

Energy Efficiency, Acoustics & Daylighting in building
Prof. B. Bhattacharjee
Department of Civil Engineering
Indian Institute of Technology, Delhi

Lecture - 12
Admittance Method 1

So what we have seen is we have we said that you know there are 2 terms, if you recollect was casual heat gain Q .

(Refer Slide Time: 00:31)

$\bar{T}_{ia} = \frac{Q}{\sum_{j=1}^m u_j A_j + C_v}$

$\frac{Q}{C_s} + \frac{\alpha I}{h_0} = \sum_{j=1}^m u_j A_j \bar{T}_{ia} + C_v \bar{T}_{ia}$

$\frac{1}{3} NV R = C_v = \sum_{j=1}^m u_j A_j (\bar{T}_{oa} - \bar{T}_{ia}) + C_v (\bar{T}_{oa} - \bar{T}_{ia})$

DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

I think we did Q_{cs} plus αI by h_0 into u into A sigma of this some j ; $A_j I_j$, because this will be on a average radiation this is the average; this is the part of heat gain and this we are calling as some \bar{Q} right? \bar{Q} and this must be equals to sigma of u_j ; here j going from some 1 to m and here $u_j A_j$, going from j going from say 1 to n where n surfaces are you know m surfaces receives radiation and there are total n surfaces into \bar{T}_{oa} minus \bar{T}_{ia} plus C_v into \bar{T}_{oa} minus \bar{T}_{ia} .

Therefore i can find out \bar{T}_{ia} i will come to that, but before that let me just what was the expression for C_v ? C_v was we said one third n into.

Student: VR

VR n into VR right approximately, CV was equals to 1 by one third n into VR right; that is what we did because that is the coefficient over ventilation heat transfer alright.

So, CV bar we used because we said n would change n can change from time to time and we are taking it like this, because we are taking all mean mean heat coming. So, it follows from there that i will have Tia bar it can be written as Tia bar will be written as you know Tia bar will be written as Q bar because we are calling this I am calling this Q bar Q bar divided by sigma u_j A_j, j going from one to n plus CV right. So, Tia is on the other side and to you know toa minus Tia would be this Q divided by all this equals to, you know Tia minus. So, know Tia minus Toa or whatever it is or plus Toa or whatever it is. So, plus minus toa. So, from this i can find out.

Now, let us solve an example problem that will make things clear, as i just repeated the previous equation was here just let me again clear it up this portion let me just remove that is what I said Q bar was this plus the casual heat wave that is that I called as Q bar.

(Refer Slide Time: 03:38)

The image shows a whiteboard with handwritten mathematical equations in red and blue ink. The equations are as follows:

$$\overline{Q} + \sum_{j=1}^m \frac{\overline{I}_j}{h_{e,j}} u_j A_j = \overline{Q}$$

$$\overline{Q} = \sum_{j=1}^n u_j A_j (T_{oa} - \overline{Tia}) + C_v (T_{oa} - \overline{Tia})$$

The whiteboard also features a logo of IIT Delhi and the text "DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI" at the bottom. The number "8" is written in the bottom right corner.

That I call as Q bar and cube bar this let me also remove just before we solve the equation. So, Q bar is equals to this equation I can set in and from this everything is known except for this one which is unknown, except for this one which is unknown, right this is what is unknown and from this equation Q bar is equals to Q bar is equals to this plus this I can find out Tia; Tia I can find out I can set the algebra or if I write Tia minus toa you know whatever

it is I am I not sure you know whatever it is. So, I can find out Tia or algebra equation I can find out.

(Refer Slide Time: 04:23)

Mean Temperature in the space

A room 6m X 5m X 3m (ht) with one external wall on the long axis has a single glazed window 4.5m X 2m facing south. Calculate the mean internal temperature given that $T_{oa} = 17^\circ\text{C}$ and the mean global irradiance on exposed wall is 180 W/m^2 . Assume α of solid wall = 0.4 and $h_o = 9 \text{ W/m}^2$. $U_{\text{wall}} = 0.7$. $U_{\text{window}} = 5.6$. Assume two air changes per hour for the room and all adjacent room to be at the same temperature. Solar gain factor for glass = 0.76.

