**Principles and Applications of Building Science**
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**Lecture – 20**
**Lighting – Design Concepts**

In the last module, we looked at the basics of lighting that is a indices which are used in lighting like luminance. Luminance few parameters we looked at in this section we will look at design concepts, how you can harvest day lighting. So, primarily we will look at daylight harnessing systems.

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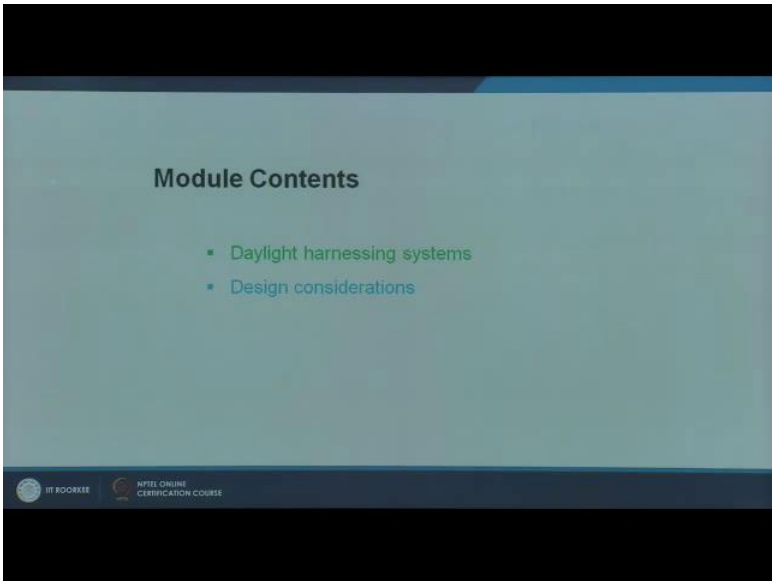


There are two types harnessing and harvesting systems. We will look at specific types and few products which are available then, we will look at what are the typical design considerations for harnessing daylight. Typically we know that daylight is very effective efficient as well as more realistic form of light, you get the actual color radiation of a particular object. Any object seen in natural daylight is you know more realistic than rendering it with artificial lighting it is more energy extensive. If you have to really render it to the actual in color of it.

So, typically you know we have been studying about various methods or logically we know that various methods of you. You know effectively getting natural light into the building instead of having single large panel windows.

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For example, you can have two clear you know sets of window like glazing, one catering to the work area close to the periphery in the other you know the typical sky light or the top you the top part of the thing can be split which will throw light on to the interiors of the building or the core areas of the building. The other simple option is instead of having linear horizontal you know elements, you can have vertical where you have a better through of light far to the core areas of the building other ways include provision of louvers provision of skylights clear stories north lighting roof trusses.

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In industry lighting see look at this is a naturally lead apart from simple, specific led lighting which is just used for a backup, there are certain lights which are still there seen there, but primary amount of light which you receive here is daylight well lit on both the surfaces it use uses all the possible daylight harvesting techniques, as to provide more or less uniform lighting across the work area different types of harnessing as well as harvesting daylight.

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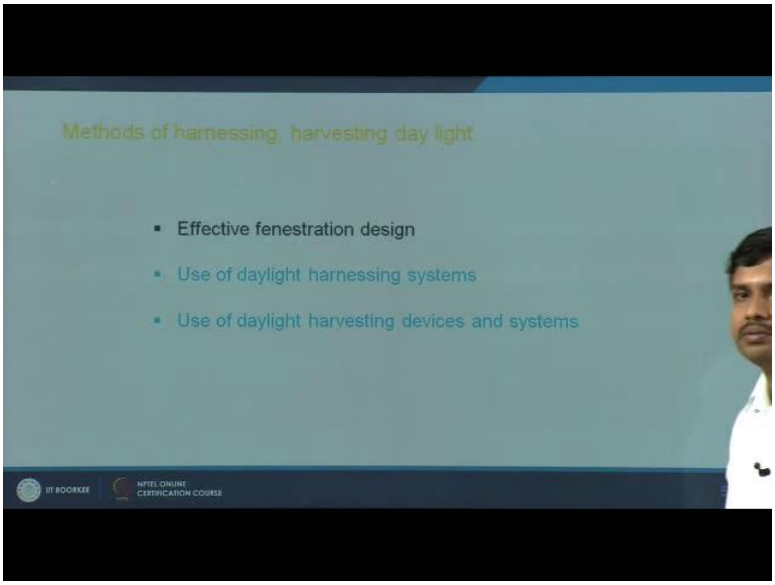


First is as we looked at effective design of fenestrations. So, we have to take an account of what type of fenestration what glass, if it is present what type of glass. If you are using what type of reflections re reflections diffusions we are using what strategy is specifically we are adopting in the fenestration design.

First is design of fenestrations second is use of daylight harnessing systems. What are the specific things where you can improve or enhance the amount of daylight available? So, you have specific harnessing systems with which are strategies adopting which, you will be able to improve direct as well as diffuse light which is entering the building third think is specific systems like harvesting system which are used even to remote part of the building core areas dark areas even to the basements. For example, we will be able to transport and get specific amount illumination which is required we will take a look at the details of systems which are available daylight harnessing systems typically, daylight know there are two types; one is which shading other is without shading the one which shading the lighting system harnessing system which shading.

