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ORIGINAL CONTRIBUTION

To Stabilize Shear Strength Properties of an Unwanted Subgrade Soil Utilizing Rock Dust

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***Abstract*— When a pavement fails, the subgrade is displaced laterally due to the pavement absorbing water, excessive deflection, and differential settling of the material beneath the pavement. The purpose of the study is to determine how rock dust additions affect the stability and increased bearing capacity of certain soils in Mardan City. For the objective of stabilizing the native soil, the physical, chemical, and engineering qualities of the soil were investigated. The soils were then treated with additions (rock dust). Rock dust is added to soils with a percentage increase of 5%, 10%, and 15%, respectively, to stabilize soils from 0 to 85%. Atterberg limits (liquid limit, plasticity index, and plastic limit), Specific Gravity, gradations test, and direct shear test were performed on the treated sample. The exact temperature and moisture content for maturation were applied to all samples. The results of the particle size study indicated that the soil's gradation is thin. With the addition of rock dust, the plasticity index (P.I.), liquid limit (L.L.), and plastic limit (P.L.) were all reduced. With the addition of rock dust, it was discovered that the value of cohesion c reduced, and the angle of internal friction decreased. The Research revealed that rock dust, at an ideal concentration of 10%, is the best stabilizer for the case study (Toru Road, Mardan City).**

***Index Terms*— Rock Dust, Subgrade, Shear Strength, Stabilization**

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I. INTRODUCTION

For any building based on the soil, the foundation is very significant, and it must be challenging to maintain the entire structure. When linked to Earth, the land around it plays a significant role. So, when working with the Earth, we must have full proper knowledge about its characteristics and factors that affect its manners [1]. The soil stabilization process helps attain the required efficiency in soil required for any construction work. Sure, lots of land is very poor and cannot be used as a base or structure material [2]. To stabilize this type of soil, various procedures are used to meet the necessities of the construction industry [3]. What brings more gainful projects? To decrease stabilization charges, studies are being conducted on the use of industrial leftovers to decrease pollution and guard the environment. Reference to these studies shows the possible use of industrial waste for soil steadying. In this document, we tried to stabilize the vast land with the aid of quarries [4]. Quarrying is a common name for any substantial that falls from the processing of pits. About 20-25% of the total creation in each crushing unit remains as a portion of waste [5]. Numerous processes produce several types of quarry waste: projections, forests, and pocket fines [6]. The projections are the delicate portions of the stone that were created after the stone was first ragged and separated by a no. 4 (4.75 mm I. sieve). The tree trunks of the skin arise when the stone is washed away in the grinder to separate the coarse aggregate. The discharge fines are free by Gravity into the dam. Concise notes can be described as Dust collected from dried plants. The effect of rock dust on compaction belongings, the cut resistance limits, and the swelling pressure of a vast earth have been argued in this project. The result of water content development stabilized with Rock dust and stabilization of Dust was also discussed [7]. Now, different resources such as lime, fly ash, etc. Use of Rock dust has a high cut resistance, which is very valuable for use as a geotechnical material. It has a good permeability and the difference in water content does not disturb its desired properties [8, 9]. The soil is a rich natural material accessible in this world. This is the economical construction material accessible [10]. But at the same period, it is also a very composite material. Soil performance differs from natural situations. They display a low cut resistance that reduces moistening or other physical changes [11]. They can be made of plastic and compressible; they Extend when you wa-

