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Soil-cement for low cost roads

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Abstract

In ensuring rapid development to take place, provision of good roads is inevitable. The high cost of the conventional roads has not been very contributive. Many areas are still being served with graded latrite roads or none at all. Laterite road is notorious for being dusty during the dry seasons, causing accumulation of undesirable blanket of dust on to houses and vegetations. The dust may also have a serious effect on health. Formation of deep ruts which are unpassable to vehicles at times is a common occurance in the wet seasons. Thus a high cost is incurred if the roads are to be maintained.

The paper intends to present the works carried out at the University Pertanian Malaysia on the stabilization of lateritic soils using cement to act both as the road base and surfacing. The works include conducting basic soil mechanics tests on the soil-cement mixture and evaluating the effect of additives such as sand and rice husk ash on strength. A field trial on the construction of the soil-cement road was also done to evaluate the weathering effect under exposure.

Introduction

Stabilization of soils aims to improve or beneficially alter the properties of such soils so that they will fulfil or enhance the requirement for usage. In road works it means to satisfy the requirement of subgrade or road pavement. There are three main techniques in soil stabilization namely mechanical, physical and chemical methods. Combination of these methods may even produce a material with a higher stability or performance.

The work done in soil stabilization at the Department of Civil Engineering, Universiti Pertanian Malaysia currently centres upon soil cement stabilization with sand and rice husk ash (RHA) admixtures. The objective of the study is to obtain a low cost construction material with substantial stability for road pavement suitable for rural, urban fringes and possibly farm application. The selection of the admixtures was mainly due to the ready availability of sand and the potential of RHA as a cementing agent. A combination of mechanical and physical stabilization were employed in the study. The mechanical stabilization sets to ensure soil stability by reducing the volume of voids through compaction and alteration of the grain distribution with sand admixture. The physical methods which consist of the hydration of cement and the possible polozzonic effect of RHA provide bonding and hardening.

A selection of soil series taken from the nearby areas were utilized in the preliminary stage of the study. Soil series classification is being used because the same series and horizon requires the same amount of cement to stabilize i.e similar parent material with similar topography and climatic exposure produce soils that have similar influence on the properties of cement treated soil (ref.1). The series selected were Melaka (S1), Serdang (S2), Muchong (S3), Batu Lapan (S4) and Padang Besar (S5). Melaka series was selected for further study based upon its relatively high strength when compared with the rest and also of its lateritic nature. Lateritic nature was chosen mainly because lateritic roads are the common feature of earth roads.

This paper sets to present some of the research findings of the above mentioned work, which include the preliminary stage of utilizing different soil series and the effects of variation of admixtures on Melaka series. Field stabilization will be mentioned briefly.

Experimentals

The initial stage of the study comprised particle size distribution, index properties, compaction and unconfined compressive strength (UCS) tests performed on both untreated and cement stabilized soils. Figures 1 and 2 and Tables 1, 2 and 3 summarise the results obtained. Further tests were carried out on cement stabilized Melaka series with varying proportion of sand and RHA admixtures. The results are obtainable from figures 3, 4, 5, 6 and 7.

All the tests performed were based upon BS 1377 and BS 1924. Both the compaction and UCS tests employed 2.5 kg rammer. The UCS samples were prepared at the respective maximum dry densities based on the compaction curves obtained.

Table 1: Index Properties for Various Soil Series Studied

PARAMETERS	SOIL SERIES				
	1	2	3	4	5
Plastic Limit, PL (%)	28	23	34	23	28
Liquid Limit, LL (%)	42	36	53	42	62
Plasticity Index, PI (%)	14	13	19	19	34
Specific Gravity, G_s (%)	2.75	-	-	2.69	2.54

