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REVIEW ON STABILIZATION OF SOIL BY GROUND GRANULATED BLAST SLAG

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Abstract: In developing country like India due to the remarkable development in road infrastructure, Soil stabilization has become the major issue in construction activity. Stabilization is an unavoidable for the purpose of highway and runway construction, stabilization denotes improvement in both strength and durability which are related to performance. Soil stabilization means alteration of the soils properties to meet the specified engineering requirements. Methods for the stabilization are compaction and use of admixtures. Lime, Cement was commonly used as stabilizer for altering the properties of soils. Reuse of waste materials have been advocated for quite a while now and the utilization of industrial wastes in improving the properties of poor soils open up a new avenue for solid waste management. Expansive soils have been one of the most problematic soils encountered by a Civil Engineer. A lot of techniques are available for stabilization of such poor soils including lime and cement stabilization. However, the utilization of solid wastes in soil stabilization is an area of potential and promise. And it also provides the double advantage of waste management along with soil improvement. In this study, we reviewed the Grand granulated blast slag in soil to enhance its mechanical properties and make it more suitable for use. In this paper, we studied the effect of stabilized soil and changes in its mechanical properties.

Keywords: Admixtures, Engineering performance, Mechanical stabilization, Subgrade soil

1.0 INTRODUCTION

Soft soils show major volume changes due to change in the moisture content. This causes major damage to property constructed on it. These soils contain minerals such as montmorillonite that are capable of absorbing water. When they absorb water their volume increases. Although mechanical compaction, dewatering and earth reinforcement have been found to improve the strength of the soils, other methods like stabilization using admixtures are more advantageous. The different admixtures available are lime, cement, fly ash, blast furnace slag etc. Innovative methods of soil stabilization are in great demand all over the world. There is growing concern over the cost of transporting large quantities of good soil from distant borrow areas for the construction of embankments and sub grades for roads. There is another concern regarding disposal of industrial wastes to avoid environmental problems. Black cotton soil which is occupying nearly 23% of the area in India is a problematic soil, available up to a depth of 3.7 meters on an average. The black cotton soil has various problems like less stability, less shear strength and large expansion & shrinkage in volume with changing seasons. These demerits obstruct construction like big infrastructure, road pavements, etc. on this soil. There are several industrial wastes which are being produced in millions of tons as unwanted by-products in the manufacturing industries & thermal power plants every year in India as well as all over the world. Most of these wastes are left unutilized and are posing environmental hazard by polluting the soil, water and air. Some of these wastes like fly ash & blast furnace slag have pozzolanic properties and are being used in the construction industry along with cement or lime as activators. Different methods are employed to improve the geotechnical properties such as strength and the stiffness of expansive soils, by treating them in situ. The methods that are commonly employed to improve problematic soils include densification such as compaction, preloading, pore water pressure reduction techniques such as dewatering and electro-osmosis, bonding of soil particles by ground freezing, grouting, chemical stabilization and use of reinforcing elements such as geotextiles and stone columns. Chemical stabilization of fine-grained and expansive soils has been proved to be effective in many of the geotechnical engineering applications such as pavement structures, building foundations to avoid damage due to settlement or the swelling of expansive soils. The improvement of the geotechnical properties of expansive soil using lime takes place through two basic chemical reactions *Short-term reactions* include cation exchange and flocculation, where lime is a strong alkaline base which reacts chemically with clays causing a base exchange. Calcium ions (divalent) displace sodium, potassium, and hydrogen (monovalent) cations and change the electrical charge density around the clay particles. In this study, experimental investigations are carried out to study the beneficial effects of stabilizing soil using ground granulated blast furnace slag along with lime in different proportions.

