Principles and Applications of Building Science
Dr. E Rajasekar
Department of Civil Engineering
Indian Institute of Technology, Roorkee

Lecture – 11
Shading Analysis- Demo

In the previous module we looked at the basics of the principles of shading design. Apart from the glazing systems we also talked about what does a methodology with which theoretically you do the shading calculations, what is the shadow protractor, how to use it along with the sun path diagrams. In this module, I will be demonstrating you the same shading analysis using a software tool. So, we will take an example a specific location and wall window example using the tool I will be demonstrating how to you know derive the defined required shading conditions and how to present the data for your projects.

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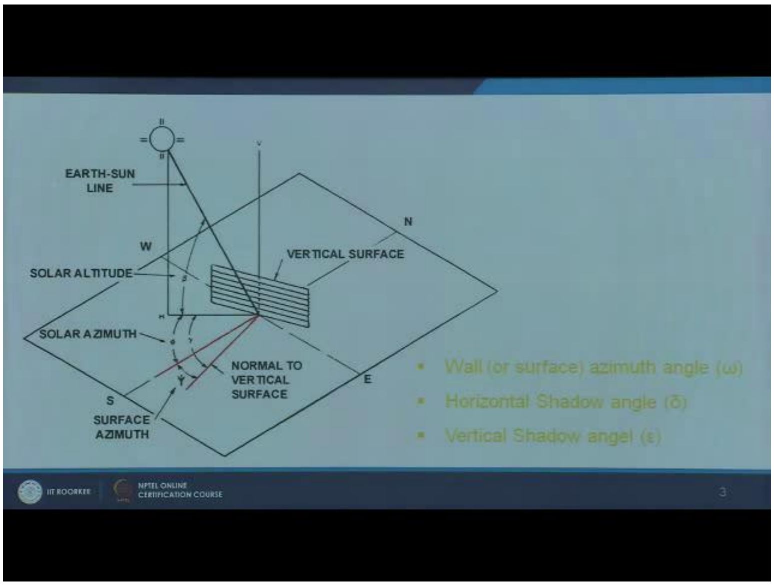

Quick recap of some of the indices that we need to remember apart from this altitude and azimuth angle which determines the position of sun in two dimensions, we also need to remember something called wall azimuth. We saw in the previous module it is nothing but the orientation of the wall it can be with reference to the north are from the south and we have to remember horizontal shadow angle and vertical shadow angle. Horizontal shadow angle determines the efficiency of vertical shading system, and a vertical shadow angle determines the efficiency of horizontal shading systems. So, these three parameters are the angles dimensions have to be kept in mind.

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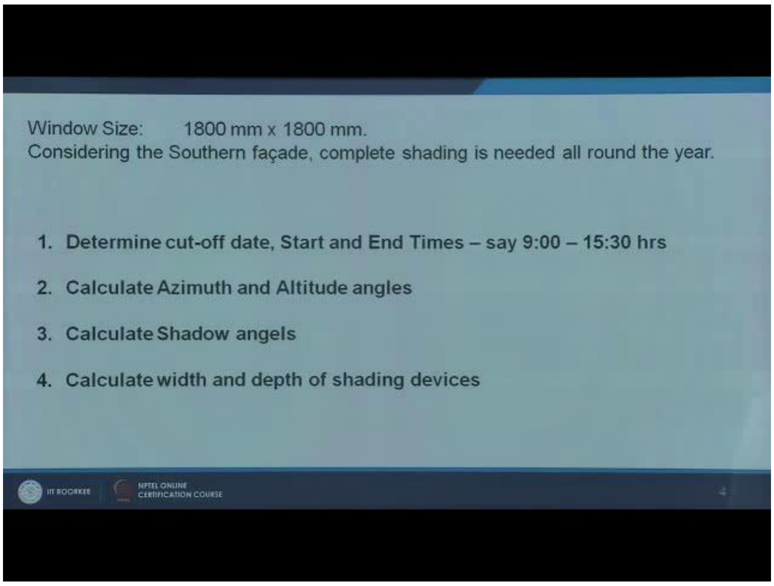

We will move on to the tool the use of the tool itself. We saw this the different steps involved first; we have to determine the cutoff date start and end times say for example, if it is like say 9 o clock to 4 o clock in the evening or 6 o clock in the evening depends on when you want to really cut off sun on a particular day as well as when do we need to cut off the sun during a particular season of the year. It can be one in summer solstice to winter solstice are do not go further to winter solstice may be just during summer, maybe 3 to 4 months in summer I need shading for this window rest can be exposed to sun it depends.

