Glass in buildings: Design and Application
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Lecture – 14
Design Tools for Glass Section

Daylighing analysis; so we have considered the geometric design aspect in the sun path by a studying the shading etcetera. And we also know by the impact of glass on your energy savings by using your whole building simulation.

Next comes your visual comfort; where you need to have daylight natural daylight enter into your building through your building openings in your building envelop.

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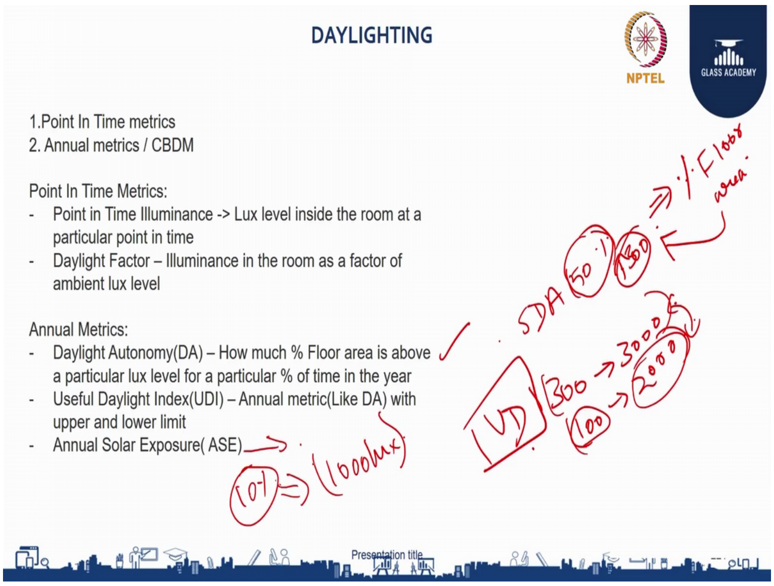

So, there are different metrics to understand that of in daylighting. So, the different daylighting metrics are listed here. So, there are two types broadly we can define; one is a point in time metric for example, what is a daylight metric at a particular point in time say 21st September 12 p m ok. So, that is a point in time metric and the annual metrics which considers the entire year into your simulation, and it let us know how much will be the daylight that is coming inside.

So, let us see one by one, first in point in time metrics. One typical you know metric that is used often this year point in time illuminance where you will understand how much is the lux level in your floor plate or your working plane at a particular point in time.

And next is your daylight factor. So, a daylight factor has a very clear ex explanation I will give you in the next slide. So, to be to understand it roughly, it is nothing, but your how much light illuminance is there inside your building compared to the illuminance outside. So, this is just for your rough understanding. So, it is a percentage it is a factor it is a percentage represented in percentage.

Next is your annual metrics, where we have three annual metrics here one is your daylight autonomy, second is your useful daylight index and annual solar exposure. So, daylight autonomy is nothing, but how much percentage of floor area gets a particular minimum lux level, when you run the simulation for the annual. Say for example, saying that at least 50 percentage of the time of the year your floor area should get above 300 lux. So, this is a daylight autonomy criteria given by a rating system. So, you need to understand that using a simulation. So, that is your daylight autonomy; so for example, ICA SDA 50 percent 300. So, this is nothing but for 50 percent of the time that you are running a simulation, how much percentage of floor area gets a lux above 300. So, that is your SDA ka understanding. So, this is your daylight autonomy.

So, next is your UDI. So, I have said that this is 300. So, when this is having an upper limit; so from 300 to 3000 or say from 100 to 2000. So, what is the percentage of floor area when it runs a stimulation for so much has of time that is your useful daylight index.

So, as the name suggests this is the range which you can understand as useful daylight when it goes below your 100 lux it will be very dark. If it goes say above your 2000 or in the range of your 2000 or 3000 you will have some visual discomfort because the contrast ratio will increase. So, from when you are viewing from one point to when you are seeing a 2000 or 3000 lux. So, you will have face a high contrast and you will face some glair. So, that we say as visual discomfort.

So, the useful lux level is between this range. So, that is why it is called as a useful daylight index. So, the difference between your daylight autonomy and is that daylight autonomy has only one limit threshold whereas, your UDI has a lower and an upper threshold and another one is your annual solar exposure. So, this is a particularly important in your lead rating, where they say that the max they said the maximum limit. This is like your minimum limit say 300. So, that should satisfy and the maximum limit should not go beyond 1000 lux. They say that when you run the simulation not more than 10 percent in the particular lead rating they are saying that, not more than 10 percent of the floor area should have above a 1000 lux level for wa say 250 hours of the simulation. So, that is what is annual solar exposure.

So, roughly you can understand. So, annual solar exposure is some the percentage of floor area that will undergo some discomfort. So, that is your rough understanding. So, these are the different metrics let us see some detailed analysis.

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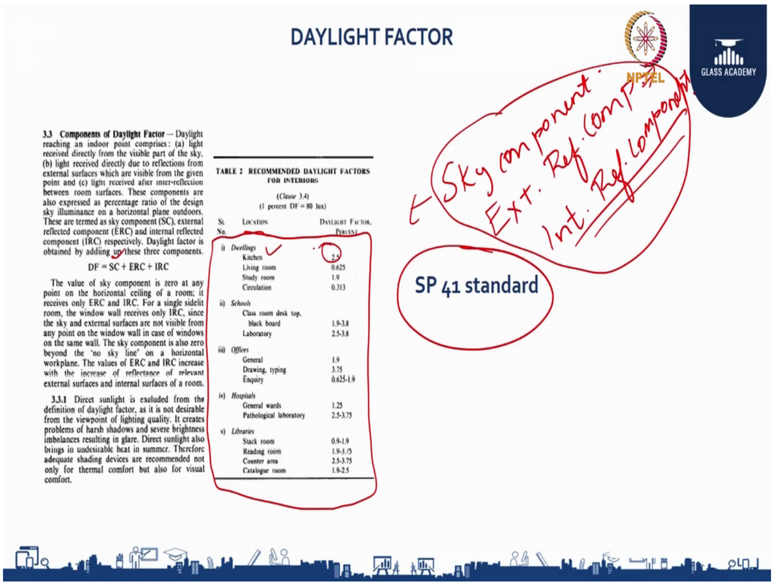

So, first is the daylight factor. So, there is this standard called SP fa 41, which gives you a detailed calculation of daylight factor.

So, in daylight factor there are critically three components one is your solar components, this is a sky component, next is your external reflected component another one is your internal reflection component. So, this is what we get as direct sunlight from the sky and this is nothing but the illuminance that you get because of reflecting surfaces from the outside and this is because of the illuminance you get from the reflected surfaces on the inside of the building.

So, they have given a detailed calculation you can refer to this standard for how to calculating the how to calculate the daylight factor in a particular room and they have also given some thresholds as to what will be the comfortable daylight factor.

For example if you take a kitchen and you calculate the daylight factor as per SP 41. If you have 2.5 as your daylight factor it is comfortable. So, this is what your SP 41 deals with when it comes to daylighting.

