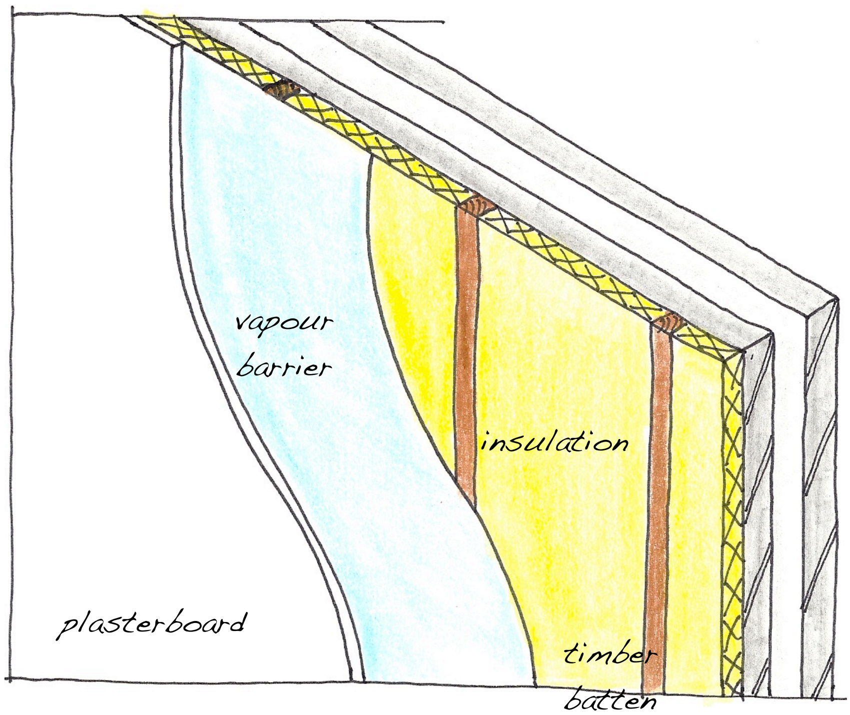
Leaving Certificate Revision Notes

U-Value Calculations



2005
Q.5.

An extension to a dwelling house has a concrete flat roof with an asphalt finish. The total roof surface is $16m^2$ in area.
The roof is constructed to the following specification:

(i)	Concrete flat roof slab:	Thickness 175mm
(ii)	Concrete screed:	Thickness 60mm
(iii)	Layer of asphalt:	Thickness 20mm
(iv)	Internal plaster to roof slab:	Thickness 15mm

Thermal data of roof:

Resistivity of asphalt	1.250	m °C/W
Resistivity of concrete screed	0.710	m °C/W
Resistivity of concrete roof slab	0.690	m °C/W
Resistivity of the plaster	2.170	m °C/W
Resistance of the internal surface (R)	0.104	m^2 °C/W
Resistance of the external surface (R)	0.413	m^2 °C/W
External temperature	11°C	
Internal temperature	21°C.	

(a) Calculate the U-value of the roof structure and the overall heat loss through the roof.

(b) Outline **two** design considerations that must be taken into account in the design of a roof for a domestic dwelling and describe, with the aid of notes and freehand sketches, the design detailing for **each** consideration outlined.

Solution:

(a) U value of roof structure:

Layer/ surface	Thickness (m)	Conductivity (W/ mK)	Resistance (m^2K/W)
int' surface			0.104
plaster	0.015	0.461	0.033
slab	0.175	1.449	0.121
screed	0.060	1.408	0.043
asphalt	0.020	0.800	0.025
ext' surface			0.413
total resistance			0.738

U value = 1/total resistance

= 1/0.738 = 1.355 = 1.35 W/m^2K

Overall heat loss through the roof:

Overall heat loss = U value x area x temp difference

- U value = 1.35 .35 W/m^2K
- Area = $16m^2$
- Temperature difference = 21°C − 11°C = 10°C

