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improve expansive soil consistency properties by the effect of broken glass waste on it

A Graduation Project Submitted To The Colloge Of Materials Engineering Of Babylon University In Partial Fulfillment Of The Requirement For The BSC Degree Of Science In Non-Metalic Materials Engineering \ Ceramic And Building Materials

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ABSTRACT

The search seeks to show the stabilization soil by using the two additives Foundationthe soils are most affected by different problems when it comes to the loose soil having low shear strength and bearing capacity. Failure of the soil with settlement and shear arises when the shear stresses in the soil exceed the limit. This study is keen to observe the effects of utilization of waste broken glass and fly ash in the enhancement of Geotechnical properties of soil by performing different laboratory tests. Collection of the soil sample from was concluded from al_hillah center and which is a low strength soil, are also being called soft soil having low bearing capacity. Furthermore, this particular soil was needed to be enhanced. The physical, chemical and engineering properties of virgin soil were contemplated and the soil was treated with added substances of Glass Powder to stabilize the local soil.

بسم الله الرحمن الرحيم

وَلِيَعْلَمَ الَّذِينَ أُوتُوا الْعِلْمَ أَنَّهُ الْحَقُّ مِنْ رَبِّكَ

صدق الله العلي العظيم

(٥٤ الحج)

الهداء

إلى من كلله هللا بالهيبة والوقار .. إلى من علمني العطاء بدون انتظار .. إلى من أحمل أسمه بكل افتخار .. أرجو من هللا أن يمد في عمرك لترى ثماراً قد حان قطافها بعد طول انتظار وستبقى كلماتك نجوم أهتدي بها اليوم وفي الغد وإلى األبد .. والدي العزيز) إلى مالكي في الحياة .. إلى معنى الحب وإلى معنى الحنان والتفاني .. إلى بسمة الحياة وسر الوجود إلى من كان دعائها سر نجاحي وحنانها بلسم جراحي إلى أغلى الحبايب أمي الحبيبة

الباحثه

طيبه خليف سعد

الشكر والتقدير :

الحمد لله رب العالمين والصلاه والسالم على سيد المرسلين واله الكرام الطاهرين

اما بعد :

وبعد كتابة هذا المشروع والجهد المتواضع ومن باب رد الجميل لا يسعني الا ان اتقدم بأسمى معاني الشكر والتقدير الى جميع اساتذة كلية هندسة المواد قسم السيراميك ومواد البناء لجهودهم وعطائهم املين من الله العلي القدير ان يكلل جهودهم بالنجاح وان يجعل كل مايقومون به في ميزان حسناتهم

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التي تفضلت مشكوره بالاشراف على هذا المشروع المتواضع والتي زودتنا بتوجيهاتها ونصائحها القيمه ووفرت لنا كافة المستلزمات من اجل انجاح هذا المشروع متمنين لها التوفيق والسداد في حياتها العلميه والعمليه .

مع جزيل الشكر وفائق التقدير

SUPERVISOR CERTIFICATION :

I certify that this project Entitled "improve expansive soil consistency properties by the effect of broken glass waste on it " Presented by "Taiba khalif saad" Was Prepared Under My Supervision As Partial Fulfillment Of The Requirement For BSc Degree Of Science in Non-Metallic Materials Engineering/ Ceramic And Building Materials

Signature :

Abeer Abduljabar Alseady

Date : \ \ 2021

Chapter 1

Introduction

Soil is one of the most abundant and cheapest of construction materials. Even so its use can be greatly extended by enhancing its engineering performance, for example, by the addition of cementitious material or by incorporation ofreinforcing elements Most civil engineering operations are caried out in soil and, obviously, poor soil conditions will be encountered on some construction sites. If such soil cannot be removed, then its engineering behavior can often be enhanced by some method of ground treatment (Glossop, 1968). Poor soil conditions usually are attributable to an excess of ground water or a lack of strength, ffid associated deformability. Treatment methods are therefore aimed at preventing ingress of groundwaterto or removing it from the site in question on the one hand or improving soil strength on the other.

Groundwater flow becomes more significant as the permeability of the soilincreases. The fact that groundwater flow is much slower in silts and clays than in sands and gravels does not mean that there are no problems associated with groundwater in the two former soil types. For example, quick conditions andpiping are associated with silts and ground heave with expanding clay soils. ,Convers Kelyinundation with water can lead to some loess .soils collapsing Other problems associated with groundwater are dissolution Of minerals such as gypsum in gypsiferous sands and the Hydration of others, for example, anhydrite. Yet other Minerals break down rapidly in the presence of Groundwater, like pynte;the resulting sulphate ions, when Caried in solution, can attack concrete foundations. Soils With low strength are also highly deformable. Lack of Strength leads tosoil failing if it is overloaded. However, this Is not a frequent occuffence in civil. .Engineeringconstruction Much more important is soil deformation ,which In terms.

Aim of the study:

Study the kaolinite soil properties and improved using (glass and fly ash) and study the effects developed by Adding deferent percentages on the soil .properties

Chapter two

Theortical part

2.1 Soil

Soil is a mixture of minerals, organic matter, gases, liquids, and countless organisms that together support life on Earth. Soil continually undergoes development by way of numerous physical, chemical and biological International Journal of Transportation Engineering and Technology weathering with associated erosion. Most of stabilization has to be undertaken in soft soils (silty, clayey peat or organic soils) in order to achieve desirable engineering propertie

2.2-Soil Stabilization

Soil stabilization is a method of improving soil properties by blending and mixing other materials. Soil stabilization is the process of improving the shear strength parameters of soil and thus increasing the bearing capacity of soil. It is required when the soil available for construction is not suitable to carry structural load.

Soil stabilization is used to reduce permeability and compressibility of the soil mass in earth structures and to increase its shear strength. Thus to reduce the settlement of structures . Soil stabilization involves the use of stabilizing agents (binder materials) in weak soils to improve its geotechnical properties such as compressibility, strength, permeability and durability. The soil stabilization is a moderen techniqe in the world , there are many types of soil such as (solid, strong, weak, and brittle).