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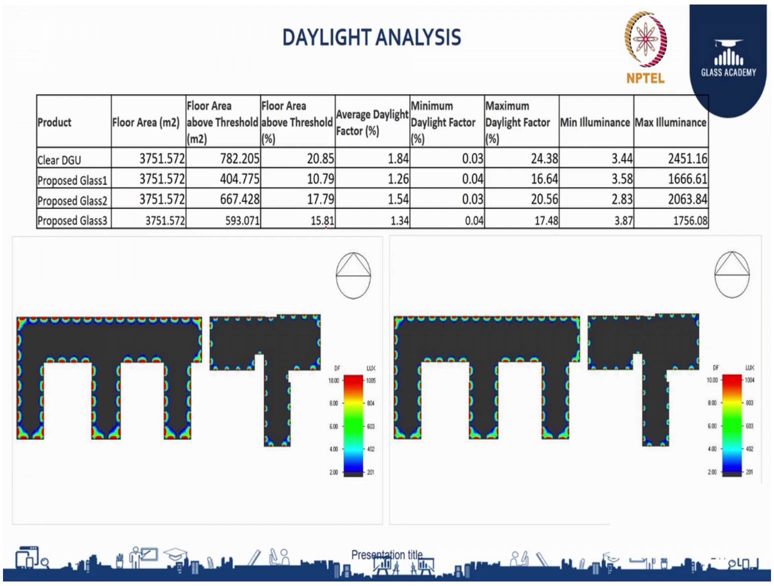

Product	Floor Area (m2)	Floor Area above Threshold (m2)	Floor Area above Threshold (%)	Average Daylight Factor (%)	Minimum Daylight Factor (%)	Maximum Daylight Factor (%)	Min Illuminance	Max Illuminance
Clear DGU	3751.572	782.205	20.85	1.84	0.03	24.38	3.44	2451.16
Proposed Glass1	3751.572	404.775	10.79	1.26	0.04	16.64	3.58	1666.61
Proposed Glass2	3751.572	667.428	17.79	1.54	0.03	20.56	2.83	2063.84
Proposed Glass3	3751.572	593.071	15.81	1.34	0.04	17.48	3.87	1756.08

So, we can go through that and one more option instead of the manual calculation given in SP 41 is your analysis. So, your there are many tools available which can tell you what will be the daylight factor and what will be the lux level when you simulate for a typical floor. So, I will take you through one such case study.

So, I am opening a new ecotech project and I am just modeling a small room.

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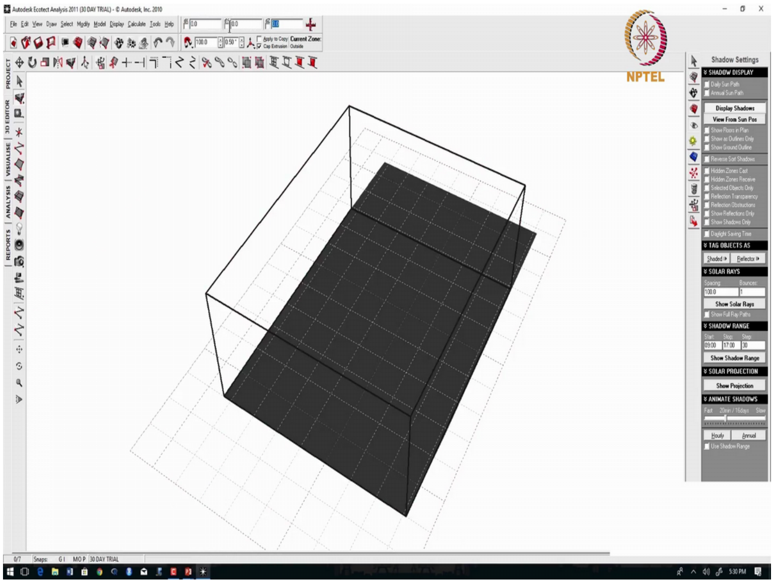

So, I am giving an extrusion of say 4000 mm say the floor to floor height you say 4 meters.

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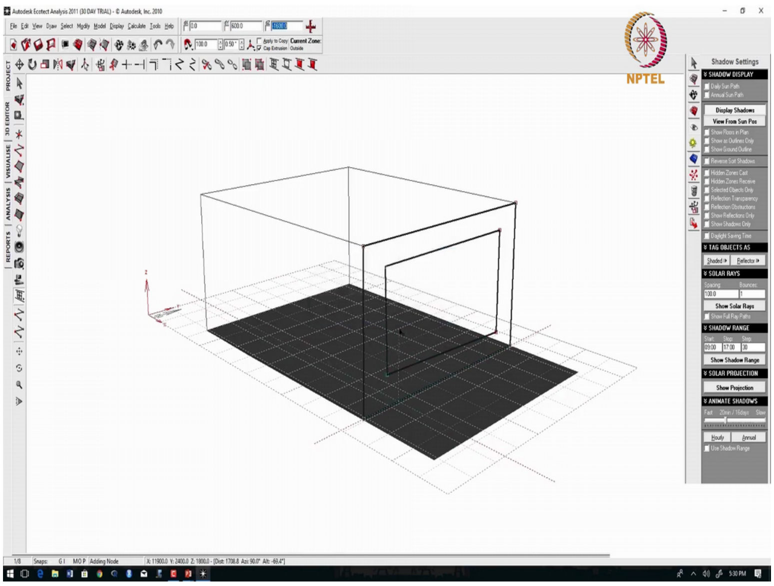

And I am going to model a window. So, I will just made a rough model of a window. So, I can go to visualize and see.

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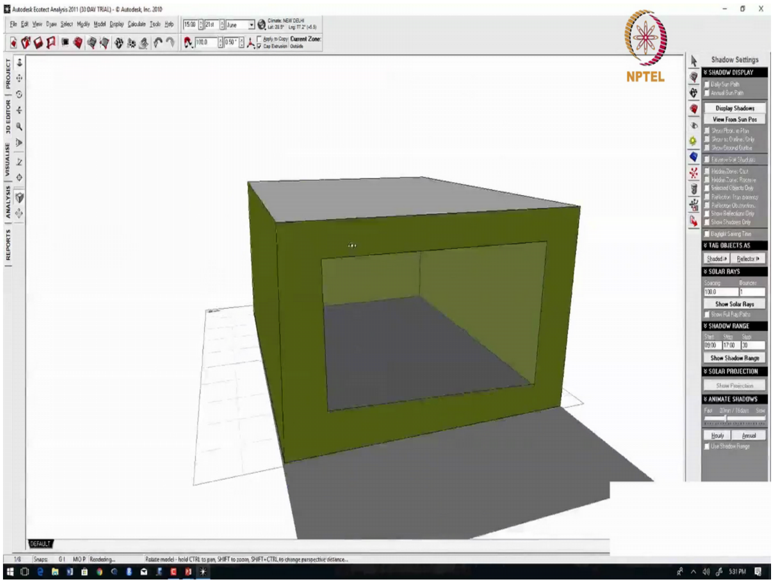

So, this is a window that has been modeled. So, I can go and set the visual light transmission. So, I am selecting that window go into materials.

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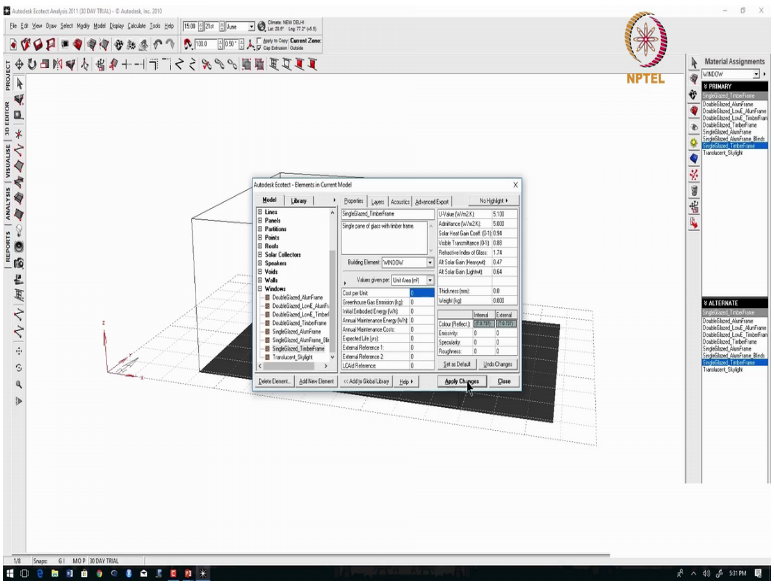

When I double click on it you can see all these properties over here. So, in this I am entering the visual light transmission say 0.8. So, this is a vlt of single glaze clear glass.

Now, I am selecting the floor plate and I am going to give the analysis grid.

