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STABILIZATION OF SOIL SUBGRADE BY SODIUM LIGNOSULFONATE AND MARBLE DUST: A REVIEW

E. Sree Keerthana[1], U. Siva Rama Krishna[2]
[1]*PG Scholar, Transportation Engineering, GMR Institute of Technology-Rajam, Andhra Pradesh, India.*
[2]*Asst. Professor, Dept. of Civil Engineering, GMR Institute of Technology-Rajam, Andhra Pradesh, India.*

ABSTRACT
The waste materials in the construction industry have risen exponentially., but the disposal of waste materials has become problematic in nature as it alters the environmental changes. In view of environment, Researchers started focusing on this usage of waste materials. Later, this waste materials are incorporated in soil and got succeeded in getting the effective results. This method of incorporation of materials in soil is known as soil stabilization which enriches the qualities of the soil and also enhances the engineering properties like stability, durability, permeability and compressive strength etc., which are obtained from varied laboratory tests like grain size distribution analysis, Atterberg's limits, compaction, CBR etc. This present study will give a review about the stabilization of soil with sodium lignosulphonate and marble dust (which acts as stabilizers). These stabilizing precursors are very flexible in working among clayey soils. Hence, stabilized soils can possess immense strength such that they can be used as a bind material in road constructions.

INTRODUCTION
There will be wide variety of soils at all places. Their nature and behavior cannot be predicted so easily. Some soils may suitable for road construction but some may not, also every time, soil from different places cannot be transported to desired site as in consideration of economic point of view. Soil sub-grade should possess immense strength, as it has to support the entire load coming from the top layers and also should give strength, stability, durability etc., to the above layers called sub-base, base course, surface course. Thus, it leaded to the soil stabilization technique. Soil stabilization is a procedure which alters the geo-technical properties of the soil by using additives like cement, fly-ash, lime etc., In economic and environment point of view, these additives are not recommended highly. Later, researchers concentrated on utilization of waste materials in construction industry like sodium ligno-sulfonate, marble dust, quarry dust etc.., which has given effective results. Hence, soil stabilization will enhance the load bearing capacity, shear strength, drainage, permeability, compressibility etc.,

MATERIALS
SODIUM LIGNO-SULFONATE: Sodium lignosulfonate (lignosulfonic acid, sodium salt) is used in the food industry as a de-foaming agent in paper production and in adhesives for food stuffs. It has preservative properties and is used as an animal feed ingredient. It is also used in construction site, ceramics, mineral powder, the chemical industry, the textile industry (leather), the metallurgical industry, the petroleum industry, fire-retardant materials, rubber vulcanization, as well as organic polymerization. Sodium Lignosulfonate is primarily used as a cement water-reducing agent, usually causes the cement group to dissipate so that the water content is precipitated out, increasing its mobility, reducing mixing water, and saving cement.

MARBLE DUST: Marble dust is a solid waste material (by-product) generated from the processing of white marble. The ground calcium carbonate is characterized by its high brightness and chemical purity. Marble Dust is used as a natural mineral pigment or as a natural mineral filler/ texture enhancer in the preparation of casein paints or lime, whitewash, coating, stucco, and cement. It is made from calcium carbonate and is white in color and also can be used as a filler material in cement or fine aggregates when preparing concrete. Marble powder can be used as an admixture in concrete to increase the strength of the concrete.

LITERATURE REVIEW

Suresh Singh prasad et.al. (2020): In India, expansive soil covers nearly 23% of the land surface. If proper geotechnical investigation and stabilization are not performed, the problems associated with such soils will cost the project a fortune. To avoid the failure of structures such as foundations, retaining structures, slopes, lightweight structures, and pavements, it is necessary to improve swelling soil in an economical and environmentally friendly manner. The use of lignin-based organic polymer, a byproduct of the pulp industry, is a viable and sustainable technique. The current study examines the compaction, plasticity, swelling, and strength characteristics of expansive soil with additions of sodium lignosulfonate in percentages ranging from 0 to 12. The plasticity characteristics of expansive soil have been significantly improved. However, the addition of lignosulfonate results in a marginal increase in strength, which increases further with curing time.

Abhijeet Gupta et.al. (2021): Soil stabilization is the process of altering soil properties in order to increase strength and durability. Soil stabilization techniques include compaction, dewatering, and the addition of chemicals to the soil. Chemical stabilization is one of the most effective and widely used techniques, having been used successfully in the field. Lime, cement, fly ash, and rice husk are examples of chemical additives. Recently, lignin, an industrial by-product, has been identified as a chemical additive for soil mass stabilization. Furthermore, lignin has no negative environmental impact. In light of this, the current study looked into the behavior of lignin-stabilized soil. The results of unconfined compressive strength tests show that the performance of lignin-stabilized soil improves as the percentage of lignin content increases. However, it has been observed that the performance of stabilized soil decreases once the lignin content exceeds 3%. This could be because if the lignin concentration rises above 3%, the soil particles become completely coated with lignin, mobilizing strength at the surface of two lignin particles, which has a lower bonding strength than the strength mobilized at the soil lignin interface. As a result, the optimal percentage of lignosulfonate for maximum performance of stabilized soil mass should be around 3% by weight.

