Airport construction in Zaire

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Construction d'aéroports au Zaïre

Flughafenbau in Zaïre

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SUMMARY
This article describes various stages of a contract for upgrading of six airports in Zaire, carried out under unusually difficult equatorial conditions in remote areas. The contract demanded particular design, logistic planning and coordination during construction. The following aspects were considered: completion time, climatic conditions, topographical characteristics, restricted local resources of materials, transportation between sites by restricted barge – road – rail facilities, limited local handling and communication services, etc. An optimum organisation enabled the planned completion to be achieved.

RESUME
Cet article décrit différentes étapes dans l'exécution d'un projet pour la remise en état de six aéroports au Zaire. Ce travail a été réalisé dans des conditions équatoriales extrêmement difficiles et en des endroits difficilement accessibles du pays. Ce marché a nécessité des solutions très particulières quant à la conception, le planning logistique et la coordination générale des travaux de construction. Les aspects suivants ont été considérés: délai d'exécution, conditions climatiques, caractéristiques topographiques et géotechniques, limite des ressources locales en matériels et matériaux, système de transport encore peu développé, combinant les voies fluviales, les pistes, les chemins de fer, les installations portuaires et ferroviaires limitées. Une organisation optimale a permis l'exécution de tous les travaux dans les délais prévus.

ZUSAMMENFASSUNG
Dieser Bericht beschreibt die verschiedenen Stadien eines Vertrages über den Aufbau von sechs Flughäfen in Zaire, durchgeführt unter ungewöhnlich schwierigen aequatorialen Bedingungen in entlegenen Gebieten des Landes. Der Vertrag erforderte spezielle Entwürfe, Logistik-Planung und Koordination während des Baues. Folgende Gesichtspunkte wurden in Betracht gezogen: Vollendungszeit, klimatische Bedingungen, topographische Eigenschaften, beschränkte örtliche Bezugsquellen von Material, Transport zwischen den Baustellen unter eingeschränkten Schleppkahn-, Strassen- und Eisenbahneinrichtungen, begrenzte örtliche Beförderungs- und Vermittlungseinrichtungen usw. Eine optimale Organisation hat die Ausführung aller Arbeiten termingerecht ermöglicht.

1. INTRODUCTION

One of Zaire's biggest problems is that of internal communications. The great river Zaire encircles the major part of the country, consisting of impenetrable rain-forests astride the equator and this serves together with numerous tributories as the main highway for much of the country. About 1950 internal air routes were opened up and have been improved from time to time, but the subsequent progress in jet age aircraft meant that the existing facilities were inadequate to cope with the increased transportation demands. In consequence the government of Zaire decided to proceed on an economical basis of the modernisation of existing provincial city airports in the interior with the country for use by modern planes such as the Boeing 737, Caravelle SE 10 and Lockheed C 130.

Initially site investigations, topographical and geological surveys, surveys of the existing runways and buildings and the investigation of the local material resources for runway construction were carried out together with preliminary design proposals and cost estimates for 9 airports.

From this information the Zaire government selected six airports for development. George Wimpey & Co. Ltd. were awarded a civil engineering and buildings contract in September 1973 for the airports at Mbandaka, Gemena, Kisangani, Kindu, Kananga and Mbuji-Mayi. See Appendix 1 for geographical layout.

The principal aspects of the construction of these airports are described in the subsequent text.

2. SITE INVESTIGATION

The initial general geophysical surveys including geological, climatic and borehole records were available from the local government resources. The subsoil to subgrade level, i.e. formation level can be broadly classified as predominantly lateritic material varying in quality from clayey to rock laterite and a silty sandy clay. Depending on the quality of this data further borehole and soils data was obtained from trialholes and tests of representative samples carried out in local laboratories or where necessary in U.K.

In cases where indigenous soil did not meet the specification or could not be brought into specification by normal site methods, such as selective mixing, compaction and drainage, prospecting for alternative materials in the particular localities were extensively carried out.

For this purpose special geological and soils engineers were brought from U.K. The geologists were essentially concerned with finding potential rock quarries to provide suitable aggregate for the construction and this often involved exploration of distant areas in almost impenetrable jungle. At Mbandaka, for example, no suitable stone aggregate could be found and consequently the aggregate (approx. 30000 Tonnes) had to be brought by river barges from the Kinshasa area a distance of about 600 km. At Kindu suitable rock was found about 40 km away in a waterlogged jungle area with a most difficult access but adjacent to an existing railway which was used for the transport of stone. In all cases a fully operational quarry was established with the necessary drilling and blasting equipment, crushers, screening and handling plant together with provision of access roads.

