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(REVIEW ARTICLE)

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Reviewing the enhancement of expansive soil through different waste material blending

Manjushree.V.Gaikwad [1,*], Sourabh Kumar Singh [2], Nagesh. T. Suryavanshi [3], Kishor P. Survase [4], Shashikant R.Yadav [4], Malakarsidha C. Pujari [4] and Onkar S. Basate [4]

[1] *Research Scholar, Shri Jagdishprasad Jhabarmal Tibrewala University, Rajasthan, India.*
[2] *Shri Jagdishprasad Jhabarmal Tibrewala University, Rajasthan, India.*
[3] *Vidya Pratishthan's Kamalnayan Bajaj Institute of Engineering and Technology, Baramati, Maharashtra, India.*
[4] *S. B. Patil College of Engineering, Indapur, Pune, Maharashtra, India.*

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Abstract

This review paper examines the efficacy of blending various materials for the enhancement of expansive soil behavior. Expansive soils, characterized by volumetric changes in response to moisture fluctuations, present significant challenges in engineering projects. The review explores the utilization of waste additives such as quarry dust, sawdust ash, glass powder, stone powder, marble dust, Lime and Polypropylene Fiber, plastic waste strips and waste brick powder Oil Shale Ash, cement kiln dust as well as innovative solutions including organic compounds and nano-materials. The effectiveness of each material blend in mitigating issues such as swelling, shrinkage, and cracking is analyzed. The study underscores the importance of material selection and optimal blending techniques in achieving desired improvements in soil properties. Additionally, the paper highlights the need for continued research and innovation to develop sustainable solutions for managing expansive soils in construction and geotechnical engineering endeavors.

Keywords: Expansive soil; Improvement; Enhancement**;** Swelling; Shrinkage.

1. Introduction

The use of quarry dust as an additive in the treatment of soft soils for moisture bound pavement geotechnics. The addition of quarry dust consistently improved the swelling potential, shrinkage limits, compression, and durability of the treated test soils .[1] Black cotton soil (BCS) is a problematic soil for construction due to its expansive nature and shrink-swell behavior, leading to cracking and differential settlement in buildings and roads. Stabilizing BCS is necessary to improve its engineering properties and suitability as a subgrade material. The use of sawdust ash and lime not only enhances the strength of BCS but also provides an economical way to dispose of sawdust.[2] Expansive soils pose challenges for civil engineering projects due to their significant volume changes when wetted and dried. Construction on expansive soils, such as highways, railways, and embankments, often faces difficulties. The improvement of expansive soils is crucial to enhance their strength and reduce their consistency limits and swelling behavior. Waste glass powder (WGP) has been selected as a material to improve the geotechnical properties of expansive soils.[3] The properties of stable soil, such as compaction consistency, triaxial compressive strength, and California bearing ratio, were assessed and compared with different concentrations of stone dust. The addition of stone dust, either at the optimum level or in a mixture, improved the sub-grade performance attributes of black cotton soil.[4] Marble dust is a waste product resulting from the quarrying and crushing of marble, and its potential as a geo-material has not been extensively studied. Expansive soil, known as Black Cotton Soil (BCS), covers a significant portion of India's

* Corresponding author: Manjushree.V.Gaikwad

total area and poses challenges for construction projects due to its differential movements.[5] Lime is commonly used for the stabilization of expansive soils due to its availability and cost-effectiveness. To investigate the effectiveness of polypropylene fibers with lime in improving the strength and swelling properties of expansive soil.[6] Locally available expansive soil is treated with brick waste powder and waste plastic strips to increase strength qualities. The combined effect of adding plastic waste strips and brick powder on the soil's engineering properties is investigated through laboratory tests.[7] cement-mixed gravelly soil (CGS) slab improvement with geosynthetics and a cohesive non-swelling soil (CNS) layer to reduce water content fluctuations.[8] Soil stabilization techniques are used to improve the characteristics of expansive soil, with chemical stabilization being a suitable method. Calcined clay is used as an admixture to study its effects on soil properties. The compaction characteristics and swelling behavior of the soil are analyzed through experiments such as the standard proctor test and free swell test.[9] Cellulose-based fibers, derived from agricultural waste products, have gained attention as a sustainable and effective solution for stabilizing expansive soils. These fibers offer advantages such as reinforcement capabilities, erosion control, soil improvement, sustainability, and cost-effectiveness.[10] Oil Shale Ash (OSA) is a byproduct of oil shale rock combustion and can be used as a building material to alleviate environmental concerns. The use of OSA and Portland Cement (PC) to enhance the geotechnical properties of expansive soil for pavement applications.[11] Expansive soil remediation using cement kiln dust as stabilizer beneficial for amending expansive soil properties.[12] The effects of sawdust ash and high calcium fly ash enhance expansive soil properties using pozzolanic materials.[13] Expansive soil properties and cracking behavior with waste fibre reinforcement to study evaluates shear strength and crack resistance enhancement with recycled fibres. Glass and polypropylene fibres significantly enhance expansive soil properties.[14] Use of recycled construction and demolition (C&D) wastes as an eco-friendly and inexpensive admixture for soil stabilization To improve the properties of black cotton soil for construction purposes.[15]

