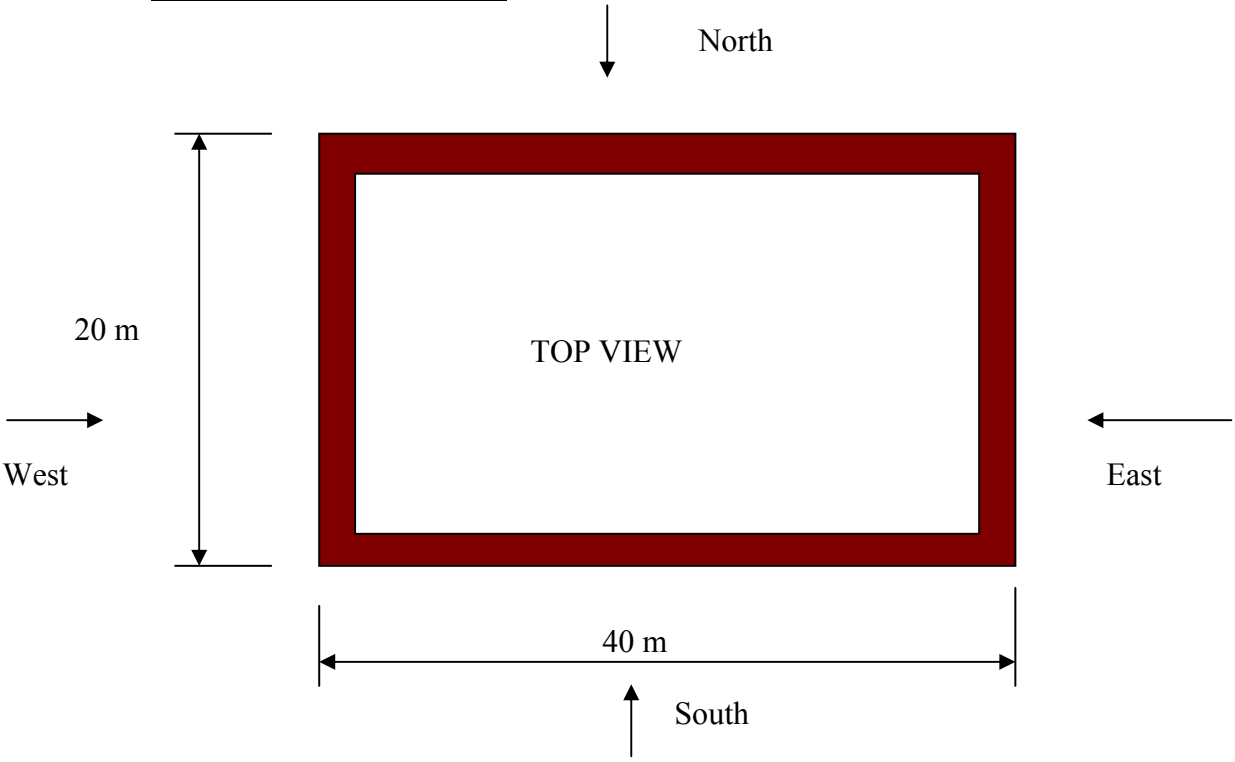
NISHAL MANILALL

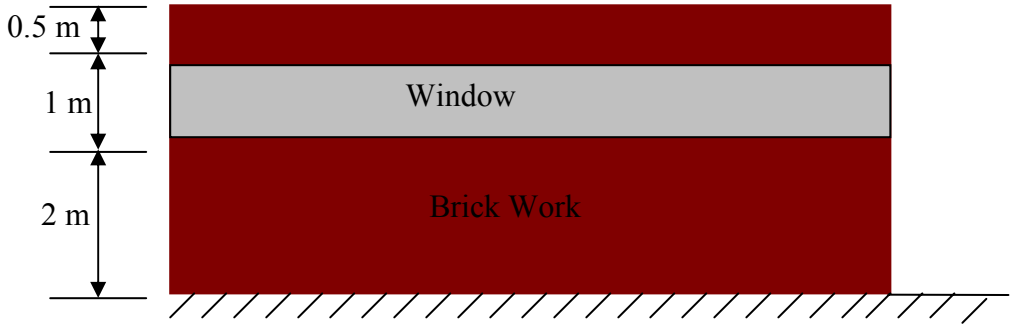
STUDENT NO : 14427052

AIR CONDITIONING AND REFRIGERATION

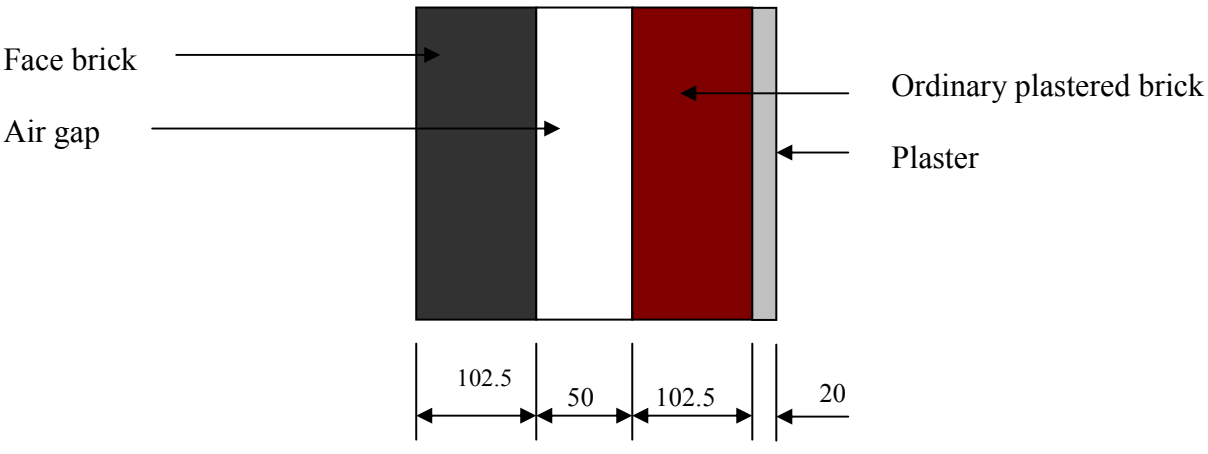
ASSIGNMENT 6 : HEAT LOAD CALCULATIONS II

1. SKETCH OF BUILDING





FRONT VIEW



SECTION THROUGH WALL

JANUARY DESIGN CONDITIONS

1. Design room temperature = 24 deg. C
2. Mass of brickwork = density x thickness
   = 1830 x 0.205 ….0.205 m is two course brick.
   = 375.15 kg/m^2

3. Mass of plaster = density x thickness
   = 1100 x 0.02
   = 22 kg/m^2

4. Total mass per unit area for the walls :
   = 397.15 kg/m^2 ~ 400 kg/m^2

Heat gain through Walls

By interpolating from table 21, the following result was achieved for the equivqlent temperature difference

EQUIVALENT TEMPERATURE DIFFERENCE - for 400 kg/m^2											
Sun Time	8	9	10	11	12	1	2	3	4	5	6
Exposure											
North	1.65	1.95	2.2	5	6.65	10	12.25	13.35	13.9	13.6	12.75
East	3.9	10.3	14.45	16.35	17.5	14.45	12.8	11.35	10.55	10.25	10
West	3.9	3.9	3.9	4.45	5	6.1	7.25	10.3	12.8	16.4	18.85
South(shade)	1.1	1.4	1.65	1.95	2.2	3.35	4.45	5.3	6.1	6.65	6.95

Correction for indoor/outdoor temp. difference and the daily range

Outdoor temperature (Cape town at 3pm) - Room design temperature = 32.2 – 24 = **8.2 °C.**
January daily range = 32.2 – 22.2 =10 °C, the correction factor as **– 1.8 °C.**