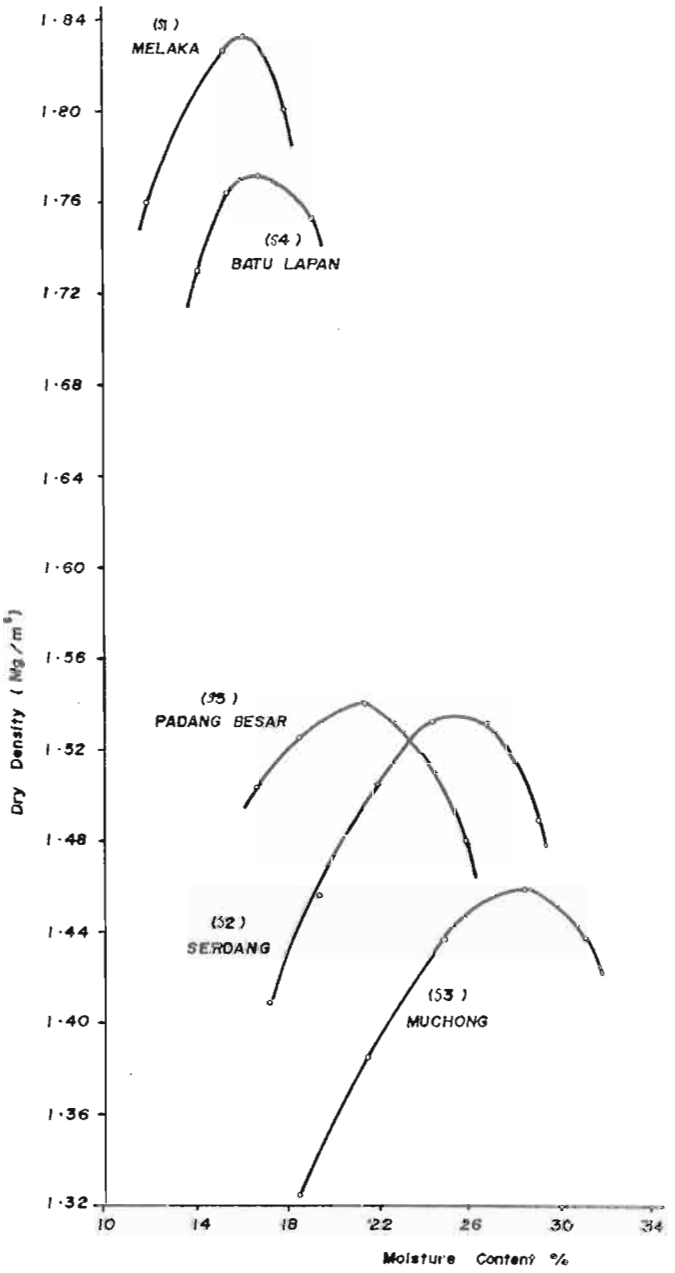

FIG. 1 Dry Density - Moisture Content Relationship for Various Soil Series

A field stabilization trial utilizing 10% cement was done to monitor the effect of weathering on the stabilized material. The six inches stabilized layer was protected by a thin layer of chipping coated with tar.

Table 2: Compaction and Unconfined Compressive Stength Tests Values For Various Stabilized Soil Series Studied

PARAMETERS	SOIL SERIES				
	1*	2	3	4**	5***
Unconfined Compressive strength 7 days, σ_7 (MN/m)	2.18	0.91	0.85	1.15 (1.07)	0.98 (0.7)
Dry density for σ_7 (Mg/m)	1.86	1.57	1.48	1.78	1.55
Compaction dry density, (Mg/m) ρ_d	1.83	1.53	1.46	1.77	1.54
Optimum Moisture Content, OMC (%)	16	26	28	17	21

Note:- All samples were stabilized with 10% cement except for: *9% , **11%, ***14% and ( ) showed extrapolated figure at 10% cement content.

