BUILDING ENERGY SYSTEMS AND AUDITING

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Week - 04

Lecture - 20

Lecture 20 : ECBC recommendation for Daylighting

So, welcome to the NPTEL course on Building Energy Systems and Auditing, module number 4, Energy Conservation Building Code, which we are discussing, and this is the last lecture on this module number 4, lecture number 20. So, we will discuss the ECBC recommendations for daylighting. So, if you remember in the last lecture, number 19, we discussed daylighting, and mostly we discussed the daylight factor. So now we will take the daylight factor to the daylight autonomy and the useful daylight illuminance, and all other parts, and how this UDI, which is the useful daylight illuminance, is calculated as per the ECBC, we will see in this particular lecture. So first of all, the daylight autonomy (DA).

So, what we have discussed in the last lecture is that the daylight factor is a very static kind of parameter. And because of the window aperture size, because of the orientation, internal reflections, external reflections, and all, VLT and aperture angles, everything if you take, and then you are getting a particular daylight factor, and you convert the daylight factor to the lux level also based on your EO, the outdoor illuminance. So, that is a particular daylight factor. Maybe you can say that is going to be available on that working plane for a particular day for a particular hour. So, it is a very static point or a particular static parameter.

Now, if you shift that particular point, the coordinate changes, and all angles and other things will change. So, the value will also change, that is number one. Number two, even if you take the same point, and if you find out for different parts of the day, morning to evening, the sun rotates from the east to the west through the south in the northern hemisphere. So, based on the sun angle and all, this particular

Point locations of the interior will not have a constant and similar type of daylight throughout the day. In the morning, it may be less; in the evening, it may be more if it is in the western part of the window in front of that. If it is in the eastern part of the window, the morning will be high, and the evening will be very, very less. If it is in the southern part of the window or near the southern part of the windows, then mostly it will be constant for a little bit of the mid part of the day and then. So, this variation for each hour if I want to calculate for a day.

So, I have to calculate maybe for 10 hours or something like that, or 6 to 10 hours, depending upon the sun hours. Now, if I have to see what is that particular daylight quality over the year, so I have to do it for one year. So, all 365 days, all those 10 hours or 6 hours, or whatever may be the possible sun hours, I have to do for the same. So, from that point of that particular concept, it is a dynamic kind of concept that can be thought of. For daylight, it is not a static concept of only one single value or one single parameter throughout the year or that particular space has what is the quality of the space based on the sunlight and all those sun angles and all.

So, daylight autonomy (DA) is represented as whatever I have written. The percentage of annual daylight time that gives a point in a space is above a specified illumination level. So, if I say it is a DA 300, that means the daylight autonomy of 300, which means how much percentage of the day throughout the year that particular point will receive either 300 or more than 300 lux. So, that is going to be a very good parameter to know that yes, this particular point has 60% of the year it will be 300 or more than 300. So, something like that, I have a perception of a space that, or I should say that yes, then this is the quality of the space, whether it is good, bad, or mediocre, whatever I may say.

So, here suppose this is a particular grid I am talking about, and this grid I have calculated how early, so I just now I have discussed and I have calculated the illumination level of the point for 365 days in a year, right? So, I have to do it because I may not do it; my software may do it, or there may be some other way, some thumb rules or whatever may do it. But my concept is I have to do it for 365 days, all for the hour, I mean for each day, some daylight hours. So, out of that, I have to count how many hours, how many numbers of hours is more than 300 or so. And then I will use this calculation or formula: how many hours more than 3000 lux and total daylight hours available for this particular window, and that also depends upon your orientation, locations, and all latitude and all those, and multiplied by 100. So, that will be the DA 300.

It is a culmination of the total daylight hours. In a whole year, depending upon the sun path, depending upon the orientation of your window, or maybe there are two or three windows or whatever, maybe all taken together, and that particular point has a particular potential amount of daylight, and this potential amount of daylight, if I say it is what is my bar 300. So, how much is the percentage of the hours is more than 300 for the whole year. So, that we have to calculate. So, here suppose this is the window, one small window is there, and there is this room has some grids.

