Sardar Vallabhbhai National Institute of Technology

SURAT

CERTIFICATE

This is to certify that **"Kandarp Rajyaguru"** of M.tech urban planning (Ist semester) has satisfactory completed his Graduate Report on **"Housing Design and Climate"** during academic year 2016 – 2017.

Date: / /2016

Signature of Guide

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Kandarp Rajyaguru

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Thank You

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1. INTRODUCTION

The weather of a place represents the state of the atmospheric environment over a brief period of time. Integrated weather condition over several years is generally referred to as climate or more specifically, as the ‘macro-climate’. An analysis of the climate of a particular region can help in assessing the seasons or periods during which a person may experience comfortable or uncomfortable conditions. It further helps in identifying the climatic elements, as well as their severity, that cause discomfort. The information helps a designer to build a house that filters out adverse climatic effects, while simultaneously allowing those that are beneficial. Discomfort and the corresponding energy demand for mechanical systems can be significantly reduced by judicious control of the climatic effects. The built-form and arrangement of openings of a building can be suitably derived from this analysis.

In this chapter, we will review the various aspects of climate and the methods of its analysis. This includes a brief description of the various climatic factors and climatic zones of India. The design requirements of buildings in different climatic zones are discussed and tabulated. Illustrative examples provide information on how to analyse the climatic conditions of a place.

2. FACTORS AFFECTING CLIMATE

Both weather and climate are characterised by the certain variables known as climatic factors.

They are as follows:

(A) Solar radiation

(B) Ambient temperature

(C) Air humidity

(D) Precipitation

(E) Wind

(F) Sky condition

2.1 Solar Radiation

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 (latitude and longitude of the place), orientation, season, time of day and atmospheric conditions. Solar radiation is the most important weather variable that determines whether a place experiences high temperatures or is predominantly cold. The instruments used for measuring of solar radiation are the pyranometer and the pyrheliometer. The duration of sunshine is measured using a sunshine recorder.

