Utilization of Waste Materials for the Strengthening of Pavement Subgrade-A Research

A.Vijayakumar, S. Naveen Kumar, P. Abhinayasai Tejareddy

Abstract— From a long period in road construction soil is used as subgrade, sub-base, and base material. While constructing a road in the weak soil areas or subgrade has poor strength, in such cases the improvement of soil is necessary. The improvement of the soil is thru by swapping by the stronger soil or stabilization with the waste material. Dispose of these waste materials is essential as these are causing hazardous effects on the environment. With the same intention, the literature review is undertaken on the utilization of waste materials for the stabilization of soils and their performance is discussed. The waste material is one of the best solutions to the improvement of submerged properties in an economical manner. This review paper presents a brief exposure to the stabilization of soil with waste material like agriculture waste, constructional waste, and industrial waste materials.

IndexTerms:Hazardous,Stabilization,Subgradelayers,WasteMaterials.

I. INTRODUCTION

The soil is highly heterogeneous, involutes and capricious material which has been subjected to the vagaries of nature, without any control. The soil properties not only depend on the type of soil, it withal depends on its characteristics at that stratum. In general, geotechnical engineers or civil engineers are forced to construct a structure on the site selected location without considering the soil conditions. The most paramount thing is that engineers should amend the properties of the soil. If unsuitable soil conditions present at that site of a proposed structure the entire poor soil is removed until to get a suitable bearing capacity to achieve it and the poor soil is replaced with another soil that leads to costly to the structure. To overcome this quandary a soil is stabilization with waste materials with suitable techniques to achieve the required properties of the soils. If it's not done in a proper manner soil stabilization lost its favor. The present exercise changes the designing properties of the local tricky soil to meet the expected conditions to the soils. In present days soils like clayey soil, salt contaminated soils and organic soils can be modified to achieve to get a congruous requisite to meet civil engineering properties with the avail of the stabilization methods. Which is one of the sundry methods of soil amelioration in our country in the year of 1970 the modern stabilization of soil is commenced with usages of petroleum and aggregates are integrated to poor properties soil its changes to good engineering properties of the soils [20]. In present days the growth of the industries are rapidly is increased due to these conditions the availability of waste material is rapidly increased. The term industrial waste is included in the form of solid, semisolid and liquid from materials dispatched by industries infelicitous techniques of solid wastes cause's deleterious effects on the ecology system which may cause epidemics and sickness.

II. LITERATURE REVIEW & RESULTS

Mehmet saltan et al., (2011) considered pumice which is an obtained in dust form from the volcanic rock with different proportions of 0%, 10%, 20%, 30%, and 40%. From his study it was evident that adding of the pumice waste to clayey subgrade, index properties are decreased and cbr value was found to be increased from 6.78% to 10% by addition of 40% of pumice waste. The resilient modulus increasing of 240mpa to 250mpa is evident by adding 40% pumice waste. It has been concluded that the utilization of 40% pumice waste is beneficial for a clayey subgrade.

Chayan gupta et al., (2014) studied the enrichment properties of expansive soil subgrade by use of microsilica fume, the replacement size of particle less than micrometer was used. The varies volumes are swapped by micro silica fume at 0%, 5%, 10%, 15%,and 20%. From the compaction test, it's evident that the addition of micro silica to expansive soil will increase the mdd by 20%., omc is also found to be increased. The maximum cbr is obtained at the 10% replacement of micro silica fume, cbr value in case of a soaked condition the expansive soil increases from 2.69 % to 5.87 %, when unsoaked cbr is increased from 7.34% to 15.56% replacement of 10% micro silica fume. It is concluded that 10% of micro silica fume is effective for replacement in expansive subgrade layers.

Prakash chavan et al., (2014) intended to grace the properties of black cotton soil by the implementation of bagasse ash at 0%, 3%, 6%, 9%, and 12% replacements. From his study, he concluded that the plasticity index of parent soil changes from 24% to 17.40% when 9% of bagasse ash used. The mdd of parent soil increased from 1.57 to 1.78g/cc and omc are decreased from 17.20% to 15% at 9% addition. The ucs of soil is increased from 93 kn/m2 to 429 kn/m2, free swell index of soil is decreased by 60% to 40% and soaked cbr value of soil increased from 1.16% to 6.8% for 9% of bagasse ash. He concluded that the usage of 9% bagasse ash is effectively used in the

Revised Manuscript Received on July 18, 2019.

