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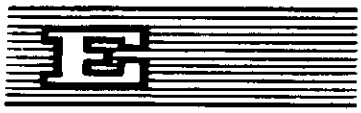

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REPORT OF THE PAN-AFRICAN CONFERENCE ON HIGHWAY MAINTENANCE AND REHABILITATION

Accra, 22-29 November 1977

CONTENT

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A. ATTENDANCE AND ORGANIZATION OF WORK

Opening of the Conference

1. The Pan-African Conference on Highway Maintenance and Rehabilitation, sponsored by the Economic Commission for Africa in co-operation with the Governments of France, the Federal Republic of Germany and the United Kingdom was held in Accra from 22 to 29 November 1977.

Attendance

2. All 49 independent African States were invited to send three participants each to the Conference. However, participants came from the following 36 countries only: Algeria, Burundi, Cape Verde, the Central African Empire, Chad, the Congo, Egypt, Gabon, the Gambia, Ghana, Guinea-Bissau, the Ivory Coast, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mauritania, Mauritius, Morocco, Mozambique, the Niger, Nigeria, Rwanda, Senegal, Seychelles, Sierra Leone, Somalia, the Sudan, the United Republic of Cameroon, the United Republic of Tanzania, Togo, Tunisia, the Upper Volta, Zaire and Zambia. A representative of the International Bank for Reconstruction and Development (IBRD) also attended.

Election of officers

3. On each day of the proceedings, the Conference unanimously elected a Chairman.

B. AGENDA

4. The Conference adopted the following agenda:

1. Economics and research

   (a) The economics of road maintenance, transport investment modelling, the Kenya Road Transport Investment Model (RTIM) and its significance for the economics and strategy of road maintenance

   (b) Research into road deterioration in relation to traffic volumes and loads, including case studies for Africa

   (c) Methods of assessing road surface parameters - roughness, profile, cracking and skid resistance

   (d) Methods for measuring the residual strength of roads, deflection surveys, the design of road strengthening measures

2. Organization and methods of maintenance

   (a) The planning of maintenance and rehabilitation

   (b) Organization of a maintenance department in a Public Works Department

   (c) The programming of maintenance

   (d) Methods of maintenance for earth, gravel and paved roads

   (e) Labour-intensive versus machine-intensive methods

3. Training and technical documentation

(a) The professional training of road maintenance personnel

(b) The design and presentation of lecture and laboratory courses and field documentations for supervisory staff

(c) The design and publication of practical manuals for maintenance staff at all levels.

C. ACCOUNT OF PROCEEDINGS

Opening addresses

5. Welcoming the participants Mr. Robert K.A. Gardiner, Commissioner for Economic Planning of Ghana, said that deficient transport was an obstacle to general economic development and that Africa faced difficulties arising out of the nature of the terrain, tropical conditions and the need to import skills and materials.

6. Consequently, the present meeting of highway engineers to focus attention on the problems of road maintenance and rehabilitation was a unique opportunity for the people of Africa to examine their problems, exchange experience, suggest solutions and disseminate research findings on the subject.

7. African countries had been investing heavily in road construction, and were continuing to do so. ECA programmes over the years had shown the possibilities for developing trans-continental highways, but as the network increased in density the cost of its maintenance also increased, and that in turn directed attention to the need to consider the design of roads.

8. It was unnecessary to stress the importance of transport in predominantly agricultural and primary-commodity-producing countries, where roads had to bring export items to the railhead or direct to the ports, as well as convey imports to the most remote areas. An efficient and effective distribution system required a reliable transport network.

9. The choice of the mode of transport - rail, road, air or even waterways - should take the cost of maintenance and rehabilitation into consideration. Despite the contribution which road transport made, and the large sums voted annually for the extension of the transport system, the lack of basic maintenance and rehabilitation rendered transport costly in terms of vehicle life. That shortcoming could result from several factors: insufficient funds for highway maintenance and rehabilitation projects; the absence of the basic traffic data necessary for effective planning of road maintenance and rehabilitation needs; inadequate contractor capacity for the construction and maintenance of roads; and the lack of proper administrative machinery to co-ordinate transport policy.

10. The net result of all those constraints was that roads sometimes deteriorated to such an extent that for months in each year important agricultural communities could neither bring their produce to urban centres nor receive manufactured articles. On the major highways the operating costs of vehicles had also increased tremendously because of badly maintained road systems.

11. In view of the strategic role played by highway transport in development, it was incumbent upon the Conference to examine critically all aspects of the problem of road

maintenance and rehabilitation in developing countries. The subject was one that required the undivided attention of all the experts, with a view to providing valuable information on how to improve highway transport in developing countries and how to advance their economies on a sound basis.

