Introduction to climatology

Climate encloses the statistics of temperature, humidity, atmospheric pressure, wind, rainfall and other climatic element over a long period. Climate can be differ from weather, which is the present condition of these elements and their variations over shorter periods. A region's climate is generated by the climate system , which has five components: atmosphere, hydrosphere, cryosphere, lithosphere ,and biosphere. The climate of a location is affected by its latitude, terrain, and altitude, as well as near water bodies and their currents. Climate commonly defined as the weather averaged over a long period.

Movement of earth around sun

The Earth revolves around the Sun because gravity keeps it in a roughly circular orbit around the Sun. The Earth's orbital path is not a perfect circle, but rather an ellipse, which means that it is like a slight oval in shape. Earth would appear revolve around the Sun. From the same vantage point, both the Earth and the Sun would appear to rotate also their respective axes.

Different elements of climate

- **Wind**
  It is simply the movement of air from high pressure to low pressure. The speed of the wind is determined by the difference between the high and low pressure. The greater the difference the faster the wind speed. The wind brings with it the temperature of the area it a coming from, therefore a high pressure in a warm region will make the temperature in the low pressure area higher. Wind chill is the effect of the wind making it fell colder than it actually is. As the wind speed increases air is moving more quickly and therefore removes warm air therefore making it seem colder than the actual temperature.
- **Temperature**

It is measurement of hot or cold in air. It is commonly measured in Celsius or Fahrenheit. Temperature is a very important factor in determining the weather, because it influences other elements of the weather.

Temperature may be affected by:

- Sunshine
- Latitude
- Altitude
- Aspect
- Sea proximity and temperature
- Ocean currents

- **Humidity**

  It is the amount of water vapor in the air, the more water vapour in the air then humidity will be more. Humidity varies with temperature. Warmer air can hold more moisture. Therefore condensation occurs at 100%humadity for a given temperature thus reducing the humidity again.

- Precipitation

  It is the term given to moisture that falls from the air to the ground. Precipitation can be snow, hail, sleet, drizzle, fog, mist and rain The water cycle drives the water from the oceans/seas on-shore were it falls as precipitation and then flows via rivers back in to the sea.

- Air pressure

  It is simply the weight of the air above the Earth. Low Pressure is when air is warmer and therefore lighter. High pressure is colder air becoming heavier. In meteorology, pressure is charting on maps with isobars. The higher the number the higher the pressure.

Climatic zones of india

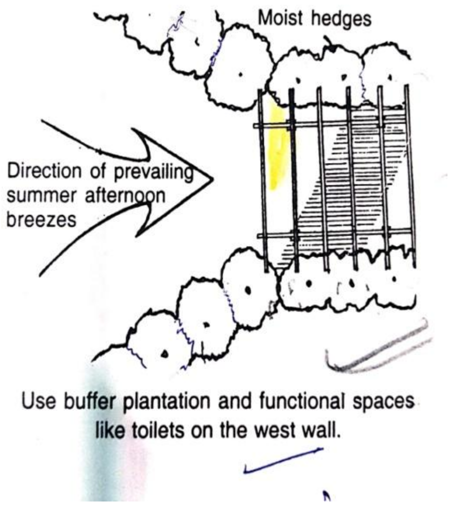
India has a large variety of climates, ranging rom extremely hot regions to very cold regions .Regions with a hot-dry climate like that in Rajasthan, places with a cold climate like in the hills, places which are hot and humid- most coastal areas and the north- east. There are places that have a composite climate like Delhi where all the seasons are felt intensely.

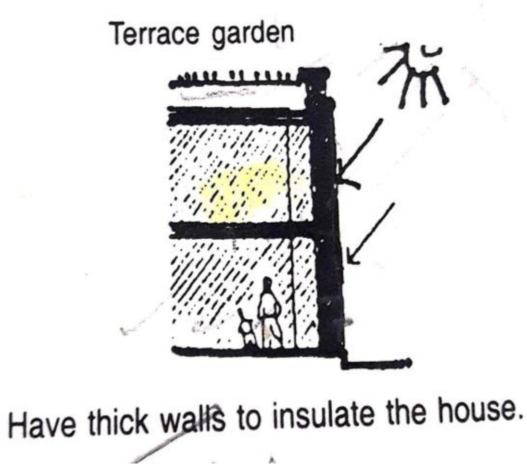
India is divided into main four climatic zones –

1. Hot and dry
2. Warm and humid
3. Cold and cloudy
4. Composite
5. Moderate
6. Cold and dry

1. **Hot and dry areas**
   1. The best place for a house in this zone is either on a flat land or on a shallow north or southeast facing slope.
   2. In the hot and arid deserts of India, proper shading is everything.

iii. The most important side of the house to shade is the West Side. You can put the garage, toilets on this side and try to avoid windows on this side.
iv. Build a large overhang on the south side to keep out the high summer sun and to let in the low winter sun.
v. High openings or ventilators will help in removing the hot air.
vi. Build in the depression or create a depression in the site. The basement can be a very effective living space.
vii. The building should have as flat a roof as possible.
viii. The building width should be the maximum in the direction of the wind.
ix. Shaded courtyards can lead to lower air temperatures.
x. Plant trees in the eastern and western portions of the house to cut off the low sun and hot winds. Plant deciduous trees.
xi. A roof pond or a roof garden can minimize heat gain through the roof.
xii. Trees, shrubs, groundcover can keep the sun from bouncing off the ground and onto your house.
xiii. Add a fountain or other water feature that uses water sparingly to cool the air.
xiv. In these areas, heavy building materials like stone, cavity walls should be used. Roofs must be well insulated.
xv. The colors should be light or soft, while textures should be rough.

