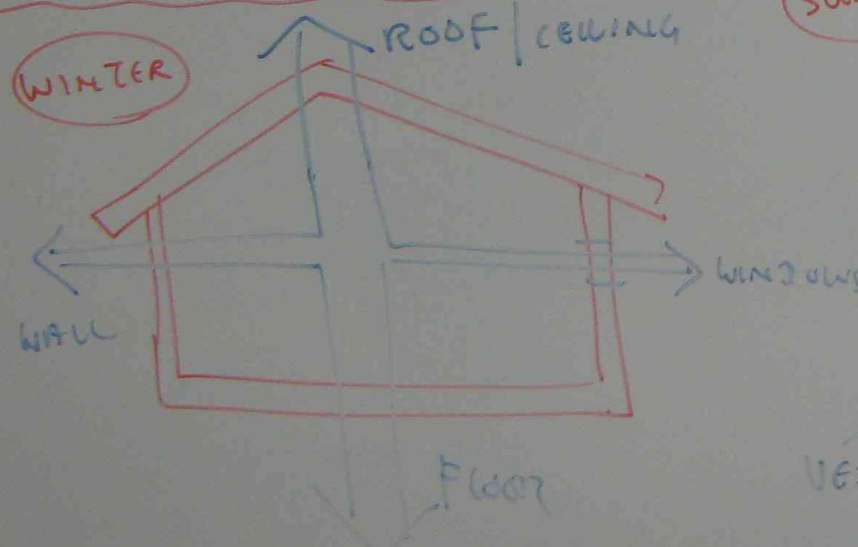
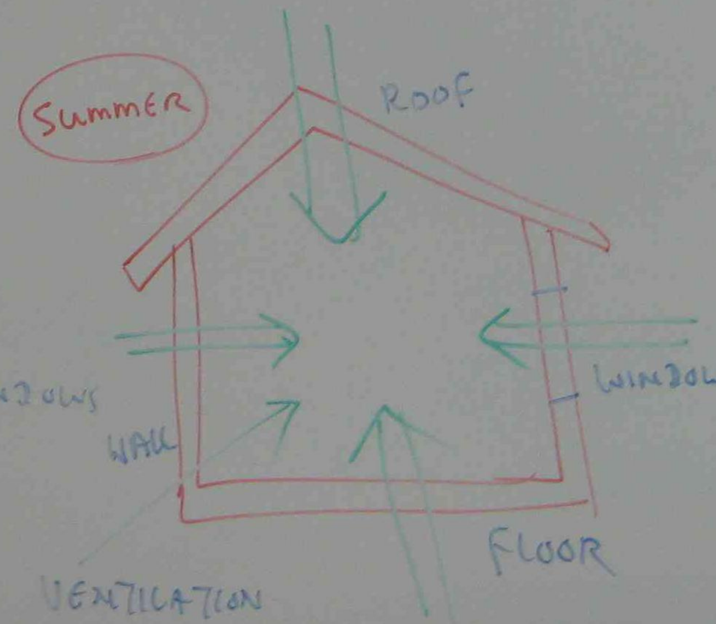
INSULATION

INSULATION PRODUCTS MAY ACT AS SOUND-PROOFING (OR) FIRE PROTECTION. THEY ARE PRIMARILY UTILIZED TO REDUCE HEAT FLOW AND HEAT LOSS IN WINTER AND REDUCES HEAT GAIN IN SUMMER.

IT REDUCES HEATING & COOLING ENERGY REQUIREMENTS AND IMPROVES THERMAL COMFORT.

HEAT TRANSFER IN BUILDING





BRICK VENEER DWELLING

RADIATION

WARM PLASTERED BOARD RADIATES HEAT TO COOLER TILES

CONVECTION

AIR HEATED BY WARM PLASTER BOARD RISES AND COMES IN TO CONTACT WITH COLD TILES WHERE IT IS COOLED DOWN BY LOSING SOME OF IT'S HEAT TO TILES.

TYPES OF INSULATION

REFLECTIVE INSULATION - REFLECTIVE FOIL LAMINATE (RFL) CONSISTS OF THIN SHEETS FACED ON ONE OR BOTH SIDES WITH HIGHLY REFLECTIVE ALUMINIUM FOIL

- IT REDUCES RADIANT HEAT FLOW.
- 3/4 LAYERS OF REFLECTIVE FOIL LAMINATE SEPARATED BY SPACERS AND AIR GAPS.

BAULK INSULATION

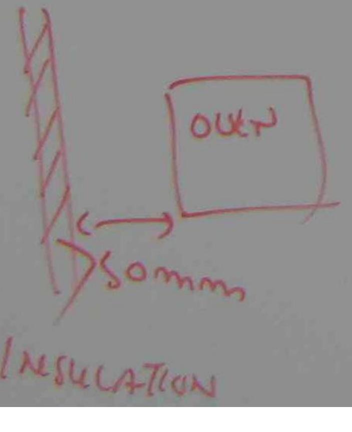
IT REDUCES CONDUCTED AND CONVECTED HEAT FLOW.

IT CONSISTS OF BUTT BLANKET, BOARD (POLYSTYRENE), LOOSE FILL INSULATION (CELLULOSE FIBRE, EDGRASS).

INSULATION MATERIAL	CONDUCTIVITY (W/m K)
CELLULOSE	0.039
FIBRE GRASS	0.043
POLY STYRENE	0.039
POLYURGTHAMG	0.025
ROCK WOOL	0.035

INSTALLATION OF INSULATION

- WHERE POSSIBLE, INSULATION SHOULD BE PLACED DURING CONSTRUCTION TO AVOID RETROFITTING.
- CHOOSE APPROPRIATE "R" VALUE.
- COLD BRIDGE (UNSULATED STRUCTURED TIMBER R = 0.6) SHOULD BE AVOIDED.
- AT LEAST 50 mm CLEARANCE AROUND APPLIANCES WHICH DISSIPATES HEAT.



