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SOIL STABILIZATION USING WASTE MATERIALS: A REVIEW

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***Abstract*— In a well-organized environment, disposal of waste poses a great threat as regards where and how to effectively dispose the waste material without any harmful effect to society. In the recent times, utilization of solid waste materials in soil stabilization has gained eminence as an effective means to manage wastes generated from various industries. In this paper, a review is given on utilization of different solid waste materials which have been used to stabilize soft soils. Though, there are lots of methods and techniques are available to stabilize these soil. This study provides how waste materials can be used to stabilize the soft soil.**

***Keywords*— soft soil, stabilization, stabilizer, waste, environment**

I. INTRODUCTION

In a well-organized environment, disposal of waste poses a great threat as regards where and how to effectively dispose the waste material without any harmful effect to society. In the recent times, utilization of solid waste materials in soil stabilization has gained eminence as an effective means to handle wastes generated from various sources. As the soil directly in touch with the object, it acts as an intermediate of load transmission and therefore, the stability of soft soil is important during the construction.

Soft soils possess very less shear strength and low CBR, alternate wetting and drying cycles. Strengthening of soil improves bearing capacity, reduces settlement and helps in reducing the liquefaction effect of soil. Ever since then considerable achievements have been made in the construction and design of geotechnical structures such as foundations, embankments, pavements and retaining walls, etc. The necessity of soil stabilization arises due to the various challenges like poor bearing capacity, high rate of settlement after construction, excavation instability and high cost of construction; improve strength of sub-grade on clayey soil. Soil stabilization is the process of enhancing the engineering characteristics of soil by amalgamating the stabilizers to increase the load carrying capacity, and resistance to weathering.

Different stabilizing agents are used to enhance the engineering properties of soft soil. These are primary binders (hydraulic) and secondary binders (non-hydraulic) additives which when come in contact of pozzolanic minerals and water reacts with it to form composite of cementitious characteristics. The objective of study is to evaluate how stabilization of soil can be done by using wastes from various sources such as agricultural and industries. The various materials are bagasse ash, rice husk ash, fly ash, coir fibres human hair fibres, banana fibres etc.

II. LITERATURE SURVEY

Brooks (2009) [1] upgraded properties of soft soil by using waste material RHA and fly ash. He studied probability of RHA-fly ash mixture between sub-grade and the footing of a foundation as a swell reduction layer. When the fly ash content was increased from 0 to 25%, UCS showed that failures in strain and stress increased in percentages by 50% and 106% respectively. By increasing rice husk ash from 0 to 12%, UCS was increased by 97% and CBR by 47%. Therefore, for strengthening a fly ash 25% and RHA 12% were taken. For blending into RHA for forming a swell reduction layer he adopted a fly ash content of 15%, as its performance in the lab tests was satisfactory.

Ayyappan *et al.*(2010) [2] analysed polypropylene fibres with fibre lengths of sizes 6mm, 12mm and 24 mm for reinforcing the soil. Samples of soil-fly ash mix were made for MDD with variations from 0 to 1.5% by weight of fiber. For all soil-fly ash mix samples optimum percentage of reinforcement was adopted as 1% by weight of soil-fly ash mix. Maximum value was attained at 12mm length of fiber for reinforcement of soil-fly ash mix. For all mixes CBR value due to fibers length 12mm at 1% by dry weight was increased. The results showed that reinforced soil-fly ash mix with 12 mm fibers at 1% gave better performance.

Saravanan *et al.* (2013) [3] studied different percentage of fly ash (10%, 20%, 30% and 40%). The Specific gravity, consistency limits, Standard Proctor's compaction, Unconfined compressive tests were performed on expansive clay soil. The result shows that in addition of fly ash reduce the specific gravity and plastic index of expansive clay soil. By adding fly ash content results showed that the OMC and MDD of soft soil increased. Properties related to strength of clayey soil had increased by 21.1%. Based on Standard Proctor's Compaction test, the Optimum Content of fly ash was found as 10 %.The UCS of given sample was increased by 21% by adding fly ash. The dry density of the clayey soil sample was increased by 15 % of the natural soil sample. The optimum content of the soil sample decreased to 9% of the natural soil sample. The unconfined compression test increased to 21% from the natural soil sample. The optimum content of the fly ash content had found that 10% in addition of the natural soil sample.

