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A Study on Soil Improvement Techniques

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Abstract : *Soil is the very important part in construction of foundation of any civil engineering structures. It is required to bear the loads without failure. In some places, soil may be weak which cannot resist the oncoming loads. In such cases, soil stabilization is needed. Numerous methods are available in the literature for soil stabilization. But sometimes, some of the methods like chemical stabilization, lime stabilization etc. adversely affects the chemical composition of the soil. This paper gives an overview of techniques that are commonly used to improve the performance of saturated clayey soil in situ, its functions, methods of installation, the applicable soil types and cost of those techniques.*

Keywords - *Soil Improvement, Soil cement, Lime admixtures, Flyash, Dewatering, Heating and Freezing, Vitrification.*

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I. Introduction

The foundations and other structures on the soil is designed after investigation of the type of soil, its characteristics and its extent by the Geotechnical Engineer. If the soil is good at shallow depth below the ground surface, shallow foundation such as footings and rafts, are generally most economical. However if the soil just below the ground surface is not good but a strong stratum exist at a great depth, deep foundations, such as piles, wells and caissons are required. Deep foundations are quite costly as compared to shallow foundation, are cost effective only in the where the structure to be supported is quite heavy and huge. Sometimes the soil conditions are very poor even at greater depth and it is not practical to construct even deep foundation. In such kind cases numerous strategies of soil stabilization and reinforcement technique is adopted. the target is to enhance the characteristics at site and create soil capable of carrying load and to increase the shear strength decrease the compressibility of the soil.

Soil improvement is one such method. Stabilizing the subgrade with an appropriate chemical stabilizer (such as Quicklime Portland cement, fly ash or composites) increases subgrade stiffness reduces expansion tendencies, it performs as a foundation. This paper contains a summary of the performance of lime, cement and fly ash used with clay and application of dewatering, heating and freezing and vitrification.

II. Soil Cement

Soil cement could be a artifact, a mix of pulp of natural soil with little plot cement and water, is typically processed in a very dense, that is compressed for primary density. Hard, semi-hardened sturdy material is created by involvement of cement particles.

Soil cement is wide used as a affordable pavement base for roads(as shown in fig.1),suburban streets, parking areas, airports, shoulders, and materials-handling and storage areas Soil cement is often used as a construction material for pipe comforter, slope protection, and construction as a sub base layer reinforcing and protective the subgrade. it's smart compressive and shear strength, however is brittle and has low enduringness, therefore it's susceptible to forming cracks.

Soil cement mixtures differ from cement concrete within the quantity of paste (cement-water mixture). Whereas in cement concretes the paste coats all mixture particles and binds them along, in soil cements the quantity of cement is subordinate and thus there are a unit voids left, and also the result's a cement matrix with nodules of un cemented material.

Fig.1 Soil cement

II.I. TYPES OF SOIL CEMENT

II.I.I *Cement-modified soils (CMS)*

Cement-modified soils (CMS) contain relatively small quantities of Portland cement, which is less than normal clay cement. The result is a replacement copy or slightly rigid material, but with improved mechanical properties like lower plastic, the bearing ratio and shear strength enhance, and the volume decreases. The purpose of modifying soil with Portland cement is to advance the engineering property of reduced soil.

II.I.II Soil-cement base (SCB)

A **soil-cement base** contains upper proportion of cement than cement-modified soil. It is usually used as a inexpensive pavement base for roads, roads, parking lots, airports and content organization areas. Specific tools, such as soil stabilizers and mechanical cement spreaders, are usually necessary. A seal coat is obligatory to keep moisture out. For use as road construction textile, apposite surface outside layer, usually a thin layer of asphalt concrete is necessary to dapper down wear.

Compared to granulated sockets, due to their slab-like behavior, distributing loads on great areas, the basis of soil cement may be thin for the correspondent load. The in-place or neighboring material can be used for construction - locally soil, stone, or renovated granular base is being repaired with a road. It maintains both material and liveliness. The strength of soil-cement bases actually increases with age, providing good long-term concert.

II.I.III Cement-treated base (CTB)

A cement-treatment base is a mixture of granular soil composition or sole content with Portland cement and water. This is similar to the use and presentation of clay-cement base.

II.I.IV Acrylic copolymer (Rhino Snot)

Developed for the U.S. Military in barren region surroundings and commercially proprietary, "Rhino Snot" may be a soluble acrylic polymer well-designed to soil or rub down that penetrates and coats the exterior. When dry, it forms a water-proof, UV-resistant, solid bond that binds the soil along, plummeting mud. In higher special treatment it creates a sturdy surface which will stand up to serious traffic, permitting easily reached soil to be used for roads, parking more than a sufficient amount, trails and deputy somber traffic areas.