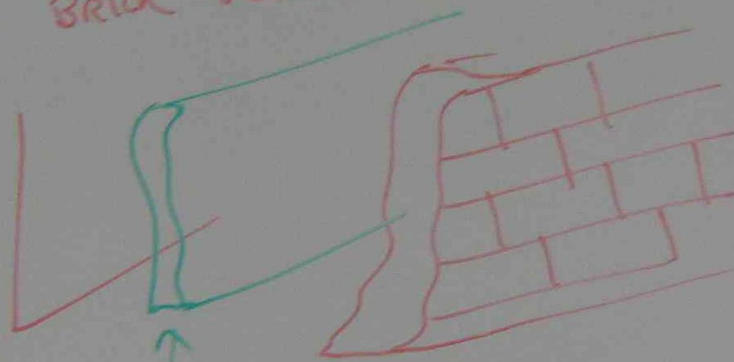
FLOORS

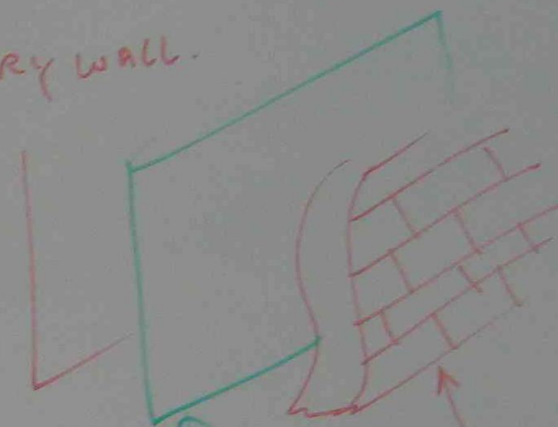
TIMBER WITH LOW THERMAL RESISTANCE.

SUSPENDED TIMBER, CONCRETE SLAB, CONCRETE SLAB ON GROUND.

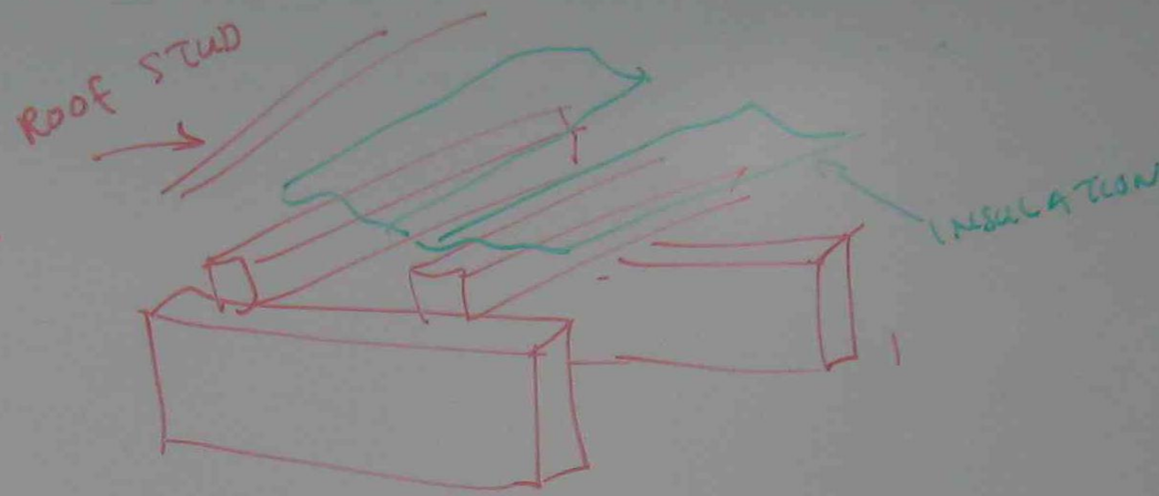
WALL

BRICK VENEER WALL. FULL MASONARY WALL.

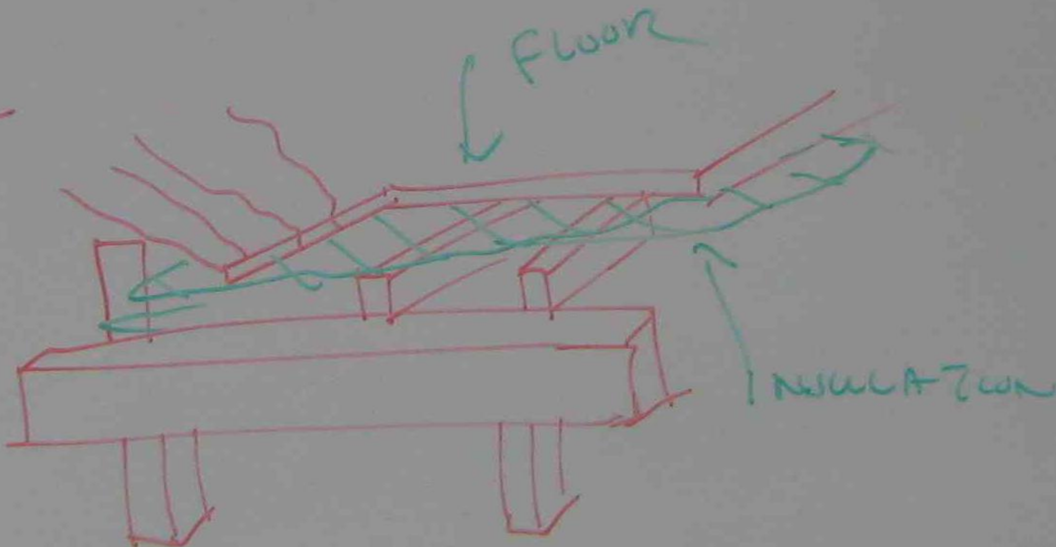




ROOF



FLOOR



RELEVANT AUSTRALIAN STANDARDS

AS 1366.3 – (1982) RIGID CELLULAR PLASTIC SHEETS FOR THERMAL INSULATION – POLYSTYRENE

AS 1366.4 (1989) RIGID CELLULAR PLASTIC SHEET FOR THERMAL INSULATION.

