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

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Lecture 03

Simple Passive Strategies- Introduction

Okay, dear students, so today we will look at simple passive strategies. In the last class, we saw how we have simple passive strategies and advanced passive strategies as ways to approach bioclimatic architecture. In today's class we will look at the introduction, what are simple passive strategies, what are its basic principles, What are the ventilation strategies, daylighting strategies, simple passive cooling strategies for warm and humid climate, simple passive cooling strategies for hot and dry climate, and simple passive strategies for cold climate. What are the benefits of simple passive strategies? And we will look at a case study. So in the last class itself, we had seen what are simple and advanced passive strategies. In this class we will focus primarily on the passive strategy, which is simple passive strategy that focuses on use of layout, spacing between buildings, air movement, opening size, opening position, protection of openings, wall material, roof material, rain protection, and storm water as a means to achieving bioclimatic architecture.

Now the basic principles, if we see. Passive design strategies refer to a set of design approaches that focus on utilizing the natural environment. What all aspects of natural environment, sun, heat—what I mean to say is using sun as a natural resource to tap heat. using wind as a natural resource to tap the breeze.

So passive design strategy focuses on utilizing the natural environment to provide heating, cooling, ventilation, and lighting for a building. The pursuit of human comfort illustrates the flaw of seeking stability in inherently dynamic systems. So we evolved an environment that varied in temperature, humidity, light, cloud cover, and wind conditions. Our activity levels, our clothing levels, our state of mind, the mood, and other factors also change either inadvertently or deliberately, consciously. environmentally responsive passive solar buildings; they are in sync with the limits of comfort.

A climate-responsive approach to architectural design includes the integration of these parameters during different design phases, so what are those parameters? First is building orientation The second is building massing. Third is thermal zoning. Fourth is wind flow. Fifth is shading. And sixth is material specification.

Now if we look at the basic principles of how this heat transfer happens. So heat is transferred because a material will attempt to achieve thermal equilibrium with its surroundings. So if you have hot water in a bucket, sometimes it cools down, but during this process it makes the air around the bucket a little warm because it is trying to achieve equilibrium with the outside cooler environment. So heat is transferred because every material will attempt to achieve this thermal equilibrium with its surroundings. Heat flow will occur within a material, whether it is solid, liquid, or gas, or between materials until the temperature of each is equal.

Heat transfer will occur through three mechanisms, which might operate alone or in combination. These are conduction, convection, and radiation. What is conduction? This is where heat energy is transferred because of the physical contact between molecules within a material or between materials that are touching each other. Physical contact is necessary in conduction. The direction of flow will be from the warm area to the cool area.

Thermal conductivity is the rate of heat flow that is a factor that is determined by the ability of the molecules to conduct heat. The human body is sensitive to heat flow rather than temperature. So if a person stands in bare feet on a concrete floor and then on a wooden floor, the body will sense the different rates of heat flow. That is, heat will be transferred from the body to the concrete more quickly than to the wooden floor because concrete is a better conductor. The concrete floor will be less thermally comfortable than the wooden one, although in fact a ground-bearing concrete floor usually offers better thermal insulation.

The second is convection. Now, convection refers to heat that is transferred by the movement of a fluid. In buildings, this fluid in question is usually air and very rarely water. When it comes into contact with a warmer or cooler surface, the air or water will either absorb heat from a colder surface or lose heat to a warmer surface. If it becomes colder, the fluid will sink because of its increased density, and vice versa.

The third one is radiation. Heat can also be transferred through the air or through space from one body to another by radiation. Heat is radiated to and absorbed from the surfaces that surround a body without heating the air. When radiant energy hits a body, some of the energy is reflected and some is absorbed. The respective amounts will vary between different materials, and for instance, colour will play an important role in determining how much heat is radiated from one body to another.

So, in this picture we can see clearly how heat transfer happens. It can happen through conduction. where physical contact is necessary between the materials. It can happen; the conduction can happen through the walls, through the floor, and through the roof; it is not possible. Convection happens along the surfaces because it is the movement of fluids, and here the fluid in question is air, and radiation can happen from or to the human body and from or to the roof surfaces.

So, this is the basic principle of heat flow in buildings through the wall, where heat flows from outside to inside if the outside temperature is hotter or higher and heat flows from inside to outside if it is colder outside. So, heat will flow from outside to inside if outside is a higher temperature and inside is a lower temperature. Heat will flow in this direction if inside is warmer and outside is cooler. Let us look at the passive design that we can adopt in buildings. First is form and building orientation.

