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SOIL STABILIZATION USING POLYPROPYLENE FIBER AND BAGASSE ASH – 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. Waste material fibers combine with polypropylene fibers are used to enhance soil strength that has attracted much research interest in the past decade [1]. In this paper the strength properties of soil blocks have been investigated by adding sugarcane bagasse fibers and polypropylene fibers in soil [2]. It was found that by utilization of an optimum of sugarcane bagasse fibers in the soil matrix improved the strength properties of the soil blocks.*

IndexTerms - soil blocks; sugarcane bagasse fibers; Polypropylene; environment; waste material.

I. INTRODUCTION

The earth, foundation and soil play a prominent importance in the field of construction. In fact, all the structure rests its load into the earth through the foundation. The soil investigation is the first step towards the inception of any construction project. Therefore, the improvement of the engineering properties, i.e density, shear strength, settlement and permeability is very important. The stabilization of soil can be utilized on roads, site development of the projects, airports, dams and many other infrastructural projects [3]. The process can be accomplished by using additives or by products of the industry, such that the particle size is smaller than the soil where stabilization has to occur. One such material is the Bagasse Ash, an agro industry waste product from the sugar industry. It is the fibrous matter that remains after sugarcane is crushed to extract their juice. It is also used as a biofuel and in the manufacture of pulp and building materials. Nearly one ton of the sugarcane can produce more than twenty five percent of bagasse ash and less than one percent of residual ash [4]. The bagasse ash was packed in the graphite air tight bags which then placed inside the electrical control furnace with a temperature of about 1200^0 C for approximately 5 hours to obtain the black ash. The Bagasse Ash having different percentage (2%, 4%, 6% and 8%) were added into the soil [5]. In addition to the Bagasse Ash, Polypropylene fibers having different sizes (2cm length, 4 cm Length and 6 cm length) with different percentage (1%, 1.5% and 2%) by weight of the soil were induced to increase the reinforcement of the soil. The result of California Bearing Ration and Unconfined Compression Test has shown that there is an increase in the values with addition of 4% of ash and Polypropylene fiber length 4cm at 1.5 %. Furthermore, there is an increase in Optimum Moisture Content and a decrease in the Maximum Dry Density with addition of the Bagasse Ash.

II. LITERATURE SURVEY

Yi Cai et al. [6] (2006) investigated the effect of mixture of polypropylene fiber and lime on soil. For the analysis, samples were prepared and tasted at three different percentages of fiber content (i.e. 0.05%, 0.15%, and 0.25% by weight of soil) and three different percentage of lime (i.e. 2%, 5% 8% by weight of soil). For the analysis, treated specimens were subjected to unconfined compression, direct shear, and swelling and shrinkage tests and the authors also performed the scanning electron microscopy (SEM) test. The authors concluded that the increase in lime content resulted in initial increase followed by slight decreased in unconfined compressive strength, cohesion, angle of internal friction and reduction in swelling and shrinkage potential, with the addition of fiber content caused an increased in strength, shrinkage potential but reduction in swelling potential. Moreover, the author also concluded the increased in curing duration improved the unconfined compressive strength and shear strength. Based on SEM, the authors concluded that the presence of fiber contributed to physical interaction between fiber and soil whereas the chemical reaction between lime and soil and changed soil fabric. **K.J. Osinubi** et al. [7] (2009) studied the effect on geotechnical property using 12% bagasse ash by weight of dry soil. For the analysis, test specimens were subjected to particle size analysis, compaction, unconfined compressive strength (UCS), California bearing ratio (CBR) and durability tests and the compaction were carried out at the energy of British standard light (BSL). The authors concluded that the change in moisture-density relationship resulting in lower dry density (MDD), higher optimum moisture contents (OMC), reduction in fine fractions with higher bagasse ash content. The authors further concluded that bagasse ash cannot be used as sand alone stabilizer. **S. Twinkle and M.K. Sayida** [8] (2011) studied the reinforcing effect of randomly distributed short polypropylene fibers on the compaction characteristics like penetration and unconfined compressive strength of lime stabilized using Compaction test, Atterberg's limit, unconfined compression test and CBR test. The authors concluded that in addition of lime and polypropylene the optimum moisture content had increased, maximum dry density decreased liquid limit of soil decreased but plastic limit increased thus the plastic index decreased. Moreover, the authors also concluded that the strength had increased 3.8 times if compared to untreated soil for 28 days curing period and in case of CBR test, the strength increased approximately 3.19 times if compared to untreated soil. **A. K. Sabat** [9] (2012) studied the effect of polypropylene fibers on Maximum dry density (MDD), Optimum moisture content (OMC), unconfined compressive strength (UCS), soaked California bearing ratio test (CBR) hydraulic conductivity and swelling pressure on expansive soil added with rice husk ash and lime. The author concluded the addition of rice husk, lime and polypropylene fiber in the expensive soil, the maximum dry density (MDD) decreased and optimum moisture content (OMC) increased, the UCS and soaked CBR increases up to 1.5% addition of polypropylene fiber and then decreased with further increased in polypropylene fibers. Moreover, the author also concluded that with addition of rice husk and lime hydraulic conductivity decreased and increased in percentage of addition of polypropylene fiber. Hydraulic conductivity decreased with increased in curing period, swelling pressure decreased with addition of rice husk, lime and polypropylene fiber.