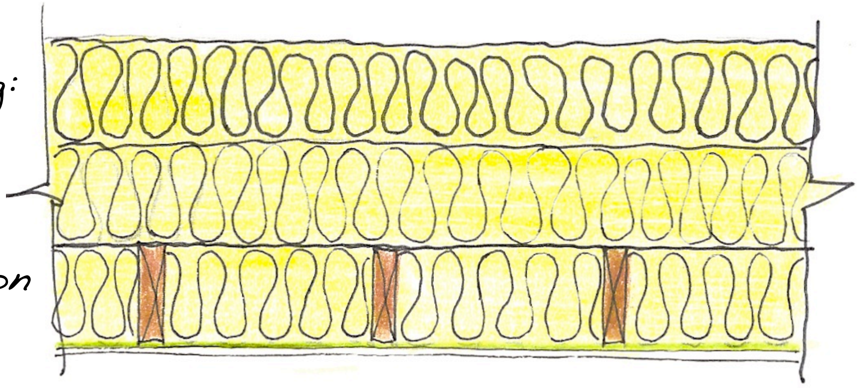
Overall heat loss = 1.35 x 16 x 10

= 216 W

(b) Two considerations for roof design:

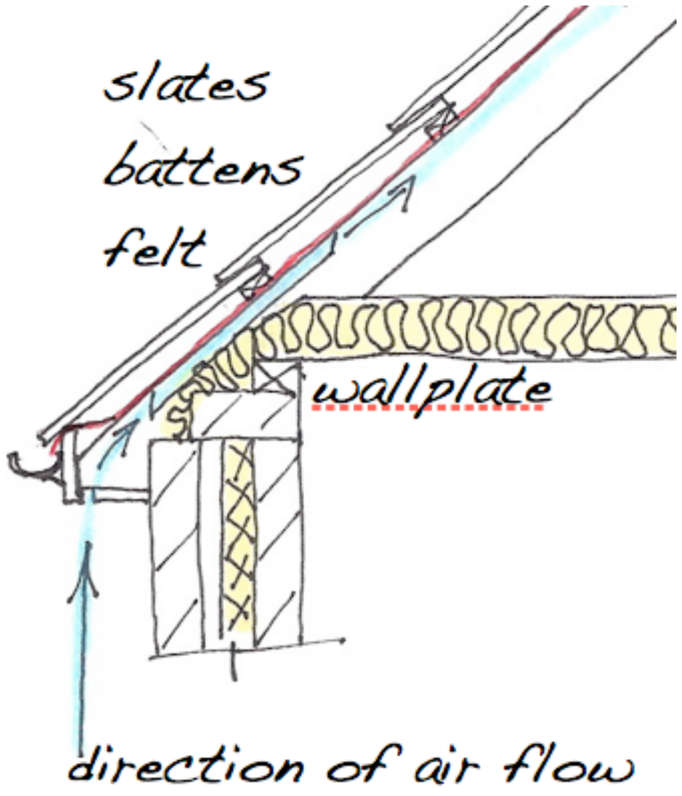
The roof structure must be adequately insulated to prevent heat loss. Roofs must achieve a maximum elemental U value of 0.16W/m^{2}K when the insulation is at ceiling level; 0.20W/m^{2}K when the insulation is on the slope and 0.22W/m^{2}K for flat roofs.

cross section of ceiling: 200x50mm ceiling joist with three layers of 200mm quilted insulation in attic space



The roof structure must be ventilated to ensure the roof timbers do not become moist and rot.

cross section of eaves: eaves vent allows air to flow into the roof space



2006
Q.5.

The external wall of a timber framed house has the following specification:

External Plaster	thickness	15 mm
Block outer leaf:	thickness	100 mm
Timber stud inner leaf :	thickness	125 mm
Urethane board insulation:	thickness	100 mm
Plasterboard:	thickness	12.5 mm

Thermal data of outer leaf :

Resistance of the external surface	(R)	0.048 m^2 °C/W
Resistivity of the external plaster	(r)	2.170 m °C/W
Conductivity of block	(k)	1.320 W/m °C

Thermal data of inner leaf :

Conductivity of urethane board	(k)	0.023 W/m °C
Conductivity of plasterboard	(k)	0.160 W/m °C
Resistance of the internal surface	(R)	0.104 m^2 °C/W
Resistance of the cavity	(R)	0.170 m^2 °C/W

Ignore the timber studs of inner leaf.