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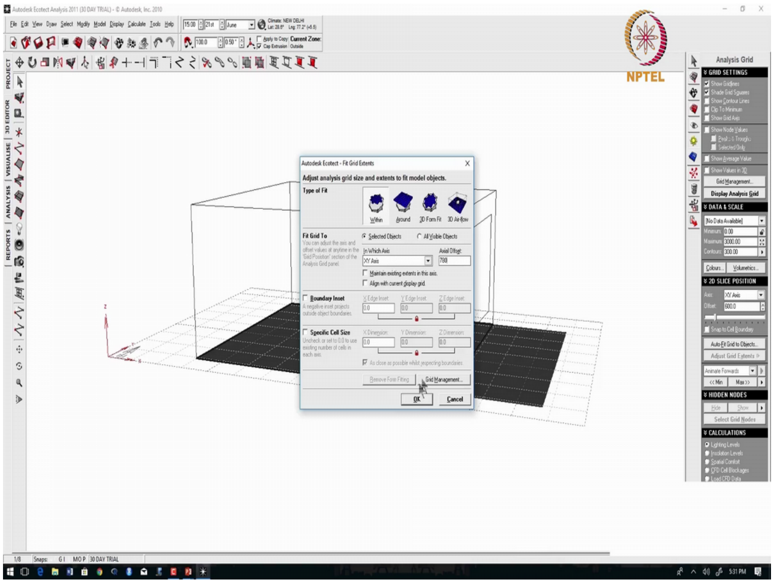

So, here you can see that part of it grid objects. So, here I am going to give the working plane say 780 mm.

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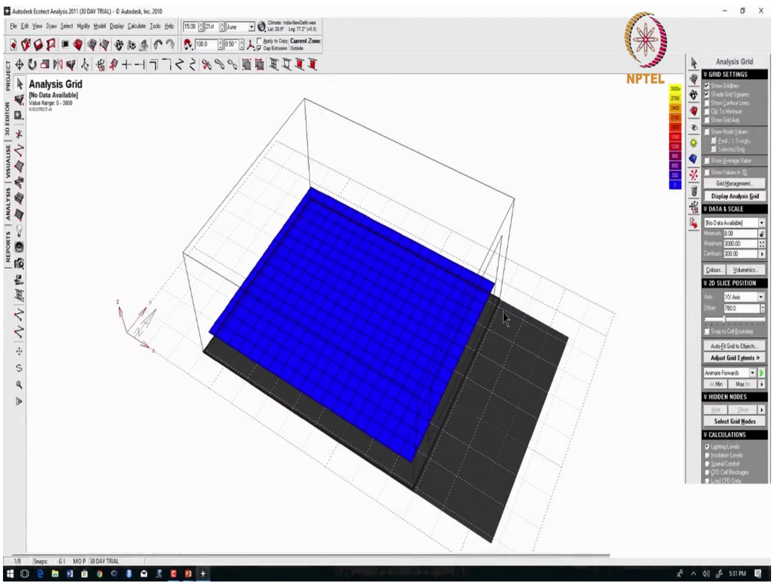

So, I can see a analysis grid here.

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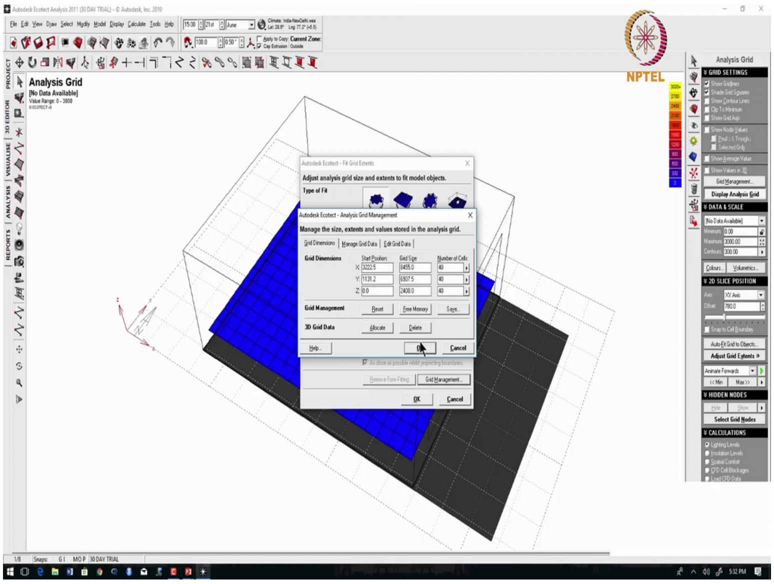

So, I can also increase the number of you know the grids that are going to come inside say I am going to give 40 ok. So, you can see that the grid has resize depending on what I gave as inputs.

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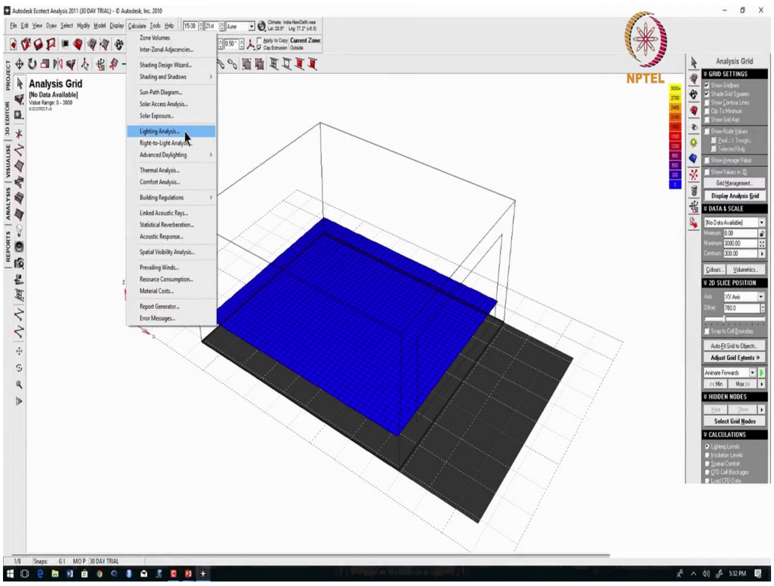

And now, I am going to run a small simulation calculate lighting analysis.

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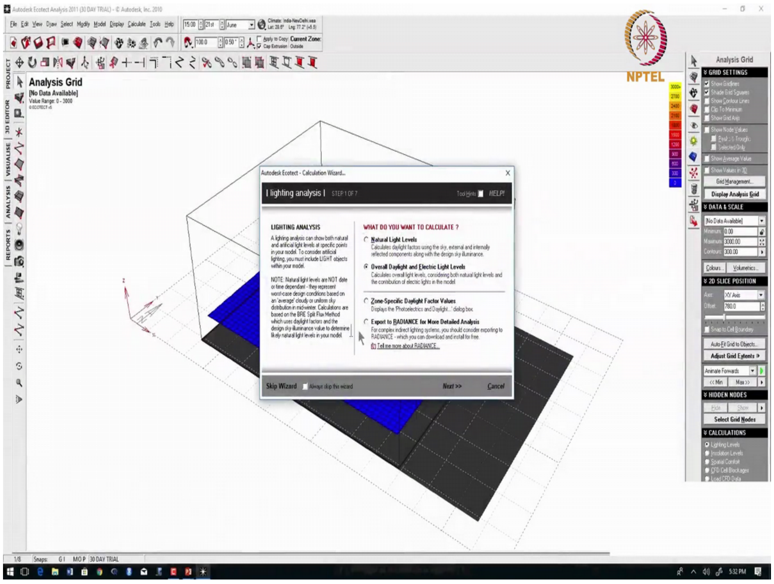

So, there are two options: this is directly doing in ecotech and this is through radiance. So, for this you should have installed this plug in called radiance.

