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WAVE TRANQUILITY ASPECTS FOR V.O.CHIDAMBARANAR PORT, TUTICORIN BY HYDRAULIC MODELLING TECHNIQUES

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Abstract:
The wave tranquility in the basin of harbor was basically decided by different standard such as bureau of Indian standard (BIS) and permanent international association in navigation congress (PIANC).the literature collected by different researcher has been reviewed and it was found that tranquility in the basin area is still challenge. The harbour tranquility can be determined by physical and numerical model studies. in this study, physical and numerical models on harbor tranquility are performed and their results are compared for wave tranquility .physical model studies is the miniature of proto based on Froude number with rigid bed and numerical models are performed by using MIKE 21 BW software. Both kind of model used for in the present study for simulation of wav propagation in harbour region with significant wave heights and directions which were considered to run the model. Such as south east (SE) and South (S) have been the wave generating heights and directions with a wave period of 7second each. It was found from model studies that extension of 300m in from of bund was an essential part to get tranquility in wave limits in harbor basin

Index Terms – **physical model, wave propagation, mike 21bw numerical model, wave tranquility**

I. INTRODUCTION

Wave is the disturbance on the surface of water. The sea waves are having different wave period, amplitude and different direction. Therefore waves are very dangerous in the sea because of different amplitude and different direction. The wave direction changes randomly as well as monsoon and non-monsoon. The wave height can be reduced with the help of break waters. Breakwaters are a device which break waves and do not allow waves to enter in the Lee side of the breakwater. Wave tranquility is a phenomena which allows the boats, sea ships and other vehicle of the sea without topple or any disturbances. The magnitude of wave tranquility is different for different type of ships such as for coal Ships it can be maximum whereas for oil tankers should be minimum. Therefore, tranquility is very much essential for the sustainable development for the port and basin areas. Naturally tranquility can be attained geographically sheltered port whereas artificial break waters are created to minimize the wave to enter in the port area. This subject is very vast and tranquility is depending on bed surface of sea, wave and tidal level. Therefore the tranquility is most advanced subject which is yet to be studied. Coastal engineering traces back to beginning when man begin building harbours to protect the navigational vessels and carried out to improve its operative conditions only. Last three decades much work has been carried out in this field to develop ports and harbours systematically. It is compulsory that the inner part of the harbours be in tranquil conditions. The tranquillity conditions are generally defined in terms of either wave heights within the harbour or various kinds of vessel movements, such as rotation and translation. No matter which factor is considered, the magnitude of the factor must be between the acceptable values. This is necessary not only for safe anchorage, but also for a safe and economical port administration.

II. Objective

In this study, physical and numerical models on harbour tranquility are performed and their results are compared. The aim of this paper is research study will focus on wave tranquility in the tutcorin V.O.Chidarmnar outer harbour are closely associated based on physical wave model studies the extenuation of breakwater or realignment of the breakwater will be proposed to increase the capacity of VOC Port, particularly container and coal traffic, the Port has proposed outer harbour.

III. Study Area

The Present Study Describes a V.O. Chidambaranar (VOC) Port, formerly known as Tuticorin Port is a major Port, situated in Thoothukudi district of Tamilnadu state on the south-east coast of India adjoining Gulf of Mannar at latitude 80^0 47'30" N - longitude 78^0 12'15"E Shown in 1. The study area considered here are 5.7km x 3.6km. Tuticorin Port is located in the close proximity to international main line shipping sea route connecting Far East Asia and the western world. For the proposed outer harbour development at VOC Port, various studies regarding wave tranquillity. The maximum tidal range in the port area is 0.90 m (MHWS 1.1 m and MHLS 0.20 m) the tidal currents in the region are weak. Due to the presence of rocky bed profile, the littoral drift and siltation problems are minimum in the region. Key commodities handled at VOC Port are coal, containers, fertilizers, granite stones, vegetable, and oil.

