Glass in buildings Design and Application
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Lecture - 29
ECBC and Green Building Requirements

Welcome back. Let us now see: what are the daylight requirements in ECBC 2017. Above grade flow areas shall meet or exceed the useful daylight illuminance or UDI, area requirements as listed in table 4.1 for 90 percent of the potential daylight time in a year.

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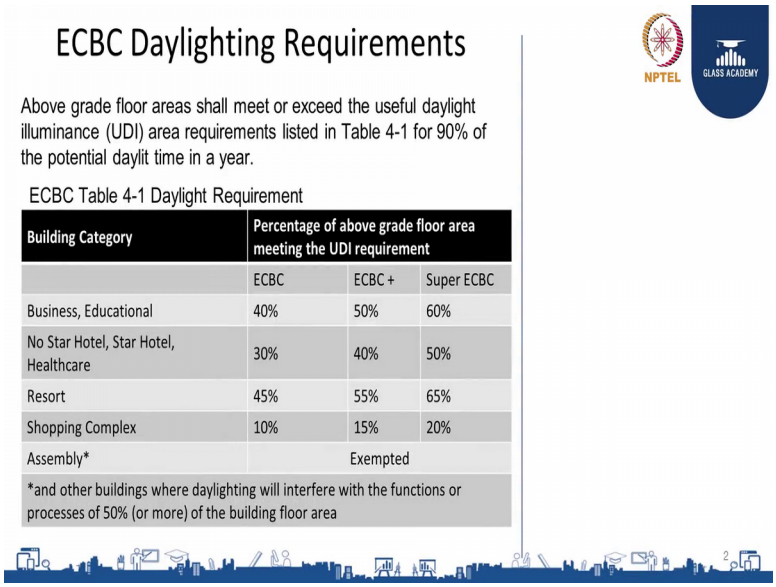

Percentage of the floor area varies with the level of ECBC compliance that a project wants to show. So, as per this table for business and educational buildings 40 percent of the area should meet or exceed the UDI requirements for 90 percent of the potential daylight time in a year. For ECBC plus it is 50 percent and for ECBC super ECBC it is 60 percent; likewise for other building types the percentages are defined.

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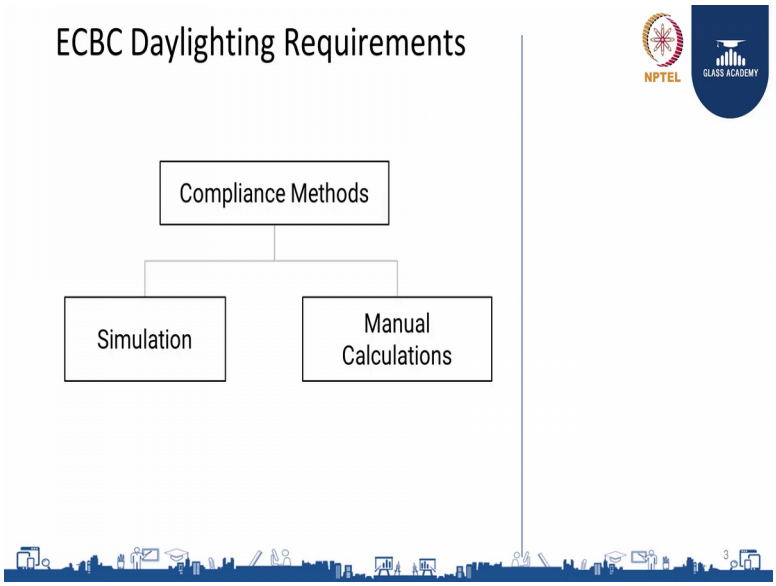

To show compliance there are two methods, one which involves simulation and the other method which needs manual calculations. Let us look at the simulation method.

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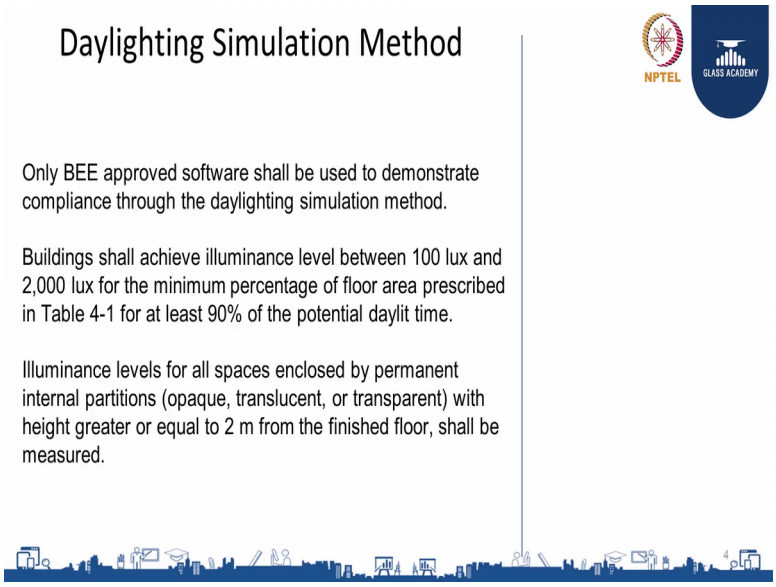

For simulation we need software; only BEE approved software shall be used to demonstrate compliance through the daylight simulation method. Building shall achieve illuminance level between 100 lux and 2,000 lux. For a minimum percentage of the floor area as was given in table 4.1 that we just saw, for at least 90 percent of the potential daylight time. Illuminant levels for all spaces enclosed by permanent internal partitions

opaque, translucent or transparent with height greater than or equal to 2 meters from the finish floor shall be measured.

