Expansive Soil Modification by the Application of waste materials

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Abstract : In this present study was to assess the effect of waste industrial materials i.e. marble dust and fly ash to enhance the index and engineering properties of expansive soil. The physical and chemical properties of soil were improved by the addition of such materials. The obtained result has been carried out for the properties like index properties, Compaction characteristic, and Strength characteristic. Expansive soil covers about one-fifth of the total area of India, particularly in the states of Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Rajasthan, Andhra Pradesh, Telangana, and Tamil-Nadu. Expansive Soils Contain clay minerals that captivate and absorb water. As conclusion, these soils expand when they get wet and shrink when they dry. The Volume changes the experience by expansive Soils can cause serious damage to concrete foundations and floor slabs. Fly-ash is a byproduct dumped out of thermal power plants that use coal as one kind of fuel. Current annual production of fly ash, a byproduct from coal-based thermal power plants (TPPs), is about 112 million tones (MT). Marble dust is generated during the cutting process of marble. India is estimated to have 3,172 thousand tons of marble dust was produced in a year. The marble dust and fly ash in Expansive soil is 10%, 20% and 30% by weight and comparison of the properties of expansive soil with the subgrade stabilized the soil. This study is to explore the favorable reuse of industrial materials i.e. marble dust and fly ash in soil stabilization. The main objective of this research work is, presenting the impact of waste industrial materials such as marble dust, fly ash on the subgrade attributes of Expansive soil. The laboratory investigation is concluded to assess the effect of waste industrial materials addition on the engineering properties and shrink-swell behavior of stabilized expansive soils. Atterberg limits, OMC and MDD, California Bearing Ratio (CBR), swelling pressure tests were performed on natural and proposed soil samples. Measure the results obtained of the natural and treated samples, the CBR increases by 250% (when 30% marble dust and fly ash are added) and the swelling reduction of 58% is found, depending on additive content. The results conclusion shows that the modification of expansive soils by fly ash and marble dust admixture is successful and more economical.

IndexTerms - Marble Dust, Fly Ash, Soil Stabilization, CBR values, OMC&MDD and Index properties.

I. INTRODUCTION

The treatments of soil are generally classified into two processes, soil modification and soil stabilization. The goal of subgrade modification is to increase the strength of the subgrade soil. This enhanced strength of soil is taken in action while road pavement design process. The Stabilization is necessary for a detailed design methodology during construction. The approach of subgrade modification and stabilization include physical operation such as soil compaction, replacement and chemical process such as mixing with marble dust, fly ash, lime, lime byproducts, and combined of any one of these materials. Soil properties like as strength, compressibility, bearing strength, workability, swelling pressure and volume change tendencies may be improve by various soil modification or stabilization methods.

Recycling of industrial waste is beneficial for environmental and economic. In economic term, it is cheap and in environmental term, it decreases pollution. One of the industrial waste is marble dust, which is minimum sized marble waste that occurs with sawing of marble blocks and plates. Fly ash has been used in stabilization, unpaved roads and highway base structures as an admixture material.

Sachin Dev and Er Neeraj Sharma (2017) implement a study on the use of marble dust and Alccofine for soil stabilization. According to their research study improve the bearing capacity of soil and reduce the swelling pressure. (1)

Amandeep Verma (2017) performed a study on "Strength Improvement of Clayey Soil by using Fly ash and Marble dust" according to this study marble dust is added in range of 5–20 % in corporation with fly ash 10-30%. It was create that addition of 20% fly ash in soil shows maximum strength value raise 114.42% Unconfined compression strength. Assist the addition of fly ash has negative effects on these properties. Triaxial test is accomplish to evaluate shear strength parameters of miscellaneous soil i.e. soil, fly ash and marble dust. It was found that cohesion character ('C') decrease and angle of internal friction (φ) increase by addition of marble dust in soil and optimized fly ash.(5)

Chayan Gupta, Dr. Ravi Kumar Sharma performed a study on "Influence of Marble Dust, Fly Ash and Beas Sand on Sub Grade Characteristics of Expansive Soil" The aim of research is, showing that the influence of waste materials such as marble dust, fly ash on the sub grade characteristics of black cotton soil. The series of test conducted in laboratory on fly ash, sand stabilized black cotton soil which further blended with 0-20 % marble dust and concluded that the 15% marble dust is sufficient to increases the California bearing ratio soaked value up to 200% approximately.(3)

