Soil Stabilization Using Cement as Binder and Nylon Thread as Reinforcement

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Abstract

Having good strength of natural soil is an absolute thing for any engineering structure. Weak and unstable soil can create significant problems as well as increase construction cost. This study investigates the effect of shear strength by the composition of several percentages of Nylon Thread with the combination of cement (2%) on natural soil samples collected from a construction site of 22, Shaheed Mirza Lane (E), Mehedibag Road, Chittagong 4000 and a paddy land of Kulapara, Mohora, Chittagong. Both soil samples have been found as silty sand with some amount of clay. The diameter of Nylon Thread has been used as 0.33 mm. The performance of soil samples has been evaluated through some laboratory tests such as Standard Proctor test, Unconfined Compressive Strength test. It has been found that the strength of soil samples increases with the increase of Nylon Thread with a percentage wise combination of 2% cement. But after a certain percentage of adding Nylon Thread, the strength starts to decrease. This percentage has been recommended as optimum percentage. The bearing capacity has been increased to a satisfactory level at the optimum percentage for both soil samples.

Keywords: *Shear Strength, Nylon Thread, Cement, Standard Proctor test, Unconfined Compressive Strength.*

1 Introduction

Earth is nature's one of the abundant material. It plays an important role for any kind of structure lies on it. It acts as a base of the structure and having a good base is an absolute thing for any engineering structure. Sometimes earth crust does have good properties and sometimes doesn't. The problem arises when it doesn't have good properties and strong enough to carry heavy weight like building or pavement on it. Construction on weak soil is susceptible to differential settlement because of its low shear strength and high compressibility (Tang et al., 2007). To mitigate this problem, the existing weak soil has to be replaced. Replacing of existing soil might not always be a good option because of high hauling cost of excavated and imported new soil. Due to economical consideration improvement or stabilization of soil using proper technique can be best option (Dhakal, 2012). The concept of soil stabilization with additives has been around for several thousand years (Marandi & Safapour, 2009). Ancient civilizations like: Chinese, Romans and Incas utilized various stabilization techniques to improve soil strength. The modern era of soil stabilization began in early 1970's, when petroleum became costly and quality aggregates were in short supply. It then became necessary to look for alternative means to improve soil other than replacing it by costly aggregates or going for deep foundation (Jahan et al., 2018).For the low raised structure, shallow foundations are provided. If the soil of that shallow layer is not strong enough to carry the load transmitted by foundations, the soil have to be stabilized. In case of pavement, sometimes it is needed to stabilize the layer of sub-base and base. Soil stabilization includes blending and mixing of materials with soil to increase the engineering properties and overall performances (Ashraf et al., 2018). This stabilization can be done by the combination of traditional stabilizers like cement, lime, bitumen etc and non-traditional stabilizers like polymer or non-polymer based products, fiber reinforcement etc with or without the combination of by-products such as cement kiln dust, lime kiln dust etc. The type and amount of the stabilizer required depends on the classification of soil and the strength needs to be increased (Rokeya et al., 2016). Among those various stabilizers, cement based stabilization is most prevalent nowadays. Cement can be used in any types of soil to stabilize unlike those having organic content greater than 2% or pH content lower than 5.3 (ACI 230.IR-90 1990). On the other hand adding fiber reinforcement like Nylon Thread or other fibers can be good additive which acts as reinforcement and prevents insidious cracks in soil. The role of cement is to bind soil particles and thus increase engineering properties. Portland cement consists of calcium-silicates and calcium-aluminates that hydrate to form cementitious products. The hydration of Portland cement is fast and causes rapid strength development in the stabilized soil. During hydration reaction, free lime [$Ca(OH)_2$] is produced. In high pH soil, this lime can react pozzolanically and add to the strength of the soil (Melese, 2014).