Dr.A.Vijayakumar, Professor Dept. of Civil Engineering, (E-mail vijayakumar.a@gmrit.org)
Mr. S. Naveen Kumar, Assistant Professor Dept. of Civil Engineering. (E-mail: naveenkumar.s@gmrit.org)
Mr. P. AbhinayasaiTejareddy, P.G.Student Dept. of Civil Engineering (E-mail: saitejareddy333@gmail.com)

stabilization of black cotton subgrade soil.

Magdi m.e. Zumrawi (2015)considered fly ash as it is mostly used in the concrete and soil stabilization purposes because the properties of fly ash are similar to the cement properties. It is the waste material obtained from combustion during the process of power generation. By the addition of a 5% fly ash with 5% cement to expansive soil, the swell pressure value is decreased from 175 kpa to 75 kpa and the swell potential value is decreased from 18.7% to 4.5%. Up to 5 % add of fly ash it's decreased by about 60% but later its decreased slowly increases the fly ash content. It was clear that the soaked cbr value increased with increasing of the fly ash content up to 15% mixed with 5% constant cement content and rather it's decreased with the increase of fly ash content, clearly observed that 15% fly ash with 5% cement is significantly greater improvement in strength and reduction in swelling characteristics. So verbally expresses that 15% fly ash with 5% cement can be effectively utilized in soil stabilization with low cost.

Manju suthar et al., (2015) stated that stabilization of clayey subgrade soil with polyester staple hollow recron3s fiber with an effective length of 6mm and 12mm.with mixed quantity of 0.3%, 0.5%, 1%, 2%, and 3%. It has been observed the mdd of the proctor test result for 6mm fiber added to clayey soil is increased from 1.87g/cc to 1.958g/cc and for 0.5% later its gradually decreased with increased its content the omc varies between 13% to 16.9%. For 12mm the values are 1.87g/cc to 1.965g/cc, for 0.3% later its decreased with increasing of its content the omc varies between 12.2% to 16.9%.in cbr test under the unsoaked condition, the values of cbr is increased up to 0.5% for 6mm length fiber the cbr is 29.3% which is 2.8 times more than the untreated soil. For 12mm fiber it's increased up to 0.3% the cbr for 0.3% is 33.2% which is 3.1 times more than untreated soil. In case of a soaked condition the cbr values increase up to 0.5% for 6mm length fiber the cbr is 10.9% which is 3.8 times more than the untreated soil. For 12mm fiber it's increased up to 0.3% the cbr for 0.3% is 11.2% which is 3.9 times more than untreated soil. It has been concluded that the cbr in soaked condition greater than 11% reduces the pavement thickness. The optimum usage of recron3s in clayey subgrade soil for 6mm length fiber is 0.5% and 12mm length fiber is 0.3%.

Altugsaygili et al., (2015)in his work he intended to the utilization of marble dust to improve the engineering properties of kaolinite clayey with disparate proportions of marble dust is 0%, 5%, 10%, 20% and 30% in substitution of kaolinite clay soil. It has been observed from tests that with increases of marble dust the omc is decreased and dry unit weight is increasing but the max dry unit is 18kn/m^3 with omc of 15.5% is obtained at 30% marble dust added to the soil. The ucs of stabilized soil is increased from 150kpa to 260kpa at 28 days test for 30% marble dust. The free swell properties of soil are decreased from 21% to 13% for 30% marble dust. So it has been concluded that marble dust up to 30% is effectively used in kaolinite clayey subgrade soil to improve its engineering properties soil.

Nishanthabandara et al., (2015) studied the stabilization of silty subgrade soil with different recycled material like cement kiln dust (6%, 8% and 12%), limekiln dust (6%), fly ash (10%, 15% and 25%) and concrete fines (4%, 12% and 25%) based on the preliminary tests it says that the usage of 8%cement kiln dust, 6%lime kiln dust, 15% fly ash, and 4%concrete fines are effectively used. Also, the mix of 5%lime kiln dust and 15%fly ash is used for stabilization purposes.

N.v.gajera et al., (2015) studied the stabilization of the black cotton soil with groundnuts shell ash with various percentages 0%, 2%, 4%, 6%, 8%, and 10%. Addition of the groundnut shell ash to the black cotton soil the index properties of black cotton soil are improved, with an addition of the 8%ground nut ash shell to the soil the mdd is increased and omc is decreasing, further increasing content the mdd is decreased and omc is increased. But the peak cbr value is obtained at 10%addition of groundnut shell ash. It concluded that 10% of groundnut shell ash is effectively used for increasing properties of black cotton soil.