The main objective of this study was investigate the beneficial reuse of marble dust and fly ash in soil stabilization. To achieve this objective, a series of tests were conducted on expansive soil mixture with added marble dust and fly ash.

a) Soil stabilization: Soil Stabilization is the alteration of one or more Soil properties, by mechanical or chemical mean, to create an improvement soil material possessing the desired engineering properties. Soil helps to stabilized increase strength and durability or to prevent erosion and dust generation. The main purpose of Soil stabilization is to improve the stability and bearing power of soil which controlled by compaction, proportioning and addition of suitable admixture or stabilizers.

b) Mechanical Stabilization: It involve control compaction by increasing the amount of compaction of the mix, strength and durability increase.

c) Chemical Stabilization: It involve the addition of suitable admixture or stabilizers such as lime, fly ash, Portland cement, lime-kiln dust, cement-kiln dust, bitumen etc.

II. MATERIALS

a) Expansive Soil: A number of major problem can be diagnosed in expansive soil volume changes {swelling and shrinkage} which can lead to pavement distortion such as leaving-waving and rutting reduce the bearing capacity and shear strength under saturation condition which lead to loss of support under pavement resulting in the severe damage in its structural severe erosion in the exposed cuts or open unsupported fills which leads to slope or edge collapse of highway and decrease of workability which lead to difficulty in compaction and reduces the density.
I take the expansive soil sample form SATI, vidisha M.P. Following are the various geotechnical properties of the procured soil are as follows:

The Engineering properties of the Expansive soil

SI. No	Properties	Code referred	Value
1	Natural Moisture Content	IS 2720 (Part 2) - 1973	9.35 %
2	Specific Gravity	IS 2720 (Part 3/Sec 1) - 1980	2.87
3	Liquid Limit	IS 2720 (Part 5) - 1985	68.29 %
4	Plastic Limit	IS 2720 (Part 5) - 1985	39.79 %
5	Plasticity Index	IS 2720 (Part 5) - 1985	28.5 %
6	Optimum Moisture Content (OMC)	IS 2720 (Part 7) - 1980	18.30 %
7	Maximum Dry Density (MDD)	IS 2720 (Part 7) - 1980	1.74 gm./cc
8	California Bearing Ratio (CBR)	IS 2720 (Part 16)- 1987	3.1
9	Swelling pressure	IS 2720 (PART 41) 1977	8.76 kg/cm^2

b) Fly Ash: A huge amount of electricity generation in our country is from the coal-based thermal power plant which provide fly ash as a by-product. Our government bodies is taking action for its safe management and disposal under FLYASH MISSION. The status of fly ash generation and its utilization in India which indicate 54.53 % utilization.
Fly ash has been used successfully in many projects to improve the strength of soils. Fly ash can be used to stabilize for base or subgrade, to stabilize backfill to reduce lateral earth pressure and to stabilize embankment to improve slope stability. Typically stabilized soil depth up to 15 to 46 centimeter (6 to 18 inche). The primary reason to use fly ash in soil stabilization and its application to improve the compressive and shearing strength of soil. I had taken the fly ash sample form Satpura Thermal Power Station, Sarni, M.P.
The various geotechnical properties of the procured soil are as follows:

SI. No	Properties	
1	Type of Fly Ash	F type
2	Specific Gravity	2.25
3	Plastic Limit	Non plastic
4	Optimum Moisture Content (OMC)	24.68 %
5	Maximum Dry Density (MDD)	1.42 gm./cc
6	California Bearing Ratio (CBR)	5.2

c) Marble dust: A huge amount of marble powder is generated during the cutting process which result in the mass of marble waste which is 20% of total marble quarried has reached as high as millions of tons. The large quantity of unattended mass of marble waste consisting of huge fine particles is today one of the environmental problem around the world. I had taken the marble dust powder sample form Mahiveer Marble Shop, Arihant Bihar Colony, vidisha M.P.

