UNIT 01
PRELIMINARY INVESTIGATIONS, LOCATION AND SITE SELECTION

Structure

1.0 INTRODUCTION

The first and most important part of the decision regarding a building project is about its location. With increasing demand for land for a variety of developmental activities, locations which would be ideal for different types of buildings, are becoming scarce. The criteria for the selection of a suitable location are becoming more and more complex, due to developmental control rules imposed by National, State and Local governments. Climatic considerations are equally important not only for functional efficiency, but also because of the adverse impact of large scale building constructions on the environment. In addition to the local topographic considerations, the engineer will have to consider the above mentioned aspects at the very initial stages of a building project. Such a detailed study is bound to help the engineer to choose an economical and appropriate location in order to avoid costly rectification expenditure at a later stage.

In these discussions, the term location is used with respect to a relatively large area, such as a district, taluk or town. The term site will refer to the specific land, within such a location. where a building or a project will be constructed.

1.1 OBJECTIVES

After studying this unit, you should be able to:

- collect the required climatic data at global and local levels and make a decision on the suitability of location, site, and orientation of building(s),
- examine the topography of the site, and assess the possible areas where the buildings can be built safely with a minimum of cut and fill and having adequate drainage,
- study the basic hydrology of the site and plan for tapping the ground water, make provision for drainage and also anticipate problems of excavation, if at all, due to higher ground water table,
- study the nature of underlying soil and its probable behavior underneath the foundations and hence, decide on the type of foundation needed,
- understand the development plans, controls, rules and regulations of the government and local agencies, which may affect the very feasibility of a construction project. Final location and orientation of a building at a particular site may be governed by these overriding criteria, and
- appreciate quality and extent of the environmental impact due to the project.

A thorough knowledge of the above aspects will enable you to anticipate problems and avoid costly errors of judgment in locating, choosing the site and orienting your buildings.

1.2 TYPES OF BUILDINGS

Buildings are generally classified on the basis of occupancy and type of construction. Since Development Control Rules and Building Byelaws are based on occupancy criteria, such a classification is essential for planning and design. The National Building Code of India (NBC,1983) has classified buildings as outlined below:

Group A: **Residential Buildings:** Residential buildings include any building in which sleeping accommodation is provided for normal residential purposes, with or without cooking or dining or bathing facilities.
Subgroups have been identified as follows:

A 1 Lodging or rooming houses
A2 One- or two- family private dwellings
A3 Dormitories
A4 Apartment houses (flats)
A5 Hotels

Group B: **Educational Buildings:** These buildings include any building used for a school, college or day-care purposes involving assembly for instruction, education and recreation.

Group C: **Institutional Buildings:** These buildings shall include any building which is used for medical treatment or care of persons suffering from physical or mental illness, disease or infirmity, care of infants, convalescents or aged persons and for penal or correctional detention. Institutional Buildings ordinarily provide sleeping accommodations for their occupants. Sub-groups areas follow:

Cl Hospitals and Sanatoria
C2 Custodial institutions.
C3 Penal and mental institutions

Group D: **Assembly Buildings:** This group shall include any building where groups of people congregate or gather for amusement, recreation, social, religious, patriotic, civil, travel and similar purposes; examples are theatres, motion-picture houses, assembly halls, auditoria, exhibition halls, museums, skating rinks, gymnasiums, restaurants, places of worship, club-rooms, passenger stations and terminals of air, surface and marine transportation services, recreation halls and stadia.

Group E: **Business Building:** Such buildings are used for transaction of business, for keeping of accounts and records, professional establishments, service facilities etc. Examples of this group are city halls, town halls, court houses and public libraries. Business buildings shall be further subdivided as under:

E1: Offices, banks, professional offices of architects, engineers, doctors, lawyers and other consultants etc.
E2: Laboratories, research establishments and test houses
E3: Computer installations

Group F: **Mercantile Buildings:** These shall include buildings that are used as shops, stores, and markets for the display and sale of merchandise, either wholesale or retail. Sub-groups are as follows:

F l Shops, stores, a market with an area up to 500 m^2
F 2 Underground shopping centers, departmental stores with areas of more than 500 m^2

Group G: Industrial Building: These are buildings in which products or materials of all kinds and properties, excepting those which are hazardous, are fabricated, assembled, manufactured or processed; examples under this category are assembly plants, laboratories, dry-cleaning plants, power plants, pumping stations, laundries, gas plants, refineries, dairies and saw-mills.

Group H: **Storage Buildings:** Such buildings are primarily used for the storage or sheltering (including servicing, processing or repairs, incidental to storage) of goods, wares or merchandise, vehicles, or animals examples are warehouses, cold storages, freight depots, transit sheds, store houses, truck and marine terminals, garages, hangers (other than aircraft repair hangers), grain elevators, bars and stables. Storage buildings are characterized by the presence of relatively small number of persons in proportion to the area.

Group J: **Hazardous Buildings:** These shall include ally building or part of a building which is used for the storage, handling, manufacture or processing of highly combustible or explosive materials or products which are liable to burn with extreme rapidity and/or which may produce poisonous fumes or explosions; for storage, handling, manufacturing or processing which involves highly corrosive, toxic or noxious alkalis, acids, or other liquids or chemicals producing flame, fumes, and explosive, poisonous, irritant or corrosive gases; and for the storage, handling or processing of materials producing explosive mixtures of dust which results in the further division of matter into fine particles subject to spontaneous ignition.

Other Classifications: While the above classification is based on the nature of occupancy, which is important for the functional design of buildings, it is also necessary to have sub-classifications on the basis of fire-resistance characteristics.

The selection of site for a particular building depends not only on its functional use and fire-rating but also on climate (global and local), topography, and the developmental needs of the site. In addition, socio-political aspects may also have to be considered. In the various sections that follow, you will learn about the relevant rules and/or requirements.

1.3 CRITERIA FOR LOCATION AND SITE SELECTION

Selection of the best site available for putting up a structure (or groups of buildings) to serve a particular function is very important. Appropriate location has a direct effect on:

a. Cost of the project
b. Accessibility
c. Structural techniques required
d. Extent and nature of site preparation needed

1.3.1 Basic Requirements:

Certain basic needs form the basis for judging the suitability of a site for all types of buildings:

a. Availability of physical resources such as good water supply, power supply and material supply
b. Climatic considerations such as temperature, humidity, solar radiation, rainfall, wind etc.
c. Physical factors such as the contour of the site and nature and condition of the Soil.

1.3.2 Zoning and Other Factors

Political factors and land use restrictions by local authorities have to be considered while choosing locations. Usually, a city or regional governmental agency divides its area into certain zones. This process sets aside land in an orderly fashion for residential, commercial and industrial use. It places industrial and commercial activities in areas where they will not interfere with the residential areas or affect the properly values. Zoning facilitates transportation planning, location of railway lines and yards and in segregating hazardous and noisy buildings from those which need a safe, dust and pollution-free atmosphere and quietude. Location is influenced also by its nearness to highways and railway lines where this factor is important to the project under consideration.

The extent of local taxes, such as property tax, sales tax, and income tax must be considered in the selection of location. Central government offers certain tax concessions including a tax holiday for locating industries in certain not-so-well developed locations. Community acceptance is another important factor.

Building bye-laws of municipalities and development control rules of various government authorities govern most of the building activities.

1.3.3 Environmental Impact Study (EIS)

Every developmental activity of man has some positive and some negative impacts upon the environment, and site developers should consider the following factors right from the very early stages of planning:

a. Air quality
b. Water quality, and quantity
c. Solid wastes
d. Noise
e. Radiation from nearby radio-active sources
f. Hazardous situations
g. Energy supply and natural resources depletion
h. Protection of environmentally critical areas— flood plains, wetlands, beaches, and dunes, unstable soil, steep slopes, aquifer recharge areas,
i. Land use in coastal areas
j. Redevelopment in built-up areas
k. Density and congestion mitigation
l. Neighborhood character and continuity.

1.3.4 Need Tor Expertise in Site Selection

Site selection is a serious professional task and should not be left to the whims and fancies of the uninitiated. The need for experts to analyze and evaluate specific requirements exists in greater urgency today than in earlier times. Because of urban growth, corporate relocations between urban centers, as well as legislation regarding new zoning limitations and building restrictions together with growing environmental considerations, the evaluation of appropriate locations and sites have become a very crucial aspect of development.

1.4 CLIMATIC CONSIDERATIONS

Climate has a considerable influence on the life of man and his economic activity. The climate of a particular site is determined, first and foremost by its location on the globe. Hence, global climatic considerations will have to be taken into account first. Secondly, local site conditions also affect the climate and hence the site-climatic considerations will have to be studied next. It is possible to control the specific climate of a particular building by structural design and/or mechanical devices.

It is important to realize that the increasing tempo of the developmental activities of man has started affecting the global environment itself (in an adverse manner) and many national and international agencies are demanding the imposition of controls on development at national, regional, and local levels. However, this is a topic beyond the scope of this text.