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ter and contract when it dries. The critical engineering topographies of the soil with which the ground engineer is involved are volume steadiness, strength, permeability, and durability [12]. The method of soil stabilization is usually adopted for generating plastic soils that are reliable with the standards and necessities of engineering projects [13]. Numerous soil enhancement techniques have been developed and practically performed in various fields. The selection of an adequate soil improvement technique relies on the soil to be treated, the obtainability of the requisite materials, and the economic feasibility [14]. These soils, which are categorized by their high plastic properties, swell when the moisture content increases, and this returns the proportion of clay in the soil and the occurrence of clay minerals in the qualitative worth of the plasticity index [15]. In particular, numerous engineering complications have been found in engineering structures such as roads, buildings, parking, and airports due to the variation in the composition of the soil structure. To avoid problems, geotechnical engineers must expand their properties in some circumstances by stabilizing the soil. This study struggles to govern the usage of rock dust to enhance soil engineering properties by conducting some laboratory tests. The quarry is one of the difficulties often criticized because of its allegations for health and the environment in the adjacent community. Due to the high demand for remains and aggregates for construction, scrap shredders and aggregates are widespread. Of the various quarries, the quarry is produced in plenty[16]. The rock material, a by-product, is a non-cementing additive freed from the process of cutting and crushing rock and aggregates, which is a concentrated material that can be used as fine aggregates. Through the explosion of the mountain, the rock will break into small rocks and, together with these dust-like particles, called quarries, will be formed as waste. The elimination of large quantities of the quarry causes serious environmental and health issues, and there is a requirement to use this waste. The quarry can be used in a considerable amount, which reduces the overall cost of construction, as well as providing a solution to an environmental problem [17]. There is limited Research on the effect of the quarry on several geotechnical properties of the expansive soil. The current document analyzes the properties of an expansive soil and a quarry selected in different proportions. Index properties (liquid limit, plastic limit, plasticity index), compass properties, and maximum dry density. By its very nature, quarries have the potential to create Dust. The geotechnical characterization of nitrogen and its behavior of interaction with soils can lead to viable solutions for its use and elimination on a large scale [18]. The use of quarry is evaluated as a stabilizing additive for liturgic clay. A study was conducted to see the effect of the powder on the resistance of liturgic clay during stabilization. Square sockets and floors are modeled and analyzed using commercial finite elements [19].

A. Clay soil formations

When water presses against the rock's surface, erosion occurs, providing clay soils with particles. However, the weathering of rocks and soil is the primary source of clay particles. Physical and chemical changes brought about by weathering produce the tiny particles required to make clay soils. Usually, with silicate support, rocks are gradually chemically dissolved over an extended period by low concentrations of carbonic acid and other diluted solvents, leading to the formation of clay minerals. These solvents, which are often acidic, seep through the worn top layers of the rocks and move through the rocks [20].

B. Principles of soil stabilization

Strengthening, durability, volume, permeability, and other characteristics of the soil are the primary aspects of stabilization. It is modifying the soil's characteristics by mechanical and chemical methods to enhance the desired soil attributes [21].

C. Mechanical stabilization

Mechanical stabilization is the methodology that improves the engineering properties of soils without adding drugs or other particles of binding energy. The methodologies are as follows: compaction, explosion, dynamic compaction, preload, sand discharge.

Compression is a process by which the porosity of the given sediment is reduced because the mineral grain is compressed by the applied weight or mechanically. The most prominent soil pores are eliminated by compaction. Compressing closed particles into the soil to increase its density and decrease its air volume is known as soil compaction [22].

D. Chemical stabilization

The technique of altering the gradation of soil and combining it with additional substances or oils to increase its strength and durability is known as soil stabilization. Chemical stabilization involves the employment of a wide variety of chemicals. Nonetheless, the kind of soil determines which addition is best. Considering the cementing agents, the materials of frequent use are Portland cement, lime, and sodium silicate. The second stabilization category includes the waterproof material for most of these bituminous materials used to cover the grain of the soil so that moisture absorption diminishes or stops completely [23].

The following are the objectives of this investigation.

- Define the physical properties of the dirt through the contrary engineer relationship.
- Increasing Shear strength of soil adding rock dust.
- Adding the admixture in clayey soil to embellish the geotechnical parameters is the central theme of the particular study, i.e. Rock Dust and Aggregate waste, by different extents, and performing tests on it. It is to notice the difference in soil properties by changing the proportions of the additive.

II. MATERIAL AND METHOD

The following are the materials used in this research work.

A. Indigenous soil

The soil sample is collected to mix it with the mixture to evaluate its effects on its properties. The properties of the indigenous soil are determined by the ASTM standards.