Then calculating azimuth and altitude angle, calculation of shadow angle and then calculate the width and the depth of shading devices. The same four steps will be applied in the software tool as well, but it gives you more hands on numbers rather than letting you do the graphic our theoretical calculations itself. We will move on to the tool now.

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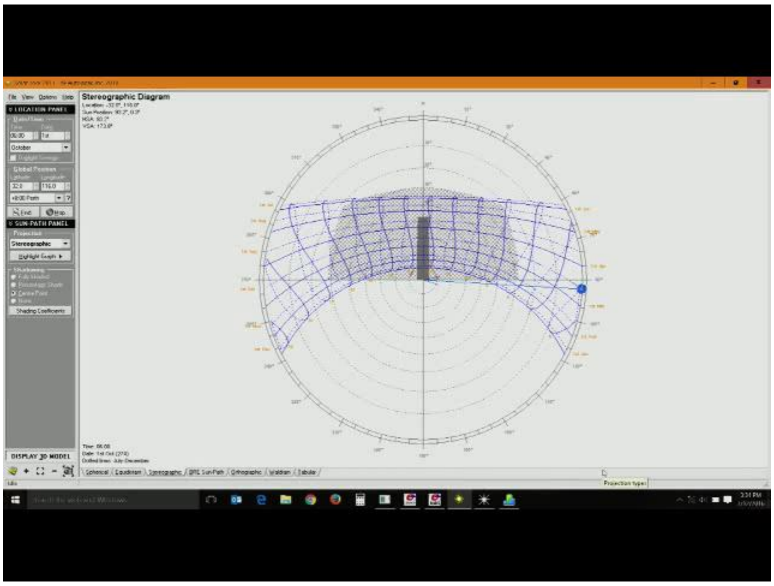

I will take you through a demonstration of a software tool using which you can easily design shading system or you can assess the performance of shading system. This is solar tool this is part of ecotect software program. Now this is you know promoted by auto desk. First now let us take a look at the interface what we have on screen. So, this basically if you see there is a bar which is in the left hand side you have the time and date plus the month can be set. You have the global position latitude and longitude plus this is the time zone you have a list of time zones, moment you set latitude and longitude the time zone gets adjusted automatically. Apart from this you have different types of projections. You have spherical liquid distance we will take a look at it shortly, then you can have a fully shaded percentage shade center point and no shading, then you can calculate shading coefficient this is what we see in the left hand bar.

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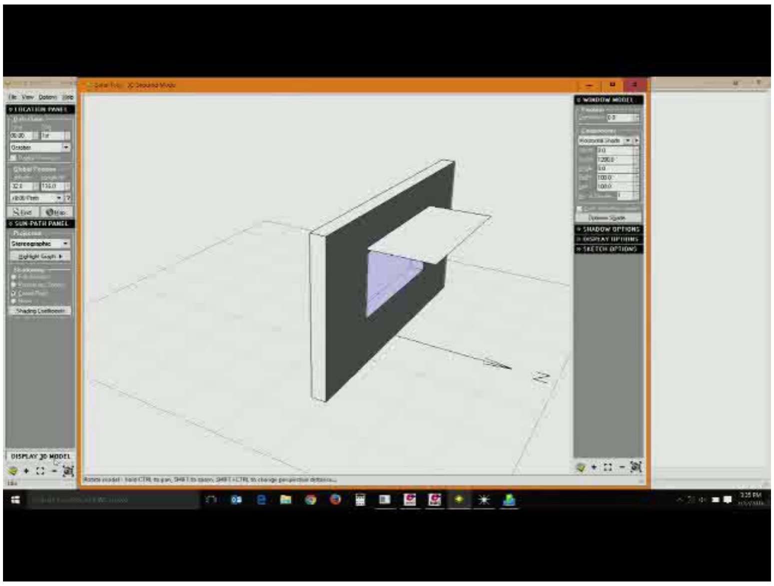

