EFFECT OF PHOSPHOGYPSUM AND FLYASH IN STABILIZATION OF CLAY

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Abstract— The major problem in clays are their low strength and high compressibility. It has created several damages to the engineering structures. Therefore some soil in their natural state needs some treatment to increase desired properties. This is achieved by adopting soil stabilization techniques. Towards this it is better to utilize Phosphogypsum, because it is a cheap material and is the by- product of the production of fertilizer also has less radioactivity. Flyash is also selected because it is the combustion product of coal. The liquid limit, unconfined compressive strength test and compaction, test by varying percentages of phosphogypsum and flyash in the Thonnakal clay has been done separately. The optimum value of the tests was used for californiya bearing ratio test for obtaining CBR value. The results of stabilization of phosphogypsum and fly ash were compared. Usage of these materials will not only improve the strength but the cost of construction can also be reduced.

Index Terms— Phosphogypsum, Flyash, Stabilization, Atterberg limit, UCS test, CBR

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1 INTRODUCTION

Nowadays civil engineers facing challenges towards the constructions in the clay soils. The major problem in this is the low strength and high compressibility of clays. So it is important to change the properties of soil to meet the required strength before construction. That is why we are adopting the stabilization technique. There are a lot of techniques by means of natural methods or by using industrial resources.

I analyzed the use of Phosphogypsum and Flyash separately to stabilize the Thonnakkal Clay of English India Clay Limited in Trivandrum District, Kerala. Phosphogypsum, chemically known as calcium sulphate hydrate. It is a product of the production of fertilizer from phosphate rock, composed of gypsum (CaSo4.2H2O). Gypsum is widely using in construction industry, but phosphogypsum is not usually using. Phosphogypsum can be easily stored because of its weak radioactivity.

Flyash is called as Pulverized fuel ash. It is the combustion product of coal, composed of the particulates coming out from the boilers with the Flue gases.

In this project work I have prepared individual test results of the strength characteristics of the stabilization of Thonnakkal Clay with the Phosphogypsum and Flyash

Aykut Senol and Ehsan Etminan (2012), they stabilized the clay soil using Flyash and Homopolymer polypropylene (HPP). The flyash and HPP were added with different percentages to the soil and determined the engineering properties of these mixtures. They conducted the standard proctor compaction test using the equipment, Harvard miniature compaction equipment. **Merlin Joseph**(2013) has conducted a study using Flyash in expansive clay soil. She collected the clay from Tiruchengode, Tamilnadu, India and conducted various experiments using different percentages of Flyash (0,10,20,30 & 40%), such as atterberg limit, specific gravity, unconfined compressive strength and standard proctor's compaction tests, and she found that plasticity index and specific gravity of clayey soil getting reduced but optimum moisture content and maximum dry density getting increased with the addition of different percentages of Flyash. **K Divyakrishnan** (2016) done with a fixed percentage of Flyash (5%) and varying percentages of Phosphogypsum (2,4 & 6%) were added on to the weak soil at varying curing condition. **Devipriya VP** (2017) studied the change in properties of swelling clays such as atterbeg limit, compaction characteristics, unconfined compressive strength and swelling characteristics with the addition of the Phosphogypsum. **Shriful Islam**(2018) collected two types of Flyash from a coal combustion electric power plant. It found that the addition of Flyash (5%) in the soil results increase in its unconfined compressive strength (UCS).

1.2 Objectives : The main objective of this project is to stabilize the clay with Phosphogypsum and Flyash separately and to compare it's performance.

1.3 Problems associated with clay : The major problem in the clay soil is its low strength and high compressibility. It damages the civil engineering structures, so stabilization using waste materials will help to decrease the overall construction cost also.

2. MATERIALS AND METHODOLOGY

2.1 THONNAKKAL CLAY

Thonnakkal clay were collected from English India Clay Limited in Trivandrum District,Kerala,which having low strength. The soil samples were collected, dried and made it in powdered form.The properties of this sample were found out as per IS 2720-1985 as shown in Table 1.