So for this raeson we were using the stabilization of soil. The soil stabilization means that improve the soil properties to be according to the soil requirement from the soil properties that can be inhance it like (increasing the strenthg , reduce the permability , control to changing in the soil size , inhance the durability and reduce the compression).

So,the requirement can be following one or more of this methods:

1-Incresing the soil density

2-Adding inert materials for high cohesive and adhasive strenght

3-Adding materials for chemical and physical changing in the soil properties

4-Reduction attribution rate of water

5-Removing or replacing the natural soils

6-Reduction the changing in the water contain moisture

The main methods used for soil stabilization :

1- mechnical stabilization (compression) 2-cement stabilization

3-lime stabilization

4-bitumen stabilization

5-chemical stabilization

6-use different techniqes for soil stabilization by temporarity or permanent like using electrical methods or freezing the soil

2.3 Soil stablization methods

In road construction projects, soil or gravelly material is used as the road main body in pavement layers. To have required strength against tensile stresses and strains spectrum, the soil used for constructing pavement should have special specification. Through soil stabilization, unbound materials can be stabilized with cementitious materials (cement, lime, fly ash, bitumen or combination of these). The stabilized soil materials have a higher strength, lower permeability and lower compressibility than the native soil . The method can be achieved in two ways, namely;

1) In situ stabilization and
2) Ex - situ stabilization.

Note that, stabilization not necessary a magic wand by which every soil properties can be improved for better.The decision to technological usage depends on which soil properties have to be modified. The chief properties of soil which are of interest to engineers are volume stability, strength, compressibility, permeability and durability.

Some stabilization techniques are listed below :

(A)Mechanical stabilization

(B) Stabilization by using different types admixtures

(1) Lime Stabilization

(2) Cement Stabilization

(3) Chemical Stabilization

(4) Fly ash Stabilization

(5) Rice Husk ash Stabilization

(6) Bituminous Stabilization

(7) Thermal Stabilization

(8) Electrical Stabilization

(9) Stabilization by Geo-textile and Fabrics

2-3 -1 Mechanical Stabilization

Mechanical Stabilization is the process of improving the properties of the soil by changing its gradation. This process includes soil compaction and densification by application of mechanical energy using various sorts of rollers, rammers, vibration techniques and sometime blasting. The stability of the soil in this method relies on the inherent properties of the soil material. Two or more types of natural soils are mixed to obtain a composite material which is superior to any of its components. Mechanical stabilization is accomplished by mixing or blending soils of two or more gradations to obtain a material meeting the required specification.

2-3-2 - Stabilization by using different types admixers

(1) Lime Stabilization

Lime provides an economical way of soil stabilization.

The method of soil improvement in which lime is added to the soil to improve its properties is known as lime stabilization. The types of lime used to the soil are hydrated high calcium lime, monohydrated dolomite lime, calcite quick lime, dolomite lime. The quantity of lime is used in most soil stabilizer is in the range of 5% to 10%. Lime modification describes an increase in strength brought by cation exchange capacity rather than cementing effect brought by pozzolanic reaction .

(2) Cement Stabilization

Soil cement stabilization is soil particles bonding caused by hydration of the cement particles which grow into crystals that can interlock with one another giving a high compressive strength. In order to achieve a successful bond the cement particles need to coat most of the material particles. To provide good contact between soil particles and cement, and thus efficient soil cement stabilization, mixing the cement and soil with certain particle size distribution is necessary. Soil-cement is a highly compacted mixture of soil/aggregate, cement, and water. Soil-cement is sometimes called cement-stabilized base, or cement-treated aggregate base. Soil-cement becomes a hard and durable material as the cement hydrates and develops strength. Cement stabilization is done when the compaction process is continuing. As the cement fills the void between the soil particles, the void ratio of soil is reduced. After this when water is added to the soil, cement reacts with water and goes hard. So, unit weight of soil is increased. Because of hardening of cement shear strength and bearing capacity is also increased.

Cement helps decrease the liquid limit and increase the plasticity index and workability of clayey soils. Cement reaction is not dependent on soil minerals, and the key role is its reaction with water that may be available in any soil [15]. This can be the reason why cement is used to stabilize a wide range of soils. Numerous types of cement are available in the market; these are ordinary Portland cement, blast furnace cement, sulfate resistant cement and high alumina cement. Usually the choice of cement depends on type of soil to be treated and desired final strength. Hydration process is a process under which cement reaction takes place. The process starts when cement is mixed with water and other components for a desired application resulting into hardening phenomena. The hardening (setting) of cement will enclose soil as glue, but it will not change the structure of soil [15]. The hydration reaction is slow proceeding from the surface of the cement grains and the center of the grains may remain unhydrated [5]. Cement
hydration is a complex process with a complex series of unknown chemical reactions [16].

However, this process can be affected by

(a) presence of foreign matters or impurities (b) water-cement ratio

(c) curing temperature

(d) presence of additives

(e) Specific surface of the mixture.

Depending on factor(s) involved, the ultimate effect on setting and gain in strength of cement stabilized soil may vary. Therefore, this should be taken into account during mix design in order to achieve the desired strength. Calcium silicates, C3S and C2S are the two main cementitious properties of ordinary Portland cement responsible for strength development [8, 17]. Calcium hydroxide is another hydration product of Portland cement that further reacts with pozzolanic five materials available in stabilized soil to produce further cementitious material [5]. Normally the amount of cement used is small but sufficient to improve the engineering properties of the soil and further improved cation exchange of clay

Cement stabilized soils have the following improved .
roperties:

(a) decreased cohesiveness (Plasticity)

(b) decreased volume expansion or compressibility (c) Increased strength.

(3)Chemical Stabilization

Chemical stabilization of soil comprises of changing the physico-synthetic around and within clay particles where by the earth obliges less water to fulfill the static imbalance. Calcium chloride being hygroscopic and deliquescent is used as a water retentive additive in mechanically stabilized soil bases and surfacing. The vapor pressure gets lowered, surface tension increases and rate of evaporation decreases. The freezing point of pure water gets lowered and it results in prevention or reduction of frost heave. The depressing the electric double layer, the salt reduces the water pick up and thus the loss of strength of fine grained soils. Calcium chloride acts as a soil flocculent and facilitates compaction. Frequent application of calcium chloride may be necessary to make up for the loss of chemical by leaching action.

