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Research Article

Effect of Soil Stabilization on Structural Design of Flexible Pavement

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Abstract

Inadequate subgrade conditions often diminish the lifespan of pavements built on these soils. However, this challenge can be addressed through various methods, including soil stabilization, which enhances soil strength. This research focuses on soil stabilization using two types of waste materials (rubber and plastic) as additives in concentrations of 5%, 10%, and 15%, along with a consistent cement inclusion of 3% across all samples. Different tests, such as Sieve analysis, Atterberg Limits, Specific Gravity, Standard proctor Test and California Bearing Ratio, were performed for both the soil and the additive materials. As a result, this stabilization approach improved the California Bearing Ratio (CBR), leading to thinner pavement layers, which potentially lowers construction costs. Notably, the highest CBR observed was 49.95% with 10% plastic, while the top result for rubber was a 28.01% CBR at 5% inclusion. These enhancements in CBR values contributed to reducing the total thickness of the pavement layers by (435 mm) for both materials.

1. Introduction

Many civil engineering projects are situated on unstable soils, which are often reinforced through methods like soil stabilization. This technique is especially prevalent in road and pavement construction to enhance soil strength and reduce costs by using local resources. Historically, cement and lime have been common stabilizers, but their prices have risen sharply due to increased energy costs [1].

Rapid population and industrial growth have led to increased construction, including road pavements. Often, the soil used cannot sufficiently support the weight of these structures. Soil stabilization is a key solution for enhancing soil properties when it lacks the necessary strength. This process involves improving shear strength, bearing capacity, and settlement through the addition of cementitious or chemical materials. Stabilization can be mechanical, by mixing, or chemical, by adding additives to op-timize soil features like moisture content and cohesion [2,3].

As hazardous waste, particularly plastics, continues to accumulate, it poses significant health and environmental risks worldwide. For decades, countries have produced waste without effective disposal solutions, leading to environmental and public health issues. Traditionally, waste was burned or buried, causing harm and incurring societal costs. Today, waste from various sources is typically disposed of in landfills or incinerated, releasing harmful gases [4]. To address this challenge, researchers have devel-oped a new soil stabilization technique using non-biodegradable materials, such as plastic bottles and recycled plastic pins. This polymer/alternative waste material method offers advantages over traditional methods, including greater effectiveness, cost-effectiveness, and reduced environmental risks [5]. Re-sponding to these harmful practices, researchers are developing eco-friendly disposal methods. One ef-fective method uses waste materials in soil stabilization to economically improve soil properties and reduce construction costs, benefiting the environment [6].

Transport infrastructure, particularly sub-structures for transportation, is essential for any long-term development program in a country. The expansion of road networks is a key indicator of progress in economic, social, and commercial areas worldwide. No country can advance without adequate transpor-tation services and road networks. Therefore, it is crucial to perform thorough soil characterization in the early planning stages before the design and construction of any road system [7]. Subgrade soil is crucial in road construction because low-quality subgrade soil can lead to insufficient support and a shorter lifespan for pavements. To address this, the problematic subgrade soil can either be replaced with a higher-quality one or enhanced through the addition of admixtures. These admixtures are mixed into the soil using sta-bilization techniques to improve performance [8].

Cement offers the advantage of serving as both a soil stabilizer and a treatment for hazardous waste. By incorporating hazardous waste material into the mix, cement can effectively solidify and stabilize soil. This method, known as soil cement-based solidification-stabilization, is widely employed for managing inorganic hazardous waste materials [9].

Lime and cement are the two most commonly used chemical stabilizers in soil stabilization. For soil interlayer stabilization, cement serves as a primary component in pavement construction. As a well-established method, cement's use in the engineering sector is significant, with 3.4 billion tons pro-duced in 2012 alone. Projections indicate that by 2050, cement production could reach 5 billion tons annually, significantly impacting limited natural resources. As a result, scientists and researchers are investigating alternative waste materials for use in pavement interlayer stabilization to reduce the reli-ance on cement for subgrade stabilization processes [10]. Cement improves soil's compressive strength and transforms cohesionless soil into moderately cohesive soil. However, cement is ineffective in highly plastic soils. Conversely, lime is better suited for stabilizing plastic clays, although it becomes ineffective if the clay has a high sulfate content or is subjected to extreme conditions [11].

Advances in technology and economic changes are promoting the use of new chemical agents for soil stabilization, enhancing compatibility, durability, and strength. For this purpose, many chemicals, particularly waste materials, remain unexplored [12]. The limitations of lime and cement are increasingly favoring the use of waste materials. Recent results show that solid waste additives outperform traditional stabilizers, leading to increased industrial interest and further research into using various industrial wastes for soil stabilization [11].

Different cement percentages' effects on various soil types using California Bearing Capacity (CBR) [13]. Increasing cement content significantly improved soil strength, especially in Sandy silt (ML) soil. Cement reduces soil plasticity, enhancing bonding between particles and strengthening the soil, particularly in clayey sand and silty sand types. This suggests that cement-based soil stabilization is a cost-effective method for improving soil strength. Additionally, cement can serve as a base for composite stabilization techniques, allowing for the incorporation of other materials like hazardous waste. Aparna Roy combined rice husk ash with cement to create a composite stabilizer, aiming to assess the suitability of stabilized soil for construction through tests like CBR and UCS.

