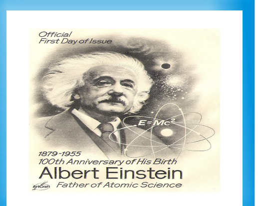

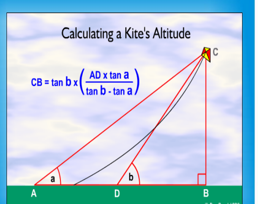

GATE - CIVIL ENGINEERING

SAMPLE THEORY

- **SOIL MECHANISM**
- **IRRIGATION SYSTEM**

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SOIL MECHANISM

Definition of Soil-

The term 'Soil' has different meanings in different scientific fields. It has originated from the Latin word Solum. To an agricultural scientist, it means "the loose material on the earth's crust consisting of disintegrated rock with an admixture of organic matter, which supports plant life". To a geologist, it means the disintegrated rock material which has not been transported from the place of origin. But, to a civil engineer, the term 'soil' means, the loose unconsolidated inorganic material on the earth's crust produced by the disintegration of rocks, overlying hard rock with or without organic matter. Foundations of all structures have to be placed on or in such soil.

Soil may remain at the place of its origin or it may be transported by various natural agencies. It is said to be 'residual' in the earlier situation and 'transported' in the latter.

Definition of Soil Mechanics-

"Soil mechanics" is the study of the engineering behavior of soil when it is used either as a construction material or as a foundation material. This is a relatively young discipline of civil engineering, systematized in its modern form by Karl Von Terzaghi (1925), who is rightly regarded as the "Father of Modern Soil Mechanics".

An understanding of the principles of mechanics is essential to the study of soil mechanics.

A knowledge and application of the principles of other basic sciences such as physics and chemistry would also be helpful in the understanding of soil behavior. Further, laboratory and field research have contributed in no small measure to the development of soil mechanics as a discipline.

The application of the principles of soil mechanics to the design and construction of foundations for various structures is known as "Foundation Engineering". "Geotechnical Engineering" may be considered to include both soil mechanics and foundation engineering.

In fact, according to Terzaghi, it is difficult to draw a distinct line of demarcation between soil mechanics and foundation engineering; the latter starts where the former ends.

Soil Mechanics

Soil mechanics, also known as geotechnical engineering, involves the use of soils as engineering materials. This line of study enables engineers to identify suitable soil environments for building and construction purposes. A soil's ability to compact and maintain its consistency under pressure determines whether it will provide a suitable foundation for building. In effect, engineers examine the physical characteristics of a soil environment as part of the pre-planning process involved with construction projects. As a result, differences between cohesive and non-cohesive soil play a significant role in determining whether a particular area will work with a building's plan.

Texture Differences

Texture differences in soils result from the types of rock that make up a particular area. Over time, the effects of weather and water erosion break down preexisting rocks into soil particles. Texture differences appear in the shapes, sizes and arrangement of particles that make up the soil. The presence or absence of clay or fine particles determines the cohesive qualities found within a soil environment. In effect, clay and fine particle materials act as binding agents that hold soil together. So non-cohesive soil environments contain little to no clay or fine particles while cohesive soils contain high amounts of clay and fine particles.

Compaction Differences

A soil's ability to compact has to do with the size of its particles and the amount of clay present in the sample. As a material, clay tends to readily absorb water when compared to a sand-type material. This absorption factor increases a soil's capacity to compact into a mold. Geotechnical engineers may analyze a soil sample to gauge its plasticity, or how well it molds together. So differences between cohesive and non-cohesive soils appear as high versus low plasticity properties with cohesive soils scoring higher. In effect, the higher a soil's plasticity properties, the more likely it will hold its shape when subjected to additional weight or pressure.

