UNITED NATIONS ECONOMIC COMMISSION FOR AFRICA

SYNOPSES OF PAPERS

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SYNOPSES OF PAPERS

PAPER A - THE DESIGN AND CONSTRUCTION OF ROADS IN AFRICA

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Synopsis

This paper summarises methods that have been used to design and construct road pavements in Africa. It draws heavily on the experience of British and French engineers who have observed the behaviour of large lengths of roads in many African countries.

Earth roads are treated briefly, only because there has been little scientific investigation of their behaviour. The selection of materials for gravel-surfaced roads is discussed in more detail and typical specifications of suitable materials have been included.

A large proportion of the paper has been devoted to bitumen-surface roads because the capital cost of these roads is high compared with the other two types and failures can be expensive to rectify. The concept of stage construction is described and two methods of designing the thicknesses of pavement layers have been included.

The first design system is a flexible method based on the cumulative number of equivalent standard axles which the pavement is to carry. This system can be used in all developing countries because the design method considers the damage caused by the magnitude of the individual axle-loads in the spectrum of axle-loads that the pavement must carry. A simplified design table, which takes account of the number of commercial vehicles or the total number of vehicles using the road, has also been included. Each design method assesses the subgrade strength when its moisture content is equal to the maximum that is likely to occur during the life of the pavement.

The traditional materials that have had wide use in the bases of sealed pavements are described, together with methods of stabilizing sub-standard materials.

The paper concludes with a short discussion on the drainage of pavement layers.

PAPER B - THE DESIGN AND CONSTRUCTION OF STRENGTHENING OVERLAYS FOR ROADS

by

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Synopsis

The strengthening of old roads which are inadequate to carry the rapidly increasing traffic is one of the most pressing problems for the African highway engineer.

This paper describes the use of deflection techniques for evaluating the condition of existing flexible roads and determining the most economical method of strenthening. The role of deflection criteria in the strengthening design process is considered and a deflection survey and analysis procedure using hand deflection beams is outlined. Particular attention is given to the design of overlays for soil-cement roads and roads on expansive clays. Typical strengthening materials available in Africa are discussed and their effectiveness in reducing deflections is assessed. In the strengthening process, adequate attention must be paid to associated remedial measures such as drainage and it is emphasised that, in the present state of knowledge, deflection measurements must not be regarded as supplying an unequivocal solution to the problem of overlay design. They must be backed up by engineering judgement firmly based on local experience.

PAPER C: THE DESIGN AND CONSTRUCTION OF BITUMINOUS ROAD SURFACINGS

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Synopsis

When traffic on earth or gravel roads increases to a certain level it becomes necessary to provide a surface with lower maintenance and vehicle operating costs and without the dust nuisance in dry weather. In the majority of cases the most appropriate form in Africa is provided by a bituminous surfacing, particularly since this allows a stage construction process of economical road improvements to be adopted.

For the first stage a cheap process, a single or double surface dressing (spray and chip treatment) prevents flying dust and surface attrition. The road is sealed against ingress of rain thus maintaining the road structure in a stronger condition with resultant reduction of need for maintenance. The design and technique of construction of surface dressings for African conditions is discussed in the light of experience in Africa, Europe and Australia.

With further increase of traffic the surface-dressed road needs overlaying with a thicker layer of bituminous material which will contribute to the strength of the road by reducing the stresses transmitted to the lower structures (base, sub-base) of the road. Normally mixtures of graded stone and bitumen are premixed in a plant for transport to the road site. The problem for the African engineer is to adapt the design of the many types of bituminous 'premix' developed in industralized, often temperate countries, to suit the different materials available to him and the more extreme climatic conditions of his region.

The two main types of premix - based on continuous or gap-graded aggregate mixtures are described with their advantages and disadvantages. Adaptions to suit African conditions are suggested. Mix design procedures for specifying properties of premix constituents and their application to local conditions are discussed.