2 Objectives

The objectives of the study are:

- To classify the soil according to MIT soil classification system.
- To analyze the unconfined compressive strength of soil by using 2%, 4%, 6% & 8% Nylon Thread with a percentage wise combination of 2% cement at different curing periods such as 7, 14 and 28 days.

3 Methodology

3.1 Materials

Components materials are:

a. Soil – The soil samples have been collected from a construction site of 22, Shaheed Mirza Lane (E), Mehedibag Road, Chittagong 4000 which is considered as Sample-01 and a paddy land of Kulapara, Mohora, Chittagong which is considered as Sample-02.
b. Cement – In this study, Portland cement has been used.
c. Nylon Thread – Nylon Thread of 0.33 mm has been used. The strength of Nylon Thread has been found as 3000 psi.

3.2 Preparation of Samples

The collected samples were oven dried and then pulverized. Index properties have been performed on the neutral soil. Optimum moisture content (OMC) has been obtained through standard proctor test. By using the optimum moisture content the samples have been prepared for unconfined compressive strength test which includes mixing of 2%, 4%, 6% & 8% Nylon Thread with a percentage wise combination of 2% cement for different curing periods such as 7, 14 & 28 days. The percentages of Nylon Thread have been used by the weight of 2% cement.

4 Results

4.1 Index Properties

According to MIT classification, both soil samples have been found as Silty Sand & some Clays. Others index properties such as Specific Gravity, Atterberg Limit, Salinity test are given in Table 1(a) for Sample-01 and Table 1(b) for Sample-02.

Table 1(a). Index Properties of Sample-01

Parameters	Percentage (%)
Sand	54
Silt	37
Clay	9
Liquid Limit	25.1
Plastic Limit	12.4
Plasticity Index	12.7
OMC	13.77
Specific Gravity	2.30
Salinity	N/A

Table 1(b). Index Properties of Sample-01

Parameters	Percentage (%)
Sand	52.5
Silt	41.5
Clay	6
Liquid Limit	43.1
Plastic Limit	23.2
Plasticity Index	20
OMC	19.89
Specific Gravity	2.63
Salinity	N/A

4.2 Engineering Properties

The optimum moisture content (OMC) has been determined through Standard Proctor test. Figure 1(a) showing the optimum moisture content (OMC) for Sample-01 and Figure 1(b) showing the optimum moisture content (OMC) for Sample-02.

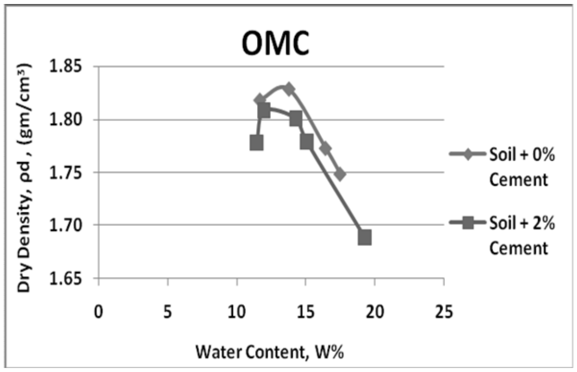

Figure 1(a). Optimum Moisture Content (OMC) of Sample-01.

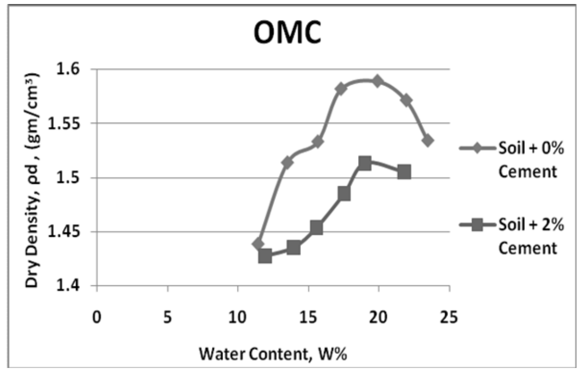

Figure 1(b). Optimum Moisture Content (OMC) of Sample-02.

