Hydrodynamic Investigations on the Shoreline Changes Due to Construction of Breakwaters at the Muthalapozhi Inlet of Kerala Coast

Girija Ravi
Deputy Chief Engineer (Rtd),
Office of the Chief Engineer,
Harbour Engineering Department,
Kamaleswaram, ,Trivandrum 69500, Kerala.

***Abstract* - Muthalapozhi inlet is in the West coast of India falling in Trivandrum District of Kerala. This is the point where the Vamanapuram River finds its outlet to the Arabian Sea. In order to make the inlet perennial, there was a proposal to construct two breakwaters for training the river mouth. After detailed model studies and subsequent expert advice from the research station a proposal to construct a northern breakwater of 410m and a southern breakwater of 330m was evolved and construction was commenced. When the north breakwater reached up to 260m and the south breakwater up to 220m, heavy siltation, choking the entrance was observed. Then re-engineering studies were done to proceed further. Based on the studies, it was decided to extent the north breakwater by 240m and south breakwater by 330m, giving a combination of parallel breakwaters. Now the construction is in progress and there is considerable improvement in the tranquility condition. Here the net drift is observed to be towards north. This paper highlights the shoreline changes for the period from 4/2008 to 1/2015 derived from actual field data. The results indicated a reversal of drift direction than predicted in the initial proposal. It is anticipated that over a period of 15-20 years there may be bypassing of sand through the tip of the southern breakwater. Short term solutions for the management of the recurring problems are suggested in this paper. Long term solutions to the problem are also suggested, such as calling for the attention of the state and local government and research organisations.**

Keywords- Shoreline changes; Rubble Mound Breakwaters; Littoral drift; Fishing Harbors; Coastal Erosion.

I. INTRODUCTION

On the West Coast of India, Kerala has a coastline of 590km with 41 west flowing rivers and 3 east flowing rivers. The confluence of these west flowing rivers with the Arabian Sea forms 23 estuaries. Generally, three types of interventions occur along the coast. They are construction of fishery harbours, ports and sea walls. In a harbour, there are components such as, entrance, approach channel, breakwater, wharves, jetties etc [3]. A breakwater is a structure protecting a shore area, harbour, anchorage, or basin from waves. Breakwaters for navigation purposes are constructed to create calm water in a harbour area, and provide protection for safe mooring, operating and handling of ships, and protection for harbour facilities [9].The Harbor Engineering Department of Kerala has taken up construction of 21 Fishery Harbors along the coast. Of which 9 fishery harbors are in estuaries and others are in open sea. Some of these harbours are also functioning as ports. As part of the harbour/port constructions, so far 22.7kms of breakwaters have been constructed. In addition to the above, some groins have also been constructed by various departments to prevent erosion. The alignment of these breakwaters has been finalized based on physical and mathematical model studies. In all the harbours, rubble mound breakwaters have been provided, which were designed using Hudson's formula. Consequent to the construction of these breakwaters there are changes to the shoreline. Muthalapozhi is one such estuary where two breakwaters of length 410m and 330m were proposed to be constructed. But when the construction was under progress heavy siltation was observed near the entrance during 2003. Hence after detailed re-engineering studies the alignment of breakwaters was modified and construction is progressing accordingly. In this paper the details of the shoreline changes for the period from 4/2008 to 1/2015 derived from actual field data are presented. The results indicated a reversal of drift direction than predicted in the initial proposal.

A. Existing scenario

Muthalapozhi is a tidal inlet in the West coast of India falling in Trivandrum District of Kerala. This is the point where the Vamanapuram River find its outlet to the Arabian Sea as shown in (Fig.1). The seasonal closing of the inlet caused many difficulties to the fishermen including capsizing of vessels leading to loss of life and

property. In order to make the inlet perennial, there was a proposal to construct two breakwaters for training the river mouth. After detailed model studies a proposal to construct a northern breakwater of 480m (280 m towards west and further 200 m towards south) to the north arm and170 m to the south arm as shown in Fig.2.[5].

