Principles and methods of building construction(volume 1)

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Dedicated to my father

A steadfast mountain and supporter of me throughout my life

Dedicated to my mother

The stone of patience that taught me the alphabet of life

Dedicated to my brothers

Kind companions of my life.

Introduction:

For a long time, shelter has played a vital and decisive role in human life and settlement. Due to the extraordinary progress of man in all sciences, the construction industry is no exception to this rule. In order to have strong and safe structures to protect the lives and property of residents, it must be accompanied by up-to-date knowledge to prevent accidents in buildings. Special attention to the principles and methods of building construction from demolition to joinery are basic and very important issues in the construction industry that in this book (Volume 1) I have tried to mention as much as possible, which are:

Geotechnics and soil testing and improvement methods, demolition of buildings and its methods, excavation, pit stabilization methods, piling and types of piles ,foundations and its types. I hope to take a very small step in the development of

the construction industry by writing this book.

With respect

Mohammad Tayyebi

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season 1

Soil testing, demolition, excavation, guard structure and pit stabilization

Classification of soil types

In construction or construction of any structure in civil engineering, one of the most determining factors affecting the design, cost and implementation is the type of soil. Soil classification helps civil and geotechnical engineers to identify the type of soil and how to deal with it. Soils are classified according to how they function for a set of physical conditions that do not necessarily have the same function in other physical conditions. One of the most important characteristics of soils is their grain size range. Soil grain size can vary from 20 cm in diameter in boulders to less than 0.1 μm in clay grains.

In the discussion of soil type classification, what affects soil properties is the percentage of clay, which makes soil behavior generally different and unpredictable.

(Types of soil by size)

Types of soil type

The importance of soil type in construction is due to the fact that the weight of the building and the effect of natural forces such as earthquakes on the structure are transferred to the soil on which the building is located, and the strength of the bed soil is very important in the tolerance of these forces. on the other hand, correct knowledge of bed soil strength also affects the construction costs of the structure.

According to earthquake design regulations for buildings (Regulation 2800), soil type is divided

into the following four types based on the average speed of earthquake waves:

- Soil type 1
- Soil type 2
- Soil type 3
- Soil type 4

Soil type 1

Rock and quasi-rock, including igneous, metamorphic and sedimentary rocks and very strong soils with a maximum of 5 meters of weaker materials to the ground are type 1 soils. The shear wave velocity in Type 1 soil is more than 750 meters per second.

Soil type 2

Very dense soil or loose rock, including very dense sand, very hard clay with a thickness of more than 30 meters, whose mechanical properties gradually improve with increasing depth, is a type 2 soil. The shear wave velocity in Type 2 soil is between 375 and 750 meters per second.

Soil type 3

Dense to medium soil, including dense to medium sand or hard clay with a thickness of more than 30

meters except type 3 soil. The shear wave velocity in Type 3 soil is between 175 and 375 meters per second.

Soil type 4

Medium to soft soils, non-cohesive or slightly cohesive soil layers with medium to low density and completely cohesive soft to firm soil layers are type 4 soils. The shear wave velocity in Type 4 soil is less than 175 meters per second.

Types of soil classification systems

Soil classification systems create a common language for summarizing soil characteristics. Most soil classification systems developed for engineering purposes are based on simple soil properties such as granulation and paste properties. The types of common classifications according to soil grain size are described below.

- Soil classification system by Ashto method
- Unified Soil Classification System (USGS)
- BS classification system
- Soil classification by the American Agricultural organization(USDA)

Soil classification system by Ashto method

The AASHTO or Ashto classification system is also known as the PRA classification system. This method was first developed in 1920 by the US Department of Public Works to classify soil for use in highway bedding.

Soils in each system are divided into two main categories of coarse and fine-grained, the sieve size of 200 determines the type of coarse-grained and fine-grained.

Naming in this method can be done according to the diagram and is classified from large to small grains as shown in the figure below. To name, we need two important parameters, LL and PI, or the same psychological limit and soil paste sign that are obtained from the experiment.

According to this system, the soil is divided into groups A1 to A7. Soils of groups A1, A2 and A3 are granular materials whose permeability to sieving is less than 35%. Soils with a sieving percentage of more than 35% fall into groups A4 to A7. These groups are often clays.

Unified Soil Classification System (USGS)

The classification of soil (the United Way)was originally developed by kasgrend(1948)and was recognized as an airport classification system.

Finally, the unified classification was approved by several amendments by the U.S Land Reclamation Department and its engineers ' group. The Unified classification is based on the size of the soil particles and soil properties of the soil.