III. METHODOLOGY

Sample proportions

S.NO	MIX PROPORTION
1	SOIL
2	SOIL+10% FLY ASH
3	SOIL+20% FLY ASH
4	SOIL+30% FLY ASH
5	SOIL+10% FLY ASH + 10% MARBLE DUST
6	SOIL+20% FLY ASH + 20% MARBLE DUST
7	SOIL+30% FLY ASH + 30% MARBLE DUST

a) Test conducted

I. Specific Gravity
The Specific Gravity was determined as per IS: 2720 (Part III/Sec I) 1980.

II. Liquid limit test & Plastic limit test
The liquid limit was determined as per IS: 2720 part-V, 1985.

III. Compaction test
The compaction test was performed as per IS 2720 part-VI 1974

IV. California Bearing Ratio
The California Bearing Ratio was performed as per IS 2720 (Part XVI) 1979.

V. Swelling Pressure
The Swelling pressure test was performed as per IS: 2720 (Part-41) 1977

b) Effect of fly ash on soil properties

i. Having fine size of particle, fly ash application improves soil texture of coarse textured soils and also expand soil porosity and water holding capacity, obtainable water capacity, water infiltration rate and overall drainage.

ii. The application of fly ash reduce the bulk density, permeability, hydraulic conductivity and modulus of rupture but did not harmfully affect the soil aggregation.

iii. The addition of fly ash to the soil of bad buffering capacity expand soil pH due to the appearance of basic metal oxides and alters the availability of some nutrients.

iv. Fly-ash application to sandy soil could permanently alter soil texture, enlarge micro porosity and upgrade the water-holding capacity.

c) Effect of marble dust on soil properties

The marble dust is fine dust made up of tiny spheres of silicon and alumina glass and also consists of small percentage of Cao. The free lime in the dust reacts with water and form $Ca(OH)_2$ which is cementatious material and hence it gives more strength to the soil. Also, due to mechanical stabilization that is the fine dust particle combination with the coarse particles of the soils, there is increase in strength (1).

IV. RESULTS AND DISCUSSION

The Specific Gravity of the Fly ash is found to be 2.87 and that of soil is 2.25. It is helpful in determining the parameters such as void ratio, density etc.

Liquid Limit Test Results of Expansive soil With Marble dust and Fly ash

Table: Different percentages of Fly ash and marble dust with soil

SI No	Soil Characteristics	Liquid Limit	Plastic Limit
1	Soil + 10% of fly ash + 10% Marble Dust	**47.72**	**17.33**
2	Soil + 10% of fly ash + 10% Marble Dust	**41.61**	**12.26**
3	Soil + 10% of fly ash + 10% Marble Dust	**21.63**	**9.39**

