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MECH 6181

Cooling load calculation for one room

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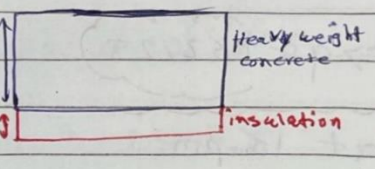
Location: Montreal Design temperature: 21°C design humidity ratio: 0.0085

Latitude = 45,5° T_{db} = 29,4°C humidity ratio = 0,138

Longitude = 73,8° T_{wb} = 21,7°C Month: July

Roof (Heavy weight concrete 152,4mm with 25,4mm insulation)



$q = U \times A \times CLTD$

$CLTD_{corr} = \left[(CLTD + LM) \times K_1 + (25,5 - T_R) + (T_o - 29,4)\right] \times f$

$U = 0,710$ Table 3-12 $\Rightarrow LM = 0$ (Horizental)

Table 5 $\Rightarrow$ for 12 pm: CLTD = 13

for 14pm: CLTD = 15

for 16pm: CLTD = 17

dark colors $\Rightarrow K = 1$ $f = 1$ (no attic) $T_R = 21°C$ $A_{roof} = 5,3 \times 6,3 = 33,39$

at 12pm:

$CLTD_{corr} = \left[(13 + 0) \times 1 + (25,5 - 21) + (29,4 - 29,4)\right] \times 1$

$\Rightarrow CLTD_{corr} = 17,5 \Rightarrow q = 0,710 \times 33,39 \times 17,5 = 414,87$

$\Rightarrow$ at 12pm: $q = 414,87$

at 14:00 pm:

$CLTD_{Corr} = [(15+0)\times 1 + (25{,}5-21) + (29{,}4-29{,}4)]\times 1$

$CLTD_{Corr} = 19{,}5 \qquad q = U\times A\times CLTD_{corr} \Rightarrow q = 0{,}71\times 33{,}39\times 19{,}5$

$\Rightarrow q = 462{,}28$

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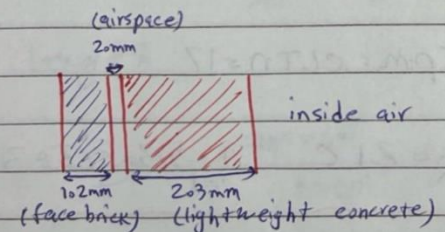
at 15:00 pm:

$CLTD_{Corr} = [(17+0)\times 1 + (25{,}5-21) + (29{,}4-29{,}4)]\times 1$

$\Rightarrow CLTD_{Corr} = 21{,}5 \qquad q = U\times A\times CLTD_{corr} = 0{,}71\times 33{,}39\times 21{,}5$

$\Rightarrow q = 509{,}7$

External wall



$R_{face\ brick} = 0{,}077 \qquad R_{outside\ air} = 0{,}044 \qquad R_{airspace} = 0{,}16$

$R_{lightweight\ concrete} = 1{,}174 \qquad R_{inside\ air} = 0{,}12$

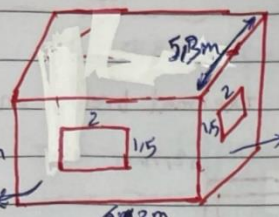
$R_{total} = 0{,}044 + 0{,}077 + 0{,}16 + 1{,}174 + 0{,}12 = 1{,}575$

$U = \frac{1}{R_{total}} = \frac{1}{1{,}575} = 0{,}6349$

(a) For North wall:

LM = 0 K = 1

CLTD { at 12pm: CLTD = 10/1/8 = 5,55
at 14pm: CLTD = 5,55
at 16pm: CLTD = 5,55



$A_{window} = 2 \times 1,5 = 3$ $A_{wall} = 6,13 \times 4,15 - 3 = 25,35$

$CLTD_{corr} = \{(CLTD + LM) \times K + (25,5 - T_R) + (T_o - 29,4)\}$

$CLTD_{corr} = (5,55 + 0) \times 1 + (25,5 - 21) + (29,4 - 29,4)$

$CLTD_{corr} = 10,05$ $q = U \times A \times CLTD_{corr} = 0,6349 \times 25,35 \times 10,05$

at 12pm ⇒ q = 161,75w at 14pm: q = 161,75w at 16pm: q = 161,75w

(b) For west wall:

