Strength Development of Lime Treated Artificial Organic Soil

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Abstract. In over many years, considerable research has been carried out on organic soils which consists of various components of organic matter but the effect of particular organic matter is less reported. Thus, some of contributing factors for each organic matter are not fully understood yet. Hence, the aim of this study is to determine the effect of organic acid concentration on the strength of artificial organic soil. There are four types of artificial organic soil created by mixing kaolin (inorganic matter) and organic acid (a kind of humified organic matter) in different concentrations. Unconfined Compressive Strength test (UCT) was carried out for all soil samples after being cured for 7 and 28 days under room temperature and 50°C. Soil samples shows highest strength when cured for 28 days under 50°C compared to those cured under room temperature. However, when the organic acid concentration decrease, the strength increased for soil 2 after 7 and 28 days cured under room temperature and 50°C. Apart from this, soil 3 and soil 4 that were cured under room temperature shows decrease in strength when the organic acid concentration decreasing but different result shown for both samples when cured under 50°C.

Keywords: Soft Soil, kaolin, organic acid, fulvic acid, humic acid, lime.

1. Introduction

Organic soils have not received attention in civil engineering due to the presence of organic matter in soils associated with high compressibility, high water content, low permeability and low shear strength. These characteristics have caused organic soils become unsuitable for engineering construction purpose. A suitable improvement method is needed to prevent excessive settlement during construction work also to enhance the shear strength and bearing capacity of the soil.

Nowadays, soil stabilization is one of the very importance knowledge in the civil engineering field because all building structures and infrastructures will stand upon the soil as the base and platform. So, strength of the soil must be strong enough in order to ensure the properties can withstand safely without damages. With the high level efficiency of soil stabilization, it does not only protects against those structures mentioned above from harmful but also against many things like erosion in many different places, economic design for sub-grade that build on soft soil and environmental concerned.

In general, lime can be used to treat soils in order to improve their workability and load-bearing characteristics. Lime is an excellent choice for short-term modification of soil properties. Pe This reaction produces stable calcium silicate hydrates and calcium aluminate hydrates as the calcium from the lime reacts with the aluminates and silicates solubilized from the clay.

This paper will discuss about the result of tests carried out on artificial organic soil mixed of kaolin (inorganic matter) and organic acid (organic matter) in different concentration. At the same time, the strength of artificial organic soils cured under room temperature and 50°C were determined. Hence, the correlation of organic acid concentration on the strength of artificial organic soils is summarized.

2. Material and Methods

The soils used in this study were artificial organic soils. The soil samples were prepared by mixing kaolin grade S300 as an inorganic component and mixed of 15% of organic acid (containing 0.37% of humic acid and 46.60% of fulvic acid) as the organic components. These artificial organic soils were prepared in 4 different dilution factors. Table 1 below shows the mixed proportion for the soil samples used in this study. Nonetheless, lime were the addictive for remolding samples. The curing time 7 and 28 days are required for the lime-treated soil samples. Not only than that, the curing temperature used was different for the remolded sample which were under room temperature and 50°C. It is believed that samples that is cured under 50°C will accelerated the hardening process.

Table 1. Type of soil.

Material	Percentage required for each samples (%)			
	Soil 1	Soil 2	Soil 3	Soil 4
Kaolin S300	85	85	85	85
Organic acid	15	7.5	5	3.75
Distilled water	0	7.5	10	11.25

Initial consumption of lime was carried out according to [1] to indicate the sufficient amount of lime and to ensure the pH during the reaction is 12.4 at 25°C. Initial consumption of lime (ICL) test was conducted as a primary step to identify the minimum amount of modification of lime added to artificial organic soil had to be determined. This was essential to ensure the amount of lime added to organic soil is sufficient for the occurrence of modification stabilization process.

Standard Proctor Compaction test was conducted in accordance to BS 1377: Part 4: 1990 with the aim to identify the maximum dry density and optimum moisture content of the artificial organic soil. Then, test specimens were remolded based on [2] with dimension 50mm of diameter and 100mm in height. There were a total of 48 samples remolded in this study. 24 units of the samples were cured under room temperature and another 24 units were cured in an oven with constant temperature of 50°C. Lastly, unconfined compression test (UCT) was conducted for all the test specimens after 7 and 28 days for both curing temperature. This testing used for determine the shear strength of the soil.

