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Review on Stabilization of Clayey Soil Using Fines Obtained From Demolished Concrete Structures

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ABSTRACT: Soil stabilization may be defined as the process of changing soil engineering properties to improve the bearing capacity and durability property of weak soil. The aim of the study was to review on stabilization of clayey soil using demolished waste material. Various methods are available for stabilizing clayey soil. These methods include stabilization with chemical additives, soil replacement, compaction control, moisture control and thermal methods. All these methods may have the disadvantages of being ineffective and expensive. Based on literature fines obtained from demolished waste is a low cost and effective soil stabilization method.

KEYWORDS: Soil stabilization, Clayey soil, Construction and Demolition waste, Sub-grade, California Bearing Ratio.

I. INTRODUCTION

Soil is an accumulation or deposit of earth material, derived naturally from disintegration of rocks or decay of vegetation, that can be excavated readily with power equipment in the field or disintegrated by gentle mechanical means in the laboratory. The supporting soil beneath pavement and its special under courses is called sub grade. Undisturbed soil beneath the pavement is called natural sub grade. Compacted sub grade is the soil compacted by controlled movement of heavy compactors. Subgrade soils are an essential component of pavement structures, and inadequate subgrade performance is the cause of many premature pavement failures. Clay sub-grades in particular may provide inadequate support, particularly when saturated. Soils with significant plasticity may also shrink and swell substantially with changes in moisture conditions. These changes in volume can cause the pavement to shift or heave with changes in moisture content, and may cause a reduction in the density and strength of the subgrade, accelerating pavement deterioration. Pavement design is based on the premise that minimum specified structural quality will be achieved for each layer of material in the pavement system. Each layer must resist shearing, avoid excessive deflections that cause fatigue cracking within the layer or in overlying layers, and prevent excessive permanent deformation through densification. As the quality of a soil layer is increased, the ability of that layer to distribute the load over a greater area is generally increased so that a reduction in the required thickness of the soil and surface layers may be permitted. The most common improvements achieved through stabilization include better soil gradation, reduction of plasticity index or swelling potential, and increases in durability and strength. In wet weather, stabilization may also be used to provide a working platform for construction operations. These types of soil quality improvement are referred to as soil modification or soil stabilization.

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II. SOIL STABILIZATION USING LOW COST METHODS

Sometimes an image may contain text embedded on to it. Detecting and recognizing these characters can be very important, and removing these is important in the context of removing indirect advertisements, and for aesthetic reasons. Construction of pavements in weak soil areas creates a lot of problems for civil engineers because of its low California bearing ratio (CBR) value and alternate swell-shrink behavior when the soil comes in contact with water. This results not only in high cost of construction but also necessitate frequent repairing as cracks of different shapes and varying depth are seen on these soils. There are different techniques to increase the CBR value and to reduce the swelling pressure of soil. Stabilization using industrial wastes is one of them.

Emerging trend of using waste material in soil stabilizing or soil strengthening is being operational all over the world in present days. The main reason behind this trend is the excessive production of waste like fly ash, plastics, rice husk ash which is not only hazards but also creating deposition problems. Using some of these waste materials in construction practice will reduce the problem in a great extent. Today, crushed concrete is available in large quantities, which results from the demolition of old structures and waste concrete from new structures. The current annual rate of generation of construction waste is 1,183 million tonnes worldwide. The land area required for filling this huge amount of waste is equivalent to the accumulation of waste. Therefore, recycling construction waste is vital, both in order to reduce the amount of open land needed for landfilling and to preserve environment through resource conservation. Also from the viewpoint of sustainable and green building technologies, the use of recycled aggregate (RA) in new concrete production has increased globally.

Recycled solid waste materials are normally referred to as solid wastes which are collected near curbsides; or generated by construction and demolition (C&D) or commercial and industrial activities. C&D materials are the excess or waste materials associated with the construction and demolition of buildings and structures, including concrete, brick, reclaimed asphalt, steel, timber, plastics, and other building materials and products. The urgent need for recycling is of global concern and is driven mainly by environmental considerations, due to the increasing scarcity of natural resources and the growing disposal cost into the landfills in many countries. It is widely accepted that recycling and subsequent reuse of C&D materials will reduce the demand for scarce virgin natural resources and simultaneously reduce the quantity of this waste material destined for landfills. This will ultimately lower carbon footprints, in contrast to using traditional quarried materials, which can lead to a more sustainable environment. The usage of C&D materials in pavement applications is a sustainable option to minimise the C&D waste while reducing the demand for scarce virgin quarried materials

It eases the production and emission of greenhouse gas and other pollutants by reducing the need to extract raw materials and transporting the materials long distances. It reduces the need for new landfills and the costs involved in it. Recycling saves energy and also reduces the environmental impact. It creates employment opportunities in recycling industries. A lot of money can be saved by reducing the project disposal costs, transportation costs and the cost of new construction materials by recycling old materials onsite. The environmental benefits of recycling construction and demolition waste are considerable. By assessing carbon dioxide and energy use at a large scale recycling plant, researchers have shown that, over its 60 year life span, the carbon dioxide emissions prevented will be ten times as much as those produced, and eight times as much energy will be saved, than is used.

