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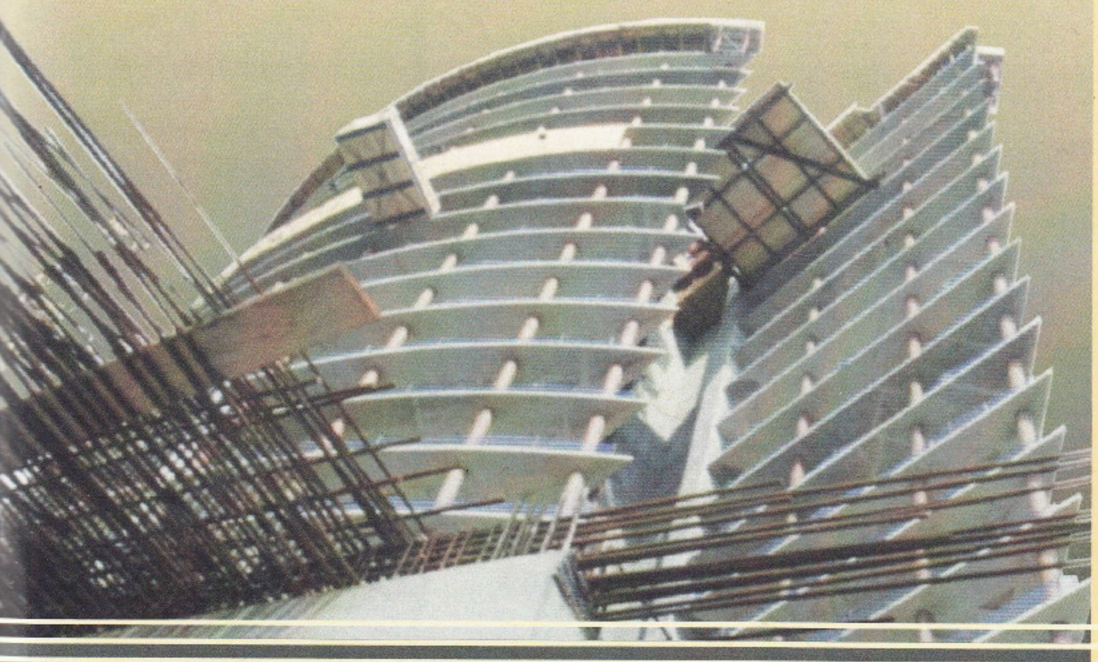

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DURABILITY OF THE STABILIZED CLAY WITH LIME AND RICE HUSK ASH FOR ROADWAY SUBGRADE

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ABSTRACT

A stabilized soil should be durable in which has ability to retain its integrity and strength under service environmental condition. The determination of the durability properties of the soils mixtures is a problem since it is difficult to simulate in laboratory the detrimental action that is produced by weathering in the field. In this study, the durability test was determined by resisntance to immersion test according to BS 1924 – 1990: Section: 4.3. Two stabilised soils, clay and clayey-sand soils, with lime and rice husk as mixtures were tested. The investigation results show, in general, the stabilised soil loses the unconfined compressive strength subjected to the immersion. Loss in soil strength was owing to water intrusion into the soil and the soil adsorbed the water. Adding of lime and rice husk ash mixture is able to increase the resistance to immersion. Based on this study, addition 6% lime and 12 % rice husk ash show a good performance in unconfined compressive strength and durability. The laboratory test showed that the effect of immersion is dependent on the level of strength of pozzolanic reaction achieved prior to beginning of the period of soaking.

Keywords: soil stabilisation, durability, resistance to immersion, lime, rice husk ash, compressive strength.

A. INTRODUCTION

In recent years, researchers from many fields have attempted to solve the problems posed. Finding a way for the utilisation of these wastes would be advantageous as they can be freely available. Recent projects illustrate that successful waste utilisation could result in considerable savings in construction costs [1, 2]. Utilisation of lime, cement, and or fly ash is widely used as a mean of chemically transforming unstable soils into structurally sound construction foundation. In clay-bearing soils, these stabilizers induce a textural change in greater ease of compaction and handling as well as moderate improvements in the resulting strength. Rice husks are major agricultural by-product obtained from the food crop of paddy. The existence is abundance all over the tropical countries, such as Indonesia, Thailand, Philippines, Brazil, and many others. Generally, it is considered a valueless product of rice milling processes.

