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C. S. A.

Scientific Council for Africa South of the Sahara
Conseil Scientifique pour l'Afrique au Sud du Sahara

ROAD RESEARCH
CONSTRUCTION DES ROUTES

LOURENÇO MARQUES
1958

C.C.T.A.

ORGANIZATION OF AFRICAN UNITY
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COMMISSION DE COOPERATION TECHNIQUE EN AFRIQUE AU SUD DU SAHARA

Créée en Janvier 1950, la Commission de Coopération Technique en Afrique au Sud du Sahara (C.C.T.A.) a fait l'objet d'une Convention Intergouvernementale signée à Londres le 18 Janvier 1954. Elle se compose, à l'heure actuelle, des Gouvernements suivants : Belgique, Fédération de la Rhodésie et du Nyassaland, République Française et Communauté, Ghana, République de Guinée, Libéria, Portugal, Royaume-Uni, Union de l'Afrique du Sud.

OBJECTIF

Assurer la coopération technique entre les territoires dont les Gouvernements Membres sont responsables en Afrique au Sud du Sahara.

ATTRIBUTIONS

- 1) Traiter de tout sujet concernant la coopération technique entre les Gouvernements Membres et leurs territoires dans le cadre de la compétence territoriale de la C.C.T.A.
- 2) Recommander aux Gouvernements Membres toutes mesures tendant à la mise en œuvre de cette coopération.
- 3) Convoquer les conférences techniques que les Gouvernements Membres ont décidé de tenir.
- 4) Contrôler du point de vue général et du point de vue financier l'activité des organismes placés sous son égide et présenter aux Gouvernements Membres toutes recommandations y afférentes.
- 5) Présenter des recommandations aux Gouvernements Membres en vue de la création de nouveaux organismes ou la révision des dispositions existantes pour la coopération technique, dans le cadre de la compétence territoriale de la C.C.T.A.
- 6) Présenter des recommandations aux Gouvernements Membres en vue de formuler des demandes conjointes d'assistance technique aux organisations internationales.
- 7) Présenter des avis sur toutes questions concernant la coopération technique que lui soumettront les Gouvernements Membres.
- 8) Administrer le Fonds Interafricain de la Recherche et la Fondation pour l'Assistance Mutuelle en Afrique au Sud du Sahara.

BUDGET

Alimenté par les contributions des Gouvernements Membres.

ORGANISATION

- 1) La C.C.T.A. se réunit au moins une fois chaque année. Ses recommandations et conclusions sont portées à la connaissance des Gouvernements Membres en vue de leur adoption à l'unanimité ainsi que de leur mise en œuvre dans les territoires intéressés.
- 2) Le Conseil Scientifique pour l'Afrique au Sud du Sahara (C.S.A.), Conseiller scientifique de la C.C.T.A., a été créé en novembre 1950, comme suite à la Conférence Scientifique de Johannesburg (1949), en vue de favoriser l'application de la science à la solution des problèmes africains. Il est composé de personnalités éminentes, choisies de telle sorte que les principales disciplines scientifiques importantes au stade actuel du développement de l'Afrique soient représentées. En tant que membres du Conseil ces personnalités n'agissent pas sur instructions de leurs Gouvernements respectifs mais sont responsables individuellement devant le Conseil.
- 3) Des Bureaux et Comités techniques traitent chacun un aspect particulier de la coopération régionale et interterritoriale en Afrique au Sud du Sahara.
- 4) Le Secrétariat de la C.C.T.A. et du C.S.A. comprend deux sièges : l'un, jusqu'ici à Londres, est en cours de transfert à Lagos, l'autre se trouve à Bukavu. Il est dirigé par un Secrétaire Général assisté de deux Secrétaires Généraux Adjointes et, à Bukavu, d'un Secrétaire Scientifique et d'un Secrétaire Scientifique Adjoint. Le Secrétaire de la F.A.M.A. est également adjoint au Secrétaire Général.

PUBLICATIONS

Des brochures traitant de problèmes scientifiques et techniques, dont les données sont habituellement rassemblées en Afrique par le C.S.A., sont publiées à Londres. Toute demande d'information devra être adressée au siège de Londres du Secrétariat, à l'attention du fonctionnaire chargé des Publications et de l'Information.

COMMISSION FOR TECHNICAL CO-OPERATION IN AFRICA SOUTH OF THE SAHARA

Established in January, 1950, the Commission for Technical Co-operation in Africa South of the Sahara (C.C.T.A.) was the subject of an Inter-governmental Agreement signed in London on 18 January 1954. It consists now of the following Governments: Belgium, Federation of Rhodesia and Nyasaland, French Republic and Community, Ghana, Republic of Guinea, Liberia, Portugal, Union of South Africa, United Kingdom.

OBJECT

To ensure technical co-operation between territories for which Member Governments are responsible in Africa South of the Sahara.

FUNCTIONS

- (1) To concern itself with all matters affecting technical co-operation between the Member Governments and their territories within the territorial scope of C.C.T.A.
- (2) To recommend to Member Governments measures for achieving such co-operation.
- (3) To convene technical conferences as agreed by Member Governments.
- (4) To supervise, from the financial and general points of view, the work of the organisations placed under its aegis and make recommendations thereon to the Member Governments.
- (5) To make recommendations to the Member Governments for the setting up of new organisations or the revision of existing arrangements for securing technical co-operation within the territorial scope of C.C.T.A.
- (6) To make recommendations to the Member Governments with a view to the formulation of joint requests for technical assistance from international organisations.
- (7) To advise Member Governments on any other subject in the field of technical co-operation which the Member Governments may bring to its notice.
- (8) To administer the Inter-African Research Fund and the Foundation for Mutual Assistance in Africa South of the Sahara.

FINANCE

Contributions from Member Governments.

ORGANISATION

- (1) C.C.T.A. meets at least once a year. Its recommendations and conclusions are submitted to Member Governments for unanimous approval and for implementation in the territories concerned.
- (2) The Scientific Council for Africa South of the Sahara (C.S.A.), Scientific Adviser to C.C.T.A., was established in November, 1950, following the Johannesburg Scientific Conference (1949) to further the application of science to the solution of African problems. Its members are eminent scientists chosen in such a manner that the main scientific disciplines important at the present stage of the development of Africa shall be represented. As members of the Council they do not receive instructions from Governments but are responsible individually to the Council.
- (3) Technical Bureau and Committees deal with specific aspects of regional and inter-territorial co-operation in Africa South of the Sahara.
- (4) The C.C.T.A./C.S.A. Secretariat has two offices, one in London and one in Bukavu. The London Office is at present being transferred to Lagos. The Secretariat has at its head a Secretary-General, who is aided in his work by two Assistant Secretaries-General and, at Bukavu, by a Scientific Secretary and an Assistant Scientific Secretary. The Secretary-General is also assisted by the Secretary of F.A.M.A.

PUBLICATIONS

Publications dealing with scientific and technical problems, the data of which are usually collected in Africa by C.S.A., are issued in London. Inquiries should be addressed to the London office of the Secretariat, for the attention of the Publications and Information Officer.

C. S. A.

**Scientific Council for Africa South of the Sahara
Conseil Scientifique pour l'Afrique au Sud du Sahara**

**C.S.A. SPECIALISTS' MEETING ON ROAD
RESEARCH
REUNION DE SPECIALISTES C.S.A. SUR
LA CONSTRUCTION DES ROUTES**

**LOURENÇO MARQUES
1958**

*Published under the sponsorship of the Commission for Technical Co-operation in
Africa South of the Sahara.*

*Publié sous l'égide de la Commission de Coopération Technique en Afrique au Sud
du Sahara.*

C.C.T.A.

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LISTE DES PARTICIPANTS**

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- D. ROSÁRIA B. COSTA.
- D. ALDA R. VAZ.
-

AGENDA

I. ROAD ECONOMICS

1. Economic assessment of priorities for road construction.
2. Evaluation of construction and maintenance costs of roads.
3. Financing problems.

II. CONSTRUCTION AND MAINTENANCE OF ROADS

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2. Bitumen roads. Different types of foundation: macadam, stabilised soils, laterites. Different types of bitumen surface, laid down while hot and while cold. Problems for study.
3. Evaluation of the thickness of construction required in African conditions. Influence of water movement underneath the surface of roads.
4. Specific problems of road construction in Africa: erosion, drainage, black cotton soil, arid conditions.

III. MECHANISATION OF CONSTRUCTION WORK AND MAINTENANCE

1. Construction: means of facilitating the acquisition of equipment; technical assistance; the problem of spare parts.
2. Maintenance: programme for maintenance under African conditions; training of teams of technicians and the organisation of mechanical equipment for maintenance; the length of road entrusted to each team.

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1. Définition des priorités pour la construction routière en fonction des études économiques.
2. Evaluation des prix de construction et d'entretien des routes.
3. Problèmes de financement.

II. CONSTRUCTION ET ENTRETIEN DES ROUTES

1. Routes de terre. Stabilisation des sols. Le problème des ondulations. Emploi des latérites. Problèmes à étudier.
2. Routes bitumées. Différents types de couche de fondations: macadam, sols stabilisés, latérites. Différents types de revêtement bitumineux posés à chaud ou à froid. Problèmes à étudier.
3. Evaluation de l'épaisseur de la construction, requise sous conditions africaines. Influence des mouvements de l'eau sous le revêtement.
4. Problèmes spécifiques de la construction routière en Afrique: l'érosion, le drainage, les sols noirs à coton, les conditions arides.

III. MÉCANISATION DES TRAVAUX DE CONSTRUCTION ET D'ENTRETIEN

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2. Entretien: programme relatif à l'entretien sous conditions africaines; formation d'équipes de techniciens et organisation de l'équipement mécanique pour l'entretien; longueur de route confiée à chaque équipe.

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Chapter I—Road Economics
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Afrique Occidentale Française

- GIRAUD, M. Programme routier de l'A.O.F.—Résultats
C.C.T.A./C.S.A. R.R. (58) 22 économiques et politique routière.

Angola

- Travaux Publics Economy of highways and mechanisation of the
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Cameroun Français

- CHIRAT, G. Note sur les techniques de construction de
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Congo Belge

- VAN HEULE, V. R. La route Rutshuru–Ouganda.
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Côte d'Ivoire

- MILLIER, J. Etude économique de l'amélioration du réseau
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Madagascar

- Travaux Publics Problèmes routiers à Madagascar et expériences
C.C.T.A./C.S.A. R.R. (58) 28 faites ou en cours.

Moçambique

- PEREIRA DOS REIS, J. Problems in the road economy of Mozambique.
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Portugal

- NASCIMENTO, U. Notas sobre os trabalhos do L.N.E.C. relativos
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Union of South Africa

- Union of South Africa Road economic studies with particular reference
C.C.T.A./C.S.A. R.R. (58) 5 to the work of the National Institute for Road Research.

