Experimental Studies on the Strength Behaviour of Clay Soil Treated with Coir Pith, Wood Ash and Rice Husk Ash

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***Abstract*—Soil stabilization is a process in which the engineering properties of the soil is altered and enhanced to increase its suitability for construction purposes. Stabilization of soil is commonly undertaken in the construction of air field, roads, foundations, landfills and embankments. The main objective of stabilization is to increase the soil strength. Clayey soil is most common in various region of India. Clay soil is having some undesirable properties like low strength and stability. It is essential to improve these properties to attain better performance. This study is to determine the strength behaviour of clay soil treated with wood ash, coir pith and rice husk ash. This paper describes a comparative of combination of this three stabilizing agents, so that the optimum percentage of the admixtures can be obtained to get maximum strength.**

Keywords — Stabilization; wood ash; coir pith; rice husk ash; OMC;MDD; Atterbergs limits ;UCC;CBR

I. INTRODUCTION

A firm foundation soil is needed for all type of structure. Soil is the medium through which the loads are transmitted . Suitable foundation soil is declining day by day due to its over use. So people are forced to use the unimproved clayey soil for various purposes such as pavement sub grade, embankment etc. It is necessary to treat such soil to improve the various soil properties by adding some additives.

Nowadays various additives are used for clay soil stabilization. The main reason for the stabilization is to increase the bearing capacity of the soil and also it affects swell and shrinkage property of soil. The liquid limit and plastic limit characteristics are also modified. Strength behavior of soil also get improved .One of the main fact to be considered for selecting the stabilizing additives is its easily availability at cheap cost. It should also yield maximum strength by adding minimum amount. They should be ecofriendly in nature. Various studies have been conducted for clayey soil stabilization by using combinations of two admixtures. Here the combinations of three stabilizing agents were involved. This paper describes the use of three wastes products wood ash, coir pith and rice husk to stabilise the clay soil samples collected. This experimental study describes a comparative study of stabilization of clayey soil with coir pith alone and a combination of coir pith and wood ash, similarly a combination of coir pith, wood ash and rice husk ash. The main objectives are to compare the performance of clay soil when stabilized with these additives and to find out which combination is the best. Also to find out the optimum percentages of admixtures which gives maximum strength to the soil and evaluate their suitability for the pavement subgrade.

II. MATERIALS

A. Clayey Soil

The clayey soil was collected from a paddy field in the location of Thamarassery, Kozhikode. The location is 11.2588 ^{0} N (Longitude) and 75.7804 ^{0} E(Latitude).

Fig .1 Clay soil

The soil samples were collected by removing the top soil upto 50cm. The sample was in fully saturated state. This collected sample is then kept for drying for several days. The air dried sample is then powdered to a fraction less than 4.75mm. The physical properties of soil obtained are shown in the Table 1

TABLE 1 PHYSICAL PROPERTIES OF SOIL

Specific gravity	2.64
Colour	Brown
Liquid limit	42%
Plastic limit	36%
Plasticity Index	6
Max. Dry density	1.04g/cc
Optimum moisture content	16.7%
Soil classification	Clayey soil with silt
Unconfined compressive strength	0.624kg/cm^2
Shear strength	0.312 kg/cm^2
CBR value	2.5%

B. Wood Ash

Wood ash was collected from house hold source. Wood ash is the residue powder left after the combustion of wood. Such as burning wood in home fire place or an industrial power plant. Wood ash is a good source of potash, so they are mainly used as a manure.

Fig .2 Wood ash

C. Coir Pith

Coir pith was collected from coir pith storage in the Pullanjimedu hilly region near Ambayathodu, Kozhikode district. This storage hills are the source of raw materials for Fisher footwear and mattress factory situated near by it. Coir pith is also called coco peat, coir fibre pith, coir dust, which are obtained by processing coconut husk and removing the long fibre. These are the byproducts of industries that use coconuts

Fig .3 Coir pith

Rice Husk Ash

Rice husk was collected from a grinding mill at Karanthur. The husk is then heated to get ash. Rice husk is the outermost layer of the paddy grain that is separated from the rice grain during the milling process. This husk is then heated to get ash.

