Study on the Strength Characteristics of Biopolymer on Kaolinite Clay

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***Abstract*: The benefit from mixing admixtures in soil to enhance properties was discovered in ancient times. Additives such as straw, bitumen, lime, cement etc are using to improve the properties of soil from the past days. As an alternative to such traditional soil treatment and improvement techniques, biological approaches are recently developed in the field of soil stabilisation. This paper investigate the benefits of using biopolymer to enhance the engineering properties of kaolinite clay. Guar gum which is an environmental friendly biopolymer was mixed with kaolinite clay at different concentrations (0.25%, 0.5%, 0.75 %, 1 %) and the effect on different engineering properties were determined.**

***Key words:* Ground improvement, guar gum, kaolinite clay, UCC, CBR.**

I. INTRODUCTION

The modification or stabilisation of engineering properties of soil is recognised by engineers as an important process for improving the performance of problematic soils and makes marginal soils to perform better as a construction material. A number of modification techniques has been identified in this field. Admixtures such as straw, bitumen, salts are conventional additives to soil, while cement, petrochemicals etc are being increasingly used as an effort to stabilise the soil from mechanical and chemical aspects.

The use of conventional materials may lead to environmental degradation. As a part of environmental sustainability biological approaches are now being actively introduced in the field of geotechnical engineering with the aim of less environmental pollution.

Microbial induced polymers or biopolymers have been introduced as a new innovative idea for soil improvemet. natural biopolymers are environmental friendly and a sustainable grouting chemicals.

Application of biopolymers to soil as a stabilising and strengthening agent of aggregates was under consideration in the agricultural engineering from 1940's (Karmi et.al 1997). Biopolymer isustainable carbon neutrality and always classified as a renewable material because it is made from agricultural non-food crops. Therefore, the use of biopolymer in geotechnical engineering would create a sustainable industry (Shipp and Braun, 1997).

Addition of biopolymers reduces drainage channel erosion, reduce organic pollutants ad prevent piping of earth dams (Lvanov et.al. 2008). Biopolymer improve slope stability on berm ranges and reduces the loss of sediment in surface water runoff (Larson et.al. 2012). Bio induced minerilisation in soil may reduce the porespace of soil and strengthen the particle contacts leading to increased strength, decreased permeability and compressibility (Dejong et.al. 2013).

Strengthening effect of guargum and xanthan gum was shown to have greatest effect on poorly graded sand with fine particle and with air drying periods (A.T. shah et.al.2016). Biopolymer addition results in the formation of new cementitious products that form chemical reactions between biopolymer and soil at micro level which improve soil structure and strength (Suksun et.al.2017).

Experimental results of expansive soil treated with various percentages of guar gum gel for various water content results the improved strength of expansive soil. Biopolymer addition leads to the increase of intercept and cbr values of expansive soils (Gujjula et.al 2018).

Objectives of study: This paper mainly focuses on the engineering properties of cohesive soil before and after the addition of nano materials.

II. MATERIALS AND METHODOLOGY

2.1 Kaolinite Clay

Kaolinite is the most common clay with soft consistency and earthy texture. They have low bearing capacities. Kaolinite clay taken from mangalapuram region, thiruvananthapuram district was selected for the study. The soil was collected, dried and powdered. It was tested as per IS 2720-1985 and the basic soil properties was found out. The basic properties of the clay is found as shown in Table 1.

Fig 1 : Kaolinite clay

2.2 Guar gum

Guar gum is a galactomannan polysaccharide extracted from guar beans that has thickening ans stabilising property. Guar gum used for the study was collected from Gajanana trading company, Bangalore.

Fig 2 : Guar gum powder

Table 1 : Properties of soil sample

PROPERTIES	SAMPLE
Specific gravity	2.64
Liquid limit, W_L (%)	77
Plastic limit, W_p (%)	40
Plasticity Index, I_p (%)	37
Shrinkage limit, W_s (%)	25
Percentage of clay	70
Percentage of silt	30
Optimu moisture content (%)	25
Maximum dry density(g/cc)	1.58
Unconfined compressive strength, q_u (kg/cm^2)	0.142
California bearing ratio(%)	1.7
USCS Classification	CH

2.3 Sample preparation

For the sample preparation dry mixing method is adopted. Guar gum powder was directly mixed with soil before adding water and then water is added to soil guargum mixture. Soil sample is mixed with various percentage of guargum powder (0.25 %, 0.5 % , 0.75 % , 1%).