So, form and orientation constitute two of the most important passive design strategies for reducing energy consumption and improving thermal comfort for occupants of a building. It affects the amount of sun falling on surfaces, day lighting, and the direction of winds. For example, this is the north and this is the east. So, in the morning, you can expect the sun to fall on this surface. And if the wind direction is say southeast, then you can expect the breeze to flow in this direction.

So, form and orientation of a building determine the amount of heat and wind that can get inside a building. We will look at the simple passive techniques in brief only in this class, and we will move on to detailed discussion and detailed classes in the forthcoming classes. Second is shading. So, shading can reduce solar gains on the building facade. Shading reduces the effective solar heat gain coefficient of the glazing.

This means that a cheaper glass with a higher solar heat gain coefficient can be used instead of a high-cost, low-solar heat gain coefficient glass. Third is natural ventilation. Fresh air provision is considered an efficient and healthy solution as it reduces the need for mechanical means to ventilate a building. For good natural ventilation, building openings should be in the opposite pressure zone since natural ventilation relies on pressure to move fresh air through the building. Daylighting in a building design is a very important factor, and it's a good strategy to use light from the sun.

The presence of natural light in an occupied space brings a sense of well-being, increases awareness of one's surroundings, and also increases energy-saving potential with reduced dependence on artificial light or on the grid. Fifth is evaporative cooling. The idea of a water body such as a pond, a lake, or a fountain to provide a cooling effect to the surrounding environment and this effect lowering the indoor air temperature is widely known as the concept of evaporative cooling. Evaporative cooling lowers the indoor air temperature; thus, it lowers the energy cost for air conditioning in buildings and thus reduces the energy load. The way a water body can be used for evaporative cooling will also depend on the climate type.

In the forthcoming classes, we will see: Which strategy is suitable for which climate type? We will be seeing that also. For now, you can see how water body, air when it moves through the water body gets laden with humidity and air that is humid is heavy. It's heavy air. What does it do? It replaces the warm air, and warm air, which is lighter, lighter in weight, and less dense, flows out if an appropriate opening is given, and this creates a cooler environment in the habitable area. by using water bodies, but water bodies cannot be used in all climate types to lower the temperature.

We will look at this in greater detail later. The next one is thermal mass and thermal insulation. Materials in buildings possess diverse densities and thermal properties. It influences the structure's thermal mass. This mass can absorb and release heat.

It serves as passive heating as well as cooling function. Solar gains heat the thermal mass by day. It releases warmth at night for heating. Conversely, effective cooling requires night time release of stored energy. Natural ventilation emerges as a key strategy for efficient energy release.

Understanding and harnessing the thermal mass of building materials is essential for optimizing passive heating and cooling methods, ensuring an energy-efficient and comfortable indoor environment. In temperate and cold climates, a primary strategy to curb heat loss is thermal insulation. By bolstering thermal insulation and minimizing air leakage, buildings can enhance energy efficiency and maintain comfortable indoor temperatures, which aligns with regulatory standards and sustainable design principles. So, in thermal mass, when you use thermal mass and thermal insulation, what happens is if there is a particular building material and heat strikes on it, the thin film of air adjacent to this surface gets heated up. This air transfers the heat to the first layer of the building material.

This first layer gets heated up and it transfers it to the second layer of building material. This transfers it to the third layer of building material and so on and so forth. Now, like this, the heat gets transferred until the layer, which is what I call the inside. The first layer of the inside gets warm, and the thin film of air adjacent to this wall gets heated up. And this is the one this layer gives warmth to the inside.

warmth to the inside. Now, thermal mass and thermal insulation become very important because you can govern the time by which this heat reaches the inside. So, what is the time?

That depends upon the thermal mass. If you have a very thin wall, the heat from outside will reach inside in say X hours, but if you have a thicker wall, then this heat will reach here in x minus y hours. It will take time for the heat from outside to reach inside. So, it depends on the thickness as well as whether it is a material property.

It is the material property that enables the heat to get transferred from one end to another within a specific duration. Building physicists can actually predict how much time it takes for the indoors to start getting warmed up. You can even prevent the heat from reaching the inside. By the time the heat gets transferred to this layer, the outside becomes cool and the reverse heat transfer starts happening. Under such conditions, the indoors will always be maintained at the same temperature, and you can maintain it at a temperature that will make it comfortable for occupants.