12. On behalf of the Executive Secretary of ECA, a representative of the secretariat thanked the Governments of France, the Federal Republic of Germany and the United Kingdom for sponsoring the Conference, and for their co-operation in providing expert lecturers and preparing publications for the Conference based on the wide range of research results and experience available to them. He also thanked the host Government for the facilities provided.

13. Transport was a prerequisite to any development. However, given Africa's accumulated backwardness in the field of transport, its case was so worrying that the international community could not remain indifferent to the problems. The Conference on International Economic Co-operation had rightly considered that something had to be done to help Africa accelerate its development. To that end it had adopted a resolution recommending that the United Nations General Assembly should proclaim a Transport and Communications Decade in Africa for the years 1978-1988. The ECA Conference of Ministers at its last meeting and the United Nations Economic and Social Council at its sixty-third session had concurred in that view.

14. Roads were the principal factor in economic, social and cultural development. By facilitating the mixing of populations, races, customs and religions, roads led to the awakening of patriotic national feelings among the citizens of a single country and to tolerance and mutual understanding among nationals of different countries.

15. ECA's fundamental duty was to guide and assist independent African countries in developing their national economies. That was particularly important in the field of multinational development, where intra-African trade was so decisive.

16. The purpose of the present symposium might be said to be to transfer to African countries part of the substantial knowledge and experience of the developed countries in the field of highways, in order to help them improve the condition of their road networks, enhance user safety and reduce operating costs.

17. The life of a highway did not depend only on the initial investment, but also and in large part on maintenance. However, that was not always very clear to the African legislative authorities which voted budgets and allocated resources. It was therefore essential to draw the attention of countries to the importance of the work of maintenance itself, which was the essential complement to construction work and which alone could guarantee the safety and comfort required by road users.

18. The value of the Conference for African countries would largely depend on the benefit the African participants derived from it in terms of increased knowledge and greater familiarity with the various types of technical improvement already developed or being developed.

19. The representative of the Federal Republic of Germany expressed the hope that the exchange of views and technical information among engineers responsible for road maintenance would not be limited to the lectures and discussions of the official programme, but would lead to valuable and lasting relations for the future.

20. He said that in many cases it would be better to maintain and rehabilitate roads than to construct a rather limited length of new road, which involved much higher investment.

21. The representative of France was of the opinion that there was no need to fear the uneasy atmosphere which usually pervaded discussions on the transfer of technology. The engineers from France, the Federal Republic of Germany and the United Kingdom who had come to the Conference would fully share their ideas and experience. He hoped that during the course of the discussions ideas and experience would be exchanged with the greatest freedom so that all who were motivated by the desire to serve the movement of traffic throughout the immense territory of Africa as best they could, with means which were often limited and sometimes excessively limited, would derive some benefit.

22. The representative of the United Kingdom pointed out that Africa needed a network of new roads to serve socio-economic advance and the unity of the continent. He felt that if the urgent problem of the maintenance of existing roads that already served the people was not tackled, there would be no traffic to feed into an international network.

23. In the section which it would lead, the British team would deal with the economic methods of deciding on investment in maintenance and with the research that would provide the essential data for decision making. He looked forward to a stimulating and successful outcome of the second conference in the series to be held in Africa.

24. Following the opening statements, the Conference turned to the papers prepared for the various items of the agenda. The papers are summarized below. A list is given in annex I.

Economics and research (agenda item 1)

(a) Economic role of maintenance

25. The paper reviewed the processes necessary for the provision of road transport, drawing attention to the sources of costs and to the interdependence of the levels of different costs. The method of measuring costs was discussed. Different categories of maintenance were described as routine, recurrent and periodic, and the various maintenance activities were described in the context of the appropriate category.

26. A simple model incorporating the main components of transport investment was described. Major studies of vehicle operating costs and road conditions had been conducted in Africa for several years, and the results of those studies enabled major extensions to be made in the model. They showed that periodic maintenance played a positive role in influencing vehicle operating costs through its effect on pavement condition. They also served as a means of relating routine and recurrent maintenance inputs to predictions of pavement condition.

27. An outline of the Road Transport Investment Model (RTIM) was given, with reference to the facilities available for either computer or manual processing of the model, which was relatively complex.

(b) Evaluating the economic priority of highway maintenance

28. The paper examined the methodology and scientific data base for the economic analysis of alternative highway design and maintenance standards, and described the

Highway Design and Maintenance Standards Model (HDM) which had been developed jointly by the World Bank, the Massachusetts Institute of Technology and the United Kingdom Transport and Road Research Laboratory.

29. Actual case studies of three typical problems were presented involving the determination of:

(i) The most economic grading and regravelling policies for unpaved roads;

(ii) The optimum timing (and traffic volume) at which to pave an unpaved road;

(iii) The most economic pavement design, maintenance and rehabilitation strategies over a 20-year life cycle of a heavily trafficked paved highway.