3. Results and Discussion

Based on Figure 1, percentage of lime 1.5% was chosen for the stabilization process in this study as more than 1.5% of lime content has been achieved pH of 12.4 among every ICL test data and to ensure a long term strength gain achieved from the stabilization process. Besides that, constant lime content for all specimens was for the purposes of eliminating multiple variables occurred in test and effect of physical and geochemical properties to the strength might hard to found.

Results of Unconfined Compressive Test are shown in Table 2. According to the data collected, overall strength of soils showing that after curing for 28 days has higher than 7 days curing. It is clearly shown in Figures 2 and 3. Either the soil specimens is placed on room temperature or 50°C, the unconfined compressive strength for specimens cured after 28 days are higher than 7 days.

Nonetheless, based on the Figure 4, for soil samples cured under room temperature recorded that the strength of soil samples decrease when increase the dilution factor of organic acids, but only soil 2 had the highest strength among the four samples. However, for the samples cured at 50°C, soil 2 had the highest strength also. By referring to the Figure 5, the graph shows the strength for soils samples after curing 28 days under different temperature. It can be clearly seen that strength for soil samples cured under 50°C are higher than cured under room temperature. According to [3], strength of soils can be improved when increasing the temperature and extended the curing time. The author had found that the strength of the soil-lime mixtures increased substantially when the curing temperature is doubling from 20°C to 40°C. This is because the pozzolanic reactions are promoted. Another study from [4] also stated that, rate of formation cementitous compounds that binding soil aggregate together will be affected by the temperature.

Table 2. Result of Unconfined Compression Strength Test after curing.

