

**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 floor 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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### ECBC Daylighting Requirements


Above grade floor areas shall meet or exceed the useful daylight illuminance (UDI) area requirements listed in Table 4-1 for 90% of the potential daylight time in a year.

ECBC Table 4-1 Daylight Requirement

Building Category	Percentage of above grade floor area meeting the UDI requirement		
	ECBC	ECBC +	Super ECBC
Business, Educational	40%	50%	60%
No Star Hotel, Star Hotel, Healthcare	30%	40%	50%
Resort	45%	55%	65%
Shopping Complex	10%	15%	20%
Assembly*	Exempted		

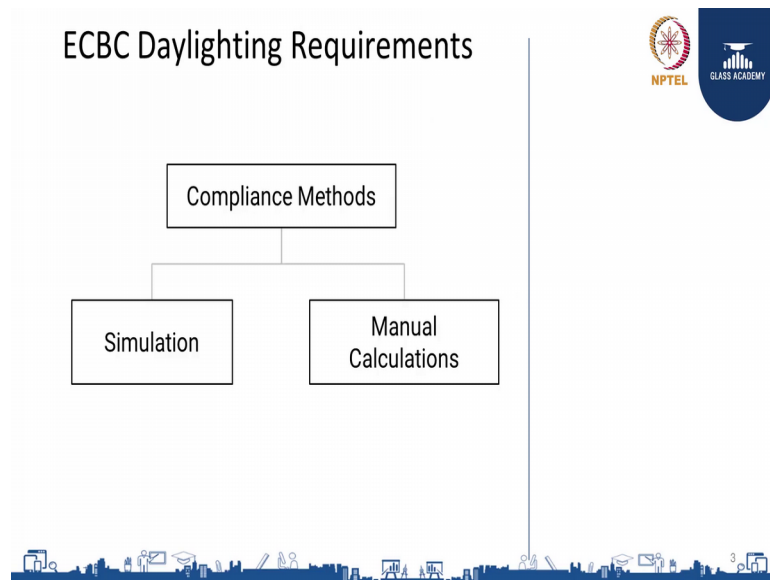
\*and other buildings where daylighting will interfere with the functions or processes of 50% (or more) of the building floor area





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.

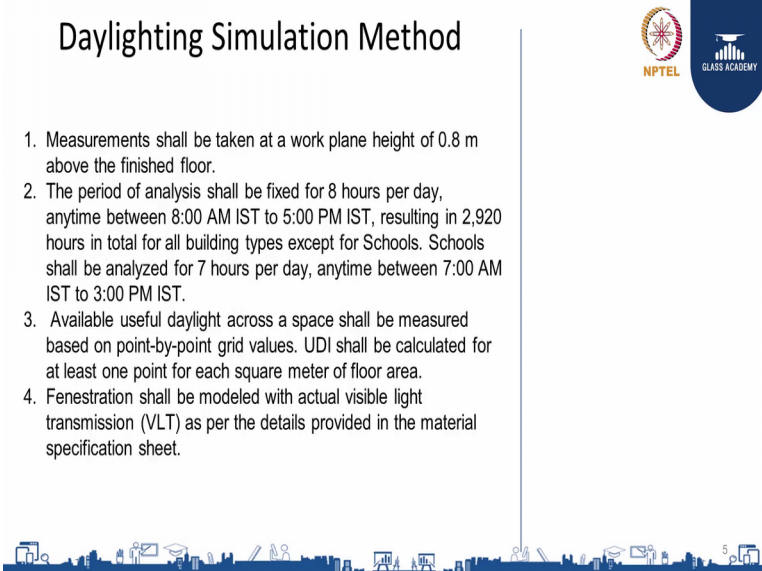
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The slide is titled "Daylighting Simulation Method". It contains three paragraphs of text. The first paragraph states: "Only BEE approved software shall be used to demonstrate compliance through the daylighting simulation method." The second paragraph states: "Buildings shall achieve illuminance level between 100 lux and 2,000 lux for the minimum percentage of floor area prescribed in Table 4-1 for at least 90% of the potential daylight time." The third paragraph states: "Illuminance levels for all spaces enclosed by permanent internal partitions (opaque, translucent, or transparent) with height greater or equal to 2 m from the finished floor, shall be measured." In the top right corner, there are two logos: the NPTEL logo and the GLASS ACADEMY logo. At the bottom of the slide, there is a decorative horizontal line with various small icons representing educational and professional fields.

