Course Name: Bioclimatic Architecture: Futureproofing with Simple and Advanced Passive Strategies

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Lecture 04

Principles of Simple Passive Architecture

Hello everyone. So last class I hinted upon what simple passive strategies are and gave a very brief outline about some of the simple passive strategies. In today's class we will continue with simple passive strategies and look at some of the basic principles. So, let us look at the principle of using building orientation and form. Now, as the warm, humid climate zones are located near the equator, the orientation of the settlement pattern should be placed preferably on southern or northern slopes. The best orientation is longer side facing north and south directions to protect from the solar radiation.

However, the east and west sides should be shaded by proper shading devices. So, if we look at a building plan that is facing north and south as its long axis and it has an east-west axis,. You can see the solar radiation - which direction hits most and which direction least. So, along this direction, which is west, intense solar radiation hits the wall.

If this building were oriented this way, then you can imagine how this entire wall would have high solar radiation from the afternoon sun. So, heat is transferred because this material will attempt to achieve a thermal equilibrium with the surrounding environment. So, heat flow will occur within the material, whether it is solid, liquid, or gas, or between materials until the temperature of each is equal. So, heat transfer will occur through these mechanisms and in this case it will be primarily conduction. If you have windows you will have convection and you will also have radiation.

So, if we combine building material and orientation, you can imagine how much heat gain will happen through the longer-facing wall along the west direction. Now, let us look at you know the building layout. As the warm-humid climate zones are located near the equator, Orientation of the settlement pattern should be placed preferably on the southern or northern slopes. The best orientation is a longer side facing north and south directions to protect from the solar radiation. So, the longer side facing north and south is the best orientation to protect from solar radiation.

However, the east and west sides should be shaded adequately using a proper shading device. Now different layouts for building developments are appropriate according to the climate. The shape of the building also has different requirement based on the local climate. Now if we look at orientation, then for warm-humid climate, you must minimize the building depth, you must minimize the west-facing wall, and you must maximize the north and south walls. Because of minimizing building depth, you will achieve good ventilation, and because of minimizing the west-facing wall and maximizing the north and south walls, you will reduce heat gain.

The surface area must be maximized so that you can tap night cooling. You must maximize the window wall to tap the ventilation. For the composite climate, you must control the building depth for thermal capacity. You must minimize the west wall to reduce heat gain. You should have a limited equator-facing wall for ventilation and some winter heating.

A medium area of window wall must be available for controlled ventilation. In the hot-dry climate, you must minimize equator-facing and west-facing walls to reduce heat gain. You should minimize the surface area to reduce heat gain and loss. You should maximize building depth to increase the thermal capacity. The window wall to window size must be minimum to control ventilation, heat gain, as well as light.

For the cold temperate climate, you should minimize the surface area to reduce heat loss. Moderate areas of pole-facing and west walls should be designed to receive heat gain. The roof area must be minimized, and that will reduce heat loss. You should have a large window wall for heat gain as well as light. Then let's look at the basic principles of heat gain.

So in direct heat gain, direct gain is a system that does not include or require any other mass but just allows the heat to pass through the building through a transparent material. Normally that is glass. Then we can have appropriate shading. This can be achieved using the shape and form of the facade, using low-transmission glass, or using certain devices inside the building. The third is natural ventilation, which relies on natural air flow and breezes to reduce mechanical cooling when the building is already occupied.

Now, let us look at the thermal mass and air tightness of a structure. Now, if you look at the thermal mass and air tightness, the angle at which the sun strikes windows and any shading becomes important because based on that, you will be providing either glazing or openings. You should use appropriate glazing of the solar heat gain coefficient, which is correct. The amount of floor and wall area reached by sunshine during the day is very important in designing for gaining heat or losing heat. As we had already discussed for ventilation strategies, you can have single-sided ventilation like this, cross ventilation like this, or you can have stack ventilation where the blue arrow indicates cool air and the red arrow indicates warm air.

So, in single-side ventilation, the incoming and outgoing wind is confined to one side. So, the wind that goes in comes out, whereas in cross ventilation the apertures are on the opposite side. In stack ventilation, it uses temperature differences to make warm air rise and escape, which means it is important to have an aperture at a higher level. You must not have openings directly facing each other. If you do that, then a large part of the interior area can fall into the wind shadow region.

The apertures should not be next to each other as a large part of the room falls under the wind shadow region. You must also not have openings parallel like this, as the centre part is a wind shadow region. And you should not have walls like this, as they function like wing walls to divert the breeze, causing a wind shadow region. You could position the windows in such a way that the inlet and the outlet do not cause a primary wind shadow region. There still will be, but it will be too little.

And the location of the wind wall is important in causing less wind shadow in the region. Let us now look at day lighting strategies. Now, how can we have day lighting inside a building? We can have day lighting through side lighting, top lighting, or core day lighting. Windows can function as side lighting. Skylights or top lighting can be used.

So, windows will be along the wall where we will get light through the sides, whereas skylights will be on the rooftop. So from top, we will get light. Sawtooth apertures are also called north lighting, where you get the light that is diffused from the top. Monitor apertures are also from the top. Atrium is also from top, but it is core daylight.

