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ORIGINAL CONTRIBUTION

Reuse of Non-Degradable Waste Polyethylene Bottles for Ground Improvement

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***Abstract*— This paper proposes the use of waste plastic bottles as a soil stabilizer. Plastics have always been difficult to dispose of since they are non-biodegradable. Today's building industry is in desperate need of low-cost materials to improve soil strength and bearing capacity. Waste plastic can be used to improve the geotechnical qualities of poor-grade soil. One of the most prevalent problems with recycling plastic is that it is typically made up of more than one type of polymer or has fibers added to it for increased strength. To measure the impact of plastic trash, various tests such as California bearing ratio (CBR), standard proctor, specific gravity and atterberg limits were performed on various samples. The current research discusses the current state of utilization of various waste plastics for soil enhancement in terms of geotechnical parameters. Outcomes of the experimental performance indicate that plastic waste can be used for soil stabilization and to alleviate the difficulty of disposing of plastic waste as well as resolving environmental issues.**

***Index Terms*— Clayey soil, Soil stabilization, Ground improvement, Waste plastic, Polyethylene bottles**

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I. INTRODUCTION

Waste plastic bottles is considered to be a sustainable waste and environmental pollutant in nature for about 300 years, therefore reusing or recycling it can be effective in reducing environmental impacts related to it [1]. This plastic waste is increasing quickly nowadays, and there are no effective disposal solutions available in our society [2]. People, at only one thing, are continually looking for more goods at lower rates, but they are also pursuing the route of garbage disposal. Since its debut over a century ago, plastic has become an indispensable component of our daily lives [3]. The only method of reducing the dangers of plastic is to recycle it. Oil, which is a limited resource, is used to make plastics. Because of its 300-year hydrophobicity in nature, plastic is considered a useful garbage and ecological disaster [4]. As a result, repurposing or discarding it may be effective in reducing the environmental problems associated with it [5].

Due to the consequences some of the plastic facts are as follows:

Every year, Pakistan wastes around 3.3 million tons of plastic. If we dump this rubbish all at once, it might reach a height of 15600 meters, making it the highest of two of the world's second-highest mountains (K2 Mountain) [6].

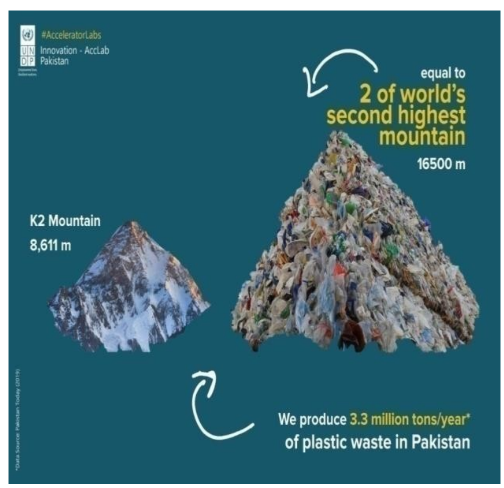

Fig. 1. Lab research of Pakistan

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According to the United States National Oceanic and Atmospheric Administration, land-based pollution accounts for 80% of ocean contamination, resulting in 8 million tons of non-biodegradable waste (plastics) and the deaths of over 1 million and 0.1 million sea birds and sea mammals every year [7]. Plastic packaging accounts for 42 percent of total use, with only a small portion of this being recycled each year. According to El Nio–Southern Oscillation (ENSO), plastic bottle production was negligible in the 1960s, but there has been an alarming growth in bottles produced and sold over the years, yet the rate of recycling remains low [8].