By using the optimum moisture content (OMC), samples were prepared for unconfined compressive strength (UCS) test. The results of unconfined compressive strength (UCS) test for different Nylon percentages such as 2%, 4%, 6% & 8% (by the weight of 2% cement) with a combination of 2% cement at different curing periods such as 7, 14 & 28 days are shown in Table 2(a) for Sample-01 and Table 2(b) for Sample-02.

Table 2(a). Results of Unconfined Compressive Strength (UCS) test for Sample-01

Curing Period	**7 days**		**14 days**		**28 days**	
%	**Stress (psi)**	**% increase**	**Stress (psi)**	**% increase**	**Stress (psi)**	**% increase**
Soil + 0% Cement (Controlled Sample)	14.89	Initial	14.99	Initial	16.57	Initial
Soil + 2% Cement	36.82	247.280	46.17	308.005	60.26	363.669
2% Cement + 2% Nylon	58.86	395.299	60.88	406.137	64.78	390.947
2% Cement + 4% Nylon	59.37	398.724	61.74	411.875	66.42	400.845
2% Cement + 6% Nylon	60.36	405.373	62.90	419.613	67.89	409.716
2% Cement + 8% Nylon	59.25	397.918	61.20	408.272	65.94	397.948

From the Table 2(a), it has been shown that the stress has increased up to 6% Nylon with a combination of 2% cement (2% Cement + 6% Nylon). Then it starts falling down. It has been selected as optimum Nylon percentage for Sample-01. Similarly, in case of Sample-02, Table 2(b) is showing the details below.

Table 2(b). Results of Unconfined Compressive Strength (UCS) test for Sample-02

Curing Period	7 days		14 days		28 days	
%	**Stress (psi)**	**% increase**	**Stress (psi)**	**% increase**	**Stress (psi)**	**% increase**
Soil + 0% Cement (Controlled Sample)	23.16	Initial	23.27	Initial	23.32	Initial
Soil + 2% Cement	29.17	125.950	36.56	157.112	41.59	178.345
2% Cement + 2% Nylon	35.83	154.706	40.25	172.969	44.65	191.467
2% Cement + 4% Nylon	37.90	163.644	41.97	180.361	45.89	196.784
2% Cement + 6% Nylon	37.29	161.010	41.01	176.235	45.24	193.997
2% Cement + 8% Nylon	37.32	161.140	40.79	175.290	45.01	193.010

From the Table 2(b) above, it has been shown that the strength has increased up to 4% Nylon with a combination of 2% cement (2% Cement + 4% Nylon). Then it started decreasing. It has been selected as optimum Nylon percentage for Sample-02.
According to Table 2(a) and Table 2(b), Figure 2(a), 2(b) and Figure 3(a) and 3(b) are shown below.

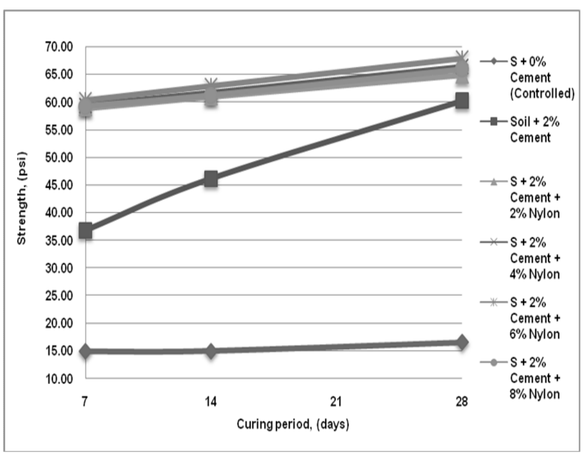

Figure 2(a). Variation of Unconfined Compressive Strength for Different Curing Periods (Sample-01)

