International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 02 | Feb 2023 www.irjet.net p-ISSN: 2395-0072

A Schematic Review on Environment Friendly Soil Stabilization Materials

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Abstract - Pavements, like the foundations of houses, are made of a hard crust laid over the earth to provide a level and sturdy base for driving and walking. In contrast, the goal will not be achieved if the soil underneath the buildings and roads is inadequate. To fix this, the foundation's soil must be strengthened. However, the typical approaches used are prohibitively expensive. Therefore, improving soil stability in a way that is both cost-effective and gentle on the environment is essential. In this work, we analyse the many low-cost and high-efficiency ground improvement methods that have been discussed in the literature. Recent research has shown that the natural soil's physical, toughness, and volume change properties can be enhanced through the application of a combination of environmentally friendly (Bio - Enzymes) as well as advanced materials (Agricultural and commercial waste) in adequate volume to effect subgrade soil stabilisation. It was also noted that traditional approaches have an adverse effect on the natural world. This means that eco-friendly and cost-effective materials may be used to support subgrade, fulfilling both economic and serviceability requirements.

Key Words - Soil Stabilization, Environment Friendly, Stabilizer Materials.

1. INTRODUCTION

Clay and silt are common in several regions of India (black cotton soil). Adding water causes these soils to swell. Therefore, these soils are also known as swelling soils or expansive soils. These low-bearing soils provide significant challenges in building. Engineers are thus compelled to discover methods of stabilization of soil that will boost the soil's carrying capacity. Large areas of soil benefit from the addition of several chemicals, which help to keep the soil in place. [1] [2] Sustainable soil stabilisation practices are now commonplace in many advanced nations. Soil stabilisation by enzymes, so the theory goes. All living things, from plants to mammals, include enzymes. It's put to use in soil stabilisation, where its mineral constituents react to make the ground more stable. [3] [4]

Soil Stabilization: Assuming all pavement layers will be of a certain minimum needed structural quality is the starting point for every pavement design. Each layer has to be able to withstand shearing, bend without causing fatigue cracking in itself or in the layers above it, and resist irreversible deformation by densifying as little as possible. [5][6]When the quality of a soil layer improves, it may often spread the load over a larger area, thereby allowing for a thinner base and top layer. By and large, stability leads to enhanced soil gradation, decreased plasticity index or swelling potential, and increased durability and strength. Stabilization may also be used as a platform for building activities during rainy periods. Soil modification refers to practises that enhance soil quality in this way. [7] [8] [9]

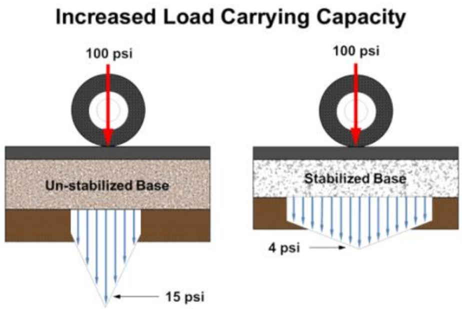

Fig. 1: Example of soil before and after stabilization

Necessity of Soil Stabilization

• The process of modifying soil qualities in order to accommodate the flow of traffic.

• Increasing soil shear strength is a general goal.

• Swelling from wetness as well as shrinkage bearing is minimised using this technique.

• To boost the soil's bearing ability.

• Due to the decrease in the moisture content, it prevents soil from cracking

A. Factors Affecting the strength of stabilized Soil

Sulphates, carbon dioxide and sulphides in the stabilised soils can contribute to the undesired strength of the stabilised materials. [10] [11]

• Sulphates

- Compaction
- Organic Matter
- Sulphides
- Freeze-Thaw as well as Dry-Wet Effect Stabilized
- Temperature
- Moisture Content

