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Study on Engineering Properties of Expansive Soil with Pond Ash and Coir Fibre

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Abstract
Construction of foundation for structures on black cotton soil (BC soil) is highly risky on geotechnical grounds because such soil is susceptible to differential settlements, poor shear strength and high compressibility. This requires a huge amount of natural soil to be excavated or to be deposited, which is an environmental issue and economical too. These issues motivates in development of alternative methods and thus leads to the reuse of suitable industrial by products. Pond ash is one such by product. Expansive nature of black cotton soil generates lot many problems in pavement construction. Thus, for good performance and long life of road it is important to improve the properties of black cotton soil. This study deals with improving the properties of black cotton soil through addition of Pond ash and naturally available coir fibre. Chemical stabilization is one of the oldest methods of stabilization of problematic soil. In recent days, it has been investigated that addition of fibres will improve the ductility behaviour of the soil there by reducing the development of crack during shrinkage. This project describes the compaction and strength behavior of Pond Ash treated black cotton soil (BC soil) reinforced with coconut coir fibres. The various percentage of Pond Ash as 10%, 20%, 30%,40% and 50% was used to find out the optimum value of Pond Ash. The optimum value of pond ash is added to Coir fibre at different percentages of fibre content, i.e. 0.5%, 0.1% and 1.5% &2% (by weight of pond ash treated soil). The tests which were carried out are Atterberg's Limits, sieve analysis, Modified compaction test, California bearing ratio test. The test result indicates that strength properties of optimum combination of BC soil-Pond Ash specimens reinforced with Coir fibre is appreciably better than untreated BC soil. And also the strength of the mixed soil increases with increase in days.

Keywords: Expansive Soil, Pond Ash,& Coconut Coir Fibre

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I. INTRODUCTION

1.1 GENERAL

For growth of country along with the technological advancements, development in infrastructure field is also required and with the rapid rate of urbanization in our country it is becoming difficult to find the proper quality of soil for engineering applications. Hence, it is a challenging task for a geotechnical engineer to come up with the ideas which would allow us to work on the even poor quality of soil with any risk of failure of the structure. With a diversification of many types of soil in our country a major category of soil which is of many problems to engineers is expansive soil which creates a lot of problems to structure formed on them. This study focuses on the expansive soils and how various geotechnical parameters can be enhanced by the use of brick bust and coir fibre.

1.2 Availability of Expansive soil or Black Cotton soil

Expansive soils also called as Black soils or Black cotton soils and Regur soils are mainly found over the Deccan lava tract (Deccan Trap) including Maharashtra, Madhya Pradesh, Gujarat, and Andhra Pradesh and in some parts of Odisha, in the Indian sub-continent. Black cotton soils are also found in river valley of Tapi, Krishna, Godavari and Narmada. In the north western part of Deccan Plateau and in the upper parts of Krishna and Godavari, the depth of black soil is very large. Basically these soils are residual soils left at the place of their formation after chemical decomposition of the rocks such as basalt and trap. Also these types of soils are formed due to the weathering of igneous rocks and the cooling of lava after a volcanic eruption. These soils are rich in lime, iron, magnesia and alumina but lack in the phosphorus, nitrogen and organic matter.
The Expansive soils are generally called as Black Cotton soil covers nearly twenty percent of Geographicalarea in India.

1.2.1 NATURE OF EXPANSIVE SOIL

Those soils which have a tendency to swell and shrink with the variation in moisture content. As a result of which significant distress in the soil occurs, causing severe damage to the overlying structure. During monsoon's, these soils imbibe water, swell, Expansive soils also known as swelling soils or shrink-swell soils are the terms applied to become soft and their capacity to bear water is reduced, while in drier seasons, these soils shrinks and become harder due to evaporation of water. These types of soils are generally found in arid and semi- arid regions of the world and are considered as a potential natural hazard, which if not treated well can cause extensive damages to not only to the structures built upon them but also can cause loss of human life. Soils containing the clay minerals montmorillonite generally exhibit these properties.

1.2.2 Problems Associated with black cotton soil

Expansive soil has low shrinkage limit and high optimum moisture content. It is highly sensitive to moisture changes & highly compressible sub grade material. It is having low shear strength, further upon wetting or other physical disturbances it reduces further. The wetting and drying process of a sub grade layer of black cotton soil results into failure of pavements in the form of settlement and cracking. Black cotton soil is one of the most prevalent causes of damage to buildings and roads. The following damages occur to change in volume of black cotton soil.

