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Importance of Soil Classification and Soil Testing in Construction Industry

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ABSTRACT

Nobody wants a construction project to turn out to be like the Leaning Tower of Pisa, right? Well, to prevent your construction project from being so and from worse fatal accidents, you need to get soil testing done after buying the piece of land and before beginning any construction.

With roughly more than 1.5 million people involved in the construction world wide, a rate of 80 deaths per 1000 workers is observed, out of which 30-40 workers die in accidents related to trenching. Trenching accidents are extremely dangerous. Workers can suffer death or serious injury in mere minutes if caught in a trenching cave in.

As the soil testing is one of the most important things to keep in mind during any construction project, however, it is the most overlooked step during the planning. The reason being the most people aren't aware of such scientific lab testing of soil and for small residential projects and excavations, it is ignored fully.

In this article we will discuss some related topics that are often overlooked, including soil classification and testing in construction particularly in excavation.

Keywords : Soil Testing, Bearing Capacity, Structures, Materials, Trenching, Cave in, Excavation

I. INTRODUCTION

As the soil has to take the pressure of a structure, it is a significant aspect to be checked. It is considered one of the first things a construction company does. Soil testing is primarily done to test the bearing capacity of the soil. It also shows the physical and chemical composition of the coil. These characteristics may vary from layer to layer of the same soil. The characteristics of the soil can change within small area due to weather, climate change and the management of the site can also change the bearing capacity of the soil. The soil must be able to withstand the weight of the structure otherwise the loss to property and life can occur. The soil investigations or analysis determines not only the bearing capacity of the soil, but it also determines rate of settlement of the soil. This rate determines the rate of the structure stabilization on the soil.

The type of tests on soil reveals the physical and engineering properties of soil that help to determine the type of foundation to be laid for construction. Knowing moisture content, mineral presence, density, permeability and bearing capacity of the soil gives an idea of working considerations for foundations and earthworks. Like higher sulphur content in the soil requires cement that provides resistance to sulphur such as Sulphate-resisting Portland Cement (SRPC). The water table of the soil can be known only from the soil testing. The level of water table shows the likely problem to the foundation of the building and level of humidity within the foundation. The choice of construction material might be affected by the chemical and mineral component of the soil.

II. SOIL CLASSIFICATION

Soil can either be cohesive or granular. Cohesive soil contains fine particles and enough clay to stick to itself. Soil that is more cohesive contains more clay, and has a reduced chance of settlement or cave in as compared to granular soil. Granular soil is more close to sand or gravel, and has coarse particles that are significantly less cohesive. When excavating in granular soil, additional safety precautions must be utilized to prevent a cave in.

The ASTM version of the unified soil classification system is ASTM D 2487-17. This classification system is based on particle-size characteristics, liquid limit, and plasticity index. According to ASTM D2487-17, there are three major soil divisions: coarse-grained soils, fine- grained soils, and highly organic soils. These are subdivided further into 15 basic groups, each with its own group symbol (e.g. GW).

The AASHTO Soil Classification System was developed by the American Association of State Highway and Transportation Officials, and is used as a guide for the classification of soils and soil-aggregate mixtures for highway construction purposes. The classification system was first developed by Hogentogler and Terzaghi in 1929, but has been revised several times since.

The Unified Soil Classification System (USCS) is a soil classification system used in engineering and geology to describe the texture and grain size of a soil. The classification system can be applied to most unconsolidated materials, and is represented by a two-letter symbol, (e.g. GW-means Gravel Well Graded).

OSHA uses a measurement referred to as “unconfined compressive strength” to classify soil into one of three categories: A, B, or C. Measuring unconfined compressive strength, which is reported in units of kg per square meter, informs us of the amount of pressure that will cause soil to collapse. As we are concerned with excavation in this article, therefore we will discuss these types as below.

A. Type A Soil

The most stable and cohesive soil with an unconfined compressive strength of 16145.8656 kg/SQM or greater. Type A soils generally include clay, silty clay, sandy clay, and clay loam. Type A soil never includes soil that is fissured, previously disturbed, has water seeping through it, or is subject to vibrations from heavy machinery or local traffic.

B. Type B Soil

Less stable but still cohesive, Type B soil does not stick to itself quite like Type A soil and possesses an unconfined compressive strength of 5381.9552 to 16145.8656 kg/SQM. Examples of Type B soil include angular gravel, silt, silt loam, and soils that are fissured or near sources of vibration that would otherwise be classified as Type A.

