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Review on Stability and Strength of the Sub Base Layers by Using Waste Materials

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ABSTRACT

Pavement structures rely heavily on the stability and strength of the sub-base and base layers. The performance and longevity of these structures can be significantly enhanced through the stabilization of the underlying soils. Black cotton soil, prevalent in India, is characterized by its porous and fragile nature, making it less suitable for construction without treatment. This project focuses on improving the engineering properties of red soil through stabilization techniques, ultimately aiming to determine the optimal pavement thickness for stabilized black cotton soil. The experimental investigations aimed to evaluate the effect of adding fly ash and construction demolition (C&D) waste to clayey soil, focusing on their impact on soil stabilization properties. Various tests, including liquid limit tests, standard compaction tests California bearing ratio (CBR) tests, were conducted with different proportions of fly ash and C&D waste added to the soil.

Keywords: Black cotton soil, Fly ash, California bearing ratio, Liquid limit tests, Standard compaction tests

Introduction

Used for soil stabilization, some notable options include fly ash, blast furnace slag, rice husk ash, and waste rubber tires. These materials not only enhance the engineering properties of soil but also contribute to sustainable construction practices by repurposing industrial by-products and reducing environmental impact. Here's a brief overview of these waste materials and their applications in soil stabilization:

A by-product of coal combustion in power plants, fly ash is rich in silica and alumina, which help to increase the strength and durability of soil. It improves the load-bearing capacity, reduces permeability, and minimizes the shrink-swell potential of expansive soils.

Each of these materials can be used individually or in combination to address specific soil stabilization needs. The choice of material depends on the local availability, soil type, and the specific requirements of the construction project. The use of waste materials in soil stabilization not only enhances the engineering properties of the soil but also supports environmental sustainability by recycling industrial waste.

Vipul Kerni et al. (2015) Soil stabilization may be defined as the process of changing soil engineering properties to improve the bearing capacity and durability property of weak soil. The aim of the study was to review on stabilization of clayey soil using demolished waste material. Various methods are available for stabilizing clayey soil. These methods include stabilization with chemical additives, soil replacement, compaction control, moisture control and thermal methods. All these methods may have the disadvantages of being ineffective and expensive. Based on literature fines obtained from demolished waste is a low cost and effective soil stabilization method.

Shish Pal et al. (2015) There is a rapid increase in generation of waste plastics all around the world due to Economic Growth, Changing Consumption and Production Patterns. The world's annual consumption of plastic materials has increased from around 5 million tonnes in the 1950s to nearly 100 million tonnes. Thus, presently 20 times more plastic is produced as compared to 50 years ago. So, with this, more and more resources are being used to meet the increased demand of plastics, which results in higher generation of plastic waste. Due to extremely long periods required for natural decomposition, waste plastic is often the most visible component in waste dumps and open landfills. Plastic waste recycling can provide an opportunity to collect and dispose off, plastic waste in the most environmental friendly way and conversely, it can be converted into a resource.

Due to growing concern about the disposal off plastic waste, and the panic in the current environmentalist, the object of this thesis was chosen as "Soil Stabilisation Using Polypropylene as Waste Fibre Material" which is one of the type of the plastic waste.

Pramod S. Patil (Jun-2014) Disposal of plastic waste in an environment is considered to be a big problem due to its very low biodegradability and presence in large quantities. In recent time use of such, Industrial wastes from polypropylene (PP) and polyethylene terephthalate (PET) were studied as alternative replacements of a part of the conventional aggregates of concrete. Plastic recycling was taking place on a significant scale in an India. As much as 60 %

of both industrial and urban plastic waste is recycled which obtained from various sources. People in India have released plastic wastes on large scale have huge economic value, as a result of this, recycling of waste plastics plays a major role in providing employment.

Ghatge Sandeep Hambirao et al.; (Feb-2014) Construction of engineering structures on weak or soft soil is considered as unsafe. Improvement of load bearing capacity of the soil may be undertaken by a variety of ground improvement techniques. In the present investigation, shredded rubber from waste has been chosen as the reinforcement material and cement as binding agent which was randomly included into the soil at three different percentages of fibre content, i.e. 5% 10% and 15% by weight of soil. The investigation has been focused on the strength behaviour of soil reinforced with randomly included shredded rubber fibre. The samples were subjected to California bearing ratio and unconfined compression tests. The tests have clearly shown a significant improvement in the shear strength and bearing capacity parameters of the studied soil.

