4th Annual Paper Meet and 1st Civil Engineering Congress, December 22-24, 2011, Dhaka, Bangladesh ISBN: 978-984-33-4363-5
Noor, Amin, Bhuiyan, Chowdhury and Kakoli (eds) www.iebconferences.info

Effect of lime and curing period on unconfined compressive strength of Gazipur soil, Bangladesh

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ABSTRACT: Presence of clay soil beneath the foundation of a structure is dangerous as the clay soil is subjected to settlement which poses threat to the structure. To reduce this threat for the structure, soil stabilization/ improvement is necessary. A very common option of soil stabilization is to mix lime with the clay soil. In this study different percentage of lime was mixed with Gazipur clay soil and unconfined compressive strength of that soil was measured by laboratory testing. The results showed that maximum value of unconfined compressive strength/ un-drained shear strength was obtained at 4% lime content for any stage of curing period. The unconfined compressive strength of 4% lime content samples is about 4- 6 times higher than sample without lime content and about 1.5 to 2 times higher compared to 2, 6 and 8% lime content samples. It also showed that the highest value of unconfined compressive strength/ un-drained shear strength was found at 28 days curing period for each percentage of lime content in the sample.

1 INTORDUCTION

In last few decades, world population has been increased rapidly especially in developing countries like Bangladesh. To accommodate the huge number of population and to produce food, all unused lands are needed to use. But a large amount of land consists of soft clay in our country where any type of construction is risky due to uneven settlement or bearing capacity failure of the clay soil. Therefore, a suitable and cheap soil improvement/ stabilization technique is required to use these soft soils for industrializations as well as to improve the communication facilities (construction of roads).

Improvements in engineering properties of soil such as increases in soil strength (shearing resistance), stiffness (resistance to deformation) and durability (wear resistance), reductions in swelling potential or dispersivity (tendency to deflocculate) of wet clay soils can be done by soil stabilization (McNally 1998). Soil stabilization involves the blending of natural soils with chemical agents such as lime, Portland cement and asphalt (Spangler & Handy 1973). These agents are generally potential binders which effectively bind together the soil aggregates to achieve the properties of binders and improve load carrying and stress distributing characteristics, and control shrinkage and swell of the soil. A very common and cheap technique to improve the soft clay soil is to add a certain percentage of lime with that soil (Petry and Glazier 2004). The aim of this study is to determine the engineering properties and unconfined compressive strength of Gazipur clay soil, Dhaka. Additionally, this study investigates the improvement of the unconfined compressive strength of soil by mixing different percentages of lime with soil. Finally, it gives information about optimum lime content for this particular soil to improve the unconfined compressive strength at four different curing periods.

2 MATERIALS AND METHODS

In this study the selected soil sample was collected at the depth of 2 meter from top of the ground surface which is located at Vurulia, Gazipur district of Bangladesh, very close to capital city, Dhaka. First, the collected soil sample was sieved by 2 mm passing and then, physical properties of soil were determined as shown in Table 1. After measurement of physical properties, moisture density relationship was investigated by standard proctor method (ASTM 698-07). Then the sieved soil was mixed thoroughly with 0, 2, 4, 6 and 8 percentages of lime (which is available in market at Chittagong, Bangladesh) at optimum moisture content condition. Next, four samples (10 cm in diameter and 12 cm in height) were compacted for each percentage of lime content by standard proctor method. After compaction, the sample was trimmed carefully to 1.5 inch in

Table 1: Engineering properties of Gazipur Soil

Properties	*Results*
Natural moisture content (%)	17.40
Specific gravity	2.68
Liquid limit (%)	50.60
Plastic limit (%)	19.09
Linear shrinkage (%)	9.62
Shrinkage limit (%)	10.27
Plasticity index (%)	31.51
Maximum dry density (gm/cm³)	2.03
Optimum water content (%)	15.00
Soil classification (*USCS)	CH

* Unified Soil Classification System

diameter and 3 inch in height. Then the four trimmed soil samples were cured for 0, 7, 14 and 28 days respectively for each percentage of lime content soil. Curing was done by covering the samples with wetted jute bags for specified time period (7, 14 or 28 days). Then unconfined compression test of trimmed and cured sample was performed using a proving ring type unconfined compression testing machine. The load was applied at the rate of 0.5 to 2 percent per minute and test was done up to the failure or 15% strain which one is earlier. Unconfined compressive strength was estimated by taking the stress value from peak of the stress strain diagram for all samples. Un-drained shear strength or cohesion was calculated using $S_u = q_u/2$ relation. Where S_u is the un-drained shear strength (lb/ft^2) and q_u is the unconfined compressive strength (lb/ft^2).

