Stabilization of Sandy Soil by Use of Phosphogypsum and Marble Dust

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Abstract : India consist of 3-4% area covered by sandy soil and whereas it covers 900 million ha worldwide. Construction over sandy soil is a major problem in India, coastal regions of United States and the Gulf Coast area. Stabilization is the only way to overcome of this problem and this study proposed two waste material which can beutilized. These two materials are; Phosphogypsum and Marble Dust. Marble dust is waste material formed with production of marble which as a by-product requires disposal method. It has been used in construction industry over the years. Phosphogypsum is also a by-product emerged with the production of fertilizer. Phosphogypsum when stacked in large amount emits radioactivity which crucially needs to be disposed. In this research work, sandy soil is being stabilized with addition of phosphogypsum and marble dust in proportion of 2,4,6,8,12 and 15% and various tests are performed. Using phosphogypsum and marble dust helped in increasing shear strength and other engineering properties as well. It is found by unconfined compressive strength increases to 278.4 kN/m2 for 14 days curing period. CBR ratio increases from 5.12% to 8.34% for soil sample. Addition of marble dust helped in increasing in optimum moisture content by 12%. With this study, it is observed that addition of phosphogypsum and marble dust in sandy soil improve its engineering properties and behaviour.

IndexTerms **- Sandy Soil; Phosphogypsum; Marble Dust; Waste Management; Soil Stabilization**

I. INTRODUCTION

Structures over the uncertain soil has been an issue for years, a tough question asked by itself. Such sand always needed improvisation to sustain against heavy structures and their specifications. There are various types of soil and Sandy soil is one among of them- a light, warm and dry. Sandy Soil cover almost 900 million ha around the globe mostly in arid and semi-arid regions.

To stabilize the soil a particular type of material is required. Also, if that material is waste than it helps in environment as well. So, this research proposed two waste materials; Phosphogypsum and Marble Dust, consists properties which help in stabilizing soil. Various researches have been done separately on the materials but they miserably couldn't get to the point and also, they lack at adjoining both of them. Marble Dust and Phosphogypsum, both are industry waste material and are found in huge amount. Marble dust got high amount of lime, which behave as the main factor in soil stabilization. Approximately 30% marble dust is being generated during marble quarries, while stones are formed as blocks. Marble dust is generated in amount of 5-6 million ton every year. While Phosphogypsum being secondary main factor plays important role. It is a calcium sulphate hydrate casted in form of by-product of the production of fertilizer by phosphate rock. It is being used in construction industry as well because of its binding property. Yearly about 100-280 Mt estimated amount of Phosphogypsum is generated worldwide.

In gulf countries and major part of western region of India is having Sandy Soil which needs soil stabilization due to their less shear strength. Rajasthan mostly consist sand which doesn't meet to the specifications or design of heavy structures.

II. LITERATURE SURVEY

S. Kumar et al.(2018) stated that phosphogypsum which is a waste material helps in OMC and MDD when treated with soil in adding variation of 2%, 4%, 6% and 8%. Their study proved that when soil treated with PG, shear strength changes with addition of PG and helps in improving soil behaviour.

Sreekumar et al.(2017) investigated that liquid limit of soil sample is 61% which is higher than before. And unconfined compressive strength increases to 286.5 kN/m2 for 14 day curing period. CBR ratio increased from 5.19% for soil sample to 8.83%. The maximum CBR value was attained as 14.5% at 14 days curing period for 9% addition of marble dust.

Krishnan et al.(2016) stated that the modification promoted an increase in strength of 162 kPa and 336 kPa from 75 kPa and 122 kPa for soil samples after 28 days of curing. The unconfined compressive strength of both the soil treated with 6% Phosphogypsum from 14 to 28 days is in order of 30 to 35%.

Minhas and Veena (2016) found that by the addition of marble powder OMC got up to 12% for a soil sample. Maximum dry density decreased with addition of marble dust because of presence of soil and marble dust having different specific gravity. Also, there was prominent improvement in CBR test results as some amount of soil was replaced by marble powder.

Al-Zaidyeen et al.(2015) resulted that addition of Phosphogypsum helped in increasing the optimum moisture content to 21%. Also, CBR and Proctor Test results were found favourable.

Singh and Yadav (2014) studied after adding marble dust in various proportions with black cotton soil. They found that liquid limit value was decreased by 23.77% (57.67% to 33.9%) and shrinkage limit value got increased by 10.33% (8.06% to 18.39%).