3. PLANNING

The geographical position of the six airports naturally led to a split of the construction operation into two groups with Kisangani, Gemena, Mbandaka in the north and Kananga, Mbuji-Mayi, Kindu in the south (see Appendix 1). As the airport sites were hundreds of kilometres apart and it was the intention to move construction equipment in sequence from one site to another, it was also essential to carry out a detailed study of the river, rail, road and airline systems together with port and railhead facilities to ensure that the selected equipment could be efficiently transported by these systems. In order to meet the contract target date of completion on an economical basis and to make the most efficient use of key personnel and equipment it was decided to carry out the work using simultaneously two basic teams each constructing three airports within a three year period.

The planning of the construction methods was controlled by existing environmental and infrastructural limitations, as already highlighted in the "SUMMARY" paragraph and the logistic and strategic situation of the worksites. The selection of construction plant and equipment was dictated by the restrictions of available handling facilities at the ports, transportation by meter railways, by river barges, existing road system and bridges, etc. The transport limitations regarding weight and size prevented the choice of larger and more efficient equipment, e.g. rubber tyred scrapers, etc.

In principle the planning was prepared on the basis that movement of construction equipment from U.K. through the single port of arrival at Maladi along the tortuous and limited system of rail and river transport of the country for thousands of kilometres was scheduled so as not to overload the available facilities. The sequence of movement in equipment and construction material was arranged to ensure continuity of work on each site.

4. DESIGN AND CONSTRUCTION TECHNIQUE

In consideration of economical aspects, classification of anticipated traffic, subsoil conditions, resources of local construction material and suitable operational plant requirements it was decided to adopt a flexible pavement for the runways, taxiways and aprons using a Marshall Asphalt surface. The layout of the airport with navigational aids and the design of the pavements and associated work were carried out to the required international standards, where relevant, and in particular with Annex 14 to the "International Civil Aviation Organization Standards (I.C.A.O), British Standard Codes and Practices and Civil Aviation Authority methods".

The basic features of the layouts comprise:-

- Runway 2200 m long (2000 at Gemena and Mbuji-Mayi) x 45 m wide
- Overrun/Undershoot 100 m long
- Clear strip 150 m wide
- Apron about 1400 m^2
- Surface and subsoil drainage system
- Airfield lighting system with standby power generators and substations
- New or renovated terminal buildings

- Fire stations
- Provision for navigational aids
- Communication system

The design of the flexible runway pavement was based on the maximum take-off weight of the Boeing 737 requiring a Load Classification Number of 40 to an average thickness of 400 mm required for adequate wheelload-spreading in order not to overstress the subgrade. The designed typical pavement consisted of the following layers laid over the formation level:- 150 mm subbase, 100 mm water bound material, 50 mm dense bitumen macadam, 60 mm Marshall asphalt base course and 40 mm Marshall asphalt wearing course.

Where possible the existing construction was incorporated in the new structure either by reprocessing and reuse of the base material or in some cases by new construction being overlaid on the existing. Construction thickness varied depending on soil conditions and the type of materials available from indigenous sources.

In situ California Bearing Ratio was used as a measure of strength of the individual layers, e.g.

- C.B.R. of 15 for formation compacted at 95% density, liquid limit $\nless$ 17%, plastic limit $\nless$ 7%, plastic index $\nless$ 12%
- C.B.R. of 25 for subbase
- C.B.R. of 60 for base

In all cases design was based on a construction sequence which would enable a minimum of half the original runway length to remain operational. Temporary hardstandings and aprons were provided so that although aircraft were limited in the weight that could be carried, the continuous operation of all airfields was maintained throughout the construction.

One of the major problems encountered was construction during wet weather with tropical rains. The rainy seasons varied throughout the vast country and the construction programme at individual airports was phased in such a manner that the construction stages most vulnerable to wet condition could be completed during the intermittent dry periods. Nevertheless this could not always be achieved but was effectively overcome by timely provision of temporary drainage system, by selection of alternative suitable materials particularly for the formation level and subbase and by special protective measures to keep the individual layers dry and to prevent from ponding and saturation of the subgrade.

In view of the heavy tropical rainfalls and high ground water level an extensive permanent drainage system was introduced for the surface and subsoil water. The drainage system incorporated, where necessary, precast concrete slot drains at the edge of pavement, french drains, Armco pipes, open lined channels, culverts and main stabilised ditches along both sides of the clear strip - all interconnected for discharge at suitable points into the adjacent natural water courses of the open countryside.

