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INTEGRATED DESIGN OF A PORT FOR A THERMAL POWER PLANT

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Abstract:

A port facility near Thirukuvalai, located 23 km south of Nagapattinam in Tamilnadu is designed to handle 12 MTPA of coal for a 2000 MW thermal power plant. The port will be augmented subsequently to handle bulk cargo, liquid cargo and containers. The cooling water (25,000m^3/hour) for the power plant will be drawn form the sea, i.e. from harbour basin and the warm water reject (20,000 m^3/hour) will be carried into the sea and released through diffuser ports. The different alternatives considered for the development of a harbour to receive capsize vessel to import coal for a 2000 MW power plant, the phase wise development, the numerical model study on littoral drift, integrated design of fishing harbour in between the groins and the numerical model study on diffusion of effluent varying the location of diffuser are presented in this paper.

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1.0 INTRODUCTION

The thermal power plants are loc ated in the coast so that the coal can be imported through a captive port. The average seabed slope near the location of the proposed power plant is 1:1000. The details of various investigations, the port layout including the commercial harbour, fishery harbour, sea water intake and outfall, shore protection methods based on numerical model study are presented in this paper.

2.0 SURVEY

The water depth contours upto 9m runs almost parallel to the coastline in this region. The water depth of 2m, 4m, 6m, 8m, 10m, 12m, 14m and 16m occur at distances of 250m, 1450m, 3200m, 4750m, 6850m, 8400m, 10700n and 14000m respectively.

The side scans survey record shows that the sea bed at nearshore, i.e. upto 5 km from the shore line consists of sandy clay. Thereafter, till 10 km distance, the seabed predominantly comprises of clayey sand.

The seismic study shows almost uniform composition of sediment thickness over this region. The entire surveyed area is covered with sedimentary layers without any hard strata. The isopach map shows that the minimum sediment thickness varies from 5m at nearshore to 15 mat offshore, i.e. at the end of the 15km long transects.

3.0 DIFFERENT ALTERNATIVES:

The different alternatives considered for the development of a harbour to receive capsize vessel to import coal for a 2000 MW power plant are

- ✓ Island Breakwater
- ✓ Open Sea jetty
- ✓ Shore connected Breakwater

Island Breakwater

The island breakwater to be located about 14km form the sho re line m ay create a tam bola formation behind the breakwater and affect the coast line. *Fig.1* shows the layout of port with island breakwater. In this type of integration of the seawater intake and outfall pipeline for cooling water and desalination water requirements is not feasible.

