Energy Efficiency, Acoustics & Daylighting in Building
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Module - 06
Lecture - 22
Comfort & Thermal Design of Unconditioned Building

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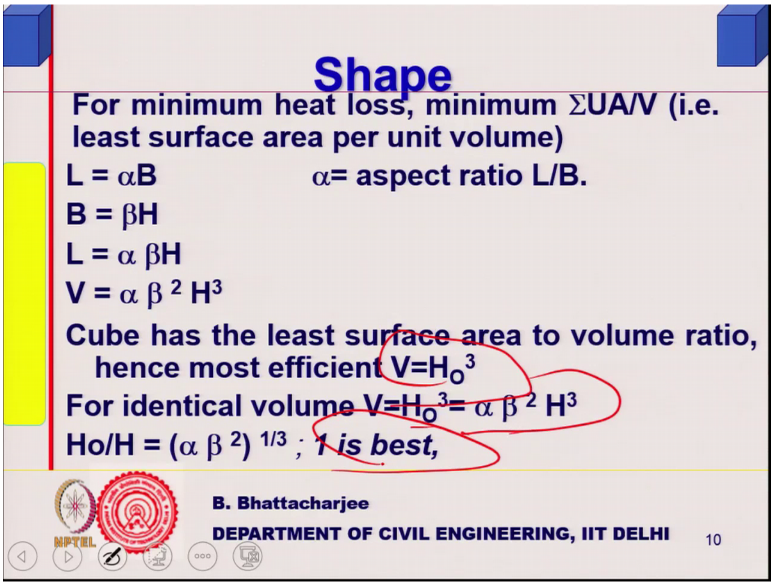

So, what we show was that shape is a shape you know one can compare with the cube what is known as thermal cube.

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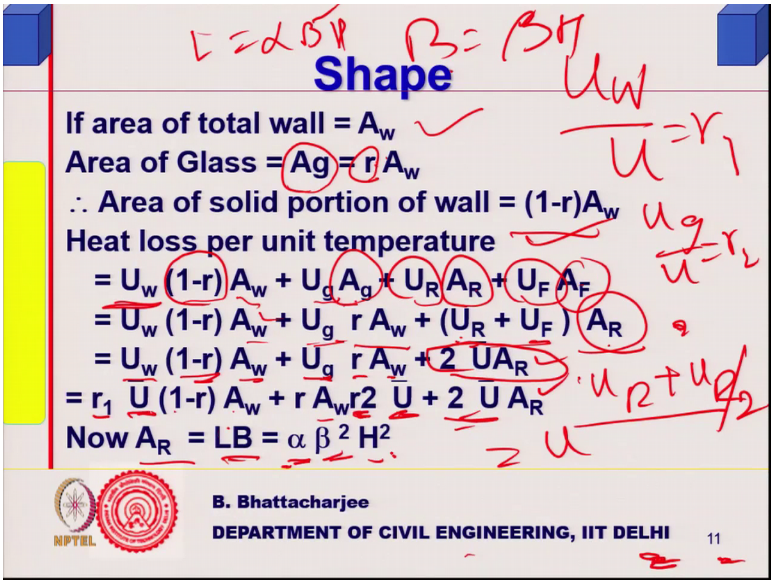

Just let see we are doing this for heat loss scenario where you would like to minimize a heat loss because that simple to understand and then when you want to do it for some you know tropical conditions where minimizing the heat gain is a concern we will have slight modification.

So, let say the total area of the total wall is A w some wall area of the corresponding glass is Ag then we write it as ratio you know Ag is equals to r A w. So, this such that it is a just a ratio, ratio of ratio of you know the proportion of the glass in the total wall area proportion of the glass in the total area. So, area of the solid portion is 1 minus r into A w, A w the total area. So, heat loss per unit temperature then one can calculate out. So, U of the wall now portion of the wall is 1 minus r into area of the wall U of the glass into Ag, U of the roof into A R, U of the floor into A F.

