International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 03 | Mar 2020 www.irjet.net p-ISSN: 2395-0072

Effect Of Biopolymers on the Behaviour Of Sand

SruthyK[1], Vishnu T.C[2], Anju E.M[3]

[1]*Reasearch student, Dept. of civil Engineering. IES College of engineering, Kerala, India*
[2]*Assistant professor, Dept. of civil Engineering. IES College of engineering, Kerala, India*
[3]*Assistant professor, Dept. of civil Engineering. IES College of engineering, Kerala, India*

Abstract -*Problematic soils are often treated with chemical stabilizing materials to improve their engineering properties. These materials have proven successful in improving the engineering properties of the soil such as shear strength, compressibility, permeability, bearing capacity etc. Most of these Chemical are toxic and hazardous for the environment and high quantity of greenhouse gases are generally created during their production. So an environmental friendly soil treatment method or Biological Treatment Method (BTM) can be used to improve the engineering properties of sandy soils. The current study illustrates the suitability of Xanthan gum and Starch as an eco friendly additive that can improve the engineering properties of sand. Experiments were performed on both untreated and biopolymer treated sand at various curing times, including Direct shear test and Permeability test. Significant engineering property improvement was observed during the first 14 days of curing. Addition of starch at same Xanthan gum concentration increased the soil cohesion and also enhance stiffness of soil.*

1. INTRODUCTION

Soil treatment and improvement is commonly performed in the field of geotechnical engineering.
The main purpose of soil treatment and improvement is to enhance the engineering characteristics of a particular soil, including its strength, hydraulic conductivity, and durability against different environmental conditions. Two primary methods are conventionally applied to produce engineered soil: mechanical improvement and chemical treatment. Mechanical improvement is a process of reinforcing the strength of the soil through physical processes such as compaction, drainage, external loading ,consolidation, or other means. Chemical treatment involves chemical reactions such as hydration or pozzolanic reactions inside the soil to create artificial binding, such as the use of calcium silicate hydrate (C-S-H) between soil particles. As an alternative to such traditional soil treatment and improvement techniques, biological approaches are now being actively investigated in the field of geotechnical engineering, including microbe injection and byproduct precipitation. In particular, microbial induced polymers—or biopolymers—have been introduced as a new type of construction binder especially for soil treatment and improvement. The current research investigates the potential of two biopolymers, namely xanthan gum and starch to enhance the strength of sand.

1.1 Objectives of the Project

This study was conducted to investigate the shear strength and permeability characteristics of sands by carrying out direct shear test and constant head permeability test. Determination of index properties, shear strength and permeability characteristics of sand is done first after that shear strength and permeability of biopolymer treated sand were studied. Finally results were compared to find the trend in values

1.2 Scope of the Study

This project is done to get more knowledge about an environmentally friendly soil stabilization technique. Project aims at improving the properties of locally available cohesion less soil using biopolymers. In the present study, a series of direct shear tests and constant head permeability tests have been carried out to investigate the shear strength and permeability characteristics of a fine sand treated with xanthan gum and starch. Xanthan gum was added at 0.5,1, and 2% by weight of the sand. Starch was added at 0.5 and 1 % by weight of sand. Index properties and engineering properties of the sand were found out from laboratory tests such as Grain size, permeability, specific gravity, relative density and shear strength. The influence of various parameters such as biopolymer content and curing time on the strength behavior of the sand-Biopolymer mixes has been studied.

2. MATERIALS USED

The materials used were locally available river sand, Xanthan gum and starch biopolymers

2.1 Sand

The sand chosen for the study was a river sand obtained from Bharathapuzha near Kuttippuram. The sand was air dried for conducting all the laboratory tests. The grain size distribution was found using IS: 2720-part 4. For conducting direct shear test the sand was sieved through 4.75 mm IS sieve

Fig -1: Sand collected from river side

2.2 Biopolymers

Biopolymers are organic polymers that are synthesized by biological organisms. They consist of monomeric units that are bonded into larger formations .Among the three typical types of biopolymers—polynucleotides (e.g., RNA and DNA), polypeptides (e.g., composed of amino acids), and polysaccharides—polysaccharides have been the most commonly applied contemporary biopolymer type in various practices. Polysaccharides are polymeric carbohydrate chains composed of monosaccharide units. Polysaccharides are widely found in nature because they are employed in key biological roles, as substances forming skeletal structures, assimilative reserve substances, and water binding substances. The properties of polysaccharides have led to their widespread use as thickening agents, stabilizers, sweeteners, and gel forming agents in the fields of food production, agriculture, cosmetics, medical treatment, and pharmaceuticals.

