# Soil Stabilization using Crusher Dust

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***Abstract:*** **Soil stabilization can be explained as the alteration of the soil properties by chemical or physical means in order to enhance the engineering quality of the soil. The main objective of the soil stabilization is to increase the bearing capacity of the soil and maximum dry density. This paper assesses the stabilizing effect of crusher dust on the soil. Crusher dust is added to the soil at varying proportions like 20%, 30% and 40% by the weight of the soil sample throughout. Consequently, specific gravity, particle size distribution and Atterberg limits tests were carried out to classify the soil. Based on the results, the soil sample obtained was identified as 'fair to poor' soil type. Thereafter, compaction and unconfined compression (UCC) tests were carried out on the soil with and without the addition of the crusher dust. The results showed improvement in the maximum dry density values on addition of the crusher dust (CD).**

***Keywords: Stabilization, Crusher dust (CD), Atterberg limits, Compaction, Unconfined compression (UCC).***

## I. INTRODUCTION

Soil Stabilization is the alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations. Stabilization can be used to treat a wide range of sub-grade materials, varying from expansive clays to granular materials. This process is accomplished using a wide variety of additives, including lime, fly-ash, and Portland cement.

Chemical stabilization with binders such as cement, lime, and fly ash can be undertaken and has become an important alternative. High purity polyacrylamide (PAM) eliminated sediment in runoff water by more than 90%when added to irrigation water at 10 ppm, or at a rate of 1 to 2 kg $ha^{-1}$ per irrigation [13]. Fly ash has been shown to effectively increase the unconfined compressive strength (UCS) of organic soils and stabilize the soil [3]. It was proved that lime acts immediately and improves various property of soil such as carrying capacity of the soil resistance to shrinkage, reduction in plasticity index and increase in CBR value [1]. Black cotton soils were tested with sand and cement to ascertain the benefits of stabilization. There was a decrease in optimum moisture content (OMC) and increase in maximum dry density (MDD) when addition of sand and cement for about 30% [14].

Therefore all the studies have been inferred that the strength of the soil can be improved and the soil can be stabilized using additives such as fly ash, lime, cement, PAM and many others by different methods. Also it has been studied that the strength of the soil after stabilization can be decreased if large amount of additive is added to the soil.

This paper deals with the stabilization of soil using crusher dust. Crusher dust is a common by product of quarrying and mining. Crusher dust have excellent load bearing capability and durability. It is also non plastic. The objectives of this study are to determine if crusher dust can stabilize the soil and to quantify the maximum dry density (MDD) and unconfined compression strength (UCS).

## II. METHODOLOGY

### *A. Soil*

The locations are chosen in such a way that undisturbed soil samples can be taken. Four soil samples are taken inside the campus of MAM College of Engineering and Technology using core cutter method. Each sample is at a distance of about 20m from each other. These soil samples are then tested to find the nature of the soil. Tests like specific gravity test, particle size distribution and Atterberg limit tests are conducted and the weakest sample is found among the four samples based on the test results.

### *B. Crusher dust*

Crusher dust was taken from Padalur M-sand unit. The properties of the crusher dust are determined by conducting various tests such as specific gravity and particle size distribution tests.

### *C. Stabilizing the soil*

Proctor compaction and Unconfined compression tests are carried out on the weakest sample and results are noted down. Then crusher dust is mixed with the weakest soil sample in varying proportions to strengthen the soil. Proctor compaction and UCC tests are carried out on the stabilized samples. The results are compared with the weakest sample and the variations are studied.

## III. EXPERIMENTAL INVESTIGATION

### *A. Basic Properties of the soil and crusher dust*

#### *1. Specific gravity*

The specific gravity of solid is defined as the ratio of means of a given volume of solids to the mass of an equal amount of water. Specific gravity can be determined using pycnometer.