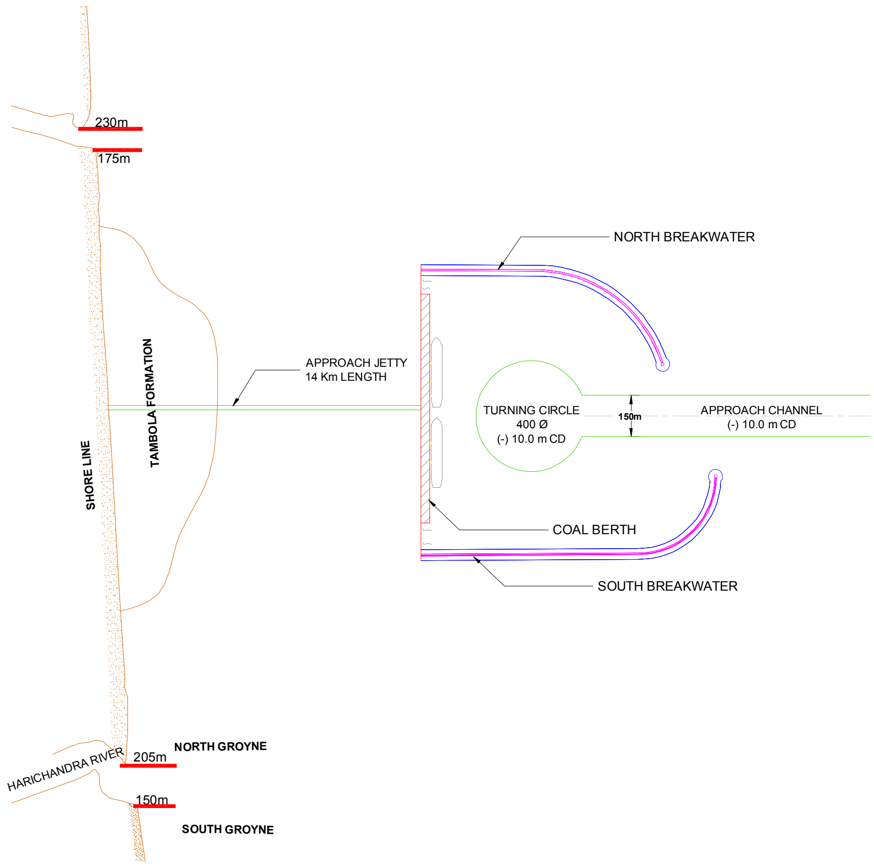

Fig. 1 Layout of port for the Island breakwater

Open Sea Jetty

This system involves construction of a RCC jetty starting from the land into the open sea to a water depth suitable for loading/unloading operation of the intended vessel size. The jetty is to be supported on piles. The top elevation of the jetty is fixed based on the environmental and operational conditions. The seaward end of the jetty consists of loading\unloading piers for berthing, mooring and loading\unloading of coal. Mobile unloading equipments placed on the deck of the pier will load\unload the coal from the bulk carriers and are transported to the shore by belt conveyors. The ship will be secured alongside the pier with a minimum of 6 mooring lines by conventional mooring system.

The approach jetty connecting the shore and pier will consist of belt conveyor systems, pipelines for water and oil, pipeline fo r power lines and an open channe l for sea water intake f or the cooling systems of the thermal power plant. Provisions for vehicle access to the pier of the jetty are also provided. *Fig. 2* shows typical open sea jetty layout of port.