- Union of South Africa Memorandum from South Africa regarding
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General — Général

- Bureau central d'études pour les équipements d'outre-mer (France) Recommandations du Comité technique créé pour l'étude générale des routes économiques. C.C.T.A./C.S.A. R.R. (58) 24
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- MILLARD, R. S. The economic assessment of priorities for road construction and improvement in under-developed areas. C.C.T.A./C.S.A. R.R. (58) 21

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- NOVAIS FERREIRA, H. Red coffee soils in Angola. C.C.T.A./C.S.A. R.R. (58) 38
- NOVAIS FERREIRA, H. Black cotton soils in Angola. C.C.T.A./C.S.A. R.R. (58) 43
- NOVAIS FERREIRA, H. An aspect of erosion on highways (Angola). C.C.T.A./C.S.A. R.R. (58) 45
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- WOOLTORTON, F. L. D. Low cost design trends in Kenya. C.C.T.A./C.S.A. R.R. (58) 46

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C.C.T.A./C.S.A. R.R. (58) 14 routes à Madagascar.

Mozambique

- MARTINS, A. Construction and maintenance of roads in
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- MILLIER, M. et SERPETTE, M. . . Note sur la stabilisation des routes en terre par
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- MITCHELL, R. L. Moisture movements under highway pavements.
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- Union of South Africa Summarised programme of Research of the
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tenance of roads.

Général — General

- Association Internationale Per- Routes économiques, X^{ème} Congrès, Istamboul,
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C.C.T.A./C.S.A. R.R. (58) 29 1955 (voir chapitre I).
NASCIMENTO, U. Nota sobre os trabalhos do L.N.E.C. relativos
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Road Research Laboratory . . Pavement design ; the influence of water move-
C.C.T.A./C.S.A. R.R. (58) 2 ment under the surface of roads.
Road Research Laboratory . . Earth and gravel roads.
C.C.T.A./C.S.A. R.R. (58) 3

Tanganyika

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- LAGOUGE, M. Le maintien en service de matériel des Travaux
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Angola

- Public Works Economy of highways and mechanisation of
 C.C.T.A./C.S.A. R.R. (58) 44 works, Public Department, Public Works
 Department (see chapter I).

Guinée Française

- Travaux Publics Note sur l'entretien des routes en terre par le
 C.C.T.A./C.S.A. R.R. (58) service des travaux publics de la Guinée
 II-bis. Française.
 REME, G. Note relative à l'entretien des routes en terre,
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Southern Rhodesia

- HARRIS, A. D. Road Maintenance Organisation, Southern
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ADDIS ABABA _____

VOTE OF THANKS TO THE HOST GOVERNMENT

The participants at the Meeting of Specialists on Road Construction wish to express to the Government of Portugal their gratitude for the hospitality and the facilities offered to them during their stay in Lourenço Marques.

REMERCIEMENTES AU GOUVERNEMENT HOTE

Les participants à la Réunion de spécialistes sur la Construction de Routes désirent exprimer au Gouvernement du Portugal leur gratitude pour son hospitalité et pour les facilités qui leur furent offertes durant leur séjour à Lourenço Marques.

RECOMMENDATIONS — RECOMMANDATIONS

I. TERMINOLOGY

In view of the close association in Africa of people speaking different languages, the Meeting **RECOMMENDS** that C.C.T.A. should strongly request the Permanent International Association of Road Congresses to bring up to date the existing Technical Dictionary of Road Terms and to include precise definitions of the terms.

I. TERMINOLOGIE

Etant donné la coexistence en Afrique de populations parlant des langues différentes, la Réunion **RECOMMANDE** à la C.C.T.A. de demander à l'Association Internationale Permanente des Congrès de la Route de reprendre l'actuel Dictionnaire Technique routier pour le mettre à jour, en donnant une définition précise de ses termes.

II. ESTABLISHMENT OF A PANEL OF CORRESPONDENTS

The Meeting reaffirms the statement contained in Recommendation 52 of the African Regional Scientific Conference which took place in Johannesburg (1949), when an important meeting of scientists, representing the majority of the scientific fields, studied the considerable importance of the road problem with regard to the general development of the African continent, and recommended :

- (a) That research on all technical and economic aspects concerning the planning of road construction and maintenance should be intensified.
- (b) That ways be found to construct low-cost roads.

In order to establish fullest collaboration in this field, the Meeting of Road Specialists

RECOMMENDS the establishment of a Panel of Correspondents in order to :

1. Collect and circulate information.
2. Facilitate exchanges of visits by training or study periods for technicians on a regional level, utilising existing arrangements within the framework of C.C.T.A. organisations.
3. Ask F.A.M.A. to consider the organisation of temporary training centres, of regional or non-regional character, for persons of various stages of training (specialisation of engineers in Africa, training or specialisation of mechanics, foremen, supervisors, etc.). This training should be designed in such a manner as to allow the technicians after participation in such courses to become instructors, on their subjects, either at their own level or at a lower level.

In addition to bodies normally working within the C.C.T.A. organisation, including Territorial Correspondents and an Inter-African Correspondent, the Meeting, bearing in mind the wide field covered by road activities and road transport,

RECOMMENDS the appointment of Specialist Correspondents for particular subjects. The Specialised Correspondents may be chosen among the Territorial Correspondents or elsewhere.

II. CREATION D'UN RESEAU DE CORRESPONDANTS

La Réunion réaffirme la déclaration contenue dans la Recommandation 52 de la Conférence Scientifique Régionale Africaine de Johannesburg (1949) par laquelle cette grande assemblée d'hommes de science représentant la majorité des disciplines a considéré l'importance considérable du problème des routes pour le développement général de l'Afrique et a recommandé :

a) Que la recherche sur tous les aspects techniques et économiques de la planification de la construction et de l'entretien des routes soit intensifiée.

b) Que l'on cherche à construire des routes à bas prix.

En vue d'établir la plus entière collaboration dans ce domaine la Réunion de Spécialistes sur les Routes

RECOMMANDE l'établissement d'un Réseau de Correspondants dans le domaine des routes et des transports routiers dont l'objectif serait de :

1. Réunir des documents d'informations et d'en assurer la diffusion.
2. Faciliter l'échange, les visites et les stages de techniciens sur une échelle régionale en utilisant les dispositions existantes dans le cadre des organisations de la C.C.T.A. déjà en activité.
3. Demander à la F.A.M.A. d'envisager l'organisation de centres de formation technique, temporaires, régionaux ou non, à différents échelons (spécialisation d'ingénieurs en Afrique, formation ou spécialisation de mécaniciens, contremaîtres, surveillants, etc.). Cette formation devrait être conçue de façon à permettre aux techniciens qui en auront été l'objet d'enseigner eux-mêmes ultérieurement à des échelons égaux ou inférieurs.

En sus des organismes travaillant normalement dans le cadre de la C.C.T.A. et qui comprennent des Correspondants Territoriaux et un Correspondant Interafricain, la Réunion, considérant l'étendue du domaine couvert par les travaux et les transports routiers,

RECOMMANDE de désigner des Correspondants Spécialisés pour certains sujets. Les Correspondants Spécialisés peuvent être choisis parmi les Correspondants Territoriaux ou en dehors.

III. CORRESPONDENTS

The Meeting RECOMMENDS that the functions of the correspondents should be defined as follows :

A. Territorial Correspondents

(a) To keep in touch with any activities on the part of national, regional or international organisations in their territory in the field of road work and road transport and provide the Inter-African Correspondent with such information as he may ask for.

(b) To provide a centre for the exchange of information between territories.

(c) To maintain up-to-date information on current road problems of particular interest to their own territory.

B. The Inter-African Correspondent

(a) To co-ordinate the work of all correspondents in order to ensure an efficient information system and promote the exchange of documents, reports, publications, etc.

(b) To suggest, in agreement with the other correspondents and at the appropriate time, the organisation of meetings, symposia, conferences and research projects, etc.

C. Specialised Correspondents

(a) To co-ordinate research on a particular subject. The particular subjects so far selected are the following :

1. Economics of roads and road transport.
2. Properties of African soils.
3. Earth and gravel roads.
4. Pavement design.
5. Soil stabilisation.
6. Bituminous surfacings.

Each Specialised Correspondent would also deal with the machinery appropriate to his subject.

(b) To collect and distribute information on his subject.

(c) It is suggested that Member Governments should be asked to appoint Specialist Correspondents for the various subjects, as follows :

1. Economics of roads and road transport : France and French African territories.
2. Properties of African soils : Union of South Africa.
3. Earth and gravel roads : Belgium.
4. Pavement design : United Kingdom and British African territories.
5. Soil stabilisation : Portugal.
6. Bituminous surfacings : Federation of Rhodesia and Nyasaland.

III. CORRESPONDANTS

La Réunion RECOMMANDE que les attributions des correspondants soient définies de la façon suivante :

A. Correspondants Territoriaux

a) Se tenir au courant des activités dans le domaine des routes et des transports routiers que peuvent avoir les organisations nationales, régionales ou internationales sur leur territoire et donner au Correspondant Inter-africain les renseignements qu'il demande.

b) Servir d'intermédiaire normal par lequel des renseignements peuvent être échangés entre les territoires.

c) Tenir à jour une documentation sur les problèmes actuels routiers intéressant particulièrement leur propre territoire.

B. Correspondant Interafricain

a) Coordonner le travail de tous les correspondants pour atteindre un système efficace d'informations et promouvoir l'échange des documents, rapports, publications, etc.

b) Suggérer en accord avec les autres correspondants et en temps opportun, l'organisation de réunions, colloques, conférences, projets de recherche, etc.

C. Correspondants Spécialisés

a) Coordonner la recherche sur un sujet particulier. Les sujets particuliers choisis à ce jour sont les suivants :

1. Economie de la route et des transports routiers.
2. Propriétés des sols africains.
3. Routes en terre.
4. Calcul des épaisseurs de chaussée.
5. Stabilisation des sols.
6. Revêtements superficiels.

Chaque Correspondant Spécialisé devrait aussi s'occuper du matériel correspondant à son sujet :

b) Rassembler et diffuser la documentation relative à son sujet.

c) Il est suggéré de demander aux Gouvernements Membres de nommer les Correspondants Spécialisés conformément à la liste suivante :

1. Economie de la route et des transports : France et Territoires français d'Afrique.
2. Propriétés des sols africains : Union de l'Afrique du Sud.
3. Routes en terre : Belgique.
4. Epaisseur des chaussées : Royaume-Uni et Territoires Africains Britanniques.
5. Stabilisation des sols : Portugal.
6. Revêtements superficiels : Fédération de la Rhodésie et du Nyassaland.

