International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 6 Issue 6, September-October 2022 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Imparting Engineering Properties in Dune Sand by Modifying it using Epoxy Resin, Stone Dust Waste and Lime Fly Ash

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ABSTRACT

Since a few decades ago, soil has been a key component in many civil engineering projects, including the construction of embankment dams, roads, and building structures. It would be cost-effective to employ the soil that is readily available nearby for construction. It's possible that the soil being utilized won't always have the characteristics needed for the intended usage. As a result, the soil's qualities, like strength and durability, are enhanced in some way to meet the needs. The practice of altering the qualities of soil to meet certain engineering requirements is known as soil stabilization. This in-length research was carried out mainly To stabilize the dune sand, the following combinations employing various additives were developed using varied percentages of Epoxy Resin, namely 2.5%, 3.5%, 4.5%, 5%, 6%, and 7% by mixing 5% Stone Dust Waste and 10% Stone Dust Waste and 10%, 15%, and 20% of a 1:4, 1:5& 1:6 mixture of lime and fly ash with dune sand. It has been discovered that mixtures comprising 10% and 15% of (1 Lime: 5 Fly Ash) produce superior strength values for all curing durations. Additional Fly Ash content increases do not result in higher strength values for various curing times. This could be because the quantities utilised in the mixtures above are sufficient to finish the pozzolanic action of the fly ash, and additional addition would not be effective for increasing the strength levels. Mix compositions of 5% epoxy resin and 5% and 10% stone dust waste respectively gain roughly 70% of their 28-day strength in just 3 days, indicating their potential for emergent constructions. So, this study is to make out something useful out of Dune Sand a civil engineering nightmare. The purpose of this study is to find a useful use for industrial trash that would otherwise be useless and take up a lot of space. The land could be used for other construction projects. The cost of the proposed structure would undoubtedly be reduced by using industrial wastes. There are many additional waste materials, and future research may look into their potential for effective utilisation

How to cite this paper: Dishabal Singh Grover | Mr. Shashi Sharma "Imparting Engineering Properties in Dune Sand by Modifying it using Epoxy Resin, Stone Dust Waste and Lime Fly Ash" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-6 | Issue-6, October 2022, pp.1310-1315, URL: www.ijtsrd.com/papers/ijtsrd52060.pdf

IJTSRD52060

1. INTRODUCTION

According to documents reviewed, dune sand is widely available in the deserts of western Rajasthan. It encompasses 12810 square kilometres, or around 60%, of western Rajasthan. a continuous stretch with a dense concentration of sand dunes next to the Thar Desert that makes up around 11% of the entire Haryana. This belt of sand dunes, which are enormous in magnitude, stretches from the southeast of Sirsa district to the Rajasthan border with Hisar district, progressively widening through Bhiwani district. Due to its fine-grained cohesionless soil, it presents challenges for both automotive and pedestrian traffic. Dune Sand's stability need to be improved so as to become compatible for construction. This can be done by stabilizing the soil using a variety of techniques, including compaction, proportioning, or by the use of the right admixtures or stabilizers.

Low C.B.R. soil can be utilized for desired engineering purposes, such as road building, and it can also be used as the base for pavements when sufficient hard material, such as rock or gravel, is not readily accessible.

There are some substances that, when added to the soil mass, quickly transform it into a hard mass, allowing it appropriate for the construction of emergent important structures like helipads and air strips. There are a number of stabilizers that, when added to soil mass, significantly lessen its permeability and compressibility, allowing for the construction of earthen dams. A significant number of industrial units have been deployed globally in recent years to boom industrial development. These numerous industries discharge an enormous amount of industrial trash, contaminating the environment and taking up a lot of space. The researchers are working to employ these wastes for soil stabilization in order to maintain ecological equilibrium.

