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MODEL STUDY OF RIVER COOUM IN CHENNAI, INDIA

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***Abstract**: The estuary of river Cooum is flowing through Chennai is always choked with sand bar formation and obstructing free drainage of water into the sea during normal flow condition. Number of studies was carried out to observe the effect of tidal propagation along river, flow during various flood discharges and effect of groins at the estuary. Observations were made on the shoreline changes in the vicinity of the two groins on north and south side of estuary and propagation of tides. Based on the observations further studies were conducted. Physical model studies were done for tidal propagation and numerical model studies for estimation of alongshore sediment transport using Mike 21 software. The wave climate has been generated using MIKE21 Offshore wave (OSW) model from wind data and the littoral drift was estimated./ The flooding reaches during high discharges were also identified using physical model studies. The details of physical, numerical model studies, field observations and conclusions were highlighted in the paper.*

***Keywords**: sand bar; groins; shoreline; littoral drift.*

INTRODUCTION

The river Cooum flows in the middle of city of Chennai. In the city reaches it becomes a sewage carrier and the estuary is alwayschoked with sand bar formations. Hence it is proposed to clean the river in stage by stage. The clim atic conditions along this region are influenced by two seasons namely, the south west(SW) monsoon from May to September and north east (NE) from October to December. The river receives heavy flow during the NE monsoons. Due to heavy monsoon discharge the m outh gets opened and gets choked during south west monsoon. The alongshore sediment transport is also high during SW monsoon. Through notable contributions of Chandramohan et al. (1988), Ananth and Sundar (1990) and Sundar and Raju (1997), it has been established that the net littoral drift along the east coast of Chennai towards the north, varies between (0.8 and 1.2) $x10^6$ m^3 per year. Due to high alongshore drift and low river flow the estuary becomes choked. This in turn results in foul smell in the city. Apart from this during high flood discharges flo oding takes places in the city . One groin on the south side was constructed in 2001 and another on the north was constructed by January 2007 to keep the estuary open. The tidal propagation was also studied .The details of the field observation s, numerical and physical model studies are presented and discussed in this paper.

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STUDY AREA

The study area is the stretch of coast of about3km. and 7km on the landward side. The coastline is oriented in SE-NW direction as in Fig 1. River Cooum (13^{0}12’N, 80^{0}20’E) flows through the Chennai city and its estuary is located south of harbor. In the city reach the river gets split in to north and south arm as in Fig 2 and again rejoins before meeting the Bay of Bengal. The estuary is always choked with sand bar formation due to blockage of alongshore drift by Chennai harbor breakwater on the north side. and low flows in the river/

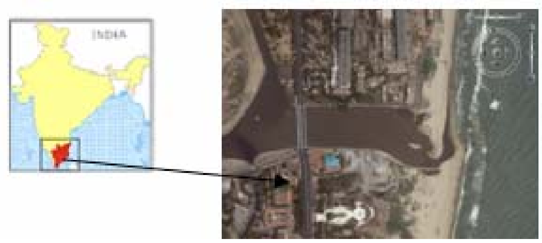

Fig 1 Index map

OBJECTIVES

- To observe the propagation of tide along the river
- To study the effect of providing gates at bridge locations and utilize the tidal for flushing
- To study the performance of the existing pair of groins at estuary
- Flood flow studies in the river
- Estimation of littoral drift

METHODOLOGY

- Field observations
- Analysis of Satellite Imageries
- Physical modelling
- Numerical modelling

FIELD MEASUREMENTS

The southern and northern groins were com pleted in 2001 and 2007 respectively. Shoreline measurements covering1 km of shoreline adjacent to south an d north groins were carried out every month from January 07 to Septem ber 07. About 70m of beach formation was seen by

March 07 adjacent to north groin. By May 07 the beach adjacent to north groin got eroded by 100m .Accretion of beach was seen adjacent to south groin and by October 07 about 65m of accretion was observed on the south side of groin. The satellite imageries available confirm qualitatively the direction towards the north. The construction of groins resulted in some tidal propagation. Hence the observations of water level variations were observed at Andrew, Harris, Peryar and Napier bridges located along the river in city covering nearly 6km of the river to assess the propagation of tide. The observations indicate variation of about 0.50m at Andrew Bridge.

Fig 2 Index map

SATELLITE IMAGERIES

The aerial photo over the study area for various periods was collected and preliminary studies were done. These include ICONOS imageries for 2001, 2002, 2004 (Fig 3). The analyses of imageries indicate that long shore drift is predominant and the sand is bypassing on the south side. About 170m of beach formation has taken place from 2001-2004.

