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INVESTIGATION ON COMPACTION AND STRENGTH CHARACTERISTICS OF EXPANSIVE SOIL BY USING LIME AND MARBLE DUST POWDER

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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 objectives of the soil stabilization is to increase the bearing capacity of the soil, its resistance to weathering process and soil permeability. The long-term performance of any construction project depends on the soundness of the underlying soils. Unstable soils can create significant problems for pavements or structures, Therefore soil stabilization techniques are necessary to ensure the good stability of soil so that it can successfully sustain the load of the superstructure especially in case of soil which are highly active, also it saves a lot of time and millions of money when compared to the method of cutting out and replacing the unstable soil. This paper deals with the complete analysis of the improvement of soil properties and its stabilization using lime.

Marble dust is used for the stabilisation of soil. Marble dust is formed from cutting and polishing of marble stone. It is one of the industry generated waste material. Marble dust contains high amount of calcium, silica, alumina which aids in the stabilization of the soil.

An experimental program was undertaken to study the individual and admixed effects of lime and marble dust on the geotechnical characteristics of expansive soil. Lime and marble dust were added to the expansive soil at 2%–10% and 0%–30% by dry weight of soil, respectively. Testing specimens were determined and examined in chemical composition, grain size distribution, consistency limits, compaction, CBR, free swell and swell capacity. The effect of lime and fly ash addition on reducing the swelling potential of an expansive soil is presented. It is revealed that a change of expansive soil texture takes place when lime and marble dust are mixed with expansive soil. Plastic limit increases by mixing lime and liquid limit decreases by mixing fly ash, which decreases plasticity index. As the amount of lime and marble dust is increased, there are an apparent reduction in maximum dry density, free swell and swelling capacity under 50 kPa pressure, and a corresponding increase in the percentage of coarse particles, optimum moisture content and CBR value. Based on the results, it can be concluded that the expansive soil can be successfully stabilized by lime and marble dust.

Keywords: Characteristics Of Expansive Soil, *Lime, marble dust, Maximum Dry Density (MDD), Optimum Moisture Content (OMC), California Bearing Ratio (CBR).*

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1. INTRODUCTION

Soil stabilization is the process of the alteration of the geotechnical properties to satisfy the engineering requirements (Attah-Okine, 1995). Numerous kinds of stabilizers were used as soil additives to improve its engineering properties. A number of stabilizers, such as lime, cement and fly ash, depend on their chemical reactions with the soil elements in the presence of water (Azadegan *et al*., 2012; Mallela *et al*., 2004; Ramadas *et al*., 2011). Other additives, such as geofiber and geogrid, depend on their physical effects to improve soil properties (Alawaji, 2001; Viswanadham *et al*., 2009). In addition, It can be combined both of chemical and physical stabilization, for example, by using lime and geofiber or geotextile together (Yang *et al*., 2012; Chong and Kassim, 2014).

Lime is the oldest traditional chemical stabilizer used for soil stabilization (Mallela *et al*., 2004). However, soil stabilization using lime involves advantages and disadvantages. This study provides details of advantages and disadvantages of using lime as soil stabilizer. In addition, to control the disadvantages inherent to lime treated soil, proposing an alternative material was discussed.

Expansive soils can be a significant problem in engineering applications and stabilization of these soils is necessary to mitigate their detrimental effects. Lime, cement and bitumen are commonly used additives for stabilization of expansive soils [1–3]. Recently, different additive materials such as fly ash, rice husk ash, silica fume, ladle furnace slag and geo fibers are used to improve some geotechnical properties of poor soils [4–10]. Besides these additives, industrial wastes such as olive oil wastes [11] and basalt fibers [12] are also used for remediation of soils. Yilmaz et al. [13] have used stone wastes in stabilization of clayey soils as a pozzolanic additive. That study had proven that using stone wastes with lime for stabilization of clayey soils gives meaningful values on unconfined compressive strength.

The main objective of this study was to investigate the effect of marble dust on strength behaviour of high plasticity silty soils. Prepared natural and stabilized soil samples were cured 28 days and after curing period uniaxial compressive strength tests were performed.

1.1 APPLICATIONS OF PLASTIC BRICKS:

- In the time of a few hours, an unconditional soil is transformed by lime into a stabilized soil which can carry the traffic load sufficiently. An added bonus is that the soil becomes less sensitive to moisture. This immediate and spectacular effect makes it possible to build job site roads that can be used regardless of whether condition.
- The technique makes it possible to retain high quality raw materials for quality applications. The building of embankments using moist plastic soils treated with lime can result in considerable savings on materials brought in from elsewhere, often at great cost, and the inevitably high costs of waste soil disposal.
- Lime treatment makes it possible to construct good quality capping layers and beds for roads, railway tracks, and runways. The stiffening/curing of the structure means that the slopes of the structure have greater stability.

