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Stabilization of Soil Using Concrete Slush Waste and Polyester Fibres

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***Abstract:** Soil stabilization is a technique used in civil engineering to enhance the engineering properties of soil so that it can withstand large loads without shear failure. Many chemicals, by products and waste materials can be utilized for stabilization. In the present work, the behavior of soil after addition of the Concrete Slush Waste (varying proportion 4%, 8% and 12%) and Polyester Fibre (varying proportion 0.5%, 0.75%, and 1.0%; length 40 mm) was studied at different proportion and then various soil properties like Optimum Moisture Content, Maximum Dry Density, California Bearing Ratio, and Unconfined Compressive Strength values were determined. To conclude the current experimental research, it was ascertained that a combination of Concrete Slush Waste and Polyester Fibre can be used to improve the various engineering properties of soil.*
***Keywords:** Stabilization of soil, Concrete Slush Waste, Polyester Fibre, and engineering Properties of soil.*

I. INTRODUCTION

The term "Soil Stabilization" refers to all physical, chemical, mechanical, biological (or combination thereof) methods of altering a natural soil structure and properties to serve an engineering goal. These qualities include plasticity, permeability and mechanical strength. This is achieved by enhancing overall bearing capacity and shear strength of soil. The primary goals in the process are to cut the costs and utilize those materials which are already readily available locally.

It is crucial to mention that current soil stabilization trends have given rise to inventive and rational methods of using locally accessible waste material for the modification and stabilization of inadequate soil. All growing nations find it difficult to dispose of their garbage because of the rising waste creation, the high expenses involved in managing it, and the variety of factors that influence the various phases of waste management.

A. Methods of Soil Improvement

There are three types of soil improvement in vogue.

1) *Mechanical:* This category includes mechanical operations like compacting or tamping using rollers or rammers. In order to establish an appropriate distribution of soil particles, distinct soil particles can also be blended (added or subtracted) to accomplish mechanical soil stability. These methods are typically applied to basis and sub-base courses of roads and is also applicable to soil layers.
2) *Chemical:* The chemical response between the soil particles and the chemical/stabilizer applied determines the degree of soil stabilization. These chemicals include among others fly ash, bitumen emulsion, lime, cement, magnesium chloride and others.
3) *Biological:* The term "biologically-based soil stabilization" refers to the addition of biological material, such as algae, to enhance the engineering and physical characteristics of soils. By interacting with the clayey particles in the soil, such materials have the tendency to make the soil stronger. The density and shear strength of the soil tend to grow as a result of the widespread usage of algae nowadays.
4) *By Product and Waste Materials:* The quantity of waste material is increasing day by day in world nowadays. The materials namely Fly Ash, Rice husk Ash, Coconut Coir Fibre, Marble Dust, etc. have wide use for soil stabilization process. These are not only economical but also eco-friendly materials.
5) *Soil using Concrete Slush Waste:* The investigated waste material i.e., Concrete Slush Waste (CSW) comes from a concrete batching plant or a ready-mix concrete plant during equipment cleaning. Durable mix prepared using the same dosage of OPC, CSW was able to stabilize its compressive strength. If used for soil stabilization, the CSW has a tremendous deal of potential to produce financial and environmental savings. CSW comprises both non-hydrated OPC particles and hydration products of OPC, such as calcium hydroxide (CH), C-S-H, and aluminate hydrates. These components are useful for improvement of soil properties such as cement and other.

Advantages of Concrete Slush Waste are as follows

1) Concrete Slush Waste increases the strength of the soil there by increasing bearing capacity of soil.
2) To improve the soil bearing capacity rather than use a deep foundation or raft foundation is more cost- and energy-efficient.

B. *Soil using Polyester Fibre*

Polyester is a synthetic fabric that's usually derived from petroleum. When it comes to chemical fibres, polyester fibres are most effective as these have special qualities resulting from their regular molecular structure, which includes aliphatic and aromatic components, as well as their existence in macromolecular chains. The reinforced soil's liquid limit rises with fibre concentration, while the plasticity index falls as a result of fibre inclusion. The shear strength increased by adding more polyester fibre as a consequence of the direct shear test's findings, which were used to make this determination.

Advantages of Polyester Fibre

1) It has excellent strength, endurance, stretch ability, dye affinity, and resistance to degradation in saline water.
2) Smooth, straight, coarse, and inflexible polyester fibre. It can be used alone or combined with wool or acrylic.
3) It is environmentally friendly, but nonrenewable resource.
4) It absorbs more carbon di oxide than it produces.
5) Its used to generate other material and ecological housing material.