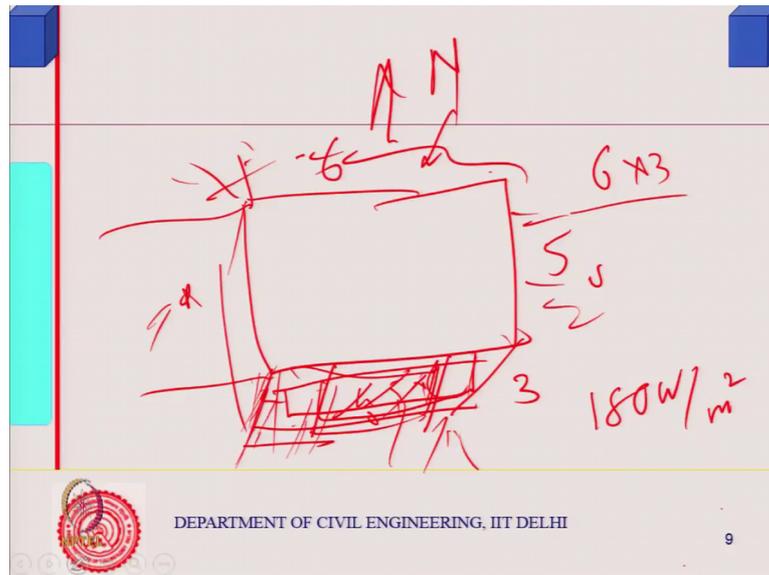
DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

8

So, let us solve in a solve an a problem, supposing I have a room 6 meter by 5 meter by 3 meter with one external wall I made it simplified one external wall because otherwise too many calculations you have to do I just want to show you how you do it, on the long axis has a single glazed window 4.5 meter by 2 meter red is a better color again let me use red, facing south. Calculate the mean internal temperature given that toa bar is 17 degree and the mean global irradiance on exposed wall is 180 watt per meter square, you know it is something like this. Assume alpha for the solid wall is h_o is 9, u is point 7, u of the window is 5 point 6 glass will all also will have a u , right?

Because you know it will have it will transmit it because of the temperature difference glass will allow radiation to come in, but there is a temperature difference due to that also heat transfer will occur and glass is very thin. So, it will allow most of the heat to come in right? For unit temperature difference the heat that will come in is very large that is why it is 5.6 compared to that of the wall, assume to your changes per hour the room that is mean and all adjacent room where the same temperature solar gain factor for glass is θ ; this is θ . So, you know it is it is something like this; it is something like this oh and right it is something like this.

(Refer Slide Time: 06:12)



You know I have a room how much is a value is given? How much is this?

Student: 6.5

6.5 (Refer Time: 06:23)

Student: 3

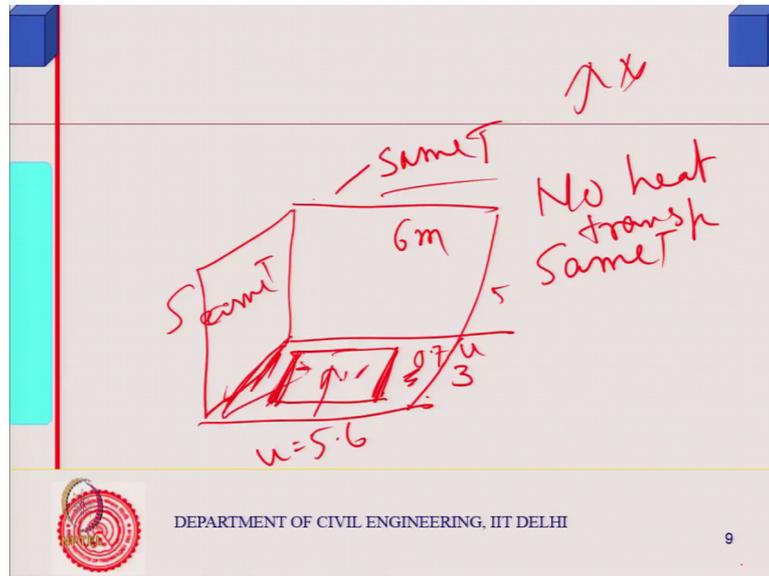
Student: 3

So this is 3 meters let us say, and this side there is a room there is a room. So, this side there is a room you know that there is a room on this side as well and there is a room on this side wall only one side is exposed; only one side is exposed.

