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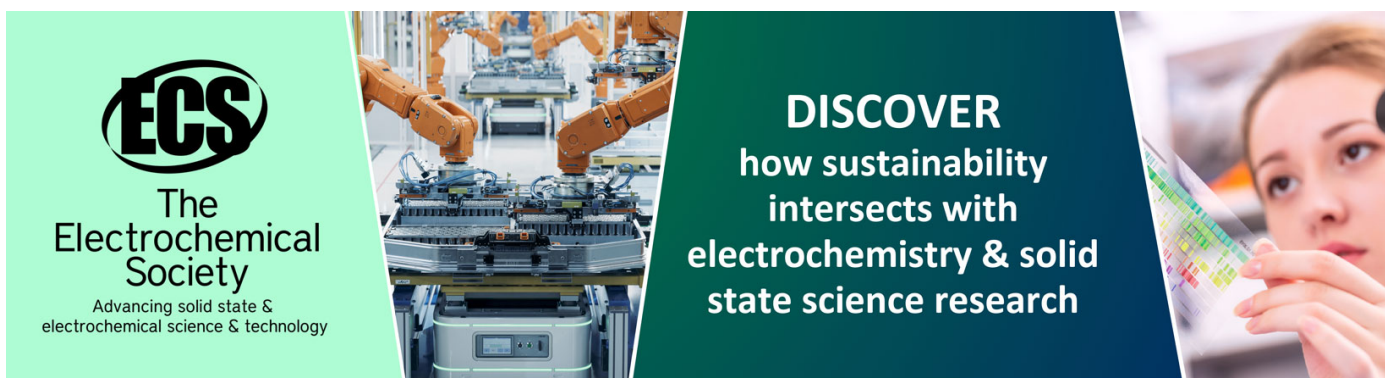
Strengthening Of Soft Soil Using Caboxymethyl Cellelouse Biopolymer

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Strengthening Of Soft Soil Using Caboxymethyl Cellelouse Biopolymer

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Abstract. The application of appropriate chemicals is a widely used strategy for soil stabilization. The drive of this study is to determine the possibility of using the biopolymer carboxymethyl cellulose as an environmentally acceptable soil stabilizer. In this work, Atterberg limits tests, specific gravity, compaction, and consolidation tests were used to determine the engineering parameters of soils treated with varying amounts of biopolymer. Additionally, changes in the morphological properties of the soft soils were evaluated using scanning electron microscopy (SEM). It was estimated that as the soil's biopolymer content increases, the specific gravity drops down, though the optimum water content (OMC) is extended. The outcomes showed diverse effects on Atterberg's limits by cumulative the liquid limit (LL) and plasticity index (PI) though decreasing the plastic limit as the bio-polymer content increases. By the addition in polymer gratified, the combination boundaries (Solidity index Cc and recompression index Cr) decline.

Keywords: Strength, soft soil, biopolymer, compressibility.

1. Introduction

Nowadays, earth dams and embankments are built and repaired utilizing the similar resources as in the earlier, soils and gravels. In the face of advancements in manufacturing, design, and construction of this serious substructure, stone blocks and embankments endure to face the similar problems throughout time. These difficulties contain interior and external erosion, loss of constancy due to wetness migration, and the inability of probable failure spots to self-heal.

Trials conducted in previous studies on clayey soil in question indicated that biopolymer treatment surges the clay's plastic and liquid limitations. This rise in Atterberg limits was shown to be irrespective of the kind and proportion of biopolymer utilized, indicating that wholly bio-polymer actions for soils have the potential to strengthen them. The results also indicated a decrease in the value of the specific density of the soil with the growth of biopolymer satisfied, on the other hand an rise in the water satisfied and a reduction in the dry mass and the combination boundaries (Compression index Cc and recompression index Cr) decline of the soil by increasing the percentage of added polymer.

2. Possible Biopolymer Famolies for Soil Steadying

Bio-polymers remain a class of polymers generated by living bacteria. They comprise a repeating construction of linked monomers parts that constitute the primary support cable, which may or may not contain branching units. Biopolymers are currently used in various fields, including restorative



materials, packaging, food additives, apparel, and substances for water action, biosensors, and information storing. [1-4].