Cement kiln dust (CKD) was used as a stabilizing agent for clayey soil on a road [10]. They tested varying CKD percentages 7.5%, 10%, 12.5%, and 15% without further treatment. Initially, they determined the clay's CBR value and then added CKD to the soil. Two sets of samples were prepared: one cured and the other uncured. Finally, they evaluated the unsoaked and soaked CBR values for the different CKD percentages. Using waste plastic to modify and stabilize soil was investigated [14]. They tested four different plastic percentages 2%, 4%, 6%, and 8% for soil stabilization and found that it increased soil strength (CBR value). They determined that the optimal plastic content for both strength and cost-effectiveness is 4%, as using more than this decreased soil strength significantly. Therefore, they concluded that 4% is the ideal plastic percentage for soil stabilization.

A study has been done on modifying soil properties using scrap rubber tires [15]. They tested black cotton soil and Shedi soil with varying percentages of scrap tires (5%, 10%, and 15%) and cement (2% and 4%). Results showed that the highest CBR value was achieved by Shedi soil stabilized with 5% rubber tires and 4% cement. They concluded that the optimal rubber and cement content for both soil types was 5% and 4%, respectively.

This study aims to apply soil stabilization methods economically and effectively to the sub-grade soil layer, ensuring that stabilization costs do not inflate the overall project expenses. Additionally, it seeks to introduce soil stabilization techniques to the community of Iraqi Kurdistan, where costly and inefficient methods like complete soil replacement with aggregates are still prevalent. By promoting the use of additive materials to strengthen sub-grade soil more affordably and easily, this research aims to reduce the strain on limited resources. Recycled waste materials, specifically plastic and tires abundant in the region, are utilized to minimize environmental impact, and enhance sustainability. The investigation also aims to determine the optimal percentage of waste materials required to achieve the desired California Bearing Ratio (CBR) value, assessing the varying effects of different percentages on soil properties post-stabilization.

2. Methodology

2.1. Study Site

In this study, the soil was collected from a section of the ongoing Baban 100 m highway project in the Sulaymaniyah-Kurdistan region of Iraq. The Baban highway project is one of the most important projects in Sulaymaniyah City. It's the first time to construct a highway project as important and as big as this project in Sulaymaniyah city. The project is to build a 100 m highway with a total length of 31260 m and a width of 100 m, and its plan is shown in Figure 1.

The project is a two-directional highway with four lanes on each side. The width of each carriageway is 21 m. The median between the two main roads is 12 m. Each directional way has a service road 10 m in width. The median between the main road and the service road is 7 m wide, with a shoulder width of 6 m on each side of the main road. With the project having such a great length, changes in soil properties will be inevitable.

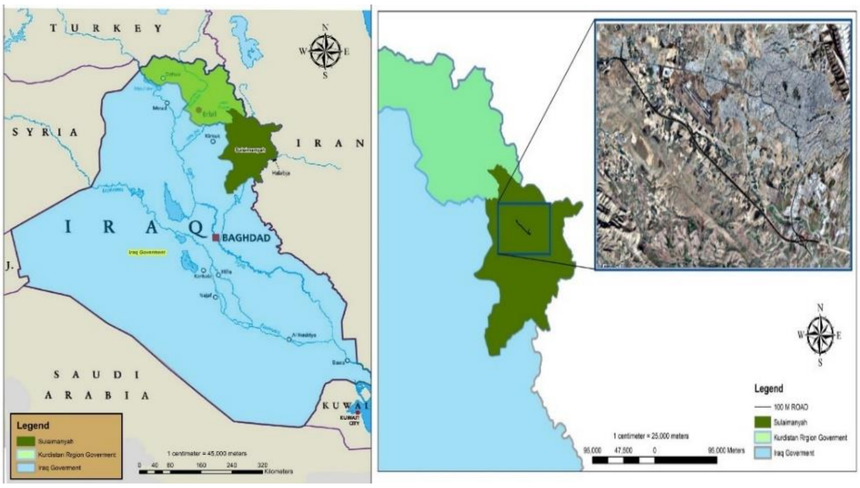

Figure 1. Baban Autoban Highway Plan

2.2. Materials and Methods

In the investigation of soil stabilization cases, soil samples were collected from the weakest section as recommended by the site engineers. Station 17+050m, of the new 100m Baban highway project. Cement-based stabilization was employed, using cement as the base material along with two additive waste materials: fine plastic waste and shredded fine rubber tires. These materials were selected to study their individual effects on soil properties. Cement was consistently added at a 3% ratio to enhance soil density and strength. Meanwhile, waste plastic and rubber tires, both accumulating as environmental hazards, exhibited positive impacts on soil properties, particularly increasing strength. These findings suggest their potential as viable soil stabilizers for road construction sub-grade layers, offering cost-effective and environmentally friendly solutions to waste management challenges.

This study integrates three key additives to enhance subgrade soil properties. Initially, we use 3% ordinary Portland cement (OPC) across all tests, acting as a binder to improve soil cohesion and compressive strength, vital for soil stabilization under load. Secondly, waste plastic is utilized as an additive. Due to its extensive accumulation and environmental impact, plastic has been repurposed for soil stabilization, effectively enhancing soil strength, as supported by the literature. Finally, shredded waste tire rubber serves as the third additive. Similar to plastic, this material poses ecological threats due to its accumulation. However, research indicates that rubber significantly improves soil properties and reduces environmental impact, making it a valuable component of soil stabilization efforts, as outlined in the literature section.