Fig 3 Satellite imageries of Cooum estuary

PHYSICAL MODEL STUDIES

Physical rigid bedmodel to a horizontal scale of 1:400and vertical scale of1:50 was constructed (Fig - 4). It was observed at the field that the tidal propagation was felt up to Andrews bridge near Chennai Egmore. The physical model was constructed by incorporating Andrew bridge as wastern boundary and Bayof Bengal as eastern boundary. The water level variations due to tide was observed as 50 cm at 6th km. This effect was reproduced in the m odel and was thus proved.

Gates were provided at the locations of Andrew, Harris, Peryar and Napier bridge locations. Initially high water level was simulated and all gates were in open condition. Then the gates were closed. Then low water level was sim ulated in the estuary reach . The gates were suddenly opened and velocities in the estuary region were observed. The veloc ity was in the range of 0.8m/s.

Fig 4 Model setup

NUMERICAL MODEL STUDIES

For studying the Coastal Process, the wave climate is an important parameter. The wave climate consists of wave height, period and direction with respect to north. The two wave models that were adopted are Offshore Spectral Wave (OSW) or WAM model and Near Spectral Wave (NSW) models of MIKE21 developed by Danish Hydraulic Institute (DHI), Denmark using the National Centre for Environmental Prediction (NCEP) wind data. The bathymetry data for the model was derived from Earth TOPOgraphy 2 minute (ETOPO2) grid data base and discretized into a spatial square grid of size 77 km . The basic equations of OSW are based on the 3[rd] generation model, WAM Cycle 4 model of (Komen et al 1994) developed for deep-water applications on global and regional scales. NSW is a wind-wave model, which describes the growth, decay and transformation of wind-generated waves and swells in near shore areas. It takes in to account the effects of refraction and shoaling due to varying depth, local wind generation and energy dissipation due to bottom friction and wave breaking. It is a stationary, directionally de coupled parametric model. For details of the model physics and equations Holthuijsen et al (2000) and DHI, 2001 can be referred. The near shore measured bathymetry shown in Fig 5 and discretized into a 10 m by 10m grid and adopted for generating the nearshore wave climate. The nearshore wave climate thus generated was adopted for the estimation of alongshore sediment transport using Van Rijn (2001) approach. The rose diagrams obtained are shown vide Fig 6 to 8. The breaker angles were calculated by Snells law and are shown in Fig 9.

