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Investigational Study on the Influence of Marble Dust and Silica Fume in the Stabilization of Clayey Soil

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Abstract: ***Marble dust and silica fume are waste materials which are being discarded every year in India in substatntive quantity into the environment. Marble dust powder is obtained as a waste product from the marble industry.Silica fume is the by-product of silicon and ferrosilicon alloy. In this study, an experimental program to study the effect of the combination of silica fume and marble dust powder on clayey soil using Indian standard light compaction test, unconfined compression strength test, and direct shear test has been undertaken. In this experimental study different ratios and different proportions have been used to find the effect of silica fume and marble dust with clayey soil. The tests that were conducted include unconfined compressive strength test, standard proctor test, direct shear test and Atterberg limits.. With marble dust kept constant at 18% MDD decreases with an addition of silica fume in clayey soil and marble dust mix.The UCS value increases from 0.934 kg/cm² to 2.838 kg/cm² with the addition of marble dust and silica fume. Based on the direct shear test results, the value of cohesion increases from 0.280Kg/cm^2 to 0.512Kg/cm^2 and angle of internal friction increases from 24.10 to 30.57. The results showed that silica fume and marble dust powder could improve the UCS, cohesion and angle of internal friction of clayey soil sample. Hence, the addition of silica fume and marble dust powder makes the soil mixes durable, economical and effective for soil stabilization.***

Keywords: Marble dust, Silica fume, Standard proctor test, Direct shear test, unconfined compression strength test

1. Introduction

During the last few years, shrinking-swelling action has been clearly observed in the semi-arid regions in the form of cracking and breakup of pavements, roadways, building foundations, slab-on-grade members, channel and reservoir linings, irrigation systems, water lines, and sewer lines. To overcome this problem, several methods of soil stabilization are studied so that the soil can be easily used for various engineering applications. Soil stabilization techniques are used to improve the shear strength, bearing capacity, reducing expansive characteristics, etc. Many waste materials are used to improve or modify the characteristics of a clayey soil. Traditionally the soils are stabilized by lime, cement, bitumen, etc.

1.1 Clayey soil

In this research work, the clayey soil was procured from R.S.Pura region of Jammu (J&K). The colour of soil is light brown. The clayey soil was collected by method of disturbed sampling after removing the top soil at 500 mm depth and transported in sacks to the laboratory. The soil was air dried, pulverized and sieved with 4.75 mm Indian as required for laboratory test.

1.2 Silica fume

The silica fume used in this study for stabilizing clayey soil was procured from Mahalaxmi Chemicals Enterprises, Delhi. The density of silica fume is 2.0–2.5 mg/m3, and its bulk density is 0.3–0.5 mg/m3. Silica fume consists primarily of amorphous (non-crystalline) silicon dioxide and it is produced in electric furnace. The raw materials are quartz, coal and woodchips. The ash that results from this process is collected and sold as silica fume.

1.3 Marble Dust

The marble dust used in this study was obtained from Randhawa Marbles and Granites , Shastri Nagar, Jammu. The marble dust is generated from cutting and polishing of white marble stone. It is white colour powder having specific gravity value of 2.69.

2. Mix Proportion

Table 1: Mixing proportion of Clayey Soil(CS), Marbel Dust (MD), Silica Fume (SF).

S. NO	Designation (CS:MD:SF)
1	100:00:00
2	88 : 12 :00
3	82 : 18 : 00
4	76 : 24 : 00
5	92 : 00 : 08
6	84 : 00 : 16
7	76 : 00 : 24
8	77 : 18 : 05
9	72 : 18 : 10
10	67 : 18 : 15

2.1 Objectives

The objective of the current research work is to ascertain the suitability of silica fume and marble dust powder as a soil stabilizing agent. For this, the various experiments conducted are

1) To determine the liquid limit, plastic limit, plasticity index and specific gravity of virgin soil sample.

2) To determine optimum moisture content (OMC) and maximum dry density (MDD) of the untreated and treated soil sample.
3) To determine the unconfined compressive strength of untreated and treated soil sample.
4) To determine shear strength parameters (cohesion & angle of internal friction) of untreated and treated soil sample.

3. Results and Discussions

3.1 Atterberg Limits

Table 2: Index properties of virgin soil sample

Parameters	Soil Sample
Specific Gravity	2.70
Liquid limit	51.915
Plastic Limit	26.76
Plasticity Index	25.15

3.2 Standard Proctor Test Results

Table 3: MDD and OMC for Clayey Soil with Marble Dust and Silica Fume

S.NO	Proportion (CS:MD:SF)	MDD (g/cm^3)	OMC (%)
1.	100:00	1.52	16.01
2.	77:18:5	1.69	16.32
3.	72:18:10	1.66	18.21
4.	67:18:15	1.61	22.68

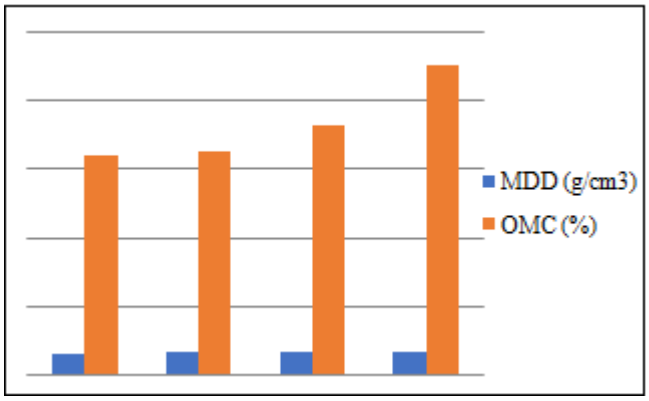

Chart 1: Variation in the dry density with moisture content for soils with varying contents of MD and SF