For the salt to be effective, the relative humidity of the atmosphere should be above 30%. Sodium chloride is the other chemical that can be used for this purpose with a stabilizing action similar to that of calcium chloride. Sodium silicate is yet another chemical used for this purpose in combination with other chemicals such as calcium chloride, polymers, chrome.)

(4) Fly ash Stabilization

Fly ash stabilization is gaining more importance recent times since it has wide spread availability. This method is inexpensive and takes less time than any other methods. It has a long history of use as an engineering material and has been successfully employed in geotechnical applications. Fly ash is a byproduct of coal fired electric power generation facilities; it has little cementations properties compared to lime and cement. Most of the fly ashes belong to secondary binders; these binders cannot produce the desired effect on their own. However, in the presence of a small amount of activator, it can react chemically to form cementations compound that contributes to improved strength of soft soil.

However,

soil fly ash stabilization has the following limitations

(a) Soil to be stabilized shall have less moisture content; therefore, dewatering may be required.

(b) Soil-fly ash mixture cured below zero and then soaked in water are highly susceptible to slaking and strength loss

(c) Sulfur contents can form expansive minerals in soil-fly ash mixture, which reduces the long term strength and durability.

(5) Rice Husk ash Stabilization

Disposal of solid waste on the land fill can be minimized if the waste is having desirable properties such that they can be utilized for various geotechnical application viz. land reclamation, construction of embankment etc. There are several methods used for improving geotechnical properties of problematic soils that includes densification (such as shallow compaction, dynamic deep compaction, pre-loading), drainage, inclusions (such as geosynthetics and stone columns), and stabilizations. Chemical stabilization of the problematic soils is especially significant in concerning with the treatment of soft fine-grained, expansive soils, and collapsible loess deposits. Soil stabilization is the process which is used to improve the engineering properties of the soil and thus making it more stable. Soil stabilization is required when the soil available for construction is not suitable for the intended purpose. It includes compaction, preconsolidation, drainage and many other such processes.

Rice husk ash (RHA) is a pozzolanic material that could be potentially used in soil stabilization, though it is moderately produced and readily available. When rice husk is burnt under controlled temperature, ash is produced and about 17%-25% of rice husk's weight remains ash. Rice husk ash and rice straw and bagasse are rich in silica and make an excellent pozzolana. Pozzolanas are siliceous and aluminous materials, which in itself possess little or no cementations value, but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cementations properties. The Rice Husk Ash would appear to be an inert material with the silica in the crystalline form suggested by the structure of the particles, it is very unlikely that it would react with lime to form calcium silicates. It is also unlikely that it would be as reactive as fly ash, which is more finely divided. So Rice Husk Ash would give great results when it used as a stabilizing material. The ash would appear to be a very suitable light weight fill and should not present great.

(6) Bituminous Stabilization

Bituminous soil stabilization refers to a process by which a controlled amount of bituminous material is thoroughly mixed with an existing soil or aggregate material to form a stable base or wearing surface. Bitumen increases the cohesion and load-bearing capacity of the soil and renders it resistant to the action of water. Bitumen stabilization accomplished by using asphalt cement, asphalt cutback or asphalt emulsions. The type of bitumen to be used depends on the type of soil to be stabilized, method of construction and weather conditions. In frost areas, the use of tar as binder must be avoided because of its high temperature maximum susceptibility. Asphalts and tars are bituminous materials which are used for stabilization of soil, generally for pavement construction. Bituminous materials when added to a soil, it imparts both cohesion and reduced water absorption.

(7) Thermal Stabilization

Thermal change causes a marked improvement in the properties of the soil. Thermal stabilization is done either by heating the soil or by cooling it. Heating: As the soil is heated, its water content decreases. Electric repulsion between clay particles is decreased and the strength of the soil is increased. Freezing: cooling causes a small loss of strength of clayey soils due to an increase in interparticles repulsion. However, if the temperature is reduced to the freezing point, the pore water freezes and the soil is stabilized.

(8) Electrical Stabilization

Electrical stabilization of clayey soils is done by a process known as electro-osmosis. As a direct current (DC) is passed through a clayey soil, pore water migrates to the negative electrode (cathode). It occurs because of attraction of positive ions (cations) that are present in water towards cathode. The strength of the soil is considerably increased due to removal of water. Electro-osmosis is an expensive method, and is mainly used for drainage of cohesive soils. Incidentally, the properties of the soil are also improved.

(9) Stabilization by Geo-textile and Fabrics

Geotextiles are porous fabrics made of synthetic materials such as polyethylene, polyester, nylons and polyvinyl chloride. Woven, non-woven and grid form varieties of geotextiles are available. Geotextiles have a high strength. When properly embedded in soil, it contributes to its stability. It is used in the construction of unpaved roads over soft soils. Reinforcing the soil for stabilization by metallic strips into it and providing an anchor or tie back to restrain a facing skin element [15].

Past research has shown that the strength and load- bearing capacity of subgrades and base course materials can be improved through the inclusion of nonbiodegradable

reinforcing materials, such as fibers, geotextiles, geogrids, and geocomposites. Use of these materials can improve the performance and durability of future highways and may reduce the cost of construction. At present, most of the research on these materials is based on tests conducted in the laboratory that are only partially complete. Further laboratory tests and evaluations will be necessary to develop design specifications based on material properties, and these specifications will need to be verified using large-scale field tests. presence of organic matters, sulphates, sulphides and carbon dioxide in the stabilized soils may contribute to undesirable strength of stabilized materials

2.4 Chemical and Mechanical Stabilization

In the construction and maintenance of transportation facilities, geomaterials—soils and rocks—must be stabilized through chemical and mechanical processes. Chemical stabilization includes the use of chemicals and emulsions as compaction aids to soils, as binders and water repellents, and as a means of modifying the behavior of clay.

