

Geotechnical Enhancement of Clayey Soil Treated with Phosphogypsum, Lime & Flyash

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Abstract -This study describes the Effective use of industrial waste material Phosphogypsum, Flyash & Lime for Stabilization of high compressible clay soil. The objective is to investigate Geotechnical properties of insitu soil & find the optimum % composition of admixture used for the stabilisation process. It is also included to improve, CBR Values of treated soil. The composition of PG in this research , on the basis of deep study, it is taken as 0%,3%,5%,7% with flyash 0%,5%,10%,15%,20% and lime 0%,3%,6%,9% in which 5 different mixes are tested to get optimum composition of these admixture. Experimental investigation shows PG to be 3% with FA to be 10% and Lime 3%. This ratio improved MDD from 1.579% to 1.70% but it also increases optimum moisture content from 19% to 21.5%, however it reduces atterberg limits and plasticity behaviour, and beneficially increases CBR value. When PG, FLYASH & LIME react with optimum dose of water in clay soil then it forms an cementitious compound C-S-H & C-A-H gel which helps to bind & interlock all the clay particle with each other. Hence PG&FA which is producing as abundant industrial waste is effectively & economically contributed towards sustainable & economical soil stabilization process.

Key Words:- Industrialwaste, Phosphogypsum, Flyash, C-S-H & C-A-H gel, Cementitious, Soil Stabilization,

1 INTRODUCTION

As we know that high compressible clay soil contains montmorillonite in its mineral constituent, Due to which it cause a lot of problem when it is used in Engineering Applications like soil subgrade construction, slope stability , Settlement in foundation work etc. So it is highly recommended to stabilize the soil using different applications like mechanical method & chemical method. Roller compaction is used in the process of mechanical stabilization . Several admixture is used for chemical stabilization process such Lime, Flyash, surkhi, cinder, GGBS, Egg Shell powder, silica fumes, iron ore tailing, Phosphogypsum etc. I have used Phosphogypsum as an admixture for my research purpose which is obtained from phosphate rock when crushed in phosphate fertiliser industries.This Admixture is collected form PPL(paradeep phosphate limited) odisha. Phosphogypsum is manufactured by the filtration process by phosphoric acid in industry, where insoluble gypsum are divided from the product. With this view an investigation is was undertaken with industrial waste to produce cementitious

binder by blending the flyash with PG for treating the expansive soil. PG with flyash [7] combination increases the later strength development by accelerating pozzolanic reaction which has been studied for increasing properties as at different curing period as the admixture is used in this stabilisation process.

In this research I used Phosphogypsum[3] along with its complementary admixture Flyash[1] and Lime to support reaction and increase the engineering properties of soil like MDD, Bearing Strength, and improve index properties. Pg supplies sulphate and calcium while flyash provide silica & alumina. Their reaction forms cementitious compound which increases soil strength. This combination reduces plasticity Index & swelling Potential of Expensive Clay Soil. Flyash fill soil void & PG helps in Binding particle together, resulting in better Compaction.[10][12]

2 EXPERIMENTAL INVESTIGATION ON RAW SOIL

For the Experimental investigation, Clay soil is collected from dudhkol, sahebganj (JHARKHAND), Flyash is collected from ACC plant Sindri, dhanbad,(JHARKHAND) & Phosphogypsum is collected form PPL(paradeep phosphate limited) Odisha. In Experimental investigation firstly find the specific gravity test with the help of Pycnometer, then find its Index properties. With the help of these properties, Soil is then classified As per I.S soil classification[18] system which comes out to be high compressible clay (CH). It is due to the presence of high % of montmorillonite in it, Hence the soil would create a lot of problem when it is used in Engg. Purposes like slope instability, swelling shrinkage, Cracks in it, settlement or differential settlement in the foundation work, subgrade work in flexible pavement construction etc. MDD value is obtained using SPT of 945cc cylinder and 2.5kg hammer gives the result Low as 1.579 gm/cc and then further tested for UCS test using 5KN cont. load and proving ring calibration as 5.917 N. CBR test is performed using 50KN load and proving ring calibration constant 0.06738KN or 67.38N. All the test result is mentioned below in the table no.1

Table-1 Experimental Investigation Results Obtained on Engineering properties of Insitu clayey soil