1.1 METHODS OF SOIL STABILIZATION

1. Mechanical stabilization
2. Cement stabilization
3. Lime stabilization
4. Bitumen stabilization
5. Chemical stabilization

1 MECHANICAL STABILIZATION

The most basic form of mechanical stabilization is compaction, which increases the performance of a natural material. The benefits of compaction however are well understood and so they will not be discussed further in this report. Mechanical stabilization of a material is usually achieved by adding a different material in order to improve the grading or decrease the plasticity of the original material. The physical properties of the original material will be changed, but no chemical reaction is involved. For example, a material rich in fines could be added to a material deficient in fines and in order to produce a material nearer to an ideal particle size distribution curve. This will allow the level of density achieved by compaction to be increased and hence improve the stability of the material under traffic. The proportion of material added is usually from 10 to 50 per cent. Mechanical stabilization is usually the most cost-effective process for improving poorly-graded materials. This process is usually used to increase the strength of poorly-graded granular material up to the well-graded granular material. The stiffness and strength will generally be lower than that achieved by chemical stabilization and would often be insufficient for heavy traffic pavements. It may also be necessary to add a stabilizing agent to improve the Final properties of the mixed material.

2 CEMENT STABILIZATION

Any cement can be used for stabilization, but Ordinary Portland cement is the most widely used throughout the world. The addition of cement material, in the presence of moisture, produces hydrated calcium aluminates and silicate gels, which crystallize and bond the material particles together. Most of the strength of a cement-stabilized material comes from the hydrated cement. A chemical reaction also takes place between the material and lime, which is released as the cement hydrates leading to a further increase in strength. Granular materials can be improved by the addition of a small proportion of Portland cement, generally less than 10 per cent. The addition of more than 15 per cent cement usually results in conventional concrete. In general the strength of the material will steadily increase with a rise in the cement content.

3 LIME STABILIZATION

The stabilization of pavement materials is not new, with examples of lime stabilization being recorded in the construction of early Roman roads. However, the invention of Portland cement in the 19th Century resulted in cement replacing lime as the main type of stabiliser. Lime stabilization will only be effective with materials which contain enough clay for a positive reaction to take place. Lime is produced from chalk or limestone by heating and combining with water. Only quicklime and hydrated lime are used as stabilizers in road construction. They are usually added in solid form but can also be mixed with water and applied as slurry. It must be noted that there is a violent reaction between quicklime and water and consequently operatives exposed to quicklime can experience several external and internal burns, as well as blinding. Hydrated lime is used extensively for the stabilization of soil, especially soil with a high clay content where its main advantage is in raising the plastic limit of the clayey soil. Very rapid stabilization of water-logged sites has been achieved with the use of quicklime.

4 BITUMEN OR TAR STABILIZATION

Bitumen or tar are too viscous to use at ambient temperatures and must be made into either cut-back bitumen (a solution of bitumen in kerosene or diesel) or a bitumen emulsion (bitumen particles suspended in water). When the solvent evaporates or the emulsion breaks‟ the bitumen is deposited on the material, the bitumen merely acts as a glue to stick the material particles together and prevent the ingress of water. In many cases the bituminous material acts as an impervious layer in the pavement, preventing the rise of capillary moisture. In a country where bitumen is relatively expensive compared to cement and where most expertise is in cement construction, it appears more reasonable to use a cement stabiliser rather than a bitumen/tar based product.

5 CHEMICAL STABILIZATION

Stabilization of moisture in soil and cementation of particles may be done by chemicals such as calcium chloride, sodium chloride etc. Although all the method is well versed for the soil stabilization but these all require money to spend. Hence to study the stabilization of soil “GROUD GRANULATED BALLAST FURNANCE SLAG (GGBS)” may be used as an admixture which is easily available. The general objectives of mixing chemical additive with soil are to improve or control volume stabilities, strength and stress-strain properties, permeability and durability. Volume stabilities namely control of swelling and shrinkage can be improved by replacement of high hydration of cations such as calcium, magnesium, aluminium or iron. It can also be improved by cementation and by water proofing chemicals. The development and maintenance of high strength and stiffness is achieved by elimination of large pores by bonding particles and aggregates together by maintenance of flocculent particle arrangement by prevention and swelling.