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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**Daylighting Simulation Method**

1. Measurements shall be taken at a work plane height of 0.8 m above the finished floor.
2. The period of analysis shall be fixed for 8 hours per day, anytime between 8:00 AM IST to 5:00 PM IST, resulting in 2,920 hours in total for all building types except for Schools. Schools shall be analyzed for 7 hours per day, anytime between 7:00 AM IST to 3:00 PM IST.
3. Available useful daylight across a space shall be measured based on point-by-point grid values. UDI shall be calculated for at least one point for each square meter of floor area.
4. Fenestration shall be modeled with actual visible light transmission (VLT) as per the details provided in the material specification sheet.


The slide features the NPTEL logo on the left and the Glass Academy logo on the right. At the bottom, there is a decorative blue silhouette of a city skyline with various icons representing buildings, a person, and a computer.

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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## Daylighting Simulation Method




5. All surrounding natural or man-made daylight obstructions shall be modeled if the distance between the façade of the building (for which compliance is shown) and surrounding natural or man-made daylight obstructions is less than or equal to twice the height of the man-made or natural sunlight obstructions. If the reflectance of the surfaces is not known, default reflectance of 30% and 0% shall be used for all vertical surfaces of man-made and natural obstructions respectively.
6. Interior surface reflectance shall be modeled based on the actual material specification. If material specification is not available, Table 4-2 Default values to be used.




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 obstructions. 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 obstructions 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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## Default Values for Surface Reflectance



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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### Daylighting Simulation Method- Example

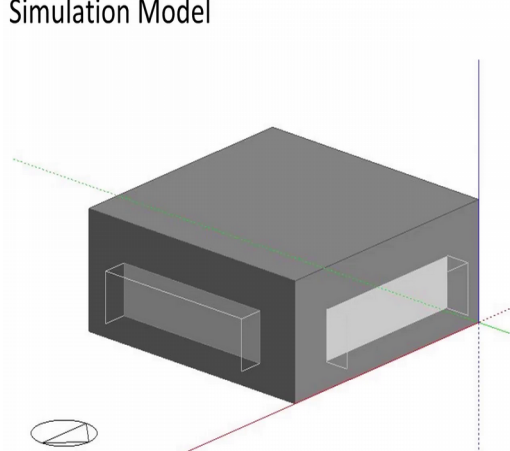
Input variable	Parameter
Location	Hyderabad
Number of blocks	1
Total built up area	100 sqm (10 m X 10 m one floor)
Floor to floor height	3 m
Window wall ratio	30%
Window Visible Light Transmittance	0.41
Occupancy type	Daytime Office
Overhang and fins depth	1 meter





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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### Simulation Model

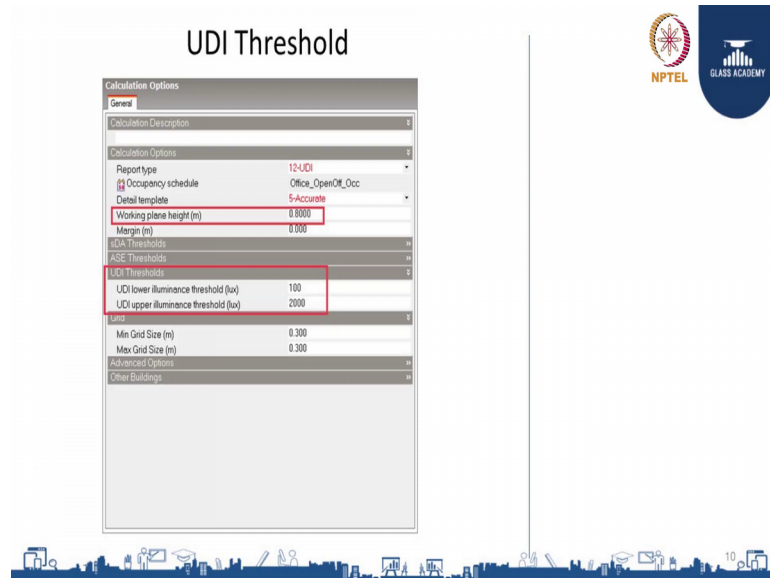


Note: Here we have used DesignBuilder for this example. Any tool approved by BEE can be used for the simulations.