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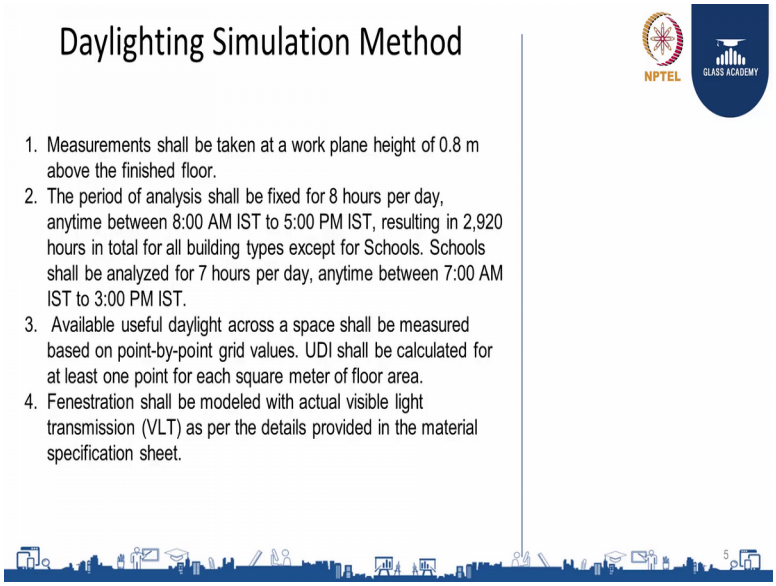

Now, let us look at the method. Measurements shall be taken at a work plane height of 0.8 meter above the finished floor. The period of analysis shall be fixed for 8 hours per day. These 8 hours can be anytime between 8 AM IST and 5 PM IST, this will result in to 2920 hours in total for all building types except schools. For schools one has to analyze for 7 hours per day and these 7 hours can be anytime between 7 am to 3 PM IST.

Available useful daylight across a space shall be measured based on point by point grid values. UDI shall be calculated for at least one pint for each square meter of the floor area. Fenestration shall be modeled with actual visible light transmission as per the details provided in the materials specification sheet.

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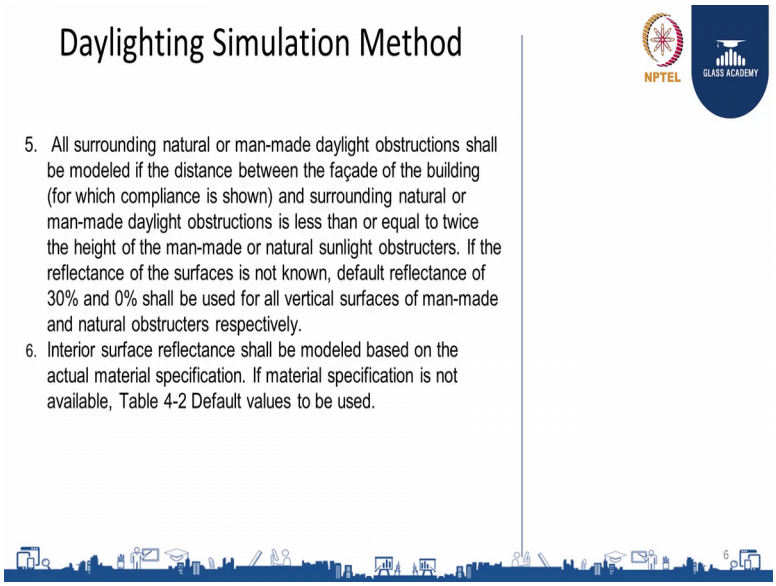

All surrounding natural or manmade daylight obstructions shall be modeled if the distance between the facade of the building and the surrounding natural or manmade daylight obstruction is less than or equal to twice the height of the man made or natural sunlight obstructers. If the reflectance of the surface is not known, default reflectance of 30 percent or 0 percent shall be used for all vertical surfaces of manmade and natural obstructers respectively. Interior surface reflectance shall be modeled based on the actual material specification. If material specification is not available, default values are given in table 4.2 and they have to be used.

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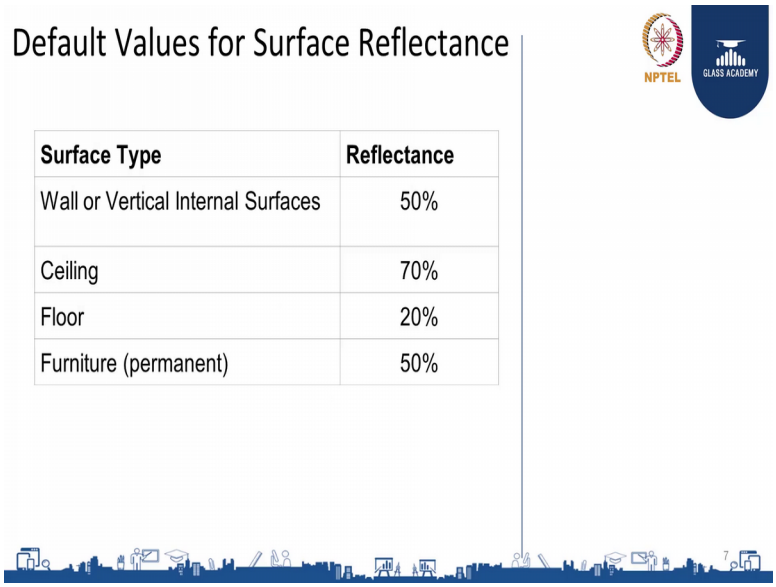

Surface Type	Reflectance
Wall or Vertical Internal Surfaces	50%
Ceiling	70%
Floor	20%
Furniture (permanent)	50%

Here the default values for surface reflectances; for wall or vertical internal surfaces 50 percent, ceiling 70 percent, floor 20 percent and permanent furniture 50 percent.

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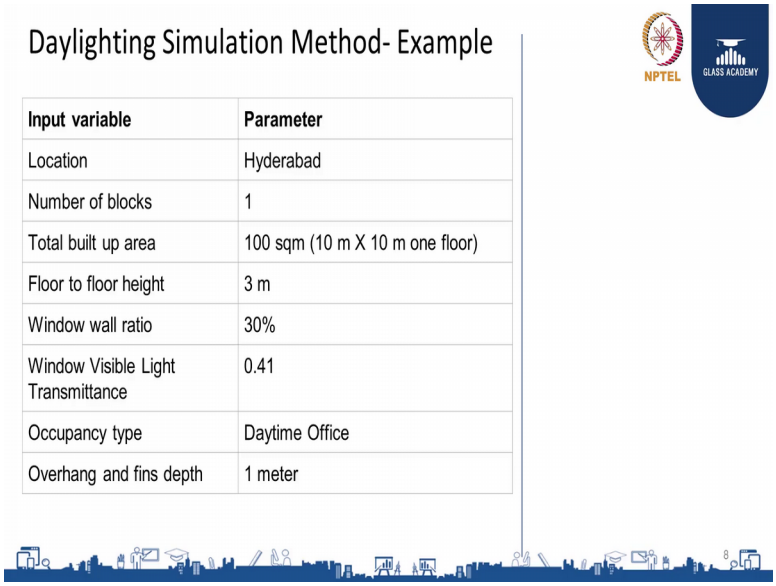

Now, let us look at the daylight simulation method we take an example. Suppose our building is located in Hyderabad and it has one block, total built up area is 100 square meter, assume the building is 10 meter by 10 meter in one floor. Floor to floor height is 3 meter, window wall ratio 30 percent, window visible light transmittance 0.41, occupancy type day type office overhang and fins depth one meter.