Fig 1 : Thonnakkal Clay

TABLE 1 : PROPERTIES OF SOIL SAMPLE

PROPERTIES	SAMPLE
Specific gravity	1.8
Liquid limit, W_L (%)	75
Plastic limit, W_P (%)	48
Plasticity Index, I_p (%)	27
Shrinkage limit, W_s (%)	21
Percentage of clay	99.65
Percentage of silt	0.35
Optimum moisture content (%)	32
Maximum dry density(g/cc)	1.35
Unconfined compressive strength, q_u (KN/m^2)	0.248
California bearing ratio(%)	2.1

2.2 PHOSPHOGYPSUM

The phosphogypsum samples were collected from Tuticorin, Tamilnadu.The properties of Phosphogypsum is shown in Table 2.

Fig 2: Phosphogypsum

TABLE 2 : PROPERTIES OF PHOSPHOGYPSUM

PHYSICAL PROPERTIES	
Color	Half white
CHEMICAL PROPERTIES	
Moisture	12%
ANALYSIS AFTER DRYING	
Calcium as CaO	%W/W 32.80
Sulphate as SO_3	45.80
Total phosphate as P_2O_5	0.30
Water soluble phosphate as P_2O_5	0.08
Total fluoride as F	0.46
Water of hydration	19.50
Magnesium as MgO	0.10
Sodium as Na_2O	0.10
Potassium as K_2O	0.04
Iron as Fe_2O_3	0.01
Aluminium as AL_2O_3	0.0
Silica as SiO_2	1.20
Cloride as CL	0.004
Organic matter	0.15
Ph of 1% solution	5.60

2.3 FLYASH

Flyash is also known as 'Pulverised fuel ash' and it is a coal combustion product. Class C Flyash is used here. The properties of Flyash is shown in Table 3.

Fig 3: Flyash

TABLE 3: PROPERTIES OF FLYASH

PROPERTIES	VALUES
Liquid limit(%)	82%
Plastic limit(%)	Non plastic
Specific gravity	2.08
Maximum dry density(KN/m3)	13.1
Optimum moisture content(%)	26%

2.4 EXPERIMENTAL WORK

Different percentages of phosphogypsum (0.5, 1, 1.5, 2&2.5%) were added to the clay soil. Then found out the atterberg limit, unconfined compressive strength (UCS) compaction test & CBR. The amount of water added for UCS test were the corresponding liquid limit for each sample. The same procedure has been carried out by using Flyash with the percentages of 2,4,6,8,10,12&14. The atterberg limit test was conducted on Thonnakkal clay as per IS: 2720 part4 (1970). The results of this study are discussed below:

The liquid limit and plasticity index are decreased with the increasing percentages of phosphogypsum and is shown in Table 4 &5.

TABLE 4: ATTERBERG LIMITS OF SOIL-PHOSPHOGYPSUM MIXTURES

PROPERTIES	% of Phosphogypsum					
	0	0.5	1	1.5	2	2.5
Liquid limit (%)	75	73	69	65	62	56
Plastic limit (%)	48	47	47	46	46	45
Plasticity index	27	26	22	19	16	10

