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Improvement in Engineering Properties of Expansive Soil using Fly ash and Brick Waste

Gaurav Jain¹, Dr. Sanjay Tiwari²

¹P.G. Student, ²Professor, Department of Civil Engineering, MITS Gwalior, Madhya Pradesh, India

Abstract: *Expansive soil contain the highly active clay mineral in the form of montmorillonite due to which expensive soil swell upto 7% upon adding 1% of water, which may lead to unequal settlement of subsoil. This research represent a complete framework to overcome this drawback of expansive soil by adding fly ash and brick waste to expansive soil in order to improve its engineering properties.*

Fly ash can be easily obtained from coal combustion plants while brick waste is easily available on demolition sites. In this research fly ash is added in different percentages 0%, 4%, 8%, 12%, 16% and brick waste is added 5%, 10%, 15%, 20%, 25% by weight of soil.

The results of test show that the addition of fly ash and brick waste reduces the liquid limit, plasticity index, optimum moisture content, % free swell index, plasticity index and increases unconfined compressive strength with increasing California bearing ratio.

Keywords: *Expansive soil, Engineering properties, fly ash (FA), brick waste (BW), California Bearing Ratio (CBR).*

I. INTRODUCTION

Black cotton soil is a form of expansive soil which contain montmorillonite which is highly active. The present study of characterization and stabilization of black cotton soil with fly ash & brick waste uses soil available near Dabra (m.p.) In India, soils are classified into different groups mainly alluvial soil, marine soil, laterite soil, expansive soil, sand dunes and boulder deposits. On an average 3 lakh sq km area covered by the black cotton soil. Which is about 20% of total land area. Black cotton soil is available in Gujrat, Maharashtra, Madhya Pradesh, North Karnataka, Andhra Pradesh and Tamilnadu. Black Cotton soil has a high percentage of clay, which is mainly montmorillonite in structure and black in colour.

Due to which it has high swelling and shrinkage property. The expansive soil has been challenge to geotechnical and highway engineers. It is very hard in dry condition, but loses its strength in wet condition. The drying and wetting process causes differential settlement or vertical movement of soil mass which leads to failure of a pavement, in the form of settlement, cracking and unevenness.

The use of By-product wastes to improve the engineering properties of the soil has been going on for many years. In recent years the efforts have been made to use waste products such as fly ash, brick waste, blast furnace slag etc. Fly ash and brick waste is the oldest and well known material to be used as a stabilizing material for black cotton soil.

Fly ash improves the geotechnical properties of soil and brick waste increases the strength properties. In the present study, an attempt has been made to combine both materials to improve geotechnical properties as well as to increase the strength of expansive soil.

II. MATERIAL AND PROPERTIES

In this study, Fly Ash & Brick Waste is used for stabilizing and considering its effects on the Expansive soil.

A. Expansive Soil

The soil for this research was collected from Dabra, Gwalior (M.P.). Black cotton soil are soil which expands directly propositional to moisture content due to presence of montmorillonite, can also be known as expansive soil. It is produce by chemical decomposition of basalt and trap.

In this type of soil swelling and shrinkage is often occurred. In some part of the soil excepting rest formed active and passive zone. This is highly unacceptable for roads. The properties of soil are given in table: 1-

Table1. Properties of Black Cotton Soil

Sr.No.	Particulars	Test Results
1.	Grain Size Distribution	
	Sand (%)	0%
	Silt (%)	9%
	Clay (%)	91%
2.	Liquid Limit (%)	56.28%
3.	Plastic Limit (%)	28%
4.	Plasticity Index (%)	28.28%
5.	Specific Gravity	2.28
6.	Optimum Moisture Content (%)	17%
7.	Maximum Dry Density (gm/cm ³)	1.61 gm/cm ³
8.	Differential Free Swell (%)	45%
9.	California Bearing Ratio (CBR) (%)	0.801%
10.	Unconfined compressive Strength (UCS) (kn/m ²)	66 kn/m ²

B. Fly Ash

Fly ash generates in combustion process of coal and it is composed of particulates (particle of burned fuels). It is also known as fuel ash. It can be used as a soil stabilization and soil solidification material. Because of its pozzolanic properties, it can be used as Portland cement partner in concrete and soil solidification. Properties of fly ash is given in table: 2.