For heavy duty surfacings on heavily trafficked roads often in urban areas in Africa the possibilities are explored of using a modified form of British hot-rolled asphalt as an alternative to the almost universal use of asphaltic concrete designed by the Marshall method.

It is concluded that no single ideal and universal solution for the design of any form of bituminous surfacing exists. The challenge for the African engineer of establishing suitable specifications will best be met through analysis of recorded experience and by conducting controlled full-scale road experiments.

PAPER D - TERRAIN EVALUATION FOR MATERIALS SURVEY

by

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Synopsis

Terrain evaluation consists of the examination of an area of ground to determine all factors that will influence the planning, design and execution of a project. The appropriate technique used to gather information depends upon the size of the project and the required level of accuracy. This paper describes the three main techniques that are used to gather information by indirect methods, with examples of their application to highway engineering.

Landscape analysis, which is usually based on a study of aerial photography, can be used to subdivide an area into survey units. The addition of engineering information to those units extends the survey into a terrain evaluation, which may be on a regional scale for broad feasibility surveys, or related to small terrain features for detailed investigations. The use of terrain evaluation before field work commences can provide advance warning of possible difficulties, and direct the survey team to the most important areas that need to be examined. In addition to recording the properties and behaviour of soil, it is possible to recommend broad engineering designs for each terrain unit, such as thickness of road pavements or maximum slope for cuttings. The reference of information to a basic classification system means that data can be stored for future use, possibly in a different geographic area where similar terrain conditions exist. Examples of terrain evaluation are described for the pre-feasibility survey for the Trans African Highway and for the design of a road in Malawi.

Air photo interpretation of panchromatic prints is still the main remote sensor used to interpret ground conditions. The accuracy of interpretation is increased by background information such as knowledge of geology, soils and vegetation and a land system analysis forms an excellent air photo key as an aid to photo interpretation. The first stage of an air photo survey is to determine regional features, such as major faults and geological boundaries, using air photo mosaics. To examine the terrain in detail in the individual prints, it is essential to observe the three dimensional image through the use of a stereoscope. The scale of the photographs imposes a limit on the size of feature that can be identified. Extra information can be obtained by using colour film or films that record reflectance of infra-red energy (eg 'false colour' film). Other forms of electronic sensors include infra-red line scan and radar (SLAR). An advantage of radar is that it is possible to obtain an image through cloud, but the resolution of present systems is only 10-30 metres.

The main geophysical techniques used in engineering surveys are seismic refraction and electrical resistivity. Both methods predict the thickness of soil layers and

give a measurement of a geophysical property. Seismic surveys tend to be more accurate, but require more field work. The interpretation of material type and its depth should be correlated with boreholes or trial pits. The seismic method can be used to predict the depth to hard rock, either for quarry location or in assessing performance of earth moving plant. Resistivity can be used to determine depth to water table, and to detect horizontal variation of material. Geophysical techniques can be used at an early stage of survey to help plan more detailed investigations, and also to extend detailed knowledge of one site over a broad area. The equipment and field techniques are described in the appendix.

PAPER E - THE ROLE AND ORGANISATION OF ROAD LABORATORIES

by

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Synopsis

This paper describes the scope of activities which are the responsibility of a road laboratory, and suggests the appropriate methods by which these means may be achieved. The operations considered in the paper include:

(a) Special studies for new roads or improvement or strengthening of existing roads. For new roads, geotechnical studies are necessary at all stages, from the feasibility study to the construction of the project.

(b) Control of construction, which must not only be confined to ensuring compliance with the specification but must also be directed to obtaining the best possible quality. These controls lead to the establishment of road standards.

(c) Observation of the performance of roads and road structures, leading to a policy of maintenance and strengthening.

(d) Studies of general interest, eg. an inventory and mapping of soils and suitable roadmaking materials, and collection and use of data on materials and methods in a particular region.

(e) Preparation of specifications adapted according to the materials available, the climate and the traffic for different regions.

(f) Research into the development of new materials and methods.

