

## STABILIZATION OF BLACK COTTON SOIL USING COIR PITH AND FLY ASH

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**Abstract-** In India most of lands are covered with Expansive soil (mainly Black Cotton soil). The property of this expansive soil is that they are very hard when in dry state, but they lose all of their strength when in wet state. Due to this property of expansive soils, these soils pose problems worldwide that serve as challenge to overcome for the Geotechnical engineers. One of the most important aspects for construction purposes is soil stabilization, which is used widely in foundation and road pavement constructions; this is because such stabilization improves engineering properties of the soil. In this paper the experimental results obtained in the laboratory on expansive soils treated with industrial waste Coir Pith (CP) & fly ash as a stabilizer are presented. A study is carried out to check the improvements in the properties of expansive soil with Coir Pith in varying percentages & fly ash kept in constant percentage that is 30%. The test results such as Atterberg's limit, SPT and UCS test obtained on black cotton soil mixed at different proportions of Coir Pith as an admixture ranging from 2%, 4%, 6%, 8% and 10%. The max dry density (MDD) of 6% addition of coir pith is more compare to untreated BC Soil, optimum moisture content (OMC) is reduced compare to BC Soil. The unconfined compressive strength (UCS) for BC Soil treated with 4% CP is more as compare to untreated BC soil.

**Keywords** - Black cotton soil, Coir pith, Expansive soil, Fly ash, stabilization.

### I. INTRODUCTION

Black cotton soil is called as expansive soils or swell-shrink soil, have the tendency to shrink and swell with variation in moisture content. As a result of this variation in the soil, significant distress occurs in the soil, which is subsequently followed by damage to the overlying structures. During periods of greater moisture, like monsoons, these soils retain the water and swell. Subsequently, they become soft and their water holding capacity diminishes. As opposed to this, in drier seasons, like summers, these soils lose the moisture held in them due to evaporation, resulting in their becoming harder. Generally found in semi-arid and arid regions of the globe, these types of soils are regarded as potential natural hazard – if not treated, these can cause extensive damage to the structures built upon them, as well causing loss in human life. Soils whose composition includes presence of montmorillonite, in general, display these kinds of properties causes extensive damage to civil engineering structures.

Soil stabilization is a general term for any physical, chemical, biological, or combined method of changing a natural soil to meet an engineering purpose. The process of improving the engineering properties of weak soil by using various stabilizing agents is called soil stabilization. Stabilization makes soil more stable by reduction in the permeability, compressibility and with increase in shear strength; it makes the soil more stable thus enhancing bearing capacity of soil.

**1.1 Objective of study:** - The basic objectives of study of black cotton soil with fly ash and coir pith are as following:

- The main objective is to stabilize and improve the locally available soil.

- To study Behavior of coir pith and fly ash with black cotton soil.
- Improvement of bearing capacity of Black Cotton Soil on addition of fly ash and coir pith.
- To reduce the compressive nature of black cotton soil.
- To check the ambit of reducing expansiveness and improving bearing capacity value by adding additives.
- To achieve volume stability means to control the swell-shrink characteristics caused by moisture changes.
- Also to establish the usage of fly ash as an additive, thereby helping utilize it which otherwise always lays as fine waste product from thermal power plants.

## II. LITERATURE REVIEW

Hakari, U.D., *et. al.* (2012) “Stabilization of Black Cotton Soils Using Fly Ash, Hubballi-Dharwad Municipal Corporation Area, Karnataka, India”– has investigate and improve the engineering properties of the black cotton soils of Hubballi-Dharwad Municipal Corporation area so that, a better understanding is facilitated for the civil engineering practitioners, while dealing with these soils. In their study they recommended optimum Dandeli fly ash percentage for different parameters of the soils. The geotechnical properties of Hubballi-Dharwad black cotton soils can be favourably changed using the Dandeli fly ash and an optimum quantity between 30- 40% can yield the best possible results [1].

