Course Name: Architectural Approaches to Decarbonization of Buildings

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Week: 11

Lecture 4

Daylighting optimized skylights

Dear students, in the last class, we saw about daylighting strategies and how we can bring in these strategies inside the building. Today's class is a continuation of the previous one and we will look at daylighting strategies and how we can bring in daylighting inside through various systems, technologies and basic architectural design inside the buildings. The first is daylight optimized building footprint. Daylight optimized building footprint can be achieved by orienting this building appropriately on the site and designing the building such that maximum surface is exposed to daylight. For example, when you have a building, which is oriented this way, you will find that the east and west is along the short direction and the north and south has a longer axis and therefore this orientation is appropriate for bringing in light from the south. It is also optimal to understand that this has to be cut as much as possible because the western light from the west brings along with it a lot of glare.

Hence, orienting a building in this way where the north and south are along the shot and the west has the longer axis is a inappropriate and a wrong way of doing things while this is the correct way, the first way is the correct way of orienting the building. Second is climate responsive window to wall area ratio. The window area has to balance between admission of daylight and thermal issues such as winter time heat loss and summer time heat gain. That is something we do not want.

So we must have an optimal window to wall area ratio. normally a percentage of between say 30 to 40 is considered appropriate in the Indian context in the in a warm humid climate to have a good day lighting inside with optimized solar gain. But if we look at hot and dry areas the window to wall ratio must be less. It must be very less because we do not want glare because the intensity of solar radiation is very high and strong in hot dry areas. So, if you have larger windows you will get glare and you will bring in a lot of heat through solar radiation whereas the same is not true for hot and humid And in hot and humid or warm and humid climate, your window to wall ratio should be high.

You must have large windows with appropriate shading device to allow for daylight as well as breeze. Whereas, in the hot and dry, the breeze should also be cut because it is a very hot dusty wind. So, we cannot look at openings or day lighting in isolation without bringing in factors of solar radiation or air movement. Then using high performance glass. Now there is continuous improvement in solar insulation and solar control performance.

Glass is a flexible building material in the sense it can improve the energy efficiency of buildings also. One way that this performance can be achieved is through the use of high performance coated glass. which is a critical part of a window or of a glazing in a window. This enables the building occupants to visually engage with the external environment from a comfortable interior. High performance glass provides natural light transmission while helping to limit heat gain and thermal energy transfer.

Energy efficient glass panes are coated with various metal oxides that reduce excessive absorption of solar heat. This reduces a structure's energy cost and also its carbon footprint. This type of glass also improves thermal comfort with a sense of openness for people working inside. So, there are broad classifications of this glass. The low E glass.

The low E glass is also known as a low emissivity glass. This has exceptional thermal insulation properties. It only allows solar light to pass through it while reflecting away most of the scorching heat. This type of high performance glass also protects the interiors of the building from harmful ultraviolet radiation and infrared radiation. Low E glass provides enhanced thermal comforts in all type of weather conditions.

It does not let a lot of cool conditioned air to escape out of the building. keeping the interiors at an optimal temperature range during the hot months. Alternatively, during the colder months, it does not let the warm air leak outside easily, keeping your interiors comfortable. The thermal comfort majorly optimizes the heating and cooling bills. while low E glass panes are even more energy efficient as compared to insulated glass panes.

They are commonly used in skyscrapers, hotels and other large facades. That is why these low E glass are called as high performance glass. The other type of glass is solar controlled glass. This is a special oxide coated glass that transfers less solar heat as well as glare from entering inside. While it reduces solar glare and heat, it does not allow ample natural light to pass through it.

This visible light does not hit sharply on the skin and it also reduces the need for artificial lighting inside your home or office during the day. Solar controlled glass

protects your interiors from infrared rays. It is not as effective as the high performance low E glass when it comes to absorbing ultraviolet rays. Solar controlled glass is suitable for conservatory roof, malls, showrooms, glass facades and educational institution. These places are mostly operational during the day and they can utilize natural light for heightened productivity with the help of energy efficient glass.

Let us look at solar controlled low E glass. Solar controlled low E glass tends to trap more heat inside that can lead to overheating especially when directly under this low solar glare. In such cases, using low-E glass or solar-controlled glass independently may not be sufficient for a glass facade which has prolonged exposure to direct sunlight. Solar control low E glass however is a perfect solution in such scenarios as it will block solar radiation and also provide the optimum amount of thermal insulation without overheating or over cooling the interiors. For example, the Burj Khalifa in Dubai houses countless glass panes that face solar glare daily.

Solar control low E glass has been used in this facade to decrease the building's air conditioning cost. If you need to have heavy duty energy efficient glass then we must go for solar control low E glass. This type of glass is highly expensive to install as compared to the two options we have discussed before. But the cost justifies themselves in the long run when the energy bills significantly get reduced. Common types of glazing used in building applications include clear and tinted float glasses, tempered glass and laminated glass as well as a variety of coated glasses offered in single or double glazing.