2.2.1 Xanthan gum

Xanthan gum is an extracellular polymer produced mainly by the bacterium Xanthomonascampestris. Xanthan gum solutions are pseudoplastic, which means that the viscosity of a xanthan gum solution decreases with an increased shear rate. Xanthan gum, unlike other gums, displays higher stability over a broad range of temperatures and pHs. In practice, xanthan gum has long been used as a drilling mud thickener in the oil industry because it provides consistent rheology through the drilling hole. It has also been used as an additive in concrete for enhancing viscosity and stopping washouts.

Fig -2: Xanthan gum

2.2.2 Starch

Starch is a polysaccharide that composed of two homopolymers of D-glucose and amylase. It can be naturally found in a variety of plants, such as maize, rice, wheat, potatoes, and cassava , and it has been applied in numerous areas outside of food and agriculture. The major area of starch application in geotechnical engineering has been in adhesives for drilling fluids.

3. METHODOLOGY

First step was collection of materials. The materials used for the study was collected from native places. Then the index properties of sand were found out to know the characteristics. Tests conducted are Specific gravity, Determination Relative density, Sieve analysis, Direct shear test and Permeability of sand. Then 0.5% of Xanthan gum is added into sand and direct shear test, permeability test were done. To know the trend in shear strength and permeability, the concentration of Xanthan gum is increased and tests were repeated. Found the concentration of Xanthan gum which gives optimum result. 0.5%,1% starch was added to the soil with that Xanthan gum concentration. Direct shear test and Permeability test were conducted to find the effect of both biopolymers on soil properties.

4. RESULT AND DISCUSSION

Experiments were conducted on soil samples for determining the index properties and engineering properties. Results of these tests are discussed and tabulated below. Further study on improvement of biopolymer added sand are done by direct shear test and constant head permeability test. Results obtained are plotted and compared below

Table -1: Properties of sand

Properties of sand			
Specific gravity	2.51	Permeability	1.9258x10^-3
Coefficient of uniformity	1.78	Angle of internal friction (degrees)	35
Coefficient of curvature	1	Cohesion(kg/cm^2)	0
Relative density (g/cc)	1.56		

Direct shear test conducted for sand with different percentage of biopolymer, Normal stress and different curing time. Graph plotted based on test results are shown below.

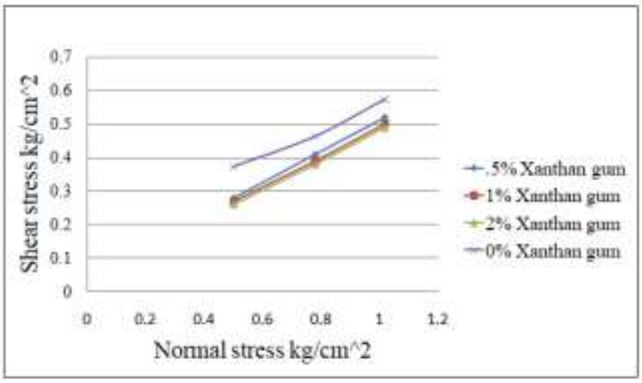

Chart -1: Shear stress Vs Normal stress plot For different xanthan gum concentration at 0 day curing

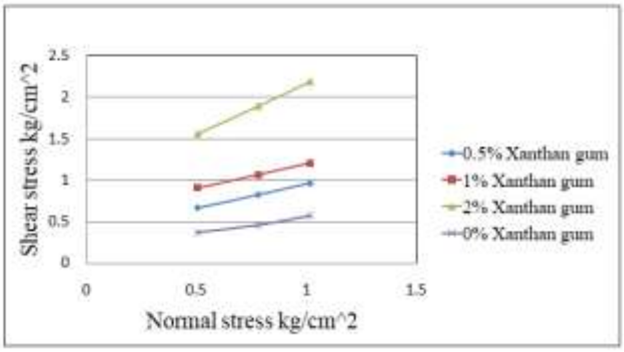

Chart -2: Shear stress Vs Normal stress plot for different xanthan gum concentration at 3 day curing

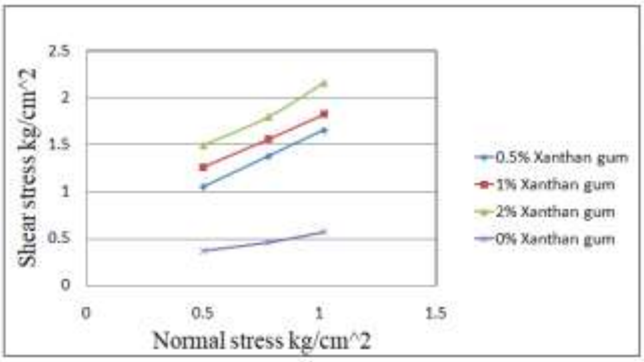

Chart -3: Shear stress Vs Normal stress plot For different xanthan gum concentration at 7 day curing

