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# DESIGN RECOMMENDATIONS FOR BUILDINGS IN CHENNAI USING MAHONEY TABLE

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## ABSTRACT
In the current scenario, the necessity of sustainable living environment is the essential need of the hour. The recent expansion of the Chennai metropolitan area as a Greater Chennai Corporation by inclusion of suburban zones makes it as one of the fastest growing cities. In addition to that Chennai city developed more infrastructure development in almost all areas that also includes "smart city" project. These types of infrastructure development lead to various climatic issues bringing negative impact on the environment leading to blocking of gifts of nature like air, wind, water. However, we cannot give up development of city since it is economically essential for the development of industries which totally depends on manual labour who are to be accommodated in these building structures. This does not mean that we can compromise with the natural environment. Even in the past, our earlier generations were aware of the benefits from certain climatic features by adopting appropriate building design. This paper gives an intuition into the design recommendations for climatic design approaches for the city of Chennai through Mahoney calculation.

**Keywords:** Climate parameters, Mahoney calculation, Design recommendations

## INTRODUCTION
The Mahoney tables are very useful traditional tools to give design solution for buildings with a set of reference tables used as a guide for the climatic design.

## CLIMATIC PARAMETERS
As per NBC (National Building Code) India can be divided into five climatic zones, namely, hot and dry, warm and humid, composite, temperate and cold.
Chennai is categorized as Warm and Humid climate.
Generally, Climate is defined as 'Region with certain conditions of temperature, dryness, wind, light, etc'.
Temperature of the air is measured in Celsius(°C). It is also called as dry bulb temperature.

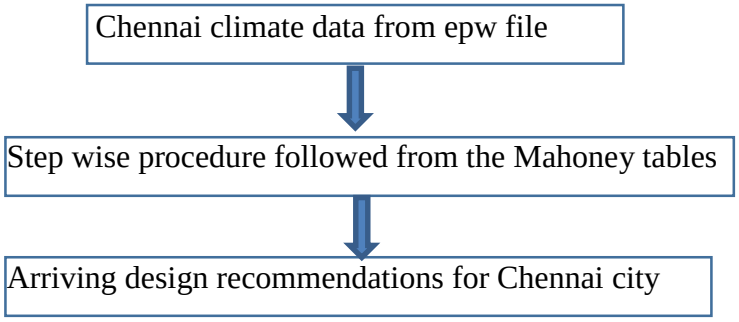
Table 1: Temperature

| Daily mean temperature | 24 hours reading (per day) | Average from 24 hours |
|---|---|---|
| Mean monthly temperature | 30 days (average of a month) reading | Average of a month /30 |
| Monthly mean maximum temperature | Each days maximum temperature | Average of each days maximum temperature /30 |
| Monthly mean minimum temperature | Each days minimum temperature | Average of each days minimum temperature /30 |

Relative humidity is the amount of water in the air compared to the amount of water that the air could possibly hold.
Humidity Ratio (HR or AH): How much water present in one gm of air (gm of water/gm of dry air).
Relative Humidity (RH): Amount of air in the form of percentage (related with temperature).
Saturation line - (100 % humidity).
Dew point - It is the temperature of saturated air.
Specific volume - It is the volume per gram of dry air m3/g.
Wind is the movement of air due to a difference in atmospheric pressure, caused by differential heating of land and water mass on the earth's surface by solar radiation and rotation of earth. Measured in m/s or km/hr.
Precipitation is a collective term used for rain, snow, dew etc. It is expressed in mm/day. Mean rainfall in mm/month.
Solar radiation is the radiant energy received from the sun. It is the intensity of sunrays falling per unit time per unit area and is usually expressed in Watts per square metre (W/m2). The radiation incident on a surface varies from moment to moment depending on its geographic location.

