SUBGRADE STABILIZATION ASSESSMENT OF KUANTAN CLAY USING LIME, PORTLAND CEMENT, FLY ASH, AND BOTTOM ASH

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ABSTRACT

This paper proposes an assessment of the utilization of lime, Portland cement (PC), fly ash and bottom ash as stabilizer of soft sub grades material in highway construction. The research conducts various contents of lime, PC, 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 lime, PC, fly ash and bottom ash at different water content. The accomplishment of sub-grade stabilization depends on the engineering properties of soils and characteristic of additives. The laboratory result shows that the strength gain in stabilization mainly depends on two factors: additives content and molding water content. The variation content of lime, PC, fly ash and bottom ash were 4%, 8% and 12% by total weight.

Keywords: Lime, Portland cement, Fly ash, Bottom ash, Soil Stabilization

INTRODUCTION

A soft sub grade in construction of roadways 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 when soft sub soil encountered is removes the soft soil, and replaces it with stronger materials likes crushed rock. The high cost of replacement causes highway contractors to explore alternative methods of highway construction on soft sub grades. One approach is to use chemical to stabilize the soft sub grade. Instead of using chemical product, fly ash and bottom ash are some of the residues those offer more economical alternatives for a wide range application of soil stabilization. This paper demonstrates the results of laboratory investigation on lime, portland cement (PC), fly ash and bottom ash-soil mixture. In this research, six types of clay sub-grades from random places in Kuantan, Pahang were used. The California Bearing Ratio (CBR) tests were performed to determine the strength properties of the soil–lime, soil-PC, Soil-fly ash and soil-bottom ash mixtures and the optimum mixture contents which can achieve better preferred sub-grade. Stabilized soil specimens were prepared at 4, 8, 12% lime, PC, fly ash, bottom ash content of the total weight of soil and in the optimum 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 were based on BS 1377-4 1990. The effects of lime, PC, fly ash and bottom ash stabilization on strength properties are discussed in this paper.

LIME, PC, FLY ASH AND BOTTOM ASH

Lime used in this research is product of the lime manufacturing process (lime kiln dust). Although they contain some reactive lime, generally have only a fraction of the oxide or hydroxide content of the manufactured product.

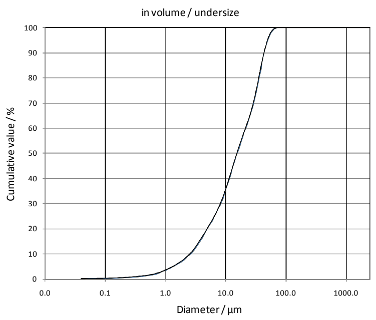
Lime are always in the form of quicklime (calcium oxide – CaO), hydrated lime (calcium hydroxide – Ca[OH]2), or lime slurry which can be used to treat soils.

PC is a common type of powdery cementitious building material made from finely pulverized alumina, iron oxide, lime, magnesia, and silica burnt together in a kiln. PC used in this research is PC Type V, composite cement.

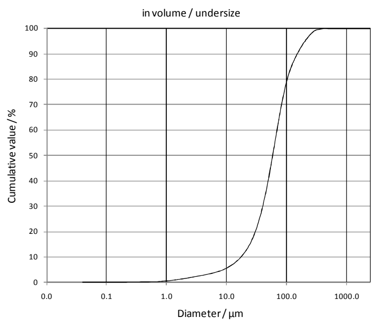
Fly ash and bottom ash refers to part of the non-combustible residues of combustion. In an industrial context, it is generated in vast quantities as a by-product of burning coal at electric power plants and comprises traces of combustibles embedded in forming clinkers and sticking to hot sidewalls of 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 falled 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 lime, PC, fly ash and bottom ash in soil stabilization are increasingly significant in the world due to abundant availability in the industry and while it is environmentally safe. Results of various investigations showed that soil stabilized using lime, PC, 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 increases (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 PC, fly ash and bottom ash tested by CILAS 1180 Liquid Particle Size Distribution are shown on Figures (a) – (c) and Specific Gravity of stabilizer is given on Table 1.



(a)



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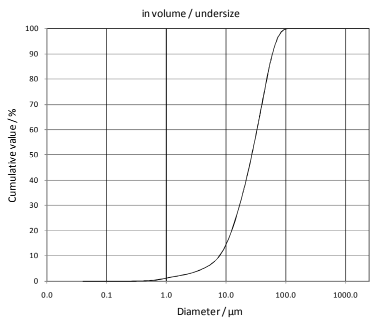

(c)

Figure 1: Grain size distribution of stabilizers: (a) fly ash; (b) bottom ash, and (c) PC

Table 1: Specific gravity of stabilizers

Stabilizer	Lime	PC	Fly ash	Bottom ash
Gs	2.34	3.15	2.60	2.55

ENGINEERING PROPERTIES OF KUANTAN CLAY

The engineering properties and classifications of soils are shown in Table 2. 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 Tested by sieve shaker for material retained sieve 0.075 mm and CILAS 1180 Particle Size Distribution for material passing sieve 0.075 mm are presented in Figure 2.