X

CORRECTION FOR INDOOR/OUTDOOR TEMPERATURE DIFFERENCE AND DAILY RANGE												
Cape town outdoor temp (3pm)					32.2		deg.C					Page 31/32
Indoor temp					24		deg.C					given
temp difference					8.2		deg.C					
Jan max. temp					32.2		deg.C					table 23
Jan min. temp					22.2		deg.C					table 23
Jan. daily range					10		deg.C					
Correction factor					-1.8			interpolated				table 23

The corrected table is :

EQUIVALENT TEMPERATURE DIFFERENCE											
Sun Time	8	9	10	11	12	1	2	3	4	5	6
Exposure											
North	-0.15	0.15	0.4	3.2	4.85	8.2	10.45	11.55	12.1	11.8	10.95
East	2.1	8.5	12.65	14.55	15.7	12.65	11	9.55	8.75	8.45	8.2
West	2.1	2.1	2.1	2.65	3.2	4.3	5.45	8.5	11	14.6	17.05
South(shade)	-0.7	-0.4	-0.15	0.15	0.4	1.55	2.65	3.5	4.3	4.85	5.15

Correction for Lattitude and Wall colour

From Table 5 - Peak Solar Heat Gains:
Cape Town – Lattitude – 33°55'; Longitude – 18°27' - Reference attached

Solar Peak Gains through reference glass - JANUARY			
	sigma_M	sigma_S	
North	230	152	
East	550	550	
West	550	550	

Using the equation below :

$$\Delta t_e = 0.55\ [\sigma_s/\sigma_m].\ \Delta t_{em} + [\ 1\text{-}0.55([\sigma_s/\sigma_m)].\ \Delta t_{es}$$

The table is updated to :

EQUIVALENT TEMPERATURE DIFFERENCE - CORRECT FOR LATT. & WALL COLOR											
Sun Time	8	9	10	11	12	1	2	3	4	5	6
Exposure											
North	-0.50	-0.20	0.05	1.26	2.02	3.97	5.49	6.43	7.14	7.38	7.26
East	0.84	4.50	6.89	8.07	8.82	7.66	7.24	6.83	6.75	6.83	6.83
West	0.84	0.98	1.09	1.53	1.94	3.06	4.19	6.25	7.99	10.21	11.70

Thermal Resistances of the walls

Conduction thru the North Wall							
Material				t	A	k or C	R
Face Brick				0.1025	100	0.82	0.00125
Plastered Brick				0.1025	100	0.82	0.00125
Air gap				0.05	100	6.2	0.00161
Plastered Brick				0.02	100	0.38	0.00053
UA							215.554

Conduction thru the East and West Wall							
Material				t	A	k or C	R
Face Brick				0.1025	50	0.82	0.0025
Plastered Brick				0.1025	50	0.82	0.0025
Air gap				0.05	50	6.2	0.0032258
Plastered Brick				0.02	50	0.38	0.00105
UA							107.67676

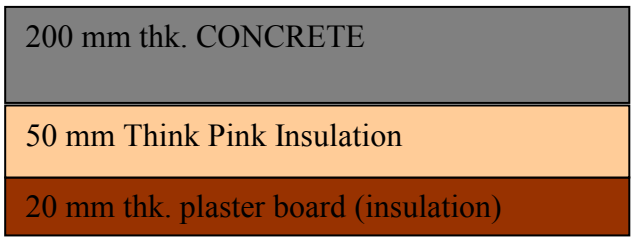
Final Heat Heat Gain through the walls

Now using Q = U.A. Δt_e , the final heat load results in :

HEAT GAIN (Watts) Q = UA.delta_te											
Sun Time	8	9	10	11	12	13	14	15	16	17	18
Exposure											
North	-107.8	-43.1	10.8	271.3	434.9	855.1	1182.3	1385.1	1538.0	1590.0	1564.5
East	90.5	484.5	742.6	869.8	950.1	825.0	780.6	735.8	727.2	736.1	735.8
West	90.5	105.1	117.2	164.4	209.1	330.1	451.6	673.6	860.6	1100.7	1260.4

