DESIGN AND CONSTRUCTION OF WEST-EAST (ARAROMI-OGHOYE) NAVIGATION CANAL AND SHORE PROTECTION WORKS AT AWOYE INLET, ONDO STATE

By

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ABSTRACT

The West-East (Araromi-Oghoye) Navigation Canal runs parallel to the Ondo State Atlantic Coast. In the 80s, the Canal had to be dredged to a depth of 2.5m below LLWs and more than 1,500,000m³ of sediment were removed. The required navigable depth was difficult to maintain due to heavy siltation caused by swift current of Oluwa River and Awoye Inlet. In this project, design studies were undertaken for improving the situation vis-à-vis the hydrographic regimes of the Oluwa River and the inlet. The entire canal was realigned using the empirical relations between channel width and depth, and sediment transport and current velocities. The construction of a revetment at Awoye has restricted the excess width of the inlet thereby reducing the tidal current flux into the canal.

The results were quite satisfactory as the heavy siltation rate has been reduced. Laudable benefits of the project includes: resuscitation of the Federal Fishing Terminal at Igbokoda abandoned due to insufficient draught for fishing trawlers to ply. Secondly, the use of Dredged materials for implodering for human settlement, offers a sustainable solution to the problem of waste disposal in dredging construction. The study also identified lack of managerial skills, technical know how, political considerations in contract award and corruption as the perculiar risks of indigenous dredging contractors.

Keywords: *Canal, Dredgers, Environmental Impact Assessment (EIA), Sea breakthrough inlet, Polders, and Revetment.*

1. Introduction

Navigation canal are provided if a free-flowing river has too shallow a depth and too high a velocity to permit navigation. Navigation Canals can be used to bypass a river section that is difficult to navigate, and be in conjunction with a single barrage or several barrages spaced wider apart than in the case of river canalization. They are an essential part of inland navigation where they connect two watersheds.

The advantages of transport by inland navigation (Novak et al, 1990), namely: a) Low energy requirement: the specific energy consumption for navigation is about 80% of that for rail and less than 30% of the consumption for road transport; b) High productivity of labour per unit of transport output; c) Lowest interference with the environment; low noise, low exhaust fume generation; d) Low accident incidence in comparison with other transport modes; e) Capability of easily transporting bulk cargo and large industrial products.

The Federal Government of Nigeria recognizing the invaluable economic importance of inland navigation embarked upon the controversial dredging of the Lower Niger River. Accordingly in 2001, the Niger Delta Development Commission (NDDC) sanctioned the re-dredging and alignment of West-East (Araromi-Ogboye) navigation canal. It is planned to link the South-West States of Nigeria at Badagry and the South-South States through Benin River. These gigantic projects have generated new impetus in the development of inland waterways, which was hitherto neglected. The Canal had been dredged in the early 80s to a depth of 2.5m below low waters. However the navigable depth could hardly be maintained due to heavy siltation. For example siltation of 2m occurred during the period. Hydrographic surveys were carried out with a view to identify the natural conditions of flow, characteristics of bed sediments, and the mechanism of siltation, so as to design a sustainable and stable canal. The results of hydrographic surveys carried out for the present scheme showed that about $9.63 \times 10^6 m^3$ of fine to medium sand and clay will be excavated through dredging. The excavated materials will be used to reclaim the adjoining wetlands for human settlement purposes. A revetment will be constructed to Awoye sea break through inlet to constrain it to its high water cross-sectional area, thus preventing it from further widening. Finally, the environmental consequences of the entire scheme were assessed through Environmental Impact Assessment (EIA), study of the project.

This paper presents the analysis, design, construction, potential environmental impacts and assessment of the peculiar problems of indigenous dredging construction in Nigeria and suggestion of possible solution.

