

LATERITE AS AN ENGINEERING MATERIAL

by

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Ringkasan

Kemudahan untuk mendapatkan tanah laterit di kawasan tropika dan sub-tropika membolehkannya digunakan sebagai bahan untuk jalanraya. Faktor-faktor alam sekeliling yang bertindak ke atas bahan asal menyebabkan terjadinya tanah laterit. Sifat-sifat fizikal tanah laterit yang terdiri daripada sifat perlekatan, pertaburan, had-had Atterberg dan sifat pemikulan beban menjadikannya bahan yang sesuai untuk tapak-tapak jalan. Bagi mengurangkan kesusutan, kawalan kepada lembapan dan beban tujah adalah mustahak.

Synopsis

The availability of laterite in tropical and semi-tropical regions provides an alternative material for low-cost roads. Environmental factors acting on parent materials cause the formation of laterite. The physical properties of laterite ranging from its nature of cementation, grading, Atterberg limits and load-bearing characteristics have made the material suitable for road bases. To reduce its degradation, moisture and impact load control are necessary.

Introduction

One of the most important problems which confronts the engineer who has to build roads in tropical and semi-tropical areas (Fig. 1) is that of using available local material in order to produce a low-cost road. Very often roads of this type have to traverse through districts and areas which are devoid of high quality aggregate and he is often forced to use whatever material available. This road then falls into the category of so-called "gravel road", and in many cases, laterite becomes the best material he can use. The objective of this paper is to describe the properties of this particular material and to offer readers some suggestions as to how they can evaluate it both in laboratory and in the field.

Origin, Nature and Classification of Laterite

The term "laterite" was introduced by Buchanan (1807) to describe a ferruginous, vesicular, unstratified and porous material with high iron content. Laterite is yellowish to reddish — brown material consisting partly of spongy open — textured pebbles which vary in colour from a rusty red to liver colour, or almost black, set in a matrix of silty clay; the texture and grading of this peculiar rough "gravel" being variable not only from place to place, but within the same pit in many cases. The spongy coarse pebbles possess the structure known to geologists as "vesicular" when applied to rocks such as lava flows. Chemically, a laterite is rich in alumina, and a particular variety of it known as bauxite is worked extensively all over the world as a source of aluminium, these together with silica and iron oxide make up the bulk of the rock.

Some laterites are thought to have been transported from their place of origin by wind or other action. But most of those with which the roadmaker is likely to have been concerned are more likely to have been formed in situ. It is thought that they have originated from the alteration and breakdown of rocks over which they occur, arising from the chemical action of warm surface waters, rich in carbon dioxide and certain bacteria, which filter down through the solid rocks after the torrential rains which occur in warm regions after a long dry period. These waters are chemically active and decompose the rocks into which they pass. In the dry season which follows, an upward suction of moisture towards the surface of the ground takes place, and this process is known by geologists as "leaching"; the resulting

product is the laterite so typical of tropical and semi-tropical areas of the globe (8). They can be formed from the alteration of many different types of solid rocks such as quartzites, sandstones, gneisses, schists, granites, dolerites and basalts; the latter class of rocks is especially prone to lateritisation and many parts of the Malaysian Peninsular have undergone this change (Fig. 2). The theory just forwarded seems a likely explanation of the origin of laterites, since these are almost never found in temperate regions.

The major difficulties in the use of this material for roadmaking lie in the fact that not only are their constituent pebbles extremely friable, but they are so variable in composition. This means that continual watch has to be kept in the field on these variations, for if this is not done, differences in physical properties cause corresponding differences in the performance of the road under traffic. Not only do laterites disintegrate during extraction, but also during sieving, consolidation and the subsequent action of traffic. Against all these facts, they are also known to harden to some extent after extraction though this hardening takes some months to complete. The hardening is thought to be due to further oxidation of the high iron content of the material, the dehydration of the free oxides of aluminium and iron as the material dries out, and the precipitation of these oxides as cementing material. This hardening has been used by the Africans in the construction of their earth houses from local laterites; the wall blocks thus made harden substantially on drying, and become most effective for building purposes (8).

Properties of Laterites

These can be considered under four headings as follows:—

- a) Nature of concretions (pebbles)
- b) Grading
- c) Atterberg limits of soil mortar
- d) Load-bearing properties

a) Nature of Concretions.

These have been mentioned above; their strength can be measured either by means of the aggregate crushing test or by some form of tup test (1,2). As an alternative to the aggregate crushing test, the engineer may prefer to use the Deval Rattler Test (3) or the Los Angeles Test (3); of these tests, only the tup test can be carried out either in a pit or on the job; all others need a properly equipped testing laboratory. If the tup test is used, it is suggested that not too heavy a falling weight, say 45 kN in weight, be used in place of the heavier weight used for higher quality aggregates.

b) Grading

The grading of a laterite can be determined by ordinary mechanical analysis (2). The grading curves of such a material usually show a marked deficiency in the sand fraction, and this is one of the reasons why the substance is not usually an ideal one for roadmaking purpose. In any case, it should be remembered that as stated above, the constituent fragments of many laterites are so friable that a mechanical analysis has little meaning when applied to such a material. Grading curves can, however, be used in a comparative way, if this disintegration is taken into account.

c) Atterberg Limits.

