BUILDING FABRIC HEAT LOSSES

In order to retain a certain amount of heat energy within a building, it is necessary to reduce the amount of heat energy flowing out to the surrounds. This may be achieved by the incorporation of thermal insulation into the fabric of a building. Thermal insulation is the major factor in the reduction of heat losses from a building thus conserving energy and reducing running costs. A high level of thermal insulation will reflect in smaller heating plant being required and associated heat emitters. Well insulated walls will also reduce the likelihood of condensation forming on internal surfaces and reduce the warm up time required before internal room temperatures reach an acceptable level.

Another benefit of insulation is the reduction of heat flow into a building. A well-insulated building will remain cooler in summer (ignoring internal heat gains) than a similar building with far less insulation. This would give rise to a reduction in the cooling load and associative running costs.

Thermal Insulation

An insulator may be defined as a material that resists the flow of energy by way of conduction from one point of a higher energy potential to that of a lower energy potential. The best thermal insulators have their atoms well spaced apart thus resulting in a material that is typically low in density and in thermal conductivity k (W/mK). Gases have well spaced atoms and as such, are very efficient insulators and form the basis of many thermal insulators such as fibreglass and expanded polystyrene where the gas used is air trapped in small cavities. However in order to act as an insulator, the air must remain stationary otherwise it will convey heat energy by way of convection.

Using materials that do not readily radiate or absorb radiant heat energy may also restrict heat energy transfer by radiation. Such materials have surfaces that are shiny in nature and reflect the electromagnetic waves of heat radiation. Aluminium foil is an example of such an insulator and can often be seen in use after a marathon where the athletes are given aluminium foil blankets to keep the heat in.

Thermal insulators widely used in the building industry may be classified as follows:

i. *Rigid preformed materials* – aerated concrete blocks.
ii. *Flexible materials* – fibreglass quilts.
iii. *Loose fill materials* – expanded polystyrene.
iv. *Materials formed on site* – foamed polystyrene.
v. *Reflective materials* – aluminium foil.

When choosing a thermal insulator for a particular application, the following should be taken into consideration:

a. Thermal characteristics.
b. Loading characteristics.
c. Moisture resistance.
d. Fire resistance.
e. Resistance to pests and fungi.
f. Compatibility to adjacent materials.
g. Impact on humans and the environment.

As well as resisting the passage or absorption of water, it is important that a material be able to regain its insulating properties after being made wet perhaps during the construction of a building. The fire resistance of many plastic materials, such as ceiling tiles, is seriously altered by the use of some paints and manufacturers' instructions must be followed. Many bituminous products tend to attack plastic materials and this should be considered when installing materials.

Thermal Conductivity

The thermal conductivity k (W/mK) of a material is a measure of the rate at which heat is conducted through under specified conditions. It is a measure of the heat flow in watts (J/s) across a thickness of material of 1 m for a temperature difference of 1 K and a surface area of 1 m^2.

The thermal conductivity of a material k (W/mK) may be calculated using the following formula:

$$H/t = [k.A(\theta_1 - \theta_2)]/d \quad (W/mK)$$

Where,

H/t	Rate of heat flow through the material W (J/s)
k	Thermal conductivity of the material (W/mK)
A	Cross sectional area of the sample (m^2)
$(\theta_1 - \theta_2)$	Temperature difference between the faces of the material (K)
d	Distance between the faces of the material (m)

The reciprocal of thermal conductivity k (W/mK) is thermal resistivity r (Km/W).

Table 1 lists the thermal conductivities k (W/mK) of some common building materials.

Building material	Thermal conductivity k (W/mK)
Aluminium alloy	160.00
Asbestos – cement sheet	0.40
Asphalt felt roofing (1700 kg/m^3)	0.50
Bitumen felt layers (1700 kg/m^3)	0.50
Brickwork, exposed (1700 kg/m^3)	0.84
Brickwork, internal (1700 kg/m^3)	0.62
Concrete, dense (2100 kg/m^3)	1.40
Concrete, lightweight (1200 kg/m^3)	0.38
Concrete block, medium weight (1400 kg/m^3)	0.51
Concrete block, lightweight (600 kg/m^3)	0.19
Copper, commercial	160.00
Corkboard	0.042
Fibre insulating board	0.050
Glass	1.022
Glass wool, mat or fibre	0.04
Hardboard, standard	0.13
Mineral wool	0.039
Plaster, dense	0.50
Plaster, lightweight	0.16
Plasterboard	0.16
Polystyrene, expanded (EPS)	0.035
Polystyrene, solid	0.17
Polyurethane (foamed) board	0.025
PVC flooring	0.04
Rendering, external	0.50
Screed (1200 kg/m^3)	0.41
Steel, carbon	50.0
Stone, sandstone	1.30
Tile (1900 kg/m^3)	0.84
Timber, softwood	0.13
Timber, hardwood	0.15
Urea formaldehyde foam (UF)	0.04
Woodwool slab	0.10

