Course Name: Architectural Approaches to Decarbonization of Buildings

Professor: Dr. Iyer Vijayalaxmi Kasinath

Department of Architecture,

School of Planning and Architecture, Vijayawada

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Lecture 1

Daylighting optimized fenestration

Dear students, we had seen the ways in which we can bring in daylight into the buildings, the architectural ways and architectural strategies and interventions to bring daylight into the buildings. We had paused with the pyramid skylight. Before that, we saw various other techniques such as tube lights, tubular lights and also barrel vault skylight. We will continue with the other methods of bringing in daylights. Daylight redirecting devices are an important tool to direct daylight into the buildings. These can be in the form of shelves like this which have a reflective coating on top of the surface.

So, this has a reflective coating Normally it is a white surface. Solar radiation falls on the reflective coating, gets reflected and this light is diffused inside. Sometimes the reflective coating is also placed at the sill level so that light strikes on it And through the reflective coating the light gets reflected inside the building. This surface is also that it need not be as reflective as the ones on top.

because this is at an eye level and therefore it could hurt the eye to have a very strong reflecting surface there. The ceiling is coated white so that it enables the light reflection and there can be blinds to control the solar penetration from the shelf or the reflecting area at the sill level. This is how the light shelf would look as it reflects light inside. The other daylight redirection device could be in the form of a chimney which has mirrors as a reflecting element. Daylight strikes, gets reflected and you could have an internal diffuser due to which the daylight gets diffused and by doing so even the darkest of areas with no access to openings can have natural daylight.

light reflectors in the form of light shells we have already seen but you can see in this picture these are the light shelves and the top of which is coated with a reflective surface light from outside strikes the light shell gets reflected and the diffused light enters the room. One can see these light shelves too. Then next is solar shading devices. Solar shading devices can be many. We could have the horizontal shading device.

The horizontal shading device could either allow direct daylight. If the direct daylight is very harsh, then it could result even in glare. The opening size determines whether reflected light could enter inside. In another case, having adequate shading will ensure that the quality of light is kind to the eye. These are multiple layers through which the light is guided in and it is a combination of direct overhang as well as light shape, shelf.

So, the double overhang functions as a direct overhang as well as a solar shelf. Then you could have multiple louvers which can direct the solar radiation inside, sorry, which can direct the daylight inside and cut the direct solar radiation. Louvered overhangs are also another way of bringing in diffused light. Outriggers and wing walls or vertical shading devices also aid in bringing in adequate solar radiation. So, this is how the vertical fins This is how the vertical fins are designed.

Based on bioclimatic principles, the fins are positioned closely or far away and you can see that this can aid in letting the reflected daylight inside, but it can cut the solar radiation completely. Then you have movable awnings, which based on the direct solar radiation, one could redirect the awnings. So, adding an overhang may significantly reduce the amount of light on the window wall. Besides, having this awning will also help in cutting down direct solar radiation. So, typical examples of such day lighting and shading systems are can be seen in the form of louvers or awnings or blinds, light shelves, vertical fins, horizontal shading devices etc.

Among these systems louvers are one of the most commonly used shading systems because they can partially or completely block the sunlight. Luvers are used not only for shading but they also serve as daylight systems because they reflect natural light using highly reflective material. So, this is what I had meant by saying that the solar radiation may fall on this and get cut while the light may get reflected and enter inside. So, louvers in the form of either horizontal or vertical louvers are the most commonly used. We can see that when you use a overhang vertical fin there is air movement is not restricted.

So, no restriction of air movement. no restriction of air movement and there is minimal restriction of outside views. Day lighting, yes, with appropriate, what should I say, appropriate surface treatment, there is good amount of day lighting. with the vertical fin. When it comes to horizontal devices, let us look at these this horizontal devices.

What happens is this horizontal device allows free air movement, unrestricted wind flow, wind flow unrestricted and therefore not appropriate for very hot climates Day lighting access is very good therefore if you want to control any of these one must go for egg crate device which is a combination of horizontal and vertical shading device. When the egg crate becomes very small, it functions more like a Jali, the Indian Jali system. So, the

egg crate system is another one which can work well. Let us look at daylight responsive electric lighting controls. Now, daylight harvesting is a lighting control technique which is used to reduce energy consumption by dimming or switching off artificial lighting.

when there is sufficient natural lighting present in the space. This is achieved by using daylight photocell sensors which are strategically placed inside the daylight zone that calibrate the lighting fixture output with the availability of natural light. The daylight photocell sensor shall continuously dim the lighting fixtures or provide a step type or control point reduction of the design lighting power. It is an automatic lighting control strategy in which interior electric lighting adjusts to maintain a target level thereby reducing energy costs. It is most effective in areas that consistently receive ample daylight.

such as lighting adjacent to windows or near skylights. So, a daylight responsive electric lighting control is a combination of a sensor based as well as nature based technique. Next, we look at the sawtooth roof. The main reason why this kind of a roofing system came is that it would increase the amount of light inside the room while reducing the effect of glare and excess heat. It captures light at certain times of the day or certain times of the year.

In India, this kind of lighting system is normally called as the north light and it is used commonly in industries and factories where lot of lighting is needed. The saw tooth contains glazing through which light enters. multiple base and therefore if you see the entire area which could be very long will get illuminated. Otherwise if you have a room like this as long as this and if you have windows on these two sides illumination will happen only in this zone. Whereas in plan if you have a north light at equal intervals each of the north light will illuminate these zones and therefore even a long hall or a large hall be illuminated with daylighting and this will have substantial savings from daylight energy.

Let us look at the advantages and disadvantages of daylight. Exposure to natural light has numerous benefits for people. These benefits range from a visual comfort to psychological, aesthetic and neurological benefits. Such as improved mood, less stress, improved sleep, improved response to immune systems. So daylight is not just a window or a skylight.

