Course Name: Architectural Approaches to Decarbonization of Buildings

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Lecture 03

Appropriate fenestration for Passive Architecture

Hello all. So, in the last class we had discussed about the simple passive strategy pertaining to form and orientation. We had seen how orientation and form are very important criteria. This time we will see about planning. There will be some overlaps between planning and a little bit on orientation might also come in, penetration may come in because these things are a little interlinked. They cannot be segregated completely as black and white.

However, I have tried my best to keep it separate. So we will see about planning. In this class, we will look at the passive architecture and planning strategies with reference to orientation and layout, form and massing, a little bit on fenestration, position of fenestration, density and zoning, green spaces. Mixed use development, transportation planning, materials and construction, natural resource management, climate responsive design and we will finally conclude with case study.

This entire content may not be possible within one lecture but the forthcoming lecture would also have this content. Now, bioclimatic architecture aligns with passive design principles by utilizing natural factors like neighboring structures, local biodiversity and climate to regulate a building's temperature and energy use. Passive design relies on natural conditions, minimizing the need for artificial climate control by optimizing layout, materials, openings and orientation for enhanced environmental comfort. Implementation of passive design not only makes individual buildings more eco-friendly, but it also contributes to a significant reduction in overall energy consumption when widely adopted. The creep principles include selecting openings for sunlight in colder months and facilitating ventilation in hot climate but at the same time optimizing the openings to ensure less solar gain.

Passive design plays a crucial role in mitigating the carbon footprint of the construction industry, a significant contributor to carbon dioxide emissions. Integration of passive design strategies is pivotal in achieving net zero building by reducing energy demand and improving indoor environmental quality. If we look at bioclimatic performance, Passive design aligns with the principles of bioclimatic architecture, which lies in utilizing natural conditions to regulate a building's temperature and energy use. This fundamentally involves considering the contextual factors surrounding a building, such as neighboring structures, local biodiversity and climate. Utilization of natural conditions pertain to passive design as an approach that relies on harnessing natural conditions to minimize the reliance on artificial or mechanical climate control.

This involves optimizing a building's layout Materials, openings and orientation to maximize the benefits of natural elements ultimately enhancing environmental comfort. Reduced energy consumption. The implementation of these strategies not only enhances the environmental friendliness of individual buildings, but also leads to a significant reduction in overall energy consumption when widely adopted. Fundamental principles of passive design include the selection of openings that allow sunlight to enter during colder months and facilitate ventilation during the warmer months. It also entails mitigating carbon footprint given that the construction industry is a notable contributor to carbon dioxide emissions with raw material production accounting for a substantial portion.

Passive design strategies play a very crucial role in reducing these emissions and contributing to a lower carbon footprint because you are not actually adding anything to the design. You are only prudently using what is there on the site with a keen understanding what is there around the site and trying to design a net zero building. In net zero building, a pivotal aspect involves the integration of passive design strategies to decrease energy demand and enhance indoor environmental quality. So, now the configuration and pattern of massing in the built form can largely determine and modify the air movement both inside the buildings and around the buildings. Depending on the relationship between the wind direction and that of streets and buildings, there may be variations in wind speed.

When large built volumes or say a long row of buildings are placed perpendicular to the wind direction, then shielded zones are established between the buildings where wind speed might be just a small fraction of the speed above the building's roof or in streets parallel to the wind direction. In this case, the distance between the buildings has little effect on the speed currents between the buildings. The first row of buildings diverts and approach wind currents upwards. The rest of the buildings are left in wind shadow regions. Thus two separate air flow regimes are created.

The regional air currents flow mainly over the top of the buildings while in between the buildings a secondary airflow pattern is created as a result of the friction between the upper air currents and the building. This may be desirable in certain climatic conditions like the cold winters or hot summers when winds are to be avoided but undesirable in warm humid climate when ventilation is required. On the other hand, when building blocks are placed parallel to the prevailing wind direction, the wind can blow through spaces between the buildings and along the streets with small retarding effect from the friction with the buildings. In this case, the interior of the buildings suffer from poor ventilation while the adjacent open spaces experience high wind velocities. Orienting buildings at an angle in relation to the wind direction can produce relatively homogeneous wind patterns around them.