Let us look at daylight optimized fenestration design. So, balancing energy performance which is balancing ingress of solar radiation along with thermal comfort and access to quality daylight are essential for proper building design. Exposure to natural light can improve occupant mood, alertness and overall health. Ideal lighting involves proper exposure to diffuse daylight as well as careful design of windows and glazing in order to avoid excessive glare and heat gain. Windows are therefore a key variable for both ensuring that occupants receive enough light for positive psychology and subjective effects, but also not too much light that causes discomfort or becomes a source of distraction.

Let us look at the differences between passive and active daylighting system as well defined by how sunlight is captured and disseminated. Daylight is an introduction to natural light into the indoor environment and it helps reduce energy consumption by artificial sources in the building. Of late, daylighting has come up as an important theme of energy conscious design along with passive solar heating and cooling. because now it is proved that In order to have good lighting inside, if day lighting is not used, then artificial lighting has to be incorporated which is expensive as well as it is not energy

efficient for the building. Daylighting can reduce the overall energy consumption by 20% and also reduce the sensible heat load on air conditioning in buildings especially in Southeast Asian region.

Now let us see the use of skylights. Skylights allow natural light to flood the space, reducing the need for artificial lighting during the day. Some skylights come with a cover that can be opened and closed. This allows for ventilation. In addition to providing natural light, skylights can also provide energy savings by reducing the need for artificial lighting and heating.

We also have fixed skylights and these are good for places like attics and stairwells where you don't need much ventilation. However, you can also get them installed in rooms with hard to reach high ceiling for some extra daylight. These fixed daylights can also be made openable by opening the glass case which results in some amount of breeze also entering the inside. Next is you have ventilated skylights. If you want daylight in your room but would like air as well, we can have ventilated skylights.

They look exactly like fixed skylights but we can open them in and let in some fresh air inside and remove excess moisture. Ventilated skylights are good for kitchens, bathrooms and living rooms. There must be a source of access to operate these skylights. Tubular skylights. If you don't have much space in your ceiling to install a fixed or ventilated skylight, we can get the daylight to illuminate the home using tubular skylights.

These skylights are in the shape of a small tube which is about 10 to 15 inches in diameter. It starts from the roof and goes all the way to the room where you need natural light. The tube uses optical techniques to direct the sunlight down the shaft and into the room. So, they can transmit daylight deep into the building darkest recesses. reaching areas beyond the wildest dreams of even large commercial skylight.

This can be achieved due to highly malleable nature of their reflective tubing, which can be bent to create elbow joints along the way. In this way, it can maneuver around most obstacles in the building plenum space such as plumbing, HVAC or electrical and transfer the light across multiple rooms through diffusers. The level of light in a room can then be controlled with dimmers or supplemented with electric light as needed. These tubes can deliver livable levels of sunlight across tube lengths of a hundred feet or more. These can be used for shorter lengths through the attics to deliver natural light inside rooms or they can be used through longer tubes which have optical devices in it which reflect the light into the darkest of basements.

Then we see the dome light. If you want the natural light to stream into the house even

when the sun is not as bright, the dome acrylic sunlights are a good option. They are made of flexible yet strong plastic that spread lightly even around the room. And the shape is such that it brightens up the room even with a little light. Most people use dome acrylic skylights in their entrances to highlight decorations like sculptures and paintings, though their main function is to transmit light. And then we see the barrel vault skylights.

This type of skylight is frequently used in non-residential buildings. This is not rarely used in residential buildings as the area of skylight is much more. Besides privacy concerns are also very you know it is an issue. Hence, complete or more than 80% of the roof area is covered by the skylight if you use the barrel vault skylight. This type of skylight is preferred usually in passageways or canopies or parking shelters, mall arcades, medical and educational institutions and in industrial complexes.

This comprises of a long vault through which light is let inside the building. Since it is on the roof of a residential building, then privacy is a concern. But in public places, you can use this in atriums or I would say courts, central courtyards or corridors. etcetera this can be used. And then we move on to the last part of this slide series which is a pyramid skylight.

A pyramid skylight is a type of roof system that is designed to allow natural light to stream into an indoor space. It typically consists of a pyramid shaped glass or polycarbonate structure that is placed on top of a roof. Pyramid skylights are popular in commercial and residential buildings because they offer several benefits. First is they make the indoor spaces brighter and more inviting by allowing natural light to enter. Second, they can help reduce energy costs by reducing the need for electric lighting during the daytime.

Additionally, pyramid skylights can improve indoor air quality by allowing fresh air to enter and circulate. Finally, they can enhance the aesthetics of a building and add value to the properties. Overall pyramid skylights are a practical and stylish way to bring more natural light and fresh air into the building while also improving its energy efficiency and value. So a pyramid light skylight is basically a pyramidical form of skylight on a terrace through which light can enter inside. This is also more appropriate for commercial areas but it can be used in residential areas because it is not too big unlike the barrel vault which is linear.

and therefore it occupies more space on the terrace unlike the pyramidal skylight which does not occupy so much space on the terrace. With this we conclude this section for today where we have seen the basics of day lighting and the ways in which we can bring

daylighting inside the building. We will continue in the next class with another dimension of daylighting. Until then thank you.