A study of the physical parameters that influence the climate will help us to choose locations properly and site our buildings in the most effective manner, and to design our buildings and services to take advantage of the natural climatic conditions and also to mitigate the negative impact of such building activities on the environment.

Climate is defined as, 'that state of the atmospheric environment that results from the combined processes of the elements of weather, averaged at any given place, over a period of years.' Climate is dependent on the geographical latitude, elevation above sea level, and the physical state of the atmosphere such as its temperature, humidity, rainfall, wind conditions, and the terrain of the place.

Let us now proceed to study the various physical aspects of climate at the global and local levels respectively.

1.4.1 Global Climate (Koenigsberger, et al, 1975)

Global climate can be understood with the help of the following parameters:

a. **Heat:** The earth receives almost all its energy from the sun in the form of radiation and thus the sun has the dominant influence on climate. This radiant energy is transmitted to the Earth as ultra-violet radiation (short waves) and infra-red radiation (long waves). Most of this energy is perceived as heat and only an insignificant part is visible as light (Figure 1.1).

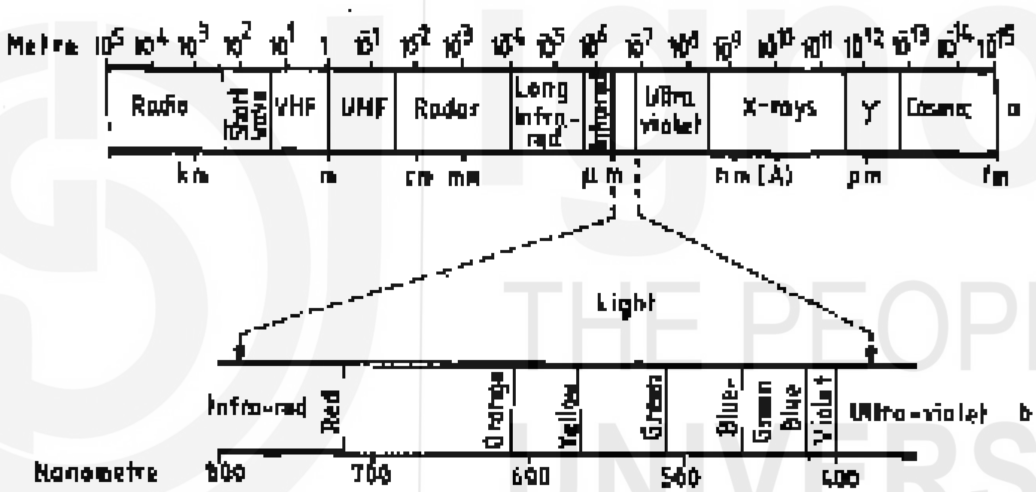

Figure 1.1: Radiation Spectrum

The earth moves around the sun in a slightly elliptical orbit (Figure 1.2). One revolution is completed in 365 days, 5 hours and 48 minutes. The solar distance varies from 152million kilometers to 147 million kilometers. The earth rotates around its own axis, every24 hours, and the axis is tilted to the plane of the elliptical orbit at an angle of 23.5' with respect to the vertical. Due to this tilted position, the area receiving the maximum radiant intensity falls alternately to north and south between the tropic of Cancer (Latitude 23.5 N) and the tropic of Capricorn (Latitude 23 S). This is the main cause of seasonal climatic changes.

The earth has an atmosphere which revolves along with it. As the earth rotates the length of the Sun's rays passing through the atmosphere changes and hence, the intensity of radiation, and incidents on the Earth's surface, from the Sun, also changes (Figure 1.3).

Figure 1.2: Earth Revolving Around the Sun

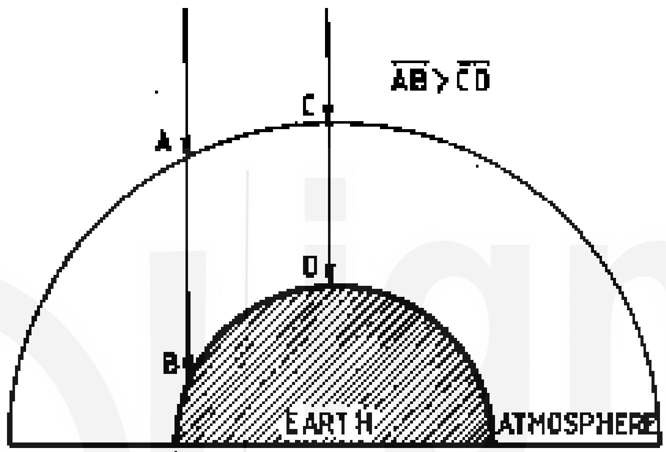

Figure 1.3: **Length of Sun's Rays Traversing Atmosphere**

Figure 1.4 illustrates the incoming radiation while Figure l.5 shows how the Earth's surface release heat and thus, achieves a heat balance, each year. Buildings and the surrounding vegetation affect the heat balance and hence, the micro-climate of the site. Unless thermal balance is maintained, the temperature of the earth and its atmosphere would keep increasing and would soon cease to be favorable to most form of life.

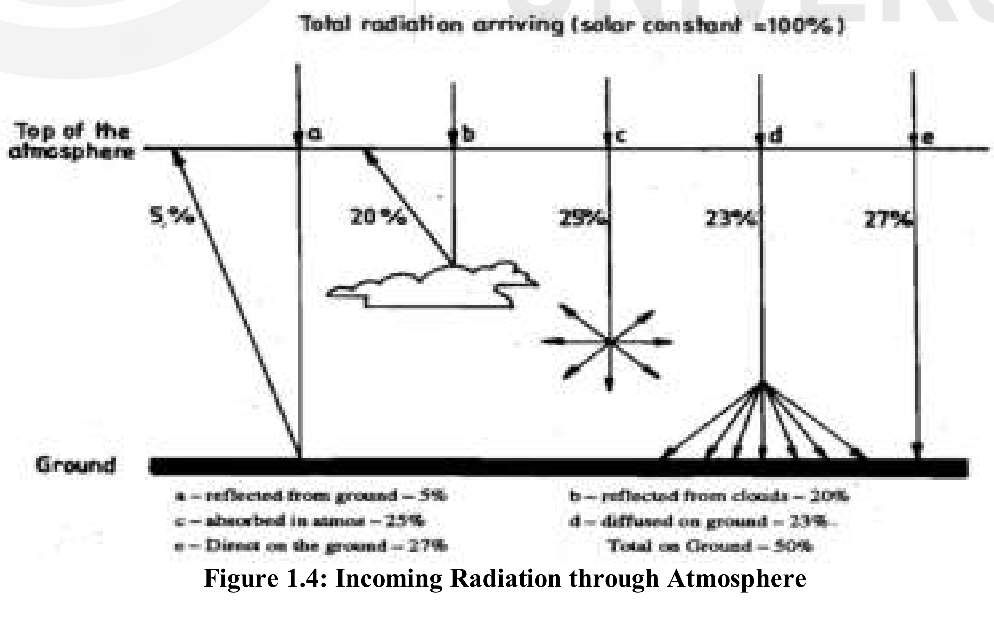

Figure 1.4: Incoming Radiation through Atmosphere

In fact, we are concerned about global warming and ozone depletion these days. There are alarming indications of this imbalance which have arisen due to uncontrolled developmental activities and use of dangerous chemicals. Temperature is measured in degrees Celsius by a maximum-minimum thermometer. A simple sunshine recorder will register the duration of sunshine, expressed in number of hours per day. The temperature which is reported usually is called dry bulb temperature (DBT).

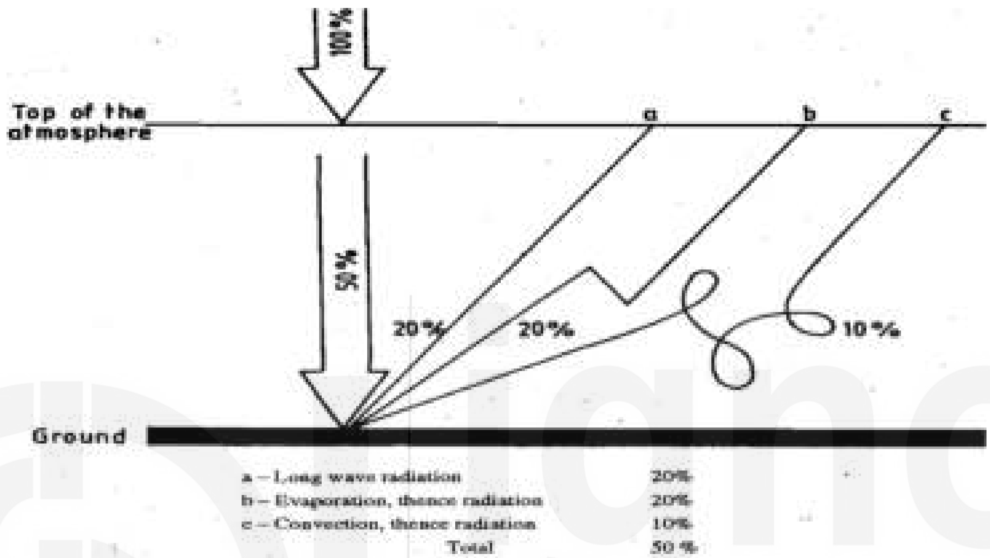

Figure 1.5: Heat Release from Ground and Atmosphere

b. Winds

Winds abasically convection currents in the atmosphere, tending to even out the differential heating of various zones. The pattern of movements is modified by the Earth's rotation which bas a speed of 27 km/min at the equator. At the maximum heating zone, which is somewhere between the tropics of Cancer and Capricorn, air is heated by the hot surface of the earth; it expands and its pressure is reduced, and thus, it becomes lighter. As a result, this air rises vertically and flows at a high level towards colder regions, parts of this air having cooled down at the higher level; and it descends to the surface in the sub-tropic regions from where the cooler, heavier air is drawn in towards the equator from both the north and south regions.

