Geotechnical Properties of the Biu Black Cotton Soil

Propriétés Géotechniques du Sol "Biu Black Cotton"

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SYNOPSIS The paper presents the laboratory and field test results carried out on the black cotton soil section of a proposed road between Biu and Maiduguri in North Eastern Nigeria. The test results are examined and the inter-relationship between such rapid tests as linear shrinkage, free swell and other long established soil parameters such as Atterberg limits, Group Index are established for this expansive soil. Equations are given for predicting free swell and linear shrinkage from index properties for this soil.

INTRODUCTION

The recent expansion in road construction in Nigeria has highlighted the problems associated with such constructions on problem tropical soils including the expansive black cotton soils in North Eastern Nigeria. The proposed Biu-Maiduguri road traverses approximately 30km of such soil which is separated from the more expansive Chad Basin black cotton soil by about 15km of silts, silty clays and sands.

The Biu black cotton soils are expansive clays the result of residual weathering of the basalts of the Biu Plateau which are Recent Volcanics.

These clays are shallow, seldom exceeding 5.5m in depth and generally with an abrupt transition from the weathered clays to the parent rock without an intermediate zone in the Biu plains; in the Biu Uplands on the lower slopes of the Plateau, an intermediate zone of decomposed clayey gravel is present between parent rock and clay.

GEOTECHNICAL PROPERTIES

The results of geotechnical tests on the Biu black cotton soil are summarised in Figs 1 - 9.

Plasticity

The Plasticity properties of the clay are shown on the Plasticity Chart Fig. 1.

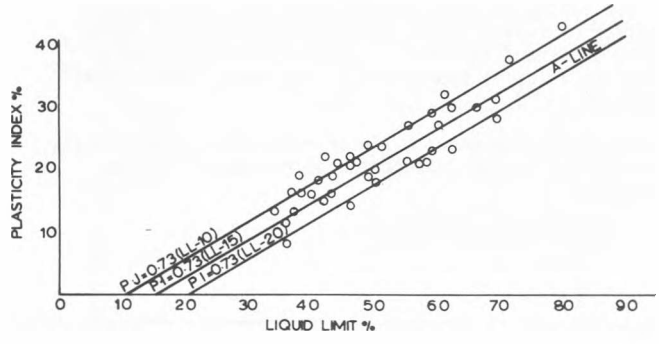

Fig. 1 Relationship between plasticity index and liquid limit

Most of the points obtained fall above and parallel the A-Line and the plasticity relationship of this soil can be represented by the equations

$$I_D = 0.73\ (W_L - 15)$$

$$\text{to } I_D = 0.73\ (W_L - 10)$$

The more expansive clays are represented by the second equation.

Linear Shrinkage

Figure 2 shows the relationship between the linear shrinkage values of the soil as determined by B.S. 1377, 1975 and the Group Index values of the U.S. P.R. classification.

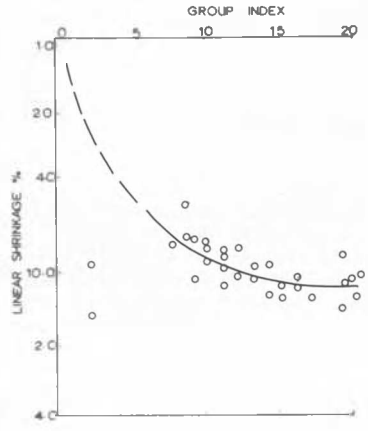

Fig. 2 The relationship between linear shrinkage and liquid limit.

At low values of Group Index, there is a considerable scatter of result. There is a rapid increase in logarithm of linear shrinkage at these low values, but a limiting value is approached as the Group Index values increase to 20.

Linear shrinkage shows a linear relation with plasticity index which can be represented approximately by the equation

$$\text{Linear Shrinkage} = 0.475 \times I_D \quad \text{(Fig. 3)}$$

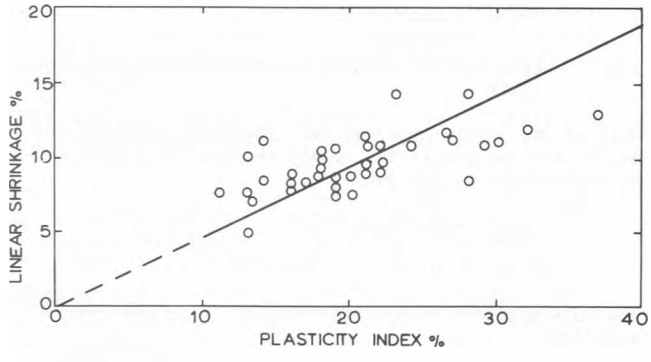

Fig. 3 The relationship between linear shrinkage and plasticity index.