So, all heat gain will occur through this and we are assuming this room, this room and this room are all at the same temperature. So, that my calculation gets reduced a little bit. So, this is 6 by 3 meter walls 6 by 3 meter and it has got a it has got a window 4.5 meter you know it has got a window. So, 4.5 meter by 2 meter facing south I mean my drawing is wrong actually this also is there is a room this side is room this is south this this is north this is south this has got a window this has got a window 4.5 meter by 3 meter, 4.5 meter by 3 meter; 4 point you know something like this, 4.5 meter by 3 meter window just showing alright that is what it is.

So, 4.2 meters; sorry 2 meters. So, so it is partial only not full. So, 2 meter window is there on this side the sun's radiation will fall onto this and this average is given as 180 watt per meter square, am i clear?

(Refer Slide Time: 07:52)



So, let me just again do this let me just do this the room is something like this alright this is the north side all this side same temperature same t , same t , same t . So, no heat transfer. So, no heat transfer. Only this side and it has got a window of this kind maybe something of this kind 4.5 meter by 2 meter window is here there is some sort of a window here that is 6 meter this was 3 meters and this 5 meter and all that.

So, this is this is the room actually and this must be receiving radiation this must be receiving radiation and also there is a temperature there. So, u of this portion of the wall is given as 0.7 u , this is got a 5.6, u is equal to 5.6 for this window area. And we got to calculate out first you know conduction heat transfer right.

(Refer Slide Time: 09:11)

Mean Temperature in the space

- $V_R = 6 \times 5 \times 3 = 90\text{m}^3$.
- $A_{\text{window}} = 9\text{m}^2$.
- $A_{\text{wall}} = 6 \times 3 - 9 = 9\text{m}^2$. 6*3-9
- $T = 180\text{W/m}^2$. Solid
- Mean heat gain through wall = $UA (\alpha I/h_0) = 0.7 \times 9 \times 0.4 \times 180/9 = 50.4\text{W}$
- Mean heat gain through window = $A I \theta = 9 \times 180 \times 0.76 = 1231.2\text{W}$ 1231.2 + 50.4
- $\bar{Q} = 50.4 + 1231.2 = 1281.6\text{W}$.

 DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI 9

So, we will calculate out conduction heat transfer through conduction heat transfer. So, volume of the room is 6 by 5 by 3; 90 meter. Now we here the exchange is given as 2. Window area is 9 meter square 4.5 by 2. Area of the wall is then you know exposed wall 6 into 3 minus 9 that is a solid, solid 9 meter square solid 9 meter square glass.

And I bar is given as 180 watt per meter square, mean heat gain through the wall will be $uA \alpha I h_0$. So, which is 0.7 u, A is 9 meter from the opaque portion I am looking here this is given as point 4 this is I bar is 180 and h is given as 9. So, this comes out to be 50 right? This comes out to be 50 casual heat gain is neglected, casual heat gain is neglected, but there is a gain through the glass which is $a I \theta$. So, ai bar a is 9 meter again this is 180 and theta is given as 0.76.

So, you can see that total heat gain is 12 point 1231.2 plus 50.4 that is the heat gain right? And that must be dissipated if the mean temperature has to remain constant right? So, Q is 1281.6 W. Q is 1281 you know this sum of these 2 is 18, 1281.6 W.

(Refer Slide Time: 11:01)

Mean Temperature in the space

$$C_v = 1/3 NV_R = 1/3 \times 2 \times 90 = 60 \text{ W/}^\circ\text{C.}$$
$$U_j A_j = 0.7 \times 9 + 5.6 \times 9 = 6.3 + 50.4 = 56.7$$
$$T_{ia} = \frac{17 + 1281.6 / (60 + 6.3 + 50.4)}{1 + 1281 / 116.7} = 27.9 \text{ }^\circ\text{C.}$$

DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

10

Cv 2 yard changes is given, 2 yard changes is given right? CV is 2 yard changes is given. So, one third NVr. So, one third to into volume of the room is 90 right? So, it is approximately 60 watt per degree centigrade, CV into delta t and uj Aj 0.7 into 9 plus the glass portion 5.6 sum of the 2.