Fig .4 Rice husk ash

III. METHODOLOGY

The basic properties and engineering properties of soil were found out. The properties include Specific gravity, Liquid limt, Plastic limit, Maximum dry density, Optimum moisture content, unconfined compressive strength, Shear strength, CBR value. Hydrometer test were also performed with the soil to find out its gradation. The liquid limit, plastic limit, compaction test, unconfined compression test, CBR test were performed in soil by adding the stabilizing agents. Firstly the soil is mixed with coir pith alone. The coir pith was varied from 0.5% to 3% in the increment of 0.5% by weight of soil. The percentage at which maximum result obtained was found out. This percentage of coir pith was kept fixed and wood ash is added. The percentage of wood ash was 2%, 6%, 8%, 10%, 15% (percentage adopted from studies of Gbenga *et.al.* (2013)). All the strength tests were performed with this coir pith and wood ash combination. The results were analysed and percentage of wood ash were find out on basis of maximum result. Finally by keeping fixed coir pith and wood ash content, the percentage of rice husk ash were varied as 3% to 15% with 3% of increment. The comparative study of clayey soil stabilized with Coir pith alone, Coir pith and wood ash, Coir pith, wood ash , rice husk ash was done .

A. Liquid Limit Characteristics

IS 2720 (Part V)-1985 Recommends the specifications for Liquid limit. Liquid limit test was conducted with various percentages of coir pith alone, coir pith and wood ash combination and coir pith, wood ash and rice husk ash combination.

TABLE 2 VARIATION OF LIQUID LIMIT BY ADDING COIR PITH, WOOD ASH AND RICE HUSK ASH IN DIFFERENT PERCENTAGES

Percentage of content	Liquid limit
Coir pith CP	
0.5% CP	34.765%
1.0%CP	29.65%
1.5%CP	40.465%
2.0%CP	45.36%
2.5%CP	47.36%
3.0%CP	31.53%
Coir pith CP and Wood ash WA	
2.5%CP + 2% WA	40.737%
2.5%CP + 6% WA	33.16%
2.5%CP + 8% WA	23.595%
2.5%CP + 10% WA	30.905%
2.5%CP + 15% WA	30.349%
Coir pith CP ,Wood ash and Rice husk ash	
2.5%CP +2%WA +3%RHA	35.357%
2.5%CP +2%WA +6%RHA	36.368%
2.5%CP +2%WA +9%RHA	37.35%
2.5%CP +2%WA +12%RHA	38.39%
2.5%CP +2%WA +15%RHA	-

B. Variation of Liquid Limit

It is noticed that the liquid limit of the clayey soil has been increased by 47.36% on addition of 2.5% of coir pith, it has been further decreased by 40.73% by adding 2% wood

ash and the value has been again decreased to 38.39% by adding 12% rice husk ash.

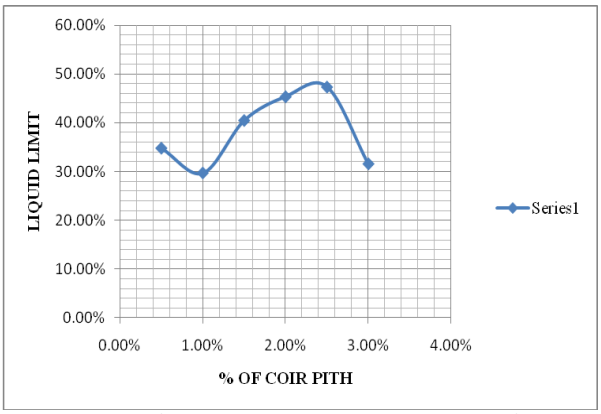

Fig. 5 Variation of Liquid Limit by increasing percentage of coir pith

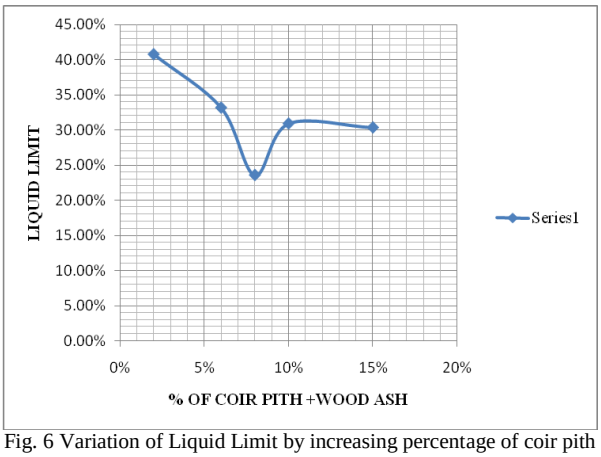

Fig. 6 Variation of Liquid Limit by increasing percentage of coir pith and wood ash