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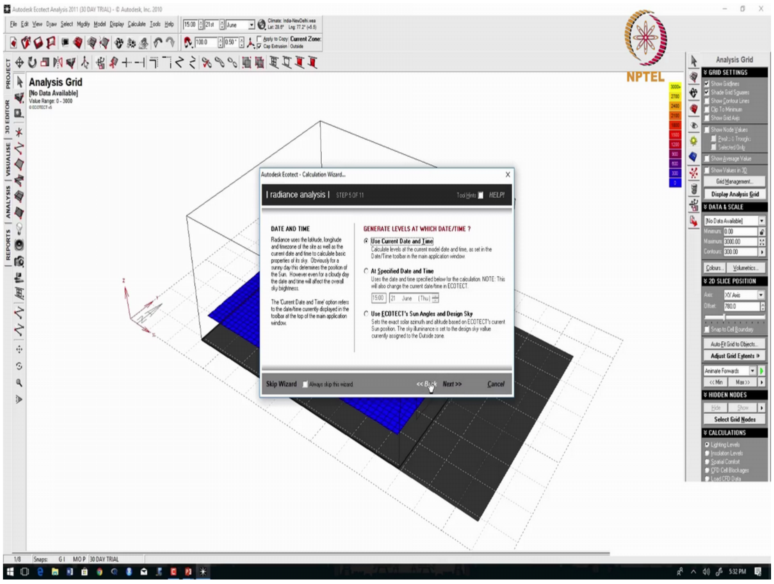

So, I am doing for the sunny sky, let us see; what is the lux level. So, I can also select what is the time I want the simulation say 12th September; 12th September 21st September and 12 hours.

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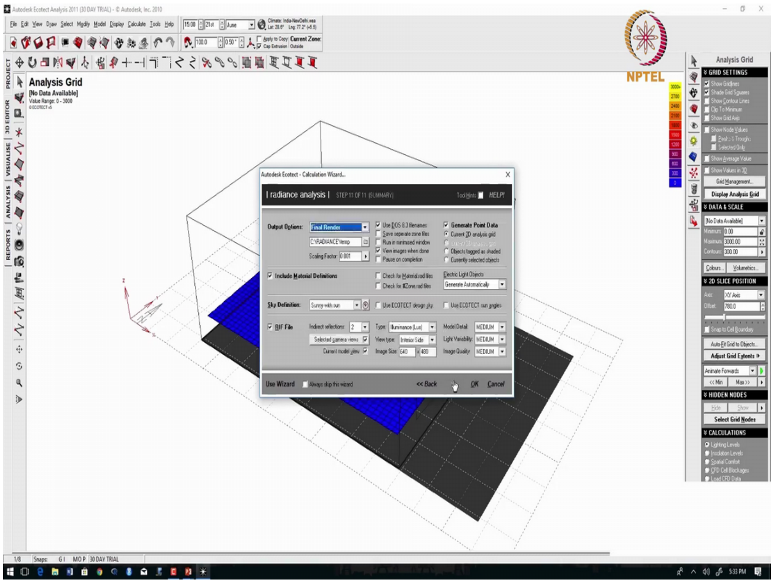

So, this is the setup of we are setting up this tool radiance. So, for detailed you know tutorials you can refer to the link that I have given.

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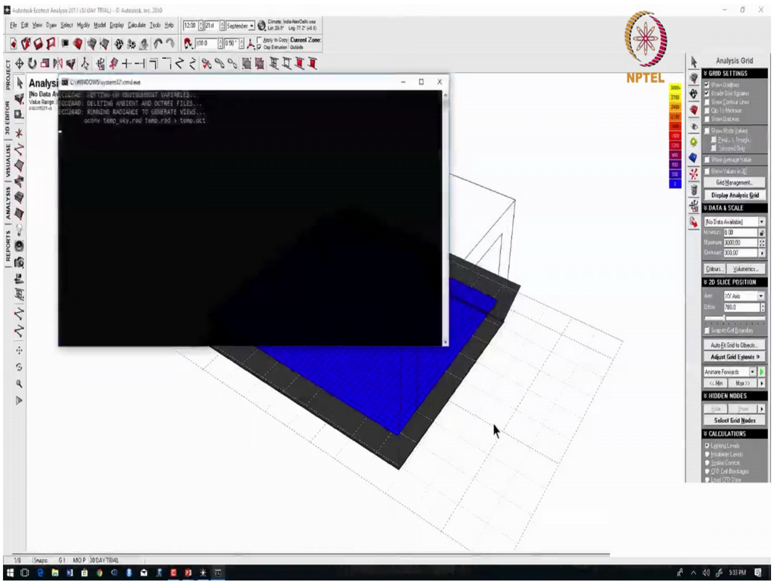

So, it runs in the background, the radiance engine is running in the background, but the modeling we have done in ecotech. So, there are many other tools that you can use for daylighting, but radiance is something that is freely available.

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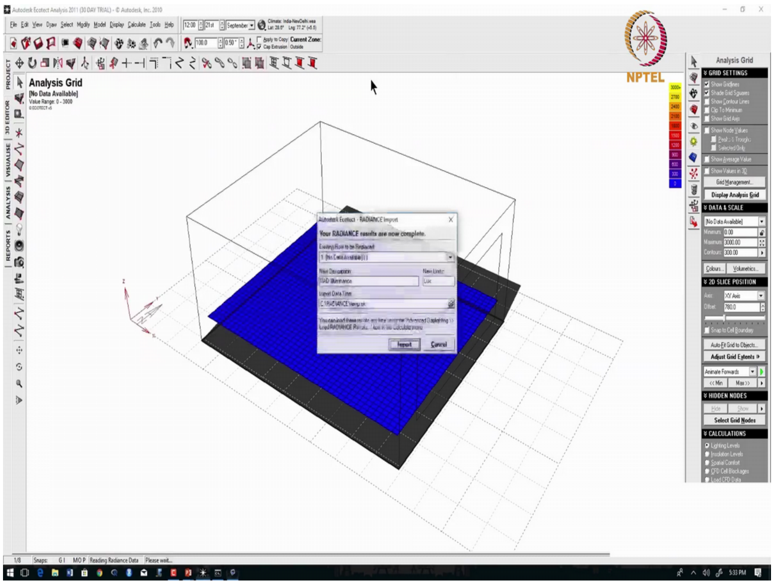

I think ecotech currently it has been stopped, there are many other alternatives for doing this analysis as well

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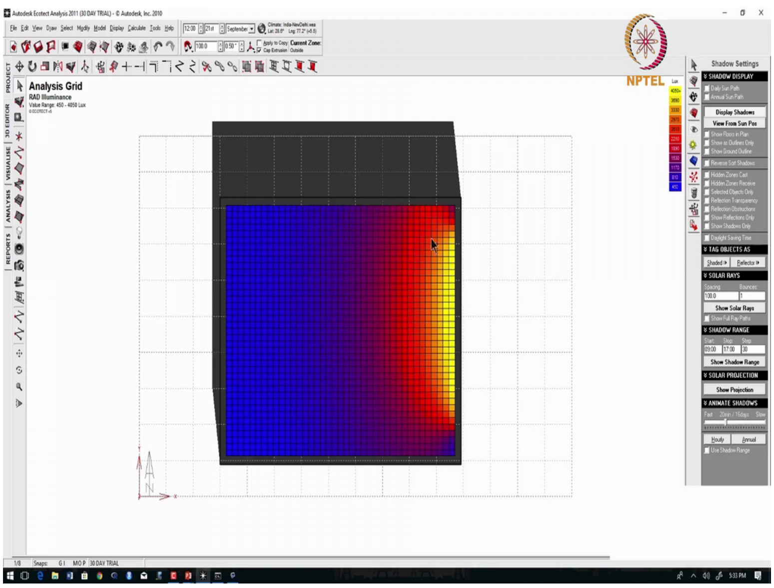

So, once it is imported, you can see that from the window the maximum lux goes as high as 4000 lux. So, I can even go and change see how much area is above a particular lux level. So, here I am giving flip to threshold. So, the average lux level is 1300 and 100 percent of the area is above your 110 lux.

So, next say I want to see for 2200 lux.

