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Strength behaviour of kaolin treated by demolished concrete materials

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Strength behaviour of kaolin treated by demolished concrete materials

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Abstract. Kaolin has claynite structure in nature, presenting several properties which may justify in many engineering and industrial applications. However, this type of soil is categorised as problematic soil because the presence of claynite properties eventually resulting the kaolin to have low shear strength and high compressibility as other clay soil. Due to that weakness, kaolinite does not meet the requirements necessary for any construction purposes particularly at the preliminary stage. Hence, to overcome this issue, soil stabilisation process is needed prior any construction works. The aim of this study is to determine the strength characteristics of stabilised soft clay soil (Kaolin S300) with demolished concrete materials (DCM). The selection of DCM as the stabilizer for the purpose reutilisation of waste materials that currently has been a great concern for the environmental sustainability. The percentages of DCM content used were 5%,10%,15%20%,25%,30% with varying curing time of 7days, 14 days and 28 days, respectively. Based on the result it was reported that, the unconfined compressive strength (UCS) test shows that the highest strength value obtained of 595.6 kPa kaolin treated with 30% DCM at 28 curing days. It is equivalent to 92% increment from the untreated kaolin sample at 0 days. However, the optimum amount of DCM which provides significant strength improvement was found when more than 20% of DCM is presented after 14 curing days. Hence, it shows the possible usage of DCM as waste material to effectively stabilize kaolin at specific amounts sufficiently.

1. Introduction

Rapid developments of construction industries in Malaysia has to face extreme challenge occasioned by the boost in so many land usage nowadays. Construction works on soft clay are always very thoughtful and challenging causing some developments projects become very complex. This is because soft clay like kaolin are generally characterized by its low strength properties [1,2,3]. Previous studies has been discussed by the researchers to overcome this issue. Pourakbar et al. [4], in his study on stabilization of clayey soil using ultrafine palm oil fuel ash (POFA) and cement found that the strength of soil increased up to 25%. Years by years, more researchers doing so and study recorded that

soil stabilization is another successful solution to alternate this issue [5,6]. Not only that, the effects of some influential factors such as types of stabilizers, water content, curing condition, replacement ratio,compaction energy and microstructure of chemicals-stabilised soil have been extensively researched [7][8][9].

However, limited research has been carried out focusing on waste materials. Nonetheless, sources, researchers found that waste materials has become a good additives to soil stabilization[10]. This is because usage of waste materials helps in terms of cost effieciency, abundance of availablitity and its impact in the research performance also cannot be denied [11,12]. According to Hsiao et al. [10], as the volume of human population getting higher, the projection of waste generation could be increased up to 60%. Waste materials includes construction waste, domestic waste or even electronic waste is then has been effectively reulitised for sustainability and environmental concern[10] [14,15]. It is necessary to have this engagement so that it become mutually beneficial to the future environment [16, 17] Malaysia itself despite the aggresive and impactful develeopments rise up years by years, the waste generation relatively started to impose so many issues [18] such as inadequate landfill's space, waste overflow and reduce the asthetics value [19]. In fact, it was reported that in Malaysia, 15% of waste generation contributed from demolition and construction waste [20]. Therefore, study on utilization of demolished concrete materials (DCM) in order to investigate its strength performance on stabilised kaolin clay is equally important.

2. Method and materials

The kaolin obtained from Kaolin (Malaysia) Sdn Bhd was used in this study as soil material. The sample as received presented in white colour and was dried at 60°C before use. Kaolin was mixed with demolished concrete materials respectively. All samples used were oven dried and stored inside the v bottle as to maintain their dry condition. Blends of kaolin-DCM sample is then stored in curing chamber within 7 days,14 days and 28 days.

Laboratory works contained both physical and mechanical properties of mixing soft clay with DCM in various percentages. After the optimum moisture content was obtained from the standard compaction test on kaolin, all mixtures were then compacted using this moisture content. Samples of compacted mixtures were tested in laboratory for unconfined compression test. The laboratory tests were based on BS 1377 [21]. The unconfined compressive test sample as shown in Figure 1.

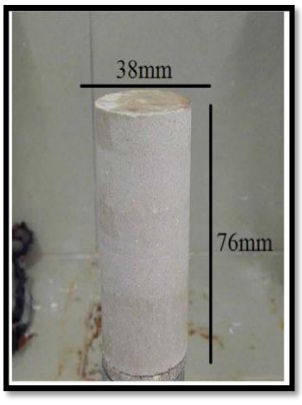

Figure 1. Sample of Koalin treated with DCM.

3. Result and discussion

Unconfined compressive strength was carried out at increment 5% up to 30% DCM content. The study was analysed based on the effect of curing time on the treated samples for 7 days, 14 days and 28 days. All the result based on the 95% of dry condition within the room temperature.

Table 1. The summarisation of UCS Strength value according to DCM content and its curing time.