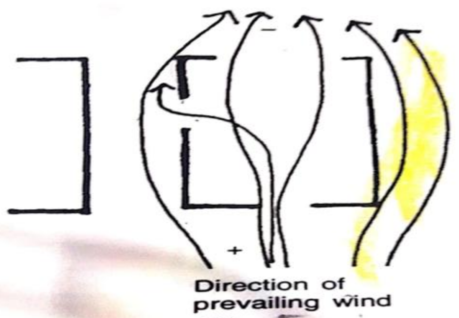




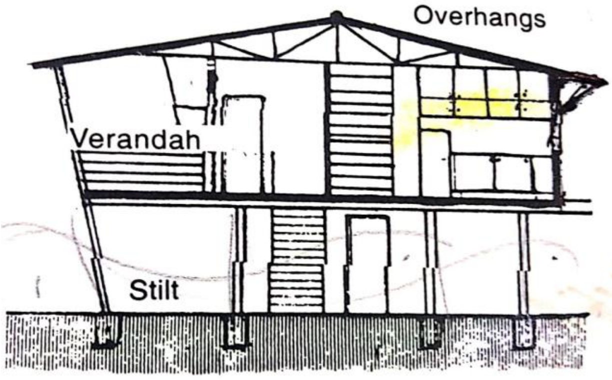
2. Warm and humid zones

i. In humid climates, your primary concern is maximizing ventilation and shading.
ii. The place your house at the top of the windward slope where the wind speed is the highest.
iii. In these areas, trees can be used to increase airflow by directing the wind through the house.
iv. The building should have its shortest width facing the direction of wind flow.
v. The buildings should not be attached so that the air can flow easily.

vi. Make the most of shading in your design. Do not be afraid of large south windows, even in this hot climate.
vii. Properly sized roof overhangs will protect them in summer but let in the winter sun. It is a good idea to have large sunshades on all sides. Large overhangs and pitched roofs will create pressure differences and result in increased airflow floor
viii. Make ventilation your top priority.
ix. Allow for cross ventilation by installing operable windows opposite each other on northern and southern walls.
x. Lower sill heights are preferable.
xi. Have high ceilings and ventilators in the leeward side of the house
xii. In these areas, light colored and rough surfaces are preferred.
xiii. Paint your house a pastel color and the roof white.
xiv. Install exhaust fans to get rid of the heat in the kitchen and bathroom.



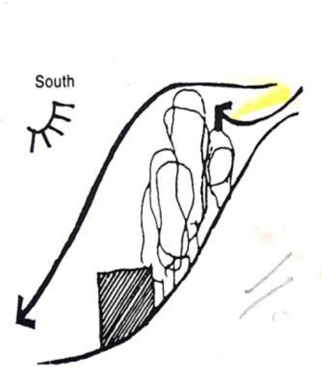
For maximum ventilation face the narrow side towards the direction of the wind.



Verandahs and elevated rooms catch more breezes.

3. Cold and cloudy areas

i. Most of your house's heat can be lost through either conduction or air infiltration.
ii. The aim is to minimize natural ventilation and maximize exposure to the southern sun.
iii. You should place your house in a depression, to protect it from cold winds.
iv. South facing slopes provide the most radiation. The house can be protected.
v. Provide evergreen vegetation on all exposed sides.
vi. Earth bermed north and west walls are also beneficial.
vii. The ground surface must be flat and dark though not smooth.
viii. The building width should have maximum frontage in the direction of the wind.



Shade your home from winds and put the house on the slope facing south.

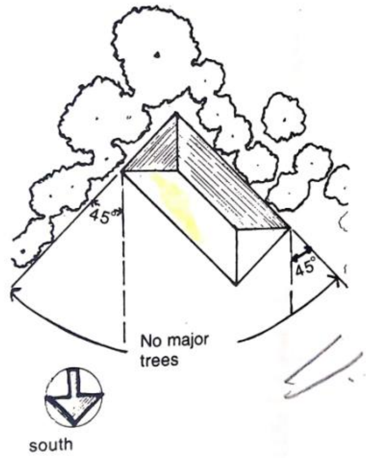
ix. Use heavy building materials with insulation.

x. Roofs must also be well insulated.

xi. The colors should be dark while textures should be rough.

xii. Place your living spaces facing the east or south side.

xiii. Glasshouses with vegetation inside them can help in natural heating.



Leave a southern sun corridor in the southern side of your house.

xiv. Windows should be large, unshaded but sealed. This will help in heat gain but cut off Cool breezes.

xv. Use double glazing on windows, which have shutters on the outside.

xvi. Consider installing fans in the bathroom, a vented hood exhaust in the kitchen and a few casement windows that can be opened during summer.

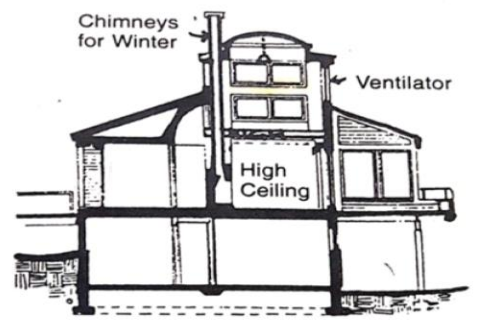
4. Composite Zones

i. Composite climates have summers and winters that are equally harsh or mild, you must divide your money equally for both.

ii. Focus towards taking maximum benefit from the winter sun and summer ventilation and shading.

iii. Maximize overshadowing on elevations and on ground around buildings. Site buildings so as to provide a southern aspect to one of the widest elevations. It is important to provide for shading.

iv. Pay particular attention to the hot west wall and try to shade it with a deciduous tree, a vine-covered pergola or a porch.



Use of a combination of windows, high ceilings and ventilators is climatically good.

v. A garage on the West Side of the house, with a breezeway connecting the two is an excellent system of climate control.

vi. Here the house will benefit enormously by a courtyard type of plan, with thermally heavyweight materials and by maximizing self-shading.

vii. It would be beneficial to have a water body in the courtyard in summer. However, it would be the best policy to drain off the water in winters and monsoons.

viii. You can also cover the courtyard with an operable louvred system.

ix. Ventilation is important in these houses. The house will need lots of windows for cross ventilation.
x. You can have another set of windows at the skirting level. This will help in ventilating the house.