(a) Calculate the U-value of the wall.

(b) Calculate the annual cost of the heat loss through the external wall of the timber framed house outlined above, using the following data:

Total external wall area:	125 m^2
Average internal temperature:	18 °C
Average external temperature:	6 °C
U-value of wall:	as calculated at **(a)** above
Heating period:	12 hours per day for 40 weeks per annum
Calorific value of oil:	37350 kj per litre
Cost of heating oil:	65 cent per litre
1000 Watts =	1 kj per second.

(c) Show, with the aid of ***notes and freehand sketches,*** a design detail which will prevent moisture reaching the insulation material from inside the building.

Solution:

(a) U value of timber frame wall:

Layer/ surface	Thickness (m)	Conductivity (W/mK)	Resistance (m^2K/W)
int` surface			0.104
plasterboard	0.0125	0.160	0.078
insulation	0.100	0.023	4.348
cavity	-	-	0.170
ext leaf	0.100	1.320	0.076
render	0.015	0.461	0.033
ext` surface			0.048
total resistance			4.824

U value = 1/total resistance

= 1/4.824 = 0.207 = 0.21W/m^2K

(b) Annual cost of heat loss:

Cost = (Time)(Rate)(Area)(Price) / (1000)(Calorific value)

time = 60 × 60 × 12 × 7 × 40 = 12096000

- rate = U value × temp difference

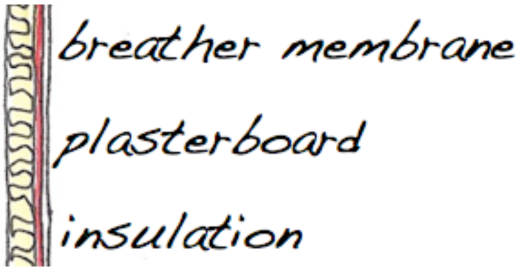
  = 0.21 × (18 - 6) = 0.21 × 12 = 2.52
- area = 125m^2
- price = €0.65
- calorific value of oil = 37350

∴ cost = (12096000)(2.52)(125)(0.65) / (1000)(37350)

- cost = €66.31

(c) Prevention of moisture penetration

cross section of inner leaf:
the breather membrane installed under the plasterboard prevents moisture entering the timber inner leaf



2007
Q.5

(a) Using the following data, calculate the U-value for the external wall of a house, built in the 1970s:

External plaster	thickness	16 mm
Block outer leaf	thickness	100 mm
Cavity (un-insulated)	width	100 mm
Block inner leaf	thickness	100 mm
Internal plaster	thickness	13 mm

Thermal data of external wall :

Conductivity of plaster	(k)	0.430 W/m °C
Conductivity of blockwork	(k)	1.440 W/m °C
Resistance of external surface	(R)	0.048 m^2 °C/W
Resistance of cavity	(R)	0.170 m^2 °C/W
Resistance of internal surface	(R)	0.122 m^2 °C/W

(b) Using the following data, calculate the cost of the heat lost annually through the un-insulated external wall:

Area of external wall	145 m^2
Average internal temperature	18 °C
Average external temperature	5 °C
U-value of wall	as calculated at **(a)** above
Heating period	10 hours per day for 42 weeks per annum
Cost of oil	68 cent per litre
Calorific value of oil	37350 kj per litre
1000 Watts =	1kj per second.

(c) It is proposed to insulate the external walls of the house to improve their U-value.
Using ***notes and freehand sketches***, show **one** method of insulating the external walls to meet the requirements of the current Building Regulations.

