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Application of Various Industrial Byproducts for Treatment of Road Soil Subgrades

Hareshwar Ashokrao Wadhonkar[1], Zeeshan Adib Ahmed[2], Dr. K. Ravi[3]

[1] ME (Structural Engineering) Student, Department of Civil Engineering, Babasaheb Naik College of Engineering, Pusad, Maharashtra, India

[2] Assistant Professor (Co-Guide), Department of Civil Engineering, Babasaheb Naik College of Engineering, Pusad, Maharashtra, India

[3] Professor (Guide), Department of Civil Engineering, Babasaheb Naik College of Engineering, Pusad, Maharashtra, India

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ABSTRACT

These days numerous exploratory studies have been carried on black cotton soil to improve its characteristics. This soils is exceedingly clayey in nature because it has low bearing capacity and high swelling shrinkage characteristics. In most of areas of India there's wide spread of black cotton soil which causes the issue to the civil related structures. This soil primarily shrinks within the absence of dampness and swells within the presence of dampness which may leads to the failure of building structures resting on it. On investigating different past investigate works, it has been found that the utilization of admixtures such as fly cinder, Rice husk ash, GGBS, WMP, WCP etc. may be utilized to increase the geotechnical properties of black cotton soil. Now a day's quick industrialization causes issues such as disposal of industrial waste materials, environmental contamination etc. In this survey, utilization of industrial material is highlighted. On appropriate checking on it has been found that there's a wide scope for utilization of industrial waste and other waste material for the stabilization of expansive soils.

Keywords: Marble Waste Powder, Ceramic Waste Powder, Black Cotton Soil

I. INTRODUCTION

Soil stabilization is a process of improving the properties of soil by improving its engineering properties. Expansive soils are those soils which swell when they come in contact with water and shrink when water is squeezed out. Due to this alternate swelling and shrinking behavior of soils, various civil engineering structures installed on them suffer damage. The severity of the damage done by the expansive soil has been well documented in worldwide literature. Several techniques are available to improve the engineering properties of expansive soil to make it suitable for construction. Stabilization of expansive soils using waste materials with binding properties such as WMP and WCP.

The disposal of industrial waste is important these days as it has a hazardous effect on the environment. Utilization of industrial wastes like WMP and WCP used in stabilization of expansive soil. In recent studies, research has mostly focused on achieving environmental and economic benefits.

It is learned from various literatures that limited research has been done on the effect of waste ceramic powder and waste marble powder on various geotechnical properties of expansive soil. Therefore the present study has been carried out to investigate the effect of waste ceramic powder and waste marble powder on index properties (liquid, plastic limit and plastic index), compaction properties - optimum moisture content (OMC), and maximum dry density (MDD). Unconfined Compressive Strength (UCS), soaked California Bearing Ratio (CBR) of expansive soils. The economy of stabilization has been achieve by enhancing the subgrade of flexible pavement has also been studied. [17]

II. MATERIALS

1] High Density Polyethylene Wastage Fibres

In recent years the uses of fibres in various fields have gained much importance. Several researches on soil reinforced fibres have been reported. The research on fibre-reinforced soils demonstrated that this material might be a practical and cost effective technique for reinforcement of sub grade soils in flexible pavements. Fibres are used to evaluate a methodology for preventing crack developments in clays due to desiccation by the use of short polymeric fibres. Such elements are available as short polyethylene fibres.

An investigation was conducted and from the results obtained, there is potential for the use of fibre reinforcing in clays as it is increasing the strength of the clay by reducing desiccation cracking. It is suggested that the reinforcing fibre concept might be improved if longer fibres with a different texture or surface coating were used. Fibres are also used as reinforcement for water contaminant soil liners. [15]

Component	Weight (%)
Silica	70.74
Aluminium Dioxide	20.67
Ferric Oxide	2.28
Magnesium Oxide	1.57

2] Stone Dust

Pulverized stone used in the construction of walkways or other stable surfaces. The dust is mixed with soil and compacted or used with gravel to fill spaces between irregular stones. Stone dust is a by-product of stone crushing operations.