The various industrial wastes include fly ash from thermal power plants, blast furnace slag from steel-producing units, copper slag, electric furnace dust from steel-producing units, condensed silica fumes from smelting units producing silica and silica alloys, cement kiln dust from cement manufacturing plants, and blast furnace slag from cement manufacturing plants. Waste from the manufacturing of ceramic tiles, porcelain, rubber tyres, rice husk ash, sugar cane ash, waste foundry sand, plastic fibres, LDPE bottles, coconut coir, geo-fibers, synthetic fluid, red mud, burnt brick dust, cement bags, glass fibres, stone dust from stone cutting units, marble powder from marble cutting units, crusher dust, iron dust waste from iron cutting units, etc.

Utilizing these different industrial wastes will lower stabilising costs, free up more land for other beneficial uses, and maintain ecological balance.

This instant study was carried out using Epoxy resin, Stone Dust Waste, Lime, and Fly Ash with the intention of maintaining ecological balance and financial effectiveness.

2. Literature Review's

Kenan Hazirbaba (2019) as per his research aeolin Sand's Bearing Capacity and Strength values were improved with the inclusion of synthetic fluid and geofibers. Aeolin Sand can be stabilized in hot regions by adding Synthetic Fluid, which also raises the soil's C.B.R. value. The best results were attained with 5% water content and 2% synthetic fluid. Geofiber @0.5% addition improved C.B.R. value @100%. The C.B.R. value improved by up to 125% after the treated soil was left to cure for 28 days. The performance of the C.B.R. after treatment of aeolin sand with synthetic fluid and geo fiber increased by 19% to 95%. The peak shear strength of the treated sand, which contains 2% synthetic fluid and 0.5% geofiber, increased by around 23% after curing.

HadiFatehi et.al. (2019) conducted study using Sodium Alginate Biopolymer to stabilize Dune Sand. Improvements in strength traits were investigated with regard to unconfined compressive strength. The U.C.S. values increased with the addition of Sodium Alginate Biopolymer, and the treated soil reached 90% of its full strength after 7 days of curing. However, curing at a temperature greater than 45 degrees Celsius resulted in a progressive decline in U.C.S. values up to an 80 degree Celsius temperature.

Substantial increase in the C.B.R. values was observed after addition of the Biopolymer. Microstructural study of the treated soil revealed that addition of Biopolymer effectively linked soil particles together through different types of bonds and resulted in the improvemen to mechanical properties of DuneSand.

Yahia Zein et. al. (May 2019) in their study used four different types of polymers, as they cure faster and transform soil into a chemically stable material. The comparison of strength values, moisture loss rates, strain energies, polymer types, test circumstances, and polymer concentrations utilised for sampling are all included in the analysis of test data. The best results were attained with 5% water content and 2% synthetic fluid.

NaeethuSS&ShruthiJohnson(2019) conductedstudytofindtheeffectofadditionofWasteFoundrySandforsoilstabilization.Thestudywasconductedwiththeaimtopreventthe environment from the hazardous effect of Foundry Sand. Addition of Foundry Sand to Kaolinite Soil resulted in increase in the C.B.R. value of the stabilized soil thus making it suggestive for its use as sub -grade material in road construction. A mixture of 80% Soiland 20% Foundry Sand was found appropriate combination for construction of sub-gradefor Rural Roads as this combination achieved Maximum Dry Density.

Neami (2018) used Recycled Waste Tyre Chips to stabilize Sandy Soil with the aim to reduce environmental hazard due to these wastes. He observed that addition of recycled waste in creased cohesion between soil particles result in gin increase in Shear Strength and Value of the treated sandy soil's C.B.R. With an increase in the amount of rubber tire waste, we found that the Specific Gravity and Maximum Dry Density significantly decreased, although the water content barely changed. The C.B.R. value increased as a result of addition by 1.6 times compared to pure sand. This resulted in stronger physical linkages between sand and rubber tyre chips, which raised the soil's capacity to support loads.

