (private)	1	3/4 * 1	3/4	3/4	1.0
Bath tub (private)	1	3/4 *2	1.5	1.5	2.0
Water closet flush valve (private)	1	3	3	--------	3.0
--------	-------	-------	$\sum = 5.25$ WSFU	$\sum = 2.25$ WSFU	$\sum = 6.0$ WSFU

But WSFU technique should never be applied to installations with only few fixtures, because in such installations, the additional use of a single fixture can drastically change the total usage pattern and in this case for small installations by refer to table in appendix

number of bathrooms 4 and with flushometer of private use and type of supply contro is flushometer

WSFU=4*8=32 fu

and every fixture flow rate in (gpm) individually will be added

clothes washer = 2 fu and kitchen sink = 2 fu

total fu = 36 and from the table related demand in gpm=44.6

4.3 Pipe size calculations:

By using the down feed distribution system in which the water is supplied to the building from water tanks on the roof.

the maximum instantaneous water demand is=36 fu which =45gpm.

the available main pressure at the level of faucet outlet is:

main pressure= static head pressure+ friction head pressure + min. flow pressure

the main pressure is equal to static pressure in this case so

static (main) pressure= (9m/0.33)ft * 0.433= 11.8 psi

TEL= longest run * 1.5 (to account for minor losses).

= 39m*3.281=128 ft

minimum flow pressure at the critical fixture=8 psi.

therefore friction head=static pressure - min. flow pressure= 11.8-8=3.8psi

from table 9.7

uniform friction loss 3.8/1.28=2.96 psi/100ft the result diameter of plastic 1.5 in

the static pressure = ((4/0.33)ft+12-3.3)*0.433=9 psi

more than 8psi hence pump not needed in this system.

The total water supply fixture unit for all risers after going back to the tables to find the total amount of water required which is 45 (gpm) for cold water & 33.75 (gpm) for hot water.
To see all water systems go to drawings from (M6-M7)

4.4 Sanitary Drainage System

The main objective of drainage system is to carry the waste water from the fixture unit to manhole and from the manhole to the septic tank or to the municipal sewage system.

The provision of drainage systems:

- Sanitary drainage
- Storm drainage

4.4.1 Drainage system components

The main components of drainage system are:

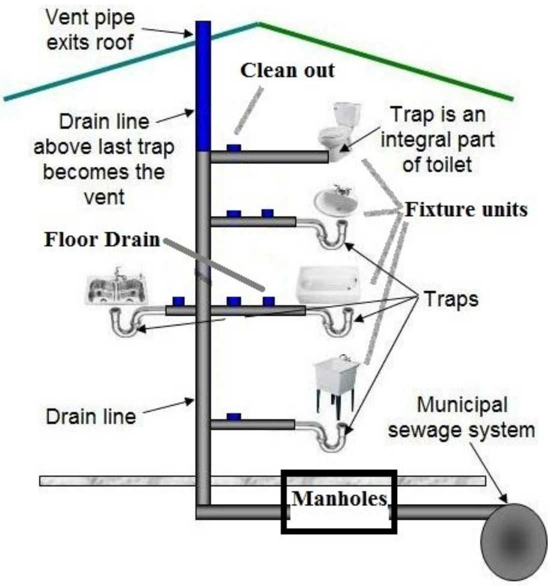


Figure 14: Drainage system components

- Fixture units
- Trap
- Clean out
- Drainage pipe
- Stack and vent pipes
- Manholes
- Septic tank or municipal sewage system
- Accessories

4.4.2Sanitary drainage

4.4.2.1 Design procedure and pipe sizing

Pipe size is calculated by using a concept of fixture units (DFU) instead of using gpm of drainage water. This unit takes into account not only the fixtures water use but also its frequency of use, which is the DFU has a built–in diversity factor. This enables us, exactly as for water supply to add DFU of various fixtures to obtain the maximum expected drainage flow. Drainage pipes sized for a particular number of drainage fixture units from appendix table which are:

- 50% fill in branches (horizontal pipes)
- (25-33)% fills in stack (vertical pipes)
- 50% fill in building and sewer drains

The recommended velocity for drainage piping:

- For branches the recommended velocity is 2 ft/s
- For building pipes the recommended velocity is 3 ft/s
- For greasy flow the recommended velocity is 4 ft/s

Velocity of water flow through drainage piping depends on:

- Pipe diameter
- Slope

Minimum slope requirements for horizontal drainage piping:

- For pipes of diameter ≤ 3" the minimum slope is1/4”/ft (2%)
- For pipes of diameter ≥ 4" the minimum slope is 1/8”/ft (4%)

Design procedure:

1. Calculation of the number of DFU for each branch
2. Calculation of the number of DFU for each stack
3. Choosing the branch pipe diameter
4. Choosing the stack pipe diameter
5. Comparing the stack pipe diameter with branch diameter
6. Choosing the building drain pipe diameter

To achieve the recommended velocities which are 3 fps in building drain, it will be chosen the slope and flow velocity in building drain

Table11:Sizing of black water stacks and building drain

#of stack	Total Dfu	Diameter (in)	Diameter of building drain	Velocity ft/s
Stack 1	3	2	4	2.43
Stack 2	6	2	4	2.43
Stack 3	12	3	4	2.43
Stack 4	6	2	4	2.43
Stack 5	6	2	4	2.43
Stack 6	3	2	4	2.43

all stacks choose to be 4" as available in local markets with slope of 0.5 in

4.4.2.2 Calculation the volume of the septic tank

The amount of flow rate discharge from the building equal 36 DFU.

Use the conversion of **1 gpm = 2 DFU** to convert this value, so

$Q_{dis.}$= 18 gpm = 4.088 m^3/h.

V = (HRT) $\times Q_{dis.}$

= 4 ×4.8

= 20 m^3

The volume of septic tank equal 20 m^3, and the dimension are 2.5*2.5*4

4.4.3 Manhole design

The design of the manholes depend on the ground and its nature around the building, and so as the first manhole height should not be less than 50 cm, and the depth of the other manholes will depend on the distance between the manholes and the slope of the pipe that connecting them.

