International Journal of Civil Engineering and Geo-Environmental

Journal homepage:http://ijceg.ump.edu.my
ISSN:21802742

Kuantan Clay Properties and Examination of Fly Ash and Bottom Ash Utilization as Soil Stabilizer

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ARTICLE INFO

Keywords:
Engineering Properties of Soil
Soil Stabilization
Fly ash, Bottom ash
California Bearing Ratio (CBR)

ABSTRACT

This publication presents the engineering properties of Kuantan clay and proposes an assessment of the utilization of fly ash and bottom ash as stabilizer of soft sugbrades material in highway construction. The research conducts various contents of fly ash and bottom ash to different types of clay soils from various sites in Kuantan. The compaction tests and California Bearing Ratio (CBR) tests were applied in soil samples to estimate the optimum mixture design. The samples were set up by mixing soil samples with various contents of fly ash and bottom ash at optimum water content. The accomplishment of subgrade stabilization depends on the engineering properties of soils and characteristic of fly ash and bottom ash. The laboratory result shows that the strength gain in stabilization mainly depends on two factors: fly ash and bottom ash content and molding water content. The variation content of fly ash and bottom ash were 4%, 8% and 12% by total weight.

1. Introduction

Soft subgrades in construction of roadways are one of the most frequent problems for highway construction in many parts of the world. In Pahang, Malaysia, these problems are also frequently encountered.

The usual approach to soft subgrades stabilization is removes the soft soil, and replaces it with stronger materials likes crushed rock. The high cost of replacement caused highway contractors to assess alternative methods of highway construction on soft subgrades. One approach is to use chemical to stabilize the soft sub grade. Instead of using chemical product, fly ash and bottom ash are one of the residues that offer more economical alternatives for a wide range of soil stabilization applications. This paper demonstrates the results of laboratory investigation on fly ash/bottom ash-soil mixture for stabilization where in this research; six types of clay subgrades from random places in Kuantan, Pahang were used. The California Bearing Ratio (CBR) tests were performed to determine the strength properties of the soil–fly ash and bottom ash mixtures and the optimum mixture contents for construction. Stabilized soil specimens were prepared at 4, 8, 12% fly ash and bottom ash content (on dry weight basis) and different water contents. The samples were subjected to CBR tests, which compacted using the standard Proctor effort in a

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Proctor mould (152 mm in diameter and 178 mm long).

The CBR test based on BS 1377-4 1990. The effects of fly ash and bottom ash stabilization on strength properties are shown in this paper.

2. Fly Ash and Bottom Ash

Fly ash and bottom ash refers to part of the non-combustible residues of combustion. In an industrial context, it is generated in vast quantities as a by-product of burning coal at electric power plants and comprises traces of combustibles embedded in forming clinkers and sticking to hot sidewalls of a coal-burning furnace during its operation. The portion of the ash that escapes up the chimney or stack is referred to as fly ash. Bottom ash forms clinkers on the wall of the furnace, with the clinkers eventually falling to the bottom of the furnace. The fly ash and bottom ash that were used in this research are from Sarawak, Malaysia.

The potential for using fly ash and bottom ash in soil stabilization are increased significantly in the world due to availability in geotechnical applications and when it is environmentally safe. Results of various investigations showed that soil stabilization using fly ash and bottom ash are encouraging.

The CBR values increased with the increase of fly ash content for some types of soils and the rate of increase of CBR values was found to diminish as the fly ash content increased (Senol et al., 2003). The CBR values of Kuantan clay increase with the increase of fly ash and bottom ash (Fauzi, et al, 2010). The grain size distribution curve of fly ash and bottom ash are shown on Figure 1 and 2.

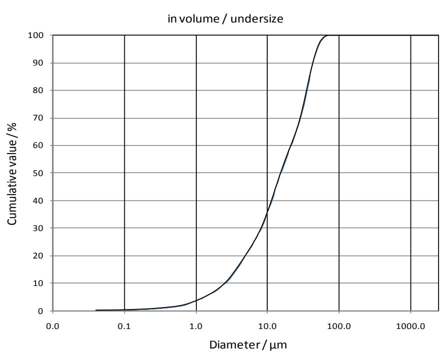

Figure 1: Grain Size Distribution of Fly Ash (Kucing, Sarawak Source)

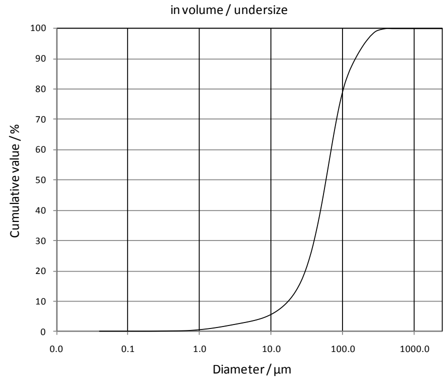

Figure 2: Grain Size Distribution of Bottom Ash (Kucing, Sarawak Source)

3.1. Engineering Properties of Kuantan Clay

The engineering properties of Kuantan Clay Soils were test in laboratory based on BS 1377-2 1990 such as Particle Size Analysis, determining the Liquid Limit and Plastic Limit, linier Shrinkage Limit, and Soil classification base on AASHTO and USCS. Proctor Compaction and CBR carried out base on BS 1377-4 1990. The engineering properties and soil classification are shown in Table 1 and maximum dry density, optimum water content and CBR value are shown in Table 2.