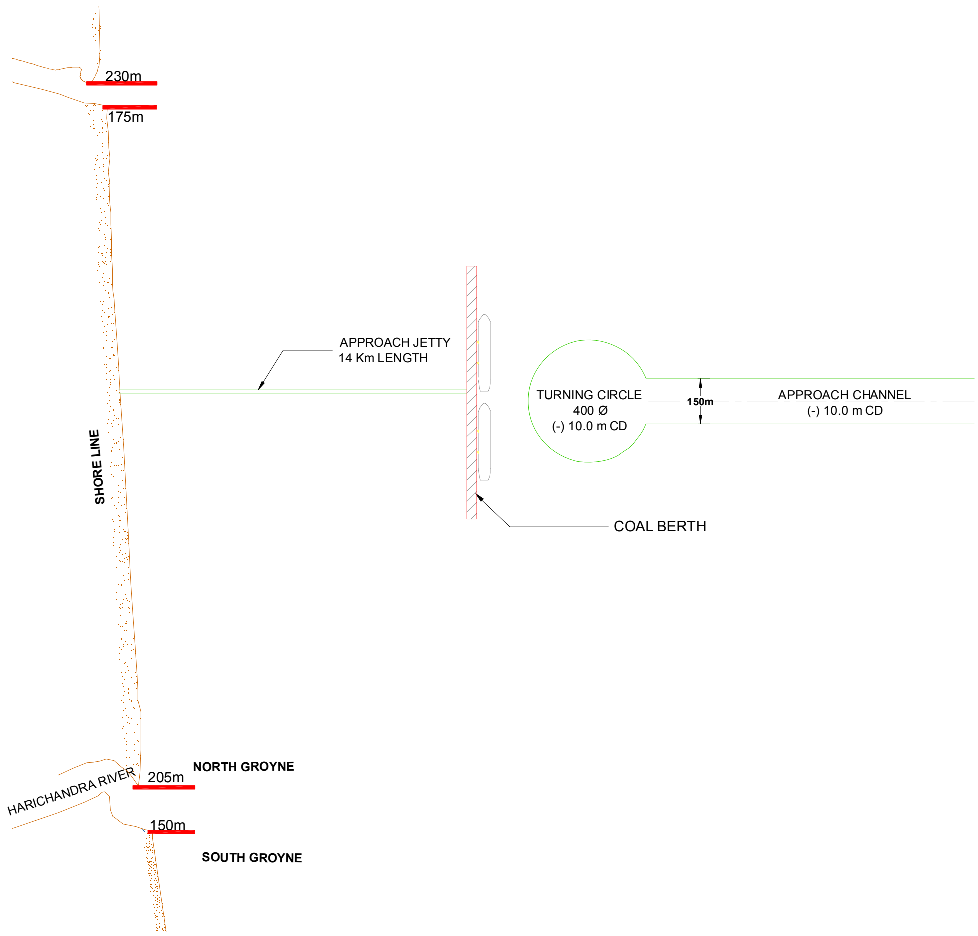

Fig. 2 Open Sea Jetty port Layout

The open sea jetty needs construction of 14km long approach jetty and provision of harbour facilities for harbour crafts is not feasible. The number of operational days also will be less.

Shore Connected Breakwater:

The breakwater is to provide tranquility for berthing and handling ships in the harbour basin. Two breakwaters are required to create tranquility in harbour basin. The shore connected breakwater needs about 2500m long breakwaters on both northern and southern sides. *Fig.3* shows the layout of port for the shore connected breakwater at Thirukuvalai port (VC Ocean Engg. & Consultancy Pvt. Ltd., 2009).

The position and orientation of the entrance to the port has been determined initially by estimate of wave penetration within the port as well as consideration of sediment movements and water quality. However, the existing littoral drift is in a net northerly direction a reasonable amount of sediment is shown to move in a southerly direction. Increased confidence in the positioning of the entrance is provided by numerical modeling for wave penetration, beach movement and water quality.