1) Admixture

Rock dust is used as an additive for stabilization. To make studies of rock dust, locally available materials were used. Waste rock dust was taken from the crushing plant of rocks at Lower Dir (Talash). Rock dust is available in powder form, so it is unnecessary to take it to the labs for crushing, etc. The powdered form of rock dust is then taken to the lab and thoroughly mixed with the dry soil for further analysis. The soil is mixed with different mixtures with 0%, 5%, 10%, and 15%, which will bring the expected change in the properties of the soil possible in its strength and load capacity.

For testing, the samples are classified into four categories according to the proportion of Rock dust.

- Type A: Pure Soil Sample.
- Type B: Rock dust as 5% by weight of dry soil.
- Type C: Rock dust as 10% by weight of dry soil.
- Type D: Rock dust as 15% by weight of dry soil

The detailed work in the laboratory is presented to achieve the objectives of this study. The soil was collected in a pilot 4x4 foot ditch from the Agriculture University of Peshawar. Rock matter was considered a candidate stabilizer to stabilize the soil.

Following is the step-by-step method based on which the Research was completed.

- Collection of soil samples.
- Add rock dust with clay in 5%, 10%, and 15% proportions.
- Different experimental performances were done on the samples as below.
  Sieve Analysis: to access the particle size distribution.
  Specific Gravity: for density of soil solids.
  Atterberg Limits: to measure the critical water content of soil.
  Direct Shear Test: to measure the shear strength property of soil.
- Measurement of different geotechnical properties, i.e., Size Gradation, Specific Gravity, Shear Strength, and Mechanical Strength of the soil sample.
- Comparison of the results between standard soil sample and stabilized soil sample.

III. RESULTS AND DISCUSSION

Results from the experimental program are extracted and discussed in this section.

A. Sieve analysis

Following is the result of the sieve analysis test done on the virgin soil sample in the laboratory.

1) Pure soil sample

Total Sample: 1100gm

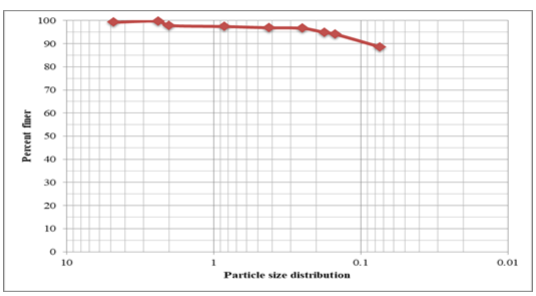

Fig. 1. Gradation curve for soil sample

The gradation curve of the soil sample is shown in the above figure. The soil sample is essentially a fine-grained material and is classified as CL-ML according to the unified soil classification system (USCS).

B. Atterberg limits

Following are the results of Atterberg limits.

1) Liquid Limit(L.L.)

Total weight of sample = 150gm

TABLE I
RESULTS OF THE LIQUID LIMIT (L.L.)

Serial No.	Additive (%)	Liquid Limit (L.L.)
1	0	31.98
2	5	29.86
3	10	28.91
4	15	26.79