2. Summarized Review analysis

Table 1 Summarised Study of literature review

Paper No.	Paper Title	Year of publication	Author name	Waste material added	Method used	Finding and conclusion	Gaps Finding
1	Sorptivity, swelling, shrinkage, compression and durability of quarry dust treated soft soils for moisture bound pavement geotechnics	2019	Kennedy Onyelowe	quarry dust	Sorptivity, swelling, shrinkage, compression, and durability tests conducted. Utilized loss of strength on immersion method to determine durability. Basic tests conducted as per British Standard to determine soil properties.	Quarry dust enhances swelling, shrinkage, compression, and durability of soils. Quarry dust is beneficial for pavement foundation materials in a moisture-bound environment.	Research gaps in the study were not mentioned.
2	Stabilization of black cotton soil subgrade using sawdust ash and lime	2019	C.C. Ikeagwuani	sawdust ash and lime	Compaction tests under BSL and BSH methods. Determination of California bearing ratio	Sawdust ash and lime enhance black cotton soil strength. Sawdust disposal is facilitated	Research gaps were not mentioned.

					(CBR) for soil strength. Differential free swell (DFS) test for expansive soil identification.	through soil stabilization.	
3	Strength improvement of expansive soil by utilizing waste glass powder	2020	Rizgar A. Blayi	waste glass powder	Expansive soil and WGP mixed, tested with various percentages. Characterization tests conducted for soil and WGP using ASTM standard.	Adding WGP improves expansive soil strength and consistency significantly. Optimum WGP percentage for enhancing soil is around 15%. WGP reduces sub-base thickness by about 63% in soil improvement.	Optimal WGP percentage for expansive soil in construction projects. Impact of WGP on geotechnical properties of expansive soils. Detailed study on the environmental impact of WGP disposal.
4	Evaluation of experimental research on black cotton soil stabilization using stone powder	2020	Mukesh Kumar	stone powder	Stone dust, iron mud, do lime fine used for soil stabilization. Experimental investigations with ash, stone dust, and metal chloride.	Stone dust improves black cotton soil properties like compaction and strength. Stone dust and plastic fibers enhance the strength of black cotton soil.	Research gaps were not mentioned
5	Geotechnical behaviour and micro-analyses of expansive soil amended with marble dust	2020	Ankush Kumar Jain	marble dust	Selection of additives and sample preparation for geotechnical properties evaluation. Comprehensive geotechnical tests, physico-chemical examination, and micro-analyses conducted.	Marble dust enhances soil plasticity and controls swell behavior effectively. Optimum Marble Dust Content for soil improvement is 20%. Alterations in gradation, cohesion, and mineralogical composition are key factors.	Quantitative analysis of factors affecting soil behavior is lacking. No detailed investigation on the impact of curing methods. Limited exploration on the influence of temperature variations on

						Factors like curing method, temperature, and longevity affect Optimum Marble Dust Content.	soil properties.
6	Improvement of Geotechnical Properties of Expansive Soil by Lime and Polypropylene Fiber Material	2021	Md. Monir Hossain	Lime and Polypropylene Fiber	Lime and polypropylene fiber improve expansive soil strength and swelling properties. Lime content up to 7.5% decreases swelling properties before increasing. Polypropylene fibers reduce axial and lateral expansion of expansive soil. Unconfined compressive strength significantly increases with lime and fiber addition.	Lime and polypropylene fiber used for soil stabilization. Laboratory tests included Atterberg limit, compaction, and unconfined compressive strength. Swelling properties tested with different lime concentrations and curing periods.	Limited research on expansive soils behavior in specific regions. Few studies on the impact of lime and polypropylene fibers.
7	Experimental study on the effect of plastic waste strips and waste brick powder on strength parameters of expansive soils	2021	Shelema Amena	plastic waste strips and waste brick powder	Soil sample characterization, grain size analysis, and strength properties investigation. Unconfined Compressive Strength Test (UCS) California Bearing Ratio (CBR) test as per ASTM D 1883.	Plastic waste strips and brick powder enhance expansive soil strength. Waste materials can be used in pavement construction, reducing pollution	Research gaps were not mentioned
8	Construction and field measurement of high-speed railway	2021	Kenji Watanabe	cement-mixed gravelly soil (CGS) slab	Construction of test embankment on black cotton soil in India.	Effective countermeasures reduce embankment deformation, enhancing	Difficulty in predicting BCS swelling property based on clay content.