Consistency Differences

Non-cohesive soils consist of large or irregular-sized soil particles with little to no clay content. As a result, these soils tend to shift or change in consistency under different environmental conditions. Rain and wind conditions cause water and air materials to move in and out of soils. These conditions create spaces in between soil particles. In the case of water absorption, large soil particles with low cohesive properties tend to change in shape and consistency as water evaporates. With cohesive soils, clay and fine particular materials maintain a certain binding capacity that works to retain a soil's shape and consistency.

Soil : its origin and formation

Soils are a mixture of different things; rocks, minerals, and dead, decaying plants and animals. Soil can be very different from one location to another, but generally consists of organic and inorganic materials, water and air. The inorganic materials are the rocks that have been broken down into smaller pieces. The size of the pieces varies. It may appear as pebbles, gravel, or as small as particles of sand or clay. The organic material is decaying living matter. This could be plants or animals that have died and decay until they become part of the soil. The amount of water in the soil is closely linked with the climate and other characteristics of the region. The amount of water in the soil is one thing that can affect the amount of air. Very wet soil like you would find in a wetland probably has very little air. The composition of the soil affects the plants and therefore the animals that can live there.

Physical and biological agents, such as wind, running water, temperature changes, and living organisms, perpetually modify the Earth's crust, changing its upper surface into products that are more closely in equilibrium with the atmosphere, the hydrosphere, and the biosphere. Earth scientists sum up all processes through which these alterations take place under the collective term weathering. One speaks of mechanical weathering in the case that the dominant forces are mainly mechanical, such as the eroding action of running water, the abrading action of stream load or the physical action of wind and severe temperature fluctuations. Similarly, one speaks of biological weathering when the forces producing changes are directly or indirectly related to living organisms. Of these, we can mention several examples, such as the action of burrowing animals, the penetrating forces of plant roots, and the destructive action of algae, bacteria, and their acidproducing symbiotic community of the lichens, or simply the destructive action of man, who continuously disturbs the Earth's crust through various activities. Processes of disintegration, during which mantle rocks are broken down to form particles of smaller size, without considerable change in chemical or mineralogical composition are known as physical weathering processes. Changes of this type prevail under extreme climatic conditions as in deserts or arctic regions. They are also prevailing in areas of mountainous relief. The most prominent agents of physical weathering are: _ differential stress caused by unloading of deep-seated rocks on emerging to the surface; _ differential thermal expansion under extreme climatic conditions; _ expansion of interstitial water volume by freezing, that leads to rupturing along crystal boundaries. Other mechanical agents enhance the effect of mechanical weathering. These may include processes such as gravity, abrasion by glacial ice or wind blown particles. The word 'soil' occurs many times in this course. In agriculture this word is used to describe the thin layer of surface earth that, like some great blanket, is tucked around the wrinkled and age-beaten form of our globe. The harder and colder earth under this surface layer is called the _subsoil_. It should be noted, however, that in waterless and sun-dried regions there seems little difference between the soil and the subsoil. Plants, insects, birds, beasts, men,--all alike are fed on what grows in this thin layer of soil. If some wild flood in sudden wrath could sweep into the ocean this earth-wrapping soil, food would soon become as scarce as it was in Samaria when mothers ate their sons. The face of the earth as we now see it, daintily robed in grass, or uplifting waving acres of corn, or even naked, waterscarred, and disfigured by man's neglect, is very different from what it was in its earliest days. How was it then? How was the soil formed? Learned men think that at first the surface of the earth was solid rock. How was this rock changed into workable soil? Occasionally a curious boy picks up a rotten stone, squeezes it, and finds his hands filled with dirt, or soil. Now, just as the boy crumbled with his fingers this single stone, the great forces of nature with boundless patience crumbled, or, as it is called, disintegrated, the early rock mass. The simple but giant-strong agents that beat the rocks into powder with a clublike force a millionfold more powerful than the club force of Hercules were chiefly (1) heat and cold; (2) water, frost, and ice; (3) a very low form of vegetable life; and (4) tiny animals-- if such minute bodies can be called animals. In some cases these forces acted singly; in others, all acted together to rend and crumble the unbroken stretch of rock.