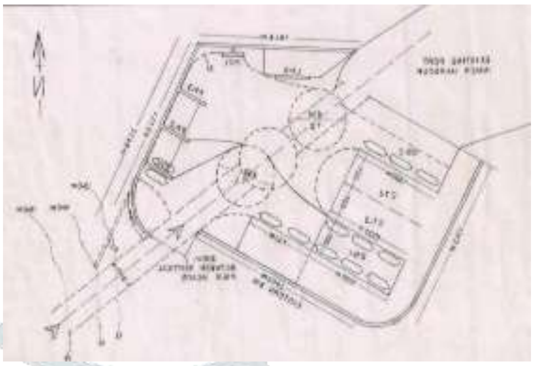

Figure 1 over view of V.O.Chidambaranar Port and The original layout for outer harbour development with outer harbour existing VOC Port, Tuticorin

The port has been developed with rubble mound type parallel breakwaters projecting the south breakwater has a length of 3.874 km and the north breakwater has a length of 4.099 km and the distance between these two breakwaters is about 1.275 km. The existing approach channel is 230meter base wide and 3.8 km long maintained at dredged depth of -12.8 m below chart datum with turning circle diameter of 480 m

In order to increase the capacity of VOC Port, particularly container and coal traffic, the Port has proposed outer harbour development by extending the existing north and south breakwaters respectively by about 4.512 km and 5.399 km and by adding 17 new berths mainly including container terminals located along south breakwater and coal berths along north breakwater. Dominant incident waves from south-east to south quadrant particularly for the coal berths located along the northern breakwater.

IV. Data Collection and Analysis

The deep water wave climate was obtained from IMD by analysing 33 years of ship collected visual wave data and are composed of sea waves, swell waves and combat ion of both. Frequency distribution of wave height analysis of the during entire period of January to December (which includes monsoon and non-monsoon period) was carried out which is called percentage occurrence of wave height & direction. These wave data were collected in the region of grid between 75^0 to 80^0 longitudes and 5^0 to 10^0 latitude Analysis of visually observed ship wave data indicated that the critical incident wave conditions south-east (SE) (Hs = 3.0 m) south directions (Hs = 2.5m) considering that the channel and entrance orientation is almost along SE direction and the harbour entrance is likely to face most predominant waves from the SE to South quadrant.

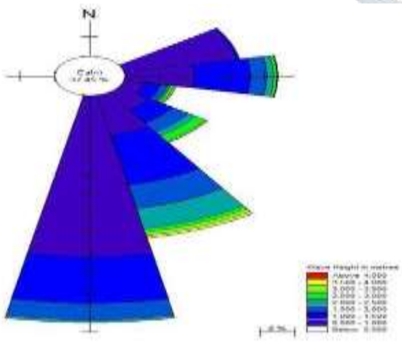

Figure 2 Annual Period (Jan– Dec)

Table no1 shown input wave condition

Wave Direction	Wave Height
East-South-East (ESE)	1.0m
East (E)	2.5m
East-South-East (ESE)	3.0m
South-East (SE)	3.0m
South-South-East (SSE)	2.5m
South(S)	3.5m

V. Hydraulic Modelling Techniques

5.1 Physical modeling techniques

Physical model study simulation of wave propagation in offshore region to harbour region respectively. Physical wave model studies were conducted in a Random Sea Wave Generation (RSWG) basin with a geometric similar (G.S.) scale of 1:120 based on Froudian similarity. Model tray is housed in the Multi-Purpose Wave Basin (MPWB) hangar of size 75m x 60m. The bathymetry of the study area for the year 2014 has been reproduced in the model to the scale as a rigid bed. Two wave paddle units of 11.0 m each have been used for generating incident waves respectively from incident SE and South directions in the model which corresponds to 2.64 km long water face (wave front) in proto. Power to wave paddles is supplied by the hydraulic power pack unit by creating required hydraulic pressures as per the input wave generation signal. Hydro Servo Actuator system is used for random sea wave generation. This RSWG system has the facilities for generation of waves in a frequency range of 0.3–3.0 Hz in model, significant waves of up to 10.0 cm and water depths of up to 25.0 cm in model. This MPWB hangar has facilities for generating random sea waves from three predominant directions of 22.0 m wave front each and can be modified as per the requirement of studies.

The RSWG system is based on Supervisory Control and Data Acquisition (SCADA) system. The multi-channel data acquisition system was utilized by using capacitance type probes for obtaining wave spectrums at 16 locations simultaneously. The physical wave model equipped with the random wave generation and multichannel data acquisition system proved to be very useful for realistic simulation of complicated wave patterns at the entrance and near the berths and acquiring an accurate wave climate in the development area. The various alternatives of the breakwater layout were tested before evolving the optimum alignment. In addition to this, the physical wave model provided very good visualization of the wave fields in the development area for different incident wave conditions.

