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A CRITICAL REVIEW ON SOIL STABILIZATION USING DIFFERENT INDUSTRIAL WASTES AND ADMIXTURES

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Abstract - *The growth of population, fast urbanization and more construction of buildings and other structures has resulted in the reduction of good quality available land. Stabilization of soils means improving the engineering properties of the soils to fulfil the specified requirements. Expansive soils are characterized by volume change due to variation in moisture content. The cyclic wetting and drying process causes vertical and horizontal movement in expansive soils leading to failure of civil engineering structures found on such soils. The problematic nature of such soils can be improved by employing industrial wastes and admixtures stabilization techniques. Soil properties like strength, compressibility, workability, swelling potential and volume change tendencies may be altered by using the various soil stabilizing agent and modification methods.*

***Key Words:** Fly ash, Marble dust, Lime, Cement, Expanded polystyrene (EPS) Geofoam, Crushed glass, Waste paper sludge*

1. INTRODUCTION

General: Every Civil Engineering structure is to be found on the soil. The soil on which the structure is to be built should be capable of withstanding the load to be imposed on it. However, naturally there exist problematic soils to be used as foundation or construction materials, such as expansive soils, whose engineering characteristics are mainly affected the fluctuation of moisture content. Black cotton soil is one such type of soil which loses its strength during rainy season due to their expansive behaviour. Construction on black cotton soil always creates a problem for civil engineers because of its swell and shrinks behaviour. In general, the problems of the expansive behaviour of soil are as follows.

a) Expansive soils have high plasticity and compressible when they are saturated.

b) These types of soil have high strength in the dry state, becomes soft after saturation. Filling up water into fissures and cracks accentuates the process of softening causing reduction of shear strength and leading to low bearing capacity.

c) The structure built in a dry season show differential heaving as a result of swelling of soils during the subsequent wet season. Restriction on swelling causes swelling pressure and making the structure unstable. This causes structure supported on soils to lift up with the development of cracks occur.

d) The structure built at the end of the wet season when the natural water content is high show shrinkage crack and settlement, during the dry season and shrinking cause a downward thrust on the foundation through skin friction thus increasing the foundation load.

One of the challenges faced by civil engineers in the design of foundation for sites having expansive Soils. Due to these reasons, expansive soils need treatment prior to use as an engineering material with industrial products. These treatments are generally classified into two processes, viz. (1) soil modification and (2) soil stabilization. Soil stabilizations is the process of blending and mixing materials with an expansive soil to improve certain properties of the expansive soil. The process may include the blending of soils to commercially available admixtures that may alter the gradation, texture or plasticity, or act as a binder for cementation of the soil (IRC: SP: 89-2010). Many problems arise from the industrial development. One of them is the proper and effective disposal of its waste. Generally, industrial waste causes many serious environment problems. So utilization of industrial waste in construction industry is the best way to dispose it. Using industrial waste in construction industry is beneficial in many ways such as disposal of waste, saving biodiversity's, increasing soil properties like strength, reduce permeability, etc., preserve the natural soil and making economic structures. Soil modification is the stabilization process in which improvement in some property of the soil but does not result in a significant increase in soil strength and durability. Soil properties like strength, compressibility, workability, swelling potential and volume change tendencies may be altered by various soil stabilization and modification methods. Stabilization is derived by thermal, mechanical, chemical or electrical means. Thermal and electrical is rarely used and less data is available about these two. Mechanical stabilization or compaction is the densification of soil by the use of mechanical energy. By the densification air is expelled from the soil voids without much change in moisture content.

1.1 Quality improvement due to stabilization

By the stabilization better soil gradation, increase in durability, increase in strength, reduction of plasticity index

and reduction in swelling potential is achieved. Stabilization improves the properties of construction materials and gives the following attributes:-

a) After saturation with water substantial proportion of their strength is retained.

b) Resistance to erosion.

c) Surface deflection is reduced.

d) The elastic moduli of layers constructed above stabilized layer are increased.

e) The stiffness and strength of a soil layer can be increased through the use of admixture to reduce the thickness of the road pavement

1.2 Possible problems due to stabilization

The stabilization of soil also causes the following problems

a) Due to thermal and shrinkage cracks stabilized layer may be crack.

b) Crack can reflect through the surfacing and allow water to enter the pavement.

c) If CO2 has access to the material, the stabilization reaction is reversible and the strength of layer can decrease.

d) The construction operation requires more skill than unstabilized materials.

1.3 Materials

A. Fly Ash

Fly ash itself has less cementitious value but it reacts chemically and form cementitious compound in presence of moisture. Cementitious compound formed improves the strength and compressibility of soil (Karthik et al., 2014).According to this review; it is observed that stabilized the clayey soil for the construction of urban roads using fly ash. The author found that the optimum ratio of fly ash with clayey soil is 15% by weight of soil. Dry density and O.M.C were measured for various fly ash ratios. The liquid limit and Plasticity Index decreased for an increase of fly ash by weight. C.B.R value of soil increased. According to Gyanen et al., (2013) it is observed that the compaction of stabilized black cotton soil using two type of fly ash, viz. (1) fine and (2) course. The Liquid Limit, Plastic Limit, Natural water content and Specific gravity of soil were determined. For coarse fly ash and Fine fly ash M.D.D of soil was determined. According to this review paper, it is observed that stabilize the Black cotton soil found in Maharashtra using fly ash. Stabilization of soil was done at the various percentage of fly ash content. O.M.C and M.D.D. were determined at different percentage of fly ash. Soaked C.B.R and unsoaked C.B.R. also determined.