5. Moderate

i. This is a climate which is generally comfortable; neither too hot, nor too cold.
ii. All of us need to do is be shaded and insulated from direct sun, let in a little breeze when we feel stuffy or warm: and shut the window if it is chilly or wear some light woolens.
iii. In Bangalore, the ideal comfortable house is built of heavy walls with high ceiling rooms, with windows that you can shut and open, surrounded by a shade giving verandah.
iv. High ceilings reduce the effect of heat that would radiate down from the roof which would get hot under the sun. This will also allow the warm air to rise and escape through ventilators, high up in the walls.

6. Cold and dry

i. Leh in Ladakh is a "mountain desert." There is very little precipitation and the temperatures vary greatly between the day and night and also from summer to winter.
ii. It is usually built on steep slopes facing southward. This allows good insolation during the day.
iii. Heavy walls (mud) and a well insulated roof (timber & mud) dampen the variations of indoor temperatures.
iv. The use of glass and nowadays, trombe- wall is very successful as heat can be stored in the building mass during the day, to stay warm indoors at night.

Orientation of building

Orientation of any building depends on climatic condition. Three parameter which govern the orientation of building are:
1. Temperature 2. Wind 3. Humidity
Factors affecting orientation are the following: (1) Solar heat: Solar heat means sun heat. The minding should receive maximum solar radiation in the winter and minimum in summer. For evaluation of solar radiation it is essential to know the aeration of sun shine and hourly solar intensity on exposed surface.
The orientation of a building is influenced by numerous environmental and built factors.
Sensory

- Thermal: solar exposure, wind direction, temperature.

- Visual varying daylight qualities in different locations and at different times of day
- Acoustical : direction of objectionable noises
- Environmental : smoke, dust, odors
- Psychological
- Privacy
- Street activity
- Local development patterns
- Street direction
- Spatial organization, land use, urban design
- Zoning
- Accessibility requirements main/'secondary entrances, parking
- Other considerations
- Aesthetic
- Direction of storms
- Site conditions: topography, geotechnical, wetlands
- Site vegetation: mature trees
- View corridors, scenic easements

Effect of climate on man and shelter

Relation of climate and comfort

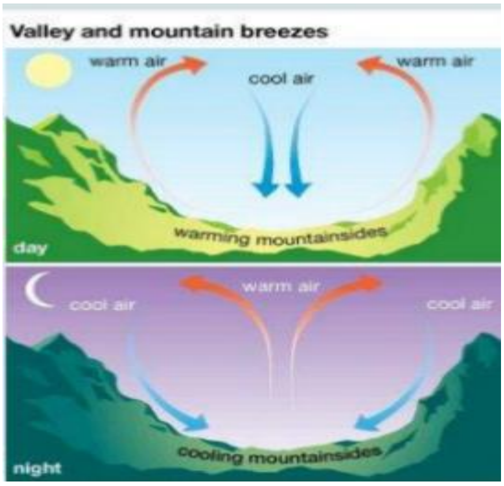
Macro climatic effects

The macro and micro climate has a very important effect on both the energy performance and environmental performance of buildings – both in Summer and Winter season. The site and design of a building can have a profound effect upon the interaction between a building and its environment. • The building site affects exposure to the prevailing wind, pollution levels, solar radiation that the building receives, temperatures and rain penetration.

The orientation of the building affects solar gains and exposure to the prevailing wind (ventilation). • The location of neighboring trees and buildings affects the solar gains (shading) and wind patterns. • Neighboring trees and buildings also protect the building from driving rain. The macro climate around a building cannot be affected by any design changes. The building design can be developed with a knowledge of the macro climate in which the building is located. General climatic data give an idea of the local climatic severity: Seasonal accumulated temperature difference (degree day) are a measure of the outside air temperature, though do not account for: a. Available solar radiation. b. Typical wind speeds and direction. c. Annual totals of Global Horizontal Solar Radiation. d. The driving rain index (DRI).

The site of a building may have its own micro climatic conditions caused by the presence of hills valleys, slopes, streams and other buildings.

Effect of Local Terrain



• Surrounding slopes have important effects on air movement, especially at the bottom of a hill. In the hills air warmed by the solar radiation rises upwards due to buoyancy effects (Anabatic flow), to be replaced by cooler air drifting down the slope (Katabatic flow).

• The result is that valley floors are significantly colder than locations part way up the slope.

• Katabatic flows often result in frosts persisting for longer in low lying locations. • The most favorable location in a valley is known as the thermal belt, lying just above the level to which pools of cold air build up, but below the height at which exposure to wind increases.

• The crests of hills and ridges have unfavorable wind velocity profiles, the wind flow is compressed (as happens with an aero foil) leading to high wind velocities.

Effect of Buildings

• Buildings contribute to create micro-climatic conditions by shading the ground, changing wind flow patterns.

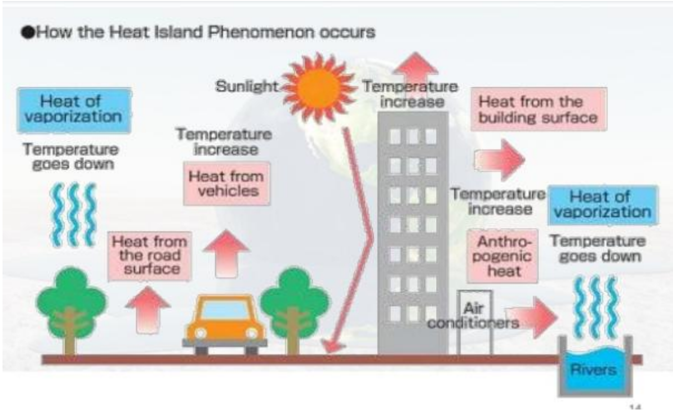
• One example of how buildings affect the local climate is the heat island effect in large cities where the average temperature is higher than the surrounding areas.