III. Lime Admixture

Wet, weak, fine crumb soil will sway be a momentous challenge at a number of construction sites. Muddy web site conditions create tough operating state of affairs. Access is hard-hitting for construction vehicles. It's tough to achieve the soil wetness and compaction requirements established by the project civil or geotechnical engineer. Wet, poorly compacted soil makes for poor pavement support and embankment/fill. At a construction web site, lost time suggests that lost cash.

Lime hurriedly improves the soil condition throughout construction and might add long run enhancements to key soil properties. Adding lime will cause 3 major soil improvements:

•Soil Drying – Reducing the soil humidity content
•Soil Modification – Reducing soil physical property, aiding compaction and ever-increasing early strength
•Lime Stabilization – Increasing long run strength and tumbling swell potential.

IV. Flyash

Fly ash has been used with success in several comes to boost the strength characteristics of soils.

Class C ash will be used as a complete material due to its self-cementations properties. Category Flyash will be utilized in soil stabilization applications with the addition of a building material agent (lime, lime oven dirt, CKD, and cement). The self-cementitious behavior of fly ashes is decided by ASTM D 5239. This check provides a customary methodology for decisive the compressive strength of cubes created with ash and water (water/fly ash weight magnitude relation is zero.35), tested at seven days with customary damp set. The self-cementitious

Characteristics area unit hierarchal as shown below:

Very self-cementing> five hundred psi (3,400 kPa)
Moderately self-cementing a hundred - five hundred psi (700 - three,400kPa)
Non self-cementing < a hundred psi (700 kPa)

It ought to be noted that the results obtained from ASTM D 5239 solely characterizes the building material characteristics of the ash-water blends and doesn't alone offer a basis to judge the potential interactions between the fly ash and soil or combination.

V. Dewatring

Dewatering suggests that modification of ground by redirecting seepages, lowering the bottom geological formation or in easy sense reduction of water content in foundation soil. 2 forms of dewatering techniques available; one is by gravity while not application of external forces, another is forced consolidation.
Dewatering is needed for not solely engineering science comes however conjointly these area unit helpful in mining comes. The objectives of dewatering area unit as follows:

- to stay operating place dry like excavation for dams, building foundations and tunnels.
- To stabilize natural or made slopes
- To treat granular soils by reducing their softness
- To decrease lateral pressures on holding walls or foundation
- to boost bearing capability of foundation soils
- to boost transportation characteristics or workability of the borrow materials
- to cut back physical change condition owing to upward gradient
- to cut back physical change potential owing to seismal activity
- to stop migration of soil particles by groundwater (phenomenon of piping)
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- to stop migration of soil particles by groundwater (phenomenon of piping)
- to cut back surface erosion
- to cut back or forestall amendment from geological phenomenon
- exposure to free Oxygen and wet.

VI. Heating And Freezing

I.I HEATING

The higher the heat contribution per mass of soil being treated, the greater the effect. Even small augment in temperature may cause strength increase in fine grained soils by reducing the electric loathing between the particles, a flow of pore water due to thermal gradient and reduction in moisture content because of increasing departure rate. Table shows the effect of increasing the temperature on shifting soil properties.

The Effect Of Temperature Increase On The Properties Of Clayey Soil

Temperature	The effect
1000°c	**Can cause drying and significant increase in strength.**
5000°c	Can origin permanent changes in the structure of clay hence diminishing in plasticity
10000°c	Can cause fusion of clay particles into asolid essence

VI.II Freezing

Soil freezing involves lowering the temperature of the soil until the moisture in the pore spaces freezes. Freezing of pore water acts as a cementing agent between the soil particles which provides significant increase in shear strength and permeability .Unlike soil heating, soil physical change could also be applicable to a wide range of soil varieties, grain sizes and ground conditions. Fundamentally, the sole demand is that the bottom has sufficient soil wetness (pore water). The process usually involves putting in double walled pipes within the soil.

A fluid is circulated through a closed circuit. In this method a refrigeration plant is used to maintain the coolant's temperature. It is used for temporary support, slope stabilization etc.

VII. Vitrification

Vitrification uses heat to become softer then solidify harmful chemicals in a very solid mass of glasslike material. It may be functional each unchanged (in-situ vitrification or ISV) and on top of ground in a very behavior unit (ex-situ). These square measure describe below.