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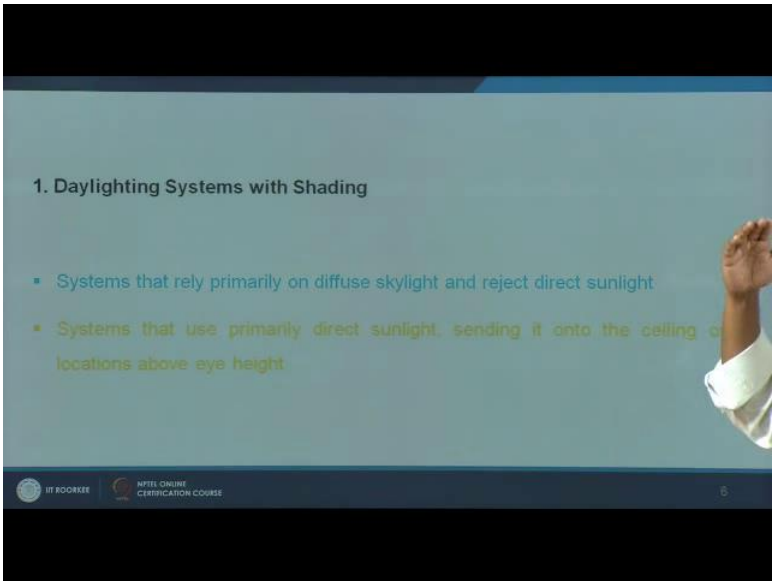


They primarily rely on diffuse skylight and reject the direct skylight which is available, there are also system that use primarily direct sunlight, which will reflect or sending it into the locations which are above the eye height. For example, there is this. This particular system will diffuse the light and reflect back the direct light the second type of system will like light shelf, we will look at the details further there is a reflective part which is getting direct light and reflecting it into the ceiling it is not allowing, It to affect your eye level where as, it is reflecting into the ceiling or the interiors of the building to get further re reflection light the core part of your space.

Second type is daylight system without shading here you have, diffuse light guiding system and direct light guiding system.

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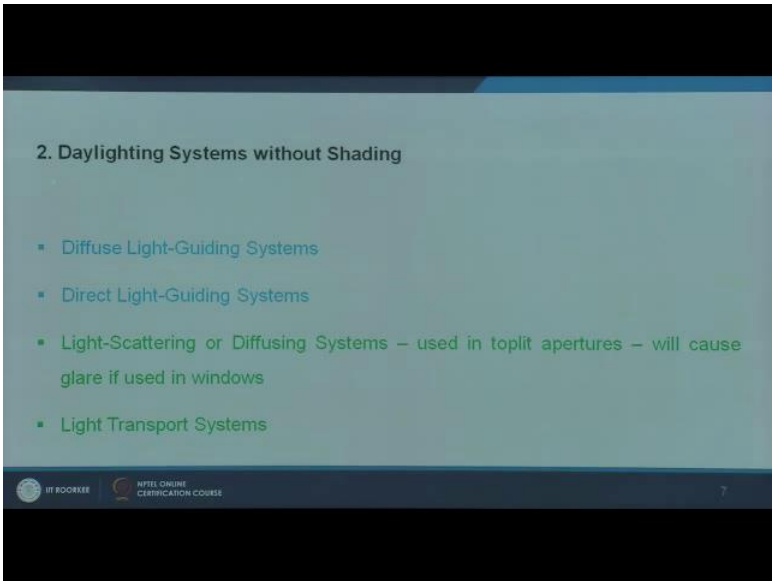


Third type is light scattering or diffusing system mainly they are used in top lit apertures they are primarily light scattering systems. If you are trying to use it in windows they will cause glare excess amount of diffuse light will be available primarily they are used in skylights or on the top and then you have light transport system which we will take a closer look at simple example of light reflecting system shades you have light shelf very commonly used it can be active it can be passive.

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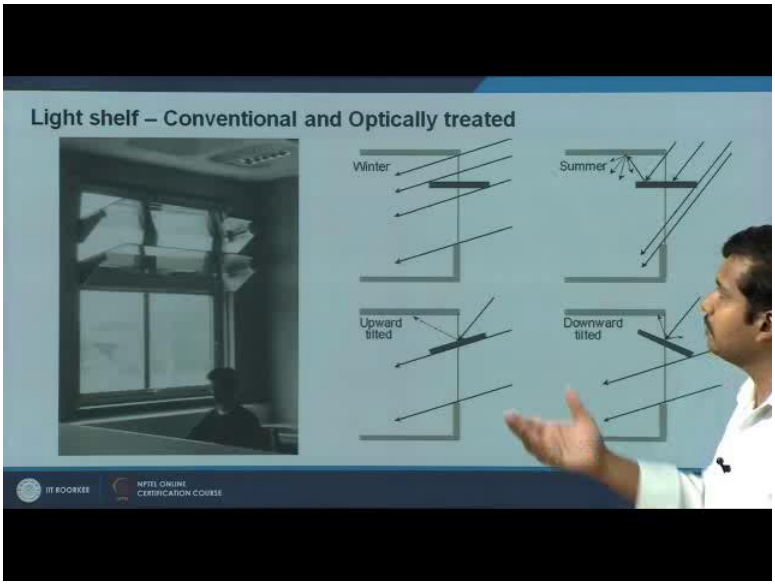


You have conventional and optically treated light shelves available it works on a simple phenomena you split the whole glazing or window area in to two the first part it caters to the peripheral areas directly then, you have it can be also attached and used as shading system it shades this particular glazing area from direct sunlight it improves the energy performance of your window then you have additional advantage. If the top surface is reflective it will get direct light reflected back here and then it will re reflected to the interior parts of it.

It can also be optically treated say for example, different times of the day winter sun versus summer sun winter sun is very low you get light directly in summer sun is very high it gets you know reflected from this and caters here some of these things are also adjustable. It can be upward or low you know downward tiltable depending on the requirement like you say in this example, it can also incorporate specific manual or automatic tilting facility.