It also includes deep mixing and grouting. Chemical stabilization can aid in dust control on roads and highways, particularly unpaved roads, in water erosion control, and in fixation and leaching control of waste and recycled materials. Mechanical stabilization includes compaction, and fibrous and other nonbiodegradable reinforcement of geomaterials to improve strength.

In applying these techniques, it is necessary to ensure the properties of stabilized geomaterials and their mixtures as applicable for use in the design of foundations, embankments, shoulders, subgrades, bases, and surface courses.

The disparity between countries with excellent roads and highway networks and those with poor ones can be expected to increase. This gap will be due primarily to differences in the funding base resulting from socioeconomic and geopolitical conditions.

At the same time, regions throughout the world share a common need to maintain and rebuild aging transportation system infrastructure. Yet if past policies prevail, money will be used primarily to build new facilities, with a smaller share of funds being allocated to maintaining and rebuilding existing facilities.

The world already has many miles of unpaved and marginally paved roads. In many areas worldwide, new roads will be unpaved as well. In places where roads are paved, they will be replaced or repaired from the ground up. Because of age, broken-down pavements may require recycling and rebuilding but more likely they are the result of poor support conditions combined with higher traffic loads. New roads, both paved and unpaved, will probably be placed in locations where there were no roads before because of less-than-ideal subgrade conditions. In all of these situations, less-than-desirable materials are likely to be used. Use of these materials will in turn require the application of stabilization techniques presently available, as well as those likely to evolve in the next century. Hence in the new millennium, we will face the challenge of developing better chemical stabilizers and mechanical stabilization techniques; new, quicker, and better testing methods; and better and environmentally safe methods for using waste materials for highway construction. Research is needed in a number of areas to develop the materials and methods required to meet this challenge

Weak resistance and variable physical properties of muddy soils is one of the biggest challenges facing the civil engineer at different construction sites. This is due to the increase in the accidental stresses that may be generated by them, in addition to the sudden change of their properties with the change of the moisture content, which makes them unsuitable as layers suitable for foundation and paving at different construction sites.

Therefore, there was a need to improve the properties of soils used in such layers, especially in construction sites where the option of replacing them and replacing other soils was not economically feasible. The addition of glass powder is one of the solutions that have been used in many previous studies as a substance that improves the properties of clay soil. Whereas the reuse of glass waste will also contribute effectively to the preservation of the environment, the focus of this research was on studying the addition of glass waste powder to some clay soils in Al-Jabal Al-Akhdar governorate, due to the possibility of using it as earthen backfill layers for external sidewalks and in buildings with limited areas. This paper presents a comparison and analysis of the results of a laboratory study of adding glass powder in varying proportions (5%, 10%, 15%, 30% of soil weight) on the physical and mechanical properties of clay soils.

The following properties of soil were studied: the limits of fluidity and plasticity, laboratory compaction, specific weight, bulk density, permeability of soil, resistance to unconfined pressure. The results showed a remarkable improvement in the properties of the soil containing the glass powder, as the values of the limits of texture and the dry density reached 22% and 8.5%, respectively, when adding the glass powder by 30%. The parameters of soil permeability, compression, and non-confined pressure resistance also changed as the proportion of glass powder in the clay soil sample increased.

2.5 Clay deposition

Clays and clay minerals occur under a fairly limited range of geologic conditions. The environments of formation include soil horizons, continental and marine sediments, geothermal fields, volcanic deposits, and weathering rock formations. Most clay minerals form where rocks are in contact with water, air, or steam.

Examples of these situations include weathering boulders on a hillside, sediments on sea or lake bottoms, deeply buried sediments containing pore water, and rocks in contact with water heated by magma (molten rock). All of these environments may cause the formation of clay minerals from preexisting minerals. Extensive alteration of rocks to clay minerals can produce relatively pure clay deposits that are of economic interest (for example, bentonites—primarily montmorillonite—used for drilling muds and clays used in ceramics.Erosion The transport and deposition of clays and clay minerals produced by eroding older continental and marine rocks and soils are important parts of the cycle that forms sedimentary rocks. The ancient sedimentary rock record is composed of about 70 percent mudstones (which contain about 50 percent clay-sized fragments) and shales (which are coarser than mudstones but which may contain clay-sized particles) (Blatt and others, 1980). Today, sedimentary environments that contain muds cover about 60 percent of marine continental shelves and 40 percent of deep ocean basins; continental aquatic environments such as lakes, rivers, estuaries, and deltas also contain high proportions of fine-grained sediments (Hillier, 1995, p. 162). Clearly, clays and clay minerals are critical components of both ancient and modern sedimentary environments.

2.5.1 Weathering

Weathering of rocks and soil is the primary way that
clays and clay minerals form at the Earth's surface today. The weathering process involves physical disaggregation and chemical decomposition that change original minerals to clay minerals; weathering is uneven, and many stages of breakdown may be found in the same clay sample. Factors governing rock weathering and soil formation include the initial type of rock, the ratio of water to rock, the temperature, the presence of organisms and organic material, and the amount of time. The types of clay minerals found in weathering rocks strongly control how the weathered rock behaves under various climatic conditions (such as humid-tropical, drytropical, and temperate conditions).

Kaolinite is found in most weathering zones and soil profiles. Montmorillonites, which are chemically more complex than kaolinites, are common in the lower parts of weathering profiles, nearer the rock, where chemistry exerts a strong control on mineralogy. Complex mixed-layer clay minerals (such as illitesmectites) are abundant in clay assemblages that develop from mica-bearing precursor rocks, such as the granite plutons that occur in temperate regions of the Northeastern United States. For example, a large component of soils formed by weathering of granites may consist of metastable muscovite, biotite, and chlorite. These minerals will alter progressively to clay minerals.

