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Review Article

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Agricultural and Industrial Waste as Soil Stabilizer: An Overview

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ABSTRACT

Soil is the foundation material which supports loads from the superstructure and is the most widely used as a sub grade in highway system, either in its natural form or in a processed form. In India, near about one-fifth of land area is overlaid with black cotton soil also known as expansive soil. These soils are found to be highly problematic because of their alternate swelling and shrinkage nature and therefore are not suitable at the construction site. To overcome these problems soil must be stabilized. Soil stabilization is a mean of altering the soil properties to maintain or enhance the performance of the soil as a construction material. Soil can be stabilized by using various methods which include compaction of soil, replacement or addition of soil with chemical admixture or wastes as a stabilizing agent. One of the most effective and economic method for soil stabilization is utilization of waste materials such as agricultural waste, industrial waste that not only improve the soil properties but also helps in management of waste. This paper shed a light on the results of works done by different researchers on agricultural and industrial waste materials as a soil stabilizing material.

Key words: *Expansive Soils, Soil stabilization, Soil stabilizing material, Agricultural waste, Industrial waste.*

INTRODUCTION

Soil is an important material for construction purpose in civil and highway engineering. Virtually all civil engineering structures have their foundation on the soil. Thus there is need of accurate studies of the engineering properties of soil in the proposed site of construction. Out of various types of soil black cotton soil also known as Expansive soil is not suitable as foundation material at construction site because of alternate swelling and shrinkage nature of the soil. These types of soils undergo severe volume changes due to changes in moisture content. So to improve or modify the engineering properties of soil, one of the best solutions is stabilization of soil. Soil stabilization can be defined as treatment of soil by which soil properties are modified and soil made more stable resulting in improved soil strength, increase in bearing capacity and durability under adverse moisture conditions. Soil stabilization can be classified as mechanical and chemical stabilization.

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The mechanical stabilization includes compaction or dewatering of soil while chemical stabilization includes blending and mixing of admixtures (cement, lime, bitumen etc.) or waste materials to improve soil properties. The stabilization of expansive soils by using admixtures such as cement or lime is found lack of interest because of the increasing cost of cement and environmental concerns related to production of these admixtures. Thus, it is a time requirement to search for materials that can be work as an effective, economic and eco-friendly soil stabilizing material to improve the soil properties. In such a scenario, one of the most effective and economic method for soil stabilization is the utilization of waste materials for altering the soil properties.

The rapid industrialization throughout the country results in the production of huge quantity of waste materials. These waste materials can be classified based on source of their generation as follows

i) Industrial wastes such as Fly ash, Ground Granulated Blast furnace slag, waste paper sludge, Copper slag, bottom ash etc.

ii) Agricultural wastes such as Rice husk ash, Bagasse ash, Ground nut shell ash etc

iii) Domestic wastes such as Incinerator ash, Waste tire etc and

iv) Mineral wastes such as Quarry dust, Marble dust etc

Out of these wastes, industrial and agricultural wastes can be used as the best alternative to traditionally used admixtures (cement or lime) for improving the quality of soil. This type of soil stabilization will give a best solution to dispose the wastes and will also help in sustain the environment.

This review paper mainly highlights the work done by various researchers on utilization of agricultural and industrial waste materials as a soil stabilizer for improving the soil properties. The alteration in properties of soil was generally evaluated in terms of CBR value, unconfined compressive strength, standard proctor test, optimum moisture content and maximum dry density test.

Soil stabilization using Industrial waste materials:

Industrial wastes are the waste generated from industrial activities, includes any material that is rendered useless during a manufacturing process in factories, mills and industries. Fly ash, copper slag ash, bottom ash, red mud, waste paper mill sludge etc. come under this category of wastes. Nowadays, industrialization has been globalised. The increase in number of industries lead to the production of large quantities of industrial wastes and the problems related with their safe disposal. To overcome these problems, there is need of the utilization of these wastes in an effective and eco-friendly manner as an attractive alternative to disposal. One of the best solutions is the utilization of these as soil stabilizing materials to improve the quality of soil. Stabilization of soils using industrial wastes results in the increased strength and stability of soils because of pozzolonic behaviour of these wastes. Recent research works conducted on soil stabilization using industrial wastes have been given below.

