Classification and the Relationship of Engineering Properties of Some Soils in Kenya, East Africa

P. J. M. ROBINSON, Tippetts-Abbett-McCarthy-Stratton

When the results of extensive tests of soils along the length of a road in Kenya scheduled for reconstruction were grouped using their agrogeological classification, it was possible to prepare curves relating liquid limit and soaked CBR values. From these curves, design charts can be prepared showing construction thickness related to liquid limit for each of the soil groups. This method of classification was then applied to the results of tests from another length of road 200 miles away and with a different climate, and yielded similar forms of curve. This relationship of construction thickness to liquid limit enables an assessment of the design requirements of soils along the length of a proposed route to be made with a reduced testing program. It may be extended to other soils and to other properties of the soil.

•IN WORK carried out in Kenya on two roads, one from Athi River to Namanga and the other from Leseru to Malaba River (Fig. 1), a problem arose in the identification of a black soil occurring on the former. As a consequence of the solution of this problem a design system was evolved.

Figure 1. Location of the two test roads in Kenya.

Paper sponsored by Committee on Soil and Rock Properties.

Figure 2. Landform of the Kapiti Plains.

Figure 3. Landform and vegetation on the basement series.

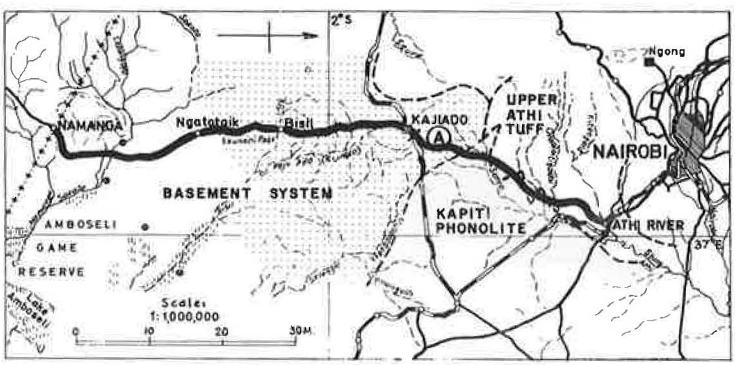

Figure 4. Geology of Athi River-Namanga area.

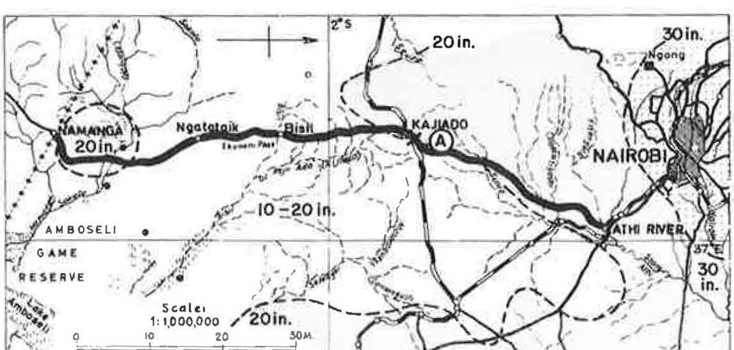

Figure 5. Mean annual rainfall of Athi River-Namanga area.

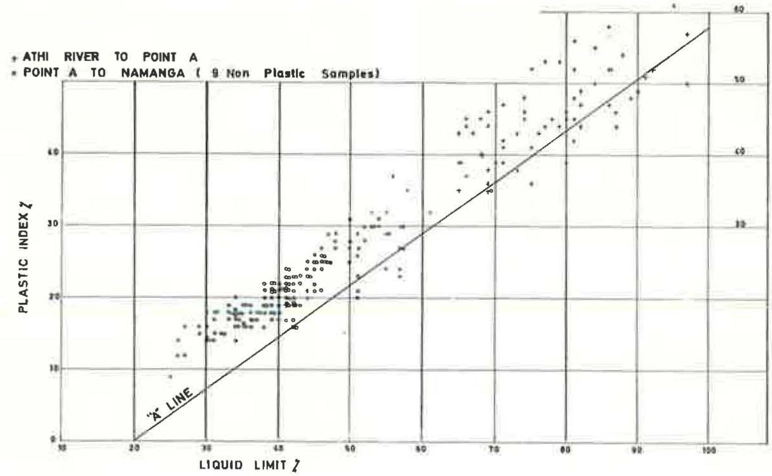

Figure 6. Liquid limit versus plasticity index for subgrade soil of Athi River-Namanga area.