According to the table below, it will be estimated the diameter of the manhole according to their depth. [11]

Table12: Diameter of the manhole according to their depth

Depth (cm)	Diameter (cm)
70-80	60
80-140	80
140-250	100
250-∞	125

4.4.3.1 Manhole calculation

The depth of the first manhole is 50 cm,the calculation of the second manhole done according to the first manhole and so on. Using these equations does the calculations:

- Depth: (M2 = M1 + (Slope × Distance) + 5 + Level Difference) in cm
- Top level: Manholes face level on the ground
- (Invert level = Top level-Depth) in m
- Outlet level = -(Depth- 0.05) in m

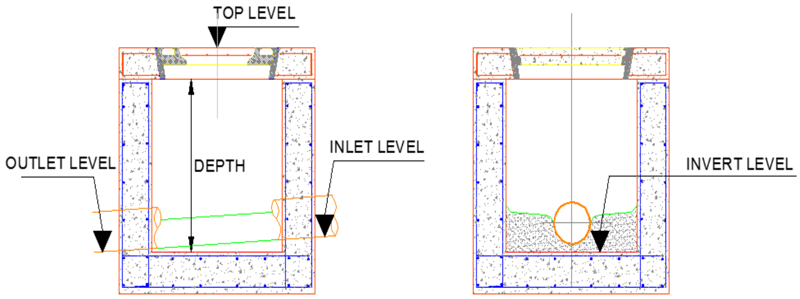


Figure 15 Manholes details

The result calculation of manholes is listed in the tables below:

Table13:Black water manholes

Manhole No.	Top level (m)	Invert level (m)	Outlet level (m)	Depth (cm)	Dia. Size (cm)	Cover Type
M01	+2.4	+1.8	+1.85	60	60	Concrete
M02	+2.4	+1.7	+1.75	70	60	Concrete
M03	+2.4	+1.55	+1.6	85	60	Concrete
M04	+0.00	-0.6	-0.55	60	60	Concrete
M05	+2.4	1.8	1.85	60	60	Concrete
M06	±0.00	-0.60	-0.55	60	60	Concrete
M07	±0.00	-0.67	-0.62	67	60	Concrete
M08	±0.00	-0.75	-0.70	75	60	Concrete
M09	±0.00	-0.87	-0.82	87	60	Concrete
M10	±0.00	-0.95	-0.90	95	60	Concrete

4.5 Storm drainage

The design of the rain collection piping, whether exterior gutters, and leaders, or interior conductors and drain depends upon three factors:

- The amount of rain fall in a specified period of time
- The size of the area being drained
- The degree of pipe fill, that is whether a pipe or gutter runs 50%, 33% or 100% fill

The general rule for the distribution of floor drain Every 100 m^2 from roof area needs one 4” FD The roof area of this building is about 250 m^2, and therefore needs three 4” FD.To see all drainage systems go to drawings from (M05).

CHAPTER FIVE

FIRE FIGHTING SYSTEM

5.1 Introduction

5.2 Types of fire fighting system

5.3 Select the most effective type

5.5 Fire fighting pumps

5.4 Pipe size calculation

5.1 Introduction

A fire fighting system is probably the most important of the building services, as its aim is to protect human life and property, strictly in that order. fire fighting systems and equipment vary depending on the age, size, use and type of building construction.

5.2 Types of fire fighting system

- Fire extinguishers.
- Fire hose reels.
- Fire hydrant systems.
- Automatic sprinkler systems.

5.2.1 Fire extinguishers

Fire extinguishers are provided for a 'first attack' fire fighting measure generally undertaken by the occupants of the building before the fire service arrives. It is important that occupants are familiar with which extinguisher type to use on which fire.

Most fires start as a small fire and may be extinguished if the correct type and amount of extinguishing agent is applied whilst the fire is small and controllable.

The principle fire extinguisher types currently available include:

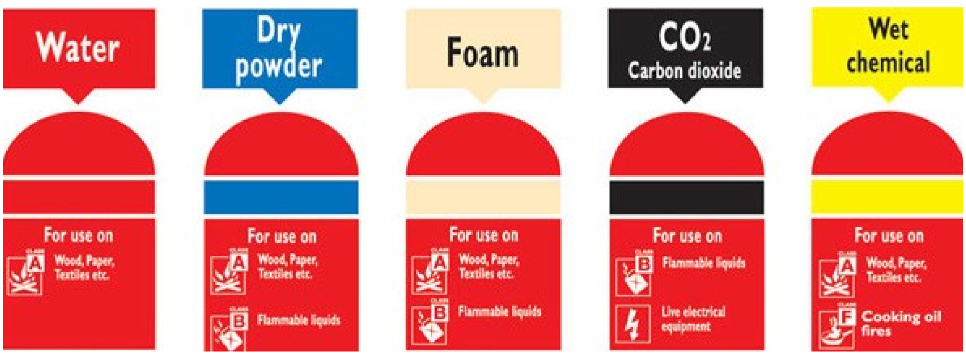


Figure 16: Fire extinguishers

5.2.2 Fire hose reel

Fire hose reel systems consist of pumps, pipes, water supply and hose reels located strategically in a building, ensuring proper coverage of water to combat a fire.

The system is manually operated and activated by opening a valve enabling the water to flow into the hose that is typically 30 meters away. The usual working pressure of a firehouse can vary between 8 and 20 (116 and 290 psi).

Fire hose reels are provided for use by occupants as a first attack firefighting measure but may, in some instances, also be used by firefighters. When stowing a fire hose reel, it is important to first attach the nozzle end to the hose reel valve, then close the hose reel valve, then open the nozzle to relieve any pressure in the wound hose, then close the nozzle.

Figure 17: Fire hose reel

5.2.3 Fire hydrate system

Fire hydrant systems are installed in buildings to help fire fighters quickly attack the fire. Essentially, a hydrant system is a water reticulation system used to transport water in order to limit the amount of hose that fire fighters have to lay; thus speeding up the fire fighting process.

Fire hydrants are for the sole use of trained fire fighters (which includes factory fire fighting teams). Because of the high pressures available serious injury can occur if untrained persons attempt to operate the equipment connected to such installations. Fire hydrant systems sometimes include ancillary parts essential to their effective operation such as pumps, tanks and fire service booster connections. These systems must be maintained and regularly tested if they are to be effective when needed.

Figure 18: Fire hydrate system

5.2.4 Automatic sprinkler system

Time is essential in the control of fire. Automatic sprinkler systems are one of the most reliable methods available for controlling fires. Today's automatic fire sprinkler systems offer state of the art protection of life and property from the effects of fire. Sprinkler heads are now available which are twenty times more sensitive to fire than they were ten years ago.

A sprinkler head is really an automatic (open once only) tap. The sprinkler head is connected to a pressurized water system. When the fire heats up the sprinkler head, it opens at a preset temperature, thus allowing pressurized water to be sprayed both down onto the fire and also up to cool the hot smoky layer and the building structure above the fire. This spray also wets combustible material in the vicinity of the fire, making it difficult to ignite, thereby slowing down or preventing fire spread and growth.

When a sprinkler head operates, the water pressure in the system drops, activating an alarm, which often automatically calls the fire brigade via a telephone connection.