AS 1903 – (1976) – REFLECTIVE FOIL LAMINATE.

AS 1904 – (1976) – INSTALLATION OF REFLECTIVE LAMINATE IN BUILDING.

AS 2454 – (1982) – ORGANIC FIBRE INSULATION BOARD

AS 2461 (1981) – CELLULOSIC FIBRE THERMAL INSULATION

AS 2627.1 (1983) – THERMAL INSULATION OF DWELLINGS.

THERMAL MASS AND STORAGE

THERMAL MASS MAY BE USED IN BUILDINGS TO MODERATE THE INTERNAL SWINGS IN TEMPERATURE DUE TO CHANGING OF EXTERNAL TEMPERATURE.

VARIATIONS IN HEAT FLOOR + TEMPERATURE $\longrightarrow$ HEAT STORAGE AND RELEASE

CHANGE IN OUTDOOR TEMPERATURE $\longrightarrow$ DELAY & REDUCE INDOOR TEMPERATURE CHANGE

HEATING | MELTING | VAPOURING $\longrightarrow$ THERMAL ENERGY STORAGE.

SENSIBLE HEAT

SENSIBLE HEAT = SPECIFIC HEAT J/m^3K x VOLUME

THERMAL CAPACITY = $C = c \times L$

c = VOLUMETRIC HEAT CAPACITY

L = THICKNESS

THERMAL RESISTANCE (R) = $\frac{L}{K}$

L = THICKNESS (m)

K = CONSTANT

LATENTENT HEAT

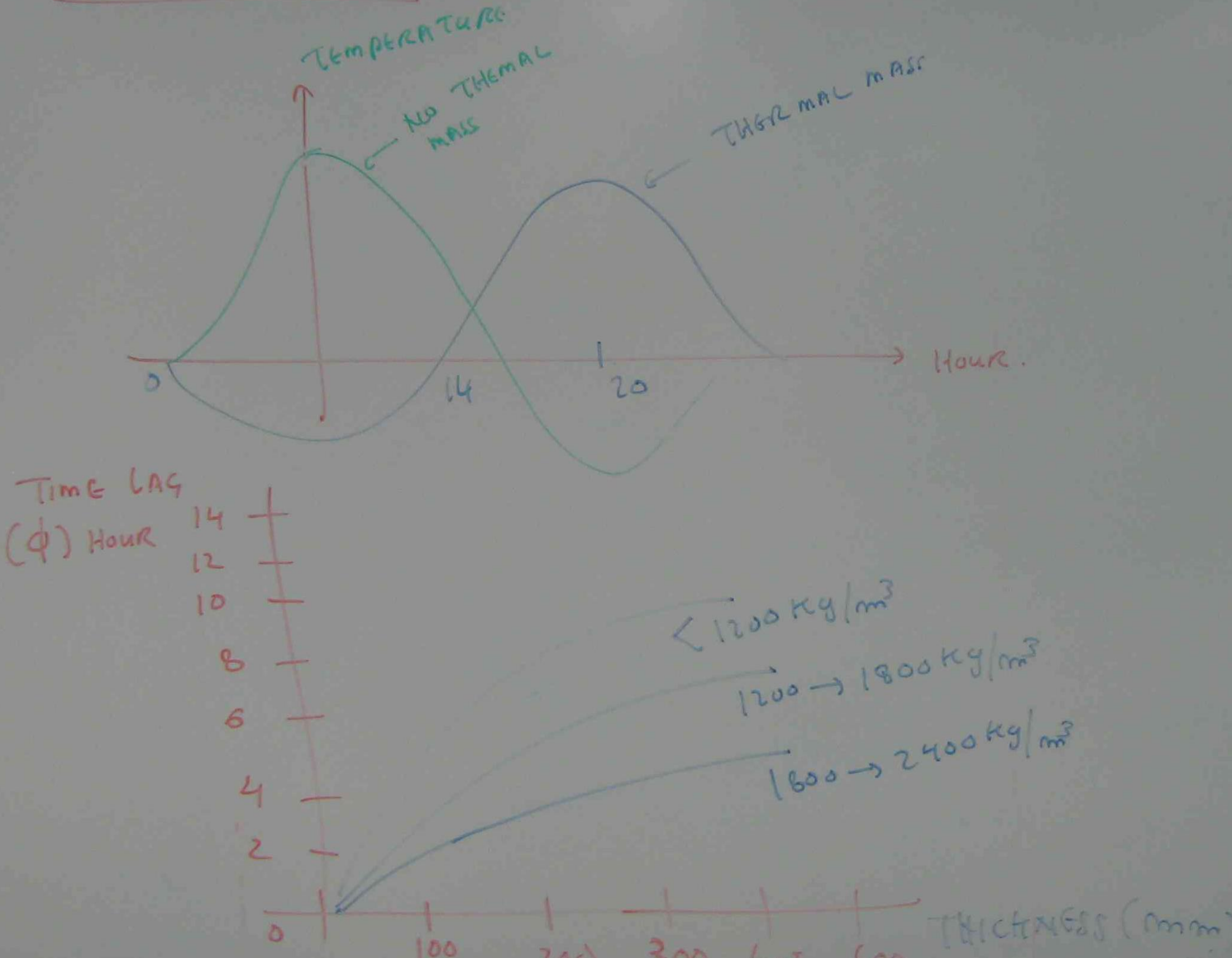
ENERGY TO BREAK DOWN SOLID TO LIQUID AND LIQUID TO GAS

MATERIALS USED FOR SENSIBLE HEAT STORAGE IN PASSIVE SOLAR SYSTEM

ROCK, BRICK, CONCRETE, WATER

STORAGE MEDIUM	DENSITY kg/m³	SPECIFIC HEAT CAPACITY J/kg K	THERMAL CONDUCTIVITY W/mK
CONCRETE	2240	1130	0.9 → 1.3
ROCK	2640	880	1.7 → 4.0
BRICK	3000	1130	5.07
WATER	960	4200	0.4 → 0.8