Malhotra M. and Naval S.[7] investigated the stabilization of expansive soils by using low cost materials such as fly ash, bottom ash and lime. A study was carried out to identify the improvements in the properties of expansive soil with fly ash and lime in varying percentages**.** Fly ash and Bottom ash (waste material) were collected from the Indraprastha Thermal Power Plant in Rajghat, New Delhi. In this study, Fly Ash and Bottom Ash were mixed in a ratio of 4:1and 5% of lime was also added to the soil mixture by weight of soil. The percentage of Lime was maintained at a constant 5% by weight of the expansive soil sample, whereas the mixture of Fly Ash and bottom ash was increased in multiple percentages of 5% up to 25% to obtain test samples on which tests were carried out and their properties were studied**.** Various tests was conducted such as liquid limit, standard proctor compaction, and differential free swelling test out to identify the improvements in the properties of expansive soil with fly ash and lime in varying percentages. It was observed that liquid limit of expansive soil was decreased with the increase in fly ash proportion, resulted in reduction of plasticity index. Moreover, as the amount of fly ash increases along with 5% lime by weight of the expansive soil sample there is apparent free swell index and increase in optimum moisture content. It was concluded that the mixing lime & fly ash in specific proportion with the expansive soil is an economic way to handle the problem of shrinkage, swelling and unequal settlement.

Joe M. A. and Rajesh A.M.[6] studied the soil stabilization by using copper slag and lime. Various tests like specific gravity, sieve analysis, proctor compaction test, unconfined compressive strength and CBR test were conducted to find the strength properties and behaviour of sub base after that the results and graphs of various mixes are compared to see their effects in sub base stabilization. From this study it was observed that there was an appreciable improvement in the optimum moisture content and maximum dry density for the soil treated with industrial waste. It was revealed that the addition of lime and industrial waste mixes to sub base increased the unconfined compressive strength value more than that by ordinary methods. This type of stabilization technique has an additional benefit of providing an environment friendly way to deal with industrial waste.

Elias N.[4] investigated the use of waste materials in geotechnical applications and evaluated the effects of waste paper sludge (WPS) on strength development of soft soil. It was found that the addition of WPS had increased the strength therefore is a suitable waste material for strengthening soft soil. When soil is treated with WPS Optimum Moisture Content (OMC) was increased and maximum dry density was decreased. It was also observed that curing of specimen showed a better bonding of WPS and clayey soil by absorbing the water content of clay soil by powdered Waste Paper Sludge. Therefore, WPS becomes a new innovation material that can be used as soil stabilizing material and this type of beneficial reuse of the paper sludge also saved landfill space.

Pandey P. K. and Jwaid S. M.[11] investigated the soil improvement using red mud and fly ash. Authors made a series of laboratory experiments on mixture of soil replaced with 3% fly ash along with red mud in the percentage range of 3%, 6%, 12%, 18%, 24%, 30% and 36% by weight of dry soil. The CBR value was increased up to 30% replacement of red mud along with 3 % of fly ash replacement by weight of soil after that it decreased. Maximum CBR value obtained was 7.354.

Dayalan J.[3] compared the stabilization of soil with ground granulated blast furnace slag (GGBS) and fly ash. In this study, different amount of fly ash and GGBS are added separately in the range of 5, 10, 15 and 20% by dry weight of soil. The performance of stabilized soil was evaluated using different physical and strength performance tests like specific gravity, standard proctor test and California Bearing Ratio (CBR) test. It was observed that with the increases of fly ash and GGBS percentage, OMC was decreased while maximum dry density was increased. From the results, it was also found that the CBR value was increased with increase in amount of fly ash upto 15% and beyond this value was decreased. The same trend was also observed in GGBS in which the maximum CBR value was attained at 20% GGBS. It was concluded that the optimum value for fly ash, GGBS was 15% and 20% respectively for stabilization of soil based on CBR value determined.

Mandal S. and Singh J.P.[8] used Ground Granulated Blast Furnace Slag (GGBFS) and Fly Ash (FA) as soil stabilizing material to improve the engineering properties of soil. The soil was partially replaced with 10% GGBFS along with FA in the percentage variation of 5%, 10%, 15%, 20% and 25%. From the test results it was found that with fix percentage of GGBS (10%) and varying percentage of FA up to 10% the OMC decreases but further increases of FA content results in increase of OMC. The CBR value for soaked and unsoaked condition was increased with fix percentage of GGBS (10%) and varying percentage of FA up to 10% by weight of soil then decreases with increase in percentage of Fly ash. The UCS of natural soil sample was 2.35 kg/cm^2 and the maximum value was found at 10% GGBS along with10% Fly ash was 4.51 kg/cm^2. It was concluded that 10% GGBS and 10% Fly ash by weight of soil gave better results as a soil stabilizer.

