Course Name: Architectural Approaches to Decarbonization of Buildings

Professor: Dr. Iyer Vijayalaxmi Kasinath

Department of Architecture,

School of Planning and Architecture, Vijayawada

Week: 07

Lecture 01

Methods of bringing in natural daylight

Hello students. So, in the last class we saw how openings can be modified, manipulated, and we can use it to our benefit in passive architecture, because of which a lot of operational energy can be saved, leading to a reduction in operational greenhouse gas emissions. Today we will briefly touch upon openings and daylighting. Now the sun is predictable and daylight can be very reliable source of light. Presence of natural light in an occupied space brings in a sense of well-being, increases awareness of one's surrounding and also increases energy saving potential with reduced dependence on artificial light. Appropriate use of windows, skylights, clear stories and other apertures in the building provides a means to harvest daylight.

In this segment, we are still continuing with the significance of openings and the other functions of openings. Bringing in daylighting beam as one of the functions. Now, the location and size of the openings matter a great deal if you want to utilize natural light in your building. Windows and other openings facing the path of the sun receive much more direct sunlight than those facing away.

However, more day lighting is not necessarily better. Bringing in too much light can cause glare and overheating. In a tropical country like India, it is very important for us to optimize the position and location of openings to have an optimum level of indoor ventilation, daylighting and overheating. Having two large openings is not necessarily a good thing because it can also bring in heat along with the ventilation. Hence, the optimization is very important.

Let us briefly look at types of windows. A window which is also called as a side light is an opening in a wall that allows the exchange of light and the passage of sound and air. It is the most common way of admitting daylight into a building. Its orientation and position means that they selectively admit sunlight and diffuse daylight at different times of the day and year. Therefore, the size, shape, position, orientation and location of windows must be carefully designed to produce the right mix of light for the building

depending upon the climate and latitude.

There are many types of openings. We will look at the four commonly used openings. The first is called a sash window, and as can be seen in the picture, the sash window is the simplest form of window. Then we have the casement window, which is normally used in our part of the world. Along with the casement window, we must ensure that we have appropriate shading devices.

More on that in the class to come. Then there are louvered windows. Louvered windows are very useful and helpful in directing the breeze inside the room. So, we can tilt the louvers to ensure proper ventilation. Then you have the bay window, which is a window that protrudes out of the wall.

These are the major types of openings that is used in our part of the world. Those openings, the ones we saw in the previous slides, are fixed on the wall whereas we have what is called as clear story openings. Clear story openings are found near the roof on top of the wall. Modern clear stories are defined as vertical windows which are located on high walls and they extend up from the roof line. They are designed to allow light and breezes into the space without compromising on privacy.

They play an especially important role besides day lighting and ventilation in making the buildings energy efficient by being part of passive strategies. So clear stories should be properly located, typically on the sunny side of the building, and protected from the summer sun by roof lines, overhangs, recessed thick walls, or other architectural elements in order to prevent overheating during the cooling season. So, clear story, which are typically located on high walls along the top of the roof, you must take care to ensure that there is an appropriate overhang here. So, the roof line must extend to protect the clear story and this opening allows adequate appropriate sunlight as well as facilitates breeze movement due to stack effect. You can see clear story very commonly in buildings which have high roof.

You can see them in churches. You can see them in town halls, marriage halls and in any rooms or halls which have a large height. Next opening type we will see,called as the sawtooth roof. A sawtooth roof is a roof which comprises a series of pitched roofs. So, this is one pitched roof.

A series of pitched roof with openings here is called as a sawtooth roof. In India it is also commonly called as the north lighting because it is supposedly oriented towards north. So, it comprises of a series of pitched roofs with a different angle to the slope on either side. The steeper surfaces are glazed to admit daylight like this and face away from the

equator to shield from direct sunlight. Yet, they allow in diffused light throughout the day.

This kind of roof admits natural light into a deep plan building or factory. It was therefore most commonly built during the machine age from the mid 19th century to the mid 20th century, when electrification of factories was not very common. This aided in giving adequate lighting and in some cases even ventilation though its primary motive was lighting in factories. The design has re-emerged in recent years as greater value and importance is placed on introducing natural light into buildings for environmental efficiency. So, if you look at any factory building, you will find a lot of north light as it is called or saw tooth roof.

As you can see, this is one saw, this is another saw, this is another saw and it facilitates natural light. In this case a reflective surface is also placed on this roof to enable the light to get reflected and get diffused light. So it can work either ways. It's important to orient it appropriately with respect to the latitude to prevent the indoors getting overheated. Next one is type of opening is called as a skylight.

A skylight also called as a top light is a light permitting structure or window usually made of transparent or translucent glass that forms all or part of the roof space of a building for daylighting and ventilation purposes. It is able to bring light into centralized areas of a building and daylight is available throughout the day from both ambient lighting from the sky and direct exposure to the sun. Even on overcast days, top lighting from skylights is 3 to 10 times more efficient than side lighting or windows. Because even during overcast sky there is direct exposure to these skylights. Normally skylights are made up of translucent glass.

