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Effect of Lime Kiln Dust on Kaolin-Slag Mixture

Amin Chegenizadeh, Felix Wong Fei Hoong, Hamid Nikraz

Abstract: ***Soil stabilsation is one of the area which needs further research due to its importance both geotechnical and environmentally. Application of landfill materials and turn them into something worthwhile has been in attention of researchers. Lime Kiln Dust (LKD) is one of the materials which shows a potential of usage into soils. On other hand, Unconfined Compressive Strength (UCS) is also one of important tests in soil mechanics to represent characteristic of soil. Surely, in order to run UCS testing, compaction tests was conducted. The compaction values then utilized in the preparation of UCS samples. This study considers the effect of lime kiln dust on the UCS behavior of kaolinite-slag mixture. Compaction and UCS testing were conducted. The results showed that OMC was increased with increasing LKD in kaolinite-slag mixture and MDD was decreased with increasing in kiln dust. UCS also found to be with increasing in kiln dust. The results was support with different curing time (i.e. 7, 28, 90).***

Keywords: Kiln dust, Slag, Kaolinite, UCS

I. INTRODUCTION

The idea of soil stabilisation has been used for centuries by different old societies, applying its essence even to the present day by means of structures built, for example, the roman streets for example, slammed earth. The start of the cutting edge time of soil stabilisation started quite a few years back. There has been many studies on different aspect of stabilsation [1-7]. The reinforcement of clayey material also been studied and number of tests such as compaction, direct shear test etc was run. [8, 9, 10] Application of slag has been studied in different type of clay and different testing in [4, 5, 6, 8]. Application of rubber tyre as another environmental approaches been studied in [5]. Another study shows inclusion of fibre into soil [7]. It is clear there have been always to incorporate alternative material to make the soil stable specifically for clay material. Lime Kiln Dust (LKD) is one of the by-product [11,12,13]. Shortterm effect of LKD on strength of soil mix was done by [11]. Application of LKD in subgrade materials also studied by [13]. The above artciles shows the importance of further study due to environmental issues associate with landfill spaces and perhaps some contamination issue due to its reaction with climate conditions. Durability of mixture with LKD has been less researched and this study in addition with conventional curing days incorporate much longer time to evaluate the effectiveness of LKD. This study is continuation of second author research thesis.

Significance of this study

Being in a time that sustainability is a real concern and removing any waste by product is helpful for environment, this study has benefit of being environmental friendly and also seek for further proof of application of LKD into geotechnical structure.

II. OBJECTIVE OF THIS STUDY

The research objectives are comprehensive study on:

- How LKD affects OMC and MDD values of mixes
- How LKD affects atterberg limits of mixes
- How LKD affects the UCS values of mixtures

III. MATERIAL

A. Kaolinite

Kaolinite clay was sourced from a local supplier in Western Australia. Atterberg conducted and the values of plastic limit (PL) is 31%. The PI was found to be 27%.

B. Lime kiln dust (LKD)

Figure 1 (a) shows the used LKD in this research. The LKD had maximum particle size of 2 µm and typical values of 1.3 µm.

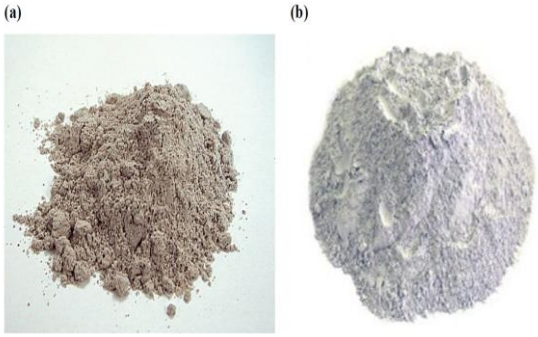

Figure 1 (a) Lime Kiln Dust, (b) Slag

C. Slag

Slag is one of the by-product which is popular to be used in civil engineering industry.

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* Correspondence Author
Amin Chegenizadeh*, **Amin Chegenizadeh,** Senior Lecturer, Department of Civil and Mechanical Engineering Schools, Curtin University, Australia.
E-mail: Amin.chegenizadeh@curtin.edu.au
Felix Wong Fei Hoong, Graduate Students, Curtin University, Australia.
Hamid Nikraz, **Hamid Nikraz,** Professor, Department of Civil and Mechanical Engineering Schools, Curtin University, Australia.
E-mail:h.nikraz@curtin.edu.au

The used GGBS (slag) was gray in color and pH was alkaline. The specific gravity (SG) 2.8-3.1 [14]

D. PORTLNAD CEMENT (PC)

The Portland cement (PC) was used in this had SG of 2.5-3.2. pH was approximately 12. The PC was grey to off-white color and odorless.[15]

IV. METHODOLOGY

A. Soil Sample Preparation

The mixes of the GGBS, PC and LKD with kaolinite clay can be seen in the following table. Table1 shows the percentage of slag as 3, 6 and 9 %, LKD as 3, 6 and 9% with the constant PC percentage of 10%. Total mixture of 9 mixtures.