Ramlakhan, B., *et. al.*, (2013) “Effect of lime and fly ash on Engineering Properties of Black Cotton soil”– has investigated that the effect of the lime and fly ash on the some basic engineering properties of BC soil such as Liquid limits, plastic limit and compaction of BC soil and California bearing ratio (CBR) of BC Soil. The liquid limit, plastic limit, and optimum moisture content (OMC), California bearing ratio (CBR) increased with an increase in lime percentage but maximum dry density (MDD) of soil decreased with increase in lime percentage. The liquid limit, plastic limit and maximum dry density (MMD) of the BC soil decreased and the optimum moisture content (OMC) increased with an increase in fly ash content. The waste material such as fly ash can be used effectively in the civil engineering construction but it is become more effective with lime [2].

Mehta, A., *et. al.*, (2013) “Stabilization of black cotton soil by Fly Ash” – has investigated that expansive soils were stabilized with various proportion of fly ash i.e. at 0, 10, 20 30, 40 & 50%. Fly ash possesses no plasticity. Plasticity index of clay fly ash mixes decreases with increase in fly ash content. Thus addition of fly ash makes expansive soil less plastic and increases its workability by colloidal reaction and changing its grain size. The CBR values of clay with fly ash mixes, tested under unsoaked & soaked conditions. At 20% of fly ash maximum CBR value and dry density achieved. So it may be reported that fly ash has good potential for use in geotechnical applications. The relatively low unit weight of fly ash makes it well suited for placement over soft or low bearing strength soils [3].

Singhai, A., *et. al.*, (2014) “Laboratory study on soil stabilization using fly ash and rice husk ash”– has investigated that the effect of fly ash and rice husk ash to improve the performance of black cotton soil. They treat black cotton soil is with fly ash (5%,10%,15%,20%,25%) and rice husk ash (10%,15%,20%,25%,30%) and examine after 28 days of curing. liquid limit is reduced to 55% for (20% FA and 25% RHA), plasticity index is reduces to 86% for (20% FA and 25% RHA), differential free swell is reduces to 75% for (15% FA and 20% RHA) mix soil sample. Also specific gravity is reduces [4].

Karthik.S, *et. al.*, (2014) “Soil Stabilization by Using Fly Ash”– has investigated that addition of Fly Ash resulted in appreciable increases in the CBR of the soil. For water contents 9% wet of optimum, CBRs of the soils are found in varying percentage such that 3,5,6and 9. We will found optimum CBR value of the soil is 6%. Increment of CBR value is used to reduce the thickness of the pavement. Bearing capacity of soil at 6 % of fly ash is 35 Kg/ sq.mm [5]. Chauhan, K., *et. al.*, (2015) “Effect of Fly Ash and Fibre on Engineering Property of Black Cotton Soil” – has study soil

sample containing 0,9,18,27%, of fly ash & determine the value CBR test strength of soil & when get maximum strength to use same content sugar cane fiber 2%,4% ,6% fibre means cut sugar cane fibre 1.5 cm and mix with fly ash .With increase in percentage of fly ash optimum moisture content decreased , the maximum dry density increases, California bearing ratio and unconfined compression strength increases. It means fly ash and sugarcane fiber is good stabilizing material in BC soil [6].

Somani, P., *et. al.*, (2016) “Use of Fly Ash in Black Cotton Soil for Stabilization” –has investigated that the proportion of admixtures at some amount mixed in soil increases its engineering properties. And find that percentage of proportion mix at which it give the maximum bearing capacity of black cotton soil at an economical condition. Also hydraulic conductivity of black cotton soil is reduced. If black cotton soil is used in road construction then there will be no need of drainage layer after treatment of black cotton soil as sub grade with fly ash [7].

