Sustainable Architecture

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Lecture – 58
Whole Building Performance – VIII

Good morning. Welcome to this lecture where we are continuing with our discussion or demonstration of this Whole Building simulation tool design builder as part of this ongoing online course on Sustainable Architecture. So, so far what we have done is we have learnt how to create a base case building, we have also learned how to make changes and also create a proposed building.

In today's lecture we will see if not just for compliance, but to improve upon our design if we want to check the performance of each energy conservation measure how do we want to how do we simulate, how do we take each energy conservation measure separately, also how do we calculate the average performance of a base case building. And, then how do we compare between a base case buildings performance with that of the proposed case buildings performance.

So, we move on to the design builder screen and I hope that you following up with us at the same pace at which these lectures are being delivered. So, that you are absolutely in sync with whatever is being discussed here, it will be good for you as a hands on exercise. So, let us switch to the design builder screen now.

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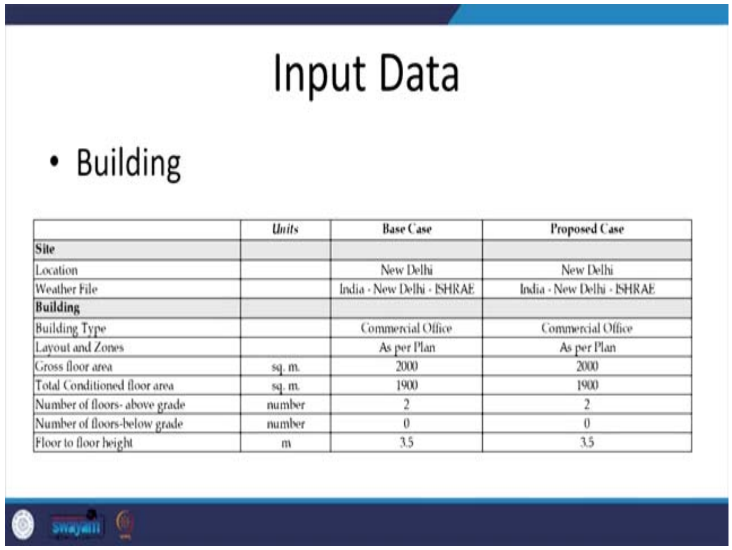

	Units	Base Case	Proposed Case
Site			
Location		New Delhi	New Delhi
Weather File		India - New Delhi - ISHRAE	India - New Delhi - ISHRAE
Building			
Building Type		Commercial Office	Commercial Office
Layout and Zones		As per Plan	As per Plan
Gross floor area	sq. m.	2000	2000
Total Conditioned floor area	sq. m.	1900	1900
Number of floors- above grade	number	2	2
Number of floors-below grade	number	0	0
Floor to floor height	m	3.5	3.5

So, by now we have already completed our base cases and we have also completed the proposed case. Just to give you a quick recap, we have the input data for both the base cases and proposed cases here. So, here we see location and weather file being the same, building type being the same, layout and zones remaining the same, gross floor area, total conditioned area, the number of floors, above and below grade and floor to floor height. So, the basic building geometry remains the same we do not have to change that in the proposed case.

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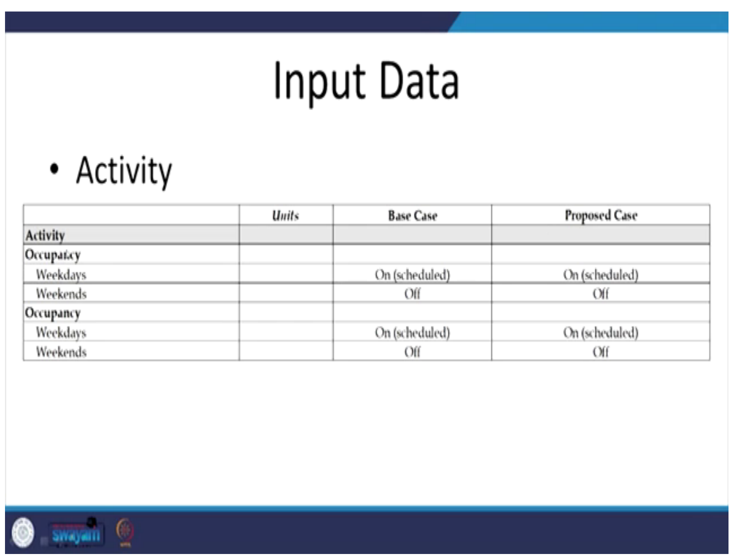

	Units	Base Case	Proposed Case
Activity			
Occupancy			
Weekdays		On (scheduled)	On (scheduled)
Weekends		Off	Off
Occupancy			
Weekdays		On (scheduled)	On (scheduled)
Weekends		Off	Off

In case of activity, the occupancy has to remain the same the schedules have to be the same. So, people come at the same time the percentage of occupants, also on both weekends and weekend week days so, the activity schedules remain the same.