Thalor Sahdeo (2018) conducted research to determine the impact of adding Gypsum and Fly Ash on the swelling characteristics of bentonite soil. Fly ash and gypsum were added, and this led to a decrease in the swelling pressure of the bentonite soil. As the Fly Ash and Gypsum concentration increased, the swelling pressure dropped.

Jangid A.K. (2018) carried out an investigation on the usage of geosynthetics in geotechnical engineering. It was found that adding geosynthetics to black cotton soil increased its shear strength, particularly when non-woven geotextiles were used. Non-woven Geotextiles and Geogrids are preferred when filtering is required. Geomembranes are preferred when separating tiny particles. Due to their high tensile strength, geogrids will provide greater shear strength for embankments and fly-overs.

Chao Xing et al. (2018) in their study used four different types of polymers, as they cure faster and transform soil into a chemically stable material. The comparison of strength values, moisture loss rates, strain energies, polymer types, test circumstances, and polymer concentrations utilised for sampling are all included in the analysis of test data.

According to the study, polymer additions considerably boosted the stabilized soil's strength in both dry and wet situations. The polymer-stabilized soil qualities improved with the curing conditions and polymer content.

Jangid A.K. (2018) investigated geosynthetics and employed them to stabilize Black Cotton Soil. It was found that adding geosynthetics to black cotton soil increased its shear strength, particularly when non-woven geotextiles were used. According to the study, non-woven Geotextiles and Geogrids were determined to be appropriate in cases where filteration needs were present. Geomembranes were chosen while separating tiny particles. Due to their high tensile strength, geogrids were able to achieve higher shear strengths for embankments and fly-overs.

Sharma Ravi (2017) carried a research to identify possible applications for jute geotextile in pavement and ground performance. Jute fabrics' engineering qualities were discovered to be ideal for the reinforcement, drainage, and filtration needs of poor soils. When combined with a drainage layer, jute geo textiles aid in quick sub grade strengthening. Its use is environmentally safe and biodegradable. By using it, soil's shear strength, dry density, and C.B.R. are increased, while the permeability and surface settling of the sub grade are decreased.

3. MATERIAL USED

Dune Sand:

Bhadra, a location in the Sirsa District, provided the dune sand that was used for testing. 100% of the test media's soil passed through a 425 Micron IS sieve while 100% was retained by a 75 Micron IS sieve. In accordance with Indian Standards for soil classification, the soil belongs to the SP group.

Dry Density (max) of soil = 1.65 gcc and Dry density (min) = 1.41 g/cm3, respectively, and the specific gravity of soil is 2.66. Coefficient of Curvature Cc = 0.94 and Coefficient of Uniformity Cu = 1.28

Epoxy Resin:

The characteristics of the epoxy resin, catalyst, and epoxy thinner utilised for stabilization were as follows (according to the manufacturer's details):

A. **EpoxyResin:**

SpecificGravity =1.00

Viscosityat30^{0}C measured by ford cup No.4 =100 seconds

=3.0 to 3.5 Poise

=300 to 350 Centipoise

%NonVolatileMatter =60%(EpoxyResin)

%VolatileMatter =40%

MeltingPoint = 65^{0}to 75^{0}C

B. **EpoxyCatalyst:**

ChemicalName =Di-Ethylene

TriamineSpecificGravity =1.00

Viscosityat 30^{0}C measuredby fordcupNo. 4 =100seconds

=3.0 to 3.5 Poise

=300 to 350 Centipoise

%Non VolatileMatter =36%(EpoxyResin)

%VolatileMatter =64%

C. EpoxyThinner:

SpecificGravity =0.90

%VolatileMatter =100%

RatioofXylene:Di-AcetoneAlcohol :Cello-solvent =60%: 20%: 20%

The Epikote Resin (Epoxy Resin) utilised for the experiments is a condensation byproduct of Bisphenol and Epichlorohydrin. It can be bought in liquid form. A catalyst for an immediate increase in strength is Di-Ethylene Triamine. Additionally, it is a liquid. The mixture of Xylene, Di-Acetone Alcohol, and Cello solvent is called Epoxy thinner, and it is used to create a workable solution.

