Course Name: Architectural Approaches to Decarbonization of Buildings

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Week: 04

Lecture 04

Passive Design Strategies in Carbon neutral Architecture

All this while we had been talking about what can we do as architects and designers to reduce the GHG and things like that. Hello everybody. So, from this class onwards, we will look at the designer's role or an architect's role in designing the building towards being more green or sustainable and also being more bioclimatic. So, this series we will be talking about what is passive design, what is the importance of energy efficient buildings in general and how orientation plays a crucial factor in passive design. We will also look at understanding passive design from the definition of what it is, and other design strategies with respect to day lighting and natural ventilation. We will also look at the benefits and the climate considerations, site specific conditions and design principles for proper building orientation, strategic placement of windows and shading device and importance of south facing windows for heating.

Now, what is the importance of passive design or what it means? Passive design maximizes the use of natural resources of heating, cooling and ventilation to create comfortable conditions inside the buildings. It harnesses environmental conditions such as solar radiation, cool night air and air pressure differences to drive the internal environment. Passive measures do not involve mechanical or electrical systems. They are devoid of being connected to the grid.

So passive design works with the local climate and is a response to the climatic conditions of that place to maintain a comfortable temperature inside the home. Good passive design should reduce or eliminate the need for additional heating or cooling depending on your location and often relies on active occupant to work properly. A passively designed home can deliver a lifetime of thermal comfort, low energy bills and low greenhouse gas emissions. Now, we see what are the solar passive techniques. Now, there are few solar passive techniques which are specific to a particular place.

So, it is dependent upon the location. So, when we talk of solar passive techniques we must remember that location and therefore, climate is a major consideration and as a

response to the climate these techniques must be followed. So, solar passive techniques is directly related to the climate of a particular place. Now, let us see what are the techniques- very briefly -so that we have enough time to delve into the techniques. First is building orientation.

So how do you orient a particular building? And building orientation is directly related to the plan form. So orientation and plan and form I would say form. Go hand in hand and that is the first technique. Based on the climate we can have appropriate building orientation and form. We will look at it in greater detail.

Then comes building envelope. Building envelope comprises of walls and roof. Roof is already here. Wall comprises of the opaque and windows. Windows we call as fenestration and the opaque wall comprises of windows along with the external colour and texture.

Windows has shading device. So, I would say this relates roof, fenestration relates to walls, colour and texture relates to walls. Shading relates to openings and therefore walls. Besides landform whether it is hilly or on plains or on valley these matter. Vegetation around the site in the form of shrubs or green cover or trees matter in green trees.

It matters in altering the microclimate. Well, I mean in many ways it alters the microclimate like no channelizing breeze inside the building so the microclimate modifications happen it's the same with water bodies water bodies can cause microclimate modification street width and orientation play a very important part because many times the aspect ratio can influence mutual shading or otherwise. Open spaces and built form as a combination can initiate ventilation and air movement. So, these are the ways in which we as architects can see what all aspects about the site and our response to the site can alter the indoor thermal performance of the building. First, what we will take is the difference between passive design and active design.

Now passive design happens when you use only the natural effects of the elements around us. So we use the sun, we probably we use the wind to alter the microclimate inside. So the endothermal performance as a result of way we handle design with the help of elements natural elements is known as passive design whereas in active design we need use of certain contraptions and those contraptions are grid dependent so they are grid dependent and how the source of electricity to a grid happens is a secondary thing. That could be through solar panels or it can be directly from the electrical grid. So, active design uses equipments to modify the state of the building and create energy and comforts.

So, it is like using fans or pumps or air conditioners that is active design. The first passive strategy that we will be discussing today is building orientation. Now good orientation can significantly improve your comfort and reduce your heating and cooling needs. The best orientation for your home is the one that suits your climate zone. The first basic principle in a passive house is the orientation in which the southern facade of the building should be oriented towards the equator in the northern hemisphere and the northern facade towards the north in the southern hemisphere.

By facing the longer axis of the building in the east and west direction, the longer dimension of the home it faces will be more likely to gain the maximum solar radiation. For that reason, areas which are most frequently used such as kitchen and living rooms must be located in the part of the building. This orientation is also advantageous for summer cooling conditions because it minimizes the east-west facades to morning and afternoon sunlight. So, you could see here, that the no the we need we should consider these three factors when we determine orientation the first is the solar path optimally buildings in cold climates should have a south facing orientation to capture more sunlight during the winter While in hot climates a strategic design will involve minimizing east and west facing openings to reduce heat gain during the summer. Prevailing winds are a dominant factor in a specific location over an extended period.

