Literature Survey on Strengthening of Sub-Grade Soil by Using Waste Material

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Abstract - *This paper study investigates the feasibility and effectiveness of using waste materials as a sustainable alternative for subgrade stabilization in road construction. The study examines the use of two waste materials: Construction and demolition (CD) material and other waste materials. The waste materials were used in the subgrade layer of a road construction project. The results show that the use of CDW and Other waste material improved the subgrade's engineering properties, including increased California Bearing Ratio (CBR) values and reduced settlement. The study also found that the use of waste materials reduced the project's environmental impact by decreasing the amount of virgin materials used and the amount of waste sent to landfills. The findings suggest that waste materials can be a viable and sustainable alternative for subgrade stabilization, offering both engineering and environmental benefits.*

Key Words: Soil subgrade, Construction and demolition materials, Waste Materials, CBR test.

1.INTRODUCTION

Subgrade soil is a critical component of road infrastructure, providing the foundation for pavements and ensuring the safety and durability of transportation systems. However, subgrade soils often exhibit poor engineering properties, such as low bearing capacity, high compressibility, and susceptibility to settlement and deformation. These issues can lead to premature pavement failure, increased maintenance costs, and compromised safety. Moreover, the increasing demand for transportation infrastructure development has resulted in a significant amount of waste materials generated from various industries, including construction, mining, and industrial processes. The disposal of these waste materials poses significant environmental and economic challenges, highlighting the need for sustainable and innovative solutions. In recent years, the use of waste materials as soil stabilizers has gained attention as a potential solution to enhance subgrade soil strength, reduce waste disposal costs, and promote sustainable construction practices. Various waste materials, such as construction demolition waste, and waste plastics, have been investigated for their potential to improve soil properties. These materials can enhance soil strength, reduce compressibility, and improve durability, making them suitable for subgrade soil stabilization. However, the effective utilization of waste materials as soil stabilizers requires a comprehensive understanding of their properties, behavior, and interactions with soil. This study aims to investigate the use of waste material as a soil stabilizer to enhance the strength of subgrade soil, addressing the knowledge gaps and challenges associated with their application.

2. LITERATURE REVIEW

[1] Moataz A. Al- Obaydi, *et. al*. (2021) evaluated the impact of three different types of CD materials (dragged asphalt, DA; crushed brick, CB; and crushed concrete, CC) The findings revealed CBR values improved after CD materials were added to the CL soil. The inclusion of DA, CB, and CC raised CBR values by 12.4, 13.7, and 49.7% correspondingly. The CBR values increased by 1.1 to 1.7 times, which is equivalent toa 50 to 100 cm increase in layer thickness. Increases in CBR values going forward range from 1.5 to 1.8 times as the layer thickness increases from 50 cm up to 150 cm.

[2] Partab Rai, et.al. (2021) investigated the stabilization of subgrade soils using waste fly ash (FA) and cement (OPC), yielding significant environmental and economic benefits. Laboratory tests (Atterberg limits, free swell index, unconfined compressive strength, California Bearing Ratio, and scanning electron microscopy) were conducted on soil treated with 0-20% FA and 0-8% OPC. Results showed decreased plasticity and swell index, and increased CBR (71.34% improvement) and UCS (48.20% increase) with optimal 20% FA + 8% OPC mixture. This study demonstrates the effectiveness of waste FA and OPC in enhancing subgrade soil stability, offering a cost-effective, eco-friendly alternative for pavement and foundation construction, and promoting sustainable waste management.

[3] Hemant S. Chore, *et. al*. (2020) replaced cement with industrial by-products like as fly ash (FA), ground granulated blast furnace slag (GGBFS), silica fume (SF), metakaolin, rice husk ash, etc., provides various advantages. The experimental studies for determining the strength characteristics of concrete produced with pozzolanic waste materials that is, supplementary cementitious materials (SCMs) like FA, GGBFS, and SF as the cementer putting materials are presented in this work. Additionally, superplasticizer was employed to increase the workability. Along with the flexural and indirect tensile strengths corresponding to 7, 28, 40, and 90 days of curing, the compressive strengths corresponding to these curing periods were also investigated. The investigation finds that industrial.