One thing most of the walls you left supposing I have a you know I am just looking at the boundary of the building. Now, all wall will have similar construction it is unlikely is that one wall is of one construction and let say simple case you are dealing with you can complicate it for large building and things like that. Now U a A w, what you can write is Ag is written as r A w and roof and floor area usually will be same. So, I am calling this as A F equals to A R and writing is at A R and this is U R plus U F therefore, everything is express in terms of A w or A R. So, U a 1 minus r A w, U g r A w plus let say average of U R plus U roof is divided by divided by 2, divided by 2 is this divided by 2 is equals to U. So, then U R plus U F will be 2 U, U R U R plus U F will be 2 U into area of the roof and this we can write as you know if I put a ratio of U w divided by U as r 1 then I can write you know I am just putting everything in terms this U, U and then this is glass U glass divided by U is equals to r 2.

So, I can get it in terms of 1 minus r A w you know and r 2 U gives me U glass twice U A R and A R is equals to nothing, but alpha beta square H square because L is equals to L is equals to alpha beta H, B is equals to beta H. So, L into B k is alpha beta square H square area of the roof will be L, area of the roof will be what? L into B, L is equals to alpha B, B is equals to beta H. So, you know this will be written as alpha beta square H square area of the roof area of the roof right. So, that is why the first time looking at that portion will come to the tropical scenario a little bit later.

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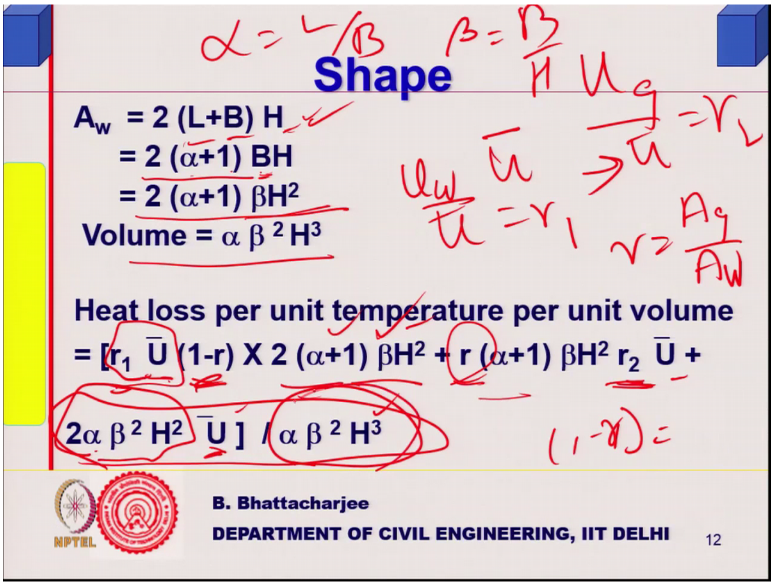

So, A w is area of the wall is 2 L plus B into H length plus breadth twice of that into height considering in, so 2 alpha plus 1 and both will have beta B, B H can be taken out and this is B H square. So, volume is wall area is two alpha plus one beta square volume is alpha beta square H cube right volume is alpha beta square H cube. So, heat loss per unit temperature per unit volume can be written like this because we said r 1 which was a ratio of U, U bar is a average of roof and average of roof and floor U values. So, this as a ratio of wall ratio of wall U value you know ratio of wall divided by the U bar. So, this is nothing, but U w. 1 minus r putting this 2 alpha plus 1 you know area of the wall and this is related to glass this is related to glass area.

So, r is the ratio of the glass portion right 1 minus r is the solid portion and r 2 is a ratio of the U values of glass divided by that of the average of roof and ceiling. So, we just write it like this and this plus that is for the roof and ceiling put together this is the area of the roof twice you know area of the roof and the floor together into U and this is the volume of the room..

So, per unit volume you can calculate out all in terms of you know all in terms of all in terms of alpha beta H alpha beta H and U bar U bar everything can be expressed in terms of U bar because we are saying U w by U bar is equals to r 1 U glass by U bar is equals to r 2 and this is directly U bar and ratios this is r's tends for area of the glass divided by total area of the wall 1 minus r is a solid portion of the wall and that is how we have done and then alpha beta alpha is equals to L by B beta is equals to B by H. So, everything can be express in this term. So, simple algebra and then divide by the volume which is alpha beta square H cube.

