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Improvement of Soft Clayey Soil by Bio-polymer

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HIGHLIGHTS

- Carboxy methyl cellulose was added to soft clay with two separated rates (0.5 and 3%) by total weight.
- Different tests were conducted to consider the impact of polymer on soil geotechnical properties.
- As the bio-polymer content increases, liquid limit and plasticity index increase.
- A huge improvement in unconfined compressive strength of treated soils was gained.
- With the increment in biopolymer content, the soil compressibility decrease.

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ABSTRACT

This examination explains the utilization of bio-polymer powder for clayey soil enhancement. The article concentrates around examining the strength attitude of the clayey soils built up with homogenous bio-polymer. Carboxy methyl cellulose was determined as bio-polymer material to build up the normal soft clayey soil. The biopolymer has been added to the soil with two separated rates (0.5 and 3%) by total weight of soil. Different tests were carried out to consider the impact of utilizing this polymer as a balancing out specialist on the geotechnical properties of soil. It was estimated that as the bio-polymer content expands in the soil, the specific gravity decreases, while the optimum water content (OMC) is expanded. The results showed different effects on Atterberg's limits; by increasing the liquid limit(L.L) and plasticity index(P.I) while the plastic limit decrease. The tests additionally mirrored a huge improvement in the unconfined compressive strength (UCS) of the treated soils. With the increment in biopolymer content, the consolidation index (Compression index Cc and recompression index Cr) decrease.

1. Introduction

Deformations occur in all engineering buildings built on soft clayey soils when these soils are subjected to extra loads or owing to clay dissolution when the soil become moist. The foundation or earth constructions may fail as a result of these deformations (cracking, collapse).Many foundation concerns, such as road construction project collapses, are linked to the consolidation of clayey soil layers. To obtain the desired performance, numerous analysts use soil stabilizing methods for ground improvement [1].

The adding of solidifying materials to soft soil to improve at least one of its geotechnical features is known as soil stabilization. Stabilization materials have for some time been added to common soils, either by mechanical blending to get a uniform soil combination or by adding the balancing out component to fill the holes in the soil [2-4].

For the readjustment of clayey soils, a variety of materials (natural, simulated, and by product materials) have been used as soil stabilizers. Lime, Portland cement, asphalt binder, fly ash, rice husk ash, silica fume, nanomaterial's, and other organic or inorganic additives, as well as their mixtures, are frequently used to modulate soil properties, including cementation of soil particles [5-9].

Bio-mineralization is the most famous strategy, which includes mineral precipitation in soil pores through natural creatures. Another cycle, in light of biofilm shaping, starts with a little fascination power between microorganisms, which later develops into a bigger, perpetual association. To relieve carbon dioxide (CO_2) discharges during the concrete assembling measure, bio-intervened soil upgrade procedures have been executed. Materials that are naturally manageable (for instance,

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biopolymers). It is safe to say that they are a feasible option in contrast to customary soil the executives and improvement techniques? (i.e., mechanical improvement and substance treatment). Biopolymers, specifically, as biodegradable polymers, have been concentrated as a dirt improvement building material. By going about as a fastener, biopolymers blended in with soil, for example, tacky rice mortar, work with soil fortifying, including improved union and strength, disintegration resistance, diminished porousness, etc. Utilizing biopolymers straightforwardly in soil enjoys numerous upper hands over traditional organic soil treatment draws near [10-15]. Soft soils occupy large areas in Iraq (over 25%) for the most part in its center and southern parts and around (30-35) % of the last bits are powerless and delicate. Accordingly, the issues of this soft soil were taken in thought by numerous Iraqi geologists and structural specialists since it is regularly utilized as common establishment bases for structures. There are most unpredictable designing issues in the mud soil, particularly when joined by ecological changes in dampness content and goes through enormous settlement under long haul of burdens. Disappointment of different designs developed on soft soils in different areas in Iraq were recorded, for example, Amara, Naseriya and Bassra that are portrayed by their weak undrained shear strength (< 40 kPa) and compression index as high as 0.3 were accounted for [16]. In this manner, it is important to improve enormous regions covered by feeble and delicate dirt soil that has made issues to streets and air terminals based on mud soils in light of their low bearing limit. This paper focuses on exploring tentatively the achievability of balancing out and improving the engineering properties of clayey soil utilizing a biopolymer material in various contents.

2. Materials utilized and technique

2.1 Materials utilized

2.1.1Soil

Soft soil has been shipped from south of Baghdad city (Iraq). The soft soil has been gone through research center tests to decide its properties. These tests contain: specific gravity and Atterberg limits (liquid limit (L.L) and plastic limits (P.L)) as per ASTM specifications. Standard Proctor test, grain size appropriation (sieve analysis and hydrometer tests) was additionally completed. The outcomes show that the soil comprises of (7%) sand, (27%) silt and (66%) clay. The soil is characterized by the Unified Soil Classification System (USCS) as CL; clay soil with low plasticity. Physical and compound properties appear in Table (I) of the soil utilized and the grain size distribution of the soil utilized is shown in Figure (1).