Physical wave model where used in present study for simulation of wave propagation in offshore region and in the harbour region respectively. It take into consideration of phenomena of wave growth by action of wind, refraction, diffraction , shoaling and dissipation due to depth induced wave breaking of waves which are Important in the transformation of waves from offshore to inshore. A major application of physical wave model are determination and assessment of wave dynamics in ports and harbours and in coastal areas. The important factors when engineers are to select construction sites and determine the optimum harbour layout in relation to predefined criteria for acceptable wave disturbance ship movements, mooring arrangements and handling downtime.

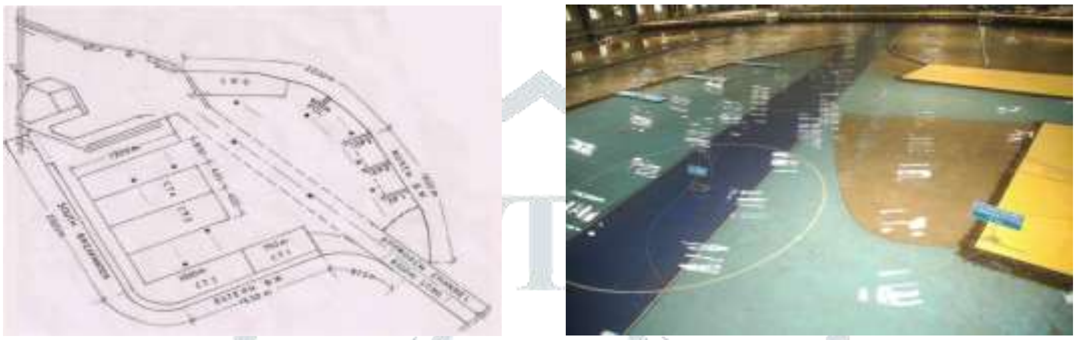

Figure 3 shown physical model setup proposed layout V.O.C Port Predominate direction, Desire wave tranquillity location with south and south east

Figure 5 shown physical model setup modified layout with additional 300m BW, V.O.C Port Predominate direction, Desire wave tranquillity location with south and south east

5.2 Numerical Model

In my present M-tech thesis mathematical model studies for wave tranquility conducted by using MIKE-21 BW model for outer harbour development of V.O.C port, tutcorin. thewave tranquility results obtained by MIKE-21 BW model were compared with physical wave model studies conducted earlier and the conformity of wave tranquility obtain on both the models have been ascertained The Boussinesq Wave model, MIKE 21 BW, isthe state-of-the-art numerical model for calculation and analysis of short and long-period waves in ports, harbours and coastal areas. MIKE 21 BW can also be used for detailed modeling of wave-induced current fields, surf zone dynamics and swash zone oscillations. The model is based on the numerical solution of the enhanced Boussinesq equations formulated by Madsen and Sorensen. MIKE 21 BW is capable of reproducing the combined effects of all important wave phenomena of interest in port, harbour and coastal engineering. These include Shoaling Refraction, Diffraction, Wave breaking ,Bottom friction, Frequency spreading, Directional spreading, Wave breaking ,Bottom friction, Frequency spreading, Directional spreading, Wave breaking ,Bottom friction, Frequency spreading, Directional spreading. Mathematical model studies to assess wave tranquility in the harbour basin were carried out using MIKE 21 BW. The mean sea level of 0.64 m at V. O. Chidambaranar Port has been considered for the wave tranquility studies using MIKE 21 BW. The model was simulated for the input wave conditions derived from the wave transformation studies for each harbour Layout suggested. The V. O. Chidambaranar Port Trust officials have different layouts for the studies. Based on the physical model studies proposed layout and Modified layout studied and thesame layout studies in MIKE 21 BW model used to study the wave distribution in the harbour area with these layouts and results are discussed