- Severe structural damage,
- Disruption of pipelines and sewer lines. Heaving of roads and highway structures, Condemnation ofbuildings.
- Cracked driveways, sidewalks and basement floors.

II. METHODOLOGY

The main objective of this study is to investigate the change in the behaviour of soil when black cotton soil and Pond Ash and coir fibres at varying percentages was mixed in clayey soil through the various geotechnical tests conducted in the laboratory

Black cotton soil

Black Cotton Soil procured from "Tummalapalli" village near Amalapuram DR.B.R Ambedkar konaseema district in Andhra Pradesh. It is used as a representative soil sample in the present study. This soil is collected from an open excavation, at a depth of 1 to 1.5m below the natural ground surface

2.1 Properties of Soil Sample:

This soil is classified according to I.S classification as inorganic clay of **high compressibility (CH)**

Table 2.1: Properties of Expansive soil

S.NO	Laboratory Test	Symbol	Results	Relevant IS Codes
1	Differential Free Swell	DFS	110 %	IS 2720 Part XI
2	**Atterberg's limits**			
	Liquid Limit	W_L	76%	IS 2720 Part V
	Plastic Limit	W_P	40%	IS 2720 Part V
	Plasticity Index	PI	46%	IS 2720 Part V
	Specific gravity	G	2.52	IS 2720 Part III
3	**Compaction parameters (Modified Proctor test)**			
	Optimum Moisture content	OMC	17.9%	IS 2720 Part VIII
	Maximum Dry Density	MDD	1.97 g/cc	IS 2720 Part VIII
4	California Bearing Ratio (Un Soaked)	CBR	3.70	IS 2720 Part XVI

2.1.2 POND ASH

Pond ash has been collected from the Thermal Power Plant Secunderabad, India. This is generally grey in colour and pozzolanic in nature. The most common chemical compositions of pond ash are SiO2, Al2O3, MgO, CaO, Fe2O3, organic carbons and others. The pond ash was collected from near the slurry disposal point which is coarser in nature.

Pond ash is the by-product of thermal power plants, which is considered as a waste material and its disposal is a major problem from an environmental point of view and also it requires a lot of disposal areas. Actually, there are three typesof ash produced by thermal power plants, viz. (1) fly ash, (2) bottom ash, and (3) pond ash.

POND ASH

Table.2 Properties of Pond Ash

Properties	Results	IS CODES
Specific gravity	2.05	IS 2720 PART 3 1980
Grain size		
Coarse sand (%) Medium sand (%) Fine sand (%) Fines (silt & clay) (%)	3.85 21.45 52.36 21.85	IS 2720 PART 4 1985
Liquid limit	NP	IS 2720 PART 5 1985
Plastic limit	NP	
MDD(KN/m^3)	11.2	IS 2720 PART 7 1980

2.1.3 Coconut Coir Fibre

Coconut Coir Fibre for this study collected from "Bandarulanka near Amalapuram", East Godavari districtof Andhra Pradesh. It is used in the present study as a stabilizer. The coir is cut into 30 length pieces

Table2.2 Chemical composition of coconut/coir Fibre

Lignin	45.84%
Cellulose	43.44%
Hemi-cellulose	00.25%
Pectin's and related compound	0.300%
Water soluble	05.25%
Ash	02.22%
Physical Properties of Coconut/Coir fibre	
Length in inches	6-8
Density(g/Cc)	1.40
Tenacity(g/Cc)	10.0

Breaking Elongation %	30%
Diameter in MM	0.1 to 1.5
Rigidity of Modulus	1.8924 dyne/ cm2

Selling in Water(diameter)	5%
Moisture of 65% RH	10.50%

Fig2.4 Coconut Coir Fibre

2.2 METHODOLOGY

The study was carried out in two stages. Firstly a number of laboratory tests were carried out on clay soil with Pond Ash and reinforced with coir fibre. Pond Ash in proportions of 0%, 10%, 20% ,30% ,40%& 50% replaced with the soil. Soil with the optimized brick kiln dust was further mixed with coir fibre proportions of 0.5%, 0.1% , 1.5% and 2% .

1. Atterberg limits

- Liquid limit [IS:2720 (Part 5)1985]
- Plastic limit [IS:2720 (Part 5)1985]
- Plasticity index

2. compaction characteristics [IS:2720 (Part 8)1983]

- Maximum dry density (M.D.D.)
- Optimum moisture content

3. California Bearing Ratio Test [IS:2720 (Part 16)1979]

III. DISCUSSION AND RESULTS

3.1 Introduction

Details of the laboratory experimentation carried-out with POND ASH& COCONUT COIR FIBER have been discussed in the previous chapter. In this chapter a detailed discussion on the results obtained from various laboratory were presented.