3 RESULTS AND DISCUSSION

Figure 1 shows the moisture density relationship for Gazipur soil. It is observed from figure 1 that maximum dry density and optimum moisture content was 2.03 g cm^{-3} and 15% respectively for the selected Gazipur soil.

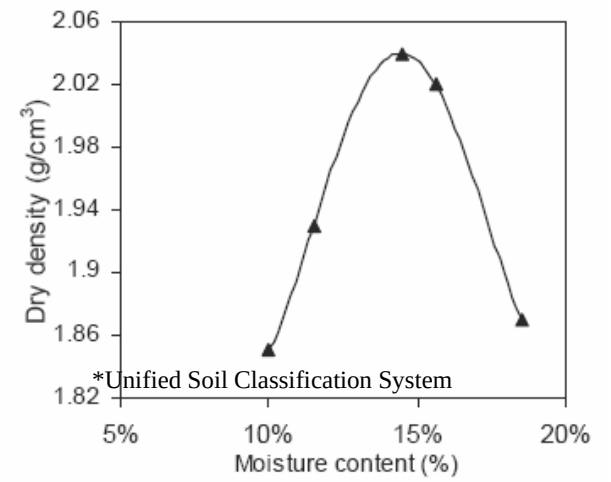

Figure 1. Moisture density relation of Gazipur soil

Axial stress against axial strain of unconfined compressive strength test for five different mixtures of soil and lime at optimum moisture content condition are shown in Figure 2. The axial stress was plotted as a function of axial strain for 0, 2, 4, 6 and 8 % lime soil mixture in figure 2a, 2b, 2c, 2d and 2e respectively for 4 different curing periods (0, 7, 14 and 28 days).

The figures show that for all cases 28 days cured sample gives highest axial stress compared to 0, 7 and 14 days cured sample similar to concrete because hydration will occur during the curing period due to the presence of cementicious materials in lime. Interestingly, 4% lime content samples give almost similar values of axial stress for 7, 14 and 28 days might be due to the initial strength development of the lime mixed sample (Fig. 2c) by hydration. For other four cases in Figures 2a, 2b, 2d and 2e stress increased slightly with the increase of curing period.

Figure 3 shows plotting of axial stress against axial strain for five different mixtures of lime and soil. The 0, 7, 14 and 28 days cured sample stress strain behavior was shown in Figures 3a, 3b, 3c and 3d respectively