The area where the air rises, and these northerly and southerly winds meet and where the tropical calm is formed is called as the **inter-tropical convergence zone.** This area experiences either completely calm conditions or light breezes (Figure 1.6).

The atmospheric envelope rotates along with the earth. As it is light in weight and behaves like a fluid, it has a tendency to lag behind the earth at the equator, where the tangential speed of earth's surface is the largest. Thus, there is a slippage at the boundary layer between the earth and its atmosphere; and this is experienced as a wind blowing in a direction opposite to that of the earth's rotation, which gives rise to the north easterly and south easterly winds. These are known as trade winds (Koenigsbergar, et al, 1975).

Around 30' N and S, there are two bands of continuously high barometric pressure zones (descending air). Winds in these zones are typically light and variable. Between 30^0 N and 50^0 N and similarly in the south. strong westerly winds prevail, blowing in the same direction as the earth's rotation. The origin of these winds have been explained by the law of conservation of angular momentum of the earth-atmosphere system.

Further, down the poles form 60^0 N and S the air flow pattern is similar to that of the equator. Hence, the north easterly and south easterly polar winds.

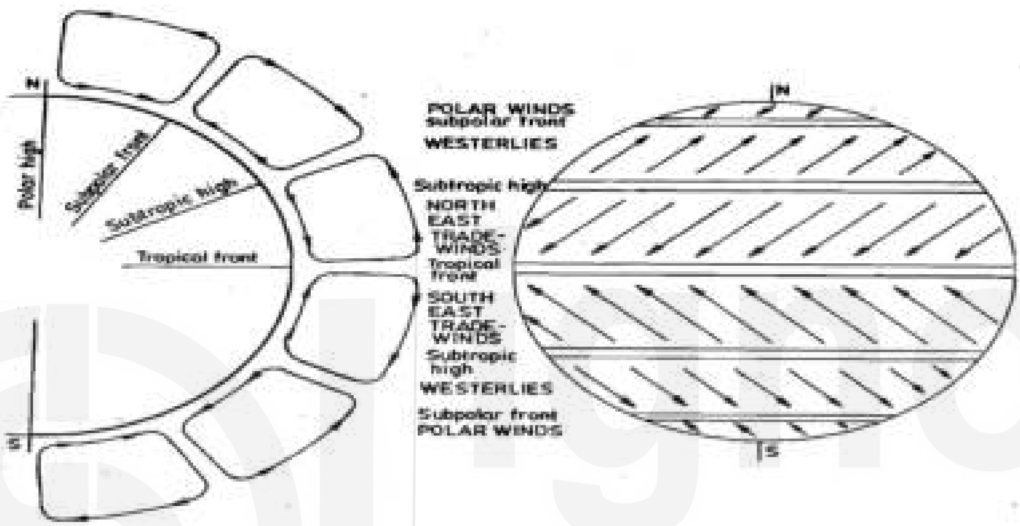

Figure 1.6 Global Pressure Belts and Prevailing Winds

The prevailing wind direction is a major factor in selecting a site for a populated place and the allocation of functional zones. Account should be taken of the fact that the local topography has a significant influence; for example, in the daytime, the earth is heated faster than water and hence the air mass near the earth becomes less dense, creating a zone of low pressure. This gives rise to a wind that blows from the sea towards the shore. At night, the temperature of the water is higher than that of the air and this condition reverses the direction of the wind.

Wind velocity is measured by a cup-type propeller known as an anemometer, and its direction is measured by a wind-vane.

c. Humidity

The air in the lowly layers of the atmosphere always contains a certain amount of water vapor resulting from evaporation of water on and in the earth's surface. The rate of evaporation depends primarily on temperature and wind. It has been estimated that the surface of the ocean, in the tropics, evaporates in a year a layer of water up to 3 meters in depth. This must be replenished by rainfall and run-off from the rivers. The ability of air to absorb and retain the maximum amount of water vapor is directly related to temperature.

Absolute Humidity is defined as the amount of water vapor in moist air at any given time and is expressed in gm/m^3 of air.

Relative Humidity (RH) is defined as the ratio of water vapors in moist air to water vapor in saturated air, expressed in percentage. For example, if the absolute humidity o fair, for any given temperature is equal to 7gm/m^3, and saturated air (at the same temperature) contains 10 gm/m^3, the ratio 7:10, expressed as a percentage will be the relative humidity.

$$\therefore RH = \frac{7}{10} \times 100 = 70\%$$

Humidity is usually measured by **wet- and dry-bulb hygrometer**.

d. Precipitation (Rainfall)

Precipitation is the collective term used for rain, snow, hail, dew and frost, i.e. all forms of water precipitated from the atmosphere. It is measured by rain gauges and snow gauges and is expressed in millimeters per day or month.

e. Climate Data

It is important to note that climate at global/regional level is best described by measured data, over a period of time, such as sunshine (hours per day), radiant heat (watts per meter square per day), wind velocity (meter/sec) and wind direction (N, NE, E, SE, S, SW, W and NW), rainfall (mm per month), relative humidity (percentage) and temperature (maximum and minimum in degrees Celsius).

It is not easy to understand the nature of a particular climate by merely looking at the vast amount of data collected by the nearest meteorological station. It is necessary to sort, summaries and simplify the available data with reference to the objectives of site-selection exercise. This is the best accomplished by adopting a standardized method of graphical representation. Figure 1.7 illustrates a graphical method that was developed for describing the climate of any location.

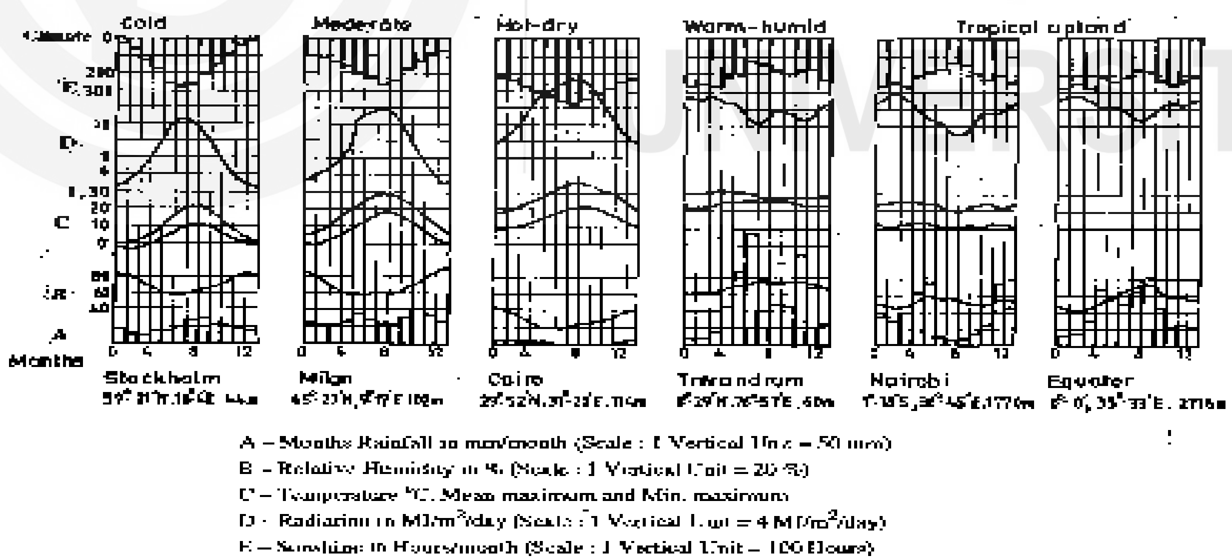

Figure 1.7: **Graphical Representation of Meteorological Data**

Figure 1.8 shows how wind speeds and directions are recorded for a specified period. Based on such climatic data certain zones and belts of approximately uniform climates have been identified and described as under (Koenigsberger, et al, 1975).

f. Classification of Climates: Climates can be classified, broadly, as given below:

(i) Warm-Humid Climate

Warm-humid climates are found in a belt near the equator extending to 15^0 N and 15's. There is very little seasonal variation except for the occurrence periods of more or less rain.

