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A TERM PAPER ON SOIL PERMEABILITY AND CAPILLARITY

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ABSTRACT

The amount, distribution, and movement of water in soil have an important bearing on the properties and behaviour of soil. The engineer should know the principles of fluid flow, as groundwater conditions are frequently encountered on construction projects. Water pressure is always measured relative to atmospheric pressure, and water table is the level at which the pressure is atmospheric.

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CHAPTER ONE

WHAT IS SOIL PERMEABILITY

Soil permeability is the property of the soil to transmit water and air and is one of the most important qualities to consider for fish culture. A pond built in impermeable soil will lose little water through seepage. The more permeable the soil, the greater the seepage.

The property of the soil by which it permits the flow of fluid through it is called permeability of the soil. The porosity in the soil material is contributed by the presence of interstices within it. The property of permeability emerges when these interstices are connected, bringing a pathway for the movement of fluids. Generally, the soil is porous and permeable in nature.

A soil with high porosity has high permeability. A soil with a smaller value of permeability is categorized as impervious. Here some basic features related to soil permeability are explained.

Permeability is one of the most important engineering properties of the soil that is a solution for a number of engineering problems encountered in construction. Some of them are:

1. Settlement of foundation and buildings
2. Seepage below the earth structures
3. Seepage through the earth structures
4. The Yield of the wells
5. Control of Hydraulic Stability of masses
6. For designing filter in hydraulic structures in order to prevent piping

Coefficient of Permeability for Different Soil Types

The coefficient of permeability is dependent on the particle size, structure of soil mass, void ratio, properties of water, the shape of the particle, water impurities, adsorbed water, etc.

Sl.no	Type of Soil	Coefficient of Permeability (mm/sec)	Drainage Properties
1	Clean Gravel	10^1 to 10^2	Very Good
2	Coarse and Medium Sand	10^{-2} to 10^1	Good
3	Fine sand, loose silt	10^{-4} to 10^{-2}	Fair
4	Dense silt, clayey silts	10^{-5} to 10^{-4}	Poor
5	Silky clay and clay	10^{-8} to 10^{-5}	Very Poor

IMPORTANCE OF SOIL PERMEABILITY

Permeability influences the rate of settlement of a saturated **soil** under load. The stability of slopes and retaining structures can be greatly affected by the **permeability** involved. The design of earth dams is very much based upon the **permeability** of **soil** used.

- Permeability influences the rate of settlement of a saturated soil under load.
- The stability of slopes and retaining structures can be greatly affected by the *permeability* involved.
- The design of earth dams is very much based upon the *permeability of soil* used.
- Filters made of soils are designed based upon their permeability.

PROPERTIES OF SOIL PERMEABILITY

- Solving problems involving pumping seepage water from construction excavation.
- Estimating the quantity of underground seepage.
- Stability analysis of earth structures and earth retaining walls subjected to seepage forces.

FACTORS AFFECTING SOIL PERMEABILITY

Factors affecting permeability of soils. A number of factors affect the permeability of soils, from particle size, impurities in the water, void ratio, the degree of saturation, and adsorbed water, to entrapped air and organic material.

Following are factors effecting permeability of soils.

1. Size of soil particle
2. Specific Surface Area of Soil Particle
3. Shape of soil particle
4. Void ratio
5. Soil structure
6. Degree of saturation
7. Water properties
8. Temperature
9. Adsorbed water
10. Organic Matter

TEST FOR SOIL PERMEABILITY

Constant Head Permeability Test

The constant head permeability test is a laboratory experiment conducted to determine the permeability of soil. The soils that are suitable for this tests are sand and gravels. Soils with silt content cannot be tested with this method. The test can be employed to test granular soils either reconstituted or disturbed.

Objective and Scope

The objective of constant head permeability test is to determine the **coefficient of permeability** of a soil.