So, windows are excellent daylighting apertures. Glare gets controlled by a set of operable blinds. Skylights are horizontal apertures that cut through the roof of a building. Sawtooth apertures—I already told you it is like north light; the glazing is on one side facing the primary solar radiation side. Monitor apertures: These are more like clearstoreys where you get only from the roof, but it is not direct.

These are shaded, and therefore you get light through which solar radiation is cut; only lighting levels increase. And then you have the atrium, which is a core daylighting concept that opens up the center of the building so that it can be daylit. We will quickly look at simple passive cooling strategies in warm and humid climates. So good natural ventilation is required to reduce air conditioning and facilitate cross ventilation by providing openings on opposite sides. Using an open plan will promote natural ventilation.

Using louvers for openings will facilitate ventilation and will also direct the wind inside. Then using a low-pitched roof with wide overhangs is also an important category. Ventilated attics with pitched roofs to shed rain and enhance air circulation. Next, we will see simple passive cooling strategies in hot and dry climates. Using plant materials, especially on the west, to minimize heat gain.

So, you should block the west. The easiest way to block the west through a simple passive strategy is through the use of vegetation. Screened porches and patios can provide passive comfort cooling through ventilation. Window overhangs or operable sunshades reduce air conditioning. Shades can be used to prevent overheating, to open to breeze in summer, and to use passive solar gain in winter. Use of light-colored building materials and cool roofs to minimize conducted heat.

Water bodies can be in enclosed courtyards, and these are ideal for evaporative cooling. If we look at a cold climate, maximize the surface-to-volume ratio and organize floor plans so that the winter sun penetrates daytime. Trees should not be planted in front of passive solar windows, but they are okay to be placed at 45 degrees from each corner. Face most of the glass area south side to maximize winter sun exposure. In cold climates, the tiles, slate, or stone facade fireplace provides good surface mass to store the winter daytime solar gain and summer nighttime cool.

You must keep the building tight and well insulated. Small, well-insulated skylights reduce daytime lighting and energy. Extra insulation could prove cost-effective and will increase occupant comfort by keeping indoor temperatures more uniform. In the last few slides, you would have seen some architecturally aesthetically pleasing graphics to depict simple passive strategies for various climate types or how from where we got this the sources we will be looking at in the forthcoming classes. Till now, what we have seen in today's classes, we have seen the principles behind each of the simple passive techniques.

Last class we saw what are the simple passive techniques. In this class we have seen the principles behind each of the simple passive techniques. And we have also kind of shown how for various climate types simple passive strategies can be used and adopted in the form of orientation, or how we place windows, how we place openings, and so on. We will end this class with a glimpse of a small case study where simple passive strategy has been adopted. will look at a low-energy office building called SD Works.

SD Works is a simple building that's a rectangular building with longer surfaces along the north and south. The east and west have shorter surfaces. So, in terms of orientation, they have played it very safe by having the shorter side along the east and west. The building plan comprises primarily of three or four types of spaces. First, one and four are office spaces; three is the core area, and two is a long corridor along the west side, and it is a G+2 office building structure.

We will see another building, which is the Energy Base, Vienna. It uses simple passive strategies in a moderate climate. Now, this follows a very holistic sustainable approach including design priorities for energy efficiency as extreme reduction of energy demand for building operation has been demonstrated in this building. Again, if you see this building along the north and south, this building has longer surfaces; east and west are oriented along the shorter surfaces and because of the orientation and other features like shading device, use of glass, etc. You can see the end energy consumption as compared to the base case.

Compared to that, there is an 80 percent reduction in the use of primary energy as compared to the reference building. The carbon dioxide emission reduction per year is 200 tons as compared to a reference building. In this building, an extreme reduction of energy demand for building operations has been demonstrated. This building uses renewable energy; 100% coverage of heating and cooling energy demand is from renewable sources, which are groundwater and solar energy. The user benefits include indoor climate and comfort for the workplace.

And of course, 80 percent reduction of end energy consumption and 200 tons reduction of carbon dioxide. This building uses appropriate orientation and uses windows that are designed specifically for this climate. It also uses shading devices and window design. It protects from direct sun through the use of appropriate shading devices. Passive techniques are passive heating of south-facing areas.

The south-facing area is exposed to sunlight, and it taps the energy to heat the rooms when required. North-facing rooms by solar-heated exhaust air via heat exchanger. So, because of doing this, 100 percent coverage by renewables for heating and cooling happens in buildings. So, hot water, heating building, cooling building - everything gets covered by the renewables. So, these are the simple passive techniques that are used in these two buildings.

There are advanced passive techniques that have been used in these buildings and in some other buildings also, which we will look at as a separate section. So in today's class we have seen what are simple passive techniques and what are the principles behind these simple passive techniques to actually work. We have seen the simple passive techniques that are used in various climates in a very brief manner. It is more like a demonstration of, for example, orientation. How orientation as a principle is used for energy efficiency, we have seen already.

But we have seen for what climate type what orientation is best. So, today we have seen the application and principles of simple passive techniques, and we have seen just one or two simple passive techniques and how they are used in case studies. Much detailed information on all these will come in the forthcoming classes. With this, we will stop today's class and we will continue in the next class with another topic on advanced passive cooling systems. Thank you so much.