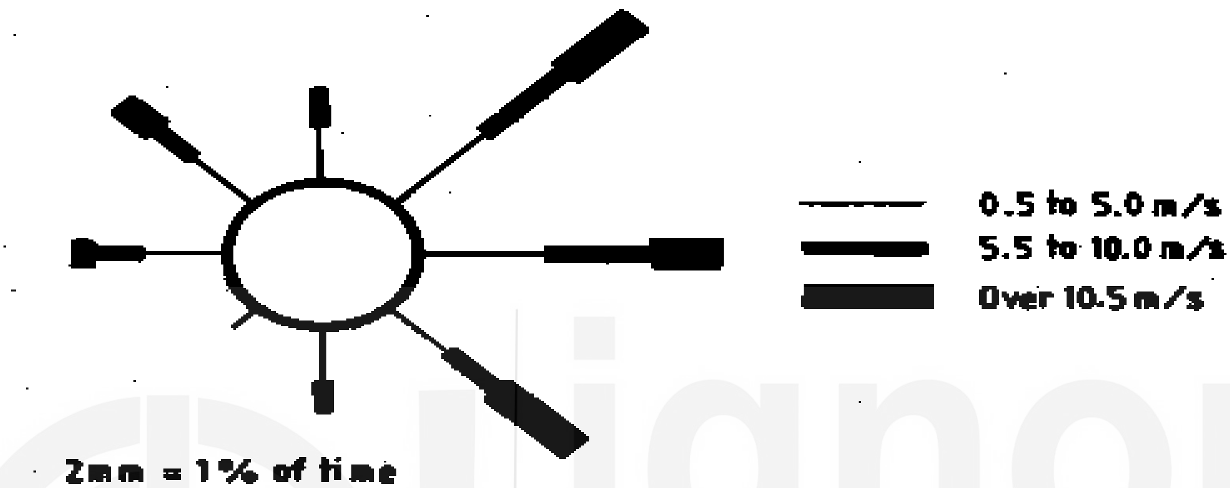

Figure 1.8: Monthly Wind Frequency Graph

Air temperature is 27^0C to 35^0C during the day and 21^0 C to 27^0 C in the night. Relative humidity remains high at about 75%; but it may vary from 55 to almost 100%. Rainfall is high throughout the year. Annual rainfall can vary from 2000 mm to 5000 mm and monthly rainfall may exceed 500 mm. During severe storms the down pour may be also as high as 100 mm/hr.

Wind velocities are low, calm periods are frequent but strong winds exceeding 30 m/s can occur during rain squalls. There are usually one or two dominant directions of wind.

Special characteristics of this region are that the high humidity accelerates mound and algae growth, rusting and rotting. Organic building materials tiled to decay rapidly. Mosquitoes and other insects abound. The thunder-storms are accompanied by frequent air-to-air electric discharges. The subsoil water table is usually high and the ground may be water-logged.

(ii) **Hot Dry Climate**

This type of climate occurs in two belts at latitudes between 15^0 and 30^0 north and south of the equator. Two marked seasons occur, a hot and a somewhat cooler period.

Air temperature during day time may reach a maximum of 43^0 to 49^0 C in the summer. The night temperature will range from 27^0 to 32^0C during summer. During the cool season the day time temperature reaches 27^0 to 32^0 C. Night time temperature may vary from 0^0 C to 18^0 C. The relative humidity varies from 10 to 55 percent. Rainfall is slight and variable throughout the year from 50 mm to 150 mm per minutes Flash storms may occur over limited areas with 50 mm rain in a few hours. Winds are usually local and whirlwinds are often created. Winds are hot, carrying dust and sand, and often develop into dust-storms.

The soil is usually dusty and very dry. The sub-soil water table is very low. The high day time temperatures and rapid cooling at night may cause materials to crack and break up since the daily temperature variation reaches 17^0 to 22^0C.

(iii) **Monsoon Climate**

Monsoon climate occurs over large land masses near the tropics of Cancer and Capricorn, which are sufficiently far from the equator to experience marked seasonal changes in solar radiation and wind directions. Our capital, New Delhi is subject to such a climate.

Approximately one-third to two-thirds of the year is hot and dry and the other third may be warm and humid or cool and dry as the latitude increases from the tropics; day-time temperatures in the hot and dry seasons will vary from 32^0 to 43^0 C. Night time temperatures may be 21^0 to 27^0 C. During the cool and dry seasons, the day time temperature may dip down to 4' to 10°C. Relative humidity during dry period rises from 55 to 95%. Rainfall varies from 500 to 1300 mm per year with 200 to 250 mm in the wettest month; there is little or no rain during the dry season.

Winds are hot and dusty during the dry period. Wind changes direction in the beginning of the warm-humid seasons, but monsoon winds are fairly strong and steady.

There is a risk of soil erosion during monsoons. In the dry season. strong ground glare is experienced. Seasonal changes in relative humidity cause rapid weakening of building materials. Dust and sand storms may occur. Termites are common.

(iv) Other Climates

Mountain regions and plateaus, more than 900 to 1200 meters above sea level experience special climates as also the coastal regions and islands. Site selection and orientation of buildings, and the selection of building designs will have to be suitably adjusted to suit such climates.

1.4.2 Site Climate (Koenigsberger, et al, 1975)

Knowledge of the climatic zone to which a site belongs is indeed important as explained earlier. But every city, town or village and even a precinct in a town may have a climate of its own, which is called the site climate. Factors which may cause local deviations from the zonal climate are:

i. **topography** - Slope, orientation, exposure, elevation, hills and valleys at or near the site, nearness to sea/lake etc.,
ii. **ground surface** (whether material or man-made) - IQ reflectivity, permeability and soil temperature which affect vegetation.
iii. **objects -** Such as trees, tree belts, walls and other buildings; they influence air-movement or may cast shadows.

A logical method will be lo follow the sequence of global climatic conditions, examined in the previous section, and see how each of the above factors will affect them. Following guidelines are available for guidance/decision making:

- The air within 2 meters of the ground is significantly affected by solar radiation and reflection from ground. If the lower layers become hot enough, upward movement of an eddy of warmer, and hence, lighter air, will take place. At night the heat of the ground is lost faster than that of the air above. The direction of heat flow will be reversed from the air to the ground. The reflection factor of the underlying surface is important in this regard. Reflectivity of concrete is 30-45 %; of lime-stone is 50-65%; of rough gray asphalt is 25%; and of newly cut lemon grass is 20%. Thus, providing lemongrass around large buildings is not a luxury, but a necessity. The most difficult conditions are to be observed in urban areas where the surface of buildings and**;** pavements provide additional sources of reflected heat. The mean ambient temperature of cities, is higher by 8^0 C or so than in rural areas nearby.

From the stand point of site climate, asphalt is the most unfavorable material. It contains noxious substances harmful to man; and it is air-tight and gas-tight. Thus, it has a negative effect on soil; a harmful influence on vegetation, and in general raises the ambient temperature. Also, accounting for higher temperatures in cities is the blanket of smoke over the cities which retards the escape of reflected radiation. It is advisable-to minimize the use of asphalt and smoke-emanating vehicles and industries in cities (Rimsha, 1976).

The phenomenon of heat flow from the air to ground which often occurs in the nights is referred to as temperature inversion. Cold air tends to settle in the deepest depressions and down the hill and along the floor of sloping valleys. Topography can thus, strongly influence air temperature, a difference of 5^0C to O°C can occur in a height of 7 to 8 m.

It is better to avoid locating buildings in valleys and it is advisable to build large buildings on level grounds.

- Relative Humidity depends as much on the air temperature as on the actual amount of water vapor in the air. During the day, as the lowest layer of air is being heated by the ground surface, its relative humidity is rapidly decreased. The rate of evaporation is increased, if there is water available to be evaporated. An open surface of water or rich vegetation would provide an abundant supply of water. At night the situation is reversed as the lowest layer cools its relative humidity increases, the point of saturation is soon reached, and with further cooling the excess moisture condenses out in the form of dew. When the dew point temperature is reached, the formation of fog wills tart, and if there is no air movement, a deep layer of (40 to 50 cm) fog can develop nears the ground. This affects the visibility prevailing on transportation network, particularly at the airports.

- Where the ground changes level by more than 300 m, the wind-ward slope can be expected to receive more than the regional average of rain fall and the lee-ward slope correspondingly less (Figure 1.9). This is due to the phenomenon that the air mass is forced to rise up the hill by the prevailing wind, and as it rises it cools and can no longer support the moisture carried by it and hence, rainfall is induced.

- Regarding the behavior of wind on a hilly site, the greatest wind speeds will be experienced on the crest of the hills. Small valleys and depressions will normally experience low velocities, except in valleys which are oriented in the direction of the wind.