2.6 Mixing Method

The mixing method involves the stabilization of soils at large depth. It is an in situ ground modification technology in which a wet or dry binder is injected into the ground and blended with in situ soft soils (clay, peat or organic soils) by mechanical or rotary mixing tool (Porbaha et al, 2005; EuroSoilStab, 2002). Depending on applications, the following patterns may be produced (Figure

4); single patterns, block patterns, panel pattern or stabilized grid pattern (EuroSoilStab, 2002). Note that, the aim is to produce the stabilized soil mass which may interact with natural soil and not, to produce too stiffly stabilized soil mass like a rigid pile which may independently carry out the design load. The increased strength and stiffness of stabilized soil should not, therefore, prevent an effective interaction and load distribution between the stabilized soil and natural soil)Thus the design load should be distributed and carried out partly by natural soil and partly by stabilized soil mass (column .)

2.6.1 Wet Mixing

Applications of wet deep mixing involve binder turned into slurry form, which is then injected into the soil through the nozzles located at the end of the soil auger (Massarsch and Topolnicki, 2005). The mixing tool comprise of drilling rod, transverse beams and a drill end with head. There are some modifications to suit the need and applications. For instance, the Trench cutting Re-mixing deep method (TRD) developed by circa Japan, in 1993 provides an effective tool for construction of continuous cutoff wall without the need for open trench.

The method uses a crawler-mounted, chainsaw-like mixing tool to blend in-situ soil with cementitious binder to create the soil-cement wall. It further consists of a fixed post on which cutting, scratching teeth ride on a rotating chain and injection ports deliver grout into treatment zone. Wall depths up to 45 m having width between 0.5 m and 0.9 m are achievable. The wall quality for groundwater barrier is high with permeability between 1 x 10-6 and 1 x 10-8 cm/s . , Germany developed the FMI (Misch-Injektionsverfahren) machine. The FMI machine has a special cutting arm (trencher), along which cutting blades are rotated by two chain system. The cutting arm can be inclined up to 80 degrees and is dragged through the soil behind the power unit . Like TRD, the soil is not excavated, but mixed with binder which is supplied in slurry form through injection pipes and outlets mounted along the cutting arm .

2.6.2 Dry Mixing

Dry mixing (DM) method is clean, quiet with very low vibration and produces no spoil for disposal (Hayward Baker Inc). It has for many years extensively used in Northern Europe and Japan. The method involves the use of dry binders injected into the soil and thoroughly mixed with moist soil). The soil is premixed using specialized tool during downward penetration, until it reaches the desired depth. During withdrawal of the mixing tool, dry binder are then injected and mixed with premixed soil leaving behind a moist soil mix column. In Scandinavians countries and Sweden in particular, this method is referred to as Lime Cement Column (LCC), whereas ,

A typical DM machine consists of track mounted installation rig and a drill motor. Binder is fed into compressed air through the hose into mixing shaft to the outlet of mixing shaft into the ground Powdery binders under compressed air are injected into soft ground without processing into slurry form. Blade rotates creating a cavity in the soil in which air and binders fill in during withdrawal. During construction, the most efficient sequence is to work the stabilizing machine within its operational radius as much as possible . The native soil is thoroughly mixed with this compressed binder resulting into hardened column within the ground; the column size up to 1.5 meter diameter may be achieved with a maximum depth up to 40 m).

Chapter Three

Materials

The materials used for the investigation were the cohesive soil and crushed glass powder. A series of tests was conducted to achieve original engineering properties of soil and waste glass powder.

Soil

The poor cohesive soil sample was collected from a site in Ganakbari area at 1.5m depth from the ground level. The geotechnical properties of the expansive soil are shown in Table 1.

Table 1. Geotechnical Properties of Soil

Item	Property	Value
1.	Sand	21%
2.	Silt + Clay	79%
3.	Specific Gravity	2.64
4.	Liquid limit (LL)	49.52%
5.	Plastic Limit (PL)	28%
6.	Plasticity index (PI)	21.52%
7.	Shrinkage Limit (SL)	9.6%
8.	Optimum Moisture Content (OMC)	17.53%
9.	Maximum Dry Density (MDD)	1.83 (gm/cm^3)

10.	Unconfined Compressive Strength (UCS)	63.2 (KN/m^2)
11.	California bearing ratio (CBR) Unsoaked	2.32%
12	California bearing ratio (CBR) Soaked	1.56%

Glass

Waste glasses were taken from the nearest glass processing plant in Dhaka, Bangladesh. The waste glasses were washed, dried and then broken down into a powder by using a hammer and covering it with a piece of cloth to avoid raveling. The glass powder was passed through the sieve number 200. The passing through such that sieve had been taken. The properties of the glass and chemical composition of the glass are shown in Table 2 and Table 3 respectively.

Table 2. Properties of glass.

Item	Properties	Values
1.	Specific gravity	2.62
2.	Compression resistance	860-1020 Mpa
3.	Hardness	5.3 mohs Hardness
4.	Density	2.45 g/cm^3
5.	Bending strength	52 Mpa
6.	Softening point	950°C

Table 3. Chemical Composition of glass.

Item	Components	Composition (%)
1.	Silica	71
2.	Sodium oxide	11.25
3.	Lime	10.25
4.	Alumina	1.5
5.	Other	6

EXPERIMENTAL PROGRAM

In this study, various proportions such as 2%, 4%, 6%, 8% and 10% (by dry weight of soil) of waste glass powder was mixed with natural soil to investigate the geotechnical propersties of the sample soil. The laboratory tests were carried out to determine the LL, PL, PI, MDD, OMC, UCS and CBR. The LL and PL test was performed according to specifications ASTM D4318 [15]. The MDD and OMC were determined by the specifications of ASTM D698 [16] and ASTM D1557 [17], respectively. The CBR was conducted according to the specification of ASTM D1883 – 99 [18]. The UCS was performed regarding the specification ASTM D2166 [19]. The direct shear test was conducted according to ASTM D 3080.

Glass Powder

Squander Glass was taken from the neighbourhood Glass processing plant at Phase 3 indirect, Hayatabad, Peshawar, where glass is produced. The waste Glass was taken to the PCSIR labs during the time spent pounding. Ball Mill is a contraption utilized for squashing materials. Squander Glass was transformed into cinder with the assistance of Ball Mill Apparatus.