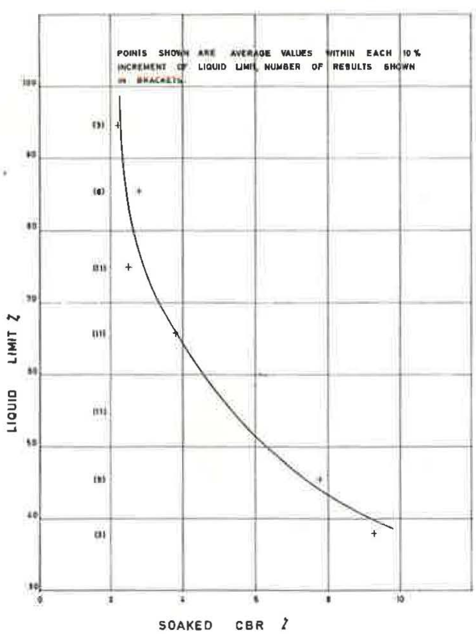

Figure 7. Relationship of liquid limit to soaked CBR for black soil.

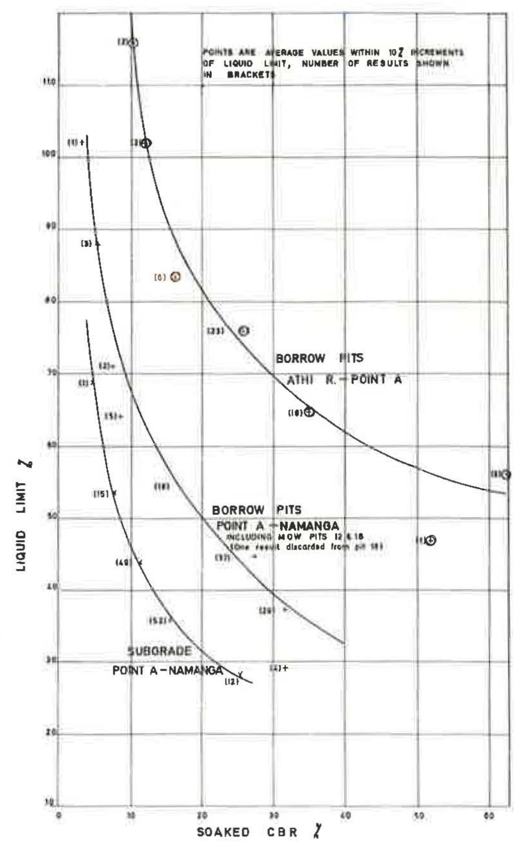

Figure 8. Relationship of liquid limit to soaked CBR for other soils.

The soil in question is locally called black cotton soil and occurs in the terrain shown in Figure 2. This does not accord with the conditions of poor drainage typically associated with black cotton soil. A typical location is that occurring further south on the same road in the bare area in the right middle distance of Figure 3.

The formation of the black soil is not explained by reference to the geological map shown in Figure 4 (1). It exists from Athi River to point A. Nor, although rainfall is the chief element in the climate causing variation of any particular parent material (2), does reference to the rainfall map shown in Figure 5 (3) explain its extent.

The author has found that, in places where other sources of information may be scarce, agricultural classifications may be used (4). Two such references (5, 6) identify black soil under these conditions as being related to a parent material of volcanic ash and as containing montmorillonite. A further source (7) describes the soils beyond point A to Namanga as being kaolinitic.

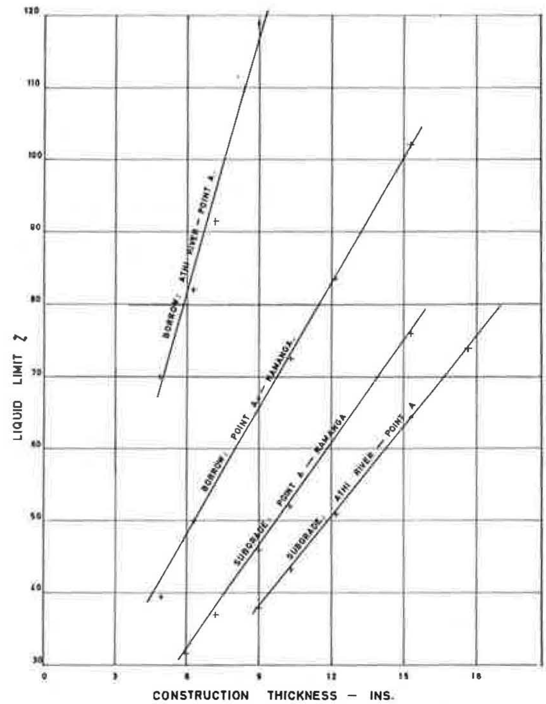

Figure 9. Relationship of liquid limit to construction thickness for Athi River-Namanga road.

From this it seems reasonable to assume that the soil to point A is formed from volcanic ash of the Upper Athi Tuff series that originally existed to point A, but is not so shown on the geological map. Over part of the area it is now present only in the form of the superficial soil to which it gave rise.