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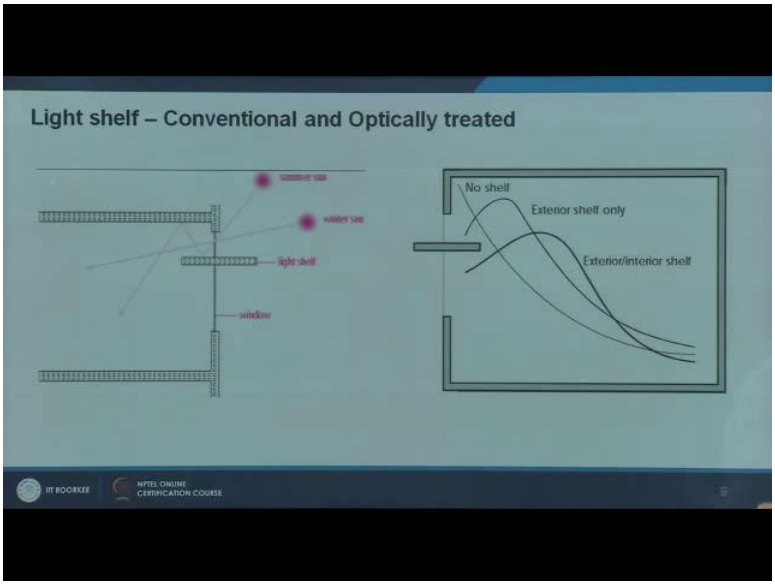


As to adjust the amount of lighting which is required in a particular space it works as I said in a simple principle it can extend into the building. If it extends further the amount of light penetration will be much higher where as if your closing it up to this it is a simple shading device which is only used the interior projects is not available then, it will only reflect to specific areas the further interiors will not be lit very well.

Of course there are other associated things I will talk about in a moment summer sun is high you get directly into the interiors not into the core they are not much heat. Whereas winter sun is directly falling and the low winter sun you will get direct skylight where, as summer sun it will reflect into the building there are other considerations. For example, one of the projects we ended up you knows giving a nice light shelf as we predicted or as we calculated the performance was also good interiors. Where well lit, but there was a problem of you know the rain fall which is causing nice this was a simple double glass which was provided here there was you know, it was a high rainy area there was a rain high rain fall which is falling on a the rain drop was creating excessive noise level into the interior then we have to also take care of sound proofing. We have to take care of water proofing there are other things associated well designing light shelf you know it is not a simple insertion of a panel there are associated factors which has to be taken into consideration.

A simple graph which says without this light shelf the light level will be very high here daylight level or light factor relates factor would be very high, eventually it will drop down. If you have only exterior shelf if this portion is not existing only a external shading kind of then the light level will be very high here eventually it will drop down, if you are also increasing it from exterior to interior like I said there if this extending in to the building then it is not excessively lit here, while the interiors are also fairly getting improved amount of lighting levels it is also not right practice to get excessive amount of light in the periphery and making it too darker in the interior.

So, ideally this type of light shelf extending into the interior of the building will have a fair distribution at least for two-third of the room area depends on the fenestration size and the depth of the system itself typical example of light, shelves you can closely look at it they are projected inside without any artificial lighting.

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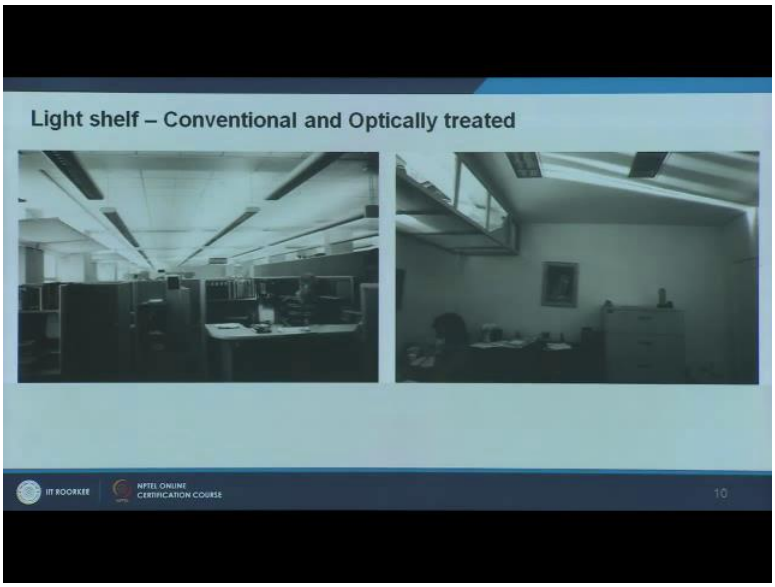


You get the desired amount of light which is available again here it is getting reflected to the ceiling getting back to the work place without artificial light. They are able to perform typical office activity the second type is use of louvers and blind system different sub divisions are there fixed and operable louvers as well as blinds you are translucent blinds and you have light directing louvers.