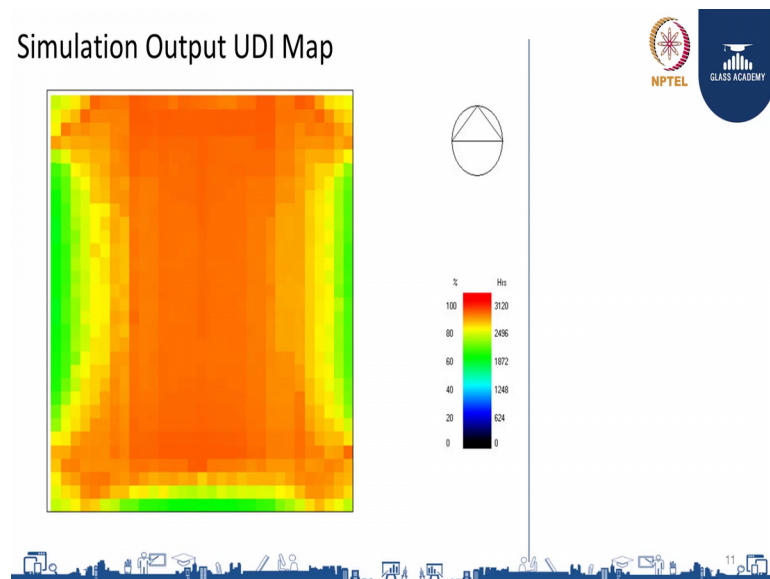
We model this in any software which is approved by the in this case we have used design builder you can see the model, it is a square building and it has window which has both the overhang and the side fins.

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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.

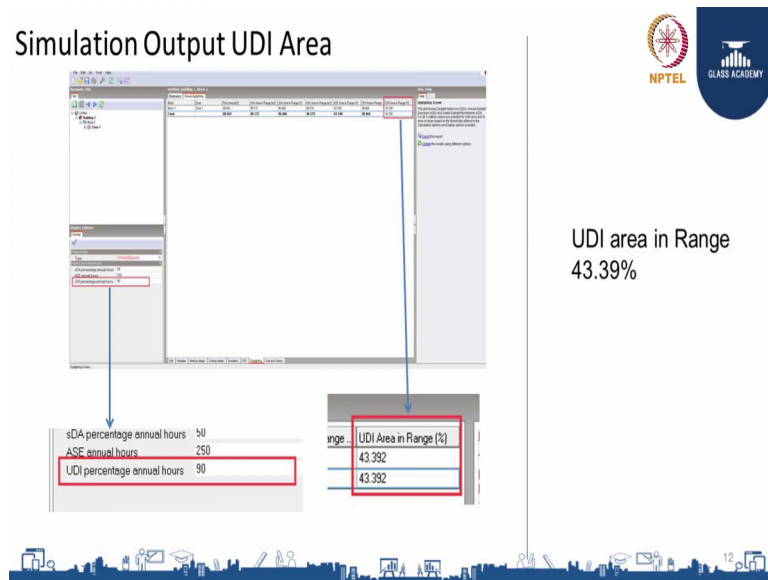
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We then simulate in the simulation we get UDI map as an output. Here you can see what areas meet the 90 percent requirement and which areas do not meet the 90 percent

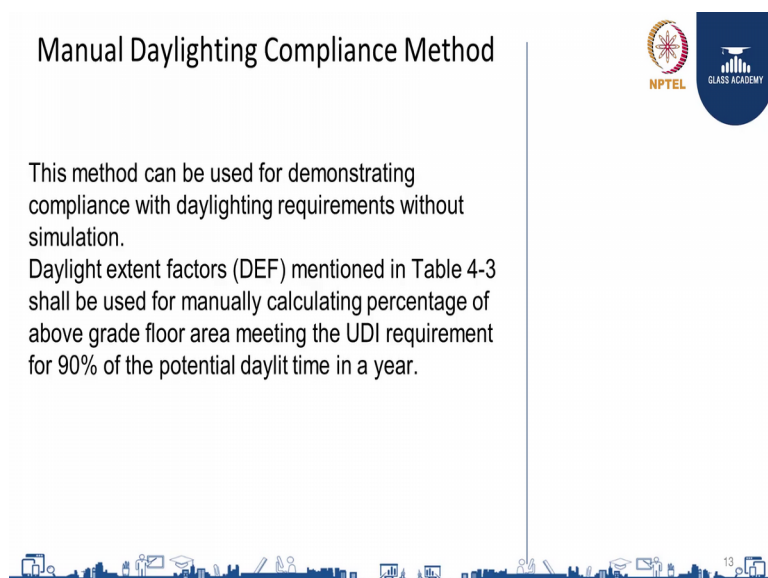
requirement. Interestingly you will see that the areas which are closer to the window are not meeting the requirements, why? Because, they are getting overlaid for several hours in the year, they are getting more than 2000 lux and therefore, they are those hours are not considered as meeting the UDI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