Numerous naturally occurring biopolymers can also be synthesized for a variety of applications. For real details, it is necessary to limit the collection to a handful of these biopolymers for use in the new and arithmetical work deliberate for this scheme and future arena deployment. The methodology used to determine the greatest talented biopolymers for soil steadying reflects the biopolymer's characteristics, usual bio-availability, our aptitude to create the biopolymer in big numbers, and manufacture costs. While toxicity is a critical consideration during the selection process, it is not a feasible worry because biopolymers are created by natural microorganisms and degrade to natural chemical compounds, eliminating possible soil or groundwater toxicity problems.

Biopolymers remain categorized according to their mainstay cable composition or basis (e.g., microbial, herbal, etc.). The former classification is used then this scheme is more concerned with the practical application of biopolymers for soil stabilization than with the explicit source of biopolymers. Biopolymers are classified chemically into three distinct families [5]:

- **Usual polyesters:** polyhydroxyalkanoates (PHAs) and polylactic acid are receiving increased care in the modern-day due to their status as recyclable plastics. These ordinary polyesters are now being used to substitute synthetic gums and plastics that are derived from petroleum [6].
- **Proteins:** represent the study's second biopolymer family. All proteins are composed primarily of amino acids, and the kind and order of the amino acids distinguish one protein after another. Silks, soy, adhesion, collagen, aspic, elastin, wheat gluten, and polyamine acids are all examples of protein biopolymers. Animal proteins (e.g., collagen) and plant proteins (e.g., chitin) can be used to make these proteins (e.g., soy). Coatings and adhesives, membrane separators, and medicinal and optical materials are all examples of protein biopolymers in use today. [7].
- **Polysaccharides** are sugar-based biopolymers found in all four living creatures [8]. Polysaccharides are the most suited biopolymer family for soil stabilization because they constitute important parts in soil organic matter [9, 10]. Furthermore, when compared to the other two biopolymer families, the cost-effectiveness of generating large quantities of diverse types of polysaccharides biopolymers [10] makes this biopolymer family more appealing for practical usage in geoengineering. The present study will investigate biopolymers as extracts to reinforce earthen dams and embankments to increase their general flexibility. The effect of biopolymer on the mechanical properties of clayey soil will be investigated.

3. Materials

3.1 Soil

The soft soil utilized in this training was excavated after an ancient embankment situated near the Al-Rasheed camp in the southeast of Baghdad city (Iraq). The soil was a stiff brown silty clay, ranging from mild to stiff. The sensitive soil has been subjected to examinations by the research community to ascertain its qualities. Specific severity and Atterberg limits (liquid limit (LL) and plastic limit (PL)) are determined following ASTM specifications. Additionally, the standard Proctor test was completed and grain size appropriation (sieve analysis and hydrometer testing). The results indicate that the soil contains (4%) sand, (30%) silt, and (66%) clay. The United Soil Cataloging System (USCS) classifies soft soil as CL; clay soil with little plasticity. The physical and chemical parameters of the soft soil utilized are listed in Table (I), and the grain size scattering of the soil is shown in Figure (1).

Table (1): Physical and chemical properties of the soil.

Property	Value	Property	Value
Specific gravity, G_s	2.7	Plasticity index (P.I), %	15
Gravel, %	0	Optimum moisture content (O.M.C), %	18

Sand, %	4	Maximum dry unit weight (γ_{dry}), kN/m ³	19
Silt, %	30	SO ₃ (%)	0.85
Clay, %	66	Gypsum content (%)	1.24
Liquid limit (L.L.), %	39	pH	9.2
Plastic limit (P.L.), %	24	Total soluble salts (T.S.S.), %	1.69