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- Because it is such a simple process, lime-stabilization of soil is easy to apply to "small" works, such as foundations for car parks, industrial platforms, and agricultural and forestry roads. The greatest benefits of this procedure, namely the savings on aggregate and disposal charges, are indeed the same as for all major earth moving works.

1.2 OBJECTIVES:

- The main objective of this research is to investigate the possibility of utilizing waste marble dust in stabilizing problematic soils (especially swelling clays).
- The research work was divided into two sections. The first section deals with the shear strength parameters and swelling characteristics, the second section deals with the microstructural investigation of the improved problematic soils.
- Test results indicate that marble dust addition improved the shear strength parameters and reduced the swell potential of the tested clay samples. Marble dust had a noticeable role in the hydration process because of high calcium content. Obtained results showed that marble dust addition to the
- Clay samples will reduce the cost of constructing structures on problematic soils, and finding new utilization areas for waste marble dust will decrease environmental pollution.
- Utilizing waste marble dust materials in problematic soils will have great contribution to the economy and conservation of resources.
- Lime is very excellent soil stabilizing agent which is very important for highly active soil and it goes through shrinkage and expansion it also, improves the properties of soil such as reduction in plasticity index, increase in the compression and resistance to shrinkage during different weather condition.
- This chemical reaction is very fast and stabilization takes time.

1.3 ADVANTAGE OF SOIL STABILAZATION:

- It improves the strength of the soil, thus increasing the soil bearing capacity.
- It is more economical both in terms of cost and energy to increase the bearing capacity of the soil rather than going for deep foundation or raft foundation.
- Limitation of the need for embankment materials brought in from outside and the elimination of their transporting costs.
- Reduction of transport movements in the immediate vicinity of the construction site.
- Machines can move about with far greater ease. Delays due to weather conditions are reduced, leading to improved productivity. As a result, the overall construction duration and costs can be dramatically reduced.
- Structures have a longer service life (embankments, capping layers) and are cheaper to maintain.
- Stabilization improves the workability and the durability of the soil.

2. MATERIALS USED& ITS PROPERTIES

The present investigation the following materials were used:

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1) Expansive soil (clayey soils).
2) Lime.
3) Marble dust.
4) Water.

2.1 EXPANSIVE SOIL(CLAY): -

Clay is a type of fine-grained natural soil material that contains hydrous aluminium phyllosilicates (clay minerals) that develops plasticity when wet. Geologic clay deposits are mostly composed of phyllosilicate minerals containing variable amounts of water trapped in the mineral structure.

Mitigation of the effects of expansive clay on structures built in areas with expansive clays is a major challenge in geotechnical engineering. Some areas mitigate foundation cracking by watering around the foundation with a soaker hose during dry conditions. This process can be automated by a timer, or using a soil moisture sensor controller. Even though irrigation is expensive, the cost is small compared to repairing a cracked foundation. Admixtures can be added to expansive clays to reduce the shrink-swell properties, as well. One laboratory test to measure the expansion potential of soil is ASTM D 4829.The physical properties of the clay are listed in Table – 1.

Table – 1: Physical Properties of clay

Appearance(colour)	**White**
Form	**Powder**
Surface area	**65m^2/g**
Diameter	**30-70 nanometer**
length	**1-3 microns**
Pore volume	**1.26-1.64 ml/gm**
PH	**4.5-7**

2.2 LIME:

Lime is a calcium-containing inorganic mineral composed primarily of oxides, and hydroxide, usually calcium oxide and/ or calcium hydroxide. It is also the name for calcium oxide which occurs as a product of coal-seam fires and in altered limestone xenoliths in volcanic ejecta. The following are showing the properties of lime.

➢ **Properties of Lime**

Lime is considered one of the important building materials because of following properties.

- It is easily workable.

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- It has good plastic properties.
- It can withstand moisture well.
- It imparts sufficient strength to the masonry when used as mortar.
- It stiffens quite easily in short span of time.
- Masonry in lime mortar is more durable because of its comparatively low shrinkage on drying.
- It has good adhering properties with stone bricks both.