In the soil classification (Unified Method), which is often used by Geotechnical engineers, a fine - grained separation and coarse grains percentage pass through sieve is 200, so that if less than 50 percent of the seeds are passing through sieve 200, then it is a fine - grained soil and is cut off.

the coarse soils in the soil classification (united method)are soil soils that are more than 50 percent of which are larger than 0.075 mm. coarse soils are classified into smaller categories, such as sand (G)and sand (S). sands are also divided into four other groups, in terms of the silt and clay content, respectively.

fine - grained soils refer to soils that are more than 50 percent smaller than 0.075 mm.fine grain soils are divided into three subgroups:

- Silt(M)
- Clay(C)
- Organic salts and clay (O)

in addition, fine - grained soils are determined based on plastic nature, with L, M and H symbols to indicate lower plasticity, moderate plasticity, and high plasticity.

the sharing system of the USGS and Ashto classification system is that both of them have a number of fine grained and fine grained soil, but the amount of sieve in each method is different and this number in the USGS method is 50 percent and is 35 % in the Ashto method.

(kinds of soil samples)

(kinds of soil samples)

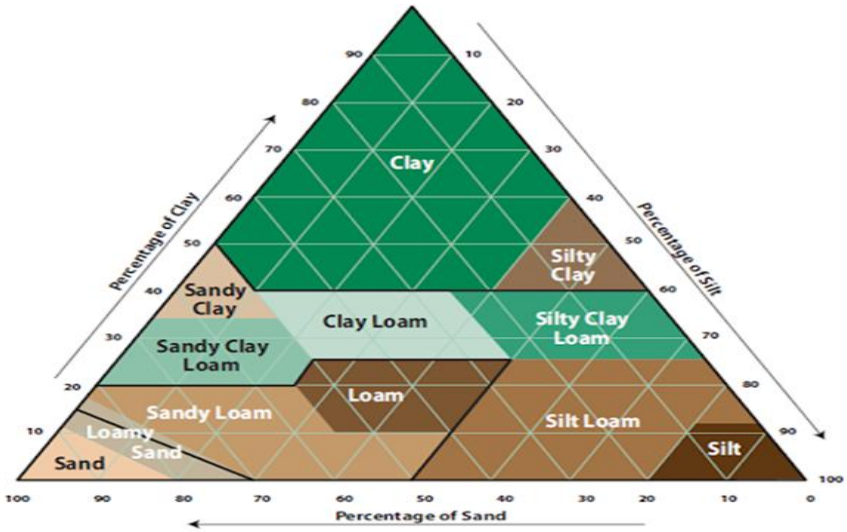
BS classification system

The BS classification system, which is based on the British Code, has many similarities in the method of classification of the USGS, and the main difference is that the BS classification system may be used in several sub - fields to describe soils. On the other hand, the difference is that, if the soil has a large amount of rock and rock, they first cut them off and the rest of the soil is fragmented. For the naming of soils in the BS classification system, we need to put together two main and sub - letters according to the properties of the soil.

Soil classification by the American Agricultural organization(USDA)

From a public point of view, the texture of the soil is attributed to its surface appearance. The soil texture is affected by the size of the existing particles in it. In most cases, natural soils are a combination of different sizes. In soil texture categories, the name of the main group, and the name of the sub - group, is mentioned as attribute. like sandy clay.

soil classification method is measured by mechanical decomposition in soil classification method, if the values of the three main categories of soil including sand (coarse and fine), silet and clay, are classified according to the soil texture triangle (USDA), which is represented in the following diagram.



for this purpose, first grade of clay, silt and clay is determined and the points related to each of them are determined on the sides of the soil texture triangle. Then, from each point, the line is drawn in parallel to one side of the triangle. This should be done in a way that is from the point of the silet, the line parallel to the clay, in the case of clay parallel to the west side and in parallel with the silet side. These lines intersect each other at a location within a context of the fabric of the soil. this type of soil texture is determined based on the name of the desired area. Within the context of the soil texture triangle 12 zones have been determined and, therefore, there are virtually 12 types of soil texture in U.S soil conservation organization.

Behaviour of soil types at the time of excavation

Vegetable soils

Soils that have low shear strength and high permeability (meaning that the soil will sit with the smallest loading). There are also high

humidity variations in the soil and are not suitable for construction. one of the apparent characteristics of this soil is also the existence of plant debris. If this soil is present at the excavation site, the maximum safety precautions should be taken during the excavation and strengthening.

Very tough - grained soil

This type of soil, as it is known from its name, has a relatively little texture and a relatively low grinding properties, and are usually classified as hard - clay soils and are normally found on the soil when a mechanical spade or loader is clearly visible.

