International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 02 | Feb 2020 www.irjet.net p-ISSN: 2395-0072

EXPERIMENTAL STUDY ON REPLACEMENT OF FINE AGGREGATE AS BLACK COTTON SOIL IN MINERAL CONCRETE

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Abstract - *This paper focus on replacement of fine aggregate as black cotton soil in mineral concrete. Black cotton soil is one of the major soil deposits of India. They exhibit high swelling on shrinkage when expose to changes in moisture content hence have been found to be most troublesome from engineering consideration. As the project has in mineral concrete, the mineral that has been used is white dolomite (powder form).Alternative name of dolomitic rock is known as dolostone. Dolomite is a Calcium Magnesium Carbonate ($CaMg(co_3)_2$). The black soil is blend with white dolomite. Stabilization occurs due to presence of lime in dolomite. Black cotton soil (Bcs) with cement can increase the sub grade bearing capacity and strength significantly. Over a past few decades, there have been a wide range of alternatives available in field of construction, especially with reference to manufacture of concrete. Further, there are some inventions like fly ash concrete, bacterial concrete etc. There are also researches using black cotton soil as a raw material in the manufacturing of concrete along with mineral to alter the additional stabilizer in the concrete as partial replacement of sand in Indian context. These soil contained abundant iron and fairly high quantities lime ,magnesia and alumina. The term is also used for a sedimentary carbonate rock composed mostly of mineral dolomite. 20mm size of coarse aggregate, grade 53 cement and high performance concrete of grade M50 is used. In present work attempt has been made to evaluate effect of dolomite powder in Black cotton soil for improvement property by performing various laboratory test by varying the proportions. 3%,6%,9% of dolomite powder is added to the concrete at various stages. This technique is cheap and cost effective.*

Key Words: *Black cotton soil, white dolomite powder, High strength concrete.*

1. INTRODUCTION

Black soil have wide development southern part of Tamilnadu, western part of Madhya pradesh, part of Gujarat and in some parts of Chennai. Black cotton soil absorbs water heavily, swell, become soft and strength this soils are easily compressible when wet and possessives in tendency to heave during wet condition. Black cotton soil shrink in volume and develop crack during summer they are characterized by extreme hardness and cracks when dry. This properties make them poor foundation soils and earth construction materials. The stability and performance of the pavement are generally influenced by the subgrade and embankment as they serve as foundation for pavement for developing a good and durable networking black cotton soil area the nature of soil shall be properly understood. On such soils suitable construction practices and sofisticated method of design need to be adopted.

2. LITERATURE REVIEW

There are number of studies on minerals to improve the performance of the weak soils. Nadgouda K.A.Hedge, R.A (2010) presented the effect of lime stabilizations on properties of black cotton soil. They concluded that the effect of lime to swelling soil is to reduce the potential upon contact with water. Ali and koranne (2011) presented the effects of stone dust and flyash characteristics of black cotton soil. They concluded that there is a marked improvement in properties of expansive soil if stone dust and fly ash is mixed in equal proportions. There is a significant control in swelling behaviour in expansive clay. Kumar and prasanna (2012) studied the effects of silica and calcium extracted from rice husk ash on geo technical properties of expansive soil. They concluded that the characteristics of such soils are improved remarkably. Similarly many researches Kumar sabat (2012) Quian Guoping et al (2011), Osman svrikaya (2013) have investigated the use of industrial waste like stone dust, fly ash, granite mill tailings, marble dust, other stone waste to improve the properties of weak/ expansive soils. They concluded that these industrial waste can increase the strength and decrease swelling behaviour of expansive soil if used individually or as an admixture to such soils. Shailendra singh, Hemant B.Vasaikar (2013) presented the stabilization of black cotton soil using lime. They concluded that the properties of black cotton soil get effectively modified varying proportions of lime.

3. MATERIALS

A. black cotton soil

The black cotton soil was accumulated in semi-dry state from the site. To make it suit to accept as a civil engineering material, improve compressive strength and

bearing capacity, it requires some additives such as white dolomite powder to stabilized to get desired geotechnical properties.

I. Chemical Composition of Raw Black Cotton Soils.

S.no	Constituents	Percentage
1	SiO_2	51%
2	Al_2O_3	4%
3	$CaCO_3$	7.5%
4	Montmorillonite mineral	37%
5	Organic content	0.5%
6	pH Value	7.2

B. White Dolomite Powder

White dolomite powder is one of the carbonate mineral composed of calcium magnesium carbonate. It is white in colour and is mainly used as filler in soaps, detergents, pain and ceramics. This powder is well known in market for easy dispersion, high purity and accurate composition. Its chiefly utilized as refractory, ramming, and fetting in steel melting shop. Provided powder is used in agriculture to reduce soil acidity and also to adjust magnesium deficiency. Dolomite is the prime content of dolostone which is a sedimentary rock. Solid white dolomite powder has the distinctive luster that resembles to the brightness of the pearl or vitreous material.