Kawade1 *et al.* [2013] [4] examined utilization of industrial and agricultural waste, sugarcane bagasse ash. Sugarcane ash had been physically and chemically differentiated and partly replaced in proportion of 10%, 15%, 20%, 25% and 30% of cement by weight. Fresh concrete properties such as slump and hardened concrete properties at the age of 7, 28, 56 and 90 days were tested. The outcomes indicated that characteristics of concrete increased with replacement of 15% SCBA in cement. The results showed that sugarcane ash mix concrete had considerably high strength in comparison to concrete without sugarcane ash. Hence, it could be concluded that cement can be replace by sugarcane ash up to a limit of 15%.

Wubshet [2013] [5] evaluated the suitability of bagasse ash for stabilization of weak soil. They studied index properties of soil. The preliminary investigations of the soil showed that it belong to A-7-5 class in the soil classification system of AASHTO. Atterberg's limits, free swell, free swell index, free swell ratio, compaction and subgrade strength tests were used to assess characteristics of stabilized soil. The soil was stabilized with bagasse ash in proportion of 5%, 10%, 15%, 20%, 25% and 30% by dry weight of the soil. Bagasse ash reduced plasticity index, swelling and MDD with an increase in OMC and CBR with all higher bagasse ash contents. It was found out that bagasse ash stabilized soil do not meet the minimum requirement of ERA (Ethiopian Roads Authority) pavement manual specification so that it could be used as a sub-grade material for pavement construction. Additional study is also incorporated as a supplementary work to investigate the effect of applying 3% lime as an activator in combination with 15% bagasse on the geotechnical properties of the soil for uncured and cured soil samples. The results indicated that lime in combination with bagasse ash is suitable for improving the plasticity index, swelling and CBR. The CBR value increased by curing showed that the mix had ability for time-dependent increase in strength that would decrease the amount of stabilizer required for the construction of roads on the soft soil. It showed that lime in combination with bagasse ash can be effectively used to improve expansive soils with low soaked CBR value and high plasticity.

Kharade *et al.* (2014) [6] studied bagasse ash with partial replacement in black cotton soil in various proportions like 3%, 6%, 9%, 12%. They establish that optimum proportion of bagasse ash was 6%. The results at this proportion were like MDD increased by 5.8%, CBR increased by 41.52% and UCS increased by 43.58% which showed that, by adding bagasse ash CBR and compressive strength increased about 40%, whereas density showed considerable change only.

Das and Roy(2015)[7] performed laboratory tests such as Atterberg's limit, compaction, specific gravity, grain size distribution, tri-axial compression on expansive soil using bagasse ash in proportions of 3%, 6%, 9%, 12%, 15% and 18%. By adding bagasse ash in virgin soil, it showed enhancement in shear strength properties on tri-axial compression test and also found that there was a decrease in liquid limit by increasing quantity of bagasse ash which was effective and economical. By increasing bagasse ash, liquid limit increased by 9% and then decreased. Further increase in content from 3 to 18 %, there was a steady increase in ϕ and c values; therefore shear strength had been improved by further adding bagasse ash.

Butt *et al.* (2015) [8] studied high compressibility clayey with human hair fibres as stabilizer in proportions of 0.5%, 1%, 1.5%, 2% and 2.5 % by weight to analyse human hair fibres outcomes on the performance of clay. HHF are non- biodegradable waste, which increase environmental and health problems. It is available in abundance and at low cost too, which could not be used as a reinforcement only to develop underprivileged locations for sustainable erection but also to reduce its disposal problems. The HHF haphazardly distributed in soil specimens were tested for its various engineering properties by performing tri-axial test and CBR on different samples of reinforced soil and then these results were compared with virgin soil. At fibre length 25mm showed various advantages like superior strength characteristics, high toughness and low cost. Therefore with increased quantity of human hair fibers, dry density first reduced slightly by incrementing the fibre and after that remained constant practically. Due to moisture absorption from hair fibres OMC increased slightly. It is found that 2% fibres enhance the un-drained shear strength and CBR of expansive soil greatly.

Abhijit and Aruna (2015) [9] analysed black cotton soil with ground granulated blast furnace slag (GGBS) and sisal fibres. They got the results that optimum moisture content decreased and maximum dry density increased by adding GGBS to natural soil. The undrained shear strength and CBR increased by adding sisal fibre with GGBS. The optimum result was optimum dosage of GGBS with 0.75% of sisal fibres.

Amrutha and KY (2016) [10] examined black cotton soil with various proportions of sisal fibre, bagasse ash and glass powder waste and mixture on the above percentages of additives. Experimental studies were kept in two phase. In the first phase, the physical characteristics like particle size distribution, consistency limits, specific gravity and swelling pressure of soil were obtained. In next phase, tests were carried out on BCS using various percentages for sisal fibre, bagasse ash, and glass powder waste and from the maximum values of strength test a combination of 0.9% sisal fibre, 7% bagasse ash and 14% glass powder waste was also performed. The results indicated that with addition of sisal fibre, bagasse ash and glass powder waste the MDD and OMC were decreased. The undrained strength and sub-grade strength characteristics increased by adding optimum percentage of sisal fibre, sugarcane ash and glass powder waste to the mixture of black cotton soil. The preeminent result for mixture of black cotton soil and optimum value of 0.9% of sisal fibre, 7% bagasse ash and 14% glass powder waste.

