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Effect of Palm Fibres on Lime Blended Sandy Clay

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Abstract. Ground improvement is a crucial and inevitable step in geotechnical engineering. Many stabilisers have been used all over the world to improve the problematic soil. The stabilized soil materials have a higher strength, lower permeability and lower compressibility than the native soil. In this study, sandy clay with silt is improved with the help of lime and palm fibre. Improvement in geotechnical properties is found out by conducting compaction and unconfined compressive strength. Here 2 cm long palm fibre with 0.1%, 0.2%, 0.3% and 0.4% are added to soil treated with 10% (OLC) lime. Upto an optimum percentage, shear strength increases with increase in fibre content. Also the value of strain increases with increase in fibre content. Tests are conducted for both random mix and horizontal mix of fibres. This research concludes that combination of lime and palm fibre is a better stabilizer for ground.

Keywords: Random mix, horizontal mix, unconfined compressive strength.

1 Introduction

Major challenges faced by geotechnical engineers are developing economically feasible and durable methods of ground improvement. Soil stabilization refers to any physical, chemical, or biological method, or any combination of such methods, that is employed to improve certain properties of a natural soil to make it adequately serve an intended engineering purpose over the service life of an engineering facility. Through soil stabilization, unbound materials can be stabilized with cementitious materials (cement, lime, fly ash, bitumen or combination of these). For a successful stabilization, a laboratory tests followed by field tests may be required in order to determine the engineering and environmental properties. Many stabilizers have been used all over the world to improve the problematic soil in terms of its compressive strength. But in order to improve the tensile strength and enhance the ductility characteristics, fibres have been used nowadays. Both natural and synthetic fibres have been used for stabilization.

2 Experimental studies

2.1 Materials used

The soil was collected from Thonnakkal region of Thiruvananthapuram district which belongs to sandy clay category. Laboratory tests were conducted to determine the properties of the soil such as specific gravity, liquid limit, plastic limit, shrinkage limit, unconfined compressive strength, optimum moisture content, maximum dry density and pH. Table 1 shows the engineering properties of the soil. Lime and palm fibres were used as additives.

Table 1. Properties of soil

Property	Value
Colour	Light Grey
Natural water content (%)	20
Clay (%)	48
Silt (%)	14
Sand (%)	38
Liquid limit (%)	49
Plastic limit (%)	25
Plasticity index (%)	24
Specific gravity	2.5
MDD (kN/m^3)	18.3
OMC (%)	15
UCS (kN/m^2)	28.49
pH	5.72

2.2 Methodology

The soil is first treated with different percentages of lime (5%, 10%, 12% and 15%) to determine the optimum lime content. With the optimum lime content as constant the fibre content is varied in order to determine the optimum percentage of fibre by conducting unconfined compression test. The various percentages of fibres used for the treatment are 0.1%, 0.2%, 0.3% and 0.4%.

3 Results and Discussions

3.1 Effect of lime on sandy clay

Standard proctor test. Compaction test was conducted with various percentages of lime such as 5%, 10%, 12% and 15% to find out the optimum moisture content and maximum dry density On increasing the proportion of the lime, the optimum moisture content increases whereas maximum dry density decreases. The pozzolanic reaction between clay and lime are responsible for the increasing the OMC of the mixture. For the same reason the MDD decreases with increasing the lime content.