Plus you can see a 3D model. If you click on it the 3D model will appear, you cannot do you know building models here you will get a wall and you can design certain fenestration systems. So we will come back to this shortly plus you have an image capture option you can capture it as Meta file or bit map file. Now the main screen what we have here this is a stereographic diagram because this tab is selected the same thing that you get in your drop down, we are in stereographic projection. What you see here is a sun path diagram. We looked at it in one of the previous modules.

Now this is a sun path diagram where you have the lines which represent the months plus these lines represent the curvilinear lines these represents the day, so it is a trigonometric projection of solar movement into a horizontal axis. Here you have the orientation the starting from north 360 degrees are mark. Once let me know set the latitude and longitude for example, let us take a latitude of say 13 degrees the sun movement the whole thing has not adjusted, let us set a longitude of say 78 degrees now the time zone as seen to plus 5.0 you know 5 hours 30 minutes that is 5.5 this is you know India Delhi time zone. What we see here is a sun path diagram for this particular location 13 degrees this is some where in the southern part of India say it can be Bangalore, Chennai or if you want to see a northern name is if u say 29 degrees you will further have some movement to the south. So, let us now work with this.

What you see here this one represents the sun actually you can click and drag this your date and time will automatically change here or you can actually set this say if I want at 12 o clock on 21st of June say summer solstice, I will find where the sun is located for this particular latitude and longitude. Similarly, if I wanted for December it would move on, if I wanted at say 5 p m 17 hours the sun is somewhere here. This gives you location suns position in terms of degrees. Apart from this you also see the horizontal shadow angle and vertical shadow angle.

In the previous module I you know demonstrated how do we calculate this horizontal shadow angle and vertical shadow angle using which further we calculate the shadow projections. Now this tool simply gives this number on screen, this is horizontal shadow angle this is a vertical shadow angle. Horizontal shadow angle gives you the effectiveness of vertical shading device VSC are vertical shadow angle gives you the effectiveness of a horizontal shading device, time data and the numbers are set here.

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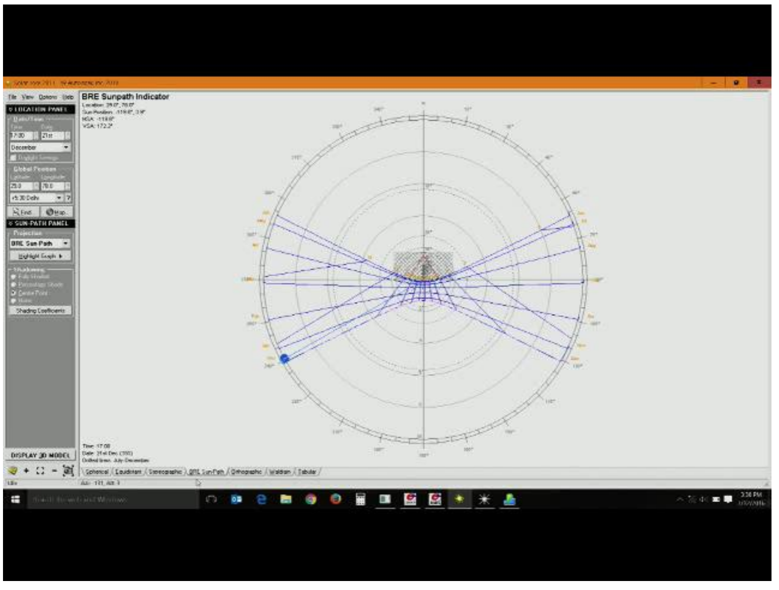

As I said there are different types of projections; first is spherical projection, then we have equidistant projection, stereographic this is what most commonly we use, then we have the building research establishment BRE sun path projection.