And therefore, thermal mass and thermal insulation play a very important role. Here we are not using any contraption to trap or store the heat or the coolness. Yet we can maintain the indoors to be permanently cool or be permanently at the same temperature. The next strategy is solar shading. So, solar shading systems play a crucial role in preventing overheating within buildings by blocking the solar radiation.

They prevent the solar radiation from hitting the window or the wall. They can be implemented through various means, such as building design, vegetation, or specialized shading devices. These devices are categorized as fixed or movable. These can be distinguished by factors such as color, material, and their position in relation to openings. By effectively managing solar exposure, shading systems regulate indoor temperatures and enhance occupant comfort.

Their design and placement are essential considerations in mitigating solar heat gain and optimizing energy efficiency within the buildings. When the indoor environment is too warm and the comfort is compromised, the air movement around the occupants may be increased. This can be done using natural ventilation techniques often categorized as single-sided, cross-ventilated, or stack ventilation, and also through wind catchers or wind towers. Now, if we first look at the shading types, you can see here we have shown three shading devices.

One is louvers. Now, louvers can be movable. So, we can categorize louvers as movable shading because they can be made to flip and become completely vertical or flip and become completely horizontal. Then you have overhangs, which can be categorized as horizontal shading devices, and side fins, which are vertical shading devices. Also, you can have single-sided ventilation, which is having an opening on one side of the wall through which breezes can flow inside. This is single-side ventilation, or you can have cross ventilation. This involves air flow through openings on opposite sides of a building.

So, in this, what happens is that in cross ventilation, you have a breeze that flows through the room. So, this is a cross-ventilated room. You have stack ventilation, which utilizes the principle that warm air is rising and cool air sinks. Why? Because warm air is lighter and cool air is heavier and this creates a natural air flow often with buildings at high and low points to facilitate circulation. So, this is the plan, but if we look at a section and if you have an outlet at the higher end and an inlet at a lower level, then what happens is that, this cool air can replace the warm air inside and allow the warm air to escape, making this zone cool and comfortable.

Then you can also have wind catchers or wind towers. So, traditional architectural elements, which are designed to capture and direct prevailing winds into a building, enhance natural ventilation. Each ventilation type offers unique advantages depending on building design, climate, and airflow requirements, contributing to improved indoor comfort and air quality. Then we have the evaporative cooling. Now, direct evaporative cooling relies on water evaporation to extract heat from warm, dry air.

This process causes the air temperature to decrease while increasing relative humidity. It is most effective in dry and hot climates, whereas the air has low water saturation. However, its effectiveness diminishes in cold, humid climates where the air is already saturated with a lot of moisture and water, and this limits the cooling potential of evaporation. A wind catcher is a traditional architectural feature that is used to capture and direct prevailing winds into a building, and it promotes natural ventilation and cooling. Typically this is found in arid and hot climates where wind catchers are designed to channel air flow through the building, utilizing the pressure differences created by wind movement.

These consist of openings positioned to intercept and funnel air currents, often leading to underground chambers or interior spaces where the air flow can be distributed. By harnessing natural wind patterns, wind catchers enhance indoor air circulation. They improve comfort and reduce reliance on mechanical cooling systems, making them a sustainable and energy-efficient ventilation solution. Let us now look at the benefits of simple passive strategies. In this class, we have seen a brief of what simple passive strategies are.

I have hinted upon what all simple passive strategies we will be dealing with in the forthcoming classes in detail. And I think this class would also give you a small understanding of what is meant by simple passive strategies where you do not need any special contraption to trap the heat and release the heat. Now let us look at the benefits of simple passive strategies. First, simple passive strategies do not cost us anything.

Economic benefits are high. For example, if we take orientation. By virtue of orienting a building properly, we can save electricity and energy. And therefore, one benefit of a simple passive strategy is energy efficiency. Automatically, the building becomes energy efficient. When the building becomes energy efficient, its reliance on active energy gets reduced, and it offers us economical benefits.

When we save energy, we reduce GHG emissions, greenhouse gas emissions, and therefore following simple passive strategies gives us environmental benefits. By following passive strategies, the occupants have a comfortable indoor environment. The health and well-being of people get improved. And sometimes this gets attached to the identity, the aesthetics, the language of architecture of that particular place.

These are the advantages of simple passive strategies. So, in this class, we have seen what is the meaning of simple passive strategies and what is the application of simple passive strategies. What do we mean in a very brief manner? In the forthcoming classes, we will be taking each of these strategies separately and dealing with them in greater detail. With this, I will stop today's class, and we will move on to the next class with yet another topic. Thank you.