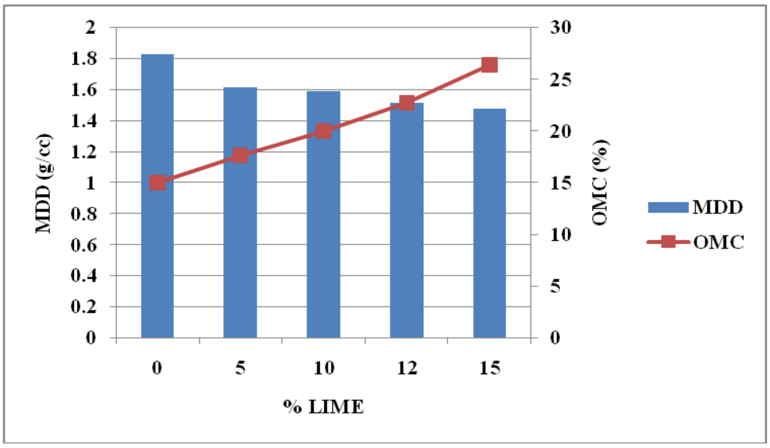

Fig. 1. Variation of MDD and OMC with different lime content

Unconfined compression test. The soil sample sieved through 425µ was taken and was mixed with 0, 5, 10, 12 and 15% of lime and the unconfined compression test was conducted. The results obtained on the zero days were taken and the optimum percentage of lime was determined. From the Fig. 2 it can be inferred that up to 10% compressive strength increases as the lime content increases. But with further increase in lime content, the compressive strength is found to decrease. Hence the optimum lime content is taken as 10%. By comparing the UCS values of the sample cured for different time periods, it can be inferred that as the curing period increases the UCS value also increases. Maximum compressive strength is obtained for the sample after 28 days of curing.

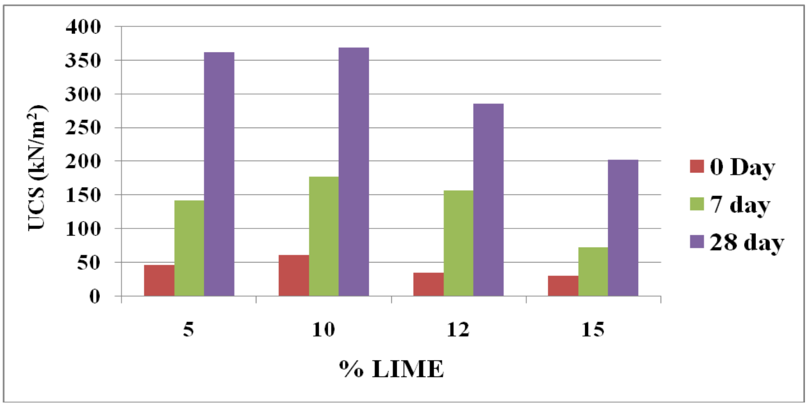

Fig. 2. Variation of UCS for different lime content and curing period

3.2 Effect of lime and palm fibre on sandy clay

Standard proctor test. Compaction test was conducted with optimum percentage of lime and varying percentage of palm fibre (0.1%, 0.2%, 0.3% and 0.4%). From the Fig. 3 and it can be inferred that for constant lime content, addition of nylon fibre decreases MDD whereas increases OMC. Same trend was observed in the work done by M. Arabani and H. Haghsheno. According to them by adding fibres to the soil-lime mixture, a portion of water is absorbed by the fibres and in order to reach the MDD a larger amount of water is needed, leading to an increase in OMC. According to Kezdi and brown, the decrease in MDD is due to the growth of micro pores which are formed due to the tendency of lime for water absorption and aggregation.