2.0 NATURAL CONDITIONS: CAUSES & PROBLEMS

The West-East Canal runs parallel to the Atlantic Ondo State Coast. The Araromi end is a cul-de-sac, and terminates there. The Oluwa river intercept the canal at Aiyetoro about 41km from Araromi while the Awoye sea break-through

inlet traverses the canal about 74km from Araromi and finally terminate at Benin River, 94km from Araromi. Consequently the hydrographic regime of the canal depends on the discharges of oluwa river and the Inlet. The strong flow velocities of the Oluwa and the inlet therefore retard the water motion in the canal. According to Engelund-Hausen equations sediment transport capacity is proportional to the fifth-power of the velocity. This explains why it was difficult to maintain and improve the West-East Canal only by dredging. Another fundamental causes of siltation problem was the inappropriate alignment of the canal. The ratio of width to depth B/h averaged 28, the maximum being 30. This was much larger than 25, the required ratio for stable sections. Besides, the following flow-structure phenomena were observed from the hydrographic surveys of the canal to analyze the cause of the problems.

i) In general, the maximum velocity during ebbtide was greater than that during flood tide, over the water column, with the exception of spring tide, when the maximum velocity was greater.

ii) Sediments from the Oluwa River were carried into the canal by flood current and settle in the canal, during stack water. It was further observed that the duration of flood slack was 1.5 to 2 times longer than ebb stack. This would allow more sediments to settle in the canal and

this is detrimental to the maintenance of the channel.

2.2 SOLUTIONS

The key point for improving West-East Canal Incorporated in the design was to bring the streamlines of both flood and ebb currents as close as possible, especially to reduce the rate of lateral movement of the ebb current in order to increase its scouring force.

A realignment design to achieve the ratio R/W > 26, where R is the centre radius of channel curvature and W is the channel surface water width.

3.0 CANAL DESIGN METHODOLOGY

Open-channels are basically of three types: lined, unlined and grass-lined. Design procedure for each channel type are different, but there are some basic concepts which are common to all three, notably the Mannings and Chezy equations which defines the conveyance as a function of hydraulic radius and wetted perimeter.

The way a channel is to be used naturally also influences its design e.g. A canal intended to transport water from a higher to a lower level over a short distance would have a high slope whereas a canal requiring maximum

conservation of potential head would have as gentle a slope as possible. In all cases, economic considerations demand the minimum amount of excavation and the bank slopes must be stable.

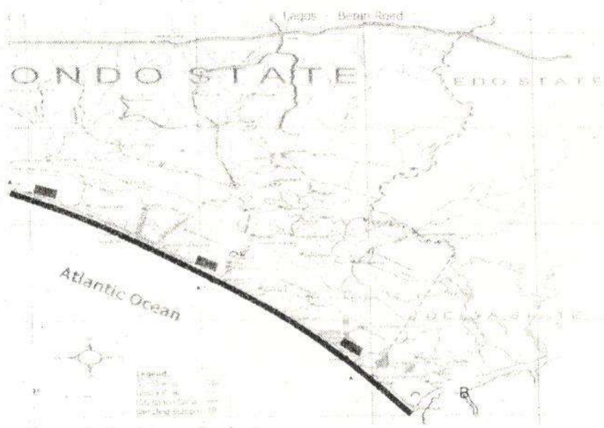


Fig. 1: Araromi-Oghoye Canal

The basic criteria for a successful design of alluvial channels may be summarized as:

i) Keeping the Froude number less than 0.1 (ii) Keeping the sediment discharge concentration less than about 500ppm. (iii) Ensuring that the sediment transport capacity of the channel is equal to the quantity of sediment diverted into the channel.

The design of alluvial channels is approached in two different ways; regime and tractive force methods. The major limitation of the regime

are restricted to the hydrographic system from which the field data were obtained.Both tractive and Regime theory method are insufficient for design of Navigation canals. Navigation canal are subjected to forces such as waves induced stress by marine craft which are not accounted for, in the tractive and Regime formulations. Navigation canal are therefore designed using two main approaches:

theory is that the empirical equations obtained

Permanent International Association of

Navigation Congress (PIANC) and U.S. Army Corps of Engineers (USACE).