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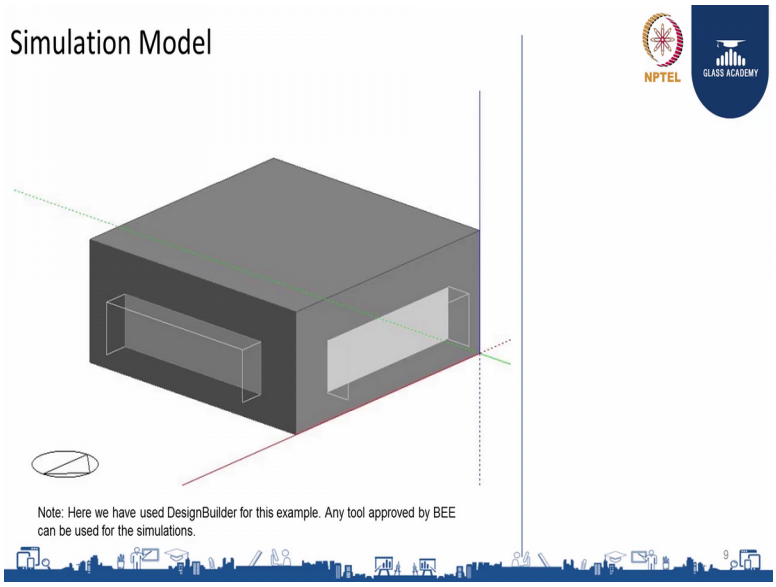

We model this in any software which is approved by the in this case we have used design builder you can see the model, it is a square building and it has window which has both the overhang and the side fins.

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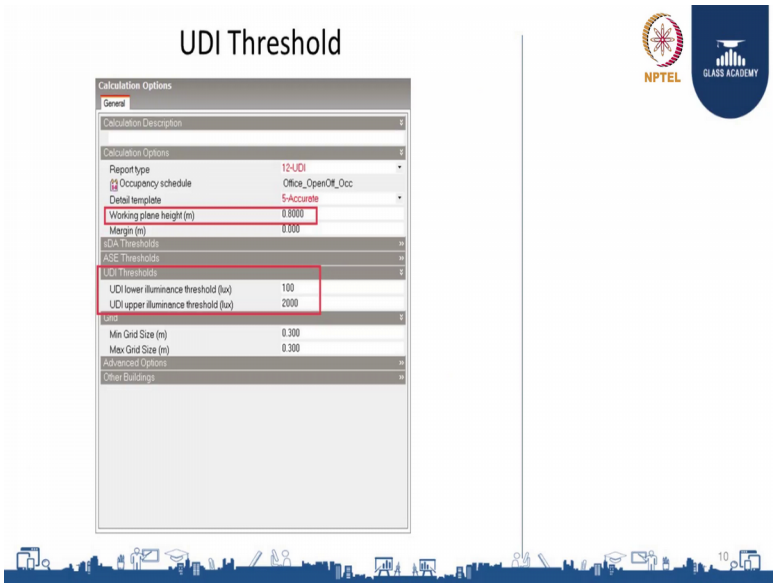

Once we model the building, then we set the UDI thresholds we have set the lower illuminance threshold of 100 lux and the upper illuminance threshold of 2000 lux.

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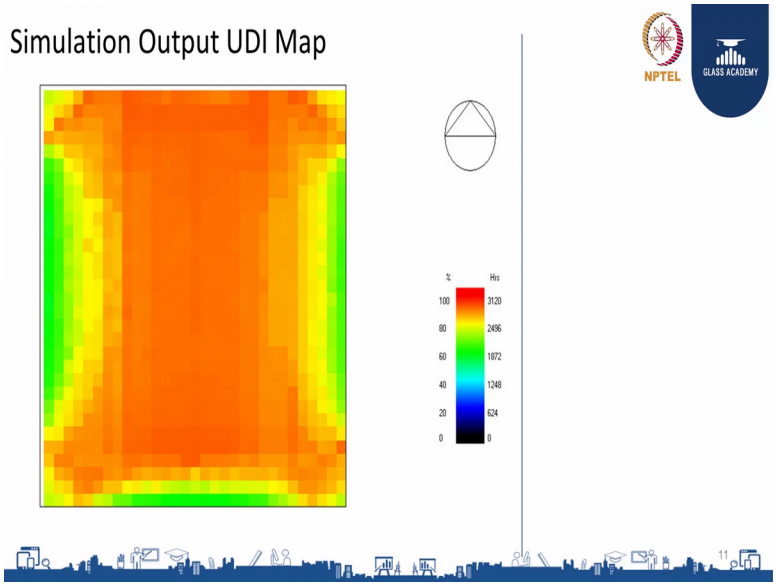

We then simulate in the simulation we get UDI map as an output. Here you can see what areas meet the 90 percent requirement and which areas do not meet the 90 percent

requirement. Interestingly you will see that the areas which are closer to the window are not meeting the requirements, why? Because, they are getting overlaid for several hours in the year, they are getting more than 2000 lux and therefore, they are those hours are not considered as meeting the UDI requirement.