II. Chemical composition of white dolomite powder

S.no	Constituents	Percentage
1	$CaCO_3$	71.67%
2	$MgCO_3$	17.89%
3	SiO_2	10.43%

4. Methodology

In this experiment, Fine aggregate is replaced by black cotton soil in mineral concrete. White dolomite powder in used as a mineral in concrete. In fine aggregate, 5%, 10%, 15%, of black cotton soil is replaced and 3%, 6%, 12% white dolomite powder is mixed and the concrete is made. Concrete is made into various mould such as cube, cylinder, prism. Test conducted in concrete are Compression test, Split tensile, flexural strength. Test where carried at 7, 28 days. Superplasticizer (SNF) of 20ml is added to the concrete.

5. Experimental Investigations

The purpose of the experimental work is to find out effects of dolomite powder on various engineering properties of the black cotton soil. In this experimental work, soil mixed with the different proportions of white dolomite powder. Various mixes where prepared and tested for liquid limit, plastic limit, plasticity index, swelling pressure and swelling index.

5.1 Mix Proportions

Soil is mixed with 3%, 6%, 9%, 13% of white dolomite powder by dry unit weight of the soil.

S.no	% of the soil	% of white dolomite powder
1	5%	3%
2	10%	6%
3	15%	9%

5.2 Testing program of black cotton soil

Black cotton soil is used for the determination of basic properties of soil such as wet and dry sieve analysis, atterbergs and standard proctor test, differential free swell test, swelling pressure test and California bearing ratio test. The test were performed on samples of white dolomite powder content varying from 3% and 6% and then compared to the result obtained from the soil with addition of white dolomite.

Sieve analysis

Dry and wet sieve analysis of the soil is performed in accordance with IS 2720 part Ⅳ-1985 and were classified in accordance with IS 1498-1970.

Atterbergs limit

The Atterbergs limit of the soil were determined in accordance with IS 2720 (part Ⅴ) – 1985.The Atterbergs limits gave the liquid limit and plastic limit of the soil, from which the plasticity index were determined. The liquid limit of untreated soil was determined as 60.5%, where it was varied between 55% - 57.5% after the white dolomite powder is added. The liquid limit of the soil is decreases with increase in lime content.

Standard proctor test

To assess the amount of compaction and the water content required in the field, compaction test(standard proctor test) was done on the soil in accordance with IS 2720 (part Ⅶ) - 1980.The water content at which the maximum dry density is attained is obtained from relationships provided by test. The dry density become constant with increase in lime content. The optimum moisture content ranges between 25%-35% .

Differential free swell test

Differential free swell test was carried out to determine free swelling index of the soil (in accordance with IS 2720 (part XL) - 1977) from which the degree of expansiveness of soil was determined as per IS2720 (part XL) - 1977. The differential free swell decrease gradually with increase in white dolomite powder. The variation in differential free swell was observed between 25-30%.

Swelling pressure

Swelling pressure is defined as the pressure which the expansive soil exerts, if the soil is not allowed to swell or the volume change of the soil is arrested. This test was carried out in accordance with IS 2720 (part XLI)-1977. The swelling pressure of the untreated soil was calculated as 2kg/cm^2. With the addition of 3% of lime, the swelling pressure of the soil is 0.5kg/cm^2. Swelling pressure of the soil decreases with increase in lime content.

California bearing ratio

The CBR value of the soil is an index which is related to the strength of the soil. The test was conducted in accordance with IS2720(part16)-1987.The CBR value of the soil decreases with increases in white dolomite powder upto 3% after which it goes on increasing.

6. Testing program of concrete

Concrete is made by the mixture of cement, fine aggregate and partial replacement of black cotton soil and dolomite powder (mineral). Due to high strength concrete 10ml of superplasticizer is added to the concrete.

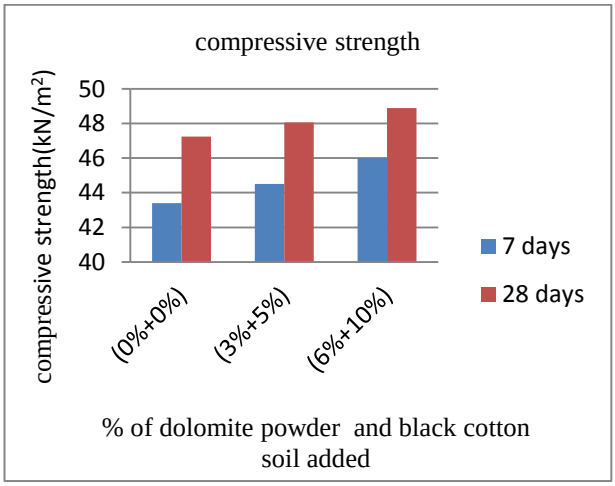
6.1 Compressive strength

Compressive strength is the ability of materials or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size, while in tension, size elongates. For these test concrete is poured into the mould of size 15cm□15cm□15cm. After 24hours mould are removed and the concrete is placed for curing. The specimen are tested by compression testing machine 7days of curing and 28days of curing. Load should be applied gradually at the rate of 140kg/cm^2 per minute till the specimen get fails. The test were carried to confirming to IS 516 – 1959.