Heat Gain through the roof

Roof Construction



Mass/area of the roof

Mass/area (concrete) = density(dense concrete) x thickness
= 2320 x 0.2 = 464 kg/m^2
Mass/area (plasterboard) = density x thickness
= 950 x 0.02 = 19 kg/m^2
Mass/area(insulation) = density x thickness
= 500 x 0.05 = 25 kg/m^2

Total mass/area of the roof = 508 kg/m^2

EQUIVALENT TEMPERATURE DIFFERENCE												Mass/area
	AM					PM						
Sun Time	8	9	10	11	12	1	2	3	4	5	6	
delta_t_em	8.3	8.3	8.9	9.4	11.1	14.4	16.7	17.8	20	21.7	22.8	400kg/m^2
delta_t_es	1.1	1.1	1.1	1.7	2.2	3.3	4.4	5.6	6.7	7.2	7.8	300kg/m^2
The tables provided dosent mass/area for 508 kg/m^2, so the cloasest values were used…												

Correction for indoor/outdoor temp. difference and the daily range

Outdoor temperature (Cape town at 3pm) - Room design temperature = 32.2 – 24 = **8.2 °C.**
January daily range = 32.2 – 22.2 =10 °C, the correction factor as **– 1.8 °C.**

The corrected table is below :

	AM					PM					
Sun Time	8	9	10	11	12	1	2	3	4	5	6
delta_t_em	6.5	6.5	7.1	7.6	9.3	12.6	14.9	16	18.2	19.9	21
delta_t_es	-0.7	-0.7	-0.7	-0.1	0.4	1.5	2.6	3.8	4.9	5.4	6

Correction for Month and Lattitude

EQUIVALENT TEMPERATURE DIFFERENCE											
	AM					PM					
Sun Time	8	9	10	11	12	1	2	3	4	5	6
delta_t_e	6.7	6.7	7.3	7.8	9.6	12.9	15.3	16.4	18.6	20.3	21.5

Cape Town – Lattitude – 33°55'; Longitude – 18°27' - Reference attached

EQUIVALENT TEMPERATURE DIFFERENCE											
	AM					PM					
Sun Time	8	9	10	11	12	1	2	3	4	5	6
delta_t_em	6.5	6.5	7.1	7.6	9.3	12.6	14.9	16	18.2	19.9	21
delta_t_es	-0.7	-0.7	-0.7	-0.1	0.4	1.5	2.6	3.8	4.9	5.4	6

From Table 5 - Peak Solar Heat Gains:

σ_m = 790 W/m^2 (40° South latitude).

σ_s = 814 W/m^2 by interpolation(33,9166° ~ 34°).

Using the equation below :

$$\Delta t_e = [\sigma_s/\sigma_m].[\Delta t_{em} - \Delta t_{em}]$$

The corrected values are below

EQUIVALENT TEMPERATURE DIFFERENCE											
	AM					PM					
Sun Time	8	9	10	11	12	1	2	3	4	5	6
delta_t_e	6.7	6.7	7.3	7.8	9.6	12.9	15.3	16.4	18.6	20.3	21.5

Conduction through the roof

$$Q = U \times A \times \Delta t_e$$

Conduction through the roof							
Material				t	A	k	R
Concerete				0.2	800	1.5	0.00017
Plasterboard				0.02	800	0.16	0.00016
Insulation(think pink)				0.05	800	0.045	0.00139
UA							584

Below is the heat gain through the roof

THROUGH THE ROOF (Watts)											
	AM					PM					
Sun Time	8	9	10	11	12	13	14	15	16	17	18
Heat gain	3924.9	3924.9	4286.1	4576.4	5590.8	7557.6	8922.6	9563.4	10868.1	11882.5	12534.0