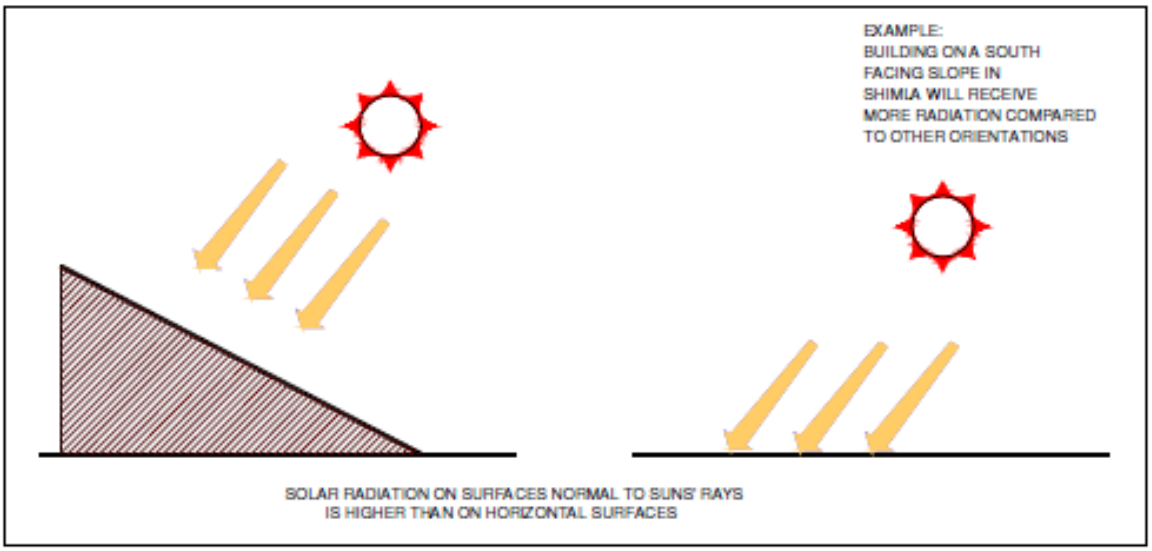


Figure 1: Effect of Orientation on Solar Radiation

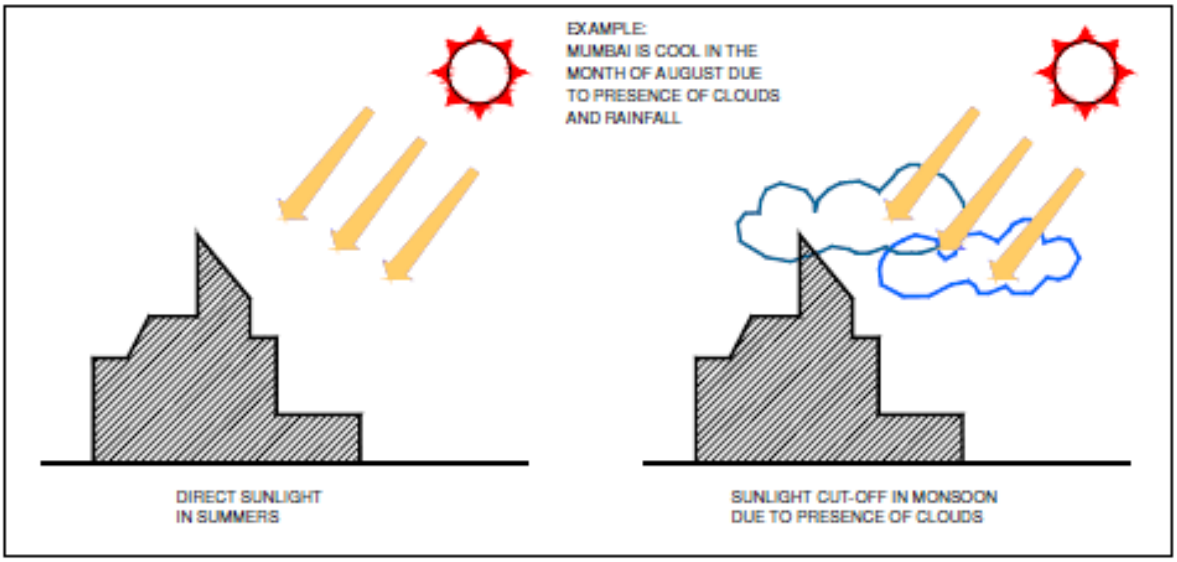


Figure 2: Effect of Skycover on Solar Radiation

2.2 Ambient Temperature

The temperature of air in a shaded (but well ventilated) enclosure is known as the ambient temperature; it is generally expressed in degree Celsius (ºC). Temperature at a given site depends on wind as well as local factors such as shading, presence of water body, sunny condition, etc. When the wind speed is low, local factors strongly influence on temperature of air close to the ground. With higher wind speeds, the temperature of the incoming air is less affected by local factors.

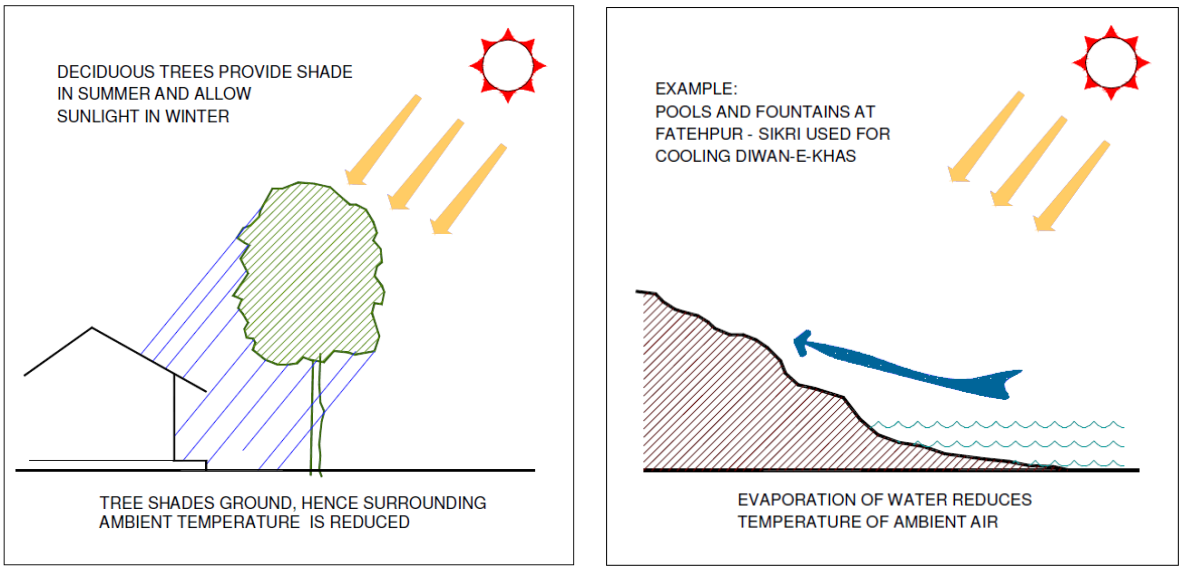


Figure 3: Effects of shading and water body on ambient temperature.

2.3 Air Humidity

Air humidity, which represents the amount of moisture present in the air, is usually expressed in terms of 'relative humidity'. Relative humidity is defined as the ratio of the mass of water vapour in a certain volume of moist air at a given temperature, to the mass of water vapour in the same volume of saturated air at the same temperature; it is normally expressed as a percentage. It varies considerably, tending to be the highest close to dawn when the air temperature is at its lowest, and decreasing as the air temperature rises. The decrease in the relative humidity towards midday tends to be the largest in summer. In areas with high humidity levels, the transmission of solar radiation is reduced because of atmospheric absorption and scattering. High humidity reduces evaporation of water and sweat. Consequently, high humidity accompanied by high ambient temperature causes a lot of discomfort.

