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Subgrades Stabilization of Kuantan Clay Using Fly ash and Bottom ash

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GROUND STABILIZATION

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ABSTRACT

The main objective of this study is the utilization of fly ash and bottom ash to improve the 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 content of fly ash and bottom ash at different water content in compaction test to obtain optimum dry unit weight and optimum water contents. This optimum water contents were used in CBR tests of mixtures of soil samples-fly ash/bottom ash. The accomplishment of subgrade stabilization depends on the engineering properties of soils and characteristic of fly ash and bottom ash. The performance analysis of fly ash and bottom ash should be based on the laboratory tests such as engineering properties of soil, compaction and CBR tests of a specific site in Kuantan. 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.

Keywords: fly ash, bottom ash, clay soil, compaction, subgrades stabilization, California Bearing Ratio (CBR)

1. Introduction

As commonly known, construction of roadways over soft subgrade is 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 Proctor mould (152mm in diameter and 178mm 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. This fly ash provides the opportunity for applications where other activators would not be required. 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 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 grain size distribution curve of fly ash and bottom ash from Sarawak are shown on Figure 1 and Figure 2.

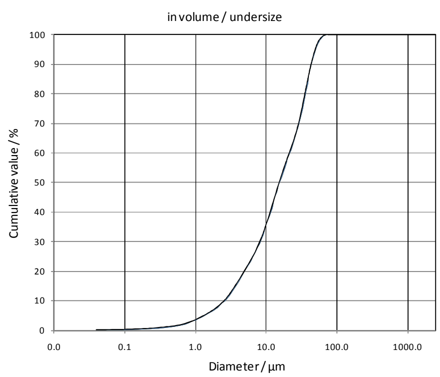

Figure 1. Grain size distribution of fly ash (Kucing, Sarawak source)

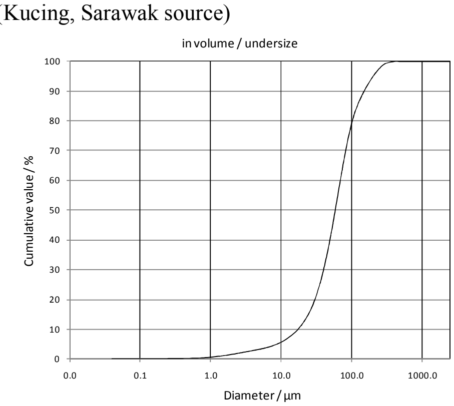

Figure 2. Grain size distribution of bottom ash (Kucing, Sarawak source)

3.1. Engineering properties of Kuantan clay

The engineering properties, compaction properties, and soil classifications are shown in Table 1.

Table 1
Engineering properties, compaction & CBR of soils

No. SAMPLE	DESCRIPTION	CLASSIFICATION	PASSING SIEVE NO. (%)			LL	PI	$\gamma_{d.max}$ (g/cm3)	ω_{op} (%)	CBR
			10	40	200					
2	White clayey silt	A-7-6	95.98	85.92	37.77	63.50	37.80	1.40	22.00	3.37
4	Yellow brownish clay	A-6	92.80	83.12	44.63	30.50	11.56	1.68	18.60	2.43
6	Yellow grayish clay	A-7-5	78.42	60.17	52.87	51.50	14.53	1.45	21.50	1.78
8	Brown laterite clay	A-7-5	82.52	57.40	52.14	53.50	14.83	1.65	22.00	4.40
24	Gray whiteish silty clay	A-7-6	83.12	52.62	36.68	47.50	12.58	1.74	20.00	3.35
25	Gray blackish clay	A-7-5	85.73	58.03	44.44	40.00	12.58	1.9	18.00	3.70

The Atterberg limit tests were performed and the liquid and plastic limits were determined. All of the soils were fine-grained materials and classified according to AASHTO. The grain size distribution curves of Kuantan clay are presented in Figure 3.