Heat gain through the windows via conduction/convection

$U = [1/\alpha_{outside} + t_{glass}/k + 1/\alpha_{inside}]$

For January, the heat transfer coefficient, $\alpha_{outside}$ = 30 $W/m^2.K$ (ASSUMED)
For June, the heat transfer coefficient, $\alpha_{outside}$ = 29 $W/m^2.K$ (ASHRAE :30.5)
Heat transfer coefficient inside (all year) = 8.3 $W/m^2.K$ (ASHRAE :30.6)

Heat Transfer through glass								
			JAN				JUN	
ho			30				29	
hi			8.3				8.3	
glass			1.05				1.05	
U			6.382745				6.3362591	

Inside and outside temperature difference

Outside temp.(table-pg 31) - indoor temp(24 deg. C).											
Sun Time	8	9	10	11	12	13	14	15	16	17	18
Δt_e	1.6	2.7	3.2	4.3	5.4	6.6	7.7	8.2	7.7	7.1	7.2

Heat Load, $Q = U.A.\ \Delta t_e$

HEAT GAIN (Watts) Q = UA.delta_te (conduction/convection)											
Sun Time	8	9	10	11	12	13	14	15	16	17	18
Exposure											
North	408.5	689.3	817.0	1097.8	1378.7	1685.0	1965.9	2093.5	1965.9	1812.7	1838.2
East	204.2	344.7	408.5	548.9	689.3	842.5	982.9	1046.8	982.9	906.3	919.1
West	204.2	344.7	408.5	548.9	689.3	842.5	982.9	1046.8	982.9	906.3	919.1

Solar Heat gain through windows

Mass per unit area of buildings

Mass/area of the building							
		No.	kg/m^2	m^2		mass	
North/South Walls		2	400	100		80000	
East/West		2	400	50		40000	
Roof			508	800		406400	
Total mass						526400	
Mass/area						658	kg/m^2

Use 700 kg/m^2 from table 7. The difference in using 658 or 700 is not significant.

Month	**January**						
North Exposure							
24 hr operation of airconditioner							
							Q_actual
Time	Area		SHGF max	SF	SASH	CLF	
8	40		152	0.15	1.1765	0.13	139.48
9	40		152	0.15	1.1765	0.2	214.59
10	40		152	0.15	1.1765	0.28	300.42
11	40		152	0.15	1.1765	0.35	375.53
12	40		152	0.15	1.1765	0.43	461.36
13	40		152	0.15	1.1765	0.49	525.74
14	40		152	0.15	1.1765	0.52	557.93
15	40		152	0.15	1.1765	0.52	557.93
16	40		152	0.15	1.1765	0.49	525.74
17	40		152	0.15	1.1765	0.42	450.64
18	40		152	0.15	1.1765	0.37	396.99

Month	**January**						
East Exposure							
24 hr operation of airconditioner							
							Q_actual
Time	Area		SHGF max	SF	SASH	CLF	
8	20		550	0.15	1.1765	0.34	660.00
9	20		550	0.15	1.1765	0.4	776.47
10	20		550	0.15	1.1765	0.41	795.88
11	20		550	0.15	1.1765	0.39	757.06
12	20		550	0.15	1.1765	0.34	660.00
13	20		550	0.15	1.1765	0.3	582.35
14	20		550	0.15	1.1765	0.28	543.53
15	20		550	0.15	1.1765	0.26	504.71
16	20		550	0.15	1.1765	0.23	446.47
17	20		550	0.15	1.1765	0.22	427.06
18	20		550	0.15	1.1765	0.2	388.24

Month	January						
West Exposure							
24 hr operation of airconditioner							
							Q_actual
Time	Area		SHGF max	SF	SASH	CLF	
8	20		550	0.15	1.1765	0.11	213.53
9	20		550	0.15	1.1765	0.1	194.12
10	20		550	0.15	1.1765	0.1	194.12
11	20		550	0.15	1.1765	0.1	194.12
12	20		550	0.15	1.1765	0.1	194.12
13	20		550	0.15	1.1765	0.13	252.35
14	20		550	0.15	1.1765	0.19	368.82
15	20		550	0.15	1.1765	0.27	524.12
16	20		550	0.15	1.1765	0.36	698.82
17	20		550	0.15	1.1765	0.43	834.71
18	20		550	0.15	1.1765	0.45	873.53