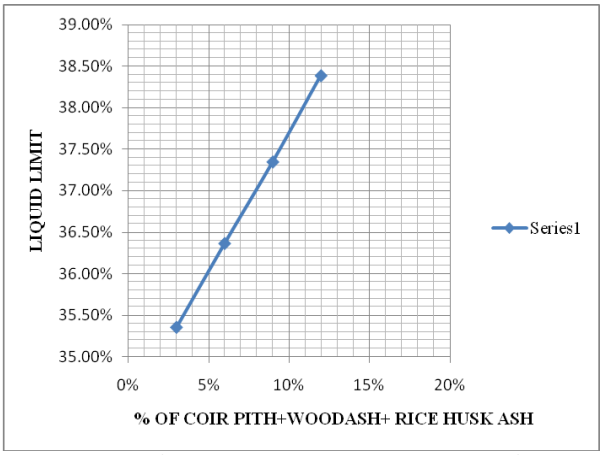

Fig. 7 Variation of Liquid Limit by increasing percentage of coir pith, wood ash and rice husk ash

C. Plastic Limit Characteristics

IS 2720 (Part V)-1985 recommends the specifications for plastic limit. Plastic limit of the clayey soil is 36% and the Plasticity index is 6. The plasticity tests give information concerning the cohesion properties of soil and the amount of capillary water which it can hold. They are also used directly in specifications for controlling soil for use in fill.

TABLE 3 VARIATION OF PLASTIC LIMIT AND PLASTICITY INDEX BY ADDING COIR PITH,WOOD ASH AND RICE HUSK ASH IN DIFFERENT PERCENTAGES

Percentage of content	Plastic limit	Plasticity index
Coir pith		
0.5% CP	21.30%	13.465
1.0% CP	27.62%	2.03
1.5%CP	24.13%	16.335
2.0%CP	28.50%	16.86
2.5%CP	26.2%	21.16
3.0%CP	21.94%	9.59
Coir Pith And Wood Ash		
2% CP+2% WA	21.733%	19
2% CP+6% WA	20.596%	12.56
2% CP+8% WA	18.586%	5.01
2% CP+10% WA	18.91%	11.99
2% CP+15% WA	-	-
Coirpith , Wood Ash And Rice Husk Ash		
2%CP + 2%WA +3%RHA	24.69%	10.66
2%CP + 2%WA +6%RHA	24.65%	11.71
2%CP + 2%WA +9%RHA	23.7%	13.65
2%CP + 2%WA +12%RHA	21.573%	16.82
2%CP + 2%WA +15%RHA	-	-

D. Variation of Plastic Limit

It is observed that the plastic limit of the clayey soil has been decreased to 28.5% on addition of 2% of coir pith and the value has been again decreased to 21.73% by adding 2% wood ash .Then it has been further improved by 24.69% by adding 3% of rice husk ash.

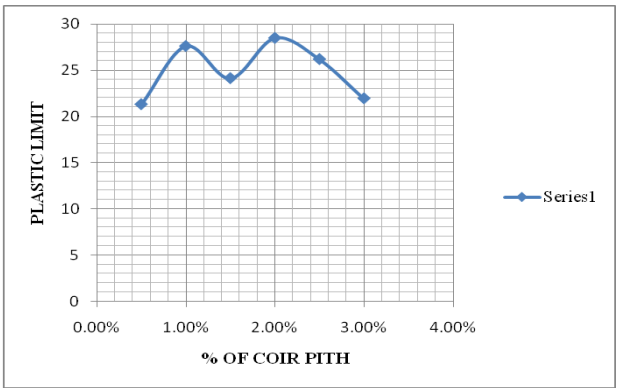

Fig. 8 Variation of Plastic Limit by increasing percentage of coir pith

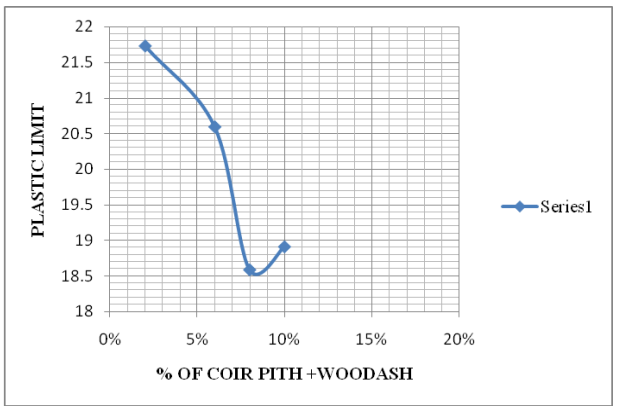

Fig. 9 Variation of Plastic Limit by increasing percentage of coir pith and wood ash