N.Vijaya Kumar et al.; (Jan-2014) A lot of waste is produced by industries and they are piled up on land which creates land and environmental problem. Government policies and regulations force us to look for alternatives. Therefore researchers are trying to utilize these wastes as reinforcement in composites. Slag is an industrial waste reinforced in polypropylene composites. The pin-on disc wear testing machine has been used to study the friction and wear behaviour of the polymer composites. The wear loss and coefficient of friction are plotted against the normal loads and sliding velocities. It is observed from the graphical representation of the result that with the increase in load weight loss decreases and increase in sliding velocity weight loss also increases.

Rifai et al. (2014) Studied the effect of volcanic ash utilization as substitution material for soil stabilization in the view point of Geo-environment. They studied the engineering properties of soil mixture, the effect of volcanic ash content and its finest level. The fineness of volcanic ash is a prime factor in the stabilization. Utilization of volcanic ash with grain size passing sieve no 270 is more effective. The study revealed that the volcanic ash content can improve the engineering properties of soft soil, change the grain size distribution curve by decreasing the fine fraction, decreases the consistency limits and become non plastic soil, increases the bearing capacity and decreases swelling potential.

Edeh et al. (2014**)** Conducted laboratory evaluation of the characteristics of lateritic soil stabilized with sawdust ash. The tests performed were unconfined compressive strength and California bearing ratio (CBR). The results of laboratory tests shows that the properties of lateritic soil improved when stabilized with sawdust ash (SDA).

Miss Apurva J Chavan (Apr-2013) Disposal of waste materials including waste plastic bags has become a serious problem and waste plastics are burnt for apparent disposal which cause environmental pollution. Utilization of waste plastic bags in bituminous mixes has proved that these enhance the properties of mix in addition to solving disposal problems. Plastic waste which is cleaned is cut into a size such that it passes through 2-3mm sieve using shredding machine. The aggregate mix is heated and the plastic is effectively coated over the aggregate. This plastic waste coated aggregate is mixed with hot bitumen and the resulted mix is used for road construction. The use of the innovative technology will not only strengthen the road construction but also increase the road life as well as will help to improve the environment. Plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes.

Ibtisam Kamal et al (Oct 2017**)** The recent work deals with using demolishing concrete waste as coarse aggregate in concrete for the purpose of reduction the natural resource exploitation and associated costs, as well as minimization waste landfill. A 2-operating parameter central composite design (with 2*2=4 factorial points, 2*2 star-points and 2 repetitions of central point) was adopted to optimize and model the impact of demolition aggregate content (8.6-86.4) wt.%, and water/cement ratio (0.43-0.57) for concrete contain demolishing components as coarse aggregate on compressive strength and density. Water absorption characteristics were also investigated. Conventional concrete specimens were prepared and tested for comparison purposes. The results obtained confirmed that the incorporation of the demolition aggregate resulted in decreasing concrete density and water absorption capacity. The model analysis results approved that concrete with lower density and water absorption, and superior compressive strength of 49.70MPa could be manufactured using demolishing concrete as coarse aggregate up to 49.3 (wt. %) at water/cement ratio 0.49.

Dr. Ramakrishna Hegde et al (june 2018) In this studied work, we have collected the demolition waste from our college work site where the column in the top floor of our college building was demolished for the purpose of renovation. The demolished column is of M20 grade concrete and the age of concrete is 10 years. Construction of any concrete structures requires huge amount of natural coarse aggregate. So by using the demolition waste, we can reduce the cost o purchasing natural coarse aggregate. Our project deals with replacing of coarse aggregate by demolished column waste in various proportions of 10,20,30,40,50 and 100. Cubes, cylinder, beams were casted for different mix proportions and kept curing for 7, 14and28 days. After the curing the cubes, cylinder and beams were tested to find the compressive strength, split tensile strength and flexural strength of concrete. The results were discussed and conclusions were made accordingly.

Alessandra Mobili et al (june 2018) Aggregates were also partially substituted by their fines at 12.5% by volume. Mortars have been tested in terms of mechanical, microstructural, and durability properties. Results show that it is feasible to replace a natural calcareous aggregate entirely by recycled aggregates. In particular, the obtained mortars, even if more porous and more prone to the water capillary absorption than that manufactured with natural aggregates, result in less stiffness and thus are less subjected to crack formation, more permeable to water vapor, and less susceptible to sulphate attack.

