BUILDING ENERGY SYSTEMS AND AUDITING

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Week - 04

Lecture - 17

Lecture 17 : EPF - Prescriptive Requirements

Welcome to the NPTEL course on Building Energy Systems and Auditing. In Module 4, we are discussing the Energy Conservation Building Code. The second lecture of Module 4 is on the EPF prospective requirement. In the last lecture, we discussed the EPF and how to calculate the EPF. Of course, we took a very basic shape of the building and all.

Today, we will discuss, and in this lecture particularly, we will see how this prospective requirement of the EPF. That is ECBC, ECBC Plus, or Super ECBC compliance can be taken care of. So, before we go to these particular compliances. Let us see the last class lecture on the Excel computation. How to do this particular Excel computation?

If you remember the last class, we got the value like 69273. So, let me discuss it through the Excel. So, in this Excel, either you see the facet areas, you have to mention over here, you have to mention the WWR, this is the U values of the wall, U values of the roof, U values of the window, this is the window SHGC, this is the SEF. SEF, as of now, we are keeping at 1, we will discuss that 1, what is how to calculate the equivalent shading factor.

So, the areas have to give and based on your table, I mean there are the tables, there are your tables. Suppose this is the EPF coefficient of the composite climate, this is your daytime building factor also, this is your daytime building. The first two columns are for the daytime, the second two columns are for your the 24-hour building. So, here you see I have taken that this one, this 6.4, 9.5 bit that one, no I have taken I think the other one. Hot and dry climate 6.4. If I take this one 6.4, which is our case, this is our case.

So, if I just copy this one and if I just place over here paste, then I am getting that 69243. This compliance and the super ECBC factors have to be given in the green these two columns and the pink columns. So, that we will discuss this lecture today. Let us suppose this is this is vanished; this is this is nothing is there just then let us suppose this is 0 now.

So, in this particular thing, suppose now I am changing my orientation. So, orientation changes like this are 200 now, this is 200 and this east and west become 400, I just change the orientation, sorry, change the orientation. So, it becomes 70. So, the EPF of it is a little higher, 69 to 70000 or so, it goes a little up. If I increase the U value, suppose 2.3 or something like that.

So, definitely it will go to increase, this will be 75000 or so. So, by your if you have your architectural design, and if you have north, south, east, west face and roof area, and the WWR is almost ready. So, from that you can do, but unfortunately your orientation may not always be in the east, west, or north, south way. So, your orientation of the building depends upon your plot orientation, your access road, and all front road.

So, but ECBC is not prescribing anything on that. So, you have to assume that your building, whatever may be the orientation, with a minimum tilt, which orientation is going to be the recommended orientation of yours. So, that you have to approximately analyze that one. So, maybe you have oriented your building 15° towards north. So, it is better to take the 15° instead of

the 75° in the other way around. So, that way you have to justify your orientations or which orientation your building is mostly oriented. So, that you have to take care. And, suppose in this particular case, I am interested to find out for this particular building, which may be located in the cold climate and that is a 24-hour building. So, I have just to crop this part, I have to copy that, and I have to paste it over here.

So, I will paste over here, and I got some new values. It is 88000 or something in a cold climate, but definitely, it is a 24-hour building. It is not a. So, like that, you just crop the values, you just put the values in the required locations, you change your facet area, and all this kind of thing. You will get your values. So, let us come back to the PPT once again. So, I have just described this thing. So, this you have to calculate as per the architectural drawing I told you, facade areas, and the WWR.

The next, this whole 1, 2, 3, 4, 5, 5 such The columns have to be filled through the material specification, BOQ, the drawings, and all those kinds of things. And finally, this cropping that I have just done now in that Excel sheet, you have to crop based on the ECBC that particular table, based on the climatic zone, and also the building type, which is a 24-hour building or 12-hour building or from that. So, these three operations if you do, these things will be very easily you can calculate, but you may say that this is a very easy way to finding out, but the actual building is very complicated also. Yes, WWR may change, or you may know only the window dimension.

So, directly you can find out the window dimension and see that how much is the facade area, and you can back calculate the WWR and put the WWR values. So, like that, we can also see that one, or you can re-modify this Excel sheet. This Excel sheet will be sent to you, and you can re-modify the Excel sheet and you can compute. So, and finally, you will get the envelope performance factor. So, change of the building time, we just did, of course, we did for the cold climate if you have the same climatic zone.

