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

Professor: Dr. Iyer Vijayalaxmi Kasinath

Department of Architecture,

School of Planning and Architecture, Vijayawada

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Lecture 04

Passive Design Strategies for Warm-Humid climate and case studies

Hello, dear students. So, we have seen the last few classes. What are the strategies adopted for simple passive techniques as well as advanced passive techniques in the cold climate? Today, we will continue with the warm and humid climate, in order to have a building designed according to principles of bioclimatic architecture for future-proofing with simple and advanced passive strategies. Let us look at the passive strategies to be adopted in warm and humid climates. So let us see quickly what defines a warm and humid climate. So, a warm and humid climate is characterized by high temperatures and high levels of humidity throughout the year.

There is no respite in this kind of climate. So, the daytime temperatures can be consistently warm and hot throughout the year. It ranges from 26 degrees Celsius to 32 degrees Celsius. As far as humidity is concerned, the air tends to have a high humidity level, which stays above 70% and often reaches 80% or even higher; sometimes it goes up to 95%, making the place very sultry. Rainfall typically exceeds 1500 mm and is evenly distributed throughout the year, but it has a very distinct wet and dry season.

So, warm and humid climates are conditions found in tropical regions near the equator. So, most of the places with warm and humid climates are densely populated. These conditions create ideal environments for lush tropical vegetation, including rainforests and wetlands. Additionally, warm and humid climates are also at risk of tropical storms, hurricanes, typhoons, and cyclones. Now, let us see what Mahoney's table finally gives as design and planning guidelines.

For warm and humid climate for Chennai climate, this is the guideline that Mahoney's table gives.

- The orientation should be north and south, with the long axis along east and west.
- There should be open spacing for breeze penetration, and there should be protection from hot and cold winds.
- The windows, the rooms should be single-banked with a permanent provision for air movement, and also
- the rooms should be double-banked with temporary provisions for air movement during certain months of the year.
- Opening sizes should range from 20 to 40 percent.
- The internal and external walls could be heavy.
- There should be heavy-roofed structures with a time lag of 8 hours.

This is the broad guideline that Mahoney's table provides. Now, let us look at what the climate consultant gives as broad planning and design guidelines.

So, we saw what Mahoney's table is giving as a suggestion for simple passive strategies for a warm, humid climate. Now, here we will see, with the help of any city's climate type (considering it to be warm and humid), what a climate consultant suggests as simple parcel strategies. Advanced passive strategies: We will see how much percentage can be improved by using simple and advanced passive strategies. We are not able to make all the hours comfortable; then, what active strategies? should be used to make 100% of the annual hours in one year to become comfortable.

Now we also know that this activity for each month is bound to be different. I have already demonstrated this in the Climate Consultant software: How, for every month, the strategies are different; so, strategies for each month is bound to be different. Just to show you how these differences happen, we will be analyzing the psychrometric chart. For four solstice periods. That is, we will look at strategies for June, September, December, and March. So, for these four months, what strategies can be used?

And if those strategies do not give 100% of the time to become comfortable, then what active strategies can be used to make these months feel 100% comfortable? This is what we will see. So, we look at Chennai for adaptation. This is how the psychrometric chart looks. I have already told you, and I have already taught you how to arrive at this. Now, once you arrive at this, it shows that If we also use the plus ASHRAE Handbook 2005, then it shows that sun shading of windows alone will reduce uncomfortable hours to 35.9 hours.

Here we are looking at simple passive strategies. For the month of March, in a warm and humid climate, solar shading of windows is recommended to make the indoors comfortable. The indoor temperature is comfortable at 36%. 267 hours, which were actually uncomfortable, will become comfortable just by shading the windows. Then, by using adaptive comfort ventilation, 47% of discomfort hours can be made comfortable.

In total, 48% can be comfortable, but 52% would still remain in the non-comfortable zone with just simple passive strategies. So, for making the indoors comfortable for the month of March with just simple passive strategies, we can have good natural ventilation. Which can reduce or eliminate air conditioning in warm weather if windows are well-shaded. So, we have seen already what shading means. We will use horizontal shading with sun shades. We can use vertical shading with our fins. We can also use the egg crate device. We can use the egg-state device. Any of these shading devices, as appropriate, can be used if we want to shift at least 34% of the hours to the comfortable zone.

Then we must provide adequate facilities for cross-ventilation within the rooms. By providing appropriate windows in terms of its position and in terms of its size. We have seen this strategy in detail as well. Screened photos can also provide comfort in warm weather and can prevent insect problems. Also on hot days,

Cooling fans of indoor air movement can make the rooms cooler by about 2.8 degrees Celsius or more. Thus, that will lessen the load on the air conditioning. Then, open fan interiors can promote natural cross-ventilation, or you can even use lowered windows, which can direct the breeze as per your requirement. So. Having lures at the inlet like this will direct the breeze downwards, and having the lures in this direction will direct the breeze upwards in the inlet.