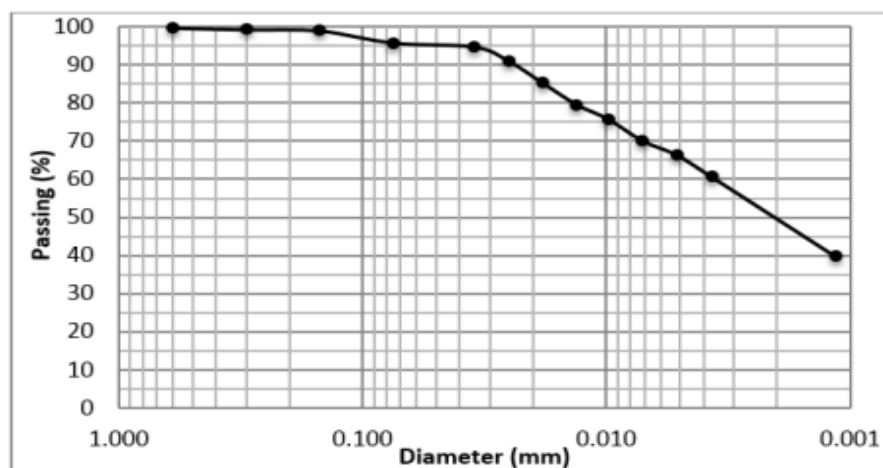


Figure 1: Grain size distribution curve.

3.2 Polymer used

Carboxyl methylcellulose (CMC):

(CMC) is a water soluble anionic cellulose copolymer. Solvency of CMC depends on the DP (degree of polymerization) and the level and consistency of replenishment. CMC's water solubility would rise with reduced DP and amplified carboxymethyl replacement and consistency. The arrangement's uniformity improves as the DP and fixation increase [12]

The significant cellulose ether is (CMC). By attacking the monocrystalline regions of cellulose, specific alkylating chemicals can be used. This is referred to as the concept of responsive construction components, and it is widely used in the development of CMC. Another way to complete a comparable response is to derivative cellulose in receptive microstructures that have been shaped through triggered stage partitioning. This interaction entails the use of anhydrous NaOH in combination with solvents such as DMA/LiCl. These CMC items have a circulation of substituents that deviates significantly from the item's factual forecasting [13]

CMC is a derivative of cellulose that contains carboxymethyl bunches formed when cellulose reacts with chloroacetate in salt to provide replacements for the C₂, C₃, or C₆ positions of glucose units. As a result, CMC is a suitable solvent for water and is more resistant to the hydrolytic action of cellulases. CMC is thus a valuable additive to both fluid and solid vehicles for identifying cellulase action. Its hydrolysis may be determined using Congo red, which is associated with pristine α -D-glucans. Zones of clearing around states transitioning to a strong medium containing CMC finished with Congo red are a valuable indicator of CMC hydrolysis and, consequently, α -D-glucanase action. Immunization of secludes onto layer channels outside CMC agar plates is a beneficial modification to this process. It allows for eliminating the channel, hence allowing for the depiction of clear zones in the agar under cellulolytic provinces [14]. Table 2 presents the chemical properties of the Carboxymethyl cellulose biopolymer.

Table 2: Properties of Carboxymethyl cellulose biopolymer.

Item	Specification
Molecular formula	$C_6H_7O_2(OH)_2OCH_2COO_2$
Viscosity (2% Solution Mpa.S)	3000-5000
Chloride (%)	< 1.8%
Degree of substitution	0.65 - 0.85
pH	6.0-8.0
Moisture (%)	< 10%
Gs	1.59

4. Experimental Work

This study uses different percentages of biopolymer 0.5, 1.5, 3, and 5 %. Results of tests (specific gravity, Atterberg limits, compaction, and consolidation) for soil with adding different percent's of biopolymer are presented in the following sections.

4.1 specific gravity:

A pycnometer was used to determine the specific gravity of soil in accordance with ASTM D 854-00 – Standard Test for Specific Gravity of Soil Solids by Water Pycnometer. The mass of a unit volume of soil at a given temperature divided by the mass of the same volume of gas-free distilled water at the same temperature is known as specific gravity.

4.2 Atterberg limits:

The Atterberg limits are determined as:

4.2.1 Liquid Limit: Casagrande Method (ASTM D4318-00)

The method establishes the point at which clayey soils transition from a plastic to a liquid condition. When comparing the prospective qualities of soil material to empirical data aids in soil classification.