Sambre, T.R., *et. al.*, (2016) “Stabilization of Expansive Soil” – has investigated that the effects of fly ash, pond ash and lime on the compaction and strength performance of expansive soil. The soil samples are prepared with different proportions of fly ash (5%) and pond ash, (10%,20%,30% , 40%) and lime (4%, 6%, 8%, 10) A series of test are conducted including Index Properties, Consistency Limits ,Modified Proctor Test, laboratory Unconfined Compression Strength Tests and  $c - \phi$  properties of soil. CBR Value .Industrial waste material which is cheaply and easily available in abunt amount i.e. pond ash and fly ash can improve the soil with the help of admixture such as lime. This type of soil improvement is environmental friendly and eco-friendly pond ash can replaces the conventional earth material in some of the geotechnical constructions also [8].

Sharma, A., *et. al.* (2016) “Ground granulated blast furnace slag amended fly ash as an expansive soil stabilizer”– has investigated that the use of GGBS mixed fly ash as binder to stabilize expansive is well suited for sustainable construction besides economic benefits. The joint use of these two materials to form a binder provides new opportunities to enhance pozzolanic activities that may reduce the swell potential and increase the unconfined compressive strength of expansive clays Sharma, A., *et. al.* (2016) “Ground granulated blast furnace slag amended fly ash as an expansive soil stabilizer” Considering the high cost of lime and cement, the use of fly ash/GGBS mixtures can represent a significant saving in the construction costs as well as reduce the environmental pollution problem [9].

Arthi, P.D., *et. al.*, (2017) “Stabilization of black cotton soil using coir pith”- has study that the improvements in the properties of expansive soil with Coir Pith in varying percentages. The test results such as liquid limit, Modified proctor compaction, and unconfined Compression strength test obtained on black cotton soil mixed at different proportions of Coir Pith as an admixture ranging from 2%, 2.5%, 3%, 3.5% and 4%. The plasticity index (PI) of 2% & 3% addition of coir pith is less compared to untreated BC Soil. The max dry density (MDD) of 2% &3% addition of coir pith is more compare to untreated BC Soil, optimum moisture content (OMC) is reduced compare to BC Soil. The unconfined compressive strength (UCS) for BC Soil treated with 2%and 3% compare to untreated BC soil. Based on the laboratory tests they concluded that the proctor compaction and CBR values increased for 2%, 2.5%, 3% and 3.5% of coir pith [10].

### III. MATERIALS AND METHODOLOGY

#### 3.1 Materials: -

The material used for various tests are as follows,

**3.1.1 Black cotton soil:** - As a part of this investigation, the expansive black cotton soil was collected from the S.N.D college campus, Babhulgaon, Tal. – Yeola, Maharashtra. The black cotton soil sample was collected by open excavation from a depth of 1 meter from the natural ground level. The black cotton soil thus obtained was carried to the laboratory. The sample was air dried for carrying out various test. The various geotechnical properties of the procured soil are as follows:

**Table 1 - Geotechnical properties of black cotton soil**

| Sr. No | Properties                                           | Code Preferred                | Value |
|--------|------------------------------------------------------|-------------------------------|-------|
| 1      | Specific gravity                                     | IS 2720 (Part 3/Sec 1) - 1980 | 2.65  |
| 2      | Liquid limit in %                                    | IS 2720 (Part 5) - 1985       | 72    |
| 3      | Plastic limit in %                                   | IS 2720 (Part 5) - 1985       | 59.15 |
| 4      | Shrinkage limit in %                                 | IS 2720 (Part 6) -: 1972      | 12.34 |
| 5      | Plasticity index in %                                | IS 2720 (Part 5) - 1985       | 37.96 |
| 6      | Maximum dry density in gm/cm <sup>3</sup>            | IS 2720 (Part 7) - 1980       | 1.37  |
| 7      | Optimum moisture content in %                        | IS 2720 (Part 7) - 1980       | 26.5  |
| 8      | Unconfined compressive strength in N/mm <sup>2</sup> | IS : 2720 (Part 10) - 1991    | 0.197 |
| 9      | Free swell index in %                                | IS 2720 (Part 40) - 1977      | 22.22 |

**3.1.2 Coir pith:** - Coir pith is also known as coco peat is the material found between coconut husk fibres and it is a by-product of the coconut industry. Also, it is spongy material that binds the coconut fibre in the husk. It is an excellent soil conditioner. The largest producers of coir fibre (and therefore coir pith) are India and Sri Lanka. Coco peat is a 100% natural growing medium. This coco peat dried in the natural sun, are processed to produce different items. For our project we buy coir pith from orgakart. Coir pith or dust is a biomass residue that decomposes very slowly due to its lignocellulosic nature.