IV. PUBLICATION OF PAPERS ON THIS MEETING

The Meeting RECOMMENDS that the publications concerning this Meeting on Roads should include, in addition to Recommendations, the Reports of the Rapporteurs, revised after receiving all the documents, and that the list of relevant documents should be attached to each report.

IV. PUBLICATION DES TRAVAUX DE LA REUNION

La Réunion RECOMMANDE que la publication relative à la Réunion sur les Routes comprenne en plus des Recommandations, les travaux de synthèse établis par les Rapporteurs, remaniés en tenant compte des documents de travail parvenus tardivement, et qu'une liste révisée des documents soit jointe à chaque rapport de synthèse.

V. INTER-AFRICAN ROADS CONFERENCE

The Meeting has considered the question of the value of convening an Inter-African Roads Conference, but feels that the time is not yet ripe.

V. CONFERENCE INTERAFRICAINNE SUR LES ROUTES

La Réunion a examiné la question de la possibilité de convoquer une Conférence Interafricaine sur les routes, mais estime que le moment ne s'avère pas encore opportun.

VI. BASIC INFORMATION

Basic statistics on roads and road transport are essential for any consideration of the problems of road economics in Africa. The Meeting therefore RECOMMENDS that Member Governments be asked to provide information of this type to the territorial Correspondent for Roads and Road Transport. This information should be presented annually in a uniform manner for each territorial unit under the following headings :

- (a) National income.
- (b) Total Government expenditure.
- (c) Estimated capital investment to date, on roads and bridges, expressed in terms of present-day values.
- (d) Annual expenditure on roads outside towns (construction and maintenance).
- (e) Capital investment in the road transport industry.
- (f) Annual expenditure on the road transport industry.
- (g) Capital investment and annual expenditure on other forms of transportation : railways, airways, waterways.

- (h) Mileage of seasonal roads.
- (i) The mileage of different classes of all-weather roads :
 1. Unimproved roads.
 2. Improved roads.
 3. Permanent surfaced roads.
 4. Gravel roads.
- (j) Total number of vehicles in service classified by types :
 1. Commercial vehicles of 3 metric tons (total weight) and over.
 2. Commercial vehicles of less than 3 metric tons (total weight).
 3. Passenger buses.
 4. Passenger cars.
- (k) Number of new vehicles registered each year classified as in (j).
- (l) Annual fuel consumption of road vehicles :
 1. Petrol.
 2. Diesel oil.

The Meeting further RECOMMENDS that the information under headings (a), (b), (d), (h), (i), (j), (k), (l) be supplied for each year from 1945 onwards.

VI. INFORMATIONS DE BASE

Toute étude des problèmes portant sur l'économie des routes et du transport routier en Afrique exige l'établissement de données statistiques de base. En conséquence la Réunion RECOMMANDE aux Gouvernements Membres de fournir les renseignements ci-après au Correspondant territorial pour les Routes et le Transport Routier, chaque année, pour chaque territoire, et présentées de façon uniforme :

- a) Revenu National.
- b) Dépenses budgétaires totales.
- c) Evaluation du capital investi à ce jour dans les routes et ponts, exprimée en valeur actuelle.
- d) Dépenses annuelles occasionnées par la construction et l'entretien des routes en dehors des villes.
- e) Capital investi dans l'industrie du transport routier.
- f) Chiffres d'affaires annuel de l'industrie du transport routier.
- g) Capital investi et dépenses annuelles pour d'autres moyens de transport : chemins de fer, transports aériens, voies fluviales.
- h) Kilométrage de routes saisonnières.
- i) Kilométrage de diverses catégories de routes permanentes :
 1. Routes non améliorées.
 2. Routes améliorées.
 3. Routes en terre.
 4. Routes revêtues.

- j) Nombre total de véhicules en service, classés comme suit :
 1. Véhicules commerciaux d'un poids total de 3 tonnes métriques en charge et au-dessus.
 2. Véhicules commerciaux d'un poids total de moins de trois tonnes métriques en charge.
 3. Autobus.
 4. Voitures particulières.
- k) Nombre de nouveaux véhicules enregistrés chaque année (voir classification j)).
- l) Consommation annuelle de carburant des véhicules routiers :
 1. Essence.
 2. Diesel oil.

La Réunion RECOMMANDE en outre que les renseignements énumérés en a), b), d), h), i), j), k), l) soient fournis pour chaque année à partir de 1945.

VII. THE BENEFITS OF ROADS

There is a great need to measure the benefits that result from the building and improvement of roads.

It is therefore RECOMMENDED that a start be made on the following two items :

(a) A study of vehicle-operating costs on roads of different standards ; in particular the study of the effect of the change from unimproved roads to gravel roads and from gravel roads to roads with a permanent surface. The question of the separate effects of improvements in geometrical standards might also be considered.

(b) A study of the effects of roads on the economic and social development of areas used for agriculture and other purposes.

VII. BENEFICES PROCURES PAR LA CONSTRUCTION ET L'ENTRETIEN DES ROUTES

Il serait d'un grand intérêt de pouvoir évaluer les bénéfices provenant de la construction et de l'amélioration de routes.

La Réunion RECOMMANDE en conséquence d'entreprendre des investigations sur les sujets qui suivent :

a) Etude des frais d'exploitation des véhicules sur les routes de types différents ; en particulier l'étude de l'effet de l'évolution des routes de l'état de route non améliorée à l'état de route améliorée, et pour cette dernière catégorie, de l'état de route en terre à l'état de route revêtue. La question des effets entraînés par l'amélioration des caractéristiques géométriques pourrait faire l'objet d'études séparées.

b) L'étude des effets des routes sur le développement économique et social des régions agricoles et autres.

VIII. COSTS OF ROADS

The Meeting RECOMMENDS that information be collected on the costs of building and maintaining roads at different levels of improvement, taking into consideration the volume of traffic, topography, climate and the availability of road-making materials.

VIII. DEPENSES ENTRAINEES PAR LES ROUTES

La Réunion RECOMMANDE de recueillir des informations sur les dépenses entraînées par la construction et l'entretien des routes des différents types en tenant compte du volume de trafic, de la topographie, du climat et des matériaux routiers disponibles.

IX. AFRICAN ROAD-MAKING MATERIALS

The Meeting recognised that one of the most important general problems of road building in Africa is the study of the engineering properties of the soils and rocks available.

The Meeting RECOMMENDS the gathering of data concerning geology, pedology, climatology and hydrology, likely to contribute useful information for the location and study of properties of materials for road building as well as for studies of drainage and anti-erosion measures.

The assistance of the relevant C.C.T.A. organisations already working in these fields should be obtained.

IX. MATERIAUX POUR LA CONSTRUCTION DE ROUTES

La Réunion reconnaît qu'un des problèmes généraux les plus importants de la construction routière en Afrique est l'étude des propriétés des sols et matériaux rocheux disponibles.

La Réunion RECOMMANDE de recueillir des données d'ordre géologique, pédologique, climatologique et hydrologique susceptibles d'apporter des enseignements pour la recherche et l'étude des propriétés des matériaux destinés à l'usage routier ainsi que pour l'étude du drainage et des mesures antiérosives.

La Réunion RECOMMANDE d'obtenir l'aide des organisations de la C.C.T.A. qui travaillent déjà dans ces domaines.

X. EARTH AND GRAVEL ROADS

The Meeting recognises the great importance of earth and gravel roads in Africa and RECOMMENDS that Member Governments collaborate in active research on this subject.

The Meeting RECOMMENDS that a pilot survey be made in one country on the composition of successful and unsuccessful gravel roads.

It is also RECOMMENDED that information be exchanged on the results obtained with special treatment for gravel roads, e.g. road oils, salts and waste products.

X. ROUTES NON-REJETUES

La Réunion reconnaît la grande importance des routes non-revêtues en Afrique et RECOMMANDE que les Gouvernements Membres suggèrent des études actives en commun sur ce sujet.

La Réunion RECOMMANDE d'effectuer dans un seul pays une enquête pilote sur la construction des routes améliorées, qu'elles aient donné ou non de bons résultats.

Il est enfin RECOMMANDÉ d'assurer un échange de renseignements sur les résultats obtenus par l'emploi sur les routes améliorées d'un traitement spécial à l'aide de différents produits tels que : huiles, sels et sous-produits.

XI. PAVEMENT DESIGN

In all African Territories the public is demanding more permanent-surfaced roads. It is not always appreciated that this requires the provision of a satisfactory base of adequate thickness together with adequate earth-works and drainage.

The Meeting distinguishes three different subjects in the field of pavement design on which studies are particularly desirable and RECOMMENDS :

1. Studies of the moisture conditions occurring in soils under roads and airfield runways.
2. Studies of the behaviour of African soils under field compaction, as a function of the compaction equipment and in relation to the laboratory results.
3. Studies of the characteristics of traffic ; numbers, wheel loads and axle loads, transverse distribution of traffic across the road.

XI. CALCUL DE L'ÉPAISSEUR DE CHAUSSEES

Dans tous les territoires africains l'usager réclame toujours plus de routes revêtues. On ne se rend pas toujours compte que ce travail exige l'établissement d'une fondation d'épaisseur appropriée, avec les terrassements et le drainage que cela comporte.

La Réunion distingue dans le domaine de l'épaisseur des chaussées trois sujets différents sur lesquels des études seraient particulièrement bienvenues et RECOMMANDE :

1. Des études sur les conditions d'humidité dans les sols sous les routes et les pistes d'aérodromes.
2. Des études sur le comportement des sols africains à l'égard

du compactage, en fonction du matériel de compactage et des résultats de laboratoire.

3. Etudes des caractéristiques du trafic : comptages, charges des roues et des essieux, répartition du trafic sur la route dans le sens transversal.

XII. BASES FOR ROADS

In many territories, particularly where good crushed stone is not easily available, soil stabilisation with cement, lime, bitumen and other products is being increasingly used for making road bases.

The Meeting RECOMMENDS the convening in Africa at an early date of a Symposium on Soil Stabilisation with two objectives :

- (a) To exchange information and ideas on present practice.
- (b) To consider co-operative studies in Africa with special reference to full-scale road experiments designed and carried out jointly.

XII. FONDATIONS DES ROUTES

Dans de nombreux territoires, et en particulier dans ceux où on ne peut se procurer de bon macadam, la stabilisation des sols au moyen de ciment, de chaux, de bitume et d'autres produits est de plus en plus utilisée pour la confection des assises des routes.

La Réunion RECOMMANDE la convocation dans une ville d'Afrique, à une date aussi rapprochée que possible, d'un colloque sur la stabilisation des sols auquel seraient assignés deux objectifs :

- a) Echange d'informations et d'idées sur les méthodes en vigueur.
- b) Prise en considération d'études conjointes en Afrique, en particulier dans le domaine des expériences routières en vraie grandeur effectuées en commun.