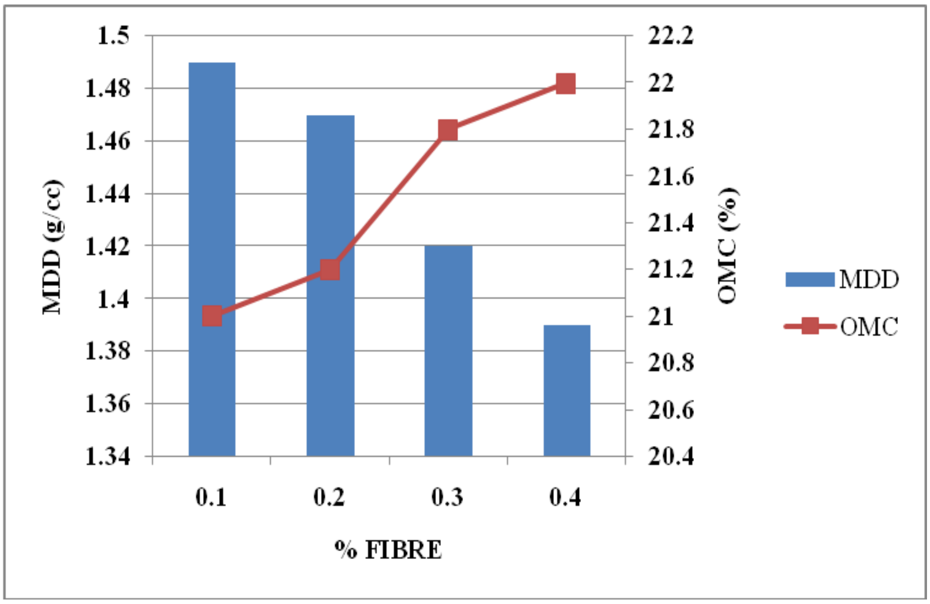

Fig. 3. Variation of MDD and OMC with different fibre content

Unconfined compression test. The soil sample sieved through 425µ was taken and it was mixed with 10% of lime and varying percentage of palm fibre (0.1, 0.2, 0.3 and 0.4%) and the unconfined compression test was conducted. Two different arrangements of palm fibres were experimented where the fibres were mixed randomly with the soil and also the fibres were mixed in horizontal layers with the soil. The results obtained after 0 and 7 days of curing were recorded.

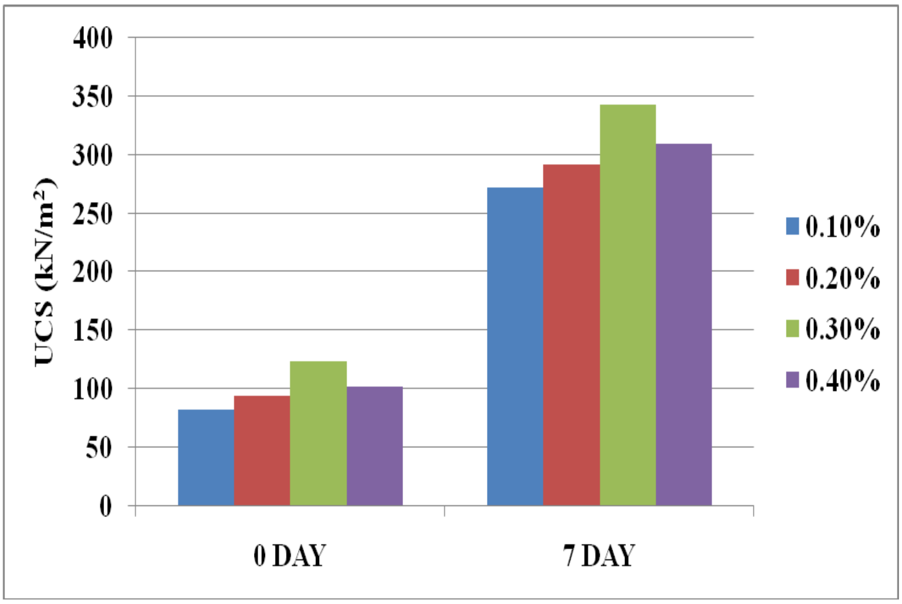

Fig. 4. Variation of UCS in random mix

The variation of UCS with time in the case of random mix is shown in Fig.4. It can be inferred that as the percentage of palm fibre increases the UCS increased upto 0.3% and with further increase in fibre content UCS decreased. Also it can be seen that as the curing period increases the UCS also increases. Maximum UCS is obtained after 7 days of curing.

In the case of horizontal mix, the fibres were placed in two layers, each layer at a depth of one-third the mould height. From Fig. 5 it can be inferred that the UCS increases with increase in fibre content upto 0.3%. The effectiveness is found to decrease with further addition of fibre. In horizontal mix also addition of palm fibre improves the compressive strength but the amount of increase is less compared to that of random mix.

According to S. Dhar and M. Hussain, the cementitious products formed after lime treatment has rough surfaces and high rigidity, which binds the fibre–soil particles together and provides a compact matrix structure. This helps to increase the effective contact area and interlocking between fibre and modified soil particles, and thus enables greater mobilization of friction between them with an increase in fibre content. After the peak value further increment in fibre content forms lumps and adheres to each other; thus, there may be deficiency in the contact between soil and fibre which is responsible for reduction of friction coefficient and hence reduces the stress and the effectiveness in improvement is reduced.

