Utilization of Industrial Waste Spent Wash in Eco-Friendly Road Construction

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Abstract - Road transport plays vital role in development of country. Developing a good network of road in villages in India is a challenging problem as it needs stabilization of sub grade and sub base with economical option. Spent wash is distillery waste product of sugar industry and harmful if not properly treated and dispersed in water. The present study deals with the study of effect of mixing spent wash in water on index properties of black cotton soil. It can be economical and environment friendly replacement option to water with improvement in index properties of black cotton soil.

Key Words: Black cotton soil, Index properties, Road construction, Spent wash

1. INTRODUCTION

Roads are crucial for a country's development and transportation system, with factors such as pavement type, subsoil layers, and local soil properties influencing pavement quality. To minimize costs, it is essential to modify local soil properties for road construction. This study aims to study the properties of spent wash for improving soil properties for road construction. Industrial waste, such as waste water from distilleries, can be used safely to increase soil productivity and address disposal issues. Organic matter can improve soil fertility, but large amounts may have adverse effects on soil health. Nutrients in effluents irrigation may be more effective in bioavailability than synthetic inorganic fertilizers. India, the world's largest sugar consumer, is the second largest producer of sugar due to industrialization. The effectiveness of using spent wash for soil stabilization has been studied and discussed in this paper.

2. Literature Reviews

The following section provides a comprehensive review of relevant literature that has informed this research paper. The review encompasses a selection of key research studies and articles that delve into the various aspects of the topic at hand. By examining these studies, we can gain a deeper understanding of the current state of research, identify existing trends and methodologies, and pinpoint any gaps or opportunities for further exploration. This literature review serves as the foundation for the analysis and discussions that follow, offering insights into the collective knowledge generated by scholars in this field.

2.1 C.V.Naik, "Uses of spent wash to improve soil properties for road construction", Volume 9, IJCIET,(2023)

Rice husk ash is a locally available material that has been successfully used for road construction. It can be stabilized with different percentages of rice husk ash and cement, reducing the cost of soil stabilization. Fly ash is also used to make black cotton soil less plastic and increase its workability. Rapid industrialization has led to pollution of surface and ground water, which is influenced by the interactions between sugar industry effluents, soil, and moisture.
A study on distillery spent wash in concrete found that its widespread use saves cement, improves concrete mix quality, and solves ecological problems. Cane molasses is used for stabilizing expansive soil, increasing its CBR values and reducing swelling tendencies. Sub base stabilization with lime and industrial waste mixes improves the strength behaviour of sub base soil. Elias (2015) investigated the effect of paper sludge on soil strength development in geotechnical applications, finding that the addition of waste paper sludge increased soil strength. Distillery spent wash, the unwanted residual liquid waste generated during alcohol production, is a critical environmental issue. Untreated or partially treated effluent often finds access to water courses, posing a serious threat to water quality in neighbouring water bodies. Clean and potable water is used for testing road pavements

2.2 Ranjeet Kadam, "Ecofriendly road construction by using industrial waste spent wash", Volume 5, International general of advance research in civil and structural engineering (2022)

The study examines the flow rectification performance of 3-D flat-walled diffuser elements, which are used in valve-less micro pumps. Simulations are conducted to study the effect of diffuser length on flow characteristics and fluidic toxicity, with the results revealing that diffuser length significantly influences flow rectification.

Industrial waste, often discharged on land or into water bodies, has gained attention for its potential to be reused for agricultural purposes. Waste water generated from distilleries

can provide a valuable source of plant nutrients but also contains high amounts of organic and inorganic materials and toxic trace elements. These elements can accumulate in soil and cause physical problems for humans and animals by entering food chains. However, industrial waste water can be safely used with proper precautions to increase soil productivity. The addition of organic matter can improve soil fertility, but it is feared that large amounts of organic matter may negatively affect soil health by increasing CO2 and temperature. Nutrients in the form of effluents irrigations may be more effective in bioavailability of nutrients to plants than synthetic inorganic fertilizers. India, the world's largest sugar consumer and second-largest producer, produces large quantities of waste due to large industrialization, which are hazardous for agriculture, aqua life, and human health. The cost of treating such wastes is higher, so minimizing these problems should be a priority. This paper discusses the effectiveness of using spent wash for soil stabilization, testing black cotton soil with 0, 5, 10, and 15% replacement of water by spent wash. The results show that contaminated water is harmful to aquatic life and humans, with higher pH, hardness, and turbidity compared to potable water. The liquid limit for black cotton soil increases with increased percentage of spent wash, shrinkage limit decreases, and consistency limit increases. Replacing water by 5% spent wash becomes economically viable.

