FEASIBILITY OF ACCEPTING VESSELS WITH LARGER DRAFT OF UP TO 18M AT INTERNATIONAL CONTAINER TRANSHIPMENT TERMINAL (ICTT) COCHIN

Final Report

Executive summary

May 2020

Client

India Gateway Terminal Private Limited (IGTPL) Consultant

Prof. K. Murali

Prof. S. A. Sannasiraj

National Technology Centre for Ports, Waterways and Coasts

New Academic Complex – 6th Floor

Indian Institute of Technology Madras

Chennai – 600 036

Contents of the Report

Feasibility of Accepting Vessels with larger draft of up to 18m at International Container Transshipment Terminal (ICTT) Cochin

Executive Summary

1. Introduction

Cochin Port is one of the 12 Major Ports of India. This all-weather natural port is located at Latitude 9° 58' N and Longitude 76° 16' E on the South West Coast of India in the state of Kerala. The existing harbour basin is within the naturally protected area of Cochin lagoon. The entrance of the Port is through the Cochin Gut between the peninsular headland of Vypeen and Fort Cochin. The approach channel to the Port up to the Cochin Gut is about 13 km long with a width of 260m for a length of 11km and 286m for the remaining length; design depths varies from (–)15.95m CD to (-) 17.4m CD and to maintained throughout the year. Main facilities of the Port are located on the artificially created Willington Island on the south and Vypeen and Vallarpadam on the north.

India Gateway Terminal Private Limited (IGTPL) has entered into a License Agreement dated 31st January 2005 with the Cochin Port Trust CoPT for the Development, Construction, Operation and Management of the International Container Transhipment Terminal and the Development, Operation and Management of the Rajiv Gandhi Container Terminal (RGCT).

2. Objective

To Conduct a Detailed Study on the Feasibility of Accepting Larger Vessels With Draft up to 18m at ICTT, the present study is to assess the stability of the existing ICTT berth while carrying out the additional dredging in front of the berth up to -18m CD from the designed depth of 16m, in order to bring the larger vessels into the harbour basin as envisaged by the India Gateway Terminal Private Limited (IGTPL) without carrying out any major modification of the existing berthing structure as per the scope mentioned hereunder;

2.1 Phase I- Feasibility study

- Assessment of navigational requirements and redesign of approach channel & turning basin as per IS 4651 & Buoy Requirements.
- Assessment / re-validation of structural stability due to deepening and proposed strengthening measures and refit of berthing /mooring arrangements based on available soil data.
- Hydrodynamic and siltation model study for estimation of siltation and maintenance dredging requirements & impact on backwater areas.
- Assessment and preliminary design of bank protection measures for a length of about 600m & assessment of stability of islands/land/shoreline within a radius of 5km.
- Preparation of Block Cost Estimate and cost-benefit analysis based on available traffic

studies.

2.2 Phase II- Detailed study

- Navigational simulation on a 360 deg. full Mission bridge.
- Assessment of stability of all berthing structures within a radius of 2 km.
- Dredging estimates in terms of quantity, cost & time. This includes cost of seabed geophysical investigations for obtaining dredging material properties and locating obstacles.
- Preparation of EIA Report using monitoring data.

  Note: The scope covered under the present study is limited to Phase-I. However, Phase-II studies shall be undertaken if required, at a mutually agreed cost, upon completion of the present scope of work.

2.3 Additional Scope

As an alternative to the option of deepening the existing berth, ICTT is considering taking up development of V4 of their original plan for handling deep drafted vessels. To this effect, ICTT had issued an variation order for the development of a New berth of 350/400 M towards Vypin side (Western side) (“V4”) in the ongoing study on feasibility of accepting vessels with larger draft upto 18m at ICTT as per the scope furnished below:

- Preparation of preliminary layout of the additional berth.
- Re-running Hydrodynamic and siltation model study for estimation of siltation and maintenance dredging requirements & impact on backwaters areas
- Assessment of Bank protection measures for an extent of about 600m & assessment of stability of islands/land/shoreline within a radius of 5km and preliminary design, if any.
- Preparation of Block Cost estimate.

3. Layout of ICTT berth and Additional Berth

The Layout of the Existing ICTT berth along with the proposed Additional Berth is shown in figure 3.1

Figure 3.1 Layout of the Existing ICTT berth along with the proposed Additional Berth

4. Contents of the Report

The Report consists of Mainly four parts viz Part I- Structural Stability and Adequacy of existing ICTT berth for larger container vessels , Part II- Dredging, Marine, Bank Protection & Part III-Feasibility Study for the additional Berth the existing ICTT berths, towards Vypin side (Western side) ("V4"), Part IV- Book of Drawings and Charts.