THERMAL PROPERTIES



THERMAL ADMITTANCE (Y)

THE RATE OF HEAT FLOW BETWEEN THE INTERNAL BUILDING SURFACE AND THE SPACE IT SURROUNDS WHEN TEMPERATURE DIFFERENCE EXISTS.

	U W/m²K	ADMITTANCE W/m²K	TIME LAG / HOUR	DECREMENT FACTOR
BRICK WALL 105mm	3.28	4.2	2.6	0.87
CAVITY BRICK WALL	1.47	4.4	7.7	0.44
CONCRETE SLAB ON GROUND	0.62	6.0	>24	0

$f_r = 2.5$ LIGHT WEIGHT

$f_r = 6$ HEAVY WEIGHT

RESPONSE FACTOR

THE RESPONSE FACTOR (F_r) IS A MEASURE OF THE ABILITY OF THE BUILDING TO CHANGE ITS INTERNAL TEMPERATURE IN RESPONSE TO CHANGE IN EXTERNAL TEMPERATURE.

THIS WILL DEPEND ON TOTAL HEAT TRANSMITTANCE OF THE BUILDING ENVELOPE, VENTILATION RATE AND THE ABILITY OF THE STRUCTURE TO

$$F_r = \frac{\sum (A \times Y) + 0.33\,NV}{\sum (A \times U) + 0.33\,NV}$$

A = AREA

Y = ADMITTANCE

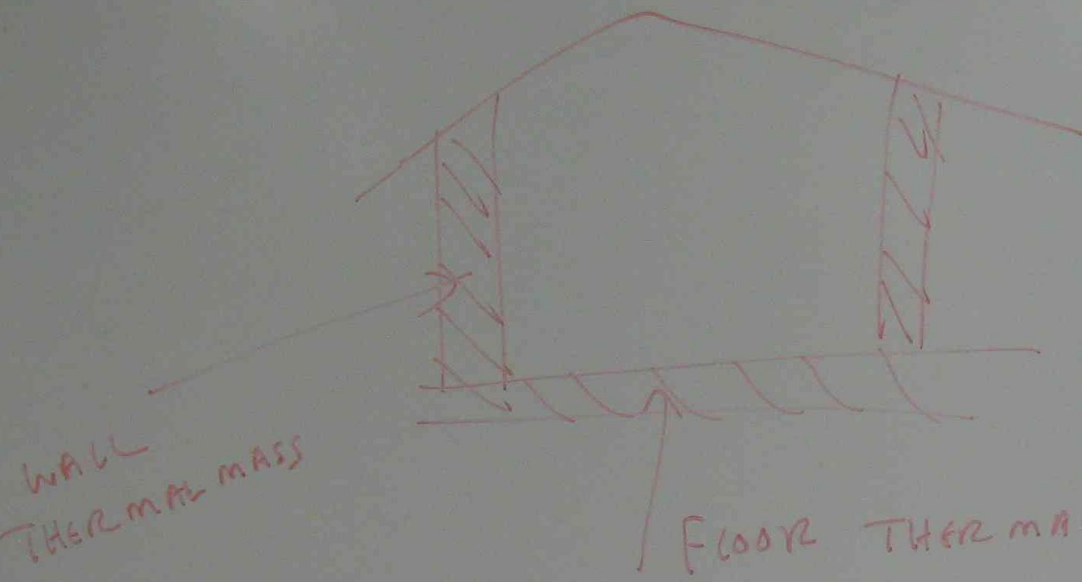
U = CONDUCTANCE

$\sum (A \times U)$ = TOTAL HEAT TRANSMITTANCE

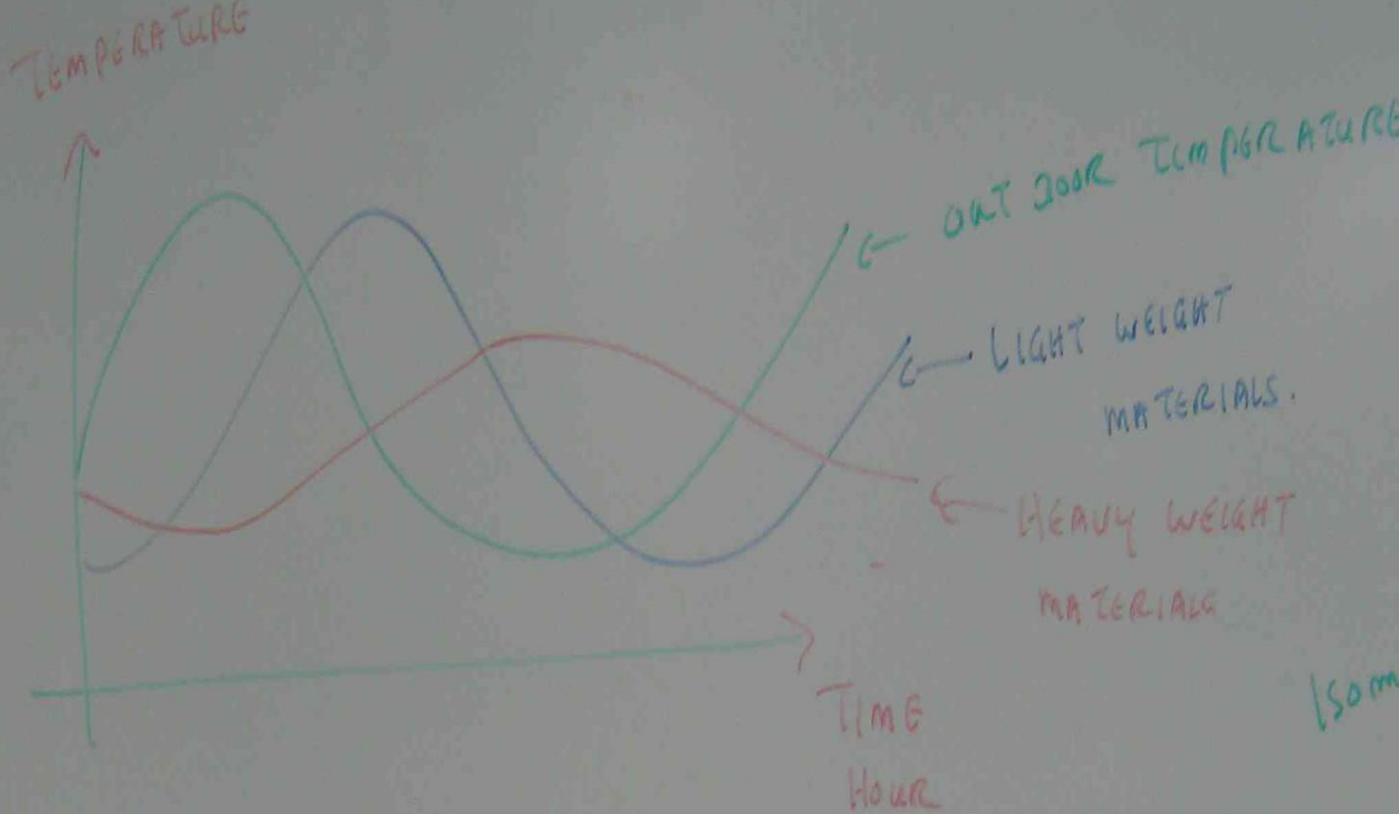
$\sum (A \times Y)$ = TOTAL HEAT ADMITTANCE

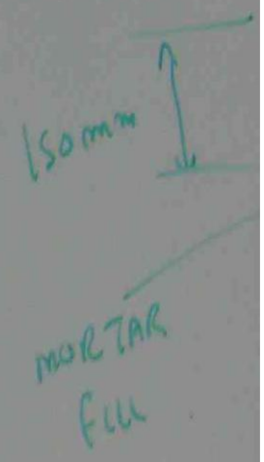
$0.33NV$ = VENTILATION HEAT FLOW RATE

HEAT STORAGE IN PRACTICE



THE EFFECT OF THERMAL MASS MAY NOT BE BENEFICIAL IF OUTDOOR TEMPERATURE IS WELL OUTSIDE THE COMFORT ZONE.


