Alluvial soil stabilization using polypropylene fibers and marble dust in the embankment of flexible pavement

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Abstract: A solid infrastructure is built in part by stabilizing the soil. Strength of the earth not only bears weight of load, but also rigidity, stability, and strength of structure. A crucial component for the construction of any project is soil with sufficient bearing capacity. Construction best practices include actual classification of strength criteria. Researchers have always had a particular interest in soil stabilization, and a variety of techniques as well as numerous additives—most notably cement, lime, fly ash, etc.—have been used to stabilize soil. Utilization of marble dust powder and polypropylene fiber is main topic of interest in soil stabilization research10%, 20%, and 30% of the soil weight as well as 0.1%, 0.2%, and 0.3% of PPF soil weight were extracted as marble dust. To understand their impact on soil stabilization, many soil characteristics were investigated. OMC-MDD, CBR, and UCS are the criteria this study took into account. According to IS 2720, test was carried out. Soil having 30% marble dust produced greatest results for OMC and MDD, whereas the soil containing 30% marble dust (MD) and 0.1% polypropylene fibers (PPF) produced best results for CBR. The investigation results an acceptable and significant improvement of soil properties.

Keywords: Alluvial soil stabilization, marble dust, grain size distribution, SPT, CBR value, OMC, and maximum dry density are some of the terms used.

1 INTRODUCTION

In alluvial soils, mostly produced by the sediment the Indo-Gangetic and Brahmaputra rivers left behind. By the sea areas, somewhat sediment Soil is created by the influence of waves. The floor is porous because it is clayey in nature (equivalent amounts of clay and sand **(10).** Additionally, the Mahanadi, Krishna, and Cauvery all contain it. Deltas where they are called delta alluvium. This kind of soil is continuously refilled by frequent flooding. Clay, silt, sand, gravel, metals, and other earthy substances are the main components of alluvial soil. Usually located close to a water source. **(14).** When streams and rivers slow down, these soils are created down. The soil of the second flood is very fertile and good for cultivation.

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The alluvial structure is mainly determined by the size of the soil's mineral-containing particles. Sand, with a diameter ranging from 0.05 to 2 millimeters, is the largest of the major soil types. However, compared to sand particles, silt particles are smaller with a diameter of 0.002-0.05 millimeters. Soil containing more than 50% sand particles is considered "sandy soil".**(16).** Soil is an important part that supports life on the earth's surface. It is formed by the fracturing of rocks as a result of various environmental processes such as weather changes, volcanic activity, rock erosion by water, etc. Some of the different soil types in our country are alluvial soils. In addition to the growth of plants, the earth helps people perform all basic activities such as travel, construction, agriculture, etc. A developing country like India requires rapid growth of infrastructure i.e. proper road and construction network. **(7).** All buildings related to land and water construction, such as a simple house or apartment building, road or highway, are all built on land. Before beginning this construction work, it is to examine the soil's entire range of technical attributes, such as cohesion, capillarity, permeability, etc., because not all soils are always suitable for construction **(16).**

1.1. MATERIALS

1.1.1. *Alluvial Soil*

Table 1: Properties of Natural Soil

Soil Property	**Value**
Gravel	8%
Sand	30%
Clay and silt	65%
Specific gravity	2.66
Liquid limit	26.60%
Plastic limit	23%
Shrinkage limit	24%
Plasticity index	36%
Type of soil	**Cl**
Optimum moisture content	18.84
Maximum dry density	1.769g/cc
California bearing ratio a. soaked b. unsoaked	 3.79 4.42
Unconfined compressive test	46.85kn/m^2
Permeability	0.0091cm/s

1.1.2 *Marble Dust*

It is wasteful to turn marble into dust. It is this dust created when cutting marble stone. Marble is a rock that results from transformation and is called metamorphic of limestone. About 7 million tons of waste, primarily in the form of sawing and polishing, are produced in India by the marble processing industry. The use of marble dust (MD) in the soil

stabilization process is growing daily as a result of this material's inexpensive processing and low cost and its ease of availability.