2.3 R. J. Salunkhe, "Eco-friendly Road Construction by Using Industrial Waste (Spent Wash)",volume 2, Tecno-Scocital (2022)

Soil stabilization is a significant issue in construction engineering, and research on the effectiveness of using industrial wastes is increasing. This experimental work explores the suitability of locally available Rice Husk Ash (RHA) for local construction to minimize environmental pollution and cost. The soil sample used is clay with high plasticity, which requires strengthening. RHA is stabilized with different percentages of RHA and a small amount of cement, observing changes in soil properties such as Maximum Dry Density (MDD), Optimum Moisture Content (OMC), California Bearing Ratio (CBR), and Unconfined Compression Stress (UCS).
Results show that increasing RHA content increases OMC but decreases MDD. The CBR value and UCS of soil are considerably improved with RHA content. The optimum amount for practical purposes is 10% RHA with 6% cement. The soil stabilization technique is recommended for pavement construction.
Various methods are adapted to improve the engineering characteristics of expansive soils, such as replacing problematic soils with better quality material or using additives. In this study, black cotton was stabilized using fly ash from a koradi thermal power plant. The plasticity index of clay fly ash mixes decreased with an increase in fly ash content, making expansive soil less plastic and increasing its workability. The CBR values of clay with fly ash mixes were tested under unsoaked and soaked conditions, and the results showed that fly ash has potential as an additive for improving expansive soil engineering properties.

2.4 Rushikesh Pawar, "Soil stabilization of road by using spent wash", Volume 10, Issue 6, June 2021 ISSN 2319 – 48

Rice husk ash is a locally available material that has been successfully used for road construction, making soil stabilization cost-effective. The addition of fly ash to black cotton soil reduces plasticity and increases its workability. Rapid industrialization has polluted surface and groundwater, affecting water quality due to the production of glucose, fructose, alcohol, and acetic acid. Distillery spent wash in concrete has been found to improve the quality of concrete mixes and solve ecological problems. Cane molasses was used for soil stabilization, increasing CBR values and reducing swelling tendencies. Sub base stabilization with lime and industrial waste mixes improved the strength behaviour of sub base. Elias (2015) investigated the effect of paper sludge on soft soil strength development and found that the addition of waste paper sludge increased soil strength. The experimental study concluded that 5% and 15% spent wash with water are effective for stabilizing black cotton soil and murum, respectively. The plastic limit and liquid limit for black cotton soil increase with an increase in the percentage of spent wash. Shrinkage limit decreases with an increase in the percentage of spent wash, and consistency limit increases with an increase in the percentage of spent wash. The optimum moisture content and maximum dry density are improved. Spent wash contaminated water is harmful for aquatic life and humans as it can lead to pH imbalances. Future research should focus on further investigation into the use of spent wash with water for soil stabilization and its potential environmental benefits.

2.5 M.ADAMS JOE, "Soil stabilization using industrial waste and lime", ISSN 227 – 0882 Volume 4, Issue 7, July 2015

The sub-base is a crucial layer in both flexible and rigid pavements, acting as a structural layer to spread wheel loads and provide a good working platform for other paving materials. It can also act as a drainage layer. The selection of material and design of the sub-base depends on the specific design function and expected moisture conditions. Stabilised sub-bases can be used for both flexible and rigid road pavements, providing greater load spreading ability, reduced stresses, and increased structural rigidity. Indian Resource Council materials have been successfully used in stabilized base and sub base applications as binder, pozzolanic material admixture, or both fine and coarse aggregate. Slag materials have also been used. A study found

that using lime and industrial waste as a stabilizing agent increases the unconfined compressive strength value more than ordinary methods, potentially reducing ground improvement costs. Slag cement can be used as the binder for stabilized base and sub base layers, while air-cooled blast furnace slag has been used as fine aggregate. Other Indian Resource Council materials used in stabilized base applications include industrial waste sand as a fine aggregate and crushed concrete for both coarse and fine aggregate. Recycling concrete keeps high-quality natural aggregates in use and reduces project costs by eliminating transportation costs associated with removing old concrete. The use of Indian Resource Council materials as aggregates in high volume applications like base and sub base layers reduces the need for mining virgin aggregate, water, fuel, carbon dioxide emissions, and landfill space.

