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

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Lecture 01

Mahoney's Tables

Hello, dear students. So today, we will discuss Mahoney's table. The Mahoney Table is a simple tool for understanding the passive techniques that are suitable for a particular climate or location. Today, we will see how to use this tool and what it is all about. The Mahoney Table is a set of reference tables used in architecture as a pre-design analysis and guide for climate-appropriate design.

The various tables used in this type of analysis contain information pertaining to the area's climate. There is data about the climate of the area.

Then, there is a thermal stress analysis conducted. What happens at what temperature, you know, is that people there would feel very warm, or at what temperature it would be considered cold, as we discussed in our thermal comfort class. So, Mahoney's table consists of four parts. They are named after Carl Mahoney, who worked on them along with Martin Evans and Otto Königsberger. They were first published in 1971 by the United Nations Department of Economic and Social Affairs.

The tables use readily available climate data and simple calculations to give design guidelines, in a manner similar to a spreadsheet, as opposed to detailed thermal analysis or simulation.

There are four tables; two are used for entering climatic data, for comparison with the requirements for thermal comfort; and two for reading off appropriate design criteria. .

These tables use available climate data and incorporate simple calculations to provide design guidelines in a manner similar to that of a spreadsheet. It's more like an Excel sheet than a simulation is. .

The data required for us to understand the passive techniques are provided with the help of Mahoney's table. The first factor is the air temperature. You need to have data related to air temperatures.

You need the maximum temperature, the minimum temperature, and the average temperature for each month. So, for 12 months, you need the maximum, minimum, and mean temperature data.

You also need the humidity, precipitation, and wind data for that location. Again, you need the maximum, minimum, and mean figures for each of the twelve months. The conditions for which each month is classified into a humidity group are as follows: We will see how we progress in the class.

Then, there is a comparison of comfort conditions and climate. The desired maximum and minimum temperatures are entered to assess heat stress and cold stress. From the temperature entered in the tables, you will be able to determine the level of heat stress or cold stress; that is, whether the building will be too cold or too hot. .

From this data, you will calculate the Annual Mean Temperature or AMT, which is the average of the highest monthly mean maximum and lowest monthly mean minimum temperatures. So, this will be T maximum plus T minimum, divided by 2. I will explain all of this in detail in the upcoming slides, but I am just trying to familiarize you with these concepts now. The annual mean range, or AMR, is the difference between the highest maximum mean temperature and the lowest minimum mean temperature So, this is called "AMR.

There are four tables, essentially. The first table pertains to entering the basic climate data. What basic climate data is available? That is something I already told you in the earlier slides.

The maximum, minimum, and mean temperatures, humidity, wind data, and so on are included. Table 2 pertains to the diagnoses. Table 3 provides the recommended specifications. While Table 4 provides detailed recommendations, it does not include the necessary context.

So, what are indicator tables? Indicators are rules provided for combining the stress obtained from Table 3 and the humidity group from Table 2 to check a box that classifies the humidity and aridity of the location.
For each of the six possible indicators, the number of months during which each indicator was checked is summed, resulting in a total for the year. For this demonstration, we will use the climate data for Chennai, the capital of the state of Tamil Nadu in India. So, you can see that the average maximum and average minimum air temperatures are recorded this way. .

Then, the rainfall must be recorded in millimeters for all twelve months. The wind direction is also recorded as primary wind and secondary wind for all twelve months.

So, first, this is how you will set up the chart: You should complete this form for Chennai.

You have filled all of this out. So, we will fill this out in Tamil Nadu, and so on. Regardless of the data you have, what is the latitude?" 13.08 degrees north. What is the longitude of this location? 80.27 degrees East. What is the altitude? 6 meters.

This is Table 1, which is used to record the most essential temperature data. The first step is to input the monthly mean maximum temperature, which is the average of the maximum temperatures recorded each day of the month, and the monthly mean minimum temperature, which is the average of the minimum temperatures recorded each day of the month, as provided in the weather data you collected.

The next step is to find the monthly mean range, which is the difference between the monthly mean maximum and the monthly mean minimum. This will be entered in this row. The monthly mean maximum and the monthly mean minimum will be entered in the areas I have marked with a red box, and this is how it will appear.

What is this data. This data represents the maximum mean for January. It means from January 1, plus January 2, to January 31." The maximum temperature of that day, when divided by 31, represents the data we have.

The same thing applies to the average minimum temperature; thus, this will become the minimum, and the average is provided below. Then, after that, you need to fill in the monthly mean range. What is the mean monthly range? The monthly mean range is the difference between the monthly mean maximum and the monthly mean minimum. Here, we have observed that the monthly mean maximum is 29.8 degrees Celsius. The monthly mean minimum temperature is 20.1 degrees Celsius. That must be entered here. In the same way, how did you arrive at this conclusion? The monthly mean maximum for February is 31.6 degrees. The monthly mean minimum temperature for February is 20.8 degrees Celsius. The difference is 10.8. This must be entered in this row.

