Course Name: Architectural Approaches to Decarbonization of Buildings

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Lecture 01

Orientation and Form for Passive cooling

Hello students, in our last class we had started our discussion on passive and active systems and passive and active designs. We had started with briefed into orientation and how orientation of a building can form an important component in creating indoor thermal comfort and thereby reducing the use of electricity dependent contraptions for indoor comfort. Today we will discuss orientation and form in greater detail. Let us take the example that I have shown here. This is the case of probably a building design that could come up in Gandhinagar in Gujarat, India. And you can see which the best orientation is and how it works.

You can see that the horizontal surface receives greatest intensity of solar radiation. Hence, in this kind of climate roof must be protected from direct solar radiation. That can happen in many ways. The roofs can be either shaded or one could go for cool roofs.

We will discuss these techniques a little later in the class. Just for perspective, I am mentioning these names to you so that you also become familiar. This south facade is highly exposed in winter but less in summer which is good. And the north facade receives very little radiation. Only in summer mornings and evenings it receives radiation which is again a very good design.

The east and west facade receives high amount of radiation both in summer and winter which means we need to insulate by some means. Again, when I say by some means, I do not mean to say that we need to add some contraption to this. What you need to do is, you need to insulate the east and the west facade either by means of vegetation or by means of a separate shading device. Like a Jaali or a screen wall. Or, you could do like this- So this is option 1.

This is option 2. And option 3 for this is. You could also have areas that are non-habitable. We had seen what these areas are likely to be. They could be store rooms, toilets or staircases.

And for a climate like Gandhinagar, it is best to orient this building in such a way that the east and the west have minimum facade areas. And the exposure to the eastern and western sun is not as much as it is to the north and south. In all this, certain things you have to remember. North facing walls and windows, they receive more solar radiation in winter than in summer because the sun is lower in the sky. East and west facade facing walls and windows receive more sun in summer in the early morning and late afternoon when the sun is lower in the sky.

So, your building design and how you treat north facing walls will determine how much solar access your home receives. So, if you look at this picture. North is down. So this is the west. So in principle, if you look at orientation as per climate, the west facade is shorter than the north and the south.

When deciding the best orientation, keep in mind that the climate is warming. So, hotter summers with more extreme heat waves are becoming more frequent. So, passive heating is still very desirable in most climate zones but passive cooling is becoming more important. Because you should also notice that along the tropics passive cooling is a very important strategy that is required. Especially because a number of developing countries are also along that belt only.

Due to economic constraints, passive cooling has to happen in a natural manner because use of air conditioners may not be possible by all. Additional attention to shading of windows and walls, particularly west facing and exposure to cool breezes and other forms of natural cooling is needed. Now look at this orientation for passive cooling, it keeps out unwanted sun and hot winds while ensuring access to cooling breezes. Some passive cooling is required in most climates. In hot humid climates that do not have cool winters orientation should generally exclude direct sunlight and radiant heat especially from nearby structures.

At all times of the year you must follow this principle while maximizing access to cooling breeze. So, if you see both these houses here, because the aspect ratio is correct and this street is along the prevailing wind direction,, there is breeze on the streets- Providing openings along the areas which have breeze direction is also bringing in a lot of cross ventilation and this cross ventilation happens because you have a chunk of trees which is diverting the breeze. So, these trees are diverting the breeze whereas in this picture there are no trees. And therefore, the breeze is just passing by without entering the house. So, here it is a combination of, in this picture, it is a combination of orientation, breeze direction, and vegetation to channelize breeze through the building.

At site level, in tropical areas, southerly solar access is not desirable. North is ideal for views because south facing windows require minimal shading. In all warm climates look for a site with good access to cooling breezes. Ensure that landscape and adjacent buildings -they funnel rather than block beneficial breezes and provide shade to all the walls. For example, in this building, by virtue of having trees at this height, the breeze is getting directed to the habitable spaces.

And building level for passive cooling. Choose or design a home with limited or no exposure to direct sun and maximum exposure to cooling breezes. Use careful designs to improve performance in the case of poorly oriented sites or existing homes. In this case, you can see that you have high level openings. These capture the window sun and they create a cooling current.

How do they do that? And you also have provision for cross ventilation. So hot air rises and cool air settles down. So the hot breeze goes up and it escapes along with this breeze. Let us look at form and massing. Along with orientation, massing can be the most important step in providing a building with passive thermal and visual comfort.

Orientation should be decided together with massing early in the design process as neither can be truly optimized without the other. It is meaningless to talk of orientation without considering form and massing. So, both of them go hand in hand together. Always orient long facades on the north-south direction. This must be ideally be the north point in the north tropical climates orienting building so that east and west axis is the longest and so Thermal gain due to solar radiation is minimized and daylight infiltration gets maximized.

Controlling sunlight through louvers and shades is easier on north and south side. So, in each of these cases, if you see the first case - You can notice that the west is, if the site is compelling you, you could have, but block the west as much as possible by various means that I said. First is buffer. With vegetation. Second, buffer with non-habitable spaces.