III.USE OF DEMOLITION WASTE IN SOIL STABILIZATION

Highway engineers are constantly searching for new and innovative engineering methods and techniques to minimize the use of natural resources as well as to protect the environment. Road construction is one of the main fields where researchers are studying the use of alternative materials. A number of waste products are currently being used in a variety of highways applications. Since 1999, in view of the huge quantities of Construction and Demolition Wastes (C&DW), this study has been concentrating on the possible utilization of fines obtained from C&DW materials as stabilizing agent for sub-grade soils. Material engineers are persistently looking for suitable and cheaper stabilizers for

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use in clayey soil stabilization as alternatives to costly additives, like, cement, lime etc. Since C&DW contains aggregates of variable sizes including coarser and finer, coarser fraction had been used as recycled aggregates in pavement construction but finer fractions is being left out still as waste material. The material passing through 1.18 mm IS sieve contains both cement and sand in sufficient quantity and which being fine enough to alter the soil gradation; on admixing of the same could improve the packing density of the soil mass and at the same time there would be chemical reaction to some extent due to presence of enormous remnant cement grains. Hence, in the present study; efforts have been made to utilize these fines as a soil stabilizer for improving the properties of clayey soil as subgrade.

IV. REVIEW ON SOIL STABILIZATION

Soil stabilization is a procedure where natural or synthesized additives are used to improve the engineering properties of weak soil. Several reinforcing methods are available for stabilizing soils. Therefore, the techniques of soil stabilization can be classified into a number of categories such as physical stabilization, chemical stabilization and mechanical stabilization. There is a substantial history of use of soil stabilization admixtures to improve poor subgrade soil performance by controlling volume change and increasing strength.

Sharif et al. (2000) conducted a laboratory study on the use of burned sludge as a new soil stabilizing agent. The sludge was burned at 550^{o} c and mixed with clayey soil at different percentages. The addition of percentages generally greater than 7.5 % by weight will decrease both the maximum dry density and unconfined compressive strength. The tests results show that this material can be used as a soil stabilizer.

Parsons et al. (2004) evaluated the use of cement kiln dust for soil stabilization. Atterberg limits and strength tests were conducted before and after selected durability test. Relative values of soil stiffness were also tracked over a 28 days curing period. The test results show a significant improvement in performance with the addition of cement kiln dust.

Seda et al. (2007) studied the use of waste tire rubber for swelling potential mitigation in expansive soil. In this study, the effect of adding small particles of waste tire rubber on the swelling potential of an expansive soil from Colorado was evaluated. The index properties and compaction parameters of the rubber, expansive soil and expansive soil-rubber mixture were determined. One dimensional tests were performed to assess the feasibility of using small particles of waste tire rubber as mechanical additive to mitigate swelling potential of the expansive soil. The tests results showed that both swell percent and the swelling pressure are significantly reduced by the addition of rubber to the expansive soil.

Okagbue (2007) evaluated the efficacy of woodash for clay stabilization. The evaluation involved the determination of the geotechnical properties of clay soil in its natural state as well as when mixed with varying proportions of woodash. The parameters tested included the particle size distribution, specific gravity, Atterberg limits, compaction characteristics, California bearing ratio (CBR) and the compressive strength. The CBR and strength tests were repeated after 28-day curing of the treated samples. Results showed that the geotechnical parameters of clay soil are improved substantially by the addition of woodash; plasticity was reduced by 35% and CBR and strength increased by 23–50% and 49–67%, respectively, depending on the compactive energy used. The highest CBR and strength values were achieved at 10% woodash. Results also showed that curing improved the strength of the woodash-treated clay. However, the strength gain was short lived as the strength quickly decreased after 7–14 days of curing. These results imply that although woodash provides some o the beneficial effects of lime in soil stabilization, such as plasticity and swell reduction, improved workability, and strength increase, it is unlikely to be a substitute for lime as strength gain is short lived.

Choudhary et al. (2010) evaluated the use of plastic wastes for improving the subgrade in flexible pavement. In this study the effect of waste plastic strip content (0.25 % to 4.0 %) and strip length on the CBR and secant modulus of strip

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reinforced soil was investigated. The study reveals that addition of waste plastic strips of appropriate size and proportions in soil results in appreciable increase in both the CBR value and secant modulus of soil.

Rao et al. (2011) performed a laboratory evaluation on utilization of industrial waste in pavement laid over expansive clay sub grades. The waste materials tested were granulated blast furnace slag and fly ash. Detailed laboratory studies have been carried out using these materials for cushioning soil system. The results indicate a significant increase in the soaked CBR value. This investigation points to the utility of these two waste materials for use in sub base of flexible pavement.