To produce stack ventilation, a maximum vertical height between the air inlet and air outlet in the form of open spaces, roof monitors can also aid in ventilation. A whole-house fan or natural ventilation can store nighttime coolant in high-mass interior surfaces. Due to night flushing, or reduce or eliminate air conditioning, so we have seen what is thermal mass; we have seen what is night flushing, which also, to some extent, can be used. Then, for the month of March, this is one of the more comfortable ways to prevent overheating. Open to breezes in summer and use passive solar gain in winter will be a good strategy. And traditional passive homes can use lifted construction with a slab on grade and operable walls and shaded outdoor spaces; this is valid even for the March climate in Chennai.

Traditional passive homes adopt a climate with high ceilings and top-level bench windows protected by deep overhangs and verandas. Shaded outdoor buffer zones, such as porches, patios, and lines oriented to the prevailing breezes, can act as living and working areas in warm or humid weather. We must provide enough north-glazing to balance dilation and allow cross-ventilation for at least about 5% of the floor area. Low-pitch roofs with wide overhangs work well during the March period or in Chennai's climate. Then.

We can use plant materials, especially those on the west, to support native plant growth. In a wet climate, well-ventilated attics will push moisture and can be extended to entrances, porches, verandas, and outdoor work areas. If the soil is moist, we can raise the building high above the ground to minimize dampness and maximize natural ventilation beneath the building. We can minimize or eliminate the west-facing glazing to reduce summer and fall afternoon heat by using either vegetation, which will cast its shadow. or by having appropriate shading devices, which will create a shadow on the western wall.

Window overhangs can be designed or operable sunshades, such as awnings that extend in summer, which can reduce or eliminate the load on air conditioning. So have extended awnings, or have extended shading devices. Use light-colored building materials and cool roofs with high emissivity to minimize conducted heat gain, as cool roofs will reflect solar radiation back and prevent it from being absorbed by the roof material. Then, in order to make 100% of the hours comfortable, what should we do? So far, what have we seen?

We saw what the simple passive strategies that can be used in a warm, humid climate for the month of March are. Now, because of that, less than 50 percent of the hours were comfortable based on all the strategies that I had told you. But we want 100 percent comfortable hours for March. What should we do for that? Sun shading of windows, which is a simple passive technique, can be done.

Adaptive comfort ventilation that can increase by 47%. Active means, such as fan-forced ventilation cooling. Dehumidification that pushes comfort hours by 8%. Fan forced cooling makes 8.3% of hours comfortable. And cooling with the aid of dehumidification—which is basically air conditioning—will push the comfort hours from 44.2% from discomfort to comfort.

And in this manner, 100% of the hours can be made comfortable by selecting these strategies. So, all this which was initially read. Has now become green by adopting active strategies, so this is by adopting active strategies for March for Chennai. So for this solstice, this is how we can shift. What are these strategies? A whole-house fan of natural ventilation can store nighttime cooling in high-mass interior surfaces due to night flushing, reducing or eliminating the need for air conditioning. We can orient most of the lava to the north, shaded by vertical fins in very hot climates, because there are essentially no passive solar needs.

During March, we do not need any solar heat gain inside the building. Also, we can raise the indoor comfort to reduce air conditioning energy load or energy consumption. especially if occupants wear seasonally appropriate clothing. So instead of having the thermostat set at 22 degrees Celsius, we can set the thermostat at 26 degrees Celsius, provided the occupants wear climate-responsive clothing. So, if they wear light-colored, lightweight material, such as cotton, maybe cotton.

cotton shorts and t-shirts, or cotton dresses; then, the thermostat set point can become 26. Instead of someone wearing very heavy clothing, like heavy jeans and a jacket, the thermostat temperature probably has to be lower. It can go even up to 22 degrees Celsius.

But by doing that, there will be more energy consumption. Then, in this climate, air conditioning will always be needed, but it can be greatly reduced if building design minimizes overheating.

So, in a hot and humid climate, it is very difficult to push all 100% of the annual hours into the comfortable zone without the aid of air conditioners, especially in the month of March. Then we will see what happens. June of three months from now, what is the shift that happens when you use a strategy for the month of June for any climate that is warm and humid? 30.7% of hours can be made comfortable just by using sun shading of windows. Then 0.1% or just one hour can be shifted from discomfort to comfort is to say, "evaporative cooling."

33.2% of the hours can be made comfortable by adaptive. In total, 33% of the hours can become comfortable by using simple passive strategies, whereas 67% will remain uncomfortable during the month of March. So, what are these strategies? Simple passive strategies which can be adopted in June for Chennai. So, good natural ventilation can reduce or eliminate air conditioning in warm weather if windows are well-shaded and oriented to prevailing breezes.