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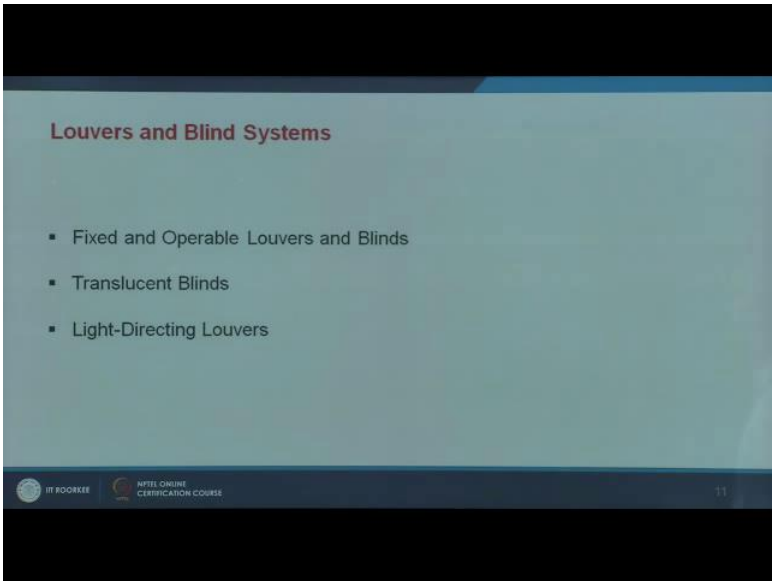


It can be used separately as a component or they can be tag to window elements, itself some of these cases they are made part of the double glazing unit's some of them are placed inside double glass unit where you know between the two panes inside the air gap.

So, they acts also act as light reflectors some of the examples. For example, these are reflective louvers placed in between two panes of glass.

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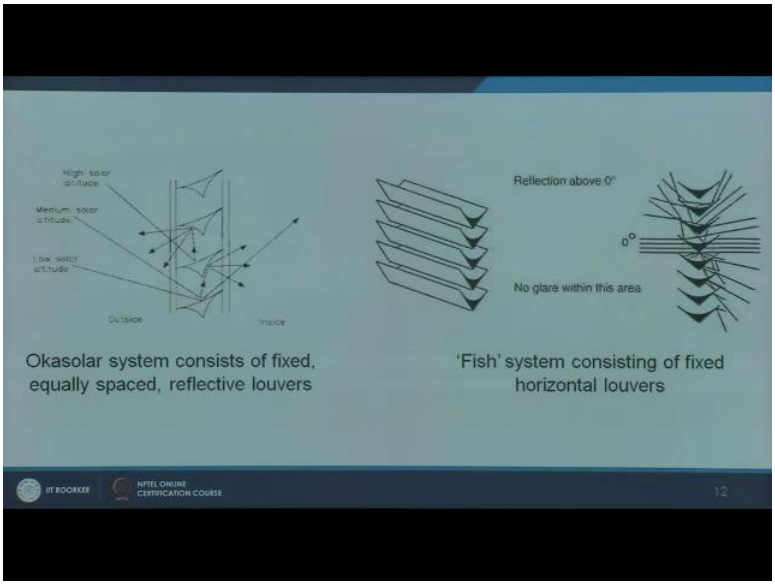


The reflect and re reflect light into the interiors you also have fish system, for example, they are another type of reflections where the light falling on it gets scattered and then you are getting more diffuse reflections focused into the particular space another concept which is in use is called prismatic panel. These are typically acrylic panels which are cut and each one of it acts as a prism backing and the angle the shape of it and the angle of it the size of it determines.

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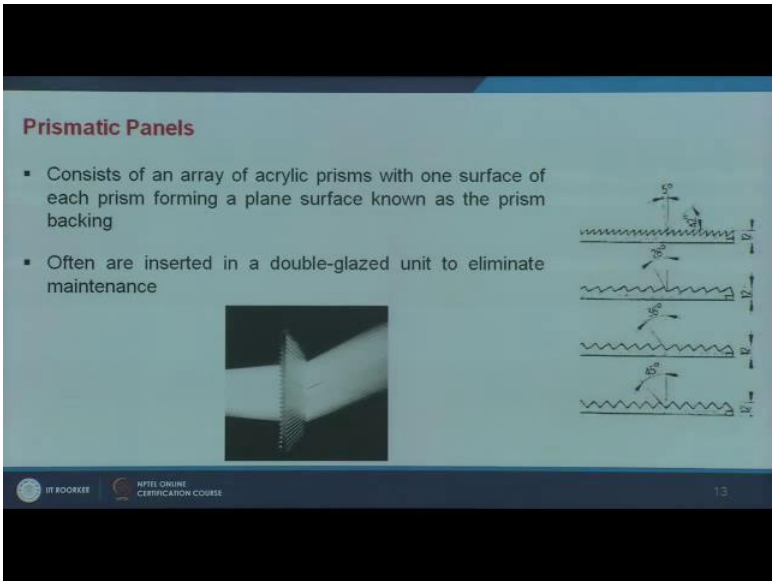


The reflection which is happening into it they are mostly inserted in to double glass units like we saw in the previous case between two panes. These are inserted and what happen this will reflect and diffuse the direct light which is falling on it different types are there simple diffuse daylight they are normally used in vertical plane facades to redirect light from outside the sky and it will be reflected into the inside the room and typically on the ceiling surfaces. The light direct light will fall these prisms will reflect these are typically placed inside the window or glazing systems.