With this assumption for the identification of the black soil, it would be logical on the grounds of the different clay element present in the soils for them to be distinguishable

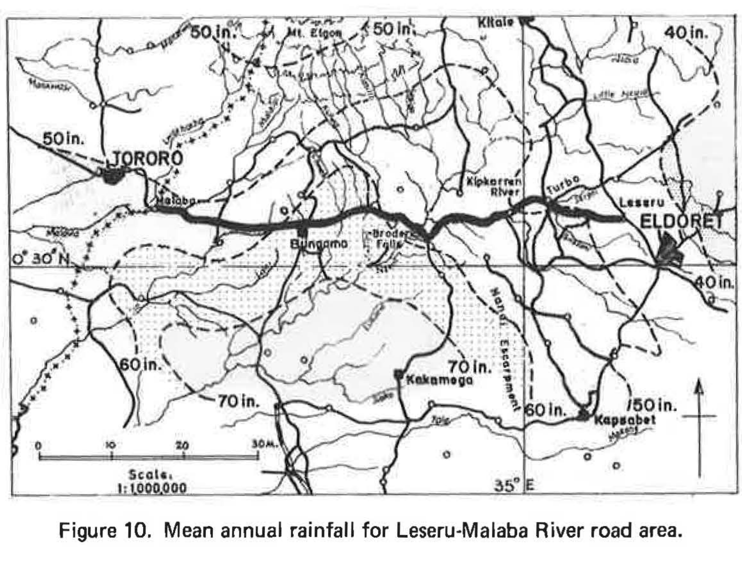

Figure 10. Mean annual rainfall for Leseru-Malaba River road area.

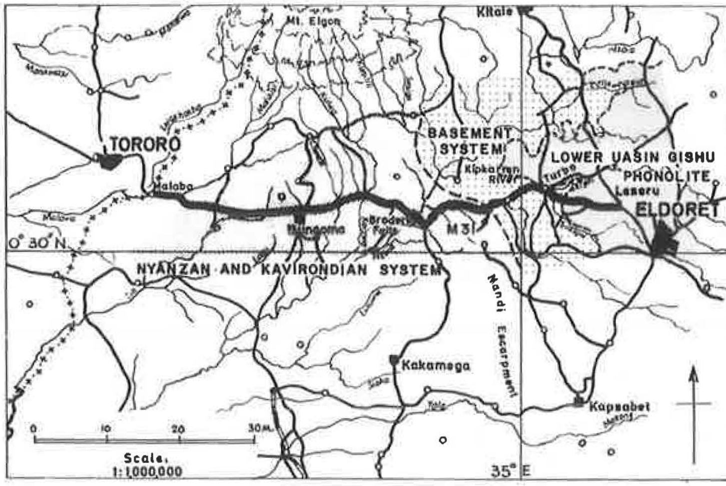

Figure 11. Geology of Leseru-Malaba River road area.

by Atterberg limits. Figure 6 shows this to be the case. An attempt was therefore made to relate engineering properties to these limits. A relationship between subgrade liquid limit and soaked CBR was found for the black soil (Fig. 7). Similar results obtained with soil from other sources are shown in Figure 8.

The next step was to apply a standard design curve to these results. A chart based on such a curve for a 9,000-lb wheel load (8) is shown in Figure 9. Thickness has been reduced by 10 percent because of absence of frost.

The same procedure was applied for the Leseru-Malaba River road. Rainfall and geological information are shown in Figures 10 and 11 (9, 10). The Atterberg limits shown in Figure 12 indicate that, for the length of the road from Leseru to mile 31 from Eldoret, points generally lie nearer to the A line than those for beyond this point. The division corresponds to the geological junction of the basement and Nyanzan systems.

There is again some relationship shown in Figure 13 between the soaked CBR and liquid limit using these divisions, and the pavement design chart derived as previously discussed is shown in Figure 14.

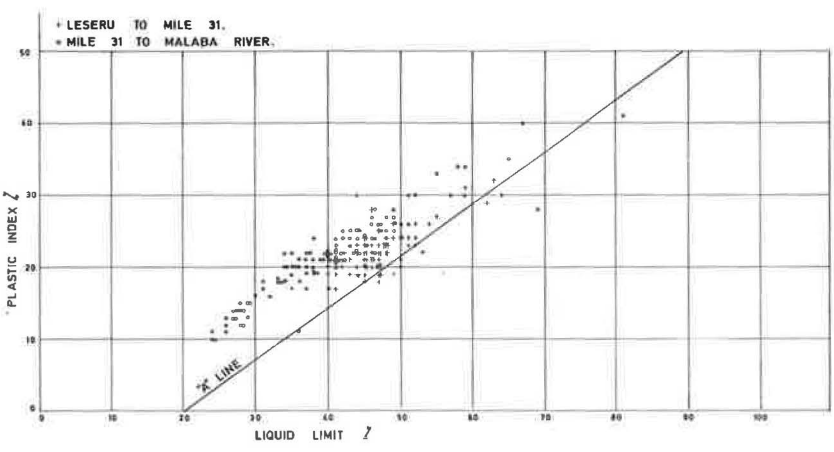

Figure 12. Atterberg limits for Leseru-Malaba River road area soils.