Teresa and Joy (2016) [11] investigated banana fibre as soil stabilizer which is a waste material. Different tests like UCS, CBR, consistency limits, and compaction were conducted and outcomes were analysed. The proportion of banana fibre varies from 0.25%, 0.75%, 1%and 2%. The banana fibres enhance the characteristics of soil. The optimal dosage of banana fibre was obtained at 0.75%for marine clay. It was found that dry density decreased and OMC increased with banana fibre. The shear strength changed from 8.5kN/m^2 to 32.91kN/m^2 with 0.75% of banana fibre and CBR changed from 2.79 to 13.2 which make it good for sub-grade.

Rathan *et al*.(2016) [12] analysed expansive soil using rice husk ash known as RHA by using different percentages 5%, 10%, 20%, 30%, 40%, 50% of it. Different test such as, liquid limit and plastic limit, free swell index, specific gravity, MDD and OMC, CBR and direct shear test were carried out. Values of LL and FSI were decreased abruptly by increasing the percentage in RHA. The OMC decreased gently from 17.89% to 13.25% and MDD increased from 16.39kN/m^3 to 19.5kN/m^3 for 80% rice husk ash for clay. For soil-RHA mix the undrained consistency was decreased from 60 KN/m^2 to 30 KN/m^2 and value of angle of friction (Φ) increased from 17°5' to 38°. The values of soaked CBR and the unsoaked CBR were increased from 2.4% to 4.4% and 3.2% to 9.3% respectively.

Subramani and Udayakumar (2016) [13] analysed soil stability by reinforcing it with waste coir fibres. Coir is a type of geo-textile which is cost effective. Lab tests such as stress state during a tri-axial test, UCS, direct shear test and CBR had been performed on virgin soil and reinforced soil with different percentages of coir like 0.25%, 0.50%, 0.75%, and 1%. The results for strength, CBR and UCS of reinforced soil were increased by increase in the proportion of coir fibres. Maximum enhancement in CBR and UCS were occurred with 0.5% of coir waste fibres. Results showed that 0.5% coir in the soil was optimum proportion having maximum value for soaked CBR. Therefore, this value could be used as economical stabilization.

Ramesh and Naik (2016) [14] evaluated the consequences of using fly ash, pond ash and lime for black cotton soil stabilization. Lab tests were carried to observe the properties of fly ash, pond ash and lime on strength as well as compaction of this soil. The soil samples were prepared with fly ash using 5%, and various percentages of pond ash like 10%, 20%, 30%, and 40% and lime by 4%, 6%, 8%, and 10%. Soil and fly ash mixes discovered that the OMC increased and MDD decreased with increased amount of fly ash. Angle of friction and cohesion was increased by increasing the proportion of lime in pond ash. The liquid limit was increased from 39.6% to 60.6% by adding lime (4%) and also increased with 19.2% to 34.7% with 6% which was nearly same. The result of unconfined compression test, which differs from 7.7N/mm^2 to 23.85 N/ mm^2 by adding 10% lime with 30% pond ash gives the maximum compressive strength.

Sodhi *et al.* (2017) [15] studied utilization of fines obtained from structural concrete debris and polypropylene fibres waste in enhancement of the different properties of intermediate clayey soil. They analysed that when the fines added at 10% by weight of soil 5.03% Maximum Dry Density of virgin soil and 10.37% moisture content was increased and insignificant reduction in the MDD of soil-mix with increase in waste fibres of the polypropylene. The reinforced mix with polypropylene fibres of length 20 mm and 0.35% by weight of dry soil sample had Φ as 23.77% and increase in cohesion by 53.12%. The optimum quantity of fibres of waste polypropylene for reinforcing the soil to enhance the characteristics of given soil (CI) was found to be 20mm in length at 0.35% of polypropylene by weight of dry soil sample for direct shear strength tests.

III **CONCLUSIONS**

The soft soil is having poor bearing capacity which make it unfit for construction. This study suggested low-cost and effective materials for stabilization of the soil. This study indicated that use of waste as a stabilizer, resolve the crisis of waste disposal and moreover facilitate in enhancing the engineering properties of soft soil and minimizing the cost of construction in comparison to other type of stabilizing agents.

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