Researchers (Phanikumar and Sharma, 2004; Osinubi and Stephen, 2005; Osinubi and Eberemu, 2006; Oriola and Moses, 2010; Ramadas et al., 2011; Bairwa et al., 2013; Osinubi et al., 2011,2015, 2016; Kumar, 2012; Mishra et al., 2014; Salaudeen et al., 2014; etc.) focused on the potential use of agricultural and industrial waste materials to improve the properties of weak/expansive soils and far-reaching results have shown that these wastes have desired influence either alone or as admixture with lime or cement.

B. *Marble dust Stabilization*

R. Ali, H. Khan, A. A. Shah (2012) utilized marble dust and bagasse ash for expansive soil improvement. Different laboratory tests on expansive soil without the addition of these wastes and with the addition of these waste were conducted and their impact on swelling and different properties were determined. Sachin N. Bhavsar, Hiral B. Joshi, Priyanka K. Shrof, Patel Ankit J. (2013) evaluated swelling potential of expansive soil in its natural state as well as when mixed with varying proportion of marble dust (from 30 to 50%). It is concluded that the impact of marble powder on black cotton soil is positive. It gives maximum improvement in the swelling and linear shrinkage properties of black cotton soil. Rozhan Sirwan Abdulla, Nadhmiah Najmaddin Majeed (2014) investigated the soil from two spots Bastora and Erbil Airport with Bastora soil as CH soil and Erbil Airport as CL soil. The marble waste powder was included in percentages of 10%, 20% and 30% by weight of soil. The results demonstrate that increase in percentage of marble dust decreases liquid limit, plasticity index and plastic limit and swelling potential. Chayan Gupta and Ravi Kumar Sharma (2014) demonstrated the impact of waste materials, for example, marble dust, fly ash on the sub grade qualities of black cotton soil. They concluded that the 15% marble dust is adequate to increase the California bearing ratio soaked strength up to around 200%. Parte Shyam Singh, and R. K. Yadav (2014) examined the impact of 0% to 40% marble dust on index properties of black cotton soil. The test outcomes demonstrated a huge change in consistency limits of specimens containing marble dust. Liquid limit reduced from 57.67% to 33.9%. The plasticity index reduced from 28.35% to 16.67% and shrinkage limit increased from 8.06% to 18.39% with the addition of marble dust. Also, differential free swell decreased from 66.6% to 20.0%.

C. *Lime Stabilization*

Ankur et al., (2014) stabilize the Black cotton soil using Lime and stone dust. For the black cotton soil had he determined specific gravity, percentage passing Is sieve 75 micron, liquid limit, plastic limit, plasticity index, differential free swell, M.D.D, CBR (soaked) and unconfined compressive strength. Author classified soil as CH according to the unified soil classification system. In their study, authors determine optimum percentage of lime and stone dust by weight of lime black cotton soil. The MDD of lime stabilized B.C. soil

increases and further increase of the stone dust decreases the value. Similarly for CBR and UCS the strength increases up to some percent of stone dust in lime stabilized soil. Malhotra and John, describes the use of mechanical equipment in the construction of four stretches of lime stabilized roads extending over a length of twenty kilometre. All the four roads were B.C soil of CH group. In his study authors stabilized the B.C soil by 2% of lime and their service behavior was observed. For a period of four year, stabilized sections behaved very satisfactorily but thereafter, the lime treated stretches started deterioration. Olugbenga et al., (2011) stabilized the Lateritic soil by the use of lime. Lateritic soil form a group comprising a wide variety of Yellow, brown, red, fine grained residual soil of light texture. They are characterized by the presence of iron and aluminium oxide or hydroxide which gives the colour to the soil. In this paper author studied the suitability and lime stabilization requirement of lateritic soil samples. Wu Li (2010) uses lime as stabilization material to stabilize the Tanzania soil. Author uses three types of soil moderately plastic silty clay, moderately plastic clay and Heavy clay with 5% of hydrated Lime. Author designated them as N-11, N-12 and N-13 respectively. He concluded that plasticity Index decreases and unconfined compressive strength increased.

D. *Cement Stabilization*

Cement can be used to stabilize any soil except highly organic soils (IRC: SP: 89-2010). Oyediran and Kalejaiye (2011) studied the effect of increasing of cement by weight on the strength and compaction parameter of lateritic soil of south west Nigeria. Three soil samples were collected from pit at depths of 0.5m, 1.0m and 2.0m. Author concluded that the increasing in percentage of cement was not guarantee for the improvement of geotechnical properties. Zoubi (2008) stabilized expansive soil from Jordan by the use of cement. According to the unified soil classification system, author classified the soil as inorganic clay of high plasticity (CH). Author study showed that the liquid limit of soil decreases, then increased as the cement content increases. The study also shows that swelling potential of soil decreases. The undrained shear strength increases with increase. The maximum rate of increase in undrained shear strength was observed.