5.3 Select the most effective type

After the identification of the fire systems now the best performance for the hotel is hose reel & extinguisher.

The number of hose reels to be used in hotel is30fire hose reel for all floors most fire hose is designed to be stored flat to minimize the storage space required.

5.4 Pipe size calculation:

The fire hose reel system is to be used, so the pipe size for this system will be calculated as follows:

The minimum flow rate for single cabinet = 23 (l/min).

Then:

$$The\ total\ flow\ rate = min.\ flow\ rate \times No.\ of\ cabinet$$

$$The\ total\ flow\ rate = 30 \times 2 = 60\ l/min$$

Table14:Pipe schedule - standpipes and supply piping

Total Accumulated Flow		**Total Distance of Piping from Farthest Outlet**		
L/min	**gpm**	**<15.2 m (<50 ft)**	**15.2–30.5 m (50–100 ft)**	**>30.5 m (>100 ft)**
379	100	2	2½	3
382–1893	101–500	4	4	6
1896–2839	501–750	5	5	6
2843–4731	751–1250	6	6	6
4735	1251 and over	8	8	8

Note: For SI units, 3.785 L/min = 1 gpm; 0.3048 m = 1 ft.

Then the Table14 is to be used to calculate the pipe size by follow the next procedure. First, the total flow rate is determined which is 60 l/min for our calculation sample. Then the total distance of piping from farthest outlet is to be chosen. Finally, the intersection between the two values in Table14 will give the size of pipe supply, which is equal to 2".

Then to determine the outlet pipe size from pipe supply to hose connection For this building. The selection diameter is (2 in.) hose stations to supply water for use primarily by the building occupants or by the fire department during initial response.

5.5Fire fighting pumps

Continuous water and pumping station supply should always be available and ready to fight fire, the following three pumps should be connected to a suction header (from water tank), and discharge header (to fire fighting network).

Pumping should be included: -

1. Electrical fire fighting pump.

2. Diesel Fire fighting Pump,(Stand-by pump).

Diesel pump works if:

- The electrical pump is out of service, or if there is a lack of electricity.
- The electrical pump is working but can’t satisfy system water requirements.

3. Jockey Pump:work to make up the system pressure in case of leakage or during the first seconds of fire.

But in this project (small residential building) the suitable choice is Jockey pump with Q=15 L/H and H range from 100-200psi, as approved std NFPA20.

To see all fire fighting systems go to drawing (M08).

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APPENDIX A

TABLE 9–1 Cooling load temperature differences (CLTD) for sunlit roofs, °C.

No.	Roof Description of Construction	U_{av}, W/m^2·°C	Solar Time, h: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Without Suspended Ceiling																									
1	Steel sheet with 25.4 mm (or 50.8 mm) insulation	1.209 (0.704)	0	−1	−2	−2	−3	−2	3	11	19	27	34	40	43	44	43	39	33	25	17	10	7	5	3	1
2	25 mm wood with 25.4 mm insulation	0.963	3	2	0	−1	−2	−2	−1	2	8	15	22	29	35	39	41	41	39	35	29	21	15	11	8	5
3	101.6 mm L.W. concrete	1.209	5	3	1	0	−1	−2	−2	1	5	11	18	25	31	36	39	40	40	37	32	25	19	14	10	7
4	50.8 mm H.W. concrete 25.4 mm (or 50.8 mm) insulation	1.170 (0.693)	7	5	3	2	0	−1	0	2	χ 6	11	17	23	28	33	36	37	37	34	30	25	20	16	12	10
5	25.4 mm wood with 50.8 insulation	0.619	2	0	−2	−3	−4	−4	−4	−2	3	9	15	22	27	32	35	36	35	32	27	20	14	10	6	3
6	152.4 mm L.W. concrete	0.897	12	10	7	5	3	2	1	0	2	4	8	13	18	24	29	33	35	36	35	32	28	24	19	16
7	63.5 mm wood with 25.4 mm insulation	0.738	16	13	11	9	7	6	4	3	4	5	8	11	15	19	23	27	29	31	31	30	27	25	22	19
8	203.4 mm L.W. concrete	0.715	20	17	14	12	10	8	6	5	4	4	5	7	11	14	18	22	25	28	30	30	29	27	25	22
9	101.6 mm H.W. concrete with 25.4 mm (or 50.8 mm) insulation	1.136 (0.681)	14	12	10	8	7	5	4	4	6	8	11	15	18	22	25	28	29	30	29	27	24	21	19	16
10	63.5 mm wood with insulation	0.528	18	15	13	11	9	8	6	5	5	5	7	10	13	17	21	24	27	28	29	29	27	25	23	20
11	Roof terrace system	0.602	19	17	15	14	12	11	9	8	7	8	8	10	12	15	18	20	22	24	25	26	25	24	22	21
12	152.4 mm H.W. concrete with 25.4 mm (or 50.8 mm) insulation	0.664	18	16	14	12	11	10	9	8	8	9	10	12	15	17	20	22	24	25	25	25	24	22	20	19
13	101.6 mm wood with 25.4 mm (or 50.8 mm) insulation	0.602 (0.443)	21	20	18	17	15	14	13	11	10	9	9	9	10	12	14	16	18	20	22	23	24	24	23	22

TABLE 9-2 Latitude-Month correction factor LM, as applied to walls and horizontal roofs, north latitudes.