Ilies N. M. *et al.*[5] compared the methods of soil stabilization by using polyethylene waste materials and binders. Various tests had been performed to evaluate the effect of polyethylene waste materials and cement on mechanical parameters of soil, cohesion and internal angle of friction. It was found that the method of soil stabilization by using waste polyethylene materials is an eco-friendly method because it has low carbon footprint than cement or other binder. Mixing of soil with 4% polyethylene was very effective for soil stabilization. From the comparison of soil sample it was concluded that cohesion and internal friction angle for soil sample with 4 % polyethylene waste were smaller than the soil sample containing equivalent cement content as soil stabilizing material. But even if the improvement was higher for cement as stabilizing material this method uses a material which has higher carbon footprint, therefore is less eco-friendly.

Soil stabilization using Agricultural waste materials:

Agricultural waste refers to the waste generated as a result of various agricultural operations. It includes wastes from farms, field areas, poultry houses and harvest waste. In India near about 350 million tonnes of agricultural waste is generated every year (12). Therefore management and utilization of agricultural waste becomes imperative to reduce the problems associated with disposal of these types of wastes. Soil stabilization can also be done by using the agricultural wastes. Various types of agricultural wastes such as rice husk as, bagasse ash, ground nut shell ash etc. can be used for soil stabilization. The recent research works conducted in stabilization of soil using agricultural wastes as soil stabilizer have been given below.

Wubshet and Tadesse[14] evaluated the stabilization of expansive soil using bagasse ash and lime. The soil was stabilized using 3% lime, 15% bagasse ash and 15% bagasse ash along with 3% lime by dry weight of the soil. The effect of these additives on the soil was investigated with respect to plasticity, compaction and California bearing ratio (CBR) tests. The plasticity index significantly decreased with addition of lime or bagasse ash combined with lime. The maximum dry density of the stabilized soil was also decreased with addition of these additives. But decrease was significant in case of soil stabilized using combination of bagasse ah and lime.

The CBR of the soil was increased with the addition of lime and lime in combination with bagasse ash. But bagasse ash alone has a minor effect on the CBR value. From these results it was concluded that the combination of bagasse ash and lime can strongly improve the strength of the expansive soil.

However, the addition of bagasse ash alone had a minor effect on all these properties of soil.

Ali R. *et al.*[1] stabilize the expensive soil by using marble dust and bagasse ash. Different lab tests were performed on expansive soil with or without the addition of these waste materials and their effect on swelling and other properties were determined. During this experiment the index properties of the soil were firstly determined in their natural form and then marble dust or bagasse ash was mixed at different percentage in the range of 4%, 8% and 12%. It was found that addition of marble dust or bagasse ash in the percentage range of 4%, 8% and 12% was resulted in reduction of the liquid limits, plastic limits, plasticity index and expansive index. Dry density of expansive soil was increased with the incorporation of marble dust or bagasse ash and attains maximum value approximately at 8% addition but again decline at 12% addition of marble dust and bagasse ash. Addition of 12% marble dust reduce The uplift pressure of the normal soil was 9.02psi and was decreased to 5.56psi and 4.72psi with the addition of marble dust, bagasse ash respectively. From this study it was observed that stabilization of soil by using industrial waste such as marble dust or bagasse ash was successfully improved the poor properties of expansive soil. The use of baggase ash and marble dust for stabilization applications was also proved to be an economical and environmental solution of the problems associated with waste disposal process.

Murari A. *et al.*[9] investigated the stabilization of local soil by using bagasse ash. A study was carried out to identify the improvement in the properties of the soil due to partial replacement with bagasse ash in varying percentages i.e. 2, 5, 7and10%. Various tests such as liquid limit, plastic limit, and standard proctor test were conducted on soil at different percentages of Bagasse Ash. The results revealed that with the increase in the percentage of bagasse ash in the soil the liquid limit and plastic limit gets reduced. The optimum moisture content of soil was increased with increase in Bagasse Ash because these admix was finer than the soil.

Oviya R. and Manikandan R.[10] conducted a research on the stabilization of soil by incorporating Rice Husk Ash (RHA) and lime as an admixture. The main objective of this study was to investigate the effect of RHA and lime on index and geotechnical properties of the soil. The soil was partially replaced by RHA with variation of percentage as 2.5%, 5%, 7.5%, 10% of the soil sample. The lime was added as a binding material at constant percentage of 2% to enhance the various properties of soil. The laboratory tests were carried out and the effect on soil properties such as optimum moisture content (OMC), California Bearing ratio (CBR) and unconfined compressive strength (UCS) was determined in both soil mixed with RHA and soil mixed with RHA and lime. From the results it was concluded that OMC of the soil was increased with the addition of RHA in soil. The CBR value was increased at 5% replacement of soil with RHA only and this percentage of partial replacement of RHA was increased to10% when 2% lime was also incorporated in the soil-RHA mixture. The UCS value of the natural black cotton soil was found to be 250 KN/m^2. With the addition of lime to Soil-RHA mixture, UCS value gets increased to 350 KN/m^2. It was revealed that stabilization of soil using Rice Husk Ash is effective in both cost and strength evaluation.