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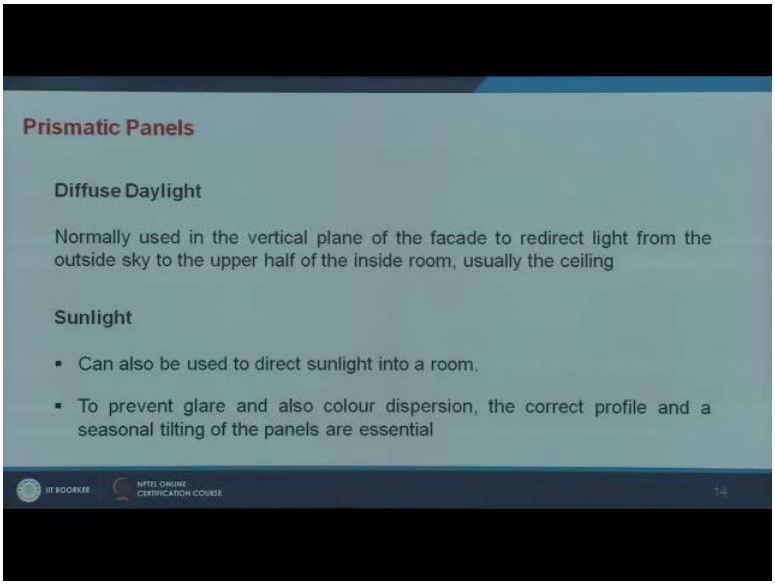


There is another type which is sunlight they can you know we used to get are direct the direct sunlight the natural light into the room if you are wanting to use it on the vertical surface typically these are used on skylight. If you want to use it on vertical surfaces they may cause glare. So, it is better to closely look at or work upon the type of profile and it is also better idea to give seasonal tilting of panels. So, as to avoid any glare related discomfort the other types include fix sun shading system they can be used as you know typically where seen in glaze roof, they can track the movement of the sun automatically moved or they can be adjusted you know or sometimes they are integrated into double glazing unit. There are also movable sun shading system where they are placed in front of double glazing system or behind it or sometimes inside it they also act as sun shading devices.

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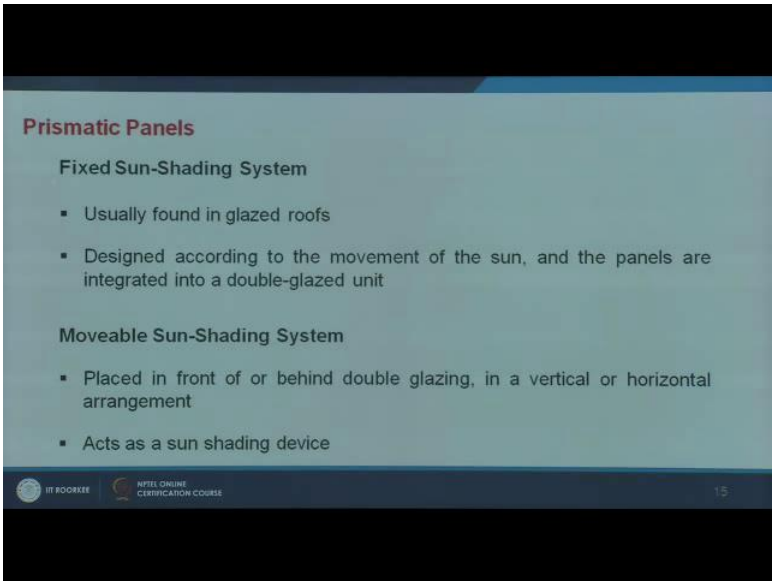


One of the emerging things which is you know lot of research is being conducted in this type of system they are also in the market some products are available these are laser cut panels they are you know typical arrays or cut within.

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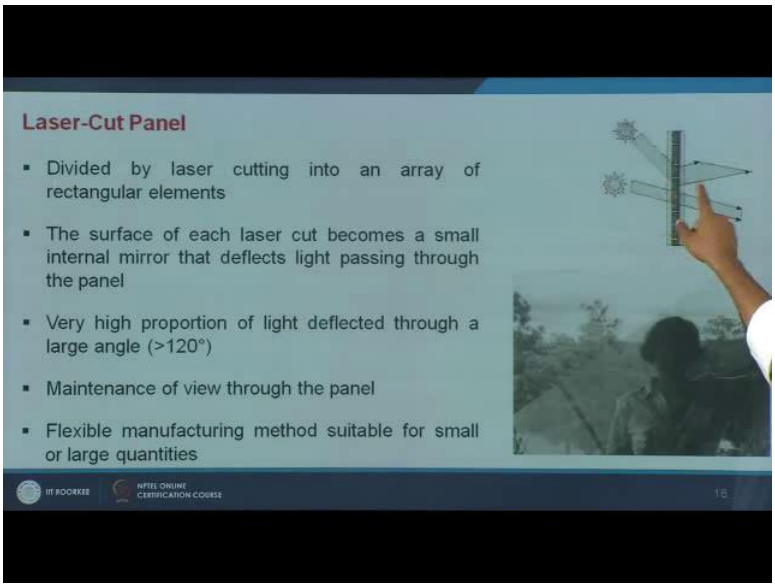

You know typical rectangular arrays or cut main advantage here is they are able to give you unaffected or less affected views. You know views are being maintained. So, the glass itself is like a see through glass you do not have any concerns about it, but still it is able to reflect or deflect through a very large angle it also gives you flexibility of manufacturing in small or large quantities, apart from this you have light guiding shades simple devices which can specifically, reflect and re reflect the primary concept with any of these devices is either it cuts the direct light diffuses or gets only the diffuse light or diffuses the light itself into the building or there are systems which will reflect the direct light into the interiors of the building periphery anyway is getting well lit.