Table: 2. Properties of Fly Ash

Sr.No.	CHEMICAL COMPOSITION	PERCENTAGE
1.	SiO ₂	60.20%
2.	Al ₂ O ₃	18.45%
3.	Fe ₂ O ₃	16.34%
4.	SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃	94.99%
5.	Mgo	1.32%
6.	Cao	2.00%
7.	So ₃	1.50%
8.	Na ₂ O	1.50%
9.	Soluble Salts	0.58%
10.	Loss of Ignition	1.07%

C. Brick Waste

Brick waste one of the construction waste produce by demolition and remodelling of construction project. It's cost is negligible in ahead of soil and it has better engineering properties then black cotton soil. So, it can be used as supplement material to improve engineering properties of black cotton soil as shown in this research.

III. TESTING METHODOLOGY

Laboratory tests were carried out on black cotton soil mixed with Fly Ash at various percentages i.e. 4%, 8%, 12%, 16% by weight of dry soil. The following tests were conducted on black cotton soil with silica fume as per relevant IS Code. The conducted tests are :-

- 1) Specific gravity (IS 2720 Part III)
- 2) Grain size distribution (IS 2720 Part IV)
- 3) Liquid limit (IS 2720 Part V)
- 4) Plastic limit (IS 2720 Part V)
- 5) Plasticity index (IS 2720 Part V)
- 6) Standard proctor test (IS 2720 Part VIII)
- 7) Differential free swell (DFS) (IS 2720 Part XI)
- 8) California bearing ratio (C.B.R.) test (IS 2720 Part XVI)
- 9) Unconfined compressive strength (UCS) test (IS 2720 Part X-1991)

IV. RESULTS AND DECLARATION

In this research, work experiments are performed to determine the mechanical and physical properties of soil. According to Indian Standard Classification System (ISCS), the sample soil is classified as highly compressible clay (CH). Firstly fly ash was mixed with black cotton soil in different proportion as shown in table: 3, which result that, the proportion of soil + 8% fly ash was found best soil-fly ash proportion on the basis of tests performed. Then, this proportion (soil + 8% fly ash) was mixed with brick waste in different-different proportion to found best combination of soil, fly ash and brick waste. Results show that soil + 8% fly ash+ 10% brick waste is best proportion.

Table: 3. Properties of Soil and Fly Ash

Sr.No.	Particulars of Test	Soil	Soil + 4% (FA)	Soil + 8% (FA)	Soil + 12% (FA)	Soil + 16% (FA)
1.	Soil Classification	CH				
2.	Liquid Limit (%)	56.28	52.67	49.52	50.88	52.45
3.	Plastic Limit (%)	28	27	25.5	26.5	27.5
4.	Plasticity Index (%)	28.28	25.67	24.02	24.38	24.95
5.	Specific Gravity	2.69	2.67	2.65	2.63	2.61
6.	Optimum Moisture Content (%)	17	16.5	16	17.5	18.25
7.	Maximum Dry Density (gm/cm ³)	1.61	1.63	1.66	1.62	1.59
8.	Differential Free Swell (%)	45	28	19	21	23

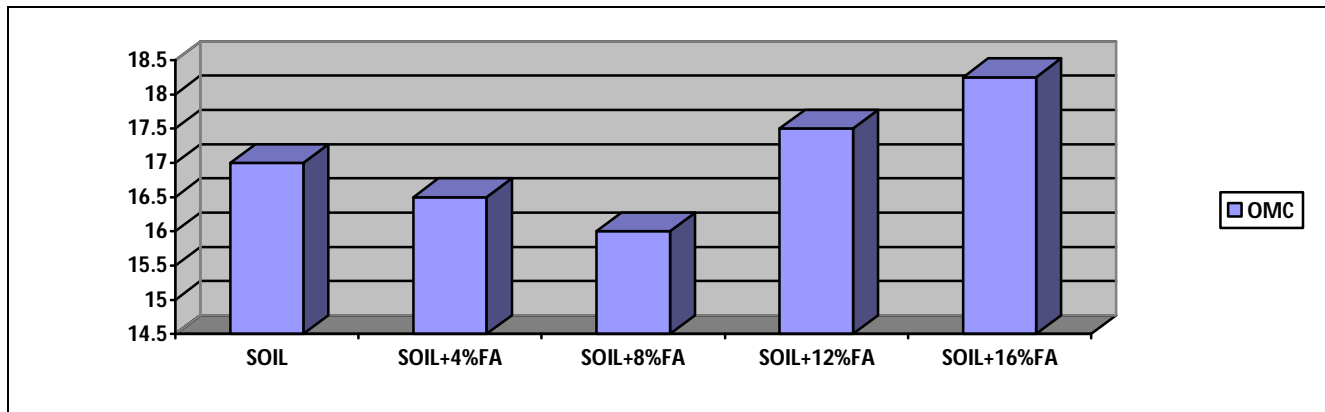


Figure 1 Chart showing the variation in OMC for mix proportion of soil and Fly Ash