Table 1 Thermal conductivities k (W/mK) of some common building materials.

It should be noted that variations in density have a significant effect of the k-values of brickwork, concrete and stone will arise and this may be in part due to the level of moisture present.

Thermal Resistance

The thermal resistance R (km^2/W) is a measure of the opposition to heat flow offered by an insulating material. When considering the thermal resistance R (km^2/W) offered by a building element, the following has to be considered:

1. Material resistances.
2. Surface resistances.
3. Airspace resistances.

Material resistances

The thermal resistance of a building element is dependant upon the individual materials that make up that building element; their thermal conductivities k (W/mK) and their respective thickness d (m). Assuming that a material is homogenous, the thermal resistance R (km^2/W) may be calculated using the following equation:

$$R = (d/k)\ (km^2/W)$$

Where,

R	Thermal resistance (km^2/W)
d	Material thickness (m)
k	Thermal conductivity of the material k (W/mK)

Alternatively,

$$R = (d \times r)\ (km^2/W)$$

Where,

R	Thermal resistance (km^2/W)
d	Material thickness (m)
r	Thermal resistivity of the material r (Km/W)

Surfaces resistances

The air that is in direct contact with a surface tends to adhere to the surface to form a thin stagnant layer. This stagnant layer forms a type of insulator, which offers resistance R (Km^2/W) to heat flow to and from the surface.

Therefore, thermal resistance R (Km^2/W) of a surface is dependant upon the conductive, convective and radiative heat flow occurring at this thin layer of air. Tabulated in Table 2 are typical surfaces resistances R (Km^2/W) for various surfaces.

Type of resistance	Building element	Heat flow	Surface emissivity *†	Thermal resistance R (Km^2/W) ††
Inside surface	Walls	Horizontal	High	0.123
			Low	0.304
	Roofs pitched or flat	Upward	High	0.106
	Ceilings, floors		Low	0.218
	Ceilings, floors	Downward	High	0.150
			Low	0.562
Outside surfaces (normal exposure)‡	Walls	Horizontal	High	0.055
			Low	0.067
	Roofs	Upward	High	0.045
			Low	0.053
Air spaces (including boundary surfaces)	Unventilated, 5 mm	Horizontal or upward	High	0.11
			Low	0.18
	Unventilated, 20 mm or greater	Horizontal or upward	High	0.18
			Low	0.35
	Ventilated loft space with flat ceiling, unsealed tiled pitched roof			0.11

Notes:

* High emissivity is for normal building materials including regular glass.

† Low emissivity is for untreated metallic surfaces such as aluminium or galvanised steel and for specially coated glass.

‡ Normal exposure is for most suburban and country premises.

†† Further standard resistances are available from the CIBSE Guide.

***Table 2** Standard surface thermal resistances R (Km^2/W).*

The factors that affect thermal resistances are given below:

i. Direction of heat flow – upward or downward.
ii. Climatic effects – sheltered or exposed.
iii. Surface properties – normal building materials with high emissivity or polished metal with low emissivity.

Airspace resistances

The thermal resistance R (Km^2/W) of an air cavity will ultimately depend upon the levels of conductive, convective and radiative heat transfer occurring within the cavity. These processes are directly influenced by the following:

- Thickness of airspace.
- Air circulation within cavity – ventilated or unventilated.
- Type of internal surface – high or low emissivity.

Please refer to Table 21 for standard thermal resistances R (Km^2/W) of air spaces.

Thermal Transmittance

The thermal transmittance or U-value (W/m^{2}K) of a building element is defined as the overall rate of heat transfer by all mechanisms under standard conditions through a particular section of construction. In other words, it is a measure of heat flow in Watts (J/s) through 1 m^2 of a structure when there is a temperature difference across the structure of 1 K.