Then the next strategy is to facilitate cross-ventilation by locating door and window openings on opposite sides of the building, with a larger opening facing upwind if possible. Then, the next strategy is to use clean coaches and tissues that can provide passive comfort cooling through ventilation in warm weather and can prevent insect problems. Another strategy is that on hot days, ceiling fans can reduce the indoor temperature by 2.8 degrees Celsius and thus reduce the requirement for air conditioning. Next strategy is to use an open-plan interior so that you can promote cross-ventilation, or you can use lowered openings which can direct the wind according to its direction. Then, in order to produce stack ventilation, even when wind speeds are low,

We can maximize the vertical height between air inlet and air outlet by means of open store wells, two-story spaces, and having roof monitors, clearstories, etc. The next strategy is to use a whole-house span of natural ventilation that can store nighttime cooling in high-mass interior surfaces along with night flushing. Thus, reducing the load on air conditioning now to shift 100% of the hours from uncomfortable to comfortable, that is, shifting all these dots to comfortable levels. 15 is the one that will shift the entire discomfort to become green, which is comfortable, and that 15 is primarily for air conditioning. Cooling at dehumidification, if necessary, is air conditioning.

So, in order to shift 100% of hours to being comfortable in the month of June, 30.7%. Hours can be made more comfortable by using sun shading on windows. 0.1% can be made comfortable by two-stage evaporative cooling. 33.2% of hours can be made comfortable by adaptive comfort ventilation. All these are simple passive strategies.

Whereas 1.1% or 8 hours can be made comfortable by fan-forced ventilation cooling, and which comes here in this zone; and then 66.7% can be made comfortable by air conditioning, which is active maintenance. leading to 100% hours becoming comfortable for the month of June, 100% comfort hours for any day, which is a representative of a warm human climate. So, how to further improve while using this strategy, we still try to be a little more sustainable. That is possible by having a whole-house system of natural ventilation with high-mass interior surfaces and night-flush techniques. The next strategy is to orient most of the glass to the north with vertical fins as shading devices and to have essentially no requirement for passive solar heat gain.

Also, we can set the thermostat to a lower temperature, and that is how we can reduce energy consumption. Also, in this climate, air conditioning is always needed, but we can greatly reduce it by building designs that will minimize overheating. Then we will see what happens for the month of September. For Chennai, what are the simple and advanced fossil fuel strategies for a hot, humid climate in September? So what happens is that 29.3% of the hours can be made comfortable in September by solar shading of windows.

0.1% or one hour can become comfortable by two-stage evaporative cooling. 26.8% of the hours can be made comfortable by adaptive comfort ventilation. So these three strategies are passive strategies. So, just by adopting passive strategies, 57% of the total hours can become comfortable in the month of September with passive strategies alone. So, what are these strategies?

How do we achieve this? The first way to achieve this is to use plant materials in bushes, trees, and ivy-covered walls, especially on the west side, in order to minimize heat gain. If summer rains support native plant growth, nothing like that; we can even have moss walls. Then, in wet climates, well-inflated attics with pitched roofs work very well to drain and can be extended to protect entry and outdoor work areas. The next way to achieve more comfort hours with passive strategies can be achieved by raising the building high above the ground if the soil is moist, thus minimizing the penetration of dampness into the building and encouraging breeze movement below the building. The next strategy is to minimize or eliminate the Sun by shading it either with shading devices or with vegetation. Window overhangs designed for this latitude, or operable sunshades like awnings, These are natural sunshades.

We can have awnings that will prevent solar radiation from hitting the wall or the glazing, thus reducing the load on air conditioners. So we can have awnings extended, and because of this, solar radiation does not strike the ball's surface. We can use lights. And cool roofs with high emissivity to minimize conducted heat gain as the roof will reflect away solar radiation, allowing less heat to be absorbed by the roof.

Then let us see what should be done in order to make 100% of the hours comfortable. 3 hours or 0.4% of the total hours can become comfortable due to dehumidification. And 42.8% of the hours have to have air conditioning if you want the indoors to be comfortable for 100% of the time. And so, air conditioning is a must if you want 100% of the hours in September to become comfortable. Now, let us see what ways we can still use this and make the buildings energy-efficient and sustainable. So, the first strategy is to use a whole-house fan for natural ventilation, which involves high-mass and deep flushing and can reduce or eliminate the need for air conditioning.

Then, we should orient most of the glass to the north, shaded by vertical fins, because we do not need any solar gain in this climate and in this month. Further, we can lower the set point of the temperature on the air conditioner and save energy. Also, in this climate, air conditioning is always needed, but we can reduce it if we design buildings as a response to the climate. Now, let us see what strategies are required for the month of December. Now, if you see for the month of December, the passive strategies that are needed for December are 26.5% of the total hours can become comfortable just by using solar shading on windows. 0.3% or two hours can become comfortable through two-stage evaporative cooling. And 62.9% can become comfortable if we use adaptive comfort ventilation. So, these three strategies put together accounts for 64% of the hours by which we can shift discomfort into the comfort zone.