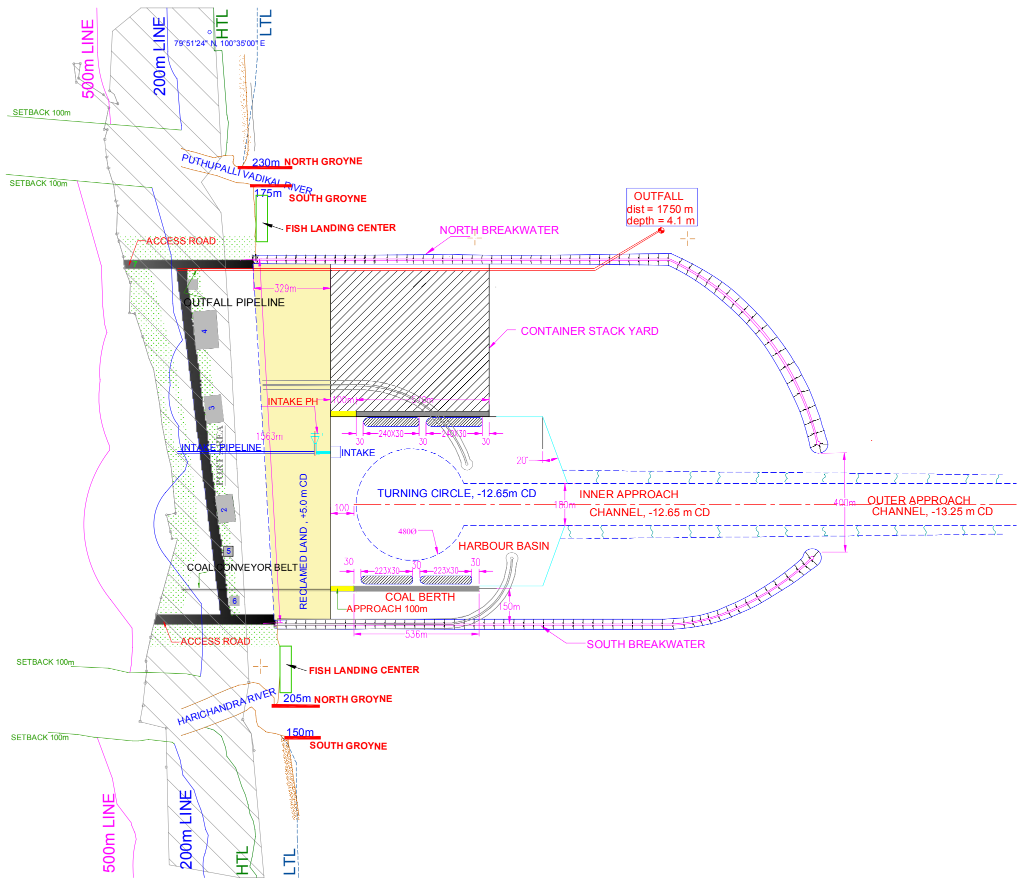

Fig.3 Layout of Port for the Shore connected Breakwater

The Harichandra River is at a distance of 410 m south of south breakwater and the Puthupalli Vadikal River is at a distance of 355 m north of north breakwater and the river mouths may be affected due to construction of the breakwaters. It is proposed to construct groins there by keeping the mouth open for free flow of water from the river as shown in fig.3. The dredging can be carried out in between the groins, since the groins will provide tranquility in between the groins. It is also proposed to provide fish landing centre in between the south breakwater and north groin of Harichandra River and north breakwater and south groin of Puthupalli Vadikal River.

4.0 TRANQUILITY STUDIES

The wave tranquility studies the harbour basin are carried out using the MIKE 21 Elliptic Mild-Slope Wave Module (EMS). MIKE 21 EMS is based on the numerical solution of the so-called ‘mild-slope’ wave equation originally derived by Berkhoff in 1972 (Indomer Coastal Hydraulics [P] Ltd., 2008).

Fair weather: The wave tranquility inside the harbour basin for waves approaching from east with a wave height of 1m and with different wave periods of 6 is shown in *Fig. 4.* Waves approaching directly parallel to the coast were observed to penetrate more into the harbour basin. It is observed that the tranquility is less for the waves having higher wave period. In the case of 6s waves, the wave height near the eastern wharf and near the turning circle, it remained with the wave heights of 1.0 m.

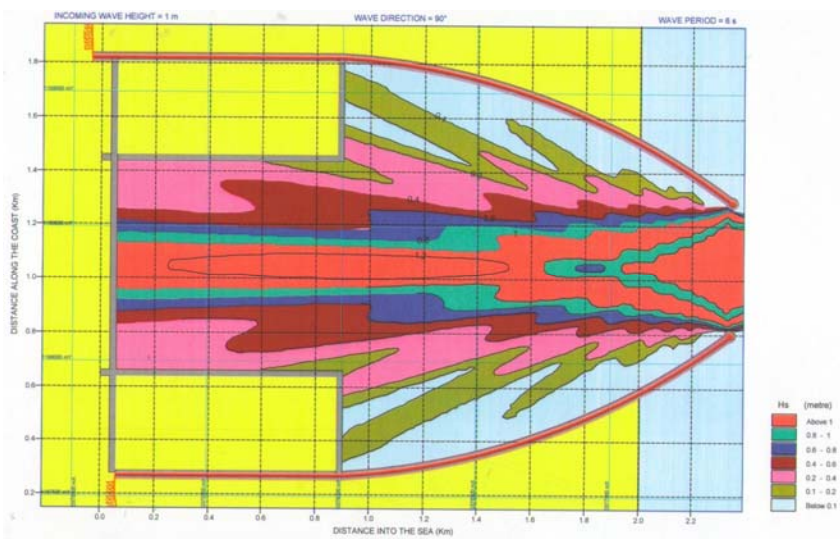

Fig.4 Wave Tranquility inside the harbour basin – Fair weather

Southwest Monsoon: The wave tranquility inside the harbour basin for the waves approaching from southeast (135^0N) with an incident wave height of 1m and with different wave period 6 is shown in *Fig.5*. The tranquility condition was not good till 1 km distance inside the harbour on the northern side. Very good tranquility conditions were observed along the berth region and on the southern side of the harbour basin.