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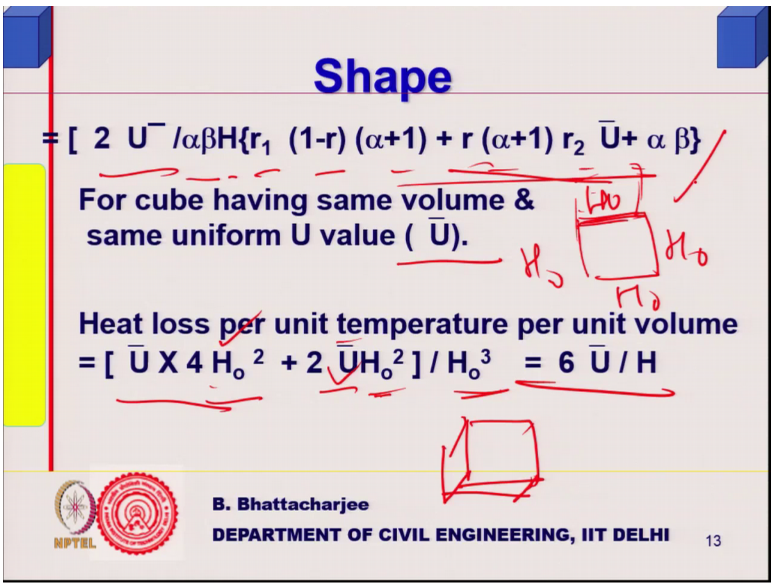

So, this you do a little bit of algebra you get something like this twice U R by alpha beta H r 1 1 minus r etcetera etcetera, something like this, you get an expression like this you know you just simplify this you will get an expression in this manner. For cube having same volume and divided by of course, per unit volume say let us say U bar is a uniform

U and I have 6 surfaces heat loss per unit temperature per unit volume will be given because everything is a U bar it is a cube. So, what is the surface area? 4 cube, 4 H 0 this is H 0, this is H 0, this is H 0, this is H 0, right. So, H 0 basically H 0 square is a surface area of the wall H 0 into H 0 and forth 4 such cases twice U bar H 0 square divided by H 0 cube right, 4 walls the ceiling and the roof everything has got their sizes H 0 because a cube volume is H 0 cube and U R is a uniform U throughout all 6 surfaces all 6 surfaces got. So, this is called a thermal cube and if you compare this, this will be 6 U R by?

Student: (Refer Time: 08:33).

H 6 U r by H. So, this divided by this if this is one that is a best or as close to one it will never be one it is as close to one as close to one that is a better one.

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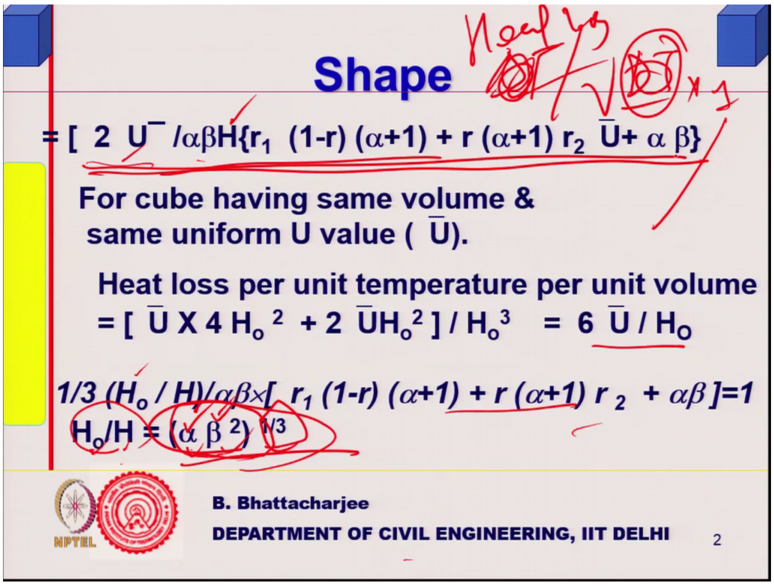