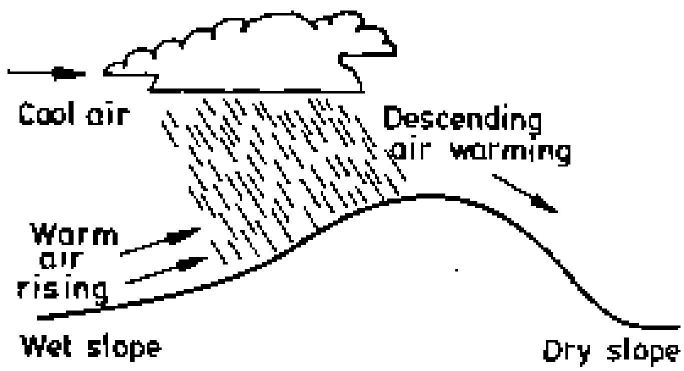

Figure 1.9: **Precipitation on Hills**

In regions where wind can provide a welcome relief from sultry weather, the crests and wind-ward slopes are preferable as building sites, to the lee-ward sides of hills.

- Large stretches of water can give rise to the local coastal breezes. On-shore breezes (from water to land) during the day may lower the temperature by as much as 10^0C, but are likely to increase the humidity.

  It is obvious, buildings should be broadly spaced for adequate breeze penetration. As a rough guide spacing between long roofs of buildings should not be less than 5 times their height.

1.4.3 Urban Climate (Koenigsbeger, et al, 1975)

Over and above the global climate and site climate, man-made environments, such as in towns and cities can create micro-climates of their own, which may be termed as the **urban climate.** The factors which cause deviations in regional climate are the following:

a. **Changed surface qualities** - pavements and buildings increase the absorption of solar radiation and reduce evaporation,
b. **Buildings** - they cast shadows, channelize winds, and store absorbed heat, and slowly releasing it at night,
c. **Energy seepage** - it occurs through walls of heated buildings, out of A. C. plants, as heat output of internal combustion engines, and due to electrical inefficiencies and as heat loss from industry and factories, and
d. **Atmospheric pollution** - water vapors from boilers exhaust from domestic and industrial chimneys exhaust air from motor vehicles, and fumes, vapor and dust in general.

The extent of deviations with respect to the site climate can be substantial. The air temperature can be $\mathbf{8^0}$ to $\mathbf{11^0C}$ higher than the surrounding countryside. The relative humidity is reduced by 5 to 10% due to quick run-off of rain water from paved areas, absence of vegetation and higher temperature. Wind velocity can be reduced to less than half of that in the adjoining open country.

1.4.4 Broad Guidelines

The choice of a site for any type of building is first and foremost governed by the global and site climates, even though it is possible to engineer a variety of climatic controls, settlement-wise and building-wise, it is obvious that natural climatic conditions should be taken advantage of, in order to reduce the overall cost. Based on the climatic descriptions given in the earlier sections, it is possible to lay down certain broad guide-lines as under:

a. In **hot-dry climates,** the walls of the largest dimension in a building should preferably face north and south, **as** these elevations receive the lowest heat loads from solar radiation. The worst orientation is the west-ward one. By aligning buildings close to each other, especially if east-west walls are placed close together, mutual shading will decrease the heat gains of external walls. For this reason, in hot-dry climates the tendency is to have close groupings of buildings, narrow streets and small enclosed courtyards.

b. In **warm-humid climates,** natural ventilation is the predominant criterion for deciding about orientation. The buildings tend to have long elongated shapes with single row of rooms to allow for cross ventilation. It may often become necessary to elevate the building on stilts, thereby avoiding stagnant or slowly moving air at the ground surface. The density of development is less than that in hot dry climates so as to permit free air movement.

c. In **monsoon climates,** the weather changes from season to season and designers face a difficult task. Experience shows that the buildings are best designed to meet the requirements of the hot seasons, a moderately dense, courtyard type, low rise development is very suitable.

In this section, we have discussed the site selection and orientation of buildings on the basis of climate.

1.5 TOPOGRAPHIC CONSIDERATIONS

For proper site selection/planning, in addition to climatic data, the following information is also important:

a. Topographic data
b. Geological information
c. Hydrology of the area
d. Soil types of the site

A site is not simply a collection of buildings and streets, but it is surfaces, spaces, living things and climatic parameters. It is a site plan whenever substantial groups of buildings are factories, shopping centers, institutions, cultural planning.

Past experience indicates the categories of data that is most likely to be useful. For example, foundation conditions and the water table are the key sub-surface conditions to be considered. The rock or the earth below the ground level has importance primarily with regard to the way in which they can be excavated, their drainage characteristics, and the manner in which they will support the structures and plants. The engineering characteristics of the soil depend on its type and moisture content. While critical problems must be studied by laboratory methods, a surprisingly good picture can be gained from field reconnaissance also. Other sources of information include small test pits, geological maps, existing cuttings and foundations, the types of vegetation at site and the experience of previous builders and engineers.

Money spent on these preliminary investigations will help in avoiding:

a. expensive site-preparation, (cut and fill, drainage of the sub-soil etc.),
b. rectification of damage caused to buildings (due to settling, sliding and tilting), and
c. discomfort due to dampness, insanitation, flooding etc.

Plants and trees are particularly good indicators; they speak not only of the climate, but of the soil, the water and the history of the place.

We shall study in the following Sections, the methods of collecting data: and reaching broad conclusions. In the case of large-scale projects, the services of experts will have to be utilized.

1.5.1 Topographic Data

The basic land form (or topographic structure) of a site is first studied by visual inspection. If need arises detailed maps are to be prepared. The following list presents the features of topography, which are important:

a. Elevation above sea level
b. Orientation of the site (e.g., east to south-east etc.)
c. Slopes in percentage (0% to 3%, 3 to 8% etc.)
d. Surface waters (such as ponds, streams and rivers and drainage patterns)
e. Hills and valleys (visibility etc.)
f. Hood plains, swamps, quick sand, etc.

Topographic Maps

The contour map is the basis for the preparation of other kinds of topographic when found necessary.

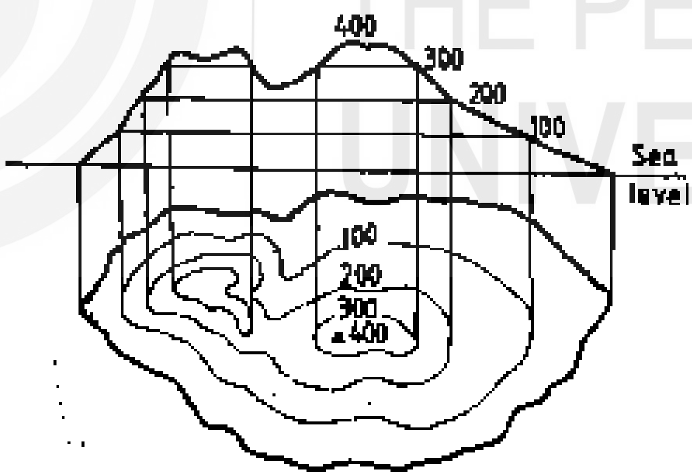

Figure 1.10: Contour Map of an Island Drawn from its Profile Section

Contours are sets of imaginary lines that connect all points of same elevation on the ground (Figure 1.10). The sets of ground points to be connected by these lines (each set of points corresponding to one particular elevation) are separated by some regular interval: 0.25, 0.50, or 1 m. Contour lines are always continuous within the space of anyone map and do not merge or cross each other except at vertical or over-hanging surfaces. The closer they are together, the steeper the ground is. The more nearly parallel they are, the more regular the ground surface slope prevails. In rolling land, they take the shape of flowing curves; over plane surfaces they run in straight lines. One easily identifies the contour patterns of typical topographic features: stream, valley, ridge, bowl, depression, flat, grade, escarpment, pass, the peak etc. Contours are easily sketched or adjusted to describe the required ground form. An easy familiarity with these patterns is essential fora site planner.

While contour maps are the standard way of representing ground form, there are other methods. One is to record the spot elevations of key points on the ground: the crests, valley bottoms, breaks in grade, floor levels of structures etc. This record may be made more useful by giving the elevation of every intersection point of some imaginary grid, a method often used for precise calculations in small areas.

The old method of hachures is still sometimes used in which short lines, perpendicular, rather than parallel to the slope, are drawn side by side the curving runs. Their direction points directly up or down the hill, their length indicates the length of the slope, and their closeness together shows the steepness. They demand skillful drafting. If well done, they give a vivid picture of the general terrain.

The visual exposure of a single point or the relative exposure of a land area can be analyzed and plotted. Figure 1.10 is a single point analysis that displays with dark gridlines areas that can be seen in 360 degrees. When one is standing at a point of observation. Such diagrams have been utilized to locate restaurants and water-towers in hill areas (Joseph De Chiara, et al, 1978).

Topographic surface, the boundary between earth and air is the richest in living things. It has a particular implication for site development. The gradient of paths, the flow of utilities, the use of areas, the disposition of buildings and the visual aspect are all affected by it. The designer must grasp the character of the land form as a whole and identity its key points for the purpose he has in mind. In most cases, the existing topography has an underlying order brought about by the flow of surface water (Kevin Lynch, 1971).