B.S. Sabitha et.al. (2021): The Kuttanad region of Kerala has the lowest elevation in India**,** at one meter above mean sea level. Because the soil in this region has a low bearing capacity, construction work on Kuttanad soil is frequently difficult and costly. Traditionally, hydrated lime, Portland cement, fly ash, and other materials have been used to stabilize Kuttanad soil. The use of industrial by-products to stabilize weak soil is becoming more popular due to the economic and environmental benefits. One such material is lignin, which is chemically known as lignosulphonates and is produced as a byproduct in the paper pulping industry. Lignin compounds come in a variety of chemical compositions depending on the cellulose separator used during the pulping process. This paper describes in detail the effectiveness of using sodium and calcium forms of lignin to stabilize Kuttanad soil. Using a series of laboratory tests, the effect of lignin on compaction characteristics, consistency limits, unconfined compressive strength, and CBR was investigated, and the optimum percentage of additive was determined. A comparison study was also conducted on the two compounds to determine which one has the best stabilization capacity.

Geethu Vijayan et.al. (2019): Soil stabilization refers to the permanent physical and chemical modification of soils in order to improve their physical properties. Stabilization can increase a soil's shear strength and/or control its shrink-swell properties, improving the load-bearing capacity of a subgrade to support pavements and foundations. Stabilization can be used to treat a variety of subgrade materials, ranging from expansive clays to granular materials. Lignosulphonate is a lignin-based polymeric stabilizer derived from the wood/paper industry as a waste byproduct. It contains both hydrophilic (sulfonate, phenyl hydroxyl, and alcoholic hydroxyl) and hydrophobic (carbon chain) groups. Lignosulfonate has shown promise as a soil stabilizing agent, particularly in soft soils. The compaction characteristics and shear strength properties were investigated in this paper.

Palsule et.al. (2018): Expansive soil's volume change behavior causes failures in structures such as embankments, retaining walls, foundations, and road subgrades. Chemical stabilization techniques are frequently used to reduce the swelling behavior of expansive soils. Traditional chemical stabilizers, such as lime and cement, are widely used and have a negative impact on the environment, either directly or indirectly during production. Many of the researchers advocated for the use of non-traditional, environmentally friendly stabilizers in soil stabilization projects. The waste product of the wood and pulp (biomass) processing industries, lignosulfonate, can be effectively used to improve the problematic behavior of expansive soil. In the current study, expansive soil is treated with varying percentages of sodium lignosulfonate powder ranging from 1% to 12%, and it is concluded that the plasticity, compaction, strength, and microstructural properties of expansive soil are improved. The poly-anionic nature of lignosulfonate causes a slight change in the MDD and OMC values for treated soils. The adsorption of lignosulfonate particles produced a waterproofing effect due to the hydrophobic carbon chain, resulting in a lower liquid limit and plasticity index. At 28 days curing, the maximum increase in unconfined compressive strength is observed for LS9, which is 1.4 times the control mix; the swelling index is also reduced from 1930 percent to 144 percent. The direct shear test in UU conditions discovered that shear parameters with increased cohesion suggested increased soil stiffness, which is supported by UCS test results. The CBR test revealed the maximum bearing value for the LS9 in soaked condition. SEM, FTIR, and XRD analysis reveal that bonds are formed between the surfaces of the clay particles and the Na-Lignosulfonate via an ion exchange process.

A.S. Mathew et.al. (2017): Marine clay is distinguished by its high organic content and as an expansive soil that shrinks and expands rapidly, causing foundation damage. Many stabilizers are used to improve the strength and other engineering properties of the material. This paper compares the modulus of elasticity in terms of E/qu with strain for marine clay stabilized with sodium lignosulfonate to cement treated clay. There was a significant increase in unconfined compressive strength for an optimum percentage of lignosulfonate (5 percent). The variation of E/qu with strain revealed that lignosulfonate-treated soil has a higher failure strain than cement-treated clay, making it less brittle. Traditional admixtures such as cement and lime have been found to cause brittleness in soil as well as toxicity to the point where vegetation on the land is affected. This problem has been solved by the use of lignosulfonate. An electrical conductivity test was performed to validate the above parameters of lignosulfonate-treated soil. It was discovered that lignosulfonate-treated soil had a decrease in electrical conductivity after 7 days of curing, whereas cement-treated soil had an increase in EC after 7 days of curing and remained the same after 28 days. This demonstrated the presence of unstable compounds in cement-treated soil, proving that lignosulfonate-treated soil is non-toxic and less brittle.