So, for various buildings you can actually choose for various building you can choose and compare find out which gives most close to 1, whichever gives most close to 1 that you can choose right. So, that is repetition of the same thing. So, this actually would be written something like this finally, if you do this algebra this divided by, this divided by, this divided by, this divided by, this divided by, you know 6 U by H 0 if do it then you will get this divided by 6 U bar by H 0 you will get U bar will cancel out H will remain, you know H will remain it will turn out to be H by H 0 is equals to alpha beta square by 1 by 3. So, you can choose alpha and beta to see that how close it is for various values of alpha and beta you know you can find out this ratio or this should be as close as 1, this should be as close as 1. So, you can find out from this one, you can find out from this one, you can find out from this one alpha beta and H 0 which one of them the other actually find out other you can find out right.

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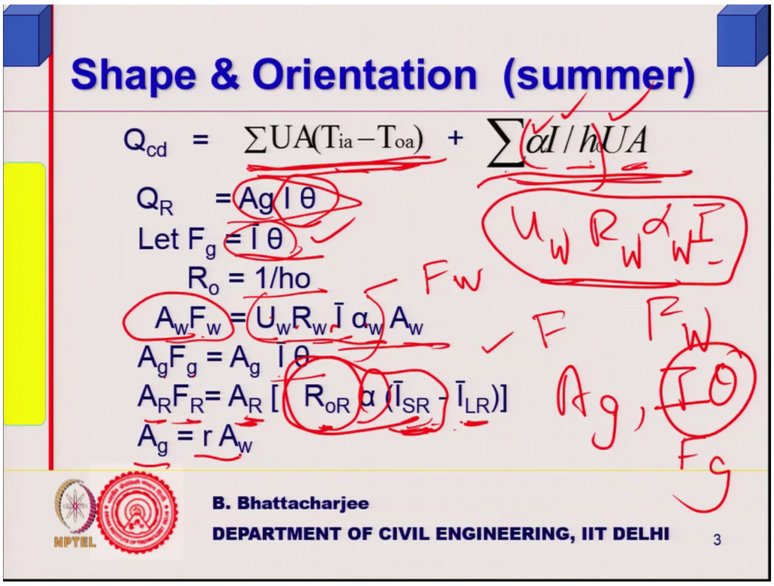

So, that is related to this one. Now, if it is summer condition where heat gain is a concern you do not want you want to minimize the heat gain then this radiation you must take into account right. So, Q cd conduction gain is this much U A T A and alpha H alpha by h naught alpha a by h naught into it should be a bracket here otherwise this will create problem; glass Ag area of the glass I into theta solar gain factor. So, you define now something like F g which is I theta. So, you can write it at U R w I alpha A w, you know this can be written as area multiplied the rest of the thing. So, you know where the question is we want to minimize the summer gain. So, summer conduction gain is given by U A T ia minus T oa or whichever way it is T oa minus T ia plus the radiation gain through opaque bodies or if it is glass then this will be through Ag into I into theta.

So, we define instead now a term F stands for, stands for in this case you know stands for stands for everything other than area such that A w F w I can write like this U w R w I bar alpha, alpha I 1 over h o I call it R o into U. So, this is what corresponds to F w for solid portion of the wall. For glass it would be Ag into I mean leaving Ag I theta. So, this is F for the glass. So, F g for class you have calling it this way. So, Ag F g is equals to Ag I theta. So, A R F R for the roof I will have area of the roof, resistance of the roof alpha and thus a you know radiation received the solar radiation minus long wave radiation loss or I might neglect this part, I can simply take for the roof for the roof I can simply take like this.