2.2.1. Mechanical Properties of Soil

According to the AASHTO classification, it is used to determine the suitability of soils for earthworks, embankments, and roadbed materials. According to this system, soil is classified into seven major groups: A-1 through A-7. Soils classified into groups A-1, A-2, and A-3 are granular materials, where 35% or less of the particles pass through the No. 200 sieve. Soils where more than 35% pass through the No. 200 sieve are classified into groups A-4, A-5, A-6, and A-7. These are mostly silt and clay-type materials.

The soil that has been used in this article is Silt-Clay material, which belongs to class A7 (specifically A-7-5 and A-7-6), according to the results from both sieve analysis and Atterberg limits tests. The soil strength is fair to poor when used as a subgrade material for highway pavement.

2.2.2. Physical Properties

According to the Texture Soil Classification (Triangular Method) U.S. Department of Agriculture System (USDA), which requires percentages for sand, silt and clay to determine the texture of the soil. The soil was found to be 100% sand. Other than that, other physical properties of the soil, such as density and grain size distribution, are mentioned in the methodology part.

2.3. Tests and Test Procedures

The research began by conducting standard tests on pure soil, including sieve analysis, specific gravity, Atterberg limits, standard compaction, and California bearing ratio (CBR), to establish baseline properties. Subsequently, we mixed the soil with waste plastic and shredded tire rubber, keeping the ordinary Portland cement (OPC) constant at 3%, to evaluate the effects of these additives on soil stabilization. The purpose is to determine cost-effective highway construction methods that maintain necessary strength standards. All tests were systematically recorded, and the results were analysed alongside previous studies to assess the enhancements provided by the additives.

2.3.1. Sieve Analysis:

In sieve analysis, a common soil test, 1 kg of soil is prepared with ASTM standard sieves [16]. The sieves are stacked, smallest at the bottom, and the soil is added to the top.

2.3.2. Specific Gravity Test

The specific gravity test measures the ratio of soil volume to the mass of an equal volume of gas-free water, indicating soil phase relationships and organic or porous content [17].

2.3.3. Atterberg Limits

The Atterberg limits liquid limit (*LL*), plastic limit (*PL*), and Plasticity Index (*PI*) determine the critical moisture contents at which a fine-grained soil transitions between physical states, impacting its strength, permeability, compressibility, and plasticity. These limits reflect the soil's capacity to retain water without altering its state from semi-solid to plastic or viscous liquid [18].

2.3.4. Standard Proctor Test

The Standard Proctor test determines the optimum moisture content (OMC) and maximum dry density (MDD) of soil, which are essential for supporting structures like pavements and foundations. This test, crucial for calculating soil stability, involves compacting soil in a mold in three layers, each receiving 25 blows from a compaction rammer. Necessary for the California Bearing Ratio (CBR) test [19], the Proctor test's results are integral for CBR computations.

2.3.5. California Bearing Ratio Test

The California Bearing Ratio (CBR) test, pivotal for determining the strength of subgrade soil and influencing pavement thickness design, is the most critical test in this study. It involves using a piston to penetrate a prepared soil sample under pressure until it reaches 2.5 mm, with the penetration to standard crushed rock ratio representing the CBR value [20].

Figure 2. The Molds Before Putting Them into The Tank

2.4. The Structure Design of Flexible Pavement.

In our case study, the structural design of the pavement adhered to the standards set by the American Association of State Highways and Transportation. This approach ensures that the design complies with recognized national guidelines for durability and safety in pavement construction [21].

2.4.1. AASHTO Guide for The Design of Pavement Structure

According to the AASHTO Design Guide [21], effective pavement design requires a comprehensive understanding of soil characteristics and the feasibility of using aggregates for the sub-base. This assessment determines whether soil modification is cost-effective and ensures high-quality construction. The AASHTO road test forms the basis for modern pavement design, stipulating predefined structural parameters necessary for determining the thickness of concrete and Hot Mix Asphalt (HMA) roadways. These parameters are also used in computer software to design pavement layers, ensuring they meet AASHTO standards [21].

2.4.2. Pavement Thickness Design Parameters

Table 1 presents a comprehensive overview of the essential criteria, design variables, pavement structural characteristics, and material properties necessary for structural design. This table is crucial for understanding the various factors that influence the engineering and integrity of pavement structures, detailing how each variable contributes to the overall design process.

Table 1. Parameter Required for Flexible Pavement [21]

Description	Flexible HMA
Performance Criteria	-
a. Initial Serviceability Index	**X**
b. Terminal Serviceability Index	**X**
Design variables	-
a. Analysis Period	**X**
b. Design Traffic	**X**
c. Reliability	**X**
d. Overall Standard Deviation	**X**
Material Properties for Structure Design	
a. Soil Resilient Modulus	**X**
b. Modulus of Subgrade Reaction	-
c. Concrete properties	-
d. Layer Coefficients	**X**
Pavement Structural Characteristics	-
a. Coefficient of Drainage	**X**
b. Load Transfer Coefficients for Jointed	-
c. Loss of Support	-

2.4.3. AASHTO Design Chart

A structural number (SN) is a critical metric used to determine the depth of each layer in pavement design. One can calculate it directly from the AASHTO design chart, as shown in Figure 3, providing a visual method based on standard guidelines. Alternatively, one can mathematically derive SN using specific equations, which allows for precise adjustments based on unique project requirements.