The liquid limit and plasticity index of the soil mortar of laterite can be found just as in the case of any other soil, and the figures thus obtained are of great value in assessing the probable roadmaking qualities of local materials (3,4).

d) Load-Bearing Properties.

The well-known California Bearing Ratio (C.B.R) test can be used for the evaluation of the probable load-bearing properties of a laterite (6,8). It is suggested that in view of the probability of road in tropical areas being liable to become inundated in the rainy season, the C.B.R. test should be carried out on a soaked specimen.

The Modified Proctor of AASHTO density test can, if necessary, be done on a laterite, but not recommended in view of the known liability of the material to disintegrate under impact.

Compaction of Laterites in the Field

It has been found that pit-run laterites are best compacted in the field by means of a sheep-foot roller followed by a pneumatic-tyred roller. If hardened lateritic crust material is being used, a flat-wheel roller gives the best results. It is suggested that a trial strip be laid containing sections with varying proportions of water in order to find the moisture content at which the material can be compacted; due allowance should be made for evaporation of water during the process of consolidation (6,7).

Suggested Specification Requirements for Lateritic Gravels

It is suggested that the soil mortar should have a liquid limit of between 25 and 30, a plasticity index of 10 and 15 and a soaked C.B.R. value of between 30 and 40 for the material as a whole. References 6 and 7 provide detailed specifications for gravels of this and other classes.

Conclusion

It is seen from the foregoing that laterite gravels are variable in character, that some are better than others, and hence accurate field evaluation of their physical properties is necessary if the best results are to be obtained. The methods outlined above are, of course, only comparative, but are none the less valuable on this account. It is necessary to point out that the best results will be achieved if the gravel surface after laying is protected from undue traffic abrasion and, above all, from unnecessary changes in soil moisture content by a light surface dressing of tar or bitumen with a thin layer of chippings above it. This will also lessen the usual tendency of laterite gravels to corrugate in dry weather.

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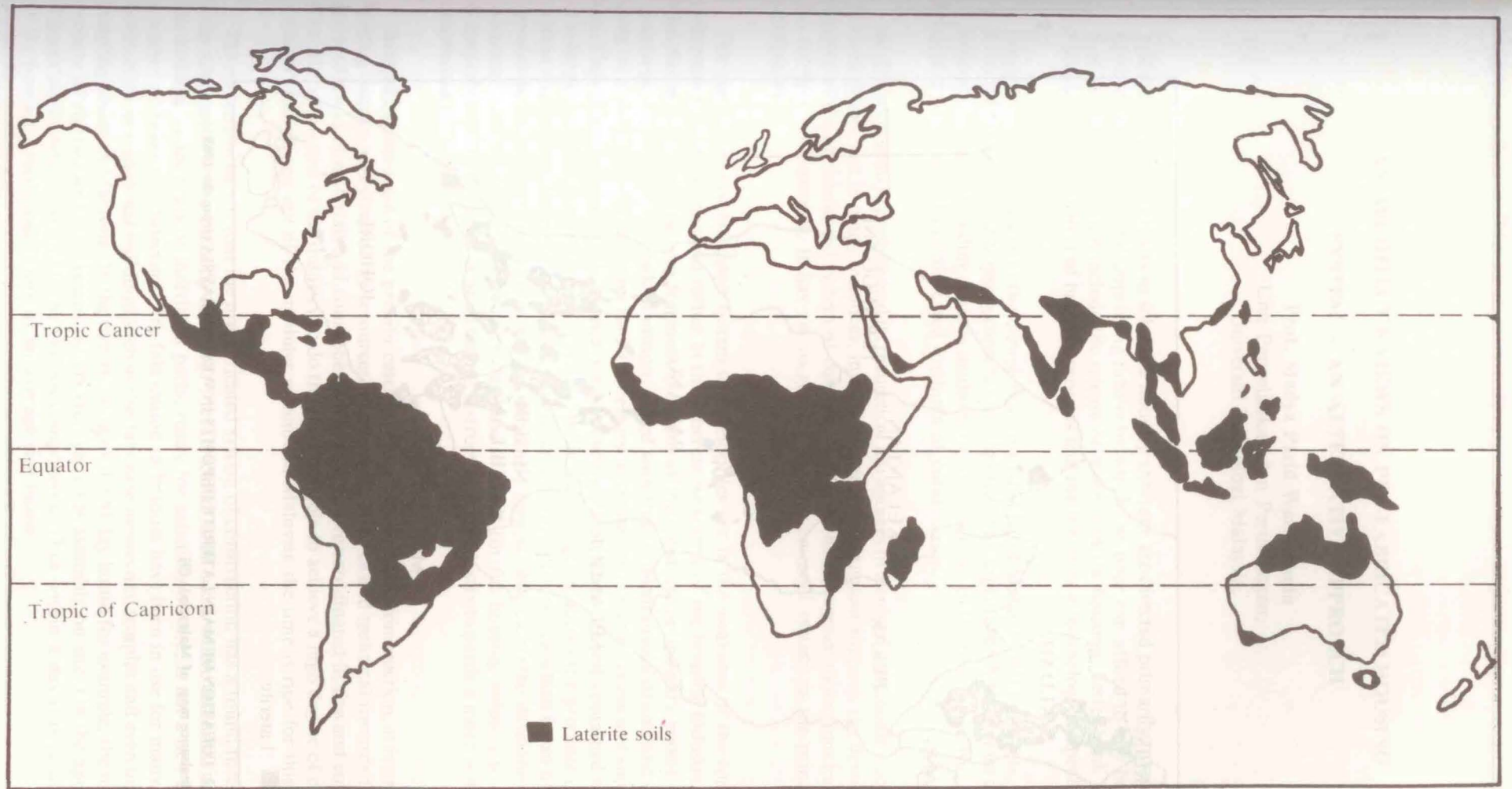