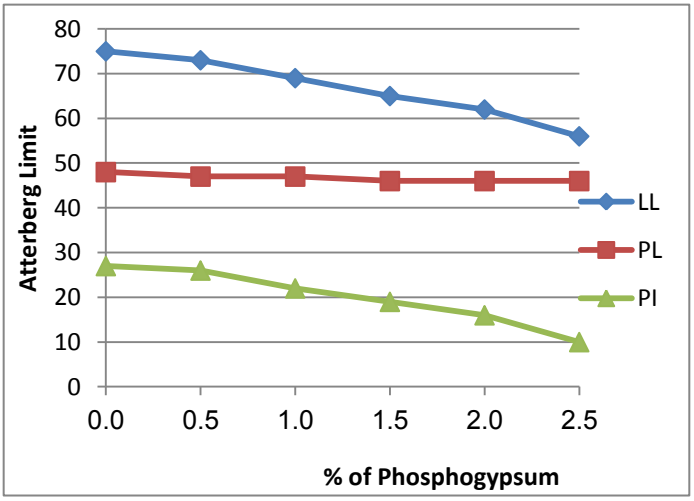

Fig 4: Vriations in Atterberg limit

TABLE 5: ATTERBERG LIMITS OF SOIL-FLYASH MIXTURES

PROPERTIES	% OF FLYASH							
	0	2	4	6	8	10	12	14
Liquid limit (%)	75	73	72	70	68	66	63	62
Plastic limit (%)	48	47	47	46	45	44	43	42
Plasticity index	27	26	25	24	23	22	20	20

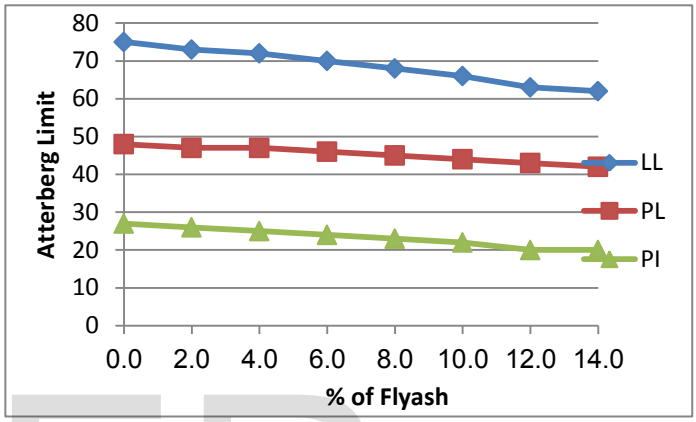

Fig 5: Vriations in Atterberg limit

The unconfined compressive strength tests were carried out as per IS 2720 part10 (1973). The amount of water added to each sample was the corresponding liquid limit. The mixing of the sample were carried out as per the standard procedure. The unconfined compressive strength values were increases with the increasing percentages of flyash and phosphogypsum also.The maximum strength obtained by the addition of 2%of phosphogypsum to the sample was compared to the Flyash addition. The results were shown in Table 6&7 and which is shown in figure 6.

TABLE 6: UNCONFINED COMPRESSIVE STRENGTH VALUES OF SOIL-PHOSPHOGYPSUM MIXTURES

% OF PHOSPHOGYPSUM	UCS VALUE (KN/m2)
0	24.8
0.5	31.4
1	81.4
1.5	90
2	102
2.5	100

TABLE 7: UNCONFINED COMPRESSIVE STRENGTH VALUES OF SOIL-FLYASH MIXTURES

% OF FLYASH	UCS VALUES(KN/m²)
0	24.8
2	16.6
4	17.2
6	18.8
8	19.2
10	23.8
12	29
14	21

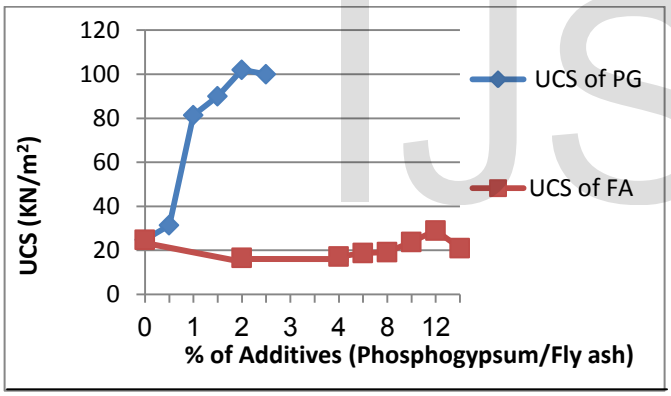

Fig 6: Vriations in UCS values

The compaction tests was done as per IS: 2720 part 6(1974) and the result shows that the maximum dry density will be increased and the OMC will be decreased with the increasing percentages of sample. In case of the soil-phosphogypsum mixtures the maximum dry density will be obtained at 2% and 12% for soil-flyash mixtures. The results were tabulated on Table 8&9 and is shown in figure 7.