[4] Seyhan Fırat, et.al. (2020) has explored the potential reuse of coal fly ash (FA) and basic oxygen furnace (BOF) slag as sub-base materials in highway pavements, diverting these industrial by-products from landfills and mitigating environmental pollution. Studies have characterized FA and BOF slag's chemical, mineralogical, and microstructural properties, then investigated their effects on kaolin soil mixtures with varying proportions (0-25% FA and BOF slag, 5% lime). Findings indicate significant improvements in dry unit weight, unconfined compressive strength, and California Bearing Ratio (CBR) with optimal results achieved at 25% FA and 15% BOF slag. XRD and SEM analyses revealed the formation of hydrated products, such as C-S-H and C-A-S-H, contributing to enhanced mechanical properties. These results demonstrate the feasibility of utilizing FA and BOF slag in road base and sub-base applications, offering a sustainable solution for waste management and construction material sourcing.

[5] Kiran Devi, et.al. (2020) generated large quantities of hazardous by-products (fly ash, marble powder, C&D waste, brick powder, agricultural wastes) that harm natural habitats and require sustainable solutions. Improper disposal into land or water bodies causes pollution, but utilizing these wastes in construction as subgrade stabilizers or cement additives offers a viable alternative. Studies have investigated the effects of various waste materials (lime, cement, plastic waste, industrial waste, fibers, mushroom waste, wet olive pomace) on soil compaction and strength, demonstrating significant improvements in engineering properties. This waste-to-resource approach mitigates environmental threats and supports eco-friendly construction practices, providing a promising solution for waste management.

[6] Raghda Kamil kadhum & Mohammed Abbas Aljumaili (2020) researched on soil stabilization for subbase course pavement highlights the potential of waste ceramic dust (WCD) and waste plastic strips (WPS) as eco-friendly and economical reinforcements. A study mixed local clayey gravel and sand with 0-25% WCD and 0.5-2% WPS, conducting California Bearing Ratio (CBR) tests. Results showed significant strength enhancement, with optimal combinations of 20% WCD and 1% WPS yielding higher CBR values. This innovative approach to ground improvement leverages waste materials, reducing disposal concerns and promoting sustainable construction practices. The findings demonstrate the viability of ceramic dust and plastic strip reinforcement in enhancing subbase soil strength, offering a cost-effective and environmentally friendly solution.

[7] Abhishek Sharma and Ravi Kumar Sharma (2020) conducted a laboratory investigation on the use of construction demolition waste in poor clayey soil to improve its strength and drainage characteristics. The results showed that the maximum dry density and optimal moisture content were both decreased in poor soil when CDW was added. In virgin soil, the modulus also increased when CDW was added. The findings of the various tests analyses indicated that the expected values and laboratory results agreed well. It follows that employing CDW to stabilize weak clayey soil will not only address the issue of disposing of it but also be environmentally friendly and cost-effective.

[8] Le Ding, *et. al.* (2020) recycled CDW into subgrade materials is a promising path to process these wastes, with significant environmental and economic benefits. But very little work has been done in this field. The CDW materials chemical and physical characteristics were examined. According to the findings, recycled CDW aggregates perform well when they are graded correctly. The soil subgrade is more deformed than the subgrade filled with recycled CDW. Lastly, in order to evaluate the environmental benefits of the treatment strategies direct landfilling and recycling for use as subgrade materials life cycle assessments (LCAs) were carried out. Large volumes of CDW will be consumed if the subgrade is filled with recycled CDW aggregates, which will significantly lesser the environmental effects.

[9] Serji Amirkhanian, *et. al.* (2020) contained structural properties, treatments, novel researches, environmental analysis, and economic analysis of each solid waste material. six most widely used solid waste materials waste rubber, waste plastics, fly ash, bottom ash, recycled concrete aggregates were ultimately chosen form additional research and evaluation. The remaining materials are not mass produced nor suitable for direct use in pavement structures, which is why only these six solid waste materials were chosen. Future researchers are encouraged to implement researches on solid waste materials in pavement engineering with consideration of both material properties and environmental/economic effects.