Table 2: Engineering properties of soils

No. SAMPLE	SAMPLE LOCATION	AASHTO CLASSCIFICATION	PASSING SIEVE NO.			LL (%)	PI (%)	Gs
			10(%)	40(%)	200(%)			
S2	Felda Lepar Hilir	A-7-6	95.98	85.92	55.88	63.50	37.80	2.67
S4	Sport Center,UMP	A-7-6	92.80	83.12	52.82	30.50	11.56	2.65
S6	Jalan Paching	A-7-5	78.42	60.17	52.82	51.50	14.50	2.66
S8	Jalan Sungai Pinang	A-7-5	82.52	57.40	54.17	53.50	14.83	2.78
S24	Kuantan Brick	A-7-6	85.73	52.62	50.09	47.50	12.58	2.65
S25	Taman Tas	A-7-6	85.73	58.03	53.67	40.00	12.58	2.64

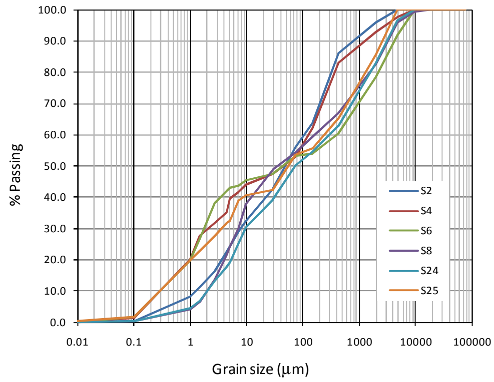

Figure 2: Grain size distribution curves of Kuantan clay

Based on the typical curves of grain size distribution and Atterberg limit, AASHTO classification of soils of all sites was found to be high plasticity clay. The test results as well as the classification are tabulated in Table 2.

ENGINEERING PROPERTIES OF STABILIZED SOILS

A. COMPACTION TESTS

For the sub base condition, the samples were prepared at 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 proposed percent of lime, PC, 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 lime, PC, fly ash and bottom ash content which are 4, 8 and 12% on dry density of soil. The relationship between the dry density of all mixture samples and lime, PC, fly ash and bottom ash contents are shown in Figures 3. The relationship between the optimum water content of all mixture samples and lime, PC, fly ash and bottom ash contents are shown in Figures 4.

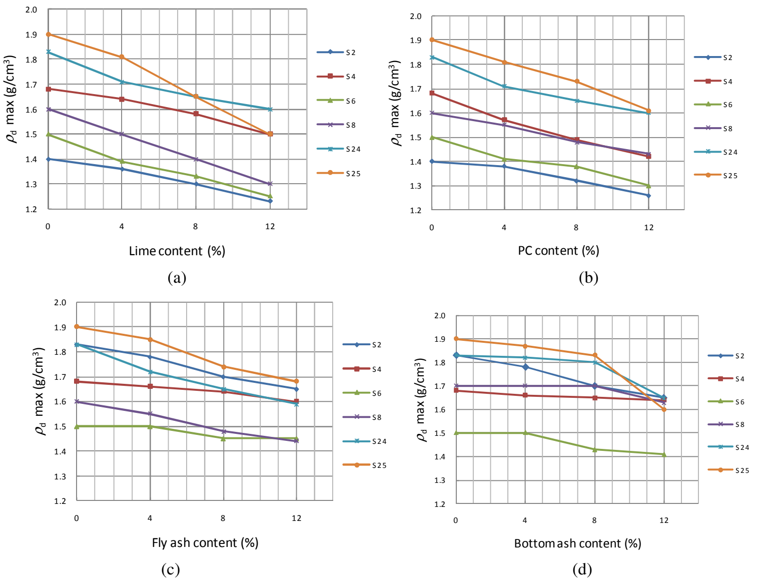

Figure 3: The relationship between soil-stabilizer mixtures content and dry density: (a) lime, (b) PC, (c) fly ash, and (d) bottom ash

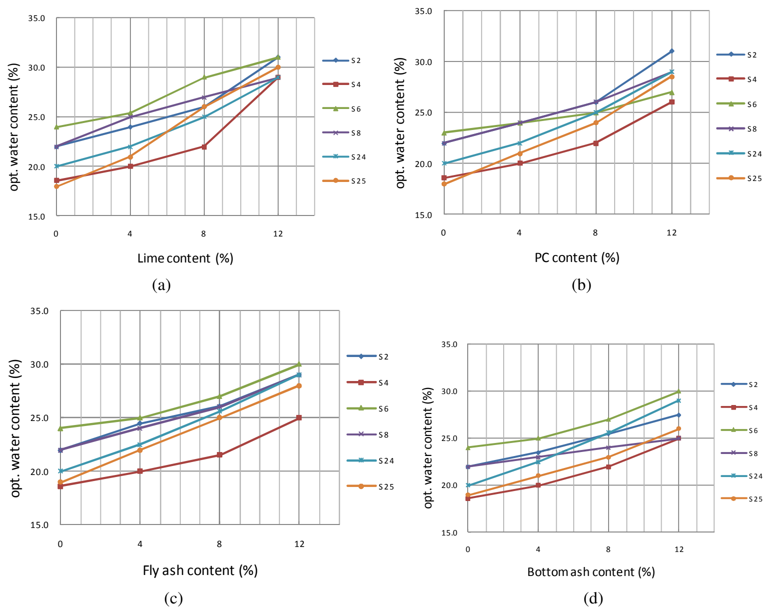

Figure 6: The relationship between soil-stabilizer mixtures content and optimum water content: (a) lime, (b) PC, (c) fly ash, and (d) bottom ash