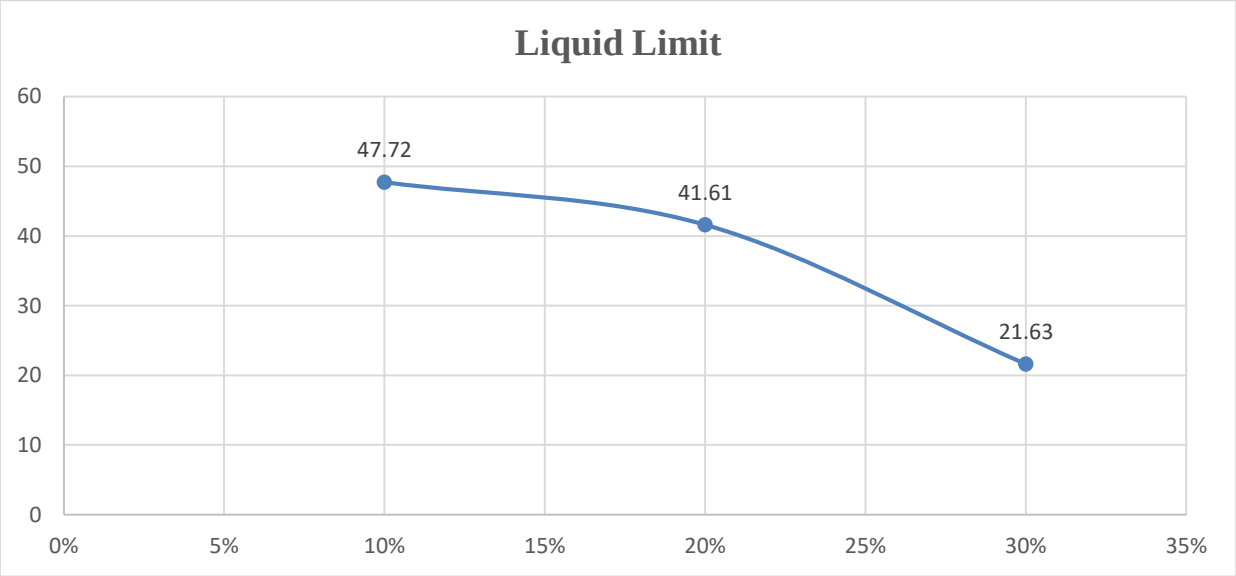
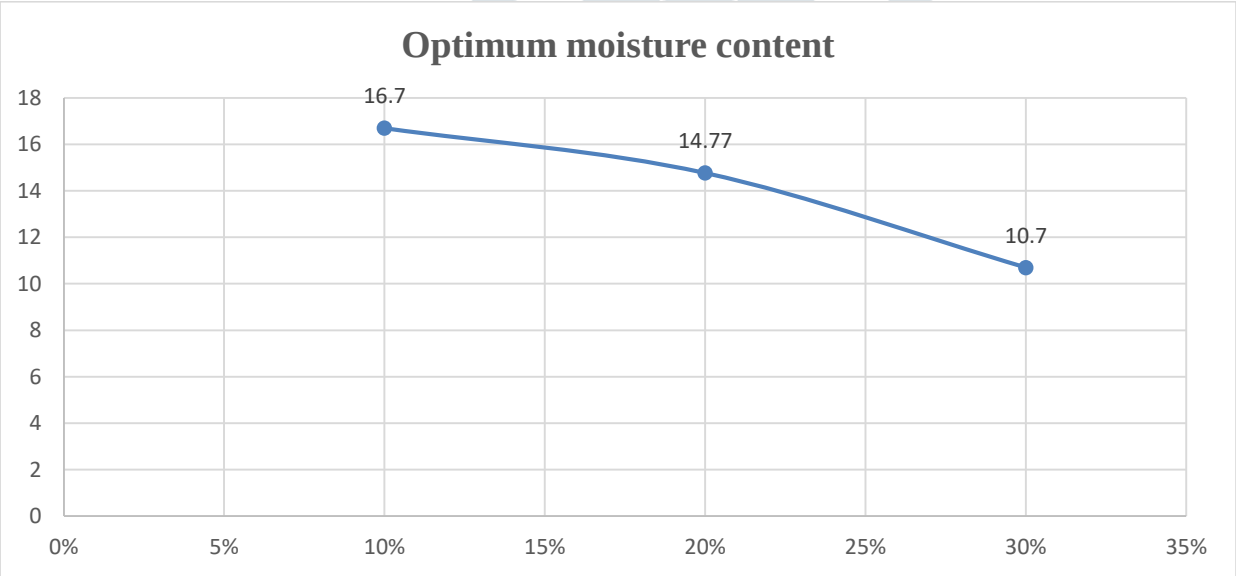


Fig 1 Variations of Liquid Limit value with equal percentages of Fly ash and marble dust