Acquired Glass Powder was utilized as altogether blended in changing rates by weight of dry soil. As the Glass Powder was in the residue shape so its fineness of the particles was strainer #200 passing. The particular gravity was observed to be 2.56. Tests were directed on the examples blended with Glass Powder at various

Research Methodology

The Following tasks are to be done for achieving the above mentioned objectives.

• A Collection of test from Pabbi, Peshawar, which is a low quality soil which should be moved forward.

• Addition of admixture in various extents following 4%, 8% and 12% and so forth.

• The Performance of various tests, i.e. Degree, Specific Gravity, Standard Proctor compaction, Atterberg Limits, Direct Shear and CBR and so forth. •

• Measurement of various Geotechnical properties incorporates Maximum Dry Density and Strength of the soil example.

• Comparison of the outcomes between typical soil test and balanced out soil test

Chapter four

TEST RESULTS AND DISCUSSIONS

Liquid Limit, Plastic Limit and Plasticity Index

The effect of Liquid Limit (LL), Plastic Limit (PL) and Plasticity Index (PI) with applying different percentage (2%, 4%, 6%, 8% and 10%) of glass powder is presented in Table 4. It is found that with the addition of glass powder, the LL was continuously decreased from 49.52% to 33.9% and PL was continuously decreased from 28% to 18.4%. This reduction is due to the characteristic of soil keeping water which occours because of the silica presence in glass works as sand which does not absorb water.

Table 4. Effect of glass powder on LL (%), PL (%) and PI (%).

Additional material (%)	LL	PL	PI
0%	49.52	28	21.52
2%	44.9	26.4	18.5
4%	40.6	23.2	17.4
6%	38.1	21.6	16.5
8%	35.6	19.3	16.3
10%	33.9	18.4	15.5

The variation of LL, PL and PI of the soil with increasing percentage of glass powder is shown in Figure 1. The percentage decrease in LL is 31.5%, PL is 34.3% and PI is 28%. The compressibility and swelling characteristics of soil changes with the changing in LL. Therefore, the compressibility and swelling characteristics of the soil was reduced due to reduction in LL and which will tend to improve the sub grade soil

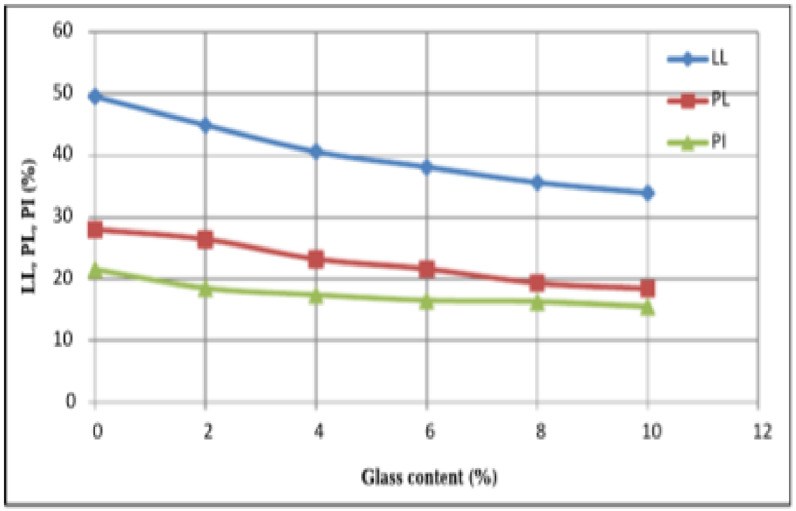

Figure 1. Variation of LL, PL and PI value for different glass powder content.

Maximum Dry Density and Optimum Moisture Content

The effect on Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) of different percentage (2%, 4%, 6%, 8% and 10%) of glass powder is tabulated in Table 5. The MDD of the pure soil was 1.83 gm/cm3 and increased to 2.03 gm/cm3 when added 8% of glass powder and remain constant after further increase the glass powder to 10%. On the contrary, OMC was decreased from 17.53% to 10.5% for adding up to 10% glass powder. The increase in MDD was due to the increased specific gravity of glass powder and the decrease of OMC was due to the fact that the addition of glass powder with soil diminishes the attraction to water particles. Figure 2 and Figure 3 reveal the variation of compaction characteristics with different percentage glass powder.

Table 5. Effect of glass powder on MDD (gm/cm^3) and OMC (%).

Additional material (%)	Glass powder	
	MDD	OMC
0%	1.83	17.53
2%	1.89	16.8
4%	1.95	15.9
6%	2.00	14.6
8%	2.03	12.7
10%	2.03	10.5

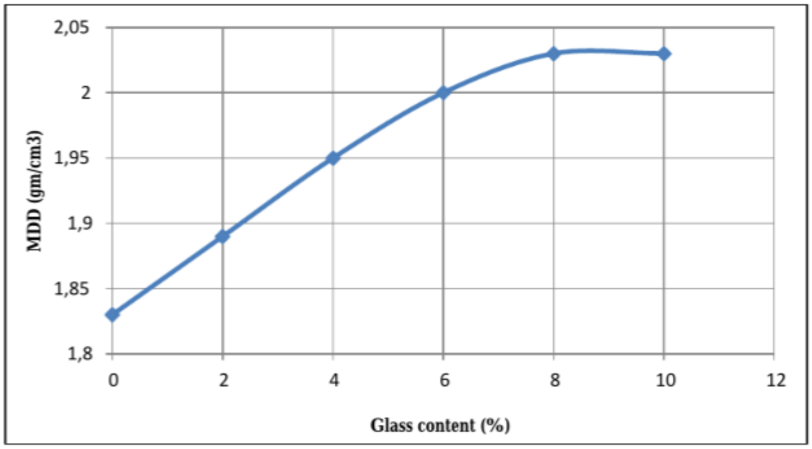

Figure 2. Variation of MDD value for different glass powder content.