Numerous works have been published on lime or cement and rice husk ash stabilised soil [3, 4, 5, 6, 7, 8). Most of those researches deal with shrinkage and cracking, application in roads and strength characteristics. Different testing procedures have been applied in various studies, which made comparison difficult. A stabilised soil should be durable in which it has ability to retain its integrity and strength under environmental service condition. Compressive strength and durability were the two major approaches made, with the Americans mori inclined towards durability technique. Other techniques employed were California bearing ratio, tensile and flexural tests. For roadway subgrade, a soil has to be able to serve the traffic load passing on the road. Therefore, a soil should have a certain conditions such as strength and durability. The earlier British unconfined compressive strength criterion of 1.7 MPa was said to satisfy the ASTM durability tests [11], namely, freezing and thawing, and wetting and drying. The strength criterion was set for lightly trafficked roads. The current British requirement stipulated 2.8 MPa to cater for the increasing traffic volume [9].

The determination of the durability properties of the soils mixtures is a problem since it is difficult to simulate the detrimental action in laboratory that is produced by weathering in the field. In this study, it was decided to examine the effect of immersion in water on the unconfined compressive strength of stabilised soils with lime and RHA.

B. EXPERIMENTAL METHOD

Materials and Specimen Preparation

The soils used in this study are commercially bentonite clay, kaolin, and fine sand. The particle size distributions of the soils are shown in Figure 1, and the basic properties are listed in Table 1. This study examined 2 soil samples that are kaolin – bentonite mixtures (KB4) and sand – bentonite mixtures (SB2). The percentage of bentonite is mixed 30% by weight. The KB4 soil and SB2 soil represents a highly-plastic clay and a clayey-sand soil. Each soil sample are stabilised with 3% and 6% lime. The rice husk ash (RHA) was mixed with the lime which, based on the Muntohar [10], the ratio between lime and RHA was 1 : 2.

Table 1 Physical properties of the soil used.

Soils description	Sand %	Silt %	Clay %	D_{50} µm	Liquid Limit	Plastic Limit	Linear shrinkage	Activity, PI/CF
Bentonite [a]	5.4	2.4	73.2	0.62	307.3%	45.4%	17.4%	3.6
Kaolin	4.3	75.6	19.9	4.1	72.3%	39.8%	6.6%	1.6
Mining Sand	71.5	4.0	0.0	820	NP	-	-	-

Note: [a] Wyoming bentonite, NP = non-plastic, PI = plasticity Index, CF = Clay fraction

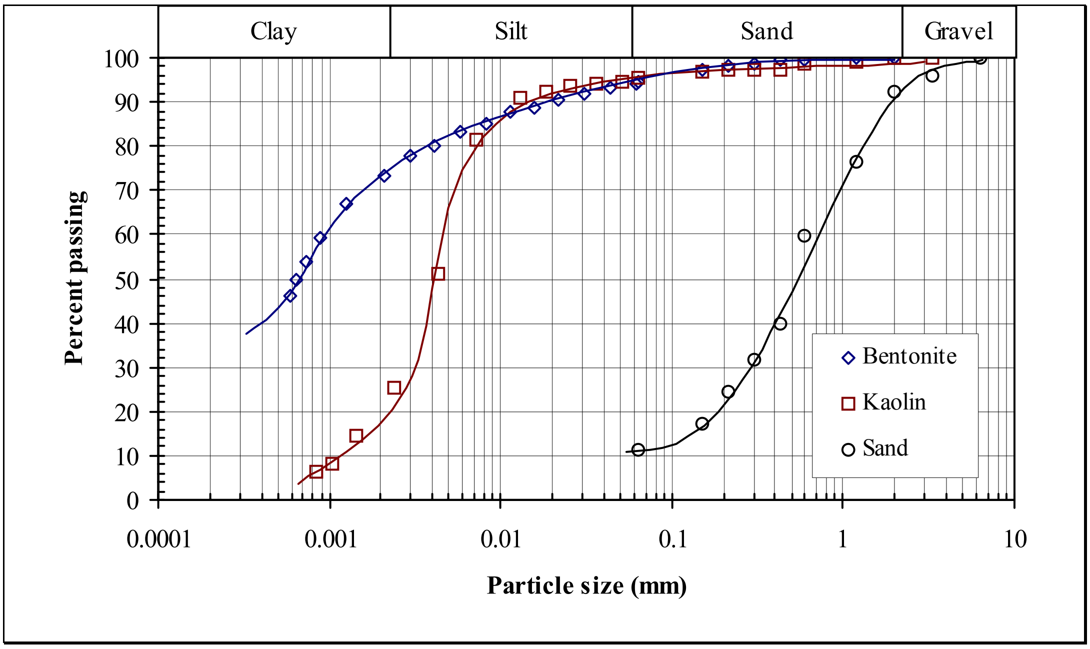

Figure 1 Particle size distribution of soils.