**3.1.3 Fly ash:** - A waste material extracted from the gases emanating from coal fired furnaces, generally of a thermal power plant, is called fly ash. Fly ash particles are generally spherical in size. Both amorphous and crystalline nature of minerals is the content of fly ash generated. Its content varies with the change in nature of the coal used for the burning process, but it basically is non-plastic silt. There are about 82 power plants in India, which form the major source of fly ash in the country. It is estimated that 170 million tons of fly ash is being produced from different thermal power plants in India consuming 70 thousand acres of precious land for its disposal causing severe health and environmental hazards.



### 3.2 Methodology adopted: -

To evaluate the effect of fly ash and coir pith as a stabilizing additive in expansive soils, series of tests are carried out, where the proportion of fly ash and coir pith were selected based on study of pervious literature in the expansive soil are as follows:

**Table 2 - Proportion of FA and CP in BC soil**

| Sr. No. | Description            |
|---------|------------------------|
| 1       | BC + 30 % FA + 2 % CP  |
| 2       | BC + 30 % FA + 4 % CP  |
| 3       | BC + 30 % FA + 6 % CP  |
| 4       | BC + 30 % FA + 8 % CP  |
| 5       | BC + 30 % FA + 10 % CP |

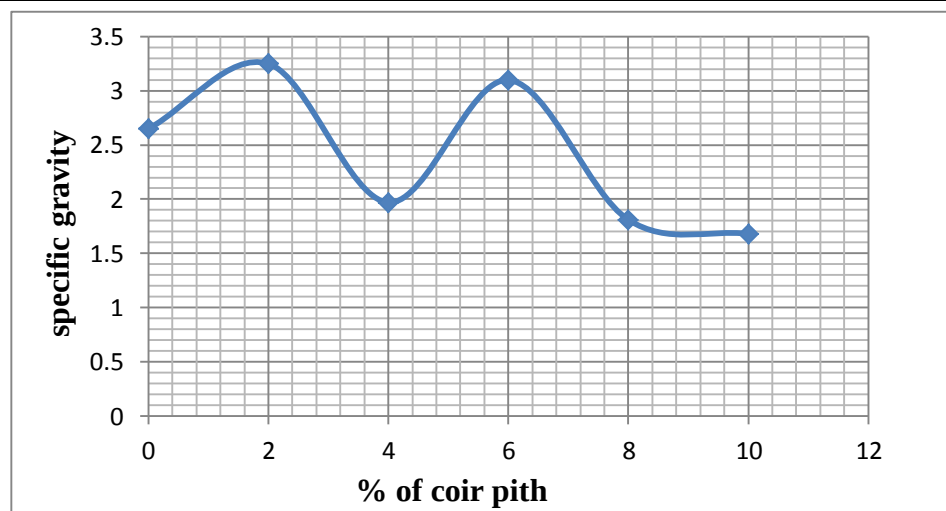
## IV.RESULTS AND DISSCUSSIONS

### 4.1 Test Results: -

1. **Specific gravity-** The knowledge of specific gravity is essential in reckoning of soil properties like-void ratio, degree of saturation and also weight-volume relationship.

