Study of Index Properties of the Soil

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ABSTRACT

Soil is the heterogeneous complex material containing different types of minerals which is the results of weathering or disintegration of the rock. The use of soil purposes as per the requirement On Earth, Soil characteristics vary from one region to another region sometimes its characteristics changes few meters or kilometres. Every structure whether it is small or big on the earth, requires a strong and permanent base or support on which it stands. Foundation fulfils that requirement of structure and provides the permanent and strong base as well as it provides stability of the structure. Structural loads (Live Load, dead Load, wind load and combination of all of these) safely transferred by the foundation. Foundation helps to transmit structural load uniformly to the soil. Therefore it acts as connecting link between the structure proper and the soil which support it, Hence it is important that load bearing soil should enough strong compacted that resist the structural load. Some time poor judgment of selection of soil the structure become unstable, unsettlement of foundation, shear failure development of cracks of the structure appears this is the very dangerous situations.

To overcome the unsettlement of foundation, shear failure, development of cracks of the structure, Geotechnical engineer needed to selection of the that type soil which is best suitable provides the hard soil strata of the structure important role safely without settlement of the soil strata, to So this is always big challenge to Geotechnical Engineer to analysis the engineering as well as Index property of the soil. Index properties are known as the inductive of the engineering properties Simple test are required for index properties are known as classification test. The test required for determination of engineering properties is generally elaborate and time consuming .Sometimes for saving the times the geotechnical engineer is interested to have some rough assessment of the engineering properties without conducting elaborate test. The index properties are given some information about engineering properties such as permeability, compressibility and shear strength. It is tacitly assumed that soils with like index properties have identical engineering properties.

Keyword: - *Soil, Index Properties, Liquid Limit, Water Content, Plastic Limit, Shrinkage Limit, Consistency*

INTRODUCTION

Index properties are the properties of soil that help in identification and classification of soil for general engineering purpose. These properties are generally determined in the laboratory. Disturbed samples or remoulded samples can be used to determine the index property of the soil. Index properties are also known as the indicative of engineering properties such compressibility, permeability and shear strength. The test required for determination of engineering properties is elaborate and time consuming. Sometimes, the geotechnical engineer is interested to have some rough assessment of the engineering properties without conducting elaborate tests. This is only possible when index properties of soil determined.

The main index properties of coarse grained soils are particle size and relative density where as for fine grained soil the main index properties are consistency and Atterberg's limit.

TYPES OF INDEX PROPERTIES OF SOIL

For convenient the index properties are sometimes divided into categories::

1. Soil Grain Properties
2. Soil Aggregate Properties

1. Soil Grain Properties:

The principal soil grain properties are the size and shape of the grains and in clay soils, the mineralogical character of the smallest grains. It also known as the properties of individual grains. The properties of individual particles can be determined from remoulded, disturbed sample (These are samples in which natural structure of the soil gets disturbed during sampling). Other main soil grain properties are specific gravity. The size of the particles that constitute of soils may vary from that of boulders to that of large molecules. Grains larger than approximately 0.06 mm can be inspected with the naked eye or by the means of hand lens. They constitute the very coarse and coarse fraction of the soils.

Grain ranging in the size from about 0.006 mm to 2 μ (μ =1 micron =0.001mm) can be examined only under the microscope. They can examine only under the microscope. They represent as fine fraction.

Grain size smaller than 2 μ constitute the very fine fraction (clay size fraction ...CF). Grains having a size between 2 μ and about 0.1 μ can be differentiated under the microscope but their shape cannot be discerned. The shape of grains smaller than about 1 μ can be determined by the means of an electron microscope. Their molecule structure can be investigated by means of X-ray Analysis.

Figure 1: Different types of the component of the soil

Uniform Soil:-If the size of most of the grains in an aggregate of soil particles is within the limits given for any one of the soil fractions, the aggregate is called a uniform soil. Uniform very coarse or coarse soils are common, but uniform very fine or colloidal soils are very seldom encountered. All clays contain fine, very fine, and colloidal constituents, and some clay contain even coarse particles. The finest grain-size fractions of clays consist principally of flake-shaped particles.

Most soils originate in the chemical weathering of rocks. The rocks themselves consist partly of chemically very stable and partly of less stable minerals into a friable mass of very small particles of secondary minerals that commonly have a scale-like or flaky crystal form, whereas the stable minerals remain practically unaltered. Thus the process of chemical weathering reduces the rock to an aggregate consisting of fragments of unaltered or almost unaltered minerals embedded in a matrix composed chiefly of discrete scaly particles. During subsequent transportation by running water the aggregate is broken up, and the constituents are subjected to impact grinding. The purely mechanical process of grinding does not break up the hard equidimensional grain of unaltered minerals into fragments smaller than about 0.01mm. On the other hand, the friable flake-shaped particles of secondary minerals, although initially very small, are readily ground and broken into still smaller particles. Hence, the very fine fractions of natural soils consist principally of flake-shaped particles of secondary minerals.