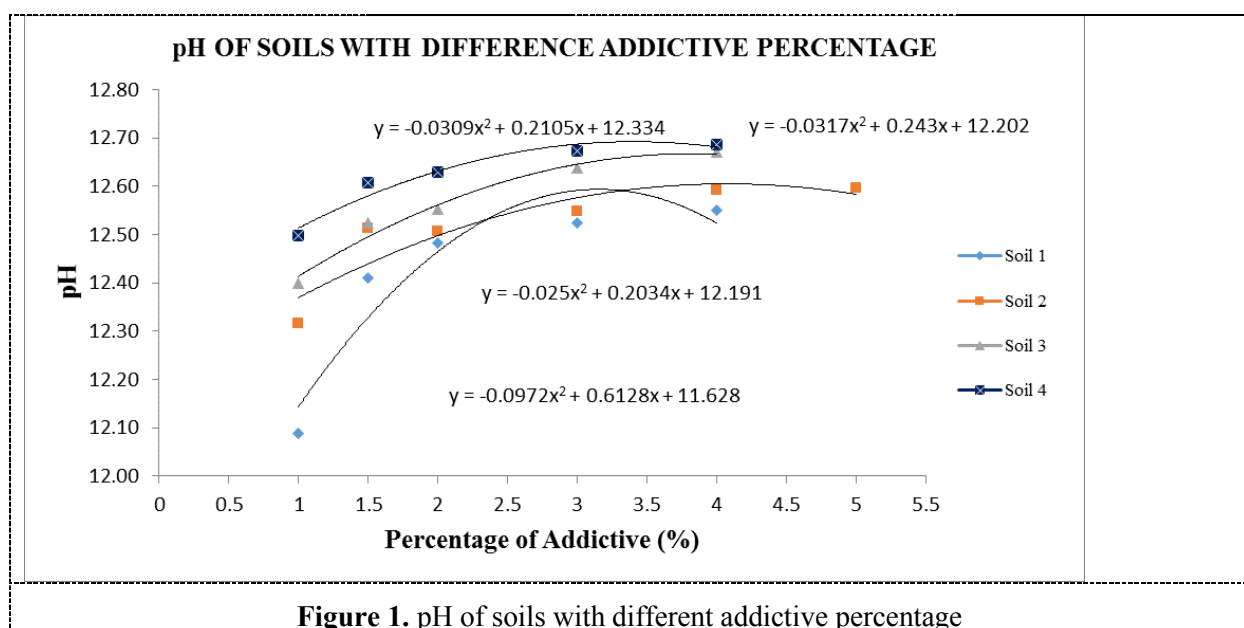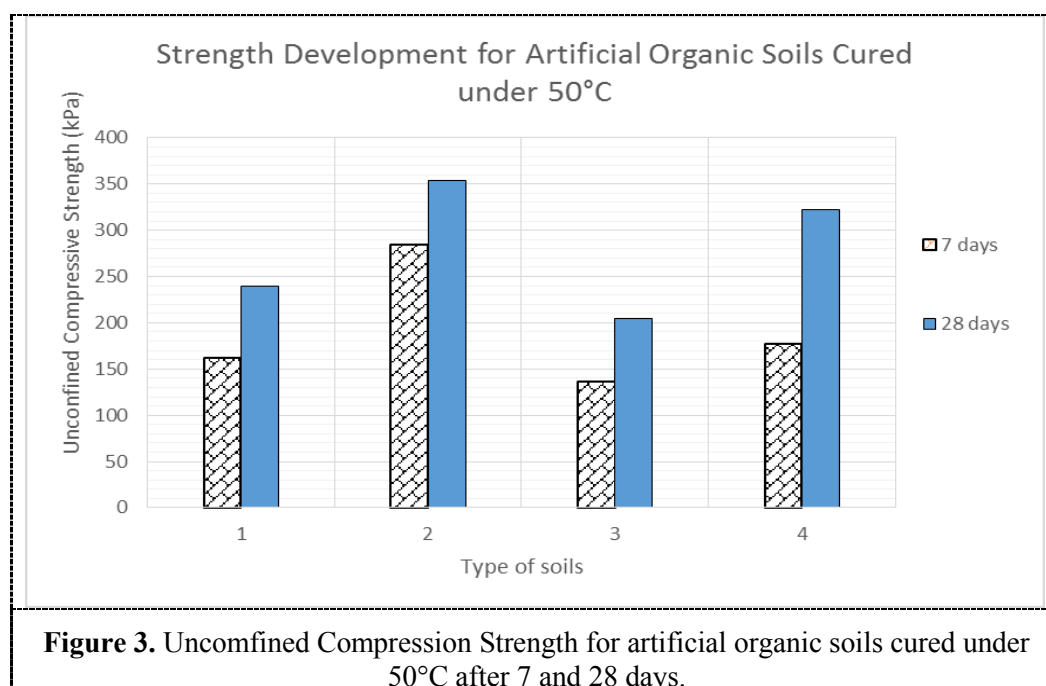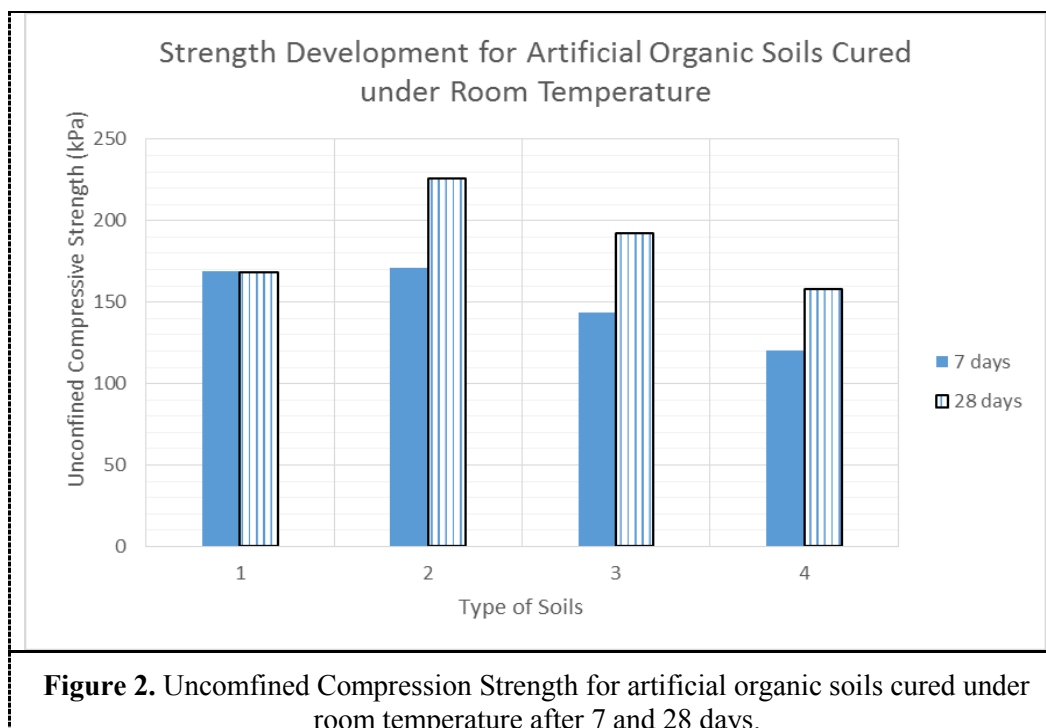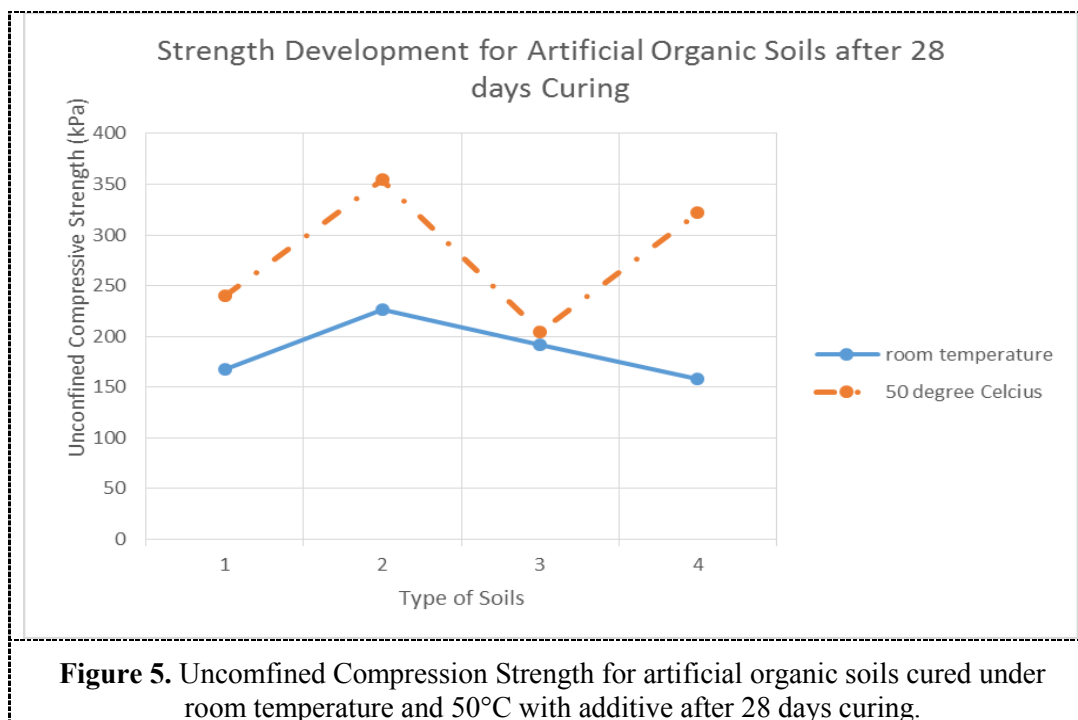| Soil Sample	Curing Temperature	Unconfined Compressive Strength (kPa)		
		7 Days Curing	28 Days Curing	Increment (%)
Soil 1	Room temperature	168.83	168.10	-0.43
	50°C	161.51	239.60	78.09
Soil 2	Room temperature	171.07	226.07	32.15
	50°C	284.75	354.36	69.61
Soil 3	Room temperature	143.43	191.97	33.84
	50°C	136.09	204.42	68.33
Soil 4	Room temperature	120.06	157.67	31.32
	50°C	177.16	322.03	144.87