B. Benefits of Soil Stabilization

- We are striving to keep the topsoil, the soil's most fertile layer, in place by preventing erosion and sedimentation. [12] [13]
- By erecting barriers to the passage of air and water over the soil, the soil particles are kept in place.
- Strengthens soil that is currently weak or suboptimal.
- Keeps soil undisturbed, allowing plants to flourish and contribute to the overall strength of the building.
- There are several environmental benefits to longer-lasting outcomes of soil stabilisation in the road building.
- Strengthens shearing as well as compressive strength, among other properties.
- Reduces as well as mitigates volume instability and the possibility for swelling and shrinking.
- Reduces the soil deformation and settling through reducing soil compressibility.
- Durability is increased so that it can withstand adverse climatic conditions such as freezing and thawing, erosion, wet-dry cycles and weathering

2. LITERATURE REVIEW

(Wu et al., 2021) [7] has proposed a new general framework for integrating various "Industrial By-Products" (IBPs) as the composite binders to replace "Ordinary Portland Cement" (OPC) in soft clay stabilisation. Different IBP proportions are calculated using TCM and SAI, and the final design mix is adjusted by adding gypsum to take advantage of the density increase brought about by the ettringite synthesis process and increase the concrete's strength. New generic framework was used to explore the stabilisation of coastal soft clay with various IBPs and gypsum.

(Renjith et al., 2021) [8] discovered that despite fly ash's usefulness as a cement substitute, it is only utilised at a low rate in engineering applications, thus it does not help to its current waste reduction initiatives. Using a 5-stage, thorough testing protocol, this study analysed the performance of fly ash stabilised soil with additional additions (enzymes & lime). First, fly ash as well as enzyme doses were determined. Using enzymatic fly ash stabilised soil, the second and third halves of the study examined the effects of time as well as lime, respectively. Using secondary additives, stabilisation was explained in detail in the fourth chapter. These additives were examined for their importance and advantages in pavement stabilisation in the fifth section.

(Renjith et al., 2020) [9] determined the optimal mix proportions of the additive by revealing its process of stabilisation in a "fine-grained field soil" which is the most common in Victoria, Australia. Under a four-stage testing programme, macroscale mechanical as well as the microscale imaging tests were done to reveal the impacts of stabilisation along with the mechanism of stabilisation. In comparison to the strength of unstabilized soil, the discovered mechanism has improved the effectiveness of the enzyme-based soil stabilisation. The findings of this study will have a significant impact on road construction industry because they will not only lead to more cost-effective and reliable construction methods, but they will also provide insight into the optimal additive amount needed to stabilise road pavements using this stabilisation mechanism.

(Consoli et al., 2020) [10] studied the potential use of quicklime as well as hydrated lime derived from eggshell residues as soil stabilisers. Here, eggshell debris is calcined to make quicklime as well as hydrated lime, using eggshell wastes and crushed waste glass. Two types of "eggshell quicklime" (EQL) and "eggshell hydrated lime" (EHL) were studied for their physical qualities (surface area, grain-size distribution, microscopy, light surface area, as well as an X-ray spectrometer), mineralogy, as well as the chemical composition ("X-ray fluorescence spectrometry").

(Behnood & Olek, 2020) [11] analysed and contrasted subgrade stabilisation scenariosin in a full-scale laboratory-based setting. Using C steel channels, a 6 3 6 ft by 4 ft test box was built to conduct this experiment. A variety of soil stabilisation methods were tested in the test box, including chemical (cement) stabilisation, usage of geogrid (GG), as well as geotextile (GT) with ABC, "aggregate base course" (ABC), as well as GT with the "cement-stabilized soil", GT with flowable fill, in-situ compacted soil, as well as lean-concrete (LC). A "single axle load" of 9,000 lbf/tire was used in the testing, and all stabilising solutions demonstrated enhanced performance of the subgrade layer by minimising deformation.

(Talluri et al., 2020) [12] tested Lime stabilisation with precompaction mellowing in an experiment to see how efficient it was in stabilising six distinct high-sulfate soils. There were three mellowing periods tested, ranging from 0 to 7 days. High-sulfate soils were subjected to a series of technical and chemical experiments before and after treatment with lime. Only two out of the six soils studied were negatively affected by precompaction mellowing prior to lime stabilisation.