So, you have to take the other part of the table. The table has four columns; the first two columns are for the daytime, C factors, and U and C factor, SHGC. The third and fourth columns are for the 24-hour building. So, I have computed the data, and what we got is 69000. If you have the same location, the building is the same envelope area, same thing, but it is the 24-hour building. Your EPF proposed building will now shoot up to 11672. So, these are the EPF points or EPF factor. So, this is a number.

So, if somebody comes up with, suppose I am designing in my office, there are 3 or 4 options coming from 3 or 4 junior architects or something, and now I am calculating those 3 or 4 options. So, I will be actually looking to From the energy conservation point of view, who can give me the less this value, the less amount of the EPF. Less EPF means less heat gain, right? The less heat gain or so because it has taken care of the compactness, it has taken care of the material, better material, protective material, or so. So, there are other kinds of criteria for selection, maybe the functionality, the building bylaws, aesthetics, and all those that are definitely there.

But from the energy point of view, the energy conservation point of view, the less EPF, the better energy conservation, the energy-conscious building, right? So, building orientation and the climatic zone are also going to be factors. So, the same building I have repeatedly used for two cases: one is the longer side, and the shorter side is the east-west and the north-south direction, just we have done it and we also got 70000 something over there. So, these are the changes.

So, every time you see there is a hike, in case of the east-west, if the long side is east-west for all the composite and hot and dry, I think I have a graph also, yes, the graph also. So, you see this is a little bit of a hike, a little bit of a hike, I think, let me take. So, it is a hike, it is a little bit of a hike in case of that, the long side, longer sides are east and west. These orange-colored buildings or these towers are a little higher than the blue-colored ones. And if you see case 1 only, that is, or case 2 only, out of all the hot and dry is the highest at 69000, composite is a little lower than the hot and dry, hot and humid is further lower, temperate is lower, and the cold is the lowest point.

So, that is also one you need to see. That gradually decreases from the hot and dry to cold, that is, the same building if you place it in the cold, direct cold locations, cold climatic zone, the same longer side eastern orientation, or so the point will be reduced. Now, we have to see the prospective requirements, those three types of requirements. So, again, let us come down to these three particular choices, choice basket. See, the first-choice basket is your design development.

You cannot change the choice basket because your design is developed. So, your fenestration areas are fixed, your wall surface areas are fixed, your roof areas are fixed, and whatever is fixed. So, you have to take the old values, the old value area I will take for my new equations for the prospective prescriptive requirements. The climatic data, that means, the C factor has to be taken from the old values because I am not going to change the location. So, what I can only change is the building envelope material to reduce down the EPA value to get to target the EPA ECBC or ECBC+ or super ECBC.

So, the new values of the U factor and the SHGC factor I have to select, I have to go for better material from the energy point of view. And we can actually achieve this performance level. So, table 4.4 to 4.11 on page number 22 to 24 of the ECBC 2017 code is prescribing those values right for ECBC and the plus or whatever. So, if you go to the roof assembly table number 4.4, All the three tables, 4.4, 4.5, and 4.6, are on page number 22.

Table number 4.4 is giving you the ECBC-compliant building. So, you have to go with this U factor for the roof, if your building is composite or your building is in hot and dry. So, I have to go with the 0.33. So, for ECBC+, My value will be 0.2, of course, we have to see one because my building does not come into this building because this is an office building.

So, if it is your school, if it is a school building, then if it is a school building, the area of the school building is less than less than 10000, then you have to take this one. If it is more than 10000, then you have to take 0.33. So, it is the other type of building. So, you have to take that also into consideration, but in our case, it is all the other type of building because it is the office building also.

So, I have to take this one. In this case, it is a kind of hospitality business. I have to take 0.26 or something like that in the case of the ECBC plus. In the case of the super ECBC, I told you the super ECBC is very strict. You have to have the U value of the roof as 0.2 for everywhere, for all types of buildings. You see the straightforward 0.2. If some scope may be in the other cases, but it is very strict.

You remember our building? We proposed the U factor of the roof as I think 2.5 or something. It is telling that if you want to have the ECBC recommendation, you have to take it down to 0.33 with some insulated material and whatever you have to do, but you have to be at 0.33. If you want to be ECBC+, then it has to be 0.26 or further below. If you have to achieve the ECBC super ECBC, things should be 0.2 or further below. So, you need more insulated materials or whatever you have to think for your roof.

