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

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Advanced Passive Strategies -Cooling Strategies

Dear students, so last time we had started with the introduction to advanced passive strategies and we had seen some advanced passive strategies. In this class, we will continue with the other advanced passive strategies, but this time we will also be looking at a number of case studies for each of the advanced passive strategies. I am not going to carry out this class focusing on any specific strategy. But this is more like an introduction of what is to come in the forthcoming classes. But, for every strategy, I will substantiate with a case study. So we will look at advanced passive strategies this time.

So again I reiterate, so what are advanced passive strategies? Strategies that require separate contraption to collect, store and disseminate heat or vice versa are called as advanced passive strategies. You have passive cooling and passive heating strategies. So we have been looking at some of the passive cooling strategy and some of the passive heating strategy. In the last class, we saw the trombe wall and solarium.

We saw earth-air exchangers, earth-air tunnels, thermal siphoning, and a little bit of passive downdraft evaporative cooling. This is all we have seen. So we will see the others in this class and forthcoming classes. So we saw here about five strategies, and then we also saw evaporative cooling and natural night ventilation. So, we saw about 7 or so strategies.

Yes. So, last class we saw the trombe wall, solarium, earth air exchanger, thermal siphoning, earth air tunnels, natural night ventilation and PDEC. So, we saw seven of them. We will continue and see the other advanced passive strategies. So, here we will see the roof pond strategy.

So, the roof pond system requires a body of water to be located on the roof. This is protected and controlled by movable covers or insulation. The body of the water is exposed to direct solar gain which absorbs and stores the heat and releases the heat when necessary.

Roofs should also be properly insulated so as to minimize heat transfer from the roof to the inside of the building. And also, the roof should be protected for waterproofing.

Provision of adequate rainwater drainage is also essential for this strategy. In this strategy, you need to have the entire roof covered with a water body, and how it operates on a summer day is like this: the roof water is completely closed, and at night the water is exposed. So, at night, what happens is that because the night sky is cool, the water absorbs the chillness by releasing its heat, which means the water has a lower temperature, and with the cover, the water body is closed during the day. And therefore, the cool water that is retained on top of the roof helpsto radiate. That helps in keeping the indoors cool.

So, this is how a roof pond system operates. This can be used in composite climate which means it can be used in hot and humid as well as hot and dry climate. In both climate types, this can be used. But the timing of when to cover the roof and when to expose the roof will be different depending on the climate type and the time of the day. Next we will see the green roof.

So,with the green roof what happens is; The top of the roof is covered with greenery, because of which a lot of effect not only on the building but also on that entire microclimate of the area can be felt. The urban heat island, see slowly I am introducing these new terms to you. The urban heat island is effect gets reduced if you have green roof. What is UHI urban heat island? We will look at it as a separate unit or a separate segment in this course. So, the because the roof is covered with greenery Sensible heat reflection gets reduced and also heat absorption gets reduced.

Of course, there is some reflected light. Stormwater runoff gets reduced. There is reduction of thermal heat gain and therefore reduction of heat energy consumption. Urban heat island effect gets reduced because the building does not reflect, the roof of the building does not reflect too much of heat. There is a reduction of thermal heat gain and, therefore, a reduction of energy consumption.

And if all buildings in a particular area have a roof that does not reflect heat, then the heat island that is formed in urban areas gets reduced. It is known to have improved the air quality. There is better sound insulation and improving roof materials' longevity is very important and therefore, you need to have proper insulation. You also get area for plantation of produce when you have the green roof. We had seen passive downdraft evaporative cooling.

If you remember the PDEC functions by having a wind tower like this. And then warm air is sucked inside. And it is made moist either with micronizers or with damp pots. And this moist air which comes down because it is heavier. And then through the baffle walls the cool air enters the room.

Of course, this cool air, when it enters, replaces the warm air, and there has to be an outlet for the warm air to leave the building. So, the IGP complex at Gulbarga has used passive downdraft evaporative cooling techniques, and you can see in the plan the towers for PDEC. There are about 10 of them, and you can see this in their view also. So, what happens to this building in terms of thermal performance? The PDEC towers are used for giving comfort, thermal comfort. When the ambient air temperature is somewhat like this.

The temperature of the air at PDEC is: you can see in January, it is approximately 10 degree Celsius lower, and you can see that it is approximately 15 degrees Celsius lower in April. Only in June and July the difference is not much. The difference is about 7 degree centigrade. So, this is the impact of having PDEC in terms of lowering the temperature. This building also uses tinted glass to reduce glare.