Rathan raj r et.al., (2016) studied with the waste rice husk ash for the stabilization of clayey soil. The proportion of rha is integrated to soil in proportion of 5%, 10%, 20%, 30%, 40%, 50% and 80%.the specific gravity of the chosen rha is in the range of 2.8 to 3.8. Adding of the 80% of rha to the clayey soil the index

properties of the soil like the ll is decreased from the 59% to 19.2%, sl is increased from 23.7% to 24.2% and the swelling index of the soil is decreased from 59% to 13.6%. The max dry density of clayey soil is increased from 16.39 kn/m^3 to 19.5 kn/m^3 with an omc range is decreased from 17.89% to 13.25%. The undrained cohesive value of mixed rha clayey soil is decreased from 60n/m^2 to 30kn/m^2 with an angle of internal friction increased from $17^0 5^1$ to 38^0. The soaked cbr value of mixed rha clayey soil is increased from 2.45 to 4.4% and the unsoaked cbr increased from 3.2% to 9.3%. It has been shown that the rha is used up to 80% for clayey stabilization.

Ravi et al., (2016) proposed to use of copper slag waste to upgrade the engineering properties of clay soil. This study copper slag in 10%, 20% and 30% of replacement are used. From tests, it had been observed that the dry density of soil of parent soil is increased from 1.597g/cc to 1.752g/cc after adding 30% of copper slag to the soil. But the omc is incremented from 12% to 18% for 10% and 20% supersession of copper slag in case of 30% supersession omc comes to 14 %. The cbr value in case of the unsoaked condition is incremented from 7.50% to 28% and in case of soused condition, it's incremented from 5.75% to 14% after adding 30% of copper slag to the soil. By integrating of copper slag more than the dry density is incremented and the same time the omc is withal increased more rapidly. He concluded that 30% of copper slag is effectively used in clay soil.

Parveen kumar et al., (2017) used crumb rubber obtained from automobiles tires.in the process of recycling steel and fluff are separated from the tires and the selected rubber is in the form of granular consistency. This continued process with mills the particle sizes is further is reduced and finally obtained the powder form. In his study, he studied that waste is used as crumb rubber for the stabilization of clayey soil. With a proportion of 5%, 10%, and 15%. With the adding of the 15% of crumb rubber to the clay soil the ll is decreased from the 39% to 34.6% and the obtained max dry density is decreased from 16.35kn/m^3 to 14.973 kn/m^3. By the study its clearly evident that the gap between crumb rubber and clay is an indication of the strength loss process. So the use of crumb rubber in stabilization purposes is reducing the cost and waste disposal of the rubber.

Hussien aldeeky et.al., (2017) proposed to use of steel slag waste to upgrade the engineering properties of highly plastic soil. This study steel slag in 0%, 5%, 10%, 15%, 20%, and 25% of replacement are used. The fine steel slag aggregate contains the sand content in 96.2% and silt of 3.8% with a sp.gravity of 3.205. It has been observed that the 20% and 25% of fssa of ip is 26.3% and 26.155, the free swell index values is 58.3% and 56.65%. With incrementing of the fssa the plasticity index and free swell index are decremented. But the unconfined compressive vigor for 20% of fssa is 310.12 kpa and 25% of fssa is 285.11 kpa, cbr value with 75 blows of compaction for 20% of fssa is 20% and 25% of fssa is 19.7%. It has been concluded that the utilization of the fssa is efficaciously up to 20% it may be elongate to 25% but the vigor of the soil is then decremented. So the optimum content for the fssa is 20%is efficaciously utilized in high plastic subgrade soil.

Ruqayah al-khafaji et al., (2017) studied with the waste ggbs for the stabilization of soft soil. The proportion of ggbs is integrated to soil in proportion of 0%, 3%, 6%, 9% and 12%. From tests, it's observed that by adding the ggbs the atterberg's limits are decreases gradually. From compaction test, the soft soil of mdd is increased from 1.51g/cm^3 to 1.63g/cm^3 and omc of soft soil is decreased from 20.5% to 19.4% it's achieved at 9% replacement of ggbs. From the ucs test, it's observed that the soft soil is increased from 190kpa to 350kpa. The max ucs of 350kpa is achieved at the 6% replacement of ggbs, 9% replacement of ggbs the ucs is 310kpa.it shows that the usage of 6% of ggbs the strength is increased 80% of parent soil. It concluded that the usage of 6% ggbs in soft soil subgrade to improve its properties

Rajamurugadoss et al., (2017) says that mixing of the waste rubber and cement in different proportions are added to the clayey soil. Cement used is opc53 grade which is acting as the binding agent between soil and rubber. For different mix proportion added to soil, based on cbr values the mix of the 4% cement with 10% rubber is effectively used for the clayey soil to improve its strength.

