Glass in buildings Design and Application
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Lecture - 31
Daylighting Controls-Part I

Welcome to this session on Daylighting Controls. Before we understand dayligthing controls let us understand: what is the control system. A control system manages or regulates the behavior of other devices or systems using control loops. It usually consists of three parts: input, process and output. Let us take a simple example to understand it, suppose we have a tank and we want to maintain the water level in this tank. There is a tap from which the water is coming into the tank and there is a valve by which we can regulate the flow of water in the tap. We put a float which tells us what is the level of the water. When the float reaches the level, where we want the water to be maintained then at that level it closes the valve.

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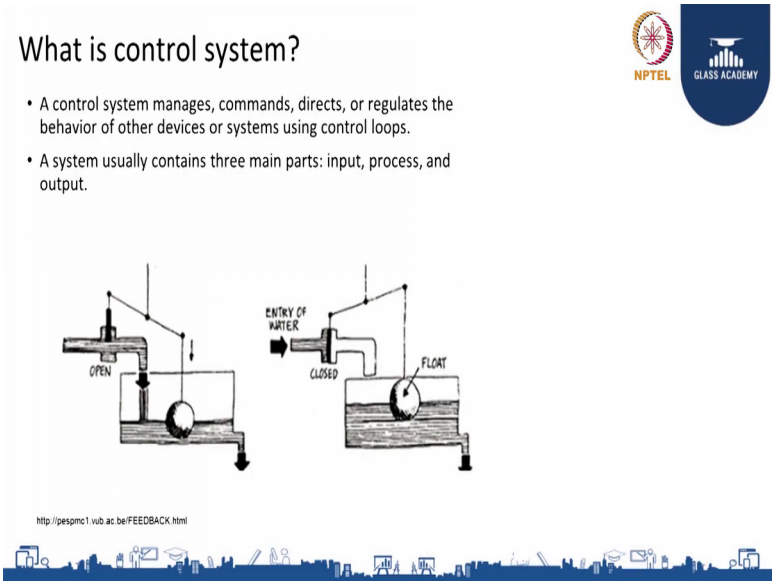

So, basically we are able to maintain the water level and control the flow from the tap by controlling the valve and achieve the desired water level. So, this is simple example of control. On the similar lines we can use controls to maintain the light levels in the space. We know that the daylight entering from windows or skylight that will keep on changing from time to time in the day or season to season. However, we would like to have a

desired illuminance level on the task surface. So, to maintain that level we will change the intensity of the light the artificial lights and get the desired level. We can sometimes also change the angle of the blinds or put shades and control the amount of daylight that is entering into this space. So, basically we want to control and achieve a desired lux levels on the task surface.

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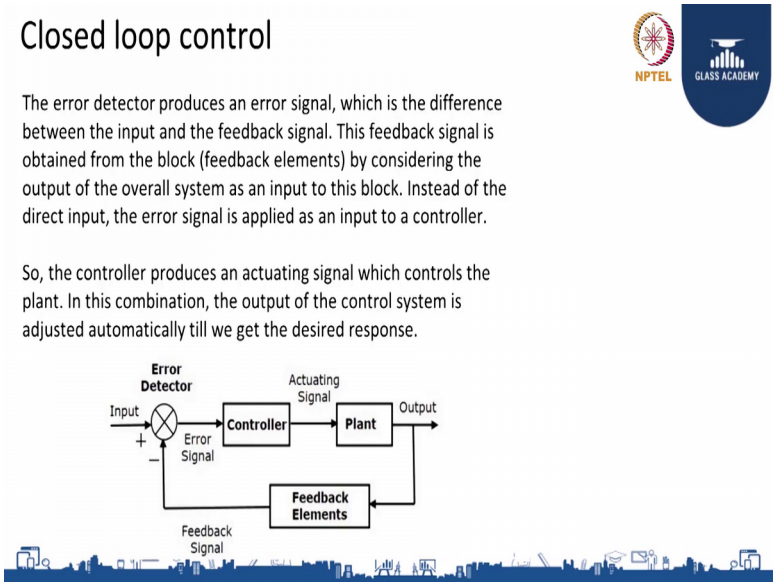

Let us see it in a little bit more details, how does closed loop control look like. In closed loop control we give the desired level that you want to achieve as an input sometimes also called set point and then we measure whether the level is equal to the set point or is it different. So, we measure this as an output from the system and we compare the input with the output, basically by subtracting the output from the input and the value; so, obtained is the error. Say for example, if you want to maintain 500 lux and we currently measure the illuminance level to be 400 lux the 500 minus 400 would be the error that is 100 lux.