VII.I. ISV and Planar-ISV

ISV uses wattage to form the warmth required to soften soil. Electrodes area unit inserted within the polluted space and an electrical current is passed between them, melting the soil between them. ISV uses very high temperatures (1,600 to 2,000 °C or a pair of, 900 to 3,650 °F). Melting starts close to the bottom surface and moves down. Because the soil melts, the electrodes sink additional into the bottom inflicting deeper soil to soften. Once the facility is turned off, the unfrozen soil cools and vitrifies, which implies it turns into a solid block of glass-like material. The electrodes become a part of the block. This causes the bottom exterior within the space to sink slightly. To level it, the sunken space is full of clean soil. Any harmful chemicals that stay underground become cornered within the shiny block that is left in situ. once the soil hardens, it forms a glass-like material that retards migration of compounds encapsulated within the glass.

The vitrification product may be a with chemicals stable, leach-resistant, glass and crystalline material kind of like volcanic glass or volcanic rock. ISV destroys or volatizes most organic pollutants by shift (i.e., application of warmth while not oxygen). A vacuum hood is usually placed over the treated space to gather off-gases, that area unit treated before unleash. Radionuclide's and significant metals area unit conserved at intervals the liquid soil. the standard technique of top-down melting in ISV usually leads to substantial over-melting of the rectification space. Planar-ISV involves beginning the melting method in specific areas of the submerged. Consequently, the melting method may be targeted directly on the region requiring treatment, and it will attain larger become softer depths..

VII.II. Ex-situ vitrification

Ex-situ vitrification is far like ISV, except that it's done within a compartment. Heating devices embody plasma torches and electrical transference furnaces. With plasma torch technology, waste is fed into a rotating hearth; the waste and melted material square measure control aligned with the aspect by force. Throughout the rotation, the waste moves through plasma generated by a at a standstill torch. To get rid of the melted material from the chamber, the hearths rotation slows and also the dross flows through a underneath gap. Effluent gases square measure usually unbroken in an exceedingly separate instrumentation wherever high temperatures combust/oxidize the contents. The arc chamber contains carbon electrodes; cooled sidewalls, endless give food to system, and associated an off-gas treatment system. During this method, waste is fed into a chamber wherever it's heated to temperatures larger than 1500¡C. The soften exits the vitrification unit and cools to make a glassy solid that immobilizes in organics. The Department of Energy has developed a movable Vitrification System (TVS) for treating mixed waste (radioactive and toxic) as a result the method may be used at numerous sites.

VII.III Limitations and Concerns

With most Stabilization/Solidification processes, there's potential for a considerable increase in waste volume. Concerns embody the sturdiness of the waste type. Glass waste forms, as compared to a grouted or cemented waste type, are expected to be additional stable over longer periods owing to the corrosion resistance of glass. However, de-vitrification of glass will occur over time periods involving thousands of years. whereas the warmth wont to soften the soil will destroy a number of the harmful chemicals, it should cause others to evaporate. The gaseous chemicals should be captured and treated.

Complete characterization of the candidate waste stream is crucial, before initiating either unmoved or ex-situ vitrification, to work out what glass forms ar already gift within the waste and what extra glass stabilizers and fluxes ought to be additional. Onsite analytical services with fast turnaround are needed to work out glass product characteristics and to validate worker performance.

There are specific limitations to ISV and ex-situ vitrification. These are delineating below.

ISV:
ISV cannot be used with buried pipes or drums and rubbish extraordinary 2 hundredth by weight.
Heating the soil could cause the subsurface migration of contaminants into clean areas.
ISV cannot be used wherever there are massive accumulations of ignitable or explosive materials.
The coagulated material could hinder future website use.ISV chop-chop volatilizes some organic compounds and volatile radionuclide's, together with Cs-137, Sr-90, and hydrogen. management of those off-gases, still because the high voltage used, gift potential health and safety risks.
ISV reduces the amount and quality of radionuclides, however it doesn't cut back their radiation. Therefore, protecting barriers that limit exposure to hot emissions should still be needed at some sites.
ISV is only for near-surface contamination, though new approaches could increase treatment depths to ten meters.

VIII. Conclusion

There are various methods available for soil improvement techniques which will be used for the needs of accelerating bearing capability, enhancing shear strength and decreasing consolidation settlement of saturated medium clay such as soil replacement, preloading with vertical drains, stone columns, stabilization with additives and thermal ways. Unfortunately, there's an absence of researches that think about all the governing factors like soil bearing capability and settlement, price of foundation works and easy execution. This paper all over that there's a vital have to be compelled to study the technique of removal and replacement for improving soil behavior taking into thought geotechnical necessities and price to realize the optimum replacement layer thickness and also the most fitted material corresponding to minimum total price of foundation works.

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