XIII. PROBLEMS OF SURFACING

On roads outside the cities in Africa, bituminous surfacings consist almost invariably of single or multiple surface dressings. To provide satisfactory protection for certain types of road foundations, these surfacings must be waterproof. Frequently they are not so.

The Meeting RECOMMENDS that full-scale road experiments be undertaken to find suitable methods for making cheap and durable surfacings. It is possible that different forms of road base may require different surfacing techniques to obtain the best results ; some require an impermeable surface.

The Meeting distinguishes a special problem in providing bituminous

surfacing for airfields which are used by modern aircraft with heavy loads and high tyre pressures.

The Meeting therefore RECOMMENDS that a survey should be made of the composition of surfacings (grading of aggregate, type and quantity of bitumen and density of the surfacing) which have been employed either satisfactorily or unsuccessfully.

XIII. PROBLEME DES COUCHES DE SURFACE

Sur les routes africaines autres que les voies urbaines les couches de surface consistent presque toujours en enduits mono-couche ou multi-couche. Pour assurer une protection satisfaisante à certains types de fondations, ces enduits doivent être étanches. Il arrive fréquemment qu'ils ne le soient pas.

La Réunion RECOMMANDE d'entreprendre des essais routiers en vraie grandeur destinés à mettre au point des méthodes appropriées pour la confection de couches de surface bon marché et durables. Il est possible que différents types de fondations requièrent l'utilisation de différentes techniques de revêtement pour obtenir les meilleurs résultats; certaines d'entre elles exigent un revêtement imperméable.

La Réunion reconnaît que le cas des aérodromes ouverts aux appareils modernes de fort tonnage et munis de pneus à haute pression pose un problème spécial du point de vue de la couche de surface.

La Réunion RECOMMANDE en conséquence d'ouvrir une enquête sur les expériences faites en matière de couche de surface des aérodromes, qu'elles aient été couronnées de succès ou non (donner en particulier la granulométrie de l'agrégat, le type et la quantité du bitume, la compacité du tapis).

XIV. MECHANISATION OF CONSTRUCTION AND MAINTENANCE

Most of the road-making machinery used in Africa comes from overseas and the special conditions under which it will have to be operated are sometimes not fully considered.

A further problem occurs in providing the road engineer in Africa with guidance about suitable equipment, for different purposes.

The Meeting therefore RECOMMENDS :

(a) That an attempt be made to detail the particular requirements for road-making machinery in Africa; equipment for earth moving, compaction, soil stabilisation and bituminous surfacing is noted for particular attention.

(b) That steps be taken to circulate information available on the

performance of different types of road-making machinery under African conditions and also any information which is available on methods of using the machinery and controlling the quality of the finished work.

As traffic increases on gravel roads it becomes no longer possible to maintain them satisfactorily by hand. Most territories have already reached the stage at which mechanical maintenance has become necessary on many roads. This makes it possible to do what has always been desirable, namely: to improve gradually the lay-out and the cross-section of the road. It is probable that the greatest prospects for economies lie in the efficient organisation of mechanical road maintenance.

(c) That a review be made of existing methods of maintaining gravel roads with the view to recommending suitable forms of organisation and methods for different conditions.

XIV. MECANISATION DE LA CONSTRUCTION ET DE L'ENTRETIEN

La plus grande partie du matériel utilisé en Afrique pour la construction des routes vient d'Outre-Mer, et les conditions spéciales dans lesquelles il est appelé à travailler sont parfois un peu perdu de vue.

D'autre part il serait nécessaire de fournir aux ingénieurs routiers africains des conseils au sujet du matériel adapté à différents besoins.

La Réunion RECOMMANDE en conséquence :

a) D'essayer de définir les spécifications particulières au matériel routier devant travailler en Afrique. Une attention toute particulière devra être accordée aux matériels destinés aux terrassement, au compactage, à la stabilisation des sols et à l'exécution des couches de surface.

b) De prendre des mesures en vue d'assurer la diffusion de la documentation disponible sur les possibilités des différents types de matériel utilisés à la construction de routes sous conditions africaines et aussi de toute documentation concernant les méthodes d'emploi des engins et les méthodes de contrôle de la qualité du travail exécuté.

Quand le trafic sur les routes en terre s'accroît au delà de certaines limites, il devient impossible de les maintenir dans un état satisfaisant par entretien manuel. La plupart des territoires ont déjà atteint sur de nombreuses routes le stade à partir duquel l'entretien mécanique est devenu nécessaire. Il devient ainsi possible de faire ce qui a toujours été souhaitable c'est-à-dire d'améliorer progressivement le tracé et le profil en travers de la route. Il est probable qu'une organisation efficace de l'entretien mécanique des routes permettra de réaliser des économies très intéressantes.

c) De passer en revue les méthodes existantes pour l'entretien des routes en terre en vue de recommander les formes d'organisation et les méthodes appropriées à différentes conditions.

CHAPTER I : ROAD ECONOMICS

A SHORT REVIEW OF CONTRIBUTIONS *

By P. J. RIGDEN

In reviewing the economic topics mentioned in the various contributions submitted, the division into three sub-headings given in the draft Agenda of Document L (58) 115 of 19th March 1958 has been followed as far as possible. The item I.(1) "Economic assessment of priorities for road construction", which is dealt with first, is taken to include also studies of benefits resulting from improvements in road systems.

I. (1) Economic assessment of priorities for road construction

(a) General

This title has obviously, and rightly, left room for considerable latitude in interpreting its precise meaning, and engineers in different countries in Africa and Europe have contributed much interesting information from several different angles.

This problem of assessing the relative importance of different construction and improvement projects in a given territory is not always easy to solve, but it is a problem to which a number of reasonably well-defined solutions have been proposed. Two methods in particular used in the U.S.A.—the "highway sufficiency rating" method and the "cost benefit analysis" method have, it would seem, serious defects when applied to newly developing countries. These questions are discussed by Dr. MILLARD¹ who goes on to consider the usefulness of calculating the rate of return on the investment as a means not only of comparing different road projects but of comparing with alternative uses of available capital.

In South Africa² it is pointed out that the economic assessment of priorities is only one of many factors to be considered and that methods of financing various classes of road, the distribution of funds territorially and other matters must also be considered. However, the "highway sufficiency rating" type of study is used to give basic data, and the "cost benefit" type of analysis is made in specific cases.

However, in reviewing available information, it would seem that many countries base their planning on a comparatively simple approach involving:

- (a) The development of the principal inter-regional connecting routes.
- (b) The present traffic volumes.
- (c) A study, in some cases, of the broader picture of economic potential.

* Amended to include *all* contributions submitted.

Madagascar, for example,³ has the great difficulty resulting from peripheral and scattered development round the virtual barrier of the plateau, but is attempting to follow (a) above.

Mozambique⁴ has a similar approach in stressing that connecting roads must come first, followed by roads carrying more than 200 vehicles per day, followed later by other roads improved by stage construction.

In Angola⁵ economic surveys are made before a new highway is planned. However, it is pointed out that prediction of trends in development is particularly uncertain in under-developed countries; external factors may cause an unforeseen increase or decrease in the need for a particular road. With the basic connecting road system of Angola still being built and absorbing their resources there will be no special priority problem in the next few years.

The importance of traffic in determining priorities ((b) above) is mentioned by others; for example, in the Cameroons⁶ it is considered necessary to bituminise the surface at a vehicle count of over 100 per day. Madagascar³ considers fifty vehicles/day justifies this step while at twenty vehicles/day one is justified in improving the road sufficiently to ensure a "permanent link". This country has also apparently considered the purely seasonal use made of some roads (for transporting an annual crop and therefore a limited tonnage) and is planning to establish or maintain such roads as carry over 300 tons in a season.

The contribution from Lisbon⁷ draws attention to the importance of studying trends in traffic volumes on roads. The paper discusses the rate of growth of traffic and the idea of adapting the standard of the road to the traffic in three main phases of development so as to match the investment against current income, as far as possible. The writer recommends that systematic counting and classification of traffic be done according to an agreed method so as to facilitate exchange of technical information in Africa. Studies of road design in relation to stage construction is also advocated.

The conception of "return on the investment" (rentability) and the wider question of the over-all economic benefits resulting from road improvements have been dealt with by a few contributors in some detail and will be considered under this general heading of "priorities".

In discussing benefits from reduced vehicle-operating costs, MILLARD¹ feels that research is needed in African territories but, in fact, the experience in the French West African territories over the years 1950-57 can already contribute much valuable information. Some particular points of interest from M. GIRAUD's general paper⁸ on the A.O.F. and from the Ivory Coast⁹ in particular are quoted below.

It is pointed out⁵ that the road transport industry in the A.O.F. is a major industry and its efficient operation is essential if costs are to be kept to a minimum. If the present amount of transport (1957 figures)

had to be operated over the road systems that existed in 1950 the Federation of A.O.F. would be faced with an additional annual cost estimated at not less than 15,000 million francs.* In spite of the continuing increases in prices since 1950, average transport rates have fallen to nearly a half as a result of road improvements.

As regards policy followed in deciding on priorities, the following points are mentioned :

(a) The roads of greatest economic importance (usually those carrying most traffic) must come first.

(b) But, during the early stages of development of a country, it is desirable to improve a considerable mileage of road to a relatively low standard rather than to limit improvements to the heavily trafficked routes at much higher standards.

(c) It is important to limit oneself to economically justified improvements and not to undertake improvements on some roads involving costs out of proportion to the value to the road user.

(d) It must be remembered that maintenance costs, in general, rise as a road is improved and that lack of maintenance can result in a complete loss of the investment made.

The use of a series of defined " levels of improvement " is advocated in helping to preserve a balance in the overall plan. See also reference ¹⁰ for further discussion of " levels of road improvement ".

An intensive effort to improve the road system of the rich Ivory Coast territory from 1950 to 1956 has made it possible to examine the economic balance sheet and to see how the considerable sums invested in roads over this period compare with the advantages gained to the territory in reduced transport costs. In brief, the analysis described in detail by M. MILLIER ⁹ has shown that, with long-distance transport over the main-road system in 1956 of 140 million ton/kilometres, a reduction in the cost of a ton/kilometre from 21 francs in 1950 to 12 francs in 1956 and a total investment in roads over this period of 4,350 million francs, the net annual saving in 1956 was 1,170 million francs (after allowing for considerably increased maintenance costs of the roads). Subtracting, say, 200 million francs for annual redemption of the investment, there is still a saving of 950 million francs. If all vehicular transport is included the estimated saving rises to 1,070 million francs.

(b) Research studies

Only two contributors ^{1,11} specifically refer to research studies in this field, though the analysis described by M. MILLIER in the Ivory Coast could be also included.

* 1 franc (French African territories) = 2 French francs.