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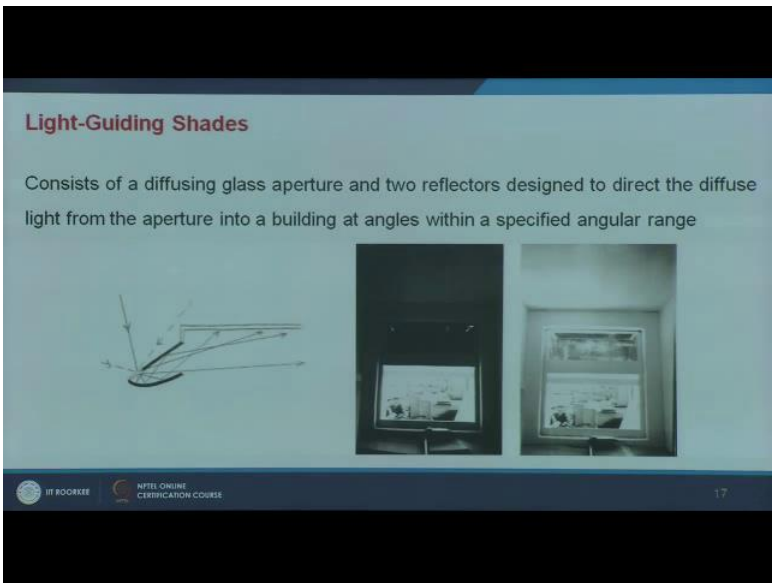


The main idea is to transit or pass through these reflections, into the core or interiors of the building which typically is a comparatively or relatively darker area compared to the periphery.

So, this is another type light guiding shades which you know the radius and the curvature of it versus the tilt of it determines, where it is getting actually reflected apart from this you have deflecting panels vertical as well as horizontal deflections. Can happens there are many such types of more than, this there are also other varieties these are some common you know things which are in the field. Let us take a look at specific guidelines

for designing skylights if you want to put these skylights into your building simple example you can distribute them evenly, so that you will get more uniform light across your space second idea are you can have certain splayed adjust.

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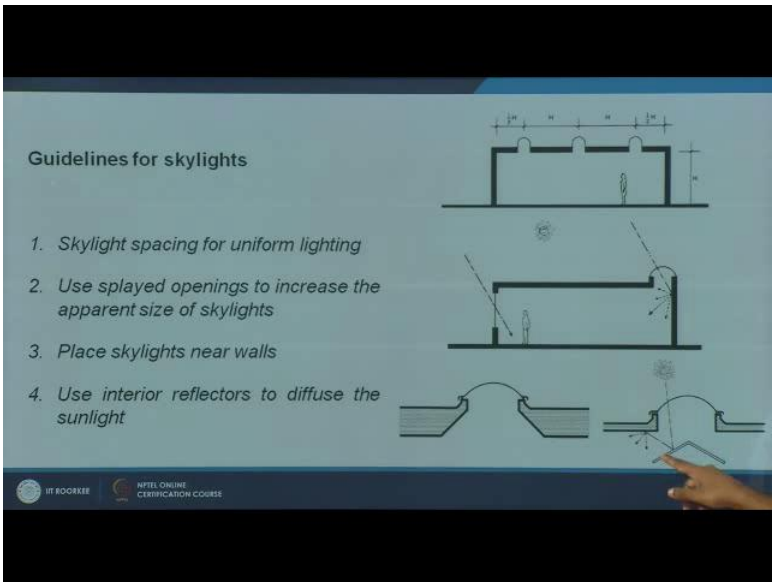


So, that you know instead of sharp adjust if you have splays here the distribution will be much wider. Then you can place them near the wall if the wall surface is reflective you will get good amount of reflection or you can place certain reflective panels. So, that they get reflected and re reflected.

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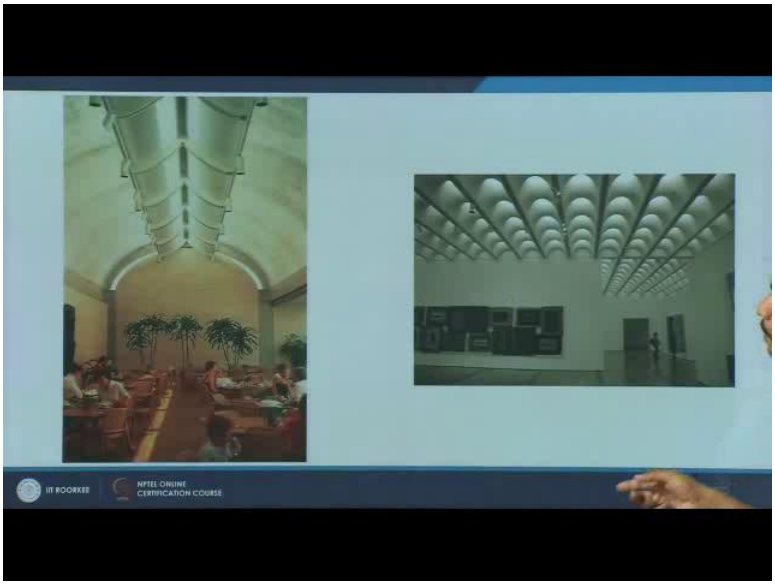


Some examples for you know for instance there is a skylight on top here they have used reflectors now the light is incident it is getting reflected back and then, it is lighting the space apart from this you can also notice they have certain supplementary lights when, daylight is less or it is not available then these lights can be turned on.

This is another type where, they have try to employ day lighting again here only few of the artificial lights are on still they are able to manage at dramatic interior with good amount of visibility. We have been looking at harnessing systems light pipes which is also another emerging technology.