2.0 LITERATURE REVIEW

Many research works have been done on the properties of soil and blast furnace slag by the different researchers for study in their suitability as a construction material in various field of civil Engineering. They are:

Dayalan J (2016) studied on the stabilization of Soil with Ground Granulated Blast Furnace Slag (GGBS) and Fly Ash**.** Soil stabilization has become the major issue in construction engineering and the researches regarding the effectiveness of using industrial wastes as a stabilizer are rapidly increasing. This study briefly describes the suitability of the local fly ash and ground granulated blast furnace slag (GGBS) to be used in the local construction industry in a way to minimize the amount of waste to be disposed to the environment causing environmental pollution. In this present study, different amount of fly ash and GGBS are added separately i.e. 5, 10, 15 and 20% by dry weight of soil are used to study the stabilization of soil. The performance of stabilized soil are evaluated using physical and strength performance tests like specific gravity, Atterberg's limits, standard proctor test and California Bearing Ratio (CBR) test at optimum moisture content. From the results, it was found that optimum value of fly ash is 15% and GGBS is 20% for stabilization of given soil based on CBR value determined.

Tarkeshwar Pramanik et al (2016) studied the behaviour of Soil for Sub Grade by using Marble Dust and Ground Granulated Blast Furnace Slag. In this paper, sandy clayey soil was stabilized using the combination of Marble Dust and GGBS in different proportion (i.e.0%+0%, 5%+5%, 10%+10%, 15%+15% & 20%+20%) and the Characteristic behaviour (i.e. OMC, MDD, UCS, CBR & Permeability) of modified soil in the laboratory was studied. The series of test has been conducted in laboratory and it is found that Marble Dust and GGBS (15%+15%) is sufficient to increases the California bearing ratio in unsoaked and soaked condition value up to 195% and 100% approximately.

A. Kavak et al (2016) studied on the reuse of Ground Granulated Blast Furnace Slag (GGBFS) in Lime Stabilized Embankment Materials. In this paper presents an effective way of utilizing the ground granulated blast furnace slag (GGBFS), which is a by-product of the steel manufacturing process with lime for stabilization of road materials. In the study Ankara clay was used for stabilization. Although slag–lime and clay mixtures do not affect optimum water contents of clay significantly, they decrease dry density and smoothes Proctor curve. Then, the soil transforms into a rapid structure and the modulus of elasticity increases. When the results of the experiments were evaluated, unconfined compressive strength (UCS) and soaked California Bearing Ratio (CBR) values of the soils have shown significant increases. These increases reach to 46 times in CBR values for Ankara clay compared to natural case in 28 day-cured samples. This stabilization technique is more effective than the lime alone and also the slag will prevent the ettringite formation that occurs in lime stabilization with sulfate rich soils that leads swelling behaviour. And finally the slag may turn from a waste material into a valuable product for road construction works with huge volumes even at far away from the steel factories.

Kayal Rajakumaran (2015) experimentally analysed the stabilization of expansive soil with steel slag and fly ash. In this paper, the stabilization of expansive soil on experimental basis. The stabilization of expansive soil is required because their volume can be change due to the variation in moisture content on it, which leads to either shrink or swell while the soil is in dry or wet condition respectively. The stabilization of expansive soil is assessed by the presence of different percentage of steel slag and fly ash on the expensive soil and the performance of modified expansive soil is evaluated using index properties test, permeability test, compaction test and unconfined compressive strength test. Based on this performance tests, optimum amount of steel slag and fly ash on expensive soil is also determined.

Jijo James et al (2015) reviewed the soil Stabilization as an Avenue for Reuse of Solid Wastes. After reviewing the various literature it has been concluded that A lot of techniques are available for stabilization of such poor soils including lime and cement stabilization. However, the utilization of solid wastes in soil stabilization is an area of potential and promise. And it also provides the double advantage of waste management along with soil improvement. With this as base, this paper attempts to review the various industrial wastes that have been adopted in soil stabilization as a standalone stabilizer without lime or cement, in order to shed light into the prospects of increased utilization of solid wastes in soil stabilization.