TEMPERATURE
OUT DOOR TEMPERATURE
LIGHT WEIGHT
MATERIALS.
HEAVY WEIGHT
MATERIALS
TIME
HOUR


150mm
MORTAR
FILL

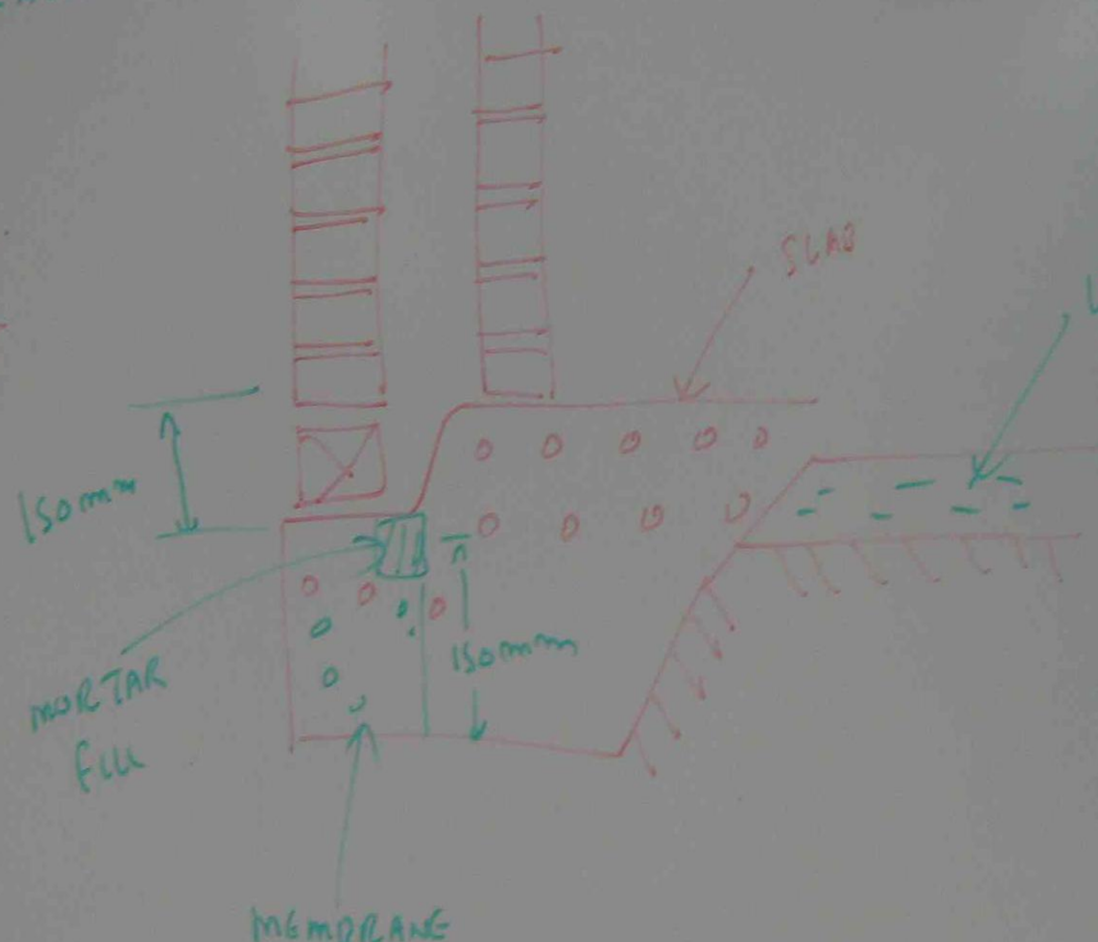
OUT DOOR TEMPERATURE

LIGHT WEIGHT MATERIALS.

HEAVY WEIGHT MATERIALS

ME

UR



Ph → CALCULATE THE HEATING REQUIRED FOR A YEAR (BASE TEMPERATURE 15°C)

FOR THE ONE STOREY HOUSE WITH THE FOLLOWING ROOFS AND WALLS IN WINTER.

ROOF

- NEW GALVANIZED IRON (METAL DECK)
- 10m × 9.4m × 22.5° SLOPE
- ALIGNED E — W
- WITH R 1.5 FOIL BACKED INSULATION
- PLASTERED BOARD ON CEILING JOISTS.

EAST WALL	NORTH SOUTH WALL	FLOOR
UN-GLAZED RED BRICK VENEER FOIL INSULATED 9.4×2.5 ONE WINDOW 1m×0.8m	UN GLAZED RED BRICK VENEER FOIL INSULATED 10×2.5 SOUT WALL 1 WINDOW 1m×0.7m NORTH WALL TWO WINDOW	CORK TILES ON CONCRETE SLAB ON THE GROUND 10m×9.4m

- ALL WINDOWS ARE SINGLE GLAZED
- ASSUME CEILING HEIGHT IS 2.5m

THE BUILDING HAS TIMBER WINDOWS, AVERAGE CEILING

- NO OPEN FIRE SPACES
- WEATHER STRIPPING AT THE BOTTOM OF EXTERNAL DOORS
- THE HOUSE IS LOCATED IN KALGOORLIE, WESTERN AUSTRALIA.

BRICK VENEER $U = 0.64$, $RFL = U = 0.64$

WINDOW SINGLE GLASS $U = 6.17$

KALGOORLIE BASE TEMPERATURE = 15°C

Floor U_i (WINTER) = 0.47 ✓ | dd = 451

