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Soil Strengthening using Caseinate: A Protein Based Biopolymer

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***Abstract*: New protein-based biopolymer introduced in this study to stabilize soil. Since the conventional soil stabilization materials, especially cement, have harmful effects on the environment, alternative eco-friendly materials, caseinate salt biopolymer have been used in this study to reduce environmental concerns. Casein and sodium caseinate biopolymer obtained from milk added to soil, and mechanical properties of biopolymer treated soil were investigated through a series of laboratory tests. The effects of biopolymer content, curing time on improving soil were studied by unconfined compression test. The caseinate is added to the soil at different percentages (0,2,4,6 amd 8%) and the liquid limit, OMC and MDD, UCS were determined. The results showed that compressive strength of biopolymer treated soil was increased when the curing time had passed, and biopolymer content in-creased. On the whole, the protein-based biopolymers propose a strong potential as additives for soil treatment rather than some material such as cement and chemical polymers**

***Keywords*: Soil Stabilization, Caseinate salt, OMC (Optimum Moisture Content), MDD (Maximum Dry Density), UCS**

1. Introduction

A. General

Soil treatment is an essential concern for geotechnical engineers because of urbanization and population growth throughout the world. Generally, ground improvement aims to resolve various geotechnical problems such as reducing differential settlements of foundations, improving mechanical parameters of subgrade layers, consolidation and compaction of the soil, and the improvement of shear strength. For these purposes, various methods and materials have been used till now. Among them, cement is the most widely used additive owing to adequate strength, availability, and low cost. In spite of advantages and various applications of cement, it has caused numerous detrimental impacts on the environment like CO2 emission which enhances greenhouse effect.

Therefore, in the current century, environmental concerns have led to the use of different eco-friendly methods and materials in geotechnical activities. For this, useful bacteria and enzymes have been employed in endeavors towards soil improvement. Although the microbial method has been satisfying with acceptable performance, some factors make this procedure complicated. In this manner, numerous environmental parameters such as temperature, pH, concentration of electron donor and electron acceptor, and the rate of nutrients and metabolites are simultaneously effective to gain adequate achievement. Moreover, microbial soil treatment is slightly more time-consuming compared with other methods. Hence we moved to polymers as stabilizers. A biopolymer is a polymeric substance (as a protein or polysaccharide) formed in a biological system. The use of biopolymers in civil engineering activities dates back several years ago. But, it has been considered more frequently in recent years by civil engineers.

Casein is a protein-based biopolymer making up 80% of the proteins of cow's milk. Casein has been derived from the Latin word ''Caseus" which means cheese. The isoelectric point of casein is about 4.6 and generally, the casein pH is 6.6 and has a negative charge. Casein chemical formula is C31 H27 NO4. Casein and sodium caseinate salt as the additives have been used in this paper. When milk becomes sour, it separates into curd and whey are prepared, now by separating the water, casein is introduced. Casein can also be extracted from the milk by reducing the milk pH and adding a mineral acid into the milk. The obtained product can be conerted into sev-eral form.

In this study caseinate salt is used as the stabilizer and various properties of the soils caseinate mixture were studied to determine the effect of caseinate.

Objective of the study:

- To investigate the basic characterization of soil from Amaravila, Trivandrum.
- To study properties of treated soil with different proportions of caseinate.
- To evaluate effect of curing in strength gain.

2. Materials and methodology

A. Materials

Materials used in this study are Amaravila soil and Caseinate

1) Amaravila Soil

The study was conducted on soil collected from Amaravila, Trivandrum. According to soil classification, it was classified as high plastic clayey soil (CH). Properties of soil were given in table 1.