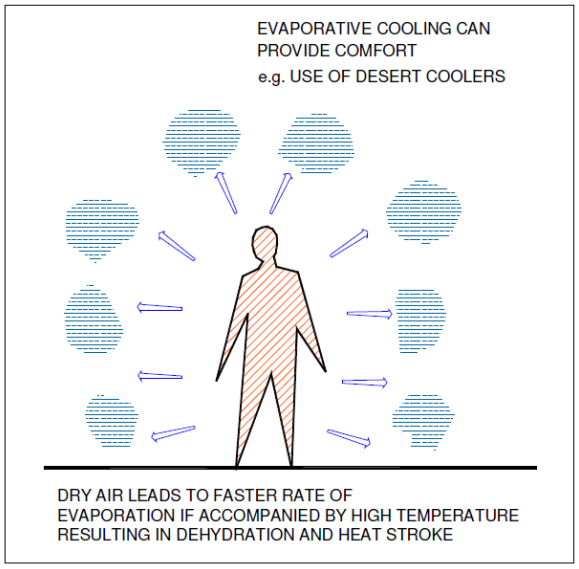


Figure 4: Effect of High Temperature and Low humidity

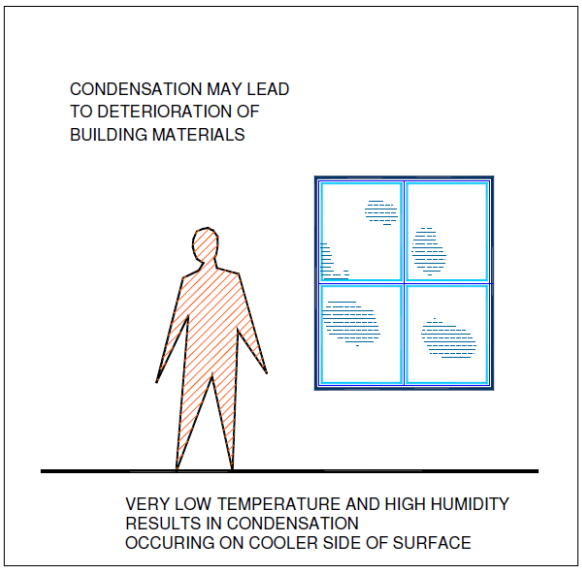


Figure 5: Effect of low temperature and high humidity

2.4 Precipitation

Precipitation includes water in all its forms rain, snow, hail or dew. It is usually measured in millimetres (mm) by using a rain gauge.

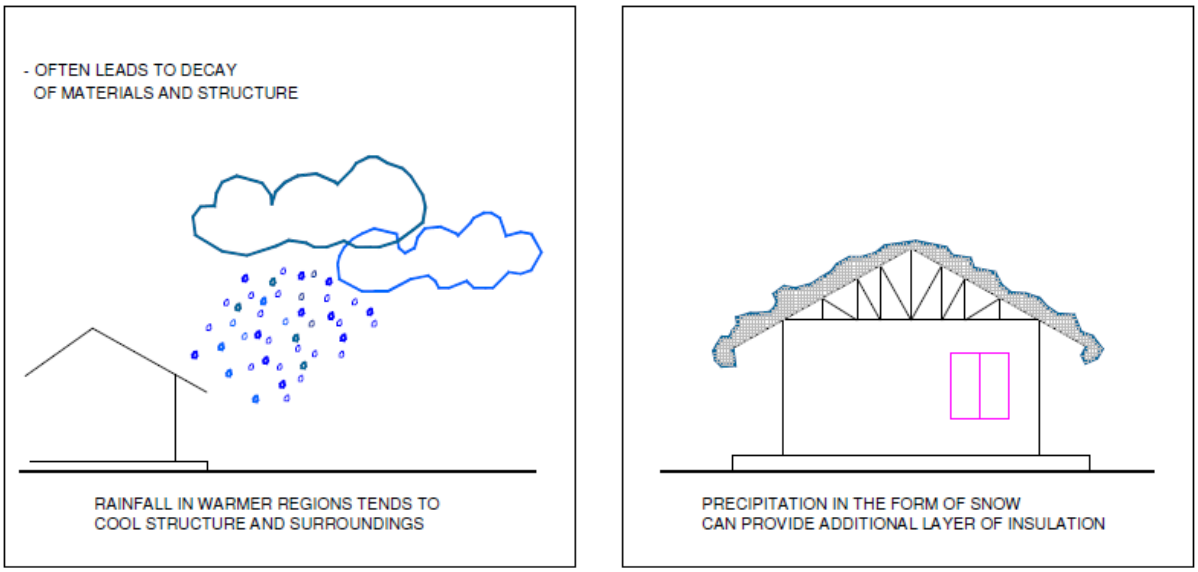


Figure 6: Effect of Precipitation on housing designs

2.5 Wind

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. Wind speed can be measured by an anemometer and is usually expressed in metres per second (m/s). It is a major design consideration for architects because it affects indoor comfort conditions by influencing the convective heat exchanges of a building envelope, as well as causing air infiltration into the building.

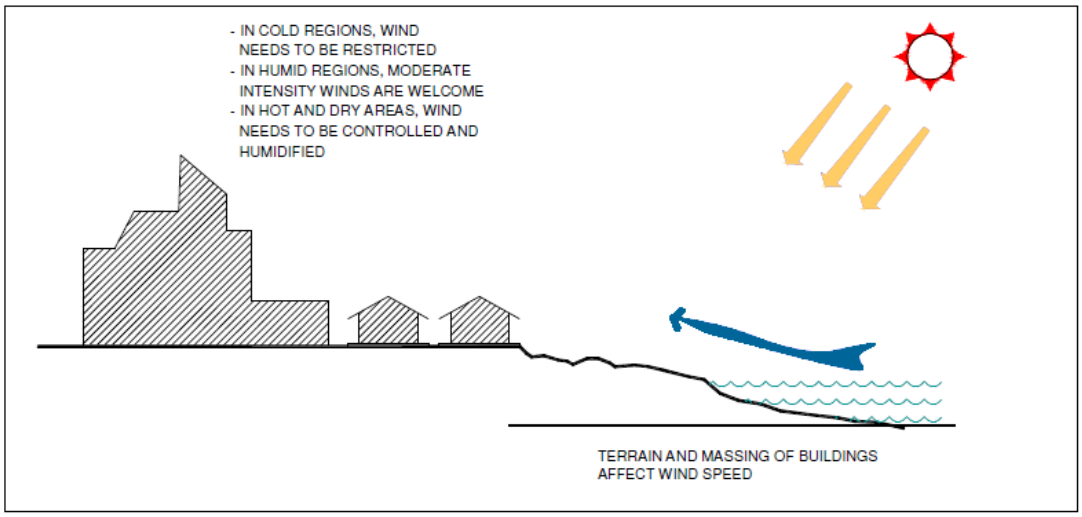


Figure 7: Factors affecting wind

2.6 Sky Conditions

Sky condition generally refers to the extent of cloud cover in the sky or the duration of sunshine. Under clear sky conditions, the intensity of solar radiation increases; whereas it reduces in monsoon due to cloud cover. The re-radiation losses from the external surfaces of buildings increase when facing clear skies than covered skies.