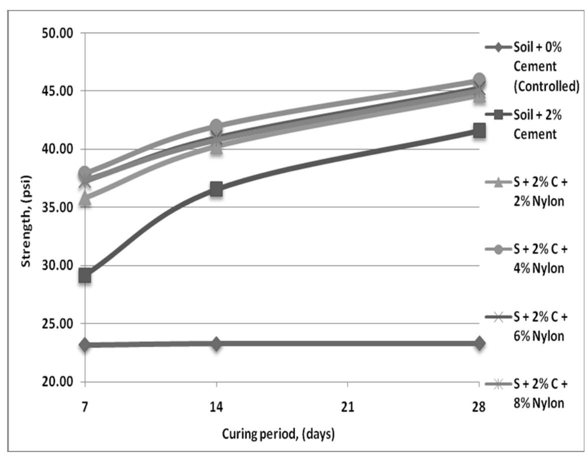

Figure 2(b). Variation of Unconfined Compressive Strength for Different Curing Periods (Sample-02)

Figure 2(a) and Figure 2(b) are showing the variation of unconfined compressive strength for different curing periods such as 7, 14 and 28 days.

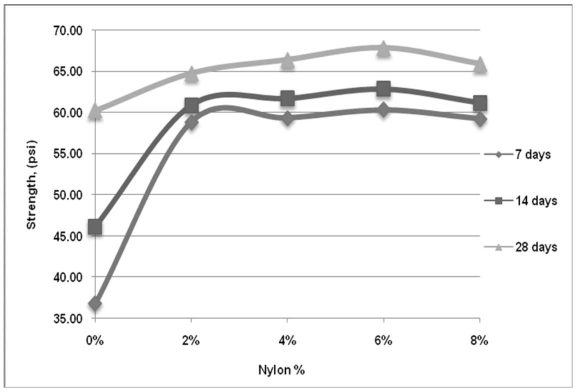

Figure 3(a). Variation of Unconfined Compressive Strength for Different % of Nylon Thread (Sample-01)

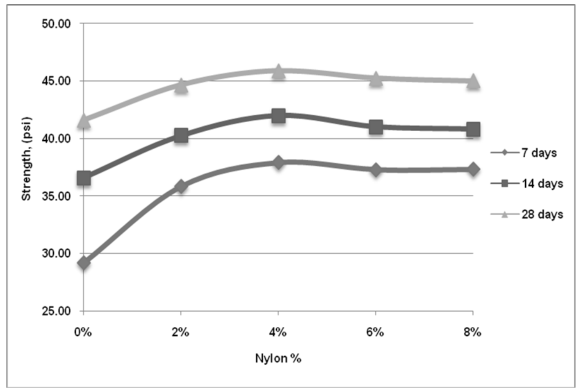

Figure 3(b). Variation of Unconfined Compressive Strength for Different % of Nylon Thread (Sample-02)

From Figure 3(a) and Figure 3(b) it has been observed that the compressive strength increased subsequently with the increase of adding Nylon percentage with a percentage wise combination of cement which is 2%. After adding a certain percentage of Nylon, the strength started to decrease. The percentage beyond that the strength started to decrease is considered as optimum percentage for both soil samples.

5 Conclusions

This study has been basically focused on the change of compressive strength of Nylon treated soil with a combination of cement. It can be concluded that there is an improvement of geotechnical properties of Nylon treated soil with a combination of cement. So it can be applied in practical field with proper care. The conclusion obtained from this study can be summarized as follows:

- According to MIT soil classification system both soil samples have been found as Silty Sand and some Clays.
- The unconfined compressive strength of Sample-01 has been found as approximately 4 times greater than the controlled sample. In case of Sample-02, that has been found as approximately 2 times greater than the controlled sample.
- Thus, 6% Nylon with a combination of 2% cement has been considered as optimum Nylon percentage for Sample-01 and 4% Nylon with a combination of 2% cement has been considered as optimum Nylon percentage for Sample-02.

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