Published by :
https://www.ijert.org/
An International Peer-Reviewed Journal

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 01 , January - 2026

Stabilization of Laterite Soil using Marble Dust and Fly Ash and Manufacturing of Bricks

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CHAPTER 1 : INTRODUCTION

1.0 GENERAL

Soil is the material formed by the disintegration of rocks on which buildings and other structures can be built. According to the Indian Council of Agricultural Research soils are classified into 8 main categories.

They are,

- Alluvial soil
- Red soil
- Laterite soil
- Black cotton soil
- Mountainous or Forest soils
- Arid or Desert soils
- Saline or Alkaline soils
- Peaty or Marshy soils

In today's climatic changes, lack of stable ground for the development of infrastructures is very common. In fact, of this, the construction of buildings and roads on unsuitable ground is unavoidable and making suitable ground before construction is a really difficult issue for Geotechnical Engineers. To overcome the difficulties experienced with problematic soil in geotechnical applications on one side and safe disposal of solid wastes on the other side, an attempt is made in this investigation to explore the possibilities of utilizing wastes to improve the engineering behavior of problematic soil. So, in this investigation, I chose a **lateritic soil** because this soil is good for low-raised buildings but not suitable for high-raised buildings and not suitable for heavily loaded vehicles moving on Pavement.

Laterite soil is rich in aluminum and iron, formed in wet and hot tropical areas. Almost all laterites are rusty red due to the presence of iron oxides. It is prepared by the long-lasting and

where laterite, soil and rock type. Over 13 million hectares, the laterite soil is typically found in high altitude and rainy regions of Karnataka, Tamil Nadu, Madhya Pradesh, Jharkhand, Orissa, Assam, and Meghalaya. In most cases, they develop warm, humid climates.

Disadvantages Laterite Soils are:

They contain a high percentage of acidity.

It is generally coarse in texture and cannot retain moisture.

1. Incompatible with many modern building techniques As these bricks are mostly used during ancient times, it is incompatible with many modern building techniques and materials.

2. High-rise buildings can't be built due to low strength The strength of laterite bricks is about 5 to 10 times lesser than that of concrete bricks. Stress tests on laterite bricks show that it can take up to 2 MPa of pressure while baked laterites can go up to 5. On the other hand, concrete bricks can handle pressure ranging from 15 to 25 and so much more if it is reinforced with steel. This makes concrete buildings stronger. This proves that we can't use laterite to create high-rise buildings or buildings more than 3 stories.

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ISSN: 2278-0181
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3. Less resistant to natural forces like earthquakes and rainfall Laterite homes are easily destroyed when earthquakes happen. Also, they have inferior interlocking and are prone to breakage when compared with concrete bricks. Laterite bricks can't be reinforced by steel while concrete bricks can be. All these make concrete constructions much more earthquake-proof than laterite constructions.

4. Difficult to withstand heavy rainfall due to high moisture retention. The laterite stones have high absorption when it comes to water. During heavy rainfall, the strength of the constructions will dip even further. So, we won't be able to predict structural damages to the buildings.

5. Prone to acidic leaching Laterite stones are also highly acidic in nature and are susceptible to leaching. This leads to corrosion of other building materials such as paint and needs. Hence, we should handle it with care.

6. Lack of availability These bricks are not available in desert regions like the Middle East and Qatar. Therefore, you have to import these bricks from elsewhere which increases the cost of these bricks. Also, be aware that the finish of the walls with laterites is ancient and rugged. This may not be aesthetically pleasing for everyone. Hence, all of these disadvantages mean a higher life cycle cost for the Laterite bricks. While laterites have served humans quite well in the field of construction, it is no longer viable today as better and stronger bricks are available to us.

7. So, for road construction and heavy raised buildings, lateritic soil needs to improve the bearing capacity of the soil.

8. Surface soil stabilization offers geo-technically sound resting mediums for the construction of roadways, railways, and runways. The process of surface stabilization involves alteration of geotechnical properties either by mechanical or by chemical means. In some cases, both mechanical rearrangements as well as chemical reactions are employed for the surface stabilization process. The widely adopted technique for degrading the ill-effect potential of Lateritic soil is fly ash stabilization.

9. The main purpose of stabilization is to improve the soil strength, bearing capacity, durability under adverse moisture, and withstand both static and dynamic stress. Stabilization of the geo-materials can aid in dust control on roads and highways, particularly unpaved roads, water erosion control, and in fixation and leaching control of waste and recycled materials. roadway needs a stable foundation to ensure the best construction and durability. The foundation itself must rest on strong soil that is able to transfer the entire load of the building adequately. If the soil is weak, over time it will compact and begin to swell. This swelling soil leads to the entire structure shifting. The very walls of the building will begin to buckle. If the soil swells too much, it can be disastrous to the structure. There will be noticeable cracks forming in the foundation, which then result in the building itself succumbing to the forces of nature. It's not just buildings undergoing soil stabilization before construction. Many construction companies also schedule soil stabilization services when constructing new roadways, overpasses, parking lots, and even airfields. As the soil swells, it can cause cracks, bumps, and weakened pavement that could prove dangerous in time. On a roadway, any noticeable damage can easily lead to an accident. On a runway, the results can be even more devastating, dangerous, and costly.

1.1 LATERITE SOIL

Lateritic soils are extensively used as fill materials for various construction mechanisms. These soils are weathered under conditions of high heat and humidity with well-defined alternating wet and dry seasons resulting in poor engineering properties such as high plasticity, poor workability, low strength, high permeability, and tendency to retain moisture content. The effective use of these soils is therefore often hindered by the difficulty in handling particularly under moist and wet conditions typical of tropical regions and can only be utilized after modification/stabilization. The modification/stabilization of engineering properties of soils is recognized by engineers as an important process of improving the performance of problematic soils and makes marginal soils perform better as a civil engineering material. Stabilization, in a broad sense, includes the various methods the engineering properties and performance of soil. Every year millions of tonnes of fly ash are produced all over India which is categorized as hazardous waste material. It is better to use such waste materials in a variety of ways, including roadbeds, construction fill, or cement admixture

1.2 FLY ASH

1. This is an industrial by-product obtained from the combustion of coal. Fly ash is the fine powder formed from the mineral matter in coal, consisting of the non-combustible matter in coal and a small amount of carbon that remains from incomplete combustion.

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ISSN: 2278-0181
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2. The fly ash has low calcium oxide (CaO) content (9.8%), and high silicon dioxide (SiO_2) content (46.02%). The CaO/SiO_2 ratio is indicative of cementing. The specific gravity of this ash is 2.06 and as in most fly ashes is a non-plastic material. Only a fraction passing through the BS No. 200(75micron) sieve was used throughout the test without additional treatment.

3. The use of fly ash as a lightweight aggregate (LWA) offers a valuable opportunity to recycle one of the largest waste streams. In addition, fly ash can offer many benefits, both economically and environmentally when utilized as an LWA. In past, fly ash produced from coal combustion was simply entrained in flue gases and dispersed into the atmosphere. This created environmental and health concerns that prompted laws in heavily industrialized countries that have reduced fly ash emissions to less than 1% of ash produced. Worldwide, more than 65% of fly ash produced from coal power stations is disposed of in landfills and ash ponds.

4. Soil stabilization with fly ash is the permanent physical and chemical alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and/or 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 from expansive clays to granular materials. Stabilization can be achieved with a variety of chemical additives including lime, fly ash, and Marble dust. Proper design and testing are an important component of any stabilization project.

5. This allows for the establishment of design criteria, and the determination of the proper chemical additive and admixture rate that achieves the desired engineering properties. Stabilization process benefits can include: Higher resistance (R) values, Reduction in plasticity, Lower permeability, Reduction of pavement thickness, Elimination of excavation – material hauling/handling – and base importation, Aids compaction, Provides "all-weather" access onto and within projects sites.

6. Another form of soil treatment closely related to soil stabilization is soil modification, sometimes referred to as "mud drying" or soil conditioning. Although some stabilization inherently occurs in soil modification, the distinction is that soil modification is merely a means to reduce the moisture content of a soil to expedite construction, whereas stabilization can substantially increase the shear strength of a material such that it can be incorporated into the project's structural design.

7. The determining factors associated with soil modification vs soil stabilization may be the existing moisture content, the end use of the soil structure, and ultimately the cost-benefit provided. Equipment for the stabilization and modification processes include chemical additive spreaders, soil mixers (reclaimers), portable pneumatic storage containers, water trucks, deep lift compactors, and motor graders.

1.3 MARBLE DUST

1. Marble dust is a minimum-sized waste that occurs with sawing process of marble blocks and plates. This dust is carried by water to the sedimentation pond.

2. Sediment dust is removed from this pond to the wasteland, but this condition has formed a serious problem for the environment because waste marble dust is used in very little quantities even though it is used in various industries such as construction, ceramics and cement industry, paint industry, agriculture, and fertilizer industry, etc. Therefore, they form a big mass in the waste areas. Some studies have been done with marble dust in soil stabilization showed that the geotechnical parameters of lateritic soils are improved by adding marble dust.

