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EXPERIMENTAL STUDY OF WASTE FOUNDRY SAND AND MARBLE DUST AS A SOIL STABILIZING MATERIAL

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ABSTRACT:-Marble dust and Foundry Sand are two of the most widely spread and easily available waste materials that are produced by the industries. Marble Dust is a dust that is generated in the process of cutting of marble stone while foundry sand is a waste product of the metal casting industry. In this research work the utilization of marble dust and foundry sand as a soil stabilizing material is tested. Stabilizing the soil is very important part of the construction process. This is because some of the soils do not have the proper strength to bear the load that is being put on them and thus many times lead to a complete collapse of the building. To avoid this situation stabilization is done so that bearing capacity of the soil is increased to withstand the designed load. Lime and cement are the two materials that were mostly used for soil stabilization since many years. But now a day, due to the depletion of the natural resources there is an increase in the utilization of the waste materials for the same. Some of the waste materials used are fly ash, marble dust, foundry sand, rice husk ash etc. These materials not only provide an alternative to the usage of conventional materials, but are also helpful in controlling the environmental pollution. At most of the places these waste materials are dumped into the open area which causes a lot of problem to the people around that area as well as to the workers working at these places. Utilizing these waste materials will not only reduce the pollution but will also reduce the human dependability on the natural resources, thus leading to a more sustainable approach of construction.

Keyword: **- Soil, Marble dust, Foundry ash, Maximum dry density, Optimum moisture content, California Bearing Ratio (CBR)**

I. INTRODUCTION

Soil is a major component of the earth's surface which sustains life. It is made up by the disintegration of rocks due to various environmental processes like changing weather, volcanic action, erosion of rocks by water etc. Some of the various types of soil that are found in our country are alluvial soil, laterite soil, peaty soil, black cotton soil or expansive soil etc. The type and availability of these soils are based upon the climatic and geographical location of a particular area. Apart from helping the plants grow, soil also helps the humans to carry out all the basic activities on it like travelling, construction, agriculture etc. A developing country like India demands rapid growth in its infrastructure i.e. a proper network of roads and buildings for development. All the civil structures, be it a simple house or a multi storey building, a road or a highway, everything is built on the soil. It is very important to check all the engineering properties of the soil like the bearing capacity, shear strength etc before starting any construction work on it because all the soils are not suitable for construction always. For example, the black cotton soil has a property of swelling and shrinking if there is an addition of moisture content, due to which it becomes unsuitable for construction. If the structures are constructed on such type of soils without taking proper measures then there is a possibility of the failure of the structure gradually. At some places the bearing capacity of the soil is not enough i.e. it cannot bear the load of the structure build on it that leads to the failure. Thus proper modification and testing of soil is required before starting any construction on it. In past when the soil of a particular region was found unsuitable for construction then that site was either abandoned or the soil was replaced with another soil of better properties. But these techniques proved to be very costly and unfeasible as the time passed. Thus a new technique of improving the soil properties was developed called as soil stabilization. Soil stabilization is a general term for any physical, chemical, biological, or combined method of changing a natural soil to meet an engineering purpose [1].Usually compaction is done to stabilize the soil. Apart from compaction, draining out of the excess water also helps in increasing the stability of the soil. Adding various materials in the soil also helps in stabilizing it. Lime and cement have been the main sources of soil stabilization since many years. But gradually, utilization of cement for stabilization is decreased because of its increasing cost and the pollution caused in the environment due to CO_2 emitted during its production. Utilization of lime is also not much suitable because lot of CO_2 is emitted during its production too. These facts necessitated the need for utilizing the waste products from various industries so that they can be used as an alternative to the conventional resources. Some of the waste products used for the stabilization of soil are fly ash, marble dust, foundry sand, rice husk ash etc. The fly ash generation in 2011 in India was about 112 million tons per year which increased to about 170 million tons in 2012 and about 225 million tons by 2017 [2]. While fly ash is a waste product generated from the coal based thermal power plants, marble dust and foundry sand are the waste products from the marble stone and the metal casting industries respectively. Various studies have proved that utilization of these waste materials

as a soil stabilizing agent have not only improved the soil properties but also helped in reducing the cost of the project gradually. There are three main methods of stabilization i.e. mechanical stabilization, chemical stabilization and stabilization with the help of geosynthetics. These three methods are as followings.