So, suppose you calculate. So, mostly we see that this particular two area, this one just next to the window or these areas, will be very well illuminated, whereas this area will not be so, right? This is the corner area; these grids will not be so. So, for the whole year, if I calculate So, I may get those thick grids may be very high percentage of DA 300 or so.

Whereas these cross boxes I will get may be a very small percentage, maybe somewhat, maybe on some summer days when there are some morning sessions or maybe the afternoon sessions, I may get somewhere maybe a few hours. So that may add up for some 3-4 months and can give me some amount of more than 300 for these cross zones, corner zones. But mostly, 90% of the time, 80% of the time maybe, I am expecting in those front areas, front zones to have more daylight than 300. So if I see So, if I see that and, just for the sake of explanation, I have just thought of, I can give, I can show that this will be almost like 80.

So, it is very close to the window and the next layer or so. This will be surrounded by 80. So, it will be something like 70% of the year. It will be around 300 lakhs or so. 80 does not mean 80 lakhs.

70 does not mean 70 lakhs. 70 and 80 mean that 70% of the total annual daytime will be receiving a particular cutoff, which is maybe 300 or so. If I want to use 300 as my cutoff. So, it will be a little less. So, further less will be the 600, sorry, 60 will be 60% of the DA will be this zone.

So, gradually if you go towards the corners or so and if there is no such window in other walls, it will decrease and go to very low values in the corner. So, it will be 50 like this, it will be 40 like this, and maybe 30, then 20, 10, or something like that. Of course, all these are just for the sake of explaining; I have just gradually given some numbers, which may not be very accurate. So, if I go back again, if I just run these things, it is 80, 70, 60, decreasing and spreading towards 30, 20, and 10 like that. Now, suppose the windows are more; I mean, instead of the two-grid opening, it is a four-grid opening.

So, more 80 will be there. So, 70 will be there, and then finally, you should end up with 30 at the corners, whereas the other time you end up with 10% of the time in the corners having more than 300 lakhs. But here, maybe because of the increased wind with the same area and same orientation, you may end up with 30% in the corner. So, more area is illuminated; if you remember in the last slide, only maybe the 4 grids are 80, now it is 8 grids of 80 or so. So, it is better.

From an illumination point of view, this particular window aperture or whatever is better, so we can actually compare now the quality of the room because of the size of the window, the positions of the window, the number of windows, and we can say that this room is good and this room is better performing from the daylight point of view. So, I am not going to depend upon only the single value of the daylight factor which we calculated in the last class or last lecture, and we are not only depending upon that one value or 1, 2, 3, 4 values in very nearby areas or deep areas and then say that this area is good or bad. No, you have to; at this point, daylight autonomy is going to give a throughout. The yearly values will give the quality of the daylight of this particular space, and then we can decide if it is good, bad, or mediocre. The next layer of this particular daylight autonomy is the useful daylight illuminance UDI, and this is.

So, UDI is a kind of modified version of the daylight autonomy. So, it is the modified DA, you may say, and this particular This particular concept was first established in 2005 and was brought into a lot of codes, the green building codes and all, from the daylight point of view. In fact, the ECBC also took this particular UDI concept in the ECBC code for the daylight. And this is again a matrix bin, just like we have discussed, a matrix bin. You see, you have to divide the whole space into so many grades depending upon your software, how much it can do, the memory of the software, and how fast it can run or whatever.

So, the grades and you should see that particular grid in three sectors: one is 0 to 100 lakhs. So, which grids are having 0 to 100 lakhs kind of a scenario, maximum time, maybe 50% time, 90% time, 80% time that. And the second grid is 100 to 200, and the third is over 2000. I am sorry, one is 0 to 100, the second one is 100 to 2000, and the third one is over 2000. So, here

The further range of this UDI is one, as just now I told, where it is some bin, some areas, some of your grids are showing that maximum time, more than 50% or more than 70% of the time. That 50%, 70%, let us decide. We are going to decide in my ECBC what will be it: is it 50% time or is it 75% time, whatever. So, that we will decide. So, a certain amount of maximum amount of time is less than 100 lakhs, which means it is insufficient UDI.