Lat.	Month	N	NNE NNW	NE NW	ENE WNW	E W	ESE WSW	SE SW	SSE SSW	S	Horizontal Roofs
16	December	−2.2	−3.3	−4.4	−4.4	−2.2	−0.5	2.2	5.0	7.2	−5.0
	Jan./Nov.	−2.2	−3.3	−3.8	−3.8	−2.2	−0.5	2.2	4.4	6.6	−3.8
	Feb./Oct.	−1.6	−2.7	−2.7	−2.2	−1.1	0.0	1.1	2.7	3.8	−2.2
	Mar/Sept.	−1.6	−1.6	−1.1	−1.1	−0.5	−0.5	0.0	0.0	0.0	−0.5
	Apr./Aug.	−0.5	0.0	−0.5	−0.5	−0.5	−1.6	−1.6	−2.7	−3.3	0.0
	May/July	2.2	1.6	1.6	0.0	−0.5	−2.2	−2.7	−3.8	−3.8	0.0
	June	3.3	2.2	2.2	0.5	−0.5	−2.2	−3.3	−4.4	−3.8	0.0
24	December	−2.7	−3.8	−5.5	−6.1	−4.4	−2.7	1.1	5.0	6.6	−9.4
	Jan./Nov.	−2.2	−3.3	−4.4	−5.0	−3.3	−1.6	−1.6	5.0	7.2	−6.1
	Feb./Oct.	−2.2	−2.7	−3.3	−3.3	−1.6	−0.5	1.6	3.8	5.5	−3.8
	Mar/Sept.	−1.6	−2.2	−1.6	−1.6	−0.5	−0.5	0.5	1.1	2.2	−1.6
	Apr./Aug.	−1.1	−0.5	0.0	−0.5	−0.5	−1.1	−0.5	−1.1	−1.6	0.0
	May/July	0.5	1.1	1.1	0.0	0.0	−1.6	−1.6	−2.7	−3.3	0.5
	June	1.6	1.6	1.6	0.5	0.0	−1.6	−2.2	−3.3	−3.3	0.5
32	December	−2.7	−3.8	−5.5	−6.1	−4.4	−2.7	1.1	5.0	6.6	−9.4
	Jan./Nov.	−2.7	−3.8	−5.0	−6.1	−4.4	−2.2	1.1	5.0	6.6	−8.3
	Feb./Oct.	−2.2	−3.3	−3.8	−4.4	−2.2	−1.1	2.2	4.4	6.1	−5.5
	Mar/Sept.	−1.6	−2.2	−2.2	−2.2	−1.1	−0.5	1.6	2.7	3.8	−2.7
	Apr./Aug.	−1.1	−1.1	−0.5	−1.1	0.0	−0.5	0.0	5.0	0.5	−0.5
	May/July	0.5	0.5	0.5	0.0	0.0	−0.5	−0.5	−1.6	−1.6	0.5
	June	0.5	1.1	1.1	0.5	0.0	−1.1	−1.1	−2.2	−2.2	1.1
40	December	−3.3	−4.4	−5.5	−7.2	−5.5	−3.8	0.0	3.8	5.5	−11.6
	Jan./Nov.	−2.7	−3.8	−5.5	−6.6	−5.0	−3.3	0.5	4.4	6.1	−10.5
	Feb./Oct.	−2.7	−3.8	−4.4	−5.0	−3.3	−1.6	1.6	4.4	6.6	−7.7
	Mar/Sept.	−2.2	−2.7	−2.7	−3.3	−1.6	0.5	2.2	3.8	5.5	−4.4
	Apr./Aug.	−1.1	−1.6	−1.6	−1.1	0.0	0.0	1.1	1.6	2.2	1.6
	May/July	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5
	June	0.5	0.5	0.5	0.5	0.0	0.5	0.0	0.0	−0.5	1.1
48	December	−3.3	−4.4	−6.1	−7.7	−7.2	−5.5	−1.6	1.1	3.3	−13.8
	Jan./Nov.	−3.3	−4.4	−6.1	−7.2	−6.1	−4.4	−0.5	2.7	4.4	−13.3
	Feb./Oct.	−2.7	−3.8	−5.5	−6.1	−4.4	−2.7	0.5	4.4	6.1	−10.0
	Mar/Sept.	−2.2	−3.3	−3.3	−3.8	−2.2	−0.5	2.2	4.4	6.1	−6.1
	Apr./Aug.	−1.6	−1.6	−1.6	−1.6	−0.5	0.0	2.2	3.3	3.8	−2.7
	May/July	0.0	−0.5	0.0	0.0	0.5	0.5	1.6	1.6	2.2	0.0
	June	0.5	0.5	1.1	0.5	1.1	0.5	1.1	1.1	1.6	1.1

TABLE 9–4 Cooling load temperature differences (CLTD) for various construction groups of sunlit walls, °C.

North Latitude Wall Facing	Solar Time *h*																								Hour of Max. CLTD	Min. CLTD	Max. CLTD	Difference CLTD
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24				
	Group A Walls																											
N	8	8	8	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	8	8	2	6	8	2
NE	11	11	10	10	10	9	9	9	8	8	8	9	9	9	9	10	10	10	11	11	11	11	11	11	22	8	11	3
E	14	13	13	13	12	12	11	11	10	10	10	11	11	12	12	13	13	13	14	14	14	14	14	14	22	10	14	4
SE	13	13	13	12	12	11	11	10	10	10	10	10	10	11	11	12	12	13	13	13	13	13	13	13	22	10	13	3
S	11	11	11	11	10	10	9	9	9	8	8	8	8	8	8	8	9	9	10	10	11	11	11	11	23	8	11	3
SW	14	14	14	14	13	13	12	12	11	11	10	10	10	9	9	10	10	10	11	12	13	13	14	14	24	9	14	5
W	15	15	15	14	14	14	13	13	12	12	11	11	10	10	10	10	10	11	11	12	13	14	14	15	1	10	15	5
NW	12	12	11	11	11	11	10	10	10	9	9	8	8	8	8	8	8	8	9	9	10	11	11	11	1	8	12	4
	Group B Walls																											
N	8	8	8	7	7	6	6	6	5	5	5	5	5	5	5	6	6	7	7	8	8	8	8	8	24	5	8	3
NE	11	10	10	9	9	8	7	7	7	7	8	8	9	9	10	10	11	11	11	12	12	12	11	11	21	7	12	5
E	13	13	12	11	10	10	9	8	8	9	9	10	12	13	13	14	14	15	15	15	15	15	14	14	20	8	15	7
SE	13	12	12	11	10	10	9	8	8	8	8	9	10	11	12	13	14	14	14	14	14	14	14	14	21	8	14	6
S	12	11	11	10	9	9	8	7	7	6	6	6	6	7	8	9	10	11	11	12	12	12	12	12	23	6	12	6
SW	15	15	14	13	13	12	11	10	9	9	8	8	7	7	8	9	10	11	13	14	15	15	16	16	24	7	16	9
W	16	16	15	14	14	13	12	11	10	9	9	8	8	8	8	8	9	11	12	14	15	16	16	17	24	8	17	9
NW	13	12	12	11	11	10	9	9	8	7	7	7	6	6	7	7	8	8	9	11	12	13	13	13	24	6	13	7
	Group C Walls																											
N	9	8	7	7	6	5	5	4	4	4	4	4	5	5	6	6	7	8	9	9	9	10	9	9	22	4	10	6
NE	10	10	9	8	7	6	6	6	6	7	8	10	10	11	12	12	12	13	13	13	13	12	12	11	20	6	13	7
E	13	12	11	10	9	8	7	7	8	9	11	13	14	15	16	16	17	17	16	16	16	15	14	13	18	7	17	10
SE	13	12	11	10	9	8	7	6	7	7	9	10	12	14	15	16	16	16	16	16	16	15	14	13	19	6	16	10
S	12	11	10	9	8	7	6	6	5	5	5	5	6	8	9	11	12	13	14	14	14	14	13	12	20	5	14	9
SW	16	15	14	12	11	10	9	8	7	7	6	6	6	7	8	10	12	14	16	18	18	18	13	17	22	6	18	12
W	17	16	15	14	12	11	10	9	8	7	7	7	7	7	8	9	11	13	16	18	19	20	19	18	22	7	20	13

TABLE 9-5 Description of wall construction groups.