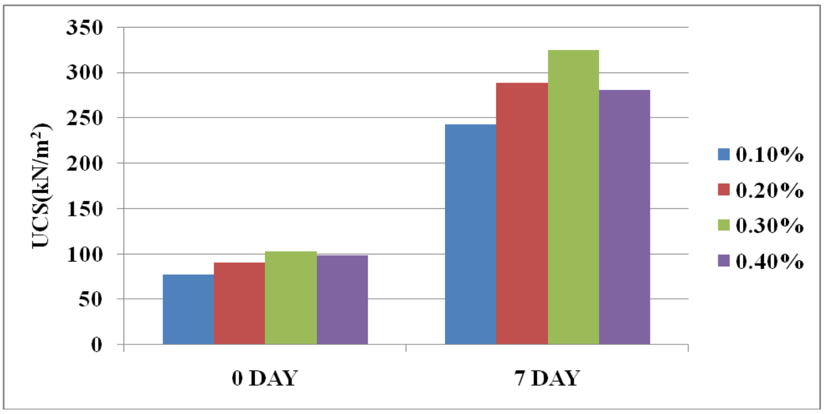

Fig. 5. Variation of UCS in horizontal mix

Because of the time-dependent pozzolanic reactions, the stabilization of the lime-treated soil is a long-term process (Rajasekaran & Rao, 1996). Thus, the strength of the stabilized soil increases as the curing time increases.

Comparison between random mix and horizontal mix. On comparing the results of both types of fibre arrangement, we can see that both cases are effective in improving the strength of the soil.

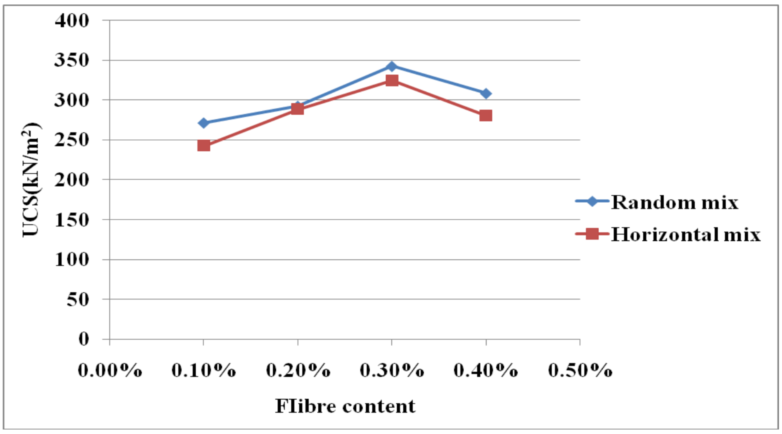

Fig. 6. Variation of UCS with percentage of palm fibre after 7 day curing

Fig. 6 shows the variation of UCS after 7 day curing for random mix and horizontal mix. Here the peak strength of 0.3% fibre reinforced soil shows 12 times increase in UCS than unreinforced soil for random mix. But in case of horizontal mix, peak strength of soil reinforced with 0.3% fibre increases by only 11.37 times than unreinforced soil.

4 Conclusions

1. With the addition of lime and fibre, optimum moisture content increases
2. where as maximum dry density decreases which is due to the pozzolanic reaction between lime and clay.
3. The compressive strength of soil increases with increase in lime upto 10%. After 10% strength decreases with further increase in lime content. Hence optimum lime content is obtained as 10%.
4. With 10% lime as constant, effect of fibre reinforcement is studied by varying the fibre content and conducting unconfined compression test.
5. Standard proctor test was conducted for soil with 10% lime and varying percentage of fibre. With the addition of fibre optimum moisture content increases where as maximum dry density decreases.
6. As the palm fibre content increases, the compressive strength first increases but after 0.3% it is found to decrease.
7. Random mix of palm fibre increases the peak strength by 12 times the unreinforced soil.
8. Horizontal mix of the palm fibre increases the peak strength only by 11.36 times the unreinforced soil.
9. Comparing the random mix and horizontal mix of palm fibres, randomly distributed fibres showed the improvement more effectively that the horizontal mix.

However, in this paper, durability of fibre mixed with soil and lime has not been investigated. There is a chance of decay of fibre which can reversely affect the stabilized soil. Hence studies regarding durability and aging of fibres have to be done. Also in this work, curing period up to 7 days has been done. It may not be sufficient to make a conclusion regarding effect of time on compressive strength of soil sample. Hence curing period extending few months have to be evaluated to reach a conclusion.

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