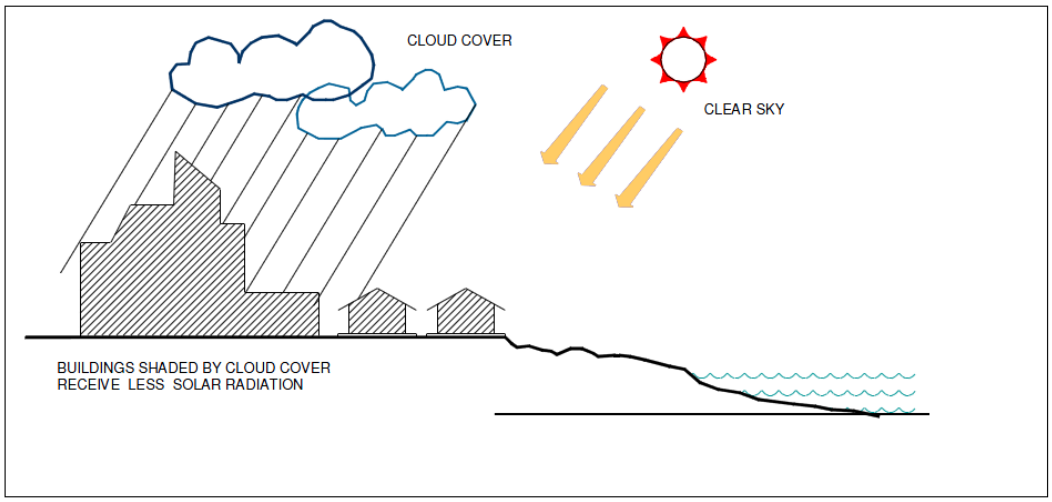


Figure 8: Factors affecting sky conditions

3. CLIMATIC ZONES OF INDIA

Regions having similar characteristic features of climate are grouped under one climatic zone. Based on the climatic factors discussed in the previous section, the country can be divided into a number of climatic zones.

- Hot and Dry
- Warm and Humid
- Moderate
- Cold and Cloudy
- Cold and Sunny
- Composite

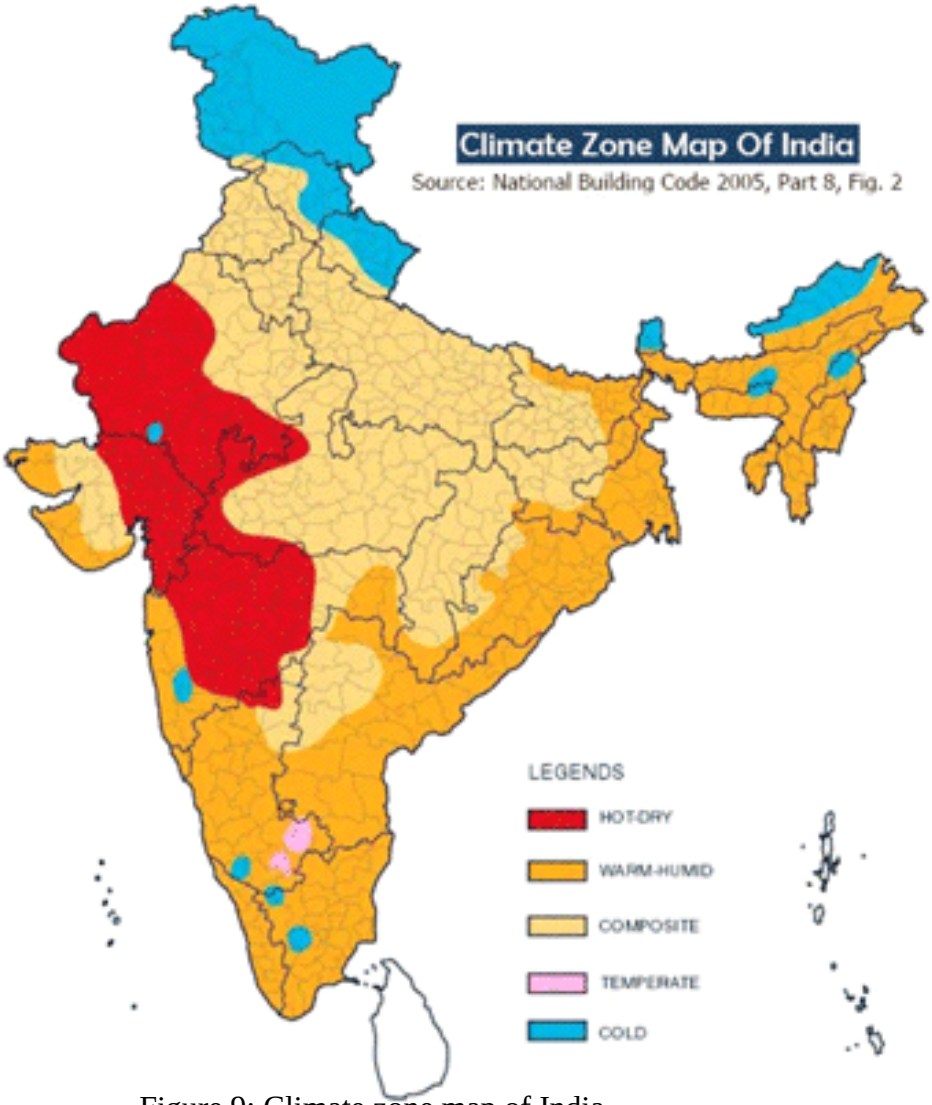


Figure 9: Climate zone map of India.