## METHODOLOGY

This paper aims to comprehend the design guidelines in the design stage from the recommendations of Mahoney table.
The climate data for the study is carried out with epw (Energy Plus weather format) file. EPW File is available for free in online from ISHRAE (The Indian Society of Heating, Refrigerating and Air Conditioning Engineers)




## CLIMATE DATA

Table 2: Climatic Data for Chennai

| Year and month | Chennai | | | | |
|---|---|---|---|---|---|
| | Max. Mean temp. | Min. Mean temp. | Humidity in % | | Rainfall in mm |
| | | | Monthly mean max.a. m | Monthly mean min.p.m | |
| January | 29 | 19.5 | 93 | 55 | 35.3 |
| February | 31 | 21 | 93 | 46 | 13 |
| March | 33 | 23.5 | 94 | 62 | 14.5 |
| April | 34 | 26 | 87 | 55 | 15.9 |
| May | 36.5 | 27 | 85 | 50 | 42.4 |
| June | 36 | 26.5 | 80 | 48 | 53.9 |
| July | 34 | 26.5 | 78 | 57 | 99.6 |
| August | 33.5 | 25.5 | 82 | 53 | 129.9 |
| September | 33.5 | 25 | 88 | 53 | 123.5 |
| October | 33.5 | 24 | 96 | 65 | 284.6 |
| November | 31.5 | 22.5 | 96 | 72 | 353.0 |
| December | 28.5 | 21 | 92 | 60 | 146.3 |

## PROCEDURE FOR DESIGN RECOMMENDATIONS FROM THE MAHONEY TABLES

Table 3: Location

| | |
|---|---|
| **Location** | Chennai |
| **Longitude** | 80.18˚E |
| **Latitude** | 13.00˚N |
| **Altitude** | 16m |

Table 4: Air temperature: °C

| | J | F | M | A | M | J | J | A | S | O | N | D | | High | AMT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly mean max | 29 | 31 | 33 | 34 | **36.5** | 36 | 34 | 33.5 | 33.5 | 33.5 | 31.5 | 28.5 | | 36.5 | 28 |
| Monthly mean min | **19.5** | 21 | 23.5 | 26 | 27 | 26.5 | 26.5 | 25.5 | 25 | 24 | 22.5 | 21 | | 19.5 | 17 |
| Monthly mean range | 9.5 | 10 | 9.5 | 8 | 9.5 | 9.5 | 7.5 | 8 | 8.5 | 9.5 | 9 | 7.5 | | Low | AMR |

Table 5: Relative humidity: %

| | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly mean max. a.m | 93 | 93 | 94 | 87 | 85 | 80 | 78 | 82 | 88 | 96 | 96 | 92 |
| Monthly mean min. p.m | 55 | 46 | 62 | 55 | 50 | 48 | 57 | 53 | 53 | 65 | 72 | 60 |
| Average | 74 | 69.5 | 78 | 71 | 67.5 | 64 | 67.5 | 67.5 | 70.5 | 80.5 | 84 | 76 |
| Humidity group | **4** | **3** | **4** | **4** | **3** | **3** | **3** | **3** | **4** | **4** | **4** | **4** |

Table 6: Reference Table (Humidity group)

| | | |
|---|---|---|
| Humidity group | 1 | If average RH: below 30 % |
| | 2 | 30-50 % |
| | 3 | 50-70% |
| | 4 | Above 70 % |

Table 7: Rainfall data

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall,mm | 35.3 | 13 | 14.5 | 15.9 | 42.4 | 53.9 | 99.6 | 130 | 124 | 285 | 353 | 146 | **1312** |

Table 8: Reference Table (Comfort limits in term of temperature and the humidity group)

| | | AMT over 20 °C | | AMT 15-20 °C | | AMT below 15 °C | |
|---|---|---|---|---|---|---|---|
| Comfort limits | | Day | Night | Day | Night | Day | Night |
| Humidity groups | 1 | 26-34 | 17-25 | 23-32 | 14-23 | 21-30 | 12-21 |
| | 2 | 25-31 | 17-24 | 22-30 | 14-22 | 20-27 | 12-20 |
| | 3 | 23-29 | 17-23 | 21-28 | 14-21 | 19-26 | 12-19 |
| | 4 | 22-27 | 17-21 | 20-25 | 14-20 | 18-24 | 12-18 |