Test is conducted as per IS-2720 (part III) 1980. Oven dried sample of 200 g passing 4.75mm IS sieve is poured into the pycnometer and weighed ($W_3$). The pycnometer is emptied and filled with distilled water completely and weighed ($W_4$).

*2. Particle Size distribution*

Particle size distribution, also known as gradation, refers to the proportions by dry mass of a soil distributed over specified particle-size ranges. Gradation is used to classify soils for engineering purposes, since particle size influences how fast or slow water moves through the soil. Test is conducted as per IS 2720 (part IV) 1985. Oven dried sample of 500 g is passed through a set of sieve and is shook using sieve shaker. The amount of sample retained on each sieve is weighed. The fineness modulus of the sample is calculated using the results. The particle size distribution curve is shown in Figure 3.1

*3. Atterberg limits*

The Atterberg limits are the basic measure of the critical water contents of a fine grained soil: its liquid limit, plastic limit and also shrinkage limit. Depending on the water content of the soil, it may appear in four states: solid, semi-solid, plastic and liquid. In each state, the consistency and behavior of a soil are its engineering properties. The plastic limit is determined by rolling out a thread of the fine portion of a soil on a flat, nonporous surface. The liquid limit is done using Casagrande apparatus.

Table 3.1
Basic properties of soil and crusher dust

| | Specific gravity | Fineness modulus | Plasticity Index (Ip) |
|---|---|---|---|
| Sample 1 | 2.49 | 3.18 | 16 |
| Sample 2 | 2.19 | 2.94 | 55 |
| Sample 3 | 2.14 | 2.41 | 59 |
| Sample 4 | 2.13 | 3.03 | 34 |
| Crusher dust | 2.55 | 3.34 | 0 |

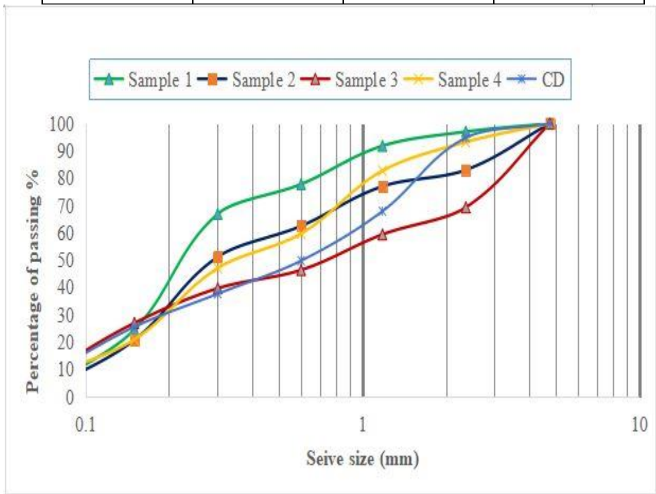


Figure 3.1 – Particle size distribution curve

*B. Classification of Soil*

Based on the basic properties of the soil, the four soil samples are classified as per Indian Standard Soil Classification System as shown below:

Based on particle size distribution, if 50% or more of the soil by weight is retained on the 75 micron sieve, it is course grained; if not, it is fine grained. Since more than 50% of the soil by weight was retained on the 75 micron sieve in all the four soil samples, there are considered to be course grained. And also it is said that if 50% of the coarse fraction is retained on 4.75mm sieve, classify the soil as gravel; if not classify as sand. Therefore, all the four soil samples are course grained sand.

Based on plasticity index, if the Ip (plasticity index value) is less than 17, it is called medium plastic otherwise it is called highly plastic.

Table 3.2
Classification of soil based on plasticity index

| | Plasticity index (Ip) | Nature of the soil |
|---|---|---|
| Sample 1 | 16 < 17 | Medium plastic |
| Sample 2 | 55 > 17 | Highly plastic |
| Sample 3 | 59 > 17 | Highly plastic |
| Sample 4 | 34 >17 | Highly plastic |

According to Table 3.2, Sample 3 is considered to be the weakest soil among the four samples and therefore it is chosen to be stabilized using crusher dust.