5.2.1 Model set up for proposed layout description and bathymetry

Proposed layout for the outer harbour consists of the south & eastern breakwater of length 4875 m and north breakwater of length 4000 m on the lee side of the southbreakwater. Berths CT1, CT2, CT3 and CT4 have been proposed. Adjacent to the north breakwater CP1, CP2, CP3, POL and LNG berths have been proposed. The berths CP1, CP2 and CP3 are normal to the north breakwater. Two number of turning circle of 650 m diameter each dredge with -18 m have also been provided the mathematical modelstudies for wave tranquility with this proposed layout were carried out which shown in figure 6

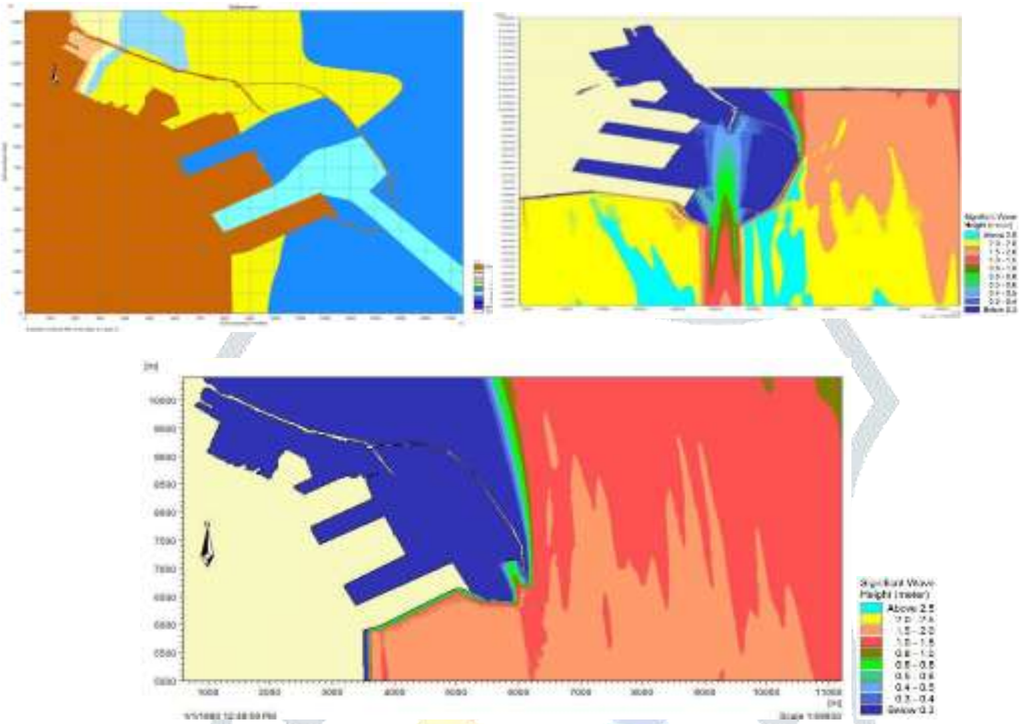

FIGURE 6 .BATHYMETRY 0F PROPOSED LAYOUT FOR MIKE 21BW STUDIES WAVE HEIGHT DISTRIBUTION PLOT FOR INCIDENT WAVEHEIGHT DIRECTION - 3.0 M/ SE FOR PROPOSED LAYOUT AND WAVE HEIGHT DISTRIBUTION PLOT FOR INCIDENT WAVE HEIGHT/DIRECTION- 2.5 M/ SOUTH FOR PROPOSED LAYOUT

5.2.2 Model set up for Modified layout description and bathymetry

to protect the developments on the lee side of north breakwater (i.e. cp1, cp2, cp3, pol, lng berths) from se and south incident wave directions a 300 m long groyne has been proposed at the entrance on the north breakwater. This is only the change considered in the layout in the study. In order to study the effect of this groyne and study of wave propagations along the channel only two wave directions were studied for this modified layout. These two wave directions were also studied through physical wave model. The mathematical model studies for wave tranquility with this modified layout were carried out. The bathymetry was discretized with 4 m grid size covering the area of about5.7 km x 3.6 km in figure 7. Bathymetry used for the studies extends up to -18 mdepth so that the waves start beyond the channel.