Slope can be classified according to their potential use, such as, a flat ground, can be used for intensive activity. Slopes over 10 percent require considerable effort to climb; and to erect buildings on them, more complicated form and foundations and more difficult utility connections are required.

Another critical aspect of ground form is the way in which it limits orientation by means of roads, gravity based utilities, such as sewers. Grades under 1 percent are difficult to drain naturally by gravity.

1.5.2 Geological Information

Engineering works may succeed or fail according to how well we understand the geological process having occurred at the area/site.

The topography, geology of the bedrock and surface deposits, and the hydrology are factors which are to be considered in planning, designing and construction of engineering structures. In this section, we will study the geological aspects that govern the site-selection process, such as:

a. Ground stability and its relevance to the foundation design for various structures,
b. Ease and cost of excavating different kinds of formations/ground
c. Susceptibility of various kinds of pound to erosion

Determining the geology of an area for engineering purposes involves more than merely locating and indicating the kind of surface deposits and rock formations. The relationships between these must be determined in order to learn about their geological history.

The earth's crust began solidifying, some four and a half billions of years ago. As the crust developed into a solid formation, water vapor, nitrogen, carbon dioxide, and other gases gradually escaped from the earth's interior through vents in the slowly cooling crust. Water vapor formed clouds and when the rains did come some four billion years ago, water running off the high ground collected to form the first streams, lakes and seas.

It was in the seas that life began and not until the photo-synthesizing organisms evolved did oxygen become a constituent of the atmosphere. The gradual evolution of life was of increasing diversity and complexity. In the course of the next three and a half billions of years, slabs of the earth's crust thickened and broadened to form the present continents. The evolution of higher forms of life and the development of the bio-chemical process, so important today in weathering and soil formation, took place in the last half billion years. Most of the surface deposits and soils which are of interest to the engineers were formed in the past few million years and many influences upon these materials date back to less than ten thousand years (Hunt, 1972).

The loose deposits covering the bedrock are called surface deposits**.** They are composed largely of mineral matter, like the bedrock from which they are derived. Their thickness may vary from 3 to 30 meters. Most surface deposits are sediments weathered from bedrock in one area and transported by water, wind or ice to another area. Because of this, they are often unrelated mineralogical to the underlying bedrock. Some surface deposits are non-transported layers and they are, as such, called residual deposits**.** Still other non-transported deposits are formed by the accumulation of organic matter at the location; accumulation of plant material forms peat.

Weathering of surface deposits causes the development of layers of different types of soil. Thus, at a building site, we may find surface deposits as well as weathered soils which are relatively modem. The engineering properties of the soil layers depend upon the nature of weathering, moisture content, degree of fragmentation and to a certain extent the chemical nature of salts present in them. Soil engineering is the subject which deals with such phenomena. Apart from this, the stability of large structures, such as dams, is influenced by geological features like faults in the earth's crust. Changes in the crust really occur on a gigantic scale resulting in earthquakes, eruption of volcanoes, faults and creation or disappearance of large land masses. The ground on which we build is, geologically speaking, really unstable, but then human knowledge is growing steadily to cater, to some extent, to such extraordinary forces of nature.

Structure of the Rocks: Bed rock, the parent material of surface deposits (and ultimately of soils), is classified according to mode of their formation: igneous, sedimentary and metamorphic. There are many varieties of each kind depending on the minerals in them, and their texture.

Igneous rocks were once molten lava; granite is a typical example.

Sedimentary rocks were once unconsolidated sediments and subsequently these became compacted and firmly adhered to each other to form a rock. Some such rocks are chemical precipitates like limestone and dolomite. Sandstones and shale are other examples.

Metamorphic rocks are those that were once either igneous or sedimentary, but were subsequently altered or re-crystallized by heat and/or pressure at great depth in the earth's crust. Marble, the metamorphic equivalent of limestone or dolomite is widely used in building construction for ornamental purposes.

Based on the structure of rocks certain physical behaviors can be predicted as under:

i. **Permeability** - it is the degree to which water can enter and flow through the interstices within the rock. It is high in sandstone, at 10 percent. But it is 14% for igneous rocks such as granite. Water absorption by small specimens is an indirect test for permeability. Specimens of igneous rocks may absorb water only up to 1 to 2 percent of water of its weight.

ii. **Fractures** are structural characteristics of a rock that influence its weather ability. Fractures in massive igneous rocks (fissures and cracks) have preferred directions, and water which may carry dissolved acids seeps into such cracks and reacts with rock walls causing chemical alterations. Few sedimentary or metamorphic rocks are massive, and most of them are stratified. Water can seep along the bedding planes and open up further fractures and damage these rocks faster.

iii. **Freezing and thawing** of water and hydration of minerals are major factors in the weathering of all types of rocks.

iv. **Erosion** of rocks takes place by the action of wind and water. Shale is easily eroded, and sandstones are susceptible to erosion by rain.

Ground Stability: Ground stability is dependent on numerous variables, one of which is slope. Rocks in which bedding planes or fractures dip in the same direction as the slope of the hill are dangerously subject to landslides, particularly if water can enter these fractures. When a cutting is made in rocks for roads and foundations, horizontal bedding planes even in poorly frosted sandstone often give near-vertical faces, which are stable. Heavy rain, especially after a drought, saturates the material forming the slope, and thus, increasing its mass and the gravitational pull; and the reduced friction between the joints, due to water thus, initiate a rock slide in hilly regions.

Constructions at Rocky Sites: Dams are meant to hold water and the rocks at the ground and those below them must be impervious. The consequences of increase in water table elevation and the deposition of sediments on the foundation rock must be studied. Fault zones filled with pervious deposits as well as open joints may serve as paths for leakage to occur.

In the case of tunneling, the feasibility, planning, design, the techniques used and the risk of serious accidents during construction are all dependent on the geology of the site.

Location of quarries for production of building stones, crushed stone aggregates etc., also requires geological studies. However, a detailed study of geology is beyond the scope of this text.

Engineering Geology

The systematic study of geology, including testing of engineering properties of rocks and surface deposits, which fall within its scope (that covers areas between classical geology and older disciplines of Civil Engineering such as tunneling, dam construction, bridge construction etc.) is called engineering geology. In a major engineering project, the following stages of geological investigations are essential:

i. preliminary investigation using published information, such as geological maps,
ii. a details geological survey of the site, possibly with aerial photographs,
iii. applied geophysical surveys to provide information about the sub-surface geology.
iv. boring, drilling and excavation to provide confirmation of the results so far arrived at and quantitative detail at the critical points on the site, and
v. testing of soils and rocks to assess their suitability, particularly their mechanical properties, either in situ or in the laboratory.

These tasks are performed by experts but it is necessary to appreciate the situations wherein the advice of these experts is needed.

1.5.3 Hydrology of the Area

The states of surface and sub-surface water at a building site are important. The surface water may take various forms, such as streams, rivers, ponds and lakes. Drainage basins(watersheds) will have to be identified for they may drain into a particular building site during heavy rains. If the building is to be located in a flood plain, special precautions will have to be undertaken. Equally important is the position of underground water table and its variations. The capability of the hydrological systems at subsurface level (wells and aquifers) becomes important if water is to be tapped and utilized for household or industrial use.

Flood Plains and Flood Protection: Many structures and potential building sites are located in flood plains and thus, are susceptible to flooding.

Studies about the use of flood plain by the building industry show that some encroachment is undertaken in ignorance of the consequent hazard; most of the encroachment takes place because it is profitable for private owners to undertake such development and shift the cost of eventual hazard to the society. To escape this dismal cycle of losses, partial protection, further induced development and further, unnecessary losses, careful building regulations and development policies will have to be laid down.

Gathering and dissemination of data on past floods, making estimates of future floods and investigating alternate methods of dealing with flood losses in areas where intensive development is envisaged, should be all be done before major actions are taken.

Flood protection requires adjustments both in structures and in building utilization practice and it involves keeping water out as well as reducing the effects of water entry into a building. It is better to avoid the construction of important buildings in flood plains (Joseph De Chiara, 1978).

Ground Water and Drainage: Essential factors (in site selection) include a water table low enough to protect buildings against basement flooding and interference with sewerage, the absence of swamps and marshes, and sufficient scope to permit surface drainage of normal rainfall and a free flow of sanitary sewers. Periodic flooding due to high ground water table should disqualify a site,

For drainage of a relatively flat site, it must be remembered that the minimum slope for paved gutters is 1 in 200.

Surface and subsurface drainage systems are to be provided by the engineers for the collection and disposal of storm drainage and subsurface water. The selection of a site should thus be based on drainage requirements also.

Water Supply Requirements: One of the first steps in the selection of a suitable water supply: source is determining the water demand based the average daily water consumption and the peak rate of demand. Protected water supply, under pressure, from municipal sources is not to be taken for granted, supply from shallow or deep wells has to be planned for.

The importance of a sanitary survey of water sources cannot be over emphasized. Persons trained and competent in public health engineering and in the epidemiology of waterborne diseases should conduct this sanitary survey.