4. IMPLICATIONS OF CLIMATE ON BUILDING DESIGN

The characteristics of each climate differ and accordingly the comfort requirements vary from one climatic zone to another. Before proceeding further, it would be useful to define comfort and the conditions that affect it. According to ASHRAE, thermal comfort is, "that condition of mind which expresses satisfaction with the thermal environment". It is also, "the range of climatic conditions within which a majority of the people would not feel discomfort either of heat or cold". Such a zone in still air corresponds to a range of 20 – 30 ºC dry bulb temperature with 30 – 60 % relative humidity. Besides, various climatic elements such as wind speed, vapour pressure and radiation also affect the comfort conditions.

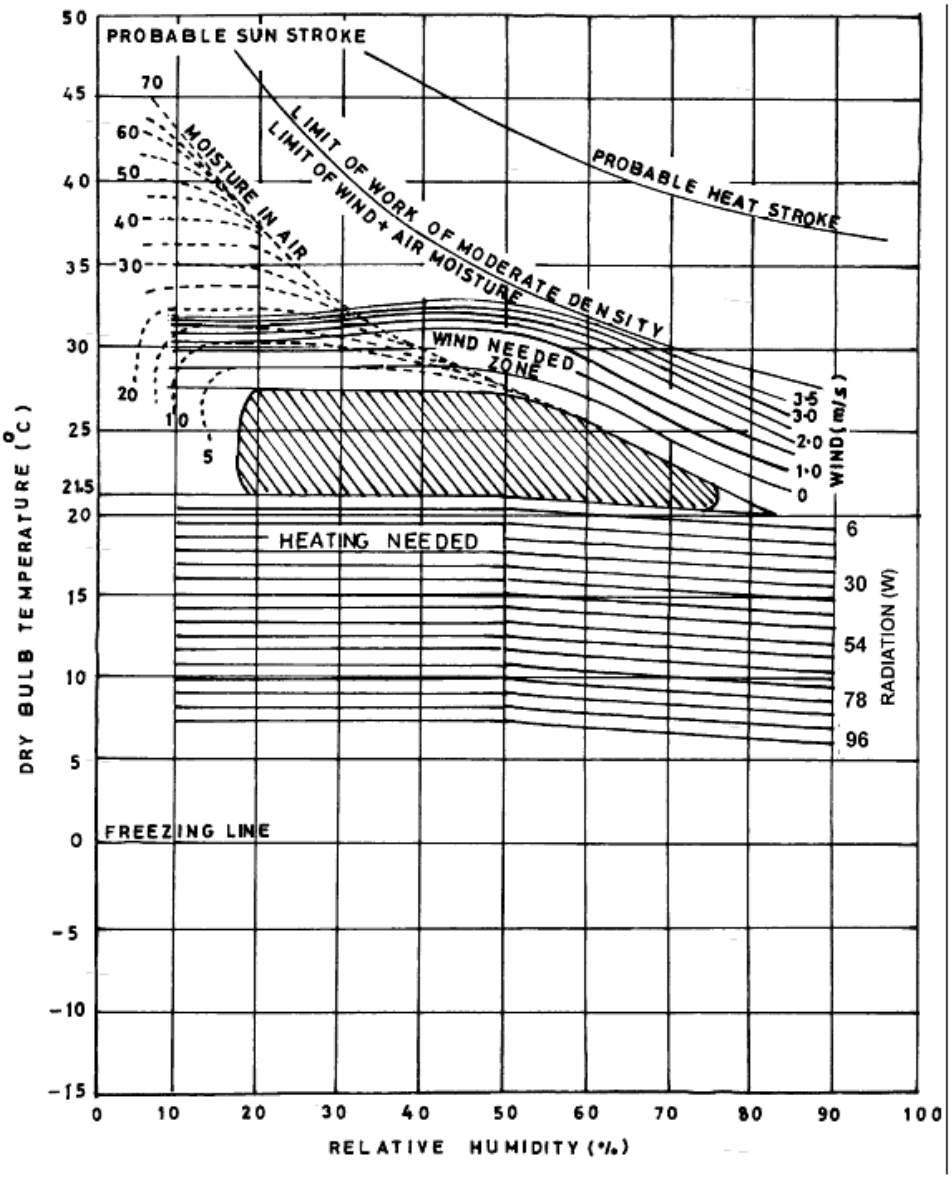


Figure 10: Bio-climatic chart.

Figure 10 illustrates a 'Comfort Zone' on a bio-climatic chart − a simple tool for analysing the climate of a particular place. It indicates the zones of human comfort based on ambient temperature and humidity, mean radiant temperature, wind speed, solar radiation and evaporative cooling. On the chart, dry bulb temperature is used as the ordinate, and relative humidity as the abscissa. Based on the dry bulb temperature and humidity of a place, one can locate a point on the chart. If it lies within the comfort zone, then the conditions are comfortable.