U-values (W/m^{2}K) are often used as a basis for comparing the thermal insulation properties of various building elements and constructions, for specifying the minimum levels of insulation required by either a client or by Building regulations and by their very nature, used for the prediction of heat losses through building fabric. The U-values (W/m^{2}K) for common types of building element construction are given in Table 3.

Element	Construction	U-value (W/m^{2}K)
Solid wall	Brickwork 215 mm, plaster 15 mm	2.30
Cavity wall	Brickwork 102.5 mm, unventilated cavity 50 mm, brickwork 102.5 mm	1.60
Cavity wall	Brickwork 102.5 mm, unventilated cavity 50 mm, lightweight concrete block 100 mm, lightweight plaster 13 mm	0.96
Cavity wall	Brickwork 102.5 mm, unventilated cavity 25 mm, polystyrene board 25 mm, lightweight concrete block 100 mm, lightweight plaster 13 mm	0.58
Cavity wall	Brickwork 102.5 mm, insulation-filled cavity 60 mm, lightweight concrete block 100 mm, plasterboard 13 mm	0.45
Timber frame wall	Brickwork 12.5 mm, insulating material 60 mm, plasterboard 13 mm	0.45
Pitched roof	Tiles on battens and felt, ventilated loft space, mineral fibre 150 mm, plasterboard 13 mm	0.25
Industrial roof	Outer rain shield (negligible insulation), insulating material 65 mm, plasterboard 13 mm	0.45
Window	Single glazing	5.70
Window	Double glazing	2.80
Window	Triple glazing with low emissivity glass	2.00
Notes: Insulating materials in this table are taken to have conductivities k of 0.04 (W/mK) or less. Floors: U-values are affected by the length of the perimeter exposed to the outside. Windows: U-values are assumed unless manufacturer shows otherwise.		

Table 3. *Typical U-values of common constructions.*

Making reference to the Irish Building Regulations Technical Guidance Document L *Conservation of Fuel and Energy*, maximum allowable U-values (W/m^{2}K) are given for various building elements. Table 4 shows the maximum allowable elemental U-values for new and existing buildings as recommended in the above document.

Construction	Maximum average elemental U-values (W/m2K)	
	New buildings and extensions to existing buildings	Material alterations to or material changes of use of existing buildings
Exposed roofs	0.25	0.35
Exposed walls	0.45	0.60
Exposed floors	0.45	0.60
Ground floors	0.45	-
Semi-exposed roofs	0.35	0.60
Semi-exposed walls	0.60	0.60
Semi-exposed floors	0.60	6.60
Exposed windows, personnel doors and roof lights	3.30	3.30
Vehicle access door	0.70	0.70

Table 4. *Maximum allowable elemental U-values* (W/m^2K) *for new and existing buildings in accordance with the Irish Building Regulations Guidance Document L, Conservation of Fuel and Energy (ref Technical Guidance Document L, Table 2)*

The thermal transmittance of U-value (W/m^2K) of a building element may be calculated by using the following formula:

$$U = [1/(R_{si} + R_1 + R_2 + R_3 + \ldots\ldots\ldots R_a + R_{so})] \ (W/m^2K)$$

Where,

- U U-value (W/m^2K)
- R_{si} Inside surface resistance (Km^2/W)
- R_1 Thermal resistance of material 1 (Km^2/W)
- R_2 Thermal resistance of material 2 (Km^2/W)
- R_3 Thermal resistance of material 3 (Km^2/W)
- R_a Thermal resistance of air gap (Km^2/W)
- R_{so} Outside surface thermal resistance (Km^2/W)

Example:

Calculate the U-value (W/m^{2}K) of a cavity wall with a 105 mm thick brick outer leaf, a 75 mm unventilated cavity containing 50 mm of fibre glass quilt, a 100 mm lightweight concrete block inner leaf with a 15 mm layer of lightweight plaster.