In comparison the PIANC approach is more documented and deterministic than the USACE approach (William O. Gray, et al, 2003). The Araromi-Oghege canal was designed using the PIANC approach as described below.

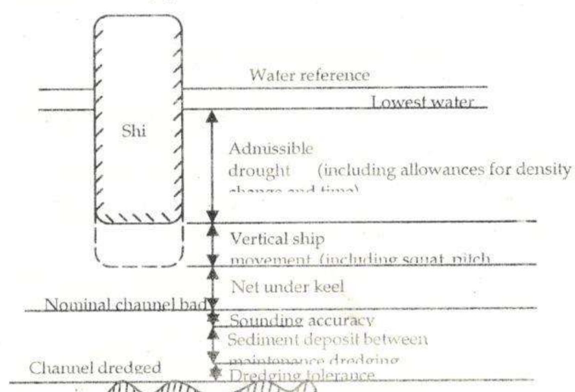


Fig. 2: Components of channel depth

3.1 DESIGN STUDIES

The design was implemented in three phases: Economic studies, Initial design and Final design.

Economic Studies: This involved the evaluation of potential volumes of commodities, by kind, origin, destination and required times were established for the short, medium and long terms on basis of social, economic and the expected developments. A cost-benefit analysis was then performed to assess the various transport possibilities, based on sound social, economic and political factors.

For the riverine Ilaje's of Ondo State, the canal is the only visible means of transportation to over 200 communities with the rest of the state. Besides, the canal is expected to transit fishing trawlers to the Coastal Fishing Terminal at Igbokoda. Consequently, no exact quantification of the flow of goods was made. Economic studies were based on a prediction of the minimum and maximum expected volumes.

Initial Design: The following factors were considered; Vessels, Alignment, Dimensioning and Screening, Shipping considerations involved selection of the vessel to be used. Alternative types and sizes produces several decisive design vessels. The factors considered in site selections and alignment was based on geology, geography, meteorology and soil mechanics.

Canal dimensions were based on the types of particulars of the design vessel and route alignments, the dimensions of the hydraulic structures required, canal cross-sections, bank protections and ancillary structures. Screening studies involved a cost-benefit or ranking basis and includes a selection of the potentially feasible alternatives. Factors such as cost of construction, maintenance and design life estimated. The initial design concluded with a qualitative, but rather rough insight into the cost aspect involved.

Final Design: The final design began with an assessment of the impacts of the remaining initial design on all relevant factors. This is inevitable to evaluate the economical, social and environmental impact of the design. The project cost and preparation of tender document proceeded the acceptance of the final design. The design phases may be represented by the number of fundamental steps taken (Fig. 3).

3.2 CANAL DESIGN

Navigation canal must be safe, efficient, reliable, and cost effective, with appropriate consideration of environmental and social aspects. The final channel dimensions includes an evaluation of ship maneuverability, user-responses at bend and entrance.

i) Design Vessel: The vessel selected from studies of the various types and seizes of vessels expected to transit the channel. This is usually the largest vessel of the major commodity mover. In this project, the Ondo State Budget in NDDC dictated the choice of the design vessel. The design vessel was identified by its principal parameters; length, draught, beam and other parameters, which affects its maneuverability in motion. The Delta tug series DT1050 was adopted. The principal particulars are; Length 10.5m, Beam 3.51m, Draught approximately 1.3m, Power rang 160-180Hp and speed range 9 knots.

ii) The design width = f(vessel size, vessel steering characteristics, vessel speed, traffic density, water depth, channel-type, currents, waves and winds),

The elements of the design width includes; maneuvering lane vessel clearance, and bank clearance. For a two-way traffic, the design width was computed;

Design width = 2ML + SC + 2BC. (1.0)

Where ML = maneuvering lane, BC = Bank Clearance, SC = Vessel clearance. The maneuvering lane is approximately 1.6times the beam of the design vessel. The components of channel width for two-way traffic are shown in Figure 4.