The building stones are obtained from rocks. These rocks have a distinct plane of division along which stones can easily split. The plane is known as the natural bed of stone and it thus indicates the plane or bed on which the sedimentary stone was originally deposited. The natural bed of stone need not necessarily be horizontal. For sedimentary rocks, it is easy to observe and locate the natural bed as it lies along the plane of stratification. For igneous rocks, the natural bed is of little significance or importance and it is also difficult to determine. [15]

Component	Weight (%)
Cao	3.5-40
$Al2O_3$	0.5-40
MgO	2.5-25
SiO_2	1-12
SO_3	0.23-3
Available Alkalis	0-4

3] Lime

Hydrated lime was used as stabilizing agent in this research. Major chemical constituent of lime is calcium hydroxides [$Ca(OH)_2$]. Lime stabilization is done by adding lime to a soil. It is useful for stabilization of clayey soils, When lime reacts with soil, there is exchange of cations in the adsorbed water layer and a decrease in plasticity of the soil occurs. The resulting material is more friable than the original clay, and is, therefore, more suitable as subgrade. Lime is produced by burning of lime stone in kilns. The quality of lime obtained depends upon the parent material and the production process. [15]

Test	Properties
Tensile Strength	553-759 mpa
Young's Modulus	3450 mpa
Specific Gravity	0.9
Melting Point	160-170 ^{0}C

U V Resistance	Poor
Acid Resistance	Very Good
Alkali Resistance	Good
Dispersion	Good

4] Bagasse Ash

Bagasse ash is a fine residue collected from burning of bagasse fibers after crushing for sugarcane juice. Bagasse ash is a non-cohesive material having a low specific gravity and it comprises of high content of silica and since it burnt, it behaves as a pozzolanic material, thus it can be used for the stabilization of road subgrade.

Hydrated lime which has 85-95 % of calcium hydroxide is an inorganic compound. The various tests are to be conducted with bagasse ash alone which in turns slightly it improves the strength of the clayey soil. The increase in strength of the combined hydrated lime-bagasse ash is higher than that of bagasse fibres employed alone.

On the investigation with calcium carbide residue is used as a admixture blended with bagasse ash to improve the strength of the clayey soil. CCR contains high CaO, so that it considered to be an admixture to reduce the plasticity index, expansion potential as well as to increase the shear strength and compressive strength of soil. The addition of bagasse ash to CCR significantly improves MDD, especially on 28 days curing time. [16]

5] Coir Waste

Coir waste consist of coir pith and coir fibre is a by-product of coir manufacturing industry obtained from coconut husk during the extraction of coir fibre. The various proportions are made for coir pith and coir fibre mixed with soil.

When the addition of coir pith alone to the soil in presence of water, it will absorbs the water and fill the voids of soil thus contributing to the dry density. At higher coir pith content, the optimum moisture content increases. The coir fibre shows the similar result as that of coir pith. When both coir pith and coir fibre are used at a correct proportions with the soil, the maximum can be
attained.

The CBR value attained for both soaked and unsoaked conditions increases with the increase in fiber content. Thus the significant increase in CBR value of soil due to the addition of coir fiber will substantially reduce the thickness of pavement subgrade. From the review, it was found that the preparation of identical soil samples for CBR test beyond 1% of fiber content was not possible and optimum fiber content is found to be 1 % by dry unit weight of soil.

The soil reinforcement is also a method to improve the bearing capacity and to reduces the settlement. The square footing was prepared as a model by providing reinforced layer with various proportions of coir fiber. Therefore, the provision of coir reinforced layer increases bearing capacity and reduces settlement, which found to be economical techniques among various types of bearing capacity improvement techniques.[16]

6] Egg Shell Powder and Quarry Dust

Egg shell powder has the similar chemical composition as that of lime, this can be used as the stabilizing material instead of using lime. From the domestic sources such as poultries, hatcheries and food centers are collected. With the addition of ESP alone constantly, there is an increase in OMC and decrease in MDD. With varying percentage of ESP, shear strength increases, permeability increases. With the addition of optimum percentage of ESP and varying percentage of quarry dust, further increases the MDD and decreases the OMC and the shear strength, angle of internal friction increases and the cohesion decreases.