*C. Stabilizing the soil*

The weakest sample among the four, i.e., sample 3 is mixed with crusher dust in various proportions such as 20%, 30% and 40% by the weight of the soil sample taken. 10 kg of the soil mixture is taken as whole in which 2 kg of crusher dust is mixed with 8 kg of soil for 20%; 3 kg of crusher dust is mixed with 7 kg of soil for 30% and 4 kg of crusher dust was mixed with 6 kg of soil for 40%.

*D. Determination of properties*

The properties such as optimum moisture content, maximum dry density and unconfined compression strength were determined for the normal soil and the soil mixtures with 20%, 30% and 40% crusher dust.

These properties were determined by conducting proctor compaction test and UCC test. The results obtained in these tests are compared and studied.

## IV. RESULTS AND DISCUSSION

### *A. Proctor Compaction Test*

The proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. This proctor compaction test was done on the normal soil and also on the soil mixture with 20%, 30% and 40% crusher dust in it. The results are shown in Table 4.1. The relation between the OMC and MDD is shown in Figure 4.1.

Table 4.1
Proctor compaction values

| | Sample 3 | 20% CD | 30% CD | 40% CD |
|---|---|---|---|---|
| OMC | 12% | 12% | 12% | 12% |
| MDD ($g/cm^3$) | $1.81 \times 10^{-3}$ | $1.86 \times 10^{-3}$ | $1.88 \times 10^{-3}$ | $1.89 \times 10^{-3}$ |

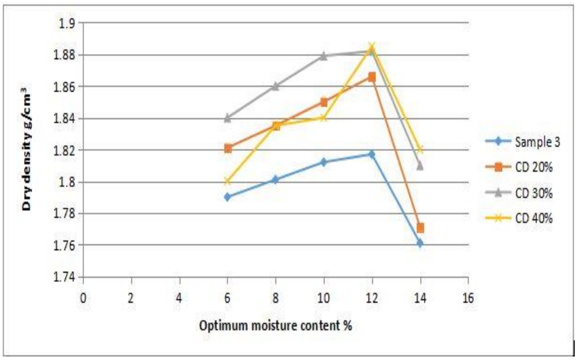


Figure 4.1
Relation between OMC and MDD

The figure 4.1 shows that there is no change in the optimum moisture content for the normal soil and the soil mixture with 20%, 30% and 40% crusher dust, but the maximum dry density value is increased by 5% .

### *B. Unconfined Compression Test*

Unconfined compression test is done to determine the unconfined compressive strength of a cohesive soil sample. This test is inappropriate for dry sands or crumbly clays because the materials would fall apart without lateral confinement. The soil specimen is placed in a loading frame, the sample is restrained on both top and bottom sides and an axial load is applied to the sample. The maximum load per unit area is defined as the unconfined compressive strength.

This test is conducted on the sample 3 as well as the soil mixture with 20%, 30% and 40% of crusher dust in it. The results are determined in Table 4.2.

Table 4.2
UCS values

| | Unconfined compressive strength ($N/mm^2$) |
|---|---|
| Sample 3 | $1.081 \times 10^{-2}$ |
| 20% CD | $1.217 \times 10^{-2}$ |
| 30% CD | $1.298 \times 10^{-2}$ |
| 40% CD | $1.325 \times 10^{-2}$ |

The results on the table 4.2 shows that the UCS value for the soil mixture is increased upto 22.5% when compared to the sample 3.

## V. CONCLUSION

In this paper, the soil is stabilized by adding crusher dust to the soil sample in varying proportions and proctor compaction and unconfined compression tests are carried out. The results have been studied and have been concluded that, the soil stabilization using crusher dust is an effective process for the strengthening the soil. During comparison, the soil obtained maximum dry density with no change in the optimum moisture content and also the unconfined compressive strength is increased by 22.5% for the maximum proportion of 40% of crusher dust.

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