Solution:

(a) U value of concrete cavity wall:

Layer/ surface	Thickness (m)	Conductivity (W/mK)	Resistance (m²K/W)
int` surface			0.122
int plaster	0.013	0.430	0.030
inner leaf	0.100	1.440	0.069
cavity	-	-	0.170
outer leaf	0.100	1.440	0.069
render	0.016	0.430	0.037
ext` surface			0.048
total resistance			0.546

U value = 1/total resistance

= 1/0.546 = 1.834 = 1.83 W/m^2K

(b) Annual cost of heat loss:

Cost = (Time)(Rate)(Area)(Price) / (1000)(Calorific value)

time = 60 × 60 × 10 × 7 × 42 = 10584000

- rate = U value × temp difference

  = 1.83 × (18 - 5) = 1.83 × 13 = 23.79

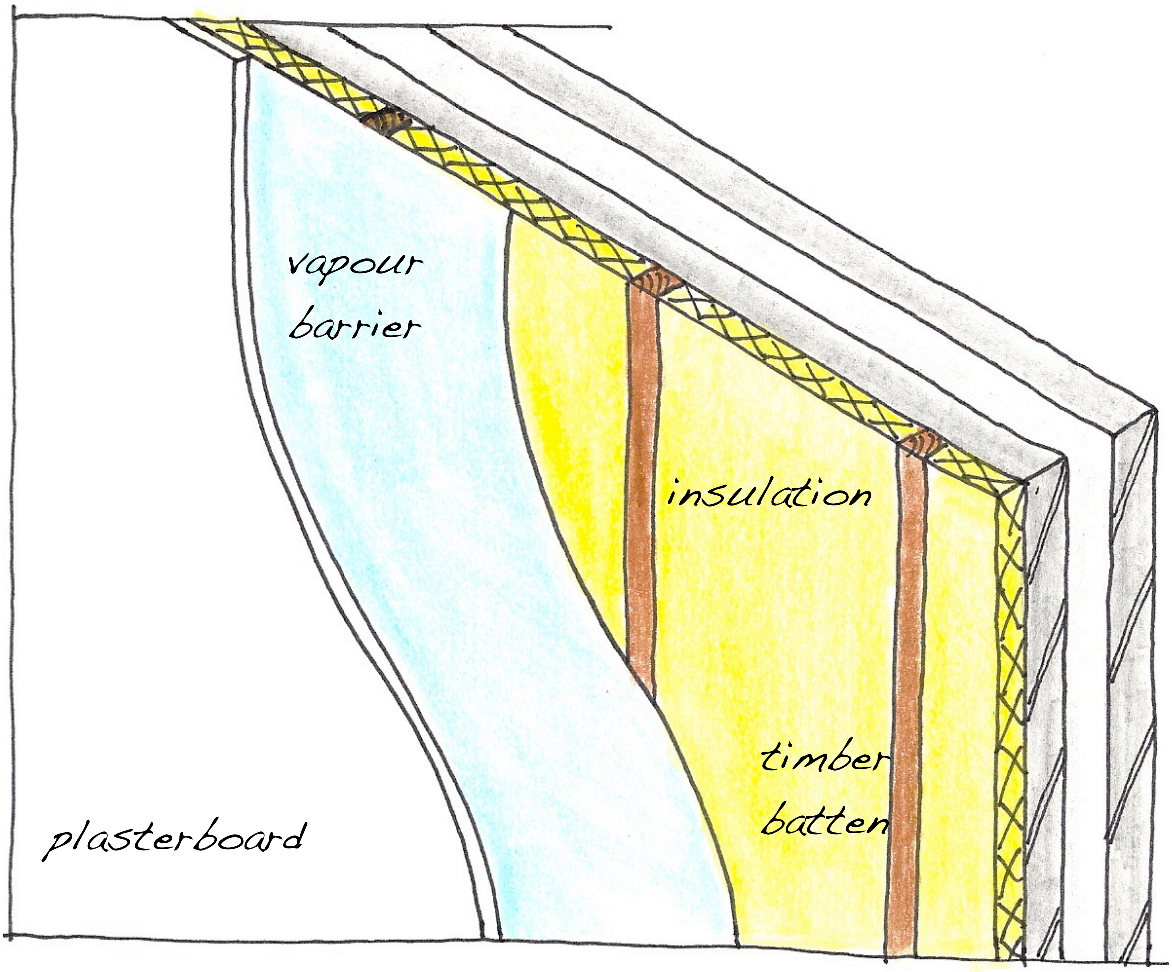
- area = 145 m^2
- price = €0.68
- calorific value of oil = 37350