(g) The provision of documentation and technical information, and of technical training.

PAPER F - THE CHOICE OF STANDARDS FOR AFRICAN ROADS

by

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Synopsis

The provision of an adequate road system must be regarded as an essential part of a programme of economic development. The paper examines what is meant by 'adequate' and adopts as a criterion the concept of lowest total transport cost over the life of the investment. It is suggested that rigidly applied road standards are clearly inappropriate in developing countries and that a programme of stage construction should be used supported by a well planned maintenance programme. One exception is likely to be in urban areas where traffic flows are particularly heavy. In this situation the use of road standards established in developed countires is appropriate but modifications due to climate and traffic composition are discussed.

Benefits resulting from road improvements, (reductions in operating costs, maintenance costs and time savings) are described and it is suggested that relationship between such costs and road characteristics should provide the basic index, as well as a method of establishing optimum standards. A method using vehicle speeds is discussed in detail.

More complex methods are described briefly but the paper points out that whatever approach is adopted it is essential that adequate data are a available. It is suggested that all countries should examine how they stand in relation to the data needed to take decisions on road investment and that any deficiencies are rectified.

Pavement design must receive attention and account must be taken of the characteristics of local materials and climatic conditions.

The analysis of road maintenance problems can only be done on the basis of local studies, extrapolation from one country to another being hazardous.

Finally the paper indicates the difficulties of transferring results obtained in one country to another but points out that the basic principles discussed can be utilized by every country in preparing its own policy for road standards.

PAPER G - ROAD MAINTENANCE

by

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Synopsis

Road maintenance varies greatly between different authorities in its scope, expenditure and standard of performance. Decisions on maintenance are too often made on subjective judgements and there is an urgent need for better systems for assessing road conditions. Meanwhile organisation and training should be improved and a more vigorous maintenance policy adopted.

Earth and gravel roads are generally classed as unimproved, intermediate and improved or engineered gravel roads. The chief maintenance needs of these roads are discussed and rates of formation of corrugations and gravel-loss given for different countries. Different grading techniques are compared. Tracks have special maintenance problems because they sometimes carry heavy traffic at peak periods despite minimal construction. Regravelling work should follow careful study of materials, water sources and climate, using rains to assist compaction where possible.

Base material for bitumen surfaced roads, needs to be more carefully selected than for gravel roads. Most kinds of bituminous road share the same problems of cracking, potholing, ravelling etc. The causes and remedial measures for these are discussed. Parameters are suggested for further work aimed at developing a method for assessing maintenance needs.

To be effective in keeping roads to an acceptable standard, maintenance organisation should be more sophisticated. With better definition of tasks all relevant data could be collected and processed to reveal areas of high and low efficiency. Data processing should be carried out by special units with the aim of improving methods, reducing costs and providing a higher standard of maintenance. Training schemes more relevant to technical and human needs should be developed.

True costs of road maintenance are often difficult to assess because of inconsistency in accounting and poor records. This paper defines the necessary chargeheads and categories of expenditure. Approximate costs of different operations in relation to traffic are quoted for different countries and an approach suggested for relating maintenance costs of bituminous roads to numbers of "standard axles".

Recommendations include:

- more test-sections covering a range of different environments
- more sophisticated information and data-processing systems
- more vigorous programmes of relevant training
- adoption of objective standards of condition and performance.

FEEDER ROAD TRAFFIC CHARACTERISTICS AND REDEVELOPMENT NEEDS IN GHANA

by

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Synopsis

The paper describes briefly past attempts at studying feeder road requirements in Ghana. It further discusses some results of studies of characteristics of traffic and commodity movement, transport charges and road condition of selected feeder roads and their implications for determining broad redevelopment needs of feeder roads in the country. The need for additional research has also been indicated.

LEARNING HAS NO END

by

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Synopsis

The Ministry of Works is the largest employer of engineers of all disciplines in Kenya and the paper outlines the practical post-graduate training, which covers a period of three years, required by civil engineers intending to join the Roads Department of the Ministry. The training includes attachment to a civil engineering contractor and a consulting firm, with shorter periods spent in the Design and Materials Sections of the Roads Department.