So, this comes out to be; you know this comes out to be sum total of this 2 be how much? 60 is this, this is 6.3 and this is 50.4. So, this comes out to be 1281 point etcetera etcetera, and using the formula Tia is 17 is the outside mean. So, 27.9 this is fairly high too high it is showing actually does not matter because it is a hypothetical problem not really only one wall is open outside is 17 mean inside mean would be significantly higher if all this heat has to be dissipated. In fact, this 180 value seems to be have I mean one could have reduced this.

So, that is how we can calculate out the mean inside temperature in an unconditioned building. You can calculate out and mean temperature in an unconditioned building you are not taking the fluctuating part so far into account sorry steady, steady part we have looked into.

(Refer Slide Time: 12:40)

Inside Temperature

Recall, Mean Room temperature

$$\bar{T}_i = \bar{T}_o + \bar{Q}_T / (\sum A U + \bar{C}_v)$$

Handwritten notes in red ink:

$$\bar{Q}_T = \bar{Q}_{cs} + \bar{Q}_R$$

Below the equation, there is a handwritten expression: $\frac{\alpha_i I u A}{h_0}$

At the bottom left, there are logos for NPTEL and IIT Delhi. At the bottom center, the text reads: **B. Bhattacharjee**
DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

At the bottom right, the number **2** is visible.

So, mean room temperature I am just rewriting this equation. Generalized this T_i is equals T_o plus Q total where Q_t bar stands for you know Q_{cs} plus

Student: QR

Right QR which was basically $A_i \theta$ which was actually $i \theta A_i \theta$ plus you know α_i by h_0 α_i by h_0 into.

Student: (Refer Time: 13:15)

No, $u_a u_a u_a$ α because this is excess part of it. So, this is this is this is the Q you know Q_t will and u_a is a sum of the C_v bar that is what we have found out that is what we have used just now.

(Refer Slide Time: 13:29)

Inside Temperature

Recall, Mean Room temperature

$$\bar{T}_i = \bar{T}_o + \bar{Q}_T / (\sum A U + \bar{C}_v)$$

Room temperature at any instant t is:

$$T_i(t) = \bar{T}_i + \tilde{T}_i(t)$$

T swing needs to be obtained

 **B. Bhattacharjee**
DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI 2

So, room temperature at any instant actually the sum of the mean and the fluctuating component. So, far we have found out the mean inside temperature, but we got to find out the fluctuating component also. So, this is the fluctuating component T swing this we call as T swing you know. So, this T swing we have to find out T swing alright. So, T swing we will have to find out this we call as T swing; T swing we got to obtain the T swing.

(Refer Slide Time: 14:05)

Fluctuating Heat gains

The total fluctuating energy gain at the environmental point and due to any particular excitation frequency is given by :

$$\tilde{Q}_T(t) = \tilde{Q}_{fs}(t) + \tilde{Q}_s(t) + \tilde{Q}_c(t) + \tilde{Q}_{fc}(t) + \tilde{Q}_v(t)$$

 **B. Bhattacharjee**
DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI 3

Now, you know total fluctuating energy gain at the environmental point due to any particular excitation frequency is given by total fluctuating heat flow. If i want to calculate it out, this

will be given by first of all fluctuating ventilation transfer we have taken mean you are not taken the fluctuating component.

So, far we have not taken the fluctuating component. Then casual heat gain, solar heat gain through the conduction gains, and radiation from the opaque bodies both. So, solar radiation through the glasses all fluctuation we have to take it out. So, each one of these terminology;

(Refer Slide Time: 14:59)

Fluctuating Heat gains

$\tilde{Q}_{fs}(t)$ is the fluctuating heat flow due to solar radiation on opaque surface

$$I(t) - \bar{I} = \tilde{I}(t)$$

NPTEL  **B. Bhattacharjee**
DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI 4

Let me give an expression for all of them 1 by 1. Q_{fs} is the fluctuating heat flow due to solar radiation on opaque surface, first term opaque surface right? I have taken the I average the excess value over the mean is the swing I at any point of time minus I mean; I call it I swing, at that particular time I swing at that point right in plus mean plus there is a fluctuating term. So, that is what it is.