If ground water is proposed to be utilized, the character of local geology, nature of soil and underlying porous strata, sc e of water table, extent of drainage area likely to contribute water to the supply, and the type and cost of the wells required are all to be studied at the planning and site selection stage itself.

1.5.4 Soil Exploration

We have already studied the need for and the methods of collecting topographic, geological and hydrologic data vis-a-vis a building site. A knowledge of the soil at the site is important not only in terms of its engineering but also in terms of its relevance to natural life systems such as vegetation, animal and insect life etc. We will emphasize in this section the engineering properties of the surface soil, vis-à-vis a given site.

Structures are heavy and their heavy weight must be borne by the land upon which they are built. But the substructure of the soil and earth is not always what it seems to be from the surface. Therefore, before the construction of a building can begin, samples of the soil, through borings, will have to be taken and analyzed. No matter what the structure is, it must be supported by a sturdy foundation. This foundation links the structure to the earth. A well-designed and well-built foundation will always help protect the structure from shifting or sagging. It will be thus, realized that soil exploration in respect of a site is an important activity which is bound to influence the site selection.

The following factors are important for site exploration:

a. Depth to seasonal high water table
b. Depth to bed rock
c. Drainage characteristics
d. Suitability for the functioning of septic tanks, excavation and grading
e. Value as foundation material
f. Susceptibility to compaction
g. Susceptibility to erosion
h. The pH rating
i. Soil fertility,

We will present a brief review, only of the items which will aid the engineer in proper site selection.

General Considerations

The type of site explorations to be carried out is dependent on the loads transmitted to the ground and the functions of a building. These factors can vary widely. The following are presented as guidelines (Krymineand Judol, 1957) in this regard:

- Generally, for lighter structures, the depth to which the investigations are carried is limited, whereas for heavier structures it is generally necessary to explore the entire depth of soil covering the rock and even to penetrate into the rock, if necessary.

- The drilling work should be limited to a strictly necessary number of holes of reasonable depth.

- Laboratory soil and rock testing are to be considered as integral part of the exploratory programme.
- Besides the soil and rock exploration proper, all information is to be obtained concerning the earth work to be done in connection with the building.
- The magnitude and especially, the cost of the exploratory prograqmme depend on the importance and cost of the building.
- The nature of exploration will depend on the proposed type of foundation such as spread footings, mat or raft, caissons, piles etc.
- The safe bearing capacity may have to be obtained from load tests for important structures, if the behavior of underlying soil is suspected, even if these be expensive.
- Some foundation problems are common to all kinds of buildings such as excavation problems: unstable foundation material and ground water problems. These may have to be considered at the very initial stages.
- Extensive geotechnical investigations for ordinary residential buildings may not be necessary. Simple trial pits or bore holes are adequate along with the observation of adjoining buildings.
- Commercial buildings are characterized by a heavy concentration of loads, generally transmitted to the foundation by columns. Many of them have, deep basements, a fact that calls for a careful ground water investigation. The ideal programme would be to have one

bore hole at every column location, but ordinarily sufficient information about stratification may be obtained from the bore holes drilled at the building comers and at the locations of the interior columns which will carry the heaviest loads. In soils, suspected to be of highly variable nature, additional holes for exact correlation of the data should be drilled.

- Industrial buildings include warehouses, factories and garages. In such buildings floor loads may be very heavy and individual footings for heavy machines may be required. In manufacturing plants, besides the usual dead and live loads, it may be necessary to consider vibration effects. Particularly sensitive to vibrations are relatively loose sands and gravels, and compaction of these materials by vibrations is responsible for settlement of footings placed on them. Because of the large site of these buildings sufficient bore holes should be drilled to locate possible critical changes in sub-surface materials. High water table is of concern, since it may cause uplift on the floor slabs when they are placed directly on the soil, and cause buoyancy on the footings or interfere with excavation.
- In the case of power plants and pumping stations, intense influence of vibrations, and their sensitivity to relative settlements are important. Subsurface investigations should be very detailed and thorough. All bore holes should go to a depth equivalent to if times the width of a power plant. All faults, shear- zones, weathered zones, closely spaced changes in rock type etc., should be studied thoroughly with the help of sufficient number of bore holes.
- Building foundations on fills have become necessary because of shortage of desirable sites in urban areas. Bed fills, including city dumps, reclaimed lands at the ocean shores and swamps and shallow water areas, permanently or periodically flooded, are to be carefully investigated. Old fills generally have a hard crust and may support a very light building; it is advisable to remove the crust and some of the underlying material to a depth of at least 1 meter and then place a new fill. Generally, field explorations should provide samples to test for shear failure and possible settlement of the fill. If piles are used to support a building, they should be driven through the fill to a firm bearing stratum.

Description of Soils (Peck, et a1 1974)

Engineers must know the principal terms which describe soils. Gravel, sand, silt and clay are the common terms used. Most natural soils consist of a mixture of the two or more of these constituents and many contain an admixture of organic material in a partly decomposed state. The mixture is given the name of the constituent that appears to have the maximum influence on its behavior and the other constituents are indicated by adjectives. Thus, silty clay has predominantly the properties of clay, but contains a significant amount of silt.

Gravels, greater than (4.75 mm particle size) and sands (4.75 to 0.75 mm) are known as coarse grained soils, while silts (0.75 to 0.002 mm) and clays are fine grained soils. Clay is predominantly an aggregate of microscopic and sub-microscopic flaky shaped crystalline minerals. It is characterized by the typical colloidal properties of plasticity, cohesion and the ability to absorb ions. These properties are exhibited over a wide range of water content. Clay particles are less than 0.002 mm in size.

Behavior of Soil Types

Gravels do not shrink gr swell and have a high bearing capacity unless they are free to flow laterally. Next to rocks, gravels form ideal foundation materials.

Sands do not swell or shrink too much, in comparison, when moisture content changes. Sand is a good foundation material when it is dense and confined (prevented from flowing out).

Silt has a slight tendency to swell or shrink. Foundation on silty soil is likely to settle significantly.

Clay cannot be drained off easily. Settlement takes place gradually and may persist for years. Clay shrinks when dried. Capillary action is significant in clayey soils and it is, difficult to construct and support foundation of buildings in a purely clayey soil.

When there are layers of these soil types underneath building foundations the resultant behavior is complex and requires the services of a soil mechanics specialist to predict the behaviors.

Safe Bearing Capacity (NBC 1983)
Safe bearing capacity of a soil is the maximum intensity of loading that the soil will safely carry without the risk of shear failure, irrespective of any settlement that may occur.

Allowable Bearing Pressure
Allowable bearing pressure is the maximum allowable loading intensity on the soil for a particular foundation, taking into account the safe bearing capacity, the amount and kind of settlement that is prescribed and the ability of the structure to take up such settlements. The safe bearing capacity of various types of soils for purposes of preliminary estimation of foundation size has been listed in NBC Group 2: 1983, and a partial list is given in Table 1.1.

1.6 PLANNING RULES AND REGULATIONS

It is to be recognized that any construction project has an impact on the neighborhood even before the first spade of earth is turned up. It is not surprising that state and local regulations have been laid down. These are to be adhered to before a building permit can be obtained. Engineers must be aware of these rules and regulations before they select a site and embark on detailed planning. In India, the following documents are to consulted for information on control rules and regulations:

i. The National Building Code (NBC 1983) and its revisions,
ii. Development Control Rules of Metropolitan areas, e.g. DDA for Delhi, MMDA for Madras,
iii. State Government or District or Municipality Building Rules.

In this section, the NBC requirements will be emphasized. Engineers will have to consult the other relevant documents which are applicable to their local areas.

All development projects have values attached to them and a wrong site selection may adversely affect the value of the project. Value of a construction is the price a prospective buyer is willing to pay and seller is willing to accept. The purchase price of a site is really only the beginning; part of the value analysis is a real estate parcel. Every parcel of property is subject to property tax which, although levied by the local government body having jurisdiction over the property, may include, in addition to the local municipal (authority), state and regional authority for taxes and levies. This aspect must be given adequate attention by the owner, while relevant control rules will influence the planning and development of the project by the engineer.