So, that the ESP alone with quarry dust used in combination with clayey soil possessed certain properties can be used for the improvement of clayey soil. From, the various tests are to be conducted to determine the optimum quantity of lime and the optimum percentage of lime ESP combinations. Here, the optimum quantity of lime is gradually replaced with amount of eggshell powder. It was found that, the lime stabilization is better than the combination of ESP and lime. [16]

7] Fly Ash

The annual production of fly ash in India is about 184 million tons per year and also it increases day by day. Fly ash can be obtained from the combustion of sub-bituminous coal exhibit self-cementing characteristics. Fly ash treatment can effectively reduce the swell potential of highly plastic clay and thus prevents the swell beneath the small foundation pressure. For highly expansive clay, a combination of fly ash with small percentage of lime is recommended for stabilization.

The plasticity index of fly ash treated soils decreases mainly due to an increase in plastic limit. Liquid limit may increase or decrease depending upon the type of soil. The greatest problem occur in soils with a high montmorillonite content. Different clays have different susceptibility to swelling. Fly ash itself has little cementitious value but in the presence of moisture it reacts chemically and improve the strength and compressibility of soils.

When the fly ash is added to the clayey soil, the California bearing ratio and unconfined compressive strength of the soil will be increased and thus improving geotechnical properties. Stabilization of weak soil with fly ash not only improves engineering properties of soil but also provides answers to issues of fly ash disposal. [16]

8] Marble Waste Powder

Marble Dust is a waste product of the marble stone. This dust is produced in the process of cutting the marble stone. Marble stone is a type of metamorphic rock that is produced as a result of transformation occurred in the lime stone. In India, marble processing industry generates around 7 million tons of wastes mainly in the form of powder during sawing and polishing processes. Out the total waste generated, the state of Rajasthan alone contributes around 6 million tons of marble dust annually i.e. about 95% of the total marble dust production. This poses a huge threat to the environment and the people because most of these marble dust is dumped into the open area which causes a major environment concern. Although there are proper areas dedicated to the dumping of this waste but marble dust being a very fine powder is capable of flowing with the wind. Thus the marble dust spreads along the outer areas also and gradually settle on the plants and animals of the surroundings of the area. The spreading of marble dust in the surrounding areas certainly creates necrotic ecological condition for flora and fauna thereby changing the landscapes and habitats gradually. Thus it becomes very important to utilize huge amount of waste in a proper manner. To combact the effect of this waste material to surrounding area, it is used in various processes such as in the production of concrete as well as in stabilization of soil. Utilizing the marble dust in the process of stabilization of soil is increasing day by day due to the low cost of the material and for its ease of availability. [13]

9] Ceramic Waste Powder

In the world a lot of ceramic dust is produced during production, transportation and placing of ceramic tiles.

This wastage or scrap material is inorganic material and hazardous. Hence its disposal is a problem which can be removed with the idea of utilizing it is an admixture to stabilize BC soil, so that the mix prove to be very economical and can be used as subgrade in low traffic roads or village roads.

It has been estimated that about 30% of daily production in the ceramic industry goes to be ceramic dust. The disposal of which creates environmental and economical problem. To overcome this situation this industrial waste can be used in different application, one of prime is soil stabilization.