So here we can shift 64% of the hours to be comfortable by adapting passive strategies. So, what are these passive strategies that you need to adapt for the month of December? So, this alone I will not repeat it now because we have already seen this. How to use these strategies? Now, let us see what to do if we need to shift this 64% to 100%.

How can that happen? That can happen if we use dehumidification, because which 25.1% of the hours are shifted to a comfortable range. Fan forced cooling is another strategy which will shift 44% of the hours to comfort. And the air conditioning requirement is only for 18% of the hours, or 134 hours, to shift from uncomfortable to comfortable.

So, in order to have 100% of the hours shifted from uncomfortable to comfortable, one needs to follow these three strategies for the month of December in Chennai. So, how do we achieve these strategies? So the first is that we can raise the building on stilts or pilings if the soil is moist, and that will also enable. The stagnant moist air can be removed by natural ventilation and a whole-house fan, or natural ventilation can store nighttime cooling with the help of a high-mass material and through night flushing to reduce the load on the air conditioner. Now we have seen what the simple passive strategies are for 4 months.

Or four solstice months of the year for Chennai, in terms of just passive strategies, and in order to make the remaining hours also comfortable, what are the active strategies that we have also seen? Now, let us compare how, for each of these months, what strategies must be used. Now, for the month of March, the comfort that is achieved using passive strategies alone is 48% of the hours that can become comfortable. In June, only 33% of hours can be made comfortable with passive strategies.

In the month of September, 57% of the hours can be considered comfortable. If we use passive strategies, then in December, 64% of the hours can become comfortable by using them. So, what are these passive strategies? For sun shading of windows is mandatory throughout the year. For these three solstitial periods (June to December), two-stage evaporative cooling can be a good strategy.

Throughout the year, adaptive comfort ventilation, which is basically having openings of appropriate size and location, well shaded with proper shading devices, is mandatory. In order to make the remaining percentages also comfortable. So, in order to make the remaining 52%, 67%, 43%, or 36% are comfortable. What should we do?

We should adopt the active strategies. What are the active strategies? Throughout the year, fan-forced ventilation can be used. Dehumidification alone can be used except for the solstice in June, for all the months of the year air conditioning for at least a few hours is mandated. So this is how we will use a climate consultant to understand.

What strategy must be used for which year? Now, once you use a particular strategy for one month, you can't dismantle it for the next month, and therefore, it becomes very important for you as an architect to understand which strategy will gain more importance. With the help of the psychrometric chart and climate consultant, which helps us understand how many hours can be pushed from uncomfortable to comfortable hours, we can decide which strategy must be adopted in that building. So, next we will see some other aspects of how to design in a warm humid climate. So, let us look at the design considerations in detail.

So, warm and humid climates are characterized by high temperatures and high levels of humidity throughout the year. This climate type, which is found in the tropics, is also a place with more population. Hence, it's important for us to understand how to design in this climate type, as it will benefit a large number of populations. Frequent rainfall is also a common characteristic of this climate, and in some locations it rains almost every day. These conditions also create a good ambiance for insects and moss to grow.

So, while deciding on building massing and spatial configuration in the warm humid climate, we must consider two important things. First is the reduction of solar exposure on the building envelope. This helps in managing solar heat gain through the building envelope, which includes walls, roofs, and windows. Second, the utilization of wind flow to ventilate internal spaces in order to evacuate heat and provide thermal comfort to the occupants.

The main building envelope features that influence daylighting in residential units are the size and location of window openings, which is very important. We have seen this concept in one class previously, as part of one lecture in this course. Shading systems for windows. Again, we have seen this in one lecture in this course. Window glazing with light-transmission properties.

We have seen this in one of the lectures as well. Color and finish of nearby surfaces. So, nearby surfaces, the color and finish are important because this climate type is in the tropics. And the tropics can sometimes give very harsh lighting. And if it is reflected from adjacent surfaces, then it can be very harsh on the eye, and also glare can happen.

Color of internal surfaces is important. The building envelope design should aim at reducing cooling thermal energy demand, improving thermal comfort, and providing adequate daylighting in typical spaces such as bedrooms, living rooms, and kitchens. Let us look at the simple passive strategies to be used in this context.

1. The first is, Building envelope form and orientation with the east-west axis, where the longer façade faces north, reduces solar heat gain from the east and west facades. Buffer spaces, like the service core, are also included, toilets, etc. should be placed along the east and west, and also sometimes along the south direction, to minimize heat gain. So, you should provide staircases and lifts along either the east or west. Envelope in these regions should be well insulated with a low thermal transmittance value or low U-value. With an increase in volume, building envelope heat gain also increases.