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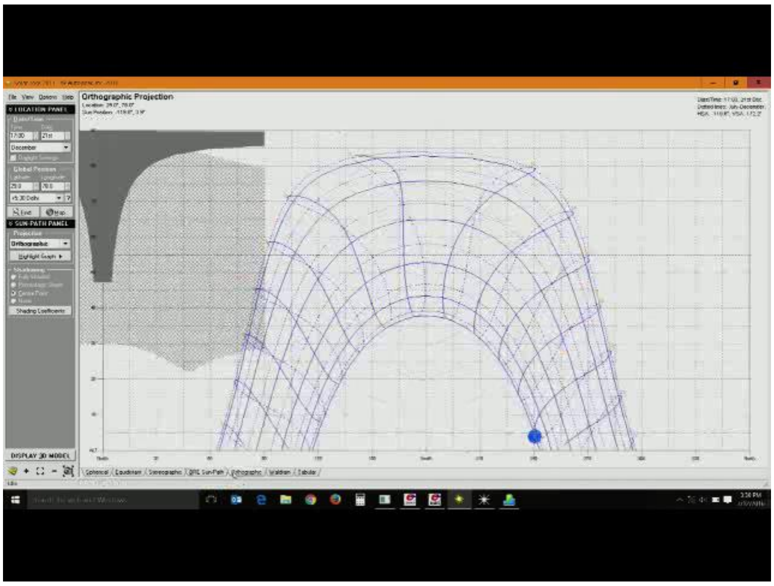

Then we have the orthographic projection.

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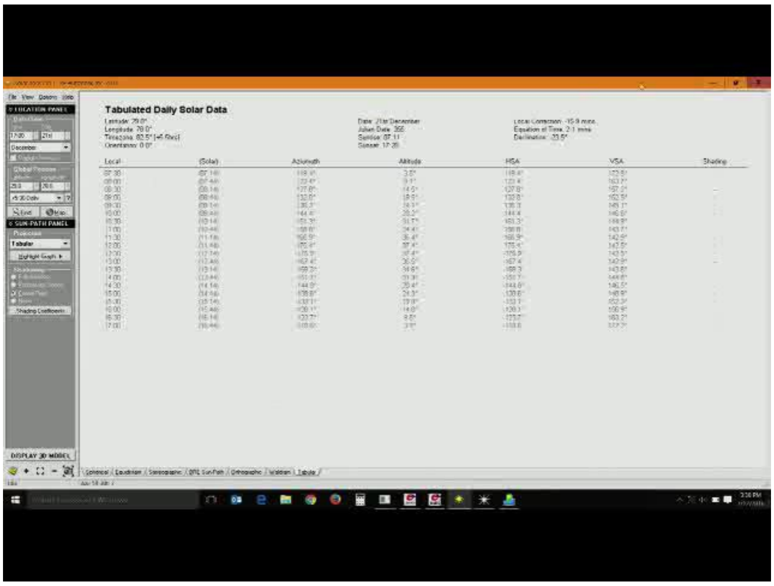

You can have a wall (Refer Time: 06:58) diagram or you can see the whole of it in terms of tabular data. During this demonstration primarily we will look at stereographic projection and the corresponding tabular data. So, now let us take a look at this you know our numbers this is a graphical representation, what corresponds to in terms of tabular data. Here the latitude longitude is set the orientation is 00 that is north now we are not changing the orientation. Date is 21st December, you have the sun rise and sun set time, you have the local time correction, and equation of time correction is also there. This also we saw in one of the modules how do we convert the global time to local correction in terms of longitude this is also given here straight and declination is given.

So, for this particular day that is 21st December winter solstice at this latitude 29 degrees north latitude the local time sun rise at 7:30 so every half an hour you get the numbers here. Local time, solar time then you have azimuth angle, you have the altitude angle for each hour then you get the horizontal shadow angle and vertical shadow angle. So, we are not calculating any shading right know we will come back to this in course of our calculation.