Table 2: Properties of Marble Dust

Property	Value
Specific gravity	2.60
Water absorption	0.80%
Bulk density	1118kg/m^3
Fineness modulus	2.03

1.1.3 *Polypropylene Fibers*

Polypropylene fiber (PPF) is a linear synthetic polymer fiber obtained by polymerization of propylene. It has a number of advantages like low weight, high durability, high strength, and resistance to corrosion. PPF is widely used in the chemical, energy, clothing, environmental protection, and building industries.

Table 3: Properties of Polypropylene Fibers

Property	Value
Average length	15mm
Tensile strength	45-60ksi
Specific gravity	0.9g/cm^3
Young's modulus	0.5×10ksi
Melting point	160˚C-170˚C
Ignition point	590˚C

Table 4: Soil Mixes of Various Proportions

S.No	Soil Description	Soil %	Marble Dust (MD) %	Polypropylene Fiber (PPF) %
1	Parent soil	100	0	0
2	Soil with 10% of MD	90	10	0
3	Soil with 20% of MD	80	20	0
4	Soil with 30% of MD	70	30	0
5	The Soil with 30% of MD and 0.1% PPF.	69.9	30	0.1
6	The Soil with 30% of MD and 0.2% PPF.	69.8	30	0.2
7	The Soil with 30% of MD and 0.3% PPF.	69.7	30	0.3

2 METHODOLOGY

The following information is based on the Indian Standard Code for determining various soil properties.

Soil accumulates Krishna river bank, Potharlanka, Andhra Pradesh. Powdered marble dust is purchased from a local merchant at ring road Vijayawada. Polypropylene fibers were collected from to the purchase the indianamart. Soil classification was done using international standards, which means it is accurate and reliable.1 98 and IS: 2720. Plotting the particle size is done using the sieve analysis result **(11).** Distribution The size of the particle (or filter) is measured on an axis that goes from tiny to huge. a curve on a semi-logarithmic graph Finer running on the ordinate axis gives a clear view of the particle sizeof the size distribution**(2).**The Atterberg's limit is calculated according to IS: 2720, Part 5, 1985. The specific gravity is determined to give an idea of unit mass various mixtures according to IS: 2720, Part 3, 1987. The different mix ratio of the material is calculated according to the set goals. Determination of OMC-MDD as per IS: 2720 Part 6 1980, a Proctor compression test is carried out on the original and additional samples. The CBR test is performed to determine the stress penetration curve in accordance with IS: 2720 Part 6 1979 of soil samples requested **(15).** The unconfined compressive strength is carried out according to IS 2720 Part 10 on both pure soil and mixed soil. Data analysis and interpretation of the results take place **(8).**

3 RESULTS AND DISCUSSIONS

3.1. Standard Proctor Test:

Table 5: MDD and OMC values for initial and stabilized soils

S.No	SOIL DESCRIPTION	Maximum Dry Density(g/cc)	Optimum Moisture Content (%)
1	Parent soil	1.45	11.62
2	Soil with 10% of MD	1.66	12
3	Soil with 20% of MD	1.75	17.35
4	Soil with 30% of MD	1.83	17.1
5	The Soil with 30% of MD and 0.1% PPF	1.92	18.7
6	The Soil with 30% of MD and 0.2% PPF	1.67	19.58
7	The Soil with 30% of MD and 0.3% PPF	1.46	20.67