[10] Mukhtar Abukhettala & Mamadou Fall (2020) used plastic waste with soil for soil reinforcement, the potential for various types and forms of plastic waste with natural subgrade soil in the road industry has not yet been properly evaluated. In this work, silty or clayey gravel and sand soil were mixed with ground, flaky, and pelleted forms of four different types of sorted plastic garbage from a recycling market. Because plastic material has a lower relative density than soil particles, the addition of plastic wastes reduces the maximum dry densities of subgrade soils, according to the obtained data. Additionally, it has been discovered that the addition of plastic garbage can alter the CBR of the subgrade. Permeability values of many subgrade soil samples increased with the addition of plastic waste, whereas the hydraulic conductivity of some soils modified with plastic remained unchanged. Subgrade soils with plastic had higher friction angle and lower compressive strength than plastic-free soils.

[11] A.Vijayakumar, et.al. (2019) explored the utilization of waste materials (agricultural, constructional, and industrial) for soil stabilization, offering an economical solution to enhance submerged properties. Effective waste management and environmental hazard mitigation are achieved by repurposing waste materials, such as fly ash, plastic waste, and demolition waste, to improve soil strength and durability, providing a sustainable alternative for road construction. Soil has been a primary material in road construction for subgrade, sub-base, and base layers. However, in areas with weak soils or poor subgrade strength, improvement is crucial. Traditionally, soil swapping or stabilization with waste materials has been employed.

[12] O. D. Afolayan, et.al. (2019) explored the potential of reusing agricultural wastes to enhance poor soil engineering properties in developing countries. Studies have shown that agricultural by-products, such as palm oil fuel ash, palm kernel shell ash, rice husk ash, seashell powder, and sawdust ash, effectively modify subgrade soils, with synergistic benefits when combined with traditional stabilizers. Utilizing these waste-derived stabilizers reduces landfill disposal, carbon footprints, and construction costs associated with traditional materials like cement, offering an eco-friendly and economical solution for highway construction in regions with abundant agricultural waste.

[13] Zaid Abdul Zahra Mahdi & Noor S. Al-Hassnawi (2018) have investigated the potential of Crushed Waste Glass (CWG) as a soil additive to enhance weak soil properties, offering a cost-effective alternative to traditional methods using cement or lime. Research has shown that incorporating CWG, passing through a 75μm sieve, at proportions of 3-9% by dry weight, significantly improves soil characteristics. Specifically, findings indicate that CWG addition decreases liquid limit, plastic limit, and plasticity index while increasing unconfined compression strength, shear strength, and California Bearing Ratio (CBR) values. Optimal improvement is achieved at 7% CWG content, with CBR values increasing by 2.5-9.4 times compared to untreated soil. These results suggest that CWG can effectively stabilize and enhance the engineering properties of weak soils, classified as A-7-5 (AASHTO) or ML (USCS), making it a viable solution for construction applications.

[14] Pradeep Kumar Gautam, *et. al*. (2018) recycled materials that have been effectively included into various layers of flexible pavements. Research has shown that using secondary materials not only offers an effective way to dispose of trash approach, but also lower the need for traditional building materials and lower the total cost of building. Additionally, an attempt has been made through this study to determine the reason why, notwithstanding while having crucial research, their field use has been restricted, and they provide potential solutions by. This can encourage the usage of recyclable materials in flexible pavement.

[15] A.M. Arisha, *et. al.* (2018) has motivated researchers to explore alternatives, and besides crushed glass, reclaimed asphalt pavement, and scrap tires, to name a few, plastic waste (unwanted or unusable plastic objects) has also gained attention in recent years. feasibility of using construction and demolition (C&D) waste materials, particularly blends of recycled concrete aggregate (RCA) with recycled clay masonry (RCM), as unbound granular materials (UGMs) for road construction. The proportions of the RCA/RCM blends were of the total aggregate mass.