E. *Waste Paper Sludge*

Waste Paper Sludge (WPS) is a waste material collected from the Paper Industry. WPS becomes a new innovation material that can be used as material for soil stabilizing agent. Recycling and reuse of paper sludge is a topic of international interest in the past few decades. Waste paper sludge (WPS) is a waste material collected from the paper industry. Elias (2015) stabilized the soil using waste paper sludge. Soil used in the study was clayey soil. When soil treated with WPS M.D.D of soil was decreased and O.M.C was increased. The addition of WPS increased the strength and it was found to be constant and optimum value of strength to soil.

F. *Crushed Glass*

Glass is a non-crystalline and amorphous material, which is brittle and transparent in nature. Glass material is soda lime glass composed of 75% silica, Na2O, CaO and several additives. Crushed glass has also been used as an aggregate for sub-base. Glass is totally inert and therefore non-biodegradable. Addition of glass powder to soil improves its engineering properties

G. *Expanded polystyrene (EPS) Geofoam*

Shelke and Murty (2010) used expanded polystyrene Geofoam to reduce the swelling pressure of expansive soil. Black cotton soil was taken for study. According to USCS soil classification, soil has CH type. In his study, authors used two type of geofoam, viz. (1) 6mm thickness and (2) 12mm thickness. Swelling of Black cotton soil reduces when EPS Geofom of 6mm and 12mm are used. Swelling pressure of 6mm geofoam is reduced and for 12mm thickness swelling pressure is reduced. Waste paper sludge (WPS) is a waste material collected from the paper industry. Elias (2015) stabilized the soil using waste paper sludge. Soil used in the study was clayey soil. When soil treated with WPS M.D.D of soil was decreased and O.M.C was increased. The addition of WPS increased the strength and it was found to be constant and optimum value of strength to soil.

2. CONCLUSION

From the above investigation it can be concluded that the industrial waste materials has a potential to modify the characteristics of expansive clay like black-cotton soil and to make it suitable in many geotechnical applications. From all the above papers it's clear that the industrial wastes used in the soil stabilization help in improving the strength and CBR value. The review of the above papers can be concluded as the following:

- ✓ Fly ash can be used to stabilize soil in different civil works such as in road construction by reducing the layer thickness, in development of low permeability etc.
- ✓ It was observed that the agricultural waste i.e. Rise Husk ash was used in soil stabilization along with cement or lime as an additive.
- ✓ The use of industrial wastes in soil stabilization proved to be effective in enhancing the strength of clayey soil for a longer period.
- ✓ By the use of marble dust for black cotton soil stabilization had increased the CBR value and UCS value.

- ✓ The above papers showed that the stabilizers/admixtures are used in combination of any two or sometimes only one. Nowhere, either the stabilizers or the admixtures are blended.
- ✓ The use of stabilized soil in this way, has the dual benefits of removal of harmful materials from the environment and the usage of cheap construction material.
- ✓ When soil is treated with Waste Paper Sludge an increase in optimum moisture content and decrease in maximum dry density is observed. It was found that the ratio of decrease in density and increase in optimum moisture content with increase in percentage of additive waste paper sludge.

Generally, recent research works in the field of geotechnical engineering and construction materials focus more on the search for cheaper and locally available materials, agricultural and industrial wastes, for use in construction industry. The use of different industrial and agricultural wastes has become a common practice in the construction industry Marble dust, Fly ash, sugarcane bagasse ash, coconut husk ash and rice husk can be sited as an example. Those by-products are increasingly playing a part in any construction, hence minimizing the problem of resource depletion, environmental degradation, and energy consumption. The disposal of industrial wastes is a major problem nowadays. Waste materials can be used as geotechnical admixtures to improve geotechnical properties of soils as well as curb environmental degradation. Stabilization of black cotton soil (expansive soil). Optimum use of admixtures to enhance the geotechnical properties of soil. Construction of pavements over black cotton soil. Slope stability of embankment construction over black cotton soil. This review paper showed that examining the potential of industrials wastes to improve the problematic nature of expansive soils to be used and to investigate the changes in engineering properties of the soil sample when treated with different industrials waste materials. These days sustainability plays the major role in every aspect of human activities. Many technologies came to end because they were not in harmony with the idea of sustainable development. Sustainability is concerned about the world we will be leaving behind for future generations. It focuses on the social, environmental and economic issues of human activities. Therefore it requires every activity to be environmentally friendly, economical and safe for the social. Industrial wastes contains a large amount of silica which is the most important component of cement replacing materials. It is also found in the large amount as a by-product of Industrial and Agricultural Waste factories. Despite this abundance and silica content, relatively little has been done to examine the potential of this material for soil stabilization.

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