3. Clay plasticity was reduced, while the strength and California bearing ratio (CBR) increased. In another study, marble dust reduced the swelling potential of clays and increased the unconfined compressive strength Moreover, it was observed that marble dust increased landfill liner strength in conditions of freezing and thawing.

CHAPTER 2 : LITERATURE REVIEW

2.1. A REVIEW OF THE STABILIZATION OF LATERITIC SOILS WITH SOME

AGRICULTURAL WASTE PRODUCTS 1-2. Department of Civil Engineering, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, NIGERIA

An attempt to reduce the amount of environmental wastes and the high cost of conventional stabilizers has led to continuous studies on the economic utilization of ash from agro-wastes for improving the engineering properties of soil. This paper therefore reviewed the impacts of some of these waste products to establish their effectiveness in improving geotechnical properties of lateritic soils. The wastes considered include saw dust ash (SDA), coconut husk ash (CHA), millet husk ash (MHA), corn cob ash (CCA), rice husk ash (RHA), bagasse ash (BA) and locust bean pod ash (LPBA). It was established that these ashes are good pozzolanic materials having satisfied the required standards. Also, increase in ash contents led to a significant decrease in the liquid limit, plasticity index, swelling index and shrinkage limit of soils. The maximum dry density of soil increased from 0 to 4% substitutions of SDA, CHA and CCA while it decreased with the addition of ashes from other wastes. CBR and UCS generally increased with increasing amount of the stabilizers whereas soil permeability and swell potential decreased as the ash content increased. Ash produced from these wastes can be used to improve the geotechnical properties of soil, to synthesize a stable soil mix, suitable for highway construction purposes.

2.2. Stabilization of Laterite Soil using GKS Soil Stabilizer Aminaton Marto Professor of Faculty of Civil Engineering, University Technology Malaysia (UTM), 81310 Skudai, Johor Bahru, Malaysia

Today, due to the increasing population and also development of construction industry, having sufficient knowledge and information about the various methods of improving the current surface soils for use in various construction projects is an essential issue for a Geotechnical Engineer. The technology for soil improvement is one of the most trustable and practical ways. It is also economically viable to increase the resistance of soil, soil strength, soil permeability, as well as to limit water absorption, control soil erosion, losing water, and soil settlement. A new liquid polymer soil stabilizer, which was developed for use as a means of stabilization treatment of soil known as SS299, was examined in this study. In order to understand the effects of SS299 on the stabilization of Laterite soil, laboratory tests on the unconfined compressive strength and shear strength of untreated and treated soil specimens were performed. The results indicated that SS299 soil stabilizer is able to significantly increase the unconfined compression strength and shear strength of Laterite soil. The unconfined compression strength increased with the duration of curing time, the variation mainly occurring in the first 7 days. Also the result indicated that this stabilizer is worth popularizing for practical projects such as road construction, backfilling, erosion control and for slope stability.

2.3. International Journal of Scientific Research Engineering & Technology (IJSRET), ISSN 2278–0882Volume 7, Issue 11, November 2018

Laterite is a soil and rock type rich in iron and aluminium and occur mostly in tropical and sub-tropical regions with hot, humid climatic conditions. Laterite contain a substantial amount of clay minerals hence its strength and stability cannot be guaranteed under load,specially,in,the,presences,of,moisture.

Stabilization using stabilizing agents improve the engineering properties and make it suitable for construction. This paper aims to present a review on the effects of various stabilizing agents used for stabilization of Lateritic soil.

2.4. A review of the use of lateritic soils in the construction/development of sustainable housing in Africa: A Geological Perspective Oyelami, C.A. and Van Rooy, J.L. Department of Geology University of Pretoria P/Bag X 20 Hatfield, 0028 Pretoria.

Lateritic soils have been described as highly weathered tropical or sub-tropical residual soils with varying proportions of particle sizes ranging from clay size to gravel, usually coated with sesquioxide rich concretions. It is sometimes referred to as brick earth based on its use. The use of laterite and lateritic soils have been found to promote the realization of decent housing and bridging the housing deficit, especially in Africa. The author has attempted to review available information on the recent trends in building bricks and housing development with the aim of identifying a suitable soil material that will meet the present challenge of sustaining the environment without costing too much and maintaining a high standard of strength, durability and aesthetics. A critical review of laterite and lateritic soils from a geological point of view indicated these soils to be one of the best natural materials used in the production of compressed earth bricks. Lateritic soils are mostly well graded, comprising both cohesive (silt and clay) and cohesionless (sands and gravels) soil fraction, it contains sesquioxides and clay minerals which are very useful in the natural binding process as well as in the presence of most chemical binders. Compressed earth bricks are mainly composed of raw earth materials (soil) with their cohesion due principally to the clay fraction present in both humid and dry states. CEB's promote building in a 'sustainable' way and offers a good prospect to using our resources in an efficient manner while creating dwellings that improve human health, well-being and preserving a better environment, with an affordable and natural alternative.

2.5. International Journal of Innovative Research in Science, Engineering and Technology) March 2020 Behaviour of Lateritic Soils

Lateritic soils, also called as red soils, are residual soils found in the tropical and sub-tropical regions. They are widely used in construction especially in pavement construction as sub-grade, sub-base or base-course, in earthen embankments or in the form of laterite blocks for building construction purpose. The properties of such soils are highly variant in nature and depend on various

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factors such as properties of parent rock material, climate and rainfall, topography, age of the deposits, vegetation etc. Alternate wet and hot seasons are mandatory for their formation and hence such soils are confined to the tropical and sub-tropical regions of the country. For a geotechnical engineer, to ensure the safety on quality of the material used, the properties and the behaviour of such soils under different practical situations must be known. This study is an attempt to review and compile the findings of the various researches carried out across the world regarding the behaviour of lateritic soils, the factors affecting their formation, the classification of lateritic soils, the different engineering and index properties of lateritic soils etc. to get a better understanding of the nature of such soils, which are widely used for engineering construction activities in our country. The characterisation study conducted on two lateritic soil samples collected from two different locations from the Malabar region of Kerala, was carried out to analyse the basic geotechnical characteristics.

2.6. Stabilization of Expansive Soil Using Fly ash,Marble Powder,and Rice Husk Ash.

Expansive soils undergo volume changes with variation in moisture content, which causes structural issues such as cracking, low strength, and high swelling. To improve these properties, industrial and agricultural waste materials like fly ash, marble powder, and rice husk ash are used as soil stabilizers.

Fly ash, a by-product of coal combustion, reduces plasticity and swelling while improving strength due to pozzolanic reactions. Marble powder, obtained from marble cutting industries, is rich in calcium carbonate and helps decrease plasticity and swelling while increasing dry density and CBR

values. Rice husk ash, an agricultural waste with high silica content, enhances shear strength, CBR, and reduces swelling characteristics.

Various studies indicate that these materials, used individually or in combination, significantly improve engineering properties such as Atterberg limits, UCS, CBR, MDD, OMC, and swelling behavior of expansive soils. Optimal improvement is generally observed at moderate replacement levels of about 15–25%.

The study concludes that fly ash, marble powder, and rice husk ash provide an economical, eco-friendly, and sustainable solution for expansive soil stabilization while also helping in effective

waste management.

2.7. Soil Stabilization Using Marble Dust Waste

High plasticity soils have low bearing capacity and high deformation potential, making them unsuitable for construction without stabilization. This study examines the use of marble dust waste as a sustainable stabilizing material to improve the physical and mechanical properties of high plasticity soils.

Laboratory tests such as Atterberg limits, compaction, specific gravity, CBR, XRF, and SEM-EDX

were conducted by adding marble dust at 0%, 7%, 17%, and 27% with curing periods of 0, 3, and 7 days. Chemical analysis showed that marble dust is rich in calcium oxide (CaO), which enhances soil particle bonding.

The results revealed that the Plasticity Index (PI) reduced significantly from 29.24% to 10.56%, while the CBR value increased to a maximum of 15.50% at 7% marble dust content with 7 days of curing, satisfying subgrade strength requirements.

The study concludes that marble dust waste is an effective, economical, and eco-friendly stabilizer for high plasticity soils and offers a sustainable solution for waste utilization in construction.

2.8. Stabilization of Guzape Laterite Using Rice Husk Ash and Marble Dust

Guzape lateritic soil exhibits high swelling, cracking during dry seasons, low strength, and poor bearing capacity, making it unsuitable for road construction without stabilization. This study investigates the use of rice husk ash (RHA) and marble dust (MD)—agricultural and industrial waste materials—as sustainable stabilizers to improve the engineering properties of laterite soil .

Laterite soil was stabilized with a constant 10% marble dust and varying RHA contents (2%–25%). Geotechnical tests such as Atterberg limits, compaction, California Bearing Ratio (CBR), Unconfined Compressive Strength (UCS), and Free Swell Index (FSI) were conducted. Results showed that free swell index reduced significantly, while CBR and UCS values increased with increasing RHA content .