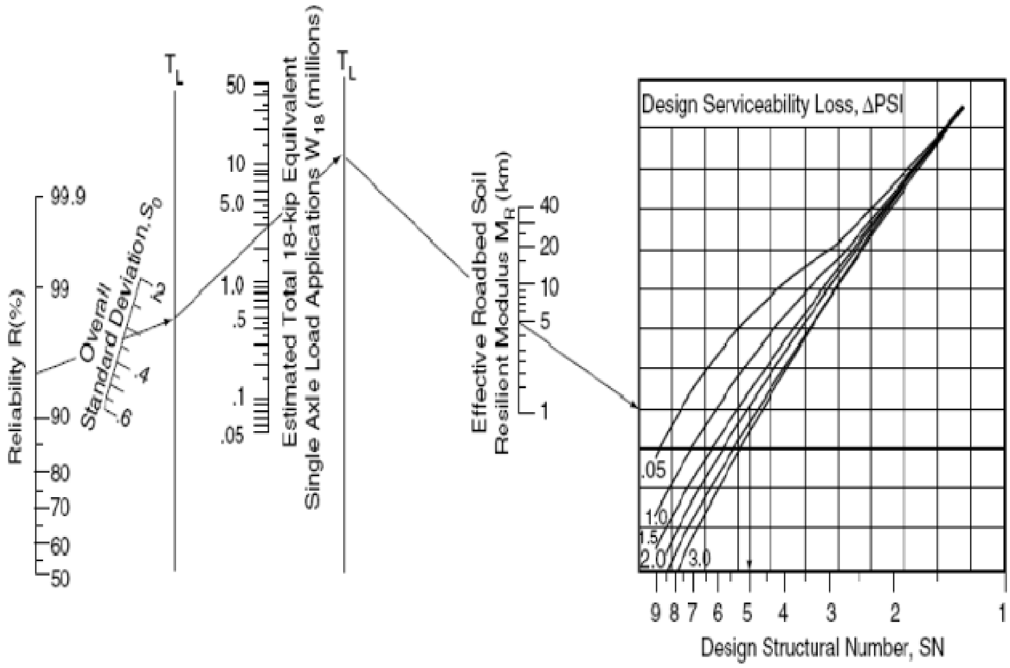

Figure 3. Design Chart for Flexible Pavement [21]

After finding the value of Structural Number (SN), through the use of the following equations, the thickness of the layers is found:

$$Log(W18) = Z_R x S_O + 9.36 Log(SN+1) - 0.2 + \frac{Log\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.4 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 Log(M_R - 8.07) \quad (1)$$

$$MR = 2555 \times CBR^{0.64} \quad (2)$$

$$SN = a_1D_1 + a_2D_2M_2 + a_3D_3M_3 \quad (3)$$

$$SN1 = a_1D_1.\ M_R \text{ of base} \quad (4)$$

$$SN2 = SN1 + a_2D_2M_2.\ MR \text{ of subbase} \quad (5)$$

$$SN3 = SN2 + a_3D_3M_3.\quad MR \text{ of subgrade soil} \quad (6)$$

Where *W18* is the predicted number of 18-kip equivalent single axle load applications, Z_R is the standard normal deviate, S_o is the combined standard error of the traffic prediction and performance prediction, ΔPSI is the difference between the initial design serviceability index, PO, and the design, terminal serviceability index, P_t, M_R is the resilient modulus (psi), ai is the ith layer coefficient, Di is the ith layer thickness (in.) and, mi is the ith layer drainage coefficient.

3. Results

This section details the outcomes and calculations of the tests described in the methodology chapter, covering the sequence from the sieve analysis test to the California Bearing Ratio (CBR) test. The section delves deeply into the results, elucidating the conduct of each test, the data collected, and the impact of these results on the overall research findings.

3.1. Sieve Analysis

The preliminary sieve analysis of soil from the Baban autobahn revealed compositions of 19.5% gravel, 80.5% sand, and 5% fines (silt and clay), as depicted in Figure 4a. This analysis produced coefficient of curvature (Cc) and coefficient of uniformity (Cu) values of 0.82 and 21.05, respectively, suggesting a gap-graded particle size distribution due to these values exceeding normal ranges. A subsequent analysis of plastic waste, shown in Figure. 4b, indicated that the particles were entirely sand-sized, with Cc and Cu values also exceeding the usual limits, affirming a gap-graded particle distribution. Similarly, the last sieve analysis on rubber waste, illustrated in Figure 4c, showed exclusively sand-sized particles, with outlier Cc and Cu values, indicating a uniform gap-graded distribution among the materials tested. Comprehensive test results are provided in the appendix.

3.2. Specific Gravity

In our specific gravity test, we utilized pycnometers of two different capacities, 500 mm and 1000 mm, to enhance the precision of our results. The 500 mm bottle was used for the first trial, while the 1000 mm bottle was employed for the subsequent two trials. The specific gravity (Gs) recorded was 2.4 in the first trial, 2.46 in the second, and 2.41 in the third. Calculating the average of these trials yielded a Gs value of 2.423 for our soil.

3.3. Atterberg Limit Test

The Atterberg limit test, which was required by the Baban highway headquarters, assessed the soil's plastic and liquid limits. Our report emphasizes the findings rather than the methods used. The soil underwent three tests, and the averaged outcome revealed a liquid limit of 40.37.

Similar to the liquid limit test, an average was computed for the plastic limit. We established the average plastic limit at 30, and found the plasticity index at 10.37.