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 20 mm standard sieves before they were used. To determine the CBR of the natural soil, a clay sample without additives tested in its natural condition, close to natural water content.

The CBR (soaked) tests were performed on stabilized soils with various lime, PC, 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 lime, PC, 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 lime, PC, fly ash and bottom ash are given in Figures 5.

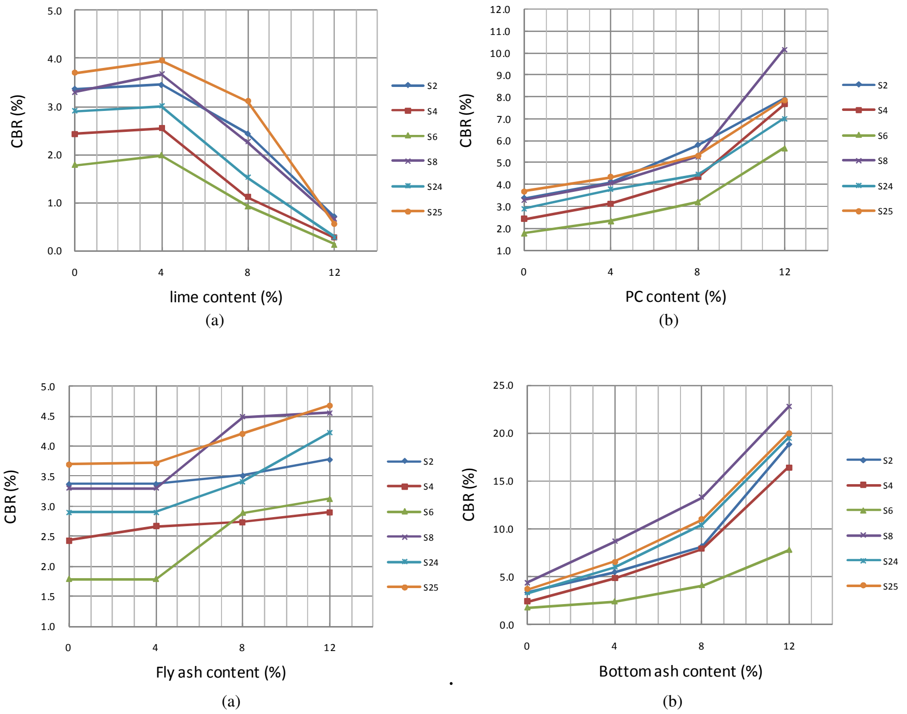

Figure 5: The relationship between soil-stabilizer mixtures content and CBR value. (a) lime, (b) PC, (c) fly ash, and (d) bottom ash

RESULTS AND DISCUSSION

Most of sample were high plasticity clay and classified as A-7-6 by AASHTO Classification. These soils cannot be used as embankment material or have to avoid. If the used of soils cannot reasonably avoided, such material shall be used only on bottom portion of embankment. The engineering properties of these soil improved by stabilizer: lime, PC, fly ash and bottom ash.

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

A general trend of increasing CBR values with increasing PC, fly and bottom ash content was observed. The increasing CBR value with increasing PC, fly ash, bottom ash content for all sample were significant, but fly ash mixtures for Sample S2 and S4 were not significant. For lime mixtures, the increase of lime content will decrease of CBR value. The gain in CBR values depend on the amount of PC, 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.

PC, Fly ash, bottom ash as soil additives were provided the benefits to improve soil engineering properties, eliminates need for expensive borrow materials, expedites construction by improving excessively wet or unstable subgrade by improving subgrade conditions, promotes cost savings through reduction in the required pavement thickness

Lime stabilization creates a number of important engineering properties in soils: improved workability, providing a working platform for subsequent construction, reducing plasticity to meet specifications, conditioning the soil for further treatment.

CONCLUSIONS

The engineering properties tested result shown that almost all of samples were high 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 PC, fly ash and bottom ash as stabilizer in soil stabilization.

Soil stabilization mixtures were prepared at different lime, PC, fly ash and bottom ash contents: 4, 8, 12% by total weigh with the specimens compacted at the optimum water content and CBR tests were then performed on these mixtures. PC, 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 sub grades improvement of highway construction and this will reduce the construction cost and solving disposal problems. But, for addition of lime, this will contribute towards the improvement of soil workability but not to increase in CBR value.

ACKNOWLEDGEMENT

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