II. RESEARCH METHODOLOGY

In the present work, the behavior of soil after adding the concrete slush waste in varying proportion 4%, 8% and 12% and polyester fibre in varying proportion 0.5%, 0.75% , and 1.0% with length 40 mm was determined. The test results are shown in Table:1. All laboratory experiments that assessed the effect of Concrete Slush Waste and Polyester Fibre have been described. The investigation methodology is described below:

1) Raw soil sample from nearby area was collected.
2) Atterberg' s Limits and Plasticity Index were determined to identify the type of soil.
3) The variation on MDD and OMC due to the addition of Concrete Slush Waste (varying proportion 4%, 8% and 12%) and polyester fibre (varying proportion 0.5%, 0.75% , and 1.0% ; length 40 mm) to the soil was determined.
4) The effect of Concrete Slush Waste (varying proportion 4%, 8% and 12%) and polyester fibre (varying proportion 0.5%, 0.75%, and 1.0%; length 40mm) on the soil of its CBR value and UCS Value was assessed.

Table I. Different Soil Mixes.

Soil Mix	Concrete Slush Waste	Polyester Fibre	Polyester Length (mm)
Virgin Soil	-	-	-
SM 1	4%	-	-
SM 2	8%	-	-
SM 3	12%	-	-
SM 4	8%	0.50%	40
SM 5	8%	0.75%	40
SM 6	8%	1.00%	40

III. RESULTS AND INFERENCES

Various tests were conducted on collected raw soil sample as per relevant Indian Standard codes. Soil Classification was done based on Sieve Analysis, Atterberg's Limits, Liquid Limit and Plasticity Index tests. The results of the tests are shown in Table II.

Table II. Properties of Soil and Classification (As per IS 2720: 1993, Reaffirmed Year:2021)

S. No.	Test Name	Obtained Values
1	Liquid Limit	26.00 %
2	Plastic Limit	20.93 %
3	Plasticity Index	5.07 %
4	Classification of soil as per IS	CL-ML
5	Specific Gravity	1.93
6	Percentage Finer of 0.075mm	51.42%

A. *Test Results for Optimal Moisture Content (OMC) and Maximum Dry Density (MDD)*

It was observed that the optimal moisture content increased after the addition of Concrete Slush Waste from the Table III, but the maximal dry density of soil decreased. Additionally, the addition of Polyester Fibre initially reduces the optimal moisture content value, but as the percentage of fibre increases, the optimal moisture content tends to rise as well. On the contrary, as the percentage of Polyester Fibre increases, the maximal dry density value continues to decrease. (See Figure 1 and 2.)

Table III. Comparison of the OMC and MDD of different soil mixtures with raw soil (IS Light Compaction Test)
(As per IS 2720: 1980 Part VII, Reaffirmed Year:2011)

Soil Mix	OMC (%)	MDD (g/cc)	Comparison of MDD (%)
Virgin Soil	11.63	1.93	-
SM 1	10.37	1.923	-0.36
SM 2	12.29	1.812	-6.10
SM 3	14.55	1.780	-7.77
SM 4	12.15	1.80	-6.74
SM 5	12.59	1.75	-9.34
SM 6	12.84	1.72	10.88

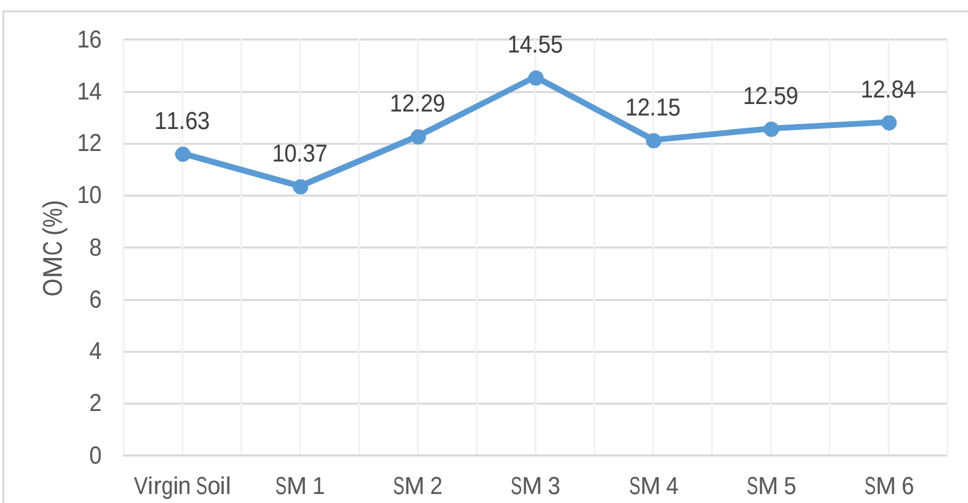

Fig.1: Comparison of OMC amongst varied soil mixtures.