C. Type C Soil

The least stable type of soil, Type C soil is granular and has an unconfined compressive strength of 5381.9552 kg/SQM. Examples of Type C soil include gravel and sand. Due to a lack of stability, any soil with water seeping through it is automatically classified as Type C regardless of its other characteristics.

III. PRELIMINARY TESTING

It is very important that a contractor or other competent person perform a visual test upon breaking ground to help determine factors that could compromise the strength of the soil on the project site. You should be seeking answers to questions such as:

- Is the soil clumpy or granular?
- Are there sources of heavy vibrations near the excavation site?
- Are there signs of previously disturbed soil, such as from utility lines?
- Are there signs of water seeping through the soil?
- Is the soil fissured or otherwise showing crack-like openings or chunks of soil crumbling off the side of a vertical excavation wall?

When choosing a soil sample, be sure to collect a sample that is indicative of all the soil in the excavation area. As you dig deeper and deeper, continue to take new samples. Always remember that a trench can be cut through multiple types of soil, so it is imperative that you understand the soil profile of your entire excavation. Failure to account for the different compressive strengths of these layers could result in a trench collapse.

OSHA recommends taking a large clump from a freshly excavated pile that has not been compacted as opposed to taking a sample from the excavation wall. Once you have your sample, test it immediately to avoid an error. When soil dries up, test results can change. There are three types of soil tests: the plasticity test, thumb penetration test, and pocket penetrometer test.

A. Plasticiy Test

The plasticity test, or pencil test, is used to determine if the soil on excavation site is cohesive. This test is performed by rolling a moist soil sample into a small piece one-eighth of an inch thick and two inches long. Then, hold the piece on one end and see if it breaks. If you can hold the rolled sample on one end without it breaking, it is cohesive. If it breaks, it is not cohesive and is, therefore, classified as Type C soil.

B. Thumb Penetration Test

This test is used to quickly estimate the compressive strength of a cohesive soil sample. To perform this test, you simply push your thumb into a fresh sample of soil. If…

- Your thumb only makes an indentation with great effort, it is Type A soil.
- Your thumb sinks into the soil up to the end of your thumbnail, it is Type B soil.
- Your thumb goes all the way in, it is Type C soil. If you are unsure whether a sample qualifies as Type A, B, or C, collect a new sample, utilize a different testing method, or consult another competent construction worker on the excavation site to obtain a more accurate result.

C. Pocket Penetrometer Test

The first two testing methods we mentioned do not require any numerical data to verify the type of soil present at the excavation site, nor do they require the use of tools. By contrast, the pocket penetrometer test requires the use of a tool that works like a tire pressure gauge to give a numerical reading that can identify cohesive and non-cohesive soil samples. This numerical data is valuable, as it could be used as evidence if a trench collapses unexpectedly.

The pocket penetrometer has a thin metal piston that pushes into the soil sample and measures its compressive strength. When you start, make sure the scale indicator is inserted into the body of the pocket penetrometer until only the zero mark is visible. Push the device into the sample until it reaches the engraved line, then take the reading. Be sure to run this test on multiple samples to ensure that your results are consistent. Soil that contains rocks or pebbles may not compress, compromising your results.

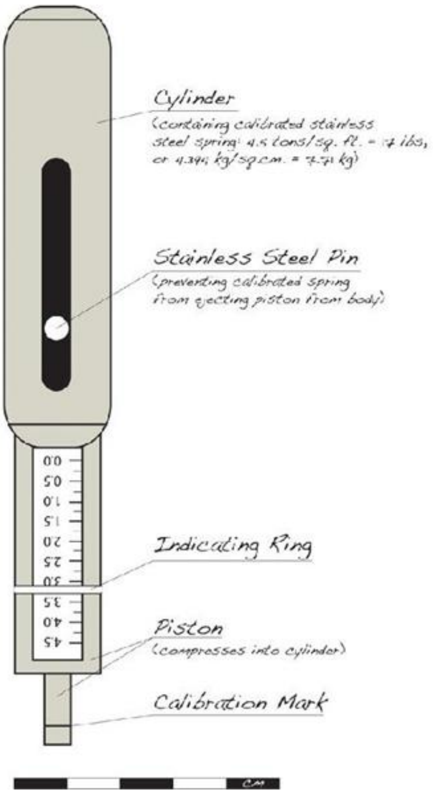

Figure 1. Pocket Penetrometer

IV. LABORATORY TESTS

If soil is not tested properly, it develops cracks in future and collapse in due course of time. Various types of tests are executed to know the surface characteristics of soil, and some of them are briefly explained below:

A. Moisture Content

Moisture content or water content in soil is an important parameter for construction. It is determined by several methods and they are

- Oven drying method
- Calcium carbide method
- Torsion balance method
- Pycnometer method
- Sand bath method
- Radiation method
- Alcohol method

Of all the above oven drying method is most common and accurate method. In this method the soil sample is taken and weighed and put it in oven and dried at 110° ± 5°C. After 24 hours soil is taken out and weighed. The difference between the two weights is noted as weight of water or moisture content in the soil.