Material	Thermal conductivity k (W/mK)	Thermal resistances R (Km^2/W)
Brickwork	0.84	-
Lightweight concrete blocks	0.19	-
Lightweight plaster	0.16	-
Fibre glass quilt	0.04	-
Internal surface	-	0.123
External surface	-	0.055
Cavity	-	0.18

Solution:

Layer	Thickness (m)	Thermal conductivity (W/mK)	Thermal resistance (Km^2/W)	
Internal surface	-	-	Standard	= 0.123
Lightweight plaster	0.015	0.16	0.015/0.16	= 0.094
Lightweight concrete block	0.100	0.19	0.100/0.19	= 0.526
Fibre glass quilt	0.050	0.04	0.05/0.04	= 1.250
Cavity	0.025	-	Standard	= 0.180
Exposed brickwork	0.105	0.84	0.105/0.84	= 0.125
External surface	-	-	Standard	= 0.055
	Total resistance R_T (Km^2/W)			**2.353**

Using the following equation:

$$U = (1/R_T)\ (W/m^2K)$$

Therefore,

$$U = (1/2.353)\ (W/m^2K)$$
$$U = \underline{\mathbf{0.425\ (W/m^2K)}}$$

Thermal transmittance for floors

The heat loss through a ground floor is greatest at the exposed edges and significantly reduces towards the centre where the ground itself acts as an insulator. As such, the calculation of the U-value (W/m^2K) for a floor is rather complex so tables and graphs are quite often used. These tables are used to determine either the U-value (W/m^2K) of the floor or the required thickness of insulation (m) in order to meet a certain regulations. It should be noted that the U-value (W/m^2K) for a large floor would probably meet the required standards, as the ratio of exposed surface area to total floor area will be small in comparison to that of a relatively small floor. When using a table for the calculation of ground floor U-values (W/m^2K), it is necessary to calculate the floor perimeter to area ratio:

$$P/A$$

Where,

P Floor perimeter length (m)

A Floor area (m^2)

Insulation thickness (mm) to achieve U-value of 0.25 (W/m^2K)			
P/A	**Thermal conductivity k (W/mK) of insulant**		
	0.02	**0.035**	**0.05**
1.00	62	108	155
0.60	56	98	139
0.20	24	42	60

Table 5. *Minimum insulation thickness (mm) for a solid ground floor in order to achieve a U-value of 0.25 (W/m^2K)*

Insulation thickness (mm) to achieve U-value of 0.45 (W/m^2K)			
P/A	**Thermal conductivity k (W/mK) of insulant**		
	0.02	**0.035**	**0.05**
1.00	26	46	66
0.60	20	35	50
0.20	4	6	9

Table 6. *Minimum insulation thickness (mm) for a solid ground floor in order to achieve a U-value of 0.45 (W/m^2K).*

Adjustments to U-values

It is sometimes necessary to calculate the effect that additional insulating material has upon a U-value (W/m^2K), or to calculate the thickness of material that is required to produce a specific U-value (W/m^2K). Use the following guide lines to make adjustments to U-values (W/m^2K):

- U-values can not be added together or subtracted from one another.
- Thermal resistances, however, can be added and subtracted. The resistances making up a particular U-value (W/m^2K) can then be adjusted to produce the new U-value (W/m^2K).

Example:

A cavity wall has a U-value of 0.91 (W/m^2K). If expanded polyurethane board is included in the construction, what minimum thickness of this board is needed to reduce the U-value to 0.45 (W/m^2K). The thermal conductivity k (W/mK) for polyurethane insulation is 0.025 (W/mK).

Solution:

Target U-value	$U_2 = 0.45$ (W/m^{2}K)
Target total resistance	$R_{T2} = 1/0.45 = 2.222$ (Km^2/W)
Existing U-value	$U_1 = 0.91$ (W/m^{2}K)
Existing total resistance	$R_{T1} = 1/0.91 = 1.099$ (Km^2/W)
Extra resistance required	$R_{T2} - R_{T1} = 2.222 - 1.099 =$ **1.123**

The resistance R (Km^2/W) of a material may be calculated using the following equation:

$$R = (d/k)\ (\text{Km}^2/\text{W})$$

Therefore,

$$1.123 = (d/0.025)\ (\text{Km}^2/\text{W})$$

d = **0.028 (m)**

Fabric Heat Loss

The fabric heat loss through a structure Q_F (W) may be calculated using the following equation:

$$Q_F = U \times A \times \Delta T \text{ (W)}$$

Where,

Q_F	Building fabric heat loss (W)
U	Thermal transmittance (W/m^2K)
A	Area of structure (m^2)
ΔT	Temperature differential (K)

The temperature differential ΔT (K) across the structure may be calculated using either one of these two equations:

$$\Delta T = (t_{ei} - t_{eo}) \text{ (K)}$$

Where,

ΔT	Temperature differential (K)
t_{ei}	Internal environmental temperature (^0C)
t_{eo}	External environmental temperature (^0C)