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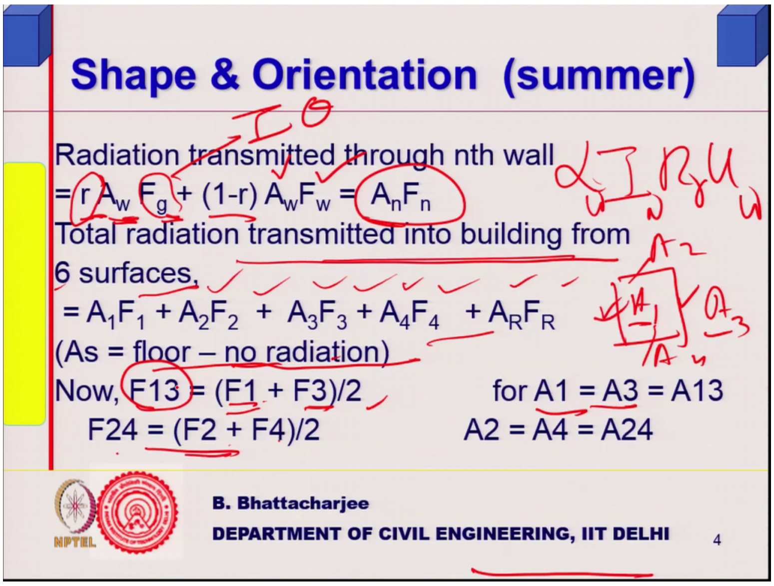

So, similarly Ag can be written as R into A w like we did earlier. So, an expression we can obtain in the same manner radiation transmitted through the wall will be given as r A w because this is for the solid portion of the wall sorry, this for the glass person of the wall into A w F g F g stands for I theta. So, that is the heat gain through the radiation heat gain through the glass 1 minus r is a solid portion of the.

Student: Wall.

Wall. Multiplied by area of the wall into F w. What is F w? F w stands for I alpha R naught into you know U, I alpha I R naught into U all for wall, all for wall. So, that is what it was. And for any wall you can find out this for nth wall you can find out in this manner. Total radiation transmitted in the building is from 6 surfaces. Heat gain will be through you know building from 6 surfaces A 1 F 1, A 2 F 2, A 3 F 3, A 4 F 4 and actually 6 surface will omit out because floor will never.

Student: (Refer Time: 14:01).

Receive the radiation. So, it is actually 5 surfaces floor no radiation. So, 5 surfaces transmitted into the building from 6 surfaces includes only 5 because a fifth one will not be the sixth one will not have anything.

Now, we can assume F 13 is equals to F 1 plus F 3 by 2 that is normally this wall and this wall will have similar, this wall and will have this wall will have similar properties. So, we can say that F 13 stands F 1 F 3 divided by 2 for area of the you know area of generally areas will be A 1 A 2 A 3 A 4. So, area of A 1 A 3 is are same A 2 and A 4 are usually same this is like this. So, we define F 2 4 as F 2, F 2 and F 4 divided by 2, F 1 do not take the average of this through and call it F 13 time to simplify this. F stands for the amount of heat gain through the surface per unit area, per unit area, due to we are taking only radiation into account. U A part is not important here because orientation and shape.

Student: (Refer Time: 15:19).

Controls because you say outside here temperature is same

Student: Yes, sir.

So, the shape and orientation will be controlled largely by radiation heat gain. So, we are trying to minimize the radiation heat gain right.

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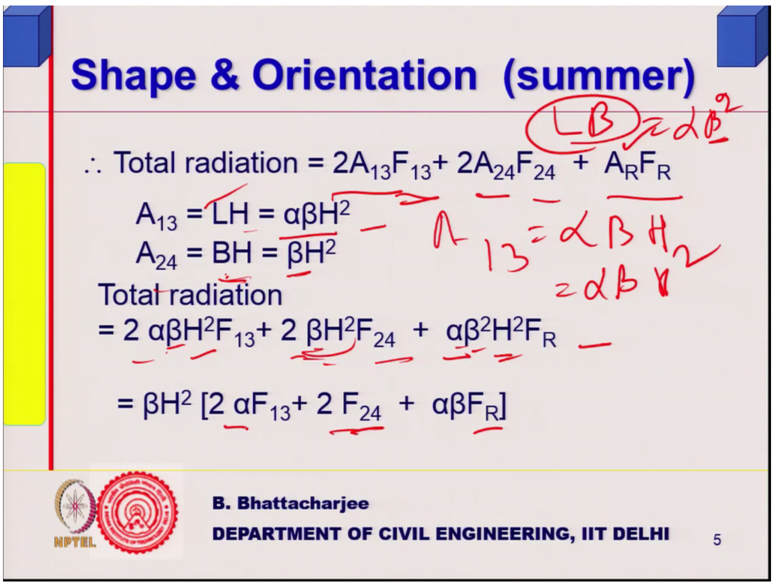