30. The results of the analysis strongly confirmed that economic returns were extremely high for levels of maintenance well above those currently practised in most African and other developing countries; they exceeded returns to new construction by wide margins. Only where local conditions made the cost of gravelling quite high was the economic justification of the (re)gravelling of very low-volume roads (generally less than 50 vehicles per day) in doubt. In the particular case examined for paved roads, a policy involving initial low pavement strength, combined with three subsequent 5-cm asphalt concrete overlays over a 20-year period, had been found to be more economical than traditional strategies involving a stronger initial pavement with various combinations of subsequent patching and resealing.

(c) Methods to limit road maintenance

31. The author suggested that failure to initiate maintenance work, or to initiate it in time, might cause serious damage to roads, leading to rapid deterioration and loss of capital, as well as to the obstruction of transport and an increase in its cost. The basic maintenance principles were outlined, and associated problems discussed in relation to traffic volumes, standardization, construction materials and methods and climatic factors. Reference was also made to the maintenance programmes implemented in highly industrialized countries such as France and the Federal Republic of Germany.

32. He suggested that:

(a) The cost of maintenance, repair and renewal could be influenced by construction methods at the time of the initial investment, but was largely a function of traffic load, in terms of speed, weight, axle load and its distribution, tyre pressure, etc. Fixed maxima accompanied by efficient control of the real weights of vehicles, of overloads and the like, might be very effective in keeping investment at economic levels and in reducing the cost of maintenance. Engineers in African countries still had some chance of avoiding the difficulties which had arisen in the industrialized countries;

(b) Special emphasis should be placed on the use of local supplies of aggregates instead of expensive materials which were - because financial resources were usually inadequate - applied in layers of insufficient thickness, with all the adverse effects that that was bound to have on maintenance, repair and road strengthening.

33. A document by the Federal Ministry of Transport (Department of Highway Construction) on "Standard Pavement Designs (RSt075)", as applicable to the Federal Republic of Germany, was provided in an appendix.

(d) Research into the deterioration and strengthening of road pavements in developing countries

34. Road traffic in many African countries was increasing rapidly, in terms both of traffic volume and the size and weight of vehicles. To carry that heavier traffic many existing roads needed to be strengthened and others might need to be rebuilt.

35. The paper described research into the deterioration of road pavements in tropical countries, research into methods of assessing the present condition of road pavements, methods of predicting the life of existing pavements and research into the design of structural overlays for strengthening roads in developing countries. Axle-load surveys conducted in Africa and elsewhere and the results in terms of damage to pavements were described.

(e) The CEBTP curviameter

36. The inherent advantages of deflection and radius-of-curvature measurements were described, and the operation of the apparatus explained. The apparatus measured, by means of an inertia sensor, the deformation of a given point of the pavement under a twin-wheel 13-tonne axle load.

37. The apparatus was fitted with a special track moving continuously at the same speed as the vehicle, placed on the ground two metres in front of the axle. The sensor was designed to monitor any surface irregularities as the vehicle approached the measuring point and then receded from it.

38. The signal emitted by the sensor was amplified, and then transmitted to an analog computer located in the cab of the vehicle. The signal consisted of two voltages proportional respectively to the maximum deflection and radius of curvature of the deformation of the pavement.

39. The apparatus travelled at a speed of 18 km/h, and it was possible to take measurements in curves of radii of 40 metres or more. Measurement spacing was every 12.46 metres.

40. The range of deflection measurements could vary from 10/100 mm to 400/100 mm. Measurement of the radius of curvature covered a distance of 2,000 metres.

41. Because of the viscoelastic properties of road materials, measurements of deflection and curvature taken at 18 km/h by the curviameter were different from those obtained with the Benkelman beam. It was possible that a correlation of the results obtained from the two systems could be established.

42. Some examples were given of routine tests carried out during supervision of the construction of highway pavements.

(f) Measuring methods for the observation of roads in the Federal Republic of Germany

43. It was becoming increasingly evident that intense measuring was the only way of learning more about the behaviour and actual state of road pavements. For that purpose efficient, non-destructive, meaningful methods of investigation were being developed in many countries. The design of measuring equipment, automatic if possible, was the subject of considerable effort in the Federal Republic.

44. Specifically, the Bundesanstalt fur Strassenwesen employed the following devices and equipment for the investigation and observation of road pavements:

(a) Planographs for determining layer-surface unevenness;

(b) Stuttgart friction meters for determining sliding coefficients with blocked sliding wheel;

(c) Longitudinal profilometers for measuring changes in the gradient of road surface unevenness as a major element for determining present serviceability;

(d) Equipment for continuous photographic recording of road surfaces in order to document damage, patches and general surface conditions;

(e) Measuring vehicles for road data detection with gyro instruments and camera;

(f) Equipment for wheel or axle loads for random sampling and for permanent registration; and

(g) Measuring vehicles for determining penetration values after Benkelman's method, and dynamic deformation modules of road pavement and base courses alone.