So, similarly due to this due to this there will be heat transfer through the opaque bodies. Which will be actually a α this multiplied by you know

Student: (Refer Time: 15:47) divided by h_0 .

Divided by h_0 multiplied by u a little bit of complication will come i will explain this right? Because this conduction through the opaque body i will have to take care about. Q_{fc} is the fluctuating heat flow due to opaque surface conduction only you know this just let me remove this first it is confusing.

(Refer Slide Time: 16:07)

Fluctuating Heat gains

$\tilde{Q}_{fs}(t)$ is the fluctuating heat flow due to solar radiation on opaque surface

$\tilde{Q}_{fc}(t)$ is the fluctuating heat flow due to opaque surface conduction fluctuation

$\tilde{Q}_s(t)$ = transparent surface solar gain fluctuation

$\tilde{I}(t) = I(t) - \bar{I}$

B. Bhattacharjee
DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

4

So, Q_{fc} is the fluctuating heat flow due to opaque surface conduction fluctuation, right? How we calculate we will come to that. This part Q_{fc} is a; you know Q , Q_{fs} is opaque body solar radiation.

Q_{fc} is the opaque body fluctuation you there is a temperature fluctuation outside Q_{st} is the transparent surface solar gain, we have taken $A_i \theta$ earlier now the swing part of it; I got to take. So, again this I swing t is equal to it minus \bar{I} which is the mean. So, that is the swing part. So, due to this swing there will be some solar gain transfer.

(Refer Slide Time: 16:53)

Fluctuating Heat gains

$\tilde{Q}_c(t)$ = casual gain fluctuation

$\tilde{Q}_{gc}(t)$ = transparent surface conduction gain fluctuation

$Q_c(t) - \bar{Q}_c = \tilde{Q}_c(t)$

B. Bhattacharjee
DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

5

Transparent surface conduction due to fluctuation transparent surface conduction gain through the glass conduction gain, casual heat gain fluctuation we have taken mean all the time addition of that we have that we have take it because $Q_{ct} - \bar{Q}_c$ is equals to Q_{ct} casual gain, right?

So, that is that is how we find it. So, this is all these are fluctuation above the mean. So, you have to take the values from fluctuation above the mean and this is the ventilation or infiltration fluctuation gain, ventilation or infiltration fluctuation gain you know over the mean.

(Refer Slide Time: 17:30)

Fluctuating Heat gains

$\tilde{Q}_c(t) = \text{casual gain fluctuation}$

$\tilde{Q}_{gc}(t) = \text{transparent surface conduction gain fluctuation}$

$\tilde{Q}_v(t) = \text{ventilation or infiltration fluctuation}$

N → 2 (example)
CV = $\frac{1}{3} \frac{N \cdot V}{R}$

B. Bhattacharjee
DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

NPTEL 5

We have taken a \bar{n} we took in earlier cases 2 for that you know for that example. Now n will have n varying from time to time. So, CV will vary CV is equals to basically one third \bar{n}

Student: (Refer Time: 17:58)

N into

Student: VR

VR now this will keep on changing. So, that i have to take into account, let us see how we do it.

(Refer Slide Time: 18:03)

Fluctuating Heat gains

$$\tilde{Q}_{fs}(t) = \sum_{i=1}^N \left[\frac{A_i U_i}{R_o \mu_i} \frac{\alpha_i \tilde{I}_{so}}{h_o} (t - \phi_d) \right]$$

$\frac{\alpha \tilde{I}_{so}}{h_o}$ $\mu u = \frac{u A \alpha \tilde{I}}{u}$


B. Bhattacharjee
 DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

6

This goes through the opaque body, and R_o stands for $1/h_o$. A_i remember this this is for the solar radiation falling onto opaque body, and solar excess was if you recollect it was αI you now bar which I am writing as solar radiation t minus ϕ there could be t you know at a given time I am writing like this divided by h_o that is corresponds to excess temperature right multiplied by u a μ now what is u a μ ; μ is what u divided by u swing divided by u . So, μ is nothing but u swing

Ratio of fluctuating heat coming in by outside temperature right? For unit temperature right?