Table 1: Engineering Properties of Soils

SAMPLE NO.	VISUAL DESCRIPTION	CLASSIFICATION		PASSING SIEVE NO.			LL(%)	PL(%)	Gs	SL(%)
		AASHTO	USCS	10(%)	40(%)	200(%)				
2	White clayed silt	A-7-6	CH	95.98	85.92	55.88	63.50	37.80	2.67	7.86
4	Yellow brownish clay	A-7-6	ML	92.80	83.12	52.82	30.50	11.56	2.65	3.57
6	Yellow grayish clay	A-7-5	CL	78.42	60.17	52.82	51.50	14.50	2.66	9.00
8	Brown laterite clay	A-7-5	ML	82.52	57.40	54.17	53.50	14.83	2.78	9.36
24	Gray whitish silty clay	A-7-6	CL	85.73	52.62	50.09	47.50	12.58	2.65	10.00
25	Gray blackish clay	A-7-6	ML	85.73	58.03	53.67	40.00	12.58	2.64	8.57

Table 2: Maximum Dry Density, Optimum Water Content and CBR values of soils

SAMPLE NO.	S2	S4	S6	S8	S24	S25
γd max	1.83	1.68	1.45	1.60	1.83	1.90
ωop	22.00	18.60	24.0 0	22.00	20.00	19.00
CBR	3.37	2.43	1.78	3.30	2.90	3.70

The grain size distribution curves of Kuantan clay are presented in Figure 3.

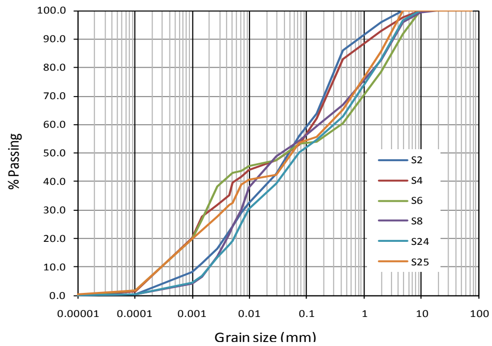

Figure 3: Grain Size Distribution Curves of Kuantan Clay

Based on the typical curves of grain size distribution and Atterberg limit, AASHTO and USCS classification of soils of all sites was found as fine soil. The test results as well as the classification are tabulated in Table 1.

3.2. Engineering Properties of stabilized Soils

a. Compaction tests

For the sub base condition, the samples were prepared approximately 7% wetter than the optimum water content. These specimens were prepared to simulate the natural wet condition observed in the field during the rainy season. The compaction curve corresponding to the standard Proctor effort was determined for each soil specimen following the procedure in BS 1377-4 1990.

Air-dried soils that pass a 20 mm test sieve are mixed homogeneously with the required percent of fly ash and bottom ash. Then the required amount of water was sprayed on the soil–fly ash/bottom ash mixture. All mixtures were prepared with fly ash and bottom ash content which are 4, 8 and 12% on dry weight of soil. The relationship between the dry unit weight of all mixture samples and fly ash and bottom ash contents are shown in Figure 4 and 5. The relationship between the optimum water content of all mixture samples and fly ash and bottom ash contents are shown in Figure 6 and 7.

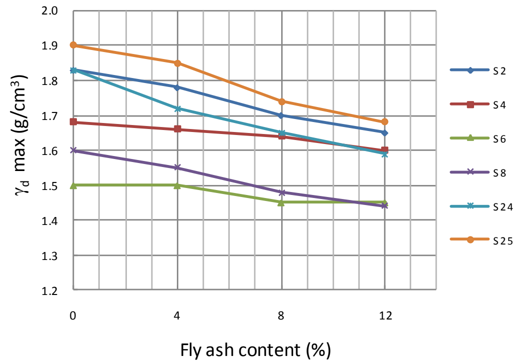

Figure 4: The Relationship Between Fly Content and Dry Unit Weight.

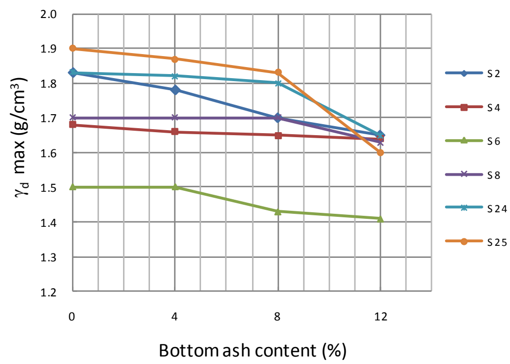

Figure 5: The Relationship Between Bottom Ash Content and Dry Unit Weight.