∴ cost = (10584000)(23.79)(145)(0.68) / (1000)(37350)

- cost = €664.71

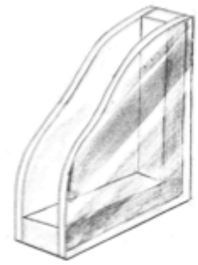
c) The thermal properties of the walls of the 1970's house could be upgraded by dry-lining them:

- timber battens are fixed to the interior surface of the external walls at 400mm centres
- a layer of rigid insulation is fixed in place between the battens
- a vapour check barrier is installed across the entire surface and sealed at all edges to prevent air infiltration
- plasterboard is fixed to the timber battens
- the plasterboard is finished (plastered).



2008
Q.5.

(a) Using the following data, calculate the U-value of the:
  (i) single glazing;
  (ii) standard double glazing.



Glass: single glazing	thickness	5 mm
Glass: double glazing	thickness	4 mm
Space between panes	width	12 mm

Thermal data of glazing:

Conductivity of glass	(k)	1.020 W/m °C
Resistance of space between panes	(R)	0.170 m^2 °C/W
Resistance of internal surface	(R)	0.122 m^2 °C/W
Resistance of external surface	(R)	0.080 m^2 °C/W

(b) A choice is to be made between the following types of double glazing:
- standard double glazing;
- low-emissivity (low-e) double glazing.

Using the U-values obtained at **(a)** above and the following data, calculate the cost of the heat lost annually through **each** of the following:
- single glazing;
- standard double glazing;
- low-e double glazing.

U-value of low-e double glazing:	1.1 W/m^2 °C
Area of glazing:	25 m^2
Average internal temperature:	18 °C
Average external temperature:	5 °C
Heating period:	11 hours per day for 40 weeks per annum
Cost of oil:	80 cent per litre
Calorific value of oil:	37350 kj per litre
1000 Watts:	1kj per second.

(c) Using the information obtained at **(b)** above, recommend a preferred glazing type and give **two** reasons to support your recommendation.

Solution:

(a) U value of single glazing:

Layer/ surface	Thickness (m)	Conductivity (W/ mK)	Resistance (m^2K/W)
int' surface			0.122
single glazing	0.005	1.020	0.005
ext' surface			0.080
total resistance			0.207

U value = 1/total resistance

= 1/0.207 = 4.831 = 4.83W/m²K

U value of double glazing:

Layer/ surface	Thickness (m)	Conductivity (W/ mK)	Resistance (m²K/ W)
int' surface			0.122
inner glazing	0.004	1.020	0.004
space			0.170
outer glazing	0.004	1.020	0.004
ext' surface			0.080
total resistance			0.380

U value = 1/total resistance

= 1/0.380 = 2.632 = 2.63W/m²K

(b)

Annual cost of heat loss: single glazing

Cost = (Time)(Rate)(Area)(Price) / (1000)(Calorific value)

- time = 60 × 60 × 11 × 7 × 40 = 11088000
- rate = U value × temp difference

  = 4.83 × (18 − 5) = 4.83 × 13 = 62.79
- area = 25m²
- price = €0.80
- calorific value of oil = 37350

∴ cost = (11088000)(62.79)(25)(0.80) / (1000)(37350)

- cost = €372.81

Annual cost of heat loss: double glazing

Cost = (Time)(Rate)(Area)(Price) / (1000)(Calorific value)

- time = 60 × 60 × 11 × 7 × 40 = 11088000
- rate = U value × temp difference
  = 2.63 × (18 − 5) = 2.63 × 13 = 34.19
- area = 25m²
- price = €0.80
- calorific value of oil = 37350

∴ cost = (11088000)(34.19)(25)(0.80) / (1000)(37350)

- cost = €202.99

Annual cost of heat loss: low-e double glazing

Cost = (Time)(Rate)(Area)(Price) / (1000)(Calorific value)