• Solar energy absorbed and re-emitted from building surfaces, pavements roads etc. creates a warming effect on the surrounding air.

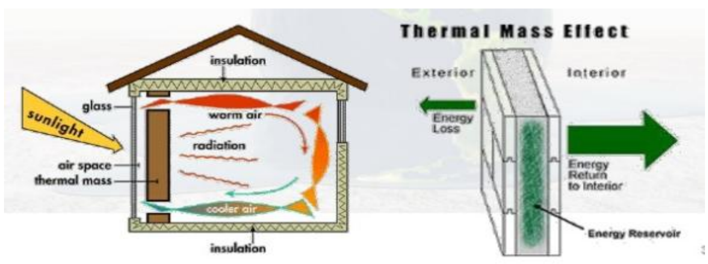
• Also the large quantities of buildings break up the wind flow, reducing wind speeds and causing the warm air to remain stagnant in the city.

• This also causes increased pollution as well as temperatures.

Urban Heat Islands
• “An urban heat island (UHI) is a city or metropolitan area that is significantly warmer than its surrounding rural areas due to human activities.”



• The main cause of the urban heat island (UHI) effect is from the modification of land surfaces, which use materials that effectively store short-wave radiation. • The less-used term heat island refers to any area, populated or not, which is consistently hotter than the surrounding area.
As urban areas develop, changes occur in their landscape. Buildings, roads, and other infrastructure replace open land and vegetation.
Heat Island
Micro climatic effects
The aims of enhancing Micro-Climate around Buildings:
• Reduce costs of winter heating.
• Reduce summer overheating and the need for cooling.
• Maximize outdoor comfort in summers as well as winters.
• Improve durability of building material (reduced rain penetration).
• Encourage growth of plants.
• Facilitate open air drying of clothes.
Means of enhancing the micro climate around a building include:
Solar Access:
• Allow maximum daylight into space and buildings.
• Allow maximum solar radiation into space and buildings (For Cold areas).
• Shade open spaces and windows from prolonged exposure to summer sun.
• Protect space and windows from glare.
Wind Protection:
• Protect space and buildings from prevailing winds and cold winds.
• Prevent buildings and terrain features from generating turbulence
• Protect spaces and buildings from driving rain and snow
• Protect space and buildings from katabatic flows, while retaining enough air movement to disperse pollutants.
Features:



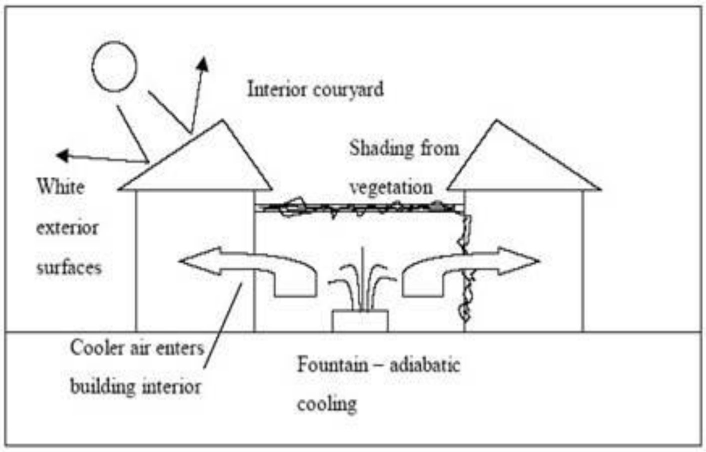
Provide thermal mass to moderate extreme temperatures
Use vegetation for sun shading and wind protection (transpiration helps moderate high temperatures).
Provide surfaces that drain readily.
Provide water for cooling be evaporation (pools and fountains).

Factors Affecting Micro Climate

Outside Designers Control	Within Designer's Remit
Area and local climate	Spacing and orientation of buildings
Site surroundings	Location of open spaces
Site shape	Form and height of buildings
Topographic features	Fenestration
Surrounding Buildings	Tree cover Ground profiling Wind breaks Surrounding surfaces (paving grass etc)

Two main possibilities for influencing Micro Climate are Solar Access and Wind Control.

Solar Access
Solar access to a site is often a case of minimising solar overheating in summer while maximising solar access during the winter.
Buildings with a heating requirement should be orientated north south with maximum glazing on the south face.
Deciduous trees offer an excellent means of site shading, with shading being reduced in winter when the trees lose their leaves.
The colour of surrounding surfaces will have a pronounced effect on the solar radiation available to the building.
Light coloured paving will increase the radiation reflected from the ground into the building.
Paving stones will also provide external thermal mass, moderating temperature swings immediately adjacent to the building.



Grass planted outside a building will reduce the ground reflected solar.
Use of courtyards and water can also moderate the effects of high temperatures on summer.

Wind Control

The form of the building can have a great effect on the impact of the wind:

· Avoidance of the building flank facing the wind.
· Avoidance of funnel-like gaps between buildings.
· Avoidance of flat roofed buildings and cubical forms.

· Avoid piercing buildings at ground level.
· Avoid abrupt changes in building heights.
· Orientate long axis of the building parallel to the direction of the wind.
· Use podium to limit down draught at ground level.
· Use pitched rather than flat roofs and stepped forms for higher buildings.
· Groups of buildings can be arranged irregular patterns to avoid wind tunneling.
Coniferous trees and fencing and other landscape features such as mounds of earth and hedges can also reduce the impact of wind and driving rain on the building structure.