And third is do not provide too many apertures or fenestrations. This is all along the western side. So, on the west side Try not to have too many openings. You try to avoid openings here and try to create rooms that are non-habitable and try to buffer the space with some kind of vegetation.

Let's look at the next case. Which is an H type of plan. This plan has a slight advantage that the mutual shading- the shading of this wall will fall on this wall and hence this shape is going to help you with mutual shading of at least a part of the western wall,

whereas this surface and this surface will have direct solar radiation and there you should again follow this 1, 2 and 3 principle. This gets saved and resolved because of the shading from the adjacent wall. Now, let us look at the next plan form. The next plan form is a courtyard type of plant.

Again, in this courtyard type of plan, you have two western facades. Facade number 1 is here and facade number 2 is here. Facade number 2 is at least saved a little bit because of the shade that may fall from this wall. But facade 1 is completely exposed in which case you need to again follow the principle of 1, 2, and 3. And three, which is this, buffer with vegetation, buffer with non-habitable spaces and do not provide too many apertures, openings or fenestration.

Call it whatever you want. But do not provide windows. So, I will add the fourth option also -windows. Next option is a Y option. But if you notice the, Y is at a slant. You see this y at a slant means that incident direct solar radiation will fall only on this surface.

This is the only area where direct solar radiation will fall. In all these other areas, it will not be direct incident solar radiation and hence its intensity will be much lesser compared to that which falls on wall A. So, wall A is your only area of larger concern and not wall B or C. B or C direct solar radiation does not fall. Now, if you look at this plan form like an E - again here, this wall is an area of concern and you follow the 1, 2, 3 principle.

Whereas, along this wall, mutual shading will help these walls. So, A is an area of concern, B and C are not areas of major concern. If you look at the next plan form, yes A is an area of concern, wall A, whereas wall B is not an area of major concern because of mutual shading. I am talking right now only from the point of view of solar radiation. This we have been discussing quite too often during the course of this class and you know what is an area of concern.

You have to have 1, 2 and 3 here. Whereas in this option again you have wall A and B as the major area of concern. Wall C mutual shading happens. So, wall C is not a major area of concern and this is how you need to first understand the various plan forms and understand the relationship between orientation and form. This slide is largely to make you aware of orientation and form. Next, we move on to the preference of typologies for multi-storied residential buildings in terms of reduced solar radiation exposure as given by the Bureau of Energy Efficiency for multi-story residential building.

Here you have a linear double loaded corridor typology that is 1. Then you have a linear typology and third you have a tower typology. So, the shape and volume of buildings should be compact yet somewhat elongated along the east-west axis. Example, the

optimum shape is probably in the ratio of 1 is to 3.

In hot and dry climates the surface to volume ratio of the building should be as low as possible to minimize heat gain. Regarding the volume, the patio house is the most suitable form and can benefit in summer from the microclimatic effects of cool air pools that occur in courtyards. Although winter conditions in hot arid regions would permit an elongated house design, the heat in summer is so severe that a compromise is required. A very old traditional solution particularly for flat land is a compact inward looking building with an interior courtyard. And we will see more of this when we look at a case study of Jaisalmer much later in the class.

This minimizes the solar radiation impact on the outside walls and provides a cool area within the building. Adjoining houses, row houses and group arrangements all continues along the east-west axis which tend to create a volumetric effect are advantages as are the high masses of the building. So, you need to look at various other things like how do you design for various climate types and what is your constraint. So, if you look at hot dry climate you must have compact and massive design. This alone would probably work well with a hot dry climate where it is very compact and massive.

It has inward facing buildings. It minimizes surface areas and openings, and exposure to the east and west. No sun and therefore this is a good option. So all your options must be worked out based on your climate types. We will look at each of this and analyze now.

Look at this planform. Now, this planform is like a fan shape with a central core and if you look at suppose we consider this as the north orientation you will see that there is no direct incident solar radiation along this massing. If this plan form were be oriented like this then this entire surface and therefore all the houses along this particular orientation if this was the West would suffer so much. So you need to consider all that and then take a call. Again when you come to this design, you can see that these surfaces are completely exposed.

These surfaces can be saved due to mutual shading. Whereas this is a vertical tower and it's a non-habitable space. Though these houses will be subjected to extreme heat. this house is highly unlikely to have direct solar radiation unless otherwise one of these directions is the western direction direct western direction and based on this you must arrive at a proper form now If we are to consider a combination of form and orientation, if you look at this example, if this is the western surface, you would notice that all the houses here are going to get affected. But if this is the western surface then you would notice that almost all the houses along this would be affected with the direct solar radiation. Similarly, these houses will be affected due to direct solar radiation if this were

the west facing facade.

Therefore it is very important for you to understand a combination of orientation and massing. Now for this class we will stop with this understanding that form and massing must go together and they are not independent and we should also understand that it is a response to climate. How is it a response to climate? We will continue with this slide in the forthcoming class. So, now I will take leave and we will join in the next class.