EUROPEAN ECONOMIC COMMUNITY

COMMISSION

A STUDY OF ECONOMICAL RAODBUILDING IN AFRICA

OVERSEAS DEVELOPMENT SERIES

A study of economical raodbuilding

in Africa

This study was carried out by the Compagnie d'Etudes du Congo and the Centre Expérimental de Recherches et d'Etudes du Bâtiment et des Travaux Publics and is published in the EEC Commission's Overseas Development Series (500 pp., 20.5 x 27 cm).

The study is in French and costs 600 Belgian francs.

It is a technical work and includes graphs and figures which can easily be understood by all technicians.

A resumé of the introduction and a summary of the study itself are attached.

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CHAPTER I

Introduction

1.1 — PURPOSE AND SCOPE OF THE STUDY

This study deals with the building of flexible roadways in Africa and is chiefly concerned with the composition of pavements. It does not claim to be exhaustive. Indeed certain aspects were intentionally omitted, notably questions of alignment and profile, earthmoving, borrowing earth for fill, and structural works.

Furthermore, the possibility of rigid roads has not been considered. There are two reasons for this, the first being that there are in Africa numerous areas with fine soils completely devoid of coarse aggregates. A glance at a geological map of Africa would show how true this is (see attached sketch map, fig. 2).

Africa is composed in the main of a Huronian mass, the older section of which comprises a series of sedimentary zones largely made up of sand and clay.

The following areas can be distinguished :

The inner basins, such as those of the Niger, Chad, Congo, Angola and Kalahari;

The outer basins, such as those of Senegal, Gulf of Guinea, Ivory Coast, Dahomey-Nigeria, Somalia, Libya and Egypt and numerous others which are smaller.

Taken together these represent a large proportion of the total area of Africa.

The second reason for this omission is financial. The use of stone and gravel almost always involves opening up quarries and pits which are of necessity used only while the road is under construction and therefore are not economic.

It is therefore preferable to make the fullest possible use of materials found near at hand, at the same time keeping down the percentage of costly materials.

The reasons given above explain why the soil-stabilization technique is being continually more widely applied. But standards which are normally accepted in Europe do not, generally speaking, hold good in African countries because of different climatic and traffic conditions.

For one thing, frost is unknown in most parts of Africa. Furthermore, whereas traffic requirements in Europe demand the laying of heavy-duty road surfaces, it is possible in Africa to use a variety of road surfacing methods adapted to current needs, and not involving excessive initial expenditure. In other words, the plan adopted must allow of improvements by stages; consequently it calls for special methods of execution.

Unfortunately, no systematic study had been undertaken up to the time of writing and the few data available were fragmentary. In particular, no general survey of earlier roadbuilding schemes had been made and there was no basis for assessing the durability of the roads and drawing positive conclusions. As a result, road-making projects were, generally speaking, either based on a preconceived idea which ignored the wide choice of possible solutions or else allowed too high a margin of safety, since governments were unwilling to take the risk of limiting contractors to light-duty construction.

In short, these were relatively new techniques, often based on semi-empirical rules, and could possibly lead to wasteful additional expense.

It seemed, therefore, that the best course would be to present a general outline of the problems involved, supplemented by individual experiments and achievements in the different African countries. A discussion of this general outline would serve as a basis for a more extensive programme of surveys and tests leading finally to the establishment of technical and economic rules.

1.2 — THE COMPLEXITY OF THE PROBLEM

The soils commonly met with in alluvial or detrital regions of Africa are mainly composed of sand and clay. This is obviously an over-simplification since there are always other elements present, and furthermore even the composition of clay and sand varies.

From the tests made, however, it is found that the majority of African soils can be regarded as an intimate mixture of a laterite type of clay and fine sand.

It is obviously impossible in the general outline mentioned in the preceding section to cover from the outset all the uncertain factors relating to the nature of the terrain, the traffic to be carried, the execution of the works and economy. Rules must therefore be evolved for the simple cases, the most common cases, subject to their being extended, amplified and improved later.

1.3 — METHODS USED FOR THE STUDY

1.3.1 — *IDENTIFYING SOIL-TYPES*

A laterite clay from the Abidjan region and a fine sand from the Dakar region were therefore chosen for the study, since these two materials could be regarded as basic materials.

Letting C stand for clay and S for sand it may be considered that the conditions set out in section 1. 2. above will be satisfied if the soils are denoted by

C

0.75 C + 0.25 S

0.50 C + 0.50 S

0.25 C + 0.75 S

S

and described in the rest of the study by the terms :

Clay

Sandy clay

Sand clay

Clayey sand

Sand.