Wind is influenced by factors such as topography, geography and climate. And incorporating an understanding of prevailing winds is crucial to optimize natural ventilation and thermal comfort within the building. More on this we will see later. Building orientation can be tailored to accommodate seasonal temperature changes. In cold climates, a south-facing orientation maximizes exposure to the low winter sun.

It aids in passive solar heating. Whereas, in hot climates, designers may minimize west facing openings to reduce heat gain during the hotter summer months. Let us look at solar gains due to orientation. Within about 15 degrees north and south of the equator, this is the equator. And within 15 degrees north and south within this belt overheating is the dominant climate related concern.

Here the east and west elevations of a building are subject to greatest solar heat gains and winter heating is only an issue at the altitudes of this place. If there are no altitude if we are not talking of any building at a very high altitude we do not have to consider solar heating at all because already the indoors i mean the issue that we have to deal with is dissipation of heat from inside Outside this band, the solar oriented facade which is south facing in the northern hemisphere and north facing in the southern hemisphere receives the most solar radiation which may be used for free winter heating but which also may result in unwanted heat gains leading to overheating in summer. In this kind of climate,

you have to be very careful to ensure that your west facade, the western side is insulated and it is short. So, it is a shorter side. I will keep on repeating this during the course of this lecture also.

Shorter side- the west facade should be shorter side and it should have fewer openings along this belt. There is another criterion also we will come to that a little later. Also what you can do is you can buffer this side with with adequate vegetation so that it creates a barrier. There is a barrier which is created and you can use that barrier to prevent the solar radiation from entering inside. Yet another factor is wind.

Now, there is a particular pattern due to the rotation of the earth. You have the northeast trade winds and southeast trade winds typically along this belt which we have been talking which is the equatorial belt. More so from 23 degrees on north and south but we have stuck to 15 degrees so we will discuss this only. Driven by the sun's variable heating of the earth and influenced by the motion of the planet global air movements follows a particular pattern. The equatorial overheating produces a good example of the relationship between sun and wind.

Therefore, within about 15 degrees of the equator, windows should be minimized on east and west facade to avoid heat gains. But the easterly trade winds make ventilation desirable. So you should have well designed shaded openings and that will be a better solution in these climate zones. So even if you are compelled to have openings along this along the east and the west. So, this is the west facade and this is the east facade.

You should ensure that you do not have large openings. So, you must not have large openings and you should also ensure adequate buffer so that there is some kind of barrier the solar radiation to enter, but you also must design this facade in such a way that you incorporate air movement because this could be the direction of the wind. Of course, you need to check in which season so that you do not bring in the hot air inside. Now, the position and direction of the sun and wind vary season by season. Knowing the relationship between these two powerful forces allows the designer to manipulate a building's orientation and form.

The location of its spaces and the position, size and design of openings to take advantage of free heating, cooling and ventilation. If in a northern hemisphere climate, the prevailing summer winds are southerly, that is from the south, then south facing openings can provide cooling ventilation without heat gain as long as they are shaded from the sun. So, you need to have, what happens specifically during this kind of climate is, you need to optimize the between solar heat gain so if you have a room and this is north facing there will be breeze inside but you should understand that this breeze can also bring in a

lot of heat and therefore you need to optimize between solar heat gain and the positive impacts of natural ventilation. One good way of doing this is through vegetation. Sometimes water bodies could also aid.

But you have to be careful because already it is a humid climate. And any further addition of humidity will make the indoors extremely uncomfortable. So what you need to do is you need to optimize and create a balance. It's the same along the western facade also.

Along the west façade, every building cannot be extremely linear and therefore you will have a west facade. You must try to stack up rooms which are more service oriented. Say like the staircase. What happens when you have stack cases along this side? It acts like a buffer.

You could have toilets. You could have store areas. If this is the north, then this is the west. So, what happens is in effect you are trying to buffer the west with non-habitable rooms or spaces. It is a good idea to do this- that you buffer the west with non-habitable spaces so that it acts also like a insulation to the other areas of the room by preventing heat gain inside. So, in today's class we saw the primary difference between passive techniques and active techniques.

Passive techniques are techniques which utilizes the forces of nature in order to create a habitable I mean comfortable indoor environment they use the forces of nature such as sun and the wind. They harness this energy to create a comfortable indoor environment. There is no need or use of any extra contraption in a passive design and the principles are very simple but they are extremely sensitive to the climate, the solar radiation, the temperature, the wind speed, wind direction, the terrain of the building. So they are very sensitive to it. Whereas, if you look at active systems- active systems need a lot of contraption.

They could be grid dependent and therefore, they do not substantially help us in mitigating greenhouse gases. Whereas, passive techniques do that. Today we saw just a glimpse of all the passive techniques that we can use and we started with the introduction of how orientation can form an important passive element and determining factor. In the next class we will see how orientation and form can be used as a passive technique for a better design. Thank you.