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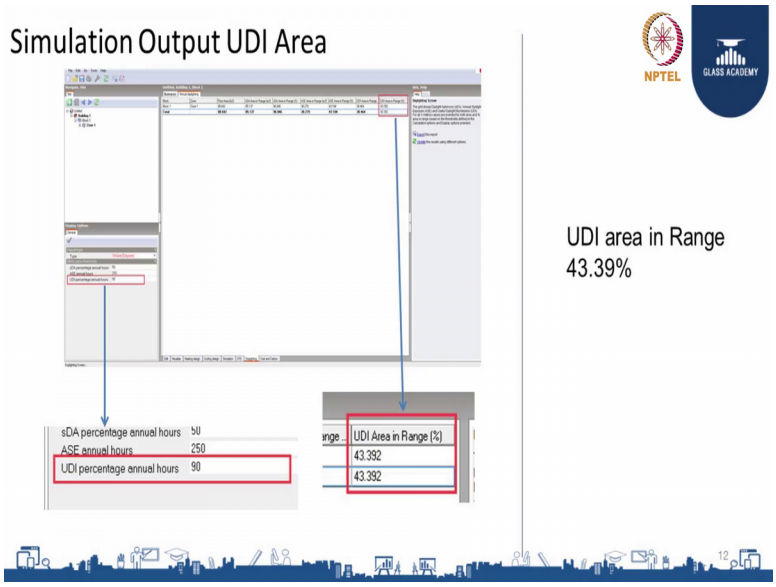

After this map we can get the actual UDI percentage area, we click the UDI percentage annual hours and set it to 90 percent, and here we can see more than 43 percent of the area is meeting the UDI requirements.

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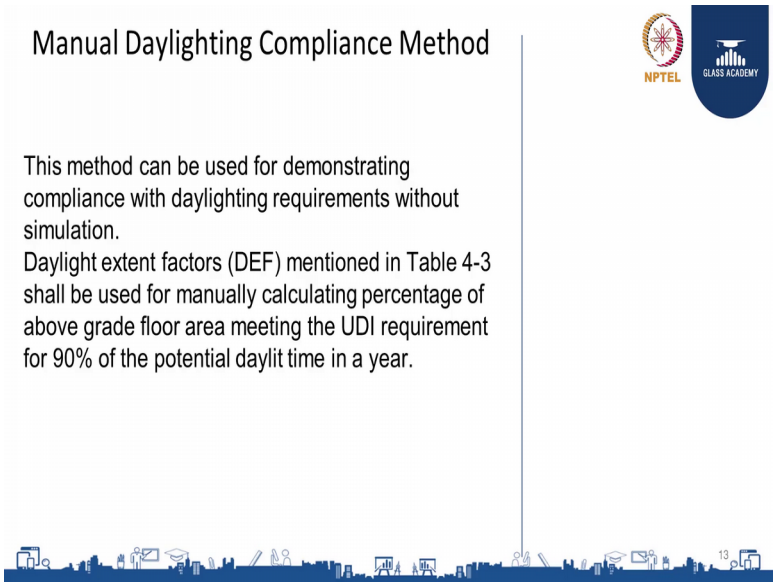

Now, let us look at manual daylighting compliance method. This method can be used for demonstrating compliance with daylighting requirements without any simulation. Daylight extent factors or DEF are mentioned in table 4.3 and they shall be used for manually calculating percentage of above grade floor area meeting the UDI requirement of 90 percent of the potential daylight time in a year.

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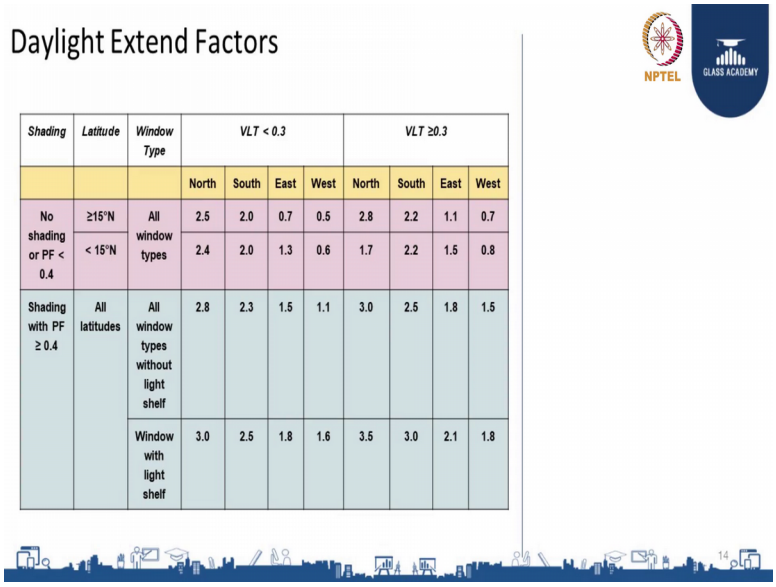

Shading	Latitude	Window Type	VLT < 0.3				VLT ≥0.3			
			North	South	East	West	North	South	East	West
No shading or PF < 0.4	≥15°N	All window types	2.5	2.0	0.7	0.5	2.8	2.2	1.1	0.7
	< 15°N		2.4	2.0	1.3	0.6	1.7	2.2	1.5	0.8
Shading with PF ≥ 0.4	All latitudes	All window types without light shelf	2.8	2.3	1.5	1.1	3.0	2.5	1.8	1.5
		Window with light shelf	3.0	2.5	1.8	1.6	3.5	3.0	2.1	1.8

Here is a table if you look at this table carefully, it has two columns for VLT less than 0.3 and VLT greater than or equal to 0.3. Then it has two major rows, one row for no shading or projected factor less than 0.4, and the another row for shading with projection factor greater than or equal to 0.4. If you look at the first row we see that there are sub rows, one for latitudes more than equal to 15 and another for latitude less than 15 degrees north.

Then for all window type we have the values for window when it is oriented towards north south east or west. Similarly for the second row which is for with shading of projection factor greater than equal to 0.4, there is no sub division based on the latitudes for all the latitudes it is applicable, but for different window types the values are different. Window types without light shelf's the values are given, and windows with light shelf different values are given. So, based on the location of the building its latitude, based on the projection factor on the windows and the window types whether they have

light shelf's or no light shelf's, we can find out for different glass VITs what would be the daylight extend factor now what do we do with this factor.