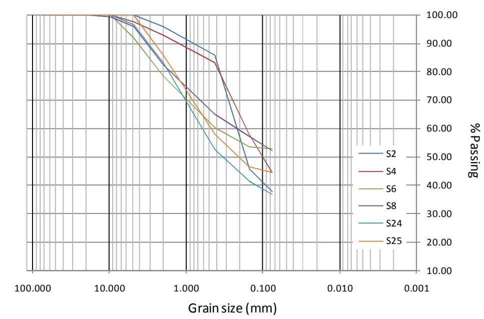

Figure 3. Grain size distribution curves of Kuantan clay

Based on the typical curves of grain size distribution and Atterberg limit, AASHTO classification of soils of all sites was found as clay. The test results as well as the classification are tabulated in Table 1. The compaction tests were also performed to get the optimum water content and maximum dry unit weight of each soil samples.

3.2. Engineering properties of stabilized soils

3.2.1. 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.

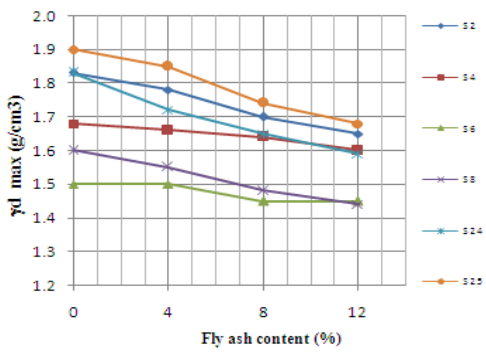

Figure 4. The relationship between fly ash content and dry unit weight.

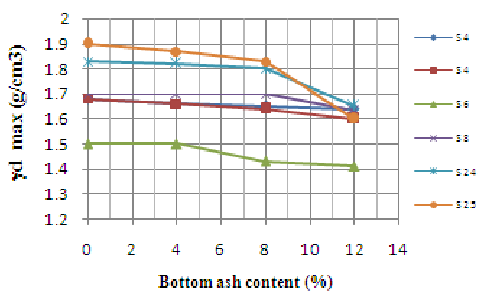

Figure 5. The relationship between bottom ash content and dry unit weight.

3.2.2. 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 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 6 and Figure 7.

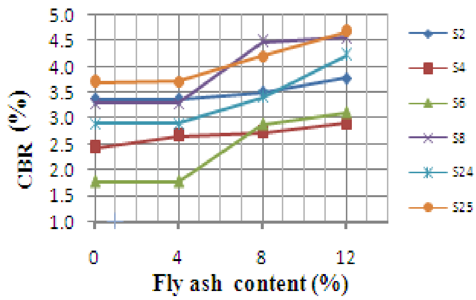

Figure 6. The relationship between fly ash content and CBR value

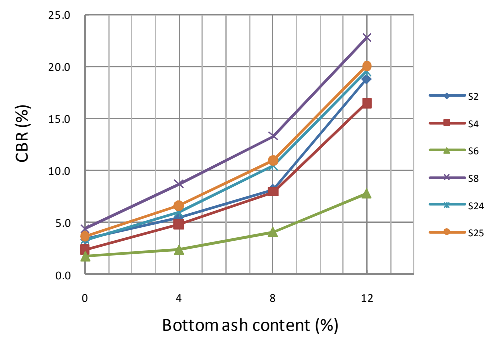

Figure 7. The relationship between bottom ash content and CBR value

4. Result and discussion

For compaction test, the maximum dry unit weight decreased and the optimum water content increased when the fly ash content increased. However, there were anomalies in Figure 5 that need more studies for samples S6 and S8.

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. However, there were anomalies in Figure 6 that need more studies for samples S8 and S24.

5. Conclusions

The improvement in engineering properties of clay soil sub grades 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. The fly ash and bottom ash stabilization increased the CBR values substantially for the mixtures tested and have the potential to offer an alternative for clay soil subgrades improvement of highway construction.

Acknowledgement

Financial support for the research was provided by University Malaysia Pahang, Kuantan and fly ash and bottom ash are provided by Dr. Lee, UTHM.

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