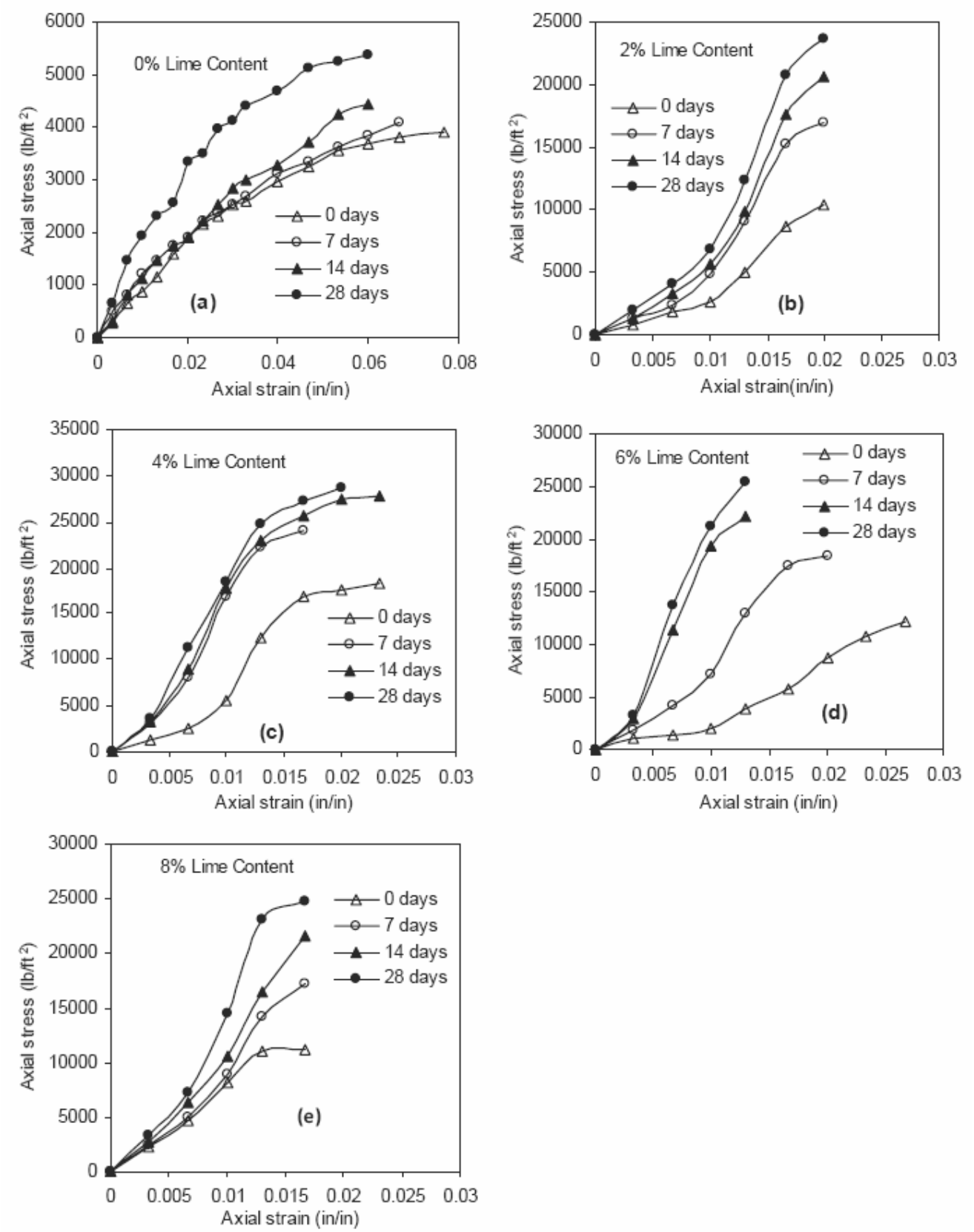

Figure 2. Axial stress against axial strain for (a) 100% Gazipur soil (b) 2% lime soil mixture (c) 4% lime soil mixture (d) 6% lime soil mixture and (e) 8% lime soil mixture at 4 different curing period (0, 7, 14 and 28 days).

for five lime soil mixture samples. From figure 3, it is shown that mixing of lime with soil improved the strength of the soil in each curing period. It is also observed that 4 percent lime content in Gazipur soil gives greatest stress for all four curing periods (Fig. 3a-d) discussed here.