2.6 Dr. E. Ravi, " Study on Effect of Molasses on Strength of Soil" (IJARTET) Vol. 2, Issue 2, February 2015

The study investigates the use of molasses as an unconventional liquid soil stabilizer to enhance the shear strength and CBR value of two types of fine-grained soils. The experimental variables included soil type, molasses amount, and treatment duration. Results showed a significant increase in unconfined compressive strength and CBR values with the use of molasses. The unconfined compressive strength increased with an increment ratio of 1.57-2.01 for both types, while the CBR value increased with an increment ratio of 2-3.5.

2.7 Aparna Roy, "Soil Stabilization using Rice Husk Ash and Cement", International Journal of Civil Engineering Research, ISSN 2278-3652 Volume 5, Number 1 (2014).

This study investigates the geotechnical properties of soil samples collected from Burdwan, West Bengal, India. The soil samples were classified as Clay with high plasticity (CH) in the IS Soil Classification System. Laboratory tests were conducted on the natural soil, including particle size distribution, Atterberg limits, Compaction, CBR, and UCS. The geotechnical properties were determined in accordance with the Indian Standard [8]. Specimen for Unconfined compressive strength (UCS) and California bearing ratio (CBR) tests were prepared at the Optimum moisture contents (OMC) and Maximum dry densities (MDD).

In the second phase, three different percentages of RHA (Round-Hole Ash) were mixed with soil in three different tests, with 6% cement mixed to achieve adequate cementation property. The variations of MDD and OMC with RHA contents mixed with soil and 6% cement are shown in Figure 1 and Figure 2, respectively. The MDD decreases while the OMC increases with increased RHA content, which is used in pavement design and evaluating the strength of stabilized soils. The variation of CBR with increase in RHA from 10 to 20% mixed with soil and 6% cement is shown in Figure 3. For unsoaked samples, the CBR value increases by 106% for RHA content of 10%. However, the CBR value slightly decreases for RHA content of 15%, possibly due to the gradual formation of cementitious compounds in the soil due to the reaction between RHA and some amounts of CaOH present in the soil and cement.

2.8 G. K. ARUNVIVEK, " EXPERIMENTAL STUDY ON PLASTICIZING EFFECTS OF DISTILLERY SPENTWASH IN CONCRETE",volume ,2013

A strategy using distillery spent wash as admixture in concrete is presented in this paper. The properties of fresh and hardened concrete made with distillery spent wash are presented and discussed. Proportions of 0-1.25% of distillery spent wash were added in concrete specimen, for the purpose of experimentation concrete mixes were designed for M20 grade. The compressive and flexural tests were conducted to study the strength, slump cone and compaction factor tests were conducted to study the workability of concrete using distillery spent wash. The results indicated that the distillery spent wash in concrete is a viable and effective reuse option, in particular when used in proportions of 0.75% addition.

2.9 Monica Malhotra and Sanjeev Nava, "Stabilization of Expansive Soils Using Low Cost Materials", International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 11, May 2013.

Soil stabilization is crucial for achieving engineering specifications, but it can be expensive for developing nations. The best way to implement this is to use locally available materials with affordable costs. Soil stabilization improves engineering properties such as strength, volume stability, and durability. The addition of fine and coarse fly ash to stabilized black cotton soil improves its strength and moisture-density relationship. The peak strength of fine fly ash mixture is 25% higher than coarse fly ash.