MAJOR SOIL DEPOSITS OF INDIA

The soil deposits of India can be broadly classified into the following five types:

1. Black cotton soils, occurring in Maharashtra, Gujarat, Madhya Pradesh, Karnataka, parts of Andhra Pradesh and Tamil Nadu. These are expansive in nature. On account of high swelling and shrinkage potential these are difficult soils to deal with in foundation design.

2. Marine soils, occurring in a narrow belt all along the coast, especially in the Rann of Kutch. These are very soft and sometimes contain organic matter, possess low strength and high compressibility.

3. Desert soils, occurring in Rajasthan. These are deposited by wind and are uniformly graded.

4. Alluvial soils, occurring in the Indo-Gangetic plain, north of the Vindhyachal ranges.

5. Lateritic soils, occurring in Kerala, South Maharashtra, Karnataka, Orissa and West Bengal.

Different Soil Types

Sandy

Sandy soil has the largest particles among the different soil types. It's dry and gritty to the touch, and because the particles have huge spaces between them, it can't hold on to water.

Water drains rapidly, straight through to places where the roots, particularly those of seedlings, cannot reach. Plants don't have a chance of using the nutrients in sandy soil more efficiently as they're swiftly carried away by the runoff.

The upside to sandy soil is that it's light to work with and warms much more quickly in the spring.

Testing what type of soil you're working with involves moistening the soil and rolling it into a ball to check the predominating soil particle. When you roll the slightly wet sandy soil in your palms, no ball should be formed and it crumbles through your fingers easily.

Silty

Silty soil has much smaller particles than sandy soil so it's smooth to the touch. When moistened, it's soapy slick. When you roll it between your fingers, dirt is left on your skin.

Silty soil retains water longer, but it can't hold on to as much nutrients as you'd want it to though it's fairly fertile. Due to its moisture-retentive quality, silty soil is cold and drains poorly.

Silty soil can also easily compact, so avoid trampling on it when working your garden. It can become poorly aerated, too.

Clay

Clay soil has the smallest particles among the three so it has good water storage qualities. It's sticky to the touch when wet, but smooth when dry.

Due to the tiny size of its particles and its tendency to settle together, little air passes through its spaces. Because it's also slower to drain, it has a tighter hold on plant nutrients. Clay soil is thus rich in plant food for better growth.

Clay soil is cold and in the spring, takes time to warm since the water within also has to warm up. The downside is that clay soil could be very heavy to work with when it gets dry. Especially during the summer months, it could turn hard and compact, making it difficult to turn. (When clay soil is worked while it's too wet though, it's prone to damage).

If moistened soil feels sticky, rolls up easily, and forms into a ball or sausage-like shape, then you've got yourself clay.

Peaty

Peaty soil is dark brown or black in color, soft, easily compressed due to its high water content, and rich in organic matter. Peat soil started forming over 9,000 years ago, with the rapid melting of glaciers. This rapid melt drowned plants quickly and died in the process. Their decay was so slow underwater that it led to the accumulation of organic area in a concentrated spot.

Although peat soil tends to be heavily saturated with water, once drained, it turns into a good growing medium. In the summer though, peat could be very dry and become a fire hazard. (I kid you not-peat is the precursor of coal.) The most desirable quality of peat soil, however, is in its ability to hold water in during the dry months and its capacity to protect the roots from damage during very wet months.

Peat contains acidic water, but growers use it to regulate soil chemistry or pH levels as well as an agent of disease control for the soil.

When wet peat soil is rolled, you won't form a ball. It's spongy to the touch and when squeezed, water could be forced out.

Soil

The soil in extremely dry regions is usually brackish because of its high salt content. Known as saline soil, it can cause damage to and stall plant growth, impede germination, and cause difficulties in irrigation.

The salinity is due to the buildup of soluble salts in the rhizosphere-high salt contents prevent water uptake by plants, leading to drought stress.