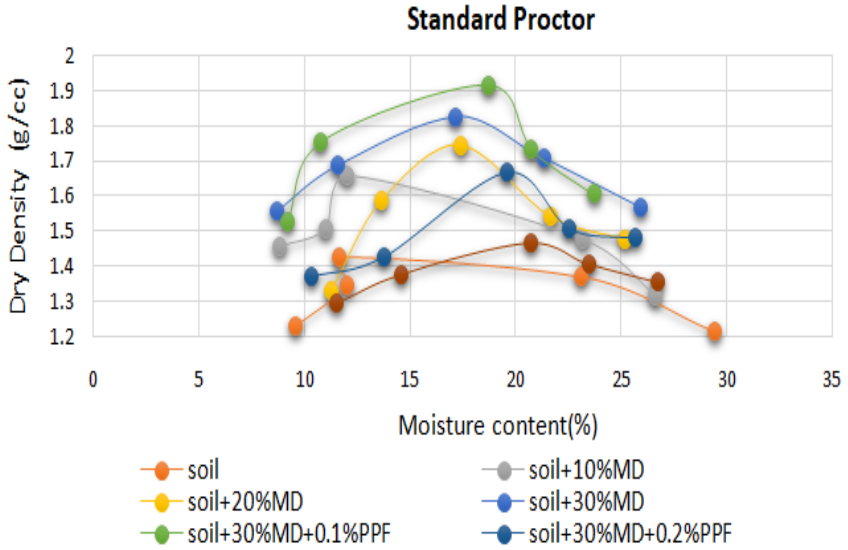

Fig. 1: Compaction curves for treated and untreated soil

3.2. California Bearing Ratio Test:

In the laboratory, various test soil samples were prepared for CBR analysis at maximum Drydensity.CBR values were measured at 2.5mm and 5mm penetration and the results are shown in the table below**.**

Table 6: CBR values for Various Proportions of MD and PPF Fibers with soil

S.No	Soil Description	Soaked CBR (%)	Unsoaked CBR (%)
1	Parent soil	3.79	4.42
2	Soil with 10% of MD	3.64	4.86
3	Soil with 20% of MD	3.98	4.92
4	Soil with 30% of MD	4.02	5.36
5	The Soil with 30% of MD and 0.1% PPF	8.65	6.47
6	The Soil with 30% of MD and 0.2% PPF	12.86	9.12
7	The Soil with 30% of MD and 0.3% PPF	11.40	8.42

3.3. Unconfined Compressive Strength Test:

Uniaxial or Unconfined compressive strength test (UCC) is used to measure soil shear strength. Raw soil was tested along with marble dust and polypropylene fibers **(14).**The results of the test are summarized below**.**

Table 7: Various Marble and Polypropylene Fibers on shear strength of soil

S.No	Soil Description	UCC (Kpa)
1	Parent soil	14.85
2	Soil with 10% of MD	19.71
3	Soil with 20% of MD	21.09
4	Soil with 30% of MD	24.11
5	The Soil with 30% of MD and 0.1% PPF.	26.51
6	The Soil with 30% of MD and 0.2% PPF	29.06
7	The Soil with 30% of MD and 0.3% PPF.	26.84

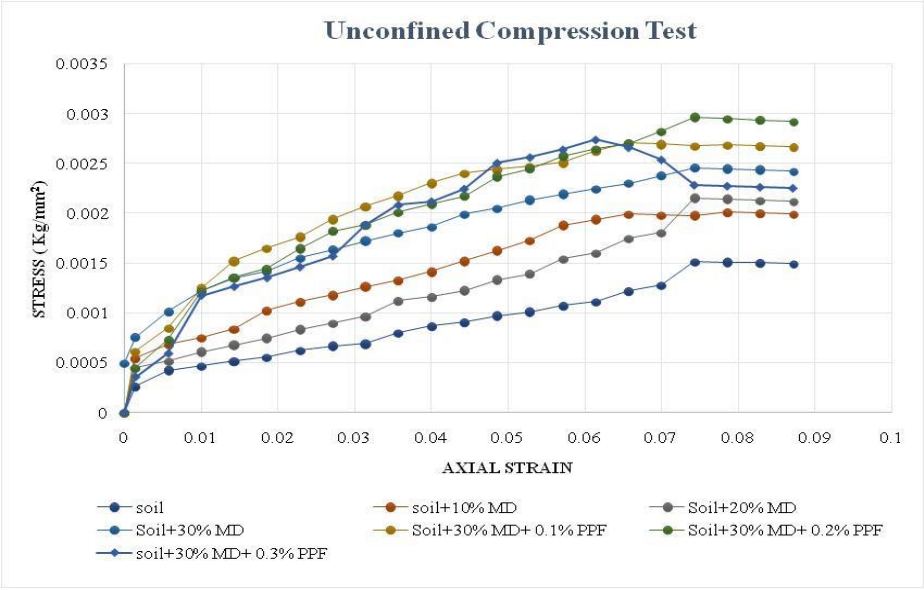

Fig. 2: Unconfined compression curves for proportions of soil with MD and PPF fiber