Table 3: Textural Properties of The Soil Series Studied

PARTICLE SIZES (%)	SOIL SERIES				
	1	2	3	4	5
Gravel (2 - 20 mm)	49	-	-	77	8
Sand (0.06 - 2 mm)	23	67	29	10	10
Silt (0.002 - 0.06 mm)	16	7	13	3	55
Clay (< 0.002 mm)	12	26	58	10	27

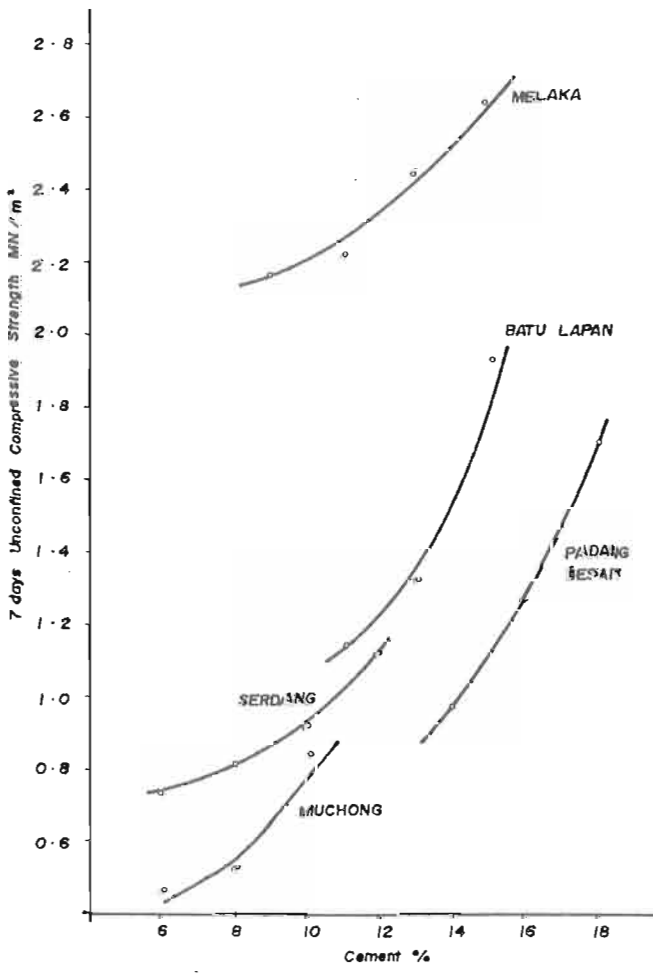

FIG. 2 Variation of UCS with Cement Content for Various Soil Series

Discussions

All soils exhibited exponential increase in strength within the narrow margin of 6 - 18% cement. Melaka series showed a remarkable initial strength achieved followed by the Batu lapan series. Judging from the compaction curve (Fig. 1) with relatively high dry density for Batu Lapan series, its initial strength is surprisingly lower than would be expected.

The Padang Besar series although obtained a higher dry density value than the Serdang series performed otherwise with regard to strength.

At this stage of the test there exist no clear relationship between the maximum dry density and the strength achieved unless the densities are significantly different. Therefore maximum dry-density cannot be used as a direct indication of strength alone. The difference in the soils characteristics as can be seen in Table 1 and 3 could have contributed to the situation.

Further tests on Melaka series with a different particle size distribution (Fig. 3) as expected gave a lower strength with 10% cement additive. The later stage utilized a soil type with 75% fines.

Seven fold increase in strength was achieved with the addition of 10% cement as can be seen from Fig. 6. Inclusion of 10% river sand showed a further 25% increase. However with further increment of the sand content resulted in lower strength attained even-though with linear increase in dry density. The average unconfined strength with 10% cement exceeded the recommended 1.72 N/mm^2 for cylindrical specimen (ref.2). Sand admixture would be a useful additive for those soils which do not meet the required standard.