So, in that area, the lighting levels are considered to be insufficient without electrical lighting. So, in those areas, you require electrical lighting almost throughout the year. So, if your bins, the space bins, some areas are 10%, some areas are 30%, you see that one. So, that may say no, this area will require daylight throughout the year or so. Now, the next one is the supplementary UDI.

Supplementary UDI, you see which area will be within 100 to It is again not 300 lakhs or so, it is 100 to 500 lakhs. So, that particular area, that particular area, that particular grid is showing more than the maximum time is 100 to 500. Sometimes it is 100, sometimes it is 500, or sometimes 400, 300, whatever. So, it is in this range.

So, this is called the supplementary UDI where acceptable daylight levels are there, and we can integrate with the electrical light. So, sometimes not throughout the year, but sometimes I may require some kind of supplementary electrical lighting, but not throughout the year. The third one is this 500 to 2500, 2500. Autonomous UDI. So, that is acceptable.

So, in some of the area, most of the time it is more than 500. So, it is plenty more than enough for any kind of work acceptable daylight level. Because for reading and all these things, we require 300 to 400 maxima, so 500 and more almost most of the time, 70% or whatever time, so electrical light would not be needed for the majority of the day. Maybe sometimes it is dark because of the overcast, the clouds, and all, so those days mostly it will not be required. Predominantly, the daylight-lit spaces are required to occupy for the period, and it may require sometimes, sometimes it may require some kind of glare control because sometimes it may be as high as 2200, 2300 or so. So, you may require some kind of glare control louvers or something like that.

So, these are the three mostly we can use, and there are another four as per the nomenclature exceedance UDI, which is more than 2500 again, it is massive. So, we are not going to use it because using this will definitely quickly come to a glare. So, to reduce the daylight in those areas by some kind of bins and blinds and all those vertical blinds and all. So, now this is the UDI criteria for the ECBC. So, that means, if I am targeting the ECBC, if you remember, we have three targets: one is ECBC, one is ECBC plus, and one is super ECBC.

So, if I am targeting ECBC, if I am targeting a business school or those kinds of educational institutes, the 40% is the cutoff for that particular. So, 40% of my area. Should have the corresponding UDI value. 40% of the area, 60% of the area may not have. If it is a shopping complex, I can get the ECBC daylight requirement only if it is 10%.

But if I want to go for the super ECBC, it should be 20%. And in this case, business and the educational school or whatever, it should be 60%. 60% will be the requirement. So 60%, what 60%?

60% of the floor area, 60% of my classroom, 60% of my lecture theater, 60% of my faculty areas or whatever should have UDI requirement of the requirement is the sufficient kind of the requirement or the earlier that the supplementary or the autonomous kind of the requirement. So, that is more than 300 lakhs or whatever. So, now, this is what I want to tell you. So, suppose there is an educational building and this is suppose one classroom or something like that.

So, count how many grids are there? There are totally 40 grids. Why 40 grids? There are 1, 2, 3, 4, 5 and 1, 2, 3, 4, 5, 6, 7, 8. So, 5 and 8 is going to give you 40 total grids, right?

The 40 grids. So, you see now this is my educational building. I have cropped that particular table, the last table. So, if 16 grids are under this UDI criteria, then I am 40% of my floor space is under UDI criteria because 16 by 40 is 16, which is 40% of 40 total grids.

So, suppose these are the 16 grids that come under the UDI criteria. So, I will get ECBC. Now, 50%. So, in the case of 50%, my 20 such grids will be under the UDI criteria on my floor. If I want to achieve 50%, not 16%, I need to have 20 grids under this.