45. A brief technical description of the devices and equipment and their capacity was provided.

(g) Theoretical and practical considerations which influence the planning of road rehabilitation

46. The paper was based on the author's experience in various African countries including Ghana, Malawi and Nigeria. A definition of rehabilitation was discussed taking the extreme cases of backlog maintenance and partial reconstruction. Maintenance cost inputs and vehicle operating costs were considered in the context of alternative rehabilitation strategies. The engineering problems were discussed with particular reference to the rate of deterioration of pavements, data collection for design purposes, selection of various levels of rehabilitation in relation to available materials, optimum solutions, the timing of investment and contract documents.

(h) Research into road deterioration in relation to traffic volumes and loads on the Maiduguri-Gamboru road

47. The results of an axle-load survey had indicated that failure of the road base in the traffic lane in the direction of Maiduguri towards Chad and the United Republic of Cameroon had been due to abnormal axle loads.

48. The remedial measures taken to repair the damage, and the performance of the road in relation to the loads carried, were discussed.

49. A case was presented for further research, the results of which could be used as a basis for future road design and construction.

(i) The development of vertical photography from a Land-Rover to monitor the performance of gravel roads.

50. The Ethiopian Road Authority, in co-operation with the United Kingdom Transport and Road Research Laboratory, had recently constructed two sections of experimental gravel road, totalling about 4 km in length. The performance of the gravels would be monitored over at least three years, during which time gravel loss and changes in density would be measured and surface characteristics such as corrugations, rutting, pot-holes, cracking and amount of loose material would be recorded.

51. The best way to measure those surface characteristics was by vertical photography. Photographs taken over a number of months provided a permanent record of a particular stretch of road. In addition, overlapping photographs gave a three-dimensional image when viewed under a stereoscope and enabled the investigator to make more accurate observations of conditions, such as the extent of loose material or cracking patterns. Moreover, using a parallax bar and simple height control, he could measure for example the depth of pot-holes and the amplitude of corrugations.

52. The paper described how that had been achieved, using a Pentax camera suspended from a ladder, mounted on top of a Land-Rover, about 4 or 5 m above the ground. All the equipment had been built in Ethiopia. The rate of photography was slow (about 250-300 m of road per day), but its main object was to cover representative sections in detail, rather than great lengths in general.

53. Future developments would centre around the use of a 70-mm photogrammetric camera which would provide more accurate height measurements, need fewer photographs to cover equivalent lengths of road and offer greater convenience in use.

(j) Main road maintenance costs

54. The procedures adopted for the maintenance of earth roads and surfaced roads were described. Information was given on the staff required per unit of work, together with details of the equipment needed for both manual and mechanized maintenance, and the materials to be used in the operation.

55. Costs were given in each case for staff, equipment and materials for the calculation of unit costs and total costs for each type of work. Budget details were given for each type of maintenance work at 1976 prices, increased by weighted percentages to 1977 values.

(k) Maintenance and road safety

56. Maintenance of roads and associated structures and furniture affected pedestrians, passengers and drivers in many ways, and could have an important influence on road safety. The paper discussed the interrelationship between maintenance operations and road safety.

57. Case studies were described to illustrate the important economic aspects that maintenance could have on road safety, and to indicate that monetary savings in the form of reduced accident figures should be offset against the cost of maintenance.

(l) The practical development of a highway maintenance programme

58. The methods used in a Highway Organization and Maintenance Study in Jamaica were described as an example of how a programme could be built up on sound engineering principles using economic viability to decide priorities.

(m) The economics of selecting appropriate legal axle limits

59. During the past year the Research Unit of the Ethiopian Road Authority had been approached to provide recommendations on the most appropriate axle-load limits for Ethiopia. The paper described the attempts made to derive an optimum axle-load limit corresponding to minimum total road transport costs. Total road transport costs were defined as the sum of road construction, maintenance and vehicle operating costs.

60. A detailed analysis of the problem was not possible because cost data were not available in a suitable form. However, a simplified (perhaps oversimplified) analysis had been carried out based on the sort of data that were likely to be available in most countries. The justification for that simplified approach was that the results of the analysis were relatively insensitive to large differences or errors in the input data.

61. There were many economic implications in implementing new axle-load limits, and their effects on the size of national vehicles were discussed. It was also emphasized that savings in vehicle operating costs were of value only if the benefit was shared by the community.