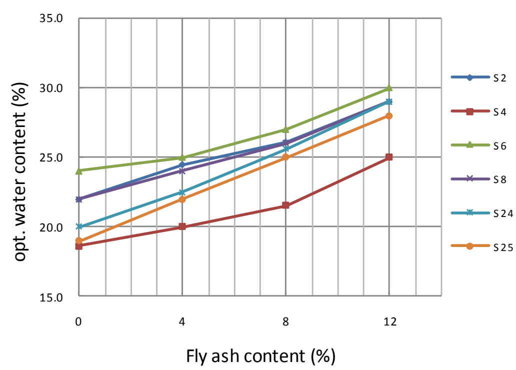

Figure 6: The Relationship Between Fly Ash Content and Optimum Water Content.

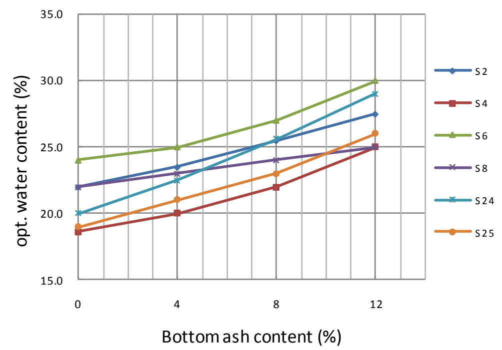

Figure 7: The Relationship Between Bottom Ash Content and Optimum Water Content.

b. CBR tests

CBR values are widely used to design the base and sub base layer for the pavement construction. Air-dried samples were sieved through #10 standard sieves before they were used. To determine the CBR of the natural soil, one clay sample without fly ash and bottom ash tested in its natural condition, close to natural water content.

The CBR (soaked) tests were performed on stabilized soils with various fly ash and bottom ash content. Then, some specimens were prepared near the optimum of the optimum water content from the compaction test by using the standard Proctor compaction effort. Then the CBR tests were performed in accordance with BS 1377-4 1990. The CBR values of the soil samples were determined. The fly ash and bottom ash mixtures of all sites were prepared for 4, 8 and 12% of total weight soil. The CBR results of the soils and mixtures with fly ash and bottom ash are given in Figure 8 and 9.

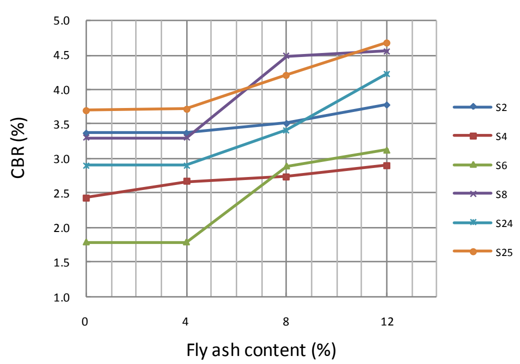

Figure 8: The Relationship Between Fly Ash Content and CBR Value

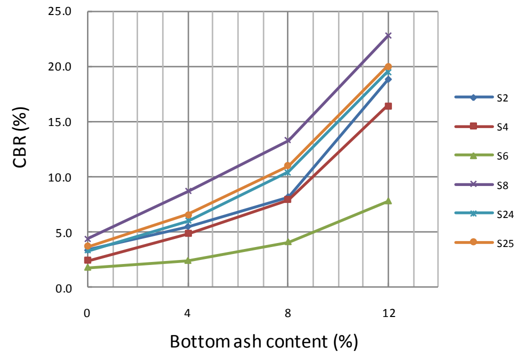

Figure 9: The Relationship Between Bottom Ash Content and CBR Value.

4. Result and discussion

Based on this studied, most of sample classified as A-7-6 by AASHTO Classification or as fine-grained soil on the USCS Classification System. These soil cannot be used or have to avoid. If the used of soils cannot reasonably avoided, such material shall be used only on bottom portion of embankment. The use of fly ash and bottom ash as stabilizer shall be improved engineering properties and increased CBR values.

For compaction test, the maximum dry unit weight decreased and the optimum water content increased when the lime, PC, fly ash content increased.

A general trend of increasing CBR values with increasing fly and bottom ash content was observed. The gain in CBR values depend on the amount of fly ash, bottom ash and water content in the mixture. For all the stabilized soil mixtures, the highest CBR values were obtained on bottom ash mixtures.

5. Conclusions

The engineering properties tested result shown that almost all of samples were highly plasticity material, classified as A-7-6 by AASHTO Classification System. That material cannot be used as embankment material for highway construction. In this study the engineering properties quality improved by adding fly ash and bottom ash as stabilizer in soil stabilization.

The improvement in engineering properties of clay soil subgrades such as CBR was investigated. Soil stabilization mixtures were prepared at different fly ash and bottom ash contents: 4, 8, 12% with the specimens compacted at the optimum water content and CBR tests were then performed on these mixtures.

Fly ash and bottom ash stabilization increased the CBR values substantially for the mixtures tested and have the potential to offer an alternative for Kuantan clay soil sub grades improvement of highway construction and this will reduce the construction cost and solving disposal problems.

Acknowledgement

Financial support for the research was provided by University Malaysia Pahang, Kuantan.

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