2.1.2 Polymer used

Carboxy methyl cellulose (CMC) is quite possibly the most regularly polymers utilized. It has amazing properties like biocompatibility, low degradability and ease contrasted with the other normally subordinate polymers.

Table 1: physical and chemical properties of the soil

Property	Value	Specification
Specific gravity(G.S)	2.7	ASTM D854 [17]
Gravel, (G%)	0	ASTM D422 [18]
Sand, (S%)	7.0	ASTM D422 [18]
Silt, (M%)	27.0	ASTM D422 [18]
Clay, (C%)	66.0	ASTM D422 [18]
Liquid limit (L.L) %	39	ASTM D4318 [19]
Plastic limit (P.L) %	24	ASTM D4318 [19]
Plasticity index, (P.I%)	15	ASTM D4318 [19]
Optimum moisture content, (O.M.C %)	18	ASTM D1557 [20]
Maximum dry density (γ_{dry}), kN/m^3	19	ASTM D1557 [20]
SO_3 (%)	0.85	B.S. 1377 [21]
Gypsum content (%)	1.24	B.S. 1377 [21]
PH	9.2	B.S. 1377 [21]
T.S.S.%	1.69	B.S. 1377 [21]

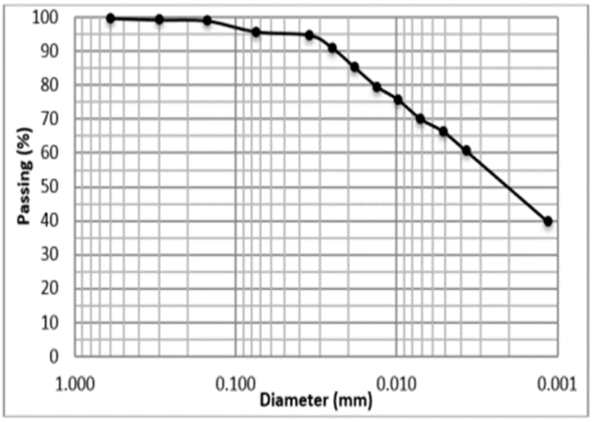

Figure 1: Grain size distribution curve

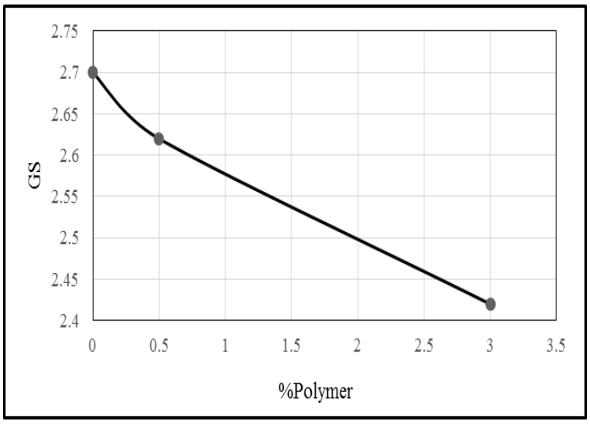

Figure 2: Relationship between (Gs) and different bio-polymer contents.

CMC, is white or marginally yellow hairy fiber powder or white powder, unscented, dull, non-poisonous; solvent in cool water or boiling water to shape a specific stick degree straightforward arrangement. Carboxymethyl cellulose-CMC is utilized in the pharmaceutical, restorative, oil, and penetrating, paper, material, printing and coloring industry.

It is a cellulose subsidiary with carboxy methyl gatherings (- CH2-COOH) bound to a portion of the hydroxyl gatherings of the glucopyranose monomers that make up the cellulose spine. It is frequently utilized as its sodium salt, sodium carboxymethyl cellulose. It is blended by the antacid catalyzed response of cellulose with chloroacetic corrosive. The polar (natural corrosive) carboxyl gatherings render the cellulose dissolvable and artificially receptive after the underlying response, the resultant blend produces about 60% CMC in addition to 40% salts (sodium chloride and sodium glycolate). The useful properties of CMC rely upon the level of replacement of the cellulose structure (i.e., the number of the hydroxyl bunches have partaken in the replacement response), just as the chain length of the cellulose spine structure and the level of grouping of the carboxy methyl substituents.