3.2 Laboratory Test Results on Black Cotton Soil:-

The soil sample used in investigation is a local clayey soil. The soil sample was collected by excavating the ground surface and from physical observation ,it was found that ,According to IS classification (IS 1498:1970)the soil is classified as clay of high plasticity in natural (CH).

Table 3.1 Physical Properties of Black Cotton Soil

S.No	Property	Value
1	**Atterberg's limits**Liquid limit (%) Plastic limit (%) Plasticity index (%)	**50.3** **26.5** **23.8**
2	**Differential free swell index**	**110**
3	**Compaction Properties** Optimum Moisture Content, O.M.C. (%)Maximum Dry Density, M.D.D(g/cc)	**22** **1.69**
4	**California Bearing Ratio (un-soaked)**	**2.42**

3.3 Index properties

Finding the Index properties of black cotton soil Liquid Limit and Plastic Limit of the samples tried in this investigation. The results of Liquid Limit tests on expansive soil treated with different percentages of Pond Ash can be seen that with increase in percentage of Pond Ash the liquid limit of soil goes on decreasing from 76% to 67% when Lime is increased from 0 to 40% as shown in fig. 5.1. The results of plastic Limit tests on expansive soil treated with different percentages of Pond Ashcan be seen that with increase in percentage of Pond Ash the plastic limit of soil goes on increasing from 40% to 49% when Pond Ash is increased from 0to 40% as shown in fig 3.2.

Table-3.1 Variation of Index Properties of Expansive soil with % of Pond Ash

S.No	Sample	Liquid limit (%)	Plastic Limit (%)	Plasticity index(%)
1	100%ES	50.3	26.5	23.8
2	90%ES+10%PA	45.5	26.2	19.3
3	80%ES+20%PA	40.2	23	17.2
4	70%ES+30%PA	37	20	17
5	60%ES+40%PA	33.5	19	15.8
6	50%ES+50%PA	32.6	18.5	13.6