Group No.	Description Of Construction	$U_{ov.}$ W/m²·°C
	101.6 mm Face Brick + (Brick)	
C	Air space + 101.6 mm face brick	2.033
D	101.6 mm common brick	2.356
C	25.4 mm insulation or air space + 101.6 mm common brick	0.987-1.709
B	50.6 mm insulation + 101.6 mm common brick	0.630
B	203.2 mm common brick	1.714
A	Insulation or air space + 203.2 mm common brick	0.874-1.379
	101.6 mm Face Brick + (H.W. Concrete)	
C	Air space + 50.8 mm concrete	1.987
B	50.8 mm insulation + 101.6 mm concrete	0.658
A	Air space or insulation + 203.2 mm or more concrete	0.625-0.636
	101.6 mm Face Brick + (L.W. or H.W Concrete Block)	
E	101.6 mm block	1.811
D	Air space or insulation + 101.60 mm block	0.868-1.397
D	203.2 mm block	1.555
C	Air space or 25.4 mm insulation + 152.4 mm or 203.2 mm block	1.255-1.561
B	50.8 insulation + 203.2 mm block	0.545-0.607
	101.6 mm Face Brick + (Clay Tile)	
D	101.6 mm tile	2.163
D	Air space + 101.6 mm tile	1.595
C	Insulation + 101.6 mm tile	0.959
C	203.2 mm tile	1.561
B	Air space or 25.4 mm insulation + 203.2 mm tile	0.806-1.255
A	50.8 mm insulation + 203.2 mm tile	0.551
	L.W. Concrete Wall + (Finish)	
E	101.5 mm concrete	3.321
D	101.6 mm concrete + 25.4 mm or 50.8 mm insulation	1.136 - 0.675
C	50.8 mm insulation+101.6 mm concrete	0.675
C	203.2 mm concrete	2.782
B	203.2 mm concrete + 25.4 mm or 50.8 mm insulation	1.061 - 0.653
A	203.2 mm concrete + 50.8 mm insulation	0.653
B	304.8 mm concrete	2.390
A	304.8 mm concrete + insulation	0.642
	L.W. and H.W. Concrete Block + (Finish)	
F	101.6 mm block + air space/insulation	0.914-1.493
E	50.8 mm insulation + 101.6 mm block	0.596-0.647
E	203.2 mm block	1.669-2.282
D	203.2 mm block + air space/insulation	0.846-0.982

TABLE 9-7 Solar heat gain factor (SHG) for sunlit glass, W/m², for a latitude angle of 32 °N.

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
N	76	85	101	114	120	139	126	117	104	88	76	69
NNE/NNW	76	85	117	252	350	385	350	249	110	88	76	69
NE/NW	91	205	338	461	536	555	527	445	325	199	91	69
ENE/WNW	331	470	577	631	656	656	643	615	546	451	325	265
E/W	552	647	716	716	694	675	678	691	678	615	546	511
ESE/WSW	722	764	748	691	628	596	612	663	716	738	710	688
SE/SW	786	782	716	590	489	439	473	571	688	754	773	776
SSE/SSW	789	732	615	445	213	262	303	429	596	710	776	795
S	776	697	555	363	233	189	227	350	540	678	767	795
Horizontal	555	685	795	855	874	871	861	836	770	672	552	498

TABLE 9-8 Shading coefficient (SC) for glass windows without interior shading.[1]

Type of Glass	Nominal Thickness, mm	Solar Trans.	Shading Coefficient, $W/m^2 \cdot K$	
			$h_o = 22.7$	$h_o = 17.0$
Single Glass				
Clear	3	0.84	1.00	1.00
	6	0.78	0.94	0.95
	10	0.72	0.90	0.92
	12	0.67	0.87	0.88
Heat absorbing	3	0.64	0.83	0.85
	6	0.46	0.69	0.73
	10	0.33	0.60	0.64
	12	0.42	0.53	0.58
Double Glass				
Regular	3	—	0.90	—
Plate	6	—	0.83	—
Reflective	6	—	0.20-0.40	—
Insulating Glass				
Clear	3	0.71	0.88	0.88
	6	0.61	0.81	0.82
Heat absorbing*	6	0.36	0.55	0.58

TABLE 9–10 Cooling load factors (CLF) for glass windows without interior shading, north latitudes.