N. Degirmenci et al.(2006) showed that Phosphogypsum can potentially stabilize the expansive or non-stabilize soils if mixed with cement, lime or fly ash content. Study found that maximum dry unit weight increase when amount of phosphogypsum increases in soil stabilization.

III. METHODOLOGY

A. Materials

Sand

Soil Sample

Phosphogypsum

A grey coloured, soggy, fine grained residue, silt or silty-sand material with a maximum size ranges between 0.5 mm (No.40 sieve) and 1.0 mm (No.20 sieve). The rate of PG is 400-450 per ton. The PG waste generated from phosphate industry.

Marble Dust

A solid waste material generated from the marble processing which is crushed into powder form, having diameter of 6 mm.

B. Applications of Phosphogypsum

1) For use as soil molding (for antacid soil) or as manure in horticulture.
2) In concrete assembling to control the setting season of concrete (as a retardant).
3) A little amount is utilized in the creation of mortar, mortar sheets, gypsum fiber sheets, and gypsum blocks.

C. Applications of Marble Dust

1) As a cement and sand Replacement.
2) In brick construction.
3) In asphaltic concrete.

D. Preparation of Sample

Marble dust and Phosphogypsum are added in proportion of 2%, 4%, 6%, 8%, 10%, 12% and 15% with virgin soil in specified process.

E. Test Schedule

1. Water Content

a) Calcium Carbide Method

b) Oven Drying Method

2. Free Swell Index of Soil
3. Plastic Limit of Soil
4. Liquid Limit of Soil
5. Particle Size Distribution of Soil
6. The Specific Gravity of Soil
7. California Bearing Ratio Test

8. Maximum Dry Density
9. Optimum Moisture Content of Soil
10. Direct Shear Test
11. Tri-Axial Test
12. Standard Proctor Test

IV. RESULTS AND DISCUSSIONS

A. Unconfined Compressive Strength

Phosphogypsum and Marble dust both plays important role in unconfined compressive strength. Study of various papers shows that Phosphogypsum and marble dust when added separately to soil sample, it improves the unconfined compressive strength. Phosphogypsum mixed with soil samples shows higher compressive strength with different curing period. UCC values of Phosphogypsum added to soil is given in Table I. Marble dust also when added to soil samples shows increase in UCC values. Values of UCC when marble dust added is given in Table II.

Hence when PG and marble dust both added together with soil samples give satisfactory results.

TABLE I. UCC VALUES WHEN PHOSPHOGYPSUM ADDED

Varying Percentage	**Unconfined Compressive Strength (kN/m²)**			
	0 Days	**3 Days**	**7 Days**	**14 Days**
2%	75	100	112	119
4%	97	114	156	221
6%	102	119	162	257
8%	114	138	178	292

TABLE II. UCC VALUES WHEN MARBLE DUST ADDED

Varying Percentage	**Unconfined Compressive Strength (kN/m²)**			
	0 Days	**3 Days**	**7 Days**	**14 Days**
2%	111	123	177	201
4%	125	169	236	260
6%	118	148	230	256
8%	104	115	136	154

B. California Bearing Ratio Test

Marble dust when added to soil sample with varying percentage, results or CBR values increases by 5% to 9%. Phosphogypsum also increases the CBR values by 3% to 8%. When both added together with varying percentage of 2%, 4%, 6% and 8% it helps to increases CBR values by 4% to 10%. CBR values when marble dust is added is given in Table III.

TABLE III. EFFECTS OF MARBLE DUST ON CBR VALUES

Varying Percentage	California Bearing Ratio (CBR) %			
	0 Days	3 Days	7 Days	14 Days
2%	7.72	8.82	11.34	12.4
4%	8.23	9.43	12.86	13.45
6%	8.31	9.91	13.01	14.04
8%	9.01	10.93	13.45	14.34

V. CONCLUSION

Marble dust addition shows improved properties in soil as well as Phosphogypsum. The presence of Ca ions is responsible for improving engineering properties. The unconfined compressive strength (UCS) of virgin soil is nowhere close to the UCC values when added PG and marble dust. The unconfined compressive strength (UCS) when soil treated with PG and marble dust increases by 30-50%. CBR increased with 5-10% after soil treating with PG and marble dust. For different curing period CBR values gradually increases when separately soil treated with both PG and marble dust. The maximum values observed at 14 days curing period. SPT values found favorable when PG and marble dust are added to virgin soil.

VI. REFERENCES

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