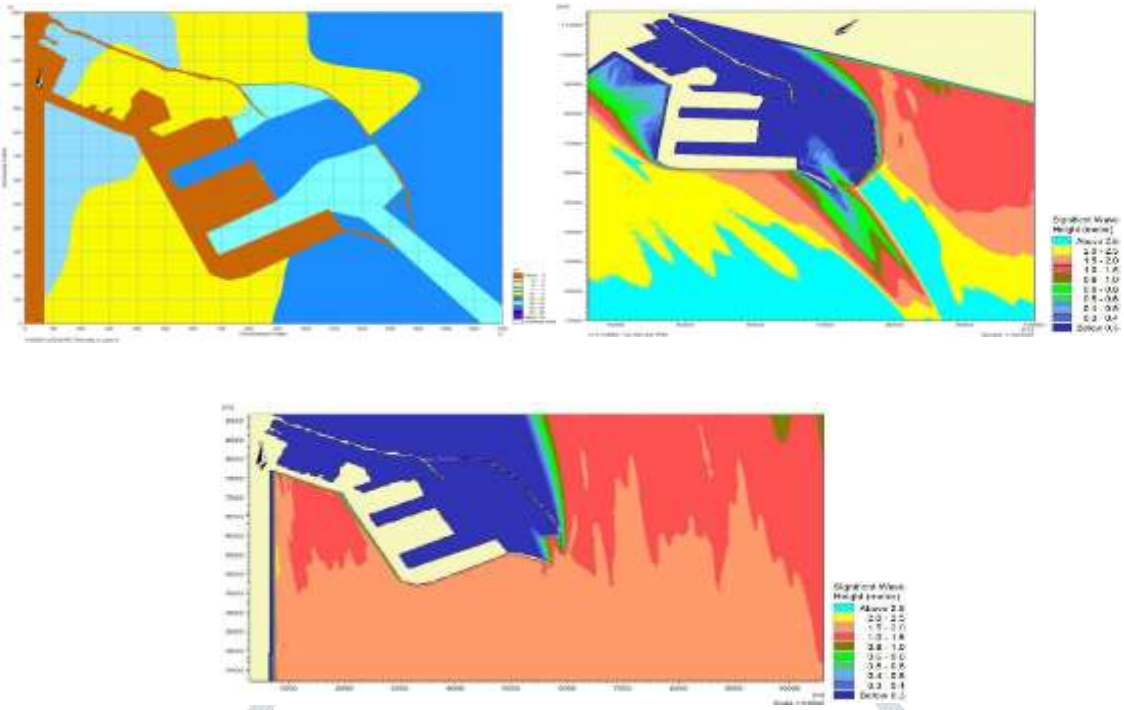

Figure 7 .bathymetry 0f modified layout for mike 21BW studies, wave height distribution plot for incident waveheight direction– 3.0 m/ se for proposed layout and wave height distribution plot for incident waveheight/direction- 2.5 m/ south for modified layout

VI. Result and Conclusions for the Wave Tranquility Studies

these hydraulics wave model studies were conducted for the proposal of outer harbour development of v.o.c. port, Tuticorin at laboratory using a geometric similar scale of 1/120 by random sea wave generation for the two predominant incident wave directions, viz. 3.0m hs – 7 sec tp (from se direction) and 2.5m hs – 7 sec tp (from south direction)

These hydraulics wave model studies indicated that with the revised Alternative –2 layout suggested by the project authorities (Figure 4.3), the berths located along north breakwater viz. CP-1, CP-2, CP-3 would experience wave disturbance greater than prescribed wave tranquility limit of 1.0 m mainly due to the incident waves from quadrant SE to South resulting into a loss of 40 operational days in a year. However, adequate wave tranquility would be obtained at all other berths

These hydraulics wave with the modified layout as suggested by experiments after providing the additional breakwater of about 300m length at about 500m from the berth CP-1, towards the entrance and perpendicular to the north breakwater, model studies indicated that the wave disturbance at coal berths CP 1-3 would be significantly reduced. With this modified layout, adequate wave tranquility would be also obtained at all berths throughout the year.