Total solar heat gain through windows

SOLAR HEAT TOTALS											
Sun Time	8	9	10	11	12	13	14	15	16	17	18
HEAT	1013.0	1185.2	1290.4	1326.7	1315.5	1360.4	1470.3	1586.8	1671.0	1712.4	1658.8

Heat Gain – Individual Walls - Total
(Walls +Window(Solar Heat Gain)+Window(convection/conduction)

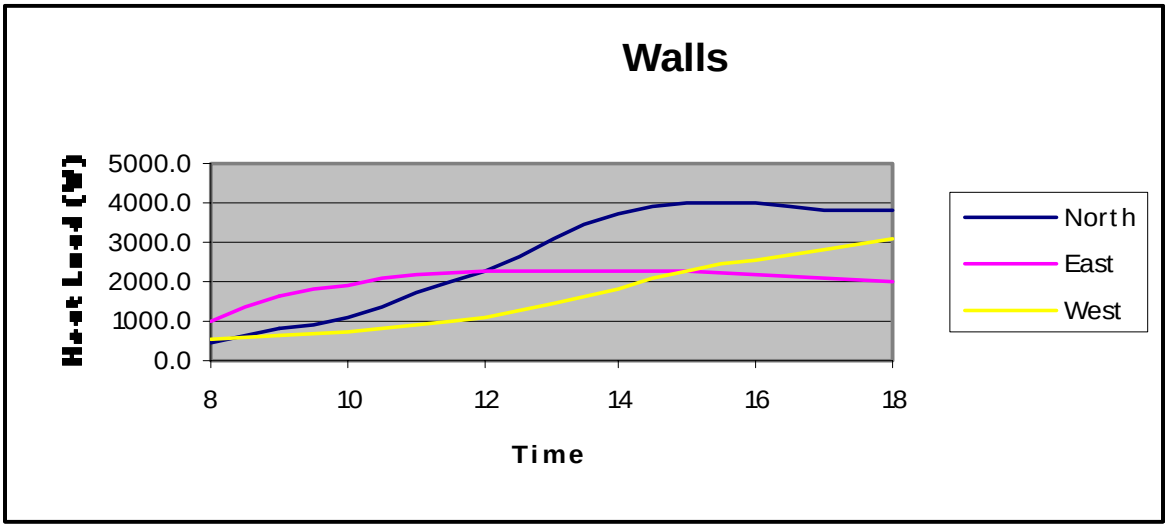
HEAT GAIN TOTALS (Watts) - INDIVIDUAL WALLS											
Sun Time	8	9	10	11	12	13	14	15	16	17	18
Exposure											
North	440.2	860.8	1128.2	1744.7	2274.9	3065.9	3706.2	4036.6	4029.6	3853.3	3799.7
East	954.8	1605.6	1947.0	2175.7	2299.4	2249.9	2307.0	2287.3	2156.6	2069.5	2043.2
West	508.3	643.9	719.8	907.4	1092.5	1424.9	1803.4	2244.5	2542.4	2841.7	3053.1