Alternatively,

$$\Delta T = (t_{ai} - t_{ao}) \text{ (K)}$$

Where,

ΔT	Temperature differential (K)
t_{ai}	Internal air temperature (^0C)
t_{ao}	External air temperature (^0C)

The use of environmental temperature t_e (^0C) for steady-state heat loss calculations is far better than the normal method using internal t_{ai} (^0C) and external t_{ai} (^0C) air temperatures. Like dry resultant temperature t_{res} (^{0}C), environmental temperature t_e (^{0}C) takes into account both the internal mean radiant temperature t_r (^{0}C) and the air temperature t_{ai} (^{0}C) however it considers the effects of convective heat transfer and as such it is recommended for the calculation of heat losses Q_F (W) and associated energy requirements.

The use of internal environmental temperature t_{ei} (^{0}C) is therefore better than internal air temperature t_{ai} (^{0}C) as an index of thermal comfort as it allows the Building Services Engineer to make a better assessment of the thermal comfort of the occupied space.

The environmental temperature t_{ei} (^{0}C) for an internal space may be calculated using the following equation:

$$t_{ei} = 2/3\ t_r + 1/3\ t_{ai} \quad (^0C)$$

Where,

t_{ei} Internal environmental temperature (^{0}C)
t_r Mean radiant temperature (^{0}C)
t_{ai} Internal air dry bulb temperature (^{0}C)

Internal air-dry bulb temperatures t_{ai} (^{0}C) may be used for heat loss calculations if the difference between the internal air temperature t_{ai} (^{0}C) and the internal mean radiant temperature t_r (^{0}C) is either negligible or very small. This is only likely to occur in internal areas of a building or a building where the level of insulation is high and the area of exposed glazing is low.

When designing heating systems for buildings, it is necessary to assume an outside environment. For winter heating, an overcast sky is assumed and the outside air temperature is used as the external environmental temperature t_{eo} (^{0}C). However, like internal environmental temperature t_{ei} (^{0}C), the external environmental temperature t_{eo} (^{0}C) is a combination of air temperature and radiative heat transfer.

Table 7 gives typical internal design environmental temperatures t_{ei} (^{0}C) for winter.

Type of building	**Internal environmental temperature t_{ei} (^{0}C)**
Art galleries	20
Assembly halls	18
Bars	18
Canteens	20
Factories – sedentary work	19
Factories – light work	16
Factories – Heavy work	13
Flats/houses – living rooms	21
Flats/houses - bedrooms	18
Flats/houses - bathrooms	22
Flats/houses - entrance hall	16
Hospitals – corridors	16
Hospitals – offices	20
Hospitals – operating theatre	18-21
Hospitals – wards	18
Sports pavilions	21
Warehouses	16
Laboratories	20
Law courts	20
Libraries	20
Offices – general	20
Offices – private	20
Restaurants	18
Hotels – standard bedrooms	22
Hotels – luxury rooms	24
Hotels – public rooms	21
Schools/colleges – classrooms	18
Schools/colleges – lecture rooms	18
Shops – small	18
Shops – large	18
Swimming baths - hanging rooms	22
Swimming baths - Bath hall	26

Table 7. *Recommended internal design environmental temperatures t_{ei} (^{0}C) for winter.*

External radiative heat transfer comes in two forms:

1. Clear sky radiation – radiation of heat outward due to high emmissivity of clear sky (night time).
2. Solar radiation – direct radiation from the sun (day-time).

The external environmental temperature t_{eo} (^{0}C) is also known as the Sol-air temperature t_{eo} (^{0}C) and is defined as the external outside air temperature, which includes the effect of solar radiation. Sol-air temperature t_{eo} (^{0}C) varies with climate, time of day and incident solar radiation or lack there of. Values can be either calculated or obtained from tables found in Volume A of the CIBSE Guide.

Infiltration Heat Loss

Infiltration heat loss or ventilation heat loss Q_v (W) is the heat loss due to the infiltration of cold air into a building. The heat loss due to this phenomenon may be calculated using the following equation:

$$Q_v = [((\rho NVC)/(3600))(t_{ai} - t_{ao})] \quad (W)$$

Where,

Q_v	Infiltration heat loss (W)
ρ	Density of air (1.2 kg/m^3)
N	Number of air changes per hour
V	Room volume (m^3)
C	Specific heat capacity of air (1.02 kJ/kg^{0}K)
t_{ai}	Internal room temperature (^{0}C)
t_{ao}	External air temperature (^{0}C)

Table 8 give typical design infiltration rates for various buildings.