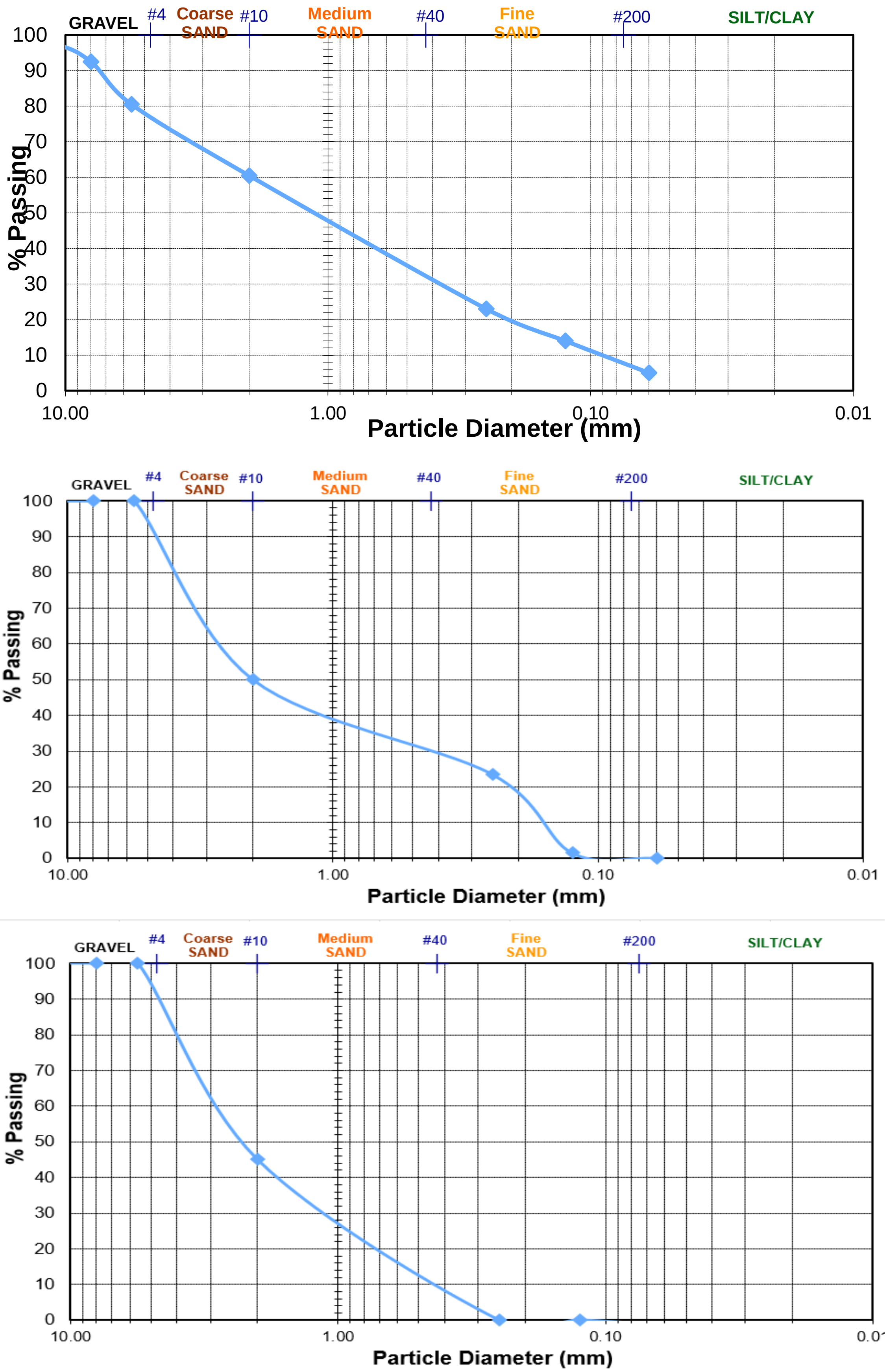

Figure 4. Particle Size Distribution for a) Soil, b) Plastic and c) Rubber

3.4. Standard Proctor Test

In this study, the standard proctor test was conducted on various prepared samples. A total of seven samples were created, including one solely consisting of soil. Three of these samples incorporated rubber in varying proportions of 5%, 10%, and 15%, while the other three included plastic at the same respective percentages. Additionally, each sample was uniformly enhanced with 3% cement. The initial proctor test targeted the sole soil sample without additives, determining its maximum dry density (MDD) and optimum moisture content (OMC) to be 1.81 gm/cm^3 and 15.5%, respectively.

Subsequent tests were performed on samples containing both plastic and rubber additives, along with the consistent 3% cement. The results, presented in Figure 5 and Table 2, indicated variability in MDD and OMC across these samples. This variation arose from the differing amounts of plastic and rubber and the stable cement addition.

Analysis of the data revealed that cement significantly influenced the MDD and OMC values due to its hydrating properties when mixed with water, necessitating a higher OMC to achieve the desired MDD. Conversely, plastic and rubber also impacted these values, as they do not absorb water and are more challenging to compact. Notably, the sample with 10% plastic content showed the highest MDD, while the highest MDD for rubber was found in the 15% sample, detailed further in the appendix.