To provide sufficient skilled technicians, the Ministry of Works sponsors courses in surveying, draughtsmanship and photogrammetry at the Kenya Polytechnic. The latter course includes periods at the Survey of Kenya and at the Swiss School of Photogrammetric Operators.

In-service training is provided for overseas, foremen, inspectors and superintendents. In addition, courses for inspectors and superintendents that concentrate on administration and supervision are organised at the Staff Training Centre of the Ministry, where training is also provided for plant operators and motor mechanics.

USE OF LOCAL LIME IN STABILISATION FOR ROAD BASES

by

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Synopsis

A locally produced lime manufactured by burning lime stone has been used to stabilize a micaceous sandy clay gravel for use in the construction of the base of a trunk road. In a laboratory trial, the gain in strength of the soils stabilized with imported quick lime was compared with the gain in strength produced by the local lime. It is concluded that lime which can be produced locally in this way can be successfully used in improving the qualities of gravels containing higher percentages of clay and having higher plasticity index than the specifications allow.

MAINTENANCE OF ROADS IN THE IVORY COAST

by

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Synopsis

The author discusses the part played by the existing road network in the Ivory Coast in the continuing economic growth of the country, and relates this to the growth in average daily traffic. The construction and maintenance of road types is described in detail, as are the effects of climatic conditions and axle loads on the work load of the respective maintenance departments.

A complete breakdown is given of the government departments associated with the road network, both in relation to equipment and personnel. The author indicates that a high level of service is required from the maintenance departments, and discusses how this may best be achieved within the limits of available finance.

ROAD MAINTENANCE IN THE NIGER REPUBLIC

BY

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Synopsis

The Republic of Niger is completely land-locked and as it has no railways and, at present, very limited water and air transportation, the roads play a major role in meeting transport requirements. As well as developing an adequate road network, it is therefore very important that the roads should be properly maintained.

This paper describes the routine and periodic maintenance required for both earth and bituminous roads and for drainage structures, and gives examples of typical costs. Details are given of the organisation of the Road Maintenance Divisions and of the Equipment Division, which has recently been re-organised to co-ordinate the planning, repair and maintenance of the equipment required for road maintenance. An analytical accounting system has been introduced to keep a check on all the equipment costs. Reference is made to the training of staff, the keeping of complete records and the need for instilling a sense of the value to the community of maintenance work.

Revision of ROAD NOTE 31 - A GUIDE TO THE STRUCTURAL PROPERTIES OF BITUMEN-SURFACED ROADS IN TROPICAL AND SUB-TROPICAL COUNTRIES (A discussion document)

by

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Synopsis

Developing countries have a wide range of legal axle-load limits, varying between 7000 kg and 13000 kg; some countries have no legal limit. In this revised Note, traffic is defined in terms of the equivalent number of standard 8200 kg axles expected to pass over the road during its design life. The method of calculating the equivalent number of standard axles draws attention to the greater damaging effect of very heavy vehicles and points to the benefits of introducing a realistic legal limit to axle loads.

In most tropical countries, provided the drainage is adequately engineered, the subgrade rarely becomes wetter than the optimum moisture content for compaction. In fact, subgrades are usually much drier and stronger than those in temperate climates. Detailed consideration is therefore given in this revised Note to selecting the appropriate moisture content at which the subgrade strength should be measured, with a view to producing an economical pavement design.

The prediction of traffic growth in developing countries is difficult, and an overestimate can result in capital being invested before it is needed. For this reason a stage construction approach is recommended. The thickness design chart in the revised Note provides for the addition of a strengthening overlay when the pavement has carried approximately 0.5 million standard axle loads. A method is given for assessing the residual life of the pavement and for determining the additional thickness required. Guidance is also given on the choice of materials for pavement construction.