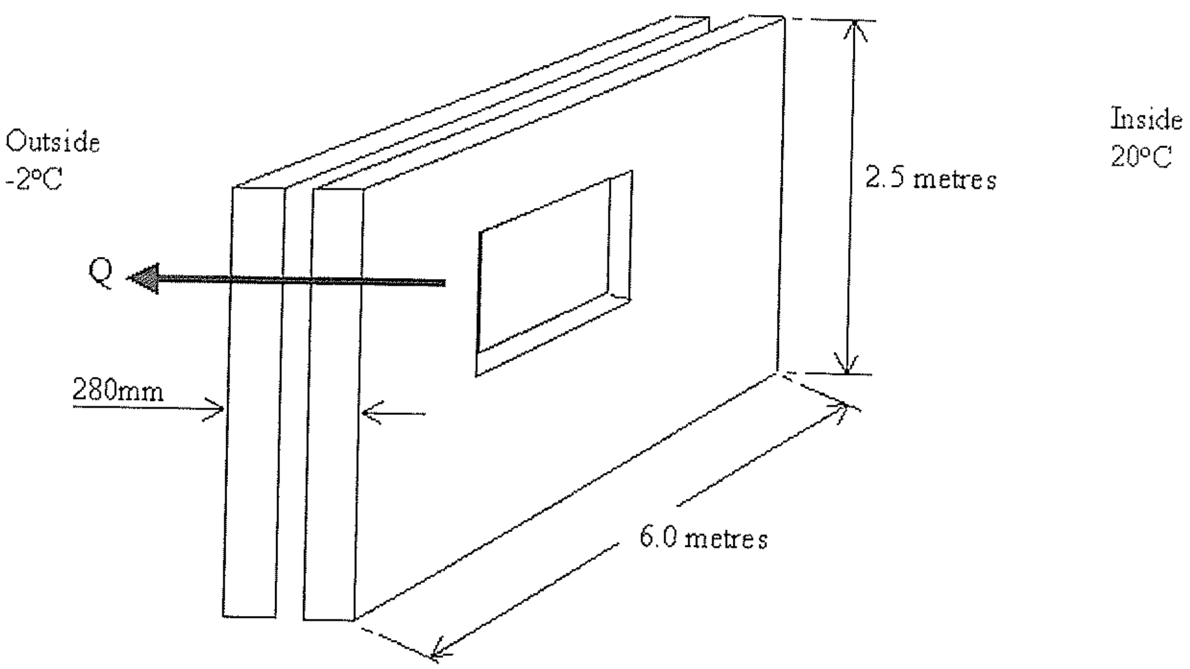
Type of building	**Infiltration, air changes per hour**
Domestic – living rooms	1.0
Domestic – bedrooms	0.5
Domestic – bathrooms	0.5
Offices, general	1
Classrooms, schools	2
Shops, large	0.5
Restaurants, bars	1.0
Hotel bedrooms	1.0
Factories, light work	1.0

Table 8. *Typical design infiltration rates.*

To calculate daily heat losses Q_v (W) appropriate temperatures would be the mean internal air temperature t_{ai} (^{0}C) and the mean external air temperature t_{ao} (^{0}C), both averaged over 24 hours. For the calculation of maximum heat losses, such as when choosing the size of heat emitters, it is necessary to assume a lowest deign temperature for the external air t_{ao} (^{0}C) such as –1 (^{0}C).

Heat Loss Examples

Calculate the heat flow through the wall shown below.



CAVITY WALL

The 'U' value for the blockwork in the wall is 0.317 W/m^2 °C

The 'U' value for the double-glazed window is 2.8 W/m^2 °C.

The window size is 2.0 m long x 1.0 m high.

Q = 'U' . A . dt

First calculate the heat loss through the window.

Q = 2.8 x 2.0 x 1.0 x (20 - - 2)

Q = 2.8 x 2.0 x 22

Q = 123.20 Watts

Next calculate the heat loss through the blockwork.

Q = 0.317 x (15.0 - 2.0) x (20 - - 2)

Q = 0.317 x 13 x 22

Q = 90.66 Watts

Finally calculate the total heat loss

Q total = heat loss through window + heat loss through blockwork

Q total = 123.20 + 90.66

Q total = 213.86 Watts.