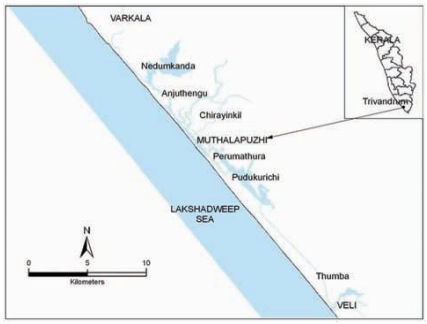

Fig.1.–Location of Muthalapozhi Harbour

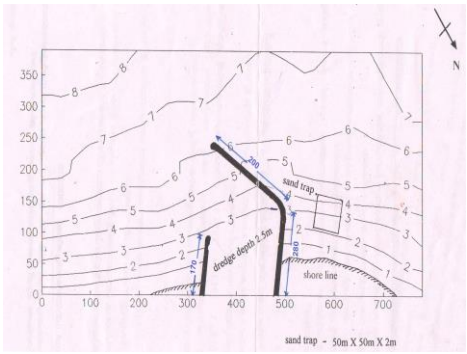

Fig.2.Layout of breakwaters as per original model study report

In the course of construction, it was observed that the mouth got chocked with sediment deposit and spit formation making the harbour unusable. Based on the expert advice of the research station, to rectify the problem, the breakwater design was modified and the extension of north arm towards south, once it reaches 280 m, was limited to 130 m and the south arm by a length of 160 m thus making the length of breakwaters to 410m and 330m as shown in blue colour (Fig.3)[2].

Accordingly construction was preceded. When the north breakwater reached up to 260m and the south breakwater up to 220m, heavy siltation, choking the entrance was observed (Fig.4)[4].

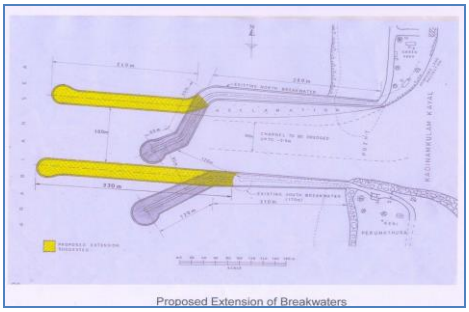

Fig.3.Alignment of the breakwaters as per the revised proposal

Fig.4.Siltation in the harbor basin

Then re-engineering studies were done to proceed further. Based on the studies, it is decided to extend the north breakwater by 240m and south breakwater by 330m, giving a combination of parallel breakwaters shown in yellow colour (Fig.3). Now the construction is in progress and there is considerable improvement in the tranquility condition. Here the net drift is observed to be towards north.

B. Scope of the present study

Questions regarding littoral and coastal management, such as how the coastline evolves over the short to long term scale with variations in hydrodynamics or beach conditions, are still open [1]. The predominant direction of the littoral drift is from the north to the south all along the Kerala coast. However, reversal of drift has been noticed in many reaches due to local topography, coastal constructions and mud banks. Analysis of charts, existing marine and coastal structures, and position of headlines and embankments, indicate that the dominant direction of littoral drift is towards South between Mangalore and Cochin. The view is further sustained by the migration of few inlets and the curvature of the coastal line from NNW to SSE direction. Any manmade structure along the coast affects the nearshore morphology [6]. Manmade structures include seawalls and groynes, to prevent erosion and breakwaters meant for tranquility inside ports and harbours. Construction of breakwaters, affect the equilibrium of shoreline both inside and outside the harbour.

Many studies on the shoreline behavior consequent to construction of breakwaters have been attempted by various authors. For example, [8] highlighted the impact of construction of breakwaters at Ponnani estuary on the coastal geomorphology. Ponnani is a major fish landing centre in Malappuram district of Kerala state. It is situated on the southern side of Malappuram district. A fishery harbour is being built at Ponnani estuary, by constructing two rubble mound breakwaters. The data on shoreline changes and migration of sandbars in the mouth was collected and analysed for different seasons, to assess the adjacent coastal changes and also the changes in the sandbar formation and inlet configuration. The results of the detailed analysis of data well established the shoreline

changes and sandbar migration in the estuary. The analyses of data on shorelines for different years and seasons revealed that the predominant direction of littoral drift at Ponnani harbour is from north to south.

Ref [7] studied the "Management of shoreline Morphological damages consequent to breakwater construction in the tidal inlet at Muthalapozhi, in Kerala". Sediment transport pattern has been reviewed and remodelled in the study to understand the siltation process leading to chocking of the harbour and suggested appropriate remedial measures. The study concluded that the sediment transport was towards north in Perumathura sector during the beach building period which bypassed the south breakwater and chocked the harbour mouth which could have been controlled and re-distributed towards south by making three transitional groynes of length 40m, 30m, 20m at 120m, 220m and 300m south of breakwater respectively.