HAM Abdelkader et.al. (2021): Every day, the marble processing industry in the Shaq Al-Thouban region of East Cairo, Egypt, generates a massive amount of waste during the cutting and processing stages. Until now, the majority of these wastes have been dumped on open land, causing serious environmental issues. The amount of waste marble generated during the processing stage is approximately 20 to 25% of the total processed stone. Egypt also faces the issue of expansive soil, which occupies a large portion of its land, particularly in new cities built on these lands. The primary goal of this research is to use this waste material in soil stabilization from the standpoint of utilizing this waste as local low-cost materials and eliminating their negative environmental impacts. The waste marble dust was mixed with soil samples in various percentages of 5%, 10%, 15%, 20%, and 25% by dry weight of soil. For natural and marble dust stabilized soils, various tests such as Atterberg's limits, standard Proctor compaction, unconfined compressive strength (UCS), California bearing ratio (CBR), swelling percentage, linear shrinkage (LS) tests, and XRF and XRD analyses were performed. The soil mixtures used for UCS, CBR, and swell tests were compacted and cured for 7 days at the optimum moisture content (OMC) and maximum dry density (MDD) using the standard Proctor compaction method. The test results revealed that there are significant effects in improving the properties of expansive soils. Furthermore, the findings revealed that as the percentage of marble dust increases the plasticity index, the swelling potential of the expansive clayey soil decreases. Furthermore, the maximum dry density rises while the optimum moisture content falls. In addition, as the marble dust content increases, so do the UCS, CBR, and calcite content of the soil mixtures.

F.E Jalal et.al. (2021): Expansive/swell-shrink soils have a high plasticity and a low strength, resulting in settlement and instability of lightly loaded structures. These troublesome soils contain a variety of swelling clay minerals that are unsuitable for engineering purposes. In order to mitigate the perilous damage caused by such soils in modern geotechnical engineering, efforts are being made to use environmentally friendly and sustainable waste materials as stabilizers. The strength and consolidation characteristics of expansive soils treated with marble dust (MD) and rice husk ash (RHA) are evaluated using a battery of laboratory tests, including consistency limits, compaction, uniaxial compression strength (UCS), and consolidation tests. The effect of curing on UCS was studied from the standpoint of microstructural changes using X-ray diffraction (XRD) and scanning electron microscopy (SEM) analyses after 3, 7, 14, 28, 56, and 112 days. A series of ANN-based sensitivity analyses were also used to examine the long-term strength development of treated soils in terms of the interactive response of impacting factors. According to the results, the addition of MD and RHA decreased the water holding capacity, resulting in a reduction in soil plasticity (by 21% for MD and 14.5 percent for RHA) and optimum water content (by 2% for MD and increased by 6% for RHA), as well as an increase in the UCS (after 3 days and 112 days of curing, respectively).

Abdul waheed et.al. (2021): Collapsible soils have very high shear strength in dry conditions but rapidly lose strength when wet. Such rapid and massive strength loss causes severe distress, resulting in extensive cracking and differential settlements, instability of building foundations, and even the collapse of structures built on these soils. Waste marble dust is an industrial byproduct that is produced in large quantities around the world and poses an environmental risk. As a result, it is critical to seek a long-term solution for its disposal. The current study focused on reducing the collapse potential of CL-ML soil using a physio-chemical process. Since the soil is prone to flooding, it must be stabilized. As an admixture, different percentages of waste marble dust (WMD) were used. The optimization process used in the study revealed that adding waste marble dust improved the geotechnical parameters of collapsible soil significantly. Plasticity was reduced, but Unconfined Compressive Strength (UCS) increased significantly, and swelling was reduced to an acceptable level. The California Bearing Ratio (CBR) improves significantly as well. This study evaluates the safe disposal of hazardous waste and converts it into material suitable for engineering purposes.

Ajay Pratap et.al. (2022): The primary issue with expansive soil is that it absorbs all available moisture, resulting in excessive swelling pressure. This excessive swelling pressure causes upheaval of the structure's foundation, which is built on expansive soil strata. This study sought to use industrial waste, Marble Dust, as a stabilizing agent for expansive soil, as well as to assess the effect of Bamboo Fibre on the properties of Marble Dust stabilized expansive soil. Marble Dust was added in proportions of 10%, 20%, 30%, and 40% by weight of soil sample, and Bamboo Fibre was mixed in proportions of 0.25 %, 0.50 %, 0.75 % and 1% by weight of soil sample in the Mix proportion of expansive soil and 30% Marble Dust.