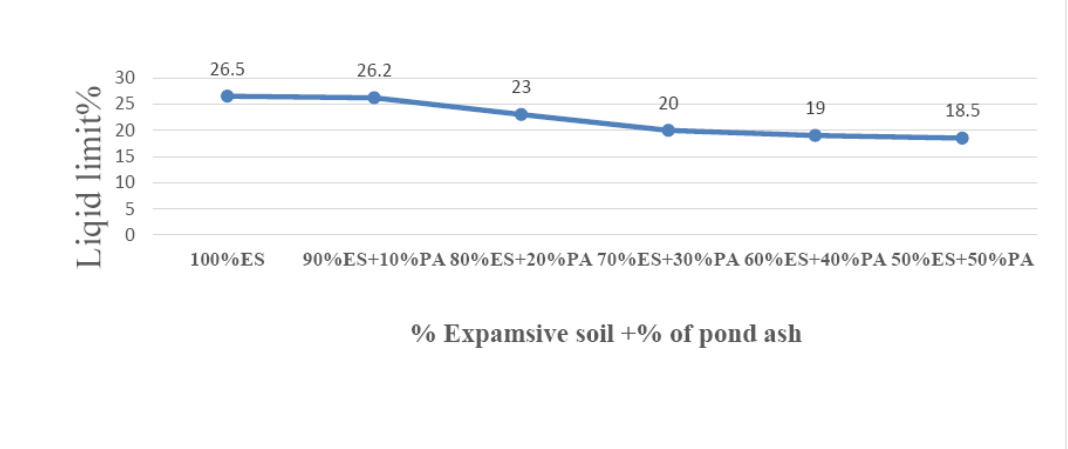

Figure 3.1 Variation of Liquid Limit of ES with different % of Pond Ash

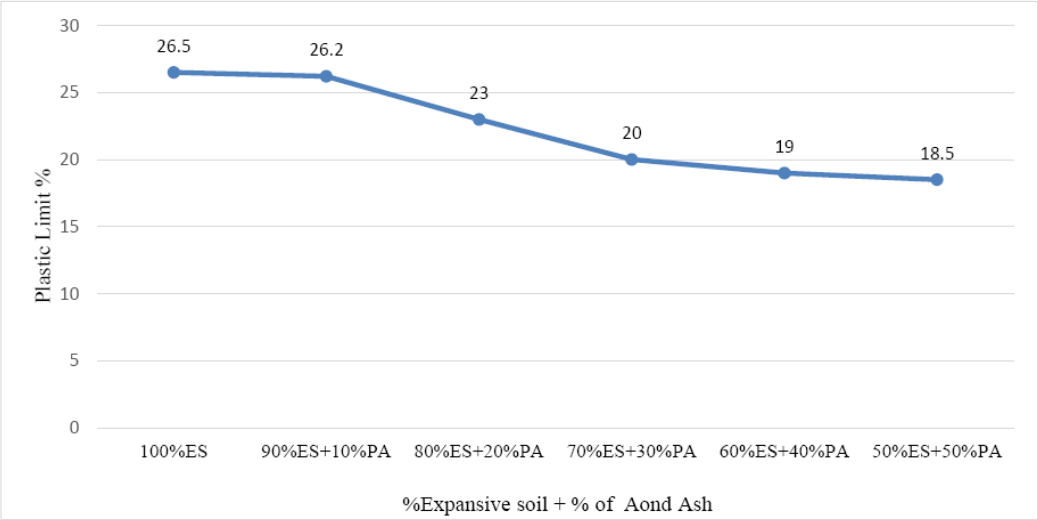

Figure 3.2: Variation of Plastic Limit of ES with different % Pond Ash

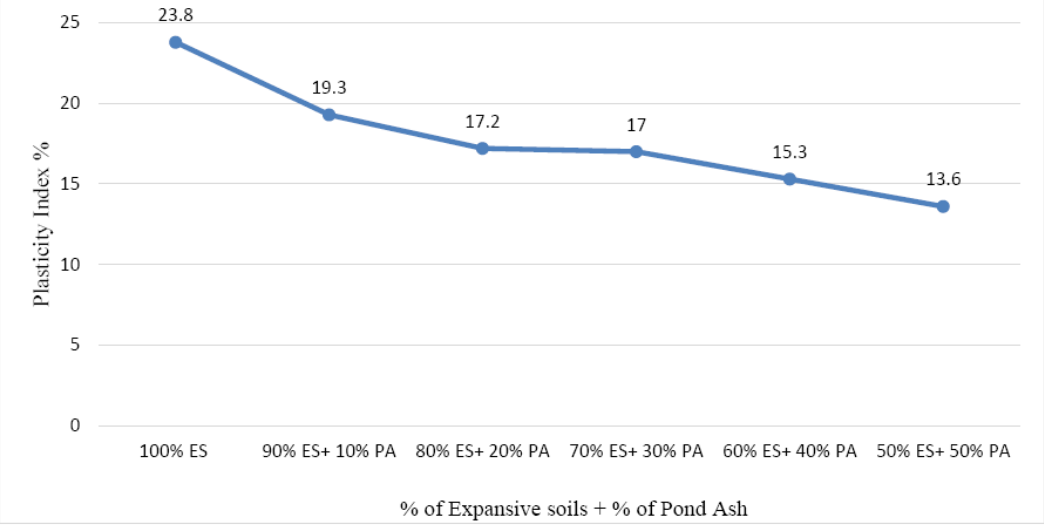

Figure 3.3 Variation of Plasticity Index of ES with different % Pond Ash

3.3 Differential free swell index test

Soil with various amount of Pond Ash added to determine the effect on differential free swell of soil, Shown in below fig.3.4

Table-3.3 Variation of DFS with % of Pond Ash

S .No.	Samples	DFS (%)
1	100% ES	110
2	90% ES+ 10% Pond Ash	85
3	80% ES+ 20% Pond Ash	73
4	70% ES+ 30% Pond Ash	61
5	60% ES+40% Pond Ash	55
6	50% ES+50% Pond Ash	40