The term "soil-type" or "material-type" will be applied to any of these soils.

It will be observed from this classification that, for example, pure silt, which is in any event rare, lies outside the scope of this study.

1.3.2 — *STABILIZATION OF PAVEMENTS*

Certain soils acquire by simple compaction the necessary mechanical properites to serve directly as a base course for a road. Compacted earth of this kind needs no more than a thin surfacing, the actual thickness depending on the traffic to be borne. This is a case of pure mechanical stabilization.

If the effect of compaction alone is not sufficient to give the soil the mechanical properties required for the road, it can be improved to meet the requirements either by incorporating another soil possessing suitable properties: (stabilization by simple addition of soil or "granulometric correction") or by adding some product such as lime, cement, bituminous binders, resins, etc. (physico-chemical stabilization).

From the economic point of view mechanical stabilization is always the least expensive. Next comes stabilization by the addition of other soils, using therefore cheap materials. The most costly method is physico-chemical stabilization which requires the use of relatively expensive products.

Nevertheless stabilization by the addition of lime, cement or bituminous binders is widely used wherever it is impossible to improve the natural soil adequately, and where road conditions demand high technical characteristics of the terrain.

At all events these methods are generally speaking much less costly than earlier ones involving a foundation of hand-placed stones or macadam.

To keep the problem within normal and reasonable limits without thereby allowing it to lose its general character, the following types of stabilization were studied in the laboratory for each of the five types of soil :

Mechanical stabilization, which also includes, in part, stabilization by the addition of clayey soils to sand or of sandy soils to clay.

Physico-chemical stabilization by the addition of lime, cement or bituminous binders.

The CBR method was used to determine thicknesses, at least for the first three types of stabilization. The use of this method is open to certain criticisms. There are, first of all, the classical criticisms of the method itself which need not detain us. Secondly, it may be asked how far the CBR method is applicable to soils which have been stabilized with lime or cement and are consequently more or less rigid. It was felt that the stabilizations in question involved nothing more than simple addition and that the proportion added did not reach a level bordering on the soil-cement technique ; it was therefore considered that the use of the CBR method was justified. Furthermore, an examination of the results of simple compression tests show that, in the favourable case of the Proctor test for optimum moisture content the resistance figures were lower than 25 kg/cm 2 ; the value at which the slab effect is generally considered to begin.

It seems worthwhile noting here the important survey recently undertaken by the American Association of State Highway Officials (AASHO) based on different criteria.

The behaviour of a pavement structure was assessed by means of a device known as a Present Serviceability Index (PSI). A thickness index D was made to correspond to the PSI, for a given load and a given frequency of application, this index being a linear and homogeneous function of the thicknesses of the various courses constituting the pavement. Once the thickness index has been established, it is possible to arrive at a certain number (in practice limited) of solutions corresponding with it, and from among these solutions the most economical will be chosen, bearing local factors in mind.

1.3.3 — *ROADBUILDING OPERATIONS*

We have also tried in this study to determine the machinery to be used for the different soil-types.

We have described the basic operations needed successively to arrive at a stabilized soil and have studied the performance of the machines used for each type of material and for a given basic operation.

1.3.4 — *ECONOMIC STUDY*

In this subsection we have dealt with the economic aspects of roadbuilding in Africa.

We have examined the different items to be considered in calculating the cost of a particular method from laboratory tests and the prices and means of treatment known, based on work already carried out by methods similar to those assumed.

It is thus possible to determine in an approximate manner general formulas in relation to the various parameters to be taken into consideration. To these parameters there may be applied a weighting factor depending upon the climatic conditions of the area.

These general formulas are, of course, no more than a basis for estimation and will very probably require adjustment in the light of experience.

The importance of the geographical factor is studied in this economic section; furthermore it is evident that certain local conditions may of themselves make a given solution unavoidable. These are, however special cases which are difficult to classify and must be regarded as exceptional.

1.4 — PLAN OF THE STUDY

The study is therefore planned ad follows :

Chapter I — that is to say this chapter — is an introduction, presenting in summary form the various ideas dealt with at length in the study.

Chapter 2 interprets the laboratory tests carried out and contains the rules derived from these tests for the composition of the pavement.

Chapter 3 deals with the use of materials and the performance of various types of machinery.

Chapter 4 deals with economic considerations connected with roadbuilding.

Three annexes follow the Chapters.

Annex I describes the methods used for the tests and the broad results.

Annex 2 gives details of some earlier road-building schemes.

Annex 3 deals with various methods of laying wearing courses.

Finally a general questionnaire is added to the study to allow readers to follow the steps which led to the solution given and to follow the behaviour of the road.

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