Table 1 Designed mixes

Sample No	GGBS %	LKD %	PC %
1	3	3	10
2	3	6	10
3	3	9	10
4	6	3	10
5	6	6	10
6	6	9	10
7	9	3	10
8	9	6	10
9	9	9	10

B. Tests

A series of compaction tests was run to obtain the values of MDD (maximum dry density) and OMC (optimum moisture content). In addition, the atterberg tests were conducted to get the Plasticity Index . Finally, UCS test run to investigate the effect of LKD on the peak UCS values.

V. RESULTS AND DISCUSSION

A. Compaction test

AS 1289.5.1.1:2017[16] followed to derive the compaction results. Table 2 represents the compaction results for all the mixes. The OMC shows increase and MDD increased by inclusion of more LKD.

Table 2 Results of compaction tests

Sample No	GGBS %	LKD %	PC %	OMC%	MDD g/cm3
1	3	3	10	24.8	1.36
2	3	6	10	25	1.184
3	3	9	10	26.4	1.114
4	6	3	10	22.9	1.165
5	6	6	10	23.1	1.115
6	6	9	10	24.5	1.06
7	9	3	10	22.9	1.26
8	9	6	10	23.5	1.169
9	9	9	10	25	1.15

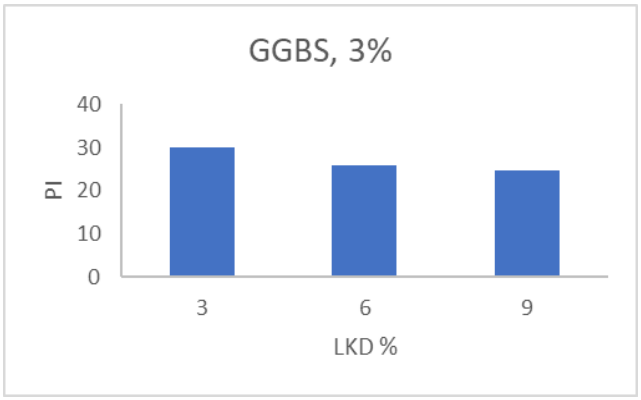
B. Atterberg limit

The attreberg limit test was conducted in accordance with AS 1289 [16]. The results of each mixture are presented in the following table. Table 3 shows the values of PL, LL and PI of the mixtures.

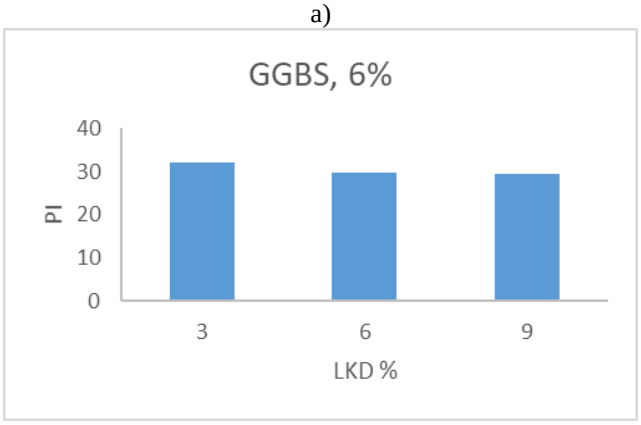
Table 3 Results of compaction tests

No	Sample	GGBS %	LKD %	PL	LL	PI
4	S1	3	3	45	75	30
2	S2	3	6	52.7	78.4	25.7
3	S3	3	9	60	84.6	24.6
4	S3	6	3	43	75	32
8	S7	6	6	45.8	75.4	29.6
5	S4	6	9	59.1	88.4	29.3
6	S5	9	3	29.6	66.9	37.3
7	S6	9	6	43.8	74.9	31.1
8	S7	9	9	49	75	26

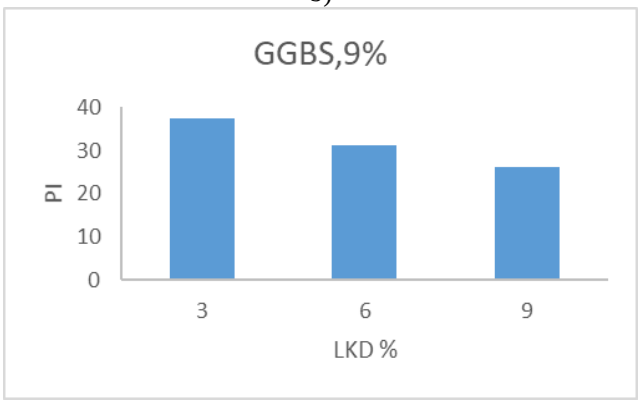
Figure 2 a, b, c shows the effect of LKD dosage on the PI values. As can be seen the values of PI decreased with increasing in the LKD dosage.



a)



b)



c)

Figure 2 PI values for (a) GGBS 3%, (b) GGBS 6 %,(c) GGBS 9%,

C. UCS test

AS 5101.4:2008[17] was followed to run UCS testing. The UCS values of the mixtures for different curing 7, 28 and 90 days were recorded. In order to assure of repeatability 3 times each mix was evaluated. The peak values was then plotted against different LKD dosage. Figure 3 a shows the UCS values with changing in LKD percentage which shows increase with increasing in LKD%. Same trend was observed in Figure 3 b and 3c.