**Table 3 – Specific gravity test result**

| % of coir pith | 0    | 2    | 4    | 6    | 8    | 10   |
|----------------|------|------|------|------|------|------|
| Sp. gravity    | 2.65 | 3.25 | 1.97 | 3.10 | 1.81 | 1.68 |

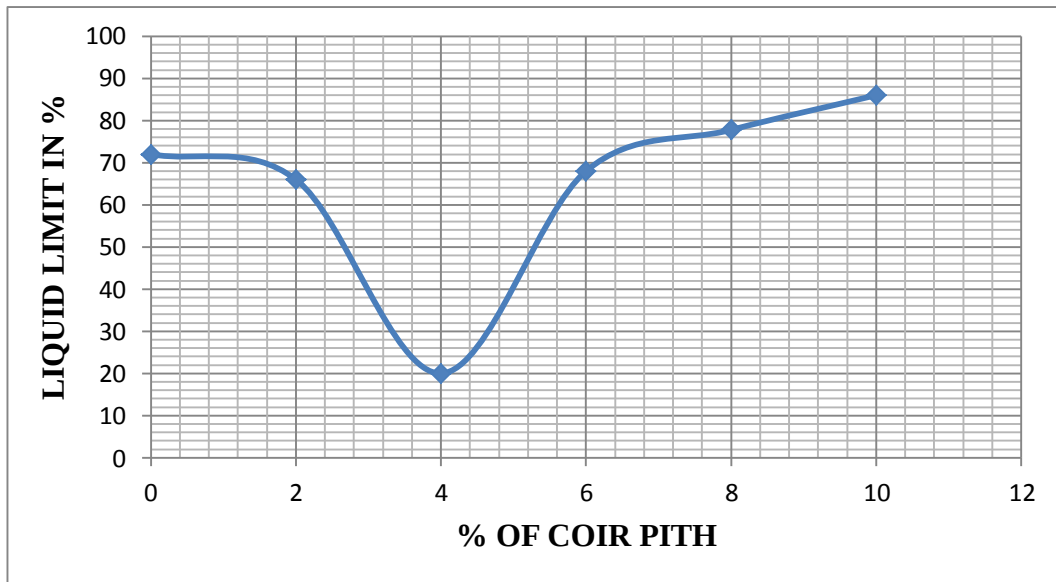


**Figure.1: - Variation of Sp. gravity with % of coir pith**

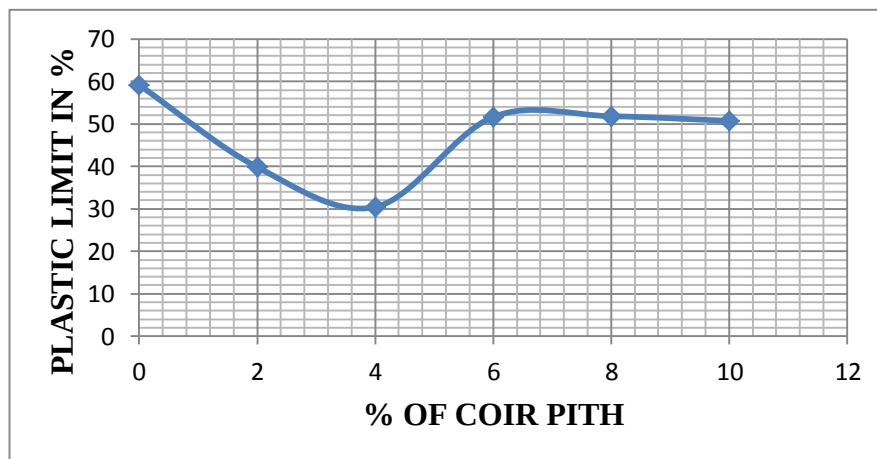
2. **Atterberg's limit-** We performed these test to find the value of Plasticity Index which helps in determine the value of Flow Index which directly helps in finding the value of Direct Shear value of black cotton soil.