The time it takes for plastic bottles to degrade is its biggest downside; on average, a plastic bottle takes 500 years to decompose [9]. The plastic breakdown is impacted by a number of elements, including the type of plastic used, the environment, and the acids present in the dump; yet, plastic continues to survive for a long time, filling wastes indefinitely [10]. Plastic is made from oil by-products and natural gas material that might be used in a variety of different applications or saved if the consumption of plastic was reduced. For example, natural gas may be used to heat homes and prepare food [11]. The use of plastic in the volume that we use now diminishes the quantity of these materials, which are forever gone when they are depleted. As a direct effect of environmental debris, wildlife is trapped in nets or large debris. It is the leading cause of death in sea creatures, crabs, and birdlife [12]. Intake is a second consequence that affects the entire food chain of the ecosystem. Because of the chemical additives employed in their production, plastics have the potential to be harmful to humans. Plastics' release of toxic materials has been linked to cancer, birth defects, reduced immunity, and other health problems [13].

It has been demonstrated that using plastic bottles as novel construction materials may be a viable alternative to traditional materials [14]. The requirement to create and utilize alternate/waste materials for building as well as improve the engineering properties of current materials is needed by the rapid development of infrastructure and lack of resources because it supplies the basis for all forms of construction [15]. Ground improvement is a useful method for improving soil parameters [16]. The real aim of any stabilization technique is to increase the strength and stiffness of the soil, as well as its workability and constructability [17]. The addition of non-degradable plastic bottles to a problematic soil with optimum composition raises the California Bearing Ratio (CBR) value thus enhancing the maximum bearing capacity [18]. The decrease in the number of voids promotes dry density. This improves compaction, decreasing the OMC (Optimal Moisture Content) and raising the maximum dry density [19]. It promotes the soil's cohesiveness, making it easier to work with. It has been found that the use of polyethylene bottles as innovative soil improvement materials in foundations can be an appropriate method for soil that is unstable or problematic soil [20, 21].

A. Aim and Objectives

The goal of this inquiry is to look at the possibility of reusing waste plastic bottles (Polyethylene) because plastic is a non-biodegradable waste in the environment, the only practical way to dispose of it is to reuse plastic bottles.

- To examine the use of plastic bottles as municipal garbage in the soil for the purpose of ground improvement.
- Increase the strength and reduce the compressibility of soil
- Reducing the permeability of the soil
- To control groundwater and environmental pollution.
- Increase the mechanical strength to evaluate the possibility of recycling waste polyethylene bottles.
- Improve CBR of soil
- The non-degradable waste improves the structure and strength of the soil in terms of compaction, energy absorption, and shear strength, CBR since their addition also helps favorably.

II. MATERIALS AND METHOD

The study of the material utilized and the methodology followed will be discussed in this section.

A. Soil

Soil is such an important component of every building project. It is important to learn about its fundamental features and conduct several tests to determine whether the soil sample chosen is suitable for the respective research or not. The soil sample collected for the investigation was loose clayey soil lying in the USCS group "CL-ML" having a specific gravity of 2.52.

B. Plastic (Non-Degradable Polyethylene Bottles)

Non-degradable waste is described as a substance that does not degrade or dissolve naturally and is a pollutant. Plastics, metal, aluminum, and cans, among other materials, are included. We choose non-degradable waste polyethylene bottles of sugary drinks and other items dumped in the trash for this research.

To accomplish study objectives, following step by step method was followed as under.

- A review of previous study's literature, including revisions to the book, scientific articles, and publications on the subject of recycling non-degradable waste polyethylene bottles for ground improvement.
- Site visits and examinations of the reused plastic handling plants to get more data and gather tests.
- Deep investigation of soil creation innovation.
- Collection of non-degradable waste polyethylene bottles and quarry dust.
- Using CBR tests, investigate the efficiency of non-biodegradable waste polyethylene bottles in enhancing bearing capacity.
- To study the maximum dry density (MDD) of soil using non-degradable waste polyethylene bottles by performing optimum moisture content (OMC) test.
- To study the compression and shear strength of the soil by performing tests.
- To study the ratio of the mass of water held in the soil to the dry soil by adding non-degradable waste polyethylene bottles in improving the Moisture content test.
- To study the compaction of the soil by using non-degradable waste polyethylene bottles in soil, and check out by Standard Procter Test.
- To study specific gravity outcomes after the additive is added to it.
- Discussion of testing results and drawing ends and suggestion.