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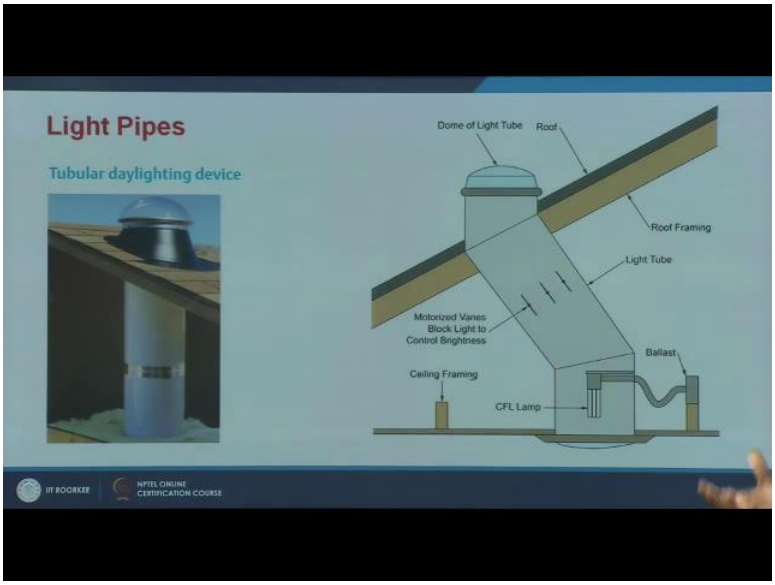


They are also there are also commercial products which are available which you can you know simply buy and assemble and fix it in your building light pipes which are typically day light harvesting system there is a unit it can be dome or pyramidal shape or in there are different types available in that. They will typically cultivate or harvest daylight on your roof top or any outside surface on they will transport it to the interiors of your building three components are there first is there is a receiving element then there is a transitional portion which will have to have good reflecting surfaces. So, that in the light is simply reflected the losses are less then you will have a final internal component which acts as your light source.

Lot of buildings have you know tried using this for dark basement areas where instead of artificial lighting you can have it in your gardens from which the light is harvested and put in to your interiors lot of energy sayings can be attained, but there is a major concern here the sky lighting gets you know fluctuated when there is cloud movement. There is a dark sky there is a bright sky by virtue of this the amount of light which is varying you know which is get you know received inside highly is fluctuating in that case, you will always need a supplementary light.

Whenever there is a dearth or reduction in the amount of daylight which is available here this supplementary lighting there will be a sensor which measures the amount of light, which is getting through if the light levels are lesser this will be actuated this light will supplement the amount. So, those interiors suddenly do not turn darker and you know you do not loose vision in that case particularly. For example, you have a basement parking you definitely need specific set of back up lights there should be a sensor and an actuator mechanism which will sense the amount of light coming in it will actuate the artificial light. So, whenever there is a less amount of light which is received this will get activated and you will have a artificial light interior light levels or lux levels does not get drastically effected.

There are also certain other methods like you know, vanes or dampers which are available when there are excessive amount of light you can control them. So, that you have a constant amount of light say you only need 300 lux. When there is excessive amount of light these dampers or vanes can tilt and minimize the amount of light which is coming in. So, that they can be maintaining, somewhere between 22 to 350 lux there is a range within which it can be maintained.

The other technology which is in practice in some of the places it is lightly prices. So, it is not you know widely available in market, but as a technology it has been proven. One is the cast like LEDs. Once say 8-10 years back LEDs where, too costly now every house tries to buy LED lights it has become very cheap you know cost effective method as well the prices of drastically come down right now. Light tubes these transport light through them without much of losses.

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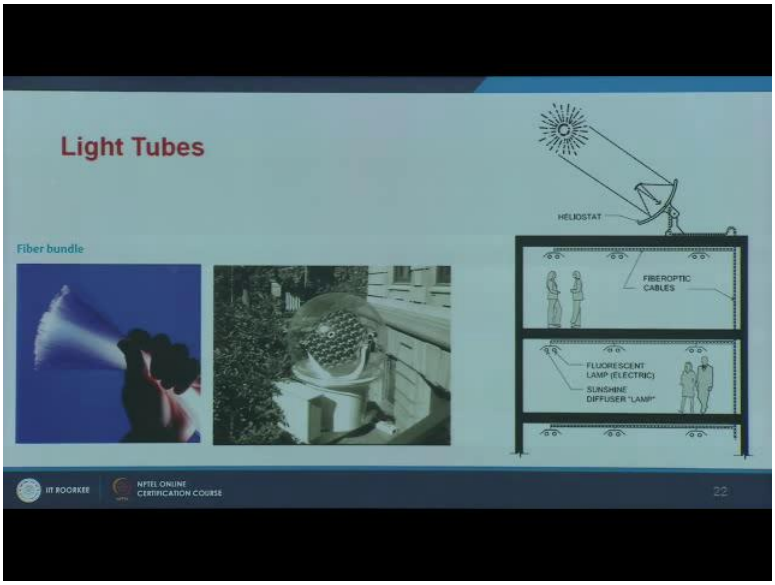


They have very thin slender fibers there is an almost 0 reduction in terms of reflection losses the light is transmitted through them. So, you have a you know receiver or a harvesting mechanism you can have it you know facing the sun this will be receiving the daylight, it will be reflected and pass through these optical fibers these are typically optical fibers called light tubes these will transmit this and then through the fiber optic cables it will be letting your interiors.

Simple mechanism, but it is slightly I said you know as I said it is slightly expensive in the current day. So, the technology is eventually picking up, but as such it is a very good harvesting system which is technically proven it can be easily tag to other light controls and actuating devices. So, supplementary artificial lights can you know act in tandem with this. So, has to maintain a uniform indoor lighting then, we talked about sensing and actuating any type of daylight harvesting system like say light tube or light pipes will require a back up artificial lighting control. So, in this there are two types typically there is a sensor which is capturing the amount of light which is falling on it. You know essentially the lux levels are measured then it is trying to give the signal to or actuate to the actuator which will be controlling the artificial light. There are two types here one is open loop and other is a close loop open loop system measures only the natural light and then it does not consider the electric light contribution.