4.1 Part I: Structural Stability and Adequacy of existing ICTT berth for larger container vessels

4.1.1 Design Vessel Parameters

The present study relates to handling of large size container vessels with Draught 16m in Phase-I and 18m in Phase-II. For this purpose the following design vessels are considered as per the requirement of ICTT

Vessel Dimensions	Length (m)	Beam (m)	Draught (m)	Dimensions of existing Berth	
				Length (in m)	Width(in m)
Phase-I	400	59	16	600	40
Phase-II	400	62	18	600	40

4.1.2 Assessment/re-validation of structural stability due to deepening and, proposed strengthening measures & refit of berthing /mooring arrangements based on available soil data" including cost estimate

- As detailed in the Interim Report dated June 2019, all transverse beams are not safe for the critical load combinations considered in the analysis as per relevant Indian Standards. However, this could not be verified with the original design documents as they were unavailable. Further, Factor of Safety 2.0 has been considered for the design checks as per the IS codal provision currently in vogue. However, the original factor of safety as per prevailing guidelines at the time of original design was 1.4. Due to this gap in the design aspects, it may be apt to parallelly explore the possibility of constructing an additional berth towards "Vypin Side" (V4) to handle vessel with capacity of 197300 DWT

- However, details about the Structural Stability of the existing berth could not be conclusively established for want of basic assumptions and Design basis from the original design consultant of the client However, the assessment on the part of NTCPWC was completed based on the available data and portions of the structure which have not satisfied design requirements as per IS codes for the proposed future vessels have been identified.

4.2 Part II: Dredging, Marine, Bank Protection

4.2.1 Assessment of Navigational requirements, redesign of Approach Channel and Turning Basin as per IS4651 and buoyancy requirements

In General, the approach and entrance channel for any Port including that of Cochin Port shall be designed as per PIANC guidelines. As per industry practice, the channel design shall serve as a conservative estimate as it accounts for all environmental, sea bed, navigational aspects. It provides for all variations and specifies safe allowances. However, the channel design may be reconfirmed by navigation studies in a bridge simulator for additional comfort and fine tuning. The design presented in the following sections, including environmental parameters used, basis of design and outcomes of design have been consulted with CoPT and approval of the same has been obtained as per emails of the Chief Engineer dt 30 & 31 Mar., 2020.

An analysis of the Siltation rate in the Outer Approach Channel based on the existing CWPRS report was carried and observed that, Prima-facie, the CWPRS report dated July 2007, shared by the Port, is related to Ship Manoeuvring to optimize the approach channel dimensions and which has no relevance to the Hydrodynamic Model. In addition, the report contains the data relating to wave, wind and current and not on Siltation rates. Hence, NTCPWC's assessment of the Siltation rates based on its own independent Hydrodynamic model is considered to be more scientific and reliable

4.2.2 Channel width required at straight portions (Up to chainage 0.0):

As per the above allowances, a single way channel IN THE STRAIGHT PORTIONS shall require a width of 3.8 x Beam. However, as per IS4651 the minimum width for a single way channel shall be considered as 3.3 x Beam. **In this case, therefore, the channel width required for the proposed design vessel will be 225 m.** The width available presently is 260m up to Cochin gut which is more than the required width. Hence, the channel does not require widening.

4.2.3 Channel width required at bends.

Considering the present traffic numbers at CoPT & ICTT, it is recommended that it is apt to provide a Single way channel for the Design vessel above. **In this case, therefore, the channel width required for the proposed design vessel will be 266 m.** In the Entrance channel also, the width of 286m is available which is sufficient for catering for the mild change in course.

Therefore, the present channel does not need any widening to cater for single way traffic of the design vessel. However, while deepening the channel, the slope portion will become extended. This quantity has be taken for estimation purpose.

4.3 Hydrodynamic and Siltation model study for Estimation of Siltation and Maintenance Dredging requirements and impacts on Backwaters

4.3.1 Methodology

Demarcation of the study domain is done to set up the extent of the model domain. Hydrodynamics modelling of the Kochi backwaters is executed using Ocirc circulation model. Modeling the bed evolution is performed using the morphodynamic routine of Ocirc and estimate of siltation is based on simulation.