It's easy enough to test if you have saline soil. You'll probably see a white layer coating the surface of the soil, your plants are growing poorly, and they're suffering from leaf tip burn, especially on young leaves.

Loam

The type of soil that gardens and gardeners love is loamy soil. It contains a balance of all three soil materials-silt, sand and clay-plus humus. It has a higher pH and calcium levels because of its previous organic matter content.

Loam is dark in color and is mealy-soft, dry and crumbly-in your hands. It has a tight hold on water and plant food but it drains well, and air moves freely between soil particles down to the roots.

The feel test for loam yields a smooth, partly gritty, partly sticky ball that crumbles easily.

Although loamy soil is the ideal material to work with, don't despair if you don't have it in your garden. That's because soil will always favor one particles size over the two others. Then again, there are many ways to condition your soil-adding beneficial soil inoculants, covering your soil with compost, or simply spraying leaves and soil with compost tea.

Cohesive and Non Cohesive Soil-

The two broad classifications of Soil are cohesive soils and cohesionless, or noncohesive, soils. Cohesive soils are those that contain sufficient quantities of silt or clay to render soil mass virtually impermeable when properly compacted. Such soils are all varieties of clays, silts, and silty or clayey sands and gravels. By contrast, cohesionless soils are the relatively clean sands and gravels, which remain pervious even when well-compacted.

Difference Between Cohesive & Non-Cohesive Soil

Part of the process for constructing a building or road involves analyzing the soil on which building will take place. Soil environments provide the physical foundation for a building or road to stand on for years. The engineering aspects of soil composition examine the differences in texture, strength, and consistency that distinguish cohesive soils from non-cohesive soil environments.

IRRIGATION SYSTEM

DUTY AND DELTA

Duty represents the irrigating capacity of a unit of water. It is the relation between the area of a crop irrigated and the quantity of irrigation water required during the entire period of the growth of that crop.

Delta is the total depth of water required by a crop during the entire period the crop is in the field, and is denoted by a symbol Δ.

Crop period : Crop period is the time, in days that a crop takes from the instant of its sowing to that of its harvest.

Base period: Base period for a crop refers to the whole period of cultivation from the time when irrigation water is first issued for preparation of the ground for planting the crop, to its last watering before harvesting.

Irrigation Efficiencies

The following are the various types of irrigation efficiencies : (i) water conveyance efficiency (ii) water application efficiency (iii) water use efficiency (iv) water storage efficiency (v) water distribution efficiency and (vi) consumptive use efficiency.

1. Water conveyance efficiency (η_o)

$$\eta_0 = \frac{W_f}{W_\gamma} \times 100$$

where η_0 = water conveyance efficiency

W_f = water delivered to the farm or irrigation plot.

W_γ = water supplied or diverted from the river or reservoir.

2. Water application efficiency (η_0)

$$\eta_0 = \frac{W_s}{W_f} \times 100$$

where η_0 = water application efficiency

W_s = water stored in the root zone during the irrigation

W_f = water delivered to the farm.

3. Water use efficiency (η_u)

$$\eta_u = \frac{W_u}{W_d} \times 100$$

Where η_u = water used efficiency

W_u = water used beneficially or consumptively

W_a = water delivered

4. Water Storage efficiency (η_s)

$$\eta_s = \frac{W_s}{W_n} \times 100$$

Where η_s = water storage efficiency

W_s = water needed in the root zone prior to irrigation

= (Field capacity - Available moisture.)

5. Water distribution efficiency (η_d)

$$\eta_d = \left[1 - \frac{y}{d}\right]$$

Where η_d = water distribution efficiency.

y = average numerical deviation in depth of water stored from average depth stored during irrigation.

d = average depth of water stored during irrigation.

6. Consumptive use efficiency (η_{cu})

It is given by

$$\eta_{cu} = \frac{W_{cu}}{W_d} \times 100$$

Where W_{cu} or C_u = normal consumptive use of water.

W_d = net amount of water depleted from root zone soil.