62. From the point of view of the Ethiopian Road Authority, the new axle-load limits would determine overlay requirements. The approach adopted for the five-year sector programme was described.

(n) Pavement deflection study on the Awash-Tendaho Road for appropriate overlay design

63. The paper discussed the pavement evaluation and overlay design of the Awash-Tendaho road.

64. The rapid growth of traffic in terms of both numbers and weight of the vehicles on the Awash-Tendaho road had caused it to deteriorate fast, and it was felt that there was the need to evaluate the pavement.

65. The deflection technique and rut depth measurements were used in the evaluation of the pavement. Values of rut depth were used to classify the surface condition of the pavement. The deflection data were analysed and compared to a recommended criterion for crushed base with surface dressing.

(o) Application of the Highway Cost Model (HCM) for appraisal of an upgrading project

66. The case study presented was only a small part of what the Highway Cost Model (HCM) could do and what a planner could expect in his analysis of projects. Nevertheless, it showed clearly that a process that could take many man-months could be avoided in achieving the same objective of selecting the economically most viable project. The model, if used properly, could become a corner-stone of highway planning in developing countries in a very short time. As a matter of fact, it was hoped that it would immediately become an important tool to the Ethiopian Road Authority, and the Authority welcomed the opportunity of sharing its experiences with similar organizations from other African nations.

(p) Long-range observations on roads in dependence upon traffic loads

67. The paper described existing design methods for road construction in the Federal Republic of Germany, derived from either empirical data or theoretical studies. It was suggested that, apart from approximate calculation method for concrete pavements, there was a lack of any genuine road construction calculation methods that could be used with any certainty. Construction methods controlled by standardized regulations, rather than as the result of design based on calculations, had therefore been adopted in the Federal Republic and that practice was discussed.

68. A test programme undertaken to observe the behaviour of selected road sections was described, which was designed to determine whether standardized methods of construction were the economic optimum and also whether they satisfied the service life requirements for the roads in question. The objectives of such long-range observations were described as the provision of data for the evaluation of such specific factors as:

(a) The effects of constructionally motivated tolerances;

(b) The effects of climate and environment;

(c) The cost of maintenance and repair as a basis for profitability and cost considerations;

(d) Aging processes and the effect thereof on the development of damage;

(e) Functional relationships between present serviceability, penetration, development of damage, and time as a prognostical basis.

69. The preparatory work on the test programme, involving the selection of test roads and collection of data and characteristic quantities, was discussed, and information was provided on methods of measurement in relation to the factors investigated.

Organization and methods of maintenance (agenda item 2)

(a) Principles and organization of highway maintenance

70. The paper described the principles of highway maintenance management and rational methods for its organization as they already existed or were being established in a number of countries. They were intended for officials responsible for the management of the Highway Department.

71. The paper drew attention to the practical difficulties which arose in attempting to base highway maintenance work on a simple method of cost-benefit optimization.

72. The paper went on to explain the concepts of preventive and remedial maintenance and then the concept of standards: quality, quantity and productivity standards. It showed how such norms might constitute the basis of an operational and more rational highway maintenance management system than the traditional ones.

73. Lastly, the paper provided a few recommendations on the introduction and development of a system for the management of highway maintenance in a country without such a system, and underlined its flexibility, which permitted its introduction even in a very simplified initial form.

(b) Thoughts about the organization of road maintenance

74. The paper stressed that road maintenance, as a wide and complex task of the road construction administration of a country, required detailed consideration and planning so that maximum results could be obtained with minimum expenditure through proper organization and suitable equipment.

75. The various important factors in that respect might differ from one country to another owing to differing conditions. Consequently, the results obtained were to be rated differently.

76. Apart from adequate financing, a decisive factor for the success of a systematic road maintenance service was the organizational unit carrying out the road maintenance work, that is to say the road maintenance depot. The ability of leading people and the management skills of the road supervisor responsible for the maintenance work were ultimately decisive for the successful performance of road maintenance.

(c) Management of equipment rental systems

77. The paper suggested that an internal rental system between the equipment depot and the subdivisions which used the equipment for road maintenance was the best way of standardizing relationships between the depot and the users.

78. It was also the best way of providing users with the costing factors necessary for a correct evaluation of the work they carried out and the proper management of budgetary allocations.

79. Furthermore, the rates charged provided an incentive for users to make proper use of the equipment on site, and at the same time enabled the depot to balance its financial operations and to replace worn-out equipment.

80. After a brief analysis of the expenditure and costs involved in the use of equipment, the paper gave some indications concerning the assessment of the length of life of equipment, the bases on which rental rates were calculated, and the provision for, and application of, facilities for renewal, under constant and variable economic conditions, in respect of fleets of vehicles and individual items of equipment.