Addition of lime and class C fly ash to highly plastic clay reduces shrinkage with increasing additive percentages. Lime arrests shrinkage at almost twice the rate of class C fly ash, and the rate of arrest slows as the amount of additive increases. The thickness of pavement decreases by 66% as the CBR value increases. The improved CBR value is due to the addition of lime and fly ash as admixtures to BC soil, reducing hydraulic conductivity and eliminating the need for a drainage layer.

This paper presents the results of an experimental study on expansive soil stabilization with fly ash and lime. The clayey soil was mixed with 5% lime and varying percentages of fly ash

to see the effect on swelling aspect, optimum moisture content, and modified dry density. The swelling potential, optimum moisture content, and liquid limit decrease with an increase in fly ash content from 5% to 25%.

2.10 J.K.M.Nadegwa , "The effect of cane molasses on streangth of expansive clay soil", Journal of emerging trends in engineering and applied sciences , 1 December 2011

This study investigates the stabilization mechanism of expansive soil with cane molasses for engineering purposes. The main goal is to determine if sugar cane molasses can be used as a stabilizing agent for expansive clay soil. The study analyzes cane molasses and assesses the strength of neat expansive soil and expansive soil mixed with cane molasses using California bearing ratio (CBR). The results show that 8% cane molasses is the maximum effective stabilizer for expansive clay soil. Lime stabilized soil specimens showed higher CBR values than cane molasses. The study concludes that the increase in CBR values for expansive soil mixed with cane molasses indicates that it increases soil strength and stabilizes expansive clay soil. Additionally, cane molasses mixed with expansive clay soil can reduce soil swelling tendencies.

2.11 Arunvivek GK, Saravanakumar R, Senthilkumar M, Logesh Kumar M (2013) Experimental study on plasticizing effects of distillery Spent wash in concrete. Int J Civ Struct Environment Infrastructure Eng Res Dev (IJCSEIERD) 3(5). ISSN (P): 2249-6866; ISSN (E): 2249-7978

The study tested the use of distillery spent wash as a super plasticizer in concrete at various dosages. The spent wash was collected from Salem co-operative sugar mills Ltd in Tamil Nadu. The study found that the pH value of the spent wash was 4.83, which is acidic. Proper treatment is required for the material before using it as a super plasticizer. Adding adsorbent like activated charcoal can improve the quality of the spent wash. Reducing water content from the reference mix and adding distillery spent wash significantly increases workability and strength without excess cement. The properties of spent wash become similar to known super plasticizers, saving cement, improving concrete mixture quality, and solving ecological problems.

2.12 Adams Joe M, Maria Rajesh A (2015) Soil stabilization using industrial waste and lime. Int J Sci Res Eng Technol (IJSRET) 4(7). ISSN 2278 – 0882

The project deals with stabilization of soil using industrial waste. Unsuitable highway sub grade soil requires stabilization to improve its properties. Industrial waste sand is used as raw materials when the sand can no longer be reused in the industry, it is removed from the industry and is removed from the industry and is termed as industrial waste sand. Ingredients used are Copper slag, cement and lime. Copper slag is a byproduct of Copper industry Lime was bought from locally available chemical laboratories. The project are planned to conduct various experiment like Specific gravity, sieve analysis, proctor compaction test, unconfined compressive strength and CBR test to increase strength properties and behavior of sub base. Then the results and graphs of various mixes are compared to see their effects in sub base stabilization. The stabilization technique has an additional benefit of providing an environment friendly way to deal with industrial waste sand.

2.13 Malhotra M, Nava S (2013) Stabilization of expansive soils using low cost materials. Int J Eng Innov Technol (IJEIT) 2(11)

Industrial waste sand, a byproduct of the metal casting industry, is a high-quality silica sand with unique engineering properties. It is typically recycled and reused in modern foundry practices, with four to seven million tons discarded annually. This project conducted experiments to determine the stabilization of sub bases using industrial waste and cement, using ASTM procedures such as Liquid Limit, Plastic Limit, Sieve Analysis, Specific Gravity, Standard Proctor Compaction Test, Unconfined Compressive Strength, and California Bearing Ratio Test. These tests help classify soils and determine their plasticity index. The project also used sieve analysis to assess the particle size distribution of granular materials.