Soil Aggregate Properties

The most significant property of cohesion less soils is the relative density, whereas that of cohesive soil is the consistency. The soil aggregate properties depend upon of mode of soil formation, soil history and soil structure. These properties should be determine from undisturbed sample (These are the samples in which the natural structure of the soil and water content not disturbed during the sampling) or preferably from in-situ tests. The consistency of fine grained soil is the physical state in which it exists. It is used to denote degree of firmness of a soil, Consistency of a soil is indicated by such term as soft, firm and hard. In 1911, a Swedish agriculture engineer Atterberg mentioned that a fine grained soil can exists in four stages namely liquid, plastic, semi -solid or solid state .The water content at which soil changes from one state to the other state are known as Consistency or Atterberg's limit. The consistency limit is the main index property of the fine grained soil. The presence of clay minerals in a fine-grained soil will allow it to be remolded in the presence of some moisture without crumbling. If clay slurry is dried, the moisture content will gradually decrease, and the slurry will pass from a liquid state to a plastic state. In the liquid state water content is very high. It offers no shearing resistance and can flow like liquids. It has no shearing resistance to shear deformation and therefore the shear resistance equals to zero. As the water content is reduced the soil becomes stiffer and starts developing resistance to shear deformation. At some particular water content, the soil becomes plastic (In figure 2) the water content at which soil changes from the liquid state to the plastic state known as Liquid Limit (LL, WL). In other words, the liquid is the water content at which the soil ceases to be liquid. The soil in the plastic state can be moulded into various shapes. As the water content reduces, the plasticity of the soil decreases, Ultimately the soil passes from the plastic state to the semi solid state when it stops behaving as a plastic the water content at which the soil becomes semi solid is known as the plastic limit(PL,W_P). In other words the plastic limit is the water content at which the soil just fails to behave plastically. The numerical difference between the liquid limit and the plastic limit is known as plasticity index (PI,I_P), Thus **Plasticity Index (PI) = Liquid Limit(LL)- Plastic Limit(PL).**

The soil remains plastic when the water content is between the liquid limit and the plastic limit. The most important property of fine grained soil is Plasticity Index. When the water content is reduced below the plastic limit, the soil attains semi solid state .The soil cracks when moulded. In the semi solid the volume of the soil decrease with a decrease in the water content till a stage is reached when further reduction of water content do not cause any reduction in the volume of the soil.

The soil is said to have reached a solid state, the water content at which the soil changes from the semi solid state to solid state known as Shrinkage Limit (SL, W_S).

Plasticity, Liquidity and Consistency Indexes

(1) Plasticity Index: Plasticity index (I_p or PI) is the range of water content over which the soil remains in the plastic state. It is equal to the difference between the liquid limit (W_L) and the plastic limit (W_P). Thus, $\mathbf{I_p = W_L - W_P}$.

When either $\mathbf{W_L}$ **or** $\mathbf{W_P}$ cannot be determined, the soil is said to be non-plastic (NP). When the plastic limit is greater than the liquid limit, the plasticity index is reported as zero (and not negative).

(1) **Liquidity Index:** Liquidity index (Il or LI) is defined as

$$\mathbf{I_p} = \frac{W - Wp}{Ip} \; X\,100$$

Where W= water content of the soil in natural condition.

The liquidity index of a soil indicates the nearness of its water content to its liquid limit. When the soil is at its liquid limit, its liquidity index is 100% and it behaves as a liquid. When the soil is at the plastic limit, its liquidity index is zero. Negative values of the liquidity index indicate water content smaller than the plastic limit. The soil is then in a hard state. The liquidity index is also known as Water-Plasticity ratio.

(2) **Consistency Index:** Consistency index (Ic, CI) is defined as

$$\mathbf{I_C} = \frac{W\,l - W}{Ip} \; X\,100$$

Where W= water contents of the soil in natural condition.

The consistency index indicates the consistency of a soil. It shows the nearness of the water content of the soil to its plastic limit. A soil with a consistency index of zero is at the liquid limit . It is extremely soft and has negligible shear strength. On the other hand, a soil at a water content equal to the plastic limit has a consistency index of 100%, including that the soil is relatively firm. A consistency index of greater than 100% shows that the soil is relatively strong, as it is the semi-solid state. A negative value of consistency index is also possible, which indicates that the water content is greater than the liquid limit. The consistency index is also known are relative consistency. It is worth noting that the sum total of the liquidity index and the consistency index is always equal to 100%, indicating that a soil having a high value of liquidity index has a low value of consistency index and vice-versa.