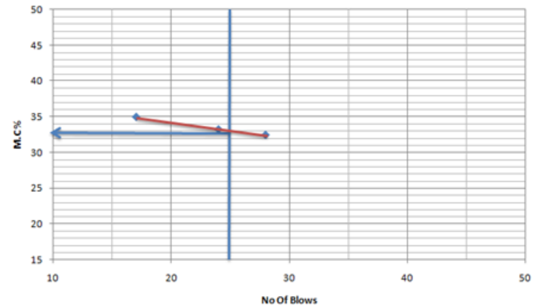

Fig. 2. Moisture content (%) vs. Number of blows at 0% additive

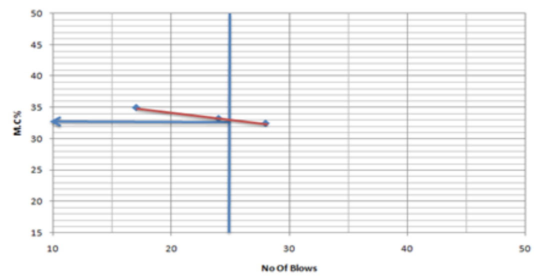

Fig. 3. Moisture content (%) vs. Number of blows at 5% additive

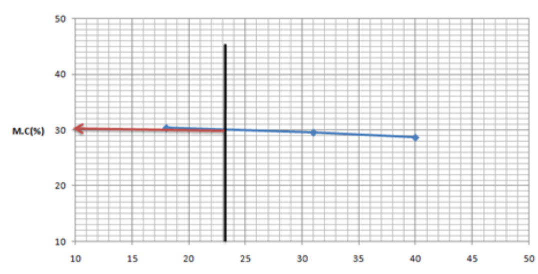

Fig. 4. Moisture content (%) vs. Number of blows at 10% additive

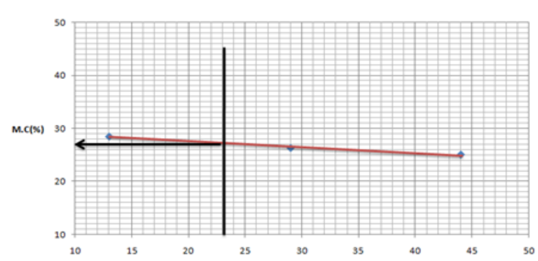

Fig. 5. Moisture content (%) vs. Number of blows at 15% additive

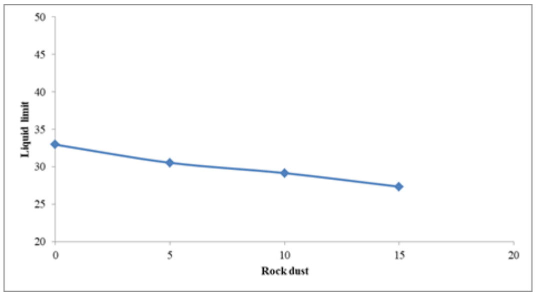

Fig. 6. Graph variation between L.L. and additive (%)

The Percentage of variation of liquid limit to the admixture is given in the above tables. It is observed that as the Percentage of admixture (Rock dust) increases, the liquid limit decreases.

C. Plastic Limit (P.L.)

Following are the results of the plastic limit (P.L.).

TABLE II
RESULTS OF THE PLASTIC LIMIT (P.L.)

Serial No.	Additive (%)	Plastic Limit (P.L.)
1	0	29.92
2	5	27.89
3	10	26.95
4	15	25.79

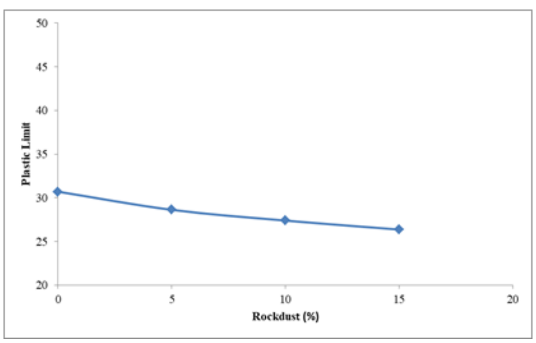

Fig. 7. Graph variation between P.L. and additive (%)

The Percentage of Plastic limit to the admixture is given in the above tables. It is observed that as the Percentage of admixture (Rock dust) increases, the plastic limit decreases.

D. Plasticity Index Test Results

The plasticity index for 5, 10, and 15% Rock dust is as follows.

TABLE III
VARIATION OF THE PLASTIC LIMIT WITH PERCENTAGE OF ROCK DUST

Serial No.	Rock dust (%)	Liquid Limit	Plastic Limit	Plasticity index
1	0	31.98	29.92	2.06
2	5	29.86	27.89	1.97
3	10	28.91	26.55	2.36
4	15	26.79	25.63	1.16

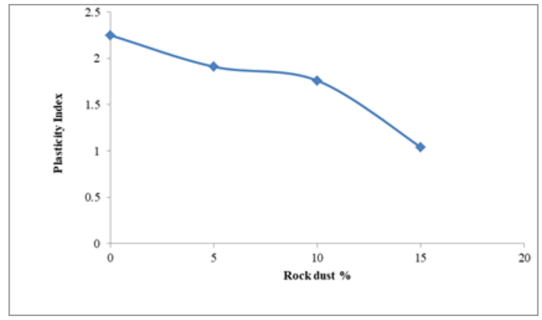

Fig. 8. Variation of graph between Plasticity index with the percentage of rock dust

The Percentage of variation of the Plasticity index to the admixture is given in the figure. It is observed that as the Percentage of admixture (rock dust) increases, the plasticity index decreases.