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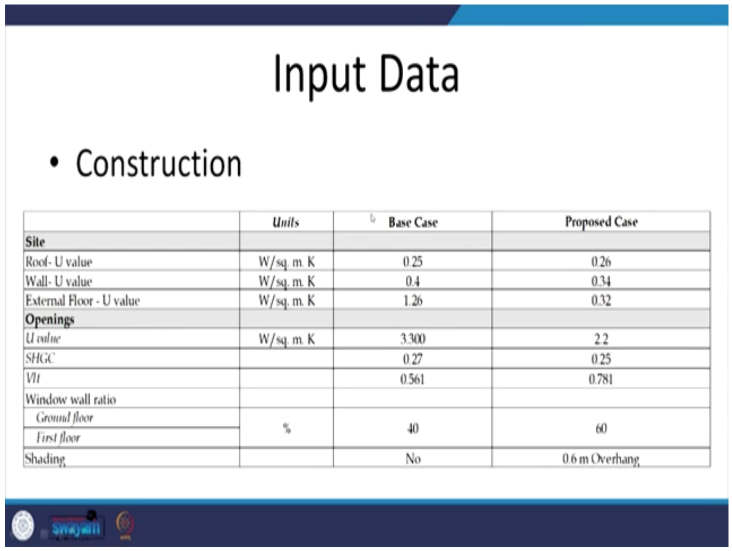

	Units	Base Case	Proposed Case
Site			
Roof- U value	W/sq. m. K	0.25	0.26
Wall- U value	W/sq. m. K	0.4	0.34
External Floor - U value	W/sq. m. K	1.26	0.32
Openings			
U value	W/sq. m. K	3.300	2.2
SHGC		0.27	0.25
Vlt		0.561	0.781
Window wall ratio			
Ground floor	%	40	60
First floor			
Shading		No	0.6 m Overhang

Now, one thing which will change and which we have already changed is the construction template. So, for the base case we have the values which are coming out of the code, in our case the relevant code was ECBC. So, the values which we have taken are from ECBC; however, for the proposed case we can change these values. We can change them to anything, but if you look at the values in the proposed case here, they are very similar to what ideally the base case should be.

So, in case of the roof U value instead of 0.25, we have proposed 0.26 for a wall U value of pro the base case as for ECBC instead of 0.4, we have taken a better base case a better proposed case which with 0.34 for U value so, which is even better.

Similarly, for openings fenestration, the U value has been further reduced from the base case 3.3 to 2.2 which implies that the proposed case should ideally perform better, as far as its overall energy performance is concerned; same as with SHGC and VLT. So, we have a better VLT which implies more daylight being available and a lower SHGC which implies lesser heat being brought in. However, what we have done here is we have increased the window wall ratio from 40 percent to 60 percent.

So, there are more windows and we have also added the overhang. So, this is what we have changed from the base case to the proposed case.

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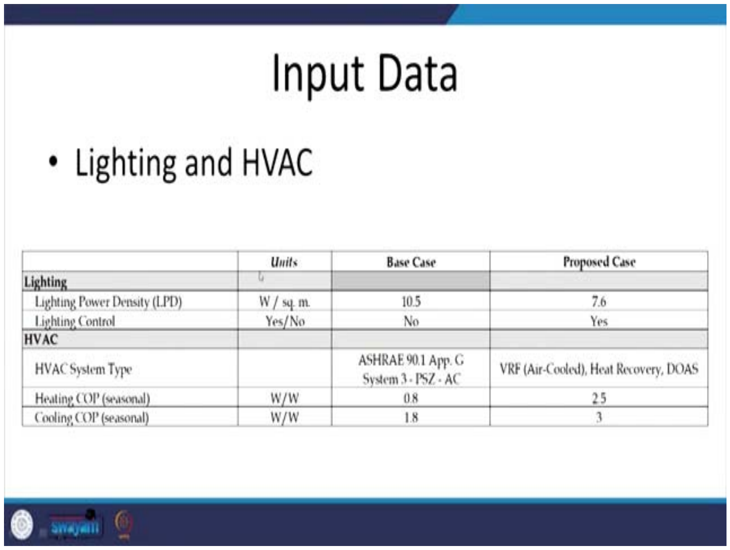

	Units	Base Case	Proposed Case
Lighting			
Lighting Power Density (LPD)	W / sq. m.	10.5	7.6
Lighting Control	Yes/No	No	Yes
HVAC			
HVAC System Type		ASHRAE 90.1 App. G System 3 - PSZ - AC	VRF (Air-Cooled), Heat Recovery, DOAS
Heating COP (seasonal)	W/W	0.8	2.5
Cooling COP (seasonal)	W/W	1.8	3

We also changed lighting and HVAC and we instead of the standard values which we got from the codes. We changed it to the technology which is available and the more contemporary numbers which are available in the market today.

