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Utilization of Industrial and Agricultural Byproducts for Enhancement of Geotechnical Properties of Road Soil Subgrade

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Abstract – *Nowadays many experimental studies have been carried on black cotton soil to improve its characteristics. This soils is highly clayey in nature as it has low bearing capacity and high swelling shrinkage characteristics. In most of areas of India there is wide spread of black cotton soil which causes the problem to the civil related structures. This soil mainly shrinks in the absence of moisture and swells in the presence of moisture which may leads to the failure of engineering structures resting on it.*

On reviewing various past research works, it has been found that the utilization of admixtures such as fly ash, Rice husk ash, GGBS, WMP, WCP etc. may be used to increase the geotechnical properties of black cotton soil.

Now a day's rapid industrialization causes problems such as disposal of industrial waste materials, environmental pollution etc. In this review, utilization of industrial material is highlighted. On proper reviewing it has been found that there is a wide scope for utilization of industrial waste and other waste material for the stabilization of expansive soils.

Key Words: Marble waste powder, Ceramic waste powder, Black cotton soil, California Bearing Ratio, Stabilization, etc.

1. INTRODUCTION

Soil stabilization is a process of improving the properties of soil by improving its engineering properties. Expansive soils are the soils which swell significantly when comes in contact with water and shrinks when the water squeezes out. Because of this alternate swell and shrink behavior of the soil, damages occur to different civil engineering structures founded on them. The severity of damages done by expansive soil has been well documented in literature worldwide [17, 18 and 19]. There are number of techniques available to improve the engineering properties of expansive soil to make it suitable for construction. Stabilization of expansive soil using waste materials such as WMP and WCP which has binding properties

Disposal of industrial waste is important in now days because it causes the hazardous effect on environment. Utilization of industrial waste such as WMP and WCP used in stabilization of expansive soil. In recent studies research is mostly focus on achieving environmental and economical advantages.

Form various literature it has been found that limited research has been carried out on the effect of waste ceramic powder and waste marble powder on different geotechnical properties of expansive soil. Therefore 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 soil. The economy of stabilization has also been studied by strengthening the subgrade of a flexible pavement. [16]

1.1 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.[11]

1.2 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%. [12]

1.3 ETHYLENE PROPYELNE DIENE MONOMER (EDPM) RUBBER

EPDM rubber is used in seals for example; it is used in cold-room doors since it is an insulator, as well as in the face seals of industrial respirators in automotive paint spray environments. EPDM is also used in glass-run channels, radiators, garden, and appliance hose, tubing, pond liners, washers, belts, electrical insulation, vibrators, O-rings, solar panel heat collectors, and speaker cone surrounds.

It is also used as a medium for water resistance in electrical cable-jointing, roofing membranes (since it does not pollute the run-off rainwater, which is of vital importance for rainwater harvesting), geomembranes, rubber mechanical goods, plastic impact modification, thermoplastic, vulcanizes, and many other applications. Colored EPDM granules are mixed with polyurethane binders and toweled or sprayed onto concrete, asphalt, screenings, interlocking brick, wood, etc. to create a non-slip, soft, porous safety surface for wet-deck areas such as pool decks and as safety surfacing under playground play equipment (designed to help lessen fall injury)[13]

1.4 FLY ASH

Fly ash is the ash removed from the exhaust gas of burning coal at power plants to generate electricity. The ash is removed from the exhaust by air pollution control equipment such as electrostatic precipitators before the exhaust is emitted through stacks or chimneys into the atmosphere. Fly ash is also known as flue-ash, it is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. In an industrial context, fly ash usually refers to ash produced during combustion of coal.

Fly ash is classified into two classes as Class F fly ash: Fly ash normally produced by burning anthracite or bituminous coal, usually has been than 5% CaO. Class F fly ash has pozzolanic properties only. Class C fly ash: Fly ash normally produced by burning lignite or sub-bituminous coal. Some fly ash may have CaO content in excess of 10%. In addition to pozzolanic properties, class C fly ash also possesses cementations properties. [13]

1.5 GRANULAR BLAST FURNACE SLAG (GGBFS)

G.G.B.S means ground granulated blast furnace slag it is a waste product of industrial waste. It is extracted when the iron ore is heated up more than 80 million tons of industrial waste is released every year. The G.G.B.S contain (30% -50%) of CaO, (28% -38%) of SiO_2, (8% -24%) OF Al_2O and (1% -18%) of MgO.

G.G.B.S (Ground Granulated Blast Furnace Slag) it is a by-product of pig iron. This G.G.B.S is used in concrete as a binding agent. It contain chemicals like CaO, SiO2, MgO etc. [14]

1.6 COPPER SLAG

Copper slag is a by-product formed during the copper smelting process. Sulphuric acid recovered from the copper smelting process provides a cost-effective by-product and appreciably reduces the air pollution caused by the furnace exhaust.