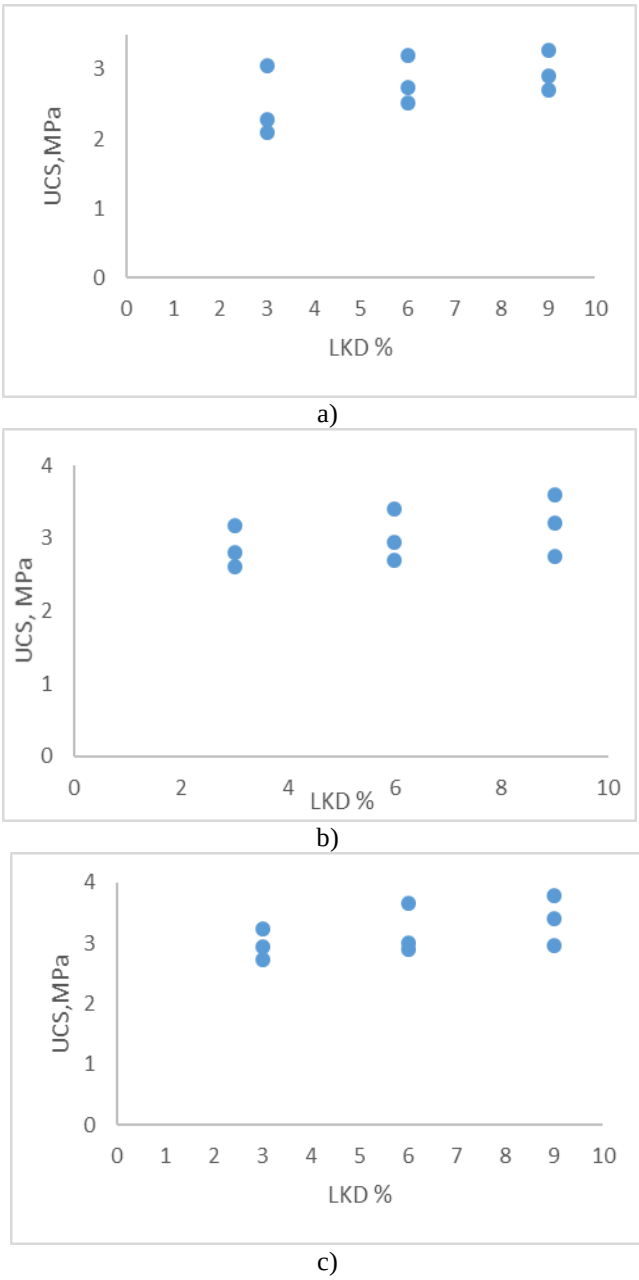


Figure 3 UCS values for (a) 7 days curing, (b) 28 days curing, (c) 90 days curing

VI. CONCLUSION

A series of testing was conducted on mixture of LKD and clayey soil stabilized with PC and Slag. The tests were compaction, UCS and atterberg limit. The outcome of research shows that:

- Increasing in LKD dosage resulted in increasing in UCS values for 7, 28 and 90 days.
- Increasing in LKD percentage in the mixture, OMC increased and MDD decreased.
- Increasing in LKD resulted in decreasing PI of mixtures

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AUTHORS PROFILE

Amin Chegenizadeh is senior lecturer in civil and mechanical engineering schools in Curtin University, Australia. His area of expertise is soil stabilization along with other geotechnical Cooperated in industry and engineering teams for 10 years to pursuit the goals of projects, Collaborated and shared the progress of works in regular construction meetings, worked with the different discipline of engineers. Extensive knowledge of local geotechnical challenges of pavements and mine infrastructures in WA throughout and Australia my career. Knowledgeable and skilled at standard laboratory tests and operation of delicate and advanced laboratory equipment. Developing the hands on practice in geomechanics lab in Curtin University.

Felix Wong Fei Hoong is a graduate student in Curtin University. His research project was on stabilsation with Lime Kiln Dust.

Hamid Nikraz is an emeritus professor in civil and mechanical engineering schools in Curtin University, Australia. He is well known for his research on geotechnical and pavement engineering. He has delivered research excellence of high international standing and is a leading international authority in the field of geotechnical and pavement engineering, with particular interest to the sustainable use of industrial by-products in soil stabilisation, a study area that is applicable to the proposed research project. Several waste products are now finding alternative uses and are becoming more acceptable and commercially attractive as a result of his efforts.