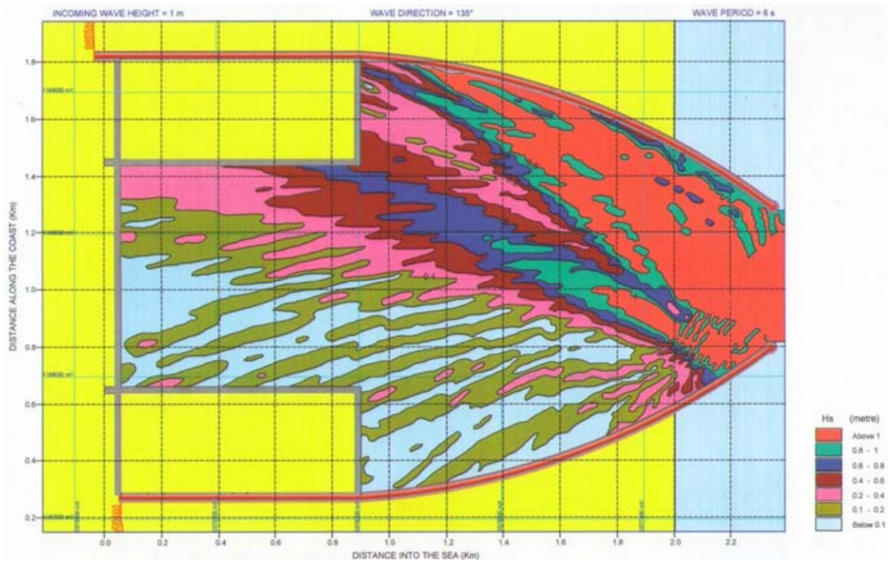

Fig 5 Wave Tranquility inside the harbour basin - southwest

Northeast Monsoon: The waver tranquility inside the harbour basin for the waves approaching from northeast (45^0N) with the incident wave height of 1m and with wave period 6s are shown in *Fig.6*. The tranquility condition was not good till 1 km distance inside the harbour on the northern side. Very good tranquility conditions were observed along the berth region and on the northern side of the harbour basin.

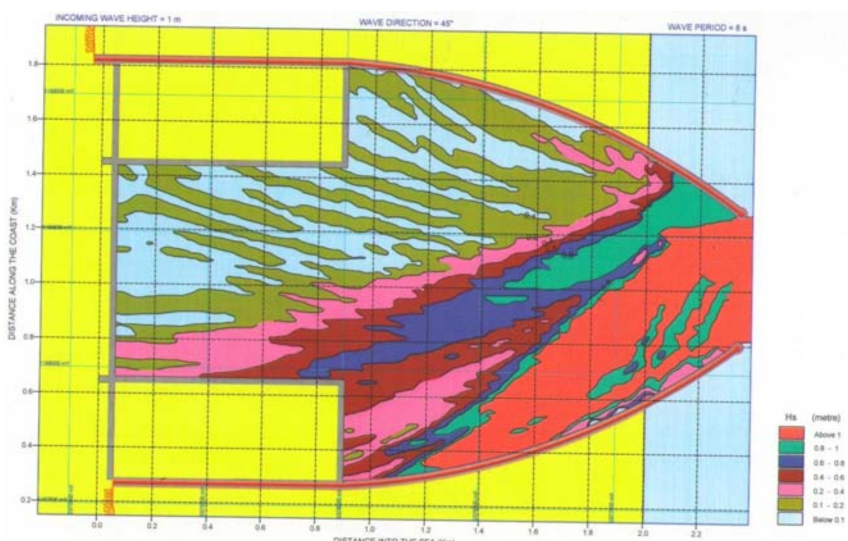

Fig 6. Wave Tranquility inside the harbour basin – northeast

5.0 PHASE WISE DEVELOPMENT

The phase wise development is proposed in two phases i.e. Phase I and Phase II to match with the phase wise requirement of power plant (Harbour and Coastal Engineering, 2002). In phase I, the coal handling capacity is expected to be 40,000 DWT for coal and 2nd Generation Container (with 1800 TEU capacity). The handling capacity will be increased to 1,00,000 DWT for coal and Panamax plus with 4600 TEU capacity for container in Phase II.