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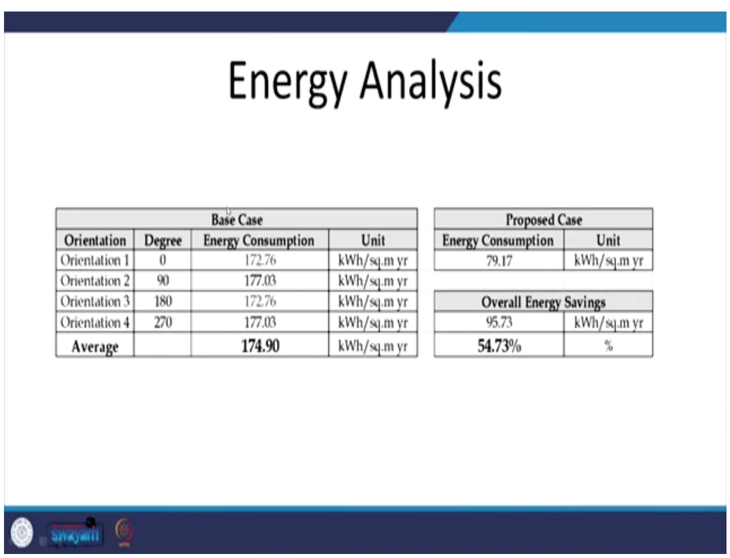

Base Case			
Orientation	**Degree**	**Energy Consumption**	**Unit**
Orientation 1	0	172.76	kWh/sq.m yr
Orientation 2	90	177.03	kWh/sq.m yr
Orientation 3	180	172.76	kWh/sq.m yr
Orientation 4	270	177.03	kWh/sq.m yr
Average		**174.90**	kWh/sq.m yr

Proposed Case	
Energy Consumption	**Unit**
79.17	kWh/sq.m yr

Overall Energy Savings	
95.73	kWh/sq.m yr
54.73%	%

Once we have done the base case and we also have the proposed case, we can do a direct analysis comparison between how the base case is performing or the proposed case is performing with respect to the base case, but to get a base case average we have to orient the building in all directions. So, the first case which we took was oriented 0 degrees. Let us quickly look at the design builder here.

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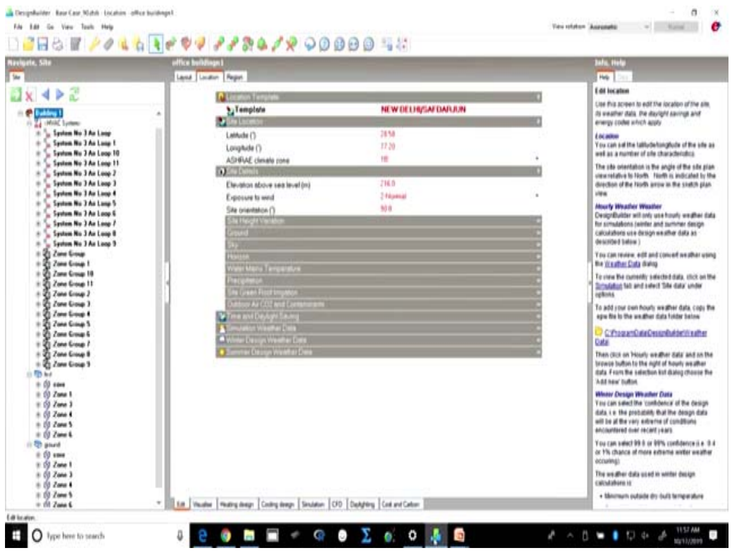

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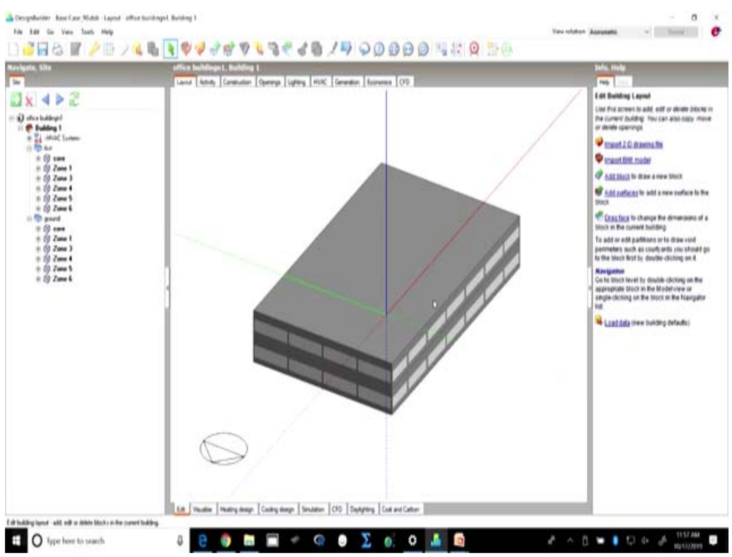

So, if you remember our building, the building was not oriented like this. This particular case is the base case 90 where we have already rotated this building by 90 degrees, at 90 degrees.