K. S. Gandhi [10] (2012) investigated the improved strength of soil using bagasse ash as the additive, which increased the stability of soil and decreased the swelling of soil. Bagasse ash was high in silica calcium and other minerals provided the homogeneous mass for preforming the required test. Different tests were carried out with varied percentage of bagasse ash to check the effect of bagasse ash on swelling pressure and basic properties. Moreover, the author suggested that bagasse ash had effectively dried wet soils and provided an initial rapid strength gain that was useful during construction in wet and unstable ground conditions. Bagasse ash also decreased swell potential of expansive soils by replacing some of the volume by cementing the soil particles. **C. Gumuser and A. Senol** [11] (2013) studied the experimental program was undertaken to investigate the effects of Multifilament (MF19average) and Fibrillated (F19average) polypropylene fiber on the compaction and strength behavior of CH class soil with fly ash in different proportions. The Authors also prepared the soil samples at three different percentage of fiber content (i.e. 0.5%, 1%, and 1.5% by weight of soil) and two different percentage of fly ash (i.e. 10% and 15% by weight of soil). Tests were performed on optimum moisture content and laboratory unconfined compression strength tests, compaction tests and Atterberg limits test. Moreover, the authors suggested that the polypropylene fibers acted as a reinforcement to prevent the formation of cracks in the sample and binder the soil particles together, leading to an increased CBR values and fiber inclusion increased the strength of the fly ash specimens and changed their brittle behavior into ductile behavior.

P. Chavan and Dr. M.S.Nagakumar [12] (2014) studied the used of blast furnace slag i.e. 3%, 6%, 9%, and 12% and the bagasse ash was evaluated using physical and strength performance tests like plasticity index, specific gravity, compaction, California bearing ratio test (CBR) and unconfined compressive strength test (UCS). The authors concluded that used of such material in road construction can increased the strength of soil and reduce the project cost. California bearing ratio (CBR) value improved from 1.16% to 6.8% and unconfined compressive strength (UCS) increased from 93 kN/m2 to 429 kN/m2. The authors concluded the plasticity index reduce from 24% to 17.40%, density increased from 1.57 to 1.78g/cc, OMC reduced from 17.20 to 15% but further addiction of bagasse ash density decreased and OMC increased. **Sadeeq** el at.[13] (2015) studied the soil treated specimens for prepared by mixing of soil with bagasse ash in variations like 0, 2, 4, 6 and 8% by weight of soil and the soil falls under silt-clay material of group A-6(9) used AASHTO classification and inorganic clay material CL according to unified soil classification system (USCS). The authors studied the natural soil had liquid limit value of 36.32, plastic limits 21.30%, plasticity index of 15.02%, maximum dry density (MDD) was 1.69 kg/m3, optimum moisture content (OMC) value of 16.8%, unconfined compressive strength (UCS) values of 269,404 and 591 kN/m2 at 7, 14 and 28 days curing periods respectively and California bearing ratio (CBR) values for unsoaked and soaked soil was 13 and 7% respectively. The authors concluded the peak UCS and CBR values of 698 kN/m2 and 43% work recorded for soil treated with 8% lime and 6% bagasse ash.