U_i (Summer) = 0.49

Roof $U = 0.44$ ← INCLUDING INSULATION)

$$Q_{hs} = \left[\sum UA \times 0.0864 + Ac \times V \times 0.0286\right] dd$$

Ac = AIR CHANGE PER HOUR

V = volume

dd = DEGREE DAYS @ 15°C BASE TEMPERATURE

(i)

$\sum UA$ FOR WALLS

$\sum UA$ (WALL) = UA (EAST WALL) + UA (WEST WALL) + UA (SOUTH WALL) + UA (NORTH WALL)

EAST WALL $A = 9.4 \times 2.5 - 1 \times 0.8 = 22.7\ m^2$

WEST WALL $A = 9.4 \times 2.5 = 23.5\ m^2$

SOUTH WALL $A = 10 \times 2.5 - 1 \times 0.7 = 23.6\ m^2$

NORTH WALL $A = 10 \times 2.5 - 2 \times 1 \times 0.7 = 23.5\ m^2$

$$\sum UA \text{ (WALL)} = 0.64\left[22.7 + 23.5 + 23.6 + 23.5\right]$$

$$= 59.71$$

(ii)

$\sum UA$ (WINDOWS)

WINDOW AREAS

EAST + WEST + NORTH + SOUTH

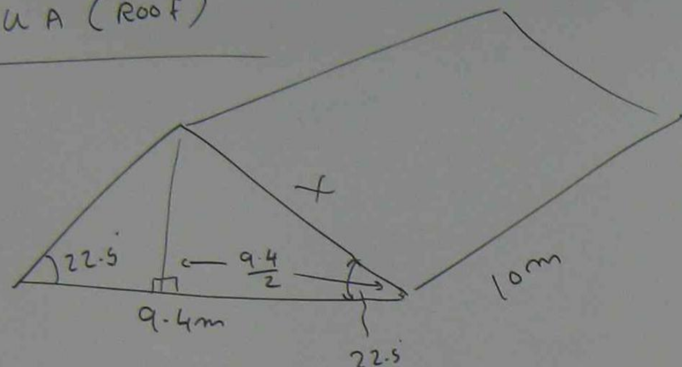
$$\sum UA \text{ (WINDOW)} = U\left[1 \times 0.8 + 0 + 2 \times 1 \times 0.7 + 1 \times 0.7\right]$$

$$= 6.17\left[0.8 + 2 \times 0.7 + 0.7\right]$$

$$= 22.82$$

(iii)

$\sum UA$ (ROOF)



$$X = \frac{\frac{9.4}{2}}{\cos 22.5}$$

$$A = 2 \times \frac{\frac{9.4}{2}}{\cos 22.5} \times 10$$

$$\sum UA_{(ROOF)} = 0.44 \times 2 \times \frac{\frac{9.4}{2}}{\cos 22.5} \times 10$$

$$= 44.7$$

(iv)