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The optimum performance was achieved at 25% RHA and 10% MD, which recorded the highest CBR (23%), highest UCS, and improved compaction characteristics. Liquid and plastic limits reduced, indicating lower plasticity and improved soil stability .

The study concludes that RHA and marble dust effectively enhance laterite soil properties, offering an eco-friendly, economical, and sustainable alternative to conventional stabilizers while also reducing environmental waste problems .

2.9. Stabilization of Laterites with Industrial Wastes

In this review of the stabilization of lateritic soils using various industrial wastes. Lateritic soils, rich in iron and aluminum oxides, are common in tropical regions and are widely used in road construction, brick manufacturing, and other civil engineering applications. However, their engineering properties often require improvement for effective use.

The paper explains the **mechanisms of soil stabilization**, highlighting processes such as cation exchange, flocculation and agglomeration, cementitious hydration, and pozzolanic reactions, which enhance strength, stiffness, and durability of lateritic soils

A major focus is on the use of **industrial and agricultural wastes**—including fly ash, bagasse ash, sugarcane ash, rice husk ash, sawdust ash, tyre ash, reclaimed asphalt pavement, bio-enzymes, coconut shell/leaf ash, arecanut coir, and corncob ash—as stabilizing agents. The reviewed studies show that these wastes can significantly improve properties such as CBR, UCS, plasticity, and compaction characteristics, either as standalone stabilizers or as admixtures with cement or lime.

This review concludes that industrial waste stabilization of lateritic soils is **economical, sustainable, and environmentally friendly**, with strong potential to partially replace conventional chemical stabilizers in road construction and other geotechnical works, thereby reducing costs and environmental impact

CHAPTER 3 : OBJECTIVES

To improve the load bearing capacity of the soil

The possibilities of utilizing wastes to improve engineering behaviour of problematic soil

Enhancing the engineering properties of the weak soil results in betterment To reduce the permeability of soil

Enhancement of binding properties in soil

To analyze the strength and durability of the manufactured bricks Can achieve good thermal insulation properties in a brick Reduction of setting time of a brick

CHAPTER 4 : MATERIALS

4.1 INTRODUCTION

This chapter presents information related to materials used in this research work. Details regarding the methods of sample extraction and methods of testing are explained in this chapter.

4.2 MATERIALS USED

Materials used in this research work are

- Lateritic soil
- Marble dust
- Fly ash

4.2.1 Lateritic soil

The soil used in this research study is obtained from a UDUPI district, Karnataka state of India. This soil is also known as No expansive Soil. The soil is collected from an open excavation at a depth of 1 meter below the natural ground surface. The soil is powdered in a rammer of 2.5 kg.

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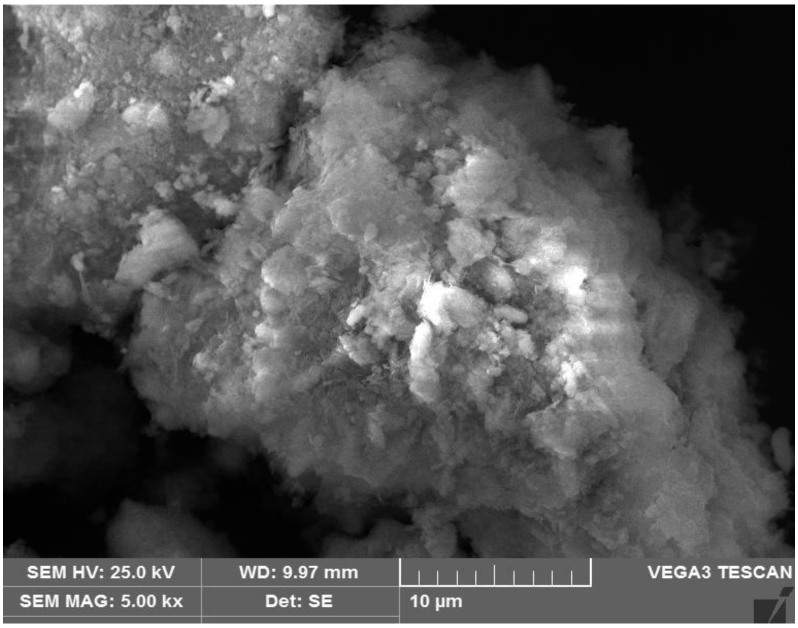
The index properties of Lateritic soil are presented in Table 4.1.

The chemical composition of the soil was analyzed as per the standards and its result is presented. The grain size distribution is presented in Figure 4.1



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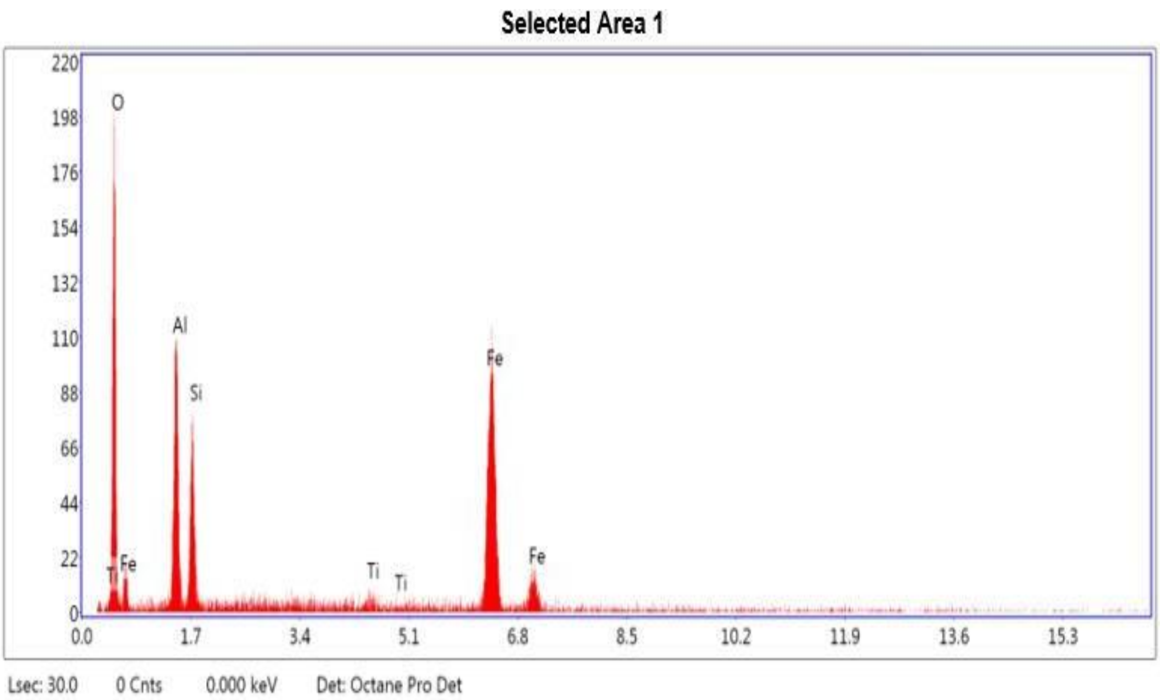

Table 4.1: Geotechnical properties of Lateritic soil used in the present study

Sl. NO.	Index Properties		Value
1	Colour		Red
2	Grain Size Distribution	Fine sand size (%)	2mm
		Silt size (%)	0.06mm
		Clay size (%)	<0.002mm
3	The specific gravity of soil solids		2.69
4	Consistency limits	Liquid limit (%)	28.0
		Plastic limit (%)	20.4
		Shrinkage limit (%)	15
	Plasticity Index (%)		7.6
5	Indian Standard Soil Classification		CH
6	IS standard Compaction parameters	Optimum Moisture Content (%)	14.06
		Maximum Dry Unit Weight (kN/m^3)	13.40
7	Free Swell Index (%)		20

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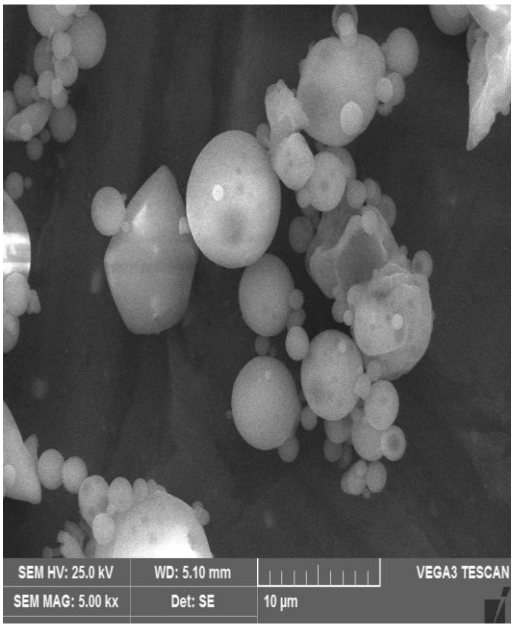
Chemical composition oxides	Values (%)
SiO_2	21.55
Al_2O_3	24.31
Fe_2O_3	29.4
Na_2O	0.07
K_2O	0.11
P_2O_5	16.71
SO_3	3.98
CO_2	3.65