Percentage of Addictive; (koalin+DCM)	Curing Period,day		
	7 day	14 day	28 day
0%		50	
5%	64.9	75.4	79.15
10%	81.65	84.3	86.35
15%	178.4	209	240.8
20%	218.95	260.55	289.6
25%	278.8	298.4	514.8
30%	308.14	312.7	595.6

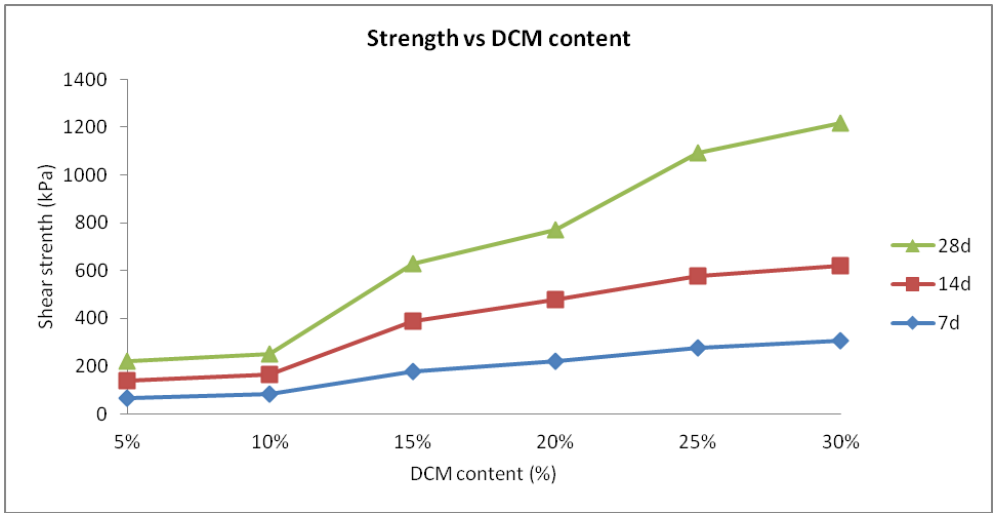

Figure 2. Graph of strength against various percentage of Koalin treated DCM.

Table 1 shows the summary of UCS results for the untreated and treated specimens with various content and curing days. The data obtained shows that the highest strength value if 595. 6 kPa which are at 28 days curing time with highest DCM content. Figure 2 shows a graph with an increasing trend line of strength value against the DCM content. The result of unconfined compression test on the kaolin-DCM treated samples was increased as more DCM content being added. Hence, strength performance of kaolin increase optimally after 20% of DCM content and it can be expected further increase with longer curing days.

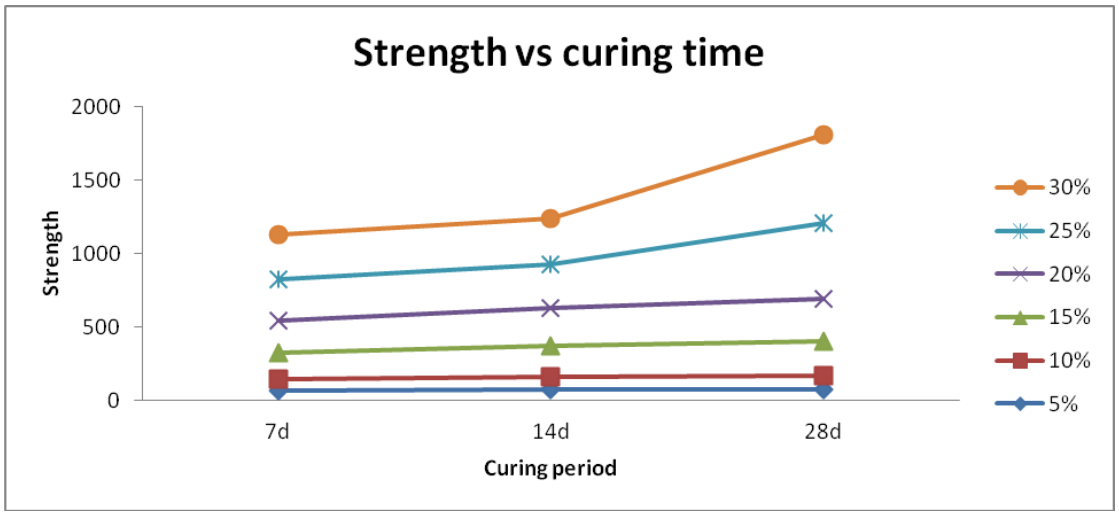

Figure 3. Graph of strength against curing period of Koalin treated DCM.

In addition from the result potrays in Figure 2, the strength of mixtures also increased with the increase of curing periods as can be seen clearly in Figure 3 Furthermore, it could be perceived that the pozzolonic reaction best occur after 14 days curing time with more than 20% DCM content. As mentioned by Wang and Lee [22], demolition waste consists of many materials such as aggregates, coarser concrete waste, asphalt, or even bulk domestic wastes included. Therefore, in order to ensure that DCM with finest sizes to really embark optimum stabilization process, it requires more DCM content to increase the strength to at least 50% from its untreated strength value. Jain and Chawda [24] quoted that the improvement of soil properties stabilized with demolished concrete materials could be due to its having the same reaction as lime or cement. The presence of cement in concrete, definitely is the possible answer for the strength increment of kaolin-DCM treated samples. The highest incerement of kaolin-DCM treated samples happened at 28 days curing time possibly due to the hydration reaction of cement water which is drying of soil-cement mix and 28 days considered enough curing time for the formation of cementatious produsct as well. All in all, the higher the DCM content being added to the kaolin clay with longer curing time, resulting in the higher strength value obtained.