Now, this is the temperature fluctuation because additional temperature fluctuation is this this multiplied by μu or u swing will give me the amount of heat fluctuating heat that will come in per unit area. So, this must be multiplied by area now u swing is written as μu . So, you see the $\mu u A$. And I am not dealing with complex things anymore, because I am taking absolute values now I am using I am using the quantities how much is the quantity will come, but i got to take that time lag because the temperature fluctuation which has occurred ϕ d hours earlier will now cause some real heat to come in now.

So, t minus ϕ t is the current time minus ϕ d corresponding to decrement factor ϕ d corresponding to decrement factor corresponding to this μ corresponding to u swing you know this; I have found out. So, this is instead I could have written h_o instead of you know. So, this part is the temperature, this is because it the temperature swing would have taken place this is the swing part of it fluctuation of the solar radiation would have taken place you

know for due to that which is occurred earlier the heat will come now. So, this is the time lag this is $1/h_o$ and $u A_i U_i \mu_i$ is nothing but this gives me u swing into A . So, that is how you know I am just calculating this right?

(Refer Slide Time: 20:54)

Fluctuating Heat gains

$$\tilde{Q}_{fs}(t) = \sum_{i=1}^N \left[A_i U_i R_o \mu_i \alpha_i \tilde{T}_{so}(t - \phi_d) \right]$$

$$\tilde{Q}_{fc}(t) = \sum_{i=1}^o A_i U_i \mu_i \tilde{T}_o(t - \phi_d)$$

$$\tilde{T}_{so}(t - \phi_d) = I_{so}(t - \phi_d) - \bar{I}_{so}$$



B. Bhattacharjee
 DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

6

So, this is how I am calculating sum up for all the surfaces which receives radiation sum up for all the surfaces which receives radiation that will give you the fluctuating conduction gain through opaque body due to solar radiation

Impinging onto it solar radiation impinging. It and direct conduction gain because of temperature is simply to swing of the outside temperature, same ϕ_d because it is related to decrement factor d ϕ_d that is a phase lag time lag due to ϕ_b right? That is why you calculated in terms of time, because t minus this i will take it the temperature swing has taken place earlier outside now it is coming in, because it will store and then transmit store and transmit. Right and this time stands for this is the u swing multiplied by area and T swing. So, therefore, that is the fluctuating component of you know f_{ct} that is the f_{ct}

Right? That is the conduction gain because of outside temperature I_{so} is that is what I said this you know this I already have mentioned you.

(Refer Slide Time: 22:09)

Unsteady Heat transfer

$$\tilde{Q}_s(t) = \tilde{Q}_{s1}(t - \phi_s) + \tilde{Q}_{s2}(t)$$

S1 direct and s2 represent indirect after absorption

OR Simply

$$\tilde{Q}_s(t) = \sum_{i=1}^1 A_i \tilde{\theta}_i(t - \phi_s) \tilde{I}_{si}(t - \phi_s)$$

B. Bhattacharjee
DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

NPTEL

7

So, that is what I have mentioned you earlier. And well for the glass you can do a little bit of complicated you can complicate it or for this one qst you can you can do a little bit of complication because it can absorb now and transmit later. So, one can do a little bit of complicity, but we do not do it that way we simply right solar radiation you know you can complicate this, but take instead we take an equivalent theta which takes into account of like the question that would it was asked is that you know what is the difference between beta and alpha?

Alpha is opaque bodies the absorption, alpha plus you know tau is tau is what gives is tau is what is transmitted, but this occurs only in case of transparent bodies the glass for example, is transparent to the solar radiation. So, it takes all the heat radiation and light radiation both in right. So, in that case tau alpha theta contribute you know theta tau contributes fully to theta, but sum of the sum of the incident radiation falling onto glass will be also absorbed because it gets heated up itself. And part of it radiate outside part of it actually transmit inside right. So, the alpha part of it is part of it is also taken into account in theta.