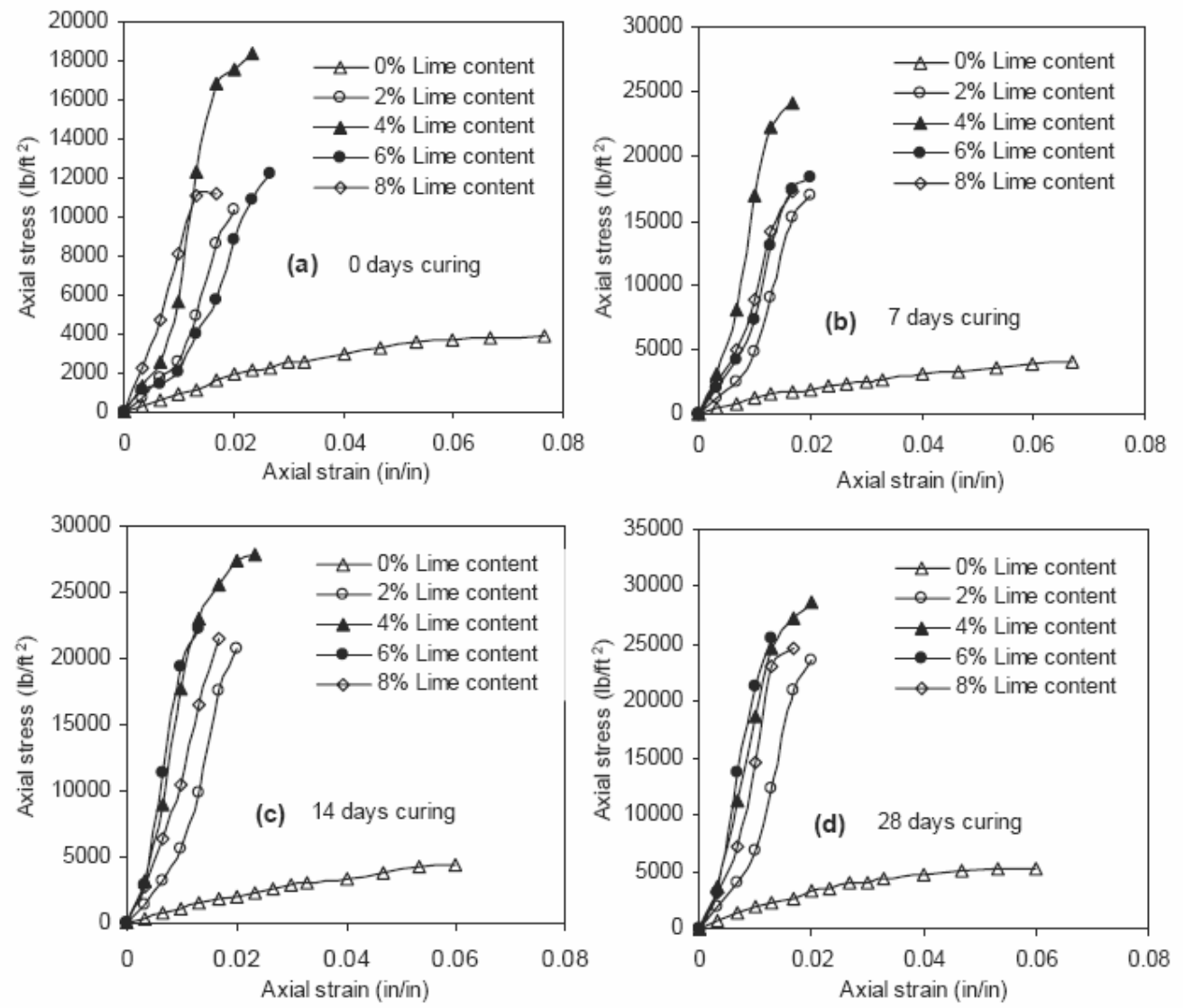

Figure 3. Axial stress as a function of axial strain for curing period of (a) 0 days (b) 7 days (c) 14 days and (d) 28 days with 0, 2, 4, 6, 8% of lime content soil.

The unconfined compressive strength was estimated from stress strain diagram and was plotted against five different percentages of lime content for four different curing periods in figure 4. It shows that unconfined compressive strength increases as the curing period increases for all the samples tested in this study. It also shows that unconfined compressive strength increases for 0 - 4% lime content sample as lime content increases and then it reduces due to further increment of lime in the samples. The initial increment of unconfined compressive strength form 0-4 percent lime content sample might be due to the hydration of lime in the soil sample and the later (4 to 8 %) decrement of unconfined compressive strength might be due to the presence of excess lime (having less compressive strength compared to soil) in the soil sample. It is clear from the Figure that 4% lime content in the soil gives highest unconfined compressive strength at each curing period used in this study.