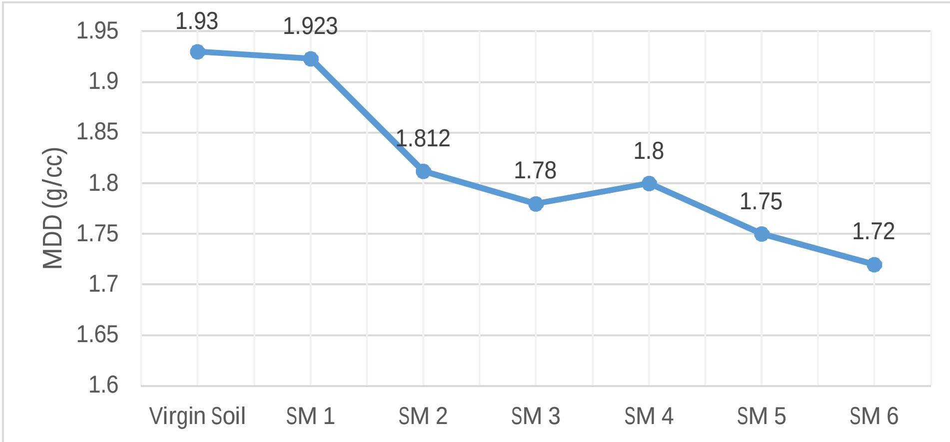

Fig. 2: Comparison of MDD amongst varied soil mixtures.

B. California Bearing Ratio test results

After determining the California Bearing Ratio values of raw soil and other soil mixtures from the Table IV, it was determined that the addition of Concrete Slush Waste (CSW) and Polyester Fibre in different compositions increases the California Bearing Ratio value in comparison to that of raw soil. A substantial increase was observed at addition of 8% Concrete Slush Waste (without fiber), where the CBR value rises by 851%. However the maximum increase in CBR value was obtained with soil mixed with 8% CSW and 0.75% Polyester Fibre of 40mm length. It is determined to be 47.80 which is an increase of 951%. Further increase in dosage of fiber resulted in marginal decrease in CBR Value. (See Table –IV and Figure 3)

Table IV. Comparison of the CBR of different soil mixtures with raw soil.

Soil Mix	CBR (%)	Comparison (%)
Raw Soil	4.55	-
SM 1	26.57	+481
SM 2	43.27	+851
SM 3	41.75	+818
SM 4	44.40	+877
SM 5	47.80	+951
SM 6	45.93	+909

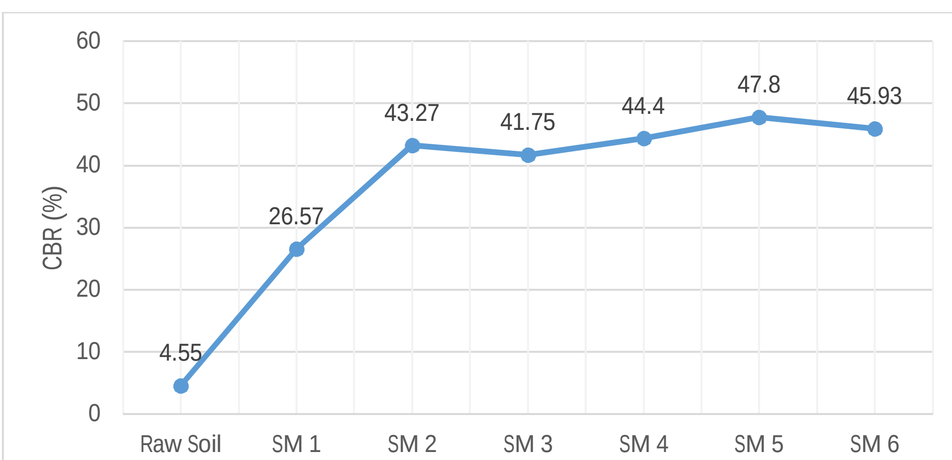

Fig. 3: Comparison of CBR amongst varied soil mixtures.