Table 4.2: chemical composition of lateritic soil

4.2.2 Fly ash

Fly ash, flue ash, coal ash, or pulverized fuel ash coal combustion residuals is a coal combustion product that is composed of the particulates (fine particles of burned fuel) that are driven out of coal-fired boilers together with the flue gases. Ash that falls to the bottom of the boiler's combustion chamber (commonly called a firebox) is called bottom ash. In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler, it is known as coal



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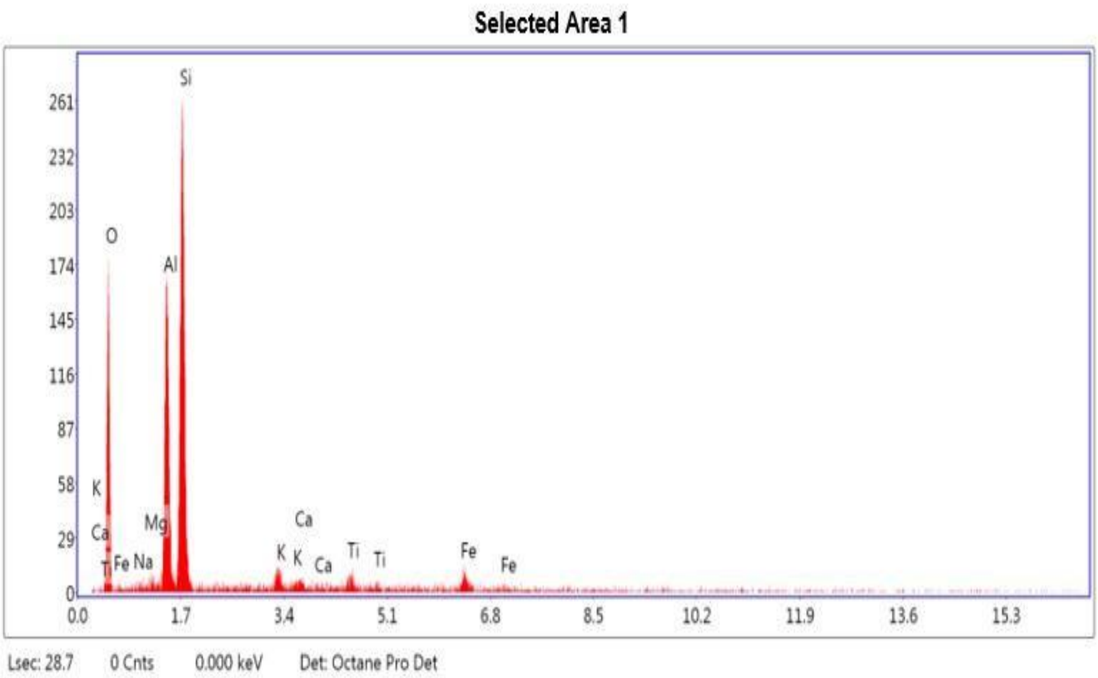

Chemical composition oxides	Values (%)
Silica	55-65
Iron oxide	5-7
Aluminum oxide	22-25
Calcium oxide	5-7
Magnesium oxide	<1
Titanium oxide	<1
Phosphorous oxide	<1
Sulphates	0.1
Alkali oxide	<1

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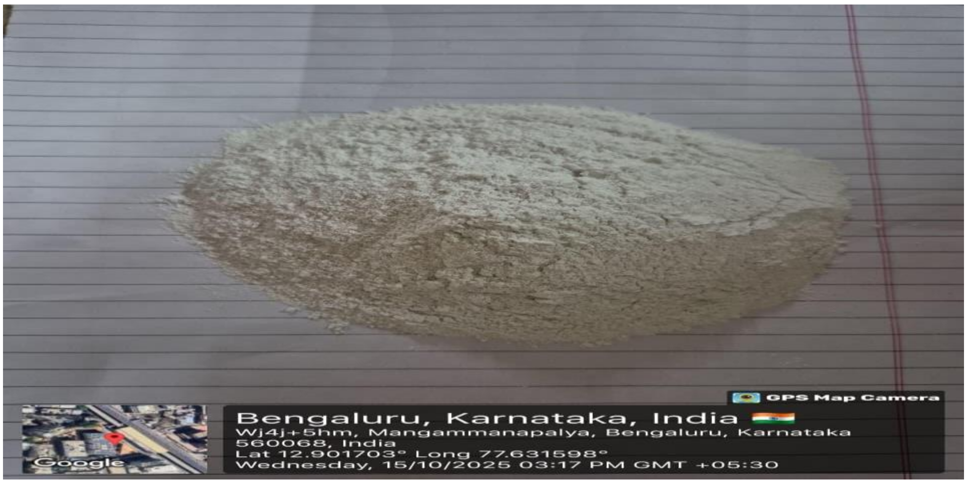
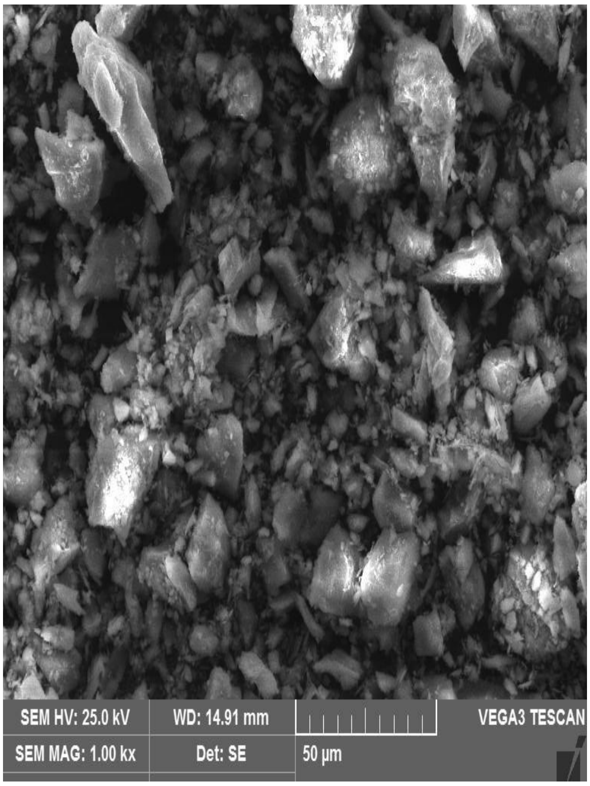
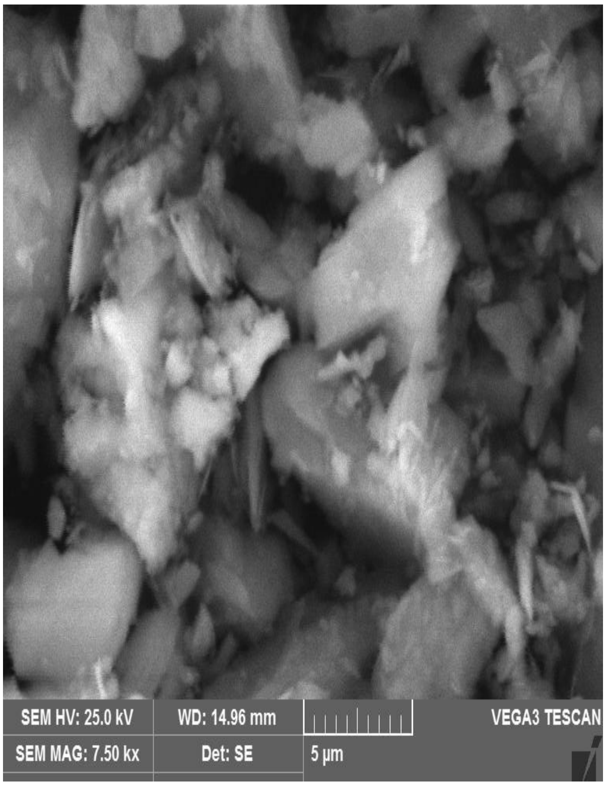
4.2.2.1 Chemical composition of fly ash as in the table