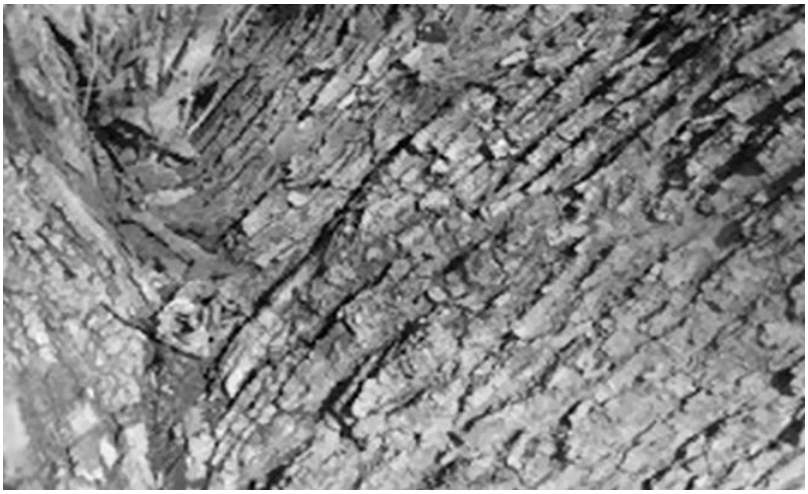
Dense granular soils with low adhesion

Such soils consist of sand and sand, and about 10 to 15 % of fine - grained soils. The tensile forces in fine sand create an apparent adhesive on the soil. If the pull - off of the stretching forces and the result of the reduction of the interfacial adhesion, the flow of water to the surface of the surface must be minimized, which can be carried out by conducting surface runoff. If water penetrates to the surface of the soil during excavation, the probability of spills in the region exists.

Glacial sediment

Glacial deposits include the heterogeneous and sometimes non - layered mixtures, and in some regions with clay, silet, sand, gravel. Because they

are usually dense, well graded and associated with a limited amount of fine - grained materials, they are sometimes very weak and weak in the face of this soil.



Dry soils without adhesion

This soil is completely dry due to the lack of fine particles and tensile properties and there is a possibility of it falling at any moment. Its stability and slip resistance are very low and excavation operations in such soils are very difficult. One of the physical characteristics of this soil is the filling of the soil removed by the machines with the surrounding soils. It is suggested that before harvesting this soil, necessary measures be taken to stabilize the pit and adjacent buildings.

Clay soils and very fine

In general, clay soils show acceptable resistance when they are dry, but when water penetrates behind the walls of this type of soil, it collapses due to a decrease in shear strength and its strength is lost. Therefore, the possibility of decay in wet conditions of such soils should be considered during excavation and appropriate preventive measures should be taken to prevent the decay of dried mud. It goes without saying that very fine-grained soils also show unstable behavior and break due to high tensile properties if moisture penetrates. Excavation of this type of soil in the dry state will not be difficult, but precautions must be taken.

What is soil testing and how is it done?

Soil covers most of the land and is a combination of minerals such as rock, sand, gravel and silt along with air, water and organic matter. Initially, due to the erosion of the rock, it breaks into fine particles and turns into soil. Its type and composition are different in different regions according to the climatic conditions. There are different types of it, each of which has its own application and characteristics.

Soil testing and its importance

Soil testing is the process of testing the strength and behavior of a soil. It is engineered to make

sure it has the strength needed to maintain the structure.

Eventually, each building transfers its weight to the ground, so this test is very important for engineers and employers. Recent earthquakes, as well as population growth, have led engineers to pay more attention to soil testing. Soil testing provides information such as the strength and hardness of the substructure, recognizing instabilities and the consequences of natural disasters such as earthquakes.

Application of soil testing

- Determine the amount of moisture
- Standard density test
- Soil flow rate
- Detection of granulation curves
- Specify the density
- Consolidation test
- Resistance and subsidence testing
- Determine the load ratio

Each of these properties describes the behavior of the soil when a force is applied to it.

What buildings need soil testing?

In recent years, soil testing has become mandatory for buildings. Leaking or leaving the building is one of the factors that we will face if we do not do soil testing. Keep in mind that you can save on the overall cost of your building for a small fee. For example, if your soil is type 2, you do not need to consider the structure of the building heavy, and with a light metal or concrete structure, you can reduce the cost of construction and use its strength well. In cases where the building has more than 6 floors or has an infrastructure of 2000 square meters, soil mechanics testing is required.