So, total radiation gain would be given by A 13 because 1 and 3 will have same area. F 13 is a average of their F values and similarly for the other two and this for the roof. The floor is not to be considered because it will not have any.

Student: (Refer Time: 15:51).

Radiation gain. So, therefore, orientation and shape really do not depend upon you know the floor area, I mean the radiation received would be on largely on the five surfaces right.

So, what I say is A 13 then can be written as alpha B H square like we did earlier alpha beta H square because L is equals to alpha into B this should be this is A 13 is equals to alpha into B into H right L into H you are saying. So, this is nothing, but B is equals to what? B is equals to beta H this will be alpha beta H square. And this will be beta into beta, beta into H and B into H and B I am writing as beta H, so beta H square. So, this two areas or something like this and what about this? This will have L B is a area which is nothing, but alpha into B square and B is nothing but beta square H square, but B square will be beta square H square.

So, this is alpha beta square H square F R twice beta square F 2 R and right. So, this is the total radiation gain depending upon the orientation and I can take beta H square common from everywhere beta square common. So, this will have alpha beta F R, this will have, this is already taken out twice F 2 R and from this I am taking out beta square common So, I will have 2 is alpha F 13 etcetera.

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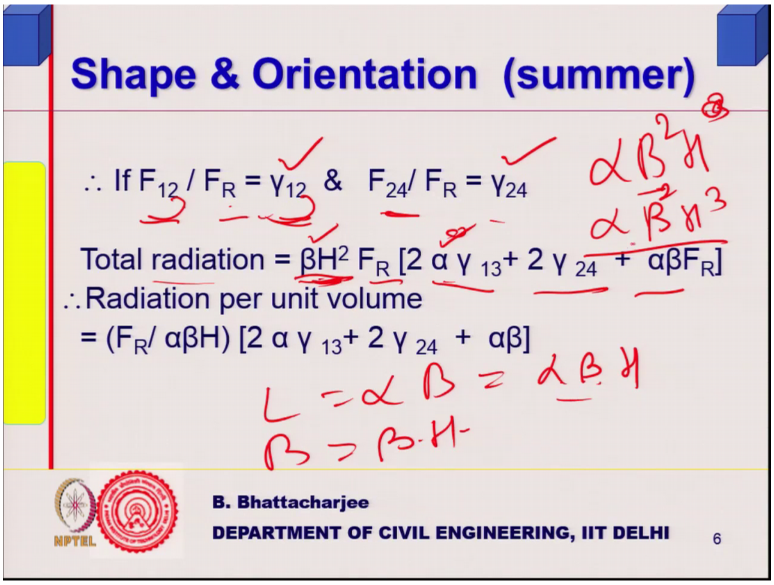

This is the radiation you can calculate out for various values of alpha and beta and again minimize you know or little bit simplification if you want to do F 12 by Y some ratio I can I can talk about in terms of ratio Y 14 and Y 12, Y 12 stands for F 12 divided by F 13 it should be F 13, F 13 Y 13 and 24 is fine. So, 24 is fine F 13 it should be. So, total radiation is you know is this as I am calling as Y 13, Y 24 etcetera radiation per unit volume I can calculate out. What is the volume alpha? L B H, alpha then B square H cube that is a volume and B square is equals to how much, beta into, beta this sorry this is.

Student: H.