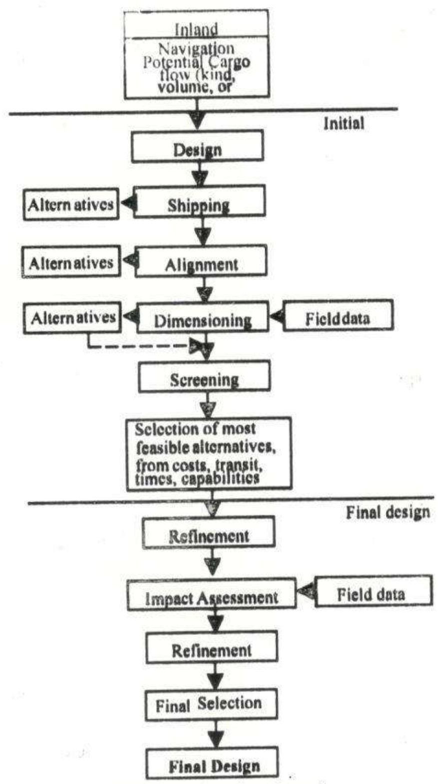
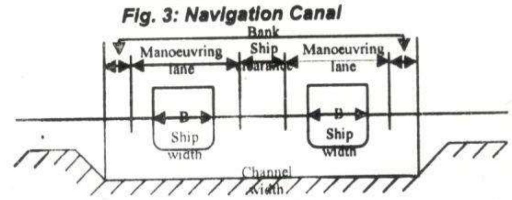


Fig. 3: Navigation Canal



3.3 SHORE PROTECTION DESIGN

The pilarczyk equation (1990) recommended for design of riprap, cabled concrete blocks, box gabions and asphast mattress was adopted in this project.

$$D = \frac{\phi}{\Delta} * \frac{0.035}{\Psi cr} K_T K_h K_s^{-1} \frac{U_d^2}{2g} \qquad 2.0$$

Where

D is the characteristic size of protective unit

Φ is a stability correction factor (appendix 1)

Δ is the relative density of the revetment (appendix 1)

K_T is a turbulent flow factor ($K_T \approx 2.0$)

U_d is depth –average velocity = 0.95m/sec

K_h is the depth factor, for turbulent flow in natural rivers,

Equation 2.0 was solved iteratively, obtaining D = 0.20m. The 200mm units were enclosed in double twisted hexagonal mesh of 0.50m thick, made up of galvanished with 1mm thick PVC coating.

4.0 PROJECT SUPERVISION / CONSTRUCTION

The supervision of construction works is an integral and complimentary function of sound contract administration. The objective of project supervision was to ensure that the contract is completed on schedule, in accordance with specification, at the agreed price or other such varies price agreeable to both client and contractor, in accordance with contract conditions and with minimal impact on the environment. The elements of contract supervision in dredging projects include the following activities;

1) Enlightenment of Marine Stakeholders (waterway users, public workers etc.)
2) Approval and coordination of work programme to ensure conformance with specifications.
3) Operation of method of contract control.
4) Agreement and quality control of measurements.
5) Progress meetings.
6) Authorizing variations in the contract and specifications.
7) Checking measurement tolerances and specifications.
8) Observance of contract conditions.

9) Joint hydrographic surveys between client, contractor and consultant, certification of completed works and preparation payments.