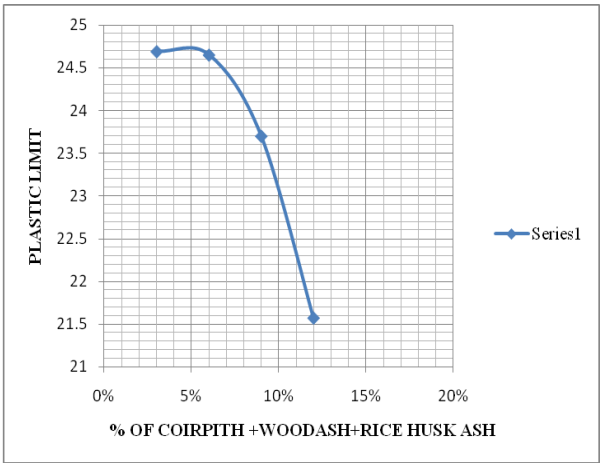

Fig.10 Variation of Plastic Limit by increasing percentage of coir pith,wood ash and rice husk ash

D. Compaction Characteristics

Light compaction test is used for the experiment. IS: 2720 (Part VII) recommends the specification of Standard Proctor Test (Light Compaction Test).

1) Variation of Dry density

It is noticed that the maximum dry density of the soil has been improved to 1.664 g/cc by addition 0.5% of coir pith, It has been decreased to 1.6071g/cc by addition of 8% of wood ash and further increased to 1.626g/cc by adding 3% of rice husk ash.

2) Variation of OMC

Optimum moisture content has been increased to 24.11% by addition of 2.5% of coir pith, it has been decreased to 20.60% by adding 2% of wood ash and has been further increased to 26.06% by adding 12% of rice husk ash.

TABLE 4 VARIATION OF MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE CONTENT BY ADDING COIR PITH IN DIFFERENT PERCENTAGES

Percentage of coir pith	Maximum dry density (g/cc)	OMC (w %)
0.5% CP	1.6446	19.59
1.0% CP	1.6098	21.69
1.5% CP	1.539	19.49
2.0% CP	1.5629	19.71
2.5% CP	1.4695	24.11
3.0% CP	1.4704	21.32

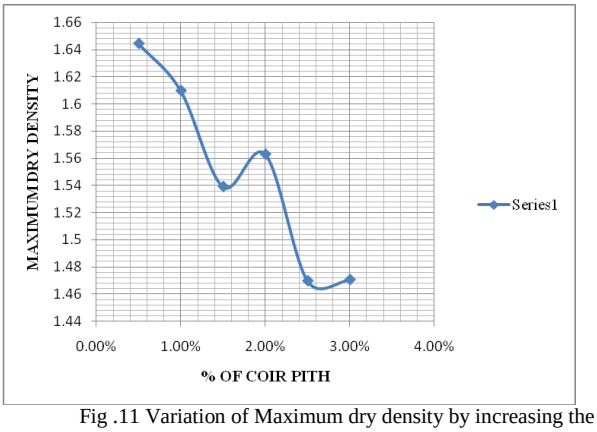

Fig .11 Variation of Maximum dry density by increasing the percentage of coir pith

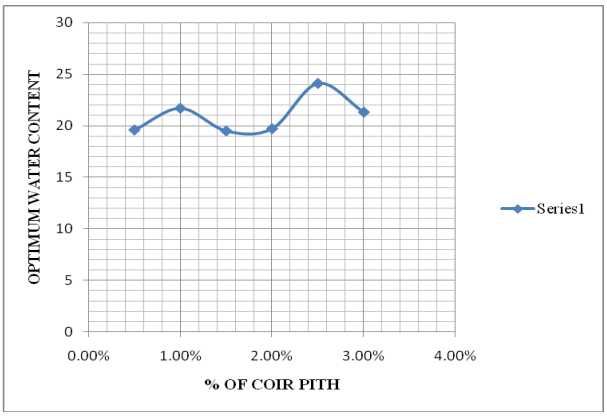

Fig.12 Variation of Optimum moisture content by increasing the percentage of coir pith