3.3 Unconfined Compression Test Results

Table 4: Values of UCS for CS mixed with MD and SF

[CS : MD : SF]	Curing period (days)	UCS (Kg/cm^2)
100:00:00	7	0.934
77:18 :5	7	2.536
72:18 :10	7	2.838
67:18 :15	7	2.358

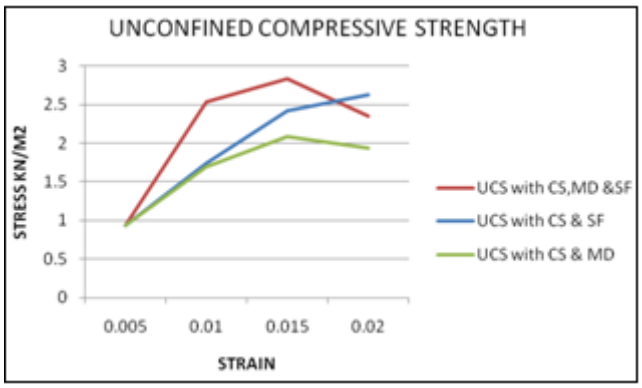

Chart 2: Combined unconfined compressive strength of soil with MD and SF

3.4 Direct Shear Test Results

Table 5: Values of Cohesion and Angle f internal friction for CS mixed with MD and SF

S.NO	CS:MD:SF	Cohesion(C)	Angle of Internal Friction (Ø)
1.	100 : 00 : 00	0.449	24.10
2.	77 : 18 : 5	0.523	27.59
3.	72 : 18 : 10	0.618	30.57
4.	67 : 18 : 15	0.592	29.56

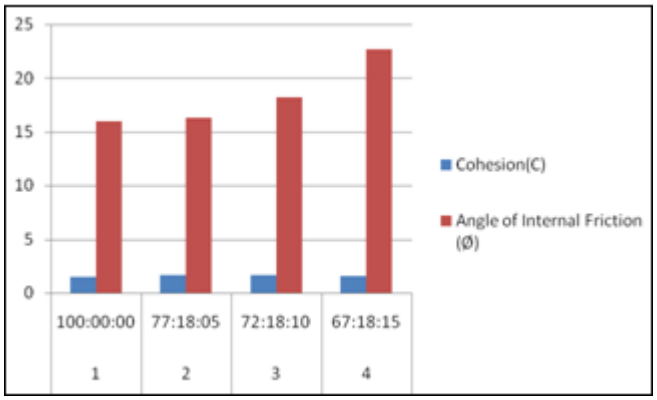

Chart 3: Variation of Cohesion and Angle of internal friction with varying contents of MD and SF

4. Conclusions and Future Scope

4.1 Conclusion

On the basis of above-obtained experimental results and discussions, the following conclusions can be drawn;

In this study, a series of standard Proctor test, unconfined compression strength test and the direct shear test was carried out to calibrate the effect of two chemical additives namely silica fume and marble dust on the clayey soil sample. The results showed that silica fume and marble dust powder could improve the UCS, cohesion and angle of internal friction of clayey soil sample.

The different percentages of marble dust and silica fume used in this study were 12%, 18% & 24% and 8%, 16% & 24%. Finally, the value of silica fume varies from 0 to 15% at the interval of 5% with the fixed quantity of marble dust 18% to clayey soil.

Addition of silica fume with clayey soil decreases maximum dry density and increases the optimum moisture content of the soil sample.

Addition of marble dust with clayey soil increases the value maximum dry density and decreases the value of optimum moisture content.

The addition of the fixed quantity of marble dust 18% with changing the content of silica fume increase the value of optimum moisture content and decreases the value of maximum dry density.

The optimum value of marble dust used in this research was 18% because the maximum value of UCS was found at 18% marble dust.

The UCS value increases with an increase of silica fume content along with a fixed quantity of marble dust. It increased 2.52 times from the untreated soil.

Based on the direct shear test results, the value of cohesion increases from 0.280Kg/cm2 to 0.512Kg/cm2 and angle of internal friction Ø increases from 24.10 to 30.57.

The optimum value of cohesion and angle of internal friction was found at 10% silica fume and 18% marble dust. Hence, the addition of silica fume and marble dust powder makes the soil mixes durable, economical and effective for soil stabilization process if these two materials are easily available near to the site.

4.2 Future Scope

In this study, clayey soil is used for the experimental work. Other soil can be used in the place of clayey soil.

In this research work, IS light compaction test, unconfined compression strength test and direct shear test are performed. Other tests like tri-axial test, CBR test, modified proctor test, free swell index etc. can be use for further study.

Unconfined compression strength test conducted with 7 days of curing period. Curing period of the work can be increased.

In place of silica fume , other binder material like sludge ash, phosphogypsum, baggase ash, fly ash etc., can be used with marble dust powder or with silica fume. Different types of fibers can also be used with marble dust instead of binder materials.

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