This error than goes into the controller and based on the logic that is built into the controller, the controller gives an actuating signal. That is it tells the actuator to shifts its position in this case it can be a light and we can increase the intensity of the light or we can decrease the intensity of the light. Here we had less light. So, it might be the control logic might give signal to the light fixture to increase the output. It can also give signal to blinds and increase the daylight coming from the windows and try to achieve the 500

lux. So, basically the controller gives the actuating signal and then the system achieves a new state, and we measure whether our set point is being met or not. So, this loop continues till we achieve the set point.

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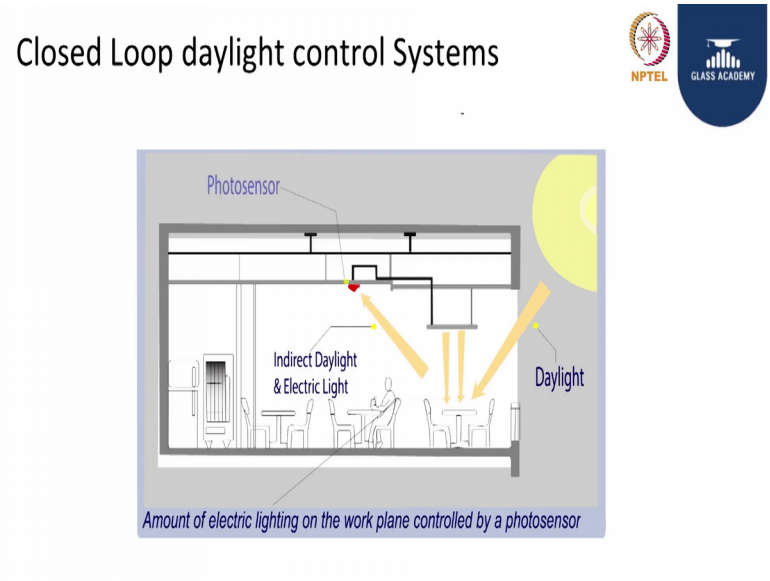

How do we apply closed loop into the daylight control system? In this image you see that there is some daylight entering from the window and it is falling onto the task table and just getting reflected. There is some light falling from the artificial light fixture on the task and then that is also getting reflected. Our objective is to maintain the illuminance level on this table.

Ideally we would like to have a sensor on the table which can tell us what is the illuminance level, but we cannot place a sensor on the table because it will disturb while we are working. So, we put the sensor on the ceiling. So, this censor indirectly measures the light that is falling on to the table. It measures both the light reflected from the artificial fixture and the light that is coming from sun and getting reflected from the table it cannot differentiate between the two. Now, to maintain this level once we estimate this lux level by this photo sensor put on this ceiling, we can give a control signal to the lamp to dim or to brighten or we can also give this signal to the shade and we can close it or we can open it.

So, in this case suppose we are getting less lux levels than desired, then we will open the blind and try to get more daylight. And if we are not able to attain the set point even after

opening the blind fully, then we will give signal to the artificial light to increase the light output till we attain the desired level. Like this we can control the daylight coming into this face and we can also control the artificial light and ensure that we get the right lux levels on to the table. There are some drawbacks of this system one the sensor cannot distinguish whether the daylight level or the artificial level as changed or this surface reflectance of the table has changed. So, if the table reflects more the sensor will gives signal as if the lighting levels have gone up.

The other problem is that the sensor cannot differentiate between the artificial light and the daylight it only knows the total amount of light that is falling on to the table, one advantage of this system is that if the light output goes down because of the lumen depreciation of the lamp then this system can compensate for it because, it can increase the light output till the desired lux levels are achieved. Usually these sensors would have a narrow field of you and they should see only the task environment. They should not see the window or the lamps because the direct light coming from the window or the lamps would give wrong signals to the sensor.

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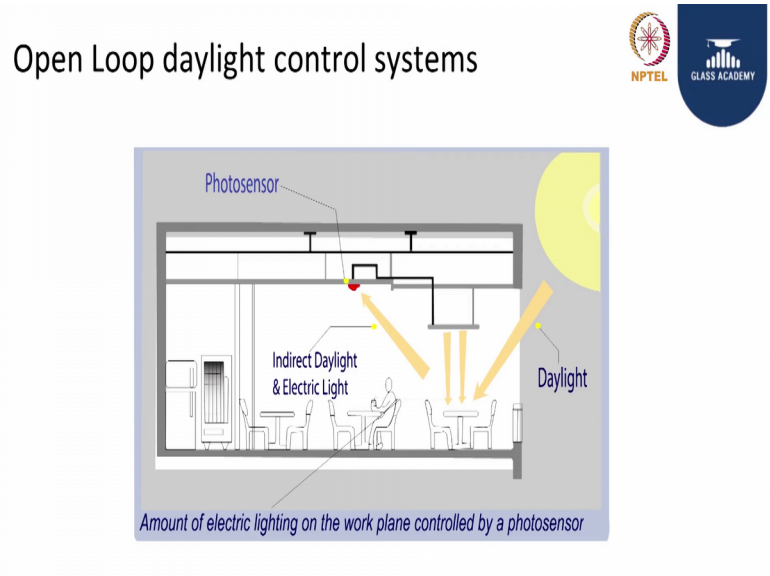