In the present study an attempt has been made to present the shoreline behaviour in continuation to the above study consequent to construction of breakwaters at Muthalapozhi based on the modified alignment of breakwaters.

C. Materials and methods

Muthalapozhi harbour is in Trivandrum District where a huge quantity of siltation had occurred contradictory to the model study findings. In this paper an attempt has been made to assess the shoreline changes consequent to the construction of breakwaters by collecting the beach profiles from the concerned field office. These details are plotted on a base drawing to observe the changes occurred to the shore on either side. The details of the shoreline analysis done for the period from 17-7-2010 to 4-9-2010 shows the intensity of the shoreline changes which is depicted in Fig.5. The original proposal was to construct a northern breakwater of 410m and a southern breakwater of 330m.When the north breakwater reached up to 260m and the south breakwater up to 220m, heavy siltation, choking the entrance was observed. Then re-engineering studies were done to proceed further. Based on the studies, it is decided to extend the north breakwater by 240m and south by 330m, as shown in Fig.3. The shoreline changes for the period from 4/2008 to 1/2013 can be seen from Fig.6. The present scenario is seen from Fig.7.Here the net drift is observed to be towards north.

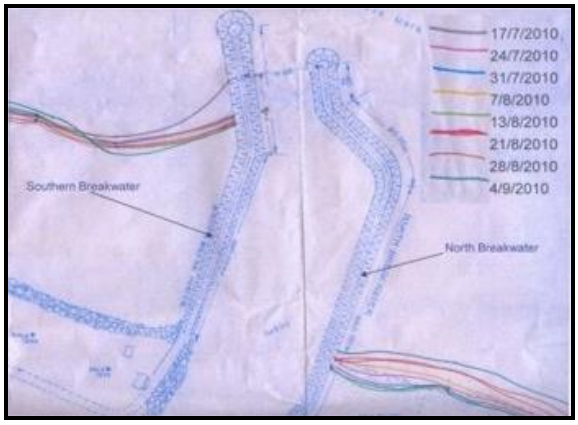

Fig.5. Shoreline changes from 17-7-2010 to 4-9-2010

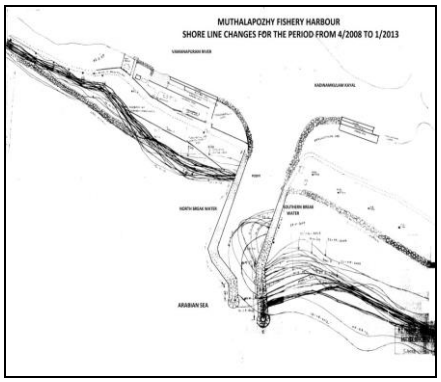

Fig.6.Shoreline changes for the Period from 4/2008 to 1/2013.

Fig.7.Google image showing the shoreline changes after the modified extension.

II. RESULTS AND DISCUSSIONS

The shoreline shows heavy accretion on the southern side which even bypassed to the entrance as shown in Fig.4. .The results indicated a reversal of drift direction predicted in the model studies and now the drift is observed to be towards North. In order to solve the problem of accretion at the mouth of the harbor, re-engineering studies

are done which resulted in to a modified alignment as shown in Fig.3. The construction based on this alignment commenced during 2013 and is progressing. The shoreline observed after re-commencing the work also indicated accretion on the Southern side indicating the trend of by-passing over a period of 15 to 20 years. Short term solutions for managing the same is either by extending breakwaters by another 300m and constructing a series of groynes on the southern side to act as littoral pockets and to protect the northern side by providing stone pitching to prevent the possible erosion or by pumping the sand depositing in the south side to the northern side for nourishing the beach on the northern side.

III. CONCLUSION

After construction of breakwaters with the modified alignment at the Muthalapozhi inlet the sand bar formation in the mouth has disappeared and navigability of the inlet has improved. Heavy accretion is observed on the southern side of south breakwater and slight erosion was observed near the northern breakwater side. It is found that accretion dominates the shoreline changes at Muthalapozhi. Thus the breakwaters were found to be very effective in training the river mouth and trapping the littoral sediments along the southern side. But the tendency of bypassing of sang inside the mouth over a period of 15-20 years is a matter of concern for the coastal engineers. Some short term measures for the present problems are suggested. Long term measures for the problems are much more cost intensive and it requires extensive studies also. Hence long term solutions of the problems of the inlet by state and local agencies are suggested, such as calling for the attention of the state and local government, research organisations.

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