6.0 LITTORAL DRIFT

The littoral sediment transport of the port region has been evaluated using the DHI-LITPACK-LITDRIFT model. This model developed by Danish Hydraulic Institute, Denmark was used for the study. The deepwater NCEP wave data comprising of wave parameters at 3 hourly intervals is transformed to 5m water depth. Using these wave data as input to LITDRIFT module, the monthly littoral drift was estimated. The volume of littoral drift is low compared to the northern part of the east coast of India. The volume of littoral drift is relatively high in January, June, August, September, November, and December. The annual gross littoral transport is estimated as 0.57×10^6 m^3/year. It shows that this coastal region selected for port development is a nodal drift region with negligible annual net transport.

7.0 SHORELINE EVOLUTION

The shore line evolution of the study reg ion is estimated using the DHI-LITPACK-LITLINE module (Danish Hydraulic Institute, 1994).

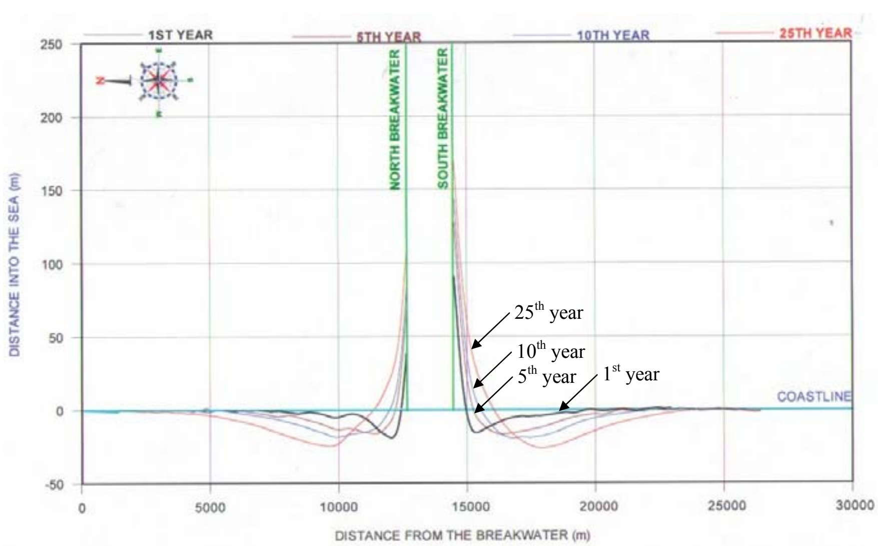

Fig.7 Shoreline changes with breakwater in LITLINE model

The shore line changes in the end of 1st year, 5th year, 10th year, 25th year and showing fig. 7. The effect of breakwater is foundto be affecting the coast for a distance of 5 km. The maximum erosion will be 20 mon the south of south breakwater and 25 m on the north of northbreakwater at the end of 25th year.

8.0 NUMERICAL MODEL STUDY ON DILUTION OF EFFLUENT AT DIFFERENT LOCATION OF OUTFALL

The seawater intake channel is located inside the port basin (Indomer Coastal Hydraulics [P] Ltd., 2008). The volume of water drawn form the port basin will be in the order of 25000 m^3/hr (6.94 m^3/s) and the amount of warm water released into the sea will be 20000 m^3/hr (5.56 m^3/s) with the temperature difference of 5^0C above ambient sea water. Thevolume brine rejects ofRO plant will be 2500 m^3/hr with the rise in salinity about 11 ppt that the ambient sea water. The brine reject from the RO plantwill be mixed with the blow down warm water (20000 m^3/hr) and hence the net increase in salinity will be about 1.0 ppt than the ambient salinity.