B. Specific Gravity Test

Specific gravity of soil is the ratio of the unit weight of soil solids to that of the water. It is determined by many methods and they are.

- Density bottle method
- Pycnometer method
- Gas jar method
- Shrinkage limit method
- Measuring flask method

Density bottle method and Pycnometer method are simple and common methods. In Pycnometer method, Pycnometer is weighed in 4 different cases that is empty weight (M1), empty + dry soil (M2), empty + water + dry soil (M3) and Pycnometer filled with water (M4) at room temperature. From these 4 masses specific gravity is determined by below formula.

$$\textit{Specific gravity of soil} = \frac{\text{Density of water at 27 C}}{\text{Weight of water of equal volume}}$$

$$= \frac{(W_2 - W_1)}{(W_4 - W_1) - (W_3 - W_2)}$$

$$= \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)}$$

Figure 2. Formula for calculating Specific Gravity of Soil

C. Dry Density Test

The weight of soil particles in a given volume of sample is termed as dry density of soil. Dry density of soil depends upon void ratio and specific gravity of soil. Based on values of dry density soil is classified into dense, medium dense and loose categories. Dry density of soil is calculated by core cutter method, sand replacement method.

Core Cutting Method for Soil Dry Density Testing: In this method a cylindrical core cutter of standard dimensions is used to cut the soil in the ground and lift the cutter up with soil sample. The taken out sample is weighed and noted. Finally the water content for that sample is determined and dry density is calculated from below relation.

$$\rho = \frac{(M/V)}{1+w}$$

Figure 3. Apparatus and Formula for Core Cutting Method

Sand Replacement Method: In this method also a hole is created in the ground by excavating the soil whose dry density is to find. The hole is filled with uniform sand of known dry density. So by dividing the mass of sand poured in the hole with dry density of sand gives the volume of hole, therefore we can calculate soil dry density by using above formula.

Figure 4. Apparatus for Sand Replacement method Test

D. Atterberg Limits Test

To measure the critical water content of a fine-grained soil, Atterberg provided 3 limits which exhibits the properties of fine grained soil at different conditions. The limits are liquid limit, plastic limit and shrinkage limit

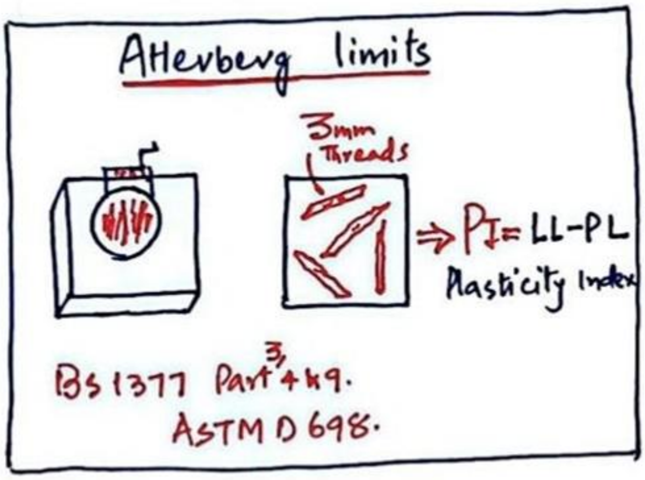

Figure 5. Apparatus and Formula for Atterberg Limits

Proctor's Compaction Test

The Proctor compaction test is a laboratory method for determining the optimum moisture content at which a soil type will become most dense and reach its maximum dry density. Through this test, the compaction of soil is determined.

Figure 6. Apparatus for Proctor's Compaction Test

The above-mentioned tests can help you save a lot in the cost of laying the foundation and ensure a safe, stable, and strong base for your construction project. Soil testing has a few benefits like identifying the type of foundation needed, helps avoid resting foundations on poor soil or inadequate depth, helps identify corrosive soil, identify soil liquefaction possibilities during trench excavation or an earthquake, etc.

V. CONCLUSION

Thus, before beginning any construction work, investing in soil testing can help save money and lives!

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