Stone Dust Waste:
One of the Stone Cutting Units located on Sirsa-Delhi Road, Sirsa, provided the Stone Dust Waste for blending with Dune Sand

Lime:
For the experiment, an area seller provided the unslaked lime. It was calcitic lime with a small amount of impurities. Prior to usage, it was kept in tightly sealed tin cans to avoid carbonation brought on by moisture. Before usage, the lime was dry-ground into powder form.

Fly Ash:
Thermal Power Station Khedar provided the Fly Ash that was used for testing

4. RESULTS & DISCUSSIONS

Test Programme:
The Test Programme included preliminary tests, Unconfined Compressive Strength determination tests and C.B.R. tests.

Preliminary Tests:
The following preliminary tests were conducted with Dune Sand for determination of various characteristics:

Determination of Particle size distribution of Dune Sand.

Determination of Specific Gravity of Dune Sand.

Determination of Maximum and Minimum Dry Density of Dune Sand. Determination of Angle of Internal Friction of Dune Sand.

Light Compaction Tests (Standard Proctor Test) were carried out for all the mix compositions of different additives mixed with Dune Sand for determination ofMaximumDryDensityandOptimumMoistureContent foreachindividualmix.

D. Maximum Dry Density and Minimum Dry Density:
With a surcharge weight of 23.82 kg, or 134.8 gm/cm2, dry dune sand was poured into a Proctor's mould that was set up on a steel sheet over cement concrete flooring. The mould was then vibrated at 2800 RPM for 8 minutes to determine the maximum dry density. The value, 1.65 gm/cm3, is displayed in Table and Figure . Sand was loosely poured into a measuring jar through a funnel at a height of 25 cms to establish the Minimum Dry Density. The value was determined to be 1.41gm/cm3.

S. No.	Water Content (%)	Dry Density (gm/cm^3)
1	2.5	1.56
2	5	1.545
3	8	1.59
4	12	1.65
5	14	1.63
6	16	1.61

Table: Dry Density v/s Moisture Content for Dune Sand

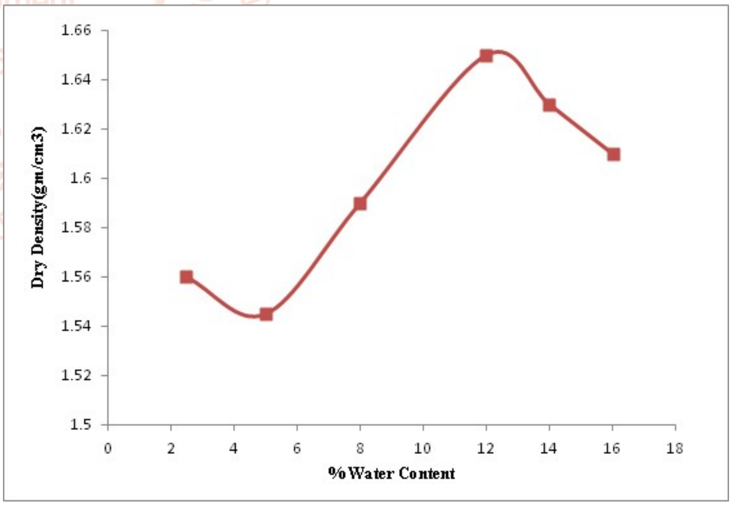

Figure: Dry Density v/s Moisture Content Curve for Dune Sand

E. Determination of Angle of Internal Friction:
The angle of internal friction was determined by a direct shear test using a strain-controlled shear box device, and it was found to be 33.