This 2.5 will never give you this particular prescriptive recommendation or the levels. Now, if you can go back to page number 23, it gives you the wall assembly recommended values of the wall assembly for the three criteria. Table 4.7 is for the ECBC. Table 4.8 is for the ECBC plus, and 9 is for the super ECBC. So, in all types of buildings, I have to have a 0.4 U value for the wall, but I think my U value was 1.5, far ahead.

In this case, it is super ECBC. I have to go with the business building less than that. And we see that in the case of the U-factor, for super ECBC, it is straightforward 0.22, right? So, you see, this is if you want to calculate the vertical fenestration. The vertical fenestration, instead of the three tables, there are two tables only prescribed. The first table, Table number 4.10, page number 24, gives you the ECBC recommendation.

And Table number 4.11 gives you both ECBC plus and also the super ECBC. Now, here you see there are two values: one is the U-value, and one is the SHGC value. The first line gives you the U-value, the first line in both cases, the maximum U-factor. So, my case is hot and dry, and this does not depend upon the type of building; for all buildings, it is the same. So, in my case, the U-value should be hot and dry.

So, it is recommended maximum 3, but in my case, it is 0.75 for less, right? So, that is good. SHGCs are given in these 4 rows. Now, here the first row, the maximum SHGC non-north, non-north means the south, east, and west. So, that is recommended as 0.27 for hot and dry.

But in the north, these two last rows are for the north. This is also for the north, and this is also for the north. Now, you have to see the latitude where your building is located, which is in Delhi. Delhi is more than 15° north, or it is somewhere in the south, in the hot and dry climate, maybe somewhere in the central part of Tamil Nadu or something, then it is less than 15° north. So, based on that, you have to choose.

So, if I say it is Delhi or somewhere, I have to take 0.5. And if I say it is somewhere in the central part of Tamil Nadu, then it is 0.27 I have to take. Similarly, the four lines are also mentioned over here in the case of the ECBC plus and the super ECBC, and these things are further more. So, it is 3, it is 2.2, it is 0.27, this is 0.25, this is 0.5, it remains the same, this is 0.25. So, let us see the calculation for my last calculation, which we did in the last lecture if you remember.

So, I have calculated for ECBC compliance and the super ECBC, the central one ECBC plus I have not done, things are the same. So, in case of the roof, if you remember, my roof was 1250. No change, I told you in case of the area point of view, there should not be any change in design development. There should not be any change from the C factor if you remember in the last lecture, or you can go through your last lecture video. You can see the C factor for the roof was 14.82 based on the hot and dry climate and 12-hour building.

So, no change. So, I should write here no change. Only change was this U-factor, which was, I think, 2.5 or something. I did not remember. You can go back and see, or 1.5 probably out of 1. This new value has to be taken from the table number whatever 4.4 is this, and this is 0.33. I have taken this one. And in the case of the super ECBC, this remains the same, no change. 1 to 5, 0 area of the roof remains the same, no change. Only this is the new value, which is the new value. This is 0.2. So, in the case of if I want to find out the ECBC+, I could have been, I have taken 0.26 then.

So, I have another row, another number. So, if I want to achieve the ECBC building, my EPF roof should be around 6100 something, and if you want to achieve super ECBC, it should be 3700 and something 5. Similarly, I have computed for the mass wall, no change. 6.4 is the C-factor for the wall. If you remember, 960 was the area of the wall, if you remember. So, no change, and this 0.4 is the change, new value, which comes from here, and 0.22 is the new value for the super AC.

So, I got those two values. Big numbers for the EPF of the valve. One first one is for the ECBC compliant, and the second one was super ECBC. Let us go to the next. This is for my vertical fenestration.

In the vertical fenestration, I have to recompute. So, this is your C1 factor, if you remember, minus 0.37 C1 factor. So, no change. The areas are Aw also no change, only what we have changed is this particular U-value. The recommended U-value is 3 for hot and dry.

So, I put the 3. The red color one is the changed value. Similarly, this is the C2 101 252, if you remember, it is also no change. The areas, this is Aw, no change. Only change in this, let us discuss this one. This is north. So, north is the last two lines. So, my building is above 15°.

So, mine will be this one, not this one, and this is my value, okay. The last three lines are for the SHGC. So, out of that, north one is the last two, and one is this first one. The third line is for the latitude more than 15°. So, this is that. Let me give the arrow. The south, east, and west are 0.27, 0.27, 0.27, why? Because they are non-north. They are not north; they are non-north.

