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

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Lecture 02

Case study of Moderate climate

So, we will look at case studies of moderate climates where passive strategies have been used. The first case study that we will take is that of a low-energy office building at SD Worx, which is in Belgium. This office building, SD Worx, is situated in Kortrijk, Belgium, and consists of two office floors on top of the ground floor with building services. At the southern end, the floors are connected with an open vertical circulation zone.

Reduction of cooling load and energy losses happens here, and the use of passive cooling and heating, along with controlled automation, leads to a low-energy office building. The plan of the building is very simple. The building comprises four parts. The first part is an office, so this becomes the office space, and this is entirely the circulation zone, whereas there are conference rooms here and one auditorium located at number four. It's a very simple rectangular office building comprising G, G plus 1, and G plus 2 structures. You would have already seen some kind of earth warming happening here, as you can see in this picture too. Now, this building uses natural night ventilation.

So, at night, the outside air enters the office floors through the bottom-hung windows located near the ceiling in the office on the north side. So, you can see along the north side, the provision for night ventilation happens. And this air is cool. The outside cool air enters the building, becomes warm, and leaves the room. Since it is lighter in weight, there is a vent provided which takes the air out.

So this air cools down the room. The exposed ceiling allows the air to leave the building at the top of the circulation zone through outlet windows along the width of the building. By virtue of this, what happens is the external temperature follows this trend and is lowest at night at 14 degrees centigrade and highest at 24 degrees centigrade. By using night ventilation, you can see that on the first floor, this is the trend of the indoor temperature, and on the second floor, this is the trend of the indoor temperature.

So the temperature ranges between 21 degrees and reaches a maximum of 24 degrees centigrade. So the measured operation of natural night ventilation, as carried out in the year 2002, shows that When the outside air, or ambient air, follows this temperature variation, which ranges, say, on a random day, from 14 degrees centigrade to about 30 degrees centigrade. Whereas on the first floor, this is the air temperature, and you can notice that the temperature ranges between 21 degrees centigrade and 25 degrees centigrade by following natural night ventilation alone.

Now, if we look at what happens on the second floor. The second floor follows this trend. On the second floor, the minimum temperature is 23.5 degrees centigrade, and the maximum temperature is 26 degrees centigrade. So when the outside air temperature is in the range of 30 degrees to 14 degrees, the temperature of the first floor is in the range of 25 degrees to 21 degrees centigrade, and

The temperature on the second floor is in the range of 26 degrees to 23.5 degrees centigrade. So you can see how much energy can be conserved through a reduction in air conditioning load during the day. So this natural night ventilation system is primarily driven by the stack effect or thermally generated pressures. Which is shown here. Which is shown here.

So wind comes, and because there is a provision for the wind to escape. So natural night ventilation operates for 55 days from the end of June until the end of September. The cooling effect is higher on the first floor due to a higher thermal stack effect. The surface temperature on the first and second floors respectively decreases by at most 4 degrees centigrade and 2.5 degrees centigrade during the nighttime. The second principle that is used in this building is

The earth air contact, which works on the principle that the soil temperature at a depth of about 12 feet or more stays fairly constant throughout the year and is approximately equal to the average annual ambient air temperature. The ground can therefore be used as a heat sink for cooling in the summer and as a heat source for heating in the winter. In this case, during the day, an earth-to-air heat exchanger cools down the supply airflow. Concrete tubes with a diameter of 80 cm and a length of 40 m each are buried 3 to 5 m deep and connected to the ventilation system. Here in this graph, you can see that when the external ambient air follows this trend, the earth-to-air temperature remains pretty much constant when the air temperature is between 14 degrees to 24 degrees. The temperature of the earth-to-air is about 15 degrees centigrade. Then, if you see the first floor and the second floor temperature. So, this blue line indicates the second floor temperature, and you can see it is constant at 25 degrees centigrade, whereas the second floor temperature is at 25 degrees centigrade, and the first floor temperature on this particular day is also in the range of 24.5 to 25 degrees centigrade. And it pretty much remains constant along that. On another random day, when the outdoor temperature is between 14 degrees centigrade to 30 degrees centigrade. So, 30 degrees to 14 degrees. We can see the first floor temperature to be between 21 degrees.

And its maximum is 25 degrees. Whereas the second floor temperature minimum is 24 degrees. And the maximum is about 26 degrees centigrade. So, this is the impact the earth-air tunnel or earth-to-air temperature has. So, the maximum temperature in summer never exceeds 22 degrees on the first floor, and the maximum temperature is between 23.5 to 26 degrees centigrade on the second floor because of the use of the earth-air tunnel here.

Ambient air enters the tube buried at a depth of 4 meters, and as it moves through the tube, it radiates the heat outside. The warm air cools itself, and that cool air is pumped into the rooms. This cool air cools the floors, and it becomes warm. Warm air rises up and escapes through this vent. So, this is the operation of the passive cooling. Earth-to-air exchanger and nocturnal ventilation by day are both shown here, and this effectively causes a dramatic reduction in indoor temperature.