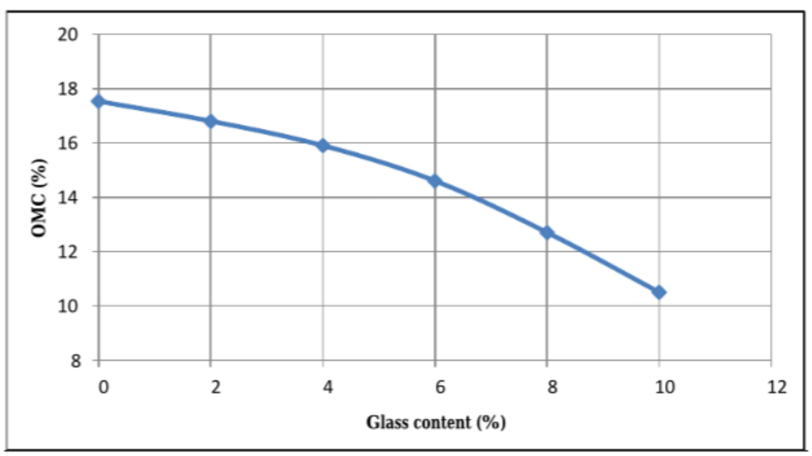

Figure 3. Variation of OMC value for different glass powder content.

California Bearing Ratio

The california bearing ratio (CBR) value of both unsoaked and soaked condition of the pure soil was 2.32% and 1.56% respectively. CBR value of unsoaked condition increased to 22.5% when added 10% glass powder. Soaked CBR value also increased to 10.4% when 10% glass powder was mixed. The effect of change in both conditions with respect to glass powder is given in Table 6. The increase in the CBR value may be due to the shear transfer mechanism between the soil and glass powder and the improvement in the strength might be due to the pozzolanic action of glass powder mix. The graphical representation of the variation of CBR value in both conditions with respect to glass powder is shown in Figure 4

Table 6. Effect of glass powder on CBR (%).

Additional material (%)	CBR (Unsoaked)	CBR (Soaked)
0%	2.32	1.56
2%	4.6	2.45
4%	7.3	4.2
6%	10.4	6.5
8%	15.7	8.9
10%	22.5	10.4

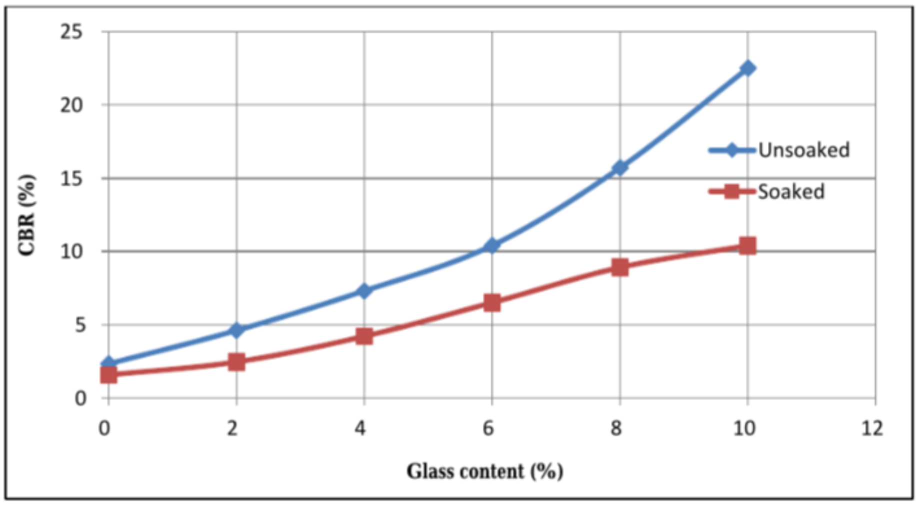

Figure 4. Variation of CBR value for different glass powder content.

Unconfined Compressive Strength

It can be seen from Table 7 that, the unconfined compressive strength (UCS) was increased from 63.2 KN/m2 to 133.5 KN/m2, with the increase of glass powder up to 8% and then, decreased to 110.7 KN/m2 when 10% glass powder is added. The increase in the UCS is for the presents of lime in glass powder and working as binder with clays after the hydration and enhance bonds. Lime causes the reduction of plasticity and improve the soil texture by pozzolanic strength. The decrease in the UCS values after the addition of 10% glass powder is may be due to decrease in cohesion of the soil. Figure 5 represents the variation of UCS of a soil with the increasing percentage of glass powder.

Table 7. Effect of glass powder on UCS (KN/m²).

Additional material (%)	UCS (KN/m²)
0%	63.2
2%	71.4
4%	86.6
6%	105.3
8%	133.5
10%	119.7

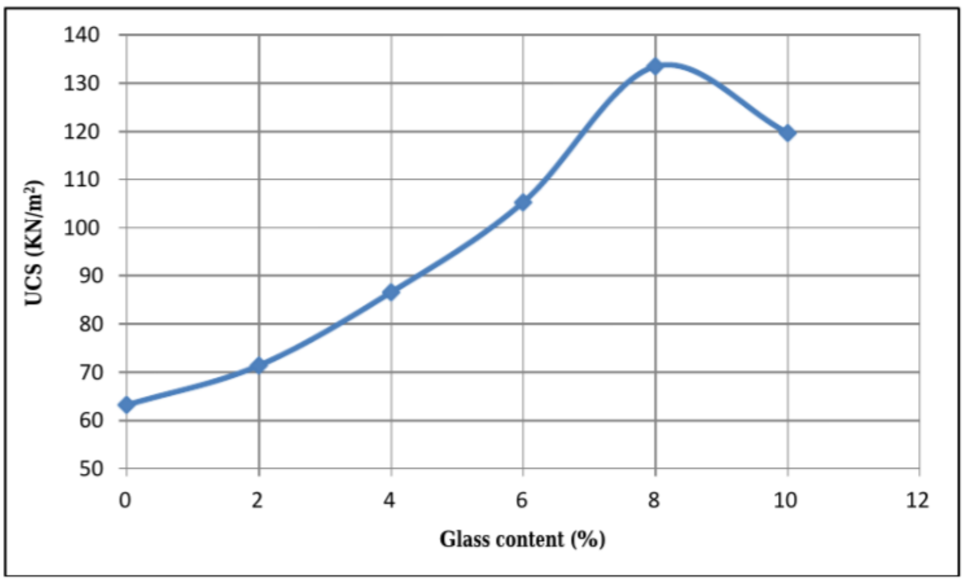

Figure 5. Variation of UCS value for different glass powder content.