So. when you design these buildings, you ensure that you buffer the east and the west well. With an increase in volume and building envelope, heat gain also increases. So compact planning with a smaller volume of exposed area reduces heat gain from the building. Rectangular plan form is beneficial.

With longer facades in the north and south directions to reduce heat gain from the shorter sides in the east and west directions. But the best would be to go for a square plan. If it is a rectangular plan, then ensure that the east and west have the shorter sides while the north and south have the longer sides exposed.

2. Second is "walls." Most exposed surface in the building envelope is the wall. Low thermal transmittance or U-value materials for walls are preferred. Lightweight construction materials for walls must be preferable. Outer surface of the wall should be shaded, light in color, and should be reflective as much as possible. Methods like cavity walls, thermal mass, external reflective materials, and light-colored finishes are preferable. Thermal mass plays an important role in maintaining thermal comfort inside the building for occupants.

These are very generic. Even in a hot and humid climate, in some places, it is better to play with light walls, and in some places, it is better to play with the thermal mass.

3. Third is Windows. Now, the window-to-wall ratio of 20 to 40 percent, as per ECBC, is required to avoid glare and and overheating. When it comes to windows or fenestration, a low U-value with a low solar heat gain coefficient is preferable to minimize heat transfer into the building. Use of double- or triple-pane glass with a low E-value is encouraged. Low thermal transmittance glazing technologies, such as electrochromic or thermal. electrochromic, which is thermo-electrochromic and reflective, glazing is also preferable.

When it comes to ventilation and the position of openings, building openings must be on the windward side. Normally, because it's a coastal place like Chennai, The direction is south and southeast. Courtyards can be provided so that warm air rises and cool air from the ground floor flows into the building.

4. Solar chimneys enhance ventilation because of the stack effect. In warm humid regions, Opening should be designed to capture wind; as ventilation is the key comfort-defining criterion throughout the day in this climate. Having openings that direct the wind upward is not a good idea because, in the working zone, there will be no ventilation. Hence,

It is better to avoid louvers or openings which direct wind towards the ceiling. It is better to have baffles which direct the wind towards the working level. Or we could even have louvers which direct wind toward the working level. The living zone is the space commonly used by occupants, and air movement should be directed through this space. The sizes of the openings can be larger and closer to the floor for maximum comfort.

They should be placed along the windward side to make sure that air moves in and out of the building freely. Therefore, regardless of the place, natural cross-ventilation in buildings is as essential as breathing is to humans. Otherwise, the sweat that forms due to high humidity makes it very sticky and uncomfortable, especially when combined with high air temperature. So, a typical plan of stacking rooms one behind the other must be avoided; whereas, a courtyard should be introduced in the plan. This can help in bringing in more natural light as well as facilitating ventilation.

They also ensure that properly designed openings can be given to enhance cross-ventilation in the houses.

5. Fifth is shading. Shading reduces the solar heat gain through openings and also reduces the mechanical cooling demands inside the building. The sun is at higher elevations during summer and lower in winter in the southern direction. So shading devices on southern fenestration only allow low-angle sun paths for winters and penetrate higher solar radiation in summers, while shading devices on northern fenestration are only meant to block higher sun angles during summers.

North and south facades can be protected by overhangs. East and west directions need special shading devices like louvers. The southern facade requires only horizontal shading devices, such as these, and strategies to penetrate solar radiation. Whereas the east and west directions require special shading devices to penetrate extreme solar radiation. So, accurate shading devices are helpful along the east and west directions.

6. Sixth is landscaping and positioning of trees. Shading of exposed surfaces reduces direct sunlight and prevents surface heating. Shading of open ground in sight is important, and shading of horizontal or vertical surfaces, like green walls, is also

important. So, green walls can act as a shading of vertical surfaces. Roof gardens, or green roofs.

7. Or even cool roofs are encouraged. There must be a buffer against hot winds and direct solar radiation, and glare must be blocked with the help of landscaping. Deciduous vines covering the wide trellis on the north and south sides of a building act as shading devices. These can provide comfortable outdoor areas and solar protection. Plant species that allow penetration of low-angle winter sun have to be used for shading the building and its outer surfaces.

Evergreen trees with a high canopy can be used on the east and west sides of the building to improve its solar protection in the morning and afternoon. These trees allow the movement of air under their canopies. Certain species of tree. Such as Saman (Samane), also commonly called the rain tree, forms an extraordinary outdoor space by creating a huge canopy effect. They should not be planted too close to each other so that the crowns form a wide hall-like space, creating a comfortable microclimate.