Now, let us look at open loop daylighting control systems in case of open loop daylight control systems we put the sensor generally outside the building. This sensor does not face the task environment it faces outside. It can only measure the daylight that is falling on to it, it cannot measure the artificial light. So, in this case based on the daylight that is

falling on to the sensor, the sensor can control both the blinds as well as the artificial light and try to maintain the desired lux levels. However, it cannot take into account the window treatment. If somebody closes the window the sensor will not come to know and it will assume that the light is going through the window. Usually these sensors would have a wide view angle so; that it can capture the overall brightness that is there and can usually these sensors would have a wide view angle.

The advantage of closed loop sensor is that, if somebody closes the window then that sensor will be able to detect that because the lux levels on the table will change when the window is closed in case of open loop it will not be able to detect it.

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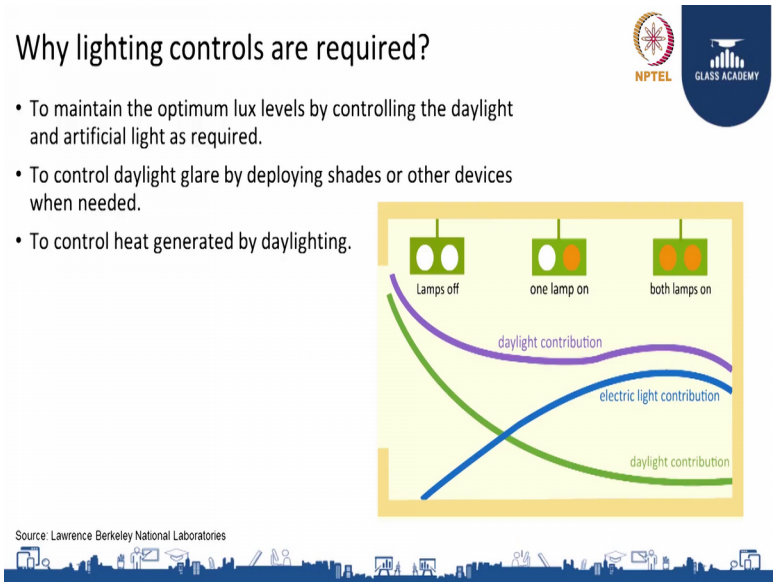

So, how are we basically achieving the control of the artificial light? We know that the daylight when it enters from the window it does not enter and reaches all the spaces in the building, more daylight will be found near the window and less when we go deeper into the building. So, this is not a uniform distribution therefore, the interior lights also should have non uniform control, it should not happen that all the lights are dimmed equally.

Generally we will have three zones in a building; the perimeter zone generally would be dimming more than the core zone, because the perimeter zone will see more daylight coming in. So, in this figure you see that the perimeter zone is totally off and the middle zone which is between the perimeter and the core zone is 50 percent off and the core

zone is 100 percent on. So, like this we are able to compensate the variation in the daylight by putting varying artificial light and trying to achieve uniform illuminance near the targeted levels, throughout this space. The daylight control not only can help us achieve the right lux levels through the space, but it can also help us in controlling the glare, it can control the shades or other devices wherever there is a possibility of glare.

It can also control the heating rays into the building. When there is too much of heat coming from the window the shades on the windows can be closed and the heating rays can be reduced. So, what is the impact of daylight controls?

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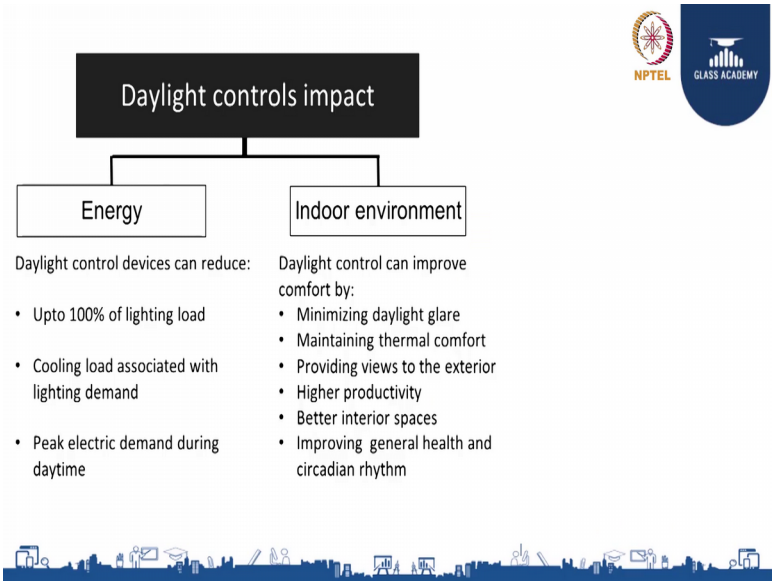

We can divide the impact into two aspects the energy aspect and the indoor environment aspect. From the point of view of energy, we save on the artificial lighting energy it can be up to 100 percent in a very nicely daylit building. We save on the cooling associated with the heat that is generated by the artificial light we can also reduce the peak energy demand during daytime. From the indoor environment point of view the control can help us in minimizing daylight glare; it can also help us in maintaining thermal comfort.