VENTILATION HEAT LOSS

This is the heat loss associated with air flow through a building.

The formula for ventilation heat loss is:

Q = N . V . Sp.ht. . dt

where

Q = heat loss (Watts) (W)
N = Number of air changes per hour. An air change is one room volume.

Sp.ht. = Specific heat factor for air. This is found from the following formula.

Sp. Ht. Factor = (Specific heat capacity of air x 1000 to convert from kJ to Joules x density of air) / 3600 to convert from hr to secs.

Sp. Ht. Factor = (1.01 x 1000 x 1.2) / (3600)

Sp. Ht. Factor = 0.34

dt = temperature difference between inside and outside (^oC)

VENTILATION RATES

Table A4.8 CIBSE Guide gives values for air infiltration rates and ventilation allowances for various buildings.

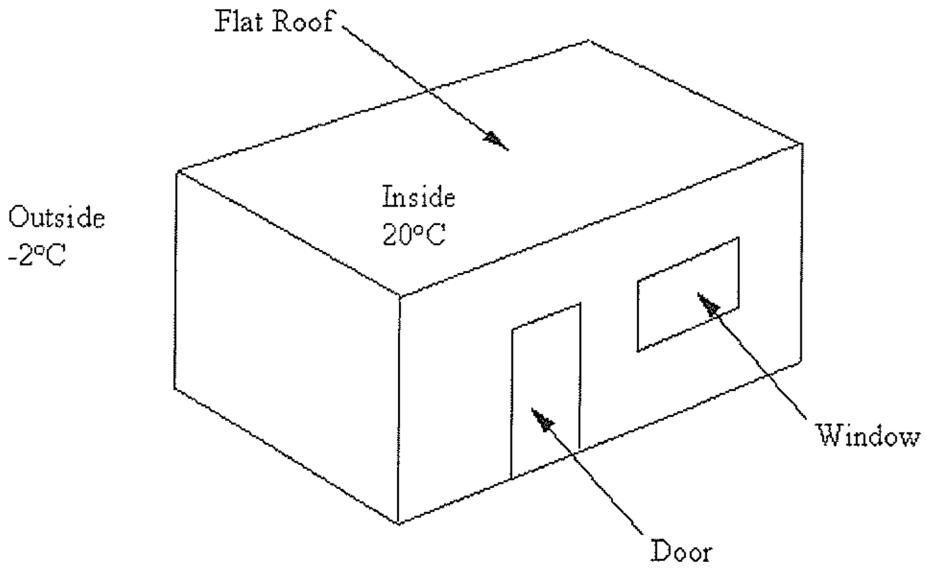
AREAS	*AIR CHANGES PER HOUR*
LIVING ROOMS	1.0
BEDROOMS	0.5
BATHROOMS	2.0
LAVATORIES & CLOAKROOMS	1.5
STAIRCASE & CORRIDORS	1.5
ENTRANCE HALLS & FOYERS	1.5
OFFICES	1.0

Example:

Calculate the ventilation heat loss from the building shown below.

Rectangular Building dimensions : 6.0 metres long x 3.0 metres wide x 2.5 metres high.

The air change rate due to natural ventilation is 2 air changes per hour.