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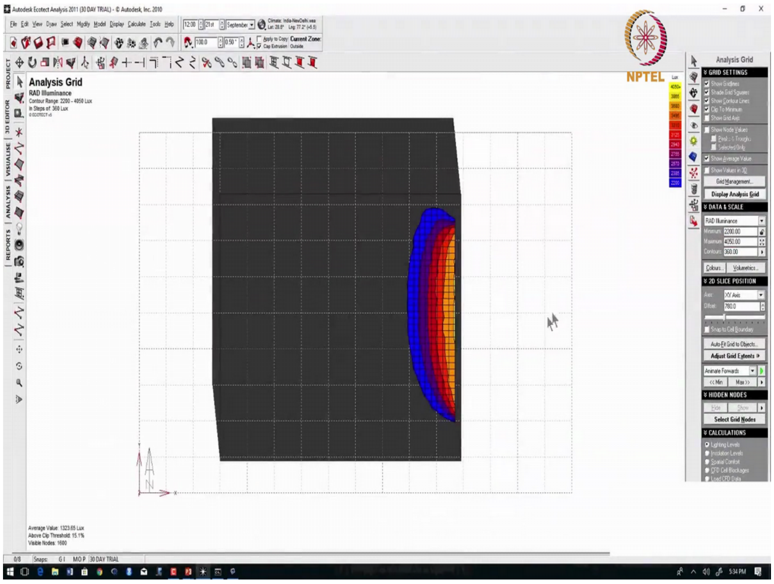

So, here you can see that 15 percent of the area is above 2200. So, this type of analysis is point in time analysis, because we had a particular time point in time which is 12 hours on 21st September; and we understood how much is the average lux level when we use clear glass.

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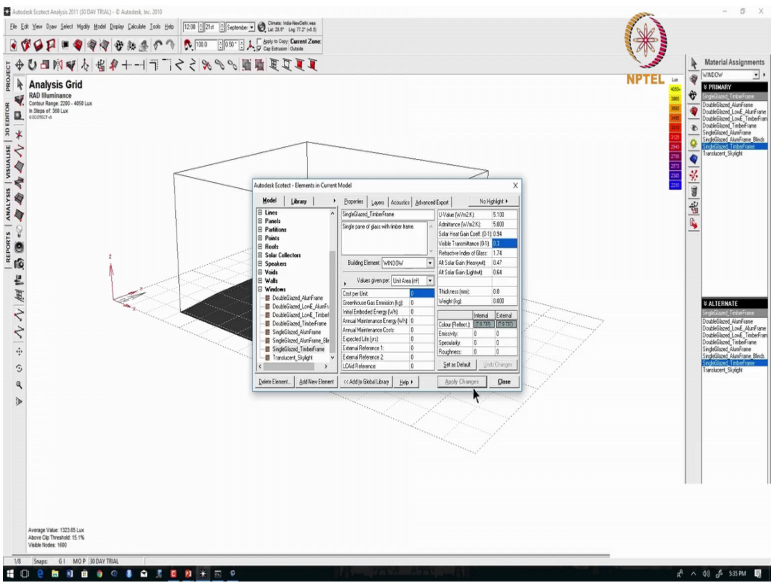

So, now we can just run the simulation for a different coated glass. So, again I am selecting this glass going to materials double clicking here say that the selector coated glass has a vlt of say 0.3 right. So, again I am selecting this floor plate and I am going to redo the analysis.

So, now you can see on the left hand bottom that the average lux level has gone down from as high as 1300 lux to around 388 lux. And also you check; how much is the area that is above 110 lux. So, almost 100 percent of the areas above 110 now I am giving 2200.

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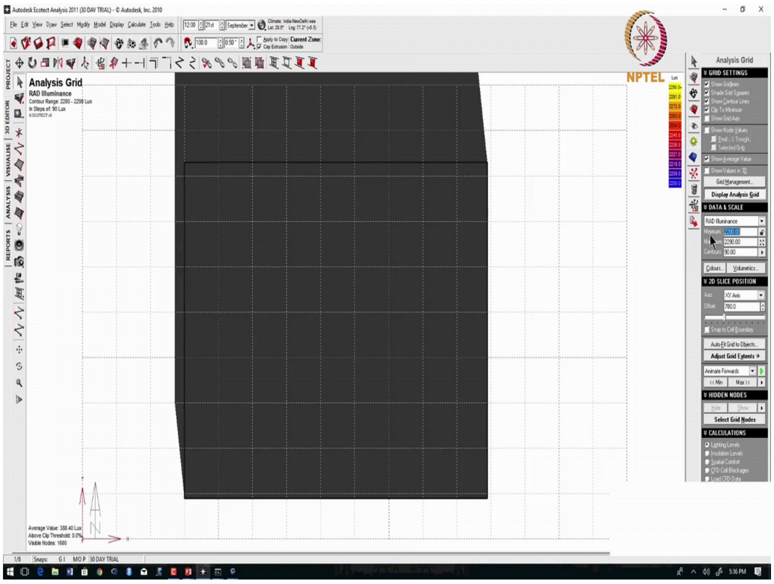

So, 0 percent of the area is above 2200 and one more check we can do say 1100 we can check about what lux level.

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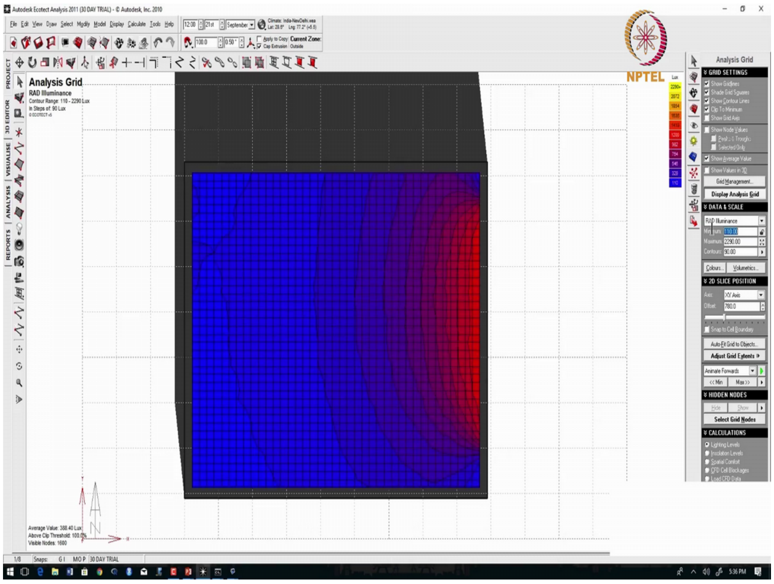

So, your maximum lux level goes up to 2000. So, what is the takeaway from here is like when we use different visual light transmissions we can understand; how much will be the average lux that is entering inside and also understand the distribution of light.

So, here it is showing a small gradient, where 110 lux is shown in blue and as we go higher the maximum lux that comes here is in the range of 700 to 900. So, you can see the color coding here and it might go as high as 1000 lux level. So, depending upon your location depending upon the orientation we need to change different vlt ranges and check; which is the comfortable range

So, how do we know this range which is comfortable or not?

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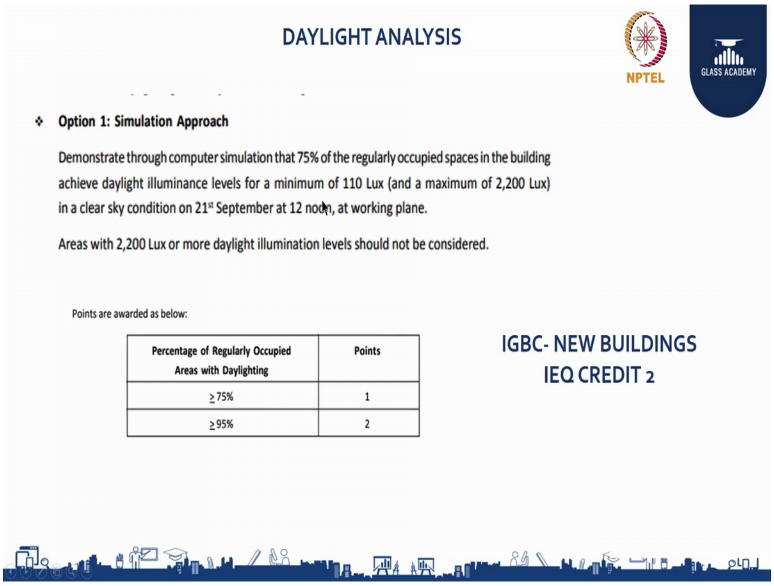

So, for that we have some directions from you know the green building rating system or some common rating systems, which tell you what will be the comfort level. And above what point if you above what particular threshold if your light is coming inside you will get some points.