TABLE 5 VARIATION OF MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE CONTENT BY ADDING COIR PITH,WOOD ASH IN DIFFERENT PERCENTAGES

Percentage of coir pith and wood ash	Maximum dry density (g/cc)	OMC (w%)
0.5%CP+2% WA	1.5911	20.6062
0.5%CP + 6% WA	1.5788	19.0757
0.5%CP + 8%WA	1.6071	19.3439
0.5%CP+ 10%WA	1.5998	17.5703
0.5%CP+ 15%WA	1.5918	19.9270

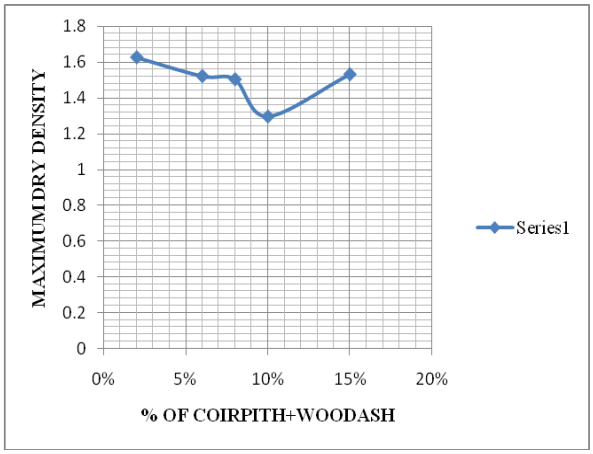

Fig . 13 Variation of Maximum dry density by increasing the percentage of coir pith and wood ash

TABLE 6 VARIATION OF MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE CONTENT BY ADDING COIR PITH,WOOD ASH AND RICE HUSK ASH IN DIFFERENT PERCENTAGES

Percentage of coir pith and wood ash and rice husk ash	Maximum dry density (g/cc)	OMC (w%)
0.5%CP+2%WA+3% RHA	1.626	11.16
0.5%CP+6% WA+6%RHA	1.521	13.82
0.5%CP+ 8%WA+9%RHA	1.503	16.12
0.5%CP+10%W+12% RHA	1.295	26.06
0.5%CP+15%WA+15%RHA	1.531	24.56

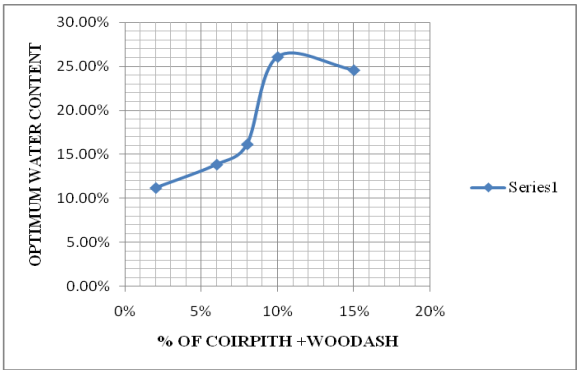

Fig. 14 Variation of Optimum moisture content by increasing the percentage of coir pith and wood ash

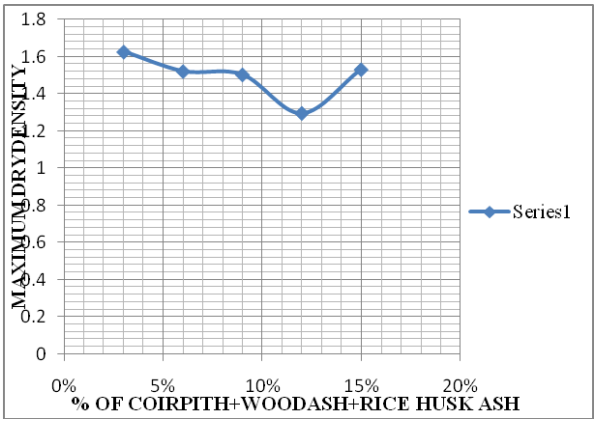

Fig . 15 Variation of Maximum dry density by increasing the percentage of coir pith,wood ash and rice husk ash