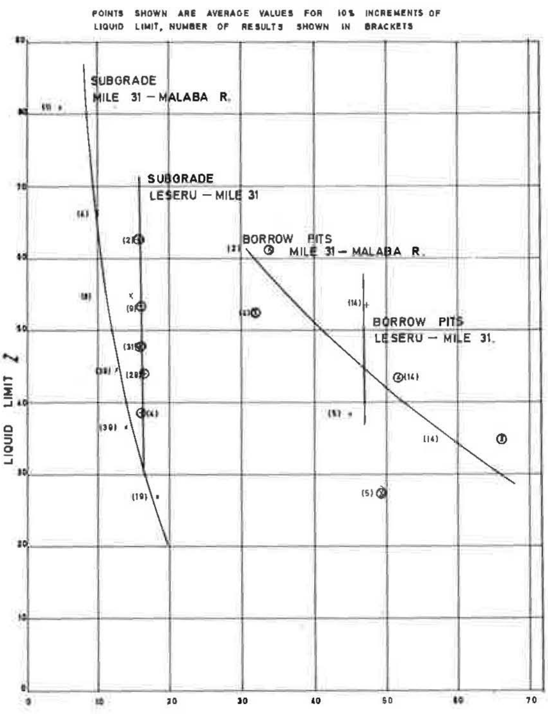

Figure 13. Relationship of liquid limit to soaked CBR for Leseru-Malaba River road area soils.

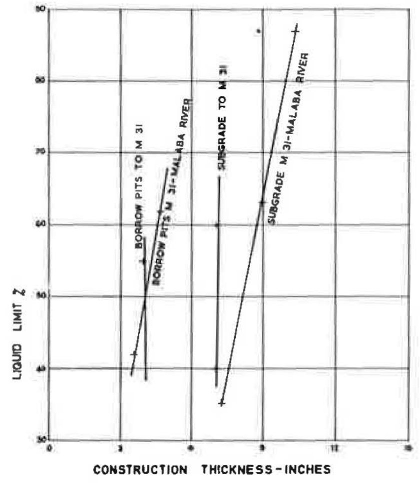

Figure 14. Relationship of liquid limit to construction thickness for Leseru-Malaba River road.

CONCLUSION

Information on the genesis of soils may enable a classification to be made in which derivation can be related to pavement design requirements. Appraisal of properties can be obtained from a much-reduced laboratory testing program. Such a relationship applies to the parent rock and, where soils are sedentary, care must be taken at the edge of a geological formation to distinguish between relict soil from a vanished layer and that from the underlying rock. Extension of this work in this area could produce a widely applicable simplified system of design.

ACKNOWLEDGMENTS

Acknowledgments are made to the Ministry of Works of the Government of Kenya—who are in no way responsible for the views expressed herein—and to Tippetts-Abbett-McCarthy-Stratton for permission to publish this work. Appreciation is also extended to the Materials Laboratory of the Ministry whose extensive tests form the basis of this paper and to S. K. Varma who made the drawings.

REFERENCES

1. Geological Survey of Kenya Rept. No. 70. Ministry of Natural Resources and Wildlife, Govt. of Kenya.
2. Glinka, K. D. Treatise on Soil Science (4th ed.). Israel Programme for Scientific Translations, Jerusalem, 1965.
3. Annual Rainfall Map, Survey of Kenya. Meteorological Dept., East African High Commission.
4. Philip, N., and Robinson, P. J. M. Reconnaissance Assessment of Soils Characteristics for a Regional Highway System in Malaysia. Southeast Asian Regional Conf. on Soil Engineering, Bangkok, 1967.

5. Mohr and van Baren. Tropical Soils. N. V. Uitgeverij W. van Hoeve, The Hague, Netherlands, 1959.
6. Collier, F. W. An Investigation Into the Water Resources of the Ewaso Ng'iro Basin, Kenya. Appx. E, Rept. No. 4, Hydraulic Branch, Ministry of Works, Govt. of Kenya.
7. Russell, E. Walter. Soil Conditions and Plant Growth. Longmans Green and Co., London, 1961.
8. Soil Mechanics for Road Engineers. British Road Research Laboratory, H.M.S.O., London, 1961.
9. The Nyanza Shield and Mozambique Belt. Bull. 7, Ministry of Natural Resources and Wildlife, Govt. of Kenya.
10. Geological Maps of the Eldoret Area. Geological Survey of Kenya Rept. No. 64, Ministry of Natural Resources and Wildlife, Govt. of Kenya.