Shinde S. S. and Patil G.K.[13] studied the utilization of agricultural waste such as Rice Husk Ash (RHA) and Ground Nut shell Ash (GNSA) as a soil stabilizer. Author separately treated the soil with various percentages of these wastes in the range of 3%, 6%, 9%, 12% and15%. For each percentage laboratory tests were carried out. The test results showed that the CBR value was increased from 2.39 to 5.09 and 4.30 respectively for the soil-RHA and soil-GNSA mixture. Maximum dry density was also increased for soil-RHA and soil-GNSA mixture. The OMC content of the soil added with RHA and GNSA was decreased to 21.67 and 24.84 respectively from 26.61 for normal soil. It was concluded that utilization of these agricultural wastes was improved the sub grade strength of weak soils.

CONCLUSION

From this above discussed review papers it can be concluded that the both industrial and agricultural wastes can stabilize the expensive or soft soil in effective and economic manner. Stabilization of expansive soil using industrial and agricultural wastes improves the geotechnical properties of soil. In all the research papers, effects of waste materials as a soil stabilizer on index properties, compaction properties, ultimate compressive strength, maximum dry density, California bearing ratio and swelling properties of the soil were mainly discussed. But results of field studies or applications by incorporating waste materials as soil stabilizer were found to be negligible in literature. Therefore, further investigation is required to find their effectiveness in field application in spite of focusing on experimental studies.

At last it can be conclude that both the industrial and agricultural wastes have ability to improve the quality of expansive soils by using these wastes as soil stabilizer. Environmental hazards can also be reduced by utilization of these wastes as soil stabilizer in eco-friendly and cost effective way.

REFERENCES

1. Ali, R., Khan, H. and Shah, A., Expansive soil stabilization using marble dust and bagasse ash. *Int J Sci Res* **3:** 2812-2816 (2014).
2. Dhakar, S. and Jain, S. K., Stabilization of Soil: A Review. *Int J Sci Res* **5:** 545-549 (2016).
3. Dayalan, J., Comparative study on stabilization of soil with ground granulated blast furnace slag (GGBS) and fly ash. *Int Res J Engi and Technol* **3:** 2198-2204 (2016).
4. Elias, N., Strength development of soft soil stabilized with waste paper sludge. *Int J Adv Technol Eng and Sci* **3(1):** 141-149 (2015).
5. Ilies, N. M., Circu, A. P., Nagy, A. C., Ciubotaru, V. C. and Bak, Z. K., Comparative study on soil stabilization with Polyethylene waste materials and binders. *Procedia Engineering* 444 – 451(2017).
6. Joe, M. A. and Rajesh, A. M., Soil stabilization using industrial waste and lime *Int J Scientific Res Eng Technol* **4(7):** 799-805(2015).
7. Malhotra, M. and Naval, S., Stabilization of expansive soils using low cost materials. *Int J Eng Innov Technol* **2:** 181-184 (2013).
8. Mandal, S. and Singh, J. P., Stabilization of soil using ground granulated blast furnace slag and fly ash. *Int J Innov Res Sci Eng Technol* **5(12):** 21121-21126 (2016).
9. Murari, A., Singh, I., Agarwal, N. and Kumar, A., Stabilization of local soil with bagasse ash, *SSRG Intl J Civil Eng*: 37-39 (2015).
10. Oviya, R. and Manikandan, R., An experimental investigation on stabilizing the soil using rice husk ash with lime as admixture. *Int J Inform Future Res* **3:** 3511-3519 (2016).
11. Panday, P. K. and Jawaid, S. M., Soil improvement using red mud and fly ash. *Glob J Eng Sci Res* **1:** 7-10 (2015).
12. Pappu, A., Saxena, M. and Asolekar, S. R., Solid wastes generation in India and their recycling potential in building materials. *Build Environ*: 2311-2320 (2007).
13. Shinde, S. S. and Patil, G. K., Study on utilization of agricultural waste as soil stabilizer. *Int J Latest Trends Eng Technol* **7(1):** 227-230 (2016).
14. Wubshet, M. and Tadesse, S., Stabilization of expansive soil using bagasse ash & lime. *J Eur Econ Assoc* **32:** 21-26 (2014).