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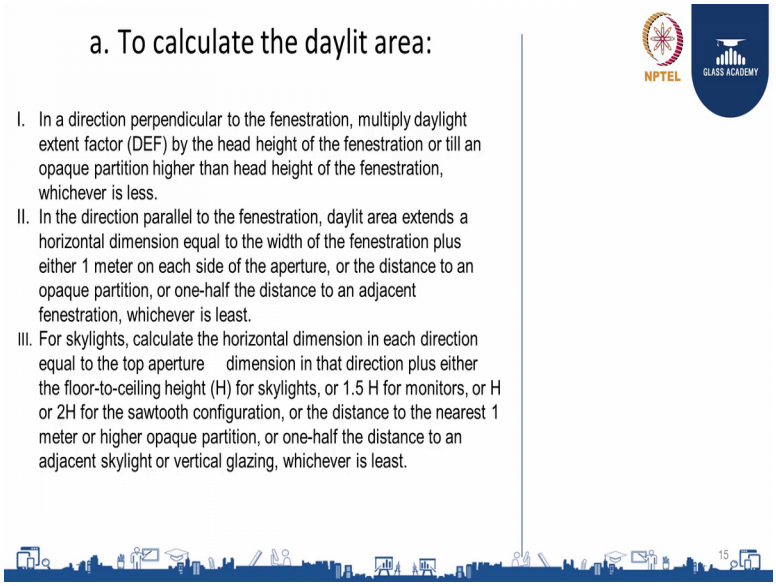

Let us see how do we calculate the daylight area using this factor. If the direction perpendicular to the fenestration multiplied daylight extend factor by the head height of the fenestration or till an opaque partition higher than the head height of the fenestration whichever is less. In the direction parallel to the fenestration, daylight area extends a horizontal dimension equal to the width of the fenestration plus either one meter on each side of the aperture or the distance to an opaque partition or one half of the distance to an adjacent fenestration whichever is less.

For skylights calculate the horizontal dimension in each direction equal to the top aperture dimension in that direction plus either the flow to ceiling height of the skylight or 1.5 times H for monitors or H or 2H for sawtooth configuration or distance to the nearest 1 meter or higher opaque partition or one half the distance to an adjacent skylight or vertical glazing whichever is the least.

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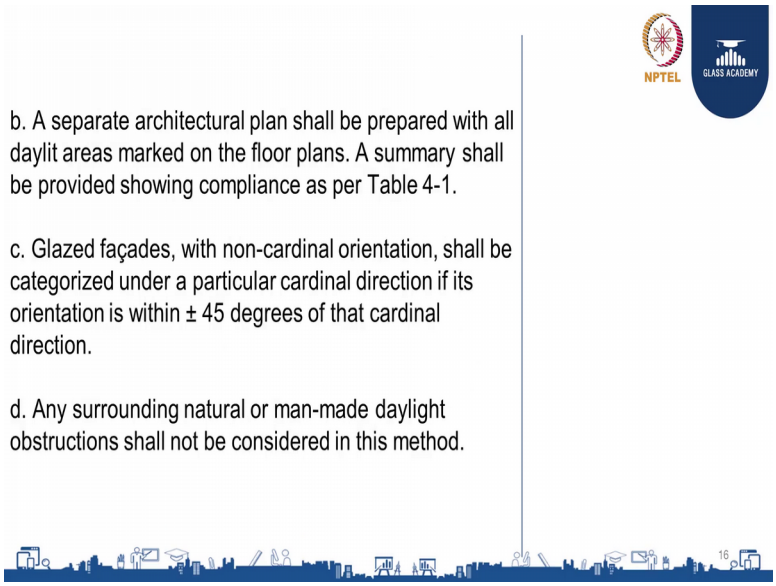

A separate architectural plan shall be prepared with all daylight areas marked on the floor plan. A summary shall be provided showing compliance as per table 4.1. Glaze facades with non cardinal orientations shall be categorized under a particular cardinal direction if its orientation is within plus minus 45 degrees of that cardinal direction. Any surrounding natural or manmade daylight obstructions shall not be considered in this method.

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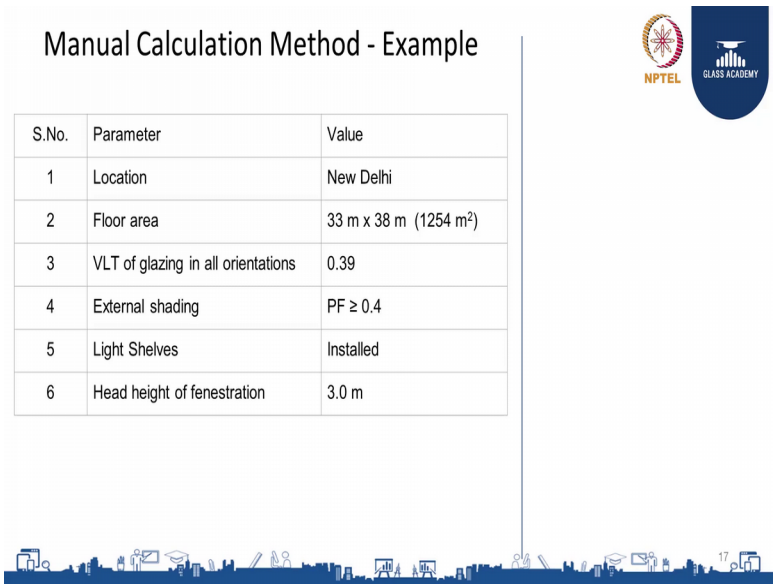

Let us take an example. Suppose we have a building located in New Delhi with the floor area of 33 meters by 38 meters, that is the total 1254 square meter per area, VLT of the

glazing 0.39 assume all the glazing's in all the way orientation has the same VLT, external shading projection factor is more than or equal to 0.4, light shelf's are installed head height of fenestration is 3 meter.

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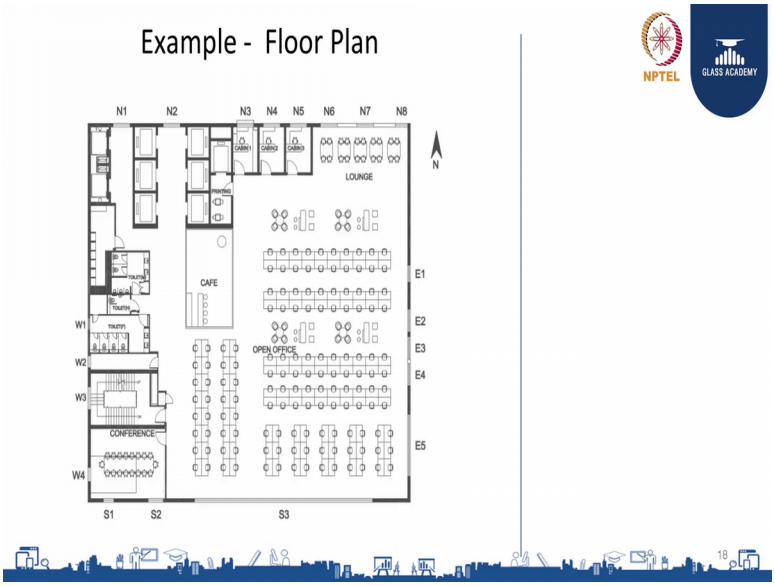

Then we look at the floor plan you see there are windows in the north east south and west, windows in the north are numbered N 1 to N 8, in the east E 1 to E 5, south S 1 to S 3 and west W 1 to W 4. Now, what do we do ?