E. Specific gravity

Following are the results of the specific Gravity of different categories of the soil samples.

TABLE IV
SPECIFIC GRAVITY TEST RESULTS FOR A VARIETY OF SOIL SAMPLES

Serial No.	Additive (Rock Dust) (%)	Specific Gravity
1	0	2.581
2	5	2.621
3	10	2.644
4	15	2.719

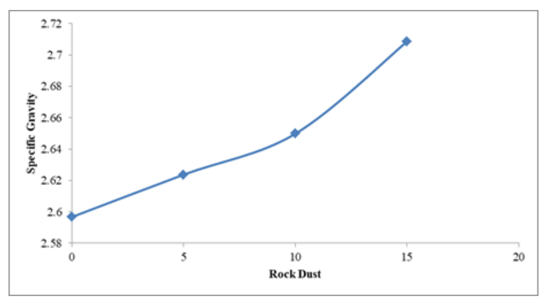

Fig. 9. Variation of graph between specific gravity with the percentage of Rock dust

F. Direct shear test

Following are the results of the direct shear test having values of cohesion and angle of internal friction extracted.

TABLE V
RESULTS OF THE DIRECT SHEAR TEST OF DIFFERENT CATEGORIES OF SOIL SAMPLES

Serial No.	Additive (%)	Cohesion C	The angle of internal friction
1	0	18.24	12.85
2	5	37.26	13.36
3	10	36.28	14.29
4	15	35.3	15.81

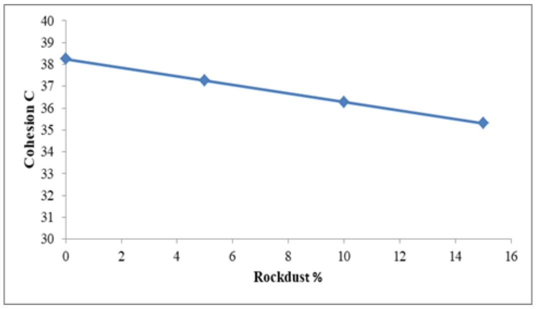

Fig. 10. Graph between Cohesion C with the percentage of rock dust

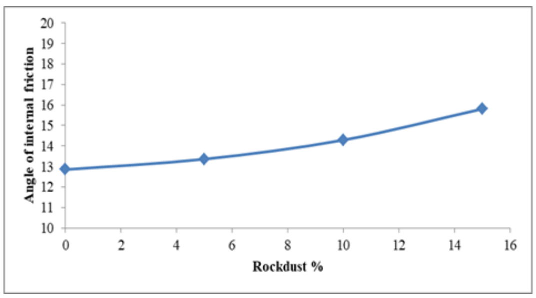

Fig. 11. Graph between angle of internal friction with the percentages of rock dust

IV. DISCUSSION

The variation of shear strength parameters is shown in Fig 4.23 and Fig 4.24. With the addition of admixture (rock dust), the cohesion of soil decreases while the angle of internal friction increases. The reason behind this is the replacement of cohesive soil with rock dust, which has a meager cohesion value and a high angle of internal friction.

V. CONCLUSION

The following points are extracted from this study. When rock dust is added in varying proportions, the Liquid Limit, Plastic Limit, and Plasticity Index decrease. Also, as the Percentage of quarry dust increases, the specific Gravity increases as well. Rock dust has a high specific gravity; from the direct shear test, the angle of internal friction increases with growing quarry dust % and lowers with adding rock dust percentage. This suggests that stone dust can be utilized as a backfill material for the base's bottom layer and as an embankment material.

VI. RECOMMENDATION

It is recommended that the maximum amount of additional soil constituents be determined; further references should be made with a value of between 5% and 10% of powdered rock material in appearance. The effect of powdery rock on other soil types should be investigated after the subsequent post-stages to determine whether such results will be obtained as a whole or ordinary soil solidification.

VII. ACKNOWLEDGMENT

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