A. Murari et al. [14] (2015) investigated the waste of industries and agriculture adversely affect the environment as high land area was required for their disposal and when they disintegrate, results in the production of harmful gases causing, soil contamination land fill space and many other hazardous effects. The authors studied to check the improvement in the properties of the soil with bagasse ash in varied percentages (2, 5, 7 and 10%). Tests were conducted such as liquid limit, plastic limit, and standard proctor test. Moreover, the authors suggested that with increased percentage of bagasse ash, the liquid limit and plastic limit gets reduced and also reduced dry density because of flocculation and agglomeration of fine grained soil particles through which the optimum moisture content of soil increased with increase in bagasse ash. **A. Nangia** et al. [15] (2015) studied the direct shears strength characteristics of soil. For the analysis, shear strength characteristics were evaluated first and then after the effectiveness of fiber inclusion in the strength characteristics of soils was worked out through the series of shear test and unconfined compression test. Polypropylene fiber of 25mm length was used and strength behavior of polypropylene fiber reinforced soil samples were studied using unconfined compressive strength test and direct shear test respectively. Results were interpreted in terms of stress-strain curve behavior, variation of failure strain and stress effect of fiber content and other strength parameters. Capability of synthetic fiber reinforcement for improving the behavior of soil was demonstrated using tri-axial tests, CBR tests, cyclic tri-axial tests, resonant-column and torsional shear tests. The authors suggested that the optimum moisture content increase in case of fine soils and distributed fibers gave batter shear strength in case of well graded samples. Shear strength corresponding to normal stress increased with increase in percentage of polypropylene fibers. **P. K. Barasa** et al. [16] (2015) investigated the properties of expansive clay soil when stabilized by the mixing of lime, bagasse ash and soil. Various tests were performed like grading test, plasticity index (Atterberg) and California bearing ratio (CBR). Lime percentage like 4%, 5% and 6% and mixing ratio of lime and bagasse ash 1:4, 2:3, 3:2 and 4:1 were used. The authors concluded the plasticity index decreased with increased in quantity of lime and ash, addition of lime or bagasse ash was reduce the shrinkage and swelling behavior of soil and reduction in plasticity. California bearing ratio (CBR) increased with increase in lime but decreased for bagasse ash. Moreover, the authors concluded the combination of lime and ash gave good result for road design manual part III for minimum CBR of 20 for sub base road. The authors also concluded that sugarcane bagasse ash cannot singly used in stabilization of expansive clay soil and both lime and bagasse ash reduce the linear shrinkage act the optimum ratio of 4:1, which gave the value of California bearing ratio was 36, plasticity index 20, linear shrinkage 9 and negligible swelling.

D. R. Hasrajani et al. [17] (2015) studied the CBR test conducted on fine sand reinforced with polypropylene fiber, under both soaked and unsoaked condition with varied fibers condition. The authors investigated that the inclusion of polypropylene fibers in sand improved strength and deformation behavior of sub grade soils. With addition rate of fiber from 0% to 2.5% at 0.5% interval, the CBR value of reinforced sand increased by 113% compared to unreinforced sand. Moreover, the authors concluded the CBR value for unsoaked condition increased 60%, 73%, 100%, 106%, 113%for unreinforced sand with 0.5%, 1%, 1.5%, 2%, and 2.5% of polypropylene fibers respectively and for soaked condition, the CBR value increased 61.6%, 76.9%, 96.2%, 113.2% and 139% for unreinforced sand with 0.5%,1%,1.5%, 2% and 2.5% polypropylene fibers. The authors further concluded the behavior of soil improved and penetration value increased.