4.2.2 Plastic limit: (ASTM D4318-00)

The plastic limit set includes a glass plate, a steel rod, a mixing dish, a spatula, and four moisture content tins. After obtaining the liquid and plastic limits for each soil, the plasticity index was calculated. After that, the soil was classified using the liquid limit and plasticity index.

4.3 Compaction test (ASTM D698-00)

Compaction is the process of densifying soil by removing air, which needs mechanical energy, and the degree of compaction is expressed in relations of the soil's dry unit weight. To determine the moisture density relations for the soil sampled. We use standard Proctor tests. This lab. test is used to investigate the connection among soil moisture content and its dry density at a specific compaction effort.

4.4 Consolidation test by odometer cell

The test specimen preparation might be accomplished by pressing the soil compacted into the ring using a compression machine. The ring dimensions are 75 mm or 50 mm, depending on the used apparatus's internal diameter and 20 mm in height, after placing the sample in the cell, providing a means of submerging the soil sample underwater. Measurement of the height of the specimen is made using a dial gauge with a sensitivity of 0.001 mm.

5. Results of Tests

5.1 Specific gravity

The specific gravity test results are shown in Figure 2.

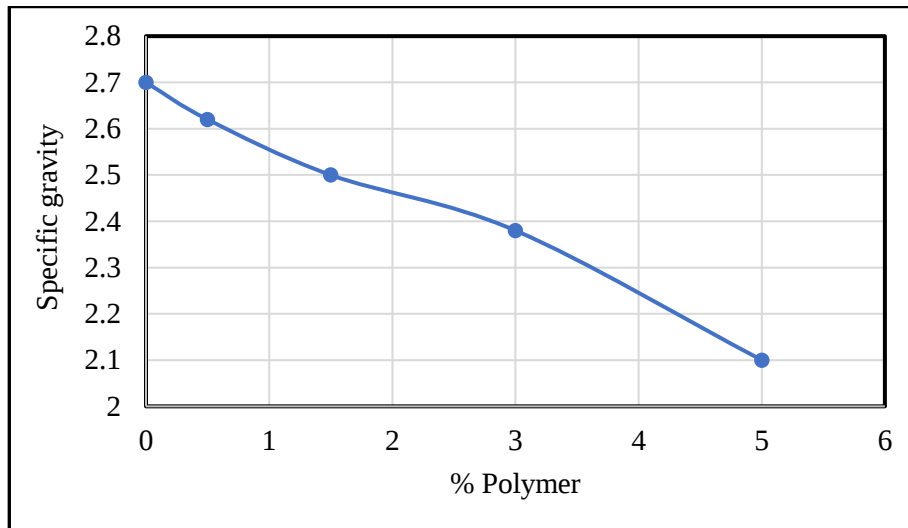


Figure 2: Specific gravity relationship with different polymer content

5.2 The Atterberg limits: The Atterberg limits test results are shown in Table 3 and Figure 3.

Table 3: Values of Atterberg limits for soft clay treated with biopolymers.

% Polymer	L.L%	P.L%	P.I%
0	39	25	14
0.5	49	23	26
1.5	56	20	35
3	63	19	44
5	72	17	54.7