Concept of comfort zone and bio climatic chart

1. Most of the time of people now is spent in buildings or urban spaces. Although comfort models mostly talks about indoor climate but both indoor and outdoor climate should be taken into consideration not only in urban design but also in buildings. So both indoor and outdoor comfort is a matter of attention for architects and urbanists.
2. Architectural Design Process Architectural design process itself is very complicated.But in few words some steps in design process is as under:
   In this process climate studies are on the first step, in which architect needs to study climate of the area using mostly metrological stations data outside or in the boundaries of the city. Almost the information is average monthly data. Usually daily or hourly data is not used because of very much time they need to be processed. Then climate responsive architects analyze this data using some approximate comfort data (winter and summer comfort zones). At the same time loading at passive heating/cooling strategies, they combine these strategies to design in sketch and other steps, if other issues such as economical and/or aesthetical considerations allow them. To simplify architectural design process after this, all other considerations rather than comfort and climate omitted to show how they could be utilized in building design.
3. Architect's needs/problems in climatic design. In comfort and climate study there are some problems that architect face for designing a successful model it is best to know them:
   Undefined conditions of buildings: (a) Human factors: In many cases architects could not exactly find a real definition of building occupants during design. He or she could only come to an approximate assumption of clothing, activities behaviors, cultures and other human factors. For instance in a residential complex of 1000 residents, practically it is not possible to exactly get all human factors, knowing that even first occupants may alter during time or even the same could happen for a small office building. So architects could not get exact human factors.(b) climatic factors: Still in many countries getting correct climatic data of a region is not easy.There are many cities without

metrological station, in such condition one might use nearer station data, sometime 100 km away. Even if there is a station most of the time the station is in different microclimate from the design site (Open space vs. urban dense space). As Givoni in his book "climatic considerations in building and urban design" mentioned that there are many factors effecting urban climate such as urban density, streets, parks, traffic. Also surrounding elements of a building such a materials, colors water surfaces green spaces etc. could have considerable effect. creating small special microclimates, hard to define. So it is not easy to obtain climatic conditions near the building
(c) Building factors : Although may be in developed countries architects could have access to building materials characteristics easily or the producers give this information. but in many cases there is not exact data about material properties.
Some points help a comfort models to fit architects' needs are mentioned) Easy process (comfort zone + climate analyses) (i) No long calculation (6) Giving direct design guidelines for different steps of design instead of numbers (iv) Giving knowledge instead of just data.

4. Simplified design procedure(climate/comfort): to define climatic design process according to comfort zone, it could be divided to four main parts: (a) Study of the design subject (climate-activities-dothing-etc.) (b) Defining the comfort zone (monthly-daily) (c) Gathering the climatic design advices (shading-thermal mass evaporative cooling-thermal insulation-suitable orientation).(d) designing the project(a climatic building).

Bio climatic chart

Bioclimatic charts facilitate the analysis of the climate characteristics of given location from the viewpoint of human comfort, as they present, on a psychometric chart, the concurrent combination of temperature and humidity at any given time. They can also specify building design guidelines to maximize indoor comfort conditions when the building's interior is not mechanically conditioned. All such charts are structured around and refer to the comfort zone.

Sun control and shading devices

Orientation for sun

Orientation is the positioning of a building in relation to seasonal variations in the sun’s path as well as prevailing wind patterns. Good orientation can increase the energy efficiency of your home, making it more comfortable to live in and cheaper to run.

Good orientation, combined with other energy efficiency features, can reduce or even eliminate the need for auxiliary heating and cooling, resulting in lower energy bills, reduced greenhouse gas emissions and improved comfort. It takes account of summer and winter variations in the sun’s path as well as the direction and type of winds, such as cooling breezes. Good orientation can help reduce or even eliminate the need for auxiliary heating and cooling, resulting in lower energy bills, reduced greenhouse gas emissions and improved comfort.
In hot humid climates and hot dry climates with no winter heating requirements, aim to exclude direct sun by using trees and adjoining buildings to shade every façade year round while capturing and funneling cooling breezes. In all other climates a combination of passive solar heating and passive cooling is desirable. The optimum balance between capturing sunlight (solar access) and capturing cooling breezes is determined by heating and cooling needs.
North orientation is generally desirable in climates requiring winter heating, because the position of the sun in the sky allows you to easily shade northern façades and the ground near them in summertime with simple horizontal devices such as eaves, while allowing full sun penetration in winter. North-facing walls and windows receive more solar radiation in winter than in summer.
Orientation for passive heating is about using the sun as a source of free home heating by letting winter sun in and keeping unwanted summer sun out. It can be done with relative ease on northern elevations by using horizontal shading devices to exclude high angle summer sun and admit low angle winter sun. Solar access’ is the term used to describe the amount

of useful sunshine striking glass in the living spaces of a home. The desired amount of solar access varies with climate.

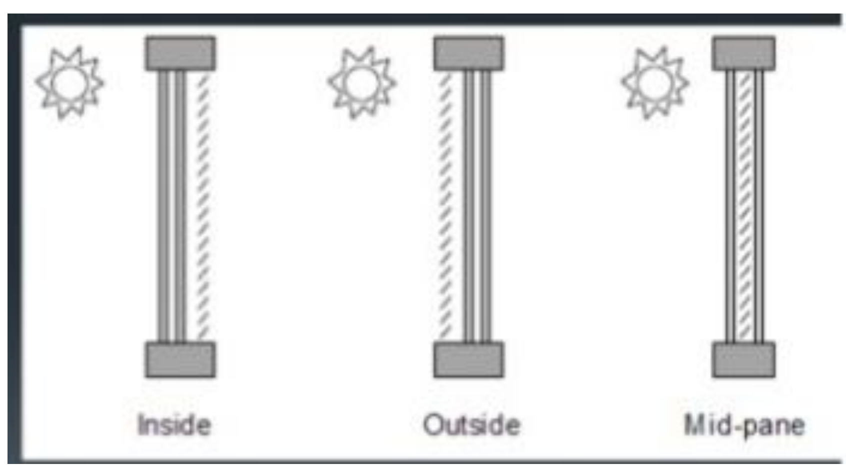
Poor orientation and lack of appropriate shading can exclude winter sun and cause overheating in summer by allowing low angle east or west sun to strike glass surfaces at more direct angles, reducing reflection and increasing solar gains.