(d) Maintenance of roads: organization and methods

81. The paper provided a brief introduction to the present organization of maintenance in Kenya and presented in some detail some aspects on the planning and programming of maintenance work, methods, materials and techniques used for maintaining roads of various types efficiently within the limits of available funds.

82. Road maintenance had traditionally received less attention from professional engineers than planning and construction work, and had unfortunately received low priority from the authorities in the allocation of funds.

83. In order to protect the enormous investment in the country's road infrastructure, that alarming trend must be reversed, and it was hoped that the maintenance element would be given higher priority.

84. The second section dealt with the organizational structure at Head Office and at provincial level, and covered matters concerning road camps, road network, staff, plant and vehicles and finance.

85. The third section dealt with planning and programming, and covered inventories, road maintenance schedules, staffing, road deterioration measurements, paved roads, maintenance costs and work programming.

86. The fourth section dealt with methods and materials used for paved roads, gravel roads and earth roads.

(e) Prospection, determination and organization of working deposits of materials for the maintenance of African roads

87. The paper endeavoured to show how a Public Works laboratory could provide the departments involved with all the elements necessary to take timely action to ensure the protection of valuable assets which must be safeguarded.

88. It was important that a road should be correctly designed: its geometry, the thickness of the pavement, the design of ancillary elements and its drainage in particular must present satisfactory characteristics. However, even if those conditions were necessary, they were not sufficient to ensure that the road lasted the length of time forecast at the design stage. It was indeed essential, especially in countries where natural conditions were often severe, that the maintenance of the structure should be taken seriously and scheduled.

89. The more the road network developed, the greater the commitments resulting from its maintenance; with that outlook it would become increasingly important for the departments in charge to have precise information on material resources available and optimal conditions for using them.

(f) Collecting and processing geotechnical road data

90. The paper stressed that both the high-ranking officials entrusted with setting up a programme of nation-wide road maintenance and the engineer, who would then have the responsibility of implementing it, needed to be informed of the type of material resources and their availability, as well as the best conditions for using them.

91. Responsibility for supplying geotechnical data often rested with the public authorities, since they quite frequently had a national laboratory sufficiently acquainted with those problems and generally had records of results of several years' research and prospection. In such a case, the work consisted of processing that mass of information into easily assimilable form, in order to supply the appropriate departments with the elements needed to draw up the maintenance programme and put it into practice.

92. An example of such work was given by describing the procedure followed to draw up a display method for geological data which could be of immediate use in a maintenance programme. That method had the advantage of easy and continuous updating by means of the simple drafting of complementary data sheets. It comprised six stages:

(a) Definition of areas;

(b) Marking the routes investigated on the map;

(c) Marking the material deposits on the map according to each route investigated;

(d) Collecting geotechnical data;

(e) Drafting geotechnical data sheets for each area; and

(f) Compiling a descriptive report for each area, giving the material resources and specific recommendations for their use.

(g) The non-destructive testing of pavements in the context of maintenance and overlay projects and its transposition to developing countries

93. The paper showed that it was relatively easy for a developing country to find a method of non-destructive testing for its road system, whether at the level of feasibility studies, preliminary design or final design studies, which could be transposed without difficulty and which was likely to prove satisfactory. Similarly, there existed a great many instruments for non-destructive testing which had proved efficient.

94. There was no doubt that it was much more difficult, if not impossible, to transpose a method of calculation, or at least the results which it provided. In that field, it seemed necessary that research should be undertaken to define the mechanical behaviour of the major formations of material encountered. Similarly, it was necessary to weigh axles at the same time as traffic was metered, in order to have better knowledge of the effect of traffic on structural design. The importance of that procedure would increase substantially since major highways like the Trans-Saharan Road and the Dakar-Mombasa Highway would soon come into being, and would pass through countries whose pavements were different because they had been structurally designed for different maximum legal axle weights and load distributions.

(h) Road maintenance problems encountered in Gabon

95. The paper described the road maintenance problems encountered in Gabon and emphasized the need to improve the quality of road maintenance in the country.

(i) Use of mechanization in Senegal

96. The paper pointed out that proper maintenance and operation following the purchase of equipment on a sound basis (i.e. equipment that suited the needs) would reduce expenditure, which at present was somewhat exaggerated by poor management of the fleet of equipment.

(j) Report on the rational use of corrugation scrapers for the prevention of road corrugation

97. The paper demonstrated the advantages of using corrugation scrapers to prevent road corrugation in the Upper Volta, and stressed that farm tractors and corrugation scrapers were better adapted to developing countries than were motor graders.

Training and technical documentation (agenda item 3)

(a) Professional training of road maintenance personnel

98. The paper outlined the various tasks with which the maintenance services had to deal within the field of competence of road administrations. It stressed that even if some of the problems had not yet been felt by the developing countries, there was good reason to assume that development would inevitably confront the authorities with a similar range of issues.