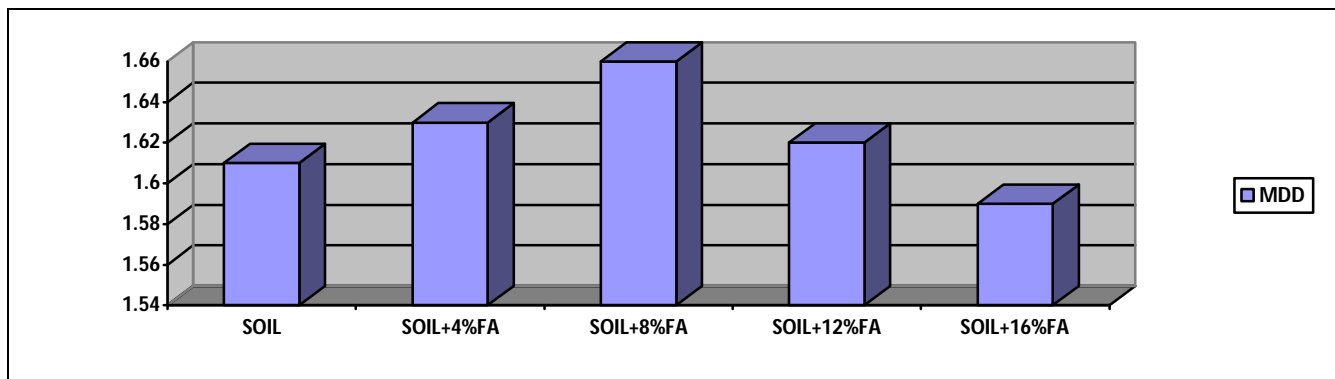


Figure 2 Chart showing the variation in MDD for mix proportion of soil and Fly Ash

CBR Value for mix proportions of soil, 8%Fly Ash (FA) and Brick Waste (BW)

Table: 4. CBR % at 2.5 and 5.0 mm penetration

Sr.No.	CBR SAMPLE	CBR % at 2.5 mm penetration	CBR % at 5.0 mm penetration
1.	Soil	0.81	0.67
2.	Soil + 8%FA + 5%BW	1.67	1.31
3.	Soil + 8%FA + 10%BW	1.75	1.42
4.	Soil + 8%FA + 15%BW	2.07	1.76
5.	Soil + 8%FA + 20%BW	3.01	2.54
6.	Soil + 8%FA + 25%BW	3.41	2.94