1	NATURAL MOISTURE CONTENT	2%
2	SPECIFIC GRAVITY	2.458 %
3	LIQUID LIMIT	51.61%
4	PLASTIC LIMIT	24.37%
5	SHRINKAGE LIMIT	10.426%
6	PLASTICITY INDEX	27.24%
7	GRAIN SIZE DISTRIBUTION < (0.075mm)	95.53%
8	FREE SWELL INDEX	21.42%
9	OMC	19.5%
10	MDD	1.579
11	CBR	1.303%
12	UCS	34.3kpa

Now Compaction is done using light Compaction Standard proctor test of hammer 2.5kg and volume of cylinder 945cc. to find MDD & OMC which comes out to be as given in fig. 1.4



Figure 1.3 Performing Light SPT test

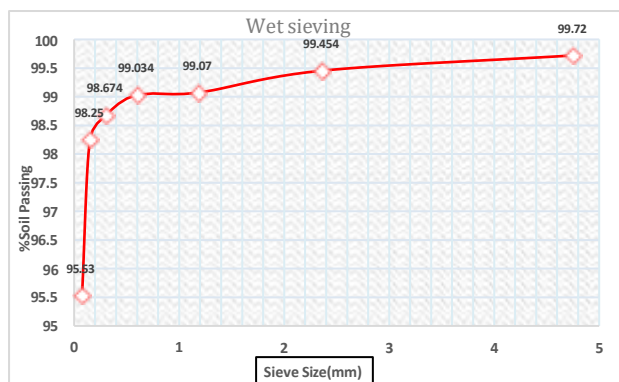


Figure 1.1 Wet sieving result of insitu clay soil

Total wt. passed through 75um sieve is 95.65% hence it is fine grained cohesive clay soil.

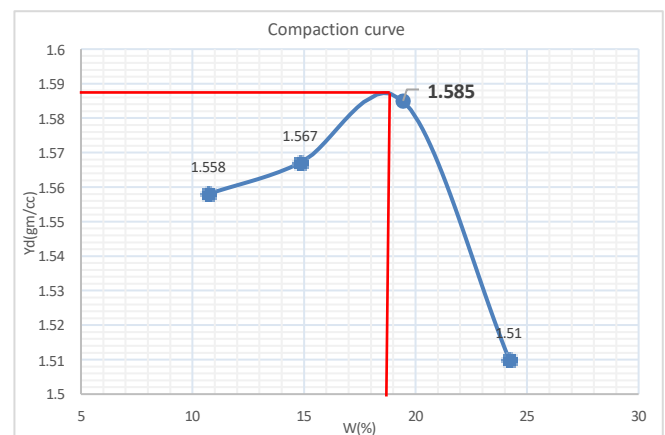


Figure 1.4 Trend of MDD v/s OMC of untreated Soil with diff. % of admixture (PG+LIME+FA)

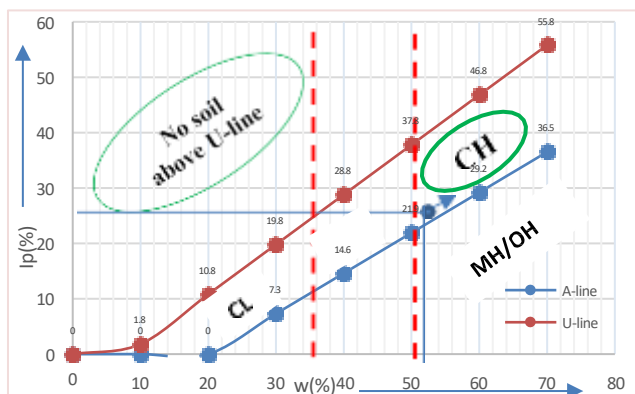


Figure 1.2 I.S Plasticity Chart of Insitu Soil

As per the observation of data after the index properties of soil is Experimentally calculated, it is found that soil is above the A-line and liquid limit comes out to be >50% hence this soil is high compressible clay soil (CH) as given in fig.1.2 [18]

When OMC & MDD is known by SPT test then UCS sample is prepared on the same OMC and 3 sample is extracted to get average of all 3 samples so that uniformity can be maintained. The reading is noted From both Dial gauge and proving ring in which one give load after calibration and other give penetration value by which strain in the sample is calculated. From all the Calculation a table is prepared which give all calculated value of strain load corrected Area and lastly the stress required to cause failure in the sample. [22][14][13]