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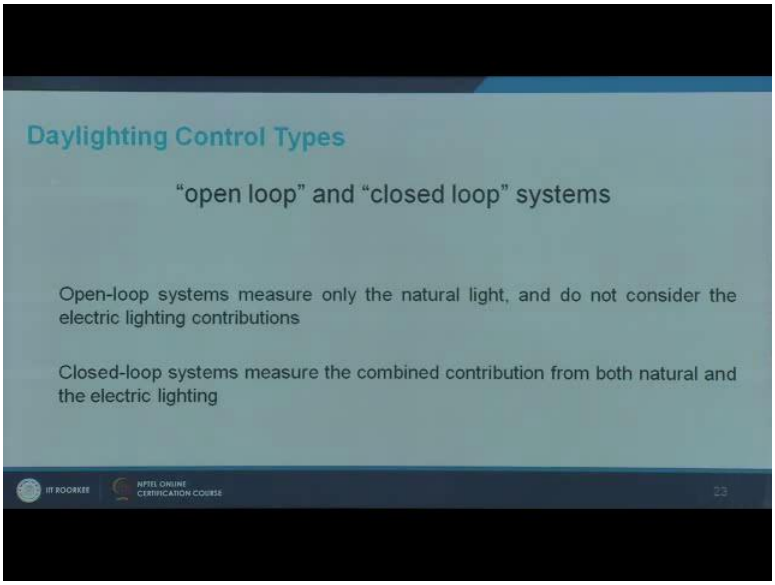


In the close loop system it is measuring the combined contribution from natural and artificial lighting system. There are two different types of lighting control systems one is a switch base that is switching daylight control system, other is a dimming daylight control system switching is working.

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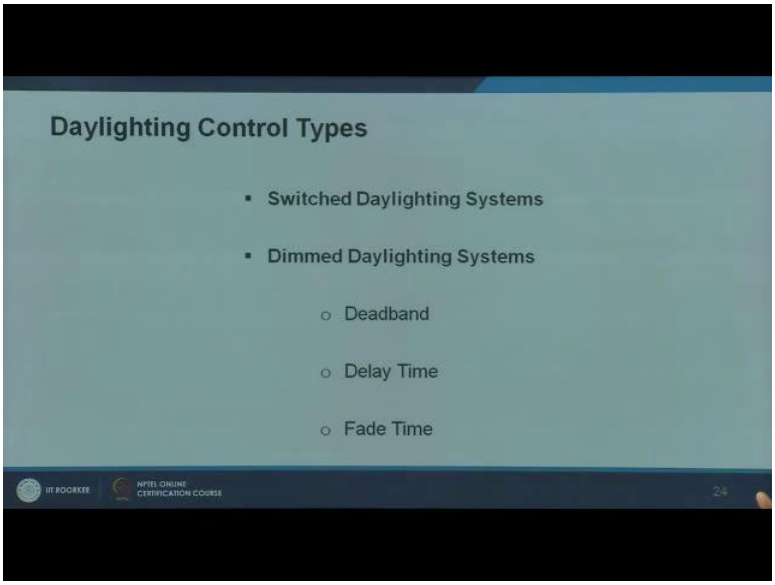

You know it is a simple binary logic it is 0 or 1. So, you have a threshold of 300 lux which is required inside a class room or an office space you said this limit to a switching control there will be a small you know buffer, which is given it can be 20 or 25 lux. So, if you say 20 lux, when the light level falls below 280 instead of 300, there will be a buffer up to 280. Once it is below 280 the artificial lights will be turned on where as in the dimming control there is a provision for adjusting increasing or decreasing the light levels initially with our conventional lighting system like incandescent and CFL lights there was a problem of wear and tear and the light fixtures getting worn away very easily.

There was you know with LED lights the dimming control are become more seamless because the life of these LED systems are very long they work very easily with the dimming controls there are 3 things associated which we have to understand first has the dead band it essentially represents a threshold beyond which or below which the actuation actually happens.

Then there is delay time for example, there is a cloud passage suddenly the sky gets dark for a moment and then it is you know it is reverting back to original. We are actually having 8000 to 10,000 lux, suddenly there is a cloud dark cloud which is passing by though you have a very small amount of instance at time within which the light level drops and then it comes in. So, you work around with the dead band and delay time. So, that the sensors and actuators are not very constantly you know standing on turning off or dimming increasing or brightening dimming of brightening, the internal lights. Then there is a fade time for example, how much time it takes for the light it is a curve how much time it takes for the lights to fade away or to start with it. It is a dimming.

So, it has to turn bright. So, how much time it takes whether that is suitable for a specific task. For example, if you are working on a very sophisticated thing you do not have the provision to lose even for a fraction of second the required amount of light level then the fade time should be very low which should immediately turn on to supplementive or if it is like a general office worker household things the fade time can be slightly longer it these all these 3 thinks, will affect your efficiency or energy consumption of your overall lighting system.

So, there are two components we have to keep in mind one is effective daylight harnessing or harvesting and second is the use of control system, which is also crucial the type of control which we are tagging to the actual artificial lighting will also determine the efficiency or energy performance of your whole system that actually determines your daylight efficiency and the reduction in artificial lighting energy.

So, in this session, we looked at two main things one is we talked about day lighting design, we continue to with the daylight factor which we start in the previous module. We talked about daylight harnessing system, we looked at daylight harvesting things like light pipes and light tubes. Then we also looked at certain design considerations for skylights apart from the type of controls, which are available with this you are closing the whole you know, program we so far we have been looked at the thermal acoustical as well as lighting park of building science. So, now, I wish you all the best for your exams.

Thank you.