FIG. 1: GENERALIZED WORLD MAP SHOWING THE DISTRIBUTION OF LATERITE SOILS. (10)

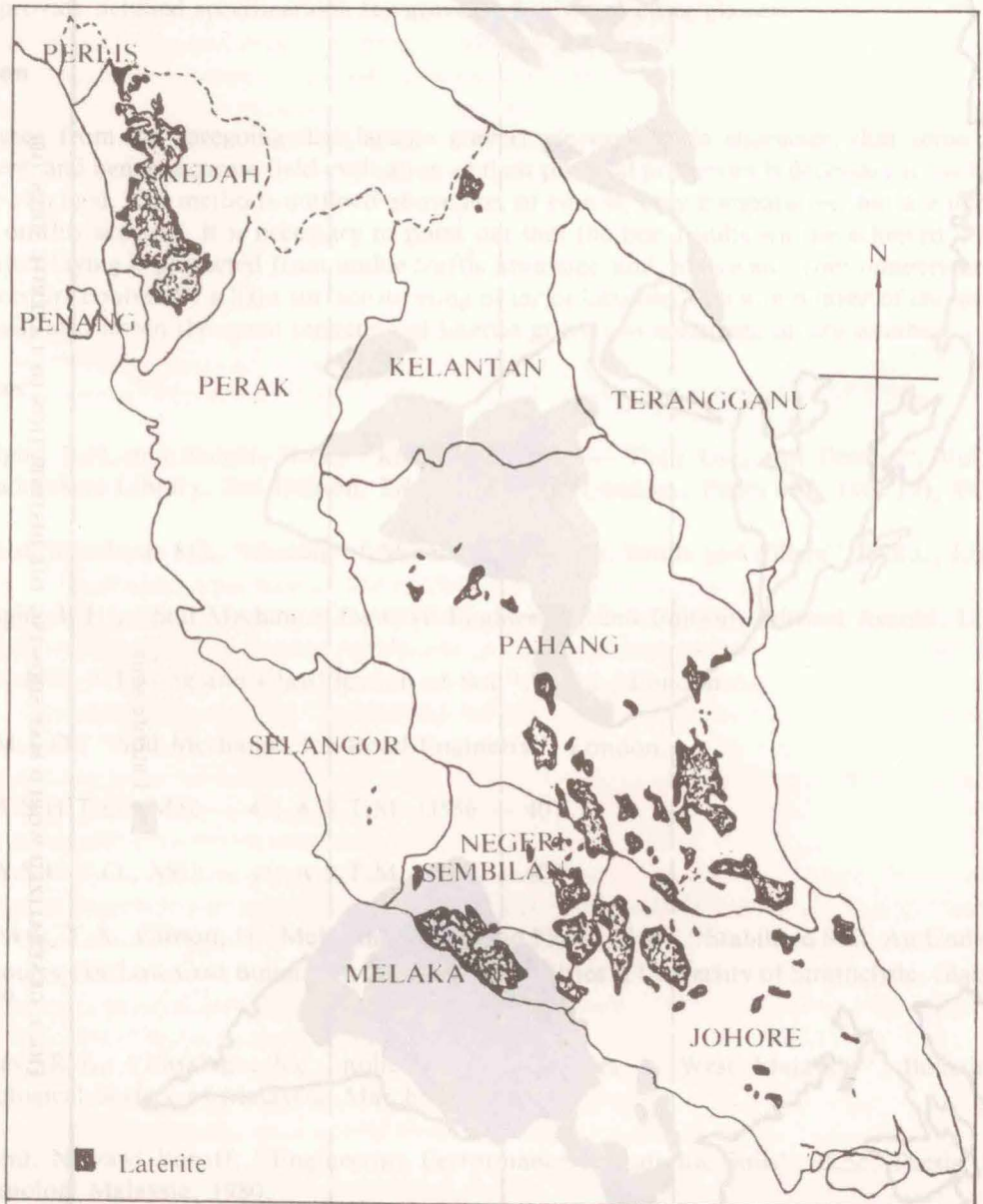


FIG. 2: LOCATION OF MAIN LATERITE DEPOSITS IN WEST MALAYSIA (from the 1968 reconnaissance map of Malaysia). (9)