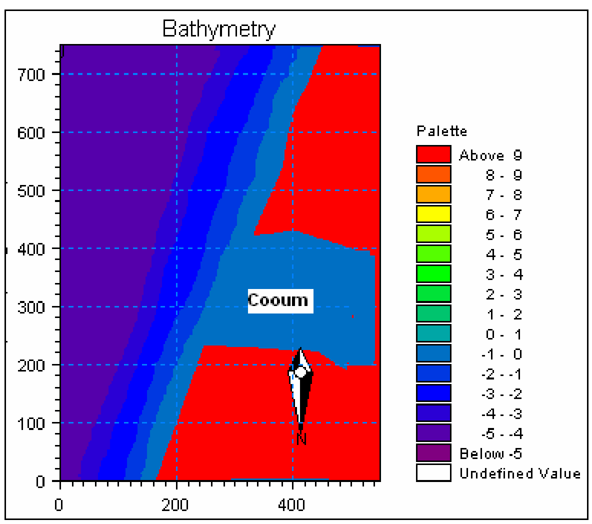

Fig 5 Bathymetry of estuary

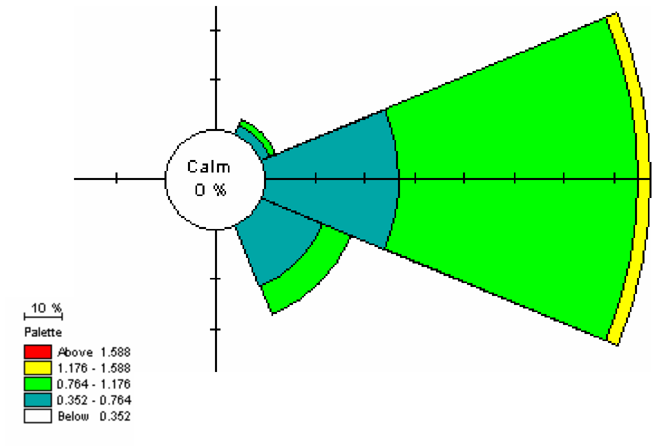

Fig 6 Wave rose for Non Monsoon period

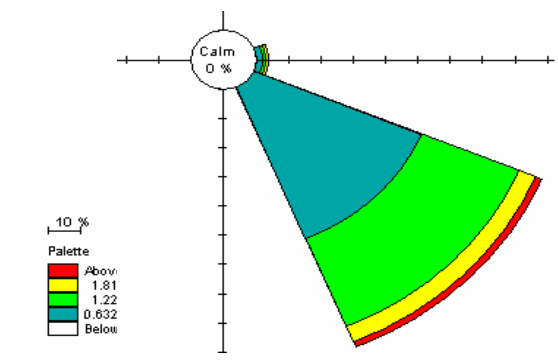

Fig 7 Wave rose for South West Monsoon period

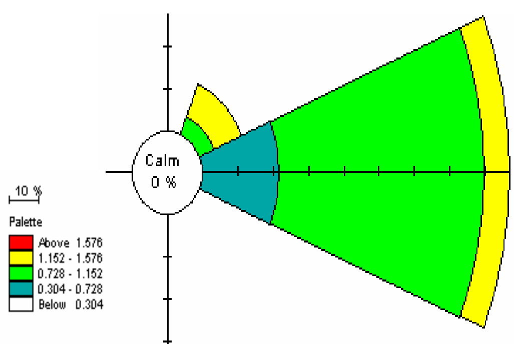

Fig 8 Wave rose for North East Monsoon period

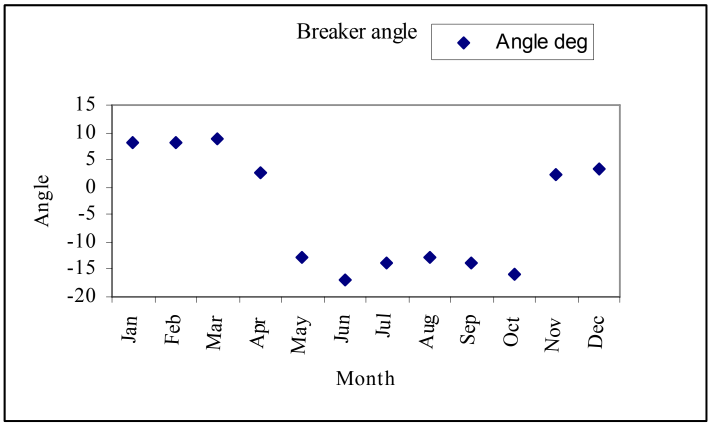

Fig 9 Breaker angle distribution

ESTIMATION OF LITTORAL DRIFT

The littoral drift estimates are made using Van Rijn (2001) formulation which considers both particle size and nearshore slope. The annual drift works out to be 0.31 million m^3 towards north. (Fig 10) The volume of littoral drift is nearly of similar order with the quantity measurement by Ramanamurthy et al. (2008) for the same coast.

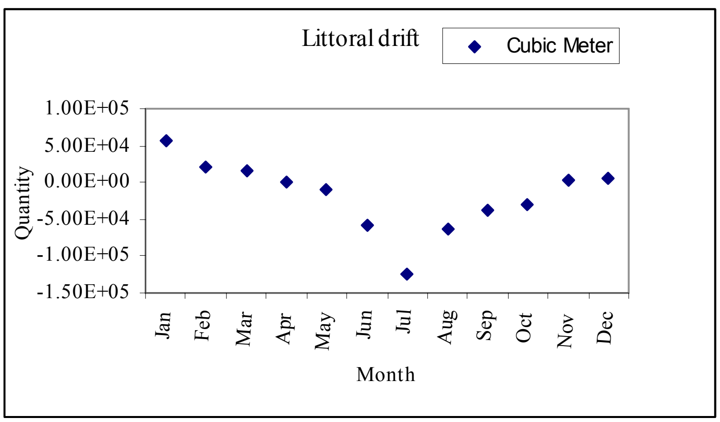

Fig 10 Alongshore sediment transport distribution

RESULTS AND DISCUSSION

The sand bar formation at the estuary and tidal flow in the river and flood flows was studied in detail using field observations, physical model and numerical model. The estuary gets opened only during north east monsoon. During the nonmonsoon periods as there was no sufficient flow velocity created, various attempts were tried for increasing the velocity by incorporating gates. The conditions at the estuary did not show any improvement. Hence the optimum arrangement is to deepen the mouth up to (-) 1.6m to facilitate more tidal influx. The southern groin can be dredged for a distance of 100m This sand can be nourished on the north side of north groin. The existing groins should not be extended any further.

CONCLUSIONS

During the tidal inflow and outflow, the main flow was in south arm only and only feeble flow along the northern arm of river Cooum was noticed during tidal flow. Hence the bed can be lowered up to (-) 1.6 up to Napier bridge so that more tidal inflow can be realised. The velocity observed was in the range of 0.8 m/s at present condition and after providing gates did not result in any appreciable increase of velocity. During flood discharge of 5 000 cusecs the river has sufficient flow in both the arms. For flood discharge above 20,000 cusecs flooding was noticed on reaches in the reach of Andrews Bridge. Provision of shutters does not result in significant increase in the velocity of flow at the estuary. The wave climate study indicates that most of waves approach from south east from April to October and from East & North east from November to March. The annual net alongshore drift works out to about 310000m^3 towards north.

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