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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a. To calculate the daylit area:


- I. In a direction perpendicular to the fenestration, multiply daylight extent factor (DEF) by the head height of the fenestration or till an opaque partition higher than head height of the fenestration, whichever is less.
- II. In the direction parallel to the fenestration, daylit area extends a horizontal dimension equal to the width of the fenestration plus either 1 meter on each side of the aperture, or the distance to an opaque partition, or one-half the distance to an adjacent fenestration, whichever is least.
- III. For skylights, calculate the horizontal dimension in each direction equal to the top aperture dimension in that direction plus either the floor-to-ceiling height (H) for skylights, or 1.5 H for monitors, or H or 2H for the sawtooth configuration, or the distance to the nearest 1 meter or higher opaque partition, or one-half the distance to an adjacent skylight or vertical glazing, whichever is least.



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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b. A separate architectural plan shall be prepared with all daylight areas marked on the floor plans. A summary shall be provided showing compliance as per Table 4-1.

c. Glazed façades, with non-cardinal orientation, shall be categorized under a particular cardinal direction if its orientation is within  $\pm 45$  degrees of that cardinal direction.


d. Any surrounding natural or man-made daylight obstructions shall not be considered in this method.




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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### Manual Calculation Method - Example



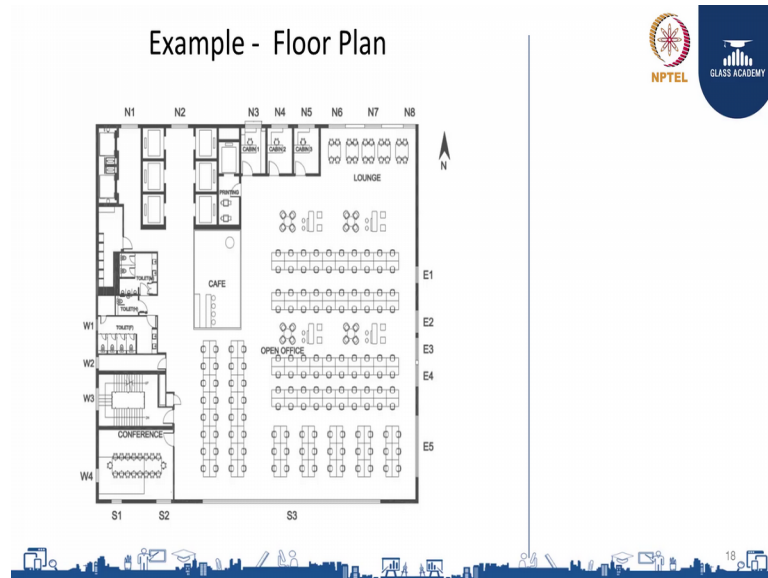
S.No.	Parameter	Value
1	Location	New Delhi
2	Floor area	33 m x 38 m (1254 m <sup>2</sup> )
3	VLT of glazing in all orientations	0.39
4	External shading	PF $\geq$ 0.4
5	Light Shelves	Installed
6	Head height of fenestration	3.0 m



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

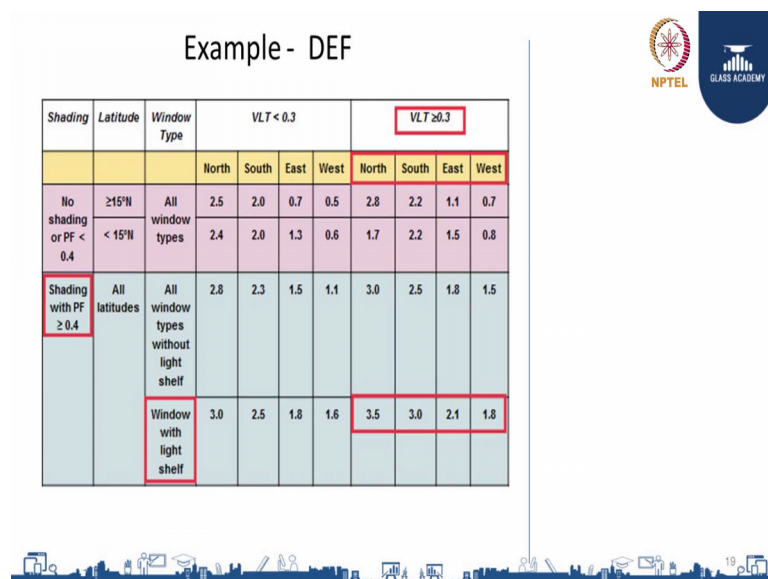
glazing 0.39 assume all the glazing's in all the way orientation has the same VLT, external shading projection factor is more than or equal to 0.4, light shelf's are installed head height of fenestration is 3 meter.