4.1 Hot and Dry

Objectives	Physical manifestations
1) Resist heat gain	
• Decrease exposed surface area	Orientation and shape of building
• Increase thermal resistance	Insulation of building envelope
• Increase thermal capacity (Time lag)	Massive structure
• Increase buffer spaces	Air locks/ lobbies/balconies/verandahs
• Decrease air exchange rate (ventilation during day-time)	Weather stripping and scheduling air changes
• Increase shading	External surfaces protected by overhangs, fins and trees
• Increase surface reflectivity	Pale colour, glazed china mosaic tiles etc.
2) Promote heat loss	
• Ventilation of appliances	Provide windows/ exhausts
• Increase air exchange rate (Ventilation during night-time)	Courtyards/ wind towers/ arrangement of openings
• Increase humidity levels	Trees, water ponds, evaporative cooling

4.2 Warm and Humid

Objectives	Physical manifestations
1) Resist heat gain	
• Decrease exposed surface area	Orientation and shape of building
• Increase thermal resistance	Roof insulation and wall insulation.
• Increase buffer spaces	Air locks/ lobbies/balconies/verandahs
• Increase shading	Walls, glass surfaces protected by overhangs, fins and trees
• Increase surface reflectivity	Pale colour, glazed china mosaic tiles etc.
2) Promote heat loss	
• Ventilation of appliances	Provide windows/ exhausts
• Increase air exchange rate (Ventilation throughout day)	Ventilated roof construction. Courtyards, wind towers and arrangement of openings
• Decrease humidity levels	Dehumidifiers/ desiccant cooling

4.3 Moderate

OBJECTIVES	PHYSICAL MANIFESTATIONS
1) Resist heat gain	
• Decrease exposed surface area	Orientation and shape of building
• Increase thermal resistance	Roof insulation and wall insulation.
• Increase buffer spaces	Air locks/ lobbies/balconies/verandahs
• Increase shading	Walls, glass surfaces protected by overhangs, fins and trees
• Increase surface reflectivity	Pale colour, glazed china mosaic tiles etc.
2) Promote heat loss	
• Ventilation of appliances	Provide windows/ exhausts
• Increase air exchange rate (Ventilation throughout day)	Ventilated roof construction. Courtyards, wind towers and arrangement of openings
• Decrease humidity levels	Dehumidifiers/ desiccant cooling

4.4 Cold (cloudy and sunny)

OBJECTIVES	PHYSICAL MANIFESTATIONS
1) Resist heat loss	
• Decrease exposed surface area	Orientation and shape of building. Use of trees as wind barriers
• Increase thermal resistance	Roof insulation, wall insulation and double glazing
• Increase thermal capacity (Time lag)	Thicker walls
• Increase buffer spaces	Air locks/ lobbies/balconies/verandahs
• Decrease air exchange rate (ventilation during day-time)	Weather stripping and scheduling air changes
• Increase shading	External surfaces protected by overhangs, fins and trees
• Increase surface reflectivity	Pale colour, glazed china mosaic tiles etc.
2) Promote heat gain	
• Ventilation of appliances	Provide windows/ exhausts
• Increase air exchange rate (Ventilation during night-time)	Courtyards/ wind towers/ arrangement of Openings
• Increase humidity levels	Trees, water ponds, evaporative cooling

4.5 Composite

OBJECTIVES	PHYSICAL MANIFESTATIONS
1) Resist heat gain in summer and Resist heat loss in winter	
• Decrease exposed surface area	Orientation and shape of building. Use of trees as wind barriers
• Increase thermal resistance	Roof insulation and wall insulation
• Increase thermal capacity (Time lag)	Thicker walls
• Increase buffer spaces	Air locks/ Balconies
• Decrease air exchange rate	Weather stripping
• Increase shading	Walls, glass surfaces protected by overhangs, fins and trees

• Increase surface reflectivity	Pale colour, glazed china mosaic tiles, etc.
2) Promote heat loss in summer/ monsoon	
• Ventilation of appliances	Provide exhausts
• Increase air exchange rate (Ventilation)	Courtyards/ wind towers/ arrangement of openings
• Increase humidity levels in dry summer	Trees and water ponds for evaporative cooling
• Decrease humidity in monsoon	Dehumidifiers/ desiccant cooling

5. MACROCLIMATE

The conditions for transfer of energy through the building fabric and for determining the thermal response of people are local and site-specific. These conditions are generally grouped under the term of 'microclimate', which includes wind, radiation, temperature, and humidity experienced around a building. A building by its very presence will change the microclimate by causing a bluff obstruction to the wind flow, and by casting shadows on the ground and on other buildings. A designer has to predict this variation and appropriately account for its effect in the design.

The microclimate of a site is affected by the following factors:

(A) landform
(B) vegetation
(C) waterbodies
(D) street width and orientation
(E) open spaces and built form

6. ILLUSTRATIVE EXAMPLES

Hot and Dry climate

Here we will discuss the bioclimatic chart of **Jodhpur**, and the inferences to be taken from chart and incorporated in design.