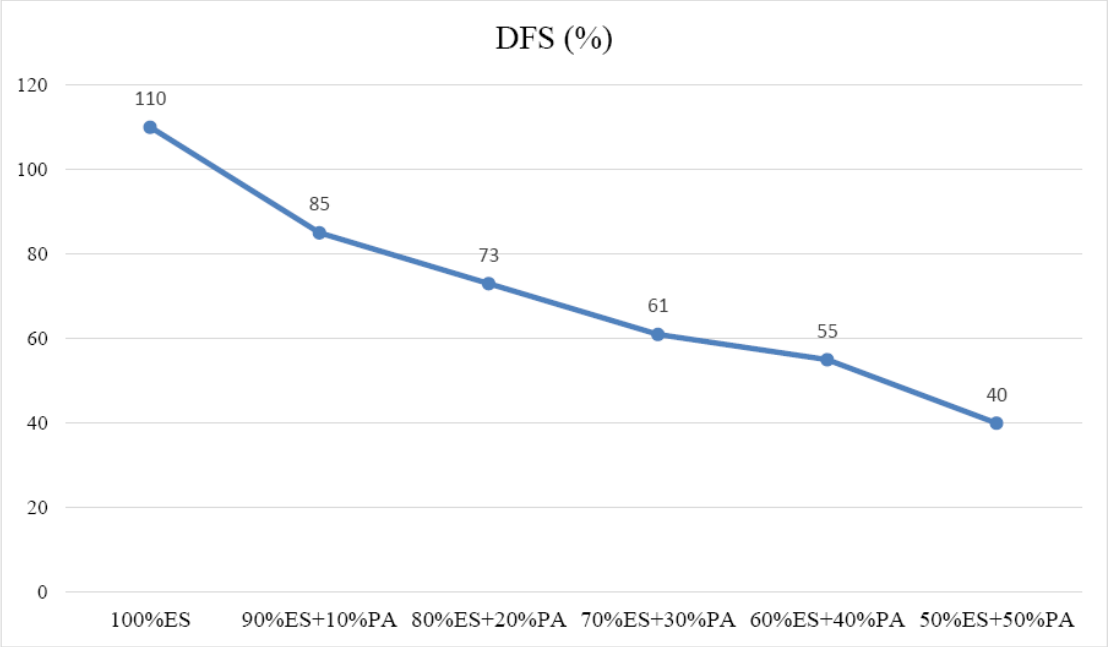

Figure 3.4 Variation of DFS of ES with different % Pond Ash

3.5 Compaction Test Results

IS Modified Proctor compaction tests were conducted. The Compaction test is carried out for both Pond Ash. At first the expansive soil Samples are mixed with different percentages of Pond Ash and later with optimum of Pond Ash mixed with soil and different percentages of coir fibre. Graph are drawn between water content and dry density for each percentage increment of Pond Ash and coir fibre to the expansive soil, from these results Optimum Moisture Content and Maximum Dry Density values are derived. The results and graph from these tests are presented below Table 3.4

Table 3.4 Variation of OMC and MDD for Expansive soil with % Pond Ash

S.No	Sample	OMC (%)	MDD(g/cc)
1	100%ES	22	1.69
2	90%ES+10%PA	20.3	1.71
3	80%ES+20%PA	18.9	1.89
4	70%ES+30%PA	17.5	1.95
5	60%ES+40%PA	16.8	1.81
6	50%ES+50%PA	15.5	1.70