Now, if I change from December to say June during summer solstice the sun rise happens quite early it is 5:20 sets at 7:15. Similarly for each of these hours you get the horizontal and vertical shadow angle. Orientation, please note this would be zero that is north facing we can reset the orientation we cannot adjust different orientations we will come back to this as I said.

Getting back to where we were, this gives you a simple sun path diagram. Now we will go back to the model which we saw little while ago. Initially it gives you a simple wall, if you click on this wall the right hand panel the term wall will appear there is a drop down, you can choose the window, you can choose the wall, you can choose the original shade vertical shade solar pergola it can be detached shading up to eight detached shadings can be provided. If you click on the wall you can adjust the height of the wall you can adjust the width of the wall and you can also adjust the depth of the wall.

Depth is crucial because if you give resist window kind of arrangements where you are wall is say you know 500 600 mm thick a bulk wall where you have a resist window or you are giving certain you know cupboards and all that the window is resist you do not have a shading system actually, but it is a resist wall system. You can use this depth you can increase the depth then your window will be on the inside, so you can calculate the shading efficiency. Right now I am taking it 200 mm deep wall here the orientation is 00 this is a north facing wall. If I want say east facing set it to 90 degree will just turn around. It is a very simple tool to use. Now this is east facing window. If you get back to this tabular data the orientation would have changed this is the east facing.

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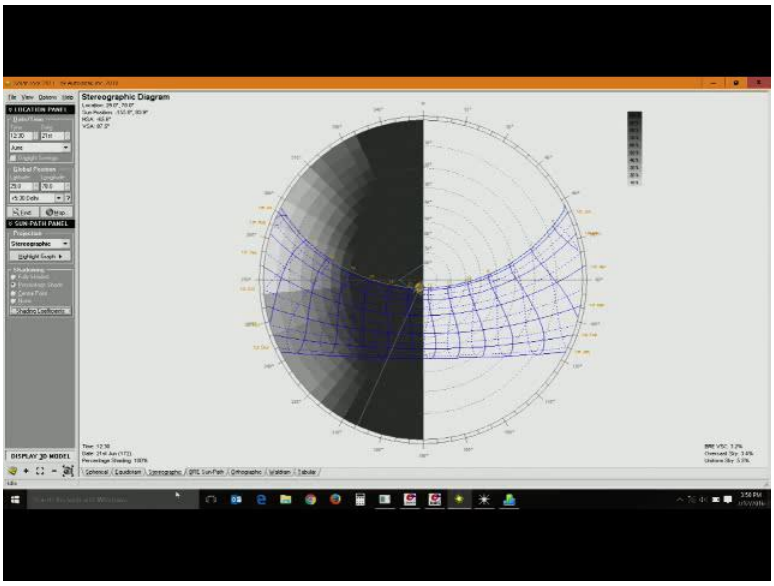

Similarly in the stereographic projection this particular shade this is center point if you say percentage shaded you will get a series of shades this is due by virtue of the horizontal shading device that we have provided. We will work on the shading efficiency shortly. For now I am just removing the horizontal shade there is no shade here. If you go to the model you do not see shading there is no shading earlier there was some shadow now that is missing. You have 0 percent shading and it also says after 12:30 the sun goes behind that is it is on the rear side of the wall. Contrarily if I change the orientation to 270 degrees that this west facing wall or the wall is facing this is north up this way is north.

Now the reverse will happen, morning time it will say sun is behind and afternoon you do not have any shading. From changing this here to 180 degree this will be the south facing; the wall is facing south getting back it says for some time it is behind and then full day it is facing the surface. If you quickly change the latitude now it is 29 degree say if you are making it is a 12 degree you will have sun behind the wall that is it is a south facing wall sun is to the north. Again if you change the wall orientation you can work around by changing certain parameters it goes behind, but still morning and evening you have direct solar incidence and changing it back to 29 degrees north latitude 178 degree longitude, this is what I am working with right now.