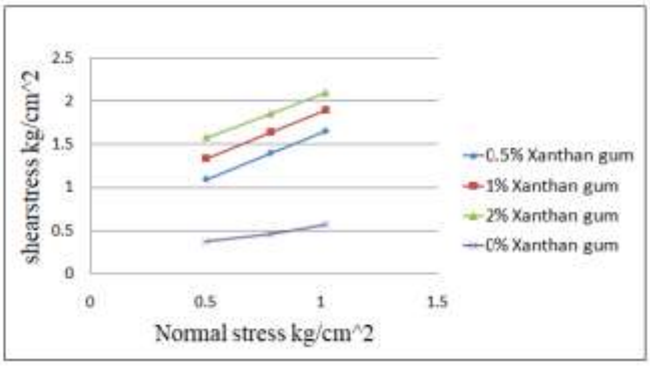

Chart -4: Shear stress Vs. Normal stress plot for different xanthan gum concentration at 14 day curing

Chart 1 to 4 shows the Shear Stress Vs. Normal stress graph for biopolymer treated sand. The percentage of xanthan gum increased in each test and studied. From the graph an increase in shear strength with increase in percentage of xanthan gum can be observed. When the normal stress is increased up to 100kpa the increase in shear stress is due to the increase in the inter particle binding of treated sand. Viscous characteristics of xanthan gum have a significant meaning for stability of the soil. Samples with greater amount of the xanthan gum appear much more stable. It is because the sand grains stick to each other, and create a linked structure.

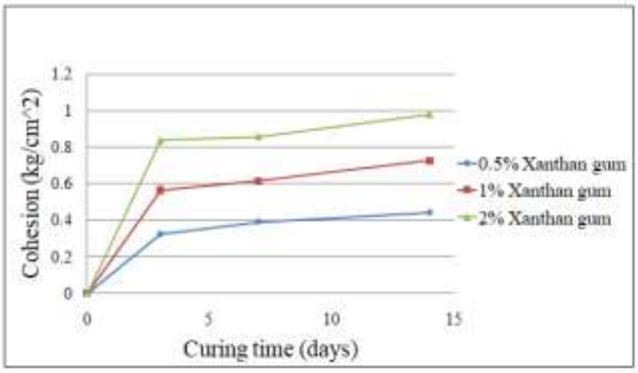

Chart -5: Cohesion Vs Curing time plot for different xanthan gum concentration

In chart 5the comparison of soil cohesion with curing time is shown. As the curing time increased from 0 to 14days the cohesion is getting increased for all concentrations of xanthan gum. The cohesion value of untreated soil was 0.

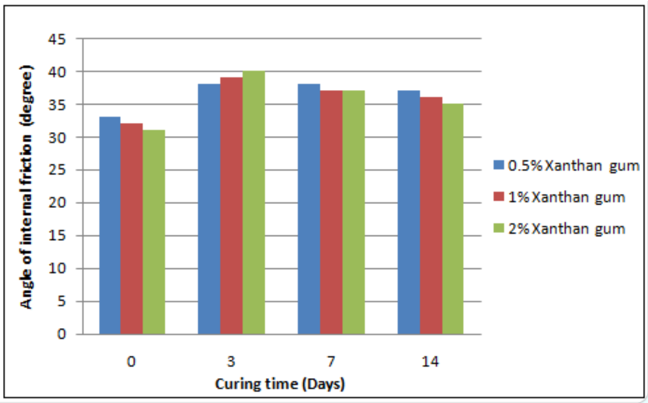

Chart -6: Angle of internal friction Vs Curing time for different xanthan gum concentration

In chart 6 the graph of Angle of internal friction with curing time is shown. The angle of internal friction increased upto day 3 and then decreased.

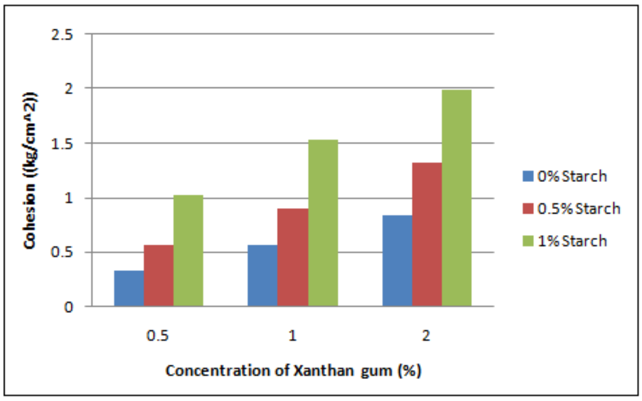

Chart -7: Cohesion Vs Concentration of xanthan gum plot for different starch concentration