MILLARD ¹ refers to investigations in Britain into the method of priority assessments based on rate of return on initial capital investment, and to the starting of research into the effects of road improvements on agricultural development, initially in the West Nile district of Uganda. He also refers to the starting of work on the effects of the standards to which roads are built on traffic operating costs.

BEARD ¹¹ describes in some detail the approach being made in research on economic assessments at the National Institute for Road Research in South Africa. Referring particularly to the cost-benefit type of analysis, he points out the difficulties of making accurate estimates of benefits, particularly of the "non-user benefits" and the "extra market benefits", but concedes that the benefits which can be evaluated with reasonable confidence are the direct user benefits, i.e. savings in vehicle-operating costs, time, etc.

I. (2) Evaluation of construction and maintenance costs of roads

Several contributors to this part of the Agenda have given typical costs for various operations in road construction and maintenance. However, in attempting to summarise the information on this item, the writer was very doubtful of the value of making comparisons of costs between different territories. So many factors can affect the cost of building a road—topography, soils, climate, etc.—and there can be so much variation in costing methods and in basic prices that it is difficult to attach significance to such comparisons. The reader is referred for more detail to the documents submitted and noted in references. ^{3,4,5,12,13,14}

Only two contributors have discussed the method of approach to the evaluation of costs.^{11,2} BEARD ¹¹ describes briefly the studies which have been started in the National Institute for Road Research in South Africa, and emphasises the importance of studying optimum combinations of the units of work (quantities) and the units of cost.

In a general memorandum from South Africa ² it is pointed out that, with the present large-scale operations of road making and the great extent of mechanisation, something more than simple pre-costing and post-costing is required for control, and activity control which permits both planning and day-to-day control at job level is being used. Distribution costing is retained merely as a secondary process for the purpose of maintaining records.

In the Cape Province, a firm of consultants has been employed over the last four years to study and devise control methods for the road construction units by developing production or output standards. Some further explanation of this will be found in the memorandum, but it would seem that, after four years study in the Cape, a useful amount of experience has been built up which could possibly be of value to other territories.

I. (3) Financing problems

Discussion under this heading has not been seriously attempted by any contributor. Financing of roads, it would seem, is essentially a domestic problem to be solved by each territory with or without help from a European country (where appropriate). Some reference is made in the contribution from French territories to the central fund (F.I.D.E.S.)—Fonds d'Investissements et de Développement Economique et Social des Territoires d'Outre-Mer administered from Paris and used essentially for new works.

A few details given by the correspondent in Madagascar³ illustrate this point, and other funds for road building and maintenance in this country are mentioned; for example, the Road Fund (Fonds d'Investissement Routier) derived from motor fuel taxation also contributes to new works and to the cost of bituminous surfacings, while all maintenance costs are borne by territorial and regional budgets.

The correspondent from Mozambique⁴ also refers to the need to finance roads out of fuel taxes and other user taxes and presumably the above holds true for other African countries. The broad picture of the financing of different classes of road in South Africa is also given.²

Generally, one has the impression that this subject of road financing is not one which is likely to provoke a lot of useful discussion at the preliminary meeting in Lourenço Marques.

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- ⁴ PEREIRA DOS REIS, J. "Problems in the road economy of Mozambique."
- ⁵ "Economy of Highways and Mechanisation of Works." C.C.T.A. Document Ref. R.R. (58) 44.
- ⁶ CHIRAT, G. "Note sur les techniques de construction de routes utilisées au Cameroun français."
- ⁷ NASCIMENTO, U. (Lisbon). "Notes on the work of the L.N.E.C. relative to Chapter I of the Subject: Road Economy."
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- ¹⁰ "Recommandations du Comité technique créé pour l'étude générale des routes économiques" (Bureau central d'études pour les équipements d'outre-mer).
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CHAPTER II : CONSTRUCTION AND MAINTENANCE OF ROADS**GENERAL REPORT**

By M. PIMENTEL DOS SANTOS, Provincial Secretary of Mozambique
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1. Introduction

Chapter II of the Agenda, relating to the Construction and Maintenance of Roads, sets up the following subjects for study :

(a) **Earth roads**.—Soil stabilisation. Problem of corrugations. Use of laterites. Problems for study.

(b) **Bitumen roads**.—Different types of foundation : Macadams, stabilised soils, laterites. Different types of bitumen surface, laid down while hot and while cold. Problems for study.

(c) Evaluation of the thickness of construction required in African conditions. Influence of water movement under the surface of roads.

(d) Specific problems of road construction in Africa : erosion, drainage, black cotton soils, arid conditions.

Papers from Great Britain, the Union of South Africa, Tanganyika, France (including the Cameroons, Senegal and Madagascar) and Portugal (Angola and Mozambique) were submitted to the consideration of your Reporter. Others were not received in time to be included in this General Report.

For better systematisation I will briefly mention the data given in the different papers on the points of the Agenda mentioned above, adding the comments based on my personal experience. This done, I shall try to draw some conclusions of general order and suggest matters which in my opinion should be given special attention in the discussions of the Meeting.

2. Earth Roads

Information regarding this point is to be found in the papers submitted by Great Britain, the Union of South Africa, Tanganyika, France (including Senegal, the Cameroons and Madagascar) and Portugal (Mozambique).

(a) Stabilisation of soils

This problem is specially dealt with in the French and Portuguese (Mozambique) papers, in so far as roads without bituminous protection are concerned. South Africa also makes mention of trials made with the use of mechanical or chemical stabilisation but does not give the results. As for many years to come neither the traffic conditions nor the economic possibilities will permit the large-scale bituminous paving of African roads

to be considered, we think there is every advantage in devoting a serious effort to perfect this technique which is fundamental in a low-cost road with acceptable traffic qualities.

The Technical Recommendations of the "Bureau Central d'Etudes pour les Equipements d'Outre-Mer", of France, have been studied and followed by many roads engineers in different territories in Africa. With the exception of minor adjustments (namely as regards the minimum thickness of each course, liquid limit) these Recommendations, dated 1951, still serve.

The paper from Madagascar makes mention of a road of 40 km. of soil improved by mixing. The plasticity indexes given (5 to 13) seem excessive in the higher value, which may explain in part the erosion of the pavement by the rain water. In Mozambique mechanical stabilisation occupies an important place. Of 7,631 km. of roads to be constructed in accordance with the General Highway Plan which is now being carried out, 5,577 km. must be designed with a mechanically stabilised pavement and without bituminous protection. The specifications followed are the A.S.T.M. ones, adapted to local conditions. Of great interest is the use of "traces" of stabilising agents.

In Lourenço Marques a laboratorial investigation has been concluded on the use of rosins in the stabilisation of soils, and the results have been so favourable as to recommend the construction of experimental sections. The admixture of this stabilising agent, in proportions which vary between 1/500 and 1/1,000 of the weight of the dry soil, brings about a notable improvement in the mechanical characteristics of the soils. Thus the C.B.R. values increased from two to four times (according to the type of soil) while the water absorption in sandy soils was greatly reduced, in some cases being cancelled out altogether. On the other hand, the absorption in clayey soils hardly suffered a change.

The paper from Senegal mentions tests made with the use of a Swedish by-product of the cellulose industries. In the phase reached in these tests, the results are promising from the technical and economic points of view. France submitted also its Report and the conclusions adopted at the Tenth International Road Congress (Istanbul), in which reference is made to the problem of earth roads. These documents are well known to road engineers.

(b) The problem of corrugation

The formation of corrugation in the pavement of earth roads during the dry season constitutes one of the major problems with which engineers are faced in territories with two clearly defined seasons. And it can be said that neither the causes of the phenomenon, nor its remedies have as yet found a satisfactory solution. The contributions from France (Recommendations of the B.C.E.E.O.M. and Reports from Istanbul), from

Tanganyika and from Great Britain, are of interest. In the latter country's paper the question is given in perfect outline, especially if complemented with the recent publication of the Road Research Laboratory on the subject. The description of the method used in Tanganyika to deal with the phenomenon likewise deserves attention.

In Mozambique certain types of soil have been located which show the curious property of not being subject to corrugation in the dry season or mud in the rainy season. In the majority of cases the soils are non-plastic, with relatively low C.B.R. values (10 to 45). The mechanical, physical and chemical study of these soils has been completed, and will be followed by the mineralogical identification. From the chemical analysis it was concluded that they contain a high percentage of iron and aluminium oxides (1.45-2.79% and 3.36-8.7%, respectively) and of exchange cations (3.5-8.8 milli-equivalents/100 gr.). The chemical analysis was made on the bulk of each soil. Directly connected with the formation of corrugations is the problem of deciding on the degree of traffic intensity where it becomes economically advisable to surface-dress the road with a bituminous carpet.

The Istanbul Congress indicated 50 to 200 vehicles per day, depending on the local conditions. The question is referred to in other papers—Tanganyika, Great Britain, Cameroons and South Africa—but without definite conclusions (the Cameroons, however, indicate 100 vehicles per day). From experience in Mozambique it would seem that the low limit indicated in Istanbul—fifty vehicles/day—corresponds to the conditions prevailing in a large part of the Province.

(c) Use of laterites

There would seem to be a general trend towards establishing solid technical and scientific bases for the understanding of the behaviour of laterites and lateritic soils in the paving of roads. As regards the use on roads without bituminous protection, the observations made in the papers of France (Recommendations of the B.C.E.E.O.M.), those relating to the Istanbul Congress, Cameroons, Madagascar and of Portugal (Mozambique) are valuable. Speaking of the latter country, a long-term investigation, conducted in collaboration by the Laboratories of Lisbon, Lourenço Marques and Luanda, is in progress, concrete evidence of which is already to be seen in Mozambique where experimental sections have been constructed and placed under observation. Everything seems to indicate that this material, used under reasonable conditions, furnishes the key to the solution of many problems in connection with pavement design in African territories.

(d) Problems to be studied

Taken together, the papers from England, the Union of South Africa and Portugal (Mozambique) give a rather complete exposition of some of

the problems which more particularly require investigation. To my mind the following deserve especial attention :

1. Corrugations.
2. Formation of dust.
3. Rutting and formation of mud during the rainy season.
4. Traffic intensity at which a bituminous pavement becomes economically advisable.
5. Scientific grounds for the empirical specifications used in mechanical stabilisation.
6. Laterites and lateritic soils.
7. Chemical stabilisation.

I leave in abeyance the problems of erosion and drainage, such problems falling under a different section of this Report.

In Mozambique, the Lourenço Marques Laboratory is at present engaged in the problems mentioned under numbers 1, 3, 5, 6 and 7. As regards the last mentioned, apart from the use of rosins, the influence of minimum quantities ("traces") of other products is being investigated.