So, theta actually encompasses anything part of the alpha part of that that is absorbed, but whatever is reflected is rejected out that is all left out. Whatever is transmitted is allowed plus part absorbed right. So, this theta is also actually a function of angle of incidence and some more complicity is there, and there were lag from the time of absorption to the transmission. Direct transmission is instantaneous radiation falls onto it comes inside straightaway, but

whatever is absorbed by the glass it will transmit it somewhat later. So, you can have a time lag for that, but that would be very small because glass is a thin member it would not store for long, and part of it will only come in. So, what you do is we do not complicate it that much we assume there is a theta swing or you might assume a assume a fixed theta value both swing as well as steady single theta value.

So, a theta t you know you can take it like this or simply you can take is as Ai theta t you know Ai theta t.

(Refer Slide Time: 24:55)

Fluctuating Heat gains

$$\tilde{Q}_c(t) = Q_c(t) - \bar{Q}_c$$

~~For Significant radiant component~~

$$\tilde{Q}_c(t) = S(t - \phi_s) \tilde{Q}_R(t - \phi_s) + L_c \tilde{Q}_c(t)$$

$$\tilde{Q}_{gc}(t) = \sum_{i=1}^T A_i U_i \tilde{T}_o(t)$$


B. Bhattacharjee
 DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

8

So, casual heat gain simply you know this you can find out how much is the swing in casual heat gain because nothing because that is from inside the room. So, you find out every hour what is the heat generated how many people are sitting? How many typically how many let us say lights are on fans are on? How many heaters on? Etcetera, etcetera. And hourly changes would be there used up time sometime it will not be used take the average that is the mean that you have used in finding out the min temperature fluctuation above that value is a fluctuating component. So, that the total at a given time minus the mean that is the fluctuating component right?

So, for significant if there is a you know if there is a radiator, if there is a radiator for example, you have a heater. So, this equation could be somewhat different if there is a radiation, because some of these radiation might go to the wall and come back and things like that. So, for significant radiant component the equation gets complicated, because there is a

time lag also associated with these how much is being radiated and if there is no usually in tropical countries will have summer condition there will be very little radiation competent. You know you will not have a heater you will not have a heater, but if you have something like a light switch you have a very high heat component usually that would be a less usually.

So, that you can again ignore and treat it simplified manner this was for the glass transmission. There no transmission conduction transmission through the glass and it will not have any in time lag conduction heat gain through the class, because by and large it is almost instantaneous u value of the glass we took it. So, u into that is what we take.

(Refer Slide Time: 26:51)

Fluctuating Heat gains

For Constant C_v Ventilation/Infiltration heat transfer at any instant t

$$Q_v(t) = C_v [\{\bar{T}_o + \tilde{T}_o(t)\} - \{\bar{T}_i + \tilde{T}_i(t)\}]$$

$C_v \{ \bar{T}_o(t) - \bar{T}_i(t) \}$

$$\bar{Q}_v = C_v (\bar{T}_o - \bar{T}_i)$$

B. Bhattacharjee
DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

9

So, this is how we calculate out all except ventilation heat transfer except the ventilation heat transfer right? So, constant CV we have already taken care of now if CV is varying it becomes a little bit problematic it becomes a little bit problematic in the sense that $Q_v t$ at any point of time; i will be writing a CV into to T_{ot} assuming constant CV throughout i have not taken variable ventilation at the moment, variable ventilation is little bit complicated we will take it later on at the moment let us assume it to be constant CV is constant.

So, at any instant the ventilator heat transfer will be given as $T_{o \min}$ plus t_{ot} fluctuating you know fluctuating parts. So, this is the outside temperature total minus inside temperature total at any time. Now you see this we have already taken into account, that is this minus this minus this we have taken into account. This we have not taken into account CV into $T_{o \bar{t}}$

minus T_i swing; T_i have not taken into account, this minus this only taken into account in mean calculation.

(Refer Slide Time: 28:15)

Fluctuating Heat gains

For Constant C_v Ventilation/Infiltration heat transfer at any instant t

$$Q_v(t) = C_v[\{\bar{T}_o + \tilde{T}_o(t)\} - \{\bar{T}_i + \tilde{T}_i(t)\}]$$

For Constant C_v steady Ventilation/Infiltration heat Transfer

$$\bar{Q}_v = C_v(\bar{T}_o - \bar{T}_i)$$


B. Bhattacharjee
 DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

9

So, this you know the heat gain due to ventilation has to be taken into account in this manner for constant CV steady ventilation infiltration reheat transfer was taken like this.