Table 2: Properties of Guargum

Content	Sample
Physical state	Dry, cream coloured powder
Ash (%)	7 – 12
Nitrogen (%)	0.3 - 0.1
Acetate (%)	1.9 – 6
Pyruvate (%)	1.0 -5.7
Mono valent salt (%)	3.6 - 14.7
Divalent salt (%)	0.085 - 0.17
Viscosity	13.37

2.4 Experimental work

The soil sample mixed with guar gum biopolymer concentration of 0.25 %, 0.5 %, 0.75% and 1%. Atterberg limits, compaction test, CBR test, UCC test etc were done on the sample prepared with different concentration of biopolymer. For performing UCS test water is added at the corresponding liquid limit for sample preparation. CBR specimens are prepared with OMC attained by compaction test.

III. RESULTS AND DISCUSSIONS

The results of the study are discussed below:

With the addition of different dosages, the liquid limit of the sample is seen to be decreasing with the increase in guar gum concentration. The results of liquid limit is tabulated in table 3 and shown graphically in fig 3.

Table 3: Variaton of liquid limit with bio polymer content

BIOPOLYMER CONTENT (%)	LIQUID LIMIT (%)
0	76
0.25	75.8
0.5	75.4
0.75	74.6
1	74.2

The results of compaction test was found as, maximum dry density is increasing and also the corresponding OMC content increasing. The MDD is obtained at 0.75 % biopolymer. The results of compaction test is tabulated on table 4 and shown graphically in figure 4.

UCC value increases with the increase in biopolymer content upto 0.75 % and decreases on further addition. The results of UCC test is tabulated on table 5 and graphically shown in fig 6.

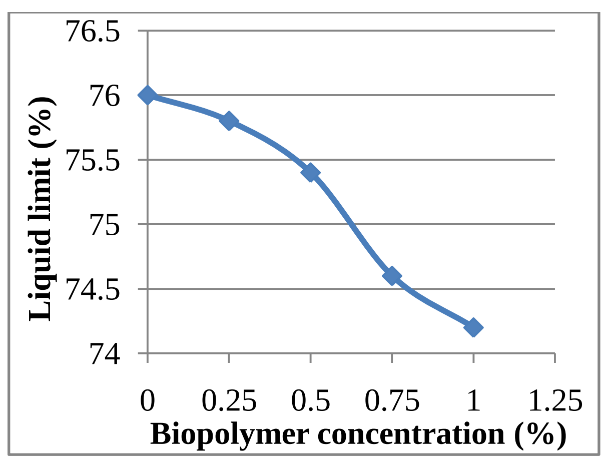

Fig 3: Variation of liquid limit with BP content

Table 4: Variation of OMC and MDD for % of Biopolymer

BP CONTENT (%)	OMC (%)	MDD (g/cc)
0	25	1.62
0.25	27	1.82
0.5	29	1.96
0.75	31	2.35
1	35	2.12

CBR value increases with increase in BP content upto 0.75 % and then decreases on further addition. The results of CBR test is shown in table 7 and figure 8.