Glass Facing	Building Construction	Solar Time, h																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
N Shaded	L	0.17	0.14	0.11	0.09	0.08	0.33	0.24	0.48	0.56	0.61	0.71	0.76	0.80	0.82	0.82	0.79	0.75
	M	0.23	0.20	0.18	0.16	0.14	0.34	0.14	0.46	0.53	0.59	0.65	0.70	0.73	0.75	0.76	0.74	0.75
	H	0.25	0.23	0.21	0.20	0.19	0.38	0.45	0.49	0.55	0.60	0.65	0.69	0.72	0.72	0.72	0.70	0.70
NNE	L	0.06	0.05	0.04	0.03	0.03	0.26	0.43	0.47	0.44	0.41	0.40	0.39	0.39	0.38	0.36	0.33	0.30
	M	0.09	0.08	0.07	0.06	0.06	0.24	0.38	0.42	0.39	0.37	0.37	0.36	0.36	0.36	0.34	0.33	0.30
	H	0.11	0.10	0.09	0.09	0.08	0.26	0.39	0.42	0.39	0.36	0.35	0.34	0.34	0.33	0.32	0.31	0.28
NE	L	0.04	0.04	0.03	0.02	0.02	0.23	0.41	0.51	0.51	0.45	0.39	0.36	0.33	0.31	0.28	0.26	0.23
	M	0.07	0.06	0.06	0.05	0.04	0.21	0.36	0.44	0.45	0.40	0.36	0.33	0.31	0.30	0.28	0.26	0.24
	H	0.09	0.08	0.08	0.07	0.07	0.23	0.37	0.44	0.44	0.39	0.34	0.31	0.29	0.27	0.26	0.24	0.22
ENE	L	0.04	0.03	0.03	0.02	0.02	0.21	0.40	0.52	0.57	0.53	0.45	0.39	0.34	0.31	0.28	0.25	0.22
	M	0.07	0.06	0.05	0.05	0.04	0.20	0.35	0.45	0.49	0.47	0.41	0.36	0.33	0.30	0.28	0.26	0.23
	H	0.09	0.09	0.08	0.07	0.07	0.22	0.36	0.46	0.49	0.45	0.38	0.31	0.30	0.27	0.25	0.23	0.21
E	L	0.04	0.03	0.03	0.02	0.02	0.19	0.37	0.51	0.57	0.57	0.50	0.42	0.37	0.32	0.29	0.25	0.22
	M	0.07	0.06	0.06	0.05	0.05	0.18	0.33	0.44	0.50	0.51	0.46	0.39	0.35	0.31	0.29	0.26	0.23
	H	0.09	0.09	0.08	0.08	0.07	0.20	0.34	0.45	0.49	0.49	0.43	0.39	0.32	0.29	0.26	0.24	0.22
ESE	L	0.05	0.04	0.03	0.03	0.02	0.17	0.34	0.49	0.58	0.61	0.57	0.48	0.41	0.36	0.32	0.28	0.24
	M	0.08	0.07	0.06	0.05	0.05	0.16	0.31	0.43	0.51	0.54	0.51	0.44	0.39	0.35	0.32	0.29	0.26
	H	0.10	0.09	0.09	0.08	0.08	0.19	0.32	0.43	0.50	0.52	0.49	0.41	0.36	0.32	0.29	0.26	0.24
SE	L	0.05	0.04	0.04	0.03	0.03	0.13	0.28	0.43	0.55	0.62	0.63	0.57	0.48	0.42	0.37	0.33	0.28
	M	0.09	0.08	0.07	0.06	0.05	0.14	0.26	0.38	0.48	0.54	0.56	0.51	0.45	0.40	0.36	0.33	0.29
	H	0.11	0.10	0.10	0.09	0.08	0.17	0.28	0.40	0.49	0.53	0.53	0.48	0.41	0.36	0.33	0.30	0.27
SSE	L	0.07	0.05	0.04	0.04	0.03	0.06	0.15	0.29	0.43	0.55	0.63	0.64	0.60	0.25	0.45	0.40	0.35
	M	0.11	0.09	0.08	0.07	0.06	0.08	0.16	0.26	0.38	0.58	0.55	0.57	0.54	0.48	0.43	0.39	0.35
	H	0.12	0.11	0.11	0.10	0.09	0.12	0.19	0.29	0.40	0.49	0.54	0.55	0.51	0.44	0.39	0.35	0.31
S	L	0.08	0.07	0.05	0.04	0.04	0.06	0.09	0.14	0.22	0.34	0.48	0.59	0.65	0.65	0.59	0.50	0.43
	M	0.12	0.11	0.09	0.08	0.07	0.08	0.11	0.14	0.21	0.31	0.42	0.52	0.57	0.58	0.53	0.47	0.41
	H	0.13	0.12	0.12	0.11	0.10	0.11	0.14	0.17	0.24	0.33	0.43	0.51	0.56	0.55	0.50	0.43	0.37
SSW	L	0.10	0.08	0.07	0.06	0.05	0.06	0.09	0.11	0.15	0.19	0.27	0.39	0.52	0.62	0.67	0.65	0.58
	M	0.14	0.12	0.11	0.09	0.08	0.09	0.11	0.13	0.15	0.18	0.25	0.35	0.46	0.55	0.59	0.59	0.53
	H	0.15	0.14	0.13	0.12	0.11	0.12	0.14	0.16	0.18	0.21	0.27	0.37	0.46	0.53	0.57	0.55	0.49
SW	L	0.12	0.10	0.08	0.06	0.05	0.06	0.08	0.10	0.12	0.14	0.16	0.24	0.36	0.49	0.60	0.66	0.66
	M	0.15	0.14	0.12	0.10	0.09	0.09	0.10	0.12	0.13	0.15	0.17	0.23	0.33	0.44	0.53	0.58	0.59
	H	0.15	0.14	0.13	0.12	0.11	0.12	0.13	0.14	0.16	0.17	0.19	0.25	0.34	0.44	0.52	0.56	0.56
WSW	L	0.12	0.10	0.08	0.07	0.05	0.06	0.07	0.09	0.10	0.12	0.13	0.17	0.26	0.40	0.52	0.62	0.66
	M	0.15	0.13	0.12	0.10	0.09	0.09	0.10	0.11	0.12	0.13	0.14	0.17	0.24	0.35	0.46	0.54	0.58
	H	0.15	0.14	0.13	0.12	0.11	0.11	0.12	0.13	0.14	0.15	0.16	0.19	0.26	0.36	0.46	0.53	0.56
	L	0.12	0.10	0.08	0.06	0.05	0.06	0.07	0.08	0.10	0.11	0.12	0.14	0.20	0.32	0.45	0.57	0.64