A.Mechanical Stabilization

Mechanical solutions involve physically changing in the property of the soil somehow, in order to affect its gradation, solidity, and other characteristics. Dynamic compaction and vibro compaction are the two techniques used for mechanical stabilization. In vibro compaction the soil is compacted with the help of vibrations while dynamic compaction uses a heavy weight for the same. This is one of the oldest methods of stabilizing the soil.

B. Chemical Stabilization

Chemical solutions are the techniques that rely on adding an additional material to the soil that will physically interact with it and change its properties. Lime and cement are the most common materials that are being used for stabilizing the soil. But with the advent of new materials and excess of industrial waste available, lime and cement are now used less. Some of the industrial wastes that are used are fly ash, kiln dust, marble dust, foundry sand etc.

C. Geosynthetic Stabilization

Geogrids are used in geosynthetic stabilization, to reinforce the road sections. Geogrid with reduced aggregate thickness option is designed for urban area and provides a stable working platform corresponding to 97% of CBR [4].

II. NEED OF SOIL STABILIZATION

Soil properties vary from place to place depending upon the climatic and geographical conditions of that area. They are not suitable for construction always and need to be modified so that they do not cause any damage to the structure built on them. The main need of stabilizing the soil is to improve the bearing capacity so that they are able to withstand the load applied on them.

1).If during the construction phase weak soil strata are encountered, the usual practice followed is replacing the weak soil with some other good quality soil. With the application of soil stabilization technique, the properties of the locally available soil (soil available at the site) can be enhanced and can be used effectively as the subgrade material without replacing it.

2).The cost of preparing the subgrade by replacing the weak soil with a good quality soil is higher than that of preparing the subgrade by stabilizing the locally available soil using different stabilization techniques.

3).The strength giving parameters of the soil can be effectively increased to be quire amount by stabilization.

4).It improves the strength of the soil, thus, increasing the soil bearing capacity.

5).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.

6).It is also used to provide more stability to the soil in slopes or other such places.

7).Sometimes soil stabilization is also used to prevent soil erosion or formation of dust, which is very useful especially in dry and arid weather.

8).Stabilization is also done for soil water-proofing; this prevents water from entering in to the soil and hence helps the soil from losing its strength.

9).It helps in reducing the soil volume change due to change in temperature or moisture content.

III. MATERIAL USED

Following are the materials which are used for stabilization of Clay soil:

a) FOUNDRY SAND: - Foundry sand is a waste product that is obtained from the ferrous and non-ferrous metal casting industry. The metal foundries utilize large amount of sand for its casting processes. The sand is used again and again for

the casting process and after a certain multiple usage it becomes a waste which cannot be used in the casting process anymore. This wastes and is termed as waste foundry sand or used foundry sand which contains high amount of silica in it. Apart from silica, foundry sand also has residue of burnt carbon and bentonite in it. Emission of foundry sand in the atmosphere is responsible for causing a lot of air pollution in the surrounding areas. Due to industrialization and development of foundries the surrounding agricultural activities of the surrounding area has been decreased. According to the recent reports, foundry market in India to expected grow at a compound annual growth rate of 10.08% during the period 2016-2020. With such a huge growth also comes the problem of waste disposal. Using this waste sand in the production of concrete as well as for soil stabilization is a more sustainable approach for development. The chemical composition of foundry sand is shown in the table below:-

Table 1: CHEMICAL COMPOSITION OF FOUNDARY SAND

Sr. No.	Characteristics	Value (%)
1	SiO_2	87.91
2	Al_2O_3	4.70
3	Fe_2O_3	0.94
4	CaO	0.14
5	MgO	0.30
6	SO_3	0.09
7	Na_2O	0.19
8.	K_2O	0.25
9.	TiO_2	0.15
10.	MnO_3	0.02
11.	Specific Gravity	2.42

