TECHNICAL NOTE

EFFECTS OF CEMENT–RICE HUSK ASH MIXTURES ON GEOTECHNICAL PROPERTIES OF LATERITIC SOILS

M. A. Rahman*

ABSTRACT

This paper presents the effects of various cement–rice husk ash proportions on the geotechnical properties of lateritic soils. Physical properties of both rice husk ash (RHA) and original lateritic soils were determined. The influences of different mix proportions of cement and RHA on Atterberg limits, compaction characteristics, unconfined compressive strength, California bearing ratio and swelling of lateritic soils were studied. Test results show that these lateritic soils stabilized with cement–RHA mixtures can be used in highway construction. From the point of view of compressive strength, California bearing ratio and economy; this study recommends a mix proportion of 6% RHA+3% cement for sub-base materials and 6% RHA+6% cement for base materials.

Key words: California bearing ratio, cement, compaction, compressive strength, highway, soil stabilization, unconfined compression (IGC: K.5/K.6)

INTRODUCTION

In third world countries, the need for locally manufactured construction materials is increasing due to greater demands for new roads and housing units created by a growing population. Over the years, the availability of conventional materials has not been sufficient to meet the demand of growing population; this has necessitated the search for materials capable of being utilized as substitutes for cement and/or decrease the quantity of cement. This shortage problem of conventional construction materials can be solved by using abundant local materials. Two types of such local materials are lateritic soil and rice husk ash. But, there is a lack of adequate data to fully understand the behaviour of these materials for effective utilization.

Lateritic soils are found abundantly all over the tropical regions of the world. A few works concerning the use of lateritic soils in highway construction have been carried out in Nigeria. Ola (1974) worked on cement-stabilized lateritic soils and found that less than 50% of the cement requirement for the temperate zone soils is required for effective stabilization of lateritic soils for road subgrade work. Nigerian lateritic soils were al-

* Lecturer, Dept. of Civil Engineering, University of Ife, Ile-Ife, Nigeria. Manuscript was received for review on September 9, 1986. Written discussions on this note should be submitted before January 1, 1988, to the Japanese Society of Soil Mechanics and Foundation Engineering, Sugayama Bldg. 4 F, Kanda Awoji-cho 2-23, Chiyoda-ku, Tokyo 101, Japan. Upon request the closing date may be extended one month.
so stabilized with cement, lime and bitumen by Ola (1978) and he pointed out that these stabilized soils could be used in highway construction and low-cost housing.

Rice husks are also abundant all over the tropical countries of the world. Houston (1972) reported that the properties of rice husk ash depend greatly on whether the husks had undergone complete destructive distillation or had only been partially burnt. He had classified RHA into (1) high-carbon char, (2) low-carbon (gray) ash and (3) carbon-free (pink or white) ash. Rice husk ash (RHA) obtained from the controlled burning of rice husks has pozzolanic properties (Cook et al, 1976). RHA in highly reactive form has been used as a suitable raw materials for making hydraulic cement (Mehta, 1977). Rahman (1986) reported that lateritic soils stabilized with rice husk ash can be used in highway construction.

### MATERIALS AND EXPERIMENTAL PROCEDURE

The materials used in this study were lateritic soils, rice husk ash and ordinary Portland cement. Physical properties of RHA and original lateritic soil are given in Tables 1 and 2 respectively. It is to be noted that the RHA passed through 0.075 mm size sieve was only used in this investigation. During compaction RHA might become much more finer than 0.075 mm and it is not unlikely that it would be as fine and reactive as fly ash.

Various laboratory tests were carried out on lateritic soils. All tests were performed in accordance with British Standards (BS 1377 : 1975). Standard Proctor compaction, unconfined compression and California bearing ratio tests were carried out on the lateritic soils with different mix proportions of RHA and cement (by weight of dry soil). All specimens used in compression and California bearing ratio tests were compacted at optimum moisture contents. Cement, RHA and soils were mixed thoroughly in a large tray and then predetermined optimum moisture content was added gradually. Mixing was carried out thoroughly and uniformly by hand.