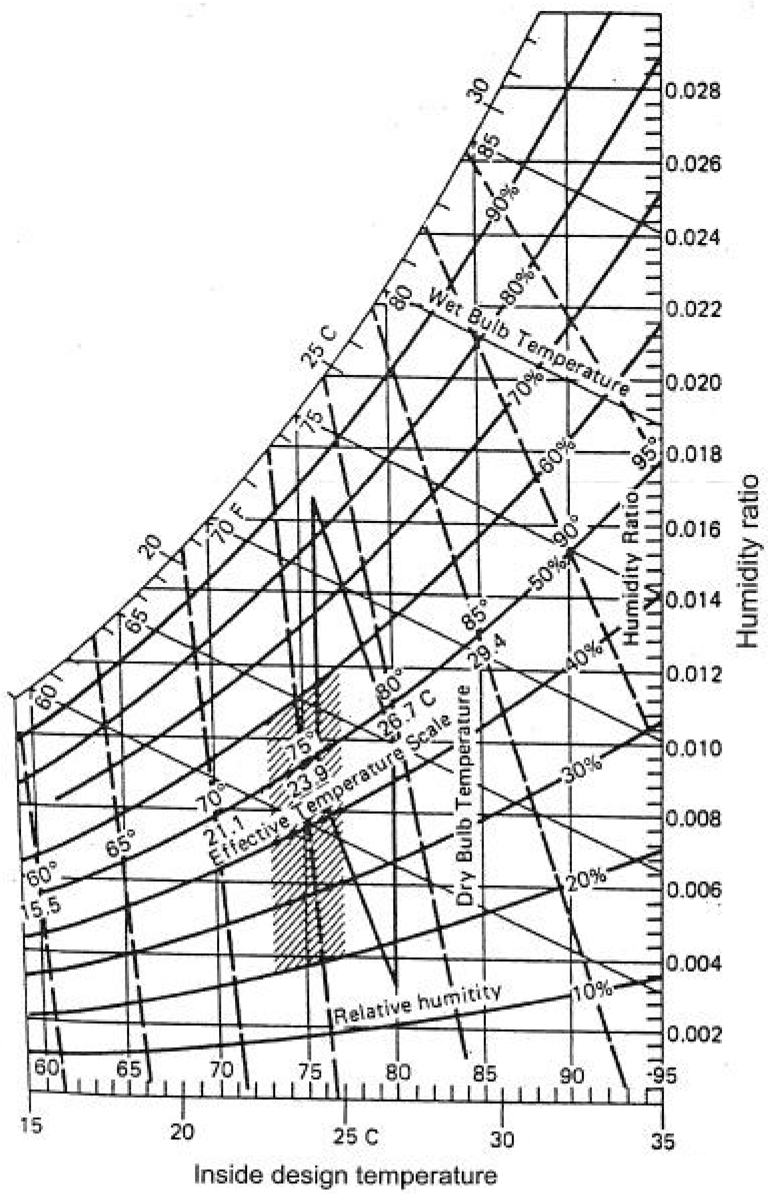
Glass Facing	Building Construction	Solar Time, h																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
W	M	0.15	0.13	0.11	0.10	0.09	0.09	0.09	0.10	0.11	0.12	0.13	0.14	0.19	0.29	0.40	0.50	0.56
	H	0.14	0.13	0.12	0.11	0.10	0.11	0.12	0.13	0.14	0.14	0.15	0.16	0.21	0.30	0.40	0.49	0.54
	L	0.12	0.10	0.08	0.06	0.05	0.06	0.07	0.09	0.10	0.12	0.13	0.15	0.17	0.26	0.40	0.53	0.63
WNW	M	0.15	0.13	0.11	0.10	0.09	0.09	0.10	0.11	0.12	0.11	0.14	0.15	0.17	0.24	0.35	0.47	0.55
	H	0.14	0.13	0.12	0.11	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.25	0.36	0.46	0.53
	L	0.11	0.09	0.08	0.06	0.05	0.06	0.08	0.10	0.12	0.14	0.16	0.17	0.19	0.23	0.33	0.47	0.59
NW	M	0.14	0.12	0.11	0.09	0.08	0.09	0.10	0.11	0.13	0.14	0.16	0.17	0.18	0.21	0.30	0.42	0.51
	H	0.14	0.12	0.11	0.10	0.10	0.10	0.12	0.13	0.15	0.16	0.18	0.18	0.19	0.22	0.30	0.41	0.50
	L	0.12	0.09	0.08	0.06	0.05	0.07	0.11	0.14	0.18	0.22	0.25	0.27	0.29	0.30	0.33	0.44	0.57
NNW	M	0.15	0.13	0.11	0.10	0.09	0.10	0.12	0.15	0.18	0.21	0.23	0.26	0.27	0.28	0.31	0.39	0.51
	H	0.14	0.13	0.12	0.11	0.10	0.12	0.15	0.17	0.20	0.23	0.25	0.26	0.28	0.28	0.31	0.38	0.49
	L	0.11	0.09	0.07	0.06	0.05	0.07	0.14	0.24	0.16	0.48	0.58	0.66	0.72	0.74	0.73	0.67	0.59
HORIZ.	M	0.16	0.14	0.12	0.11	0.11	0.11	0.16	0.24	0.13	0.43	0.52	0.59	0.64	0.67	0.66	0.62	0.56
	H	0.17	0.16	0.15	0.14	0.13	0.15	0.20	0.28	0.16	0.45	0.52	0.59	0.62	0.64	0.62	0.58	0.51

TABLE 9–11 Cooling Load factors (CLF) for glass windows with interior shading, North latitude.

Fenestration Facing	Solar Time, *h*																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
N	0.08	0.07	0.06	0.06	0.07	0.73	0.66	0.65	0.73	0.80	0.86	0.89	0.89	0.86	0.82	0.75	0.78
NNE	0.03	0.03	0.02	0.02	0.03	0.64	0.77	0.62	0.42	0.37	0.37	0.37	0.36	0.35	0.32	0.28	0.23
NE	0.03	0.02	0.02	0.02	0.02	0.56	0.76	0.74	0.58	0.37	0.29	0.27	0.26	0.24	0.22	0.20	0.16
ENE	0.03	0.02	0.02	0.02	0.02	0.52	0.76	0.80	0.71	0.52	0.31	0.26	0.24	0.22	0.20	0.18	0.15
E	0.03	0.02	0.02	0.02	0.02	0.47	0.72	0.80	0.76	0.62	0.41	0.27	0.24	0.22	0.20	0.17	0.14
ESE	0.03	0.03	0.02	0.02	0.02	0.41	0.67	0.79	0.80	0.72	0.54	0.34	0.27	0.24	0.21	0.19	0.15
SE	0.03	0.03	0.02	0.02	0.02	0.30	0.57	0.74	0.81	0.79	0.68	0.49	0.33	0.28	0.25	0.22	0.18
SSE	0.04	0.03	0.03	0.03	0.02	0.12	0.31	0.54	0.72	0.81	0.81	0.71	0.54	0.38	0.32	0.27	0.22
S	0.04	0.04	0.03	0.03	0.03	0.09	0.16	0.23	0.38	0.58	0.75	0.83	0.80	0.68	0.50	0.35	0.27
SSW	0.05	0.04	0.04	0.03	0.03	0.09	0.14	0.18	0.22	0.27	0.43	0.63	0.78	0.84	0.80	0.66	0.46
SW	0.05	0.05	0.04	0.04	0.03	0.07	0.11	0.14	0.16	0.19	0.22	0.38	0.59	0.75	0.83	0.81	0.69
WSW	0.05	0.05	0.04	0.04	0.03	0.07	0.10	0.12	0.14	0.16	0.17	0.23	0.44	0.64	0.78	0.84	0.78
W	0.05	0.05	0.04	0.04	0.03	0.06	0.09	0.11	0.13	0.15	0.16	0.17	0.31	0.53	0.72	0.82	0.81
WNW	0.05	0.05	0.04	0.03	0.03	0.07	0.10	0.12	0.14	0.16	0.17	0.18	0.22	0.43	0.65	0.80	0.84
NW	0.05	0.04	0.04	0.03	0.03	0.07	0.11	0.14	0.17	0.19	0.20	0.21	0.22	0.30	0.52	0.73	0.82
NNW	0.05	0.05	0.04	0.03	0.03	0.11	0.17	0.22	0.26	0.30	0.32	0.33	0.34	0.34	0.39	0.61	0.82
HORIZ.	0.06	0.05	0.04	0.04	0.03	0.12	0.27	0.44	0.59	0.72	0.81	0.85	0.85	0.81	0.71	0.58	0.42

TABLE 4–2 Instantaneous heat gain from occupants in units of Watts[a].