- time = 60 × 60 × 11 × 7 × 40 = 11088000
- rate = U value × temp difference
  = 1.10 × (18 − 5) = 1.10 × 13 = 14.44
- area = 25m²
- price = €0.80
- calorific value of oil = 37350

∴ cost = (11088000)(14.44)(25)(0.80) / (1000)(37350)

- cost = €85.73

(c) I would recommend the low-e double glazing:

- it is more energy efficient - using less energy means less fossil fuels are consumed to heat the home - this reduces greenhouse gas emissions,

- it is cheaper - the calculations show that the low-e double glazing is significantly cheaper per annum - the extra cost of installing a higher quality window would be recouped in a short period of time.

2009
Q.5.

(a) Calculate the U-value of the external wall of a new dwelling house, given the following data:

External render	thickness	12 mm
Concrete block outer leaf	thickness	100 mm
Cavity	width	150 mm
Insulation	thickness	100 mm
Concrete block inner leaf	thickness	100 mm
Internal plaster	thickness	15 mm

Thermal data of external wall of new house:

Resistance of external surface	(R)	0.048 m^2 °C/W
Conductivity of external render	(k)	1.430 W/m °C
Conductivity of concrete blocks	(k)	1.440 W/m °C
Resistance of cavity	(R)	0.170 m^2 °C/W
Conductivity of insulation	(k)	0.018 W/m °C
Conductivity of internal plaster	(k)	0.430 W/m °C
Resistance of internal surface	(R)	0.122 m^2 °C/W

(b) Using the thermal data below and the U-value obtained at **5(a)** above, calculate the cost of the heat lost annually through the walls of:

- the new house specified at **5(a)** and
- a house built in the 1970s with an external wall U-value of 1.80 W/m^2 °C.

Thermal data:

Area of external wall	152 m^2
Average internal temperature	17 °C
Average external temperature	6 °C
U-value of wall of new house	as calculated at **5(a)** above
U-value of wall of 1970s house	1.80 W/m^2 °C
Heating period	11 hours per day for 41 weeks per annum
Cost of oil	65 cent per litre
Calorific value of oil	37350 kJ per litre
1000 watts	1kJ per second.

(c) Using notes and ***freehand sketches*** show **one** method of upgrading the thermal properties of the external wall of the house built in the 1970s to meet the requirements of the current Building Regulations.

a) U-value of wall:

Layer/ surface	Thickness (m)	Conductivity (W/ mK)	Resistance (m^2K/W)
int' surface			0.122
plaster	0.015	0.430	0.035
inner leaf	0.100	1.440	0.069
insulation	0.100	0.180	5.555
cavity	0.050		0.170
outer leaf	0.100	1.440	0.069
render	0.012	1.430	0.008
ext' surface			0.048
total resistance			6.076

U-value = 1/total resistance

= 1/6.076

= 0.165 W/m^2K

b)

House from part (a) above:

Cost = (Time)(Rate)(Area)(Price) / (1000)(Calorific value)

- time = 60 × 60 × 11 × 7 × 41 = 11,365,200
- rate = 0.165 × (17 − 6) = 0.165 × 11 = 1.815
- area = 152
- price = €0.65
- calorific value of oil = 37350

∴ cost = (11,365,200)(1.815)(152)(0.65) / (1000)(37350)

- cost = €54.56

House from 1970's:

Cost = (Time)(Rate)(Area)(Price) / (1000)(Calorific value)

- time = 60 × 60 × 11 × 7 × 41 = 11,365,200
- rate = 1.80 × (17 − 6) = 0.18 × 11 = 19.8
- area = 152
- price = €0.65
- calorific value of oil = 37350

∴ cost = (11,365,200)(19.8)(152)(0.65) / (1000)(37350)

- cost = €595.26

c) The thermal properties of the walls of the 1970's house could be upgraded by dry-lining them:

- timber battens are fixed to the interior surface of the external walls at 400mm centres
- a layer of rigid insulation is fixed in place between the battens
- a vapour check barrier is installed across the entire surface and sealed at all edges to prevent air infiltration
- plasterboard is fixed to the timber battens
- the plasterboard is finished (plastered).