2.1.3 Test's arrangement

To assess the impact of bio-polymer material on the geotechnical properties of the clayey soil utilized, soil-biopolymer combinations have been readied utilizing two unique rates of polymer material. From the start, the clay soil has been dried in air and squashed before it is utilized in the blends. At that point ascertain amount of soft soil was taken then the biopolymer was added to that soil at a ratio of (0, 0.5 and 3 %) of the weight of soil at room temperature. For every ratio, specimens were taken to be tested immediately and other specimens were cured (after storing them in nylon bags to keep them moist) for 7 and 28 days to test. In this article, laboratory tests have been accomplished to evaluate the impact of bio-polymer expansion on the physical properties, compaction, unconfined compressive strength and consolidation of the untreated and treated delicate soil specimen.

The unconfined compressive strength is applied to determine the unconfined compressive strength (UCS, ASTM D 2166-00 [22]. Then, the undrained shear strength (or undrained cohesion Cu, of a cohesive soil was calculated which is equal to one-half the unconfined compressive strength (qu). Then curing for 7 and 28 days for different polymer content, table present the results of Cu for (0.5 and 3) % polymer and for (0, 7, and 28 days). The consolidation test is performed by ASTM D 2435-02 [23]. Stacking pressures were (25, 50, 100, 200, 400 and 800) kPa and reloading pressures were (800, 200, 50, and 25) kPa. From e-log p connection, the compression list (Cc) and recompression list or expanding file (Cr) during dumping were resolved at various polymer substances.

3. Result and discussion

As aforesaid, it has been needed in this examination to assess the viability of the delicate clay soils blended in with bio-polymer powder article (CMC) as a stabilizer specialist. The aftereffects of physical properties and mechanical properties previously (0% biopolymer) and in the wake of blending in with 0.5 and 3% polymer will be discussed:

3.1 Specific gravity (G.S)

The expansion of biopolymer influences soil′s (Gs). It is clear in Figure (2) that with expanding the biopolymer content, the (Gs) of the treated soil pointedly drops from (2.7) for pure regular soft soil to 2.42 when 3 % biopolymer added because of low specific gravity to the polymer.

3.2 Dry unit weight (γ dry) and optimum moisture content

The effect of adding the biopolymer to the soil on the properties of compaction test is represent in figures (3-5), where it shows a decrease in the dry density due to the light weight of the added polymer as well as the high-water absorption property of the polymer, so the optimum water content of the soil increase with the increase of the added polymer because of the high water absorption to the polymer.

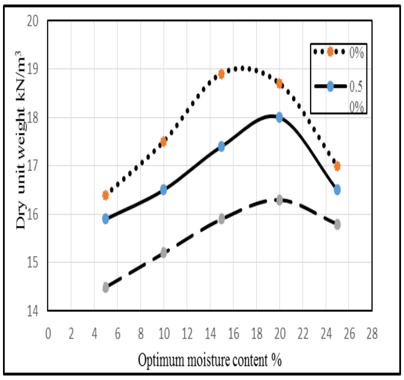

Figure 3: Compaction curves from the standard compaction test with different bio-polymer contents.

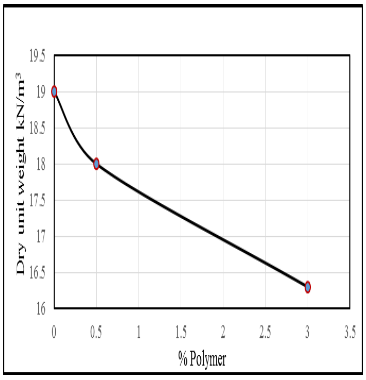

Figure 4: Maximum (γ dry) variation with different biopolymer contents.

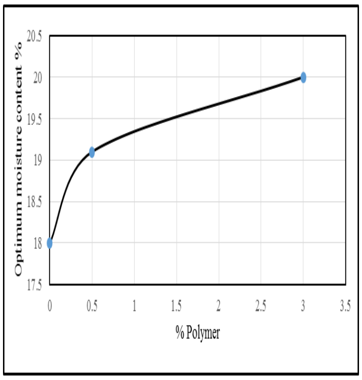

Figure 5: Relationship between optimum water content and different biopolymer contents.

3.3 Atterberg's limits

Concerning the impact of bio-polymer content on Atterberg's limits appears in Figure (6), it’s seen that expanding the biopolymer content, there is an expansion in (L.L) and (P.I) from 39% and 15% for untreated soil to 63% and 45 % at 3 % bio-polymer. On the other hand, the(P.L), the converse is valid. It diminishes from 24% to 18% for untreated and after added (3% bio-polymer) separately. As an overall pattern, this would be because of its higher water retention property of the polymer (for example the water that needed in hydration)

3.4 Unconfined compressive strength (UCS)

As respects the aftereffects of the unconfined compressive strength if there should be an occurrence of untreated soil test, the pressure increments slowly with the expansion of strain. While for the soil-polymer, the strain quickly expanded with the expansion of stress. The stress-strain bends of the unconfined pressure test are introduced in Figure (7) which shows increment in the unconfined compressive strength (q_u) from 42 kN/m^2 for untreated to 116 kN/m^2 for 3 % polymer expansion. While the curve in,Figure (8)shows increase in the unconfined compressive strength for 3% polymer content from 116 kN/m^2 for 0 days to 206 kN/m^2 for 7 days and 275 kN/m^2 after 28 days. By explaining the stress - strain curves, it tends to be expressed that the expansion of biopolymer (especially 3%) adjust the soft soil conduct and deformity attributes in terms of weakness or flexibility.