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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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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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**Manual Calculation - North Facade**



Orientation-NORTH, DEF-3.5, Fenestration Head Height H - 3m				
Window without opaque obstructions	Fenestration Width W (m)	A= H x DEF (m)	B= L <sub>1</sub> +W+ L <sub>2</sub> (m) L <sub>1</sub> = L <sub>2</sub> =1m	Area meeting the UDI requirements = AxB (m <sup>2</sup> )
N7	2.0	10.5	4.0	42.0
N6	2.0	10.5	4.0	42.0
N2	2.0	10.5	4.0	42.0
Window with opaque obstructions	Fenestration Width W (m)	A= Distance till parallel Obstruction (m)	B= L <sub>1</sub> +W+ L <sub>2</sub> (m) L <sub>1</sub> = L <sub>2</sub> =Distance to perpendicular Obstructions	Area meeting the UDI requirements = AxB (m <sup>2</sup> )
N1	2.0	10.5	0.3+2+0.3=2.6	27.3
N3	2.0	4.0	0.4+2+0.4=2.8	11.2
N4	2.0	4.0	0.4+2+0.4=2.8	11.2
N5	2.0	4.0	0.4+2+0.4=2.8	11.2
N8	1.5	10.5	0+1.5+1.0=2.5	26.3
Daylit area meeting UDI requirement				<b>213.2</b>


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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### Manual Calculation - South Facade




Orientation-SOUTH, DEF-3, Fenestration Head Height H - 3m				
Window without opaque obstructions	Fenestration Width W (m)	A= H x DEF (m)	B= L <sub>1</sub> +W+ L <sub>2</sub> (m) L <sub>1</sub> = L <sub>2</sub> =1m	Area meeting the UDI requirements = Ax B (m <sup>2</sup> )
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 <sub>1</sub> +W+ L <sub>2</sub> (m)	Area meeting the UDI requirements = Ax B (m <sup>2</sup> )
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				<b>254.7</b>




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

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### Manual Calculation - East Facade

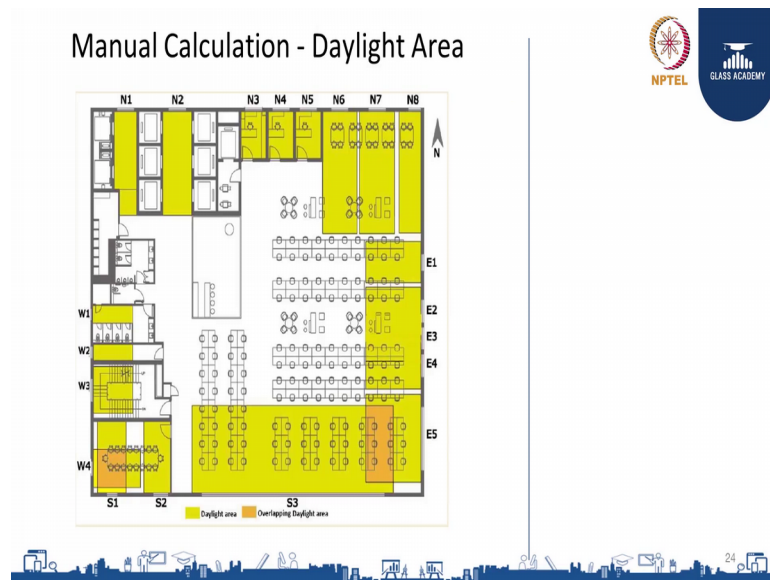


Orientation-EAST, DEF-2.1, Fenestration Head Height H - 3m				
Window without opaque obstructions	Fenestration Width W (m)	A= H x DEF (m)	B= L <sub>1</sub> +W+ L <sub>2</sub> (m) L <sub>1</sub> = L <sub>2</sub> =1m	Area meeting the UDI requirements = Ax B (m <sup>2</sup> )
E1	1.5	6.3	1.0+1.5+1.0=3.5	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 <sub>1</sub> +W+ L <sub>2</sub> (m) L <sub>1</sub> , L <sub>2</sub> =one half of distance to adjacent fenestration	Area meeting the UDI requirements = Ax B (m <sup>2</sup> )
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				<b>124.9</b>