Figure 1.5 UCS test Apparatus and sample testing

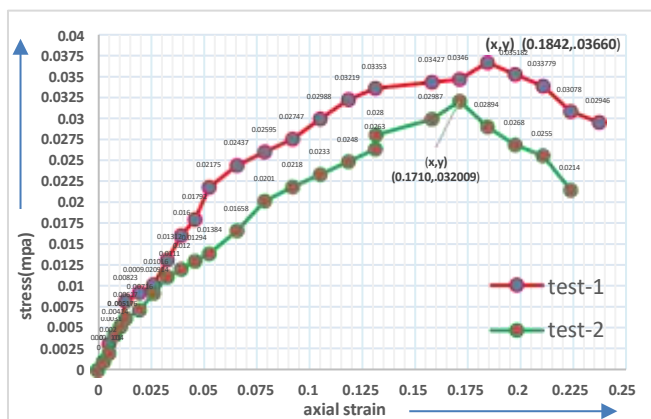


Figure 1.6 UCS test result of two sample of untreated soil

This test gives the result of unconfined compressive strength of soil by which Cohesion value of soil is further calculated by doing half of UCS values.

California Bearing Ratio (CBR) test [23] is basically done to find the quality of soil to use it as soil subgrade during flexible pavement construction. With the help of CBR value, the thickness required for soil subgrade is calculated. Test sample is prepared at OMC which is shown in the figure 1.7



Figure 1.7 CBR test apparatus & Sample

The test result of CBR is plotted in the graph in the figure 1.8

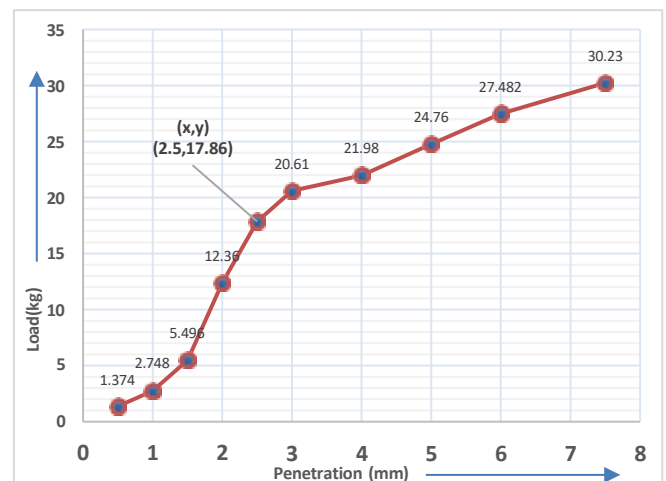


Figure 1.8 CBR test result

It is observed that graph is going convex initially that means the test is okay if it is found concave initially, then test is repeated again. Finally the load corresponding to 2.5mm penetration value is noted and CBR Value is calculated by std. formula.

3 EXPERIMENTAL INVESTIGATION USING ADMIXTURE TO THE SOIL

Specific gravity is find separately to all admixture. Then mix is decided to be prepared for the test, as per the literature review so that it would be within the limit of its optimum % to stabilize the Clay soil. 5 mixes are prepared with different % of admixture & soil. Keeping two admixture constant. One is varied and then variation is recorded similarly dose is increases and optimum mix is recorded by repeating the same process.



Figure 1.9 All admixture & soil kept in Container

White powder is Quick lime, Greyish colour is Flyash, and off white colour is of phosphogypsum in the Container

Table- 2 Mix proportion of Admixture and soil

MIX PROPORTION	PG(%)	FA(%)	LIME(%)	SOIL(%)
A	3	5	3	89
B	3	10	3	84
C	3	15	3	79
D	5	20	6	69
E	7	20	6	67

Soil is firstly prepared [16](oven dry, crushing, sieving etc.) for all the test Atterberg test is carried out to find Index properties of treated soil & classify the soil. On the Basis of Experimental investigation it is found that with the replacement of soil with % admixture, liquid limit is found to be decreasing. On the basis of lab test on different mix sample the optimum mix is then classified[18] as given in the fig. 1.9