2.14 Arockiadoss T (2012) Green cement for sustainable construction. United States patent application publication pub. No.: us 2012/0145043 a1 pub. Date: Jun. 14, 2012. Sens Actuators A: Phys 113(2):226–235 (2004)

Green" cements, which can be carbon neutral or negative, can be prepared at lower temperatures (450° C.-500° C.) by utilizing feed compositions comprising (i) TiO_2, TaO_xN_y, TiO_xN_y, RuO_2, Pt, TaO, band gap materials, or a first mixture thereof; (ii) Al_2O_3; and (iii) Ca_2SiO_4, $MgSiO_2$, $MnSiO_2$, or a second mixture thereof; and spent wash with melanoidin as a binder.

2.15 Combined Effect of Marble Dust and Waste Paper Sludge in Improving Engineering Properties of Black-cotton Soil of Gelan Area, Ethiopia Dereje Kebede a , Afzal Khan a* , Argaw Asha a and Chimdi Gedfa Benti

The study investigates the stabilization of black-cotton soil in construction sites in Gelan, Ethiopia, using the combined effects of marble dust and waste paper sludge. Standard compaction and unconfined compressive strength tests were conducted by mixing black-cotton soil with waste paper sludge of 5, 10, and 15% by mass of soil. The optimum blend was

found to be 5% waste paper sludge with 30% marble dust, resulting in significant improvements in soil plasticity, swelling, and strength characteristics.

Various studies have shown that replacing soil with marble dust of different percentages can improve swelling and linear shrinkage properties of black-cotton soil. The plastic index reduced from 26.1 to 18.14% for 50% of marble dust, and the dry density increased. Linear shrinkage also decreased with the increasing amount of marble.

Waste paper sludge (WPS) has been found to have a positive effect on the strength of clay soil. The liquid limit and plasticity index were reduced, and the differential swelling index was reduced. The Stabilization of Black-cotton Soil by WPS resulted in a reduction of plasticity index from 43.52% to 11.82%.

3. CONCLUSIONS

1. Plastic Limit and Liquid Limit Increase:

The plastic limit and liquid limit are measures of soil consistency. An increase in these limits indicates that black cotton soil becomes more malleable and retains more moisture with higher percentages of spent wash. This leads to enhanced workability during road construction, providing more flexibility in compaction and laying processes.

2. Consistency Limit Increase:

Consistency limits, which include plasticity and liquidity limits, reflect the moisture content at which soil transitions from a solid to a plastic or fluid state. Increased consistency limits suggest that the spent wash enhances soil's resistance to deformation, contributing to greater stability and resilience in road applications.

3. Improved Optimum Moisture Content (OMC) and Maximum Dry Density (MDD):

The OMC and MDD are critical factors in determining the optimal conditions for soil compaction. Improved OMC indicates that the soil can be compacted at higher moisture levels, while increased MDD suggests greater compaction density. Both improvements result in stronger and more durable roadbeds.

4. California Bearing Ratio (CBR) Increase:

The California Bearing Ratio is a standard test to assess soil's load-bearing capacity. An increase in CBR implies that soil mixed with spent wash can withstand greater pressure, making it more suitable for road construction and reducing the need for additional reinforcement.

5. Increased Consistency Limit:

This aligns with the first conclusion, where the increased consistency limit highlights the soil's enhanced resistance to deformation under varying moisture conditions. This benefit improves the soil's stability and durability for road use.

6. Decreased Void Ratio:

A lower void ratio indicates fewer air pockets within the soil structure, leading to denser soil compaction. This reduction in void ratio contributes to the soil's improved load-bearing capacity, reducing the risk of soil settlement and providing a more stable base for road construction.

7. Overall Strength Increase:

The combination of increased CBR, reduced void ratio, and improved consistency limits results in a more robust soil structure. The overall strength increase indicates that the soil mixed with spent wash can better endure road traffic and environmental stresses.

8. Overall Settlement Decrease:

Reduced settlement is critical in road construction to prevent uneven surfaces and structural failures. A decrease in settlement suggests that the spent wash addition provides a more stable base, lowering the risk of road deformation over time and improving the longevity of the constructed roads.

Together, these conclusions highlight the benefits of using spent wash industrial waste in road construction, emphasizing enhanced soil stability, durability, and performance.

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