(3) **Shrinkage Index**: The Shrinkage Index (I_S) is the numerical difference between the liquid limit (W_L) and the Shrinkage Limit (W_S).

$$\mathbf{I_S = W_L - W_S}$$

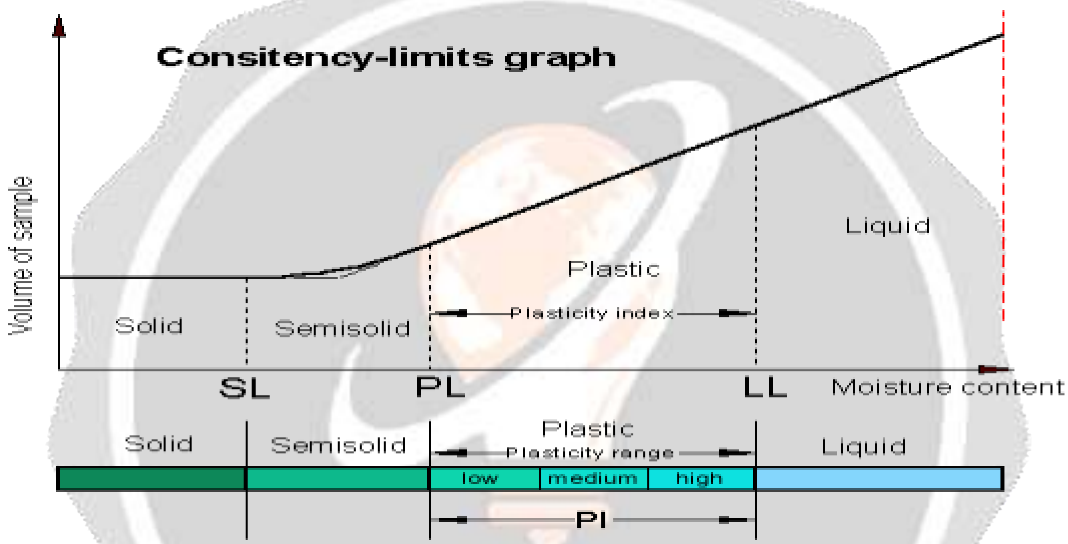

Figure 2: Different stages of soil at different water content

Table:-1 Showing the degree of expansion of Fine Grained Soil

Liquid Limit (W_L)	Plasticity Index (I_P)	Shrinkage Index (I_s)	Free Swell (Percent)	Degree of Serviceability	Limits of Serviceability
20-35	<12	<15	<50	Low	Non-Critical
35-50	12-23	15-30	50-100	Medium	Marginal
50-70	23-32	30-60	100-200	High	Critical
70-90	>32	>60	>200	Very high	Severe

Measurement of Consistency

Consistency is defined as the degree of firmness, for conventionally Consistency described as very soft, soft, medium, stiff, very stiff and hard .These terms are relative and may have different interpretation to different geotechnical engineers. For quantitative measurement of consistency, it is related to the shear strength or compressive strength. The unconfined compression strength of a soil is equal to the failure load per unit area when a standard, cylindrical specimen is tested in an unconfined compressing testing machine.

Table 2:- Consistency in terms of Consistency Index and Unconfined Compressive Strength

S,No	Consistency	Consistency Index (%)	Unconfined Compressive Strength(q_u) (kN/m^2)	Characteristics of Soil
1.	Very Soft	0-25	<25	First can be pressed into soil.
2	Soft	25-50	25-50	Thumb can be pressed into soil.
3	Medium(Firm)	50-75	50-100	Thumb can be pressed with pressure.
4	Stiff	75-100	100-200	Thumb can be pressed with great difficulty.
5	Very Stiff	>100	200-400	The soil can be readily indented with thumb nail.
6	Hard	>100	>400	The soil can be indented with difficulty by thumb nail.

Conclusion:

In Geotechnical Engineering, more than in any other field of civil engineering success depends on practical experience. The design of ordinary soil supporting or soil supported structure is necessary to based on simple empirical rules but these rules can be used safely only by the engineer who has a background of experience. Large projects involving unusual features may call for extensive application of scientific methods to design, but the program for the required investigation cannot be laid out wisely, the engineer in charge of design possesses a large amount of experience. Since personal experience is necessary somewhat limited, the engineer is compelled to rely at least to some extent on the records of the experience of others. If these records contain adequate descriptions of the soil conditions, misleading. Consequently, one of the foremost aims in attempts to reduce the hazards in dealing with soils has been to find simple methods for discriminating among the different kinds of soil in given category .The properties on which the distinctions are based are known as index properties and the test required to determine the index properties classification test.

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