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Specimens of 50 mm diameter and 100 mm length are compacted by static compaction method. All the specimens, stabilised and unstabilised, are prepared at their MDD and OMC. The desired amount of soil is placed into cylindrical mould (Figure 2). During filling, the materials are tamped gently and uniformly so that the upper plug can be inserted in about 15 mm. The mould assembly is then placed in the compression device and a compressive force is applied to the upper plug until the flange is in contact with the barrel of the mould. The force is maintained for about 30 seconds before specimens are released. The specimen is extruded from the taper by gentle pressure using hydraulic jack.

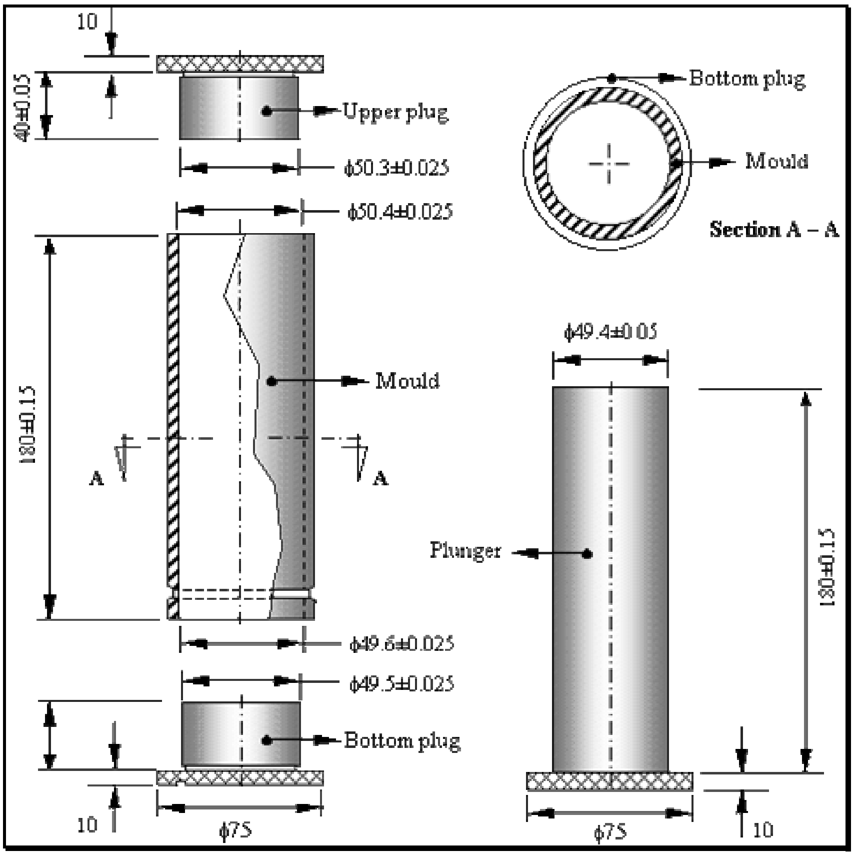

Figure 2 Design of the cylindrical mould and the plunger

Durability test

Determination of the effect of immersion in water on the compressive strength is termed as durability test. This test follows the procedure stated in BS 1924 – 1990: Section: 4.3 [12]. The method is performed to evaluate the resistance to immersion. To study the effect of age and duration of immerstion, three different methods are administered as:

1. Method A: This method is as suggested in BS 1924 – 1990 Section 4.3 that is the specimens are moist-cured for 7 days and capillary soaked for 7 days.
2. Method B: The second method is that the sets of specimens are moist-cured for 5 days and submerged for 2 days.
3. Method C: The last method is applied to examine a set of specimens that are moist-cured for 21 days and then immersed for 7 days.

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The schema of capillary soak is illustrated in Figure 1.