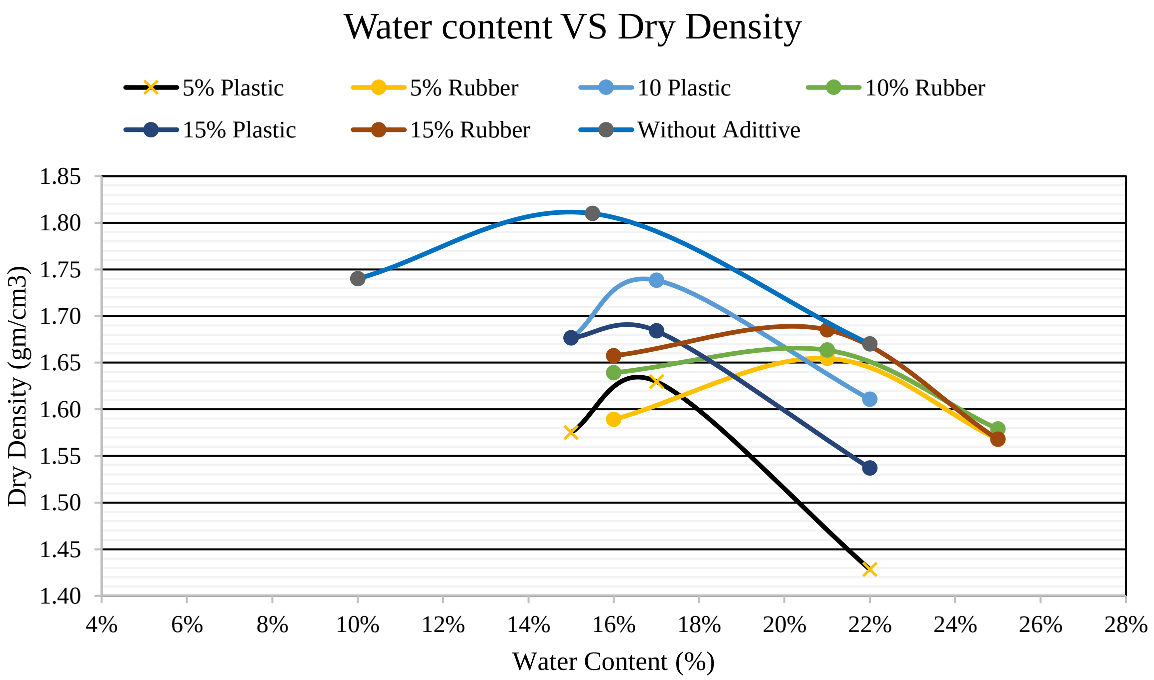

Figure 5. Graph of MDD & OMC of Baban Auto-Ban Soil With & Without Additive

Table 2. Proctor Test Result

Baban Auto-ban Proctor test Result			
Soil + Stabilizer	**Additive %**	**OMC %**	**MDD gm/cm^3**
No Additive	0	15.5	1.81
	5	20.9	1.655
Rubber	10	20.4	1.665
	15	20.2	1.69
	5	16.6	1.635
Plastic	10	16.7	1.74
	15	16.5	1.69

3.5. California Bearing Ration (CBR)

Following the determination of the optimum moisture content (OMC) through the standard proctor test, the research advances to its critical phase—the California Bearing Ratio (CBR) test. The OMC obtained from the proctor test is incorporated into the various samples to achieve maximum dry density, ensuring the soil is at its optimal strength for the CBR test. Figure 6 hows the CBR value for the soil without any additives.

Figure 6 illustrates how the California Bearing Ratio (CBR) changes with varying amounts of rubber and plastic additives, alongside a constant 3% cement addition—except in the case where no additives are used. Figure 6a demonstrates the impact of rubber and cement on the CBR. Initially, the soil alone had a CBR of 3.39%. Introducing 5% rubber increased the CBR dramatically to 28.01%, likely due to the cement's hydration with water and soil particles and the rubber's elasticity. However, increasing the rubber content to 10% decreased the CBR to 25.53%, and at 15% rubber, it dropped further to 19.48%.

In contrast, as shown in Figure 6b, adding 5% plastic raised the CBR from 3.39% to 38.56%, indicating that plastic enhances soil strength through the density and robustness of the plastic particles. At 10% plastic, the CBR further increased to 49.94%. However, at 15% plastic, the CBR slightly decreased to 48.05%.

In summary, the results clearly demonstrate that stabilization using cement with plastic waste outperforms stabilization with rubber. From the data presented in the previous figures, the effectiveness of plastic is evident; even 15% rubber cannot match the stabilizing power of just 5% plastic. This underscores the significant role of plastic in the soil-stabilizer mix. It is common for stabilizers to sometimes reduce soil strength, often due to chemical interactions between the stabilizers and soil particles. Typically, there exists an optimal concentration for stabilizer addition. Exceeding this optimal value can lead to a gradual decline in soil strength [14].

a)

b)

