

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

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Lecture 02

Climate characteristic of composite climate

Hello everyone. In our last class, we saw the climate characteristics of two climate types in India. One is warm and humid, and another is hot and dry. Today we will look at the climate characteristics of a slightly complex climate type, and that is the composite climate. Composite climate is always a challenge for any architect. You will see why.

So, today we will see the climate characteristics of a composite climate. We will have a look at the geographic distribution, what the climate characteristics consist of, the building design considerations, and what NBC says about this climate type. If you look at the geographic distribution, a climatic zone that does not have any season for more than 6 months is called a composite climate. A composite climate displays the characteristics of hot and dry, warm and humid, as well as a cold climate.

That is why I said it's a big challenge to architects and designers. The composite climate is neither constantly hot and dry nor warm and sticky. Their characteristics are ever-changing, interspersing between long hot and dry ages to shorter ages of downfall and high moisture. There is a significant difference in air temperature, moisture, wind, sky, ground conditions throughout the time. Geographically, if you see, parts of Gujarat, Andhra Pradesh, Chhattisgarh, Madhya Pradesh, Jharkhand, Bihar, Uttar Pradesh, Rajasthan, Haryana, Punjab, Himachal Pradesh, Chandigarh and Uttarakhand have this composite climate type.

Today we will look at the climate characteristics of composite climate with reference to New Delhi. Now, Delhi features a dry winter and humid subtropical climate. According to Copen, it is CWA bordering a hot semi-arid climate, which is BSH according to Copen with high variation between summer and winter temperature and precipitation. But it is different from many other humid subtropical cities such as Sao Paulo, Houston and Brisbane in that the city features dust storms, something more commonly seen in a desert climate and has wildfire haze, something seen in the Mediterranean climate due to its semi-

arid climate. Here you can see the figures, which show the respective monthly average daily maximum and minimum temperature in Delhi.

So here you can see that Delhi reaches an average of 40 to 39 during the hottest part, and for a large part for 4 months it has 36 plus as its temperature. The minimum temperature is low for at least 3 to 4 months, and the temperature can peak to even 45 or 48 degrees Celsius. So, summers start in early April and peak in late May or early June with an average temperature around 29 to 25 degrees. But many times the temperature touches 38 degrees to 45 degrees. During the monsoon, the average temperature is around 29 to 25 degrees.

Whereas in winter the temperature can peak with an average of 14 degrees and go low even up to 2 or 3 degrees centigrade. Delhi typically has seasons. If you see April to June is summer. During April to June is the summer season. Summers are characterized by extreme heat, low humidity, very hot winds, and thunderstorms more like a semi-arid place.

The maximum temperature exceeds 40 very easily and remains very dry, whereas the nighttime temperature crosses 20 degree Celsius, and because of this, there are high diurnal variations. The second season is between July to September, which is a monsoon season. Here, high levels of humidity and high heat are its characteristics. Day temperature drops between 40 degrees Celsius and humidity suddenly increases. August is Delhi's almost wettest month. Between October and December is the autumn season.

It has a very dry ambience, and during this time the days are warm and nights are very pleasant. The maximum temperature touches 30 degrees Celsius and the minimum touches 10 degrees Celsius, and because of this, the diurnal variation is 20 degrees Celsius. Between January and March is the winter season, where it can be bitterly cold. By early January, when the winter peaks in Delhi, the minimum temperature can plunge to even 0 degrees Celsius. Maximum temperature is below 15 degree Celsius.

By March, the maximum temperature starts increasing and crosses 20 degrees centigrade. So this is characterized by very dense fog, not to be mistaken with smog. Then the fifth season is between mid-February and March, which is the spring season. During spring, the days are warm and the nights are cool. The ambience is dry, and very lively natural surroundings like the plants and flowering of shrubs happen.