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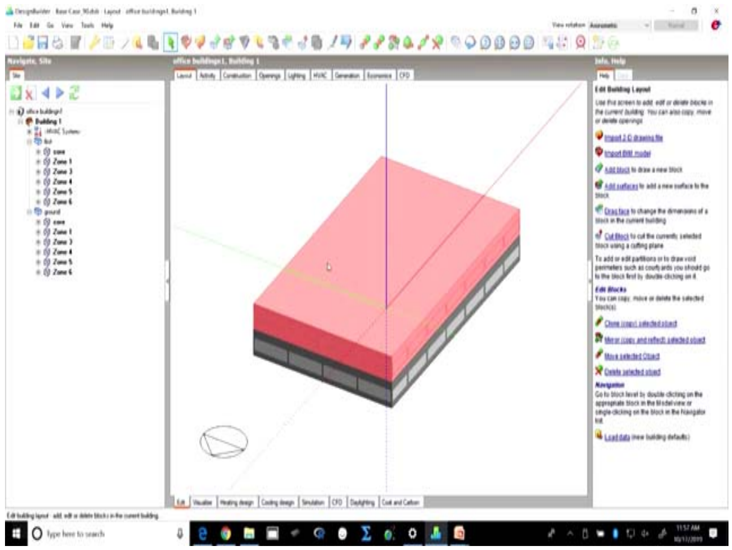

So, if you want to rotate the building, you can just copy the file the base case file which we have created.

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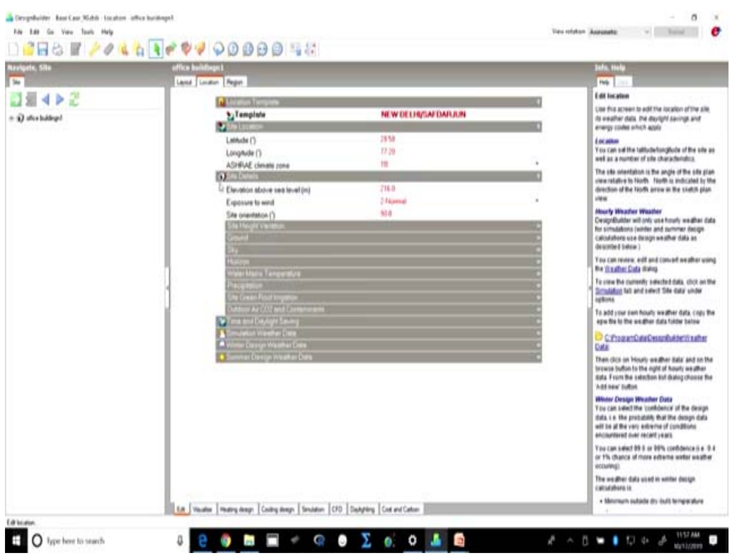

And we go to the location and inside details we can change the site orientation to 90 and we just keep everything else as the same and we simulated and we get the results; similarly, we will develop the cases for 180 degrees and 270 degrees as well. All the 4 cases and the average for them will be taken as the average energy consumption for the base case the EPI.

Here, if you can see since the building is a regular rectangle even after orienting it twice we would get the same values for 2 orientations and for the other 2 we get the same values and hence this average. So, in comparison to that the proposed case that we had taken gave us an energy consumption of 79.17 kilo Watt hours per square meter per year, which implies that there is an overall energy saving of around 54.73 percent which is a very good scenario.

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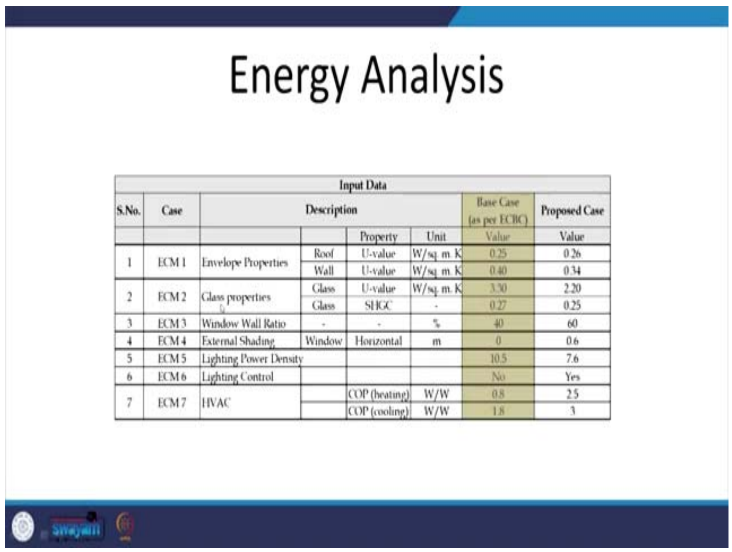

Input Data							
S.No.	Case	Description				Base Case (as per ECBC)	Proposed Case
				Property	Unit	Value	Value
1	ECM 1	Envelope Properties	Roof	U-value	W/sq. m. K	0.25	0.26
			Wall	U-value	W/sq. m. K	0.40	0.34
2	ECM 2	Glass properties	Glass	U-value	W/sq. m. K	3.30	2.20
			Glass	SHGC	-	0.27	0.25
3	ECM 3	Window Wall Ratio	-	-	%	40	60
4	ECM 4	External Shading	Window	Horizontal	m	0	0.6
5	ECM 5	Lighting Power Density				10.5	7.6
6	ECM 6	Lighting Control				No	Yes
7	ECM 7	HVAC		COP (heating)	W/W	0.8	2.5
				COP (cooling)	W/W	1.8	3

However, in real cases we may not be employing all the energy conservation measures which we implemented or added in the proposed case. So, if we look at the energy conservation measures we change the envelope properties, we change the glass properties, we change the window wall ratio, we change the external shading we added, we change the lighting power density, we change the lighting controls, we added the lighting controls and we also change the HVAC system.