Direct Shear Test

The effect on shear strength parameters of different samples were tested and is shown in Table 8. The increase of glass powder also provides a positive influence in the development of cohesion and angle of internal friction. The cohesion of the pure soil was 42.7 KN/m2 and increased to 106.4 KN/m2 when added 10% of glass powder. The rate of increasing became to decrease after the addition of 8% glass powder. Likewise, the angle of internal friction was also increasing with the increase of percentage of glass powder. Angle of internal friction was found to 27.4 and increase to 43.5 when added 10% of glass powder. Figure 6 and Figure 7 shows the variation of cohesion and angle of internal friction with different percentage of glass powder .

Table 8. Effect of glass powder on shear strength parameters.

Additional material (%)	Cohesion (KN/m^2)	Angle of internal friction (ϕ)
0%	42.7	27.4
2%	54.4	31.6
4%	63.8	34.4
6%	76.8	38.5
8%	98.6	41.3
10%	106.4	43.5

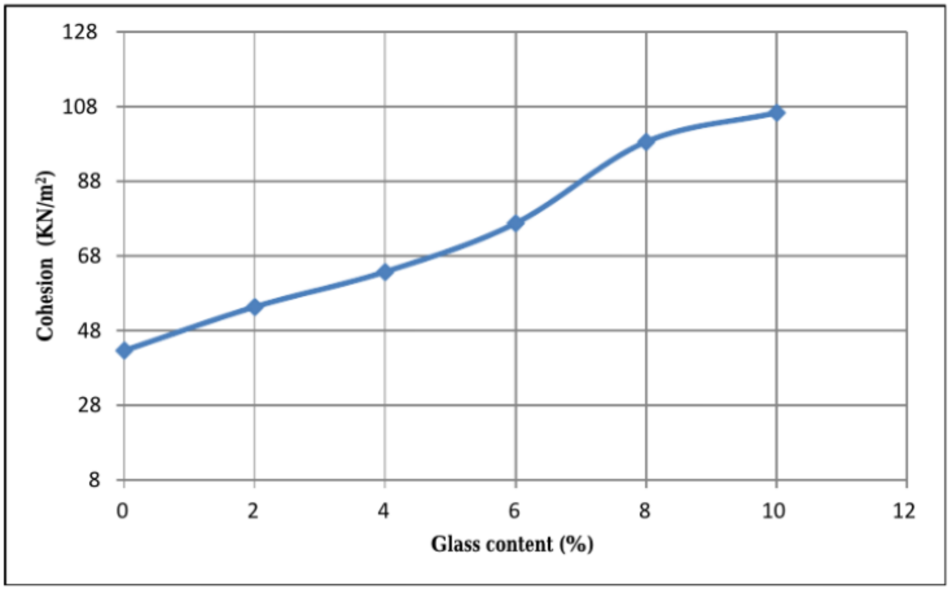

Figure 6. Variation of cohesion value for different glass powder content.

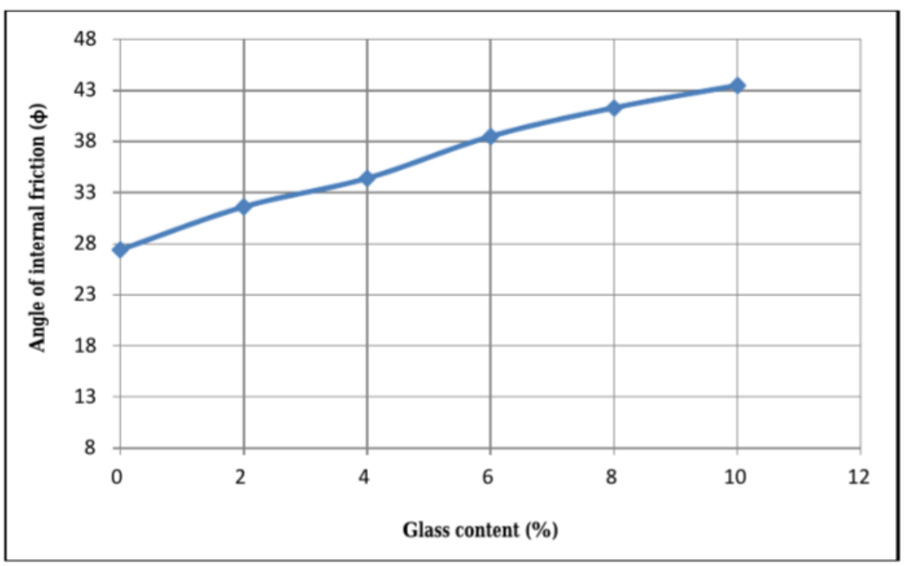

Figure 7. Variation of angle of internal friction value for different glass powder content.

Chapter five

CONCLUSIONS

This study concluded that the waste glass powder is useful for improving the clay soil. Using waste glass for stabilization not only help to reduce the environmental effect, but also for economic solutions as this material are locally and cheaply available. Based on the results, it can be said that LL, PL and PI continuously decreased with the increase of the glass powder which will potentially improve the subgrade. The MDD value increased from 1.83% to 2.03% with the addition of waste glass up to 8% of the dry weight of soil and remain constant when added 10%. On the other hand, OMC decreased from 17.53% to 10.5% with the increment of glass powder. The both unsoaked and soaked CBR increased with addition of glass powder and maximum value found to 22.5% and 10.4% respectively. The UCS increased to 133.5 KN/m2 when added 8% and then decreased to 119.7 KN/m2 when added 10% glass powder of the dry weight of soil.

The shear strength parameters also increase with the increase of the glass powder but the rate of increment was decreasing after the addition of 8% glass powder. Therefore, the optimum percentage of waste glass powder for improvement the soil is found to be 8%.

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