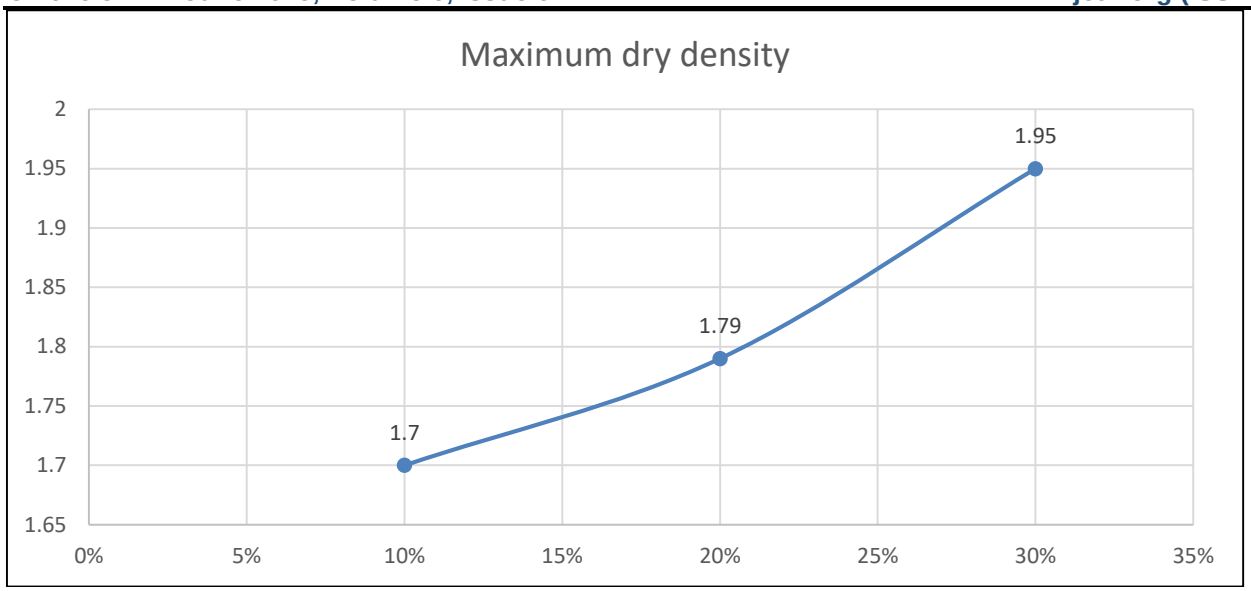
Proctor compaction characteristics

Compaction of soil is the process of densification for reducing air voids. The degree of compaction is measured by dry density. Optimum Moisture Content was gradually decreasing with the addition of Stone Dust and Fly ash because lime present in stone dust reacts with moisture. Also maximum Dry Density begins to increase with the addition of stone dust and fly ash (6).

At different percentages of marble dust and fly ash to the soil, the optimum moisture content and maximum dry density was obtained by proctor compaction test as per IS 2720.



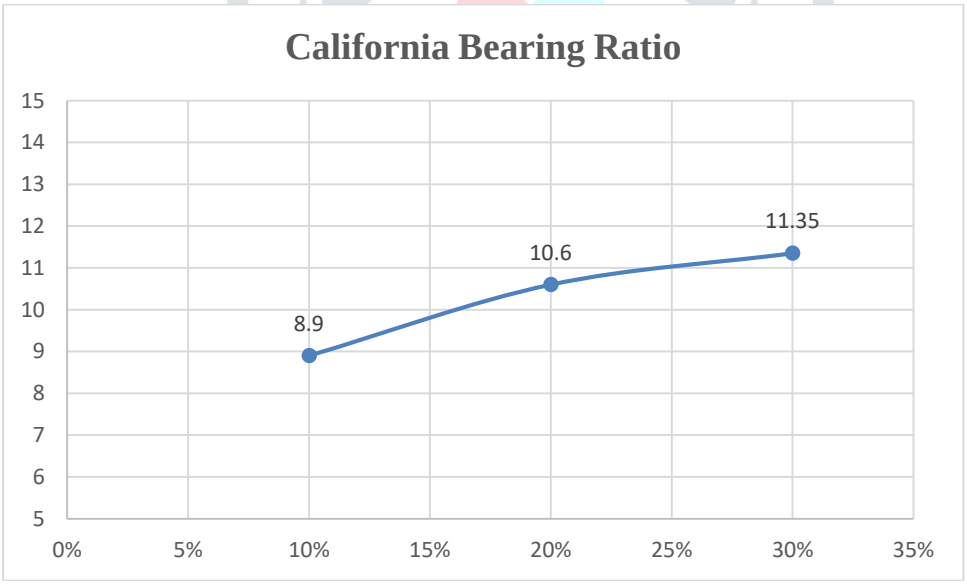
Variation of MDD value with different percentage of fly ash and marble dust