99. Well trained personnel were needed at all levels:

(a) Top management;

(b) Middle management and supervisory staff; and

(c) Executive staff.

A breakdown of the personnel structure generally applicable to road maintenance services in African countries was given.

(b) Training of highway maintenance specialists

100. The paper described three relatively recent French assistance projects in the field of highway personnel training in developing countries - in Algeria in 1975 and 1976, in Indonesia from 1973 to 1975, jointly with the American consulting firm Roy Jorgensen, and in Mali from 1973 to date.

(c) Road maintenance training - the work of a specialist organization

101. The first section of the paper looked at training from the point of view of an organization with vast world-wide experience in this field. The second section gave some details of the projects of the Organization for Rehabilitation through Training (ORT) in road maintenance training in Africa. A third section gave an outline of ORT's general approach to such projects from initial survey through implementation to evaluation. The fourth section dealt with the lessons learned by ORT. and recommended ways of making training for road maintenance personnel more effective.

(d) General reflections in regard to road maintenance in Africa

102. The paper dealt with methods of training and recruitment, and discussed job descriptions and the qualifications required of road maintenance staff.

(e) Technical instructions, practical guidelines, manuals etc., for road maintenance

103. The paper stressed the importance of well trained personnel for the implementation and success of road maintenance, which depended on three factors:

(a) The laws and regulations in force, as well as the financial resources;

(b) The knowledge and ability of the head of the road maintenance depot and his staff; and

(c) The organizational ability and educational qualifications of the head of the road maintenance depot.

104. Items (b) and (c) were the most essential, because in the final analysis they were decisive. Practical experience was of importance, but further education acquired on a continuous basis was also indispensable. One means of refreshing and improving the knowledge of staff was to compile data in the form of a "Manual for road maintenance services", which should cover important aspects of road construction and road maintenance. The following outline was suggested:

(a) General definitions and road construction technology;

(b) Geometric elements of road design;

(c) Description of activities in the area of road maintenance services; and

(d) Tasks of road maintenance personnel.

(f) Notes on the methodology of the writing and presentation of manuals

105. The training of supervisors, technicians and workers was an essential condition of progress in developing countries, and in the highway engineering sector as in other fields it involved the circulation of basic technical information. Problems of maintenance constituted a special point worthy of close attention.

106. It was therefore essential that personnel at all levels - engineers, technicians and workers - should have manuals suited to their respective levels of education, which clearly set forth the rules to be followed with regard to work to be planned, supervised and performed.

107. Maximum use should be made of African peoples' naturally developed powers of observation, stress being laid in the manuals on illustrations, and recourse being had to the numerous graphic possibilities available.

108. Furthermore, advance preparation for the circulation of manuals was necessary, and explanatory sessions should be held using audiovisual methods and instructional material in programmed form.

109. The important problem of the cost of producing manuals might be effectively solved by grouping countries which had a common language, similar climatic conditions and identical natural materials.

Recommendations

110. The recommendations adopted by the Conference appear in annex II.

Vote of thanks and closure of the meeting

111. After an exchange of courtesies, the participants moved a vote of thanks to the Government of Ghana for its hospitality, and to the Governments of France, the Federal Republic of Germany and the United Kingdom for their generous assistance and valuable technical contributions. The Chairman then declared the Conference closed.

ANNEX I

LIST OF CONFERENCE PAPERS

1. Economics and research

(a)	Roberts, P.W.D.H.	Economic role of maintenance
(b)	Harral, C.G., and Fossberg, P.E.	Evaluating the economic priority of highway maintenance
(c)	Nakkel, E.	Methods to limit road maintenance
(d)	Bofinger, H.E.	Research into the deterioration and strengthening of road pavements in developing countries
(e)	Bouche, M.	The CEBTP curviameter
(f)	Schulte, W.	Measuring methods for the observation of roads in the Federal Republic of Germany
(g)	Gandy, J.J. and Viapree, R.J.	Theoretical and practical considerations which influence the planning of road rehabilitation
(h)	Ibrahim, A.	Research into road deterioration in relation to traffic volumes and loads on the Maiduguri-Gamboru road
(i)	Ethiopian Road Authority	The development of vertical photography from a Land-Rover to monitor the performance of gravel roads
(j)	Ministry of Public Works, Transport and Urban Development (Upper Volta)	Main road maintenance costs
(k)	Cooper, L.	Maintenance and road safety
(l)	Thriscutt, H.S.	The practical development of a highway maintenance programme
(m)	Ethiopian Road Authority	The economics of selecting appropriate legal axle limits
(n)	Ethiopian Road Authority	Pavement deflection study on the Awash-Tendaho road for appropriate overlay design
(o)	Ethiopian Road Authority	Application of the Highway Cost Model (HCM) for appraisal of an upgrading project
(p)	Schulte, W.	Long-range observations on roads in dependence upon traffic loads