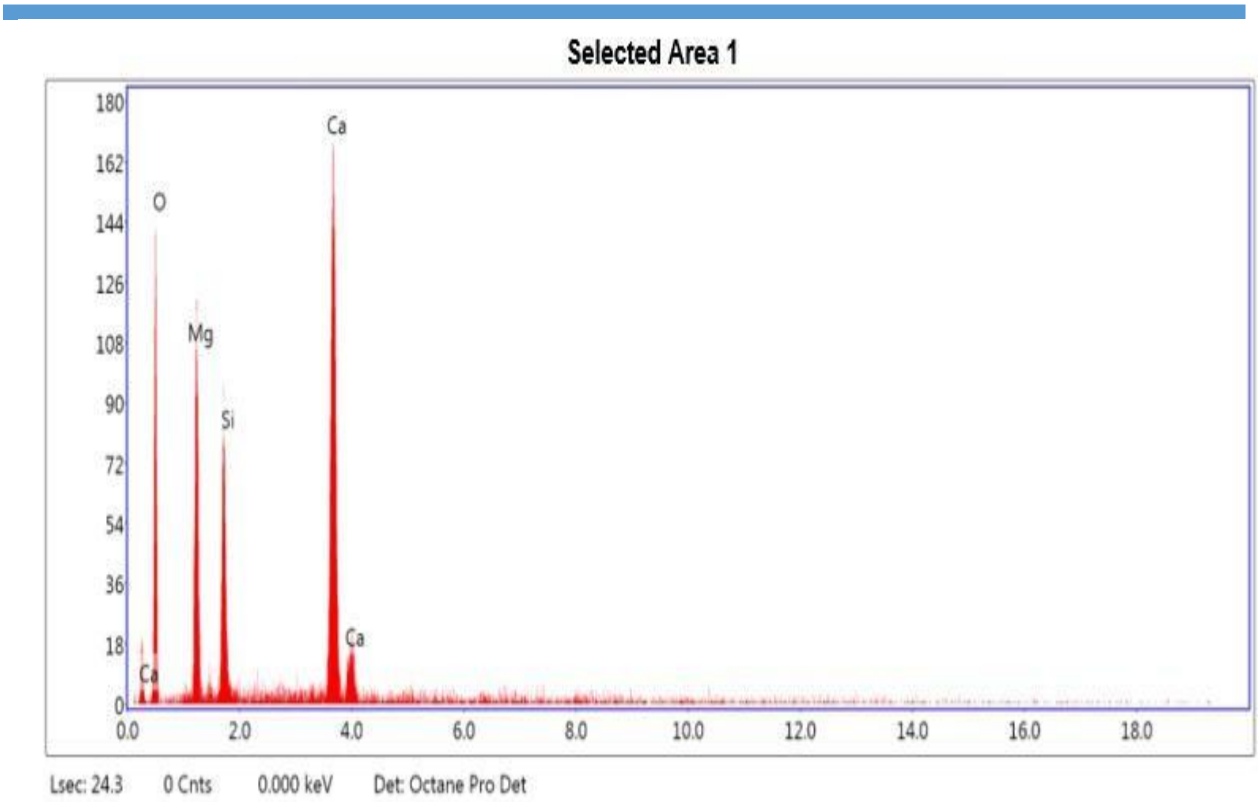
4.2.3 Marble dust

Marble dust is crushed or ground marble particles that can still be formed to make a solid object. Waste marble powder is generated as a by-product during cutting of marble, the reuse of marble wastes provides benefits to reduce construction costs and increase sustainability.









Chemical composition oxides	**Values (%)**
SiO2	0.42
Tio2	0
Al2O3	0.07
Fe_2O_3	0
Mno	0
Mgo	0.24
Cao	55.65
Na2O	0.36
K_2O	0.01
S	0.03
LOI	43.232

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4.2.2.1 Chemical composition of Marble dust

CHAPTER 5 : TEST CONDUCTED

- Sieve analysis
- Specific gravity
- Liquid limit
- Shrinkage Limit
- Proctor compaction

CHAPTER 6 : TEST PROCEDURE

6.1. SIEVE ANALYSIS:

A gradation test is performed on a sample of aggregate in a laboratory. A typical sieve analysis uses a column of sieves with wire mesh screens of graded mesh size.

1 A representative weighed sample is poured into the top sieve which has the largest screen openings. Each lower sieve in the column has smaller openings than the one above. At the base is a pan, called the receiver.

2 The column is typically placed in a mechanical shaker, which shakes the column, usually for a set period, to facilitate exposing all of the material to the screen openings so that particles small enough to fit through the holes can fall through to the next layer. After the shaking is complete the material on each sieve is weighed. The mass of the sample of each sieve is then divided by the total mass to give a percentage retained on each sieve. The size of the average particle on each sieve is then analysed to get a cut-off point or specific size range, which is then captured on a screen.

3 The results of this test are used to describe the properties of the aggregate and to see if it is appropriate for various civil engineering purposes such as selecting the appropriate aggregate for concrete mixes and asphalt mixes as well as sizing of water production well screens.

4 A suitable sieve size for the aggregate underneath the nest of sieves to collect the aggregate that passes through the smallest. The entire nest is then agitated, and the material whose diameter is smaller than the mesh opening pass through the sieves. After the aggregate reaches the pan, the amount of material retained in each sieve is then weighed.

6.2. SPECIFIC GRAVITY :

Test Procedure to determine specific gravity of solids using density bottle consists following steps.

1. Firstly clean the density bottle and put it in an oven at a temperature of 105 ^{0}C to 100 ^{0}C for drying. After drying, put it in the desiccator to cool down.
2. Now the density bottle along with stopper is weighed using balance to an accuracy of 0.001 gm. Note down this reading as "M1"
3. Take 5 to 10 g of oven dried sample in the density bottle and weigh the bottle along with stopper and dry sample. Note this reading as "M2".
4. Now add de-aired distilled water to the soil in the density bottle up to the soil level and shake gently to mix soil and water.
5. Now remove the stopper of density bottle and place it in vacuum desiccator and connect the vacuum pump.
6. The air entrapped in the soil is expelled by applying vacuum pressure of 55 cm of mercury for about one hour in vacuum desiccator.

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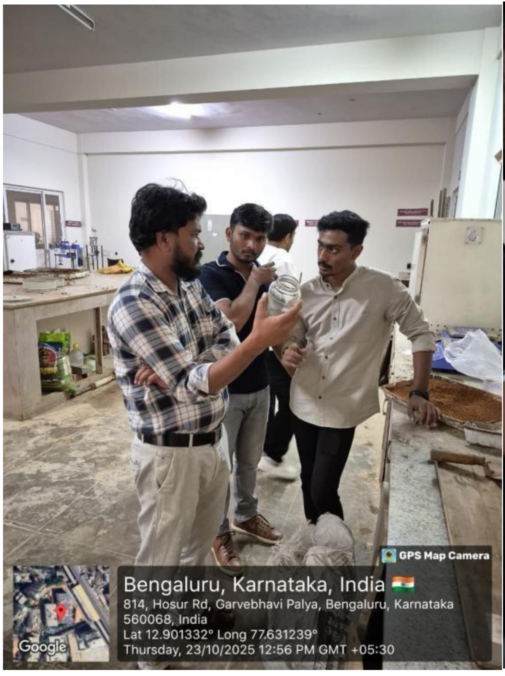
7. After that, remove the lid and stir the soil using spatula. The soil adhere to the spatula is washed into the bottle with air free distilled water. Again apply vacuum pressure for some time which is stooped when there is no more air evolved from the specimen.
8. The entrapped air can also be removed by heating in the absence of vacuum desiccator.
9. Remove the bottle from the desiccator and add more distilled water until the bottle is full. Insert the stopper.
10. To attain the constant temperature through the bottle, immerse it into the water bath for one hour.
11. Takeout the bottle from water bath after attaining constant temperature and clean and dry the outside using smooth cloth.
12. Now the bottle is weighed which is the total mass of bottle, soil and water. Note down this as “M3”.
13. In the final step, empty the bottle wash it and refill it with only distilled water. Now also place it in water bath for one hour to maintain same temperature during experiment.
14. Now weight the bottle with full of distilled water along with stopper which is “M4”.
15. Now repeat the same procedure for three times and take the average reading of three observations as final result.



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6.3. LIQUID LIMIT:

1. Adjust the drop of the cup of the liquid limit device by releasing the two screws at the top and by using the handle of the grooving tool or a gauge. The drop should be exactly 1 cm at the point of contact on the base. Tighten the screw after adjustment.

2. Take about 120g of the air-dried soil sample passing 425 micron IS sieve.

3. Mix the sample thoroughly with distilled water in an evaporating dish or a glass plate to form a uniform paste. Mixing should be continued for about 15 to 30 min, till a uniform mix is obtained.

4. Keep the mix under humid conditions for obtaining uniform moisture distribution for sufficient period. For some fat clays. This maturing time may be upto 24 hours.

5. Take a portion of the matured paste and remix it thoroughly. Place it in the cup of the device by a spatula and level it by a spatula or a straight edge to have a minimum depth of the soil as 1cm at the point of the maximum thickness. The excess soil, if any should be transferred to the evaporating dish.

6. Cut a groove in the sample in the cup by using the appropriate tool. Draw the grooving tool through the paste in the cup along the symmetrical axis, along the diameter through the centre line of the cup. Hold the tool perpendicular to the cup.