Table 9: Nature of thermal stress

| | J | F | M | A | M | J | J | A | S | O | N | D | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly mean max | 29 | 31 | 33 | 34 | 36.5 | 36 | 34 | 33.5 | 33.5 | 33.5 | 31.5 | 28.5 | 28 | AMT |
| Day comfort: upper | 27 | 29 | 27 | 27 | 27 | 29 | 31 | 29 | 27 | 27 | 27 | 27 | | |
| lower | 22 | 23 | 22 | 22 | 23 | 25 | 23 | 22 | 22 | 22 | 22 | 22 | | |
| Monthly mean min | 19.5 | 21 | 23.5 | 26 | 27 | 26.5 | 26.5 | 25.5 | 25 | 24 | 22.5 | 21 | | |
| Night comfort:upper | 21 | 23 | 21 | 21 | 21 | 23 | 24 | 23 | 21 | 21 | 21 | 21 | | |
| lower | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | | |
| Thermal stress: day | H | H | H | H | H | H | H | H | H | H | H | H | | |
| night | O | O | H | H | H | H | H | H | H | H | H | O | | |

H (hot) -if mean is above limit

O (comfort) –if mean is within limit

C (cold) –if mean is below the limit

Table 10: Indicators (six ‘indicators’ (three humid indicator H 1, 2, 3 and three ‘arid indicators’ A 1, 2, 3)

| | J | F | M | A | M | J | J | A | S | O | N | D | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Humid:H1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | 10 | Totals |
| H2 | | | | | | | | | | | | | 0 | |
| H3 | | | | | | | | | | ✓ | ✓ | | 2 | |
| Arid: A1 | | | | | | | | | | | | | 0 | |
| A2 | | | | | | | | | | | | | 0 | |
| A3 | | | | | | | | | | | | | 0 | |

Table 11: Reference Table (Indicators)

| Applicable when: | Indicator | Thermal stress | | Rainfall | Humidity Group | Monthly mean range |
|---|---|---|---|---|---|---|
| | | Day | Night | | | |
| Air movement essential | H1 | H | | | 4 | |
| | | H | | | 2,3 | Less than 10 |
| Air movement desirable | H2 | O | | | 4 | |
| Rain protection necessary | H3 | | | Over 200mm | | |
| Thermal capacity necessary | A1 | | | | 1,2,3 | More than 10 |
| Out-door sleeping desirable | A2 | | H | | 1,2 | |
| | | H | O | | 1,2 | More than 10 |
| Protection from cold | A3 | C | | | | |

## RECOMMENDED SPECIFICATIONS

| Indicator Totals from Table10 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| H1 | H2 | H3 | A1 | A2 | A3 | | | |
| 10 | 0 | 2 | 0 | 0 | 0 | | | |
| **Layout** | | | | | | | | |
| | | | 0-10 | | | ✓ | **1** | **Orientation north and south (long axis east-west)** |
| | | | 11,12 | | 5-12 | | | |
| | | | | | 0-4 | | 2 | Compact courtyard planning |
| **Spacing** | | | | | | | | |
| 11,12 | | | | | | | 3 | Open spacing for breeze penetration |
| 2-10 | | | | | | ✓ | **4** | **As 3, but protection form hot and cold wind** |
| 0,1 | | | | | | | 5 | Compact lay-out of estates |
| **Air movement** | | | | | | | | |
| 3-12 | | | | | | ✓ | **6** | **Rooms single banked, permanent provision for air movement** |
| 1,12 | | | 0-5 | | | | | |
| | | | 6-12 | | | | 7 | Double banked rooms, temporary provision for air movement |
| 0 | 2-12 | | | | | | | |
| | 0,1 | | | | | | 8 | No air movement requirement |
| **Openings** | | | | | | | | |
| | | | 0,1 | | 0 | ✓ | **9** | **Large openings, 40-80%** |
| | | | 11,12 | | 0,1 | | 10 | Very small openings, 10-20% |
| Any other conditions | | | | | | | 11 | Medium openings, 20-40% |
| **Walls** | | | | | | | | |
| | | | 0-2 | | | ✓ | **12** | **Light walls, short time-lag** |
| | | | 3-12 | | | | 13 | Heavy external and internal walls |
| **Roofs** | | | | | | | | |
| | | | 0-5 | | | ✓ | **14** | **Light, insulated roofs** |
| | | | 6-12 | | | | 15 | Heavy roofs, over 8 h time-lag |
| Out-door sleeping | | | | | | | | |
| | | | | 2-12 | | | 16 | Space for out-door sleeping required |
| Rain protection | | | | | | | | |
| | | 3-12 | | | | | 17 | Protection from heavy rain necessary |