Copper slag was collected from Srinivasa metallizers, Cherlapalli, Hyderabad. 10 kg of copper slag was used for conducting the experiments, which is passed through 600microns IS sieve was used in mix proportions of black cotton soil in the range of 0%, 10%, 20% and 30%.

It has been estimated that the production of one ton of blister copper generates 2.2 tons of slag. Birla Copper Industries at Dahej, Gujarat, produces roughly 0.5 million tons of copper slag per year and its captive thermal power plants produce 18,000 tons of fly ash per year. In addition, by mixing it with fly ash, it becomes suitable for embankment fill material. [15]

1.7 RICE HUSK ASH

RHA was collected from the Lalitha rice mill industries private limited, chowdariguda, near Ghatkesar, Telangana. Rice husk ash is used in the range of 2%, 4% and 6% mix proportions. Rice mill industry generates a huge amount of rice husk during milling of paddy that comes from the fields. Rice husk is used as fuel in the boilers for power generation and processing of paddy. Rice Husk Ash is about 25% by weight of rice husk when burnt in boilers. This RHA is a considerable environmental threat causing damage to the land and surrounding area on which it is discarded.

During paddy milling 78% by weight is received as rice, broken rice and rice bran and 22% by weight of paddy is received as husk. Rice mills use this husk as fuel to generate steam for the parboiling processes, which contains about 75% of organic volatile matter, and the remaining by 25% of the weight of this husk is converted into ash during the firing process, which is known as Rice Husk Ash. This RHA sequentially contains around 60% to 90% Silica. It is estimated that 1,000 kg of rice grain produces 200 kg of rice husk. On burning the rice husk, about 20% or 40 kg would become rice husk ash. [15]

2. LITERATURE REVIEW

2.1 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]

2.2 Ramoo Ram and Ravi Kant Pareek (2018)

The main objective of study is to investigate the use of waste marble dust in geotechnical applications and to evaluate the effect of marble dust on OMC & MDD and CBR values of unsaturated soil by carrying out standard Proctor test and CBR test on different soil sample.

The result obtained are compared for different percentage of marble dust and inferences are drawn for the bearing strength soil with different combination of marble dust. Soil stabilization can be explain as the increasing or maintaining the soil properties by physical and chemical alteration of soil to enhance their engineering properties. [2]

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]

2.4 Baser, O. (2009)

Expansive soil deposits occur in the arid and semi-arid region of the world and are problematic to the engineering structure because of tendency to heave during wet season and shrink during the dry season. Expansive soil causes more damages to the for civil engineers structures.

In this study, suitability of marble waste as a stabilizer for a swelling potential of an expansive soil was studied.

The addition of waste dolomitic marble to the expansive clay reduces the clay content and corresponding increase in the percentage of coarse particle, reduces the liquid limit and raise the shrinkage limit and reduces the plasticity index of soil and hence swelling potential. [4]

2.5 Rajbeer saini, Deepak Pathak, sumit shringi (2018)

The cohesive soils are widespread to the point that it ends up noticeably difficult to dodge them for roadway development. Numerous roadway offices, private associations and investigates are doing broad examinations on squander materials and research ventures concerning their attainability and ecological appropriateness. Swelling of far-reaching soils causes significant issues and delivers damage to many structures. Many research associations are doing broad work on squander materials concerning the feasibility and ecological reasonableness. Broad muds are the most dangerous soils because of their novel interchange swell-shrivel conduct with changes in dampness content. World over, many contextual investigations of fizzled structures based on extensive soils have been accounted for. The circumstance in India is additionally the same With broad scope of extensive soils that possess just about one-fifth of the geological land region. Suitable site conditions are not accessible wherever because of wide varieties in the subsoil uniquely the nearness of misleading soils represents a test to the structural designers.

The earlier ceramics were pottery objects made from clay, either by itself or mixed with other materials, hardened in fire. Later ceramics were glazed and fired to create a colored, smooth surface. The potters used to make glazed tiles with clay; hence the tiles are called as "ceramic tiles". The raw materials to form tile consist of clay minerals mined from the earth‟ s crust, natural minerals such as feldspar that are used to lower the firing temperature, and chemical additives for the shaping process. A lot of ceramic tiles wastage is produced during formation, transportation and placing of ceramic tiles. This wastage or scrap material is inorganic material and hazardous. Vitrified tiles are the latest and largest growing industry alternate for many tiling requirements across the globe with far superior properties compared to natural stones and other man made tiles. Hence its disposal is a problem which can be removed with the idea of utilizing it as an admixture to stabilization.