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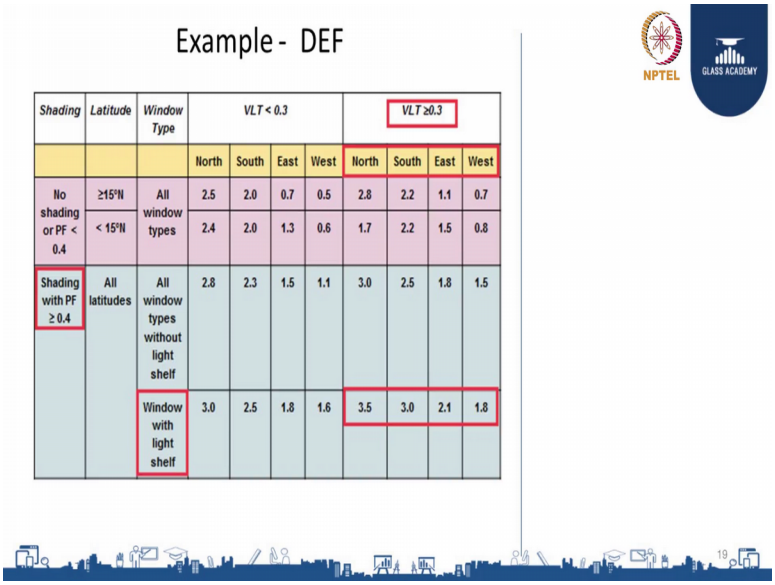

Shading	Latitude	Window Type	VLT < 0.3				VLT ≥0.3			
			North	South	East	West	North	South	East	West
No shading or PF < 0.4	≥15°N	All window types	2.5	2.0	0.7	0.5	2.8	2.2	1.1	0.7
	< 15°N		2.4	2.0	1.3	0.6	1.7	2.2	1.5	0.8
Shading with PF ≥ 0.4	All latitudes	All window types without light shelf	2.8	2.3	1.5	1.1	3.0	2.5	1.8	1.5
		Window with light shelf	3.0	2.5	1.8	1.6	3.5	3.0	2.1	1.8

We find out the DEF as given the VLT is more than 0.3 therefore, we take the corresponding column, we know that the shading is there in the building with projection factor greater than or equal to 0.4. So, we take the second major row there is a light shelf. So, we take the row which has a light shelf related values, then we get the DEF of 3.5 for north, 3.0 for south, 2.1 for east and 1.8 8 for the west facing windows.

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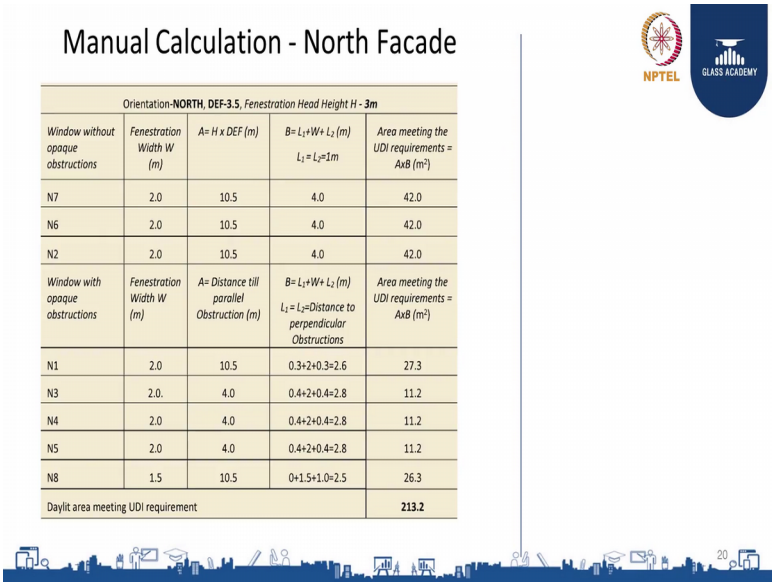

Once we get these values then we can do this calculation. The calculation is very simple first we take the windows, we do not have opaque obstructions in front of them. Windows and 7 and 6 and 2 do not have opaque obstructions let us see the drawing again. So, N 6 N 7 and N 2 and two do not have obstructions remaining windows have obstructions in front of them.

So, for these windows we do not have obstructions like N 7, we take the fenestration width W as given in the drawing 2 meters, we find out A which is height into DEF in this case it is 10.5, you find out B which is L 1 plus W plus L 2, in this case we extend in both the sides by one meter. So, the B becomes 2 plus 1 plus 1 which is 4 the area meeting the UDI requirements is equal to A into B is equal to 42 meter square. We find out for all the windows we do not have opaque obstructions. Those which have opaque obstructions in this case we take a different calculation, where A is distance till the parallel obstruction and then again we find out the B and the areas with sum total all this areas.

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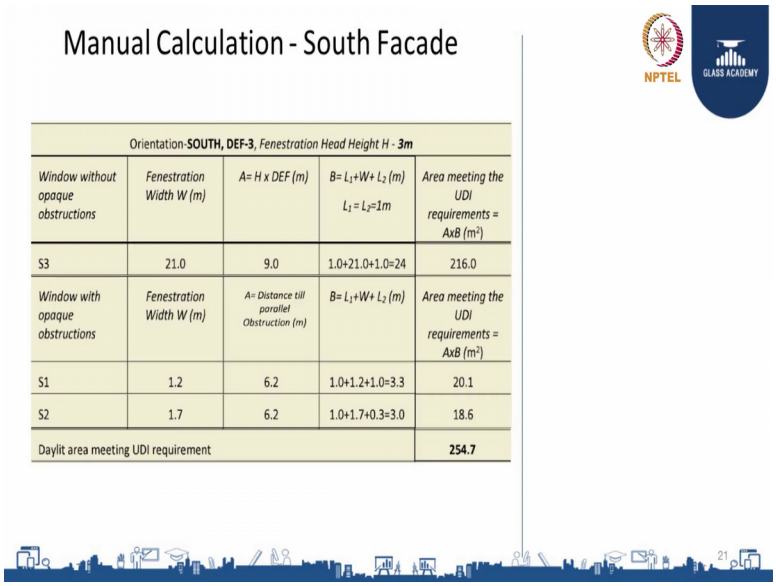