Rains may be accompanied by hail and can be heavy sometimes. The diurnal variation becomes considerable, reaching 20 degree Celsius, because the maximum daytime temperature could reach 35 degrees Celsius and the minimum could be 15 degrees Celsius. So, if we look at the detailed climate characteristics in terms of its relative humidity, the highest humidity is in January, which is around 98 percent, and the lowest is during the

summer between March and May, which is around 19 to 27 percent. So, the highest humidity is somewhere between January. During summers between March, April, and May the humidity dips.

So here it is low humidity, and it reaches even 20%. So the summers can be very hot and dry because of lower humidity. Whereas, if you look at August, the humidity levels can touch 60 percent somewhere between August and September. So, the average relative humidity ranges between 19 to 61 percent throughout the year. So, the range is very high, 19 to 61 percent, and one repercussion of this will be on buildings.

Next is wind speed. The average wind speed ranges between 1.8 meters per second to 3.8 meters per second. The highest is during June which is around 7 meters per second, and the lowest is around October-December which is very minimal and sometimes non-perceivable, which is around 0 meters per second.

If you look at precipitation, Delhi experiences extreme seasonal variations in monthly rainfall. The rainy period of the year lasts for about 9 months from January to October with a sliding 31-day rainfall of at least 1 cm. The month with the most rain in Delhi is August with an average rainfall of about 20 cm. The rainless period of the year lasts for about 3 months from October to January. The month with the least rain in Delhi is November with average rainfall of about 1 cm.

If we look at sky cover in Delhi, the average percentage of the sky covered by the clouds experiences extreme seasonal variation over the course of the year. The maximum sky cover is in July and August, which is around 90 to 94%, whereas the least is in November, which is around 2%. Now, if we look at the detailed climate of Delhi, here you can see that the record high temperature in Delhi crossed or touched 40 degrees Celsius for 7 months. 40 degrees Celsius plus, whereas for the remaining time of the year it is 30 plus. If you see the mean maximum temperature, the mean maximum temperature is low in January and December.

If you look at the relative humidity, the relative humidity can be as low as 25%. We are talking of the average relative humidity that is about 25 plus, and the average does not exceed 65 to 68 at the most. So, if you actually see when the temperature is touching 40, the mean maximum touches 40 and the humidity is 60. This combination can make it very dry and can cause the skin to have a burning sensation. Now let us look at the vegetation characteristics.

The major types of vegetation in this region are tropical thorn, tropical dry deciduous, tropical moist deciduous, desert vegetation, moderate subtropical, and temperate, which

has mostly evergreen and semi-deciduous tree species. Now the vegetation here can comprise of a tropical thorn forest, which is a type of desert formation that consists of shrub-like vegetation. Vegetation in these areas is very scarce, and tall trees are laid against each other where there is a lack of grass. Whereas the tropical dry deciduous forests are a transitional type of forest between moist deciduous and thorn forest on the wetter side and thorn forest on the drier side. The tropical moist deciduous kind of forest flourishes in areas that have rainfall of over 200 centimeters.

The desert vegetation is mostly herbaceous or stunted shrub. These are drought-resistant trees occasionally dotting the landscape. So, in Delhi, there are both type of vegetation. The ones that thrive in warm-humid conditions and the ones that thrive in hot and arid desert conditions. Let us now look at the building design considerations.

Some characteristics of composite climate that designers should keep in mind include large seasonal variations. The characteristics of composite climate are ever-changing, interspersed between long hot and dry ages and shorter ages of decline and winter. To tackle this fluctuating climate, designers must look for solutions that aim to resist heat gain in summers and prevent heat loss in winters. The climates are extreme. So there is a significant difference in air temperature, moisture, wind, sky, and ground conditions throughout the year.

We already saw Delhi has 5 seasons. Because the climate conditions of composite climate are varied and solutions for one season might not be suitable for another, this duality of the matter should be handled very carefully. Let us now look at the building design considerations for this climate. In this climate, one must use plant materials such as shrubs, bushes, and trees on the western side. So, it is important to buffer the waste completely.