People who sit close to the window can feel uncomfortable when direct solar radiation is coming through the window and warming up this face near them. The daylight control system can also provide views to the exteriors whenever there is an opportunity, these systems can open and provide nice views outside. Overall all these controls can help in

increasing the productivity can help in improving the general health and circadian of the occupants.

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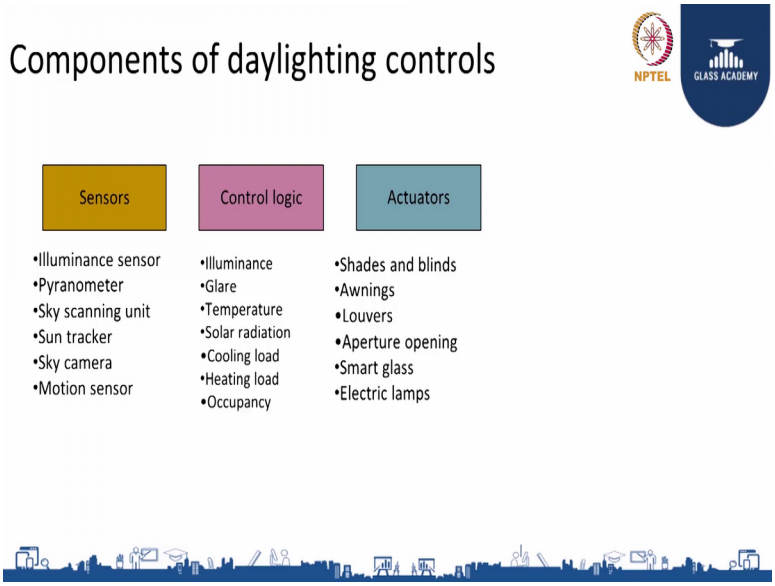

So, what are the components of daylighting controls? We can divide them into three we can say that there are sensors, then there is some control logic and then they are actuators. Sensors can be as simple as an illuminant sensor, a pyranometer or can be more complicated like sky scanning unit sun tracker or sky camera. Besides measuring the light related parameters, we also measure different other parameters and one of the most common one is to measure the occupancy in the space.

For measuring that we can use motion sensor. Once we have sensed naturally we would like to control something. So, the activators that are commonly used in buildings are shades and blinds, awnings, louvers we can control them according to the requirement, according to the sun angle, according to the light that is coming in through the window. There are also apertures which can be controllable these can be found in light pipes.

So, if too much light is coming from the light pipe, the aperture inside can reduce the area and less light will come inside. We have already seen smart glass. So, we can control this smart glass and change its transmitivity as per our requirements. And naturally besides controlling the daylight coming into the space we can also control and we should actually control the artificial lamps (Refer Time: 14:08) energy savings will

only be achieved, when we reduce the indoor daylight illuminance by reducing the light output from the artificial lamp whenever there is enough daylight available.

Now, the question is: what is the logic which sets here and controls these actuators. So, a simple logic would just measure the illuminance level from the task environment, this signal can come from an illuminance sensor or any other sensor, and then try to maintain it by controlling the daylighting devices as well as the artificial light. However, usually it is not that simple we might like to control glare. So, estimating glare is not that easy, we might also like to control based on other parameters like outdoor temperature.

Just imagine a case if it is building in a cold environment and say outdoor temperature is minus 5 degrees and it is night time. Usually we will see we will think that as there is no sun light where would I need to control the daylight devices. But, in this case in the night time and the outdoor temperature is so low the building would be using heat and we might like to control the shade and bring down the shade not to plant any life from coming inside to outside or from outside to inside, but for increasing the insulation on the window so, that the heat that is going out from the building is reduced.

So, that daylight control systems can also operate on temperature, we can even imagine the other way round in case of summers in tropical region when we are doing cooling inside, if the outdoor temperatures are high and lot of light is light is coming as well as light is coming to the window, and if the space is unoccupied. We will not like to provide the desired lux levels, because if the space is unoccupied we are unnecessarily bringing in daylight and heating up the space. So, we m might like to close the shading devices and reduce the heat rays from the window. So, the control logic can be based on various other factors such as the cooling load heating load occupancy and the solar radiation that is falling on to the window.

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