TABLE 8: COMPACTION TEST RESULTS OF SOIL-PHOSPHOGYPSUM MIXTURES

%OF PHOSPHOGYPSUM	MDD(g/cc)	OMC(%)
0	1.35	32
0.5	1.48	28
1	1.58	26
1.5	1.814	24
2	2.1	22
2.5	1.9	22

TABLE 9: COMPACTION TEST RESULTS OF SOIL-FLYASH MIXTURES

%OF FLYASH	MDD(g/cc)	OMC(%)
0	1.35	32
2	1.36	30
4	1.42	30
6	1.49	28
8	1.56	26
10	1.59	26
12	1.61	24
14	1.58	22

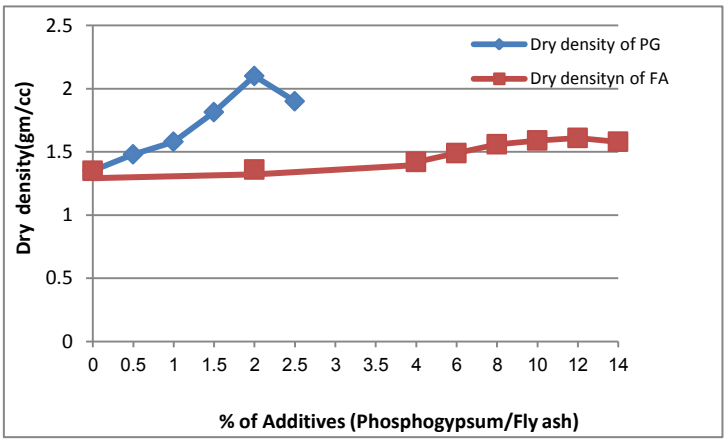

Fig 7: Variations in Dry density

The CBR values increases with the increase in percentages of materials are shown in Table 10.

TABLE 10: VARIATION OF CBR VALUES

MATERIAL	CBR VALUE(%)
2% of phosphogypsum+clay	10.1
12% of flyash+clay	8.2

3. CONCLUSION

- ✓ The flyash and phosphogypsum improves the properties of the clay
- ✓ The addition of materials improve the plasticity characteristics. Thevalues of the liquid limit ,plastic limit and plasyicity index will decreases with an increase in percentage of phosphogypsum. It indicate the decrease in plasticity properties. The more decrease in plasticity properties will occurs with the increase.
- ✓ Compared to flyash stabilization a small percentage of phosphogypsum improves the properties of the clay.
- ✓ The UCS value of the clay increased to 102KN/m^2 by the addition of 2% of phosphogypsum. But by the addition of 12% of phosphogypsum the UCS value only increased to 29KN/m^2 and hence the only small percentage of phosphogypsum provide more strength to the clay.
- ✓ The MDD increases to 2.1g/cc by the addition of 2% of phosphogypsum.
- ✓ CBR value increases from 2.1 to 10.1% by the addition of 2% of phosphogypsum and in case of 12% of flyash addition the value will increases only up to 8.2%, hence.

phosphogypsum will provide more strength to clay

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REFERENCES

[1] Aykut Senol and Ehsan Etminan. (2012) "Stabilization of clayey soils using flyash and homopolymerpolypropylene", GeoCongress.

[2] Merlin Joseph(2013) "A study on soil stabilization of clay soil using flyash", International Journal of Research in Civil Engineering, Architecture & Design Volume 1, Issue 2, pp. 33-37.

[3] K Divyakrishnan (2016)"Uttilization of phosphogypsum and flyash in soil stabilization".

[4] Devipriya VP (2017)"Effect of phosphogypsum as a stabilizing agent for swelling clays",National conference on recent advancements in geotechnical engineering.

[5] Shriful Islam(2018)"Sstrength development in clay soil stabilized with fly ash".