Thus creating better ventilation regardless of the relative position of buildings within the built up arrangement. Now, solar radiation -we have to plan buildings to take advantage of the natural sunlight. The key points here which we have to understand is we need to maximize exposure of the sun in cold climates. We need to reduce solar heat gain in hot climates. Energy efficient use of sunlight reduces reliance on artificial lighting and heating while proper solar orientation enhances occupant comfort.

We need to take care to ensure that we orient structures to maximize exposure to the sun in cold climates or reduce the solar heat gain in hot climates while reducing the need for artificial lighting and heating. The considerations we must have when we design for wind patterns that the prevailing wind patterns for optimal natural ventilation must be tapped. We must improve indoor air quality with fresh air intake with natural cross ventilation. We should also reduce the reliance on mechanical ventilation system. Therefore, with wind patterns, we must consider prevailing wind patterns when placing buildings to optimize natural ventilation.

This helps improve indoor air quality and reduces the reliance on mechanical ventilation systems. It also the effect of massing on wind staggered versus not staggered layout. The staggered clustering has a better wind performance without dead wind zones. What I mean by this is staggering the building. Once the buildings are staggered, the wind seamlessly flows around it and hence all the rooms get the benefit of its ventilation.

When the buildings are not staggered but they are in file it causes a small wind shadow region. Now when we have two compressed street pattern it results in air movement at a higher height. Winds are placed on less compressed areas. With more spacing, when you have very less space in between the buildings as shown here, it results in the air movement over the buildings. Percolation does not happen whereas if you have wider spaces between the buildings then the wind is dragged to the bottom in the open spaces than that is potentially uncomfortable.

This is intensified by tall buildings and tornadoes are appeared. I mean very small tornadoes- also resulting in heat loss. Building form also affects the quality of open spaces due to channelizing the wind in the street. So, having winds on the streets are also important and building forms play an important role. They create tornadoes, small tornadoes in the lot in front of tall buildings which you could capitalize or otherwise.

So, building form is very important and it is important that the buildings are placed in ascending heights so that all the spaces get benefited by the wind instead of having all blocks in the same height which can cause a wind shadow region in between the buildings as the wind would slip and move on top because wind is after all a fluid. So, now in hot dry climates windows need to be appropriately shaded. It is preferable if they are small in area. Being a sunny zone smaller openings would allow sufficient daylight. So, in hot dry climates One must have very small windows because we do not want the aggression of heat inside.

Already it's a warm place and we do not want heat inside. Now being a sunny zone, smaller openings will allow only daylight, that too sufficient daylight. Air flow need not be encouraged since daytime air is hot, in fact very hot. Due to low night temperatures, natural ventilation may be desirable at night. Window sizes if increased for this purpose must be efficiently shaded from radiative heat gain.

High openings or ventilators would be effective as heat vents. How does that work? When you have a high ventilator, hot air always rises up. And therefore, hot air will rise up and escape through the vent whereas the lower air which is at a working zone will be cooler and warm air will rise up and escape. So, you could have vents at a higher level. And you should have the fenestration must have large overhangs to cut the solar radiation.

The fenestration height should be such that there is a good distribution of air flow over the human body. Lower sill levels might therefore be preferable. In cold climates, fenestration should be large, unshaded but sealed. This would enable heat gain but reduce cool breezes. Fenestration location would be of little consequences.

In composite zone where all the three conditions may occur, which is very complex, Windows shaded hold the key. The shades must cut off summer sun but permit winter heat gain. It should be controllable. The window area would be determined by the duration of each season. If the winters or humid season is long, large windows are preferred.

Window location makes a difference to the quality of light obtained indoors. High windows something like ventilators provide the best distribution of the direct and diffuse light. However, they also maximize the potential for glare and should have baffles. Low windows allow ground reflected light.

Light being reflected from the ceiling provides the most uniform ventilation. The middle located window in comparison distributes neither skylight nor ground reflected light well. Some basic thumb rules can be followed in the positioning of windows to enhance air movement. Window should be staggered rather than aligned unless the incident window is already at an angle. What do we mean by that? The windows should be staggered.