(Rahgozar et al., 2018) [13] studied the results of addition of RHA and conventional Portland cement to a sample of clayey sand from the Sejzi region east of Isfahan, Iran. To begin, the "X-ray fluorescence" (XRF) test was used to identify the cement, oxide compounds in RHA, as well as soil. Increased RHA concentration led to an increase in opt and a reduction in d, according to the findings.

(Clay et al., 2016) [14] Some emerging nations, like Indonesia, are struggling to deal with the issue of industrial solid wastes. In recent years, the environmental concern of how to lessen industrial wastes via reuse or recycling processes has gained widespread attention. Ashes used in this study were obtained by burning discarded coffee husk, which is regarded to be a solid waste product of the coffee manufacturing industry. Cot Bagie Village soil from Blang Bintang, Aceh was combined with coffee husk ashes for this experiment. Several tests of the soil's physical qualities, including its specific gravity, Atterberg limit, and grain size distribution, were carried out in accordance with the applicable ASTM standards.

(Ehsan, 2015) [15] This research aims to assess olivine's potential as a novel binder for soil stabilisation. Recent studies have shown an increase in the use of eco-friendly products for soil stabilisation. Research into discovering ecologically friendly materials for soil stabilisation has also been prompted by the rising levels of greenhouse gases (GHG) like CO2. Cement has been used as a binder in soil stabilisation for a long time, but because to its high CO2 emissions and high energy consumption, civil engineers have started using other materials and by-products.

(Shillito & Fenstermaker, 2014) [16] In this study, we will examine the use of basic chemical and physical principles for stabilising soil in their natural environments. In order to evaluate stabilisation techniques, a brief summary of soil's physical and chemical characteristics is also provided. Based on prior research conducted at the NNSS, a set of criteria for evaluating stability have been established.

(Amiralian, 2013) [17] Chemical stabilisation of soil involves amending the soil with binders or by-products like lime or fly ash to improve its geotechnical performance. Soil's compaction, compressibility, hydraulic conductivity, and strength qualities have been the focus of a wide range of studies. The effects, however, vary greatly. As for the potential quality and quantity improvements to soil properties brought about by lime and fly ash, there is a lack of available studies.

Authors	Work
Arsit Iyaruk, Panu Promputthangkoon and Arun Lukjan [18]	Using waste biomass bottom ash (BA) as a recycling material for civil engineering infrastructures is still difficult and troublesome from the point of view of sustainable waste management and its environmental effect. Lateritic soil (LS) that was stabilised with cement and biomass BA was tested in this research to see how well it would function as a subbase.
Samuel J. Armistead, Colin C. Smith & Sarah S. Staniland [19]	In semiarid and arid locations, where fresh water is in short supply, salt water is increasingly being used in mining. There may be unintended consequences for Mine Tailing (MT) management as a result of this change. Considering the susceptibility of current stabilization/solidification approaches to MT toxicity and salinity effects, it is important to investigate the potential for more ecologically lasting sustainable alternatives.
Akhila Jayaprakash; Revathy V S [20]	All liquefaction processes may be traced back to one primary cause: the development of excess pore pressure under undrained loading conditions. Many scientists throughout the world have conducted studies on liquefaction evaluation using various approaches. Colloidal silica (CS), a product of nanotechnology, has been presented for use in ground improvement and liquefaction mitigation due to its impressive capacity to dampen pore pressure development during seismic events.
Bakhshizadeh, Amin Khayat, Navid Horpibulsuk, Suksun [21]	Chemical stabilisation is well acknowledged for enhancing the mechanical qualities of difficult soils. To improve the “unconfined compressive strength (UCS)” of a high plasticity clay, sodium alginate was studied as a potential soil-surface stabiliser.
Torricelli, Fabrizio Alessandri, Maddaloni, Marina Torsi, Luisa [22]	This study introduces and evaluates the eco-friendly materials and technologies that are driving the creation of sustainable organic transistors, which have the potential to become essential building blocks for environmentally friendly, ubiquitous electronics and bioelectronics.
Prasad Jadhav, Shital Sakpal, Harshal Khedekar, Pramila Pawar[23]	Alum sludge and other waste products were put to good use in this project by being put to work as a soil stabiliser. Waste management