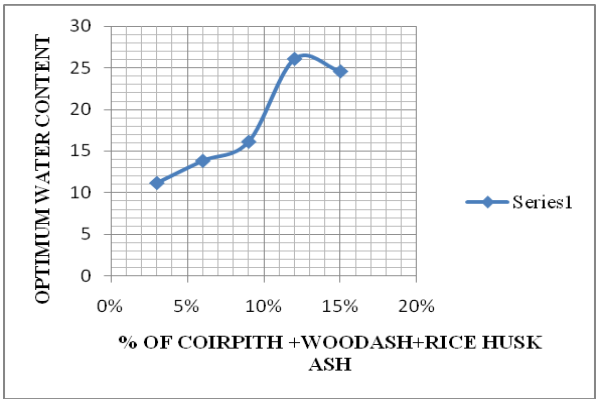

Fig . 16 Variation of Optimum moisture content by increasing the percentage of coir pith ,wood ash and rice husk ash

E. Unconfined compression strength characteristics

IS 2720 (Part 10)-1991 recommends the specifications for the unconfined compression strength test. It is the load per unit area at which an unconfined cylindrical specimen of soil will fail in the .axial compression test.

1) Variation of UCS

Unconfined compressive strength value gets decreased to 0.504 kg/cm^2 by addition of 2.5% of coir pith. It has been further decreased to 0.345 kg/cm^2 and it has been again decreased to 0.341 kg/cm^2.

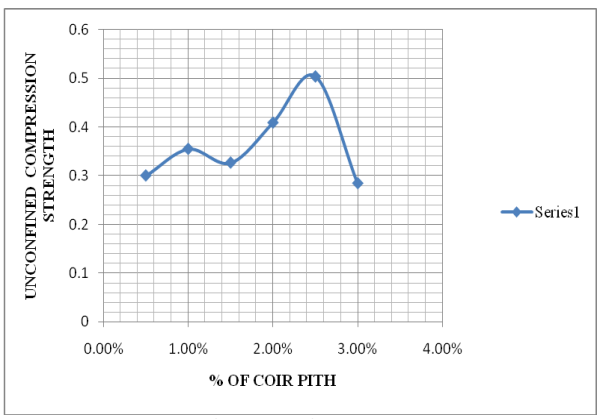

Fig . 17 Variation of by Unconfined compressive strength by increasing the percentage of coir pith

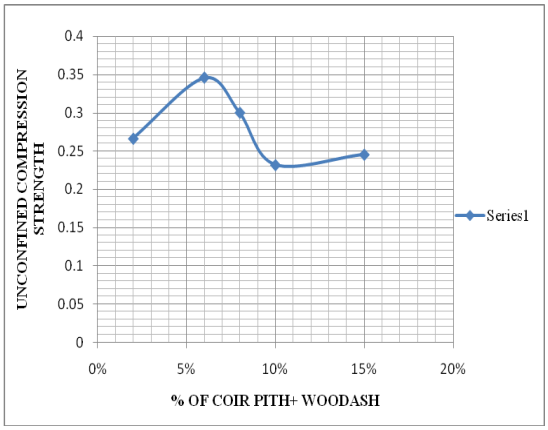

Fig . 18 Variation of by Unconfined compressive strength by increasing the percentage of coir pith and wood ash

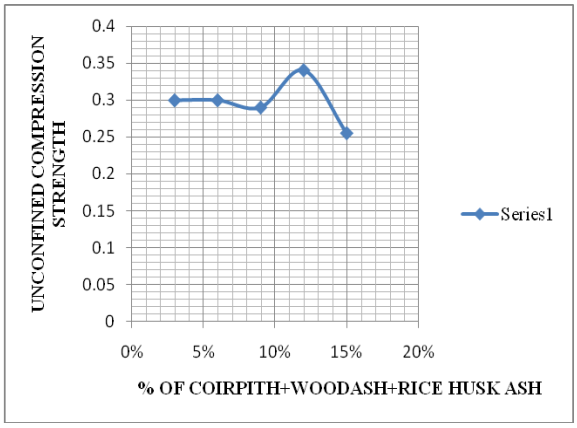

Fig . 19 Variation of by Unconfined compressive strength by increasing the percentage of coir pith,wood ash and rice husk ash

F. CBR Value Characteristics

IS 2720 (Part 16) -1987 recommends the CBR test specifications. The ratio expressed in percentage of force per unit area required to penetrate a soil mass with a circular plunger of 50 mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration in a standard material.

1) Variation of CBR value

CBR value has been increased to 12.15% by addition of 1% of coir pith and it has been further reduced to 9.74% by adding 10% of wood ash and again the value is increased to 10% by adding 12% of rice husk ash.