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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### Manual Calculation - Overlap Area




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




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

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### Manual Calculation - Meeting Compliance

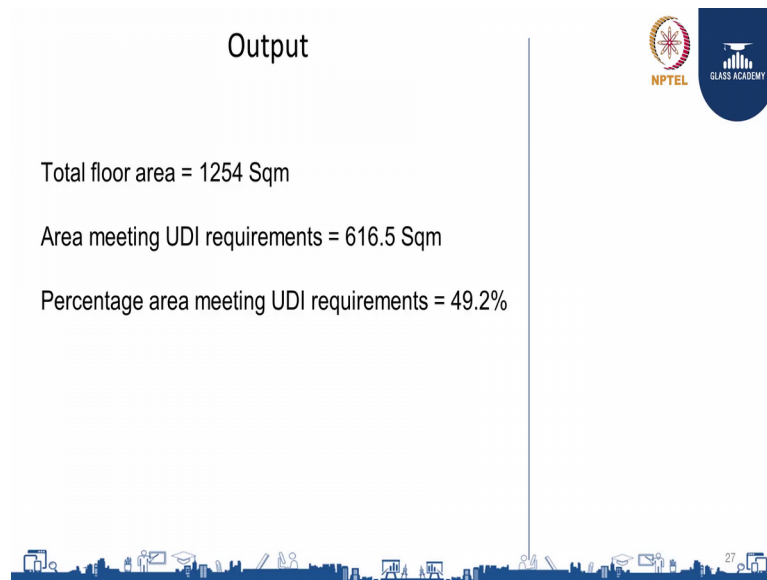


Total Daylit area	
ORIENTATION	Daylit area (m <sup>2</sup> )
NORTH	213.2
SOUTH	254.7
EAST	124.9
WEST	56.1
Total daylight area (a)	648.9
Total Overlapping daylight area (b)	32.4
<b>Total daylight area meeting UDI requirement during 90% of the year (a-b)</b>	<b>616.5</b>



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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Output

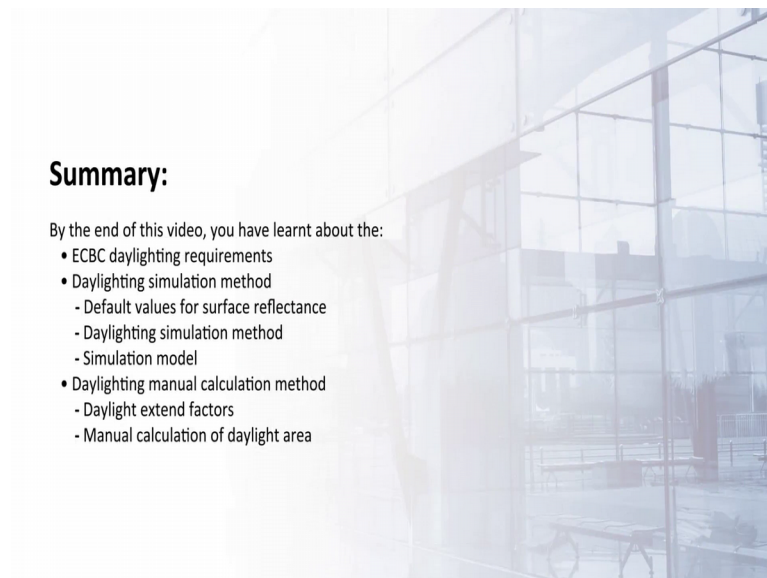
Total floor area = 1254 Sqm

Area meeting UDI requirements = 616.5 Sqm

Percentage area meeting UDI requirements = 49.2%

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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**Summary:**

By the end of this video, you have learnt about the:

- ECBC daylighting requirements
- Daylighting simulation method
  - Default values for surface reflectance
  - Daylighting simulation method
  - Simulation model
- Daylighting manual calculation method
  - Daylight extend factors
  - Manual calculation of daylight area

Thank you.