So, what will happen in the end? You will receive a range of figures, with the highest being 37.4. The highest monthly mean maximum must be entered here, and the lowest monthly mean minimum must also be entered here.
So, what are AMT and AMR? I have already told you about them.

That must be entered. So, we have our AMT and AMR.
Table 1: used to record the most essential climatic data

For temperature:

Step 1: input the monthly mean maximum temp. (the average of the maximum temperatures recorded for each day of a month) and monthly mean minimum temp. (the average of the minimum temperatures recorded for each day of a month) as given in the weather data collected.

Step 2: find out the monthly mean range, which is the difference between the monthly mean max. and monthly mean min.

Step 3: find the max. and min temperatures and fill in the high and low boxes respectively.

Step 4: calculate the annual mean temperature (AMT) by adding the high and low and dividing by 2.

Step 5: calculate the annual mean range (AMR) (for temperature) by subtracting the low from high.
You have to provide the monthly mean maximum and the monthly mean minimum; this is how they will appear.

For Chennai, these are the monthly mean maximum and monthly mean minimum temperatures obtained from the weather data files. For several months
What would the average be here.

The average here is clear. 93.8 plus 41.3, divided by 2, equals 67.55.

In this way, you can do this for each month, and you will obtain the average relative humidity.

For relative humidity:

Step 1: input the monthly mean maximum R.H and monthly mean minimum R.H as given in the weather data. In majority cases only the average R.H values are available and can be used directly.

Step 2: fill in the humidity group according to the categories given below.

Now, look at this table and fill in the humidity categories. Now that table indicates that if the humidity is 67.5, it falls into that category. So, here you will simply write "3." Similarly, 67.1 falls into this category; it is 3.0.
So, this will fall under the humidity category: Group 4. Similarly, this is 4, and that is also

4. In this way, you will enter the values for each month. And this is how your table will look after you enter the humidity group. Next, what will happen?

Here, we will feed in the direction of the wind for all twelve months of the year. Finally, after you fill in the total rainfall in millimeters, You should also add that information and include the total amount of rainfall. That amounts to 478 millimeters per year. For that year, it was probably the rain. The local weather data will provide you with this information, as well as information about rainfall.

Table 2 is used to diagnose climate data and develop a series of climate indicators. So, what you need to do is insert the monthly mean maximum and minimum temperatures, as well as the AMT, from the first data slide where we recorded the humidity group.

Do you remember that slide? Based on that, you need to write for each month. In the case of Chennai, we observed that the AMT is 28.8. In the case of Chennai, we observed that the AMT stands at 28.8. In this manner, you first fill in the average maximum temperatures for each month. Then, write the humidity group as follows: With the AMT provided in this table, this is a standard table, so it is not something you can modify. Everything that is grey-colored is standard and part of Mahoney's table, while all the non-grey entries are where you need to enter the data.

Therefore, you should check this, and then. You write the humidity group, and based on the combination of the AMT and the humidity group, what should you do? You should enter both the upper limit and the lower limit. In this way, you will write for each month.

Again, for the same reason, you should write down the lower limit. It is 23 degrees and 17 degrees. In this way, you fill in the entire row so that you can see that for February, it again consists of a combination of 28, 28.8, and 3. Therefore, this would be the amount you need to fill in for daytime comfort and nighttime comfort. However, when it comes to October, November, and December, the amount is 28.8, and the humidity group is 4. This is the color to which I will change it so that you can understand it.

For October, November, and December, it is a combination of this AMT and the humidity group. You enter a comfort range of 22 to 27 degrees, while the minimum, as stated here, is between 17 and 21 degrees. ; .

So, after you enter this, it means that 29.8 is greater than 29. The mean is above the limit; therefore, it is either warm or hot. So, you describe thermal stress during the day as being hot. In this way, you provide information for each item.

So, pick a month and consider its thermal stress for both day and night, as well as for

rainfall, humidity, and the monthly mean range. So, for January, we know that the thermal stress during the day is H, and at night, it is O.

Step 1: Insert the monthly mean max. and min. temperature and AMT from the 1st data slide (also write humidity group for each month for reference)

Step 2: By considering the value of AMT, decide which comfort limit table is applicable (in the case of Chennai; AMT= 28.8 hence comfort limit table of 'AMT over 20 °C' is applicable)

Step 3: Find the upper and lower limit for day and night comfort by selecting the values corresponding to the humidity group of that month (for example: January humidity group is 3 hence day comfort upper and lower limits are 23 and 29 respectively)

Step 4: To find the **thermal stress** of the day, compare the mean max. temp. with the limits of day comfort of that month. If the monthly mean max is above the upper limit then thermal stress is HOT (H), if it is within the limits then thermal stress is COMFORT (O), and COLD (C) if it is below lower limit.