At Mbandaka, Kindu, Gemena and Mbuji-Mayi great difficulties were experienced in providing alternative drainage systems and emergency measures in view of the highly progressive erosion and waterlogging of the soft lateritic-clayey ground adjacent to the runways and due to deteriorated subsoil drainage discovered during excavation and grading work. The clear strips between the runway and open ditches were cleared of jungle vegetation, regraded to falls and protected from erosion by planting of Paspalum grass.

The detail construction programme and sequence of construction together with construction technique for the individual sites had to be suitably revised from time to time in order to ensure effective continuity of work in consideration of the encountered problems deriving mainly from the weather conditions, transport problems, provision of suitable construction materials, national shortage of cement and fuel, maintenance of plant and equipment and many other local particular difficulties.

It should be mentioned that all the construction plant and equipment together with spares had to be imported from U.K. and the duration of supply by sea and internal transport averaged about 6 months. In critical construction stages the supply was overcome by special charter planes directly to construction sites from U.K. as well as national airlines - in total approximately 100 charters.

Another significant feature of the project was the problem of dealing with infestation by termites and woodworm of the timber structure in the terminal and other ancillary buildings. A team of specialists from U.K. surveyed the affected structures and effectively carried out any necessary protective measures.

5. MATERIALS AND PROCUREMENT

The rate of progress necessary to maintain the 12 month construction plan for each airport demanded a rate of supply of all materials well in excess of the production by local resources.

Supplies of bulk materials, fuel and bitumen were arranged from international suppliers and imported to the Country. Cement was arranged from three manufacturers within the Country with whom a supply programme was agreed to suit our needs.

For the terminal buildings, in some cases refurbished and extended, the finishing materials such as tiling, electrical and plumbing fittings, glass etc. were imported. Where new buildings were required these were imported from the U.K. as prefabricated steel complete with all furnishing, this achieving the rapid construction necessary.

The transport of all materials from the port of arrival was handled by a team of Wimpey staff with a representative resident at all strategic and transhipment points. These ports were all in radio communication with the central base and maintained a close cooperation with managers of the various transport authorities.

6. CONTRACT ORGANISATION

The contract was served by a small project team in the London office of Wimpey who coordinated the completion of detailed design, procurement of materials, supply of equipment and personnel to the main programme. This team called on the services of the various specialist departments such as Plant, Transport, Personnel, Procurement, Shipping etc. as necessary.

In Zaire a central base was set up in the capital Kinshasa through which everything was received as the international sea and air services went through this city. To ensure good communication with each of the construction sites a radio network was installed and three small twin engined aircraft maintained a daily service for the transport of staff mail and essential spares for construction equipment from the central store in Kinshasa.

The central base also controlled the finances, general planning on a monthly basis and procurement of materials that were available within the country.

Each site was controlled by a Project Manager supported with a team of engineers, foremen and administrators from the U.K., controlling the labour force recruited from over the whole country. Where possible experienced tradesmen and operators were recruited in the local areas of each site. If sufficient numbers were not available, the locals were supplemented by recruiting outside the area. Where special trades were required, in plant operation and maintenance and electrical installation for instance, additional expatriate staff were used and national staff trained on site for this work. Expatriate staff, including the specialists, reached a maximum of approximately 200 men and the national labour reached 1800 men.

To house the expatriates a demountable prefabricated camp was used and moved from site to site. This camp included cooking, medical and recreational facilities.

The problem of different languages had to be overcome by the use of interpreters recruited locally. After the initial months of the contract a number of the U.K. staff had obtained sufficient knowledge of the local languages to deal with most matters without use of an interpreter.

7. QUALITY CONTROL

The site staff included engineers and technical assistants with the responsibility for quality control of soils, aggregate, concrete and asphalt mixes continuously at all stages of the construction operations.

Two field laboratories were set up on each site - one for soils and concrete and one for asphalt. All materials and construction elements were subject to regular test procedures laid down by Wimpey in compliance with the specification requirements. Reports on these tests were returned to London for overall control and record purposes. The tests were all witnessed by representatives of the Client.

Basically the tests comprised:-

for soils - gradings, liquid limits, plastic limits, moisture content, C.B.R. in situ and laboratory, sampling in situ, dry densities, etc.