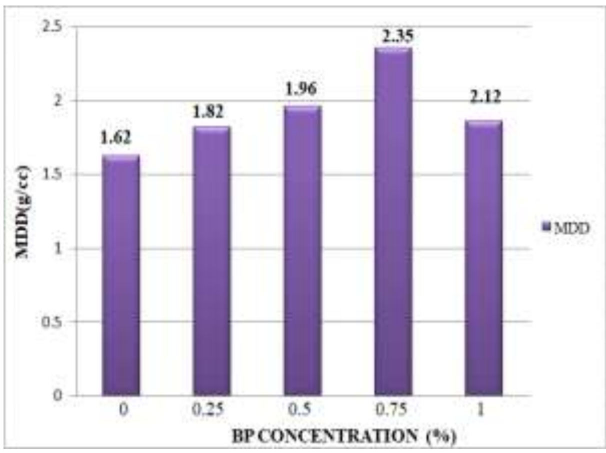

Fig 4: Variation of MDD with BP content

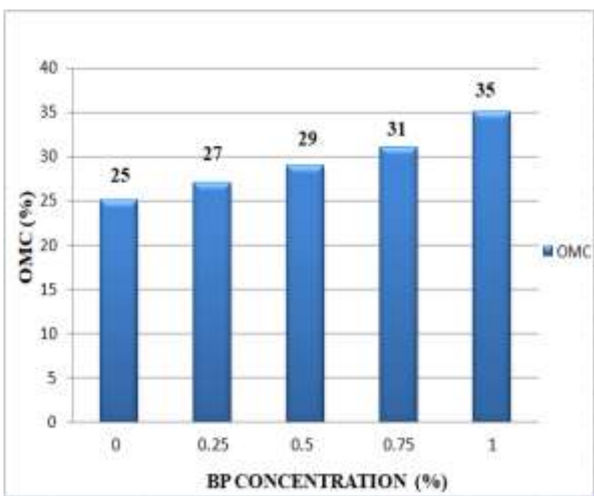

Fig 5: Variation of OMC with BP content

Table 5: Variation of UCC value with BP content

BP content (%)	UCC Value (kg/cm^2)
0	0.12
0.2	0.13
0.5	0.14
0.75	0.15
1	0.13

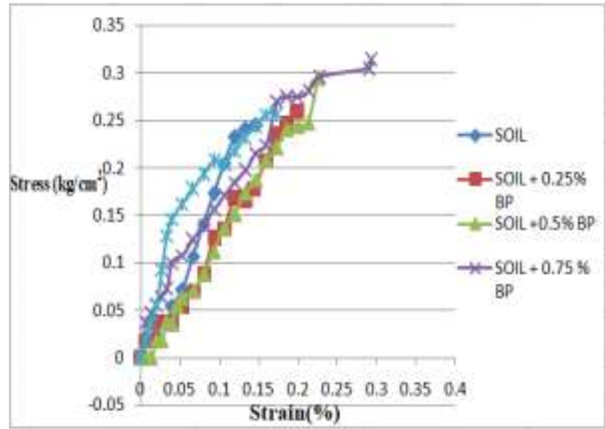

Fig 6 : Stress v/s strain curve for varying % of BP content

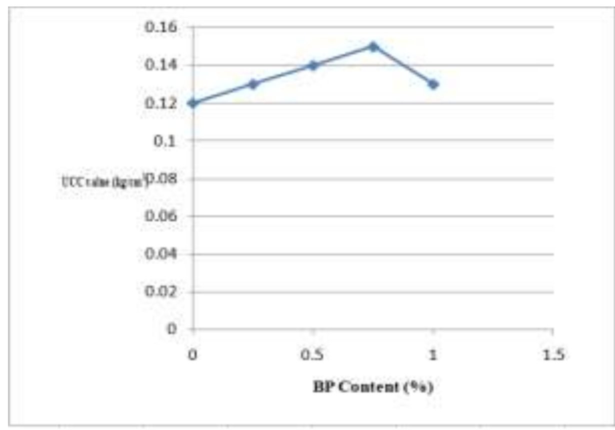

Fig 7: Variation of UCC value with BP content

Table 6: Variation of CBR value with BP content

BP CONTENT (%)	CBR VALUE (%)
0	1.9
0.25	2.5
0.5	4.8
0.75	6.9
1	5.6

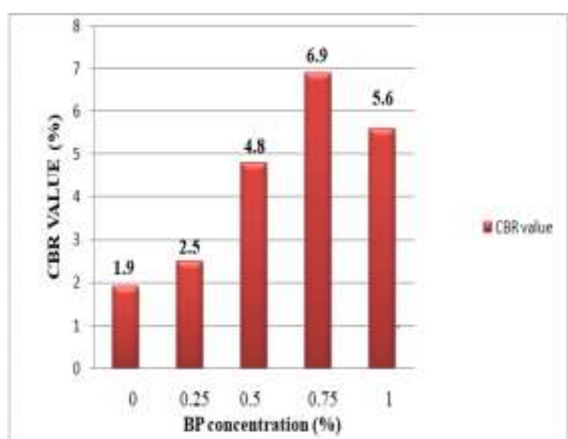

Fig 8: Variation of CBR value with BP content

IV. CONCLUSIONS

The addition of biopolymer improved the properties of selected clay. The CBR and UCC value increased and the liquid limit of the clay is decreased with biopolymer addition.

- The optimum value of biopolymer content is found to be 0.75 %.
- The liquid limit of clay is reduced to 74.2 % from 76%.
- The MDD of Clay is increased to 2.35g/cc when treated with 0.75 % of guar gum.
- CBR value of the clay is increased to 6.9% from 1.9% with the addition of guargum. Therefore the clay became suitable for pavement construction.

Therefore it can be concluded that biopolymer addition improve the engineering properties and index properties of clay and make it more suitable for different purposes.

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