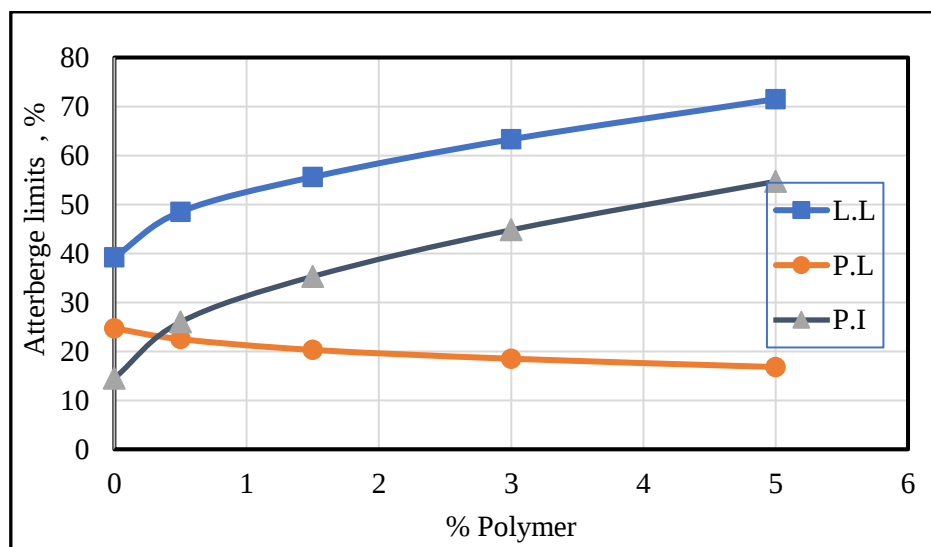


Figure 3: Effect of biopolymer on Atterberg limits.

5.3 Compaction test (ASTM D698-00)

Table 4 and Figure 4 show the results of the compaction test and the relationship between optimum moisture content and maximum dry unit weight at different polymer contents.

At 5% polymer, the optimum water content increases from 18% to 20%. This increase is due to the reduced shallow area caused by flocculation and collection, as well as the extra fine contents to the tasters, which require more water, in addition to the polymer, which required more water for the reactions to take place.

Table 4: Values of the dry unit weight and O.M.C.

% polymer	γ_{dry} (kN/m ³)	O.M.C (%)
0	19	18
0.5	18	19.1
1.5	17.2	19.3
3	16.3	20
5	15.2	20.7

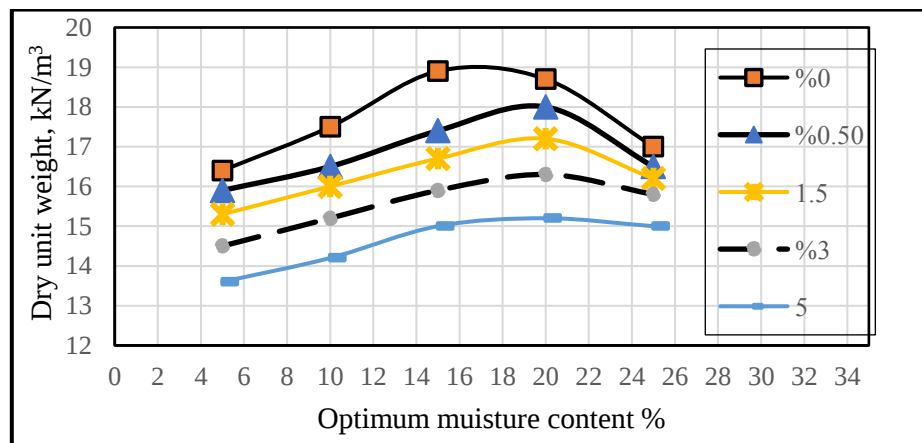


Figure 4: Relationship between optimum moisture content and maximum dry unit weight at different polymer contents.

5.4 Consolidation test

Figure 5 shows the pressure-void ratio relationship for the natural soil and soil treated with different percents of biopolymer while Figure 6 displays the variation of compression index and rebound index with biopolymer content.

The biopolymer creates an excellent pressure effect between the soft soil content and the result of the interactions of polymer ions and soil ions, causing a decrease in the amount of water in the soil structure, which leads to clumping of clay particles with each other.

Fattah et al. [16] The reduction in the dispersed water layer allows the clay particles to come into closer contact with one another, resulting in flocculation/agglomeration of the clay particles and the transformation of the clay into a more silt-like or sandlike material.