7. Turn the handle of the device at a rate of 2 revolutions per second. Count the number of blows until the two halves of the soil specimen come in contact at the bottom of the groove along a distance of 12mm due to flow and not by sliding.

8. Collect a representative sample of the soil by moving spatula width-wise from one edge to the other edge of the soil cake at right angles to the groove. This should include the portion of the groove in which the soil flowed to close the groove.

9. Remove the remaining soil from the cup. Mix it with the soil left in evaporating dish.

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6.4. SHRINKAGE LIMIT :

1. Take about 100 gm of the soil sample from a thoroughly mixed portion of the material passing through 425 microns IS sieve.
2. Take about 30 gm of soil sample in evaporating dish and mix thoroughly with distilled water till the voids are filled in completely
3. Determine the weight of an empty shrinkage, dish (W1) Coat inside of shrinkage dish with a thin layer of grease or oil to prevent adhesion of soil. Fill the paste in the shrinkage dish in three equal layers.
4. Find the weight of the shrinkage dish with wet soil and note it down as W2.
5. Dry the sample gradually first in the atmosphere for 24 hrs and then in the oven at temperature 105° C to 110° C to ensure no crack in a sample.
6. Find the weight of shrinkage dish plus oven-dried soil and note as W3.
7. Take out the soil cake from the shrinkage dish; keep the empty shrinkage dish in a stainless steel cup to preserve overflowing mercury during filling the dish. Find the weight of shrinkage dish with full of mercury (W4).
8. Fill the glass cup to overflowing with mercury and remove excess mercury by pressing the glass plate with three sponges firmly over top of the cup, collecting the excess mercury in a suitable container.
9. Place the cup, filled thus with mercury in the evaporating dish taking care not to spill any mercury from the glass cup, and place the oven-dried soil pat on the surface of mercury in the cup.
10. Then carefully force the pat under the mercury by means of the same prongs and press the plate firmly over the top of the cup. Take the displaced mercury from evaporating dish, find out the weight of the dish with that mercury, and note as Ws.

    Make necessary calculations as tabulated in the observation table.

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6.5. PROCTOR COMPACTION

1. Take sufficient quantity of representative soil, air dry & pulverize it with a rubber mallet.
2. Sieve the soil through No: 4 sieve & reject the coarser material. 3. Take about, 3 kg of soil, add water to bring its water content to about 5% below the estimated optimum moisture content (for coarse-grained soil 4% initial water content & for fine-grained soil 10% initial water content is preferable).
3. Then Mix it thoroughly.
4. Clean the mold, measure its diameter & height & weigh it without the collar.
5. Fit the collar & compact the moist soil in three equal layers by the rammer with evenly distributed blows to each laver.
6. Use 25 blows for 4 inches diameter & 56 blows for 6 inches diameter mold to the total height of mold with collar.
7. Remove the collar trim the compacted soil even with the top of the mold with a straight steel edge.
8. Clean outside of the mold & base plate & weigh
9. Remove the soil from the mold, split it & take about 100 grams sample for water content determination.
10. Break the soil lamps, mix it with remaining soil in the tray.
11. Add more water to increase the water content by 2 to 3% & repeat the compaction procedure for each increment of water until the mass of the compacted soil decreases.
12. Calculate Water content for each trail & corresponding dry density.
13. Plot the compaction curve between water-content as abscissa & dry density as ordinate.
14. Note the water content against the peak of the curve as optimum moisture content & the corresponding dry density as maximum dry density.

CHAPTER 7 RESULTS

IS SIEVE	PARTICLE SIZE D (mm)	WEIGHT OF SOIL RETAIN ED	% RETAINED	CUMULATIV E % RETAINED	% LINER N = 100 CUMALATIVE % RETAINED
4.75mm	4.75	0.274	27.4	27.4	72.6
2.36mm	2.36	0.184	18.4	45.8	54.2
1.18mm	1.18	0.146	14.6	60.4	39.6
600M	0.600	0.084	8.4	68.8	31.2
425M	0.425	0.170	17	85.8	14.2
300M	0.300	0.100	10	95.8	4.2
150M	0.150	0.026	2.6	98.4	1.6
75M	0.075	0.016	1.6	100	-
PAN	-	0	-	-	-

Cu= D60/D10	=2.9/0.27	D10= 0.27
CC= (D30)*2/D10*D60	= 0.415	D30=0.59
-	-	D60=2.9
CO-EFFICENT OF PERMIABLITY = C*(D10) = 7.29		

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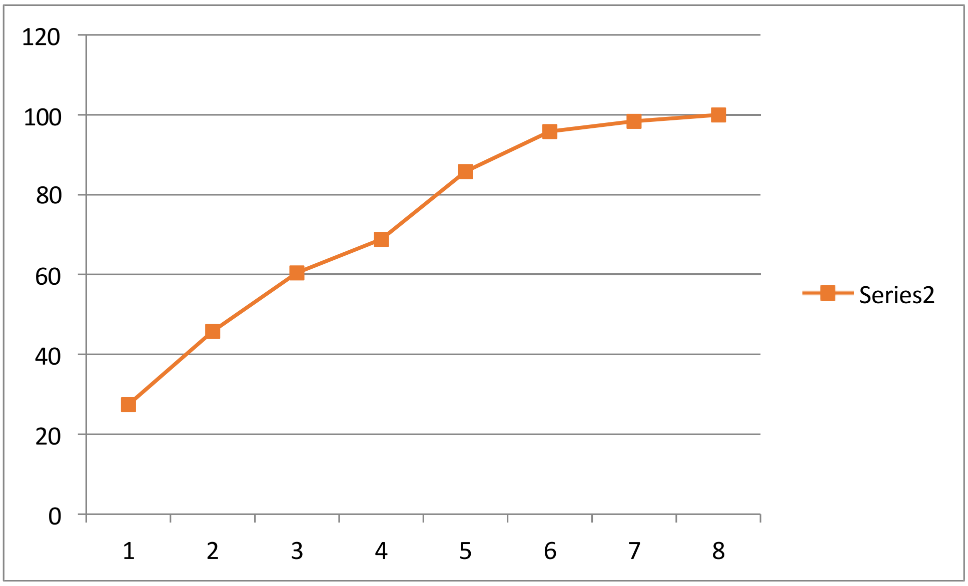

FIG:7.1.3

7.1 SPECIFIC GRAVITY BY DENSITY BOTTLE

DETERMINATION NO :	
WEIGHT OF DENSITY WITH CONICAL BRSS CAP (W1)g	0.596
WEIGHT OF DENSITY BOTTLE WITH A CONICAL BRASS CAP AND OVEN DRY SOIL SAMPLE (W2)g	0.998
WEIGHT OF DENSITY BOTTLE WITH A CONICAL BRASS CAP, AND OVEN DRY SOIL SAMPLE AND DISTILLED WATER (W3)g	1.692
WEIGHT OF DENSITY BOTTLE WITH A CONICAL BRASS CAP AND DISTILED WATER (W4)g	1.486
SPECIFIC GRAVITY (G) AT ROOM TEMP	
AVG SPECIFIC GRAVITY (G) AT ROOM TEMP	
AVG SPECIFIC GRAVITY (G) AT ROOM TEMP	

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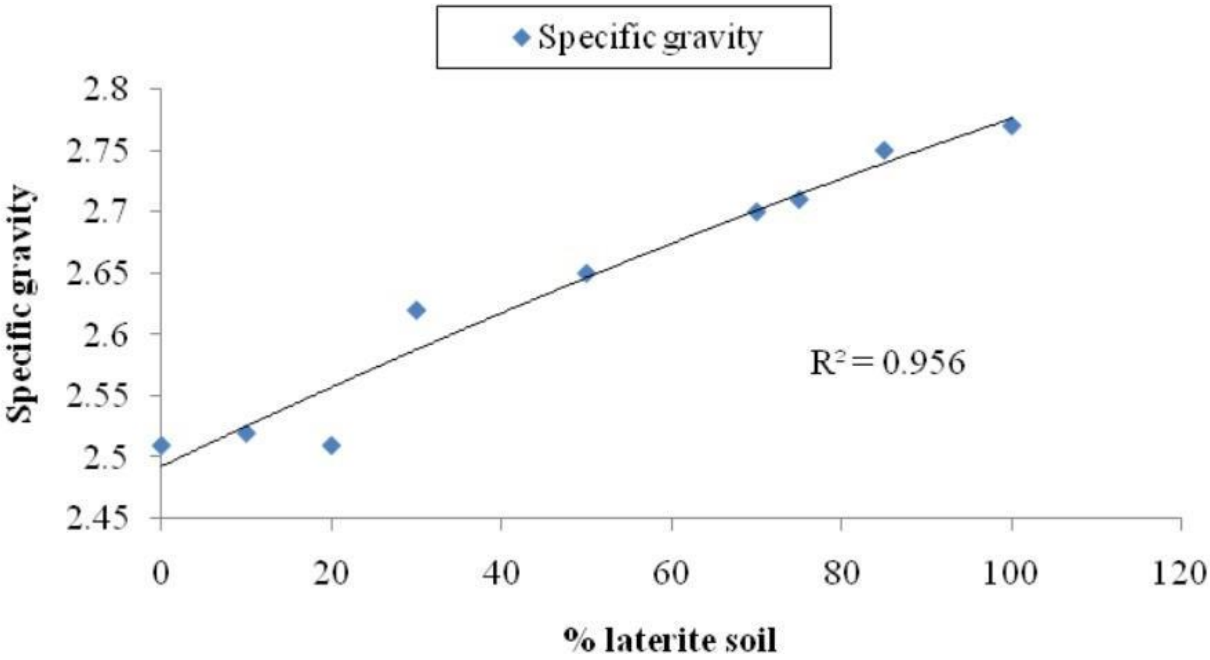
FIG:7.2.1