For example this is one such criteria from IGBC, which says that demonstrate through computer simulation that 75 percent of the regularly occupied spaces in the building achieve daylight illuminance level. For a minimum of 110 lux and a maximum of 2200 lux in clear sky condition on 21st September at 12 noon. So, this is what we have done? So, we have taken the working plane which is around 780 mm and we had set the date to this particular day, and we set these two thresholds calculated how much is the area percentage area.

So, in the first case it was in a different level and in the second case it was in a different level, from that we can understand which product we will satisfy or the which vlt range we will satisfy this particular requirement.

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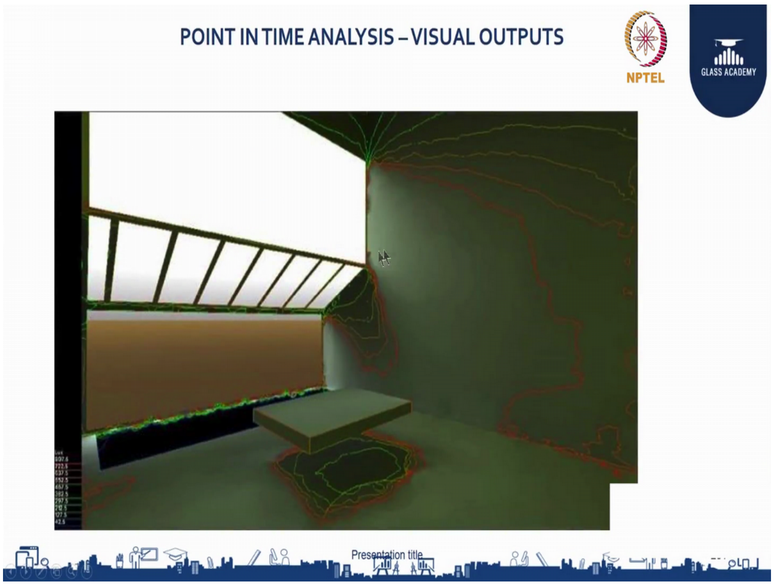

So, this kind of visual outputs can also be taken, to understand what will be your contour lines at different areas from a three d point of view for example, here you can see that the different areas in the wall get, different dispersions of the lux level coming inside. So, here we have the legend say for example, this is this area is getting around 900 lux whereas, it is going down as we go towards the center. So, this is one output that we take out of radiance.

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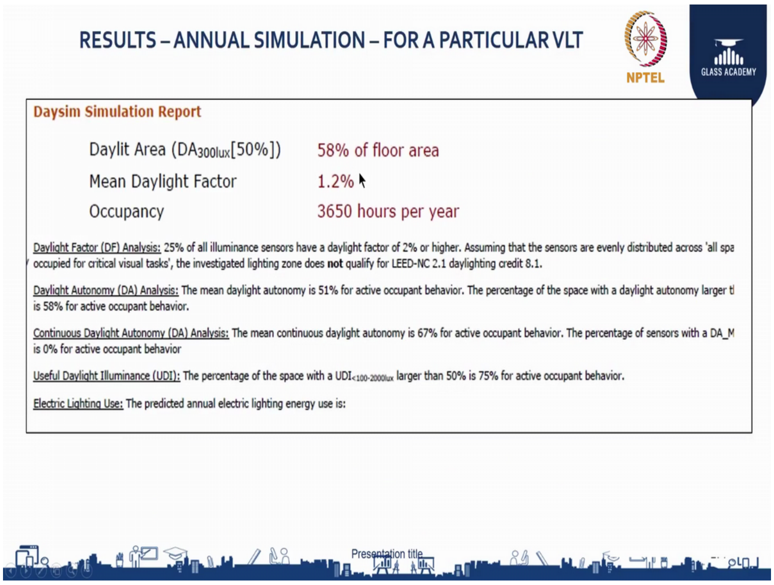

So, next is your annual simulation this is quite similar, but you depending upon the definition we get the output. So, for example, you want the daylight autonomy for 300 lux and 50 percent of annual hours, you can understand how much percentage area is getting this condition. So, this is an output from daysim. So, daysim is a software that will give you annual simulation. So, radiance this is a again radiance you can use for point in time simulation daysim is more helpful in terms of your annual simulations.

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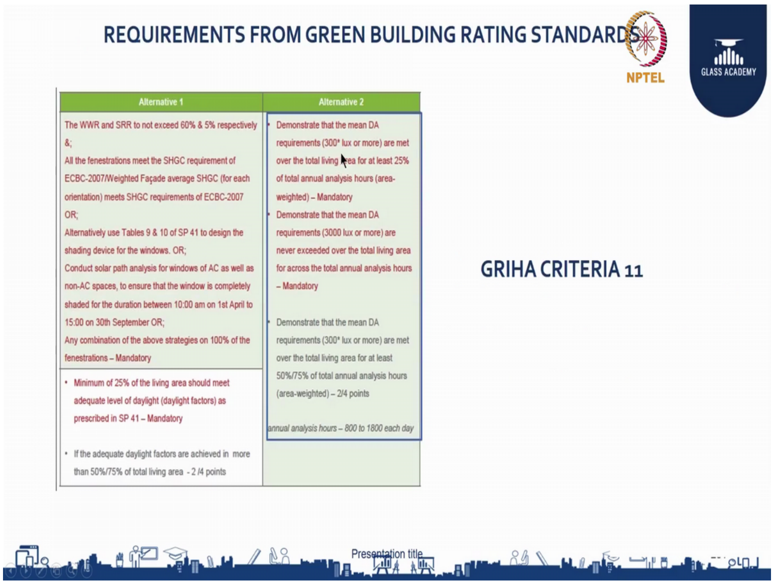

So, why this annual metric is important? You can see that this is again another snapshot from a green building code on the right there are two alternatives to achieving it on the right side. They have given the alternative saying three 100 the daylight autonomy of 300 lux or more should be the met in your living area for at least 25 percent of your annual hours. So, depending on this you can run a simulation and see how much percentage is satisfying these criteria.

And they have also given a upper limit, it should not go beyond 3000 lux. So, when you go beyond this 25 percent say 50 percent or 75 percent you get more points.

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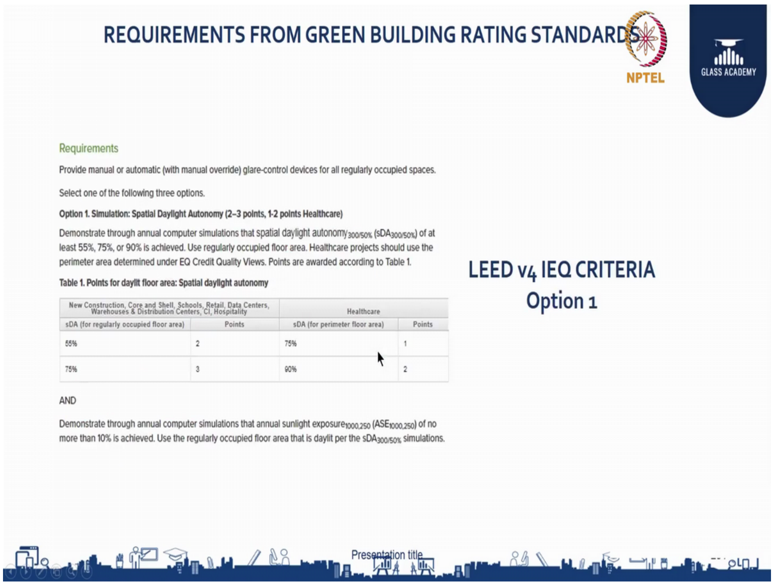