LM = 1 K = 1

CLTD { at 12pm: CLTD = 19/1/8 = 10,55
at 14pm: CLTD = 18/1/8 = 10
at 16pm: CLTD = 18/1/8 = 10

$A_{window} = 2 \times 1,5 = 3$

$A_{wall} = 5,13 \times 4,15 - 3 = 20,185$

at 12pm $q = U \times A \times CLTD = 0,6349 \times 20,185 \times 10,55 = 139,65w$

at 14 pm: $q = U \times A \times CLTD_{corr} = 0.6349 \times 20.85 \times 10 = 132.37\ W$

at 16 pm: $q = U \times A \times CLTD_{corr} = 0.6349 \times 20.85 \times 10 = 132.37\ W$

window: (double glazing Aluminum without thermal break and 12.7mm airspace):

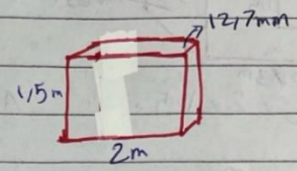


Table 5.5b

$U = 4.162\ W/m^2 \cdot C$ $A = 2 \times 1.5 = 3$

For conduction: $q = U \times A \times TD = 4.162 \times 3 \times (29.4 - 21)$

$\Rightarrow q = 116.42\ W$

For north and west windows, the heat transfer is the same.

For radiation in north wall:

open weave, Light colour $\xrightarrow{\text{Table 22}}$ S.C = 0.67 (for insulating glass 13mm airspace)

Table 3.25 → latitude: 44 Deg, July ⇒ SHGF = 37 × 3.147

⇒ SHGF = 116.439

Table 14: CLF { at 12pm: CLF = 0.89
at 14pm: CLF = 0.86
at 16 pm: CLF = 0.75

at 12pm $q = A \times SC \times SHGF \times CLF = 3 \times 0.167 \times 116.439 \times 0.189 =$

$\Rightarrow$ at 12pm: $q = 2081.3\ w$

at 14pm: $q = A \times SC \times SHGF \times CLF = 3 \times 0.167 \times 116.439 \times 0.188$

$\Rightarrow$ at 14pm: $q = 201.276\ w$

at 16pm: $q = 3 \times 0.167 \times 116.439 \times 0.175 = 175.53\ w$

For radiation in west wall:

S.C = 0.167 SHGF = 3,147 (latitude: 48°, july, E/w)

$\Rightarrow$ SHGF = 673.45 CLF { at 12pm: CLF = 0.17; at 14pm: CLF = 0.153; at 16pm: CLF = 0.182

$q = A \times SC \times SHGF \times CLF$

at 12pm $\Rightarrow q = 3 \times 0.167 \times 673.45 \times 0.17$

$\Rightarrow$ at 12pm: $q = 230.11$

at 14pm: $q = 3 \times 0.167 \times 673.454 \times 0.153 = 717.426$

at 16pm: $q = 3 \times 0.167 \times 673.454 \times 0.182 = 110.919\ w$

partition for unconditioned internal walls

There are no unconditioned internal walls

Internal light

$q = input \times CLF$ $input = 25\ w/m^2$

based on Table 15 ~~[illegible]~~: $a = 0.45$ (Heavy weight simple furnishings, no carpet) and 16 (b classification, 203.2mm concrete floor, high room air circulation) → C

work hours from 8:am to 4:00pm

CLF: { at 12pm: CLF = 0.163
at 14pm: CLF = 0.167
at 16pm: CLF = 0.171

at 12pm: $q = input \times CLF = 25 \times \underbrace{613 \times 513}_{\text{floor area}(m^2)} \times 0.163$

$\Rightarrow q = 5251.9\ w$

at 14pm: $q = 25 \times 613 \times 513 \times 0.167 = 559.128\ w$

at 16pm: $q = 25 \times 613 \times 513 \times 0.171 = 592.167\ w$

people (office 8hours, opens at 8:00 am)