Step 5: Similarly, find the thermal stress for night.

For the Indicator Table

Step 1: Pick a month and take its thermal stress for day and night, rainfall, humidity group and monthly mean range. We will take the example of May

Step 2: Similarly do for all months and tally it at the end.

The humidity level is 30%. The monthly mean range is 9.7. With this combination, you will achieve air movement, which is crucial. The combination suggests that you will need air movement in January.
The humidity level is 30%. See, this is H. During the day, it remains H. You see, the humidity level is 30 percent.
The monthly mean range must be less than 10. That is what the indicator indicates.

We will mark this as the indicator, H1, and we will indicate H1 here. Let us take a look at what February is like. Now, in February again, the thermal stress during the day is high. The rainfall is zero. Therefore, there is no rainfall. The humidity level is 30%. The monthly mean range is 10.8. Therefore, we consider thermal capacity to be necessary for the month of February. In March, thermal stress is high, with hot temperatures both during

the day and at night.

Rainfall is 0, and the humidity level is 3%. The humidity group of three is either this or that. We must choose between the two options.
The average monthly range is 10.9. If it had been less than 10, we would have chosen this option. So, we will choose the thermal capacity needed for March

What is the data for April? The data again show that thermal stress during the day is high. The rainfall is zero. The humidity is 30%. The monthly mean range is now less than 10. Therefore, we choose this box, H1, which indicates that air movement is essential.

In May again, if you see that the monthly mean range is less than 10, The humidity level is 30%. The day is H; therefore, only this fits the bill, and air movement is essential.

Once again in April, we received data indicating that the monthly mean range was less than 10. Then you have a humidity group of 3, which again fits this description; therefore, we will say that air movement is essential. Then, we will examine July in a similar manner, emphasizing that air movement is essential.

What happens in August? Then we look at September, where the monthly mean range is again less than 10, the humidity group is 3, thermal stress is classified as H, and rainfall is less than 56 mm. So, we get H_1. Similarly, what we do in October, we will also do in November, and we will prepare for December.

In H1, there are 10 months, and in A1, there are 2 months. So, what do these indicators mean? So, this applies to places that typically have a large diurnal range. What is a large diurnal range?
If we look at A2, it indicates the desirability of having an outdoor sleeping area. It is now needed when the nighttime temperature is high and the humidity is low.

The Mahoney tables establish a relationship between climate indicators and building designs. This applies when high temperatures are combined with high humidity or when high temperatures are combined with moderate humidity and a small diurnal range.

H3 indicates that precautions against rain penetration are needed, and problems may arise even with low precipitation; however, they will be inevitable when rainfall exceeds 200 mm per month. Based on what we saw in Table 3, it translates the indicators into performance specifications.

If you remember, we had to mark H1, tick against H1 and A1, and do things like that. . . So, check the requirements for each design strategy and mark them wherever applicable.

Because we had the total number of months under H1 as 10 and the total number of months against A1 as 2, as you may remember from that slide. Once we add that, this will be the recommendation we receive. Once again, the openings can be medium-sized, and the walls can be lightweight, with a short time lag.

Because this is for ages 0 to 2 months, it corresponds to an A1 rating. Again, when A1 is between 0 and 5, a light-insulating roof is required. ; If this were between 2 and 12, then protection from heavy rain would have been necessary; however, it is less than 2.

So, let's examine what correlates with the indicator we have, whether it is this, that, or something else.

So, for this, we have A1; this is the criterion we will use for selection. It states that we must have low thermal capacity. Our A1 is between 2 and 2.0, so it falls within this range, and H1 is between 10 and 12. This means we should have a light-reflective surface with possibly cavity walls.

Again, this is between 10 and 12, so we could also consider using lightweight and well-insulated walls. Regarding Vadodara, which we consider to have a hot, dry climate, I will also examine another cold climate.

We will see what the outcome will be. For Vadodara, I have already filled in the average maximum air temperature, average minimum air temperature, average maximum relative humidity, average minimum relative humidity, average rainfall, and wind direction. After filling this out, I calculated the AMT and AMR, along with the high and low values. I have also noted the monthly mean maximum and monthly mean minimum relative humidity, calculated the average relative humidity, and entered the humidity groups. .

Okay, let's say I entered 2 because it fits into that category
As I demonstrated in Chennai, my findings were well received. I have recorded the rainfall.

The wind direction is clear.

So, when I make the diagnosis I find that It is very comforting. It is quite comforting. And it is cold.