b) MARBLE DUST:- Marble Dust is a waste product of the marble stone industry. This dust is produced in the process of cutting of marble stone. Marble stone is a type of metamorphic rock that is produced as a result of transformation occurred in the lime stone. In India, marble processing industry generates around 7 million tons of wastes mainly in the form of powder during sawing and polishing processes [5]. Out the total waste generated, the state of Rajasthan alone contributes around 6 million tons of marble dust annually i.e. about 95% of the total marble dust production. This poses a huge threat to the environment and the people because most of this dust is dumped in to the open area which causes a major environmental concern. Although there are proper areas dedicated to the dumping of this waste, but marble dust being a very fine powder is capable of flowing away with the wind. Thus the marble dust spreads along the outer areas also and gradually settles on the plants and animals of the surrounding areas. The spreading of marble dust in the surrounding areas certainly creates necrotic ecological conditions for flora and fauna thereby changing the landscapes and habitats gradually. Thus it becomes very important to utilize this huge amount of waste in a proper manner. To combat the effect of this waste material to the surrounding area, it is used in various processes such as in the production of concrete as well as in the process of soil stabilization. Utilizing marble dust in the process of stabilizing the soil is increasing day by day due to the low cost of this material as well as for its ease of availability. The chemical properties of marble dust are shown in the table below:-

Table-2 chemical composition of marble dust

Sr. No.	OXIDE COMPOUNDS MASS	Value (%)
1	SiO_2	28.35
2	Al_2O_3	0.42
3	Fe_2O_3	9.70
4	CaO	40.45
5	MgO	16.25
6.	Density (g/cc)	2.80

IV. OBJECTIVE OF THE STUDY

The main objective of this study is to stabilize the soil by using foundry sand and marble dust and present a brief comparison among these two materials for the optimum of performance.

Scope of the Study

1) There are many waste products in India which are not utilized for any purpose. They are still getting disposed as waste without knowing that they can be used for many researches so that the method will be eco friendly and may not harm any environmental conditions. Therefore, this research is made to use waste materials for the major problem that is instability of soil.

2) Stabilization of soil is done by the one of major waste product found in India marble dust and foundry sand. Using these materials as soil stabilizing material is very beneficial as they do not harm any environmental conditions and lower the cost of construction as well.

3) Both the materials when mixed with virgin soil, makes it more strengthen and gives more durability. As a result of this study, soil will become stable and can be able to take more load of sub structure for long time period. Foundation of structure will have strength to handle the load of sub structure above it.

4) The materials used in this investigation are able to make soil stable in very small content. They all are easily available in the local markets or industries at very cheap rates or free of cost. Therefore, it is very beneficial to use these materials for soil stabilization process.

V. LITERATURE REVIEW

1) Yadu &Tripathi (2013) had studied the effects of granulated blast furnace slag in the engineering behaviour of stabilized soft soil. The performance of GSB stabilized soil was evaluated using physical and strength performance tests. Based on strength performance tests the optimum GBS was determined as 9% among 3, 6, 9 and 12%. Inclusion of GBS increases the strength of soil as well as the soaked and un soaked CBR values.

2)Amrendra Kumar, Dr. Ravi Kumar and Babita Singh (2014), Studied the compaction and subgrade characteristics of clayey soil by mixing it with foundry sand, fly ash and tile waste. These materials were taken in a ratio of 10% to 50% with an increment of10%. Results showed an increase in the value of the CBR value from 2.43% to 7.35% when all the three materials were added into the soil. Thus they concluded that clayey soil mixed with foundry sand, fly ash and tile waste can be effectively used in the construction of sub-grades of roads with low traffic volume.

3) Jadhav & Kulkarni (2014) carried out the Feasibility Study of Improving Properties of Black Cotton Soil Using Industrial Wastes. The studies revealed that stabilization using industrial wastes from 0 to 60% saves the natural materials. The Pavement thickness for stabilized road is reduced by 280mm and cost saving is 21.91% with respect to flexible pavement of 1km road length. It is economical to construction as well as maintenance of road.

4) Parte Shyam Singh and R K Yadav (2014) carried out experiments to study the effect of marble dust on the index properties of black cotton soil. Marble dust was taken in the ratio of 0% to 40% by the dry weight of the soil. Results concluded that the plasticity index of the black soil decreased gradually from 28.35% to 16.67%, while the shrinkage limit increased from 8.06% to 18.34% at 40% addition of marble dust. Apart from this the expansiveness of the soil reduced from being very high to low on addition of marble powder, thus making the soil suitable for construction.

5) Sachin N. Bhavsar, Hiral B. Joshi, ET. al. (2014) had studied the impact of marble powder on engineering properties of black cotton soil. The experiment involved determining the swelling potential of expansive soil in its natural state as well as when mixed with different proportion of marble dust from 30 to 50%. The test results showed a positive impact of marble powder on the black soil. The optimum moisture content of the soil decreased from 18.08% up to 12.2% while the maximum dry density increased from 1.71 g/cc up to 1.95 g/cc on addition of 40% marble powder.