So, much more so, maybe you have to increase the window, place another window, increase the depth of the window, whatever you can do, but you have to go with more area to be illuminated. 20 grids should be illuminated. How to calculate this, we will discuss just after this slide. Then I will get ECBC plus because 50% of the grids are under that UDI criteria and illuminated criteria also. But if I want to achieve super ECBC, at least 60% the floor area should be illuminated by that.

So, at least 24 grids have to be illuminated. So, I have to again increase the size or you have to put more windows, maybe on other walls or whatever. You have to have those 24 grids illuminated under the UDI criteria, and you will achieve 60% of the whole area in that particular. Now, it will not be like magic that these 16 grids and then 20 grids and then 24 grids like that suddenly it is increasing. This increase increment is not magic; it has to do with some kind of physical changes in the building, in the windows, and in the building, mostly in the fenestration.

So, you may have to increase your VLT. You have to mostly increase your window size. Maybe you have to go for too many instead of one window on one side; it may not be sufficient. You may have to add a few more windows and then only some physical changes of the window. Point of view is required; otherwise, these grids from 16 to 24 or through 28 will not be achieved. It is not going to be like some other things that you will know. No, this is going to be the only some physical change of the window is required. So, let us see, and this will have to be that 100 to 2000 that 90% of the autonomy is also.

We have discussed that one; there is an E mean or E average also. So, we will see that particular how to do that shortly. So, let us discuss the uniformity ratio. E minimum versus the E average that we have discussed. So, for the lit side lit to the rooms, uniformity lit ratio should be 0.3 to 0.4, and top lit surfaces, that means if there is a skylight or some atrium or whatever, you have to have 0.7.

So, the brightest part of the illumination, suppose this is the brightest part, is just next to the window. So, we see the illumination is almost 1500 lux, and the total number of grids is 6. There is a medium part of the illumination that has 900 lux. Of the 26 grids under this, 26 grids under the illumination, there are 40 grids, and there is the darkest part of the room, which has 300 lux of illumination, and there are 8 such grids. So, in total, if you add up 6 plus 26 plus 8, it should be 40.

So, what should be the average illumination? I have to take the weighted average. So, it is 870 lux, and what is the minimum illumination? 300. So, E mean by E average is 300 by 870, sorry.

So, it is 0.34. It is quite good in that way. So, the average and the minimum should have a kind of parity or some kind of good ratio. It is not that it is too dark, and then the other side is too illuminated, so your average is too high. So, that will create a kind of glare issue or so.

So, there are two rules that we will use to calculate this UDI criteria. So, the first one is called the 2H rule. What is the 2H rule? H is height. So, if the height of the window from the

floor is h, that means it is not the actual height of the window, but the height of the lintel or the top of the window from the floor is h. You may have a sill, or you may not have a sill; you may have a window from the sill. So, the actual window aperture may be smaller, or you may not have the sill; you may have the window from the floor itself. Whatever the case, h is the height from the floor to the top. We may say that the 2h depth towards the room side, towards the space, is a 2h depth from the top of the opening. You will get good illumination. This criterion, of course, falls on the floor, not on the working plane, because the working plane may be here or there. So, this particular length is not 2h; it is a little less than that. We will discuss the floor as our criterion as per the ECBC.

So, we can say up to 2h, or twice the depth. So, if this h is 2 meters, then 4 meters from that. If it is 3.5 meters, then 7 meters from the wall side will be illuminated properly as per the UDI, 90% UDI criterion. Of 100 to 250 is the look, I think, throughout the year, that 90% of the time, it is going to be illuminated properly. So, that is one criterion to know the depth from the wall, how much illumination is based on the height of the window or the top height of the window, and the second one is called the 1-meter rule.

The 1-meter rule is that the opening of the size is the width of the window. 1 meter on this side, the right, and 1 meter on the other side, the left. These two can be added together, and 2H, we know 2H already, we know that is the depth from the wall, and this particular area will be illuminated and also a daylight area. So, this area can be considered for the calculations. And there are other rules, such as the area 20 rule.