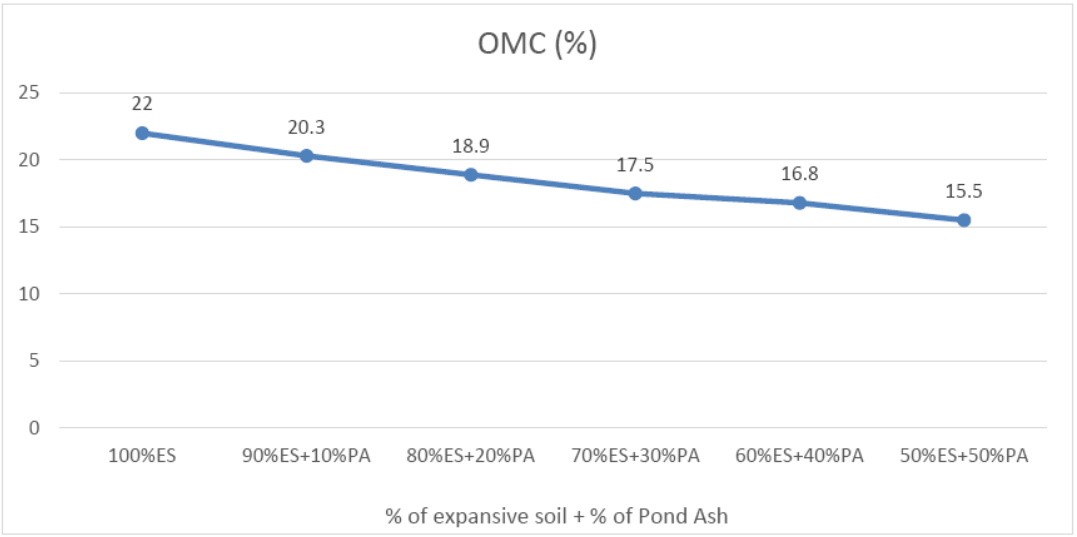

Figure 3.5 Variations of OMC for ES with different % of Pond Ash

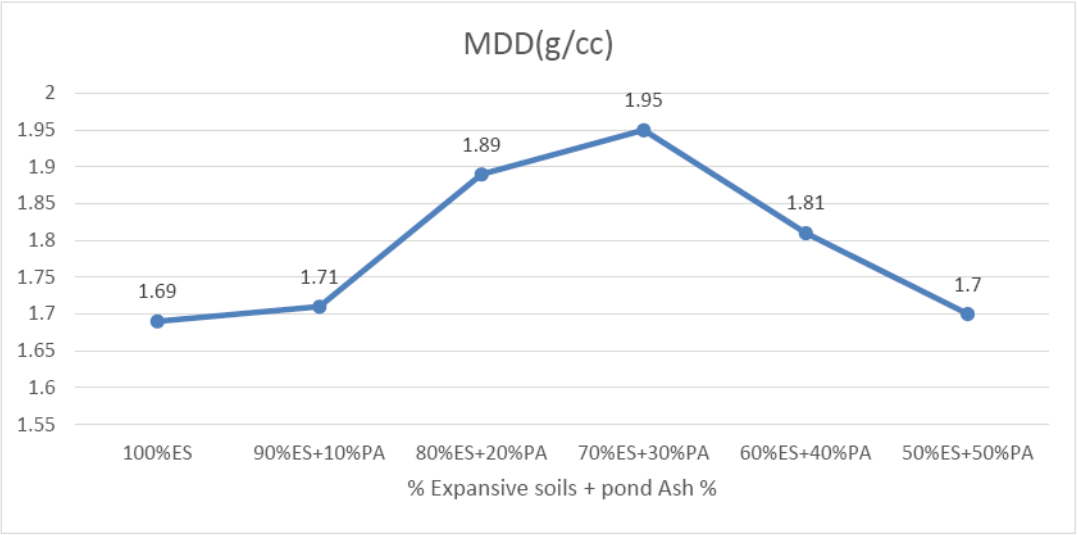

Figure 3.6: Variations of MDD for ES with different % of Pond Ash

3.7 California Bearing Ratio (CBR) Test Results

The CBR tests were conducted in the laboratory for all the expansive soil samples treated with different percentages of Pond Ash. The results of Un soaked CBR tests on expansive soil treated with increase in percentage of Pond Ash goes on increasing up to the optimum percentages of additives and the results are presented in below Tables 3.5.

Table 3.5Variation of Un-Soaked CBR for Expansive soil with different percentages ofPond Ash

S.NO	% OF Pond Ash	CBR(%)
1	100%ES	2.42
2	90%ES+10%PA	3.09
3	80%ES+20%PA	3.75
4	70%ES+30%PA	4.4
5	60%ES+40%PA	4.1
6	50%ES+50%PA	3.9

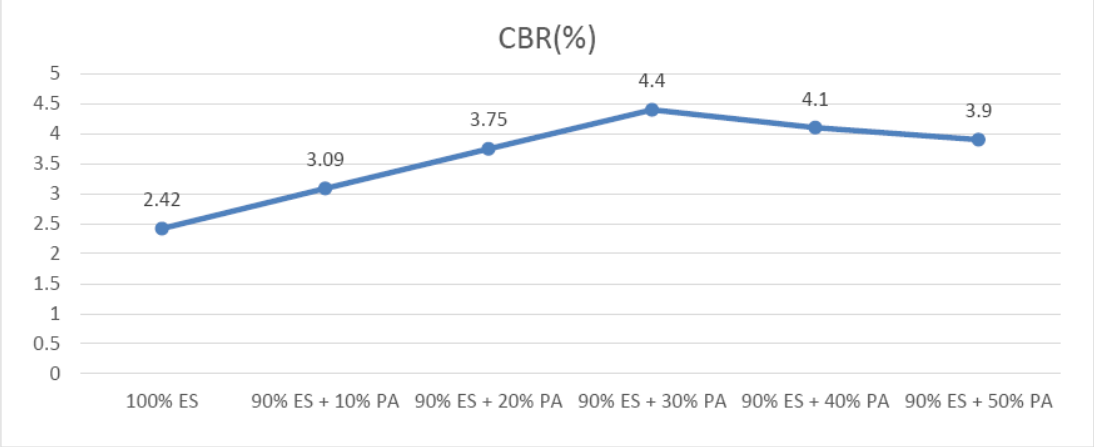

Figure 3.7 Variation of Un-Soaked CBR for % ES with different % of Pond Ash

3.7 Soil Pond Ash Mixture with Coir Fibre

The Pond Ash treated Expansive soil is mixed with various percentage of coir fibre as 0.75% to 1.25% with an increment of 0.25% to perform modified compaction test and California Bearing Ratio test are presented in BelowTable 3.6&3.7.