Now, let us start assembling a set of shading systems. The orientation is again north let us make it is a no for now let it be south facing wall, right now there is no horizontal shading device. The window it has the dimension of height of 1200, width is 2400, sale level is 900 you can adjust the sale level if you want what window on the higher side the (Refer Time: 12:36) to be higher you can adjust it as well. You can adjust it on the side where which side you want to move top and bottom. You know every single adjustment as possible in the window.

Now let us add one single horizontal shading device. Right now if you select horizontal shade number of shades is 0 just increase it to 1 by default there is a shading device either you can click and drag this or you have the dimension here. Now let us just go for a 450 mm typical shading device. There is no angle you can tilt it, if you want right now let us just keep it straight it is not a tilted shading device 0 degrees. You want some extension to the right yesterday you know the last session we calculated it in terms of a a dash that is how much projection is needed to the left and right.

You can do that right now I am leaving it like this. The single shading device if you want to check how efficient this particular shading device is, simply go back graphically this is a duration in which you are getting full shade and in the months of say June July August and in the months of April and May during 11 o clock to 2 p m, 11 a m to 2 p m you are getting more or less 90 percent shading. After that further hours say for example, if you are taking ten o clock or 9 o clock in a month of say March you will have only a part shading it will be 20 to 25 percent shaded. It is not very effective shading it is a south facing surface.

If you have to look at it now we are let us take summer solstice June 21st look at the tabular data this will clearly tell you how much percentage you have shading sun is behind here and then you have 100 percent shading like we said somewhere from 11:30 12 o clock you have 100 percent shading for about 2 hours you have complete shading, up to 1 1:30 you have fully shading after that the efficiency eventually goes down. It varies somewhere between 87 88 percentage to 90 percentage. And after that there is no direct solar incidence.

On the other side if you look at December. This shading device may not be effective because you have direct solar incidence most part of the day, this is December in the table the maximum efficiency are getting with this shading device is 22 percentage. And some part of the day it is 0 that is there is no use of this particular shading device or it is not offering any effective shading. So, it is slightly increases during noon it is close to 20 22 percentage then eventually it drops down. You also get corresponding horizontal shadow angle and vertical shadow angle you will go back to the model.

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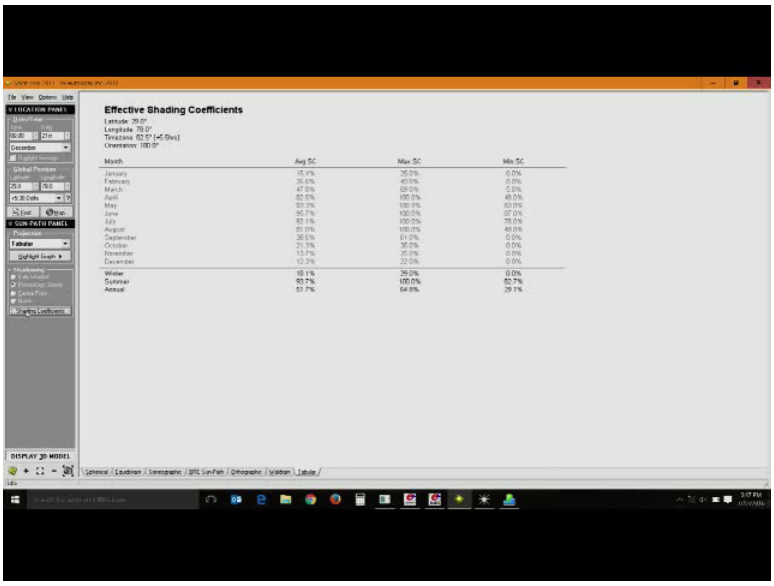

There is another thing before that; we were looking at the stereographic projection and tabular data if you click on shading coefficients, just click on shading coefficient tab you will get a summary of shading coefficients monthly average shading coefficients; that is during January February up to December you will have an average shading coefficient that the windows providing. If you look at it January February are later in the year like October to December, efficiency is almost the minimum efficiency 0 maximum you get is around 22 percentage, average is only 12 percentage. The best efficiency it is giving is during summer May and June say it can be from April if you take 80 as a cut off it can be from April all the way to August. It is giving up to 80 percent it looks promising, but we also have to note in the month of April. The maximum you get is 100 percent average is 82 percent, but minimum is 48 which means 50 percent shading efficiencies also there in part of the day. We may not be able to call it a completely effective shading system.

