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

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Lecture 01

Passive Design Strategies for Moderate Climate

So, dear students, so far we have seen the simple passive as well as advanced passive strategies in order to have a bioclimatic architecture moving towards sustainable architecture. From today onwards, we will look at the strategies for passive design for various climate types. As well as case studies where these strategies have been implemented so that we understand in a holistic manner the application of these strategies with respect to the building. As the first case, today we will take the moderate climate. So today we will study the strategies for passive design approaches with the moderate climate. So we know that buildings, as propagated by the international style, contribute to environmental issues, and all this ends up in the consumption of natural resources as well as energy for the operation of the building. In order to have a holistic approach to reduce the consumption of this energy and also meet the occupant comfort, that is where the bio and climate-responsive buildings, climatic, bioclimatic, come into play. So it becomes very important that we have a holistic understanding of various strategies. Now the holistic approach to climate-responsive architecture entails technically understanding the climate, which we did by the demonstration of the climate consultant.

In today's class, I will also teach you another method to understand the climate and adopt simple passive methods. Then incorporate advanced passive techniques in buildings. Use low embodied energy materials. This we are not covering in this course, but I have another NPTEL course on low embodied energy materials or rather building materials as a large segment. Then use recycled materials and components.

Use renewable energy systems and design energy-efficient HVAC and lighting systems. Today, we will look at the moderate climate with Coimbatore as the example. If you see the NBC, it has designated Coimbatore as a moderate climate, and Coimbatore lies in Tamil Nadu. Today, we will discuss a little bit about the Mahoney's table.

If we look at the 2018 data of Coimbatore, I have done all these entries and eventually arrived at this table. In this table, I have followed all the rules leading me to a set of

indicators. After having entered all the data, eventually, I land up with a recommended specification. For Coimbatore, the recommendations as given by Mahoney's table are like this.

- That is, the orientation of the building should be along the north and south.
- The long axis must be along the east and west.
- Then, the building must be protected from hot and cold winds.
- The rooms must be single-banked with permanent provision for air movement.
- Openings can be medium-sized.
- The walls must be heavy, both external and internal walls.
- Roofs must be heavy with an 8-hour time lag.

These are the broad criteria as given by Mahoney's table. Now, this is an age-old table, but I thought it is important for you to know the existence of the table and how people started their design right from Mahoney's table.

Today, we have the Climate Consultant. So, we saw how we must select the passive strategies with the help of Mahoney's tables. Now, we will see how the climate consultant can also help us with a slightly more advanced and scientific way of selecting the strategies. For temperate climate, today we will look at Bengaluru city, Bangalore, Bengaluru, whatever you may call it, which falls under moderate or temperate climate classification. Based on what you follow, Bansal or SP 2007 classification.

Bangalore comes under the temperate or moderate climate. So, let us see what strategies must be used for the month of May in Bangalore. Now, left to itself, Bangalore will have 2 hours of comfort in the month of May. Whereas, If you provide solar shading for windows, you will get 249 hours out of 744 hours to become comfortable.

So, appropriate shading can enhance comfort inside by 33.5%, which is approximately One-third of the month of May. Whereas, if you additionally use adaptive comfort ventilation, then the indoors become comfortable for 341 hours. And that amounts to 45.8%.

So, in order to use only passive strategies, 45.8% of the month of May, or 341 hours of the month of May, becomes comfortable, whereas 54% would still remain not comfortable. And what should be done to make this not comfortable part convert into comfortable? We will see next. So, what are the passive strategies to be followed in Bengaluru for the month of May? So, good natural ventilation, which we have already called comfort ventilation, can reduce or eliminate air conditioning in warm weather if windows are well shaded and oriented to prevailing breezes. So, shading and comfort ventilation, as we have already seen. To facilitate cross ventilation, locate door and window openings on opposite sides of

the building, with large openings facing upwind if possible. So, try to bring in more breeze or wind from outside. Thus, you are going to encourage comfort ventilation.

On hot days, ceiling fans or indoor air motion can make it seem cooler by 2.8 degrees centigrade or more. Thus, it will reduce the load on air conditioning. So, fans will enhance evaporative cooling. Low-pitched roofs with wide overhangs will work very well in this climate type. Then, screened porches and patios can provide passive comfort cooling by ventilation in warm weather and can prevent insect problems.