Dredging construction in Nigeria has had a poor reputation for coping with risk, consequently many projects fail to meet deadlines and cost targets. In order to minimize the risk, the project was divided into five sections; Araromi-Etugbo (20km), Etugbo-Aiyetoro (22km), Aiyetoro-Obe-Rebiminu (16.5km), Obe-Rebiminu-Awoye (20.5km) and Awoye-Benin River (20km). Each section was awarded to a separate contractor. Each contractor was then mandated to produced a work programme and mobilization plan to site, engagement of a adequate technical team, and dredging fleet consisting of Cutter suction dredger, grab dredger, excavator and ancillary equipment at site. A managing consultant was appointed to manage the site, who is turn communicates between the Client and contractors through monthly progress reports, site meeting, etc..

The progress after four years was appraised and the following conclusions about indigenous participation in the dredging industry may be deduced; the contractors should have the requisite professional training. Clients must pre-qualify Contractors to assess their experience, financial capability and performance records before awarding contracts and removal of political considerations in awards. It should be remembered that for successful completion of any civil engineering works within schedule reflects with credibility upon Contractors and client alike. Clients should employed selective tendering as oppose open tendering which is wasteful and inefficient.

5.0 ENVIRONMENTAL ASPECTS

The term "environmental issue" usually implies to one or two of the following interpretations;

1) Wind, waves, tide, sediment characteristics, and/or other environmental factors involved in channel design and usage or
2) Environmental Protection in the sense of reducing the negative impact on water quality or aquatic and costal habitat quality.

In the first sense of the term, the relevant factors have been incorporated in the analysis leading to canal and revetment design. The second category has been addressed through an Environmental Impact Study of the project.

5.1 ENVIRONMENTAL ASPECTS:

The Environmental Impact Statement gave the summary of the direct and indirect, adverse and benefits, environmental impacts of the proposed project. Since the canalization will involve widening and deepening the 94km waterway, the following impacts are perceived to be precipitated.

i) At considerable size of the freshwater swamp/riparian forest which bear the bulk off the economic species will be destroyed, thus aggravating the extensive logging operations already going-on in the area:
ii) Most of the wildlife will loose their habitat, and so will be prompted to migrate in any direction of refuge. In the process some may find themselves exposed to unfavourable or harsh environment and may eventually die.
iii) Animals that will be immensely affected are the arboreal species, particularly the monkey, birds, chameleons, squirrels, and those amphibious forms like the crocodiles, nile

monitors and turtles which risk and spawn and nurse their young ones along the shorelines. The macrophytges and associated biota (insects, water spider, mites, leeches, etc.) will equally be destroyed.

iv) As the canalization progresses, the bulk of the water will become more turbid as large quantities of fine particles; clay and mud, will be placed in suspension. These particles will clog the gill of fishes and crustaceans, which will in turn, impair oxygen intake.

v) Benthic organisms will be thrown out of water and deposited among dredge spoils. Besides the heaps of dredge spoil will

vi) smother some plants and animals on the banks.

vii) With dredging, more saline water form Idiogba and Awoye will intrude into the freshwater causing death of riparian vegetation and subsequent replacement by mangrove vegetation.

viii) The project would have a beneficial economic influence by providing communication, a major factor in the local economy, with navigation improvement which would reduce transportation costs through the use of larger vessels. The creation of specially liked areas (mini-polders) for disposal of dredged materials and their use after consolidation, for settlement purposes may hold the key to one solution of the dredge material disposal problem. Thus the dredged material is not a waste product but potential productive nature resources.

6.0 CONCLUSION

The objective of this paper is to design and construct navigation canal with improve sediment transport capacity, particularly the complex flow interaction with Oluwa River, the inlet and the numerous outlets to the Sea. Problems of massive siltation associated most canals were addressed using empirical relations between sediment transport and flow and

realignment of the entire canal. In order to improve the design life, the outlets to the sea have been closed, together with the revetment at Awoye which prevent further widening of the inlet.

To accurately predict the effect of the proposed construction, mathematical and physical modeling studies should be incorporated in studies leading to construction of coastal projects. Finally, for successful indigenous participation in the dredging industry, contractors and personnel should have the required professional training.

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