3. Bituminous Roads

As a result of the high expenditure required to keep earth pavements in a satisfactory condition once a certain traffic intensity has been reached, there has been a pronounced tendency in recent years in many African countries and territories to extend the network of bituminous roads. This fact is also a direct consequence of the increase in number, speed, pressure of the tyres and tonnage of the commercial transport vehicles as well as of the ever greater use of trailers towed by a tractor vehicle.

It is for this reason that an ever greater variety of bituminous pavements is classified under "economic roads", a concept of such fundamental interest to under-developed territories. The inclusions of this topic in the Meeting's Agenda is therefore of the greatest importance.

Let us analyse the various aspects of the problem :

(a) Different types of base course

If we adopt the British nomenclature for the structural division of pavements (**surface course**, **base course**, **sub-base** and **sub-grade**), then the base course must be included in the interpretation of the subdivision of the Agenda relating to the foundation layer. It was expressly requested that the types of base constituted by macadams, stabilised soils and laterites be considered.

1. **Macadam**.—Only the papers from France, the Union of South Africa and Portugal (Mozambique) refer to the construction of macadams. In Mozambique, and until about ten years ago, the bituminous semi-penetration type of macadam was used almost exclusively in the paving of roads. Because of its high cost and also because in vast regions of the Province there is no stone to be found, this type of pavement has practically

been abandoned. In its stead, the pre-scripts contained in the "Recommendations of the B.C.E.E.O.M.", above mentioned and which deals with the matter extensively, are now being followed, with good results. But ordinarily, the solution of macadam is made use of only when a cheaper one (mechanical stabilisation, laterites, soil cement) is not possible. The report from Madagascar tells how bitumen is being used to a large extent, over already existing stone paving. In the Cameroons 40/70 macadams are used in semi-penetration. In South Africa penetration macadam is used in some pavements.

2. Stabilised soils.—Soil stabilisation, as a means of constructing base courses for bituminous roads, is at present much used throughout Africa. The papers from Great Britain, the Union of South Africa, France and Portugal (Mozambique) refer to this type of pavement, in greater or lesser detail. The Istanbul Congress concluded that there is definite advantage in using it in economic roads.

The British paper contains useful indications in connection with the use of local materials, whether mechanically stabilised or mixed with stabilising additives (cement, hydrated lime or bitumen). It also refers to the difficulties met with and investigations in progress.

The South African contribution again gives an important place to base courses of soil-aggregate type, for which it furnishes specifications, and refers also to stabilisations with cement or lime, normally of the "modified soil" type (low percentages of additive).

In the French papers there are also many indications of interest, especially in the "Recommendations" to which apply the reservations we have already made as regards mechanical stabilisation without bituminous carpet, and also assertions not altogether accurate (in connection with soil-cement) as also in the contribution from Madagascar (experimental sections of soil-cement or mechanical stabilisation, use of emulsions).

In Mozambique the experimental period of the soil stabilisation which today constitutes the basis for the highway programme, is just about over. The results obtained in close on ten years are frankly encouraging, and the respective paper supplies a schedule of the solutions adopted on different roads.

3. Laterites.—It is possible to obtain base courses of the best quality with the use of laterites and lateritic soils. The papers from Great Britain, France and Portugal (Mozambique) give particulars as regards the different solutions. The British paper makes a sound suggestion as regards the nomenclature of these materials and gives the results obtained with their stabilisation by means of lime or cement. The studies carried out in Portugal (Laboratories of Lisbon, Luanda and Lourenço Marques) seems to show that the lateritic materials behave satisfactorily even when they do not observe the usual specifications for mechanical stabilisation. The observation of lateritic experimental sections—although it is too early to

arrive at definite conclusions—show acceptable conduct, up to now, of lateritic soils for which the plasticity index varies between 15 and 21. These results agree with the ones supplied in Madagascar's paper.

Other particulars in connection with laterites included in the French Reports (Lantenois, "Recommendations", Cameroons, besides the one from Madagascar above mentioned) must also be emphasised.

(b) Different types of bituminous surface dressing

We have already pointed out the present tendency towards bituminous roads in Africa. It will therefore be appreciated how very important it is economically to choose types of bituminous carpet that are not very costly and yet able to stand up to the traffic intensity and local conditions prevailing at each moment, in accordance with the concept of progressive evolution of the road. It is especially in South Africa that the problem seems to be faced more extensively and realistically through investigations covering a large number of variables, such as the quality of the materials, construction and maintenance techniques, factors causing failure, etc. Hot and cold types of carpet are described. In Mozambique the solutions most often used are the "armour-coat" type carpets, sand-asphalt and bituminous concrete. Some specifications are given in the respective Report.

The Tanganyika paper also mentions a type of bituminous carpet constructed with success for traffic exceeding 150 vehicles/day.

In the French territories emulsions are frequently used ("Recommendations", Lantenois and Madagascar). Mention is made in the French reports, however, of other types of bituminous surface dressing.

(c) Problems to be studied

The Union of South Africa, Great Britain and Portugal (Mozambique) are more specifically concerned with indicating the problems to be studied (South Africa's report is extremely valuable also from this aspect).

As I have already had occasion to remark, the need for research under this heading is obvious. I give hereunder some topics of major interest:

1. Scientific grounds for empirical specifications used in mechanical stabilisations.
2. Laterites and lateric soils.
3. Chemical stabilisation. Simple, safe and speedy methods for determining the minimum dosages of stabilising agents. Use of "traces" of chemical agents in stabilisation.
4. Types of bituminous surface dressings to be used in the construction of roads, taking into account the quality, granulometry and quantity of the aggregates, quantity and quality of the binders, width of the bituminous wearing course, evolution of the traffic and local conditions.
5. Necessary frequency of re-sealing for good maintenance of bituminous pavements.

In the Lourenço Marques Laboratory all these problems are in a more or less advanced phase of investigation.

4. Thickness of Pavements and Influence of Water Movement under Bituminous Pavements

The evaluation of the thickness of pavements is gone into, in greater or lesser detail, in the Reports of the Union of South Africa, France and Portugal (Angola and Mozambique). There seems to be no doubt that the C.B.R. method has become solidly rooted, although it is at times admitted that there would be advantage in perfecting it. But it must be borne in mind that there is no need for greater precision than that allowed for by the very nature of the materials and the conditions of execution. On the other hand, it is interesting to note Great Britain's and Mozambique's efforts towards adopting the C.B.R. method as a means of determining the dosage of soil-cement. Neither can the observation made in the paper from South Africa on the influence which deformations of the pavement have on its stability, go unheeded.

An important question which to my mind must be resolved with an eye to the future is that of selecting the C.B.R. curve to be used in the design. As the curve of 7,000 lb./wheel is going out, the choice lies between 9,000 and 12,000 lb./wheel. The following points must be taken into consideration: the rapid increase in traffic that is always noted in Africa whenever new roads are opened, the present trend towards heavier vehicles with greater tyre pressure, the fact that the thickness of the pavement only increases with the C.B.R. until a certain C.B.R. value is reached (30 for a pavement of 15 cm. minimum, in the case of a wheel of 12,000 lb.) and, lastly, the problem of finance. In Mozambique the curve of 12,000 lb./wheel is standard.

It is worth noting, as a contribution of interest, the method of statistical calculation of the thickness of pavements based on the C.B.R., as presented in Portugal's (Angola) paper. It has a vast field of use when it is impossible to obtain the optimum degree of compaction.

As regards the influence of the movement of water under bituminous pavements, this is dealt with in the papers from Great Britain and the Union of South Africa. But it is in Britain's paper that the most valuable information is found on this problem, which is of the greatest importance. In Mozambique the study in this connection has only been started; nevertheless, control measures of the level of the water table are made use of.

5. Specific Problems in the Construction of Roads in Africa

In the construction of roads in Africa there are some problems which have characteristics peculiar to them. Some of them were included in the Agenda.

(a) Erosion

The papers from Tanganyika, the Union of South Africa and France (Cameroons, Madagascar) treat of erosion. There are different aspects to the problem: the formation of gullies in the platform of the road or in the slopes of embankments of cuts, the deepening of the ditches, the destruction of the arable land bordering on the road, excavation around the mouth of the aqueducts, and the protection measures against these effects.

In Mozambique a study has been made, in collaboration with the agricultural authorities, of the most suitable species for counteracting erosion in slopes of embankment or cuts. Of the varieties which have proved of particular interest the most important are "star grass", "tanner grass" and "kikuyu"; these are being experimented with on the Beira-Rhodesia road.

(b) Drainage

The Union of South Africa and France deal with this question, making relatively succinct observations. It seems that it would be of advantage to examine two aspects of the problem, namely:

1. Measures for speedy evacuation of the run-off water from the platform of the road.
2. Controlling of the level of water table.

In Mozambique fairly wide experience has been gained on these two points and the measures used at present include bituminous membranes, french drains and raising the bed of the road at least 1.20 m. above the water table.

(c) Black cotton soils

Particulars on this type of soil are given in the papers from Tanganyika, the Union of South Africa and France (Cameroons). The reference contained in South Africa's contribution is very short, and suggests that in the areas where these soils are, roads should be constructed in phases. Tanganyika's paper supplies more details both as regards the construction of embankments and on the trafficability of pavements, by mixing of sand and, in the final phase, by the use of a thickness of 6 in. to 9 in. of gravel in the upper layer. The importance of good drainage is duly emphasised.

The paper from the Cameroons, again, mentions the need for an embankment of (40 cm.) material that be not very expansive and construction of a wearing course.

In Mozambique the construction of important embankments in regions with soil of this kind is accompanied by special precautions: elimination of all soils of which the maximum dry density in the modified A.A.S.H.O. test does not exceed 1.60 gr./cu. cm., or with a high organic matter content, slopes of 3:1, study of the stability of foundations and strict control of the compaction. As regards pavements, experiments made in one of the

northern districts reveal that it is possible to make use of the usual standards of design. Thus, in one case, the sub-grade was compacted; then on it a sub-base constituted by local soil mixed with 10% was made, followed by a stabilised base containing 90% of sand. The overall thickness of the pavement (45 cm.) and the thickness of each layer was determined by the C.B.R. method. It stands to reason that a satisfactory drainage is necessary, but this is difficult to obtain in low areas.

The contribution from Portugal (Angola) furnishes a detailed study on another type of tropical soil which causes road engineers grave worries: the red coffee soils. One could have wished that a similar report in respect of the black cotton soils had been submitted to the Meeting.

(d) Arid conditions

Only France (Cameroons) and Portugal (Angola) mention this point of the Agenda which, in my opinion, deserved fuller treatment. In the paper from the Cameroons the problem is raised of the characteristics to be borne in mind for the wearing course (plasticity index or field moisture equivalent minus shrinkage limit). Mention is also made of the technique used in compaction.

The contribution from Portugal (Angola) applies the calculation of the thickness of pavements by statistical methods to the arid conditions for which it is not economic to reach the standard densities.

