

Transport of materials and equipment for the construction of the Kainji hydro-electric development, Nigeria

R. W. A. MacKICHAN & P. F. JEFFERY

Mr T. D. Kershaw, Balfour, Beatty and Co., Limited

As Resident Engineer for the first three years of the construction period at Kainji I am convinced that, had this investigation in depth not been carried out, the project would not have progressed as smoothly as it did, and possibly would not have been finished on time.

56. The fact that the policy on transport must be developed at the same time that certain design parameters are set, and the major contracts are taking form, ruled out the practicability of doing this study from site once work had begun.

57. No claims or disputes arose in the Kainji contracts on the question of delays in the transport of materials as the facts of such delays were never in dispute.

58. It is in some ways a pity that the proposal of a transport executive was not acceptable to the Client. Although the combined Resident Engineer and Contractor teams with their Lagos representatives effectively constituted such an organization a transport executive as originally visualized could have handled customs problems, prevented certain delays and subsequent claims arising from hold up at customs. However, a transport executive with Client and Government involvement might not have proved effective during the period of the civil disturbances and the subsequent civil war. During this period the site organizations were free to take action on a day to day basis on their own initiative with the minimum involvement of Government departments.

59. The Resident Engineer's central store for Client's electrical and mechanical materials and equipment transported by the main civil works Contractor was a central clearing house for information on the transport and delivery of these materials. There was never dispute on the facts of the status of the delivery of materials. The whereabouts of vital components was always known.

60. Despite all the pre-planning for the transport of materials to Kainji, there were occasions when things went wrong. Before the Mokwa-Kainji road was completed heavy plant and materials were transported up the west bank road from Ilorin to the site. Without the tolerance of the Provincial Roading Engineer, the early stages of construction would have been delayed.

61. The introduction of the rail/road transporter would also have been delayed but for the personal interest and drive of the Chief Civil Engineer of Nigerian Railways. After the civil disturbances, but for the special efforts of the local road haulage contractor, there would have been serious delays in the delivery of materials.

62. I believe that the preliminary exercise of assessing transport facilities is vital even if the end result indicates no special measures are required. This survey should be carried out before the various construction and erection contracts are finalized. The planning must be flexible, with alternatives to meet various contingencies. If at all possible there must be a central form of control covering sea and inland transport, shipping clearance and customs clearance and storage on site.

63. Despite the work that went into this facet of the Kainji construction planning, without the main civil works Contractor's determination to control transport arrangements, this project would not have been completed on schedule.

64. This Paper should be a useful guide for anybody planning a similar exercise.

Paper published: *Proc. Instn Civ. Engrs*, 1971, 49 (May) 23-36.

DISCUSSION

Mr L. Guglielmini, Impregilo

When studying the transport of bulk cement for later plants of importance, the expediency of using the Kainji system for unloading plant at the end of the works was taken into consideration. However, this system was geared to Norwegian ships. The technique of unloading bulk cement had made progress so that it was possible to unload cement from ships, not specially equipped, by using easily operated plant on the berth. The travelling hopper of Apapa was no longer useful.

66. The new suction units make it possible to discharge without dust and give faster output, speed up discharge operations and reduce the number of personnel in charge.

67. Plants using vacuum rotary blowers make it possible to use unequipped bulk carriers or even normal ships.

68. Norway Cement (the supplier of cement for Kainji) has chosen this system for supplying cement to its clients on the Atlantic Coast of the USA. Its port of unloading is New York. Claudius Peter of Hamburg supplied the necessary equipment.

69. The suction unit has a capacity of 180 tons/h, and a pressure of about 8×10^5 N/m².

70. A cylindrical steel tower, equipped with a hydraulic jib which sustains the suction head and the eleven relevant connecting pipes, contains a cement silo and the filters. The suction head is equipped with two rotating discs which move the cement and send it to the suction nozzles. The jib can be moved so as to place the suction nozzle all round the hold easily. A control cabin is fixed to the tower. The cement arrives in a cyclone at the centre of the tower where it separates from the air and falls down into a small tank installed in the lower part. Air flows out through conventional filters installed on the top of the tower. Air slides feed the cement into a Fuller pump, which conveys it to the silos 40 m away.

71. The feeding of this pump is regulated by a flow control gate which works in connexion with a level indicator placed in the cement tank.

72. Rotary blowers, Fuller pumps and compressors are installed in a shed at the foot of the tower. This structure can move on rails to reach all the holds or it can be stationary. The capacity can be increased with extra suction heads attached to the tower, and the power used is 1.7–2.2 kW/ton.

73. A transport system using nearly spherical rubber containers called Sealdbins has been used in the USA. The containers hold 2–10 tons of cement. They are made of tough neoprene-coated tirecord fabric, vulcanized into a collapsible, one-piece container which is puncture resistant. Internal cables for added strength brace the Sealdbins against stress and shock. They can be filled by gravity or pneumatically, and the emptying is just as simple. They are easy to manoeuvre and are designed to withstand severe exposure, and can also be folded when empty. However, techniques are evolving continually.