(Refer Slide Time: 28:32)

Fluctuating Heat gains & internal temperature

Remaining unaccounted portion is

$$Q'_v(t) = C_v[\tilde{T}_o(t) - \tilde{T}_i(t)]$$

Assuming uniform room temperature, fluctuating component of temperature is the ratio of fluctuating heat gain through surfaces to admittance.

$$Q_v(t) = C_v[T_o(t) - \bar{T}_o(t)] = C_v\tilde{T}_o(t)$$


B. Bhattacharjee
 DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

10

Remaining unaccounted portion is this much, and that you must take into account.

So, assuming uniform room temperature fluctuating component of temperature is the ratio of. So, you take all this into account sum them, up sum. I will tell you the philosophy in next class, I will tell you about how to calculate out the inside doing. So, sum them up now i have given you all formula for calculating all the heat that is coming in right? Assume that all this heat will go in increasing the fluctuating component of the temperature, because we have admittance, and admittance is defined as the amount of heat flux required to cause unit temperature swing inside. Total heat coming into the room and we assume constant room temperature. So, swing in the room is any point you know we are not distinguishing temperature from one corner of the room to the other; that is again an approximation there can be some variation, but we are assuming as if it is constant. In that case the amount of heat that will come in will cause the temperature swing all across the room.

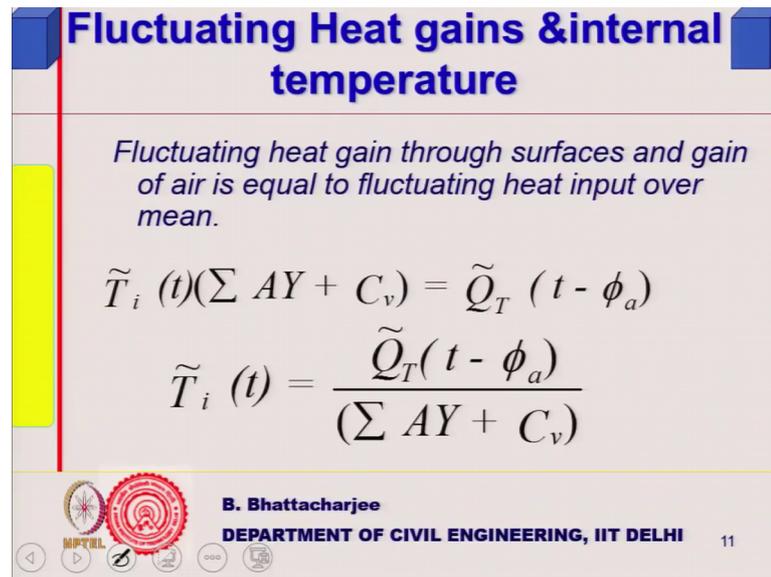
So, I can now sum them up and use my admittance concept to find out the temperature swing. How do I find out the heat coming in? By using decrement concept and all simple ones like ventilation and all they are fairly simple ventilation I mean radii you know all casual heat gain they are fairly simple simply fluctuating component I have calculated. And all fluctuating component I assume that they have gone increasing the;

Student: (Refer Time: 30:09)

Temperature swing. So, admittance is get linked now because admittance is defined is the temperature I mean the amount of heat required to cause unit temperature.

So, if I know the total heat gain how much is the temperature swing that I can find out. So, we will look at that in the next class. We will look at that in the next class and maybe solve a problem, but remember all that we have done is we have assumed.

(Refer Slide Time: 30:41)



Fluctuating Heat gains & internal temperature

Fluctuating heat gain through surfaces and gain of air is equal to fluctuating heat input over mean.

$$\tilde{T}_i(t)(\sum AY + C_v) = \tilde{Q}_T(t - \phi_a)$$
$$\tilde{T}_i(t) = \frac{\tilde{Q}_T(t - \phi_a)}{(\sum AY + C_v)}$$

  **B. Bhattacharjee**
DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI 11

You know a constant

Student: (Refer Time: 30:37)

Ventilation we have not varied the ventilation. If I vary the ventilation then it becomes far more complex in inside equation will be something like this; I will start from this slide back into the next class. So, that is it for the today.