All the results obtained shown in Fig. 7 utilizing RHA admixture are below the above mentioned limit even with 10% cement mix. The variation in the strength of 10% cement stabilized soils could be attributed to the difference in operators employed. Addition of RHA was thought to improve the strength by combining with the lime in the cement but

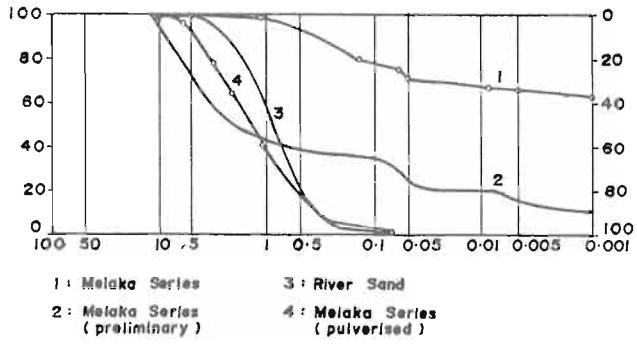

FIG. 3 Dry and Wet Sieving of Melaka Series and River Sand

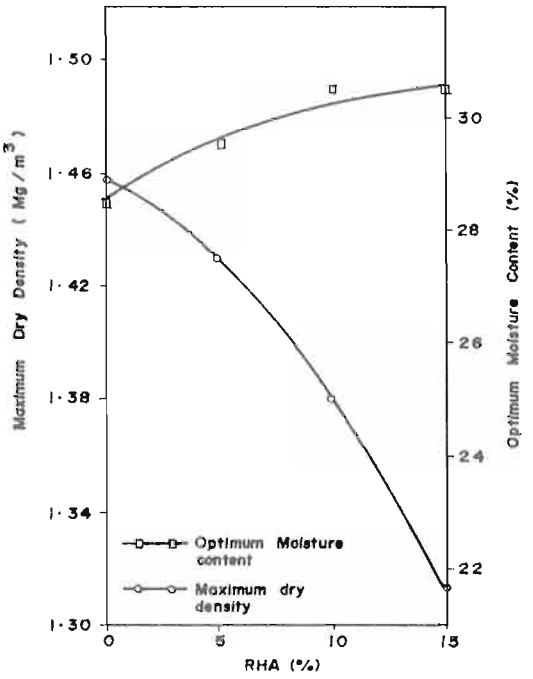

FIG. 4 Variation of Maximum Dry Density and Optimim Moisture Content with Varied RHA Content for Melaka Series with 10 % Cement Mix

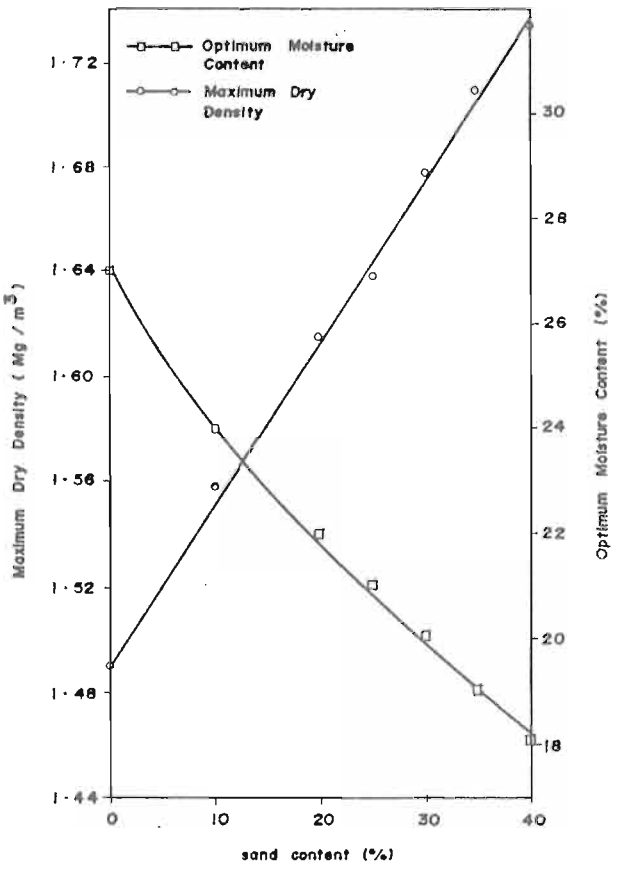

FIG. 5 Variation of Maximum Dry Density and Optimum Moisture Content with Varied Sand Content for Melaka Series with 10 % Cement Mix