Nirmala r et al., (2017) studied with the waste glass for the stabilization of clayey subgrade soil. The waste glass (soda lime glass which is passed through to 300-micron sieve) in 0%, 20%, 25%, 30%, 35%, 40%, and 45% replacements. From proctor test the maximum dry density of soil is increased from 1.92g/cc to 1.936g/cc, omc is decreased from 13% to 9% for replacement with 40% waste glass. But the max dry density is 1.938 g/cc and omc is 11% is obtained at 30% replacement of glass waste. The shear strength of the soil is increased

from 6.23n/mm^2 to 6.37n/mm^2 replacement of 40% waste glass. In addition, of the waste glass to the clayey soil the cbr in both cases like soaked and unsoaked condition its increases, but the max cbr is obtained at a replacement of 40% waste glass. It concluded that a waste glass of 40% is effectively replaced with clayey subgrades.

Divya patle et al., (2017) studied with the plastic waste for the stabilization of black cotton soil. In this study plastic waste in 0%, 2%, 4%, 6% and 8% addition are used. The density of the plastic strips 0.44g/cc is used. From modified proctor test the mdd of the soil is increased from 1.62g/cc to 1.81g/cc and omc is decreased from the 20.5% to 18.5% is obtained in 4% of plastic waste used. An increase in the content of plastic the omc is decreased, but mdd is also decreased. The soaked cbr increased from 1% to 11.70% is obtained at 4% plastic waste used. It concluded that 4% of plastic waste is effectively used in black cotton subgrade soils.

Sooraj p. Sudhakaran et.al., (2018) studied with the bottom ash and areca fiber wastes for the stabilization of clay soil. The varies volumes are substitution of bottom ash in percentages is 0%, 10%, 20%, 30% and 40%, the areca fiber percentages is 0%, 0.5%, 1%,

1.5% with an addition of 3% cement used. From the test results, it's observed usage of bottom ash the mdd is increased gradually 1.44g/cc to 1.65g/cc. The max occurs at 30% of bottom ash if adding more than 30% the mdd is decreased. Omc is decreased from 28.7% to 18.5% for the addition of 30% of bottom ash. Cbr for soil in case of unsoaked condition its increases from 2.25% to 39.45% , soaked condition it's increases from 1.2% to 29.98% a mix of (30% bottom ash + 1.5 areca fiber + 3% cement). It concludes the improve the properties of clayey subgrade soil by use of 30% bottom ash along with 1.5% areca fiber and 3% cement in soil content.

Sharmila kc et al., (2018) studied with the cashew nuts shell ash and lime waste for the stabilization of clayey soil. The cashew nuts shell ash with various percentages like 5%, 10%, 15%, 205 and 25% along with a lime percentage of 5%. With the addition of the lime and cashew nuts shell ash to the soil the mdd and omc are decreased, but the cbr value of the soil is increased, in case of a soaked condition the stabilized cbr is 2.38 times more than untreated soil and the soaked condition is 2.33 times more than untreated soil. It concluded that 20% cashew nuts shell ash and 5% lime is effectively used in clayey subgrade soil which economical for road construction.

Tao zhang et al., (2018) used lignin is a byproduct obtains from industries likes timber and paper due to perpetual incremented usages of waste material in highway works the lignin is one of the options for the utilization in the subgrade construction. In this study the comparison of silty soil stabilization with lignin with an optimum content of 12% to the silty soil with quick lime stabilization an optimum content of 8%. The index properties of the silty soil is decreases in both cases. In case of lignin stabilization the ll is 31% and pl is 23.2% in case of quicklime stabilization ll is 42.7% and 36.7% those are higher than lignin stabilizer. According to the ucs test results the stabilization values of the lignin 12% is approximately same to the quicklime stabilization with 8% but the cbr values of lignin stabilization are 16.3% at 94% degree of compaction and 22.2% at 96% degree of compaction are higher than the quick lime stabilization. It has been concluded that the stabilization of silt soil with lignin is giving best result than the quicklime.

III. CONCLUSION

The following concluded were drawn from a broad overview of the literature review.