So, the total area of the window should be 20% of the floor area. So, those can also be used for our calculations or so. But we will use this 1-meter rule and the 2H rule, the earlier one, the 2H rule, for our UDI calculation in the next slide. So, for the guidelines of the UDI, those are the guidelines. The working plane is assumed to be 0.8 meters above the floor finish level, and from that, this criterion has been developed. All those kinds of areas are in the morning. If you want to do the simulations or so, you have to keep it at 0.8 meters above the floor finish level. And the total sunshine hours and all have to be calculated. For school, it is some other hours or so. VLT also, you have to take some amount.

So, these are some of the VLT reflectance of the room you can take. So, you can go through this, and this is supposed to be the thumb rule for the UDI calculations given by the ACBC. Suppose we have an area of 12 meters by 8 meters. So, 12 meters by 8 meters is almost 96 meters square. So, I have 1 meter by 1 meter, 96 such grids, but see, I have 3 windows, one is 3 meters by

Width and this one, this one is 3 meters by this one is 3 meters x 1.5 meters. 1.5 meters height is from the floor, and this is 2 meters x 1.5 meters again from the floor, and this is 4 meters by 2 meters, 2 meters again from the floor. So, like that, 4 meters is the width, so by 1 meter rule and 2 h rule, so I can. 2 h means, sorry, 1 meter means 1 meter on this side, the left and right, and 2 h is it is 3 meters because h is going to be 1.5 meters. So, this is 1, 1, 1, 3 meters. So, this will be my daily area as per the UDI criteria. The second one is this, which is 2 meters, so 1 meter on the left side will be common for the other window, and this is 1 meter on the right side, and again, it is 3 meters.

And the third window, which is 4 meters, so it will go till this 1 meter rule, and this is 4 meters means 2 meters, 1, 2, 3, 4. So, till this, you see it will be illuminated, right? This will be illuminated. So, this will be illuminated. So, now you count how many squares are illuminated.

So, these 3 I have counted. So, the total delete area is 42 meters square. These are the 42 boxes or the squares that are illuminated by virtue of that thumb rule, 2 h and 1 meter rule. And so, it is 43% only. So, if it is a school, it will get only the ECBC, not the ECBC plus or a super ECBC.

Super ECBC requires 60%, ECBC plus requires 50%, ECBC requires 40%. So, it is quite good for ECBC, not for Super ECBC or ECBC+. Now, see that same area. I have a small chamber. Suppose some small chamber if I place. So, this is I have calculated. This is again I have calculated. So, those are the calculations I have written down here.

This is calculated also the same 42. Those if you add up these 3, it will be going to give you I think 42, but here deleted is 42 considering overlapping. But you see this area, you should not count it because this area should not be deleted because there is a partition wall. Because of this partition wall, this particular area will be dark, OK. So, if it is an open kind of thing, then these 6 modules or 6 grids can be taken in my calculation. So, considering this area 42. So, this is 96 by this is 43%.

So, now I have to revisit because now it is 36 meter square because 42 earlier minus 6. So, this comes with 42 minus 6 is 36. This is minus 6. These 6 are the minus 6.

These all are the 42. And then my new calculation is 37.5, so if you put a room over there or something like that, you are not going to get the ECBC also because you are less than 40% or so. So, like that, with a very simple thumb rule without going to go for the laborious software, the simulations. Laborious software, the simulations. From a basic thumb rule point of view, we can also check whether my building or my school building or the classrooms are more than 60 or less than 60 or 40% or whatever, and what criteria I may get from the ECBC.

So, that is all for this particular lecture on this particular module. So, in this module, in fact, we have discussed the whole ECBC criteria, initially the EPF factors and all, and now we have discussed the daylight autonomy UDI requirement of the ECBC as per our board of energy efficiency and ECBC code. Thank you very much.