Soil testing costs

Soil testing costs depend on the location of drilling, manual drilling, machine drilling and the type of laboratory tests, type and number of field tests. Manual drilling takes more time, although today only projects can use manual drilling that do not allow the installation of a drilling machine. If it is possible to install the machine but the drilling is done manually, the company will be fined and the drilling report will be canceled. Therefore, it is

better to use a drilling machine to test the soil. In general, it can be said that it takes approximately 1 to 2 months to complete the excavation and receive the result, and after receiving the result, the construction of the structure can begin.

Today, some laboratories have submitted invalid reports and tests for a lower cost, which will lead to problems for the project because the type is not specified correctly. If the skeleton of the building is designed to be stronger than required, it will cause additional costs and is not cost-effective, and if the skeleton of the work is weaker than required, it will cause catastrophic results. Therefore, spending a little money at the beginning of the work will save the final cost of the work. An expert from the company must be present when drilling and performing local tests to manage and control the work process.

Steps of soil testing

In the first stage, the start of drilling should be announced to the Engineering System Organization, which is done by a laboratory company. The laboratory company determines the price after viewing the map and specifications of the place. Then the necessary drilling should be done, drilling can be manual or machine. Drilling

rigs perform the necessary drilling, then STP tests and sampling are performed, and a code is assigned to each sample. The next step is to inquire about the green leaf of the soil test. Reports prepared by the laboratory are sent to the engineering system. The testing engineering organization reviews that these steps take approximately 10 days. After 10 days, the confirmation report will be sent to the municipality. After the report is placed in the municipal system, the construction of the building skeleton begins.

What is the importance of soil testing for building construction?

Soil testing is a mandatory step for the construction of all types of buildings. The reason for this requirement is to identify the soil type. Following the determination of the soil type, the necessary measures to strengthen the building are determined. The weight of the building and the effect of natural forces such as wind on the structure and the transfer of the sum of these forces to the soil texture on which the building is located, is an inevitable necessity. Soil testing examines the mechanical structure and geotechnical layers of the soil. Sampling is done

manually and by machine. In the past, sampling was done manually, which is unacceptable today, and only the machine method is used for this purpose. Soil tests of building test it in terms of shear strength, load bearing capacity, acidity, penetration rate, soil granulation and soil density.

Soil testing performed by the laboratory, including SP tests or standard penetration tests, equivalent sand, hydrometry, flow limit, serand method, straight cutting, triaxial, permeability coefficient through drop water test, coefficient Permeability through fixed water load test, uniaxial sticky soil, consolidation and compaction, each of which is described below.

SP test or standard penetration test: In this test, soil resistance parameters are evaluated by examining the density of the layers and the possibility of variability in their texture.

SE Equivalent Sand Test: The aim is to determine the amount of fine particles or materials including clay or similar materials in soil and aggregates.

Hydrometric test: with the aim of determining the diameter of soil particles, the method of

suspending these particles in water with special calculations is performed.

Flow limit test: The purpose of this test is to calculate the amount of water that causes the soil to change from a paste to a fluid state. Determining this boundary in construction calculations in which the strength of the building is the main goal is necessary and vital.

Granulation test by serand method: It is done to determine the size distribution of soil grains. The use of a mechanical serand in this method has been replaced by the use of a sieve.

Direct shear test: Determines the resistance of soil tissue to various stresses on this tissue.

Three-axis test: In this part of the soil test, the sample is placed between two metal plates and pressed through a piston in the vertical direction. In addition, the vertical pressure is exerted on both sides by a fluid, which is mainly water, and all these forces are measured.

Permeability coefficient test through constant water load test: To estimate the permeability of coarse particles in the soil texture, a fixed water load soil test is performed.

Permeability coefficient test through water load test: If the purpose of understanding the soil texture is to calculate the permeability for particles of different sizes, fine and coarse, the blue load soil test is used, which is not limited in terms of particle size unlike fixed load test.

Uniaxial test of sticky soil: If we want to measure the amount of stress resistance in the soil that has sticky tissue, this method is used.

Consolidation test: This test is performed to estimate the amount of clay soil settling.

Density test: This test is performed when the execution project requires a dense infrastructure. This soil test is measured by removing the gases in the soil texture by impact, measuring the soil density and drawing the corresponding diagram.

As mentioned above, the types of soil types that are the result of soil testing from the site in question include types of types 1 to 4. The best type of soil is type 1 and the worst type is type 4. The quality of different soil types in this experiment is determined by the shear strength or velocity of seismic waves in the soil to a depth of 30 meters. Type 1 soil has the maximum shear

strength and type 4 soil has the minimum shear strength.