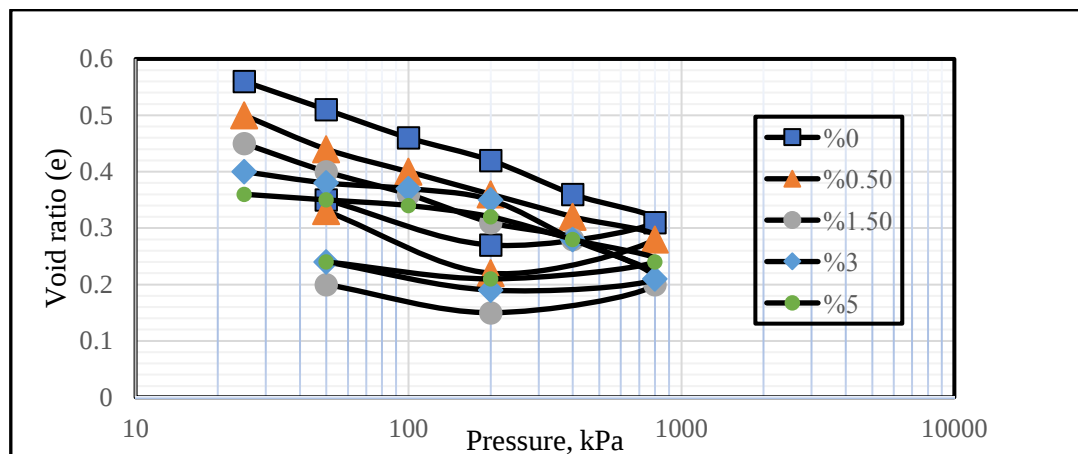


Figure 5: Void ratio versus effective stress curves from the consolidation test on soil stabilized with different bio-polymer percents.

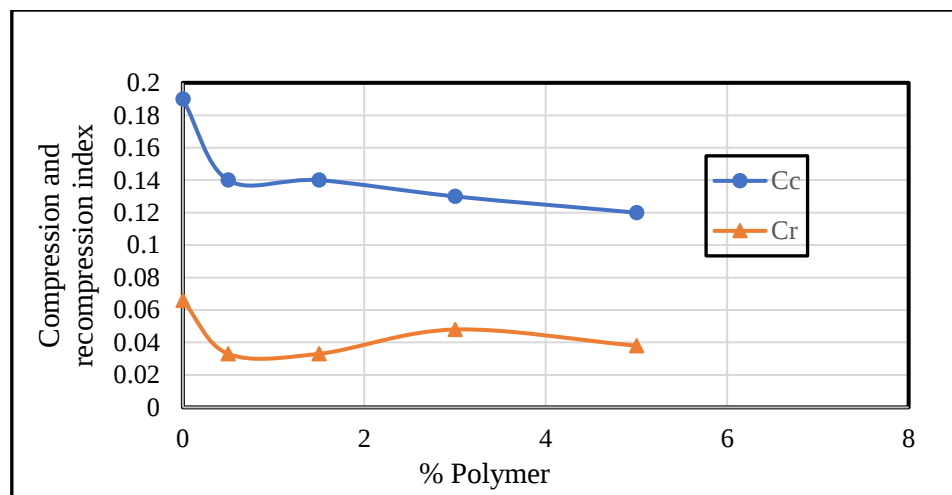


Figure 6: Compression and recompression index at different polymer content.

6. SEM and EDS analysis

To better understand the relationship between the microstructure and macrostructure of specimens, scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS) analysis was performed on soil treated with varying amounts of biopolymer. Analyses were conducted for each added percentage (0, 0.5, 1.5, 3, 5) of the polymer, and images of the soil particles as a whole were obtained as shown in Figure 7.

The shear strength parameters of sand/guar gum mixes can be evaluated using SEM. The polymer and soil particles are linked via polymer accumulations (i.e., clay). In the SEM, van der Waals forces as physical absorption provide the weakest connections over a long distance.

Biopolymers system face clay layers when fused with kaolinite clay films and produce film coatings when interacting with sand particles, according to a scanning electron microscopy (SEM) study. According to Chang et al., these biopolymers give maximal strength in the presence of fine-grained soils (clay) because they establish strong hydrogen and ionic connections with the electrically charged clay particles. [17].