In summer you have a good efficiency winter it is just 18 percentages. For a quick calculation if you have to present your client that this is the shading system this is what its efficiencies this table will surface, but if you want to do a detailed calculation or day in day out calculation then it is a good idea to go for a particular day. If you just click on the stereographic and come back to tabular you will get the daily data. You can tabulate summer solstice as well as winter solstice separately.

We will go back to the model this shading device is there, if you want to increase the number of shading devices now we have a horizontal shading device make it to 2 horizontal it evenly spreads out want to make it 3 instead of 450 mm say let us go for a 300 mm shading device the thin one, but I can go for 3 numbers. We will go back and see what we have got December 21st same numbers are slightly changed you get around 44 percent. And the earlier one, we had almost 9 percent efficient, but now the shading efficiency is slightly increased.

Look at the shading coefficient it also provides you slightly improved version during the winters as well and during summer it gives you almost 100 percent shading efficiency. You can do the tilting you can now tilt the angle say is very minimum tilt say ten degree tilt I want to introduce 10 degree tilt I have introduced. Looking at the numbers, this is slightly gone up look at the stereographic projection you get a considerably good amount of time in which you get 80 percent or above shading. Lot of you know the months date and month points you will find a darker shade which means the shading system is slightly more efficient than the previous one.

Let us look at an alternate orientation I will revert back to one shading device in 450 mm deep the tilt angle is 0, but I am going to change the orientation. I will put it west oriented a west facing wall the window is the same dimension the window remains the same, but you have a shading device 450 mm simple horizontal. Just go back to this, so it is a west facing so the shading that you get the highlighted in your left hand side of the sun path diagram. So here is your efficiency, if you look at the table sun is behind the morning then the shading device this is you are looking at say let us say June 21st, a shading device is effective up to 130 then eventually drops down and say somewhere around 3 o clock 3:30 the efficiency drops below 50 percent goes further low.

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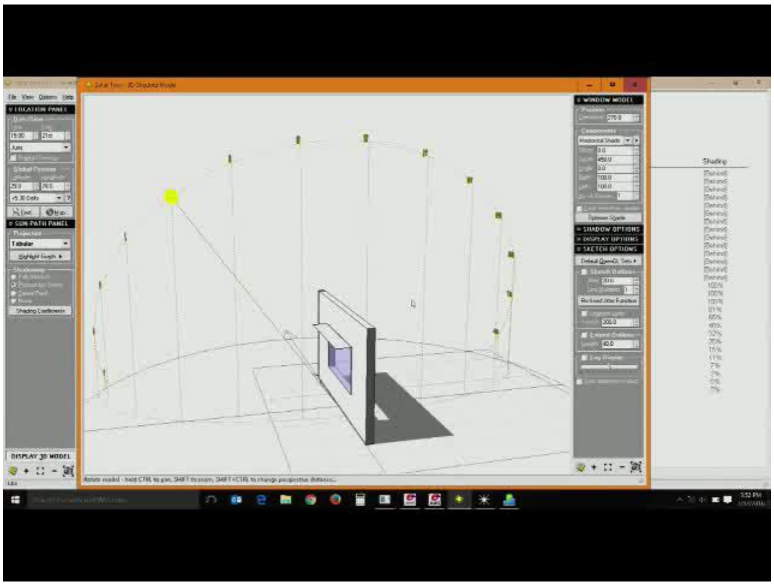

So, what do we do know, I have given it morning so you are getting the shade on the other side 17 hours I am making it look at the image, so sun will be on this side you can go to display options. You can set the daily sun path it will also tell you where the sun movement is happening there are certain sketch options you can adjust the sketchy things if you want if you are interested doing that you can do it, but this is where your sun is you can record animations in this as well. So, now this is a sun path diagram.