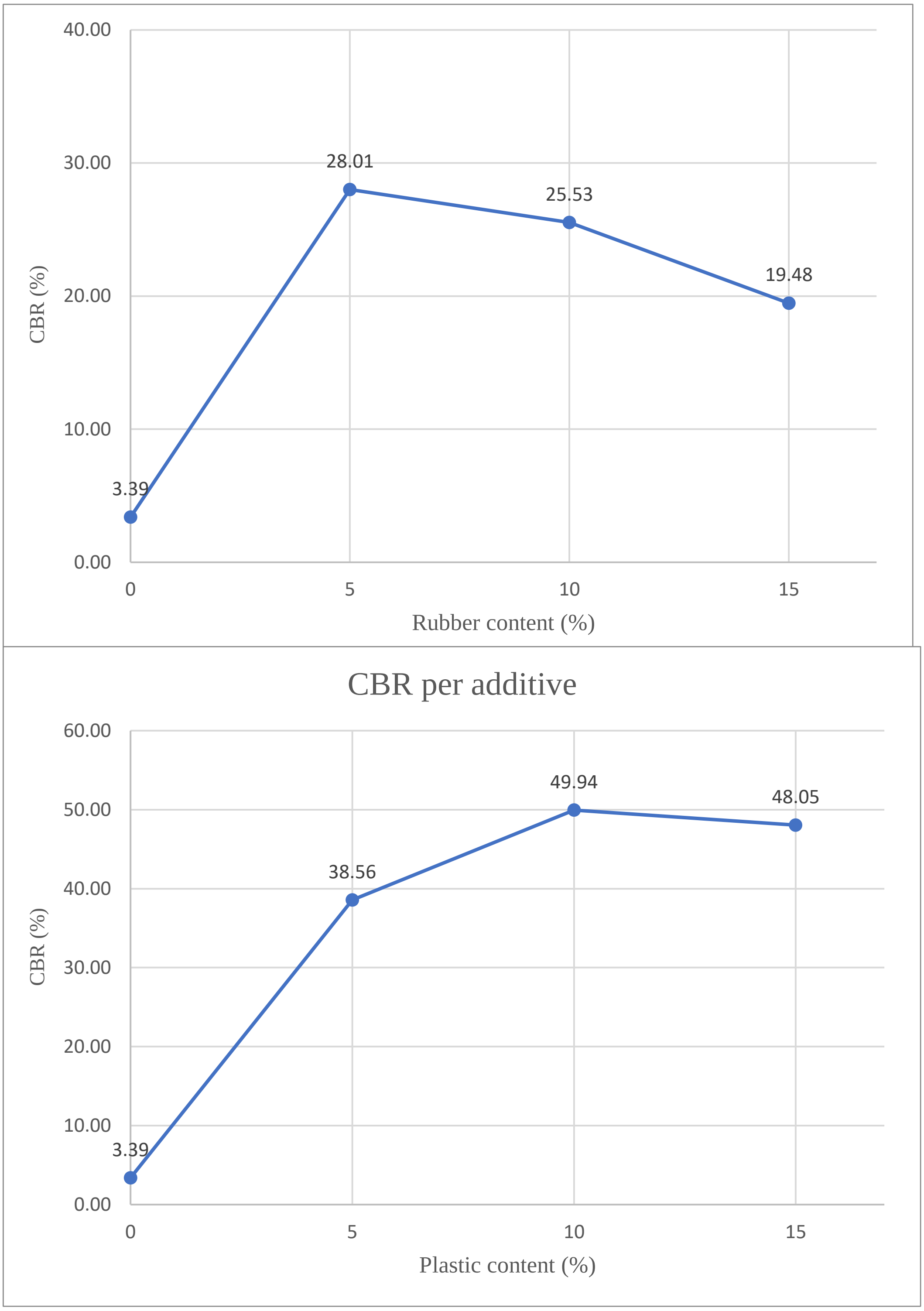

Figure 6. The Variation of CBR Per the Addition a) Plastic, b) Rubber

3.6. The Structural Design of Pavement Layers

Upon completing all the necessary tests, we will proceed to the final phase, which involves designing the pavement layers based on the results obtained from our tests. We employed the AASHTO method to determine the thickness of these layers, with particular attention to the subgrade layer. While the strength and other relevant data for the additional layers have been estimated according to AASHTO standards, it's important to note that this study primarily concentrates on the subgrade's CBR or strength. Consequently, certain factors are assumed to maintain consistency across all samples, as the main focus is on how the CBR value influences the subgrade's thickness.

Table 3. shows the parameters for structural design of layers calculation, most of the parameters are fixed, because the data are assumed data. The only data that changes is changing is CBR value, since its important parameter and the only data has been developed and increased.

Table 3. Parameters and their values for designing of The Subgrade Layer for Baban Auto-Ban Soil with No Additives

Inputs Box	Quantity	Unit	Name
W18 =	35,000,000	Ib	ESALs Applications Over Design Period
R =	90	%	Reliability
So =	0.45	unitless	Standard Deviation
CBR =	3.39	%	California bearing ratio
MR =	5,581.09	psi	Subgrade Resilient Modulus
P_i =	4.2	unitless	Initial Serviceability
P_t =	2.5	unitless	Terminal Serviceability

Table 4 presents a summary of the pavement layer thicknesses using various stabilizer contents in the soil. For comprehensive calculations, details will be provided in the appendix of this study.

The table referenced earlier illustrates how changes in the CBR value affect the thickness of the sub-base and the overall pavement. It is evident that the soil with a plastic additive is more robust compared to the soil with a rubber additive, attributed to the strength and rigidity of the fine plastic particles in the soil mix. Additionally, when comparing the different stabilizers, the cement-based stabilization with plastic consistently proves more effective than that with rubber, reducing the overall thickness by approximately 47.8% compared to the original.