It has a lot more of other repercussions. Now due to daylight, improved mood is one advantage. So when sunlight hits a specific area in the eye, especially the retina, it triggers serotonin. It's a feel-good chemical to the brain. This is linked to higher mood levels.

In fact, a lack of sunlight can lead to a condition called seasonal affective disorder, sometimes called as winter depression. This disorder is characterized by low mood and is extremely common in places during winter months when you have fewer hours of daylight. Not having daylight also affects the mood and it is determined to be a psychological issue. Sunlight also supports the production of melatonin which is a chemical that helps us to sleep well and therefore insomnia is not caused. Places which have darker winter months for longer duration, it is said that many people there suffer from insomnia.

And therefore, there are many psychological advantages of daylighting. More hours of daylight can also encourage people to socialize more and move out more. Socializing and connecting with other people is associated with improved mood and well-being. More light in the evenings also gives many people more of an opportunity to go outside at the end of the day. The extra hour of light at the end of the day should be even more meaningful to us especially because we have seen what happens when we are stuck indoors what during covid.

Energy saving is a very empirical and numerical benefit that we can actually count Natural light is one of the key ways of saving energy. Day lighting minimizes the amount of artificial light and reduces electricity and HVAC. These costs get reduced and can add to substantial savings. Electrical lighting produces a lot of heat Whereas natural lighting generates hardly any heat if it is properly controlled as we have seen in the previous slides. Making use of natural light can save up to 75% of energy used for lighting buildings and reduce cooling costs.

Designing for day lighting has to be considered at the initial stages of building design itself. The orientation of the building and glazing relative to the sun path is the most important decision. This is followed by the design of the roof and then the facades. The selection of glazing system and the daylight controls such as blinds or louvers increases productivity. Natural sunlight is a powerful source of energy that can have a profound effect on our productivity and well-being at work.

When our bodies and minds are exposed to natural sunlight, we can experience improved concentration and focus, reduced fatigue and a better overall mood. This can have a positive impact on our productivity and creativity and this can allow us to get more done and enjoy a much higher level of satisfaction at workplace. The benefits of natural sunlight at work are humongous. Exposure to sunlight can help us regulate our circadian rhythm, allowing us to maintain alertness and focus throughout the day. While sunlight also provides us with vitamin D which is essential for maintaining a healthy immune

system and fighting off illnesses.

But day lighting also calls for controlling the amount of heat that enters a building. Because the sun is such a powerful source of light, it can also produce tremendous amount of heat. If planned properly, we can avoid it. It may seem that it would be difficult to increase the amount of light without bringing in extra heat. However, the use of window treatments such as window films and glazing can shade a window or diffuse direct sunlight minimizing heat gain.

Glare is another very common and a difficult aspect to handle. It is commonly defined as discomfort to the eye caused by bright light or extreme contrast. One important point is controlling glare. Direct sunlight penetration in areas such as classrooms or office spaces produces a very unpleasant glare on work surfaces making it difficult to work or view a computer screen or concentrate on the work. The proper orientation of windows and skylights can admit direct and diffused daylight producing the best combination of light for a building while also reducing glare.

The selection and placement of windows and skylights should be determined by the amount of light needed and should be based upon climate and the design of the building. Glare is familiar to most of us but it is a complex phenomena influenced by many different factors such as environmental factor individual and temporal factor. It is important to be aware of these while aiming to ensure occupants visual comfort in space with natural light in the past few years Lighting has become a focus of every energy saving idea. However, not enough effort has gone into maximizing the use of natural light either in building design or legislation. Good day lighting solutions demand an integrated building design approach.

Daylighting design should be holistic, developing solutions that are part of the main concept while meeting visual, thermal and energy needs. We should discover how the sun shapes our experience and apply this lesson to building design from its start. There are humongous advantages of daylight. we have seen and in a nutshell, what does it do? It increases productivity, reduces drowsiness in workers, leads to fewer headaches, improves the mood, decreases eye strain, helps increase exposure to vitamin D, improves the quality of sleep, helps to warm up the room, reduces lighting cost, reduces heating cost, is environmentally friendly, helps prevent mold formation and gives us greater connection to the outdoors.

However, there are certain disadvantages. These include that it can cause glare specially on screen. It can lead to excess heat in the room. It can lead to excess light in the room. It can cause difficulty to control levels of light in room if not designed appropriately. The

bills on cooling can increase dramatically.

It can create distraction during sunny weather. It can lead to skin damage too. Hence, it is very important for us to design a space specially for lighting while in consideration with designing the space also for solar heating. Let us now look at daylighting strategies and embodied emissions. The consideration of daylight performance is integral to meet low carbon and climate resilient objectives in building design.

We must consider its impact pertaining both to operative and embodied carbon emissions of buildings. The embodied carbon emissions of daylighting strategies heavily influenced by choice of material and construction techniques. For example, while choosing smaller windows, it may seem to decrease the life cycle impact of a building due to lower amounts of glazing material and reduced heat exchanges. This decision may ultimately increase overall carbon emissions of the building because of reduced reliance on solar gains, increased wall area. and higher electric lighting needs to maintain adequate illumination.

Life cycle assessment offers a great potential in shifting the focus of day lighting from merely operational benefits to the total life cycle carbon emissions. It is advised to look at overall carbon impacts both operational and embodied for simple as well as complex buildings in the future. Hence, let us not dismiss the importance of daylighting in reducing the operational carbon of a building. A mistake done in a building leading to daylight issues will continue to escalate the operational cost of due to that one design mistake. It is in the hands of architects and designers to ensure adequate appropriate lighting leading to reduced operational carbon.

With this we will stop this class and we will continue with yet another set of information for our next class. Thank you.