Now, in real scenarios we may not really be requiring all these energy conservation measures to be incorporated. In fact, since each measure comes at a cost at a price, we might want to see what is the impact of this envelope this energy conservation measure on the performance of the proposed case. So, what we do rather is we add each energy conservation measure step by step.

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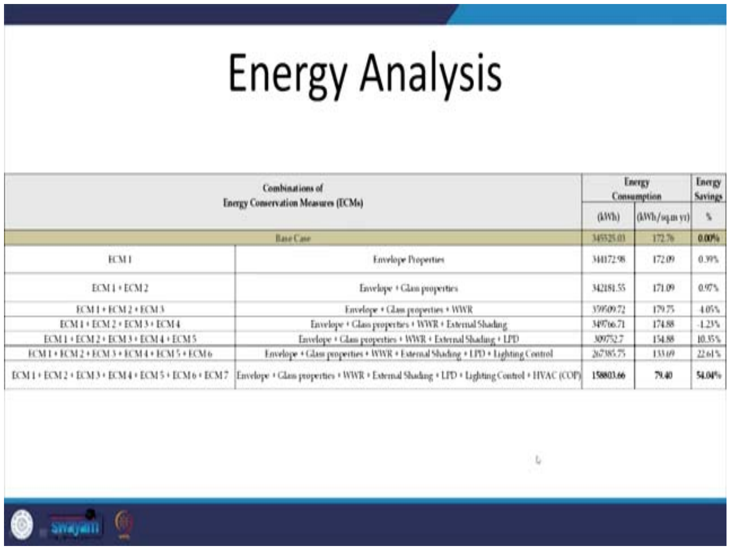

So, we start from a base case and then we start adding the energy conservation measures. So, what we have done here is if you do not consider these energy saving so far, but if we look at this matrix. So, what we have done is we have a base case which we have already shown how to do and then to the base case we add energy conservation measure 1 which was changing the envelope properties and then we simulated. So, we have already developed a scenario a case where the base case has been changed only or added with energy conservation measure 1 and then simulated it.

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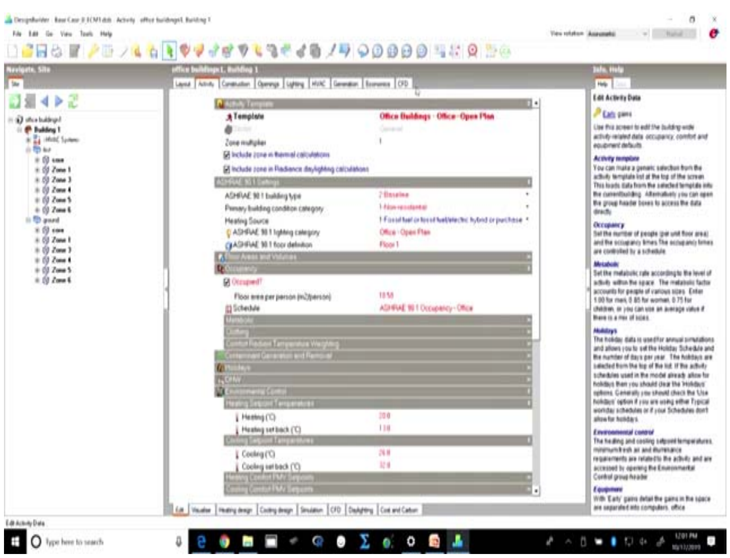

So, if you look here we have copied the same base case here and if we look at the different tabs, the rest of the properties they remain exactly the same as that in the base case and the only thing which will change here is the construction template.