Orientation-**SOUTH, DEF-3**, *Fenestration Head Height H - **3m***				
Window without opaque obstructions	*Fenestration Width W (m)*	*A= H x DEF (m)*	*B= L_1+W+ L_2 (m) $L_1 = L_2$=1m*	*Area meeting the UDI requirements = AxB (m^2)*
S3	21.0	9.0	1.0+21.0+1.0=24	216.0
Window with opaque obstructions	*Fenestration Width W (m)*	*A= Distance till parallel Obstruction (m)*	*B= L_1+W+ L_2 (m)*	*Area meeting the UDI requirements = AxB (m^2)*
S1	1.2	6.2	1.0+1.2+1.0=3.3	20.1
S2	1.7	6.2	1.0+1.7+0.3=3.0	18.6
Daylit area meeting UDI requirement				**254.7**

We do this for the south facade we do this for the east facade.

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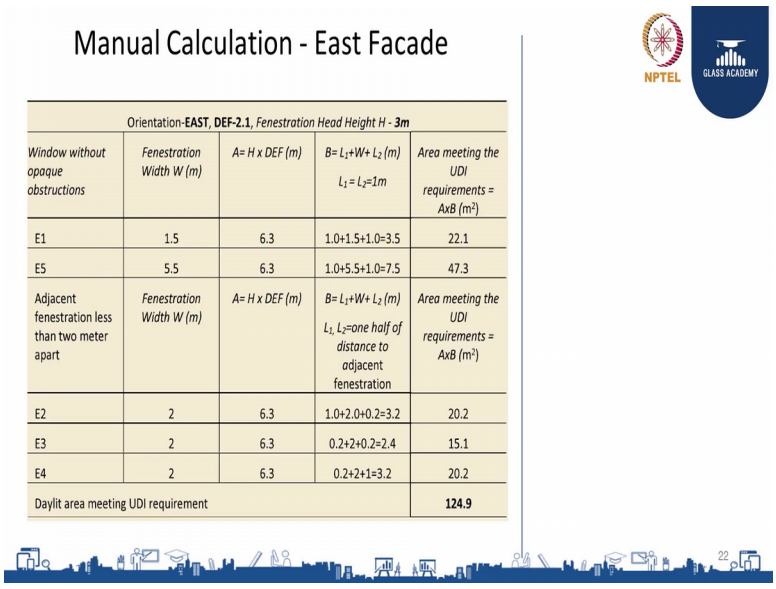

Orientation-**EAST**, **DEF-2.1**, *Fenestration Head Height H - **3m***				
Window without opaque obstructions	*Fenestration Width W (m)*	*A= H x DEF (m)*	*B= L_1+W+ L_2 (m) $L_1 = L_2$=1m*	*Area meeting the UDI requirements = AxB (m^2)*
E1	1.5	6.3	1.0+1.5+1.0=3.5	22.1
E5	5.5	6.3	1.0+5.5+1.0=7.5	47.3
Adjacent fenestration less than two meter apart	*Fenestration Width W (m)*	*A= H x DEF (m)*	*B= L_1+W+ L_2 (m) L_1, L_2=one half of distance to adjacent fenestration*	*Area meeting the UDI requirements = AxB (m^2)*
E2	2	6.3	1.0+2.0+0.2=3.2	20.2
E3	2	6.3	0.2+2+0.2=2.4	15.1
E4	2	6.3	0.2+2+1=3.2	20.2
Daylit area meeting UDI requirement				**124.9**

And similarly we do it for the west facade.

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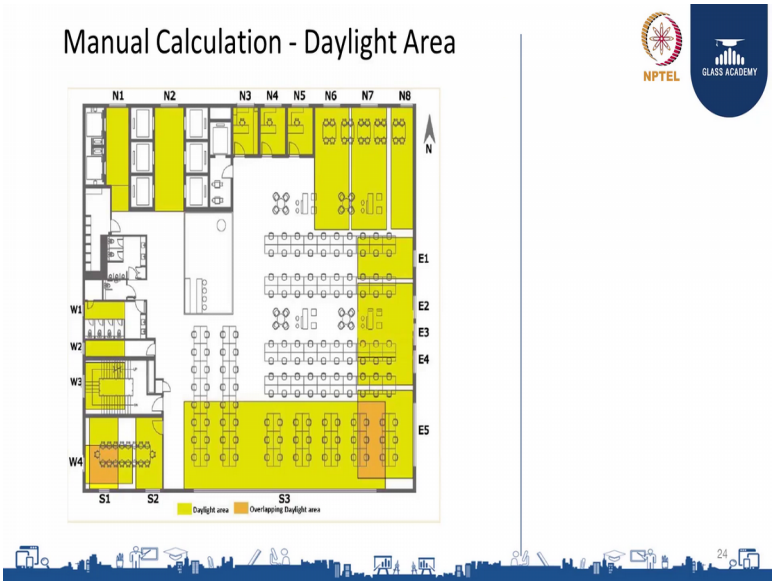

So, we not only calculate, but we also mark these areas on the drawing on the floor plan why do we do that? And why cannot we just sum these areas. We cannot do that we simply cannot sum all these areas because sum of these areas are overlapping.

So, if we see these orange areas these two orange areas, these areas are being overlapping and they are counted twice. Let us take the area which is towards the window E 5, this area is counted as daylit in the window S 3 and it also counted daylit in the window E 5 therefore, this area needs to be subtracted from the total area. Similarly, the area near window S 1 and window W 4 is being counted twice it is counted N W 4 as well as one therefore, this also needs to be subtracted.