	test embankment built on Indian expansive soil ‘‘Black Cotton Soil”				Use of CNS layer, CGS improvement, and geogrid installation. Comparison of experimental data with literature methods for swelling soil. Arrangement of measuring instruments like extensometers and moisture sensor.	high-speed railway construction. CNS layer below embankment not as effective as expected. Indian embankment material can achieve Japanese railway standards.	
9	Effect of calcined clay on the improvement of compaction, swell and microstructural characteristics of expansive soi	2023	V. Janani	Calcined clay	Chemical stabilization, X-Ray Diffraction, Scanning Electron Microscope. Standard proctor test, Free Swell test, Microstructural analysis.	Calcined clay improves soil compaction, reduces deformation, and increases shear strength. Optimum soil behavior observed at 8% calcined clay addition. XRD and SEM analysis show mineralogical changes in treated soil. Free Swell Index decreases from 210 to 80 with 10% clay.	The research lacks discussion on long-term field performance. Limited focus on the economic feasibility of calcined clay utilization.
10	Optimization of physical and strength performance of cellulose-based fiber additives stabilized expansive soil	2024	Frehailea b Admasu Gidebo	cellulose-based fiber.	Taguchi method for optimization of soil properties and fiber reinforcement. Analysis of Variance (ANOVA) for validating statistical results. Mechanical sieve shaker for identifying	Cellulose-based fibers significantly enhance physical and mechanical soil properties. Cellulose fibers improve cohesion, resistance to deformation, and shear failure. Statistical analysis	Research gaps were not mentioned.

					particle sizes of cellulose fibers.	validates the effectiveness of cellulose-based soil stabilization.	
11	Effect of using Oil Shale Ash on geotechnical properties of cement-stabilized expansive soil for pavement applications	2023	Samer R. Rabab'ah	Oil Shale Ash	Atterberg limits, compaction, UCS, swell, linear shrinkage, CBR tests Scanning Electron Microscopy (SEM) for micropores and morphology variation.	OSA and cement improved soil properties, reducing swelling and enhancing strength. OSA-stabilized soil suitable for subgrade and base layers in pavements.	Limited research on long-term performance of OSA-cement-stabilized soil. Few studies on the impact of OSA on expansive soil properties. Scarcity of data on the microstructural changes induced by OSA-cement mix.
12	Expansive soil remediation using cement kiln dust as stabilizer	2023	Sultan Almuayth ir	cement kiln dust	Evaluation of CKD as a stabilizer for Al-Qatif expansive soils. Comparison of MD relationships, SCP, and UCS of treated and untreated soil.	CKD effectively stabilizes Al-Qatif expansive soil, improving its properties. CKD reduces maximum dry density, increases optimum moisture content. SCP fully diminishes, UCS substantially increases with CKD addition.	Limited research on the long-term effects of CKD stabilization. Lack of studies on the impact of CKD on hydraulic conductivity. Few investigations on the relationship between CKD and soil compaction.
13	Improvement of expansive soil characteristics stabilized with sawdust ash, high calcium fly ash and cement	2023	Abubaker Ahmed Mohamed Salih Mohamed	sawdust ash, high calcium fly ash	Investigated effects of sawdust ash, high calcium fly ash, and cement. Conducted tests on physical and mechanical characteristics	Addition of 1% cement to 10% HCFA-SDA enhances expansive soil properties. HCFA-SDA combination reduces swelling characteristics	Limited information on geotechnical properties and chemical stability with HCFA. Lack of data on new uses for properly

					of expansive soil. Analyzed the potential of enhancing expansive soil properties with different mixtures. Examined the impact of HCFA, SDA, and cement on soil properties.	of expansive soil. HCFA and SDA decrease liquid limit and plasticity index of soil. Short-term reactions improve soil plasticity, swelling potential, and clay aggregation.	discarded HCFA.
14	A study on the shear strength and dry-wet cracking behaviour of waste fibre-reinforced expansive soil	2022	Zhen Huang	wasteFibre reinforcement	Indoor shear strength tests Dry-wet cracking tests Evaluation of crack resistance enhancement.	Fibre reinforcement enhances shear properties and inhibits expansive soil cracking. Polypropylene fibre shows better improvement effects compared to glass fibre. Optimum fibre content for both types is 0.5%.	Lack of studies on natural shrinkage cracking of expansive soils. Limited research on the impact of fibre content on crack resistance.
15	At-rest lateral earth pressure of compacted expansive soils: Experimental investigations and prediction approach	2024	Zhong Han	-	Soaking-consolidation tests Constant volume soaking tests Long-term wetting-drying tests	Proposed approach predicts at-rest soaking sL-sV relationships accurately. Anisotropy reduces with increased compaction energy and molding water content. Long-term wetting-drying cycles reduce sL and show stress relaxation.	Lack of discussion on unsaturated specimens during wetting in study. No exploration of lateral stress with suction and moisture content. My columns

3. Conclusion

Concluding remarks from above reviews the utilization of various waste materials for soil stabilization presents a promising avenue for sustainable construction practices. By mitigating environmental concerns associated with waste disposal while concurrently addressing soil stabilization needs, this approach aligns with the principles of circular economy and sustainable development. From overall review seen that experimental studies, the utilization of various waste materials has been shown to enhance the properties of soil. However, further research and field applications are warranted to fully understand the long-term performance and environmental implications of these techniques. Embracing innovation and collaboration within the construction industry can lead to the widespread adoption of waste-based soil stabilization methods, contributing to a greener and more resilient built environment for future generations.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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