Buildings should be separated by large free spaces between them. This allows airflow, which provides ventilation for cooling and a hygienic environment. An unshaded pavement should be avoided as far as possible, and air should not be allowed to pass over such surfaces before reaching the buildings. Low vegetation and bushes, however, should be avoided near the buildings because the space between the ground vegetation and the high crown of the trees should remain open, providing free access for the wind at the level of the living spaces, and also prevents dampness. The next criterion is to have a green roof.

Green roofs are excellent in providing water retention or stormwater drainage, as we had seen when we discussed green roofs. It provides green space, improves water and air quality, reduces energy consumption, and insulates the roof. Provides ambient air temperature reduction. It alleviates pressure on the sewer system. It protects the roofing membrane.

It reduces noise and filters pollutants. Next is the roof. Roof is the area from which maximum solar radiation and heat enter the house in a hot and humid climate. Cool roofs are a good option under such circumstances. Cool roofs are basically roofs that are painted in light-color shades or have a reflective material coating so that they reflect most of the solar radiation and reduce thermal heat gain.

As per some studies, it is seen that conventional roofs reach about 60 degrees Celsius in summer, whereas cool roofs stay at 28 degrees Celsius, which is much cooler than conventional roofs. Low-thermal-transmittance U-value roof construction can be used to reduce heat gain from roof assembly. Solar panels or rooftop panels. Building-integrated photovoltaic systems can also act as a second skin on the roof to provide shade, which can also reduce solar heat gain through the roof assembly. So, in hot climates and climates with hot summers, a light-colored roof reflects sunlight and remains cooler and offsets carbon dioxide warming and reduces the amount of heat transferred to the interior of a building. Coal roofs have surfaces that reflect sunlight and emit or discharge heat efficiently, keeping them cooler on sunny days. The two surface properties that determine a roof's temperature are solar reflectance and thermal emittance. which range on a scale from 0 to 1. The larger the two values are, the cooler the roof will be.

The roof surface should be a light color and the roofing material should have a surface with solar reflectance of more than 0.7 and thermal emittance of more than 0.75. In hot climates, cool roofs can help mitigate urban heat island effects. Reflect solar radiation back to space and keep indoor spaces comfortable. Next is the double-roof. Now, in hot climates, the structure located just above the roof shades the roof and allows warm air to build up between the roof and the structure to escape.

In hot climates, Direct sunlight is the largest contributor to building cooling loads. Because a roof receives the most direct sunlight during the day, a double roof or shade structure above the roof will reduce the cooling requirements. In hot climates, incorporate a double-roof structure separated by an air cavity. And extend the roof line to shade exterior walls and create shaded outdoor living spaces.

Use cross-ventilation or ridge vents to ventilate the air cavity between the roofs. A double-roof structure located high above the roof can also provide shading for an outdoor roof garden or terrace. Next is cooling. So, you can have thermal mass cooling, which is thermal mass that regulates the space temperature by controlling stored thermal energy in the building. Heavy thermal mass buildings maintain comfort even after the HVAC is shut down.

It delays heat ingress, combined with natural ventilation and night purge, which ensures natural pre-cooling. In warm humid climates, low-thermal-mass buildings prevent heat buildup and dissipate it quickly. If we look at radiant cooling, conventional air conditioning relies on convection and a radiant system to use radiation for heat transfer. Radiant systems often combine with thermal mass and maintain comfort by absorbing and radiating heat. Coils in floors for heating and ceilings for cooling optimize the performance of the radiant system.

8. Radiant cooling systems include chilled slabs and ceiling panels, offering different cost and performance benefits. Next is the dehumidification or desiccant cooling system. A desiccant is a substance that absorbs water from air to dehumidify it and releases the moisture later when heated, in a continuous cycle. Desiccant systems are categorized into open and closed systems depending on whether the desiccant directly contacts air. Solid desiccant systems use materials like silica gel or zeolite, while liquid desiccant systems utilize substances like lithium chloride or calcium chloride.
9. Desiccant systems are effective in regions with low heating demand but have limited application in high-humidity areas, with ongoing research in India to enhance their viability. Normally, if desiccants are used, they are used in combination with the air conditioning system because the act of removing moisture from the air by the desiccant is an exothermic reaction and it gives off heat, further increasing the temperature of the surrounding air. And last but not least, we will look at the lighting system. The activity zone is important for daylighting distribution. Areas that require the same amount of lighting can be placed adjacent to each other.

Daylighting areas are divided into three zones: fully lit, partially lit, and non-daylit areas. Less artificial lighting reduces the internal heat gain in the building. Side lighting and top lighting can be used for natural light without allowing direct sun rays to penetrate the building. Top lighting is effective for spaces directly below the roof, and side lighting blocks direct sunlight, providing glare-free light into the building. In this technique, direct sun rays are reflected toward the ceiling.

After which, it provides diffuse light throughout the area. We will look at case studies of buildings in warm and humid climates where some or most of these techniques have been applied. The first case study we will take is Arcot Plaza. The Arcot Plaza is a commercial building. An award-winning one located in Chennai.