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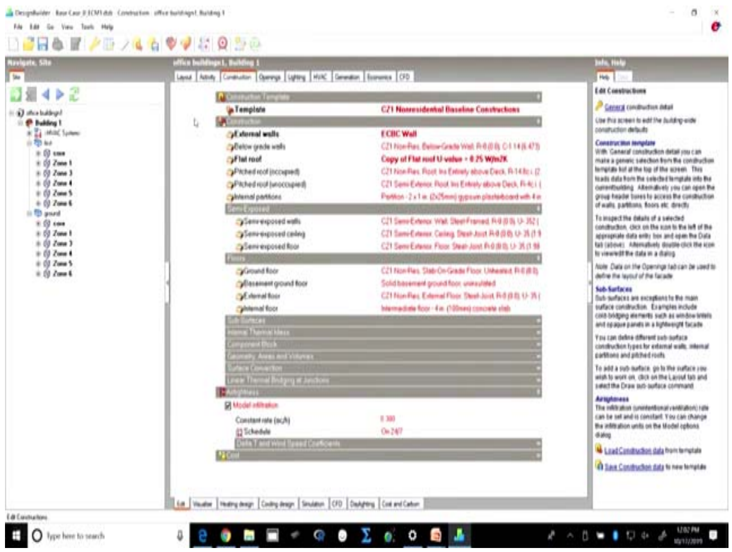

So, we change the construction properties. So, the flat roof U value and the wall U value. So, only these properties will change, if we look at the ECM 1. So, here the envelope properties, only these 2 properties have been changed to get the proposed case with ECM 1; so, base case plus ECM 1 is this.

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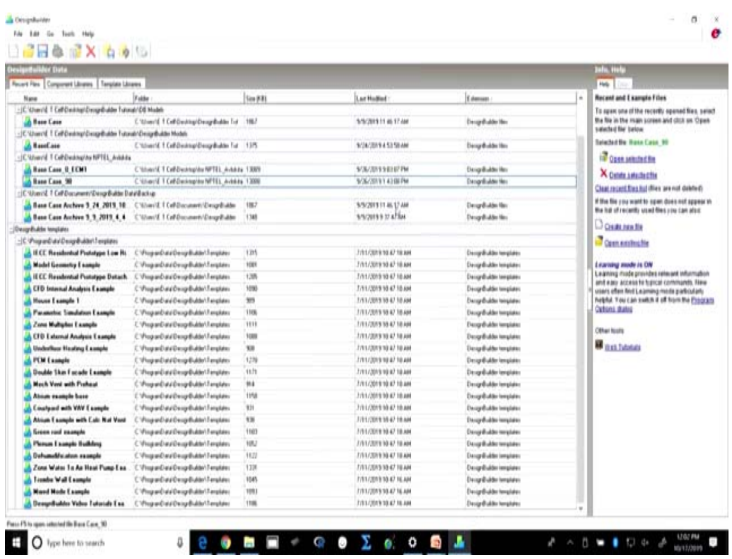

In a similar manner, we would then go to the second energy conservation measure which we have here. So, what we have done is to the base case and the ECM 1 case where base case at 0 degrees plus ECM 1 was there, we all we also added the ECM 2.

Now, ECM 2; so, the ECM 2 has glass properties changed. So, instead of the values for glass U value and glass SHGC, we have these values here for the proposed case. So, here we have also changed the glass properties which is the glass U value and glass SHGC.

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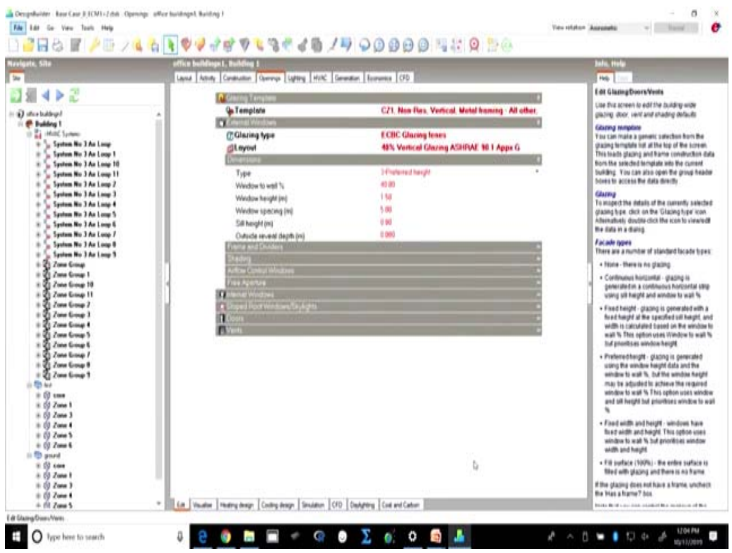

If we look at this particular case in openings, we have also changed the glass values. So, we have already changed the type of glass which is going to be used and here it will be changed with the values; so, ECM 1 plus ECM 2. We are continuously sim simulating them and the results are being recorded simultaneously.

So, we keep changing these values here envelope and then added glass properties in ECM 1 plus 2 plus 3, we add further the window wall ratio. So, instead of 40 percent which was taken as the base case, we now have taken the 60 percent and then the energy consumption for them be recorded here; the normalized value which is kilowatt hour per square meter per year and the overall energy consumption value. So, as we go ahead as we move on introducing each ECM measure.

Now, this is just one way of doing it we can have multiple permeations combinations. But, we can see that or we could also do it this way where we just have the base case plus ECM 1, base case plus ECM 2 only base case plus only ECM 3 and like that. So, we know the individual effect of this individual ECM or we could do it this way or we could have some other combination, but what it will give us is, what is the impact of this energy conservation measure which is here over the base case.