It is observed from compression of significant wave height for proposed layout and modified layout (providing additional breakwater of about 300m length at about 500m from the berth CP-1) compression of south east direction (Hs 3.0m- Tp7 seconds).with both physical model and mathematical model.it is observed thatwith final modification layout the overall wave tranquility in harbour basin increase and thus all the berths would be safe with adequate wave tranquility throughout the year Hydraulic models are commonly used during design stages to optimize a structure and to ensure a safe operation of the structure. They have an important further role to assist non-engineering people during the decision-making process. A hydraulic model may help the decision-makers to visualize and to picture the flow field, before selecting a suitable design. Such computationaltechniques are essential tools for design activity in which activity waves play a significant role. The wave tranquility studies that conformity is obtained between physical wave models as well as mathematical model studies which is shown in table no2

Table no 2
Compression table of Significant Wave heights for proposed layout and modifiedlayout with additional 300B/W for south –east direction

Location	South-East(SE) Hs 3.0m – Tp7Seconds		South-East(SE) Hs 3.0m – Tp7Seconds	
	Physical modal		Mathematical modal	
	Propose d layout	Modified layout with additional 300m B/W	Propose d layout	Modified layout with additional 300m B/W
CP1	0.62 m	0.40 m	0.30 m	0.28 m
CP2	0.60 m	0.45 m	0.27 m	0.25 m
CP3	0.55 m	0.35 m	0.30 m	0.22 m

POL	0.58 m	0.40 m	0.45 m	0.24 m
LNG	0.60 m	0.42 m	0.48 m	0.20 m
TC1	0.80 m	0.35 m	0.35 m	0.24 m
TC2	0.85 m	0.45 m	0.75 m	0.32 m
CT1	0.35 m	0.35 m	0.35 m	0.28 m
CT2	0.25 m	0.25 m	0.20 m	0.19 m
CT3	0.35 m	0.35 m	0.21 m	0.22 m
CT4	0.40 m	0.39 m	0.20 m	0.23 m
Multipurpose Berth	0.50 m	0.42 m	0.45 m	0.24 m

It is observed from compression of significant wave height for proposed layout and modified layout (providing additional breakwater of about 300m length at about 500m from the berth CP-1) with south east direction (Hs 3.0m-Tp7 seconds).the wave tranquility studies that conformity is obtained between physical wave model as well as mathematical model studies. it is observed from compression of significant wave height for proposed layoutand modified layout (providing additional breakwater of about 300m length at about 500m from the berth CP-1) compression of south direction (Hs 2.5m-Tp7 seconds).with both physical model and mathematical model.it is observed that with final modification layout the overall wave tranquillity in harbour basin increase and thus all the berths would be safe with adequate wave tranquillity throughout the year Hydraulic models are commonly used during design stages to optimize a structure and to ensure a safe operation of the structure. They have an important further role to assist non-engineering people during the decision-making process. A hydraulic model may help the decision-makers to visualize and to picture the flow field, before selecting a suitable design. Such computationaltechniques are essential tools for design activity in which activity waves play a significant role. The wave tranquillity studies that conformity is obtained between physical wave models as well as mathematical model studies which is shown in table no 3.

Table no 3Compression table of Significant Wave heights for proposed layout and modifiedlayout with additional 300B/W for south direction

Location	South(S) Hs 2.5m –Tp7Seconds		South(S) Hs 2.5m –Tp7Seconds	
	Physical modal		Mathematical modal	
	Proposed layout	Modified layout with additional 300m B/W	Proposed layout	Modified layout with additional 300m B/W
CP1	0.60 m	0.55 m	0.27 m	0.26 m
CP2	0.65 m	0.50 m	0.26 m	0.25 m
CP3	0.50 m	0.55 m	0.29 m	0.24 m
POL	0.45 m	0.38 m	0.30 m	0.30 m
LNG	0.50 m	0.32 m	0.27 m	0.22 m
TC1	0.48 m	0.60 m	0.25 m	0.25 m
TC2	0.50 m	0.50 m	0.26 m	0.24 m
CT1	0.25 m	0.25 m	0.20 m	0.19 m
CT2	0.25 m	0.25 m	0.18 m	0.17 m
CT3	0.25 m	0.25 m	0.24 m	0.21 m
CT4	0.50 m	0.47 m	0.23 m	0.19 m
Multipurpose Berth	0.42 m	0.45 m	0.29 m	0.20 m

VII. ACKNOWLEDGMENT

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