H only. So, this is H cube, alpha beta square H cube alpha beta square H cube the volume is you know L is equals to alpha B equals to alpha beta H, B is equals to beta H. So, alpha beta square H square multiplied by H. So, this is what I get it. So, total radiation per unit volume I can calculate out and total radiation per unit volume if I calculate out this will be you know this was this if you remember total radiation was B H square F R. So, I take out alpha beta alpha is not coming out sorry. So, beta gets cancelled out beta will get cancelled out because I will divide by alpha beta square. So, this divided by just let me do this.

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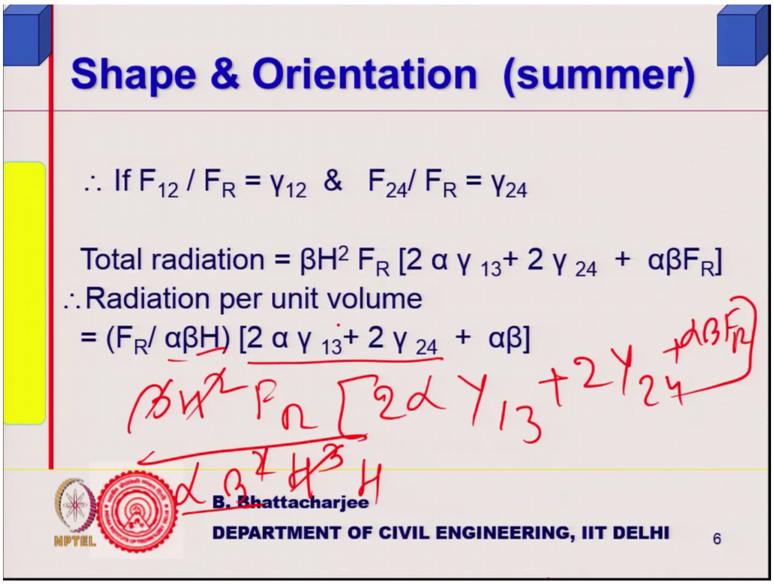

So, beta H square F R into twice alpha Y 13 plus twice Y 24 plus alpha beta F R and this I am dividing by alpha beta square H cube. So, what I get? This beta cancels out. So, I am left with alpha beta here and the H the H here and rest of the thing remains as it is. So, this is the radiation per unit volume, this is the radiation per unit volume and this has to be radiation gain per unit volume, this has to be minimal. So, say simple calculation that would tell you how to find out, that is a simple calculation how to tell you into choose a shape for minimum radiation heat gain, minimum radiation heat gain right. So, this is minimum radiation heat gain.

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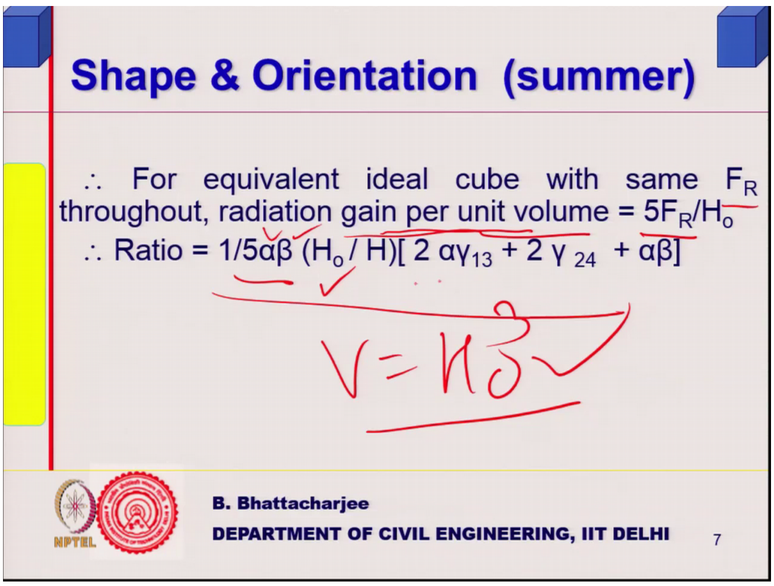

If you now try to find out for equivalent ideal cube which has got F R as throughout and radiation per unit gain per you know per unit radiation gain per unit volume will be 5 F R divided H naught. Why 5 instead of 6? Because here only 5 surfaces here considering bottom surface will not have anything, so ratio one can calculate out this should be as close to as 1 or you minimize simply this value, this value you minimize find out various values for alpha beta values choose one of them other one you can find out.