2.3 MARBLE DUST:

Marble dust is a waste product formed during the production of marble. A large quantity of powder is generated during the cutting process. Marble dust, a solid waste material generated from the marble processing can be used either as a filler material in cement or fine aggregates while preparing concrete or soil stabilizing material. The following table-2 shows the properties of marble dust.

Table-3: Properties Of Marble Dust

S.NO	PROPERTIES	M-SAND
1	Specific gravity (g/cm^3)	2.71
2	Surface by Blaine(cm^3/g)	4.372
3	Sio_2(%)	0.94
4	Fe_2O_3(%)	0.46
3	$CaCO_3$(%)	97.35

2.4 WATER: The water used for experiments was potable water Fresh portable water free from organic matter and oil is used in mixing the preparation of plastic bricks. Water in required quantities were measured by graduated jar and added to the quarry dust and M-sand mix. The rest of the material for preparation of the mix was taken by weigh batching. The pH value should not be less than 7.

3. Mix Design

The soil modification or soil stabilization. The purpose of subgrade modification is to create a working platform for construction equipment. No credit is accounted for in this modification in the pavement design process. The purpose of subgrade stabilization is to enhance the strength of the subgrade. This increased strength is then taken into account in the pavement design process. Stabilization requires more thorough design methodology during construction than modification. the soil sample was collected soil sample at NH5 near audishankara college gudur. We took 3kgs of sample for each sample of test which is passed from 425 micros sieve. We add water percentage from 6%, 8%,10% etc until the weight loose of soil sample in mould .for that soil we add the lime & marble dust having the percentage of

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2%,4%,6%,8% &15,20,25,30,35% by the weight of soil. The methods of subgrade modification or stabilization include physical processes such as soil densification, blends with granular material, use of reinforcements (Geogrids), undercutting and replacement, and chemical processes such as mixing with cement, fly ash, lime, lime by-products, and blends of any one of these materials. Soil properties such as strength, compressibility, hydraulic conductivity, workability, swelling potential, and volume change tendencies may be altered by various soil modification or stabilization methods.

3.1 Preparation Of Test Specimen

- Take a representative oven-dried sample, approximately 3/5 kg in the given pan. Thoroughly mix the sample with sufficient water to dampen it to approximately four to six percentage points below optimum moisture content.
- Weigh the proctor mould without base plate and collar. Fix the collar and base plate. Place the soil in the Proctor mould and compact it in 3 layers giving 25 blows per layer with the 2.6 kg rammer falling through and in 5 layers giving 56 blows per layer with the 4.9 kg rammer falling through for standard and modified test respectively.
- Remove the collar, trim the compacted soil even with the top of the mould by means of the straight edge and weigh.
- Divide the weight of the compacted specimen and record the result as the wet weight $\square_{wet}$ in grams per cubic centimeter of the compacted soil.
- Remove the sample from the mould and slice vertically through and obtain a small sample for moisture determination.
- Thoroughly break up the remainder of the material and add water in sufficient amounts to increase the moisture content of the soil sample by one or two percentage points and repeat the above procedure for each increment of water added.
- Continue this series of determination until there is either a decrease or no change in the wet unit weight of the compacted soil.

Fig: **Preparation Of Test Specimen**

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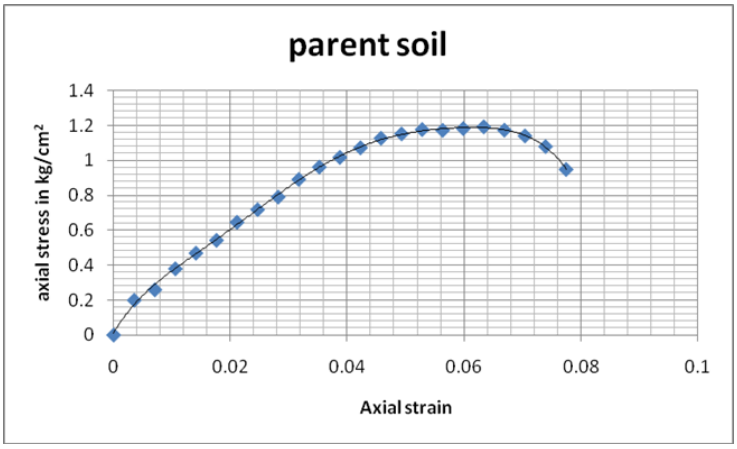
4.Results and Discussion