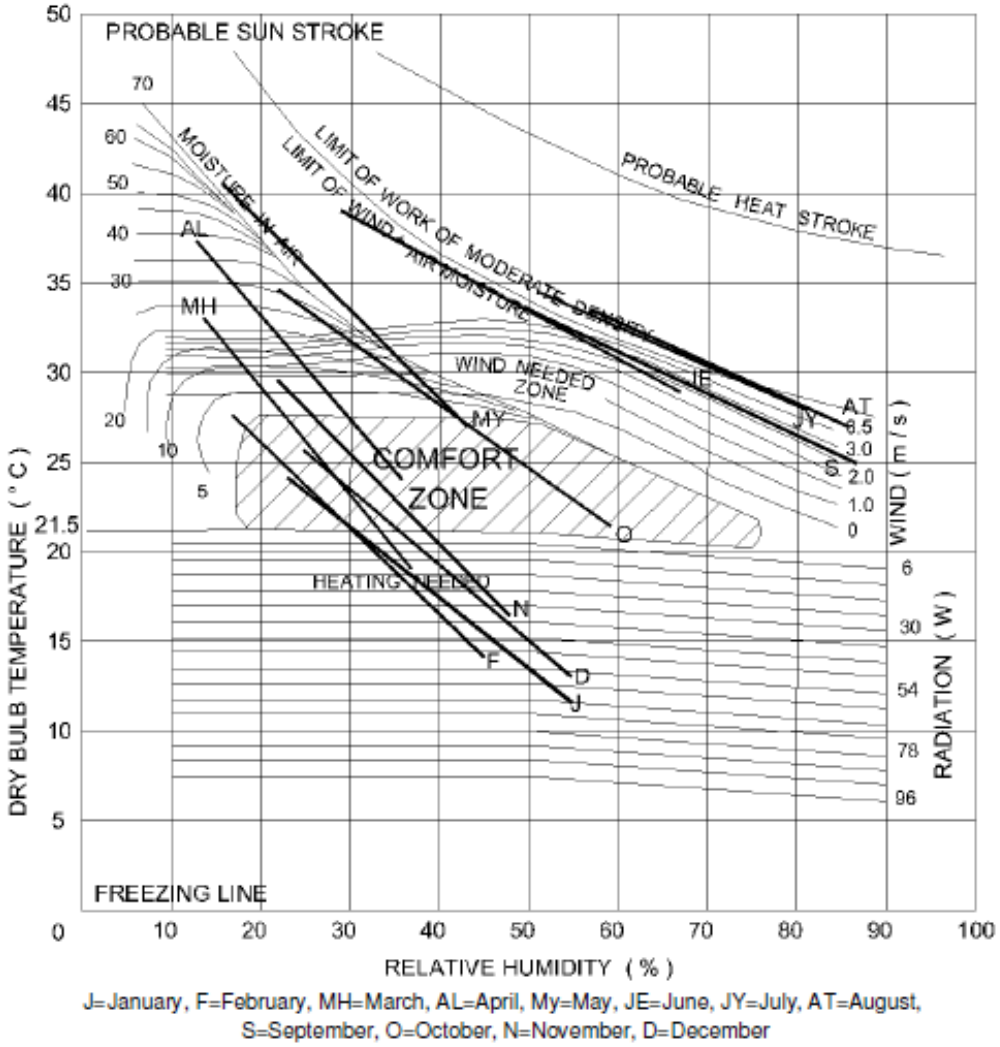


Figure 11: Bio climatic chart of Jodhpur

Inferences

- Evaporating cooling method is desirable in April and May.
- Mechanical air-conditioning is required from June to August due to high humidity coupled with high temperatures.
- September is a relatively cooler month, during which ventilation may be adequate to provide comfort.
- Evaporating cooling is desirable during daytime in October.
- Daytime conditions are comfortable during January, February, November and December. Nights are cool in these months.

Haveli Design at Jodhpur

Climatic features of the design are as follows:

- Compact settlement plan
- Narrow streets with tall buildings around
- Courtyard planning
- Heavy structure
- Shaded colonnades and semi open areas
- Flat roofs with insulation layer
- Small openings with thick shutters, jali screens
- Wind towers