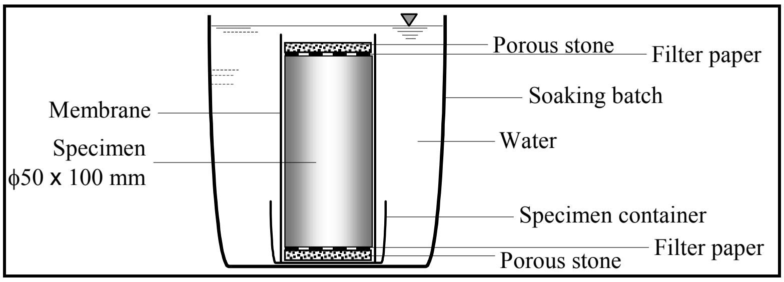

Figure 3 Immersion in water method for assessing durability

Two identical sets of specimens are both prepared to be cured in the normal manner at constant moisture content for 5, 7, and 21 days. At the end of the curing period one set is totally submerged in water for 2, 7, and 7 days respectively, whilst the other set is continued to be cured at constant moisture content. When both of them are 7, 14, and 28 days old, they are crushed. The diameter, length, and mass of the specimen, after immersion, are documented. A representative sample of fragment of the specimens is taken immediately after crushing for determination of moisture content. The strength of the sets immersed in water is calculated as percentage of the strength of the sets cured at constant moisture content. The index R_i is a measure of the resistance toward the effect of water in immersion which is ratio of the unconfined compressive strength of moist-cured (P_c) to immersed unconfined compressive strength (P_i).

C. RESULTS AND DISCUSSION

The principle of the durability test in this study is to assess the loss of unconfined compressive strength under immersion in water. Figrue 4 shows the development of soil strength with elapsed time. The figure show that the soils have better performance, that is high strength and durable to water immersion, if they are stabilised with 6% lime. Based on the unconfined compressive strength test, the SB2 soils are suitable to serve as subgrade according to British Standard critetion as mention perviously.

Influence of water immersion has been examined on KB4 and SB2 soils subjected to three different treatments. The results are shown in Figure 5. The figure shows obviously that addition of the RHA in lime-stabilised KB4 and SB2 soils increased the ability to retain the strength from immersion effect. The resistance to immersion increased with increasing the RHA content. The figures show that at low lime content (3%), the soil mixtures has low ability to retain the strength of clay specimens (KB4), while all other specimens exhibit more resistance to the immersion. For 3% lime treated soils, Method-A (7 days moist cured – 7days immersed in water) results in considerable deterioration, followed by Method-B and Method-C. But, for a higher lime content (6%), Method-B (5 days moist cured – 2 days immersed in water) causes significant effect, followed by Method-A and Method C. All the results showed that duration of curing and immersion considerably affects the treated soils with lime and rice husk ash. In other words, the effect of soaking is dependent on the level of strength of pozzolanic reaction achieved prior to beginning of the period of immersion.

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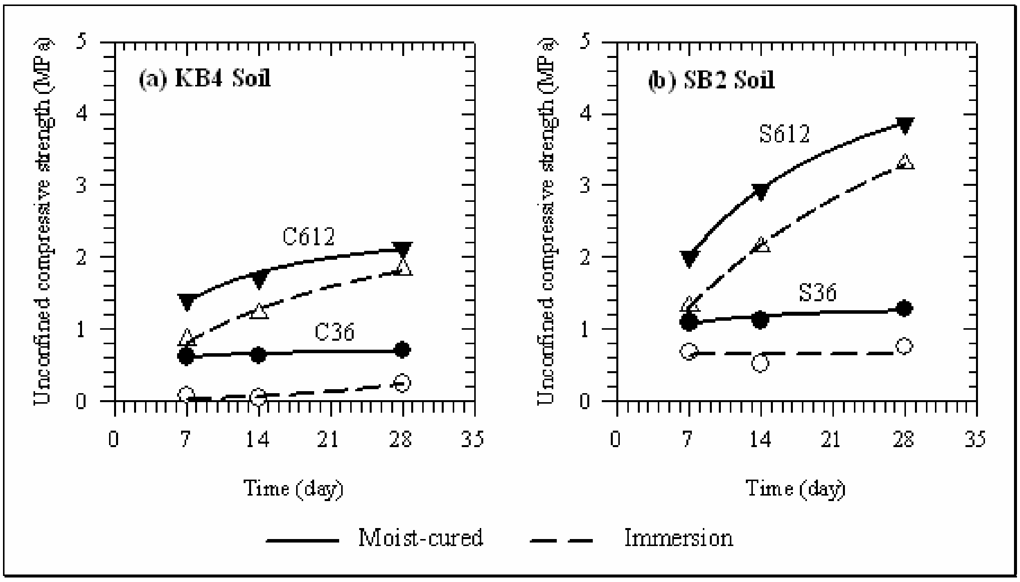

Figure 4 Soil strength development (a) for KB4 soil, (b) for SB2 soil
(Note: C36 = KB4 soil + 3% Lime + 6% RHA; C612 = KB4 soil + 6% Lime + 12% RHA; S36 = SB2 soil + 3% Lime + 6% RHA; S612 = SB2 soil + 6% Lime + 12% RHA)