4.1 Parent Soil



Interpretation and reporting

Unconfined compressive

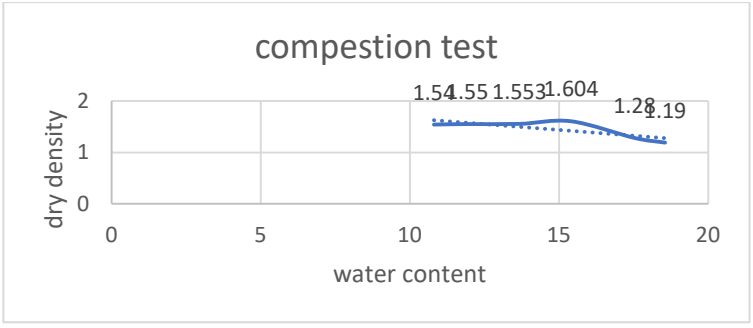
strength of the soil = 1.1928

Shear strength of the soil

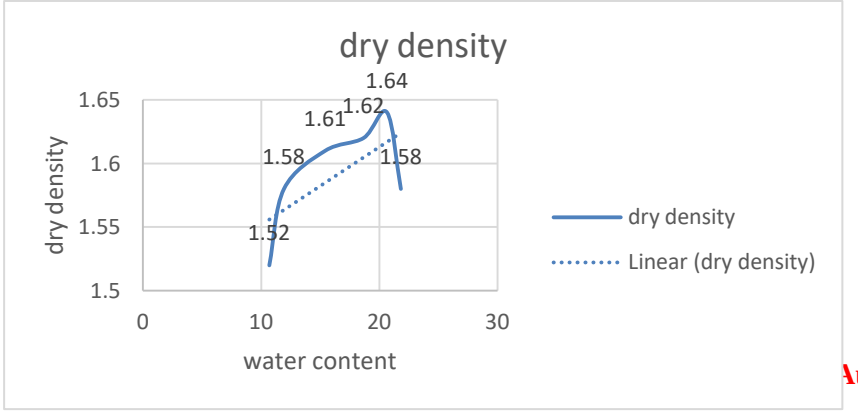
=1.1928/2 = 0.5964

4.2 Compaction test:

- **Compaction Test @2% Lime:**



- **@4% Lime:**



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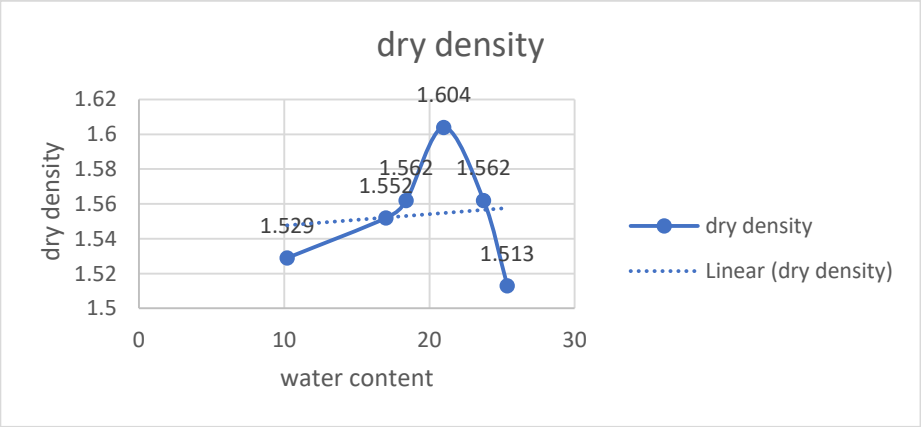
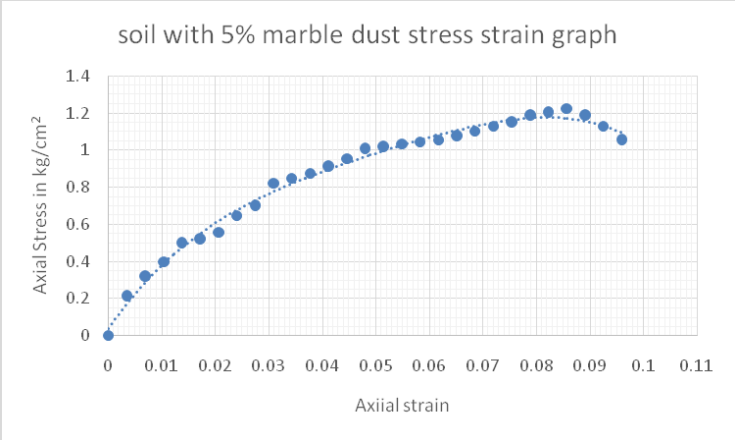
➢ **@6% Lime:**