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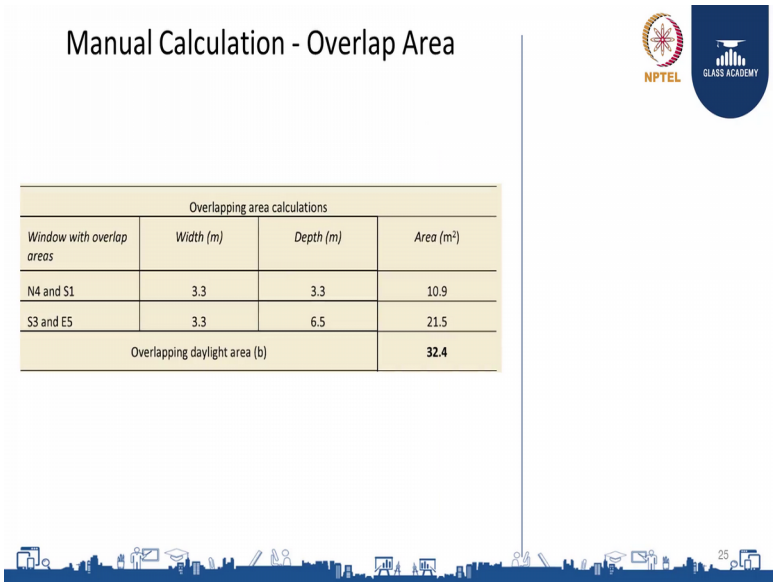

Overlapping area calculations			
Window with overlap areas	*Width (m)*	*Depth (m)*	*Area (m^2)*
N4 and S1	3.3	3.3	10.9
S3 and E5	3.3	6.5	21.5
Overlapping daylight area (b)			**32.4**

So, we remove the overlapping areas by a first adding the total overlapping areas and reducing it from the total daylit areas that we got for from each orientation.

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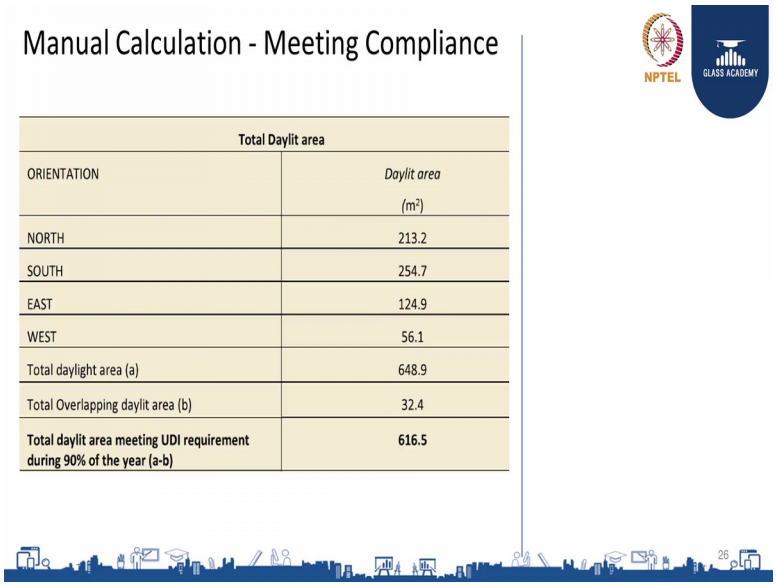

Total Daylit area	
ORIENTATION	*Daylit area (m^2)*
NORTH	213.2
SOUTH	254.7
EAST	124.9
WEST	56.1
Total daylight area (a)	648.9
Total Overlapping daylit area (b)	32.4
Total daylit area meeting UDI requirement during 90% of the year (a-b)	**616.5**

So, in this example we are getting 616.5 meters square area which is meeting the daylight requirements of UDI 90 percent of the year.

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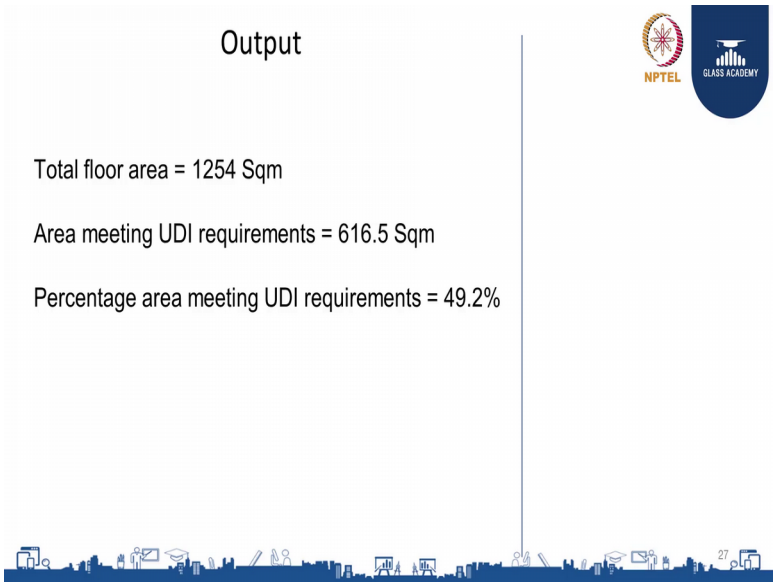

Now, 616.5 is 49.2 percent of the total floor area that is 1254 square meter and this is more than 40 percent which is required by ECBC and therefore, this floor and this design meets the UDI requirements of ECBC 2015.

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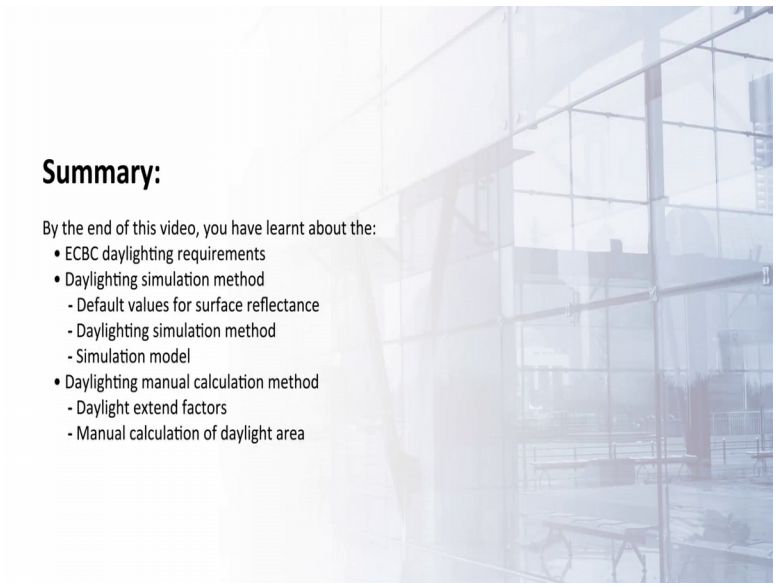

Thank you.