An ideal solution lies for reducing project cost, increasing longevity and reduce accumulation of waste shall be through utilization of industrial waste combined with weak soil for pavement construction. Few types of waste materials namely crusher dust, fly ash and tile waste are popular as admixtures in improving weak soils. From the available literature it is found that limited research has been done to study the effects of tile waste on different geotechnical properties of expansive soil. In the present study has been undertaken to investigate the effects of tile waste on index properties, compaction properties, soaked California Bearing Ratio (CBR) and swelling pressure of an expansive soil .The economy of stabilization has also been studied by strengthening the expansive soil subgrade of a flexible pavement. Thus use of ceramic waste not only improves the soil properties but problem of their disposal can also be solved. In the present study ceramic waste materials have been used to improve the properties of clayey soils and effect of ceramic dust on various soil properties have been evaluated. [5]

2.6 Sachin N. Bhavsar, Hiral B. Joshi, Priyanka K. Shrof, Patel Ankit J. (2014)

In this study, the effect of marble dust on expansive soil is evaluated. The evaluation involves the determination of the swelling potential of expansive soil in its natural state as well as when mixed with varying proportion of marble dust (from 0 to 30%). Addition of marble dust decreases liquid limit, plasticity index and shrinkage index, increase plastic limit and shrinkage limit. Also experimental results shows that the swelling percentage decreases and rate of swell increases with increasing percentage of marble dust in expansive soil for curing period of 7 and 28 days. The rate of swelling and swelling percentage of the stabilized specimens was affected by curing in a positive direction such that effectiveness of the stabilizer increases.

The black cotton soil contains high percentage of montomonillonite which renders high degree of expansiveness. These property results cracks in soil without any warning. The behaviour of black cotton soil is uncertain when subjected to moisture content. The strength properties of these soils change according to the amount of water contained in the voids of the soils.

The engineering behaviour of fine-grained soils depends on their water content. Liquid limit (WL) and plastic limit (WP) are important water contents as well as two important parameters of plasticity index (PI), which is the main index parameter of the classification of fine- grained soils. Plasticity index has also been used in correlation with many other engineering properties like internal friction angle, undrained shear strength, lateral earth pressure over consolidation ratio etc. Shrinkage limit (SL) is also an important parameter in which soils tend to shrink when they lose moisture. [6]

2.7 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, Expansive 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 stabilization 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. [7]

2.8 Dr. K. RaviKumar Sharma and Chayan Gupta (2013)

Rapid growth of industrialization produces hazardous waste material at large extent. If there is any fault in disposal process of waste materials then they act as a pollutant and also affect the ecological system of environment. It shows that there is argent need of exploring the alternative of disposal of these materials. In current practice, these waste material may be good alternative as a construction materials. This paper shows the influence of waste materials such as Beas river sand, Fly ash on compaction, and Strength characteristics of black cotton soil. The utilization of these materials have measurable advantages on the economy as well as the strength when used as construction materials.

In infrastructure projects like pavements, hydraulic structures, embankments etc. and reduces the impact on the environments. [8]

2.9 Mrs. Vrunda Sule1, Vyas Brinda2, Chauhan Vandana3, Khilji Sohel4 (2018)

Expansive soil is 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 subgrade problem. Design of various layers of pavement is dependent upon the strength of the subgrade soil over which layer of pavement are going to be laid. Strength of subgrade mainly expressed in CBR. Soil stabilization is an effective method for improvement of soil properties and pavement system. Black cotton soil mainly stabilizing using fly ash, lime and cement. Some agricultural wastes are also used, but they can't be used be use as a single stabilization. The project is an attempt to improve the cbr value and properties of soil using locally available materials on order to effectively laying of road pavement and increase strength of the road pavement economically. [9]

2.10 Monica Malhotra and Sanjeev Naval (2013)

For any structure, The foundation is very important and it has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very critical role. To work on soils, we need to have proper knowledge about their properties and factors affect their behavior.

Expansive soils always create problems more for lightly loaded structures than moderately loaded structures. By consolidating under load and changing volumetrically along with seasonal moisture Variation, these problems are manifested through swelling, shrinkage and unequal settlement.

In this paper the experimental results obtained in the laboratory on expensive soils treated with low cost materials (lime and fly ash) are presented. A study is carried out to check improvement in the properties of expansive soils with fly ash and lime in varying percentages. The test results such as Liquid limit, standard proctor compaction and differential free swelling test obtained on expansive clays mixed at different proportion of lime and fly ash admixture are presented and discussed in this Paper. The result shows that the stabilized clay has lesser swelling potential whereas increase in optimum moisture content has been observed. [10]

3. CONCLUSIONS

From the study it can be observed that WMP and WCP have positive effects on various properties of Black cotton soil when replaced at a specific quantity. From study it was also observed that there are very less investigations on use of Waste Marble Powder and Waste Ceramic Powder jointly for Black Cotton Soil Stabilization. Therefore, there is a scope for joint utilization of WMP and WCP in Black Cotton Soil.

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