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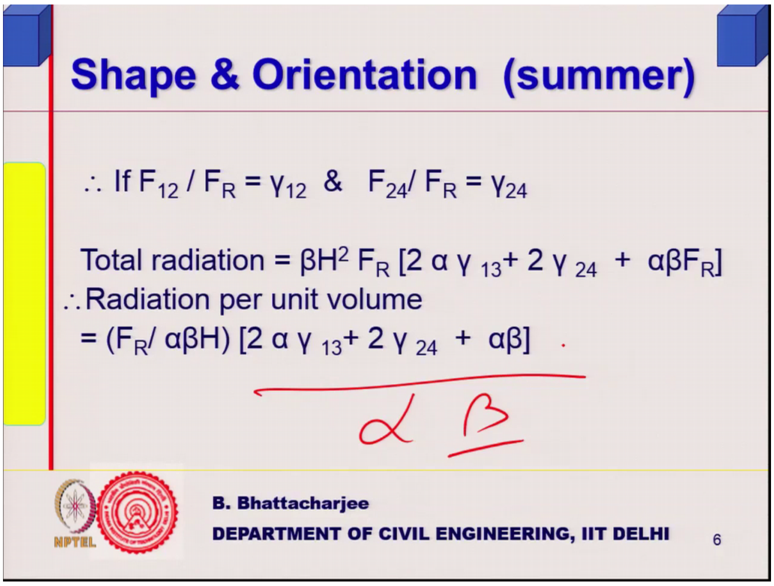

So, find out whichever is list right for various values you can actually find out what orientation is better right. The ratio is something like this. So, one can compare and this ratio should be as close to as 1.

The total volume is known. So, total volume is equals to H 0 cube, total volume is equals to H 0 cube. So, H 0 you can obtain from the volume and put it here for various values of alpha beta you can tabulate out this value this should be as close to, as close to you know as far as close to 1, list the value minimum will be 1 anything as go away from 1 it would be less efficient the shape will be best if it is close to 1, right. So, that was related to that is what that was related to shape.

Now, let us look at glass and somebody was ask me a question other day why does you know like, why does glass allow solar radiation does not allow long wave radiation something some ideas are here.

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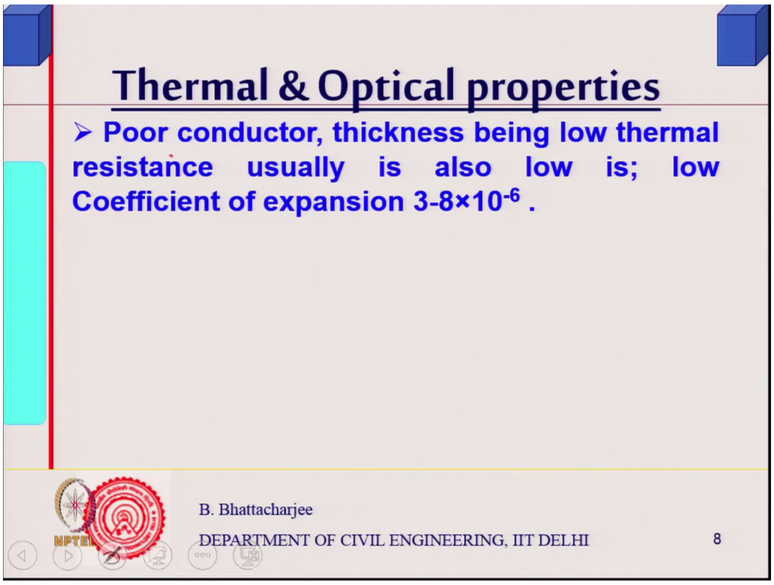

Glass is a poor conductor. So, will break then go to glass.