It is designed by architect V.S. Vigneshwar of Architecture Plus Value. Now this building is located on a very busy transportation corridor. The ground plane is extended as a public plaza, which connects the double-height retail to the street. The office floors above are capped with green terraces.

The design idea was to maximize the visibility of the building and tap into its potential in terms of footfall, as the site is located between the existing railway station and an upcoming metro station. The ground plane is designed as a public zone. The front edge of the site is Is designed as a public plaza, extending the sidewalk into the site, with the building featuring an inviting, double-height atrium for the retail branch. The office floors have a separate entrance lobby at the rear with a vehicular drop-off.

The top floor is designed as a premium office with a large terrace garden, which cuts the heat load of the office. If we look at the conscious design decisions taken, the form of the building was a direct response to the climate. The northern side faces the street and care is taken to protect the glass frontage of the building with appropriate and innovative shading devices, thereby providing effective daylighting and reducing solar heat gain on the building. The retail facade is protected by the office floors cantilevering from above. The western and eastern sides have been designed with appropriate openings to facilitate cross-ventilation inside.

This building has north-light louvers in order to get constant daylight without glare along the north side. which is its front facade. The eastern openings on the other side have larger openings with sunshade to allow more daylight. There are large overhangs that protect the glass from direct sunlight. The glass on the north side is protected by this large overhang.

So, the built form is a response to the climate, the context, and the function of the building. The building also has a service core which is positioned on the south. So this is positioned on the south to minimize the building's heat. On the west side are smaller slit windows. So these are small slit windows with adequate sunshade.

To prevent the harsh western light but allow the southwest wind to enter. Also, if you look at the site and the design context, you can see that there is a public plaza in front. And this facade offers maximum visibility with a glass. but yet has adequate shading provided at higher levels. Here you can see how each of the facades has been treated.

The north side has north-light louvers, which give continuous daylight without glare. The western side has small slit openings, which are well shaded, through which the southwest winds pass. Can go in, and yet the harsh sunlight is cut off. The eastern side has larger openings than the western side, and it allows for more daylight. Southern side has minimum openings.

The openings are very minimal on the southern side, and it minimizes the building's heat gain. The building also has a green roof, partially on top. The form of the building is a direct response to the climate, as the north side faces the street. Care is taken to protect the glass frontage of the building with appropriate and innovative shading devices. Now, if you see on the east, there are operable windows, and the openings can be angled based on the solar direction, sun's direction, and wind direction.

Similarly, along the west, the slit windows are arranged in random patterns. Protect the inside from harsh sunlight, and it also has adequate shading; and the operable windows can also be turned toward the direction of the wind. So, care is taken to protect the glass frontage of the building with appropriate and innovative shading devices. thereby providing effective daylighting and also reducing solar heat gain on the building. The retail facade is protected by the office floors cantilevering from above.

The west and the east side has been designed with openings that facilitate cross-ventilation inside. Let us now look at the north openings. On the western side, in Chennai during summers, the setting sun moves northward. During such months, the fins provide diffuse light. During other times, they cut the glare from the bright sky.

It also offers an interesting view of the street from the office spaces, breaking the monotony of the spaces. Also, the glass used is solar-rated glass to cut heat gain. Let us now look at the north façade. Now, innovative daylighting façade has been adopted here. The northern facade of the building for the office floors was designed to provide glare-free daylight for the workspaces.

The triangulated translucent polycarbonate fins, placed in carefully determined patterns, cut the direct sunlight. To cut off excessive solar heat falling on the glass and the associated glare, the architect has structured the shading devices in the form of triangulated translucent polycarbonate fins in a designed pattern. The fins project perpendicular to the facade. Some of the design objectives achieved through this project are to maximize site visibility by creating a public plaza and an iconic form. Creation of an iconic building with the lowest possible budget.

Natural light without glare for office spaces. Solar passive design with appropriate shading features. Climate-responsive design with lower heat gain. Maximum visibility for retail spaces with higher footfall and achieve maximum revenue. So, the northern façade of the building for the office floor was designed with an outer stainless-steel frame.

And a polycarbonate sheet attached to it. Now these provide glaringly natural lighting. And you can see that there is adequate natural daylight at the workstation as well as in the conference hall. So, this is the north-side and west-side view. So, continuing with the glass frontage of the ground and mezzanine floors for the rest of the floors, rather than the concrete facade overlaid by heat-trapping panels, the architect has given the street-facing side of this building a solar-rated glass frontage.

With this, cost-free daylighting for the workspace has been achieved. Chennai, being a city where heat and light are in surplus, It really works and helps. At night, when everything is lit up, the fins reflect the interior lighting of the building in various geometric patterns. Now let us look at the second case study.