The relationship between linear shrinkage and liquid limit values is very good for the soil (Fig. 4), and can be represented by the equation

$$\text{Linear Shrinkage} = 0.2 \times W_L$$

Linear shrinkage increases with increasing liquid limit.

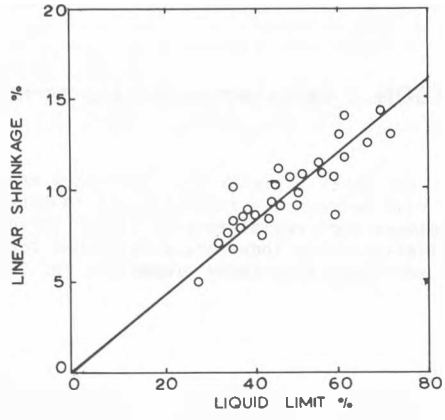

Fig. 4 The relationship between linear shrinkage and liquid limit.

Free Swell

The relationship between free swell and Group Index values are shown in Fig. 5.

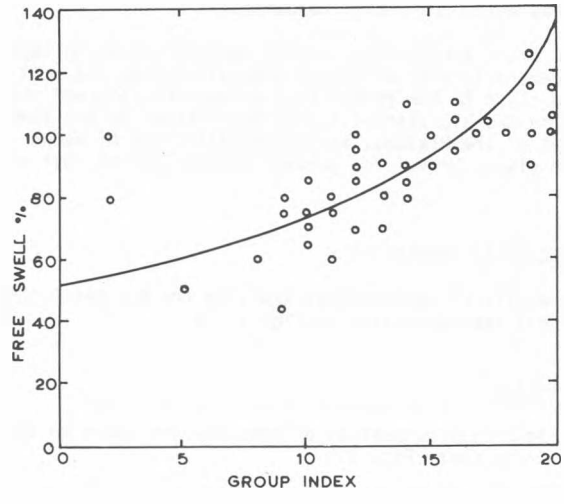

Fig. 5 The relationship between free swell and group index.

Although a considerable scatter is again shown at low Group Index values, a general increase with Group Index values is obtained.

The relationship between free swell and I_D and L.L. are linear (Figs. 6 and 7) and are represented respectively by

$$\text{Free Swell} = 4.0 \times I_D$$

$$\text{Free Swell} = 1.85 \times W_L$$

Free swell increases as both plasticity and liquid limit increases.

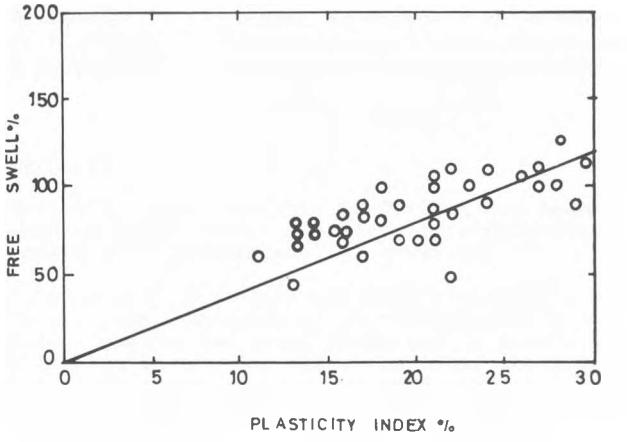

Fig. 6 Relationship between free swell and plasticity index.