**Table 4 – Atterberg's limit test result**

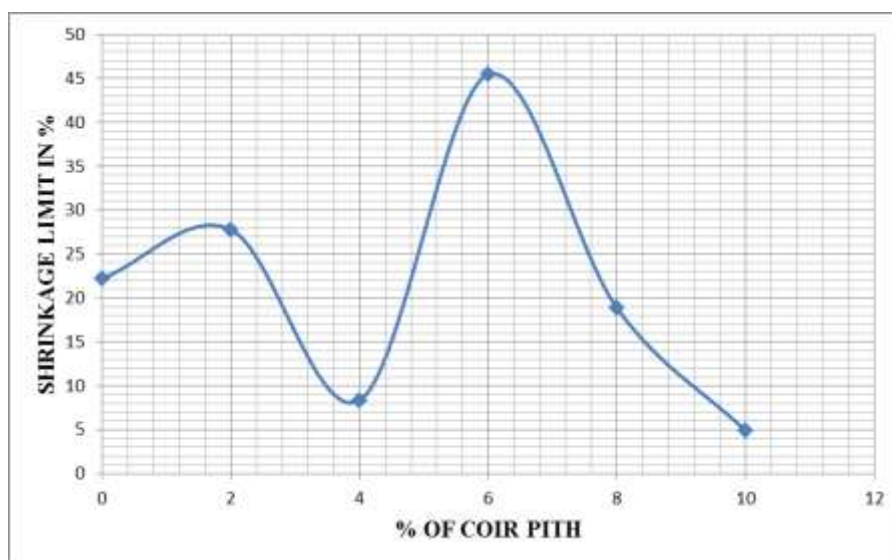
| % of coir pith        | 0     | 2     | 4     | 6     | 8     | 10    |
|-----------------------|-------|-------|-------|-------|-------|-------|
| Liquid limit in %     | 72    | 66    | 20.5  | 68    | 77.78 | 86    |
| Plastic limit in %    | 59.15 | 39.83 | 30.42 | 51.64 | 51.81 | 50.72 |
| Shrinkage limit in %  | 12.34 | 17.32 | 10.31 | 49.52 | 58.57 | 14.80 |
| Plasticity index in % | 37.96 | 33.58 | 10.42 | 35.04 | 42.18 | 48.18 |



**Figure.2: - Variation of liquid limit with % of coir pith**



**Figure.3: - Variation of plastic limit with % of coir pith**



**Figure.4: - Variation of shrinkage limit with % of coir pith**

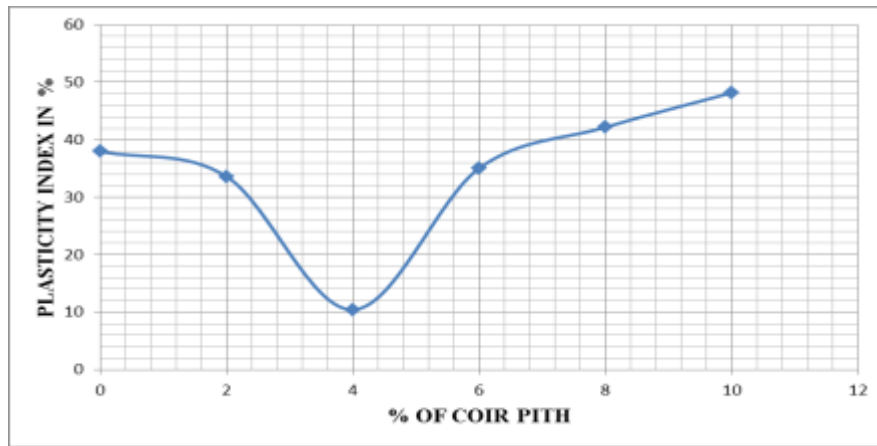


Figure.5: - Variation of plasticity index with % of coir pith

3. **Free swell index-** This test is performed to find out swelling characteristics of soil sample.