Here, we can see the measured operation of the earth-to-air exchanger in the cooling season. So, the outdoor temperature follows the trend that I am showing in the blue line. The outdoor temperature on a random day: the minimum is about 16 degrees centigrade, and the maximum is 22 degrees. Here, if we take it, it is about 14 degrees centigrade and about 26.5 degrees centigrade. Then, if we look at the temperature of the soil below, that ranges from 15 degrees centigrade to 18 degrees centigrade. And in this case, 15 degrees to 19 degrees centigrade. Now, if we look at the first-floor air. The first-floor air follows this temperature, wherein you can see that the minimum temperature here is 24 degrees centigrade, and the maximum is 25 degrees centigrade. And on this day, the minimum is 22 degrees centigrade, and the maximum is again 25 degrees centigrade.

So we can see that when the outside temperature is in the range of 22 to 16 degrees centigrade or in the range of 26.5 to 14 degrees centigrade, the temperature of the first floor is 25 degrees centigrade to 24 degrees centigrade or 25 degrees centigrade to 22 degrees centigrade. Whereas the temperature of the second floor is also somewhere in that range except here, which is 23. So this ranges between 25 degrees centigrade to 23 degrees centigrade. Whereas the temperature of the earth heat earth to air is almost in the range of 19 degrees centigrade to 15 degrees centigrade.

So effectively you can see that the temperature of the first and second floor is in the range of 23 degrees to 25 degrees centigrade, causing a dramatic reduction in energy required to cool the building using electricity or air conditioning. The next strategy that is used here is evaporative cooling or the roof pond cooling system. Now the roof pond cooling system is not used on SD Worx, but I am saying it is a strategy that can be used in this climate type. Evaporative cooling lowers the indoor air temperature by evaporating water, and in dry climates, this is commonly done directly in the space.

But indirect methods such as roof ponds allow evaporative cooling to be used in more moderate climates too. So when you use evaporative cooling through the roof pond cooling system on a winter day, the roof pond is exposed to solar radiation. The water gets heated. At night this covering is slid, and the water is covered.

So now here we have warm water, which radiates its heat to the inside on a winter night. So the indoors become comfortable. On a summer day, what happens is, at night the water is kept exposed, and then the night sky acts like a cooling sink. It absorbs the heat that is radiated from the water body and becomes cool.

So, this water becomes cool. During the day, this covering is slid, and the water is covered. So, the solar radiation falls on the cover, but this cool air is instrumental in cooling the room. So, the room becomes cool during the summer day. This is the concept of the roof pond cooling system.

Then the next one is the radiant cooling or structural slab cooling. Now radiant cooling is exchanging thermal energy to the space through convection and radiation. So the structural slab has a series of pipes which are laid out, through which cool water is passed during summer. And this cool water in the slab is instrumental in radiating chillness or absorbing the heat of the room and making the room cool.

So, this is a surface cooling system where water tubes are placed in the roof slab in section. This is how it looks. And the pipes are laid all along the roof and the floor slab. Then, the heat from the heat source of the room is radiated. And the slab absorbs the heat and exchanges it with the circulating tube.

In which chilled water is placed. So, the warm water is then pumped to a chiller or a geothermal heat exchanger, re-cooled, and then returned to the slab. The next case study is that of the Carnegie Institute for Global Ecology by architect EHDD. It's a top 10 green project of 2007, and the building uses 45% less energy and 40% less water. In this building, again, the radiant cooling system is used by placing structural slabs with these tubes through which cool water is pumped in, and that cools the occupied spaces, and the cycle gets repeated. Yet another technique that is followed here is the night sky cooling system, in which water is sprayed on the roof at night. Now, when the spray is exposed to the night sky, it gets cooled by radiation. This water is then collected and stored in an insulated tank and used the next day.

So here you can see at night water is sprayed on the roof, and therefore the roof becomes wet and cool because of evaporative cooling. This water, which is sprayed, flows down, and this water, which is actually cool because it is exposed to the night sky, is collected in a tank. And it is used the next day as cool water. Now, this building also uses the stack effect to cool the rooms. Then, another few cases where structural slab cooling is used is the Clinton Presidential Library.

And it includes 10 miles of tubing embedded in its concrete slab. The advantages of structural slab cooling include that it provides maximum comfort, gives draft-free or no-noise cooling, has lower sensed temperature, has lower investment cost, and has lower energy cost. It gives architectural freedom for design because it does not hamper the design of the building, requires minimal maintenance, and is malfunction-free in its operation. The same pipe can be used for heating as well as cooling. So, in general, if we see why we must apply these simple and advanced passive strategies.

It is because, an environmentally responsive architecture is not a fixed idea, but it is an evolving concept which should be redefined with context. Education should take a driving role in this evolution, and we need to move beyond the technical fixes perpetrated by current practices and start extending the architectural vocabulary towards a climate-responsive architecture. Which means it is not just a cosmetic treatment but has value addition to the building. Being environmentally friendly is not just about energy saving but also about the better use of suitable materials. We have to use materials far more efficiently than we do currently.

Increased importance must be placed on the use of materials that are renewable, recycled, and non-toxic, especially in the current scenario of accelerated global warming. Resource reuse and management will go a long way in the efficient management of energy. Architects have to be creative in applying passive techniques and reusing materials for building components, without compromising on the safety and security of the inhabitants. Public awareness must be generated that such buildings are far superior to conventional concrete buildings.

So, in today's class, we saw case studies where simple and advanced passive techniques have been applied in order to have energy-efficient and sustainable buildings. We stop our class with this, and we will continue to have a look at the other climate types where simple passive and advanced passive strategies can be adopted. Thank you.