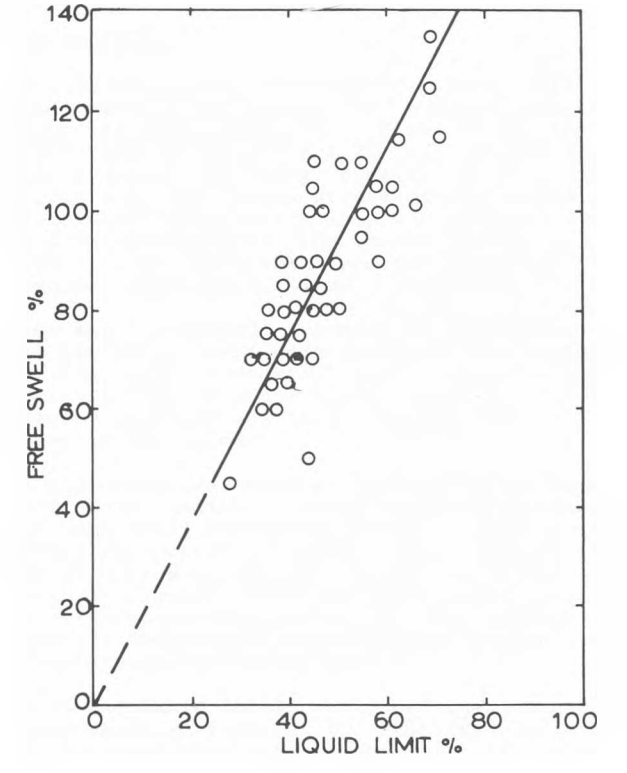

Fig 7. The relationship between free swell and liquid limit.

B.S. Compaction Characteristics

The relationship between optimum moisture content and plastic limit is linear (Fig. 8), the optimum moisture content increasing as plastic limit increases.

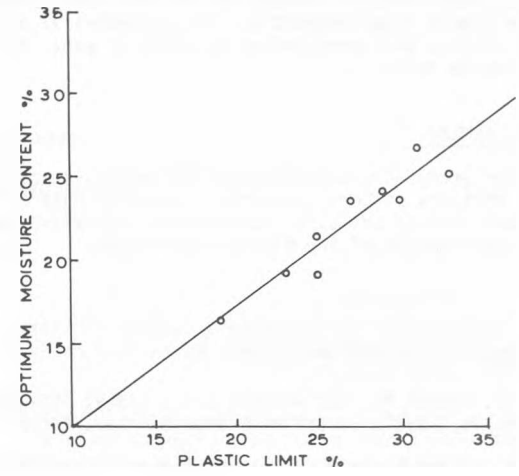

Fig. 8 Relationship between optimum moisture content and plastic limit.

A linear decrease in maximum dry density (B.S. compaction) with increasing Liquid limit is also obtained for the soil (Fig. 9).

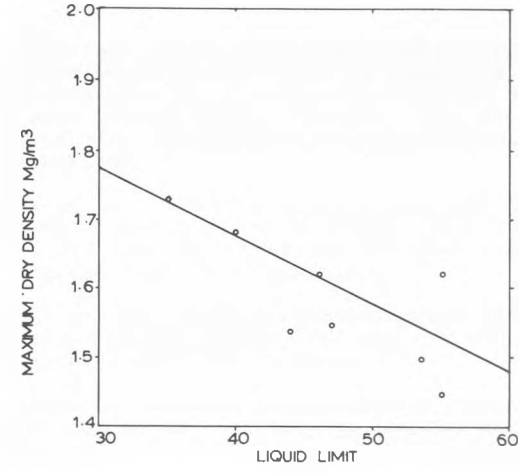

Fig. 9 The relationship between maximum dry density and liquid limit.

Both relationships are similar to those summarised by Morrin and Todor (1975) for African expansive clays, and for similar soils in Israel, Kassif, Livneh, and Wiseman (1969).

CONCLUSIONS

Linear shrinkage values parallel free swell values in correlation with such other established properties such as Group Index, Plasticity Index and Liquid Limit. It seems therefore an alternative to the free swell test for expansive soils.

A linear shrinkage of 5% is the lower limit for troublesome expansive soils and corresponds to the free swell value of 50% which is the lower limit for clays likely to cause problems for foundation and road construction purposes.

Free swell and linear shrinkage can be reasonably predicted from simple index properties. The geotechnical properties of this soil are similar to those of other African expansive soils.

ACKNOWLEDGEMENT

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Morrin W.J., and Todor P.C., (1975) "Laterite and lateritic soils and other problem soils of the tropics", U.S.A.I.D. Pub.