So, the non-north value is this. 0.27, yes, non-north SHGC for the non-north. So, this is for south, east, and west. So, that comes here, that comes here, this one, this one, and this 0.27, and I multiplied, added up, and then this is my values for, but please remember this is for the ECBC compliant. Similarly, I have recalculated this thing for the ECBC, super ECBC cases also, where these are the no-change cases.

You see, these are the no-change cases. I am not writing, and this red color were the new values. So, the new value of the U-value is taken into account. This 0.5 is the new value of the non-north, of course, for the latitude more than 15° north, and 0.25 is the maximum value of this one. South, east, and west recalculated, it is coming around 13141; the earlier one is 13700, a little higher. Now I will add those values, and you see my proposed one, which was we have discussed in the last class, was 69000, which is this proposed.

If I want to achieve the ECBC-compliant building, ECBC building, then it should have been 22000 only; it should be, we have to put it down. We have to insulate the building. If we want to achieve a super ECBC, it is further below 18000. In between, there may be an ECBC; in between, there will be your in-between. I have not calculated to be ECBC+. It may be in between 22000 and 18000, maybe 20000 or something.

So, if you have to go further below, if you are making more insulation or something like that, then you can actually get the super ECBC. So, these values are your guiding values, but why it is called a trade-off is because you can put, suppose, very insulative material, you propose very high insulative material for your roof. And that brought down the roof EPA value too much, and you can have a little bit more in the fenestration or in the wall. So, that kind of scenario is known as the trade-off kind of scenario that we can do.

So, I have calculated for this something like which we discussed: longer side north and south, and the longer side east and west, and proposed values. So, all cases use green tall buildings or the tall bars are your proposed values for all these 5 climatic zones, and the purple ones are your ECBC compliant, which is very, very low, and the red ones are the ECBC super ECBC, which is further low. So, you can see how much insulation is required for all the climatic zones. to reduce your green bars to similar to your purple bar or maybe the red color bar.

So, the equivalent shading factor SEF, that also we can calculate. We will introduce this thing in today's lecture, and we will discuss it widely in the next lecture. So, a building may have a shading device. Overhang, something overhang, or maybe the fins, and based on that particular geometrical shading device, we can calculate some benefit we can get in the EPF. So, in this, we can find out the vertical depth from the sill level to the bottom of the overhang.

So, from the sea level to the bottom of the overhang. So, if the overhang is your chhaja or the sun shade is here, this will be your actual V. So, I have just taken it a little bit above, so this is your V and this is your H, the projection, which shows how much your horizontal projection is. This H and V will actually decide the sun cut, sun angle, or how much shading will be provided over your window. So, we decide, we call that the projection factor (PF), which is H by V. So, as per my design, I can find out what the projection factor H by V is, and based on this projection factor, I can find out this SEF. That shading equivalent factor will reduce my SHGC value if you go back to our earlier equation, of course, we will discuss it a little further in the next lecture.

$$SEF = (C_3 \times PF^3) + (C_2 \times PF^2) + (C_1 \times PF) + C_0$$

The equation given to find out this SEF is C3 into PF to the power of 3, C2 into PF squared, and C1 into PF, where PF is your projection factor, plus C0. So, this C3 C2, C1, and C0. Again, there are some tables from which you have to take values that depend on the latitude, whether it is over or below 15° north, and the facet orientation like north, east, west, northeast, and all. These are the two such tables.

The first table, Table number 4.12, is for latitudes equal to or greater than 15°, and the second table is for latitudes less than 15°. So, suppose those are the overhangs. So, for overhang my values are this. Suppose my windows are in the east. So, C1, C2, C3, and C0 are those four values.

So, that has to be taken into the earlier equation. So, those values have to be put over here, and PF I know from this. So, I will see this, and then finally, compute what the SEF is, and SEF is always greater than 1. It will be greater than 1, and that will give some kind of reduction in the SHGC value. So, here, what we did is we discussed the prospective requirement, 4 types of requirements.

One is, in general, benchmarking the building, a normal building, and 3, of course, the 3 levels, not 4 as such, but 4 times you may have to compute: one is for the typical building, and ECBC compliance, ECBC+ compliance, or super ECBC compliance. So, by virtue of those tables given in the code and by virtue of only changing the central part, the central part is the material specification part, or so, the rest two parts will remain constant. Thank you very much.