$\sum UA$ (FLOOR)

$$\sum UA(\text{FLOOR}) = 0.47 \times 9.4 \times 10$$

$$= 44.18$$

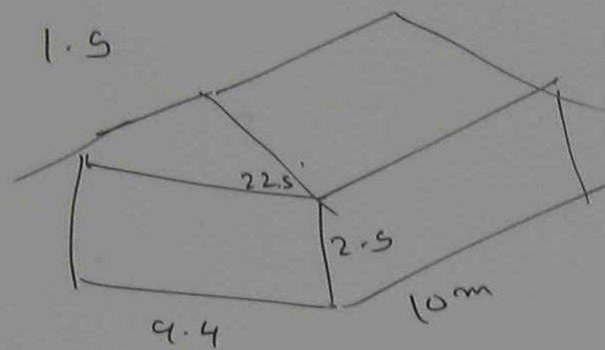
$$\sum UA = \sum UA_{(WALL)} + \sum UA_{(WINDOW)} + \sum UA_{(ROOF)} + \sum UA_{(FLOOR)}$$

$$= 59.71 + 22.82 + 44.7 + 44.18 = 171.41$$

$$Q_{hs} = \left(\sum UA_{TOTAL} \times 0.0864 + AC \times V \times 0.0286 \right) dd$$

$AC = 1.5$

$V =$



$V = 9.4 \times 10 \times 2.5 =$

$$Q_{hs} = \left(171.41 \times 0.0864 + 1.5 \times (9.4 \times 10 \times 2.5) \times 0.0286 \right) \times \underline{\underline{451}}$$

$$= 11229.1 \text{ MJ} / \text{yr}$$

$$= \frac{11229.1 \times 10^6}{365 \times 24 \times 3600} \text{ J/s} = 356 \text{ WATT}$$

HEATER

ph

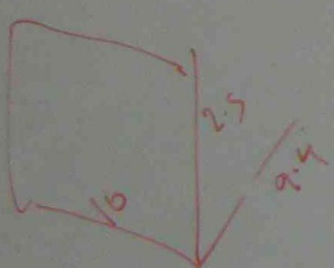
CALCULATE THE SOLAR HEAT GAIN ON

(a) A NORTH FACING BRICK VENEER, UN INSULATED WALL IN JULY AND JANUARY IN MELBOURNE

(b) A NORTH FACING BRICK VENEER REFLECTIVE FOIL INSULATED WALL IN JULY AND JANUARY IN MELBOURNE

(c) A WEST FACING WALL IN JULY AND JANUARY IN MELBOURNE

(d) A 22.5° PITCH ROOF IN JULY AND JANUARY IN MELBOURNE.



THE FOLLOWINGS ARE SPECIFICATIONS FOR THE BUILDING ELEMENTS ABOVE

NORTH WALL	WEST WALL	ROOF
10m x 2.5m WALL	9.4m x 2.5m	NEW GALVANIZED IRON METAL DECK
1 x 1.5m WINDOW	NO WINDOW	10m x 9.4m (22.5° SLOPE)
EAVES WITH WIDTH 0.6m	EAVES 0.6m	ALIGNED E—W
RED UNGLAZED BRICK	WHITE PAINTED BRICK	R1.5 FOIL BACKED INSULATION
BRICK VENEER	BRICK VENEER REFLECTIVE FOIL	PLASTERED BOARD ON CEILING JOISTS

(a

U BRIC

R_o = AIR FILM RESISTANCE

$0.04\ m^2K/W$

WIND SPEED 3.5 m/s

IN

(a) $Q_s = U \times A \times T_{sx}$

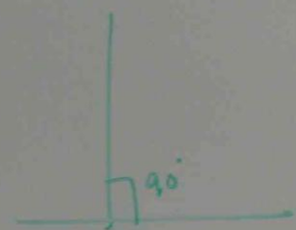
T_{sx} — SOLAR EXCESS TEMPERATURE

$$T_{sx} = 11.57 \times \alpha \times H \ R_o - T_{sky}$$

R_o = 0.04

$\alpha = 0.68$ (BRICK/RED UNGLAZED)

$U_{\text{BRICK VENEER}} = 2.11$



H_{JAN} = 90° TILT PLANE = $10.32\ MJ/d\text{-}m^2$

WALL

$H_{July} = 11.11$

E

$$T_{sx(JAN)} = 11.57 \times \alpha \times H \ R_o - T_{sky} = 11.57 \times 0.68 \times 10.32 \times 0.04 - 0 = 3.2\,K$$

$$T_{sx(July)} = 11.57 \times 0.68 \times 11.11 \times 0.04 = 3.5\,K$$

$$A = (\text{NORTH}) = 10 \times 2.5 - 1 \times 1.5 = 23.5\,m^2$$

OPE)

$$Q_{s\,(JAN)} = U \times A \times T_{sx(JAN)} = 2.11 \times 23.5 \times 3.2 = 161.04\,W$$

ICATION

$$Q_{s\,(July)} = U \times A \times T_{sx(July)} = 2.11 \times 23.5 \times 3.5 = 52.64\,W$$

$Q_S = U \times A \times T_{SX}$

↑ SOLAR EXCESS TEMPERATURE

R_o = AIR FILM RESISTANCE

$0.04\ m^2K/W$

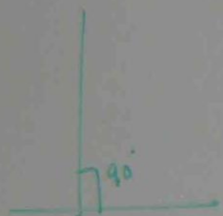
WIND SPEED 3.5 m/s

$T_{SX} = 11.57 \times \alpha \times H\ \underbrace{R_o}_{0.04} - T_{SKY}$

$\alpha = 0.68$ (BRICK/RED UNGLAZED)

H_{JAN} = 90° TILT PLANE = $10.32\ MJ/d\text{-}m^2$

$H_{July} = 11.11$ ↑ WALL



=2.11

$T_{SX(JAN)} = 11.57 \times \alpha \times H\ R_o - T_{SKY} = 11.57 \times 0.68 \times 10.32 \times 0.04 - 0 = 3.2\ K$