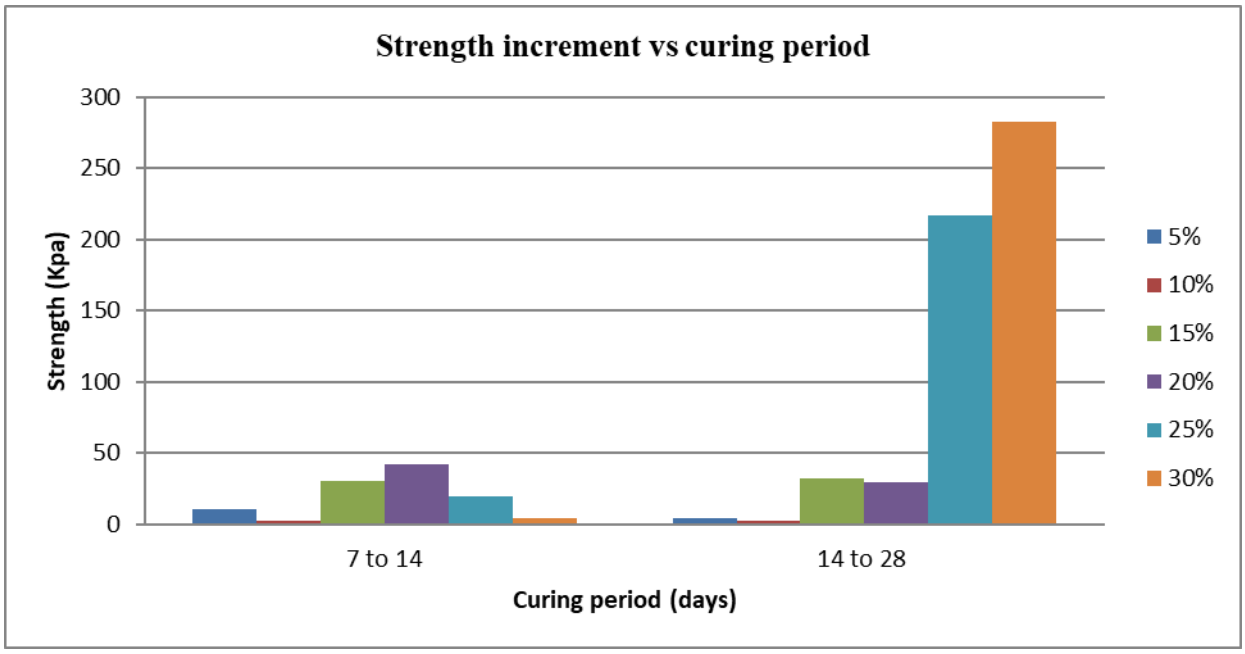

Figure 4. Graph of strength increment of Koalin treated DCM against curing period.

Figure 4 shows a comparison of percentage of strength gained based on the curing period. In order to determine the optimum amount of DCM that sufficiently stabilize kaolin. The strength gained has been calculated by the reduction of the final strength value and its initial value according to particular curing period.

From the graph it could perceived that maximal strength gained is within the period of 14 to 28 days. While within the period of 7-14 days it can be noted that, the strength starts to develop especially when more DCM content being added. This shows that, DCM does not effectively to provide early strength gained on kaolin itself. Thus, when it comes to curing period, demolished concerete materials required about 2 weeks to stabilize and reacts well with the kaolin clay. This result is similar to the study conducted by Ibrahim et al. [25], whereby the kaolin treated with lime getting better in terms of strength as it increased 20% after 14 days curing time. Hence, it can be considered the strength gained sufficiently at 20%DCM content after 14 days curing time.

4. Conclusion

In conclusion, DCM effectively stabilised kaolin clay after 2 weeks curing time at maximum DCM content.

The summarization of the results are listed below:

a) White kaolin clay used has liquid limit 36% , plastic limit 28% and plasticity index 23%
b) From the standard proctor test, an optimum content (OMC) of Koalin is 18% and maximum dry density (MDD) is 1.64 (Mg/m^3) were obtained.
c) The UCS value of untreated kaolin sample is 50 kPa.
d) The UCS result convince that the higher percentage of DCM content, the strength would increase as well.
e) The strength of treated kaolin clay increase significantly as compared to untreated kaolin clay with the highest value is 595.6 kPa in 28 days with 30% DCM being added.
f) In terms of curing period, the optimum stabilization for Koalin-DCM treated samples occur after 7 days of curing time.

g) Maximal strength gained occur within 14 to 28 days curing periods. Earlier than that, the strength started to develop.
h) Hence, it can be considered that kaolin treated well after 20% of DCM content with more than 14 days curing period.

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