DETERMINATION OF IRRIGATION REQUIREMENTS OF CROPS

It order to determine the irrigation requirements of a certain crop, duting its base period, the following terms are required.

(i) **Effective Rainfall (R_e)**

Effective rainfall is that part of the precipitation falling during the growing period of a crop that is available to meet the evapotranspiration needs of the crop.

(ii) **Consumptive Irrigation Requirement (CIR)**

Consumptive irrigation requirement is defined as the amount or irrigation water that is required to meet the evapo - transpiration needs of the crop during its full growth. Therefore, C I R = Cu – Re

Where C_u is the consumptive use of water.

(iii) **Net irrigation Requirement (NIR)**

Net irrigation requirement is defined as the amount of irrigation water required at the plot to meet the evapo - transpiration needs of water as well as other needs such as leaching etc. Thus

NIR = C_u – R_e + water lost in deep percolation for the purposes of leaching etc.

(iv) **Field Irriation Requirement (FIR)**

Field irrigation requirement is the amount of water required to meet ' net irrigation requirements' plus the water lost in percolation in the field water courses, field channels and in field application of water. If η_a is water application efficiency, we have

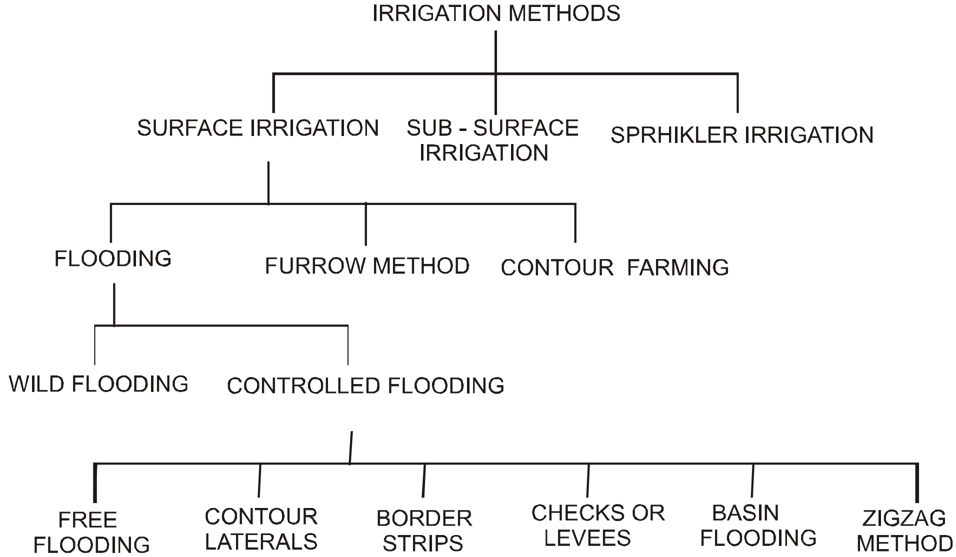
$$GIR = \frac{NIR}{\eta_a}$$

(v) **Gross Irrigation Requirement (GIR)**

Gross irrigation requirement is the sum of water required to satisfy the field irrigation requirements and the water lost as conveyance losses in distributatries up to the field. If η_o is the water coveyance efficiency, we have

$$GIR = \frac{FIR}{\eta_0}$$

MODES OR METHODS OF APPLYING WATER TO CROPS



Free Flooding

In the controlled flooding, water is spread over the land, with proper methods to control the depth of application.

Contour Laterals

This method is applicable for steeper terrain the field is cut by relatively dense network of small contour laterals, the spacing of which depends upon the prominent grade of the field between two adjacent ditches or laterals, the uniformity of slope and the soil type.

Border Strip Method

This method is especially suited to forage crops, its advantage being that for a relatively low investment a system can be developed which can afford the highest irrigation efficiency and lowest labour requirements.

Check Flooding

The method is also suitable for impermeable soils in which the percolation rate is so slow that infiltration would be inadequate in the time required for the sheet of water flowing over it.