Specimens used in unconfined compression tests were compacted in the mould with the same compactive energy per volume as in the standard Proctor compaction test. The dimensions of every specimen were 115.5 mm in height and 105 mm in diameter. Specimens were air-cured at room temperature for 7 days, 14 days and 28 days before being loaded in compression. The room temperature was low and humidity was very high.

Specimens for both soaked and unsoaked California bearing ratio tests were compacted in the CBR mould. Specimens for soaked CBR were cured under water for 96 hours and percentages of swelling were also determined during curing periods.

### RESULTS AND DISCUSSION

**Chemical Composition and Physical Properties of RHA and Lateritic Soils**
Chemical composition, specific gravity and % passing No.200 BS sieve of RHA were determined and are shown in Table 1. It can be seen from the table that RHA is composed of mainly silica. Since the colour of RHA was whitish gray (little carbon or carbon-free), the rice husks have been burnt very well. It has been reported by Houston (1972). General properties of lateritic soils were determined and are given in Table 2. The particle size distribution curve of the soil is shown in Fig.1.

**Atterberg Limits Tests**

The results of Atterberg Limits tests on the lateritic soil with various percentages of RHA (0, 6, 12 and 18) are shown in Table 3. The nature of changes of liquid limits, plastic limits and plasticity indices with different percentages of RHA is also presented in Fig. 2. Both liquid and plastic limits increase linearly with increase in RHA, but, the plas-
Fig. 3. Variation of optimum moisture content of soil with cement-rice husk ash contents

Fig. 4. Variation of maximum dry density of soil with cement-rice husk ash contents

Fig. 5. Variation of unconfined compressive strength of soil with cement-rice husk ash contents

Compaction Characteristics

The summary of results of compaction tests is shown in Table 4. The trend of changes of optimum moisture content for different mix proportions is also presented in Fig. 3. Optimum moisture content increases almost linearly with increase in both RHA and cement. The nature of changes of maximum dry density of soil with various mix proportions of RHA and cement is presented in Fig. 4. It is clear from the figure that the maximum dry density decreases with increase in RHA contents. But, the maximum dry density increases with increase in cement contents. It is the opinion of the author that these changes in the dry density occur as a result of both the grain size distribution and specific gravities of the soil and stabilizers.

Unconfined Compressive Strength

The results of unconfined compression tests on lateritic soils with various mix proportions of RHA and cement are shown in Table 4. The nature of changes of compressive strength with different mix proportions is also presented in Fig. 5(a), 5(b) and 5(c) for 7 days, 14 days and 28 days respectively. It is seen from the figures that the compressive strength increases with increase in both RHA and cement. The compressive strength increases nonlinearly with RHA. In the case of cement, the increase in unconfined compressive strength is higher and almost linear.

Since 7-day strength of 1,723.75 kPa is used as a criterion for adequate cement stabilization for base materials in road construction (Ola, 1978), all specimens made from various mix proportions of RHA and cement (Table 4) are capable of being utilized as base materials.
cement–RHA stabilized lateritic soils:
1. From the point of view of economy, compressive strength, California bearing ratio (soaked) value and percentage of free swell; the lateritic soils stabilized with a mix proportion of 6% RHA + 6% cement can be used for base materials.
2. The lateritic soil can be also used as sub-base materials when stabilized with a mix proportion of 6% RHA + 3% cement.
3. Since rice husk ash can potentially stabilize the lateritic soils and both of these materials are abundant supply all over the tropical regions of the world, rice husk ash can be utilized as an alternative or a partial replacement of cement in stabilizing lateritic soils in order to reduce construction cost, particularly in the rural areas of developing countries.

REFERENCES

SUMMARY AND CONCLUSIONS
The following conclusions can be drawn on the basis of test results obtained from the