In Mozambique the problem is tackled from different aspects: night work, to diminish the discomfort of the high temperatures; taking advantage of the natural conditions of the rainy season; carrying out test sections beforehand to determine the best conditions for compaction as regards minimum degree of moisture and characteristics of the equipment to be used; careful study of effective means of assuring proper watering of the soil, including prospecting for water for the purpose.

6. General Conclusions

Although it is a pity that delays in reception did not permit of all the papers being included in this General Report, from the mass of material submitted to your Rapporteur some conclusions of general order can already be drawn. Thus:

1. In all the African countries and territories which submitted contributions one notices a remarkable effort towards improving their standards for the construction and maintenance of roads, with due regard for putting the teachings of modern techniques to the best possible use.

2. The road without surface dressing will still for many years predominate in the highway networks in Africa. The direction taken is towards improvement of its pavements through the use of soil stabilisation, laterite and lateritic soils, combating corrugations and mud, and proper drainage conditions.

3. The road without bituminous carpet only offers economical advantage up to a certain traffic limit comprised between 50 and 200 vehicles per day, but the exact value of such limit is not yet known with sufficient approximation.

4. Once the above-mentioned limit has been reached, a bituminous pavement becomes imperative, the type of carpet having to be selected to suit the prevailing conditions. In view of the steady increase in traffic and of the evolution of the means of road transport themselves, strong pressure is brought to bear in the direction of increasing the mileage with bituminous wearing course.

5. Financial restrictions make it imperative that the design of pavements be done in such a way that technical satisfaction is obtained with maximum economy, whence the ever increasing recourse to the use of local materials, to soil stabilisations, to laterite and lateritic soils, etc., and whence the need to study the types of bituminous carpet that are less costly while easy to maintain.

6. The problems connected with the movement of water on the surface or in the sub-grade, with the dreaded consequences of erosion, failure of pavements, sliding of slopes, cutting of communications, etc., tend to occupy an important place among the worries of road engineers, and some progress has been made in the conceptions and means of action related to them. But there is a great need for intensification of the research in this field, always with the aim of finding economical solutions.

7. It is impossible today to carry out any solid and important work in the field of road construction without the aid of laboratory facilities, duly extended to field investigations and the control of the actual construction.

7. Suggestions for Discussion

As the time for discussions will be inevitably short, it seems to me it would be best in the first place to concentrate on some essential points, namely:

1. The traffic intensity at which a bituminous paving becomes economically advisable.

2. Evaluation of the thickness of flexible pavements, with a view to simplicity, speed and safety as regards the results.

Wheel-load for the design of flexible pavements.

3. Local materials recommended for the construction of pavements. Different types of soil stabilisation, their advantages and disadvantages. Use of laterite and lateritic materials. Use of stone.

4. Combating corrugations.

5. Economic types of bituminous carpets. Periodicity for re-sealing.

6. Water movement and its consequences. Erosion, drainage and control of the level of the water-table.

ADDITIONAL REPORT ON CHAPTER II OF THE AGENDA

By Eng. M. FERREIRA MENDES

I have few comments to offer concerning the Report which I am to submit on the subjects listed by M. PIMENTEL DOS SANTOS on Part II of the Agenda.

In view of the amplitude of this part of the work, its diversity and the numerous documents received, as well as the direction of the work indicated by M. PIMENTEL DOS SANTOS, according to indications received from C.S.A., the best possible way of working is the approach by way of a synthesis rather than analysis.

M. PIMENTEL DOS SANTOS has done his work with the competency, clarity and precision which those among us who followed the scientific and technical part of the work of the general Rapporteur, know already.

Consequently this Report can serve as a basis for the discussions which will take place on these subjects.

However, there are three points which I should like to mention :

1. Additional documents arrived after the Report had been written. I feel obliged to make a few remarks in this respect.

2. The Agenda does not seem clearly arranged as far as certain subjects in the various chapters are concerned.

3. In my opinion it is useful to mention the list of suggestions for discussions at the end of the Report submitted by M. PIMENTEL DOS SANTOS.

I. Documents which are not included in the Report on the synthesis of the work

Document R.R. (58) 15 : The Rutshuru-Uganda Road

This document concerns a new liaison of the eastern part of the Belgian Congo with the western part of Uganda and deals *inter alia* with the problems of black cotton soil, stage construction, surfacing, and preventive measures against erosion.

Document R.R. (58) 16 : Axial Road Leopoldville-Bukavu, Kindu-Kalima Section

This document deals with the problems concerning mechanical stabilisation and cement stabilisation, the organisation of work yards and the control of compacting with the " sand-bottle " method.

Document R.R. (58) 17 : Axial Road Bukavu-Stanleyville, Kahuzi Section

The author, who has also submitted the two afore-mentioned documents, discusses the use of lava ashes in the laying of bases and their bitumen treatment.

Document R.R. (58) 19 : Moisture movements under the highway pavements

This document represents an almost complete study of the conditions existing in Southern Rhodesia.

Document R.R. (58) 20 : Problems connected with the construction of roadways in Southern Rhodesia

The same author, who gives a short survey of the problems, discusses the conditions necessary for construction, stage construction of surfacings, the lining of the surface, drainage and moisture movements and laboratory studies. At the end of his paper the author recommends studies on the humidity in the roadways and the walls and suggests an experimental method applicable to the whole of southern Africa.

Document R.R. (58) 30 : Characteristics and application of laterites in the Belgian Congo

This paper is of great interest because it deals at great length with a problem which deserves special mention with regard to the construction of bases in Africa.

Document R.R. (58) 31 : Notes concerning the direction of bridges and roadways in the Belgian Congo. The adding of cement to improve laterites

This paper deals with the stabilisation of laterites by means of adding small quantities of cement, and reports on laboratory experiments and field experiments. In my opinion this is a problem to be dealt with by specialists.

Black cotton soil in Angola

In his synthesis Report, M. PIMENTEL DOS SANTOS regrets that Angola did not submit a paper on this subject, such as was submitted on red coffee soil. Finally this was done and the document concerned represents an important contribution containing information on experiments in Angola as well as some recommendations with regard to the use of materials.

An erosion aspect of roadways (Angola)

The author, being the same as for the previous document, studies certain erosion problems, deals with protective measures and concludes that surfacing with clayey earth, well compacted and without fissures in the herbaceous cover, can contribute towards the solution of the problem of roadway erosion.

Remarks on the work of the " Laboratório Nacional de Engenharia Civil " Chapter II of the Agenda (Portugal)

The " Laboratório Nacional de Engenharia Civil " in Lisbon has in recent years collaborated with the Laboratories in Luanda and Lourenço

Marques, in the study of certain problems concerning techniques applicable to the construction of roads in Portuguese overseas territories. This document describes the results of a number of studies on the subject.

The index of the document indicates the subjects dealt with, and I mention the following :

Earth road : homogeneity, selection and stabilisation of soils, undulations, use of laterites.

Road with bituminous surfacing : base layer, types of paving.

Dimension of surfacings and the influence of water movement under the surfacing.

Erosion and drainage.

Black cotton soils.

The author submits a list of the problems to be studied :

(a) Laterites :

Classifications to be drawn up concerning laterite materials.

Study of the specifications for the use of laterites in road construction.

(b) Roads with bituminous surfacings :

Characteristics of instant and deferred resistances of materials used for surface construction. Characteristics of the qualities of the upper layer of surfacings and its resistance to the influence of traffic and climatic factors.

(c) Dimensions of surfacings and the influence of water movements under the surfacing :

Pressure due to the increase of traffic. Development of methods with a view to establishing the dimensions in sympathy with the amount of traffic planned. Determining of the depth of scraping ; thickness of the covering layers and height of the fills.

(d) Erosion :

Systematic study of the protection of engineering work against erosion.

II. Is the inclusion of the following documents under Chapter II desirable ?

The generic heading of Chapter II " Construction and Maintenance of Roads ", which comprises in four parts the statement of subjects which fall under each part, does not contain questions with regard to maintenance.

Several papers submitted are linked with maintenance, others deal with maintenance only ; with the exception of documents which deal with mechanisation of construction work, included in Chapter III, there are four more papers which concern non-mechanised maintenance. I consider it necessary to decide whether these questions should be treated under this part of our work. The documents questioned are the following :

R.R. (58) 32 : Reorganisation of the non-mechanised dividing into Sections.

R.R. (58) 34: Non-mechanised dividing into Sections. Report D: June, 1957 (Belgian Congo).

R.R. (58) 35 and addendum: Information on non-mechanised maintenance (Belgian Congo).

III. Proposals to be discussed

It is obvious that four working sessions will not give us the opportunity of discussing in detail all the subjects on point II of the Agenda. It is for this reason that M. PIMENTEL DOS SANTOS, under point 7 of his Synthesis Report, indicates the order of priority to be given to subjects which seem to him to be of major importance.

I think that the questions listed under "priority" truly deserve the attention of the specialists; however, the priority of some of the problems, although of importance, is not quite clear, and there may be others which should be added to the list contained in the Synthesis Report. The general scrutiny of the Report and the papers submitted—work which will have to be very short in view of the time limit—will help to determine the choice of problems to be discussed in greater detail.

Besides, according to document L (58) 115, the main aim of this Meeting is the preparation of a symposium or Inter-African Conference for the study of economic and technical questions in connection with road construction. We must conduct our work above all with this aim in view.

CHAPTER III : THE MECHANISATION OF ROAD CONSTRUCTION AND MAINTENANCE—REVISED REPORT

By Dr. R. S. MILLARD, General Rapporteur on Chapter III

Reports on this subject have been received from :

Angola
French Equatorial Africa
French Guinea
Madagascar
Mozambique
Southern Rhodesia
Tanganyika
Union of South Africa.

Some of these reports contain detailed information on the organisation of construction and maintenance units together with lists of the items of plant employed. Such detail would be out of place in a general report, and in this note an attempt has been made to summarise the main issues raised in the reports. The author has also drawn on information obtained directly from some territories. The report is presented under the sub-headings given in the agenda and concludes with some suggestions as to where research is likely to be of most value in this field.

Construction

New road construction is carried out both Departmentally and by Contract. The chief advantages in working departmentally are that work can begin with a minimum of preliminaries, and adjustments can be made to details of construction without difficulty whilst work is in progress. On the other hand, contractors are generally able to be more flexible in the arrangements for employing staff.

New construction in African territories normally involves operating Mechanical Road Construction units many miles away from the Central Depot where main workshop facilities will be established. Several contributors list the items of equipment in such units and a common feature is the need for local workshop facilities to carry out all but the most serious repairs and overhauls.^{1,2,3,5,6,8}

Means of facilitating acquisition of equipment

The report from Mozambique refers to a need for Government help to contractors in buying plant.⁶ Three different categories of contract are distinguished according to the extent to which the cost of the plant can be

set against the total cost of the work, and suggestions are made as to how Government might provide financial help in each case.