Table 3.6 Variation of OMC and MDD of Pond Ash treated ES with different % of coirFibre

S.No	Sample	OMC(%)	MDD(g/cc)
1	30%PA+0%Fibre	17.5	1.9
2	30%PA+0.5%coir Fibre	18.2	1.92
3	30%PA+1.0%coir Fibre	19	1.99
4	30%PA+1.5%coir Fibre	18.9	1.96
5	30%PA+2.0%coir Fibre	18.7	1.93

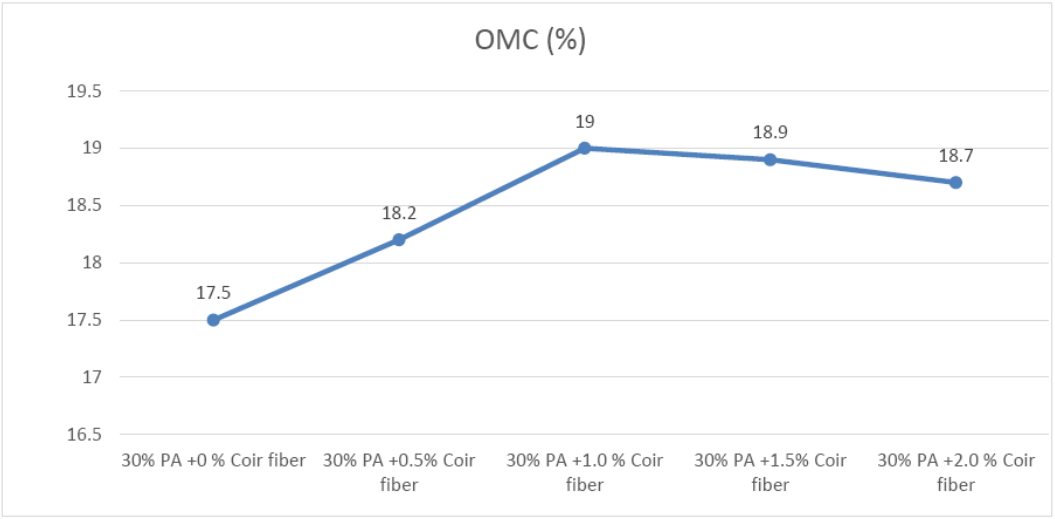

Figure 3.8Variations of OMC for PA treated ES with % of coir Fibre

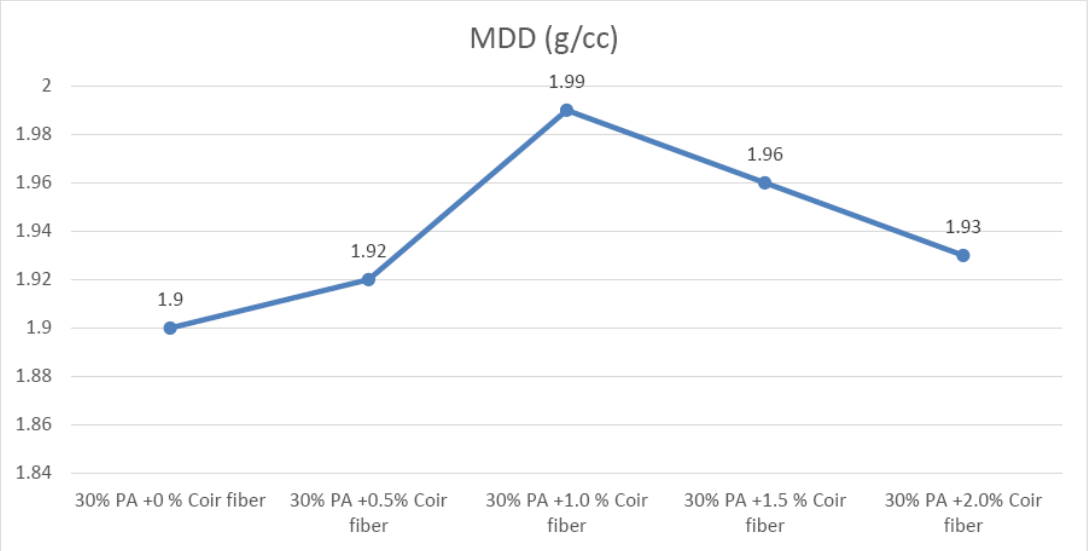

Figure 3.9Variations of MDD for PA treated ES with % of coir Fibre

Variation of CBR value of Pond Ash treated soil with different percentage of Coir Fibre

Table 3.7 Variation of Un-Soaked CBR for Pond Ash treated ES with different percentages of coir Fibre.