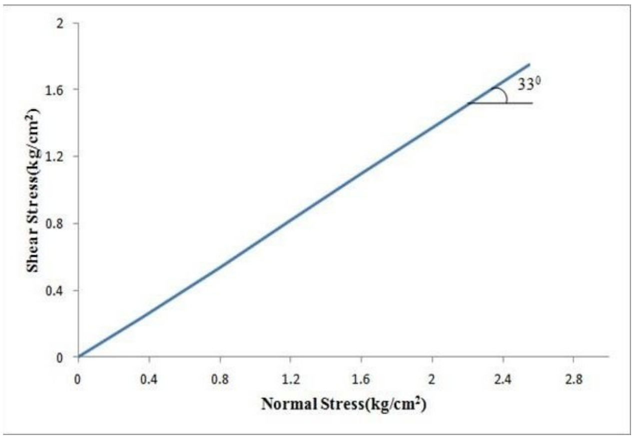

Fig Angle of internal friction

F. Light Compaction Test:

For all mix compositions and all the additives chosen for the current experiments, a light compaction test (also known as the Standard Proctor Test) was performed. For each blend, the optimum moisture content and maximum dry density were found.

About 3 kg of dunes and containing the required amount of additive was extracted, and 8% water was added. With the aid of a 2.6 kg rammer, 25 evenly spaced blows were used to crush the mixture into three equal layers in a cylindrical metal mould with the required ratio. The dimensions of the mould were 100 mm in diameter, 127.3 mm in height, and 1000 ml in capacity. Bulk Density could be calculated by weighing the mould after compaction. A sample of each mix was maintained in the oven while the water content was calculated. The experiment was repeated with a 2-3% increase in water content. The water content could be used to calculate dry density. The maximum Dry Density and Optimal Water Content for a given mix were discovered using a plot between Dry Density and Water Content.

The same test was repeated using other additives in mix compositions, and the maximum dry density and ideal moisture content values were established for each mix.

5. CONCLUSION

the experimental procedures, the analytical process, the test results, and the conclusions taken from them. Below is a summary of the study's findings based on several sources:

Stabilization of Dune Sand using Epoxy Resin and Stone Dust Waste:

Dune Sand was stabilized utilising mix compositions containing 5% of waste stone dust in the first set and 10% in the second set, as well as 2.5%, 3.5%, 4.5%, 5.5%, 6%, and 7% epoxy resin. Here are a few conclusions that can be made:

1. As the curing period lengthens, the unconfined compressive strength grows. During the first three days of curing, the increase in Unconfined Compressive Strength for mix compositions including Epoxy Resin 4.5%, 5%, 6%, and 7% is rapid.
2. As the percentage of epoxy resin plus stone dust waste rises, so does the unconfined compressive strength.
3. Mix compositions of 5% epoxy resin and 5% and 10% stone dust waste respectively gain roughly 70% of their 28-day strength in just 3 days, indicating their potential for emergent constructions.
4. In just seven days, the mixture of 7% epoxy resin and 5% and 10% stone dust waste reaches 90% of its 28-day strength.
5. It was found that C.B.R. values rise as the proportion of epoxy resin in the mix rises.
6. After preparing the samples, the unsoaked C.B.R. values for mix compositions containing 4.5%, 6%, and 7% epoxy resin + 5% stone dust waste and 4.5%, 6%, and 7% epoxy resin + 10% stone dust waste were determined. For the determination of the soaked C.B.R values, the same mix compositions containing 5% and 10% stone dust waste were first air cured for 7 days before being submerged in water for 4 days. After 7 days of air drying, the soaked C.B.R. values were significantly greater than the unsoaked C.B.R. values. The outcomes show that the material is suitable for use as a wearing course in paving.
7. The percentage of water absorbed is at a minimum for samples that have been air-cured for 2 days after being submerged in water for 7 days across all mix compositions and curing periods (i.e., 2 days, 4 days, 7 days, 21 days, and 28 days). This may be because the polymerization process is still ongoing and not fully complete. The water absorption rises with the length of the curing process, or, to put it another way, rises with the degree of polymerization. For all curing times, the sample with 5% Epoxy Resin and 5% Stone Dust Waste had the lowest percentage of water absorption.

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