A. Babu et al. [18] (2016) studied the shear strength parameters of the collected soil samples by means of direct test and mainly deal with strength behavior of fiber reinforced. Polypropylene fibers content in collected soil sample varied as 0%, 0.25%, 0.5%, 0.75%, 1%, 1.25%, 1.5% and 1.75% respectively. Moreover, the authors suggested as the angle of internal friction increased with increase in addition of polypropylene fiber up to some fix value and then decreased. Strength increased in low percentage of polypropylene fiber. The authors concluded that the higher amount of polypropylene fiber gave lesser strength to the sandy soil and strength was increased in the low percentage of polypropylene fiber. **M.S. Dixit** [19] (2017) investigated the applications of polypropylene in retaining structures, embankment, stabilization of subgrade and improvement of soil beneath pavements and footings. Author observed that the fiber reinforcement technique could be used as natural as well as synthetic fibers for soil reinforcement. The author studied the comparison of properties of soil with addition of varying percentages of fibers by dry weight of soil and having different aspect ratios. Addition of polypropylene fibers resulted in increased optimum moisture content and decreased maximum dry density increased in the value of cohesion and decreased value of angle of internal friction with the inclusion of the fibers increase in CBR value and unconfined compressive strength observed and specific gravity of black cotton soil decreased with addition of polypropylene. **R.S Balagoudra** et al. [20] (2017) studied the “soil stabilization using waste materials” and investigation the use of waste fiber materials in geotechnical applications and evaluated the effects of waste polypropylene fiber on shear strength of unsaturated soil by carrying out direct shear tests and unconfined compression tests on two different soil samples. The authors conducted tests using different percentage of fiber reinforcement like 0%, 0.05%, 0.15% and 0.25%. Moreover, the authors investigated that the specific gravity of soil with mixing of 0.05%of polypropylene fibers specific gravity of soil increased by 0.3% and strength of soil was directly proportional to specific gravity, more the specific gravity, more the strength of soil. Various tests were conducted with increment of 0.25% polypropylene fiber (PPF) up to 1% and constant 4% lime by weight of soil and the maximum strength was obtained at 0.75% polypropylene fiber and maintaining 4% lime. The author investigated that the optimum moisture content had decreased up to 0.75% after gradually decrease, maximum dry density, compression strength, shear strength, CBR value increased up to 0.75% after that gradually decreased. **S. S. Deshpande and M.M. Puranik** [21] (2017) studied the properties of polypropylene fiber and observed that polypropylene fiber was highly tensile in nature as well as it was cheap in cost. The authors conducted Standard Proctor Test, Unconfined Compression Test and Tri-axial Shear Test and also discussed their effect on maximum dry density and optimum moisture content, effect on cohesion(c), effect on angle of internal friction (ϕ) and effect on unconfined compressive strength. Moreover, the authors suggested that the maximum dry density decreased and optimum moisture content increased as polypropylene content increased and also unconfined compressive strength of soil increased with increased in polypropylene percentage and angle of internal friction (ϕ) increased with the addition of fly ash and polypropylene. **M. Kumar** et al. [22] (2017) investigated the properties of soil were prepared by adding 5%, 10%, 15%, 20%, 25% and 30% bagasse ash with lime added 0%, 5% and 10%. Various tests were performed like standard proctor test (SPT) and unconfined compressive strength (UCS) test to analyze the Optimum moisture content (OMC), Maximum dry density (MDD) and compressive strength of soil mixture. The authors concluded that in standard proctor test, with increase in bagasse ash, percentage in the dry density was increased up to 20% and after the maximum dry density (MDD), Optimum moisture content (OMC), values decreased with increase in percentage of lime. The authors also concluded the UCS value increased up to 5% and after that the value of UCS decreased with increase in lime content. The authors concluded that the lime not only act as an activator but also reduced the plasticity of the soil and Soil-Bagasse-Lime failed by formation of vertical cracks.

III. CONCLUSIONS

For construction purposes the soft soil has poor bearing capacity which is unable to use in construction. In the study state-of-the-art review on using the polypropylene and bagasse ash have suggested low-cost and effective materials for stabilization of the soil. Also it has been seen that use of stabilizer from waste material helps to resolve the crisis of waste disposal and even facilitating to enhance the engineering properties of soft soil and reducing construction cost in comparison to other type of stabilizing agents.

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