Ceramic dust consist of high SiO2,Al2O3 and Fe2O3 contents reaching up to 96%, but the amount of Fe2O3 and Tio2 is 1.22%. [14]

III. LITERATURE REVIEW

1) Rakhil Krishna R and Devi Krishnan (2016)

The expansive soil alternatively swells and shrink depending upon the presence of moisture in it. This behavior causes the volume change of the soil and it results the cracking and failure of structures built on that soil. To improve the geotechnical properties of this expansive soil so as to make them suitable for construction purposes, various methods are in

available. This paper reviews the results of the experimental programme which is already carried out by stabilizing the expansive soil using ceramic dust made from locally available waste ceramic tiles. Also it reviews the economic feasibility of utilizing the ceramic dust for improving the properties of expansive soil used for construction. Expansive soils are the soils which swell significantly when come in contact with water and shrink when the water squeezes out. They are also referred as swelling soils, are those soils which have tendency to increase in the volume whenever the moisture content (i.e. water content) in it is increased. Because of this alternate swell - shrink behavior of the soil, the change in soil volume will occur and it can cause shifting and cracking in different civil engineering structures founded on them. Foundation with swelling soil will heave and can cause lifting of a building or structure laid on it whenever the moisture content rises. This can ultimately lead to the failure of foundation and structure laid on it. [1]

2) Muthu Kumar M, Tamilarasan V S (2015)

Soil stabilization is required when the soil available for construction is not suitable for the particular use. Of all the soils, Exapansive soils causing major problems to the civil engineering structures, Such as soils having the high volume changes upon adding the water soil stabilization upon changing the water. soil stablilization using chemical admixtures is oldest and most wide spread method of ground improvement. The conventional soil stabilization techniques are generally expensive and requiring large quantities of costly materials. Due to shortage of energy, and materials and also high cost of construction operation there is need to go for alternative low cost material

In this study, waste marble dust which is the by product of marble industry, is used for soil stabilization. The marble powder is high lime (CaO) content and is reported many researchers. We have added marble powder to expansive soil as 5%, 10%, 15%, 20%, 25%, and 30% and studied the compaction characteristics and strength characteristics. [2]

3) Sabat A. k. (2012)

It has been estimated that about 30% of daily production in the ceramic industry goes to waste. The disposal of which creates soil, water and air pollution. Koyuncu et al. (2004) had added ceramic tile dust wastes up to 40% to study its effect on swelling pressure and swelling potential of Na –bentonite and found that swelling pressure and swelling potential decreased by 86% and 57% respectively at 40% addition of ceramic tile dust waste.

From the available literature it is found that limited research has been done to study the effects of waste ceramic dust on different geotechnical properties of expansive soil. Therefore the present study has been undertaken to investigate the effects of waste ceramic dust on index properties (liquid limit, plastic limit, plasticity index), compaction properties - optimum moisture content (OMC) and maximum dry density (MDD), unconfined compressive strength (UCS), soaked California bearing ratio (CBR), shear strength parameters (cohesion and angle of internal friction) and swelling pressure of an expansive soil .The economy of stabilization has also been studied by strengthening the subgrade of a flexible pavement. [3]

4) Guru S, Krishna Puthiran V S, Manikandan G (2017)

A pavement is a hard crust constructed over a soil for the purpose of giving the stable and even surface for the vehicles, likewise buildings meant for habitation. But if the soil supporting the buildings and pavements is weak, it will leads to failure and the purpose will not be served. So the supporting soil needs to be stabilized. But the conventionally used methods are uneconomical. So, the need of developing the soil stability with low cost and environment friendly is necessary. In this paper, various articles have been reviewed in order to discuss the various economical and effective ground improvement techniques (GIT). In those articles the various stabilizing agents employed for soil stabilization are Bio Enzyme, terrazyme, permazyme, lime, fujibeton, renolith, lime, quarry dust, fiber, etc. The effect of these stabilizing agents and its optimum content for effective Ground Improvement process are also been discussed. [4]

5) Dr. K. Murali, S. Ashok, N. Giridharan, K. Kaniyan pandiarasan, P. Logesh (2018)

Expansive soil or clayey soil which can change its volume when the water content is available i.e., swelling and shrinkage occurs. In urban areas, borrow earth is not easily available which has to be hauled from a long distance. Quite often, large areas are covered with highly plastic and expansive soil, which is not suitable for such purpose. It results on damage of building structures and road pavements due to its low strength and high expansion. The usage of admixtures can adversely improve the soil properties, thus stabilizing the clayey soil. A critical review on various admixtures used for stabilization of expansive soil is discussed in this paper. [5]