Now, if we see here, from the base case after adding energy conservation measure 1 which was the envelope property, we got a saving of only 0.39 percent. Now, it appears that the envelope properties do not have much impact, but if we look at the input data; if we look at the input data there is hardly any difference in the proposed case from the base case.

So, the base case is already at a very higher level, very good value which would be there. Conventionally, these values will not be available for having a roof U value of 0.25, you will have to add substantial amount of insulation to it. Similarly, for a wall U value achieving it at 0.4, we have to have good amount of insulation being provided here which will result in a high base case performance as we are seeing here, it is a good base case performance.

And on top of that if we have changed the envelope property slightly that is why it is not giving us much difference, much advantage over the base case. Here, in this proposed case we may decide that we do not want to add these envelope properties; we do not want to change the envelope properties at all, because the base case is anyways complying with it. Or, the other scenario could have been where we change the envelope property properties to make it lenient.

So, instead of a proposed case of 0.26 we might have had a roof U value of say 1.3 which is which is absolutely not good if we look at the base case values or the wall U value from 0.4 goes on to become 1.8 which is what typically we would get in a conventional building and then we simulate. So, here we would have seen that the performance dips down. So, it consumes more energy and there will be a negative number as far as energy savings are concerned; so, it consumes more energy.

If we look at this particular table we see here that the moment we increase the window wall ratio from 40 percent to 60 percent. We see a 4 percent dip in energy savings which means that this option with more windows more having added 20 percent WWR consumes more energy.

So, we know that higher WWR is going to result in more energy consumption. There could be another energy conservation measure here where instead of a uniformly distributed window wall ratio, we might have say the northern facade with complete windows.

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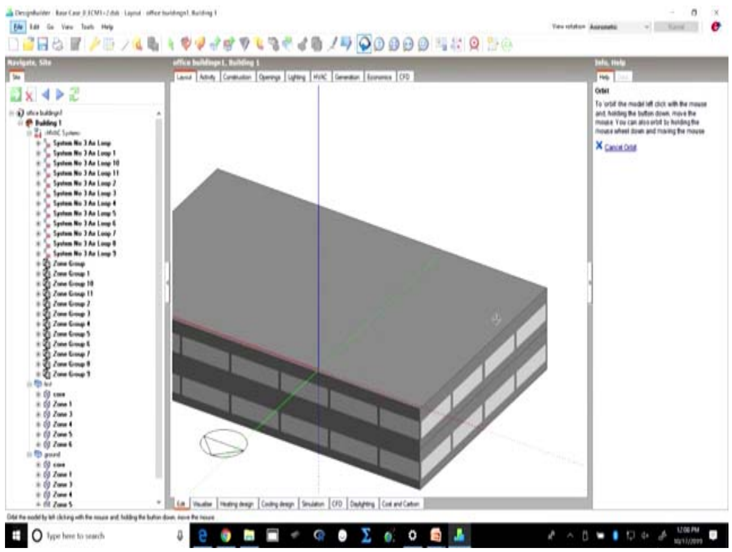

So, we might have the entire north facade, here with 100 percent windows.

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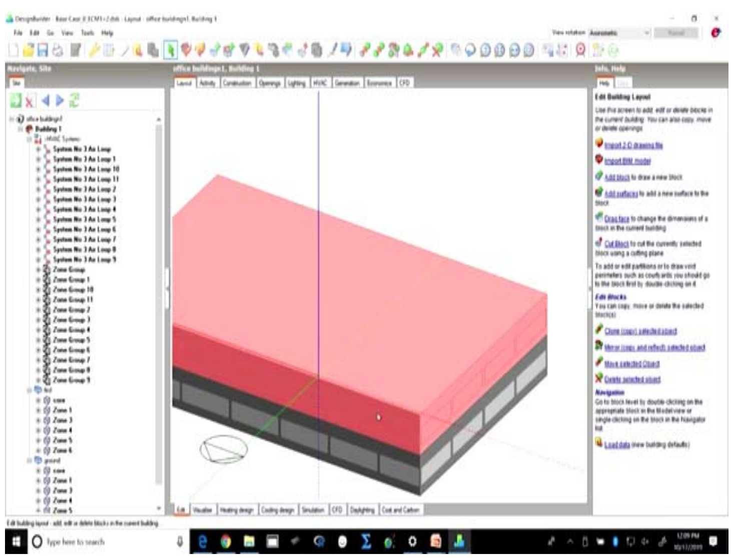