Coefficient of permeability helps in solving issues related to:

1. Yield of water bearing strata
2. Stability of earthen dams
3. Embankments of canal bank
4. Seepage in earthen dams
5. Settlement Issues

Apparatus for Constant Head Permeability Test

1. Permeameter mould, internal diameter = 100mm, effective height =127.3 mm, capacity = 1000ml.
2. Detachable collar, 100mm diameter, 60mm height
3. Dummy plate, 108 mm diameter, 12mm thick,
4. Drainage base, having porous disc
5. Drainage cap having porous disc with a spring attached to the top.
6. Compaction equipment such as Proctor's rammer or a static compaction equipment, as specified in IS:2720 (Part VII)-1965.
7. Constant head water supply reservoir
8. Vacuum pump
9. Constant head collecting chamber
10. Stop watch

11. Large funnel
12. Thermometer
13. Weighing balance accuracy 0.1 g
14. Filter paper.

CHAPTER TWO

WHAT IS SOIL CAPILLARITY

Capillary action (sometimes capillarity, capillary motion, capillary effect, or wicking) is the ability of a liquid to flow in narrow spaces without the assistance of, or even in opposition to, external forces like gravity. The effect can be seen in the drawing up of liquids between the hairs of a paint-brush, in a thin tube, in porous materials such as paper and plaster, in some non-porous materials such as sand and liquefied carbon fiber, or in a biological cells. It occurs because of intermolecular forces between the liquid and surrounding solid surfaces. If the diameter of the tube is sufficiently small, then the combination of surface tension (which is caused by cohesion within the liquid) and adhesive forces between the liquid and container wall act to propel the liquid.

Capillary action describes the attraction of water molecules to soil particles. Capillary action is responsible for moving groundwater from wet areas of the soil to dry areas. Differences in soil potential drive capillary action in soil.

Capillary action is the same effect that causes porous materials, such as sponges, to soak up liquids. Capillarity is the primary force that enables the soil to retain water, as well as to regulate its movement.

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- Capillarity is the primary force that enables the soil to retain water, as well as to regulate its movement.
 - The phenomenon of capillarity also occurs in the soil. In the same way that water moves upwards through a tube against the force of gravity; water moves upwards through soil pores, or the spaces between soil particles.
 - The height to which the water rises is dependent upon pore size. As a result, the smaller the soil pores, the higher the capillary rise.
 - Finely-textured soils, like in Maui, typically have smaller pores than coarsely-textured soils. Therefore, finely-textured soils have a greater ability to hold and retain water in the soil in the inter-particle spaces. We refer to the pores between small clay particles as micro pores. In contrast, the larger pore spacing between larger particles, such as sand, are called macro pores.

- In addition to water retention, capillarity in soil also enables the upward and horizontal movement of water within the soil profile, as opposed to downward movement caused by gravity. This upward and horizontal movement occurs when lower soil layers have more moisture than the upper soil layers and is important because it may be absorbed by roots.

Capillarity can be measured by the speed at which water rises up in the soil and the extent to which the water rises.

Capillarity depends on the size of the spaces between soil particles

The smaller the spaces the higher the water rises in the soil. This means that clay soil allows water to rise highest compared to sand soil and loam soil

RELATIONSHIP BETWEEN SOIL PERMEABILITY AND CAPILLARITY

Permeability is the capacity of the rock or body of sediment for transmitting a fluid. This ability is dependent upon pore spaces between sediments, be they sediments comprising soil or those compacted and cemented within a classic sedimentary rock. Optimum permeability exists where sediments are rounded and large. Pore spaces are also large and water easily passes in between sediments. Permeability is poorest when sediments are of mixed sizes and shapes.

Igneous and metamorphic rocks, with their grown crystals, are too dense to allow water infiltration unless they have many interconnected cracks. In such a situation, water can enter these cracks. Clastic sedimentary rocks, on the other hand may have pore spaces between sediments that comprise the rock and so water may infiltrate some specimens belonging to this rock group.

Capillarity is the action by which water actually moves against the downward pull of gravity. Water is able to travel upwards and sideways within the rock material. Surface tension created by the forces of cohesion (attraction between water molecules) and adhesion (attraction between water molecules and the rock material) allow slow migration within pore spaces between rock particles

Capillarity is worst when sediment is poorly sorted with angled particles and mixed sizes and shapes present. The angled particles prevent ample pore space

between rock fragments so there is no space available through which water can migrate. Capillarity is not present in igneous and metamorphic rocks nor is it at its best within the structure of Clastic sedimentary rocks. It is most prevalent and most important in unconsolidated (loose) sediments as would be present in soils