S.NO	Sample	CBR(%)
1.	30%PA+0%Coir fibre	4.7
2.	30%PA+0.5%Coir fibre	5.2
3.	30%PA+1.0%Coir fibre	6.1
4.	30%PA+1.5%Coir fibre	5.9
5	30%PA+2.0%Coir fibre	5.3

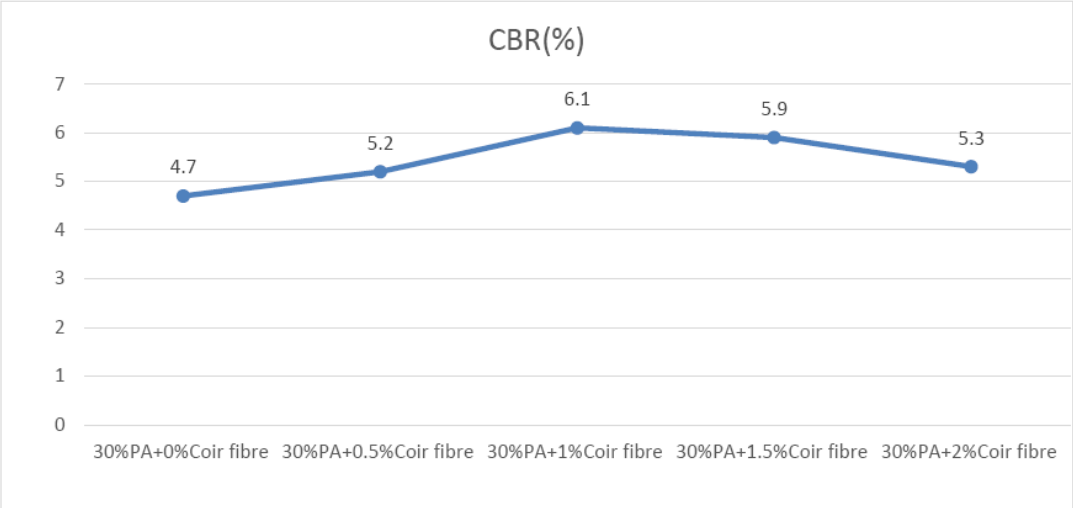

Figure 3.10 Variation of Un-Soaked CBR for Pond Ash treated ES with different % of coir Fibre

III. CONCLUSION

The following conclusions are drawn based on the laboratory studies carried out in this investigation, the optimum percentile of the waste brick dust and coir fibre mixed with the soil for strengthening its stability is being studied. Thefollowing observations are being made after performing several experiments:

❖ Addition of Pond Ash has shown decrement in liquid limit from 53.2% to 30.6% and improvement in plastic limit from 26.5% to 18.5% and plasticity index decrease from 23.8% to 13.6% when the Pond Ash content varies from 0% to 50% with an increment of 10% mixed in expansive soil.

❖ The effect of adding Pond Ash with soil, it results decrease of optimum moisture content (OMC) and increase of maximum dry density (MDD). When 30% of the soil is being replaced with Pond Ash, the optimum moisture content (OMC) obtained 17.5% and maximum dry density (MDD) 1.95g/cc. Next, when the soil is being mixed with a combination of coir fibre and Pond Ash, there was a decrease in value on OMC parameter and an increase in the value on MDD.

❖ To find the effect on CBR value, when Pond Ash is being mixed with soil in varying percentile, its value was seen to rise and increase CBR. For combined addition of coir fibre and Pond Ash in soil with varying percentile, the CBR value increases continuously.

❖ From the experiments performed, it is established that the optimum value of brick dust and coir fibre with the soil is 30% and 1.0% respectively. Such kind of findings is valuable in the consideration of economyand cost.

❖ When the clayey subgrade becomes stabilized with 30% Pond Ash and 1.0% Coir Fibre.

❖ From the study, it is concluded that by mixing the clayey soil with waste Pond Ash and coir fibre, it can result in stabilizing the soil. It is useful for construction of subgrade of the road, paths and embankment. Thus, the Pond Ash and coir fibre is suitable to be used as a suitable stabilizing agent for the purpose of admixture with the soft clay soil.

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