S.P.Kanniyappan et al (2019) Long term performance of pavement structures depends on the stability of sub-base and base soil. Stabilization of sub-base and base soil improves its properties and strength. Red soil is the third largest soil group in India and it possess lower strength compared to other soil due to its porous and fragile structure and it has a higher swelling capacity, thereby it requires stabilization. Red soil stabilization is usually done using lime, fly ash, granulated blast slag etc., of which construction & demolition waste is the major factor. This project aims to study the engineering properties of

red soil & to determine the pavement thickness. The debris is added in varying percentage to the soil & the CBR value is calculated. The variation in CBR value may result in the reduction of pavement thickness.

Vipul Kerni et al (2022) soil stabilization is one of the primary and major processes in the construction of any highway. The aim of this paper is to evaluate the utilization of fines (passing 1.18 mm IS sieve) obtained from demolished concrete structures in subgrade soil stabilization. The evaluation involved the determination of the California Bearing Ratio (CBR) value of the clay soil in its natural state as well as when mixed with different proportion of fines. Results showed that the CBR (both Uncooked and Soaked) value of the clay soil is improved substantially by the addition of fines and the highest CBR value was achieved at 10% fines.

Vinod Kumar Reddy et al (2022) Stabilization of soil is the process by which the soil properties can be modified to meet the requirements. Clay soil has a very high swell index which leads to improper settlement of roads and footings. Improvement of strength and subgrade characteristics of soil by stabilization is one of the popular techniques nowadays. Construction demolition waste in soil stabilization is still under research as much work has not been done in this area. This paper presents a comparative study of utilization of C&D waste in soil stabilization. The results showed that with increase in the content of C&D waste, the reaction between water and C&D waste is enhanced, OMC and MDD are yielded to better results at 8% of C&D. In this process, UCS and CBR were increased whereas plastic limit doesn't show any significant changes. And liquid limit was reduced at 5% and becomes more or less the same with increase in C&D content. It was concluded that using C&D was helpful in improving the soil properties up to 8% C&D and declines with increase in C&D waste.

After critically studying the literature review followings gaps are drawn:

a) A number of research work have been reported for the use of waste demolished fines and the waste fiber materials separately but they can be used as a composite material to enhance the properties of the soil such as soil bearing capacity, shear strength of the soil and or unconfined compressive strength of the soil, which is identified as a major gap from the various papers as listed above.

b) As the current annual rate of generation of construction and demolition waste in India is estimated to 11.4 to 14.69 tons. These statics shows that there is a need to reuse these construction and demolition wastes.

c) Coarser fraction obtained from construction and demolition waste finds their application in improvement of soil bearing capacity and or pavement construction, but the finer material is being left out still as waste material.

d) Extensive research work is reported on use of oriented and randomly oriented fiber reinforcements using laboratory testing, while this brought out the positive improvement of geotechnical behavior of soils. However, little work reports on the use of waste fiber polypropylene materials.

e) The overview has brought out the need for systematic investigations into the various aspects of reinforcement in particular considering the influence of types of waste fiber inclusions.

f) The majority of works carried out in the field of sub-base or base improvements of the various types of pavements using coir geotextiles to control erosion and watershed management. Only a few works have been reported regarding the utilization of polypropylene for the improvement of engineering properties of soil. Therefore, a scope of systematic research work in this area is lacking.

METHODOLOGY

Laboratory tests were conducted to evaluate the effects of fine admixtures on clayey soil samples. These tests aimed to determine changes in Atterberg limits, maximum dry density, optimum water content, and California Bearing Ratio (CBR) values for both untreated (virgin) clayey soil and clayey soil mixed with varying percentages of fines.

Atterberg Limits: The addition of fines generally resulted in changes to the liquid limit, plastic limit, and plasticity index, reflecting variations in the soil's consistency and plasticity with different percentages of fines.

Compaction Characteristics: Variations in MDD and OWC were observed with different percentages of fines, indicating how fines influence the compaction behavior of clayey soil.

CBR Values: The CBR values varied with the percentage of fines, demonstrating the impact of fines on the load-bearing capacity of the soil. The laboratory investigations reveal that the addition of fines to clayey soil significantly affects its geotechnical properties. The results indicate that by adjusting the percentage of fines, the soil's plasticity, compaction characteristics, and strength can be modified, which is crucial for applications in civil engineering and construction.

CONCLUSION

The study concludes that the appropriate addition of fly ash and construction demolition waste can effectively stabilize clayey soil, enhancing its suitability for construction purposes. The improvements in strength, reduced permeability, and increased bearing capacity demonstrate the potential for these waste

materials to be used in sustainable construction practices. However, careful proportioning is crucial to achieving the desired soil properties without compromising its structural integrity.

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