The biggest disadvantage of having skylights is disadvantage. disadvantages include extremely high levels of solar radiation and it can cause indoors to heat up very fast and the temperatures can rise very high. There are several advantages. Advantages include maximum natural lighting. Also light is a natural disinfectant, so it is appropriate for areas that need to be dried immediately (instantaneously) and that has opportunity of moisture on the floor and this light (skylight) is a very good option for such spaces.

For example, a washroom area, the service areas of a kitchen of a large new kitchen not talking of residential kitchen, skylights can be a very important or a very impactful opening type in those areas. The next type of opening type is called as a light shelf A light shelf is a passive architectural device used to reflect natural daylighting into a building. Bouncing sunlight off a horizontal surface it distributes it more evenly and deeply within a space. Light shelves are used where light can be reflected. and you can

get even more quantum of light and this light bounces off this light shelf which has a reflective coating on it direct sunlight can cause glare near an opening And it also leaves dark areas further in.

But light shelves allow light to penetrate through the building. They are also designed to shade near the windows due to the overhang of the light shelf itself. And they help reduce window glare. Exterior shelves are generally more effective shading devices than interior shelves. A combination of exterior and interior shelves will work best in providing an even illumination gradient.

Whereas, a direct lighting window can introduce glare, light shelves which could be either partially inside and partially outside can be very effective or some of the light shelves are completely on the inside And they are not very effective. They are not as effective. And there could be light shelves which are completely projecting outside. Which are the most effective ones. Shading devices are an integral part of openings in any passive design strategy but can cause too much glare and increase heat gain if the openings are not shaded properly with the shading devices.

Shading devices can reduce solar heat gain through glazing by up to 80%. By designing shading devices according to the sun's seasonal path, both summer shading and winter solar gain can be achieved in climates with seasonal variations. We have horizontal overhangs, louvers, vertical fins, egg crate devices. shading device and we will see each of this now. This type A type is called as the horizontal shading device and it is a single piece of slab over the opening.

B a horizontal shading device but it has a pergola. Here C is a combination of horizontal and vertical shading device. D looks like a light shelf, again a horizontal shading device. E is a series of horizontal shading devices and F is a vertical shading device along with a horizontal shading device. So, you have a horizontal and two vertical shading devices like a box.

This is highly effective along the west side for tropical climate like say Chennai. G is called as an egg crate device and is a combination of horizontal and vertical shading device. H is a combination of a perforated horizontal and vertical shading device. I is a series of vertical shading devices. J K and L are all lowered shading devices, each of varying design.

The advantage of lowered shading device is that it can be tilted to the desired angle for optimal ingress of air movement as well as solar radiation. Now, what should be the size of opening? The size of opening is an important factor to be considered while designing

for ventilation. The rate of air flow as well as the solar heat gain and daylight are dependent on it. To measure the effectiveness of your ventilation strategies, you can measure, both, the volume and speed of the airflow. The volume of the airflow is important because it dictates the rate at which stale air can be replaced by fresh air and determines how much heat the space gains or loses as a result.

The volume of airflow due to wind is airflow volumetric rate of the wind is determined as coefficient of effectiveness multiplied by the area of opening multiplied by the outdoor uninterrupted wind speed. The coefficient of effectiveness is a number from 0 to 1 adjusting for the angle of the wind and other fluid dynamic factors such as the relative size of inlet and outlet openings. These are standardized values which we normally adopt directly. Now, What is the measure of the size of opening? Appropriate opening sizes can be determined using window to wall ratio also known as WWR. Net glazing area divided by gross wall area gives us window to wall ratios.

ECBC Energy Conservation Building Code recommends maximum WWR for each cardinal directions. The WWR should be 20% on east and west sides. The WWR should be 40% on south side and 60% on north side for India. Another factor which is used is called as window floor ratio WFR that is total openable window area divided by total carpet area. ECBC recommends minimum WFR for each climate zone as below.

For composite climates, it must be 12.5%. For hot dry climates, it can be 10%. For warm humid climate, it can be 16.

66%. Temperate climates, it can be 12.5%. And for cold climates, it can be 8.33% for India. These two WWR and WFR is a widely used term especially in research areas. So, when we talk of opening sizes instead of talking of absolute areas it is best we talk of the opening sizes in terms of either WWR or WFR. So, with this we conclude the class on opening sizes, openings, positioning, benefits of opening, types of openings and how openings are measured.

Openings are a very important strategy to reduce indoor heat gain and enhance the thermal performance of the building. It costs nothing in terms of an added contraption and can be effectively used as a passive design strategy to reduce the operational energy and therefore operational carbon emissions which is directly related to carbon neutrality of a building. With this we stop this lecture and we will continue with a new topic in the coming lecture. Thank you.