$q_s = No \times Sens.\ H.G. \times CLF$

$q_L = No \times Lat.\ H.G.$

For office work: Sens. H.G. = 250 btu/person = 73 w/person

Lat. H.G. = 200 btu/person = 58165 w/person

Table 4.6 (total hours = 8,

CLF: at 12:00 pm: CLF = 0.172

at 1 pm: CLF = 0.180

at 16 pm: CLF = 0.184

at 12:00 pm: $q_s = 6 \times 73 \times 0.172 = 315.36$ w

$q_L = 6 \times 58165 = 3519$ w

at 13:00 pm: $q_s = 6 \times 73 \times 0.18 = 350.14$ w

$q_L = 6 \times 58165 = 3519$ w

at 16:00 pm: $q_s = 6 \times 73 \times 0.184 = 367.92$ w

$q_L = 6 \times 58165 = 3519$

appliance

Computers (average valu, continious) = 6 (number of computers) × 55 w = 330 w

monitor (medium continious) = 6 (number of monitors) × 70 = 420 w

laser printer (small desktop): 6 (number of desktops) × 10 = 60 w

total heat: 330 + 420 + 60 = 810 w

table 4.11 => at 12 pm: CLTD = 0176

=> q_s => q_s = heat gain × CLF => q_s = 0176 × 810

=> at 12pm => q_s = 615.6 w

at 14:..pm => q_s = 810 × 0182 = 664,2 w

at 16:00 pm => q_s = 810 × 0187 = 704,7 w

Infiltration

$Q_s = 1232 \times \frac{L}{s} \times \Delta T$ $Q_l = 3012 \times \frac{L}{s} \times \Delta w$

ACH = 1,5

$\frac{L}{s} = \frac{1,5 \times (6,3 \times 5,3 \times 4,5) \times 1000}{3600} = 6216$

$Q_s = 1232 \times 6216 \times (29,4 - 21) = 64783 w$

$Q_l = 3012 \times 6214 \times (0,0138 - 0,0085) = 99612 w$

Now we want to calculate the total cooling load at 3 times (12:00 pm, 14:00 pm and 16:00 pm)

at 12:00 pm $\Rightarrow q_s = 44187 + 161175 + 139165 + 116142 + 116142 + 20813 + 23011 + 525,9 + 315136 + 61516 + 647183$

$\Rightarrow q_s = 349221$ $q_l = 35119 + 996112 = 1348$

$q_t = q_s + q_l = 349221 + 1348 = 484021w$

at 14:00 pm $\Rightarrow q_s = 462128 + 161175 + 132137 + 116142 + 201226 + 201226 + 717426 + 559128 + 35014 + 66412 + 647183$

$\Rightarrow q_s = 421415w$ $q_l = 35119 + 996112 = 1348w$

$q_t = q_s + q_l = 421415 + 1348 = 556215w$

at 16:00 pm $\Rightarrow q_s = 50917 + 161175 + 132137 + 116142 + 175153 + 175153 + 110919 + 592167 + 362112 + 704,7 + 996112$

$\Rightarrow q_s = 503618w$ $q_l = 35119 + 996112 = 1348w$

total cooling load $q_t = q_s + q_l = 503618 + 1348 = 638418w$

Now we use Carrier software to validate our results.

TABLE 1.1.A. Component Loads For Space "Office 1 - Roor			
	DESIGN COOLING		
	COOLING DATA AT Jul 1600 COOLING OA DB / WB 29.4 °C / 21.7 °C OCCUPIED T-STAT 21.0 °C		
		Sensible	Latent
SPACE LOADS	Details	(W)	(W)
Window & Skylight Solar Loads	6 m²	705	-
Wall Transmission	46 m²	230	-
Roof Transmission	33 m²	628	-
Window Transmission	6 m²	186	-
Skylight Transmission	0 m²	0	-
Door Loads	0 m²	0	-
Floor Transmission	33 m²	0	-
Partitions	0 m²	0	-
Ceiling	0 m²	0	-
Overhead Lighting	835 W	662	-
Task Lighting	0 W	0	-
Electric Equipment	810 W	735	-
People	6	319	360
Infiltration	-	636	756
Miscellaneous	-	0	0
Safety Factor	15% / 5%	615	56
>> Total Zone Loads	-	4715	1172

As we can see above, The total sensible cooling load for our room is 4715 watt, and the total latent cooling load for our room is 1172 watt, which gives a total cooling load of 5887 watt. Based on my own calculations, the total

cooling load for our room is 6384.8 watt which is only 8.4% higher than the one calculated by Carrier software. I also have to mention that the value of cooling load at 16:00pm is greater than the other two times (12:00pm and 14:00pm),so it’s considered as the total cooling load.