1. The waste materials like fly ash, baggage, ggbs, plastic waste, and rice husk ash are easily available in many parts of india and also have a low cost compared to other conventional material.
2. Adding of the waste material to expansive soil like black cotton soil we can control the swelling nature of the soil and increase the properties of the soil.
3. Usages of waste material in the highway field we have not only protect the environment but also to achieve the sustainable development of the country. The utilization of industrial wastes are economical for the local area and it is environmentally friendly.
4. Adding of fiber to waste material we can improve the properties of soil effectively.
5. Stabilization of soil sample with the combination of cement with other material can be effectively used to compare to the combination of lime with other material.

REFERENCE

1. Mehmet saltan, yucel kavlak, and f.selcan ertem (2011), “utilization of pumice waste for clayey subgrade of pavements,” american society of civil engineering, pp.1617-1623.
2. Chayan gupta, and ravi kumar sharma (2014), “influence of micro silica fume on subgrade characteristics of expansive soil,” international journal of civil engineering & research, pp. 77-82
3. Prakash chavan, and dr.m.s. Nagakumar (2014), “studies on stabilization by using bagasse ash,” international journal of scientific research engineering & technology, pp 89-94.
4. Magdi m.e. Zumrawi (2015), “stabilization of pavement subgrade by using fly ash activated by cement,” american journal of civil engineering and architecture, pp 218-224.
5. Manju suthar, and praveen aggarwal (2015), “clayey subgrade stabilization with lime and recron fiber,” journal of the indian roads congress, pp 104-109.
6. Altug saygili (2015), “use of waste marble dust for stabilization of clayey soil,” material science, pp 601-606.
7. Nishantha bandara, ph.d., p.e., m.asce; tarik habib binoy: haithem s. Aboujrad, and juliana sato (2015), “pavement subgrade stabilization using recycled materials,” air field and highway pavements, asce, pp 605-616.
8. mr.n.v. Gajera, and mr.k.r. Thanki (2015), “stabilization analysis of black cotton soil by using groundnut shell ash,” international journal for innovative research in science & technology, pp 158-162.
9. Rathan raj r, banupriya s, and dharani r (2016), “stabilization of soil using rice husk ash,” international journal of computational engineering research, pp 43-50.
10. E. Ravi, r.udhayasakthi, and t.senthil vadivel (2016), “enhancing the clay soil characteristics using copper slag stabilization,” journal of advances in chemistry, pp 5725-5729.
11. Parveen kumar, dr. Rajesh goel, and vishal yadav (2017), “stabilization of soil using crumb rubber,” international journal of advance research in science and engineering, pp 38-47.
12. Hussien aldeeky, and al hattamleh (2017), “experimental study on the utilization of fine steel slag on stabilizing high plastic subgrade soil,” advance in civil engineering, hindawi.
13. Ruqayah al-khafaji, hassnen m jafer, anmar dulaimi, and w.atherton, zahraaswaida (2017), “soft soil stabilization using ground granulated blast furnace slag,g” the 3rd buid doctoral research conference 2017, at british university in dubai.
14. Dr.j.rajamurugadoss, k.saranya, and a.ram prasanth (2017), “soil stabilisation using rubber waste and cement (standard proctor test and cbr)”, international journal of civil engineering and technology, pp 630-639.
15. Nirmala r, and shanmuga priya m (2017), “feasibility study on enhancing the properties of subgrade material using waste glass,” international journal of chemical sciences.
16. Divya patle, mamta burike, sayli d. Madavi, and suvarna raut (2017), “soil stabilization using plastic waste,” international journal of research in science & engineering, pp 58-68
17. Sooraj p. Sudhakaran; anil kumar sharma, ph.d., a.m.asce., and sreevalsa kolathayar, ph.d. (2018), “soil stabilization using bottom ash and areca fiber: experimental investigations and reliability analysis”, asce.
18. Sharmila k c, supriya c l, madhu k.m, chetan k m, and ashish dubayb (2018), “stabilization of black cotton soil by using cashew nut shell ash & lime,” international journal of scientific development and research, pp 225-229.
19. Tao zhang, ph.d., guojun lai, ph.d.; and songyu liu, ph.d. (2018), “application of lignin-stabilized silty soil in highway subgrade: a macroscale laboratory study”, asce.
20. Amruta lage, pradeep kumawat, and karishma sayyad (2018), “a review paper on expansive soil stabilization by using bagasseah and risehuskash,” international journal of advance research in science and engineering, pp 264-270.