Now, let us look at December 21st that is winter solstice. The sun is moving somewhere here take a look at the shading coefficients you have less than average that is most part of the year are almost all of the year you have average shading coefficient which is less than 50 percent and the minimum is like most part of the year the shading is not effective this is the best facing wall it is a thin 450 mm deep shading system, if you want to let us try and improve the efficiency of this particular system. Let us get back to the previous example we had three you know lower slats 300 mm deep each there is no tilt right know, take a look at this there is a marginal improvement from 35 40 percentage the shading average shading coefficients have gone up to around 55 60 percentage, but still you have the minimum shading coefficients much lesser than which is desirable.

Further if you want to improve we can improve by increasing the number of slats introduce a little bit of tilt, but still we find the minimum shading coefficients are further below the mark. If you resent it out clearly the sun is towards the south you have sun over the horizon, but you have direct incidence from the southern side. So, ideally you will need a vertical shading device as well. If you look at the horizontal and vertical shadow angles you will get the answer.

You will need a vertical shading device let us go to vertical shading device that is 0 number, first add a vertical shading device take it as a 300 mm only right now. If you add more vertical shading devices the next will appear on the other side the more you add it will give you an (Refer Time: 22:32) shading system. I have added 5 devices for now each one is 300 mm deep. The horizontal shading system I will cut the angle this is not angular anymore, so ideally I am getting an accurate system. Now take a look at what happens on December 21st you have almost 100 percent shading up to 3 o clock in the evening even after that you have about 50 percent shaded till 4 o'clock in the evening.

If you look what happen in the summer solstice December June 21st, you have a very effective shading up till around 4:30 in the evening even after that up to 5 5:30 you have 50 percent shading available.

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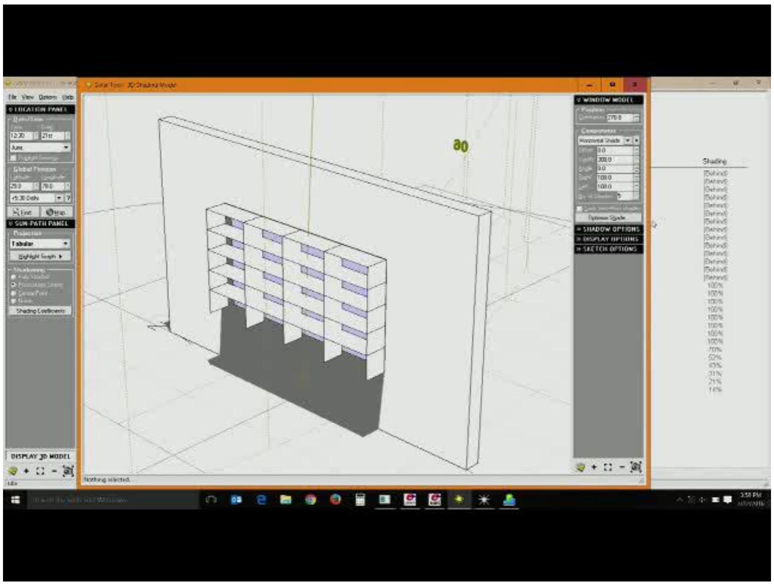

You can introduce tilts both for horizontal as well as vertical shading system or if you want to introduce a pergola this is possible, if you want to provide a detached shading system you can also do that using this. The simple way to tabulate as I said you can click the shading coefficients you can get this thing or you can take the stereographic projection. This is as good as calculating using your sun path diagram as well as the solar protractor. The manual way that we discussed about in the previous module you will get the similar thing animated here you can record animations as well or alternately you can go to the tabular value set the date and time specifically for the whole day you will get all the desired values starting from azimuth altitude, horizontal shadow, angle vertical shadow angle and the percentage shading available.

So far in this module we looked at the shading system design and analysis I demonstrated the use of solar tool which is a part of auto desk studio. It actually tags along with ecotect you can also use the shading tool results or you can model the whole thing in ecotect you can do the shading assessment parallel. It goes hands in hand with ecotect software tool. So, using that you can more quickly or seamlessly do the shading system design as well as analysis of a pre designed shading system.

Thank you.