CALCULATIONS :

SPECIFIC GRAVITY (G) AT ROOM TEMP : W2-21/ (W2-W1) – (W3-W4)

= (0.998-0.596)/(0.998-0.596)-(169.2-1.486) SPECIFIC GRAVITY = 2.05



7.2 LIQUID LIMIT

LIQUID INDEX = 38.5

DETERMINATIONS	TRIA L : 01	TRIAL :02	TRIAL : 03
CONTAINER	30	29	28
NUMBER OF BLOWS,N	13	27	31
WEIGHT OF CONTAINER, WITH LID AND (MOIST SOIL) SAMPLE , (W1) g	26.83	27.61	23.59
OF EMPTY CONTAINER, WITH LID AND (MOIST SOIL) SAMPLE , (W2) g	35.88	40.31	37.80
WEIGHT OF CONTAINER, WITH LID AND (MOIST SOIL) SAMPLE , (W3) g	33.32	36.77	33.86
WEIGHT OF WATER (W2-W3) =WWG	2.56	3.54	3.94
WEIGHT OF DRY SOIL, WD = (W3-W1)g	6.49	9.19	10.27
WATER CONTENT, W= WW/WD*100%	39.44	38.64	38.36

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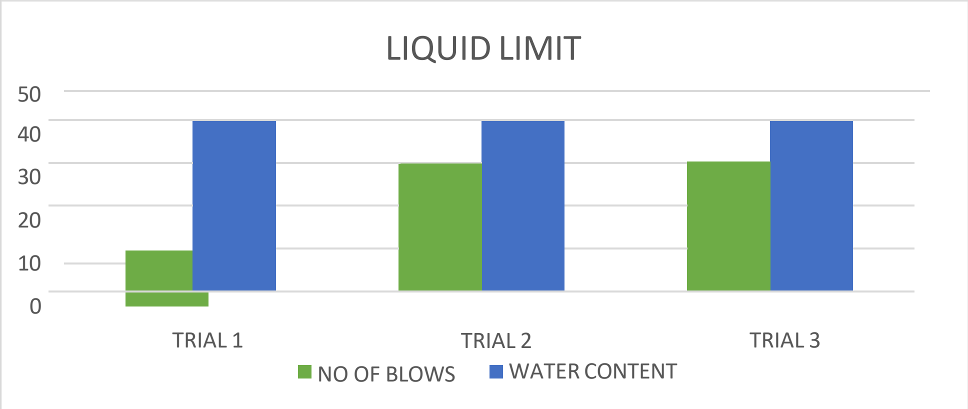
FIG:7.3.1

FLOW INDEX , IF = W1-W2/LOG10(N2/N1) 39.8-37.3/LOG10(100/10) = 2.5



1.CONTAINER NUMBER	1
2. WEIGHT OF THE CONTAINERS WITH LID (W1)g	8.04
3. WEIGHT OF THE CONTAINERS WITH LID AND MOIST SOIL SAMPLE (W2)g	10.83
4. WEIGHT OF THE CONTAINERS WITH LID AND DRY SOIL SAMPLE (W3)g	10.46
5. WEIGHT OF WATER WW = (W2-W3)g	0.37
6. WEIGHT OF DRY SOIL WD = (W3-W)g	2.42
7. MOISTURE CONTENT OF SOIL , W W=WW/WD*100=	15.29%
PLASTIC LIMIT WN, NATURAL MOISTURE CONTENT	15.29% 30%

FIG:7.3.2

7.3 SHRINKAGE LIMIT

CALCULATIONS

SHRINKAGE LIMIT WS=	(W-V-VD/WD)*100 = 43%
SHRINKAGE RATIO = WD/ V-VD	= 1.242
VOLUMETRIC SHRINKAGE VS= W-WS*SR	= 24.8%
LINEAR SHRINKAGE, LS =	100{1-(100/VS-100)}
SPECIFIC QUANTITY,	GS= 1/µW/µd -WS/100
	= 2.69

FIG:7.5.1

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7.4 Unconfined Compressive Strength Test

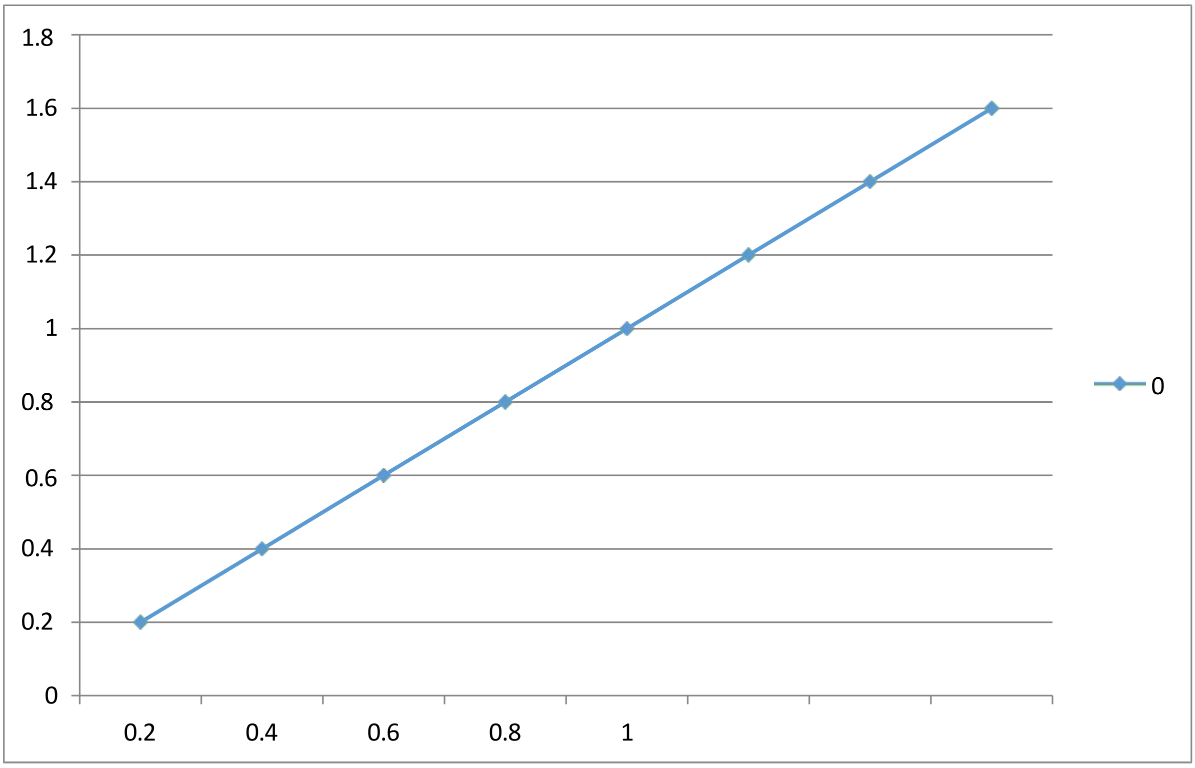
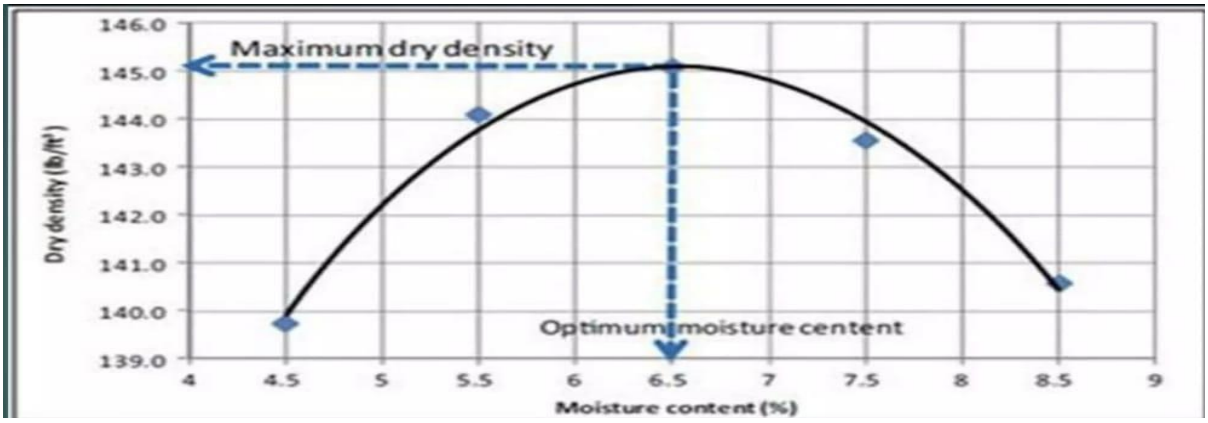