## LIST OF DETAILED RECOMMENDATIONS

| Indicator Totals from Table 2 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| H1 | H2 | H3 | A1 | A 2 | A3 | | | |
| 10 | 0 | 2 | 0 | 0 | 0 | | | |
| **Size of opening** | | | | | | | | |
| | | | 0-1 | | 0 | ✓ | **1** | **Large 40%-80%** |
| | | | | | 1-12 | | 2 | Medium 25%-40% |
| | | | 2-5 | | | | | |
| | | | 6-10 | | | | 3 | Small 15%-25% |
| | | | 11-12 | | 0-3 | | 4 | Very Small 10%-20% |
| | | | | | 4-12 | | 5 | Medium 25%-40% |
| **Position of Openings** | | | | | | | | |
| 3-12 | | | | | | ✓ | **6** | **In north and south walls at body height on windward side** |
| 1-2 | | | 0-5 | | | | | |
| | | | 6-12 | | | | 7 | As above, opening also in internal walls |
| 0 | 2-12 | | | | | | | |
| **Protection of Openings** | | | | | | | | |
| | | | | | 0-2 | ✓ | **8** | **Exclude direct sunlight** |
| | | 2-12 | | | | ✓ | **9** | **Provide Protection from rain** |
| **Walls and Floors** | | | | | | | | |
| | | | 0-2 | | | ✓ | **10** | **Light low thermal capacity** |
| | | | 3-12 | | | | 11 | Heavy over 8h time lag |
| **Roofs** | | | | | | | | |
| 10-12 | | | 0-2 | | | ✓ | **12** | **Light, reflective surface, Cavity** |
| | | | 3-12 | | | | 13 | Light, well insulated |
| 0-9 | | | 0-5 | | | | | |
| | | | 6-12 | | | | 14 | Heavy over8h time lag |
| **External features** | | | | | | | | |
| | | | | 1-12 | | | 15 | Space for outdoor sleeping |
| | | 1-12 | | | | ✓ | **16** | **Adequate rain water drainage** |

Table 12: Design recommendations for Chennai

| S. No | Design parameters | Design recommendations from Mahoney tables |
|---|---|---|
| 1 | Layout | Orientation north and south (long axis east-west) |
| 2 | Spacing | Open spaces for breeze penetration, but protection from hot and cold winds |
| 3 | Air movement | Rooms single banked with permanent provision for air movement |
| 4 | Openings | Large openings, 40% - 80% |
| 5 | Position of openings | In windward side at body height |
| 6 | Walls | Light walls, short time -lag |
| 7 | Roofs | Light, insulated roofs |
| 8 | External features | Adequate rainwater drainage |

## CONCLUSIONS

Based on the above calculations and ultimately as highlighted in Table 12 it is recommended to adopt these design guidelines specifically for Chennai city. Chennai which is classified under warm and humid climate has to adhere to those strategies as Mahoney Table is considered as a traditional tool for creating climatic building design. These initial recommendations help the designer to design the environment in such a way by enjoying natural gifts for all the living systems. The advantages of these sustainable tools bring the energy efficient building design with building components and building materials playing an important role in providing thermal comfort to the users.

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