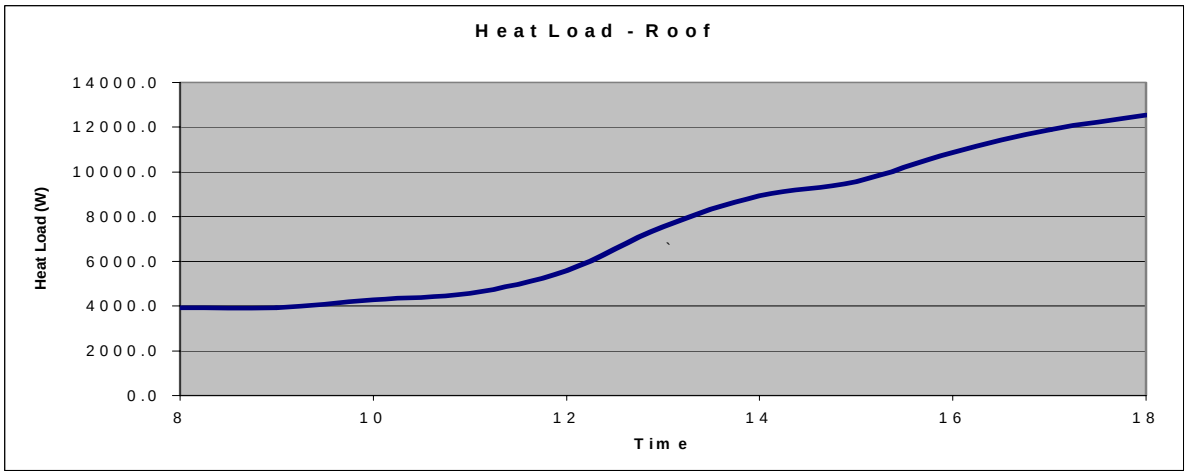
Block Load

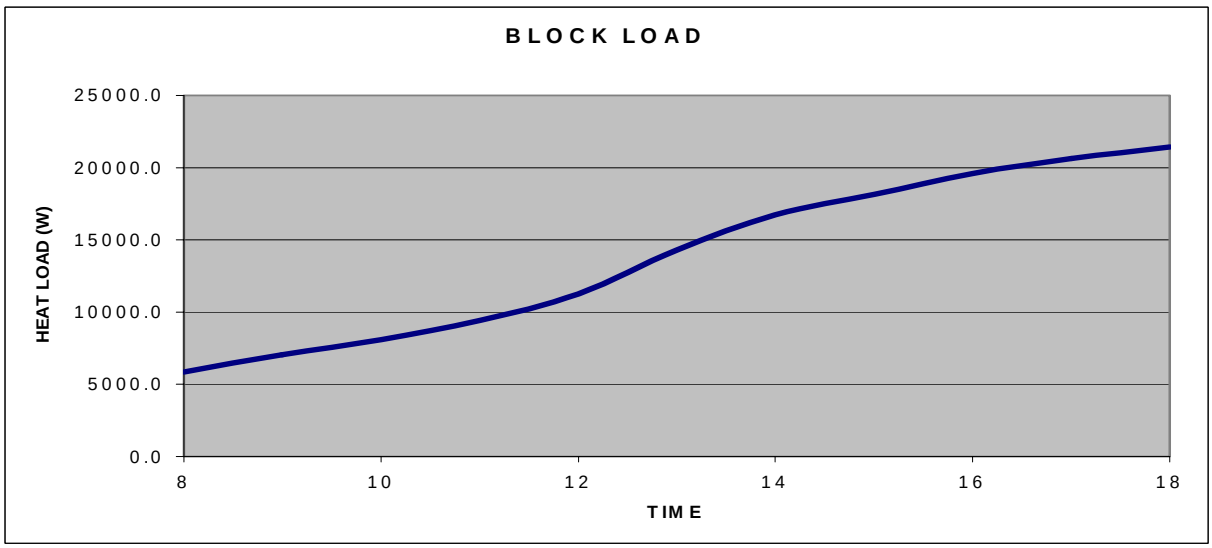
Below is the block load,
Heat gain through walls + Heat gain Through Windows + Heat gain through Roof

BLOCK LOAD - WALLS + WINDOWS + ROOF											
Sun Time	8	9	10	11	12	13	14	15	16	17	18
BLOCK LOAD	5828.2	7035.2	8081.0	9404.2	11257.7	14298.4	16739.1	18131.8	19596.7	20647.0	21430.0

PLOTS FOR JANUARY







PLOTS FOR JUNE (same procedure was followed as for January)