A north-facing slope increases the potential for access to northern sun and is ideal for higher housing densities. A south-facing slope increases the potential for overshadowing. Your design for solar access should not compromise that of your neighbors. At subdivision level, smaller individual lots are ideally located on north-facing slopes where they still receive solar access at increased densities. South-facing slopes are often better suited to medium density where party walls can be designed to provide thermal buffers and smaller floor areas can be solar heated with carefully designed and shaded east or west-facing windows using advanced glazing.

Internal and external sun protection devices

Sun Shading Devices are any mechanical equipment or textiles that are used either internally or externally or in between the internal and external building space. The primary objective of creating a comfortable internal environment, that is, cool in the summer and warm in the winter.

Types of Sun Shading Devices On the basis of their position in a building:-
Internal External Interpane



1. Internal shading device

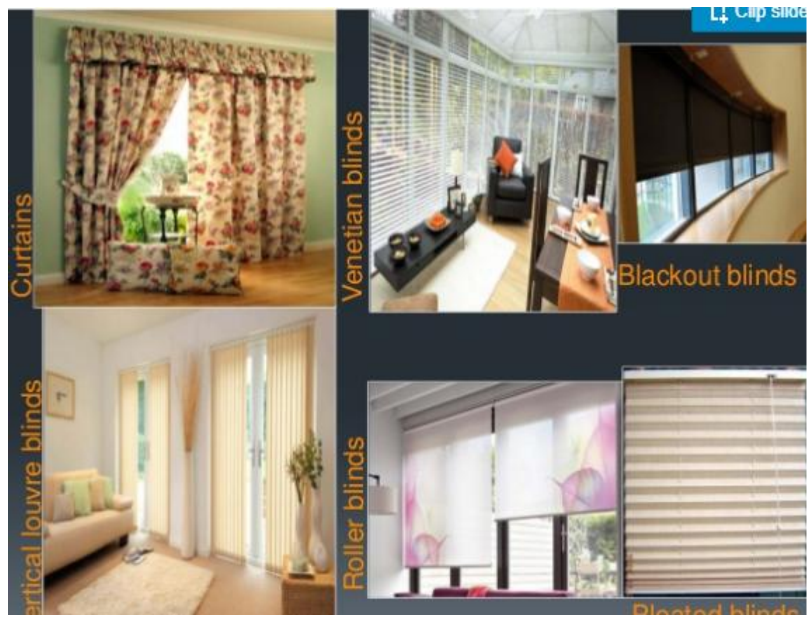
· Limit the glare resulting from solar radiation.

· Usually are adjustable and allow occupants to regulate the amount of direct light entering their space.

· Curtains: It is the most commonly used shading device, mostly used on residential buildings. It is cheaper in comparison and can be found in various varieties, colors and texture. A curtain also acts as a decorative item.

· Venetian blind: Venetian blinds are basic slatted blinds made of metal or plastic, wood or bamboo can also be used. Suspended by a strip of cloth called tapes.

· Vertical Louvre blinds: Suitable for many applications in commercial and public buildings where the control of heat, light and glare are of concern. It can be used in larger windows and doors too.



· Roller blinds: Roller blinds are usually stiffened polyester, mounted on a metal pole and operated with a side chain or spring mechanism. Roller Blinds are a practical blind for everyday use, Block Outs, Sun Screens and Translucent with a metal or plastic chain available, that operates the blind through an aluminum tube to roll up and down.

· Pleated Blinds: Pleated blinds are shades made from a pleated fabric (which helps to add texture to a room) that pull up to sit flat on the top of a window to hide from sight when open.

· Blackout blinds: Blackout blinds stop light from passing through thanks to special treatments and extra tight woven fabrics to help control the light levels in a room. It is designed to block the external light to enter the room.

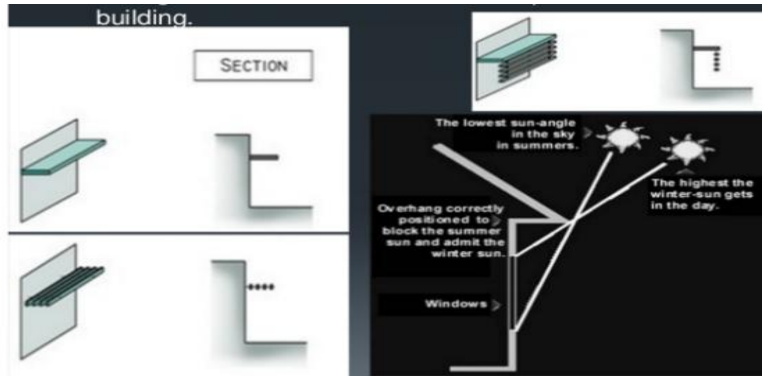
2. External shading devices

Ø Considered better than internal

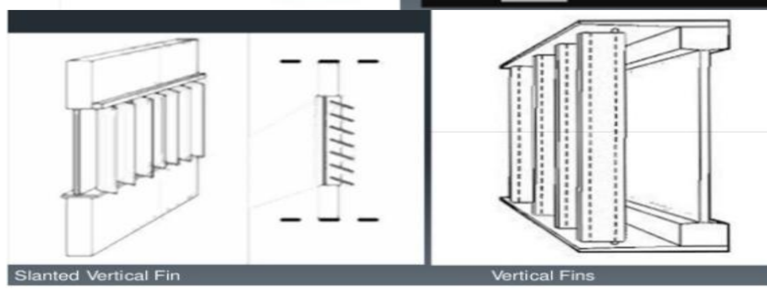
Ø Horizontal, Vertical or inclined projections