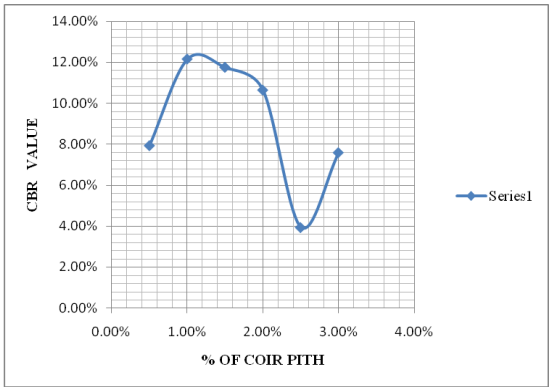

Fig . 20 Variation of by CBR Value by increasing the percentage of coir pith

TABLE 7 VARIATION OF CBR VALUE BY ADDING COIR PITH, WOOD ASH AND RICE HUSK ASH IN DIFFERENT PERCENTAGES

Percentage Of Contents	CBR Value
Coir Pith (CP)	
0.5% CP	7.93%
1.0% CP	12.15%
1.5% CP	11.75%
2.0% CP	10.64%
2.5% CP	3.941%
3.0% CP	7.591%
Coir Pith (CP) and Wood Ash (WA)	
1.0%CP + 2% WA	4.076%
1.0% CP + 6% WA	7.068%
1.0% CP + 8% WA	6.776%
1.0% CP + 10% WA	9.74%
1.0% CP + 15% WA	6.67%
Coir Pith(CP),Wood Ash(WA) and Rice Husk Ash(RHA)	
1.0%CP+10% WA+ 3.0% RHA	4.023%
1.0%CP+10% WA+ 6.0% RHA	8.682%
1.0%CP+10% WA+ 9.0% RHA	6.988%
1.0%CP+10%WA+ 12.0% RHA	10.006%
1.0%CP+10%WA+ 15.0% RHA	7.068%

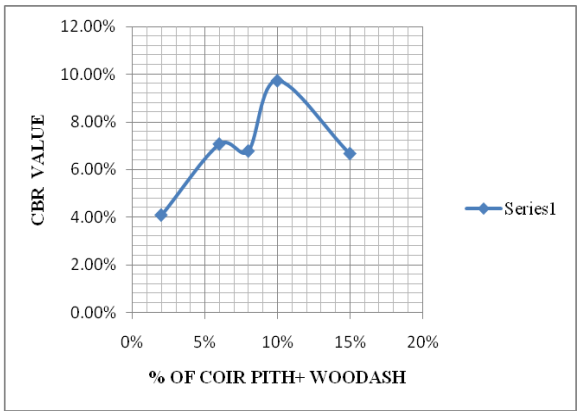

Fig .21 Variation of by CBR Value by increasing the percentage of coir pith and wood ash

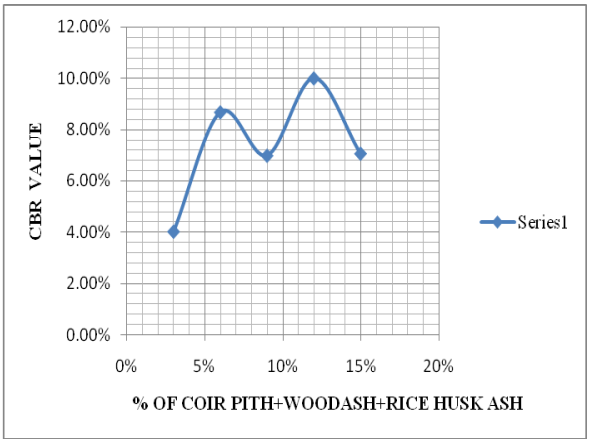

Fig . 22 Variation of by CBR Value by increasing the percentage of coir pith,wood ash and rice husk ash

CONCLUSION

- The maximum value of liquid limit can be obtained by adding 2.5% of coir pith alone.
- The maximum value of plastic limit can be attained by addition of 2% of coir pith alone.
- Plasticity index will gave a maximum value by the addition of 2.5% of coir pith.
- Maximum dry density value is observed by adding coir pith by 0.5%./
- Optimum moisture content is getting maximum value by adding 2.5% of coir pith, 2% of wood ash and 12% of rice husk ash.
- Unconfined compressive strength get decreased by adding these three admixtures.
- CBR value is increasing 4 times of its initial value.
- This test can be done by adding plastic fibre along with the additives. So that unconfined compression strength get improved.

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