Therefore, it is due to a combination of factors. So, an AMT of 27.5 corresponds to a humidity group of 2. So, this is the humidity group. So, I need to check where and what

data I should enter. This is what I will enter because my AMT for Vadodara is 27.5. So, I will enter this range, 25 to 31, and this range, 17 to 24, here, and I will perform the further calculations as I showed previously. Then, based on this, I am also working on the indicators. So, after I complete the indicators, as I have already demonstrated, we will proceed with the recommended specifications. The recommended specifications relate to layout, spacing, and air movement.

Then, when it comes to openings, we consider having medium openings that range from 20% to 40%. Walls must be heavy on both the outside and the inside.

That is what this diagnosis indicates. Okay: So, do not judge me. Based on the data we entered and obtained from the MET department, this is the diagnosis. Here are the detailed recommendations: the size of the opening should be very small, and the north and south openings should be at body height on the windward side.

We must exclude direct sunlight. Additionally, the walls and floors must be heavy, with a time lag of over eight hours, and the roof must also be heavy, with a time lag of more than eight hours.

We will consider Shillong to have a cold climate.' I am entering the data, having already entered the air temperature, monthly mean maximum, monthly mean minimum, and monthly mean range.

Similarly, I have entered the monthly mean maximum and minimum temperatures, relative humidity data, and average values. Based on this, I have categorized the humidity groups. So, this is above 70; therefore, the humidity group is also above 70. Everywhere the average humidity is above 70, the humidity group consistently remains at 4 for all twelve months.

Then I enter the rainfall for each month and calculate the total rainfall in millimeters. Then, I will enter the prevailing wind direction and proceed to the diagnostic table. So, when I see the diagnosis table as a combination of AMT and humidity groups, I input the thermal stress based on that combination. So, this is 4, and 16 will go here.

The number is between 15 and 20. I received the indicators indicating that under H2 I have 10 months, under H3 I have 5 months, and under A3 I have 2 months. Based on this, the recommended specifications are that we should have compact courtyard planning with a compact layout of estates; we should have double-banked rooms with temporary provisions for air movement; we must have large openings, and the walls should be lightweight with short-term lag.

The roof should be a lightweight insulated roof, and the openings should be large. The position of the openings in the north and south at body height on the windward side requires us to protect them from direct sunlight and to provide protection from rain. This is what the recommendations indicate. It also states that we should have a light, low-thermal-capacity wall and that the roof must have a light-reflective surface.

After this, we will compare all the recommendations for the three types of climate. Now, if you look at the comparison, you can see that Chennai is warm and humid, Vadodara is hot and dry, and Shillong, in Meghalaya, is cold. Now, for warm, humid, and hot, dry climates, it is stated that the orientation should be along the north-south axis. Whereas Shillong is characterized by compact courtyard planning, it also features a unique blend of cultural influences. For warm, humid, and hot, dry conditions, it is stated that open space is needed for breeze penetration; however, protection from both hot and cold winds is also necessary. The same applies to Vadodara.

Whereas Shillong should have a double-banked room with a temporary provision for air circulation, it is important to consider other factors as well. The openings must be medium-sized for warm, humid, and hot, dry climates, whereas large openings of 40 to 80 percent are specified for cold climates. Now, the walls for warm, humid climates should be light with a short time lag, while for hot, dry climates, they should have heavy external and internal walls. In contrast, for Shillong, they should have light walls with a short time lag.

Again, a roof suitable for warm, humid climates is a light-insulated roof, whereas for Vadodara, it is a heavy roof with an 8-hour time lag. In Shillong, roofs are said to be insulated against the heat. Provision for outdoor sleeping is required for warm and humid conditions, as well as for hot and dry conditions, indicating that space for outdoor sleeping is necessary. For hot and dry weather, it provides protection against heavy rain. What I am trying to convey by comparing is that, while most of the recommendations are valid, these tables are not completely accurate, as you can observe from this slide, for two reasons.

Reason one is that it depends on the input values or the weather data files. Now, weather data has changed due to climate change. Therefore, what you insert for one year may not be valid for the other years. Now, according to this table, it states that protection from heavy rain is necessary in hot and dry climates. Now, according to this table, protection from heavy rain is stated to be necessary in hot and dry climates.

Today, we are experiencing very heavy rainfall, even in desert areas. So, for all you know, what this table says might be accurate. However, it is not very logical.Therefore, all I am trying to say is that these tables provide fairly good rule-of-thumb recommendations on which passive strategies we should use.

So, be very careful when entering generic data. Data for the generic year should be entered, not data from a year in which something unusual occurred at that particular location. Do not enter that year to get your recommendations. Today, we saw a very simple tool that does not require any major skills other than entering the data and following the instructions provided to you in order to make decisions.

You will also receive all the thumb rules for simple, passive techniques. With this, I will conclude today's class. In future classes, we will see how this is converted into an intensive simulation software program.

For now, I will end today's class. Thank you very much.