FIG:7.6.1

7.5. PROCTOR COMPACTION



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ISSN: 2278-0181
Vol. 15 Issue 01 , January - 2026

MANUFACTURING OF BRICKS

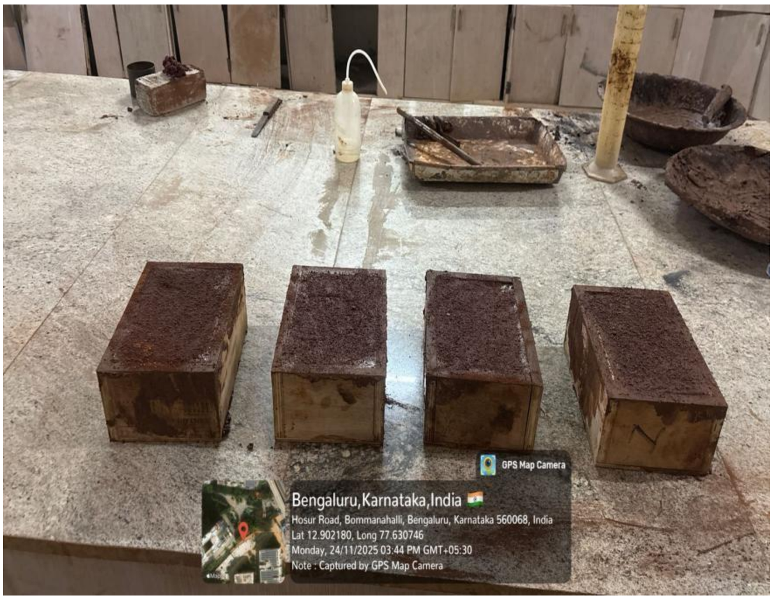
INTRODUCTIONS

Bricks are one of the oldest and most widely used construction [1]materials due to their durability, strength, and ease of production. With the increasing demand for sustainable and eco-friendly building materials, the use of industrial and agricultural waste in brick manufacturing has gained significant importance. Lateritic soil, which is abundantly available in tropical regions, provides a strong and stable base material for brick production. The incorporation of waste materials such as marble dust and fly ash not only improves the engineering properties of bricks but also helps in reducing environmental pollution caused by the disposal of these wastes.
Cement is used as a binding agent to enhance the strength and durability of the bricks.

The combination of lateritic soil, marble dust, fly ash, and cement results in an economical, lightweight, and eco-friendly brick that requires no kiln firing. This innovative brick-making approach contributes to sustainable construction practices, efficient waste utilization, and overall cost reduction in the building industry. This report discusses the manufacturing process, properties, and advantages of these composite bricks.

MIX PROPORTION

- Laterite Soil - 3360 gms - 70%
- Marble Dust - 720 gms - 15%
- Fly Ash - 336 gms - 7%
- Cement - 384 gms - 8%
- Water - 25 - 35%

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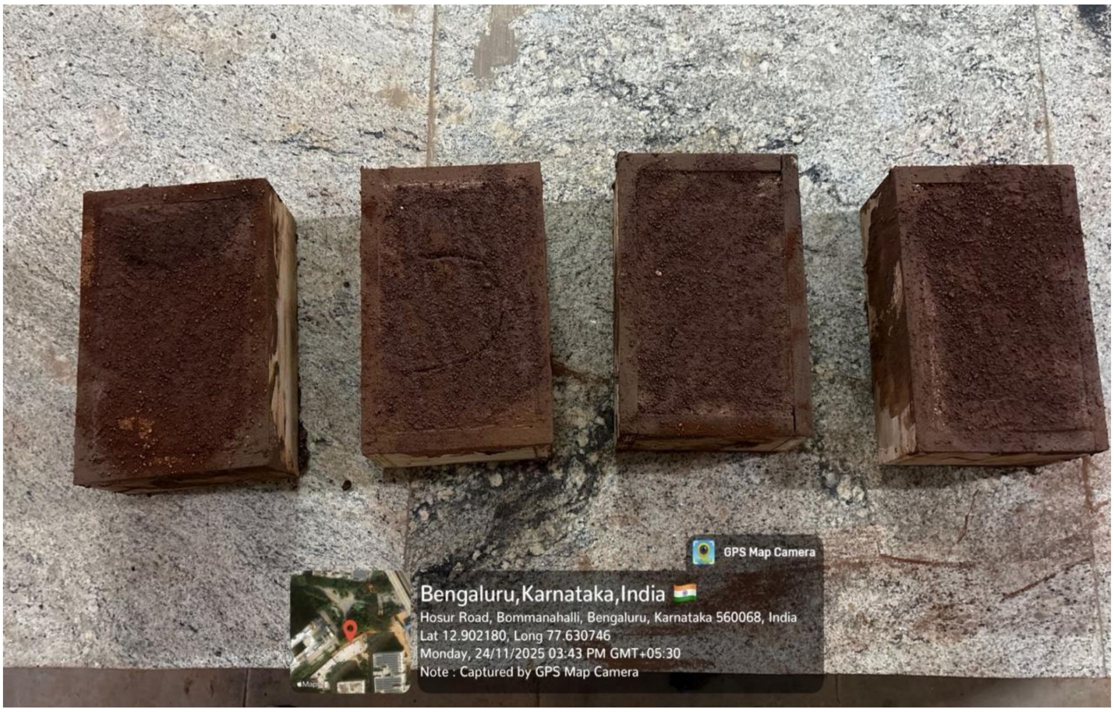
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International Journal of Engineering Research & Technology (IJERT)
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Application on bricks

1. Material Collection

Lateritic soil – main raw material providing body and strength.

Marble dust – acts as a filler, improves smoothness and reduces shrinkage.

Fly ash – increases workability, reduces weight, and improves durability.

Cement – acts as a binder to provide strength through hydration.

2. Material Proportioning (Typical Mix) Lateritic soil – 60–70%
Fly ash – 10–20% Marble dust – 10–15% Cement – 5–10%

3. Dry Mixing

All dry materials (soil, marble dust, fly ash, cement) are measured and mixed thoroughly**.** Mixing is done until the colour becomes uniform

4. Water Addition

Small quantity of water is added gradually.

The mixture should reach **optimum moisture content (OMC)** — slightly moist but not sticky.

Proper moisture helps in compaction and binding**.**

5. Moulding / Compaction

Two common methods:

a) Manual moulding

Mixture is placed in wooden moulds. Hand-pressed to achieve shape

6. Demoulding

Mould is removed carefully.

Fresh (green) bricks are placed for drying.

7. Curing

Since cement is used, curing is essential:

Bricks are kept **under shade** for 1–2 days.

After initial setting, they are **water cured for 7–14 days**. Curing helps develop required compressive strength.

8. Drying

After curing, bricks are air/sun-dried for 3–5 days.

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No burning is required (these are **unfired / eco-friendly bricks**).

9. Quality Testing Common tests: **Compressive strength Water absorption**

Advantages of These Bricks

- Eco-friendly—no kiln firing.
- Utilizes waste materials (fly ash & marble dust).
- Good strength and durability.
- Reduced cost.
- Smooth finish and improved workability.
- Reduced amount of binding material used for construction
- Provides better thermal insulation
- Increased crack resistance by reducing the permeability of the brick

REFERENCE:

- A REVIEW OF THE STABILIZATION OF LATERITIC SOILS WITH SOMEAGRICULTURAL WASTE PRODUCTS 1-2. Department of Civil Engineering, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, NIGERIA
- Stabilization of Laterite Soil using GKS Soil Stabilizer Aminaton Marto Professor of Faculty of Civil Engineering, University Technology Malaysia (UTM), 81310 Skudai, Johor Bahru, Mal

CONCLUSION

- On the basis of above analysis, and test results , we had achieved better results in the stability of laterite soil using marble dust and fly ash.
- The laterite soil we took is known as problematic soil because for its low strength , high compressibility, and high shrinkage characteristics.
- Thus , it is inappropriate for building foundation and for other heavy construction such as road construction ,bridge construction.
- By the use of marble dust and fly ash which is waste material dumped in the nature, by mixing it with laterite soil to face these problems by improving the strength and other engineering property of the soil .
- From marble dust and fly ash we get calcium and silica ,from which we get cementitious property which increased strength of the soil.
- These present the parameters which influence significantly the strength of the soil with marble dust and fly ash