III. RESULTS AND DISCUSSION

This section presents the data gathered, outcomes of the experiments, analysis done, and the interpretation of the findings. All the outcomes are presented in the tables and graphs as follows.

A. Proctor Compaction Characteristics

The OMC and the MDD values can find out by the standard proctor test. Investigations were done on virgin soil as well as the modified soil with plastic waste additive. The following are the results:

TABLE I
VARIATION OF DRY DENSITY AND OMC WITH PERCENT ADDITIVE (PLASTIC WASTE)

S. No.	Percent Additive (%)	Dry Density (mg/cm3)	OMC (%)
1	0	1.53	13.81
2	1	1.43	13.12
3	2	1.48	13.41
4	3	1.41	13.08

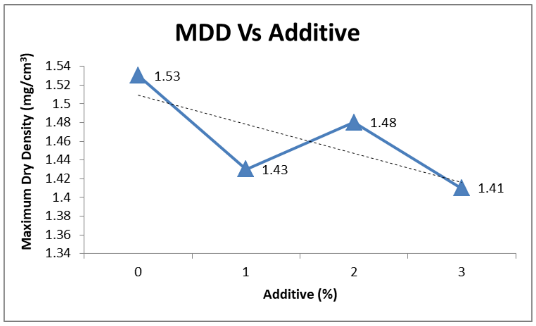

Fig. 2. MDD Against Percent Additive (Waste Plastic Bottles)

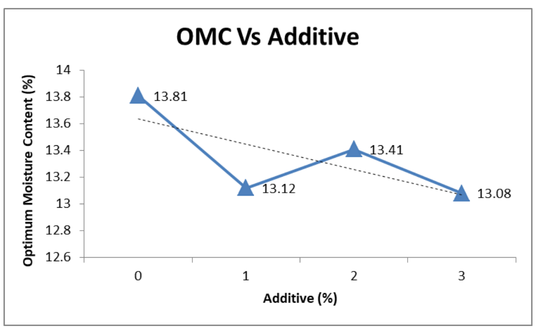

Fig. 3. OMC Against Percent Additive (Waste Plastic Bottles)

B. Discussion

Maximum Dry Density (MDD) values are high in pure soil but as the percentage of additive is increased, the value of MDD decreases which ultimately indicates the decreasing rate of optimum moisture content (OMC).

C. Atterberg Limits

Plastic Limit (PI), Liquid Limit (LI), and Plasticity Index (PI) were investigated in the soil with and without admixture and the following results were drawn.

TABLE II
VARIATIONS OF LL, PL, AND PI FOR SOIL AND WASTE PLASTIC BOTTLE MIXES

S. No.	Soil + Plastic Bottles (%)	Liquid Limit (LL) %	Plastic Limit (PL) %	Plasticity Index (PI) %
1	100 + 0	33.10	29.14	3.96
2	99 + 1	31.73	28.78	2.95
3	98 + 2	31.35	27.94	3.41
4	97 + 3	28.22	25.63	2.59