Besides, in order to enhance stack ventilation, even with low wind speed, We can maximize vertical height between air inlet and outlet by means of stairwells, double storage spaces, attic spaces, roof, etc. Window overhangs should be designed appropriately for this latitude, or we can have operable sunshades like awnings that extend in summer. And can reduce or eliminate air conditioning. So, either you design the shading device or you have movable awnings which you can extend based on the necessity.

So, the awning can be this much for a particular month or it can extend in such a way that you are able to shade the window. Shaded outdoor buffer zones like porches, patios, or lanais oriented to the prevailing breezes can extend living and working areas in warm or humid weather. Now, let us see what are the passive strategies to be followed in the month of June for Bangalore climate. We see that without any intervention, 7 hours or 1% of the month of June becomes comfortable by itself. Then, if you provide sun shading of windows, then 203 hours of the month of June becomes comfortable, amounting to 28 hours.

Percent of the month. Further, using adaptive comfort ventilation will increase comfort hours by 313 hours, totaling 43.5 percent of the month of June being made comfortable with just two strategies. One is solar shading of windows or sun shading of windows, and the second is adaptive comfort ventilation. If just these two strategies are followed, then 43.6% of the total month of June can become comfortable.

But We can see that there are some hours which are beyond the comfort zone. How to make these comfortable so that the remaining 56% of the hours also get translated and can become comfortable? How do we do that? That can be done by using some active strategies, dehumidification of the air inside can shift 548 hours into comfortable time, so 76.1 percent of the month can become comfortable if we are able to dehumidify the air, whereas the remaining 101 hours can become comfortable if cooling along with dehumidification is adapted, and Therefore, it means the use of air conditioning will make 14% of the month comfortable. Thus, adding dehumidification and air conditioning. So, dehumidification and air conditioning will make 100% of the time into a comfortable period.

So, for the month of June, what are the strategies that must be followed? They aren't much different from what we saw for the month of May. So, good natural ventilation can reduce or eliminate air conditioning in warm weather if windows are well shaded and oriented to the prevailing breeze direction. To facilitate cross ventilation, locate door and window openings on opposite sides of the building with larger openings facing upwind if possible. Then, on hot days, ceiling fans or indoor air motion can reduce the indoor temperature by at least 2.8 degrees centigrade or more.

And this can bring the place either into a comfort zone or at least reduce the load on the air conditioner. Screened porches and patios can provide passive comfort cooling by ventilation in warm weather and can also prevent insect problems. In order to produce stack ventilation, even when wind speeds are low, we can maximize the vertical height between the air inlet and outlet by using stairwells, two-story spaces or double-storied heights, having differential roofs, attics, mezzanine floors, etc. Window overhangs designed for this latitude or operable sunshades like awnings that extend in summer can reduce or eliminate air conditioning completely.

Now let us see what happens for the September solstice period. For the September solstice period, left to itself, 16 hours. You can see the red dots not being inside the comfort zone. So, these 16 hours, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 hours. 15, 16.

So these 16 hours remain comfortable by themselves. If you provide solar shading or sun shading, then 174 hours out of 720 hours become comfortable, and that amounts to 24.2 percent of the month put together with comfort as it is. Then, if we are able to provide adaptive comfort ventilation, then 361 hours out of 720, amounting totally to 50.1 percent of the hours, become comfortable. Therefore,

By using only passive strategies, we will be able to make 51% of the hours for the month of September comfortable. So, Only 49% of the hours remain uncomfortable during the month of September if we adapt only simple passive strategies. Now, in order to make 100% of the hours comfortable, what should you do? Already, we saw that 16% remains comfortable by itself.

Adapting only comfort ventilation will make 50.1 percent of the hours comfortable. Then, using dehumidification can shift 595 hours to comfortable. So, air conditioning is actually needed only for 50 hours out of 720 hours for the month of September, thereby making 100% of the hours comfortable.

So, what are the strategies that must be followed for the month of September in Bangalore? Good natural ventilation can reduce or eliminate air conditioning in warm weather if windows are well shaded and oriented to prevailing breezes. To facilitate cross ventilation, locate the door and window openings on opposite sides of the building with larger openings facing upwind if possible. You should also minimize or eliminate west-facing glazing to

reduce summer and fall afternoon heat gain. Having low-pitched roofs with wide overhangs will work very well in a temperate climate.

Screened porches and patios can provide passive comfort cooling by ventilation during warm weather and simultaneously prevent insects like mosquitoes and flies from entering the house. To produce stack ventilation, even when wind speeds are low, We must maximize vertical height between air inlet and outlet by using stairwells, double-story height, or attic roofs. Window overhangs designed for this latitude or operable sunshades like awnings can be extended during summer. This can reduce or eliminate air conditioning.