Type of Activity	Typical Application	Total Heat Dissipation Adult Male	Total Adjusted[a] Heat Dissipation	Sensible Heat, W	Latent Heat, W
Seated at rest	*Theater*:				
	Matinee	111.5	94.0	64.0	30.0
	Evening	111.5	100.0	70.0	30.0
Seated, very light work	Offices, hotels, apartments, restaurants	128.5	114.0	70.0	44.0
Moderately active office work	Offices, hotels, apartments	135.5	128.5	71.5	57.0
Standing, light work, walking	Department store, retail store, supermarkets	157.0	143.0	71.5	71.5
Walking, seated	Drug store	157.0	143.0	71.5	71.5
Standing, walking slowly	Bank	157.0	143.0	71.5	71.5
Sedentary work	Restaurant	168.5	157.0	78.5	78.5
Light bench work	Factory	238.0	214.0	78.0	136.0
Moderate work	Small-Parts assembly	257.0	243.0	87.0	156.0
Moderate dancing	Dance halls	257.0	243.0	87.0	156.0
Walking at 1.5 m/s	Factory	286.0	285.0	107.0	178.0
Bowling (participant)	Bowling alley	428.5	414.0	166.0	248.0
Heavy work	Factory	428.5	414.0	166.0	248.0



درجات حرارة المنطقة الرابعة(س°)

الشهر	1	2	3	4	5	6	7	8	9	10	11	12
المتوسط الشهري	8.3	8.2	9.5	17.4	19.9	21.7	23.6	24	22.3	20.1	16	10.8
المتوسط الشهري للدرجة القصوى	11.2	11.8	13.6	20.8	25.3	27.5	29.3	30	27.4	21.2	19.3	13.7
المتوسط الشهري للدرجة الدنيا	5.3	4.7	5.4	13.9	14.5	15.8	17.9	18	17	15.9	12.6	7.9
المدى	5.9	7.2	8.3	6.9	10.8	11.7	11.4	12	10.4	8.3	6.7	5.8
الدرجة القصوى	14.3	19.7	19.7	34.1	33.2	33.2	35.8	36.1	36.1	32.9	28.6	25.3
الدرجة الدنيا	-2	1.2	-1.3	4.4	7	10.9	13.8	13.7	14.7	14	11.9	6.6

درجة الحرارة التصمية للمنطقة الرابعة.

صيفاً: 30 س°

شتاءً: 4.7 س°

قيم الرطوبة النسبية التصميمية (بالمائة)

	صيفاً		شتاءً	
	ادنى	اقصى	ادنى	اقصى
المنطقة الاولى	44	49	65.7	69.3
المنطقة الثانية	44	49	65.7	69.3
المنطقة الثالثة	55.5	61.9	68	69.7
المنطقة الرابعة	49.7	53.7	68	71.7
المنطقة الخامسة	61.5	65.2	65.9	73.7
المنطقة السادسة - غزة	75	77	62	69
المنطقة السابعة- غزة	55.5	61.9	68	69.7

Table (P-1): Table for Estimating Demand

Supply Systems Predominantly for Flush Tanks		*Supply Systems Predominantly for Flushometers*	
Load, WSFU[a]	*Demand, gpm*	*Load, WSFU*[a]	*Demand, gpm*
6	5	—	—
10	8	10	27
15	11	15	31
20	14	20	35
25	17	25	38
30	20	30	41
40	25	40	47
50	29	50	51
60	33	60	55
80	39	80	62
100	44	100	68
120	49	120	74
140	53	140	78
160	57	160	83
180	61	180	87
200	65	200	91
225	70	225	95
250	75	250	100
300	85	300	110
400	105	400	125
500	125	500	140
750	170	750	175
1000	210	1000	218
1250	240	1250	240
1500	270	1500	270
1750	300	1750	300
2000	325	2000	325
2500	380	2500	380
3000	435	3000	435
4000	525	4000	525
5000	600	5000	600
6000	650	6000	650
7000	700	7000	700
8000	730	8000	730
9000	760	9000	760
10000	790	10000	790

Fixture[a]	Use	Type of Supply Control	Fixture Units[b]	Min. Size of Fixture Branch[d] in.
Bathroom group[c]	Private	Flushometer	8	—
Bathroom group[c]	Private	Flush tank for closet	6	—
Bathtub	Private	Faucet	2	1/2
Bathtub	General	Faucet	4	1/2
Clothes washer	Private	Faucet	2	1/2
Clothes washer	General	Faucet	4	1/2
Combination fixture	Private	Faucet	3	1/2
Dishwasher[f]	Private	Automatic	1	1/2
Drinking fountain	Offices, etc.	Faucet 3/8 in.	0.25	1/2
Kitchen sink	Private	Faucet	2	1/2
Kitchen sink	General	Faucet	4	1/2
Laundry trays (1–3)	Private	Faucet	3	1/2
Lavatory	Private	Faucet	1	3/8
Lavatory	General	Faucet	2	1/2
Separate shower	Private	Mixing valve	2	1/2
Service sink	General	Faucet	3	1/2
Shower head	Private	Mixing valve	2	1/2
Shower head	General	Mixing valve	4	1/2
Urinal	General	Flushometer	5	3/4[e]
Urinal	General	Flush tank	3	1/2
Water closet	Private	Flushometer	6	1
Water closet	Private	Flushometer/tank	3	1/2
Water closet	Private	Flush tank	3	1/2
Water closet	General	Flushometer	10	1
Water closet	General	Flushometer/tank	5	1/2
Water closet	General	Flush tank	5	1/2

Water supply outlets not listed above shall be computed at their maximum demand, but in no case less than the following values:

Table (P-3) Horizontal Fixture Branches and Stacks

	Maximum Number of Fixture Units That May Be Connected to			
			Stacks with More Than Three Branch Intervals	
Diameter of Pipe, in.	*Any Horizontal Fixture Branch,[a] dfu*	*One Stack of Three Branch Intervals or Less, dfu*	*Total for Stack, dfu*	*Total at One Branch Interval, dfu*
1 1/2	3	4	8	2
2	6	10	24	6
2 1/2	12	20	42	9
3	20[b]	48[b]	72[b]	20[b]
4	160	240	500	90
5	360	540	1100	200
6	620	960	1900	350
8	1400	2200	3600	600
10	2500	3800	5600	1000
12	3900	6000	8400	1500
15	7000			

[a] Does not include branches of the building drain.

[b] Not more than two water closets or bathroom groups within each branch interval nor more than six water closets or bathroom groups on the stack.

Note: Stacks shall be sized according to the total accumulated connected load at each story or branch interval and may be reduced in size as this load decreases to a minimum diameter of half of the largest size required.

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