Screened porches and patios can provide passive comfort cooling by ventilation in warm weather, and this can also prevent insect problems. Mosquitoes and flies are a major problem in this climate type. Window overhangs must be designed specifically for this latitude, and it is preferable to have operable sun shades like awnings that extend in summer, as these can reduce the load on air conditioning. Now this is one of the climates where shade is needed to prevent overheating. So, you need to have long shades or long overhangs and long porches.

Shaded outdoor buffer zones like porches, patios, and lanai oriented to the prevailing wind directions can have very comfortable living spaces. Especially during the warm and humid climate times. Using light-colored building materials and cool roofs with high emissivity will also help. Next we will look at the design considerations where you need to have good natural ventilation during the warm and humid period because if you try to do that in the

hot period you will bring in the hot air, which is the ambient air outside. To facilitate cross ventilation, you must have windows on the opposite side aligned along the primary wind direction.

Use an open plan inside for also cross ventilation. Low-pitched roofs with wide overhangs work in this climate because you have heavy rainfall and also only one part of the season is hot and dry. The other part remains warm and humid with adequate rainfall. Orient most of the glass to the north, shaded by vertical fins, in a very hot climate because there is essentially no solar passive heat gain requirement during the hot period, though there is this requirement during the cold period. If we look at NBC guidelines, then NBC guidelines for summer, winter and monsoon period state that reduction in the ingress of heat during day by insulation, thermal mass, buffer spaces, orientation, shading, etc. is needed in the summer, winter, and monsoon periods. Introduction of naturally occurring air through the use of courtyards, wind towers, properly positioned windows, or mechanically pre-cooled air into the building with adequate airflow during the day is essential in the warm time but definitely not during the winter period. A substantial increase in airflow velocity during the day as well as night is required in the monsoon period. Adequate airflow of natural ventilation is needed during the summer period and during the winter period. Reduction of the temperature variation within the building during day and night as compared to temperature variation of ambient temperature is needed in summer as well as winter period.

Adequate air changes are required by the activities within the building and the density of the occupancy for the summer period. A marginal reduction in the ingress of cold into the building during the day as well as night is needed. There has to be a reduction. Then reduction of humidity within the building throughout the day in some form or the other is needed during the monsoon period, and substantive increase in natural ventilation in all spaces is not really needed during the monsoon period.

So, this is what NBC says in its guidelines. Further, NBC also provides guidelines on the U values of the various wall assemblies, roof assemblies, vertical fenestration, and skylight glazing. So, the U values as well as, so you can see opaque wall assembly U values and insulation R values are given. Also, vertical fenestration U values and SHGC requirements are given. Skylight U value and SHGC requirement are given. Roof U value and insulation R value requirements have also been prescribed by NBC.

So, we have seen the composite climate comprising of warm, humid as well as hot-dry conditions. It is a combination of both climate characteristics predominantly, but if you specifically talk of Delhi, then we can see that Delhi has five climates. Delhi has extremely hot summers, and it is very common to see the impact of heat waves during the summers because the summers are so intense. So, there is a very high summer where the

temperatures are very high and the humidity is very low. Then there is the winter season, where the temperature takes a big dip, and then this again is an issue for human thermal comfort because we see homeless people also suffering.

So, the temperature can touch 1 degree to 3 degrees sometimes in Delhi during winter, and it becomes bitterly cold. Now, the design of buildings also gets primarily affected right from the choice of building materials because a building material that is extremely appropriate for the summer season may not be appropriate for winter. So, striking a balance is important. Beyond this, monsoons can get very, very heavy there. So during monsoon season again, the rainfall can be very heavy, and this can also be an issue.

The two moderate climates there would be the autumn and the spring. The spring is supposedly the most pleasant of all seasons. Now, according to these seasonal variations, the vegetation changes, and also, as architects and designers, we should be able to have (a) proper choice of material in this climate and (b) proper design guidelines or proper design solutions for this variation in the climate characteristics. So today we have seen the composite climate, taking Delhi as the example. In the next class, we will continue with temperate climate and cold climate characteristics. Until then, thank you.