Ø Vegetation and other buildings

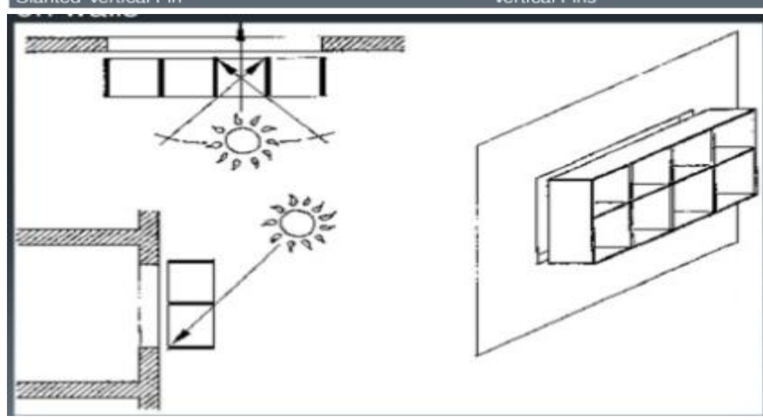
Ø Horizontal Devices: to shade a window during hot summer months, but to allow sunlight to shine through a window in the winter, to help warm a building.



Ø Vertical Devices: Primarily useful for east and west exposures to improve the insulation value of glass in winter months by acting as a windbreak.



Ø The egg-crate: A combination of vertical and horizontal shading elements commonly used in hot climate regions because of their high shading efficiencies. The horizontal elements control ground glare from reflected solar rays. The device works well on walls



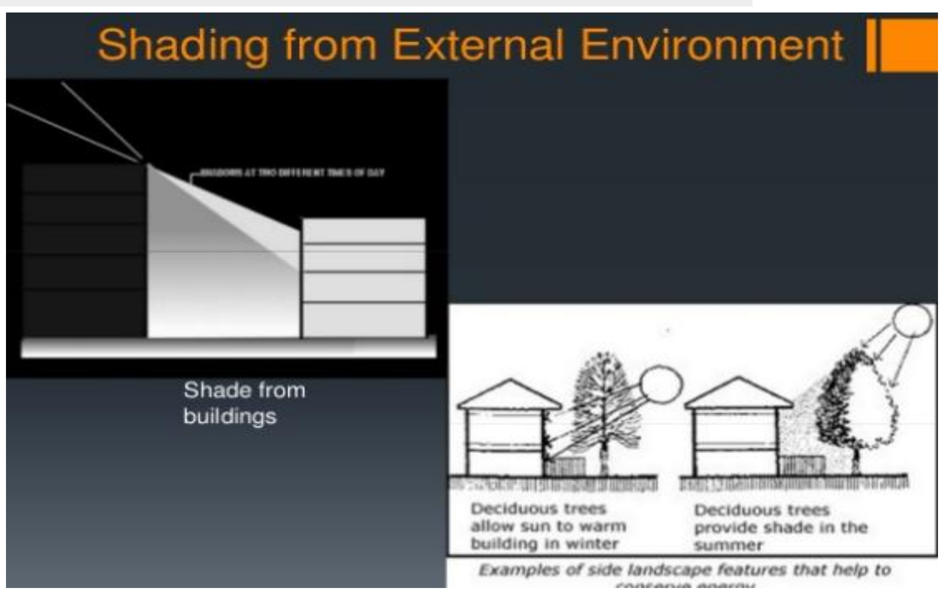
3. Shading from External Environment Shade from buildings

§ Designing a Shading Device

§ Select Shading Type

§ Identify Design Dimensions

§ Identify Category



Natural lighting

Natural lighting, also known as daylighting, is a technique that efficiently brings natural light into your home using exterior glazing (windows, skylights, etc.), thereby reducing artificial lighting requirements and saving energy. Natural lighting has been proven to increase health and comfort levels for building occupants.

SOURCES OF NATURAL LIGHTING

Effective natural lighting will admit natural light, but will avoid admittance of direct sun on task surfaces or into occupants' eyes. Daylight inside a home can come from three sources:

DIRECT SUNLIGHT
Direct light from the Sun.

EXTERNAL REFLECTION
Light reflecting off of ground surfaces, adjacent buildings, light shelves, and wide window sills. Excessive reflectance is undesirable as it causes glare.

INTERNAL REFLECTION
light reflecting off of internal walls, ceiling, and the floor of your home. This also includes high reflective surfaces such as smooth or glossy surfaces, light colored finishes, and mirrors around a room.

NATURAL LIGHTING DESIGN

Most day lighting components are integrated in the original construction plan, however, technologies such as tubular daylighting devices, skylights, electric lighting controls, and optimized interior design may be considered in retrofit projects.

The science of day lighting design is more complex than simply bringing light into a home. When adding a day lighting fixture, you must consider balancing heat gains and losses, glare control, and variations in daylight availability. Additionally, window size and spacing, glass selection, the reflectance of interior finishes, and the location of interior partitions all must be considered.

Passive solar heating and cooling

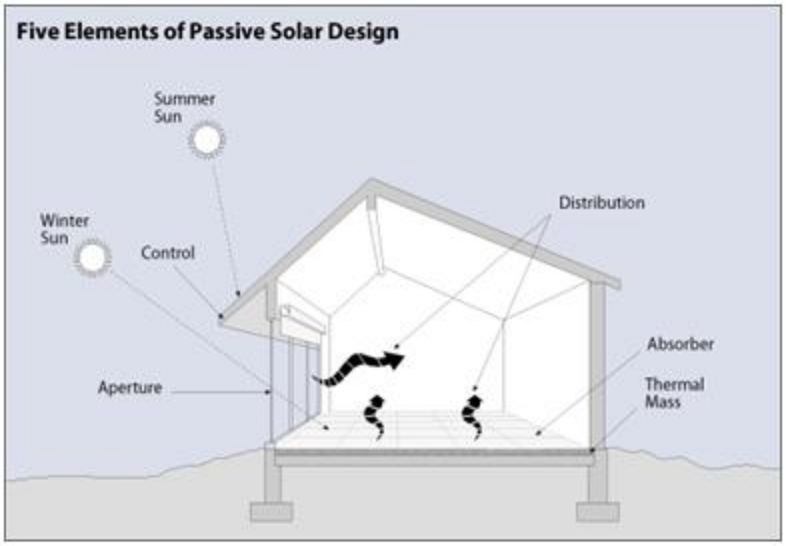
Passive solar design refers to the use of the sun’s energy for the heating and cooling of living spaces by exposure to the sun. When sunlight strikes a building, the building materials can reflect, transmit, or absorb the solar radiation. In addition, the heat produced by the sun causes air movement that can be predictable in designed spaces. These basic responses to solar heat lead to design elements, material choices and placements that can provide heating and cooling effects in a home. Unlike active solar heating systems, passive systems are simple and do not involve substantial use of mechanical and electrical devices, such as pumps, fans, or electrical controls to move the solar energy.