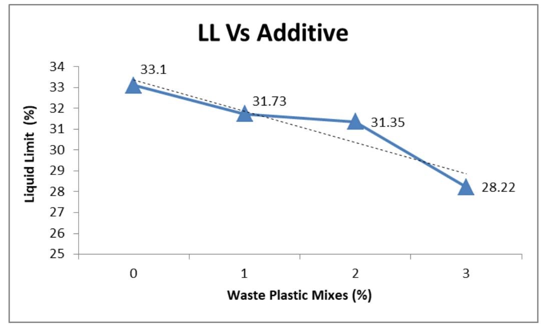

Fig. 4. Plot of the Curve between LL with Percentages of Waste Bottles

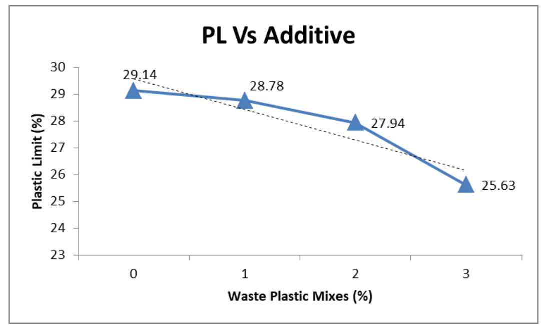

Fig. 5. Plot of the Curve between PL with Percentages of Waste Bottles

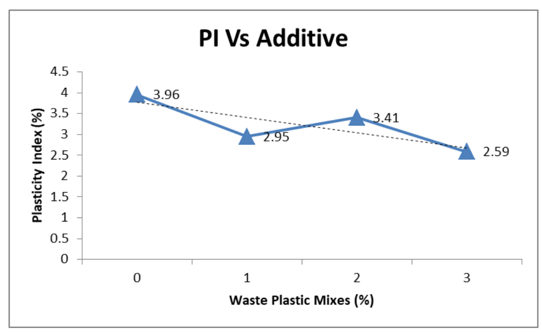

Fig. 6. Plot of the Curve between PI with Percentages of Waste Bottles

It is observed that as the amount of additive (plastic bottle wastes) increases, the liquid limit, plastic limit, and plasticity index continue diminishing and is depicted CL-ML according to USCS by plotting the qualities on the plasticity chart.

D. Specific Gravity

The Percentage of variation of specific gravity to the admixture is shown in figure.

TABLE III
VARIATIONS OF SPECIFIC GRAVITY WITH DIFFERENT PERCENTAGES OF SOIL + WASTE PLASTIC BOTTLES

S. No.	Soil + Waste Plastic Bottles	Specific Gravity (Gs)
1	100 + 0	2.52
2	99 + 1	2.59
3	98 + 2	2.54
4	97 + 3	2.61

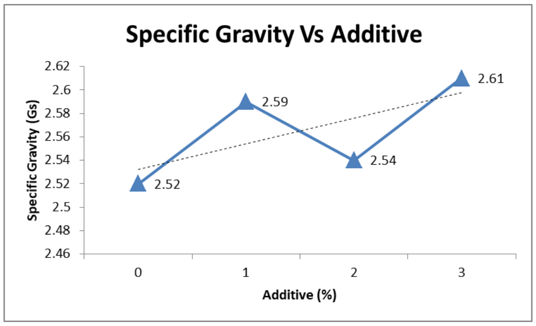

Fig. 7. Specific Gravity with Percentages of Waste Plastic Bottles

It is observed that as the percentage of admixture (waste plastic polyethylene bottles) increases, the specific gravity increases except on 2% additive where the reduction is observed.

E. California Bearing Ratio (CBR)

Following are the outcomes of the California bearing ratio experiment presented in the form of graphs.

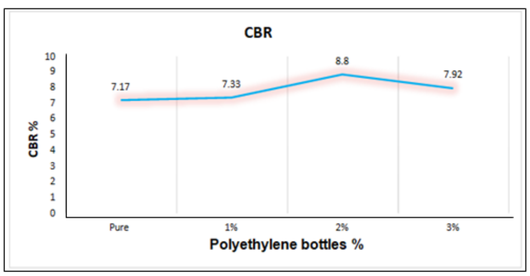

Fig. 8. CBR Values Against Waste Polyethylene Bottles (Additive)