And this is one requirement from USGBC leed which talks about the same 350 and they are saying that it should be 55 percent 75 and 90 percent for different types of you know the different types of buildings like new construction or core and shell this is their typical rating system different rating systems are there, for schools they have a different rating system etcetera. So, for that if you get 55 percent and above, you get two points and 75 percent and above you get three points. So, this is these are all examples of different rating systems and how what importance they give for this kind of daylighting indices

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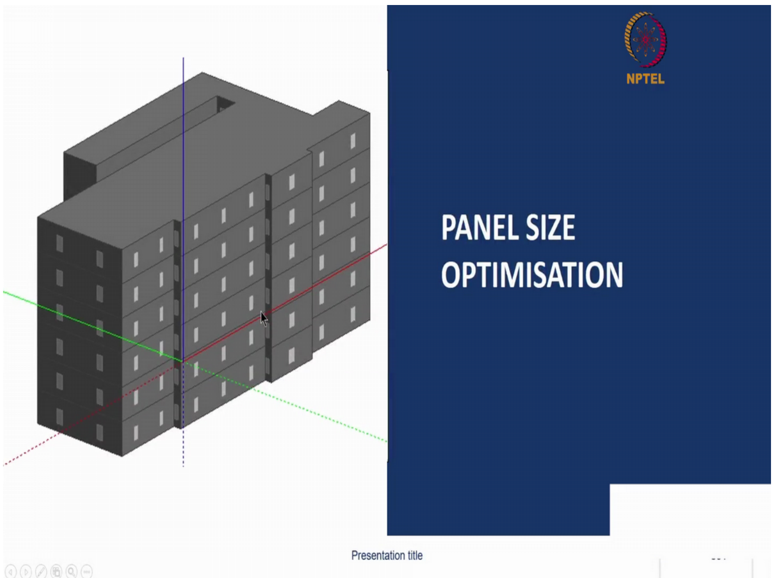

So, this is the end of your daylighting and next we enter into an interesting topic called panel size optimization. So, now, we have decided from the sustainability point of view with the you know glass that I am going to use; whether it is going to be a coated glass of solar factor of. So, and. So, range. So, that I achieve my green building requirements or you get a comfortable lighting inside; so based on that you have decided on vlt solar factor etcetera.

Next comes a geometric properties which is your panel width panel height and your panel thickness of each glass.

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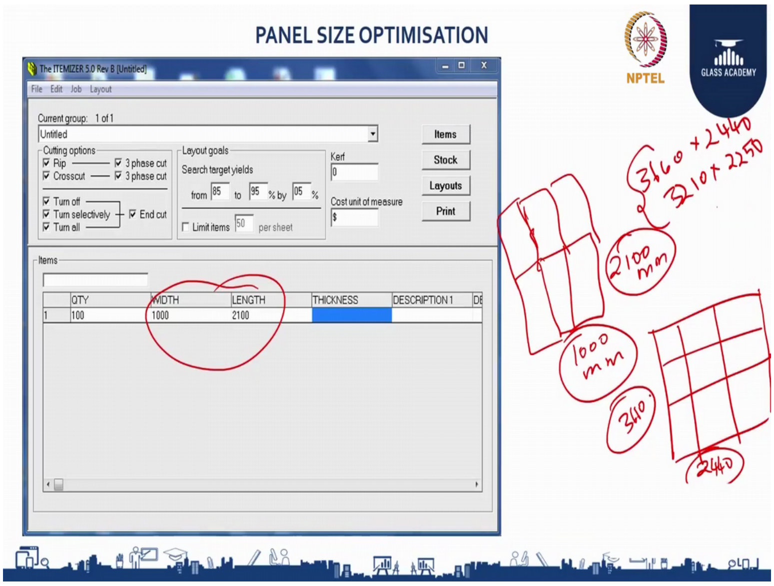

So, why this is a criteria because depending on the panel size that you are using in a building the wastage that is going to incur from the panel size made by the manufacturer can be impacted. So, for example, I am taking a 1000 mm by 2100 mm panel. So, this is the panel that I am going to have throughout my building say 100 such panels are going to come.

So, I have to cut this 1000 mm by 2000 on 100 mm from the sheet size supplied by the manufacturer, but the manufacturer will manufacture only in standard sizes say for example; one size is 3660 by 2440 say another size is 3210 by 2250. So, this is bigger or smaller. So, adjust that. So, based on this you need to cut. So, this 1000 mm by 2000 100 mm has to be cut from different sheets from the manufacturer. I will redraw it say for example. So, your 100 panels that you require here has to be cut from these panel sizes for example.

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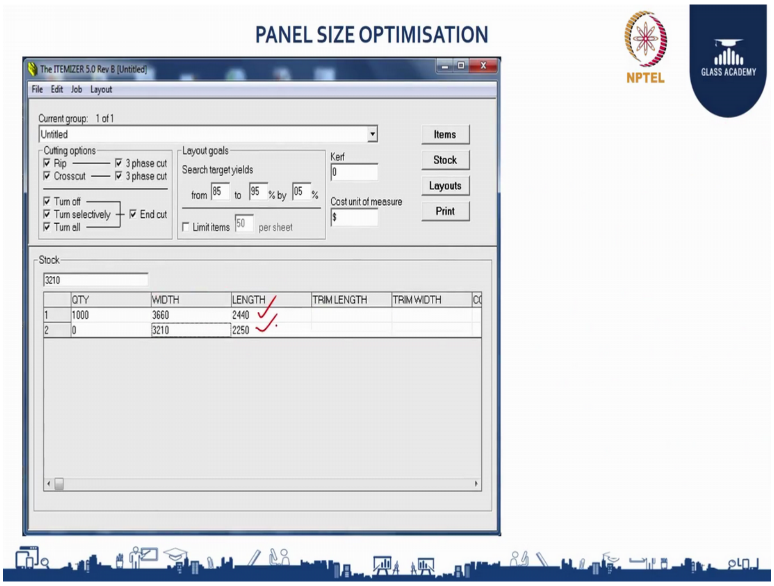

So, here I have entered those two panel sizes here.

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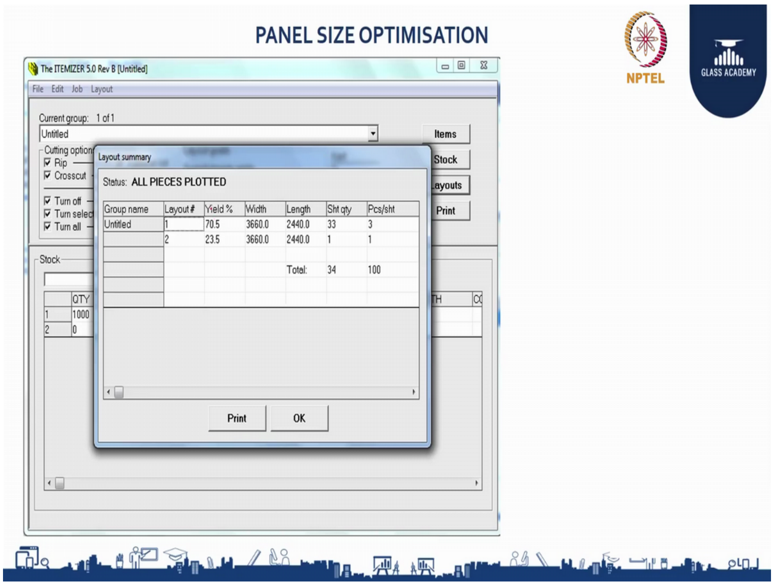

And now I am checking the yield how much percentage of this sheets are effectively utilized to take out this panel the remaining is going to be wasted.