Mr G. Belloni, Impregilo

The team who studied the transport of cement for Kainji Dam, in co-operation with a large group of engineers and experts, have subsequently carried out a study to solve transport problems at Tarbela Dam in Pakistan, where 80 million tons of gravel and silt had to be moved from borrow areas to the dam, with a hauling distance of 6 miles and a rate of placing of 3.1 million cu. yd/month. A conveyor system has been installed which carries the materials from the borrow area to the dam site, in tunnel and in the open.

Mr J. H. C. Sorber, (formerly United Nations, now Crown Agents)

If § 14 means that the Government or the Client wanted the railway built, was consideration given to making a branch line from Mokwa to Kainji, which could be cheaply

built if second-hand permanent way materials were available, or from re-laying elsewhere, and using the west road for access for light motor traffic only? It could then be constructed to a lighter standard.

76. Referring to § 50, was the Mokwa-Kainji road built under the Contract or by the Government separately? What was the cost per kilometre?

77. Was the deficiency in quality, mentioned in §§ 23 and 26 in connexion with the cement factory at Ewekoro, serious or was it something that with expert advice, better training, or supplementary equipment, could have been put right? Governments usually insist on local resources being fully exploited.

78. Did the Client or the Government ask for the products to be upgraded in quality?

Mr J. D. Gwynn, Balfour, Beatty and Co., Limited

Referring to § 50, I think the blame for the accidents lies in the skill and judgement of the drivers and this Paper is not one on human transport. In terms of accidents to transport vehicles and to plant in transit the record is good. The economics and advisability of building a railway from Mokwa to the site would have needed more consideration had not the paving of Nigerian roads been ahead of the project requirements.

80. The Mokwa-Kainji road is to form a section of the east-west trans-Africa highway and will inevitably be multi-purpose, contributing to national and international communications in terms of road and river transport.

Mr MacKichan

I should like to thank **Mr Guglielmini** for his description of the developments in the field of cement transportation since the time of construction of the Kainji Dam.

82. **Mr Belloni** has spoken of the problems of transporting 80 million tons of fill dam materials for the construction of Tarbela Dam, at the rate of 3.1 million cu. yd/month. There were 10 million cu. yd of materials in the Kainji fill dams and at this rate they could have been finished in a little over three months. Physically this could not have been possible but it is an interesting comparison and emphasizes the enormous size of the Tarbela Dam.

83. At Portage Mountain Dam in British Columbia, Canada, of the order of 50 million cu. yd of materials had to be moved to form the dam. A conveyor was also used there to transport the processed gravels and silts 17 miles to the dam site.

84. **Mr Gwynn** rightly said that the cause of the road accidents was basically due to human errors. New roads had been provided, which compared with other local roads invited fast driving, but once the speed limit was rigidly enforced the number of accidents was reduced. On the whole the incidence of accidents was no more than elsewhere in the country. The record for the transport of plant was good as **Mr Gwynn** says.

85. During the tender period when tenderers' delegations were visiting Nigeria and the dam site to obtain necessary information for their tenders, high floods were experienced in Nigeria. Bridges were washed out, people were marooned and road surfaces suffered. The timing was opportune as tenderers were thus able to see what some of their transport difficulties might be. In the event, the happenings of that year were much more severe than experienced during construction.

Mr Jeffery

Mr Sorber referred to § 14 concerning the possible construction of a railway spur from Mokwa to Kainji. Road access on the right bank, road access on the left bank from the main north road (all weather) at Mokwa, and a rail spur from Mokwa separately and in combination were considered. An all weather road on the left bank from Mokwa was far more economical than the equivalent on the right bank, and, by

DISCUSSION

providing sufficient capacity a rail spur was rendered unnecessary and uneconomical. If a standard gravel surfaced access road had already been in existence on the left bank, it might then have been economical to construct a railway spur to provide the main access, restricting the amount spent on road improvement. A saving on transportation and facilities at Mokwa, e.g. cement silos, would then have been attained.

87. The Mokwa-Kainji road was built under the Contract by the main Contractor and during the year it took to build he had to use the alternative access on the right bank, which suffered from restrictions referred to in § 11. The cost per kilometre of the Mokwa-Kainji road was approximately \$ 34 000.

88. Referring to § 23 and the use of the cement from the Ewekoro factory, the normal Portland cement was up to standard and was used by the Contractor on a small scale at the start of the works. Cement was being imported into the country at the time and there was not the local capacity for the Kainji supply and other local requirements without expansion. The Contractor was not bound under the Contract to use local cement, partly for this reason, and chose cement that met the required specification from the world market.

Conversion factors

<i>Imperial units</i>	<i>SI units</i>
1 ton	1·016 t
1 cu. yd	0·7646 m ³