6) Brajesh Mishra (2014) based on this study and experimental investigation It was observed that with the addition of foundry sand in and y clayey soil the Maximum Dry Density (MDD) and California Bearing Ratio (CBR) Values of the soil foundry sand mixture initially increased up to a certain value but on further addition of foundry sand in sandy clayey soil the values of Maximum Dry Density (MDD) and California Bearing Ratio (CBR) showed a decreasing trend. Hence it can be concluded that there exists a optimum percentage of foundry sand which was responsible for increased strength of soil.

7) M. Adams Joe and A. Maria Rajesh (2015) had studied from the study, it is observed that there is an appreciable improvement in the optimum moisture content and maximum dry density for the soil treated with industrial waste. In terms of material cost, the use of less costly Admixtures can reduce the required amount of industrial waste. Soils had the greatest improvement with all soils becoming non-plastic with the addition of sufficient amounts of industrial waste. The study after conducting several experiments revealed the following significances in using lime and industrial waste as a stabilizing agent

- **California Bearing Ratio Test** The CBR test is carried out on the parent soil sample in unsoaked and soaked soil conditions. Further Marble Dust and Foundry Sand are added in proportion of 13%, 16%, 19% and 22% in the parent soil sample, to test the CBR Value. The CBR values are studied at penetration of 2.5 mm and 5 mm respectively. The CBR Value at penetration of 2.5 mm is 14.16% for virgin soil in unsoaked condition.

Table 3:-CBR values at 2.5mm penetration for soil sample on addition of various percentages of Marble Dust (Unsoaked condition):-

Sr.No.	% of marble dust	CBR value in %
1.	13	11.51
2.	16	14.16
3.	19	12.04
4.	22	10.11

Table 4:-CBR Value at 2.5mm penetration for soil sample on addition of various percentages of Foundry Sand (Unsoaked condition):-

Sr.No.	% of foundry sand	CBR value in %
1.	13	12.48
2.	16	15.3
3.	19	16.85
4.	22	19.21

CHART-1 CBR value at 2.5mm penetration on addition of marble dust in parent soil

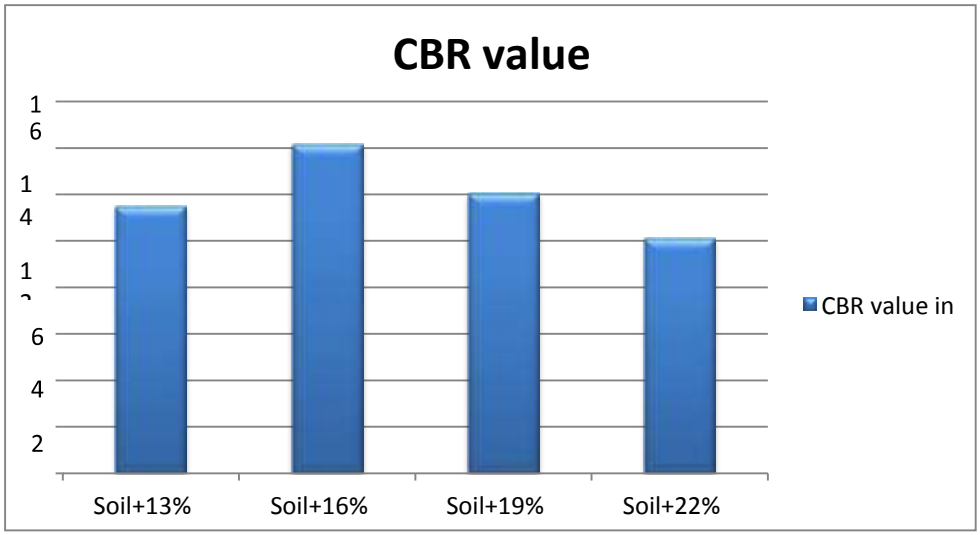
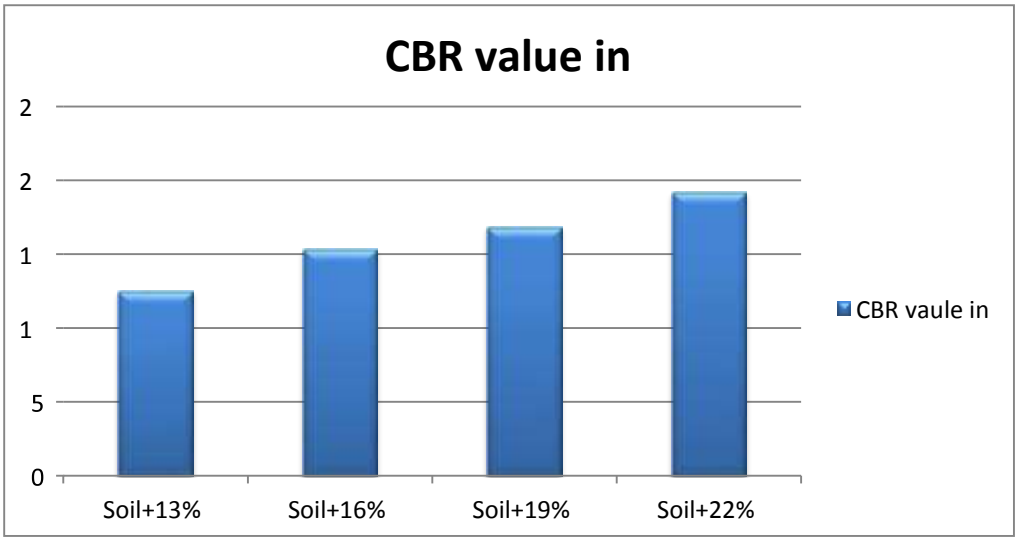