Basin Flooding

The basin flooding is a special form of check flooding adapted to orchards. The basin are formed for each tree ; in some cases one basin may be formed for two or more trees.

Furrow Method

The furrow method of irrigation is very much used for row crops like maize, jowar , sugarcane, cotton, tobacco, groundnut, potatoes etc.

Contour Farming

Contour farming is practised in hilly areas having steep slopes with quickly falling contours. contour farming is the practice of conducting field operations, such as ploughing, planting and cultivating land, across the slope rather than up and downhill.

Sub- Surface Irrigation

The sub - surface irrigation method consists of supplying water directly to the root zone of the crop. The favourable conditions for the sub - surface practice are :

(i) Soil is errosive

(ii) Soil is excessively permeable or impermeable

(iii) depth of soil is shallow over gravel or sand.

WATER LOGGING & DRAINAGE

The agricultural land becomes waterlogged when the soil pores within the root zone of the crops get saturated and the normal circulation of air is cutoff. The waterlogging affects the productivity of the land and leads to a reduction in the crop yield. Waterlogging generally occurs because of over - irrigation, high water table and the poor water management.

Due to the presence of water at or near the land surface, evaporation takes place continuously. Because of evaporation, there is a continuous upward of water from the watertable if it is high. This upward flow of water occurs because of capillary action in the soil. Water brings salts with it. When the water is evaporated, these salts get acccumulated at the land surface.

Waterlogging can be prevented to a large extent by providing and effective drainage system. The drains may be open drains or closed drains. The type of drain most suitable for a particular site depends upon the purpose for which it is provided and the site condition.

Causes Waterlogging

Waterlogging of the land occurs when the water table rises and the soil in the root zone of the plants gets saturated and the air circulation is stopped. Waterlogging generally occurs because of intensive irrigation and inadequate drainage of the irrigated land. Waterlogging affects the productivity and the fertility of the land and causes a reduction in the crop yield.

Drainage Systems

A properly - designed drainage system is quite effective for prevention of waterlogging. It is also an effective method for reclamation of the waterlogged land. A well - designed drainage system is required in the regions where the water table is high and the irrigation facility is extended, Such as delta regions.

The design of a drainage system depends upon a number of factors. Before undertaking the design of a drainage programme, it is necessary to conduct topographical , geological and soil surveys .The properties of the soil, especially the permeability , should be determined. The depth of water table below the land surface should be ascertained. Moreover , the fluctuations of the water table during the year should also be studied.

Types of drainage systems . The drainage systems can be broadly classified into two types.

1. Surface drainage systems 2. Subsurface drainage systems.

The surface drainage system consists of surface drains, storm sewers, culverts etc. Which are constructed to dispose of the surface water (or surface runoff) after the rains.

The subsurface drainage system consists of sub - surface drains to dispose of the subsurface.

Open Drains

1. Shallow open drains.
2. Deep open drains.

Fluid capacity - It is the moisture content of the soil after free drainage has removed of the gravity water.

Permanent wilting point - it is the water content at which plants can no longer extract sufficient water from the soil for its growth.

Cumecday - Quality of water flowing for one day at the rate of perpendicular cumec.

Paleo - It is the first watering before sowing the crop.

$$\text{Nominal duty} = \frac{\text{Period}}{\text{Mean supply for the baseperiod}}$$

Root zone depth - maximum depth in soil strata in which the crop spreads its system and derives water from the soil.

Garden crop - requires irrigation throughout the year.

Crop rotation - it implies that nature of crop sown in a particular field is changed year after year.

An agricultural land is said to be water - logged when it productivity get affected by the high water table.

Land reclamation is a process by which and unculturable land is made fit for cultivation . Saline and water logged land given very less crop yields and are, therefore unfit for cultivation, unless they are relamed.

Leaching - in this process the land is flooded with adequate depth of water.

Land drainage - White designing canal irrigation, it is some times desirable to provide a suitable drainage system, so as to remove the excess water.