Oormila.T.R. et.al. (2014) proved that the utilization of industrial waste materials in the improvement of soils is a cost efficient and environmental friendly method. Stabilization of the soil is studied by using fly ash and ground granulated blast furnace slag. This paper includes the evaluation of soil properties like unconfined compressive strength test and California bearing ratio test. The soil sample was collected from Palur, Tamil Nadu and addition to that, different percentages of fly ash (5, 10%, 15% and 20%) and GGBS (15%, 20%, 25%) was added to find the variation in its original strength. Based on these results CBR test was performed with the optimum fly ash, optimum GGBS and combination of optimum fly ash with varying GGBS percentages (15%, 20%, and 25%). From these results, it was found that optimum GGBS (20%) gives the maximum increment in the CBR value compared with all the other combinations.

Sridevi G et al (2014) et al studied on the efficacy of GGBS Stabilized Soil Cushions With and Without Lime in Pavements. In this study, expansive soil, stabilized with Ground Granulated Blast furnace Slag (GGBS), with and without lime was used as cushioning material above an expansive clay sub-grade to study its performance in improving the properties of the sub-grade. The investigations show that the GGBS-stabilized expansive soil, with and without lime, as a cushioning material is effective in reducing the heave of the underlying clay bed apart from improving the soaked CBR and increasing the unconfined compressive strength of the soil, GGBS mix system. The studies also indicate that the cushioning material possesses all the properties needed for use as sub-base material. So, the cushion also serves as a sub-base layer in the pavement structure. The use of GGBS-stabilized soil alone, or in combination with lime, has significant effect in improving the properties of potentially swelling clays.

Ashish Kumar Pathak et al (2014) studied the soil Stabilization Using Ground Granulated Blast Furnace Slag. In this research the soil are stabilized by ground granulated blast furnace slag (GGBS) and this material is obtained from the blast furnace of cement plant, which is the byproduct of iron (from ACC plant, sindri). It is generally obtained in three shaped one is air cooled, foamed shaped and another is in granulated shaped. The use of by-product materials for stabilization has environmental and economic benefits. Ground granulated blast furnace slag (GGBS) material is used in the current work to stabilize soil (clay). The main objectives of this research were to investigate the effect of GGBS on the engineering property (optimum moisture content and maximum dry density, plastic limit, liquid limit, compaction, unconfined compressive strength, triaxial and California bearing ratio test) of the soil and determine the engineering properties of the stabilized. Granulated shaped blast furnace slag is most suitable for increasing the strength of the soil and for this we check the following property of soil. GGBS are added from 0% to 25% by dry weight of soil, first of all check the all soil property at 0 % (no GGBS) and then compare after addition of GGBS from 5% to 25%. The investigations showed that generally the engineering properties which improved with the addition of GGBS. The addition of GGBS resulted in a dramatic improvement within the test ranges covered in the programme. The maximum dry density increased and the optimum moisture content decreased with increasing GGBS content and at 25% we got the maximum value of dry density.

CONCLUSION

From the results of this study, the following conclusions can be made:

1. The primary benefits of using these additives for soil stabilization are
a. Cost Savings: because slag is typically cheaper than cement and lime; and
b. Availability: because slag sources are easily available across the country from nearby steel plants.
2. Waste management one of the industrial wastes can be done economically.
3. It is observed that with increase of slag, more stability of soil is achieved as compared to using lime alone.
4. With the increases of GGBS percentage compressive strength increases that means arrangement of soil particles are very closely, which reduces the voids.
5. With percentage increases of GGBS specific gravity goes on increasing, thus making the soil denser.

With the increases of GGBS percentage, percentage finer goes on decreases, which strengthens the soil.

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