$T_{SX(July)} = 11.57 \times 0.68 \times 11.11 \times 0.04 = 3.5\ K$

(NORTH) = $10 \times 2.5 - 1 \times 1.5 = 23.5\ m^2$

S (JAN) = $U \times A \times T_{SX(JAN)} = 2.11 \times 23.5 \times 3.2 = 161.04\ W$

S(July) = $U \times A \times T_{SX(July)} = 2.11 \times 23.5 \times 3.5 = 52.64\ W$

(b) NORTH FACING BRICK VENEER WALL WITH REFLECTIVE FOIL INSULATION $U = 0.64$

$Q_{S(JAN)} = U\ A\ T_{SX(JAN)} = 0.64 \times 23.5 \times 3.2$

$= 48.13\ W$

$Q_{S(July)} = U\ A\ T_{SX(July)} = 0.64 \times 23.5 \times 3.5$

$= 52.64\ W$

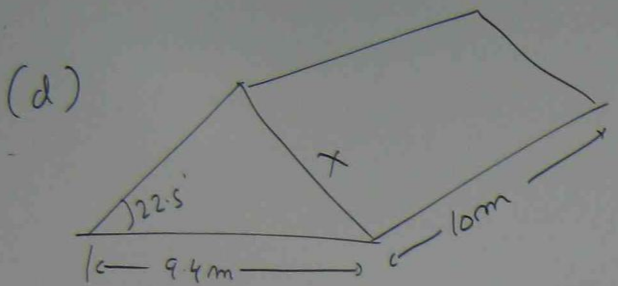
(c) $Q_{S(JAN)} = U\ A\ T_{SX(JAN)} = 0.64 \times (9.4 \times 2.5) \times 3.2$

$= 32.44$

$Q_{S(July)} = U\ A\ T_{SX(July)} = 0.64(4.4 \times 2.5) \times 3.5$

$= 11.13$

(d)



$$T_{sx} = 11.57\, \alpha\, H\, R_o - T_{sky}$$

$$Q_s = u \times A \times T_{sx}$$

$T_{sky} = 0$ FOR WALL,

ROOF

BUILDING ELEMENT	T_{sky} (°C)
FLAT ROOF	3
22.5° ROOF	2
45° ROOF	1
WALL	0

$u = 0.35$

$$H_{(22.5^\circ \text{ TILT})(\text{JAN})} = 23.47 \text{ mJ/d-m}^2$$

$$H_{(22.5^\circ \text{ TILT})(\text{JULY})} = 9.47 \text{ mJ/d-m}^2$$

$R_o = 0.04$

GALVANIZED IRON = 0.3

$$T_{sx\,(\text{JAN})} = 11.57\, \alpha\, H\, R_o - T_{sky}$$

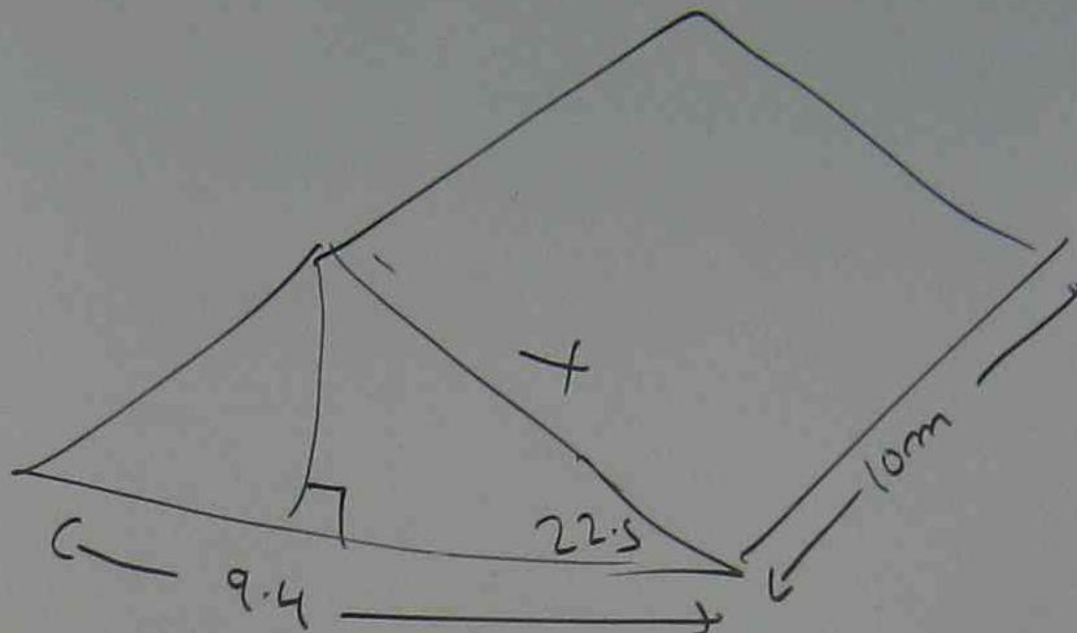
$$= 11.57 \times 0.3 \times 23.47 \times 0.04 - 2 = 1.33\text{ K}$$

$$T_{sx\,(\text{JUL})} = 11.57 \times \alpha\, H\, R_o - T_{sky}$$

$$= 11.57 \times 0.3 \times 9.47 \times 0.04 - 2 = -1.51\text{ K}$$

$$Q_{s\,(\text{JAN})} = 0.35 \times 50.87 \times 1.33 = 45.76\text{ W}$$

$$Q_{s\,(\text{JUL})} = 0.35 \times 50.87 \times (-1.51) = -47.68\text{ W}$$



$$x = \frac{9.4/2}{\cos 22.5}$$

$$A = \frac{9.4/2}{\cos 22.5} \times 10 = 50.87\ m^2$$