Table 4. Summary of Pavement Layer Thickness with The Addition of Different Contents of Different Stabilizers for Baban Autoban Soil

Baban Auto-ban soil					
Sample No.	**Description**		**CBR %**	**Layer Name**	**Layer Thickness (mm)**
1	No addi-tive	----	3.39	Surface Coarse	190
				Base Coarse	135
				Subbase Coarse	585
				Total	910
2	rubber	5%	28.01	Surface Coarse	190
				Base Coarse	135
				Subbase Coarse	150
				Total	475
3	rubber	10%	25.53	Surface Coarse	190
				Base Coarse	135
				Subbase Coarse	150
				Total	475
4	rubber	15%	19.48	Surface Coarse	190
				Base Coarse	135
				Subbase Coarse	150
				Total	475
5	plastic	5%	38.56	Surface Coarse	190
				Base Coarse	135
				Subbase Coarse	150
				TOTAL	475
6	plastic	10%	49.94	Surface Coarse	190
				Base Coarse	135
				Subbase Coarse	150
				Total	475
7	plastic	15%	48.05	Surface Coarse	190
				Base Coarse	135
				Subbase Coarse	150
				Total	475

However, if a layer thickness of less than 150 mm is permissible, the reduction in thickness can reach up to 72% of the original thickness when 10% plastic is used. With 5% rubber, the minimum reduction is at least 50% of the original thickness, as illustrated in Figure 7. If a layer thickness under 150 mm is allowed, the saved thickness could amount to 655 mm, significantly lower than the original thickness of 910 mm.

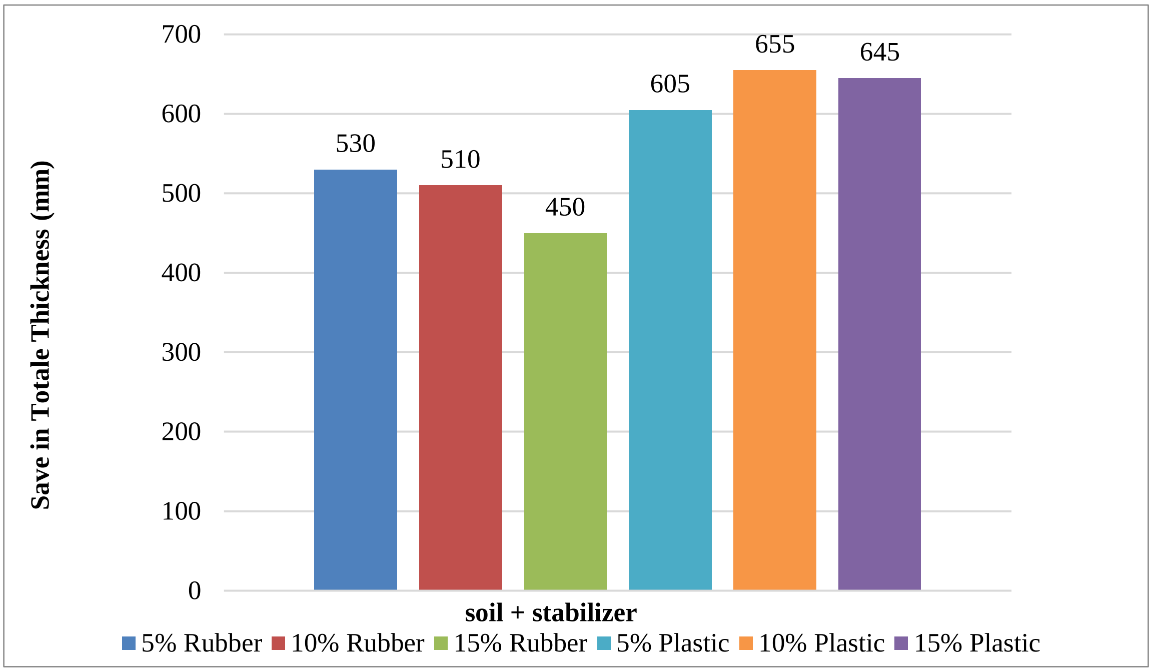

Figure 7. The Amount of Save (In Millimeters) in the Total Pavement Thickness in The Different Cases of Adding Additives to Baban Autoban Soil if Less Than 150mm Was Allowed

4. Conclusion

The study case can be concluded by clarifying the importance of stabilization in the real life of engineering, especially in highway and transportation projects, where this technique can be a very adequate alternative to remove weak soils and backfilling them with stronger soil. In the study the selected soil type was to be stabilized by using two additives with three different percentages for each additive and with a constant ratio of cement, which was 3%. The stabilizers proved to be effective and resulted in further strengthening the soil and improving its response to traffic loads on a pavement by making the pavement layer thinner, meaning more economical pavement construction, while at the same time having the ability to resist the same load. One of the parameters for designing pavement is CBR value, which is an indication of soil strength for pavement, was increased while using cement-based stabilization, in which the increment in strength reached 49.95% in the soil for plastic. Rubber stabilization also improved the CBR value, but in a smaller amount compared to plastic stabilization, in which the maximum CBR for rubber was 28.01%. This increase in CBR causes a decrease in Flexible pavement layers since CBR plays an important role in the structural design of pavement. The total decrease for all cases was 435 mm. The CBR value affects the thickness of the subbase and the overall pavement. It is evident that the soil with a plastic additive is more robust compared to the soil with a rubber additive, attributed to the strength and rigidity of the fine plastic particles in the soil mix. Additionally, when comparing the different stabilizers, cement-based stabilization with plastic consistently proves more effective than that with rubber, reducing the overall thickness by approximately 47.8% compared to the original value.

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