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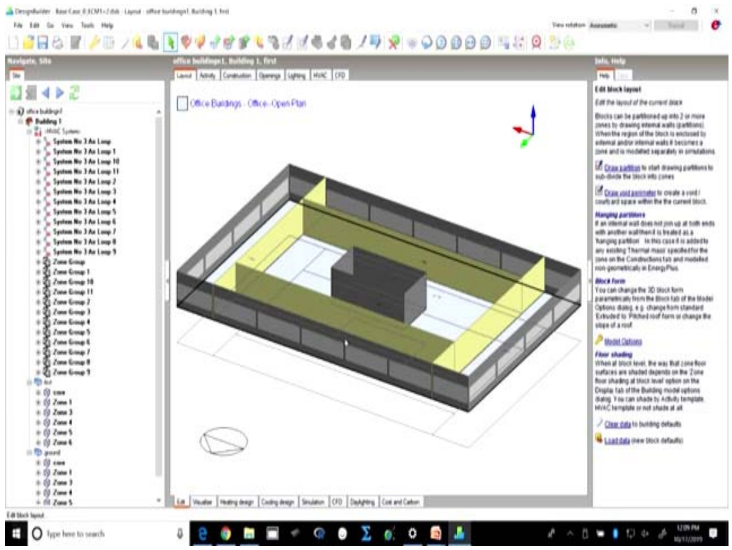

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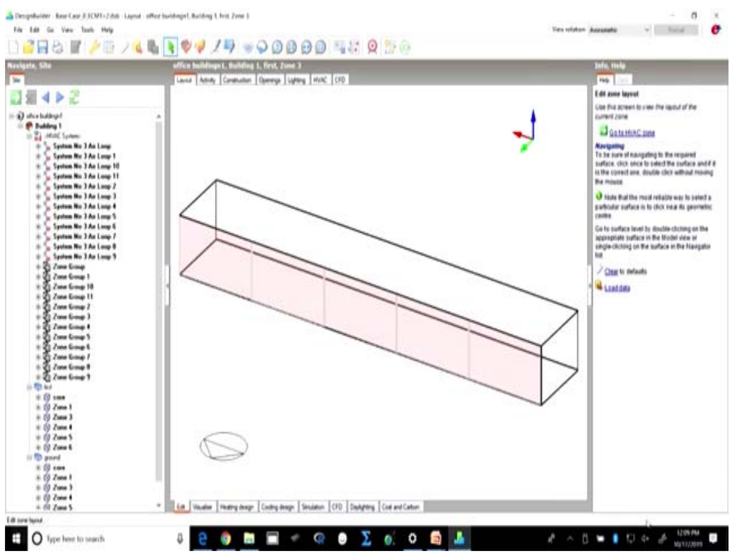

So, we can also change if we wish we can go to this individual wall, we can select a wall and we can change the openings on this wall. So, instead of 40 percent we can make the openings to say 100 percent, but this will be only for this wall. So, if you come back we can see that this entire wall has become a glazed wall.

So, it is 100 percent we can add all the zones we can select all these walls and make it 100 percent, we can totally remove the windows from here or we may reduce it to say just 10 percent. So, the overall WWR comes out to be 40 percent only, but the impact of it could be seen in the performance. So, we know that WWR matters and any design strategy towards WWR will be accounted for here.

The next what we did we added external shading to the increased WWR where we made it from 40 to 60 and we can see that immediately there is a substantial saving. So, just by adding external shading to all the windows, we have been able to bring it back to almost the same performance which was with 40 percent WWR and change the last properties.

Then next, once we have done with all the passive design parameters next we moved on to the lighting power density. So, if you remember we change the lighting power density from 10.5 to 7 point; so, we change the lighting power density from 10.5 to 7.6 and we can immediately see the savings being brought in. So, we have around 10.35 percent, 10.5 percent of energy savings being brought just by reducing the lighting power density and it is very easy today.

So, in any case we have to use artificial lights, but instead of using the conventional lighting system we may go in for lights like LED which have which have better efficiency. On top of that if the lighting controls are added, we get an additional saving of around another 12 percent. So, we can see that lighting controls, they are equally contributing as LPD the change in lighting power density towards bringing energy savings energy betterment of energy savings.

And, the last where we change the HVAC system because it was considered to be an energy an air conditioned building and the moment we change the HVAC. And, we just change the coefficient of performance and selected a better system, a better performing system which had higher efficiencies and coefficient of performances, we can see that there is an additional saving of almost 30 percent which is a huge saving.

So, we see here that all these systems, all these energy conservation measures have the contribution to towards energy savings. Now, once we have completed all this exercise, it could be done individually or in groups or whichever way you want, but you will be able to have a good idea of how this energy saving is happening.

And simultaneously, we can take we can take the cost impact. The capital requirement for adding each one of this energy conservation measure and we can compare whether the cost which is incurred in installing each of this energy conservation measure is worth looking at the energy savings they bring about with them.

So, maybe that we would decide that we really do not need to increase the WWR from 40 percent to 60 percent we might rather do with 40 percent WWR or we may distribute it differently like on individual facades. LPD comes at a very reasonable price it comes at a very little capital investment and similarly lighting control, they require a little more capital investment, but the percentage of saving is that it brings along is tremendous it is huge. So, we make a wise judgment of how much of energy savings will be brought in vis-a-vis the capital investment which is required for each of these energy conservation measures.

So, we will stop here today and we will continue with a few more tools which are available as part of the whole building simulation using design build up. So, thank you for a very much for being here with us today and see you again tomorrow and where we will be continuing with the software only.

Thank you.