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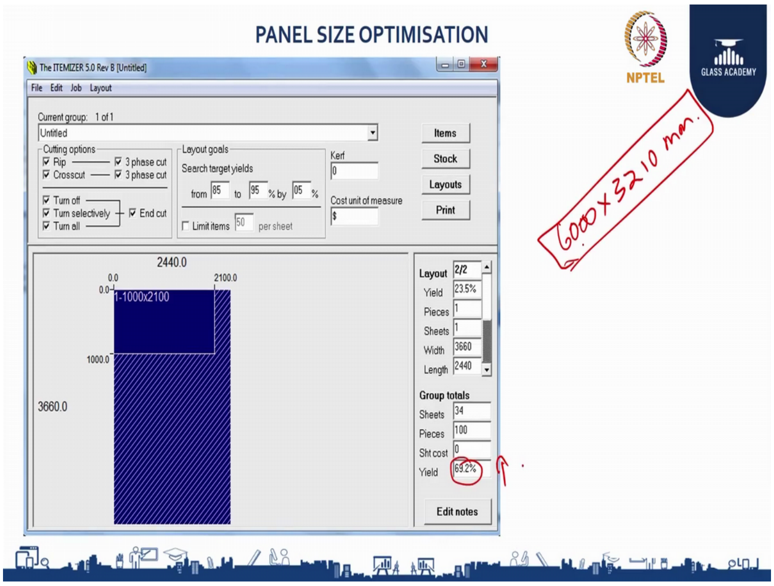

So, here I can see that the yield is going as high as 69.2 percent which means that the remaining 30 percent will not be used for the building, but they will be wasted. But as a client or a owner of the building they will have to pay for the entire parensee, the parent sheet of the glass that is supplied. So, to minimize the wastage that is incurring you need to increase your yield. So, when you increase your yield your wastage will get reduced. So, based on that if you resize your grid well close to accommodating the sizes manufactured by the manufacturer, then you can get a higher yield that is my point.

So, then based on that you can get a lesser wastage. So, there are even panels as high as 6000 mm by 3210 mm. So, this is one of the largest panels that can be manufactured in India. So, as high as this is available as a standard size

So, when you design the elevation of the building if you can consider even the manufacturing sizes by the manufacturer glass manufacturer that will give you a better yield and lesser wastage. So, this is one point that you need to consider.

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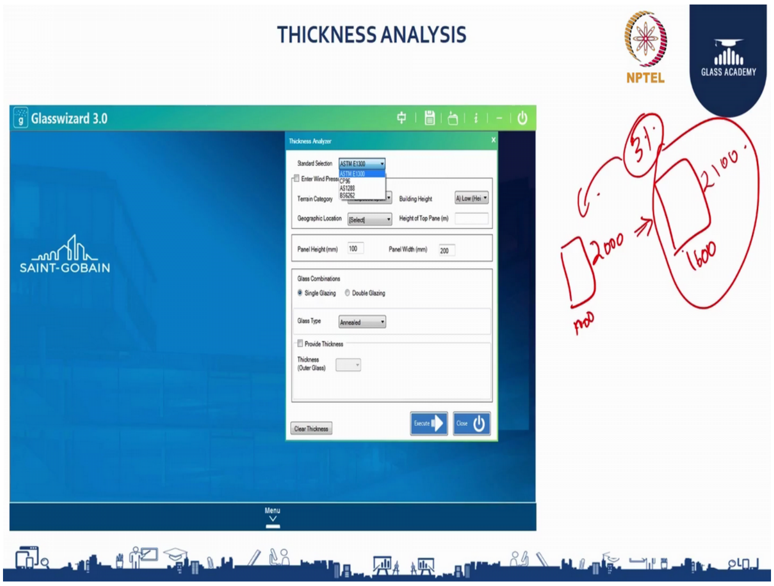

But one more thing is your safety aspect. So, when you are resizing your grid say from 1200 mm 1000 mm you are going to resizing it to say 1600 mm maintaining the same height. So, from 1000 d into 2000, I am increasing to 1600 into 2001 100 say for example.

So, this is matching with one of my manufacturers sizes and it has a very less wastage say 3 e percent or 4 percent say 5 lesser than your natural wastage. So, in that case your panel width and height are increasing. So, you need to check whether your glasses thickness is safe enough to take the load say take the same wind load.

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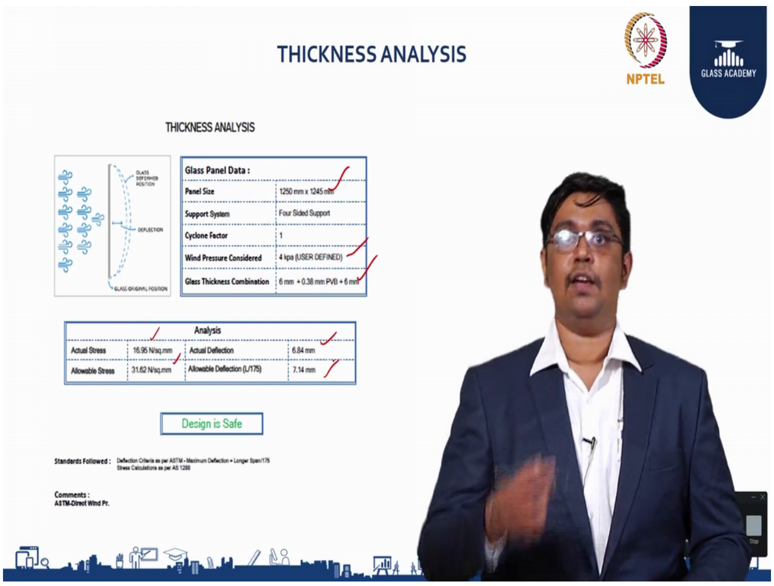

So, this kind of analysis needs to be done like for example: When you are increasing your panel width you are reentering that; what is the wind load, and what is the thickness combination that your selected then it gives you what is the actual stress what is the allowable stress what is the actual deflection and allowable deflection.

So, there are many standards available for doing such calculation and there is one tool called glass wizard, which does this calculation using the algorithms and the tables given in ASTM E 1 3 00. So, this is one calculation which let us whether a particular thickness is safe enough to take the load or not

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And so, we have covered the sustainability, we have covered the panel sizing, we have covered the thickness. And next is your aesthetics because considering all this. So, you will be installing a glass on your building and you need to understand how it will look.

So, there are many you know ways you can understand the aesthetics of glass one is through samples one is there will be mockups done and current digital technology available is there are apps available on your devices, a where you can go and just go and select a particular glass from here, and it will change the glass alone in this template. So, this is one app that is there called glass pro, it is available in our ipad ipad app store where you can download, and see if you put a particular coated glass how it looks from a particular manufacturer alone.

So, there is also another method in which we can render the product in your in a particular design itself. So, that is also being done by some of the manufacturers.

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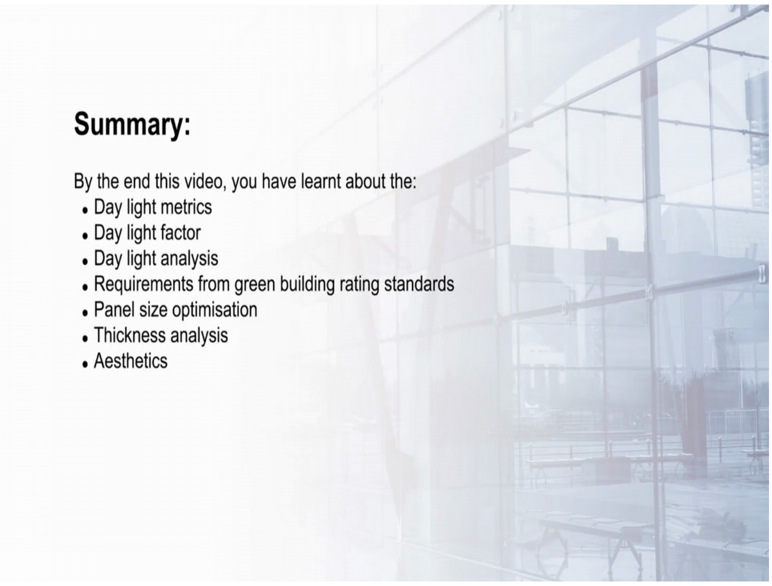

Thank you.