So, the one window is here and the outlet is staggered. It is not in the same line and that ensures cross ventilation. Low windows allow ground reflected light Light being reflected from the ceiling provides the most uniform ventilation. The middle located window in comparison distributes neither skylight nor ground reflected light well. Some basic thumb rules can be followed in the positioning of the windows to enhance air movement.

Partitions should not be placed near windows causing an abrupt change of wind direction. Similarly, windows on adjacent walls should preferably not be placed so as to cause an abrupt change of wind direction. It has been said earlier that indoor air speeds are greater if outlets are large than inlets. It would be desirable to provide every room with window on at least one third of the wall. If the natural wind is incident on any one of the windows, the other window and the door will act as outlets.

Not being aligned, the airflow indoors would be better distributed. If the outside air is incident on both windows, then the large volume is likely by itself to make the conditions comfortable. The wind direction may not be incident on either of the opening but on a window in another room. In such a case, the door acts as the inlet. The two windows now outlets would lead to a good air flow.

If the total area is greater than the door, then the air velocity would be increased. Only if one external or free wall exists, it might be preferable to provide two windows on it rather than one. This would improve the ventilation when the air is incident angularly on the windows. So, here the summary is that when you have windows, try not to place the windows exactly opposite to each other. The air would pass by leaving out zones where ventilation would not happen and therefore, when you have to position the windows, try to have staggered windows so that breeze moves and you do not really have dead zones. Also try to consider doors also as a possible inlet for air movement.

When you orient the room ensure these things that the prevailing wind direction along the prevailing wind direction you must have openings. If there were openings here and this is a prevailing wind direction then this place would have been ventilated. Now this place remains unventilated because it is along the wind path. Whereas here you can see that vegetation has been used to divert the wind and therefore the wind which comes here gets diverted through the building causing good amount of ventilation. And this is the principle of a wind catcher. Where this is the roof of the catcher, clean air enters here. Because warm air is light, it enters here- it gets mixed with the slightly cool air -descends down, because it becomes heavy. And there has to be an outlet for this wind to go.

Only then at a human level there will be adequate ventilation. And this principle can be used to position the wind catcher. So, you could have a wind catcher either on the corner with one outlet, you can have it in the center with multiple outlets or you could have multiple wind catchers with multiple outlets. Again here we need to understand all this we have already seen that we need to have we need to consider and have certain elements outside the house such as vegetation or compound walls which will try to which will aid us in bringing the breeze or directing the breeze inside. In a situation as A, there are no openings along the direction of the wind and the house acts as an element to divert the breeze out.

In the second scenario B, the wind flows, it is diverted out but here you have two elements, which divert the breeze in and because of this the house will be ventilated. And here you have a third case where the wind has to pause- the speed is broken. Because of that, it gets diverted inside the house- because of the pause that comes. And here you have another scenario where you divert the breeze on one side to exit and you divert the breeze to pause so that the indoors get ventilated. Here is another scenario which we had just discussed about where to locate the apertures so that the wind blows inside.

Now if you have wind- if you have an inlet and an outlet at a diagonally opposite direction, you would get it ventilated. Cross ventilation will happen. But you see a large part of the room remains unventilated or there is no breeze movement. This is not a good scenario because wind is passing through the house. The house will have ventilation in terms of having a good indoor air quality.

But the breeze will not touch the human being. This case scenario is also similar where wind just blows through the house and there are too many unventilated zones. Here the inlet is small and the outlet is big fizzling out the air. And in this case scenario if you see even if little breeze comes it will circulate and go in because there is no provision for an outlet. hence location of inlet and outlet size of inlet and outlet in the planning of the buildings along with how you plan the buildings where are you locating each of the block is very important so based on the location of the blocks there could be wind shadow regions or regions of small tornadoes Or there can be direct cross ventilation. We need to understand the basics of movement of air around buildings so that we are able to plan our settlement or plan our campus to facilitate air movement outside and inside the building.

So, with this I stop with the first segment of this series on planning. We will meet next class with the continuing series.