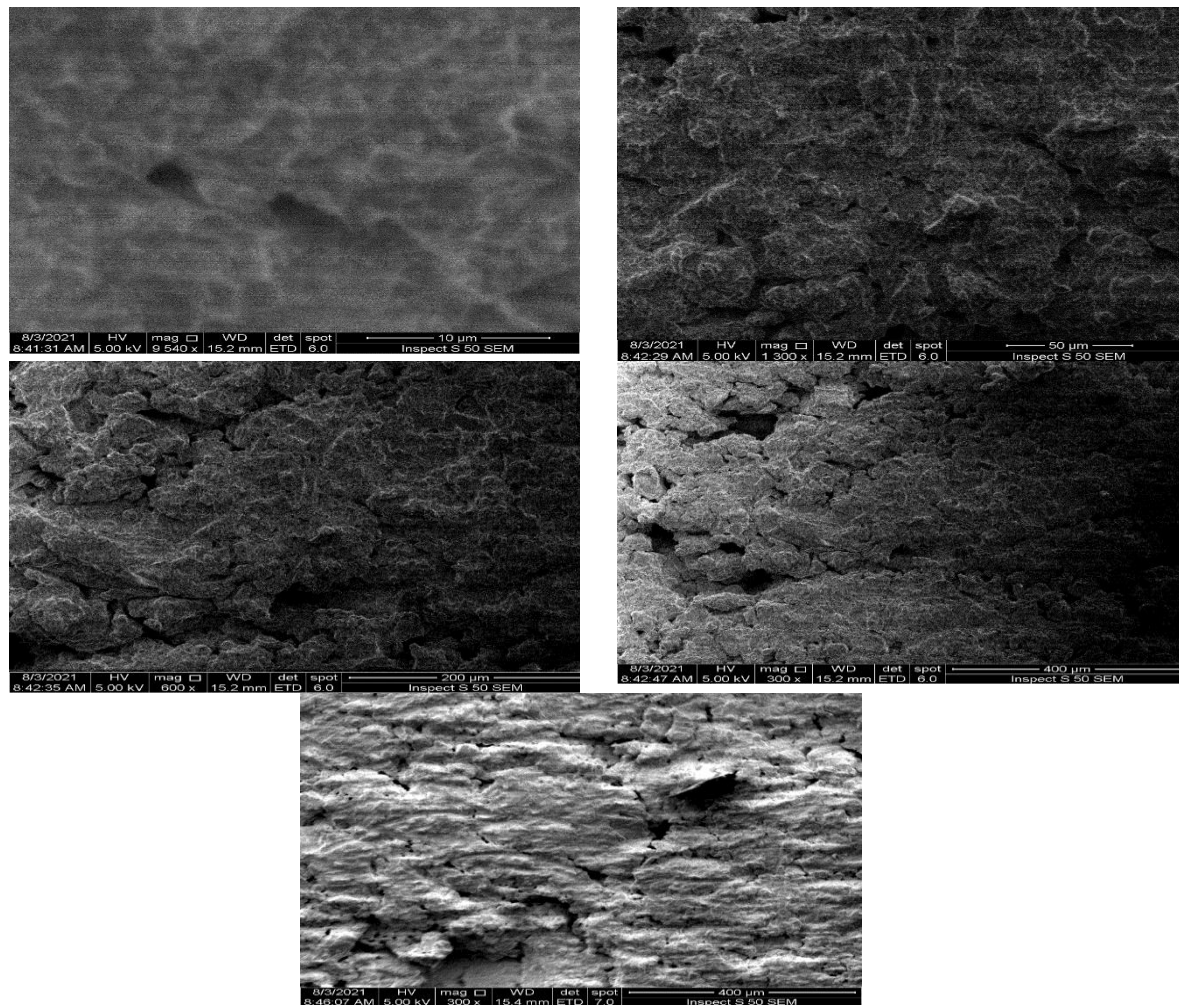


Figure7: SEM of soil treated with different percent's of biopolymer.

7. Conclusions

An increase of liquid limit and plasticity index was obtained when adding the polymer to the soft soil, while a decrease in the plastic limit took place because of the high water absorption property to the polymer. A decrease in specific gravity of soil was obtained with increasing polymer content due to the low value of the specific gravity of polymer (1.59). The optimum water content increases from 18% to 20% at 5% polymer. Stabilizer content (polymer) decreases the maximum dry unit weight from 19 to 15.2 kN/m³. The consolidation test results showed a decrease in the compression index from 0.19 to 0.12 at 5% polymer content.

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