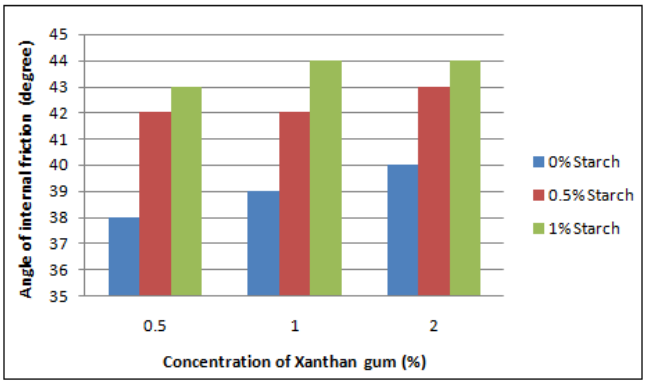

Chart -8: Angle of internal friction Vs Concentration of xanthan gum plot at different starch concentration

In chart 7 and 8 the comparison of soil cohesion and Angle of internal friction with concentration of xanthan gum for different starch content is shown. As the xanthan gum concentration increased from 0.5 to 2% the cohesion is getting increased for all starch content. And also the angle of internal friction shows an increasing trend for all starch contents. When the biopolymer is placed in the soil matrix, it is desired to undergo some form of cross-linking in order to enhance strength and decrease its mobility in the ground. Cross-linking connects polymeric chains through chemical reactions, which might be initiated by temperature rise, change in pressure and pH. The process can form a comprehensive lattice in the soil matrix, which rigidifies the whole polymeric structure, enhance its mechanical strength.

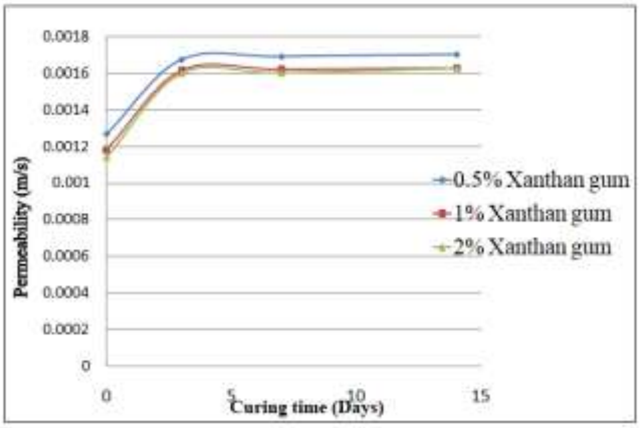

Chart -9: Permeability Vs Curing time plot For different biopolymer concentration

In chart 9 the graph of permeability with curing time is shown. The permeability of sand decreased as the concentration of xanthan gum increased. And a longer curing time provide a lower hydraulic conductivity. It is because xanthan gum reduce the permeability of sandy soils by filling their pores and enhance the soil erosion resistance by increasing water retention.

5. CONCLUSIONS

A series of laboratory experiments were conducted to quantify improvements in strength and Permeability of xanthan gum and starch treated sand. Direct shear test results indicated that 2 % xanthan gum and 1 % starch additive levels achieved optimal stabilization results for sand. Generally, increased additive levels and curing time yielded increases in shear-strength values measured in direct shear tests and increased stiffness for tests conducted on stabilized specimens. The most significant improvement in the permeability of the treated specimens generally occurred on 2 % Xanthan gum concentration and the permeability increases as time passes. In general, significant improvements in engineering properties were observed over the 14 days of specimen curing for biopolymer treated sand, at fairly low levels of additive use. These observations illustrate the potential of xanthan gum and starch as an effective stabilizer for problematic sandy soils. The improvement in performance of sand treated with xanthan gum was found to be directly dependent on the biopolymer concentration. In conclusion, biopolymer treatment occurs to be a promising tool to modify the engineering behavior of soils. The eco-friendliness and cost of biopolymers also add to their attractiveness for use in engineering applications

REFERENCES

[1] Hamid Reza Khatami1 and Brendan C. O'Kelly, "Improving Mechanical Properties of Sand Using Biopolymers" Journal of geotechnical and geoenvironmental engineering, August 2013

[2] Mateusz Wiszniewski and Ali FiratCabalar "Hydraulic Conductivity of a Biopolymer Treated Sand" New Frontiers in Geotechnical Engineering , ASCE 2014

[3] Mohamed K. AyeldeenAbdelazim M. Negm "Using biopolymer materials to enhance sandy soil behavior" International Multidisciplinary Scientific Geo-Conference , 2014

[4] NimaLatifi, SuksunHorpibulsuk,ChristopherL.Meehan, MuhdZaimiAbdMajid,Mahmood Md Tahir, and EdyTonnizam Mohamad, "Improvement of Problematic Soils with Biopolymer—An Environmentally Friendly Soil Stabilizer" Journal of Materials in Civil Engineering, 2017

[5] NurullahAkbulut and Ali FiratCabalar "Effects of Biopolymer on Some Geotechnical Properties of a Sand" New Frontiers in Geotechnical Engineering , ASCE 2014