3.4. Permeability Test:

Table 8: Various Marble and Polypropylene Fibers on permeability

S.No	Soil Description	Permeability (10^{-7} cm/sec)
1	Parent soil	1.78
2	Soil with 10% of MD	1.19
3	Soil with 20% of MD	1.15
4	Soil with 30% of MD	1.12
5	The Soil with 30% of MD and 0.1% PPF	0.98
6	The Soil with 30% of MD and 0.2% PPF	0.66
7	The Soil with 30% of MD and 0.3% PPF	0.54

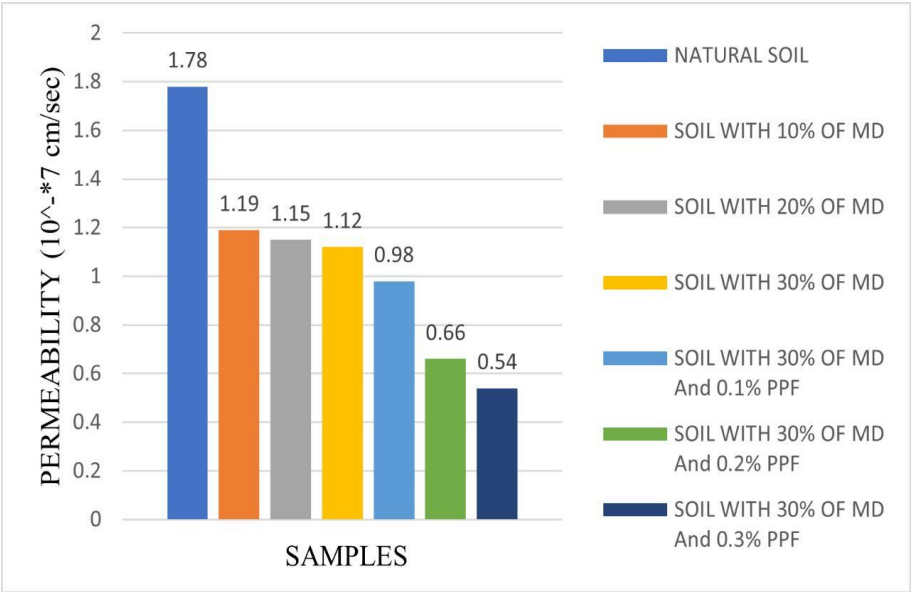

Fig. 3: Permeability of treated and untreated soil of samples

4 CONCLUSIONS

1. Maximum Dry density obtained for the Soil with 30% of MD and 0.1% PPF is 1.92 g/cc with OMC of 18.7% for Unconfined Compression test.
2. Lowest Dry density obtained for the Soil with 30% of MD and 0.3% PPF is 1.46 g/cc with OMC of 20.67% for Unconfined Compression test.
3. CBR has maximum of 12.86% for soil with 30% MD and 0.1% PPF, and miimum of 3.64% for Soil with 10% of MD for soaked CBR.
4. CBR has maximum of 9.12% for Soil with 30% of MD and 0.2% PPF, and minimum of 4.42% with Parent soil for unsoaked CBR.j
5. Soil parameters show an increasing trend with increasing MD, with the exception of CBR, which peaks at 0.1%PPF and 30%MD**.** As such, alluvial soil types are better than clay soils when these additives are used to stabilize the soil.
6. The use of marble dust and polypropylene fibers also solves the waste disposal problem to some extent.

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