[16] Ali Toghroli, *et. al*. (2018) used recycled materials (secondary) as opposed to virgin ones (primary) have lessened the demand for extraction and landfill pressure. (secondary) instead of virgin ones (primary) have reduced landfill pressure and extraction demanding. This study has reviewed the waste materials (Recycled crushed glass (RCG), Steel slag, Steel fiber, Tires, Plastics, Recycled asphalt) used in the pavement porous concretes and report their respective mechanical, durability and permeability functions. Waste material usage in the partial cement replacement will cause the concrete production cost to be reduced; also, the concretes' mechanical features have slightly affected to eliminate the disposal waste materials defects and to use cement in Portland cement (PC) production.

[17] Ahmed Mancy Mosa, et.al. (2017) has demonstrated the potential of waste glass powder in enhancing the engineering properties of poor subgrade soils. A study investigated the effects of grinding waste glass bottles into two particle size categories (S1: 425μm-75μm; S2: <75μm) and adding 5-20% glass powder to a selected soil. Results showed that increasing glass powder content improves soil strength and reduces volume change susceptibility, with finer particles (S2) yielding better outcomes. Notably, incorporating 20% S2-glass powder increased maximum dry density by 12%, resilient modulus by 394%, and California Bearing Ratio (CBR) by 853%, while decreasing liquid limit by 15%, plasticity index by 32%, optimum moisture content by 20%, and swelling ratio by 49%. These findings suggest that waste glass powder can effectively stabilize and enhance the properties of poor subgrade soils.

[18] Achmad Fauzi, et.al. (2016) has highlighted the limitations of clayey soils as embankment materials due to their expansive nature, leading to pavement failures and increased maintenance costs. To address this issue, studies have explored the potential of utilizing waste materials as additives for soil subgrade improvement. Specifically, investigations have focused on incorporating High Density Polyethylene (HDPE) and crushed glass into clayey soils. Findings have consistently shown that the addition of these waste materials enhances the engineering properties and California Bearing Ratio (CBR) of the stabilized soil, with optimal results achieved at additive contents of 4-12% by dry weight. The use of SEM-EDS analysis has provided valuable insights into the chemical composition and microstructural changes occurring in the stabilized soils. These studies demonstrate the feasibility of waste HDPE and glass as viable additives for improving the performance of clayey soils in pavement construction, warranting further investigation into their applications and scalability.

[19] Hanna Pau l& Sobha Cyrus (2016) stabilized weak subgrade soils for flexible pavements has shown promising results using crushed demolition concrete waste as a stabilizer. A study on Kaolinitic soil found that adding 40% waste material optimized compaction characteristics and California Bearing Ratio (CBR) values. This resulted in a 22% decrease in Optimum Moisture Content (OMC) and a 18% increase in maximum dry density. CBR values increased by 230% (3.4-11.2%), allowing for a 25cm reduction in pavement thickness. Utilizing construction and demolition wastes as stabilizers reduces carbon footprints and transforms these materials from "waste" to "resource," offering an eco-friendly and economical solution for pavement construction.

[20] Leema Peter, et.al. (2016) studies have showed that stabilizing soft soils with 0-3% coir pith and 0-1% coir fibre significantly improves compaction, elastic modulus, and California Bearing Ratio (CBR) characteristics. This eco-friendly approach addresses problematic waste disposal while enhancing soil strength, offering a sustainable and cost-effective alternative for pavement construction significant challenges as pavements subgrades due to low bearing capacity and strength, exacerbated by high water tables. Traditional solutions like excavation, replacement, and chemical stabilization are often costly and environmentally impactful. Recent research explores utilizing locally available industrial wastes, such as coir waste (coir pith and fibre), to enhance soft soil properties.

[21] R.R Singh & Er. Shelly Mittal (2014) has demonstrated the effectiveness of using natural fibers, such as coconut coir, to enhance soil properties. An experimental study investigated the stabilizing effects of coconut coir on clayey soil, mixing varying percentages (0.25-1%) of coir fiber. Results showed significant increases in unsoaked and soaked California Bearing Ratio (CBR) values (8.72-13.55% and 4.75-9.22%, respectively) and Unconfined Compressive Strength (UCS) (2.75-6.33 kg/cm^2) with 1% coir fiber addition. This natural fiber reinforcement transformed soil behavior from brittle to ductile, reducing pavement thickness and construction costs. The eco-friendly and cost-effective use of coconut coir fiber offers a promising solution for sustainable highway construction.