Whether work is done Departmentally or by Contract, it is frequent practice for the machinery to be provided from a central pool of the organisation concerned with a standard hire rate to the construction team. This is done for instance in Departmental work in Ghana, Kenya, Southern Rhodesia ⁷ and South Africa.⁹ This hire rate generally includes an item for depreciation of the plant and may also include an item to cover interest on the capital invested in the plant. This is a means of building up a fund towards the ultimate replacement of the plant; in Departmental work such an arrangement comes into conflict with normal Governmental methods of accounting from year to year.

Technical assistance

In the report from Mozambique ⁶ the suggestion is made that contractors might be enabled to call on the resources of Government workshops for urgent repairs to machinery and for repairs that demand particular care and skill. Coupled with this is the suggestion that specialists from Government workshops might visit contractors from time to time to advise on the upkeep of plant.

The problem of spare parts

This problem is greatest in the less developed territories where there may be only a small number of machines of a particular type. Continuing the theme developed above, the report from Mozambique suggests that contractors should acquire similar equipment to that used by Public Works Departments.⁶ Several reports instance the desirability of standardising on the types and makes of machinery in a particular territory. Such standardisation considerably simplifies problems of maintenance and of training operators to a high standard of proficiency. The report from French Equatorial Africa ² discusses the principles which should govern the selection of types of plant.

Construction teams must carry larger stocks of spares than is usual in more developed areas. An equitable arrangement is that these spares should only become a charge to the job when they are issued from the stores on site, to be used. It may also be appropriate to charge to the job interest on the cost of the unused spare parts held locally.

Maintenance

Most of the reports concern the maintenance of earth and gravel roads, as these constitute by far the greatest proportion of African roads. It is scarcely necessary to say that on many such roads traffic is now so heavy that the stage is long past when the roads could be maintained by hand labour alone. This, coupled with growing difficulty in obtaining

large labour forces, particularly at harvest time, has made large-scale mechanisation necessary.

Programme for maintenance under African conditions

A pattern emerges from the reports, showing that there are generally three distinct operations in maintaining gravel roads, for which separate teams are usually maintained.

1. **Regravelling.**—Teams are employed to locate and win gravel and to transport it to the road. Regravelling is referred to as a yearly operation in one report from French Guinea.³ In other territories it is done at intervals from one to five years or more, depending on the traffic and probably also on the suitability of the gravels used. Details are given in individual reports of the equipment provided in such teams. In some cases the teams are provided with equipment to spread and compact the gravel. In other cases the gravel is dumped in heaps at the roadside to await the wet season, when it is spread by teams which are wholly employed in grading the road surface.

2. **Correcting the profile.**—In some territories teams are employed with drags and, during the dry season, with brushes to remove corrugations and preserve an even riding surface. The use of motor graders is however becoming more general for this type of work and patterns of maintenance have been developed in different territories to suit local climatic conditions, both during the dry and the wet seasons, and to suit the traffic and the particular types of soil available as road surfacing. A high degree of skill is necessary if motor graders are to be used during the dry season. Details are given in some individual reports of the equipment employed in these maintenance teams.^{1,2,5,6,8} Each team is generally responsible for a particular length of road varying from 30 to 100 miles and the report from French Guinea describes how these teams are organised with, typically, eight such teams operating in a subdivision responsible for the upkeep of some 250 miles of road.³

3. **General maintenance.**—Gangs of lorry-borne labour are employed for such tasks as cannot normally be carried out as part of the major maintenance operations. These tasks include the patching of pot-holes, grass cutting, cleaning and trimming of ditches, and cleaning of culverts. Normally such teams contain eight to twelve men on the basis of one to two men per mile of road. In some cases, these gangs operate in association with the mechanical units occupied in correcting the road profile.

Maintenance units for the resurfacing of bituminous roads are referred to in the reports from Madagascar,⁵ Southern Rhodesia⁷ and South Africa.⁹ The creation of such mobile units makes it possible to employ mechanical bitumen distributors, and gritters for spreading the chippings. The first advantage gained over hand spraying and gritting is in the speed

with which the work can be done. Equally important is the prospect mechanisation offers of obtaining uniform and durable surface treatments. Mobile surface-treatment units may have to cover a large area of country and because of this, the programme of surface treatment may be determined as much by the need to employ machinery when it is available in a particular area as by the condition to which the road surfaces have deteriorated.

Training of teams of technicians and organisation of mechanical equipment for maintenance

Training schools are run in most territories for plant operators, foremen and inspectors. The report from Southern Rhodesia⁷ refers to the special course run by the school of the Mechanical Department where African and Coloured operators are trained in the care, maintenance and use of motor graders, and the point is made that practical experience is necessary before the operators acquire a reasonable level of skill. In Kenya a school for plant operators has been established for some years; after a course of several months, the more successful trainees continue for a further period of training, to equip them to undertake supervisory work. In South Africa maintenance personnel are normally trained on construction works.⁹

Most territories are divided into districts with organisations for road maintenance established in each district, normally under the control of an engineer or general foreman. The maintenance system is usually co-ordinated from the centre as in Madagascar, where a Chief Maintenance Engineer, aided by a Civil Engineer and a Mechanical Engineer, prepares general plans, controls the purchasing and maintenance of plant and undertakes the instruction of operators.⁵

Length of road to be entrusted to each team

This varies considerably according to the amount of maintenance required, which depends on the intensity of traffic, on climate and on the suitability of locally available soils as gravel surfacings.

A regravelling team may be able to find and bring in gravel sufficient to resurface from 25 to 60 miles of road per year.

This fresh material may be spread and compacted at a rate varying between 1 and 3 miles per day. A motor grader operating alone in regrading the surface may cover between 4 and 8 miles per day. Such regrading is normally required after the passage of approximately 1,000 vehicles. If regrading is called for more than once a week, it is normally considered desirable to provide a bituminous-surfaced road. The motor grader operates over a length of road which may vary between 30 miles and 120 miles depending on local conditions.

General

Problems in the mechanisation of road construction and maintenance fall into two categories. Most are problems of organisation: in the financing

of plant purchase, in the costing of plant operation, in the establishing of efficient plant maintenance organisations, in the planning and operation of construction teams and maintenance teams. If there is a field for the research worker here, it is in the application of work-study methods to the different processes. It is not easy to systematise knowledge in this field and much depends on the organising ability of senior staff.

The other category of problems concerns the design and selection of machinery for each process and efficiency in operating the machines. Always important, this is particularly so when by deliberate policy a territory is endeavouring to reduce the variety of machines available in the territory.² Here the research worker has much to contribute, in helping to define the criteria by which machines are to be assessed, in promoting the development of new items of plant where a need is apparent, in measuring the performance of plant, and suggesting how the best use may be obtained from it. Three particular types of plant merit special mention:

- (a) Compaction plant
- (b) Plant for soil stabilisation
- (c) Plant for bituminous surfacing.

In all three of these, the type of plant selected and the method by which it is used have a considerable influence on the ultimate performance of the road.

For some years the Road Research Laboratory in Great Britain has been examining the performance of different types of compaction equipment with soils ranging from heavy clay to sands and gravels of low cohesion and over a range of moisture conditions including those normally encountered in the tropics. Results of these tests have been published.^{10,11} The work continues and has lately included tests on heavy rubber-tyred rollers.

In most of the soil stabilisation undertaken in South and Central Africa, Portland cement or hydrated lime has been incorporated in the soil using heavy agricultural equipment and motor graders. In West and in East Africa, purpose-made in-place mixers have been employed. There is no doubt that such purpose-made machines can produce more intimate mixing of the soil and the stabiliser. Single pass mix-in-place stabilisers have the additional advantage that they simplify control of the moisture content of the soil, and are thus an aid in achieving good compaction. Under what circumstances are these advantages worth while? In almost all cases the soil to be stabilised is imported from a pit or stockpile nearby. Are there circumstances when premixing of the stabilised soil is desirable?

The improvement of machinery for bituminous surface treatment has already been the subject for much research in Great Britain and in South Africa.¹² Minimum standards for tank sprayers are set down in British

Standard 1,707¹³ and some territories are equipping themselves with the apparatus necessary for testing sprayers, particularly for determining the uniformity of the rates of spread of bitumen. The operation of gritting machines has also been studied.¹⁴ There appears to be a need for easily manoeuvrable rubber-tired rollers for use in surface treatment.

There is no mention in any report of the use of mechanical equipment for controlling roadside vegetation (excepting the use of motor graders, which many tend to avoid, as in uprooting vegetation they expose side-ditches to an increased risk of erosion). Is there any prospect in developing methods of chemical control which can inhibit growth in the wet season, and possibly also encourage the selective growth of plants which have not a vigorous habit of growth and which provide good protection against erosion?

List of papers submitted to the Conference, relevant to Mechanisation

- ¹ Angola: "Economy of highways and mechanisation of works." Public Works Department.
- ² French Equatorial Africa: "The maintenance of plant in the Public Works Department of the Congo". M. Lagouge.
- ³ French Guinea: "Note on the maintenance of gravel roads by the Public Works Department of French Guinea." Travaux Publics.
- ⁴ French Guinea: "Note on the maintenance of gravel roads." G. Reme.
- ⁵ Madagascar: "Road problems in Madagascar; work completed or in progress." Travaux Publics.
- ⁶ Mozambique: "Mechanisation of road construction and maintenance in Mozambique." A. J. Almeida Pereira.
- ⁷ Southern Rhodesia: "Road maintenance organisation in Southern Rhodesia." A. D. Harris.
- ⁸ Tanganyika: "Maintenance costs of roads." Public Works Department.
- ⁹ South Africa: "Mechanisation of construction work and maintenance."

Other references

- ¹⁰ WILLIAMS, F. H. P. and MACLEAN, D. J. The compaction of soil: a study of the performance of plant. *Department of Scientific and Industrial Research, Road Research Technical Paper No. 17*. London, 1950 (H.M. Stationery Office).
- ¹¹ LEWIS, W. A. Further studies in the compaction of soil and the performance of compaction plant. *Department of Scientific and Industrial Research, Road Research Technical Paper No. 33*. London, 1954 (H.M. Stationery Office).
- ¹² NATIONAL INSTITUTE FOR ROAD RESEARCH. Binder distributors. *Bulletin No. 1*. Pretoria, 1956 (South African Council for Scientific and Industrial Research).
- ¹³ BRITISH STANDARDS INSTITUTION. British Standard No. 1,707: 1954. Binder distributors for road surface dressing. London, 1951 (British Standards Institution).
- ¹⁴ WATERS, D. B. and WILSON, D. S. Gritting machines for surface dressings. *Department of Scientific and Industrial Research, Road Note No. 12*. London, 1951 (H.M. Stationery Office).

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