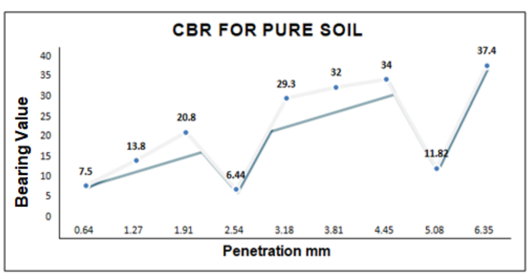

Fig. 9. CBR Against Penetration for Virgin Soil (0 % Additive)

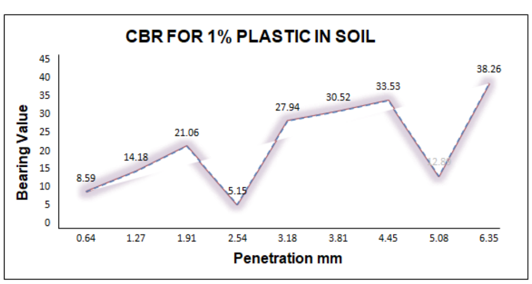

Fig. 10. CBR Against Penetration for Soil with 1% Additive

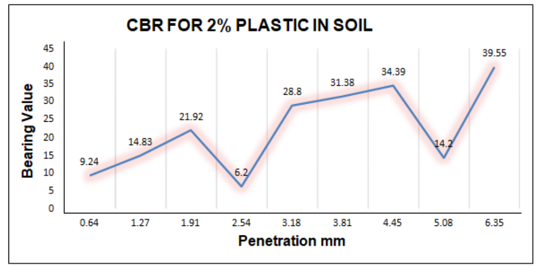

Fig. 11. CBR Against Penetration for Soil with 2% Additive

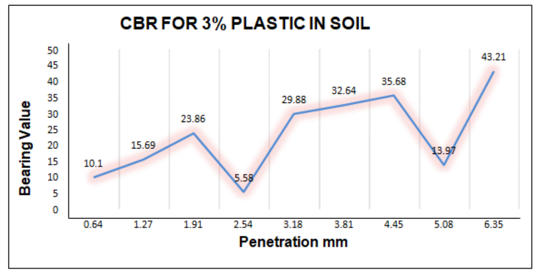

Fig. 12. CBR Against Penetration for Soil with 3% Additive

From the laboratory experiment, it is observed that the addition of plastic bottles with optimum content increases the value of CBR. As a result of the findings, the value of CBR rose by 2% of the amount of garbage plastic utilized. However, when the content of disposable cups surpasses 2%, the value of CBR begins to fall. According to the lab results, the CBR value goes up from 7.33% to 8.88% for 2% plastic bottles. On adding 2.5% or 3% plastic trash, the value of CBR rises to 7.9%. These findings indicate that 2% of plastic trash is the ideal quantity of polyethylene bottles that should be applied to maintain the soil.

IV. CONCLUSION

It can be ended up in the sight of results attained that plastic bottle waste can be positively consumed as a soil stabilizer meanwhile it could make inspiring variations in the properties. Consuming plastic bottle waste to amend weak soil properties has practical, financial, and ecological advantages. Based on the investigation of our work, we can infer that adding plastic in the right amount and with the right dimensions to soil can improve its engineering qualities.

The following conclusion can be drawn from the experimental studies carried out.

- CBR data is compared to find the section with the highest CBR values.
- The cost of building in the case of plastic waste is less expensive than the cost of soil stabilizers.
- The rise in the maximum dry density of the soil is due to the addition of plastic, which reduces the number of voids in the soil, resulting in efficient compaction and an increase in cohesion.
- As soon as the percent waste plastic bottles additive is increasing, the values of the atterberg limits diminish.
- The specific gravity of soil increases with the growth in waste plastic content.

From the above, it may be concluded that there is an urgent need to recycle waste plastic collected from various sources. Garbage all over the world opposes soil stabilization, which will help to reduce the need for valuable land for their disposal while also reducing the severe environmental effect. For sustainable foundation and subgrade improvement, reducing the quantity of plastic waste and manufacturing usable products from non-useful waste materials.

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