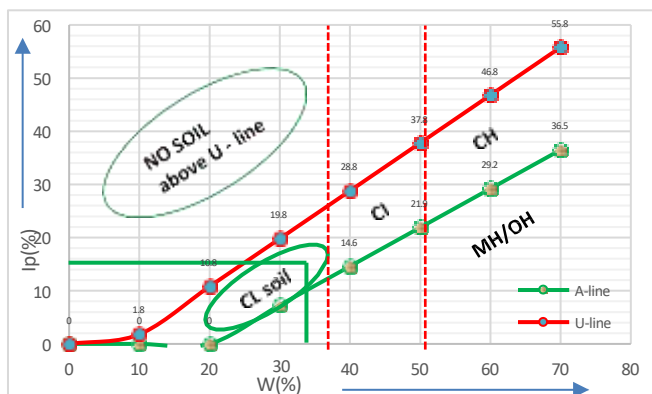


Figure 1.9 I.S Plasticity chart of treated soil at optimum mix.

Some of the index properties is plotted with increasing replacement of flyash content in the soil is shown below in Table 3 and fig. 2.0

Table 3 Effect of Increasing flyash on index properties of soil

Mixture (soil+FA)	W _{opt} (%)	Y _d (g m/cc)	W _L (%)	W _p (%)	Ip(%)
1.Soil+FA (0%)	19.5	1.579	51.61	24.37	27.24
2.Soil+FA (5%)	17	1.56	53.2	27.12	26.08
3.Soil+FA (10%)	18.2	1.57	47.21	25.4	21.81

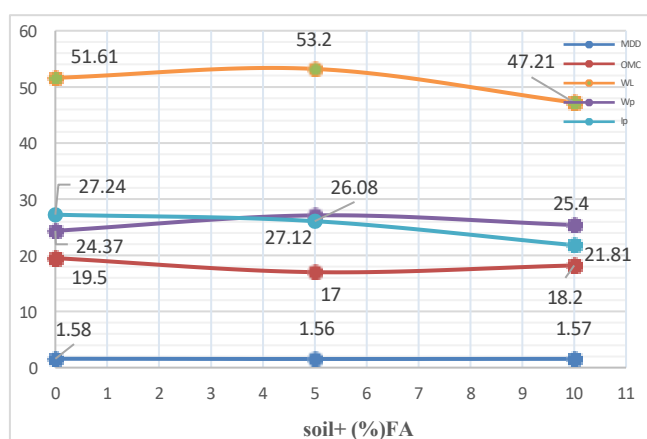


Figure 2.0 Variation of index properties with increasing % of FA.

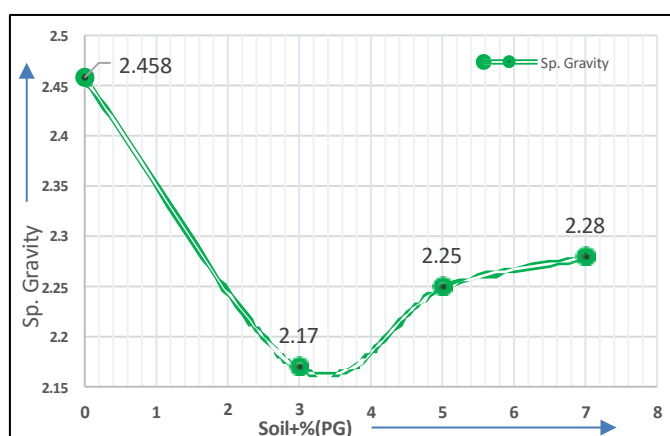


Figure 2.1 Variation of Sp. Gravity with [soil +%PG]

When soil is replaced with %PG in increasing then Sp. gravity increases. [17] As shown in figure no. 2.1

In case of performing Atterberg test, liquid limit [19]for the case of optimum mix sample is observed as 33.4% corresponding to 25 no. of blow which is Represented in terms of flow index in the given fig. 2.2

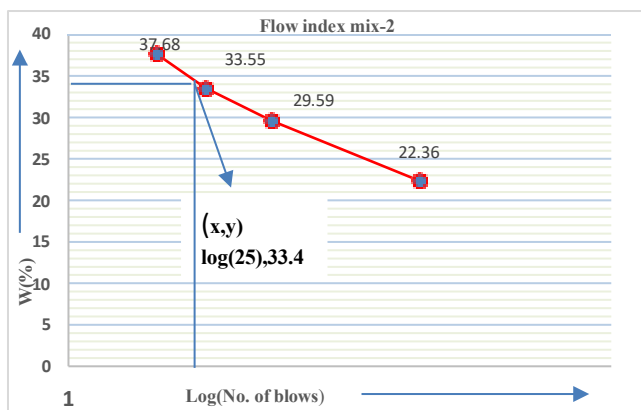


Figure 2.2 flow index of mix sample -B(optimum)