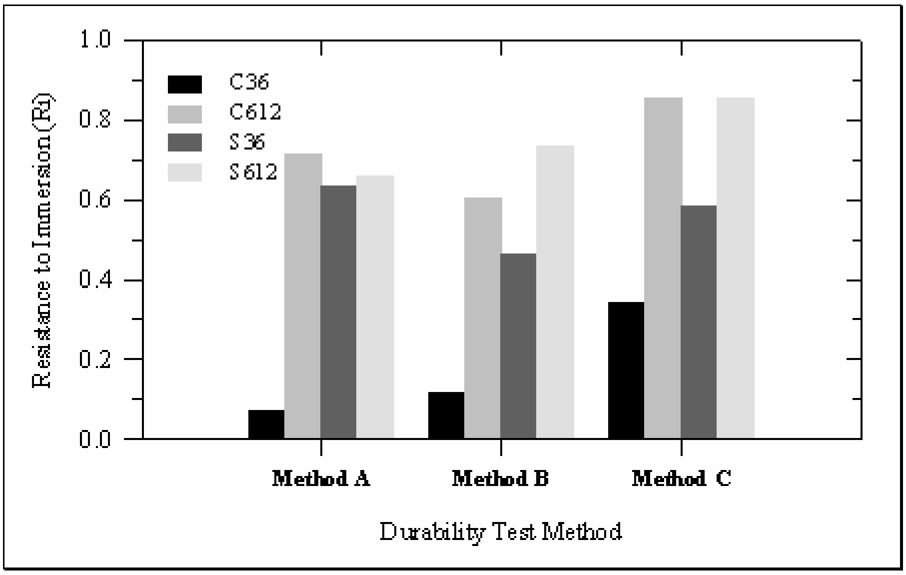

Figure 5 Resistance to immersion of the stabilised soils
(Note: C36 = KB4 soil + 3% Lime + 6% RHA; C612 = KB4 soil + 6% Lime + 12% RHA; S36 = SB2 soil + 3% Lime + 6% RHA; S612 = SB2 soil + 6% Lime + 12% RHA)

In general, the stabilised soil loses the unconfined compressive strength, which the R_i is lower than 1, when treated in water immersion. Loses in strength of specimens subjected to immersion is possibly owing to water absorption along immersion. Figure 6 shows degree of water absorption of various stabilised soils. It is observed that the soils which imbibed much water have low resistance to immersion. Imbibing much water is indicative of deterioration. As a result, the soils lose strength significantly.

Moreover, this is a sign of the disability of the mixtures to retain their integrity of strength after immersion.

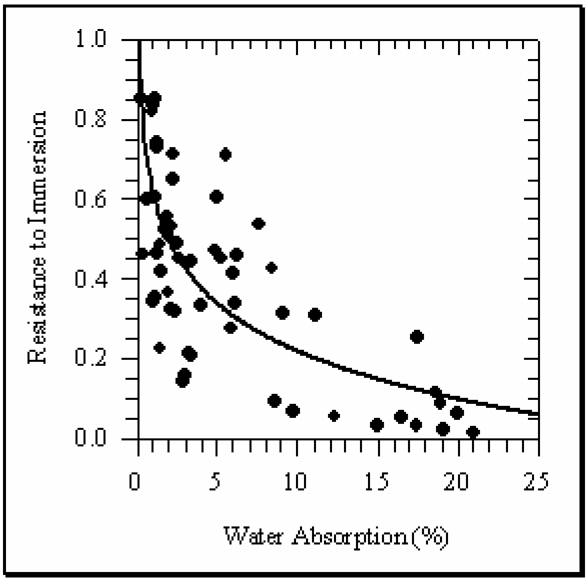

Figure 6 Effect of water absorption on the resistance to immersion

D. CONCLUSIONS

In general, the stabilised soil loses the unconfined compressive strength subjected to the immersion. Loss in soil strength was owing to water intrusion into the soil and the soil adsorbed the water. Adding of lime and rice husk ash mixture is able to increase the resistance to immersion. Based on this study, addition 6% lime and 12 % rice husk ash show a good performance in unconfined compressive strength and durability.

All the results showed that duration of curing and immersion considerably affects the treated soils with lime and rice husk ash. In other words, the effect of soaking is dependent on the level of strength of pozzolanic reaction achieved prior to beginning of the period of immersion. Method-B (5 days moist cured and 2 days immersed in water) causes significant effect, followed by Method-A (7 days moist-cured – and 7 days immersed in water), and Method C (21 days moist-cured and 7 days immersion in water).

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