Soil improvement by injection method and various injection methods in soil

Soil improvement by injection method was first done by a person named Brini in 1802 AD, but in Iran this method was performed independently from 1363-1364; In 1802 in France, injections were used to improve the bearing capacity of the constituent materials under a catchment structure. The spread of cement injection continued from 1800 in France and England. The applications of this method have been mostly in the case of civil structures such as canals, anchorages and bridges.

The first use of cement injection in the construction of underground spaces dates back to 1864. In that year, Peter Barlow used a molded iron cover to create a cylindrical tunnel-shaped shield that was made from the inside. In this case, the spherical empty space at the end of the bumper was filled using injection mortar (Yetrolo 1994). In 1938, the first regular rock mass injection operation in the United States took place at the New Craton Dam (Weaver 1991). The Hoover Dam is said to have been the starting point for the

systematic design of injection programs in the United States between 1932 and 1935.

Purpose and application of soil improvement by injection method

Although injection into soil, rock and structure may have different purposes, but it can be said that in a general view, various methods of soil improvement through injection due to increased stability, increased strength, reduced permeability or connection between structure and construction site It happens. Injection operations are widely used in modern civil engineering. These applications include:

A) Reducing the permeability of the organization located under the foundation of water structures to control seepage and reduce reservoir water

B) Control of uplift force of the structure or prevention of the risk of erosion of the foundation soil

C) Increasing the strength of materials under heavy structures or reducing the ductility of foundation materials, which is sometimes called reinforcement injection.

D) The relationship of separate structural elements in a homogeneous structure by means of injection such as weighted concrete dams or in arched dams

E) installation of reinforcement cables in precast or prefabricated concrete structures

C) Installation of pre-compression shafts

G) Raising and verticalizing inclined buildings and structures

H) Filling the cavity between the rocks and the tunnel cover, which is called contact injection

G) Renovation and strengthening of damaged historic buildings

D) Making concrete under water by injecting it into previously replaced sands, known as the Pirpakt method.

Soil improvement method by injection method

Pressure injection is one of the soil improvement methods in which slurry is injected into the soil with high pressure and high speed and destroys the existing soil structure. During this process, part of the soil particles and slurry come out of the drilling site and the other part is mixed with the slurry in situ. As a result of this process, a mass of

modified soil is formed, which is called a cement soil mass.

The cement soil column created by the method of pressure injection into the soil has high strength, low ductility and very low permeability and strengthens the soil properties. In other words, pressure injection operations strengthen the physical and mechanical properties of the soil, including compressive strength, adhesion and internal friction angle up to several times.

Advantages of soil improvement by injection method

• Increase bearing capacity and soil capacity in saturated state

• Stabilization and compaction of loose layer in depth

• Repair and fill all pores inside the construction site

Types of injections into the soil

• Permeation Grouting

• Consolidation Grouting

• Compaction Grouting

- Hydrofracture Grouting
- Contact Grouting
- Jet Grouting
- Micropile

Consolidation Grouting

Consolidation injection method is one of the types of soil improvement methods in which slurry injection strengthens a layer of soil substrate, which leads to improving the quality of soil compaction. This method is also used to fill discontinuities and gaps between rock masses. The purpose of these works is integration; Filling fractures and discontinuities of rock masses with cement slurry.

Discontinuities in rocks affect the properties of rocks such as permeability and strength. The main injection process is to fill the cavities that if air and liquids penetrate into these cavities, it is possible for the rocks to disappear. The purpose of the injection is to reduce the hydraulic slope that prevents the transfer of liquids and gases. The injection operation improves the basic properties of the stones.

Uses:

• Construction of dams and strengthening of dams

• Drilling and tunneling of land

• Water subsidence control

Compaction Grouting

In this method, by injecting slurry with high viscosity and higher pressure and in several stages, bubbles of slurry are created which cause the soil to move and thus compact it. This method is widely used for karst environments (a phenomenon in the earth's crust whose effects are present in various forms such as cavities and caves, on the surface and below the surface), very loose soils and sandy and fine-grained subsidence. This method rarely causes minor displacements on the ground, and if there is a sensitive structure in this area, this method should be used with caution. Here are some tips for this method:

• The mixing design of the slurry should be carefully selected so that it does not penetrate the cavities in the soil or mix with the soil, instead, it should be replaced in the soil to be injected.

• The volume of empty spaces decreases and the environment becomes denser.

Mortar is very hard injected into loose soils and a bubble of injected mortar is formed and replaced in the soil, compacting the surrounding soil without penetrating the soil cavities.

• Does not have maximum density in sandy environments, but performs better in loose fine-grained environments.

• Often used in shallow foundations to raise subsidence slabs.

• Can be used in almost all types of soils.