For finding the optimum mix composition of admixture & soil at which, MDD & OMC is obtained, SPT test is performed on all the mix prepared and variation is plotted on the graph & maximum compaction is noted in all the mix which is shown in the figure 2.3 [19]

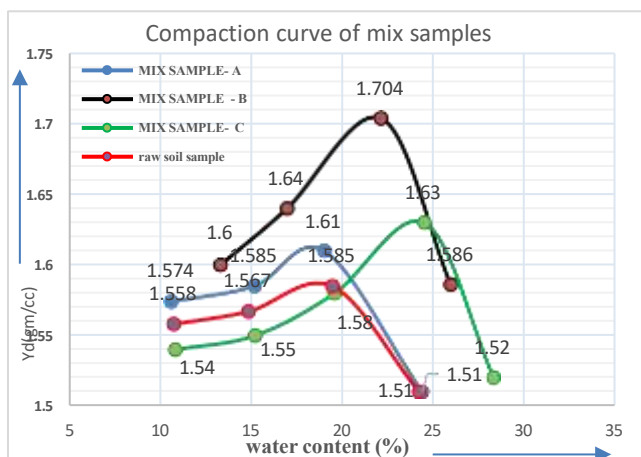


Figure 2.3 Compaction Curve of Different Mixes of Soil with Admixture

For the Construction of pavement Subgrade CBR % helps to Calculate the thickness of material required as per its quality .So different mix prepared is tested for CBR test[23] and reading in the test is noted and plotted on graph shown in figure 2.4 [7][10]

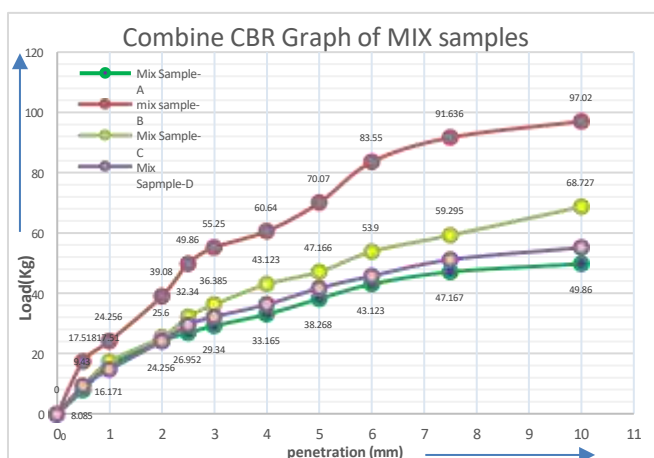


Figure 2.4 Combine CBR graph of All mix prepared

It is observed that Mix sample-B is showing maximum CBR value as compared to other hence this mix can be adopted for the compaction process in CBR test and further this ratio can be also applied on the field .

4 RESULTS AND DISCUSSIONS

S.N	PROPERTIES	UNTREATED SOIL	TREATED SOIL
1	SP.GRAVITY	2.458	2.25
2	LIQUID LIMIT	51.61%	33.6%
3	PLASTIC LIMIT	24.37	18.435%
4	PLASTICITY INDEX	27.24	15.165%
5	SOIL CLASSIFICATION	CH	CL
6	OMC	19.5	21.5%
7	MDD	1.579	1.70
8	CBR	1.303	3.64%
9	FREE SWELL INDEX	21.40%	

5 CONCLUSIONS

After performing all the Experimental investigation it is concluded that:-

- 1.) Plasticity behavior (W_L , W_s , W_p , I_p ,) is improved with respect to virgin soil.
- 2.) MDD increases After optimum compaction, which stabilizes the soil to use it for Engg. Purposes like pavement subgrade construction, foundation work etc.
- 3.) CBR value increases as to the desired range so that upto this level the soil is fit to use for the construction purposes.
- 4.) A step is taken towards the sustainable development as the industry waste PG&FA can be used as construction material to stabilizes the soil for achieving its desired Engg. Properties.

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