Passive Solar Design Basics

A complete passive solar design has five elements:

Aperture/Collector: The large glass area through which sunlight enters the building. The aperture(s) should face within 30 degrees of true south and should not be shaded by other buildings or trees from 9a.m. to 3p.m.

daily during the heating season.



· **Absorber:** The hard, darkened surface of the storage element. The surface, which could be a masonry wall, floor, or water container, sits in the direct path of sunlight. Sunlight hitting the surface is absorbed as heat.

· **Thermal mass:** Materials that retain or store the heat produced by sunlight. While the absorber is an exposed surface, the thermal mass is the material below and behind this surface.

· **Distribution:** Method by which solar heat circulates from the collection and storage points to different areas of the house. A strictly passive design will use the three natural heat transfer modes- conduction, convection and radiation- exclusively. In some applications, fans, ducts and blowers may be used to distribute the heat through the house.

· **Control:** Roof overhangs can be used to shade the aperture area during the summer months. Other elements that control under and/or overheating include electronic sensing devices, such as a differential thermostat that signals a fan to turn on; operable vents and dampers that allow or restrict heat flow; low-emissivity blinds; and awnings.

Passive Solar Heating

The goal of passive solar heating systems is to capture the sun's heat within the building's elements and release that heat during periods when the sun is absent, while also maintaining a comfortable room temperature. The two primary elements of passive solar heating are south facing glass and thermal mass to absorb, store, and distribute heat. There are several different approaches to implementing those elements.

Direct Gain

The actual living space is a solar collector, heat absorber and distribution system. South facing glass admits solar energy into the house where it strikes masonry floors and walls, which absorb and store the solar heat, which is radiated back out into the room at night. These thermal mass materials are typically dark in color in order to absorb as much heat as possible. The thermal mass also tempers the intensity of the heat during the day by absorbing energy. Water containers inside the living space can be used to store heat. However, unlike masonry water requires carefully designed structural support, and thus it is more difficult to integrate into the design of the house. The direct gain system utilizes 60-75% of the sun's energy striking the windows. For a direct gain system to work well, thermal mass must be insulated from the outside temperature to prevent collected solar heat from dissipating. Heat loss is especially likely when the thermal mass is in direct contact with the ground or with outside air that is at a lower temperature than the desired temperature of the mass.

Indirect Gain

Thermal mass is located between the sun and the living space. The thermal mass absorbs the sunlight that strikes it and transfers it to the living space by conduction. The indirect gain system will utilize 30-45% of the sun’s energy striking the glass adjoining the thermal mass.The most common indirect gain systems is a Trombe wall. The thermal mass, a 6-18 inch thick masonry wall, is located immediately behind south facing glass of single or double layer, which is mounted about 1 inch or less in front of the wall’s surface. Solar heat is absorbed by the wall’s dark-colored outside surface and stored in the wall’s mass, where it radiates into the living space. Solar heat migrates through the wall, reaching its rear surface in the late afternoon or early evening. When the indoor temperature falls below that of the wall’s surface, heat is radiated into the room.Operable vents at the top and bottom of a thermal storage wall permit heat to convect between the wall and the glass into the living space. When the vents are closed at night, radiant heat from the wall heats the living space.

Passive Solar Cooling

Passive solar cooling systems work by reducing unwanted heat gain during the day, producing non-mechanical ventilation, exchanging warm interior air for cooler exterior air when possible, and storing the coolness of the night to moderate warm daytime temperatures. At their simplest, passive solar cooling systems include overhangs or shades on south facing windows, shade trees, thermal mass and cross ventilation.

Shading

Overhang design for shading. The steeper arrow shows the angle of the sun's rays during the summer, while the shallower arrow indicates the angle during the winter.

To reduce unwanted heat gain in the summer, all windows should be shaded by an overhang or other devices such as awnings, shutters and trellises. If an awning on a south facing window protrudes to half of a window’s height, the sun’s rays will be blocked during the summer, yet will still penetrate into the house during the winter. The sun is low on the horizon during sunrise and sunset, so overhangs on east and west facing windows are not as effective. Try to minimize the number of east and west facing windows if cooling is a major concern. Vegetation can be used to shade such windows. Landscaping in general can be used to reduce unwanted heat gain during the summer.

Thermal Mass

Thermal mass is used in a passive cooling design to absorbs heat and moderate internal temperature increases on hot days. During the night, thermal mass can be cooled using ventilation, allowing it to be ready the next day to absorb heat again. It is possible to use the same thermal mass for cooling during the hot season and heating during the cold season.

Ventilation

Natural ventilation maintains an indoor temperature that is close to the outdoor temperature, so it’s only an effective cooling technique when the indoor temperature is equal to or higher than the outdoor one. The climate determines the best natural ventilation strategy.In areas where there are daytime breezes and a desire for ventilation during the day, open windows on the side of the building facing the breeze and the opposite one to create cross ventilation. When designing, place windows in the walls facing the prevailing breeze and opposite walls. Wing walls can also be used to create ventilation through windows in walls perpendicular to prevailing breezes. A solid vertical panel is placed perpendicular to the wall, between two windows. It accelerates natural wind speed due to pressure differences created by the wing wall.