C. Unconfined Compressive Strength test results

After determining the Unconfined Compressive Strength of raw soil and other soil mixtures as presented in Table V, it was found that the Unconfined Compressive Strength of diverse soil mixtures increases with addition of Concrete Slush Waste and Polyester Fibre. When 8% Concrete Slush Waste is added to raw soil, the UCS increases by approximately +14.78 percent. Soil with addition of 8% Concrete Slush Waste and 0.75% Polyester Fibre of 40mm length yielded maximal UCS of 4.088 kg/cm^2, which is +22.80% greater than the Unconfined Compressive Strength of untreated soil. (See Table V and Figure 4) . Further increase in fiber content resulted in minor decrease. The trend is very similar to as that observed for CBR Values .

Table V. Unconfined Compressive Strength at various dosages of CSW and Polyester fiber.

Soil Mix	Unconfined Compressive Strength (kg/cm^2)	Comparison (%)
Raw Soil	3.329	-
SM 1	3.442	+3.39
SM 2	3.821	+14.78
SM 3	3.707	+11.35
SM 4	3.934	+18.17
SM 5	4.088	+22.80
SM 6	4.009	+20.43

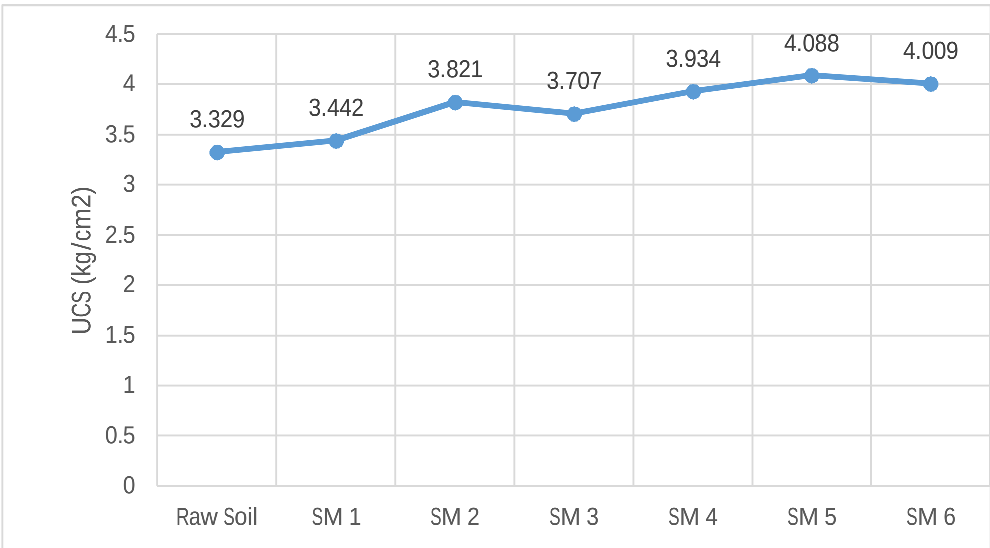

Fig. 4. Comparison of UCS amongst varied soil mixtures.

IV. CONCLUSIONS

The present study drew the following conclusions following execution of numerous laboratory experiments on a variety of soil samples:

1) The raw soil was found to have Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) values 11.63 % and 1.93g/cc, respectively.
2) It was determined that the optimal moisture content increases after the addition of concrete sludge waste, but the maximum dry density of soil decreases. Furthermore, the addition of Polyester Fibre (40mm long) initially reduced the Optimum Moisture Content value, but as the percentage of fibre increases, the Optimum Moisture Content tends to rise. In contrast, the Maximum Dry Density value continues to decline as the proportion of Polyester Fibre increases. This happens mainly due to light weight of fiber. In comparison to the Maximum Dry Density of raw soil, the maximum decrease in Maximum Dry Density was 9.34%.

3) Both CBR Value and UCS values show significant improvement when soil is combined with Concrete Slush Waste and Polyester Fibre. The optimal combination is 8% CSW and 0.75% Polyester Fibre of 40 mm length . The maximum California Bearing Ratio value at this combination was 47.8 % which is an increase of approximately 951%. For this blend the Unconfined Compressive Strength was found to be 4.088kg/cm^2, which is +22.80% greater than UCS of virgin Soil. Both, the CBR and the UCS value decrease marginally on further addition of polyester fibre. The California Bearing Ratio value increases by approximately 850% when 8% Concrete Slush Waste only is added to virgin soil; correspondingly the Unconfined Compressive Strength increases by 14.78% .

To summarize the current experimental study, it is proposed that a combination of 8 % Concrete Slush Waste and 0.75 % Polyester Fibre be used to improve the various engineering characteristics of soil.

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