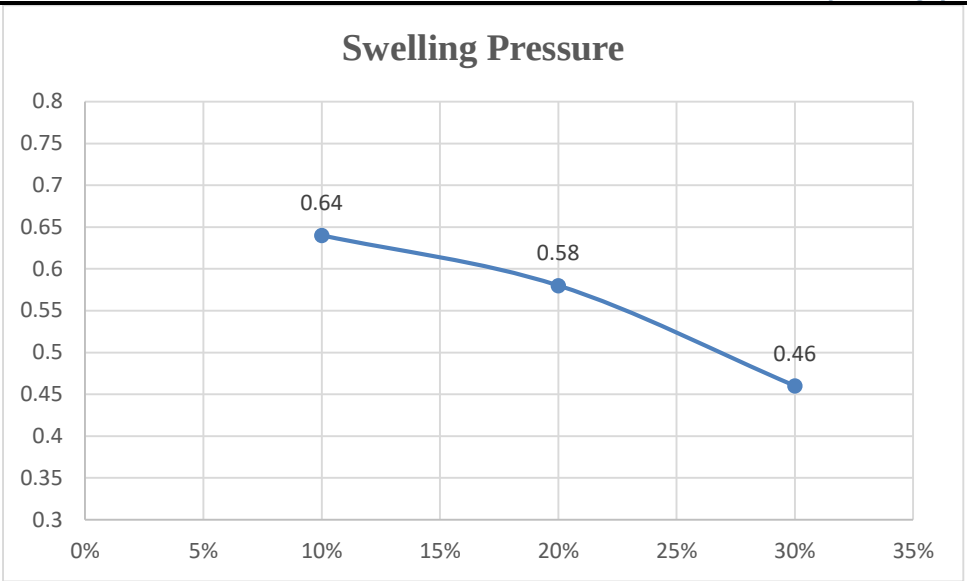
Variation of MDD value with different percentage of fly ash and marble dust

From the data analysis I observed that Optimum moisture content is decrease with the addition of fly ash and marble dust and maximum dry density value is increase.

CALIFORNIA BEARING RATIO TEST: CBR test is load penetration test. It is used to determine the California Bearing Ratio value of soil. CBR test carried out for evaluating the suitability of sub grade. The soil is mixed with different percentage of marble dust and fly ash and then compacted in mould and then load is applied and reading is taken at penetration of 2.5, 5, 7.5, 10, and 12.5mm respectively.
With the addition of marble dust and fly ash with different percentage in soil, it observed that the value of CBR is increase which is beneficial for road construction.



SWELLING PRESSURE TEST: The swelling pressure value is increase with the addition of fly ash and marble dust in Expansive soil, which increase the strength of Expansive soil.



V. CONCLUSION:

This study is carried out to keep in mind the best possible utilization of the fly ash and marble powder in soil stabilization by replacing the soil with fly ash and marble powder in the proportion of 10%, 20% and 30%. The study shows that inclusion of fly ash and marble powder makes it a good alternative for the soil stabilization.

On the basis of research work conducted, following conclusions are come out: -

- Liquid limit of the stabilized soil is decreased from 68.29% for expansive soil to 47.72%, 41.61% and 21.63% with partial replacement of soil with fly ash and marble powder as 10%, 20% and 30% respectively.
- Plastic limit of the stabilized soil is decreased from 35.33% for expansive soil to 17.33%, 12.26% and 9.39% with partial replacement of soil with fly ash and marble powder as 10%, 20% and 30% respectively.
- Plasticity index of the stabilized soil is decreased from 32.96% for expansive soil to 30.39%, 29.35% and 12.24% with partial replacement of soil with fly ash and marble powder as 10%, 20% and 30% respectively.
- OMC of the stabilized soil is decreased from 18.30 % for expansive soil to 16.70%, 14.77%, and 10.70% with partial replacement of soil with fly ash and marble powder as 10%, 20% and 30% respectively.
- MDD of the stabilized soil is increased from 1.74gm/cc for expansive soil to 1.70gm/cc, 1.79gm/cc, and 1.95gm/cc with partial replacement of soil with fly ash and marble powder as 10%, 20% and 30% respectively.
- CBR of the stabilized soil is increased from 3.1 for expansive soil to 8.9, 10.6 and 11.35 with partial replacement of soil with fly ash and marble powder as 10%, 20% and 30% respectively.
- From the above study it is clear that the fly ash and marble powder is being used as a soil stabilizer.

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