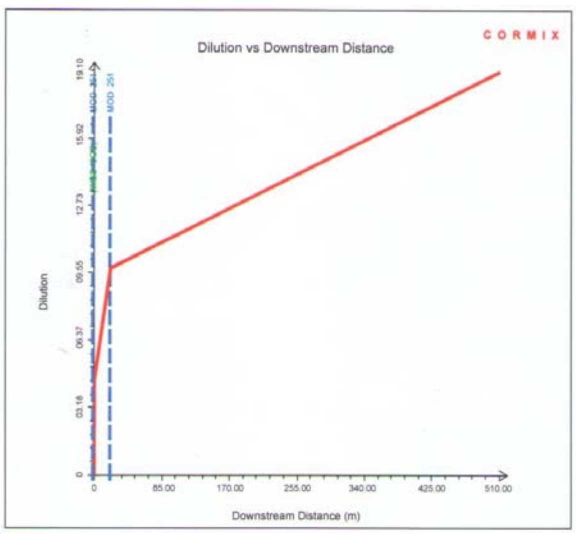

Fig.8 Dilution with Distance

The dilution of any effluent released in the sea takes place in two stages, viz. (i) initial dilution due to jet mixing and (ii) secondary dispersion due to turbulence. The initial dilution due to nearfield mixing is estimated using CORMIX (U.S. EPA and Cornell University, 1985-1995) model. The secondary dispersion due to farfield mixing is estimated using DHI-MIKE21-FLOW-AD model (DHI, Denmark). The study on CORMIX model shows the initial mixing zone i.e. the rising of plume to the surface is having a length of 100 m and a width of 35 m. Within this mixing zone, the warm water temperature reduces to 0.5^0C in less than 6 minutes.

Once the plume rises to the surface, the mixing zone extends further as secondary dispersion and the temperature further falls.

The modeling study was carried outto understand the extent of secondary dispersion and mixing of the warm water and brine reject in case of outfall located at 1500 m, 1750m and 2000 m distance into the sea. The simulation showed that the order of mixing due to secondary dispersion is less effective for the outfall located at distance of 1500 m compared to the results obtained at 1750 m and 2000 m distances into the sea.

The model results show that even in the absence of any initial dilution, the temperature difference of the warm water reduces to 1.0 ^{0}C in 210m distance from the outfall and the difference in salinity of brine reject reduces to 0.5 ppt within 10 m distance form the outfall in shore normal direction. The order of mixing increases with the distance of outfall from the shore.

9.0 CONCLUSION

Based on the detailed study on the following three layouts,

1. Island breakwater
2. Open sea jetty
3. Shore connected breakwater

It is proposed to use the layout with shore connected breakwater due to the following:

i) The island breakwater to be located about 14km from the shore line may create a tambola formation behind the break water and affect the coast line. In this type of facility integration of the sea water intake and outfall pipeline for cooling water and desalination water requirements is not feasible.

ii) The open sea jetty needs construction of 14km long approach jetty and provision of harbour facilities for harbour crafts is not feasible.

iii) The shore connected break water needs about 2500m long breakwaters on both northern and southern sides. The tranquility studies indicate that the long harbour basin between the breakwaters is found to dissipate the wave energy and the tranquility is very good at the location of the berths, about 1km inside the entrance. The long breakwaters also provide sufficient stopping distance for the vessels. The maintenance dredging in the navigation channel outside the harbour is estimated to be less than 5% of the capital dredging which indicated favorable operation costs. The capital dredging will be used for the reclamation of land inside the harbour basin for container yard and on south of south breakwater and north of north breakwater for the fish landing centre. The sea water intake is planned inside the harbour and the outfall pipeline is planned on top of the northern breakwater. The phase wise development is also feasible to match with the phase wise requirement of power plant.

iv) The numerical model study on littoral drift indicates accretion of shoreline on either side of the breakwater for a distance of about 1000m. Since the river mouths are in the accretion zone two groins each on either side of the two rivers are proposed to facilitate dredging of the river mouths. The space in between the groin and breakwater is planned as a fishing landing centres.

v) The primary treatment of storage of the disposal water from cooling tower for a day and mixing the disposed water from the power plant and desalination plant is observed to reduce both the temperature and salinity of the mixed effluent. Based on the numerical model study on diffusion of effluent varying the location of diffuser as 1500m, 1750m, 2000 m location of diffuser at 1750m is a water depth of 4.1m is recommended.

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