SMALL BUILDING

$$Q = N \cdot V \cdot Sp.ht. \cdot dt$$

$$Q = 2.0 \times (6.0 \times 3.0 \times 2.5) \times 0.34\ (20 - -2)$$

$$Q = 2.0 \times 45 \times 0.34 \times 22$$

$$Q = \mathbf{673.2\ Watts}$$

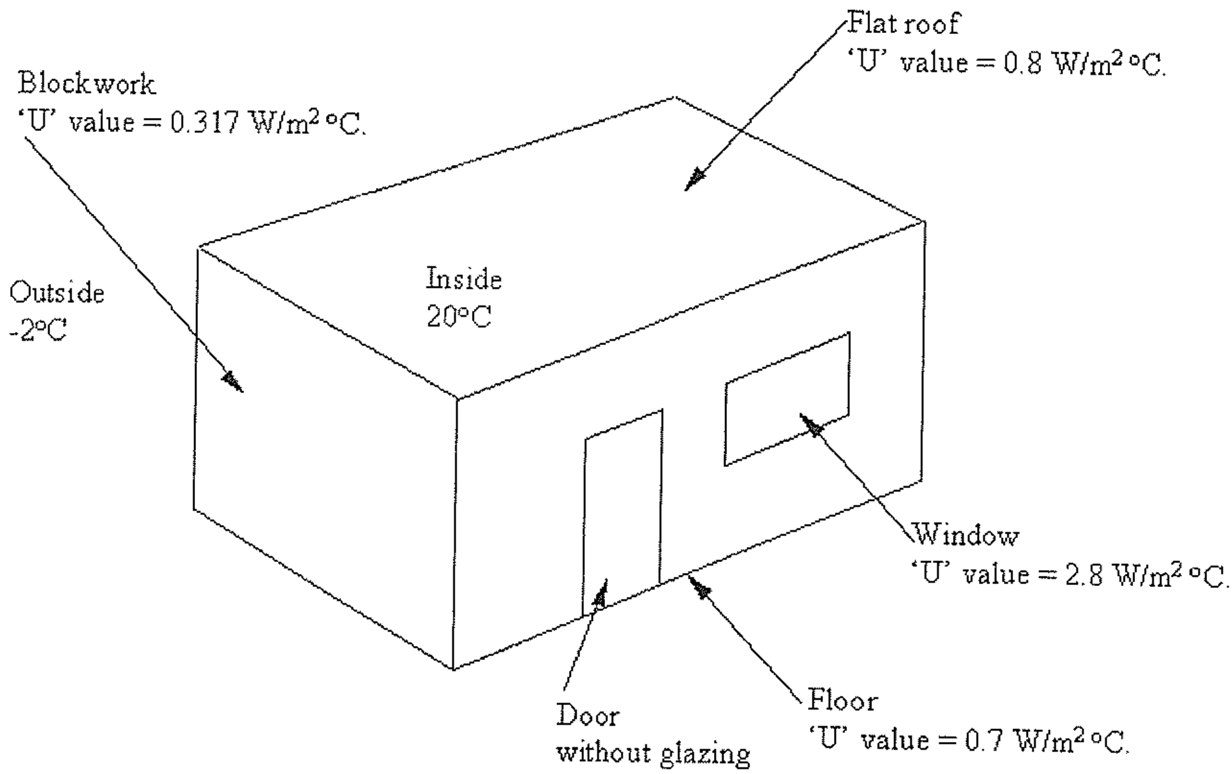
TOTAL HEAT LOSS CALCULATIONS

EXAMPLE

Calculate the total heat loss from the building shown below i.e. the fabric and ventilation losses.

Rectangular Building dimensions : 6.0 metres long x 3.0 metres wide x 2.5 metres high.
The window size is 2.0 m long x 1.0 m high.
The air change rate due to natural ventilation is 2 air changes per hour.

It is normal to ignore the door without glazing and add it into the wall area in most calculations although for very accurate methods the door could be calculated separately.



SMALL BUILDING

Q = 'U' . A . dt

First calculate the heat loss through the window

Q window = 2.8 x 2.0 x 1.0 x (20 - - 2)
Q window = 2.8 x 2.0 x 22
Q window = 123.20 Watts

Second calculate the heat loss through the blockwork.

Q front wall = 0.317 x (15.0 - 2.0) x (20 - - 2)
Q front wall = 0.317 x 13 x 22
Q front wall = 90.66 Watts

Q rear wall = 0.317 x 15 x 22

Q rear wall = 104.61 Watts

Q side walls = 0.317 x 2 (3.0 x 2.5) x 22

Q side walls = 104.61 Watts

Q walls total = 90.66 Watts + 104.61 Watts + 104.61 Watts = 299.88 Watts

Third calculate the heat loss through the floor.

Q floor = 0.7 x 6.0 x 3.0 x 22

Q floor = 277.20 Watts

Fourth calculate the heat loss through the roof

Q roof = 0.8 x 6.0 x 3.0 x 22

Q roof = 316.80 Watts

Fifth calculate the heat loss by ventilation

Q = N . V . Sp.ht. . dt

Q = 2.0 x 6.0 x 3.0 x 2.5 x 0.34 (20 - - 2)

Q = 2.0 x 45 x 22

Q = 673.2 Watts

Finally calculate the total heat loss

Q total = heat loss window + heat loss blockwork + heat loss floor + heat loss roof + ventilation heat loss