The second case study is the REC Tech Park in Thandalam, Chennai. Again, by architect V.S. Vigneshwar of Architecture Plus Value. So, here in this building, the client had requested to develop a tech park within an REC campus. For computer science engineering students, training and startup incubation.

So, the Rajalakshmi Engineering College wanted to have its own tech park. It was aimed to encourage recent graduates to enter the startup ecosystem. The requirement was that the building must be completed fast within 180 days. An innovative and futuristic design at the campus entrance must be available to see. The concept of the tech park was to provide space for training, socializing, and starting up.

Learning extends beyond classrooms into non-program spaces to foster innovation. The design features achieved include a sustainable and cost-effective glass façade. maximized natural light and ventilation, vibrant colors and materials to enhance creativity, climate-friendly design considering solar orientation, social spaces for student interaction, efficient space planning with zero waste, context-responsive architectural design, and an iconic building created cost-effectively. And it will be completed with steel or dry construction within 180 days. The design process mainly had the site and climate influence the design decisions.

There was an atrium designed for natural light and ventilation. So, some of the tangible aims achieved through this design are Designing a sustainable and cost-effective glass façade-based building. Provision of maximum natural light and ventilation for all areas through careful design of the façade and roof. Use of color and materials to bring vibrancy and a sense of identity to the tech park, which helps to create a startup-friendly atmosphere and enhances creativity.

Some of the passive features used are a thorough analysis of the climate; wind flows from southwest to northeast. Reflecting glass and panels were used. Double-skinned wall has been used. Clear story lighting has been used here, along with the double-skinned wall. With an understanding of the climate.

This building was designed in a climate-friendly manner. Each side of the building is designed to respond to climate and solar orientation. The facade detailing is done in such a way as to bring in constant reflected natural light without glare. There is provision for social spaces in all the common areas of the building to enhance interaction between students and provide breaks in the non-programmatic areas. These were done through providing seating areas, green spaces, and natural light pockets within the building's atrium and outside the building in the setbacks.

Efficient planning in the use of all built and unbuilt areas. Have been done. The circulation and program spaces are designed with zero space wastage, responding to the context and creating an identity for the center through sound architectural design. An iconic building is created in a cost-effective manner. Use of complete steel or dry construction enables the building to be completed within the stipulated 180 days.

The most influential factor in this design is the site and the climate. The north side has the administrative entrance. This side also has many trees and a good green cover. The south side has a playground, and this acts as a student entrance. The atrium was conceived as a playful space that bridges both areas.

The atriums were designed to be naturally lit and ventilated. Thus, the cost of lighting and ventilating a large space was cut. The roof of the atrium is made up of translucent polycarbonate sheets, allowing natural light into the atrium. This, in turn, leads to reflected glare-free light inside the classrooms and programmatic areas. The natural ventilation is aided in the atrium through the operable facade on the north and south sides of the atrium.

The vegetation on the north and the playground on the south lead to a pressure differential, allowing for constant air movement in the atrium, which creates a pleasant environment inside. Structural steel skeleton with insulated boards has been used. The atrium facade with operable glass windows for ventilation. North and south facades with solar-rated mirror glass and wooden HPL sheets have been used. Double-skin facades on classroom facades have been used to reduce heat.

Subtle interior colors reflecting nature have been used for psychological appeal. The construction system was an innovative system consisting of a structural steel skeleton with a decking sheet floor system. The sides were clad with insulated boards, and the roof of the building was designed with polyurethane foam sheets. The atrium façade was detailed with operable glass openings, allowing natural ventilation throughout the building. The north and south facades were detailed with solar-rated mirror glass interspersed with wooden HPL sheets.

They reflect and mimic the natural surroundings, enhancing the presence of the building and giving it a futuristic feel. The classrooms and the programmatic spaces were organized on the east and west sides. These facades of the classroom had an external double skin that cuts the heat. The AAC wall with openable windows was covered with an MS structure mounted with louvers to cut down the heat and glare. Also, the services were allocated between the two skins, which provided an additional thermal buffer and provides a way to conceal the otherwise ugly and visible service lines in the building.

Here you can see that the north and south facades were detailed with solar-rated mirror glass interspersed with wooden HPL sheets. With the façade having a structural steel skeleton and insulated boards. The atrium facade with operable glass openings for ventilation was present. The north and the south facades had solar-rated mirror glass and wooden HPL sheets. Double-skin façades were used in classrooms to reduce heat gain and subtly reflect interior colors to mimic nature for psychological benefit.

So, in today's class, we saw two case studies from a typically hot and humid zone, though it is classified as warm and humid. We have seen two case studies from Chennai which have been designed with some climate consciousness and in response to the climate. With this, we will stop today's class and we will continue in the next class by looking at the strategies for hot and dry climates. Until then, thank you.