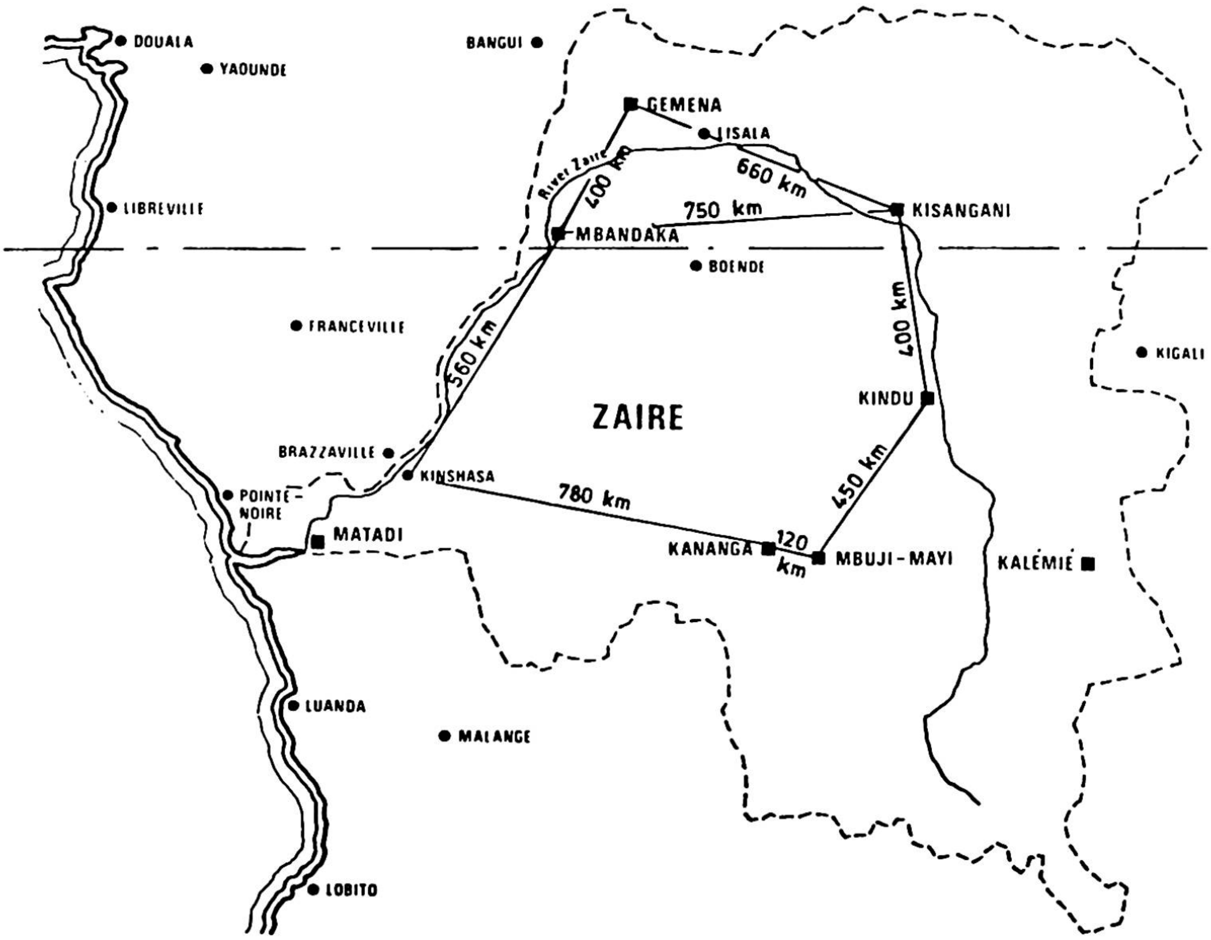
for concrete - gradings, cube strength, flakiness, alongation, aggregate crushing values, slump tests, compacting factors, concrete mixes, etc.

for asphalt - bitumen densities, binder recovery tests, gradings, mixes for dense bitumen macadam and mixes for Marshall asphalt, etc.

The quality engineers were also constantly involved in exploration of suitable soils and aggregate resources from the vicinity of the construction sites. In some instances samples were sent to Wimpey Main Laboratories in U.K. for special tests.

8. GENERAL DATA

Earthworks	800,000 m^3	
Asphalt Placed	205,000 tonnes	
Sand/Stone. Crushed	400,000 tonnes	
Wimpey Staff	140 No.	
Specialist Staff	30 No.	
Local Staff	1,800 No.	
Camp Living Units	180 No.	
Transport Vehicles	165 No.	Maximum size 6 x 4 tipping trucks of 15 tonne capacity.
Construction Plant (approx. 20,000 tonnes)	300 Items	Maximum size. 100 tonne per hour stone crushing plants.



Airport construction in Zaire Layout

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