Table 5 – Free swell index test result

| % of coir pith        | 0     | 2     | 4    | 6     | 8     | 10   |
|-----------------------|-------|-------|------|-------|-------|------|
| Free swell index in % | 22.22 | 27.78 | 8.33 | 45.45 | 18.82 | 4.85 |

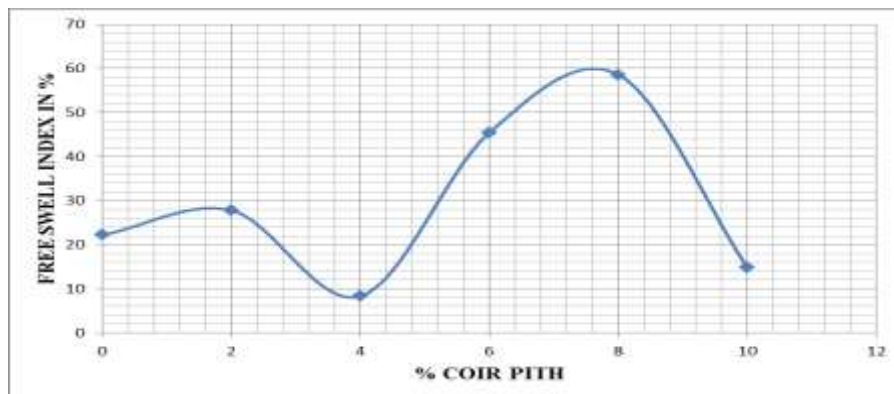


Figure.6: - Variation of free swell index with % of coir pith

4. **Standard proctor test-** The O.M.C. value indicates that at this water content value UCS test can be done in correct way. SPT is an in-situ dynamic type of penetration test which is designed to provide facts on the geotechnical engineering property of soil.

Table 6 – SPT test result

| % of coir pith            | 0    | 2     | 4    | 6    | 8    | 10   |
|---------------------------|------|-------|------|------|------|------|
| MDD in gm/cm <sup>3</sup> | 1.37 | 1.305 | 1.21 | 1.43 | 1.15 | 1.39 |
| OMC in %                  | 26.5 | 27    | 33   | 17.5 | 27.5 | 22.5 |

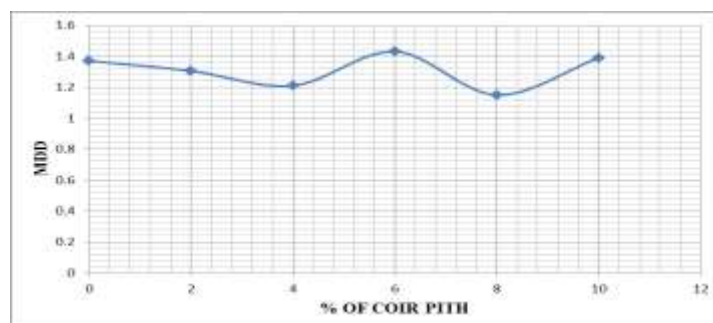


Figure.7: - Variation of MDD with % of coir pith

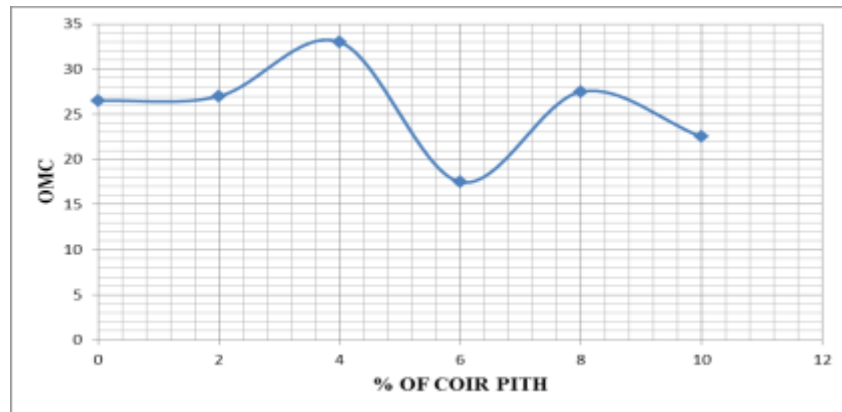


Figure.8: - Variation of OMC with % of coir pith

5. **Unconfined compression test-** The purpose of this test is to obtain a quantitative value of compressive and shearing strength of soils in an undrained state.