We can use plant material like bushes, shrubs, trees, or moss walls, especially on the west side. This will minimize heat gain if summer rains support native plant growth. Now let us see. What strategies must be used for Bengaluru to have maximum comfort through passive means for the month of December? For the month of December, 246 hours out of 744 hours are comfortable by themselves.

So, you can see. That the place is pretty comfortable for one-third of the month. One-third of December is comfortable by itself. If we use sun shading on windows, then an additional 123 hours become comfortable, which is 16.5%. Whereas,

Using high thermal mass can help by making the indoors comfortable for 6 hours. Using adaptive comfort ventilation can push 269 hours out of 744 hours into the comfort zone, which is about 36.2%. Meanwhile, internal heat gain Can also make the indoors comfortable by 200 hours. Passive solar direct gain with high mass can push the indoors into comfort by 124 hours. So, these passive strategies, if adapted, will make 79.2% or 589 hours out of 744 hours comfortable.

But suppose we want 100% of the hours to be comfortable. Then what should be done? In order to make 100% of the hours comfortable, we already saw that 246 hours are comfortable by themselves. Then, by adapting comfort ventilation, 36.2% of the hours become comfortable, and if we are able to dehumidify, Then 265 hours become comfortable.

Whereas cooling by adding dehumidification will push 23 hours into comfort mode. While heating and adding humidification will push 206 hours into comfort mode. Thus, we can achieve 100% comfortable hours for the month of December. So, let us see the strategies which are passive and must be adopted for Bengaluru for the month of December. So, this is one of the more comfortable climates.

So, shade in order to prevent overheating. And opening the building to summer breezes and using passive solar gain in winter is a good strategy. Pitched roofs with wide overhangs will work very well in this climate because pitched roofs will shed rain and protect

entryways from cold winds, providing an additional layer of climate control. Well-insulated roofs and walls are a good strategy. So, insulate your roof and your walls also.

So, window overhangs designed for this latitude or operable sun shades like awnings that extend in summer can reduce or eliminate air conditioning because they insulate the window. So, sometimes you can even use thick curtains to retain warmth during cold nights. So, if we look at the comparative analysis of how passive strategies work for March, June, September, and December, then we can see that 46% of the hours in March can become comfortable using passive strategies. Whereas 44% of the hours in June can become comfortable with passive strategies.

In September, 51% can become comfortable, and in December, 79% becomes comfortable. You must try these strategies to see which work best for each month: March, April, May, June, July, August, September, October, November, December. I have tried random months: May, June, September, and December. Then, sun shading of windows is needed throughout the year. So, this is an important strategy that is useful throughout the year.

Whereas in December, you need internal heat gain, passive solar direct gain with high mass, and also high thermal mass. Besides, adaptive comfort ventilation is a requirement that can push the number of hours into comfort mode just by using adaptive comfort ventilation. Dehumidification is a strategy that is active in nature. So far, all strategies are passive, and this is an active strategy. What active strategy are we using? Dehumidification alone is needed throughout the year, whereas during the months of September and December, some amount of dehumidification could be needed. Whereas for the month of March, cooling and dehumidification are needed.

In December, heating and adding dehumidification are needed for some hours. So, sun shading of windows, adaptive comfort ventilation, dehumidification, and cooling and dehumidification are the four strategies that can be very useful throughout the year, with additional strategies for certain months alone, in order to have 100% cool hours throughout the year for Bangalore. Now, we will study the other aspects. Next, we will see. Now, we have seen the passive techniques as advanced passive techniques and simple passive techniques.

Let us now look at these passive techniques as adaptable to a moderate climate. Whichever is suitable for a moderate climate, we will have a look at those strategies. So, in a moderate climate, The long axis should be along the east and west.

So, here Peter Stutchbury architects planned development on the shore of Rybinsk reservoir for a moderate climate in Europe.

And you can clearly see how the long axis is along the east and west direction. Open space for breeze penetration with the facility to protect from hot and cold winds must be there,

and there must be medium-sized openings of 20 to 40 percent. For opening positions, on the north and south walls, the opening positions work well on the windward side at the working level. Windows must be protected and exclude direct sunlight inside. In whichever way possible by designing appropriate shading.