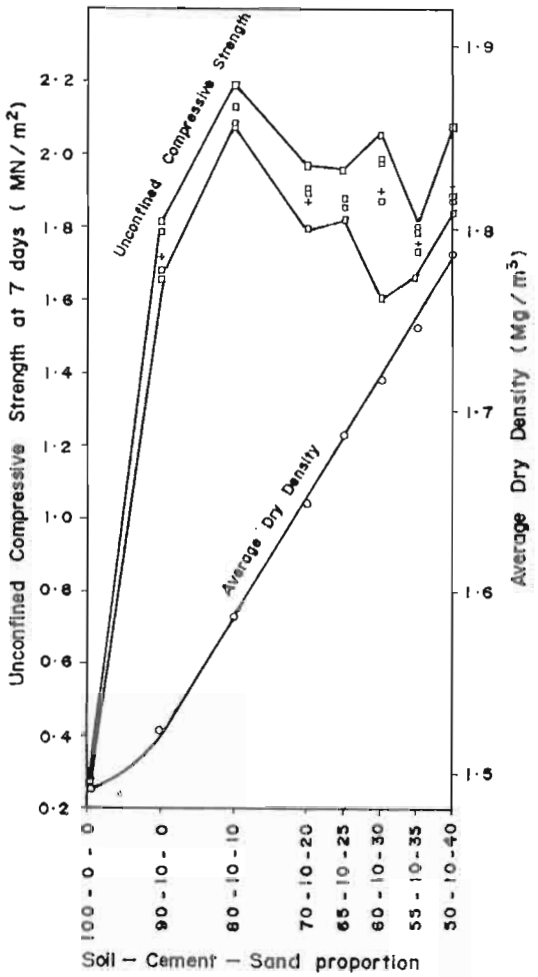

FIG. 6 Relationship between Compressive Strength and Dry Density with Various Sand Mix Proportion

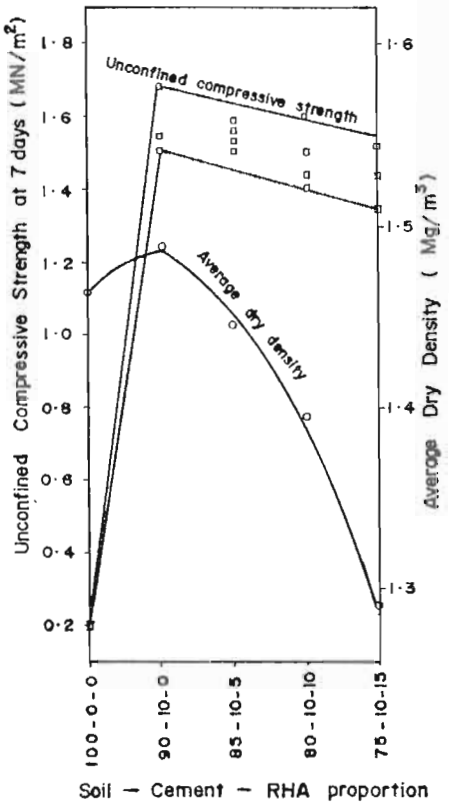

FIG. 7 Relationship between Compressive Strength and Dry Density with Various RHA Mix Proportion

proved otherwise. Substantial decrese in the dry density with increase in RHA content may have affected the strength obtained. RHA may however be used in areas where the initial moisture content is much higher than the optimum moisture content based upon its ability to hydrate the water content as shown in Fig. 4.

The trial stabilization plot still remain intact after 9 months of exposure without any change in moisture content. Samples extracted were very brittle.

Conclusion

Dry density alone cannot be used to gauge the strength of stabilized soils. Soils of the same series but of different horizon exhibit different characteristics including stabilized strength. Cement stabilization can improve the strength of the soil tremendously. Addition of sand admixture will increase the strength further. RHA is not an effective admixture for improving the strength but can be employed to enable the moisture content of wet soils be at the optimum. The trial plot remain intact with unchange in moisture content during the wet season gives some indication of the ability to resist weathering.

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