6) P. Bharath Goud, D. Sruthi Laya (2018)

Stabilization of Black Cotton (BC) soils have been in recently attracted many researchers. The stabilization of Black Cotton Soils by Copper slag (CS) and Rice husk ash (RHA) were tried in the past separately. The authors tried to use both of them together in stabilization of BC soils. Present study was undertaken to evaluate the effectiveness of different percentages of rice husk ash and copper slag as soil stabilizers. The tests performed on the mixed proportion of BC soils, Copper Slag and Rice Husk Ash are Vane shear, California Bearing Ratio (CBR), Atterberg limits, free swell index (FSI), and compaction tests. Limited studies have been reported for the combination of copper slag and rice husk ash in soil stabilization. The optimum mix was found to be in the proportion of 64%BC+30%CS+6%RHA. FSI of soil treated with RHA+CS decreased steeply from 100% to 20.4%. There was a slight change in maximum dry density of the treated soil. The unsoaked CBR test shows that strength of optimum mix was 12.7%. The stabilized soil mixtures have shown satisfactory strength characteristics and can be used for low-cost constructions to build houses and road infrastructure. Laboratory vane shear tests have been carried out under undrained conditions to study the shear strength parameters of the stabilized soil. [6]

7) D. Srinadh, P. Praneeth, D. Manideep reddy, K. Shyam Chamberlin, N. Sandeep Kumar (2019)

Soil Stabilization is one of the modern techniques for modification of soil which are using in our daily life in construction. Due to increase in population land is also getting scarce so we need to build in the available area. So this technique we use is called Soil stabilization or modification of soil. As we know that some of the soils are not useful for construction. As a result while constructing pavements like national highways (NH) we should definitely build the pavement on soils like black cotton soil by improving its strength because the original nature of the soil will have poor bearing capacity and less strength. So by adding admixtures from Industrial wastes such as Ground granulated blast furnace slag(GGBS) which is the waste of iron ore i.e., in powder form and Lime which will increase the bearing strength of the soil, So that it will also increase the pavement design over long period of time which is the ultimate goal for the design of the pavement or any other construction purpose. So by adding these admixture using the industrial waste which is available in a low cost so that we can easily improve the strength of the soil because of the availability of admixtures in economy. After adding the admixtures Soil should be tested by some basic tests of U.C.C (Unconfined Compressive Strength) and also California bearing test (CBR) and also some basic tests like MDD (Maximum Dry Density) & OMC (Optimum Moisture Content), Plasticity index and liquid limit etc.., should be carried out in order to test the improved strength of the soil. [7]

8) Mrs. Vrunda Sule, Vyas Brinda, Chauhan Vandana, Khilji Sohel (2018)

Expansive soil is a highly clayey soil it has very low bearing capacity and high swelling-shrinkage characteristics. Due to very low CBR value of black cotton soil, it forms a very poor foundation material. In most of places of India there is wide spread of black cotton soil which causes problems to the construction activities, especially sub-grade problem. Design of various layers of pavement is dependent upon the strength of sub-grade soil over which layers of pavement are going to be laid. Strength of sub-grade is mainly expressed in CBR. Soil stabilization is an effective method for improvement of soil properties and pavement system. Black cotton soil is mainly stabilized using fly-ash, lime and cement. Some agricultural wastes are also used, but they can't be used as a single stabilizing. This project is an attempt to improve the CBR value and properties of soil using

locally available materials in order to effectively lying of road pavement and increase strength of the road pavement economically. [8]

9) Ramoo Ram, Ravi Kant Pareek (2018)