It has composite walls comprising of granite blocks on the outer side and rat-trap-bonded brick walls on the inside to reduce the heat. It acts more like a cavity wall. Filler slabs have been used, and a central atrium to enhance cross ventilation and day lighting has been used. Solar PV lighting and pumps are used in this building, and rainwater harvesting and water conservation facilities have also been incorporated in the IGP complex Gulbarga. Then the next advanced passive technique we will see is radiant cooling, which is structural slab cooling or structural roof cooling.

Now the basic principle of this is that inside the roof slab or inside the floor slab there are pipes that are embedded inside the slab. In these pipes, cool water is run through. Because of conduction and radiation, the cool air inside the tube cools the entire floor slab or the roof slab in whichever it is embedded, and that gets radiated inside the room, making the rooms very cool. So, radiant cooling is exchanging thermal energy to the space through convection and radiation. Structural slab radiant cooling system is a surface cooling system where water tubes are placed in the roof slab, which absorbs the heat from heat sources in the room.

The heat sources in the room heat or warm up the slabs, and this cool water inside the tube helps in reducing the temperature of the slab. The slab absorbs the heat and exchanges it with the circulating water. The warm water is then pumped to a chiller or a geothermal heat exchanger, recooled, and then returned to the slab. We will see in the example of the Carnegie Institute for Global Ecology. Now, this is one of the top 10 green projects in the year 2007.

When it was built, it was a much-hailed project because of the conscious attempts the building has made to reduce its energy consumption. The building uses 45% less energy and 40% less water than a benchmark similar building. Structural slab cooling cools the buildings and absorbs heat from the occupied spaces, and the cycle gets repeated. So, you can see in their slab how these tubes are embedded. These tubes are embedded in the slab, and through this tube, cool water passes, and the slab is able to absorb the chillness of the cool water in the tube, which is then radiated to the room.

The Carnegie Institute for Global Ecology also uses the concept of PDEC passive down draft evaporative cooling. It uses a number of concepts; the simple passive strategy it uses is long shading devices. It uses PDEC passive downdraft evaporative cooling. You can see, as shown here, these are the micronizers. The warm air goes in, becomes moist, settles, and makes the indoors cool while there is an outlet at a higher end through which the warm air is pushed out.

Then it also uses evaporative cooling, whereby night sky cooling system is used, in which water is sprayed on the roof at night. When the spray is exposed to the night sky, the night sky is already cool. That cools this water, and the roof becomes really cool; its temperature gets reduced. And therefore, during the day, when the outside is warm, the already cooled roof passes its chillness to the room below. Then we will look at some of the other few buildings where structural slab cooling is used.

The Earth Rangers Wildlife Centre in Canada, the Institute for Computing Information and Cognitive Systems at the University of British Columbia, the Clinton Presidential Library, which includes approximately 10 miles of tubing embedded in its concrete slabs. What are the advantages of structural slab radiant cooling? It provides the maximum comfort possible because there are tubes with chilled water flowing on the roof as well as on the floor. It is draft-free, and no noise comes out of this cooling. It has a lower sensed temperature.

It has lower investment costs. It has lower energy cost. It does not interfere in the architecture or the designing because for other passive strategies, say, the sun space, you need to have an extra space, which means architectural intervention becomes important there, whereas since the pipes are embedded in the roof, it has nothing to do with the architecture or the aesthetics of the designer. Minimal maintenance is required, malfunction-free operation, and the same pipe can be used for heating as well as cooling. During colder parts of the year, warm water is pumped through the pipes, and the exact same conceptual process is followed because of pumping in the hot water through the pipes. Another case study of buried pipe techniques or earth-air tunnels is the low-energy building at SD Works.

So, SD Works uses the earth-to-air heat exchanger, which has pipes running at about 3 to 5 meters in depth. Air is pumped through this pipe and because of the lower temperature of the earth in the subsoil, which is actually the average of that place, that cools the air that passes through the pipe, and therefore, cool air enters the building. And because of this, you can see how it works in SD Works. This is the earth to air temperature. This is the temperature of earth to air, and this is the temperature of the external climate.

The external climate is this. The first flow temperature is almost stable here, and the second flow temperature is also on similar lines. So, the maximum temperature in summer never exceeds 22 degree Celsius on the first floor, and the maximum temperature is between 23 and a half degrees and 26 degrees Celsius on the second floor, making the indoors extremely comfortable and free from most of the common active means of cooling the building. Then we will see the solar air conditioning. So, cooling loads in tropical countries like India peak during say April or May, which are hot summer seasons, and solar radiation is available in abundance. Thus, the application of solar cooling technology uses a renewable source of energy to reduce the cooling loads when air conditioning demand is at its annual peak.