Table 7 – UCS test result

| % of coir pith                                       | 0     | 2     | 4     | 6     | 8     | 10    |
|------------------------------------------------------|-------|-------|-------|-------|-------|-------|
| Unconfined compression strength in N/mm <sup>2</sup> | 0.197 | 0.195 | 0.206 | 0.176 | 0.170 | 0.166 |

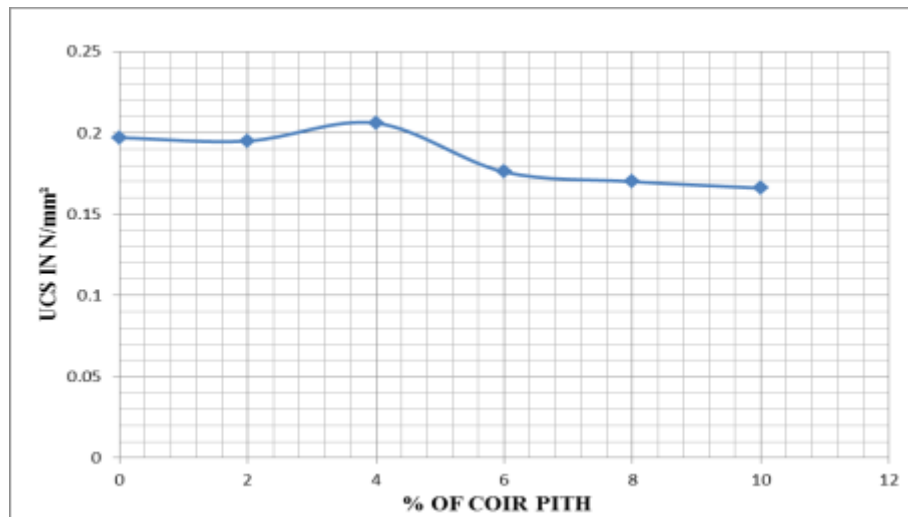


Figure.9: - Variation of UCS with % of coir pith

## V. CONCLUSION

Based on the laboratory tests and experimental studies in the above the following conclusions were drawn.

1. Liquid limit and plastic limit of BC soil decrease with increasing % coir pith upto 4 % and further increases. That means at 4 % of coir pith optimum result is obtained.
2. Addition of coir pith and fly ash brings in an improvement in the compaction parameters of the study soil, by increasing the maximum dry density of soil with decrease in the corresponding values of optimum moisture content at 6 % of coir pith.
3. The liquid limit and plastic limit of the soils decrease with the addition of coir pith which indicates a desirable change as the soil + coir pith + fly ash mix can gain shear strength at an early stage than the virgin soil with the change in the water content. The relative decrease in the

plasticity index of the soils is another favorable change since it increases the workability of these soils. The shrinkage limit of the soil is optimum at 4% of coir pith which is 10.31 %.

4. The unconfined compressive strength of these soils increases upon the addition of coir pith and fly ash.
5. The specific gravity is decrease with addition of coir pith from 2.65 to 1.68.
6. The swelling characteristics is decreases from 22.22 % to 8.33 % at 4 % of coir pith and 4.85 % at 10 % of coir pith.
7. Coir pith& fly ash is used as a stabilizer for improving the geotechnical characteristics of black cotton soils. Addition of coir pith & fly ash significantly improves the index properties and engineering characteristics of black cotton soils understudy and the effects of coir pith and fly ash treatment vary depending upon the quantity of coir pith that is mixed with the study black cotton soil samples.

From above discussion it has been concluded that Industrial waste material which is cheaply and easily available in large amount i.e. coir pith and fly ash can improve the soil. This solution for soil improvement is environmental friendly and eco-friendly.

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