Table 1.1 : Safe Bearing Capacity of Some Rocks and Soils

Sl. No.	Types of Rocks	Safe Bearing Capacity kN/m^2	Remarks
1.	Granite, trap and diorite	3240	
2.	Sandstone and limestone	1620	
3.	Residual deposits of broken bed rocks and hard shale, cemented material	880	
4.	Soft rock	440	
5.	Gravel and sand-gravel offering high resistance to excavation	440	
6.	Coarse sand, compact and dry	440	Dry means that the ground water level is lower than the width of foundation below the base of the foundation.
7.	Medium sand compact and dry	245	
8.	Fine sand, silt	150	
9.	Fine sand, loose and dry	100	
10.	Soft shale, hard or stiff clay in deep bed, dry	440	This group is susceptible to long term consolidation.
11.	Medium clay, readily indented with thumb nail	245	
12.	Moist clay and sand-clay mixture which can be indented with strong thumb pressure	150	
13.	Soft clay indented with moderate thumb pressure	100	
14.	Very soft clay which can be penetrated to several cm with thumb	50	

1.6.1 NBC Rules and Requirements (NBC, 1983)

Such rules and regulations which affect the selection of site alone are listed as follows:

- Limitations of build-up areas and heights of buildings are achieved by specifying them in terms of **Floor Area Ratio** (FAR). The FAR is the quotient obtained by dividing the total covered area (Plinth area) at all the floors by the area of the plot.

$$\text{FAR} = \frac{\text{Total Covered area of all floors}}{\text{Plot area}}$$

Certain guide lines are given in the NBC and the local authority is likely to modify them, by taking into account other aspects like density of population of any area, parking facilities required, traffic load (road width) and the services available etc. The height of buildings may be regulated, in addition, keeping in view the local firefighting facilities.

- Land use is controlled by zoning and the classification of zones is given as under:
  a. Residential zone, including residential with shop lines at ground floor,
  b. Commercial zone, both local and district areas,
  c. Industrial zone, consisting of service, general and special industries,
  d. Green zone, including ribbon development along roads,
  e. Special reservations for governmental, defense and transportation purposes.

The various building uses and occupancies permitted in the various zones shall be as given in the master plan of the area, which is to be consulted before the selection of a site.

- Development on plots shall be permitted only when it is accessible by a public street of width not less than 6 meters. For high rise buildings and buildings other than residential buildings, additional provisions of means of access shall be ensured as outlined below:
  a. the width of the main street on which the building abuts shall not be less than 12 m and one end of this street shall join another street, not less than 12 m in width.
  b. the main entrance to the plot shall be of adequate width (4.5 m) to allow access to a fire engine.
- The building line, the line up to which the plinth of a building adjoining a street may lawfully extend, shall be set back at least 3 m from internal means of access in a layout of buildings in a plot;
- In residential and commercial zones of 0.3 hectares or more, community open spaces of 15 percent of the area of the lay out, shall be provided subject to a minimum of 450 m^2.
- In industrial zones of area 0.8 hectare or more, 5 percent of the area shall be reserved for amenity open space and parking space. Where such amenity open space exceeds 1500 m^2, the excess area can be utilized for construction of banks, canteens, and welfare centers etc.
- Each residential plot shall have a minimum size/frontage as under:

Type	**plot size (m2)**	**Frontage (m)**
Detached Building	> 250	> 12
Semi-detached	125 to 250	8 to 12
Row type	50 to 125	4.5 to 8

- For industrial plots the minimum plot size is 300 m^2 and its width shall not be less than 15 m.
- For community halls the size of the plot shall not he lets then 1000 m^2
- For theatres, the minimum size of the plot shall be calculated on the basis of seating capacity of the building at the rate of 3 m^2 per seat.
- The maximum height of a building shall not exceed 1.5 times the width of the road abutting plus the front open space.

- Layouts shall provide for facilities such as nursery and primary schools and higher educational facilities, health facilities, commercial & communication facilities etc.

It is evident from the foregoing that development control rules, while restricting to some extent the freedom of the owner in developing his site towards maximum utilization, ensure ventilation, insulation, natural lighting, prevention of shadows on streets, good access and facilities for firefighting, and good living.

1.6.2 Master Plans and Municipal Rules

It is obvious that more detailed rules are required to cover a particular city or town or a village. These are specified in the Master Plans of a city and Municipal Building Rules of State Governments.

For example, Madras Metropolitan Development Authority (MMDA) has documented the following:

1. The authority who is to issue permission for development as also the various requirements for site approval.
2. Specified ten types of zones.
3. Specified certain general provisions.

MMDA has divided its 1170 sq. km into various divisions, townships and panchayats and allocated Survey Nos. for appropriate zonal development.

On the other hand, the Tamil Nadu Municipal Building Rules have specified the form of application for construction, specified extensive regulations for sites, location of foundations, plinths, substructures, spaces around buildings and height of buildings, parking spaces, dimensions of rooms, and ventilation of building stairs, chimneys and drains and sanitary conveniences. Similar rules are found in Bombay Municipal Corporation Building Rules or those of Delhi, Calcutta and other cities.

Engineers are advised to get familiar with the above rules, regulations and guide lines for the area; they govern the planning and construction of buildings. It is not enough to acquire analysis and design capabilities to raise a structure in the village, town or city.

Furthermore, it must be realized that we, in this country, have adequate rules and regulations for orderly development of all types of building projects and services which are considered adequate for orderly development of human habitats.

1.7 IMPACT ON ENVIRONMENT

The advancing process of urbanization, generated by the intensive land development, has posed challenges to maintaining adequate environmental protection and improvement of quality of life. Pollution of the environment is already having harmful effects on the health and life of people and, in near future, it may threaten all life on our planet.

We, now dominate the earth which earlier man could not do, or burn a forest, wash away a field, foul a river, exhaust a mine, or extinguish local species etc. Today, we can pollute great lakes and even dirty the ocean, the global air and diffuse chemicals throughout the living world.

A new road, for example, may block natural rain drainage, induce erosion of soil, overturn soil dunes, destroy hill plants and animals, displace residents, bring in new builders, scar the hill sides, pollute air and water and import exotic chemicals into the environment. The more developed a site becomes, the more these manmade features obstruct circulation of air and surface water. Utilities become more important over-riding factors of soil topography and plant cover.

We live in an ocean of air, constantly subjected to the variations of temperature, humidity and purity to the light and sound transmitted through it. All construction activities affect this ocean of air and hence all of us. Polluted air has a harmful effect on respiratory tract, a depressing effect on the psychics, injurious to plants, animals and to the very buildings and structures we build. Equally serious are our contributions to the pollution of water and the land, we use.

If we continue like this without adequate checks and measures, we may inadvertently initiate an irrevocable process of permanent damage to our ecology and hence, ensure our extinction. Engineers must lead to save this planet earth by initiating environmental impact studies (EIS) for each one of their projects. In a simple manner, an engineer should avoid dust pollution, discharge of contaminated water, and due to construction activity into habitable areas, and also hazardous disposal of building wastes. He should take every possible measure to avoid noise pollution as well during construction.

1.8 SUMMARY

In this unit, we have noted the basic objective of the subject matter to enable you, as an engineer, to locate and site important constructions and buildings, taking into account the considerations of climate, site drainage, nature of foundation required, planning and control regulations of authorities, tax implications and the environmental impact of such constructions.

First, we have noted the various types of buildings classified on the basis of their occupancy.

For the location of a project in a state, or district, or town, it is necessary to consider zonal climate, taxation regulations, availability of transportation including railways, zoning regulations of the competent authority and community acceptance.

Site selection depends upon local climate, site drainage and availability of physical resources such as water, materials and labor, and also the local topography.

We have noted how different climates come about which is due to the tilting of the earth's axis in its revolution around the sun, the differential heating of the tropics and consequent winds. We have also noted how much of solar radiation reaches earth at different times.

The climates in tropical zones have been classified as: warm humid climate, hot dry climate and monsoon climate, and we have understood their broad features. Elevated places have special climates.

We have noted that site climate and urban climate can be different from zonal climate of the area due to topographical features (hilly, deep depressions, man-made surfaces, heavily built-up, wooded). Wind speeds register a decrease, and air temperatures register a rise in built-up areas where industries are present, etc.

We have noted the broad guide-lines for the orientation of buildings in the three tropical climates.

We have also noted how topographical features are represented on paper, e.g. contours, slopes so that we can note the implications of cut and fill, and drainage.

We have looked at the importance of geological considerations when large and critical structures such as dams are being planned. Rocks have been classified and some elementary but important characteristics of rocks have been identified, such as water absorption and fracture.

The implications of identifying and planning buildings in flood prone plains have been seen. Flood protections measures are needed as well as measures for draining the accumulated rain water are essential.

Water supply requirements from a very essential part of location and site planning exercise. Ground water sources should be investigated for purity, adequacy, depth of availability and type of wells needed.

Soil below the surface where a building is going to be built should be investigated thoroughly for all projects except ordinary ones. Observations normally to be made at site include water-table depths, drainage features, suitability for septic tank construction, suitability as foundation soil, erodability, consolidating nature, alkalinity or salt-proneness, and fertility.

For important projects a geotechnical investigation is required, for which bores are made, and expert assessment is done. The extent to which bore holes are to be made is noted.

A brief description of different types of soil is given. Safe bearing capacity of soil is defined.

Typical safe bearing capacity values of different types of soils are available from tables. Brief introduction on the role of bye-laws and regulations of local authorities are noted.
A little more detailed presentation of National Building Code prescriptions is noted in terms of FAR, Land-use zoning, access-related controls for construction, amenity areas to be provided in land-zoning to different types of occupancy, height regulations etc. More detailed rules and regulations are to be obtained from locally governing bye-laws.

We have noted the possible impact of constructions and structures on the environment and the engineer's obligation to minimize air, water and land pollution.