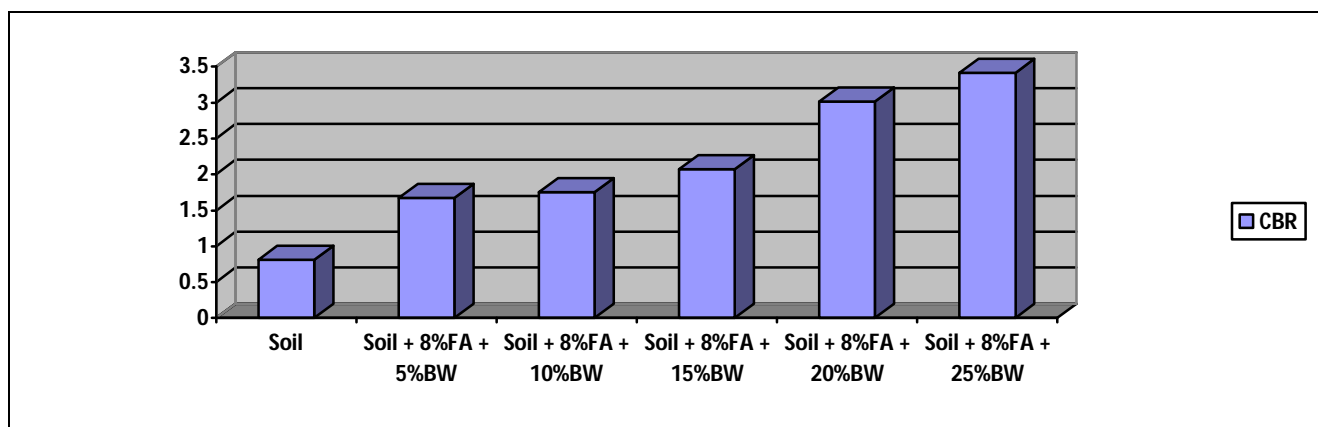


Figure 3 Chart showing the variation in CBR for mix proportion of soil, 8%Fly Ash & Brick Waste

Liquid Limit for mix proportions of soil, 8%Fly Ash (FA) and Brick Waste (BW) are shown in table: 5.

Table: 5. Liquid Limit Samples and Results

Sr.No.	LIQUID LIMIT SAMPLE	TEST RESULT (%)
1.	Soil	56.28
2.	Soil + 8%FA + 5%BW	51.48
3.	Soil + 8%FA + 10%BW	43.43
4.	Soil + 8%FA + 15%BW	45.65
5.	Soil + 8%FA + 20%BW	47.85
6.	Soil + 8%FA + 25%BW	49.90

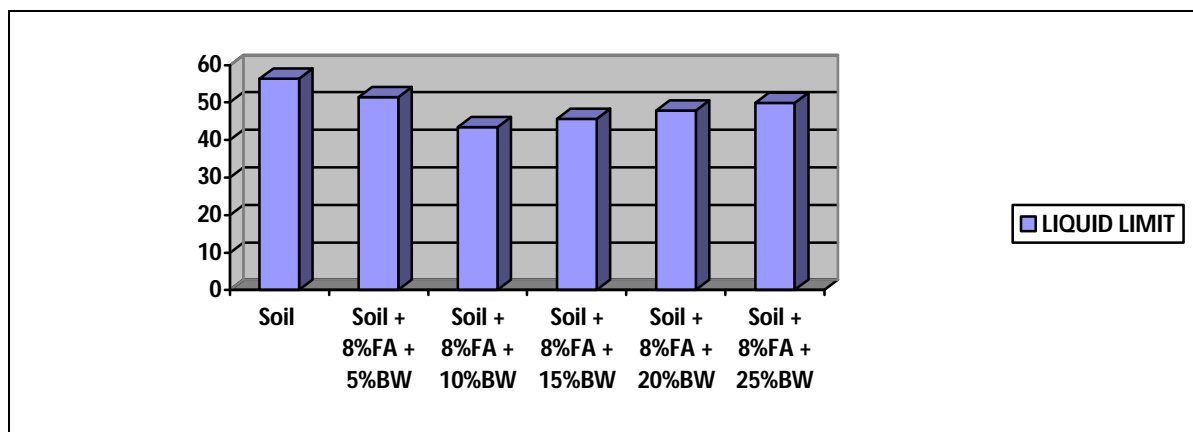


Figure 4 Chart showing the variation in LIQUID LIMIT for mix proportion of soil, 8%Fly Ash & Brick Waste

V. CONCLUSION

From the carried out study, following significant observation have been made. The effect of addition of fly ash and brick waste to soil

- A. According to above results the combination of 8% fly ash reduce the liquid limit and plasticity index of black cotton soil..
- B. OMC decreased from 17% to 16% at 8% replacement of fly ash with soil. A slight increase is noted in maximum dry density and high amount of decrement in DFS is observed.
- C. According to above result the 8% fly ash is found the best combination for mixed it with brick waste.
- D. Liquid limit decreased from 56.28% to 43.43% at combination of 8% replacement of fly ash and 10% replacement of brick waste with soil.
- E. CBR value is increased from 0.81 to 1.75 at combination of 8% replacement of fly ash and 10% replacement of brick waste with soil.
- F. It has been observed that the optimum requirement for stabilization for different proportion are different, but the optimum content is soil +8% fly ash +10% brick waste. Depending on the requirement of particular project, suitable proportion of fly ash and brick waste can be chosen to improve the characteristic of black cotton soil.

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