We have already seen the various ways of designing shading devices. Then use heavy internal and external walls with a time lag of 8 hours. Roofs must be well insulated. Rain protection may be from heavy rains which occur only once in a while, and adequate rainwater drainage must be provided. Let us have a look at a case study now.

We will look at the case study of Energy Base in Vienna, which follows a simple passive design for a moderate climate. The design of Energy Base follows a holistic sustainable approach, including design priorities for energy efficiency, extreme reduction of energy demand for building operation, renewable energies, and 100% coverage of heating and cooling energy demand by using renewable sources, especially solar PV. Underground means what? Using earth air tunnels or some other such method. The user benefit is achieved through having an indoor climate and comfort in the workspace for the maximum time of the year.

So, the Energy Base in Vienna is a building with about 7500 m2 of office space. And this office building projects itself as the future of how office buildings must be designed. The architectural and energy concepts are very ahead of their time, and they focus on sustainable and innovative technologies. As a passive house standard, it focuses on sustainable as well as innovative technologies. For the building envelope, for groundwater, for heat pumps, for free cooling, solar air conditioning, integrated photovoltaics, and ecological air humidification by using plants in the ventilation system.

In order to keep the energy demands as low as possible, the energy performance is concentrated by using locally available renewable energy sources. This building is considered an outstanding building because of its innovative architecture, advanced building technologies, and the attempt to provide the highest possible user comfort. The low-cost saving energy consumption, which is in line with the passive house standard, is completely covered by renewable, ecologically sustainable energy sources. The Energy Base building is a very good example, which shows how to harmonize economic and ecological considerations in the construction of state-of-the-art office and commercial real estate. The three main principles which serve as the underlying basis for this building are insulation against heat loss, So, it airtightness and controlled ventilation with heat recovery make it an energy-efficient building. Second is energy efficiency.

So, extreme reduction of energy demand for building operations is achieved through the use of passive strategies. Then, third is the use of renewable energies as much as possible. So, there is 100% coverage of heating and cooling energy demand by the use of

groundwater and solar energy. And therefore, the user benefit is that it achieves an indoor climate and comfort good enough for a workspace. The natural daylight in the energy-based building in Vienna is another example of how energy can be conserved by tapping natural daylight.

The glazing on the south facade, slightly overhanging to increase the proportion of diffuse to direct sunlight entering the room, while incorporating TV panels and reflective blinds, enhances daylighting as well as taps the solar energy. In winter, the building combines solar preheating of ventilation air with heat recovery in a very different way. Ventilation air flows laterally from the north side to the south side of the building, then is overheated. the desired indoor temperature by the space next to the glazing, which functions as a solarium.

This overheated air passes through the heat exchanger, which is particularly effective in warming the incoming fresh air. Use of a light shield and window design facilitates Good, clear, diffused light devoid of glare makes this building, which has a well-calculated position and size of glazing. Now, let's look at the protection from direct sun. The south facade has been specially angled to make the best use of insulation, both passive and active.

In winter, when the sun is low, its heat is captured and fed indirectly to the rooms on the north side of the building through customized ducting. The sunscreen, made of perforated lamellae, is located just behind the angled facade, and waste air from the entire story is vented at ceiling level. Because of this, heated air is drawn upwards behind the facade to the vents instead of spreading out into the indoor space. On sunny winter days, this air passes through a heat exchanger in which fresh air from outside is preheated.

The geometry of the elevation is such that the windows are in shadow in summer when 100% of the radiant insulation is exploited by the PV modules mounted above the fold. In this case, only indirect radiation or daylight enters the building. The active PV components and solar collectors are arranged specifically to maximize energy yields from the sun. Because of using these passive techniques, such as passive heating of south-facing areas and north-facing rooms by solar-heated exhaust air via a heat exchanger, this building, compared to a benchmark building has been able to achieve 100% coverage by renewables for its lighting demand, cooling demand, ventilation, hot water, and artificial lighting. The other advanced passive techniques which can be applicable in moderate climates include natural night ventilation, earth-to-air heat exchangers, evaporative cooling, passive downdraft evaporative cooling, and radiant cooling. So the other advanced passive techniques for moderate climates include natural night ventilation, earth-to-air heat exchangers, evaporative cooling, passive downdraft evaporative cooling, and radiant cooling.

With this, we stop today's class where we have seen how to approach a moderate climate by understanding the climatic elements and arriving at the strategies with the help of either a Mahoney table or climate consultant, and we solved what these strategies are for a moderate climate. In the next class, we will look at case studies of this climate where these strategies have been adopted. Thank you.