So, with solar air conditioning, you have an attractive payback when configured with power generation and hot water heating. It has low distribution losses and ranges only between 5 to 10 percent, whereas conventional technology is between 75 and 80 percent sometimes. It eliminates the use of greenhouse gases like CFC, HFC, and HCFC refrigerants. System operation generates less noise and no vibrations. It has high efficiency in triple effect absorption designs.

But it has its own limitations. It requires a large amount of space for the solar panels and the solar concentrators. Thus, it is suitable only for very large projects. It costs almost twice as much as the conventional chillers. It requires greater pump energy as compared to an electric chiller. A higher flow rate of condenser water is required as absorption chillers have low COPs.

It requires a large cooling tower capacity compared to an electric chiller as a larger volume of water is circulated. Let us look at another case study of CII Saurabhji Godrej. This is located in Hyderabad on a piece of land that is four and a half acres, designed by architect Karan Grover, and it is one of the first few lead-platinum-rated buildings. The concept of this building is based on Panchamahabhotas, which is an ancient belief, and if you see bioclimatic architecture, it also looks to tap energy from Sun, which in Panchamahabhuta is fire, water, air, earth and space. So they are associated with the five senses, and they act as the gross medium for the experience of sensations.

In this building, there are many simple and advanced passive strategies used that lead to energy efficiency, natural ventilation, using renewable energy effectively, socio-cultural response, water management, sustainability, reuse and recycling, land use, and reduced carbon footprint. So, some of the simple passive strategies we will quickly see. A central courtyard and colonnaded corridor ensures that the hot air cools before entering the indoors. The courtyard also acts as an area for interaction. The plants collectively create a space of diffused light that just adds more to the liveliness.

The other passive strategies are wind towers. So, this building has two air cooling towers, which are erected when air is cooled up to 8 degrees Celsius by sprinkling water. The cool air is circulated inside the building, minimizing the load on the air conditioner. The wind tower is connected to the AHU, substantially reducing the load on the air conditioning system. Due to the unpredictable wind direction, openings on all four sides are provided with an additional effect due to wind pressure. Now, merely because of the use of some of the other advanced passive techniques, such as terrace gardens and solar panels, a lot of energy savings have happened.

Nearly 55% of the roof is covered with a terrace garden. This helps in many ways. It reduces interior temperatures. It reduces the UHI, urban heat island effect.

The radiation back to the earth is also reduced. Solar photovoltaic cells on the roof terrace produce nearly 20% of the building's total electricity consumption. Then this building also uses vertical landscaping, which is kind of experimental. So vertical landscaping is an essential feature of this building, and it has been used as a facade element, while some has been used as a partition. So vertical landscaping is an influential element to enhance the vibrance of green buildings. Apart from aesthetics, these act as additional mass to the wall and reduce the heat load on the building.

So in the CII Godrej building, they have used most of these simple passive techniques and some of the advanced passive techniques suitable for their climate, which is in Hyderabad. Because of this, because of using so much simple passive strategies and advanced passive strategies, the building has become energy efficient and the building was able to get its green building certification lead rating for the building. This building uses all the simple passive strategies such as appropriate orientation, windows, windows size, position, shading of the windows, etc. And some of the advanced passive techniques, such as wind towers, green roofs, etc.

have been used. Apart from this, this building has also used certain green building strategies, like for the treatment of their sewage, they have used a roof pond treatment, which is chemical-free and also a more greener way of treating the sewage. So, it is all these factors that have added and given the building a green building certification. So, in today's class, we saw the remaining part of advanced passive systems, which is more of a continuation of the previous class. In the previous class, we saw about seven advanced passive systems, and in this class, we saw the remaining advanced passive systems. For almost all the passive systems, we have seen the case study building examples.

And we have taken one overall case study exam building, which is the CII Godrej building in Hyderabad. So, with this, we will stop today's class. And for tomorrow's class or yet another class, we will be moving on to another important topic. And from now on we will be a little more concentrated and specific on the topics. The first few lectures were more of an orientation kind of lecture on various passive strategies, simple as well as advanced.

But after this, and if you notice these strategies are very specific to certain climates; not all strategies can be used for all the climate. So understanding the climate of the place becomes important. In the forthcoming class, we will look at how climate is even classified across the world and what the climate classification is followed in India. So, we will be looking at the world climate classification, which is acceptable to the world. We will look at two types of classification, and we will also see how India is classified into various zones based on climate types acceptable by Indian standards.

So, with this, I stop today's class, and we will continue our next class, where we will move into a slightly more technical topic of the classification of climate. Thank you.