CHART 2:- CBR value at 2.5mm penetration on addition of foundry sand in parent soil



VI. CONCLUSIONS

Based on the laboratory tests conducted for this study the following conclusions are given below.

1. Stabilization of soil was carried out in the experimental work using the two widely produced industrial wastes i.e. marble dust and foundry sand.
2. Marble dust and foundry sand are the two most widely produced wastes from the industries, but their utilization in a productive way has not been studied on a larger scale yet.
3. Stabilization of soil has become a necessity now days due to excessive construction on the soil surface.
4. The natural bearing capacity of some soil is suitable for carrying out the construction activities, while for some it is very less and thus stabilization is required.
5. Stabilization is required to be carried out even when the construction of very tall buildings or heavy structures like dams and bridges is to be executed.

6. From the above experimental results it was very evident that foundry sand was a better stabilizing material for the soil when compared to marble dust.

7. The maximum CBR value achieved was 14.16% on addition of 16% of marble dust in the parent soil, whereas the maximum CBR value achieved on addition of foundry sand was 19.21% at 22% addition.

8. The CBR value decreased after addition of 16% marble dust in soil, whereas there was a continuous increase in the CBR value on addition of foundry sand.

9. There was a continuous increase in the optimum moisture content value of the parent soil on addition of marble dust and foundry sand.

10. The maximum value for optimum moisture content obtained was 18.56% at 16% addition of marble dust. While there was a decrease in the optimum moisture content on further addition of foundry sand after 16%.

11. The maximum dry density value of 1.81 g/cc was achieved at 16% addition of marble dust and decreased thereafter.

12. The maximum dry density value of 1.99 g/cc was achieved at 19% addition of foundry sand.

13. Thus all the above test results concluded that foundry sand was a better stabilizing material when compared to marble dust.

14. Foundry sand was a sand with high silica content in it and hence was able to interlock with soil particles in a better way, thus increasing the soil bearing capacity.

VII. SCOPE FOR FUTURE WORK

1. Stabilization of soil using marble dust and foundry sand helps in improving the soil properties.

2. The practical application of this experiment work needs to be studied further so that the actual soil behavior can be known.

3. There is a gradual increase in the CBR value of soil on addition of foundry sand, even at 22% addition the CBR value keeps on increasing, thus the maximum percentage for addition of foundry sand can be studied further.

4. The above materials can be used in future in construction field and are very economic too.

5. It will also help in the reduction of industrial waste in society and create fewer problems for waste management in the cities.

6. Apart from utilizing these materials in soil, they can be added in concrete too.

7. Utilizing of waste materials in a better way will help to reduce the pollution caused in the environment due to their disposal.

8. The conventional materials like cement, sand, limes etc are declining continuously and will become scare in the near future.

9. These waste materials when utilized properly will help in eliminating the need for the conventional materials there by promoting sustainable development.

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