Figure 5 shows the plotting of unconfined compressive strength against four different curing periods for five different percentages of lime soil mixture. It shows that for soil (0% lime content) unconfined compressive strength is almost similar for all four curing periods indicating no effect of curing period on unconfined compressive strength for 100 percent clay soil. However, for other cases (lime soil mixture) considerable variation of unconfined compressive strength was observed with varying percentage of lime content in soil indicating the effect of lime content on unconfined compressive strength. From the figure 5, it is also found that soil without lime gives the lowest unconfined compressive strength. The 2, 6 and 8 % lime mixed soil give almost similar values of unconfined compressive strength lying in between 0% and 4% lime content soil and 4% lime content soil shows largest values of unconfined compressive strength for all curing periods. The unconfined compressive strength of 4% lime content samples is about 4- 6 time higher than sample without lime

content and about 1.5 to 2 times higher compared to 2, 6 and 8% lime content samples. Therefore, adding only 4% of lime with Gazipur soil gives considerable improvement of strength property of soil.

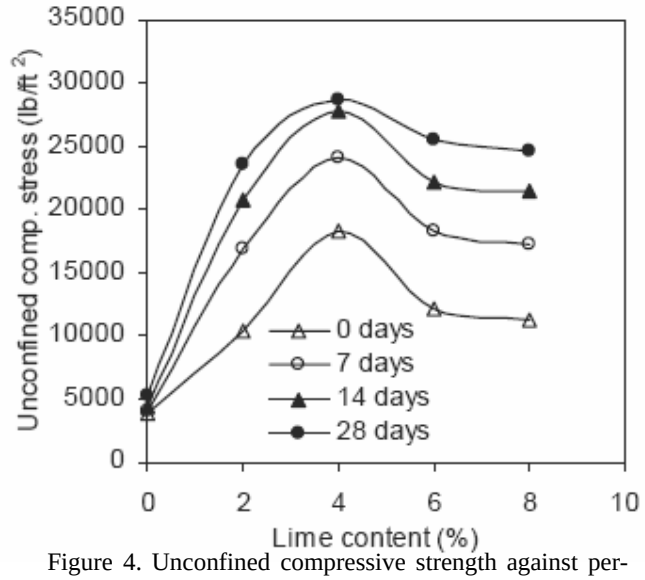

Figure 4. Unconfined compressive strength against percentage of lime content for 0, 7, 14 and 28 days curing period.

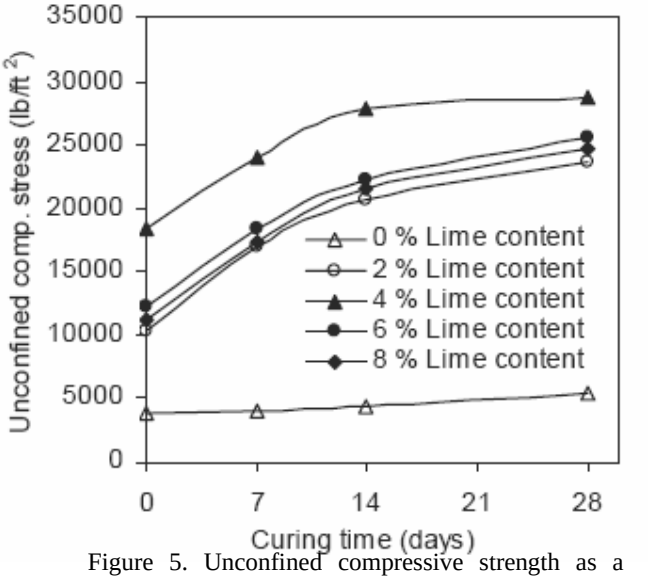

Figure 5. Unconfined compressive strength as a function of curing period for five different lime soil mixture

4 CONCLUSIONS

This study shows that only 4% addition of lime with Gazipur soil increases 4 to 6 times the unconfined compressive strength/ un-drained shear strength of the soil at different curing period used in this study. Though further investigation is necessary using other clay soils and other additives (such as cement, fly ash and slag), this study provides useful information about the optimum lime content and capability of unconfined compressive strength gain for selected Gazipur soil which is very important to stabilize the soil for any necessary development work.

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