D.B. Hamdy et.al. (2022): The primary goal of this study is to look into the possibility of using waste marble dust to stabilize collapsible soil. The marble dust addition ratios investigated in this study were 0, 5, 10, 20, and 30% by weight. Different physical and mechanical properties of soil and soil-marble dust mixture samples were investigated. According to the results of the tests, a 20% marble dust addition increased maximum dry density by 9%, decreased optimum moisture content (OMC) by 29%, increased soil cohesion by 350%, and increased friction by approximately 22%. A 5% marble dust addition resulted in a 33% improvement in California bearing ratio (CBR) values. Formulas for estimating shear strength parameters, CBR values, and compaction characteristics corresponding to MD content were developed. Furthermore, the effect of curing on soil samples containing varying amounts of marble dust was investigated. A 20% marble dust addition to samples cured for 15 days improved soil cohesion and friction by an additional 25% and 22%, respectively. Aside from the demonstrated improvement capabilities of marble dust addition to soil samples, this procedure is also economically and environmentally sustainable, as it reduces the cost of constructing structures on problematic soils and discovers new utilization areas for waste marble dust, thus reducing environmental pollution.

S. Amena et.al. (2022): Expansive soil must be treated before it can be used as a safe foundation soil for roads and buildings. The use of agricultural and industrial wastes is the best option in terms of environmental conservation and economics. The effects of using plastic waste and marble waste dust on the engineering properties of expansive soils were investigated in this study. Several laboratory tests were performed on sampled expansive soil by adding 10, 15, and 20% marble and 0.25, 0.5, and 0.75 percent 5 8 mm2 plastic strips. The laboratory test results revealed that the addition of marble dust and plastic strips resulted in significant improvements in strength parameters. California Bearing Ratio (CBR) values rise as the percentages of marble dust and plastic strips increase. Unconfined compressive strength (UCS) values increase linearly with the addition of marble dust, but only up to 0.5 percent with the addition of plastic strips. The proportions of marble dust and plastic strips in the soil decrease significantly as the proportions of marble dust and plastic strips increase. This demonstrates that waste marble dust and plastic strips from environmental pollution can be used to strengthen the weak subgrade soil and reduce its swelling properties. As a result, this study discovered that expansive soil treated with polyethylene terephthalate (PET) plastic and marble dust can be used as a subgrade material because it meets the standards' minimum requirements.

SR Mahapatra et.al. (2022): Construction costs can be significantly reduced by using locally available resources for the pavement's lowermost layers. In the current urbanization and industrialization situation, several hazardous and non-hazardous wastes have formed. This promotes landfill space draining, soil contamination, and a variety of other hazardous effects; therefore, in this study, waste (i.e., rice husk ash) is used to improve soil properties. The influence of Marble dust on the quality characteristics of Rice husk ash stabilized expansive soil to increase the features of subgrade soil was determined in the current study. On specimens of native soil and expansive soil with stabilizers, Atterberg's limit, compaction, unconfined compressive strength (UCS), direct shear strength, and California bearing ratio (CBR) experiments were performed. Based on UCS tests, the optimal percentage of RHA was determined to be 10%. At a 5% increment, marble dust was added to RHA stabilized expansive soil to increase its dry weight by up to 30%. The maximum dry density (MDD) of expansive soil increases up to 25% while the optimum moisture content (OMC) decreases regardless of the percentage of marble dust added to RHA stabilized expansive soil. The UCS, direct shear strength, and soaked CBR of RHA stabilized expansive soil increased by up to 15% when marble dust was added; cohesion was clearly increased. The mixtures' UCS and CBR were 120.05 and 199.42 percent higher than the untreated soil, respectively. The addition of more marble dust had a negative impact on these properties. The results showed that expansive soil had lower values for strength parameters, but after stabilization, expansive soil had higher values for UCC, Shear Strength, and CBR. The optimal percentage of soil, rice husk ash, and marble dust for better stabilization was discovered to be 75:10:15.

CONCLUSIONS

Based on the results obtained in the present study, following conclusions are made –

- The optimum moisture content decreased with addition of sodium ligno-sulfonate and marble dust individually.
- The maximum dry density increased with addition of sodium ligno-sulfonate and granite dust separately.
- Liquid and plastic limits go on decreasing by the addition of sodium ligno-sulfonate and marble dust to the clayey soil at varying percentages separately.
- Compressive strength increases with the addition of sodium lignosulfonate and marble dust individually.
- Optimum dosage that has been obtained from the results i.e., sodium lignosulfonate is nearly 4% and marble dust is 10%.
- When compared to sodium lignosulfonate, marble dust has shown the effective results especially in case of CBR, the percentage increase is 41.18% in unsoaked CBR and 22.4% in soaked CBR.
- Hence, many researches have given the usage of sodium ligno-sulfonate and marble dust for soil stabilization. Therefore, here we have studied in this paper in combined usage of both sodium ligno-sulfonate and marble dust.

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