FORMULA:

Compressive strength = load / Cross-sectional area.

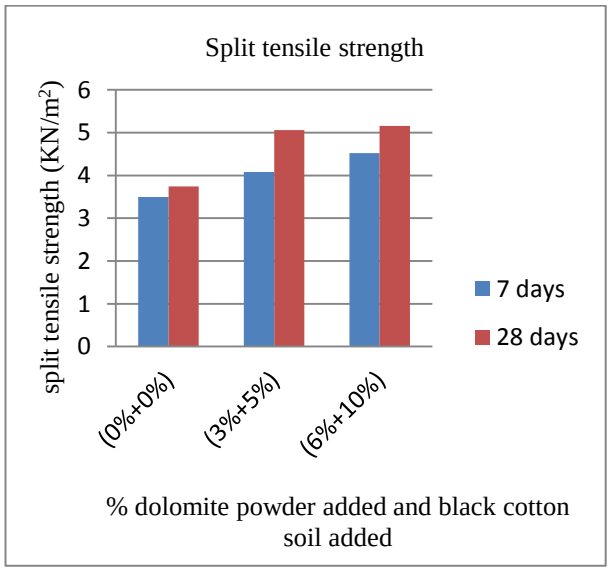
%of dolomite powder	% of black cotton soil	7 days	28 days
0%	0%	43.2	47.25
3%	5%	44.5	48.06
6%	10%	46	48.45



6.2 split tensile test

Split tensile strength was found according to the IS:5816–1999 and the same three cylindrical specimens were casted and tested after 7days and 28days of water curing. The cylindrical specimens were of diameter 150mm and of height 300mm. Crack pattern after testing of a particular cylinder specimen.

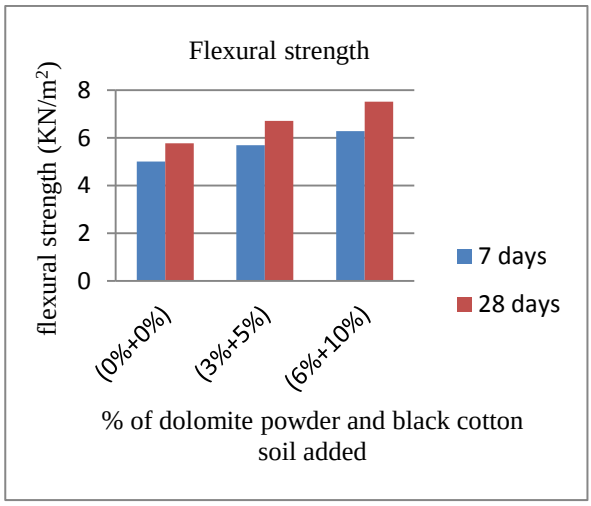
% of dolomite powder	% of black cotton soil	7 days	28 days
0%	0%	3.5	3.7
3%	5%	4.08	5.06
6%	10%	4.52	5.16



6.3 Flexural strength

Flexural strength was found according to IS : 516 – 1959 and for the same three beam specimen were casted and tested after 7 days and 28 days of water curing. The rectangular specimen were of dimensions of 500mm200mm100mm.

% of dolomite powder	% of black cotton soil	7 days	28 days
0%	0%	5.01	5.79
3%	5%	5.69	6.72
6%	10%	6.29	7.52



7. CONCLUSIONS

- Concrete made with partial replacement of conventional fine aggregate with 5% of black cotton soil had 48MPa of compressive strength with 3% of dolomite powder.
- Concrete made with partial replacement of conventional fine aggregate of conventional fine aggregate with 10% of black cotton soil had 49MPa with 6% of dolomite powder.
- It also found that 3% of dolomite powder decreases the liquid limit of 55%, while 6% of dolomite powder decreases the liquid limit of 57.5%.
- The liquid limit of the soil decreases when lime content increases.
- The dry density of concrete remains constant with increase in dolomite powder (lime content). The optimum moisture content ranges between 25% - 30%.
- The differential free swell decreases with increase in lime dolomite powder (lime content). The differential free swell varies between 25% - 30%.
- Swelling pressure of soil decreases with increase in dolomite powder (lime content). Addition of 3% of dolomite powder, the swelling pressure of soil is 0.5kg/cm².

- The CBR value of soil decreases with increases in white dolomite powder. And it goes on increases with increase in dolomite powder.

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- IS2720 (part16) -1987 for determination of CBR value of the soil.