Table 1
Properties of dredged soil

Soil Properties		Values Obtained
Specific gravity		2.63
Liquid limit (%)	(IS 2720 PART 5 1985)	52
Plastic limit (%)	(IS 2720 PART 5 1985)	21.52
Plasticity index (%)	(IS 2720 PART 5 1985)	30.48
IS classification		CH
OMC (%)	(IS 2720 PART 7 1985)	20
Dry density (g/cc)	(IS 2720 PART 7 1985)	1.56
% clay	(IS 2720 PART 4 1985)	64
% silt	(IS 2720 PART 4 1985)	28
% sand	(IS 2720 PART 4 1985)	8
UCC strength (kPa)	(IS 2720 PART 10 1985)	47.56

Table 2
Composition of caseinate biopolymer

Composition	Values obtained
Total protein (%, Wt/Wt)	87
Casein (% TP)	97
Whey protein (% TP)	1.2
Lactose (% Wt/Wt)	1.27
Ca (mg/100g)	193
P(mg/100g)	68

2) Caseinate

Protein based biopolymer was obtained from ERIC India Pvt. Lmtd, Bikaner. The physical composition of biopolymer is given in the table.

B. Methodology

1) Index properties

The test to determine the index properties were done as per IS 2720 (Part v). The variation in liquid limit was studied with the addition of various percentages (0, 2, 4 ,6 and 8%) of caseinate on soil individually.

2) Compaction test

The test to determine the optimum moisture content and maximum dry density were done using standard proctor test according to IS 2720. 1980 (Part VIII). The variation in optimum moisture content and maximum dry density was studied with the addition of various percentages (0, 2, 4, 6 and 8%) of caseinate on soil.

3) Unconfined compression test

The unconfined compression test (UCS) test is done for determining the compressive strength of soil, tests were conducted to determine the strength of the original soil as well as for the soil mixed with different percentage of caseinate (i.e. 0%, 2%, 4%, 6% and 8 %) by weight of the soil. The test was conducted in accordance with IS: 2720 part 10.

3. Results

A. Effect of caseinate on liquid limit of soil

The variation in the Liquid limit of the soil with the addition of the caseinate is studied as per IS 2720 Part 51985. The various percentage of caseinate (0, 2, 4, 6 and 8%) added to the soil, result obtained as the wL decreases upto 6% and a negligible increase shown after that.

Table 3
Effect of Caseinate on Liquid limit of soil

% Additives	Liquid Limit (%)
0% Caseinate	52
2% Caseinate	51
4% Caseinate	49
6% Caseinate	46
8%Caseinate	48

B. Effect of caseinate on compactio characteristics of soil

IS Light compaction test was carried out on various proportions of Caseinate and soil in accordance with IS: 2720-VII-1980. From the standard proctor test, it can be observed that the Maximum Dry Density (MDD) increases and optimum moisture content decreases.

Table 4
Variation of OMC and MDD with various percentages of caseinate + soil

% Additives	OMC	MDD
0% Caseinate	20	1.566
2%Caseinate	19	1.579
4% Caseinate	18	1.625
6% Caseinate	17	1.698
8% Caseinate	16	1.624

C. Effect of caseinate on UCS strength of soil

The unconfined compression test (UCS) test is done for determining the compres-sive strength of soil, tests were conducted to determine the strength of the original soil as well as for the soil mixed with different percentage of caseinate (i.e. 0%, 2%, 4%, 6% and 8 %) by weight of the soil. The test was conducted in accordance with IS: 2720 part 10. The UCS value increased with addition of caseinate upto 6% and then started decreasing.

Table 5
Table title comes here

% of Additives	Strength (kPa)
0	47.56
2	58.74
4	68.15
6	80.80
8	92.86

4. Conclusion

The study has dealt with the influence of caseinate on the strength behavior of the soil collected. The conclusions that can be derived from the study are:

- The liquid limit of the soil increased with increase in addition of caseinate upto 6%.
- Unconfined compressive strength obtained is maximum up to 6% of addition of caseinate.
- The maximum dry density increases with addition of caseinate and optimum moisture content decreases.
- The optimum usage of caseinate is determined as 6%.

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