The main objective of this study is to investigate the use of waste marble dust in geotechnical applications and to evaluate the effects of marble dust on OMC & MDD and CBR values of unsaturated soil by carrying out Standard Proctor Test and CBR test on different soil samples. The results obtained are compared for the three different percentage of marble dust and inferences are drawn towards the bearing strength of soil with different combination of marble dust. In this study, the waste material of marble industry, were used for stabilization of clayey soils. [9]

10) Dayalan J (2016)

Stabilization is a broad sense for the various methods employed and modifying the properties of a soil to improve its engineering performance and used for a variety of engineering works. Soil stabilization has become the major issue in construction engineering and the researches regarding the effectiveness of using industrial wastes as a stabilizer are rapidly increasing. This study briefly describes the suitability of the local fly ash and ground granulated blast furnace slag (GGBS) to be used in the local construction industry in a way to minimize the amount of waste to be disposed to the environment causing environmental pollution. In this present study, different amount of fly ash and GGBS are added separately i.e. 5, 10, 15 and 20% by dry weight of soil are used to study the stabilization of soil. The performance of stabilized soil are evaluated using physical and strength performance tests like specific gravity, Atterberg's limits, standard proctor test and California Bearing Ratio (CBR) test at optimum moisture content. From the results, it was found that optimum value of fly ash is 15% and GGBS is 20% for stabilization of given soil based on CBR value determined. [10]

11) A. Kavak, G. Bilgen (2016)

In this paper presents an effective way of utilizing the ground granulated blast furnace slag (GGBFS), which is a by-product of the steel manufacturing process with lime for stabilization of road materials. In the study Ankara clay was used for stabilization. Although slag lime and clay mixtures do not affect optimum water contents of clay significantly, they decrease dry density and smoothes Proctor curve. Then, the soil transforms into a rapid structure and the modulus of elasticity increases. When the results of the experiments were evaluated, unconfined compressive strength (UCS) and soaked California Bearing Ratio (CBR) values of the soils have shown significant increases. These increases reach to 46 times in CBR values for Ankara clay compared to natural case in 28 day-cured samples. This stabilization technique is more effective than the lime alone and also the slag will prevent the ettringite formation that occurs in lime stabilization with sulfate rich soils that leads swelling behaviour. And finally the slag may turn from a waste material into a valuable product for road construction works with huge volumes even at far away from the steel factories. [11]

12) Ashish Kumar Pathak, Dr. V. Pandey, Krishna Murari. J. P. Singh (2014)

Studied the soil Stabilization Using Ground Granulated Blast Furnace Slag. In this research the soil are stabilized by ground granulated blast furnace slag (GGBS) and this material is obtained from the blast furnace of cement plant, which is the byproduct of iron (from ACC plant, sindri). It is generally obtained in three shaped one is air cooled, foamed shaped and another is in granulated shaped. The use of by-product materials for stabilization has environmental and economic benefits. Ground granulated blast furnace slag (GGBS) material is used in the current work to stabilize soil (clay). The main objectives of this research were to investigate the effect of GGBS on the engineering property (optimum moisture content and maximum dry density, plastic limit, liquid limit, compaction, unconfined compressive strength, triaxial and California bearing ratio test) of the soil and determine the engineering properties of the stabilized. Granulated shaped blast furnace slag is most suitable for increasing the strength of the soil and for this we check the following property of soil. GGBS are added from 0% to 25% by dry weight of soil, first of all check the all soil property at 0 % (no GGBS) and then

compare after addition of GGBS from 5% to 25%. The investigations showed that generally the engineering properties which improved with the addition of GGBS. The addition of GGBS resulted in a dramatic improvement within the test ranges covered in the programme. The maximum dry density increased and the optimum moisture content decreased with increasing GGBS content and at 25% we got the maximum value of dry density. [12]

IV. CONCLUSION

It can be seen from the study that WMP and WCP have positive effects on various properties of black cotton soil when replaced in a specific amount of admixtures. It was also observed from the study that there are very few investigations on the combined use of waste marble powder and waste ceramic powder for black cotton soil stabilization. Therefore, there is scope for combined use of WMP and WCP in black cotton soil.

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