2. Organization and methods of maintenance

(a)	Frejacques, J.L.	Principles and organization of highway maintenance
(b)	Jacob, H.	Thoughts about the organization of road maintenance
(c)	Joneaux, R.	Management of equipment rental systems

(d)	Onduto, B.N. and Gjos, T.	Maintenance of roads: organization and methods
(e)	L. Roellec, J.	Prospection, determination and organization of working deposits of materials for maintenance of African roads
(f)	Liautaud, G.	Collecting and processing geotechnical road data
(g)	Autret, P.	The non-destructive testing of pavements in the context of maintenance and overlay projects and its transposition to developing countries
(h)	Ministry of Public Works (?)	Road maintenance problems encountered in Gabon
(i)	Ndout, Sitor	Use of mechanization in Senegal
(j)	Bertrand, P.	Report on the rational use of corrugation scrapers for the prevention of road corrugation

3. Training and technical documentation

(a)	Neubauer, H.J.	Professional training of road maintenance personnel
(b)	Baillon, M.	Training of highway maintenance specialists
(c)	Hamilton, I.	Road maintenance training - the work of a specialist organization
(d)	Gbarre, I.G.	General reflections in regard to road maintenance in Africa
(e)	Jacob, H.	Technical instructions, practical guidelines, manuals etc., for road maintenance
(f)	Brunschwig, G. George, A. and Mattei, O.	Notes on the methodology of the writing and presentation of manuals

ANNEX II

RECOMMENDATIONS

A. Implementation of the recommendations adopted by the Conference of Highway Engineering in Africa, held in Addis Ababa in April 1974

The Conference,

Noting that only some of the recommendations of the Conference held in Addis Ababa in April 1974 have been implemented,

Considering the importance of the subjects covered by the recommendations,

Stresses the imperative need to implement the recommendations of the above-mentioned Conference, particularly those dealing with the establishment of Inter-State Technical Committees for the co-ordination of road research, documentation and training, as amended below.

B. Importance of road maintenance and relevant standards

The Conference,

Bearing in mind the interest of all the delegates in the problems of road maintenance,

1. Specifically directs the attention of the Governments of African States and international organizations to the importance of road maintenance, since roads in fact play a decisive role in economic and social development;

2. Recommends the harmonization of road maintenance standards, the preparation of a road maintenance manual for Africa, taking account of the geographical diversity of the countries, and the establishment of a documentation centre responsible for the collection and dissemination of research results;

3. Requests ECA to approach the sponsor countries with a view to the preparation of a draft manual on road maintenance for circulation to African countries for their comments.

C. Training

The Conference,

Considering that the organization of road maintenance services and the procurement of suitable equipment must necessarily be supplemented by an adequate complement of skilled staff so as to make road maintenance both operational and efficient,

1. Directs the attention of the Governments of African States and international organizations to the importance of training staff in road maintenance;

2. Recommends the establishment of national administrative structures for staff training, and their strengthening where they exist, and the establishment of regional centres for the same purpose, taking account of the characteristics of the various geographical zones.

D. Equipment and spare parts

The Conference,

Noting the concern clearly expressed by the participants as a whole as regards the problem of equipment and vehicles, their management and maintenance,

Recommends strongly the search for a solution to the problems relating to the supply of spare parts, possibly in the form of regulations governing the supply of spare parts by manufacturers, the establishment of regional depots responsible for ensuring the supply of spare parts, or the adoption of measures granting those concerned a great degree of latitude in their choice of equipment.

E. Institutional arrangements

The Conference,

Noting Recommendation I of the 1974 Conference regarding the establishment of Inter-State Technical Committees for the co-ordination of road research,

1. Recommends that such Committees be given the status of Subregional Institutes for Highway Research, the functions of each subregional institute being to:

(a) Co-ordinate road research being carried out in national laboratories on problems affecting each subregion;

(b) Define research priorities in the respective subregions; and

(c) Establish African norms in respect of road construction and maintenance, and a standardized terminology;

2. Further recommends that institutes be established in the following four subregions:

(a) North Africa;

(b) Central Africa;

(c) West Africa; and

(d) Eastern and southern Africa.

F. Issues to be considered by the next conference

The Conference,

Considering the problems concerning equipment and vehicles, their management and maintenance and the supply of spare parts,

Considering further the importance of the human element in road maintenance,

Recommends that these issues be considered at the next conference.

G. Trans-African Highway projects

The Conference,

Considering that contacts and exchanges should be facilitated,

Recommends that efforts already under way be intensified with a view to completing the Trans-African Highway projects.