[22] Aditya Kumar Anupam, et.al. (2013) has explored the potential of agricultural and industrial waste materials as soil admixtures to enhance the engineering properties of clayey soils for road construction applications. Studies investigated the effects of adding fly ash (FA), rice husk ash (RHA), bagasse ash (BA), and rice straw ash (RSA) to clayey soil at varying proportions (5-35% by weight). Findings indicate that incorporating these waste materials significantly improves soaked California Bearing Ratio (CBR) values and reduces dry density. Specifically, admixing FA, RHA, BA, and RSA substantially enhanced load-bearing capacity, demonstrating their viability as soil stabilizers. These results suggest that repurposing agricultural and industrial waste as soil admixtures can effectively upgrade marginal soils for use in road construction, offering a sustainable waste management solution.

[23] Ambika Kuitya & Tapas Kumar Royb (2013) research explored utilizing waste materials (rice husk ash) and lime as additives to enhance the strength of poor subgrade silty clay soil, while reducing environmental pollution. Experimental studies mixed soil with various ratios of waste materials (S:P, S:R, S:P:R, S:P:L) and measured California Bearing Ratio (CBR) values. Results showed significant increases in unsoaked (1.16-2.06 times) and soaked (1.22-3.72 times) CBR values. Introducing geogrids at different heights further enhanced strength, with optimal mixes (S:P:R 10:15:2 and S:P:L 50:75:1) showing substantial increases in soaked CBR values (1.08-1.44 times). This study demonstrates the feasibility of utilizing waste materials and geogrids to improve subgrade soil strength, reducing pavement thickness and environmental hazards.

[24] Mohammad M. Khabiri (2009) explored the use of waste materials stabilized with lime in subbase layers to enhance strength and mitigate compressive strains in subgrade soil, manifested as rutting depth. Studies have investigated the effectiveness of stabilized recyclable materials in reducing rutting depth, demonstrating potential benefits for road construction, including cost savings, improved pavement performance, and environmental sustainability. The increasing generation of waste construction materials worldwide necessitates sustainable solutions. Utilizing these materials in pavement layers, particularly in subbase layers, offers a viable alternative, reducing project costs and minimizing environmental impacts.

3. AIM

1. To improve the strength of subgrade soil by utilizing waste material.

2. To use waste materials in subgrade soil can contribute to a more sustainability.

4. OBJECTIVE

1. To improved pavement performance.

2. To enhance durability.

3. To investigate the use of waste materials.

4. To assess the environment benefits

5. CONCLUSIONS

This comprehensive study has demonstrated the efficiency of utilizing demolished materials in soil stabilization for pavement construction, yielding significant improvements in soil properties. The findings indicate a direct correlation between the amount of demolished material added and soil strength, underscoring the potential for optimized pavement design. The incorporation of demolished materials has been shown to increase the layer coefficient, facilitating reductions in pavement thickness and initial construction costs. This advancement has profound implications for the construction industry, enabling more efficient and cost-effective pavement construction. Moreover, reutilizing demolished materials mitigates environmental concerns associated with waste disposal.

The study's results align with the principles of sustainable development, promoting the adoption of eco-friendly construction practices. By leveraging recycled materials, the industry can minimize its ecological footprint and contribute to a more environmentally conscious built environment. The reduced reliance on virgin materials also alleviates pressure on natural resources. While the findings are encouraging, further research is necessary to fully explore the feasibility of using demolished materials in subgrade pavement layers. Future studies should investigate the long-term performance, durability, and scalability of demolished material-stabilized soils. Experimental research examining varied demolished material proportions, soil types, and environmental conditions will provide invaluable insights.

In conclusion, this study highlights the potential of demolished materials to enhance soil stability, reduce construction costs, and promote sustainable development. Future research will be instrumental in unlocking the full potential of demolished materials, informing evidence-based decision-making, and driving innovation in pavement construction. By exploring the possibilities of demolished materials, the construction industry can move towards a more resilient, efficient, and environmentally responsible future.

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