Saltan et al. (2011) examined the potential of pumice waste as a stabilizing additive to clayey sub grade of pavements. The tests conducted were solidity, strength, Atterbergs limit, California bearing ratio and dynamic repeated load triaxial. The results of the experimental research showed that pumice waste can be used as a soil stabilizer for clayey sub grades.

Zhang et al. (2012) conducted an experiment study to evaluate the use of lime sludge as subgrade stabilizer. Experimental study was conducted on five typical types of sub grade soils in Ohio. The study shows that addition of lime sludge increases the soil deformation modulus and reduces the plastic behaviour of soil.

Yadu (2013) evaluated the potential of granulated blast furnace slag (GBS) with fly ash to stabilize clay. Study shows that clay can be effectively stabilized with the addition of fly ash-GBS mixture.

Ransinchung et al. (2013) evaluated the efficacy of fines obtained from demolished concrete slabs as a soil stabilizer. The demolished concrete slabs were collected from Shabzi Mandi of Roorkee. In addition to FDCS, ordinary Portland cement 43 grade was chosen as base stabilizer so that the findings obtained out of FDCS admixed soil shall be compared with. The clayey soil used in the present investigation belongs to CI soil group when classified in accordance with IS: 1498. Cement and FDCS were admixed with clayey soil separately at equal increments of 3 per cent upto 15 percent. Reductions in dry densities and plasticity indices were observed on admixing of both cement and FDCS. Admixing of FDCS enhances the soaked CBR value, unconfined compressive strength and split-tensile strength.

Thomas et al. (2013) enlightens the importance of reduce, reuse and recycle (3R) concept for managing construction waste in India. The study shows that the total quantum of C&D waste generated in India is estimated to 11.4 to 14.69 million tonnes per annum.

Vizcarra et al. (2014) evaluated the applicability of municipal solid waste incineration ash in base road pavement layers through the mixture of ash with the clay soil. Fly ash reduced the expansion of material and increases the CBR value of soil. The results obtained are satisfactory depending on the content and type of ash used.

Rifai et al. (2014) studied the effect of volcanic ash utilization as substitution material for soil stabilization in view point of geo-environment. They studied the engineering properties of soil mixture, the effect of volcanic ash content and its fines level. The fineness of volcanic ash is a prime factor in the stabilization. Utilization of volcanic ash with grain size passing sieve no 270 is more effective. The study revealed that the volcanic ash content can improve the engineering properties of soft soil, change the grain size distribution curve by decreasing the fine fraction, decreases the consistency limits and become non plastic soil, increases the bearing capacity and decreases swelling potential.

Edeh et al. (2014) conducted laboratory evaluation of the characteristics of lateritic soil stabilized with sawdust ash. The tests performed were unconfined compressive strength and California bearing ratio (CBR). The results of laboratory tests shows that the properties of lateritic soil improved when stabilized with sawdust ash (SDA).

Kumar (2015) conducted a study on use of construction and demolition waste. The study concludes that construction and demolition wastes like bricks, concrete, tiles etc. may be used for mechanical stabilization of very poor soils, by adding extra cementitious materials or commercial stabilizers accredited by IRC as per IRC:SP:89. The C&D waste

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material shall have gradation as per IRC: SP: 89. Alternatively, it may be used partly as soil after doing testing on leachability, durability in addition to unconfined compressive strength. After satisfactory trial results, this type of mixed material may be used for stabilization of poor soil alone or by mixing with some good soils and/or with suitable additives. The unconfined compressive strength obtained shall be 0.8 MPa for sub base and 1.75 MPa for base course as per revised MORTH and IRC: SP: 89.

V. NEED FOR PRESENT STUDY

After critically studying the literature review followings gaps are drawn.

1. Various waste materials such as rubber, fly ash, wood ash, rice husk ash, cement kiln dust etc. had been used by the researchers as soil stabilizers but the construction and demolition waste still not been used by the researchers as soil stabilizer although C&D waste materials finds their application in base and sub base of pavement construction.

2. As the current annual rate of generation of construction and demolition waste in India is estimated to 11.4 to 14.69 tonnes. These statics shows that there is a need to reuse C&D waste.

3. Coarser fraction obtained from C&D waste finds their application in pavement construction but the finer material is being left out still as waste material.

Above gaps shows that there is a need to use the fines obtained from construction and demolition waste in soil stabilization.

VI. CONCLUSION

From the above discussion it can be concluded that there is a need to utilize the waste material obtained from the construction and demolition of buildings in the soil stabilization. Using C&D waste in soil stabilization helps to reduce the hazardous environmental impacts of the waste and improves the engineering properties of soil which ultimately reduces the cost of construction and increases the life of the structure built on stabilized soil.

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