Figure 1. pH of soils with different addictive percentage

Figure 2. Uncomfined Compression Strength for artificial organic soils cured under room temperature after 7 and 28 days.

Figure 3. Uncomfined Compression Strength for artificial organic soils cured under 50°C after 7 and 28 days.

Figure 4. Uncomfined Compression Strength for artificial organic soils cured under room temperature and 50°C with additive after 7 days curing.

Figure 5. Uncomfined Compression Strength for artificial organic soils cured under room temperature and 50°C with additive after 28 days curing.

5. Conclusion
The curing periods had contribute in the soil strength enhancement. Soil samples cured under 28 days have given higher strength compare to 7 days curing. Soil 2 had contribute to higher strength among the 4 samples. However, soil 3 and 4 had lower strength compared to others when cured under 50°C and room temperature respectively. Besides that, among the two condition curing temperature of soil samples, room temperature and 50°C shown the significant differences in term of strength after curing for a given period where the strength of soil samples that cured under 50°C was higher than samples cured under room temperature. Hence, different dilution factor for organic acid used will influenced not only the physical and chemical properties of soils, it will also influenced the strength of the soil. Although the strength of soil samples do not shows a significant increasing or decreasing in term of dilution factor increasing, but it was believed that this may cause by the behavior of soil itself when reacts with the organic acid. The internal bonding of the soil particles have been affected through the concentration of organic acid added.

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