	on a massive scale is made easier by the fact that alum sludge may be used as a cheap soil stabiliser. Using alum sludge is an eco-friendly and long-term option.
Gohel Sagar P, Chotaliya Hardik K, Makwana Pratik[24]	In this study, we conduct a number of experiments on sub-base material to improve its strength attributes and behaviour. The effectiveness of each mixture in terms of sub-base stabilisation is then evaluated by comparing the findings and accompanying graph. The stabilising method also offers an eco-friendly solution for dealing with textile scraps from the manufacturing sector.
Hanna Sarosh Z A [25]	Ash, the by-product of burning sugarcane bagasse, has a high concentration of silica. Bagasse from sugarcane is a pozzolanic substance with promise as a soil stabiliser. In this study, sugarcane bagasse ash is compared to lime in terms of its ability to stabilise soil.
Zane Vincevica-Gaile , Tonis Teppand [26]	Logistics of equipment and lack of accessible and relevant materials often impede the implementation of building activities on weak (e.g., compressible, collapsible, expansive) soils like peatlands. There must be soil stabilisation if preloading or floating roadways on geogrid reinforcement or piled embankments are not possible.
Iqbal, Rashid Aown, Muhammad Raza, [27]	This study also discusses several issues that might arise with different types of mulch. Certain researchers like mulches while others have noticed some drawbacks. Depending on the kind of crop, the management methods used, and the environmental circumstances, the mulching material chosen is essential.
Eshetu Mekonnen, Ameha Kebede,[28]	Soil stabilisation is the process of changing one or more of the soil's characteristics using mechanical or chemical means to produce an enhanced soil material with the required engineering qualities. The purpose of this essay was to examine the history, current state, and potential future of soil stabilisation methods that make use of bioenzymes.
Ekrem Kalkan [29]	When a soil's engineering qualities aren't up to standard for a certain project, stabilising techniques are used to make them more usable. When it comes to the soil's physical properties, there are a number of different stabilising techniques that might be used.
ERIK ARNESSON KTH [30]	Sustainable alternatives to traditional bearing materials in multifamily dwellings were the focus of this research, as well as the associated benefits and drawbacks.
Navarro Ferronato and Vincenzo Torretta [31]	In this study, we examine the most significant consequences brought on by improper waste management in third-world nations, with a special emphasis on environmental pollution and societal issues. We also looked at the informal economy in emerging metropolises, with an emphasis on the most pressing health concerns associated with rubbish scavenging.
Ali Al-Baidhani, Abbas Al-Taie[32]	In this study, we take a close look at brick waste, a common kind of building and demolition debris. This study presents and discusses the characterisation and exploitation of brick waste in stabilisation of expanding soil and other civil engineering applications.
Z. Sabzi [33]	For engineers, working with soft soil is a common difficulty. Soil stabilisation is the process of enhancing a soil's engineering qualities. In order to make soils and associated materials and buildings stronger and more long-lasting, this study focuses on soil stabilisation materials and procedures.

4. CONCLUSIONS

When dealing with difficulties caused by soft soil, the standard approach has been to remove the problematic soil and replace it with hardier material. Reviewing the available literature, we find that stabilising clayey soil with particular additions enhances its strength, allowing its application in the building industry. One might deduce that the bearing capacity of clayey soil is enhanced by a combination of a lower plasticity index and a higher dry density.

Thus, the adhesion between the fibres and the matrix, as well as the mechanical characteristics of the reinforced soils, may be enhanced by altering the properties of these fibres using chemical treatments. Natural fibre is a renewable resource that can replace synthetic fibres in many composites and geotechnical applications in the future. Primary research has to focus on both the long-term reliability and the broad applicability of the technology. Also, future research into the combination of natural fibres with additional pozzolanic materials is encouraged.

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