3.5 Consolidation test

In the consolidation test, the aftereffects of (Cc) and (Cr) show a reduction in these indices with expanding polymer content as represented in Table (II). It was tracked down that the bio-polymer adjustment uniquely diminished the (Cc) esteems. The first examples the void ratio(e) different from about(0.5 - 0.3) over a pressure scope of (25 – 800) kPa. The estimation of Cc for the example without adjustment was discovered to be 0.19 and diminished progressively to 0.14 for the principal boundary and halfway decreased to 0.13 for the other one at polymer substance of 3 %. The treated examples have very much like pressure conduct, with a void ratio(e) shifting as indicated by the polymer substance over a similar pressure range. The curing showed decrease in the compression index (Cc) from 0.13 for 7 days to 0.11 after 28 days at 3% polymer content.

The clarification is with expanding bio-polymer content, the consolidation in dices have been by and large diminished as the bio-polymer creates large pressure impact between the soft soil content, so that is difficult to pack the particles and furthermore difficult to acquire the principal circumstance. Where the Cc was completely decreased while the Cr was halfway diminished yet at the same time with lower esteems contrasted with the untreated soil.

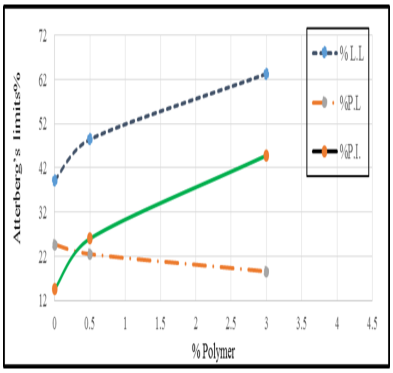

Figure 6: Relationship between Atterberg limits and bio-polymer contents.

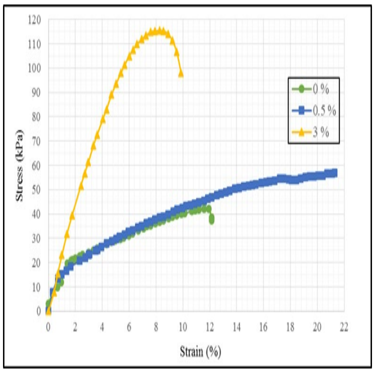

Figure 7: Stress strain curve variation with different polymer contents.

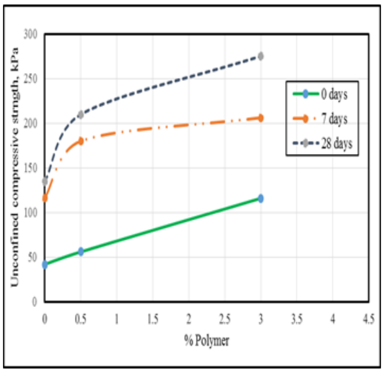

Figure 8: Unconfined compressive strength variation with different polymer contents at different curing days.

Table 2: Compression index (Cc) and recompression index (Cr) for soil treated ty different polymer contents.

	Polymer%	Curing period		
		0days	7days	28days
Cc	0	0.19	0.19	0.17
Cr	0	0.066	0.033	0.033
Cc	0.5	0.14	0.16	0.13
Cr	0.5	0.033	0.016	0.038
Cc	3	0.13	0.13	0.11
Cr	3	0.048	0.016	0.014

4. Conclusions

1) When the biopolymer content is increased, the optimum water content (OMC) increased while the specific gravity drops down.
2) The outcomes showed increase in(L.L) and (P.I) while diminishing (P.L) with increment in biopolymer content due to the high absorption water property of the adder polymer wich increase in the soils need for water to extent of liquidity.
3) The tests additionally mirrored an impressive improvement in the unconfined compressive strength of the treated soils because of the polymer absorption of the water surrounding clay particles which lead to its convergence and increase its strength. With the expansion in polymer content results in a decrease in the consolidation indices (Cc and Cr).
4) The expansion of polymer (especially 3%) changes the soil behavior and misshaping qualities in term of weakness or flexibility. There is increment in the unconfined compressive strength (qu) from 42 kN/m^2 for untreated to 106 kN/m^2 for 3 % polymer expansion. There is additionally increase in the unconfined compressive strength from 16 kN/m^2 for 0 days to 206 kN/m^2 for 7 days curing and 257 kN/m^2 following 28 days at 3% polymer content.

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