4.2 UCS (Unconfined compressive strength):

➢ **@5%Marble Dust:**

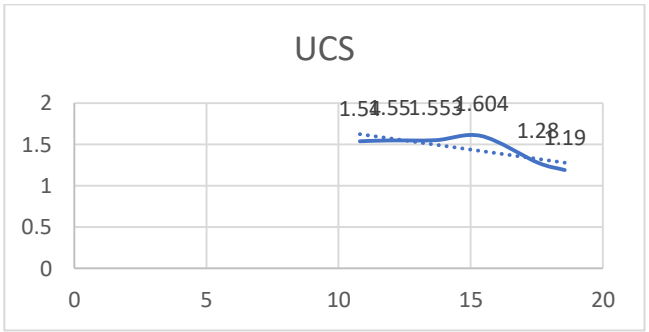


Interpretation and reporting

Unconfined compressive strength of the soil = 1.22

Shear strength of the soil = 1.22/2 = 0.61

➢ **@10%Marble Dust:**



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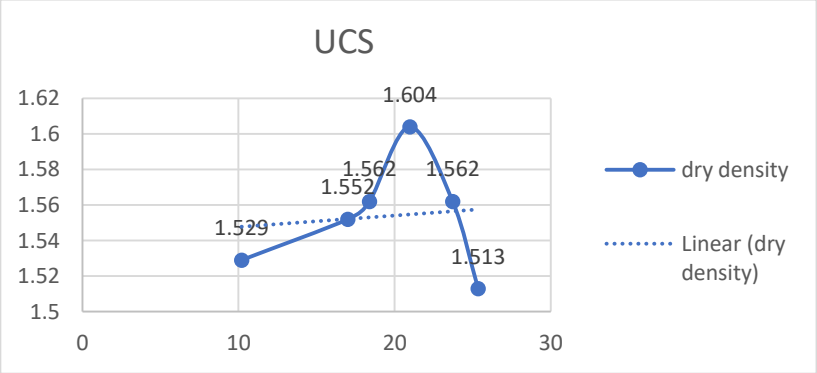
Unconfined compressive

strength of the soil = 1.2933

Shear strength of the soil

=1.2933/2 =0.6466

- **@15%Marble Dust:**



Interpretation and reporting

Unconfined compressive

strength of the soil = 2.064

Shear strength of the soil =

2.064/2 =1.032

5. CONCLUSION

On the basis of result obtained during the experimental investigation, following conclusion was drawn:

- Lime is used as an excellent soil stabilizing material for highly active soils which undergo through frequent expansion and shrinkage.
- Lime acts immediately and improves various property of soil such as carrying capacity of soil, resistance to shrinkage during moist conditions, reduction in plasticity index, increase in CBR value and subsequent increase in the compression resistance with the increase in time.
- The reaction is very quick and stabilization of soil starts within few hours.
- The graphs presented above give a clear idea about the improvement in the properties of soil after adding lime.

- Optimum value of marble dust comes out to be 15% by weight of dry soil.
- Maximum unconfined compressive strength of sample is = 1.032 for 15% marble dust addition.

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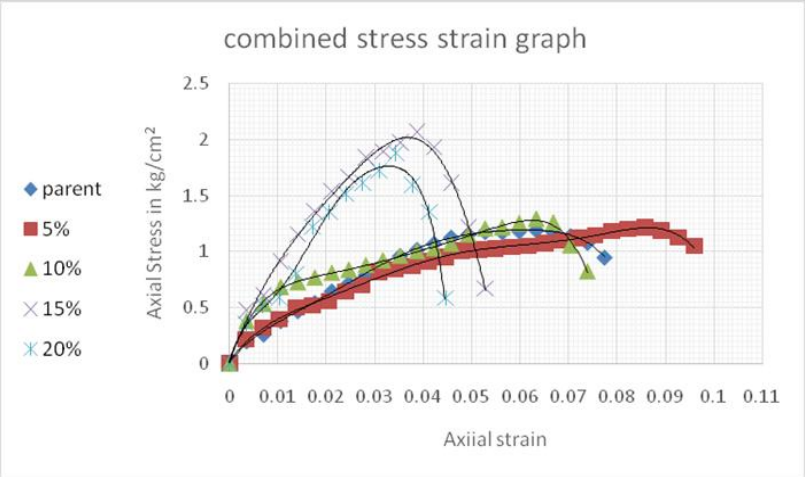
- With increase in percentage of marble dust dry density decreases and optimum moisture contain increases.
- Samples turned brittle on higher percentage of marble dust.



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