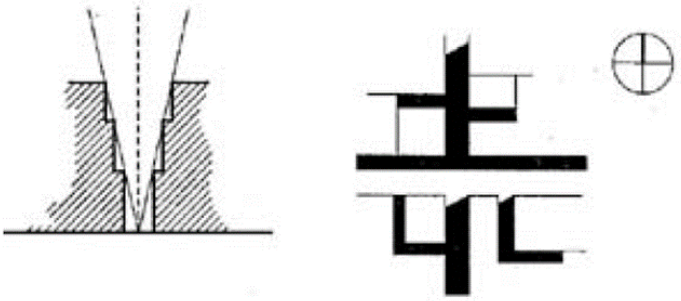


Figure 12: Narrow streets of Jodhpur

Figure 13: Bird eye view of haveli

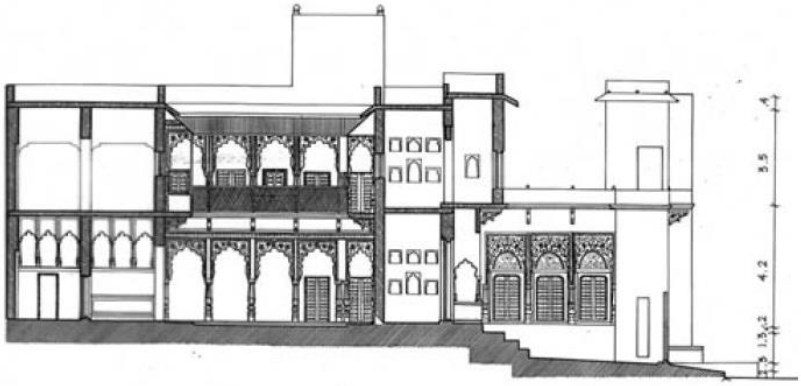


Figure 14: Section of haveli showing both courtyards

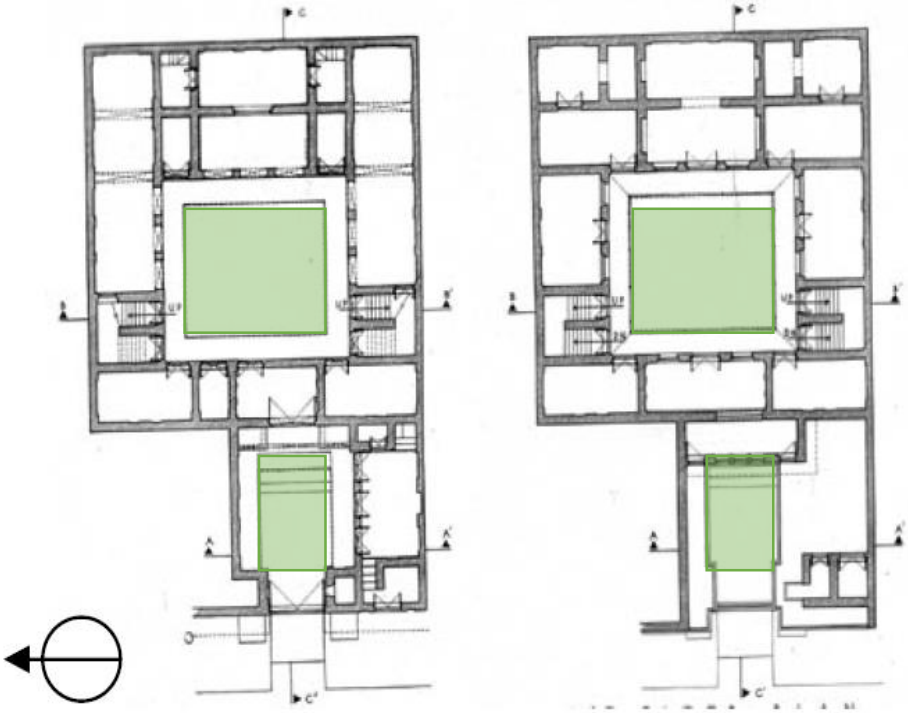
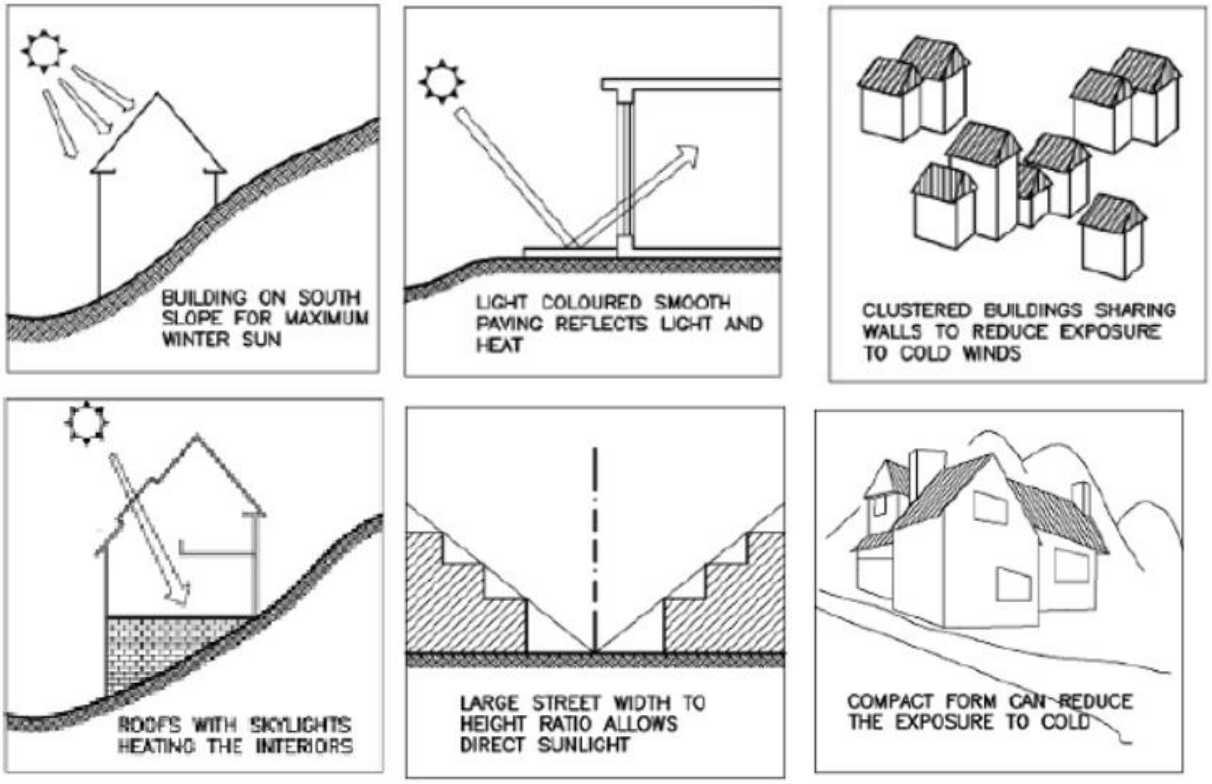


Figure 15: Haveli floor plans

Cold climate

- In cold climates, heat gain is desirable. Hence, buildings should be located on the south slope of a hill.
- Parts of the site which offer natural wind barrier can be chosen for constructing a building.
- Buildings can be clustered together to minimise exposure to cold winds.
- In cold climates, the street orientation should be east-west to allow for maximum south sun to enter the building. The street should be wide enough to ensure that the buildings on one side do not shade those on the other side.
- Windows on south façade for maximum heat gain. Also north façade must be well insulated. Living areas can be located on the southern side while utility areas such as stores can be on the northern side.
- A sufficiently sloping roof enables quick drainage of rain water and snow.
- Skylights on the roofs admit heat as well as light in winters. Skylights can be provided with shutters to avoid over heating in summers.



7. REFERENCES

1. Chapter – 2, Journal of Ministry of New and Renewable Energy
2. Avlokita Agrawal, Prof. R.K. Jain (2006), Shekhawati: urbanism in the semi-desert of India A climatic study.
3. Krishna Jahwar (2009), High Performance Building for cold climate.