4.3.2 Hydrodynamic Modelling

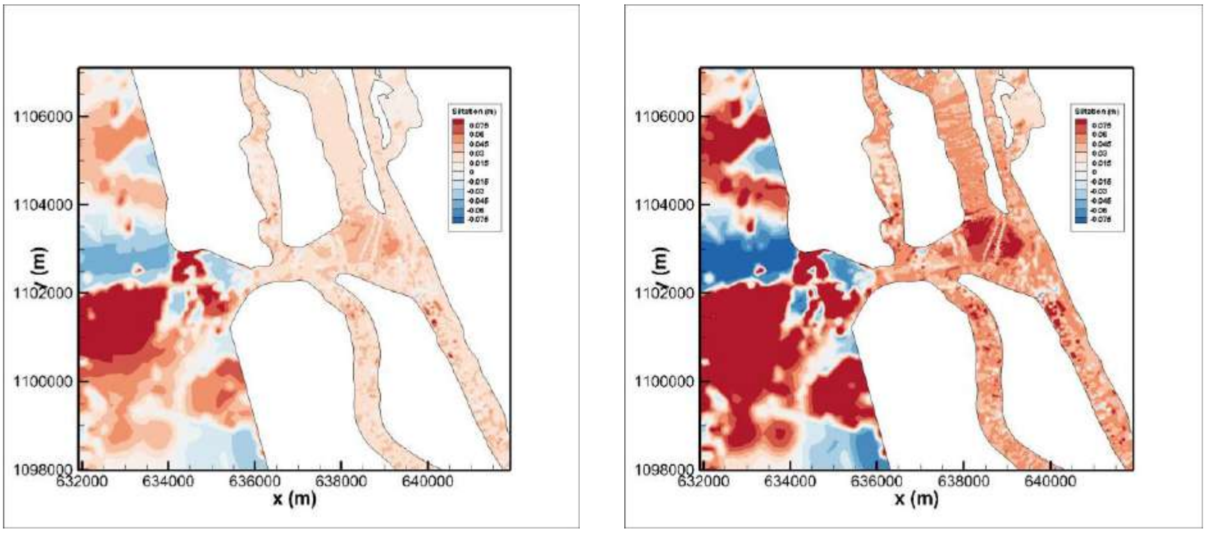
Siltation study predicts the siltation rate in the ICTT basin of Cochin harbour. The average siltation rate is 0.04-0.05m/14 days. Based on the simulation the siltation is more in the approach channel which is of range, 0.05-0.06m/14days than near the turning circle and here the maximum siltation rate of siltation is 0.055m/14days.

During monsoon season the rate of siltation increase by 60-80% with increased TSS. The morphodynamic simulation is carried out implementing the Phase-II changes in the bathymetry, and the same is incorporated in the numerical model. The details of the bathymetry with the proposed increased depths are incorporated in the model.

Based on the morphodynamic results, it was observed that, there is a 20-40% increase in siltation overall, on implementing the phase-II dredging. Some parts of the channel or the dredged areas show very low increase in rate of siltation by 5%. In some parts the rate of siltation remains the same. This study is done for both monsoon and non-monsoon periods.

4.3.3 Morphodynamic Modelling

The dredge estimation discussion is carried out for ICTT basin of Cochin harbor. The estimation of dredge quantity is discussed for non- monsoon and monsoon respectively. The total dredge quantity estimated for ICTT basin is 0.937 Mm^3/yr for phase-II dredge developments. The dredge quantity increased by 27% overall from the current situation due to phase-II development.



a) b)

Typical bed level changes at the end of 14 days simulation for a) non-monsoon and b) monsoon condition for phase-II

4.4 Assessment and preliminary design of bank protection measures for an extent of about 600m and assessment of stability of islands/land/shoreline within radius of 5kms,

The significant wave height is taken in seven different location along the berth for the present condition and after deepening up to -20m CD and the analysis , shows that the there is no significant change in wave height even after deepening to -20m.

4.4.1 Phase I- 16m Draft vessel:

Based on the the above hydrodynamic and wave propagation modelling results, it is understood that the ambient environmental forcing conditions such as wave and current, which dictates the shoreline stability will not appreciably change in view of the proposed increase in the water depth in front of the ICTT jetty from existing to 20m. The shoreline presently are stable and not eroding. These are also protected by dense vegetation. Hence, the stable shoreline around the ICTT jetty protected by the dense vegetation at present would continue to be stable for further deepening for accepting 16m draft vessels. In the vicinity of the jetty, on its east and west, the shoreline is already protected. Even here also, as there is no significant change in the waves & current from present to future conditions, there is no requirement for providing additional shore protection.

4.4.2 Phase II- 18m Draft vessel:

Based on the the above hydrodynamic and wave propagation modelling results, it is understood that the ambient environmental forcing conditions such as wave and current, which dictates the shoreline stability will not appreciably change in view of the proposed increase in the water depth in front of the ICTT jetty from existing to 20m. The shoreline presently are stable and not eroding. These are also protected by dense vegetation. Hence, the stable shoreline around the ICTT jetty protected by the dense vegetation at present would continue to be stable for further deepening for accepting 16m draft vessels. In the vicinity of the jetty, on its east and west, the shoreline is already protected. Even here also, as there is no significant change in the waves & current from present to future conditions, there is no requirement for providing additional shore protection.

4.5 Block cost estimate and cost-benefit analysis based on available traffic studies

4.5.1 Capital Dredging Cost

As per the present scope of the study the Dredging quantity has to be worked out under two Phases viz Phase-I to handle 16m Draft Vessel of dimension 400(LOA)X 59(Beam)X16m (Draught) and Phase-II 18m Draft Vessel of dimension 400(LOA)X62(Beam)X 18m (Draught), requirement of width of the Channel to handle the above vessels has been assessed based on PIANC guidelines and ascertained the present width of the channel is sufficient to handle 16m draught vessel & 18m draught vessel.

However, when additional dredging is carried out to handle 16m draught vessel as well as 18m draught vessel, apart from the quantity of dredging arising out of deepening the channel to the corresponding depth, their will be some extra quantity for maintaining the side slopes.

Subsequent to the discussion held with CoPT , the mail confirmation from CE vide mail dated 31.03.2020, the response from NTCPWC vide mail dated 01.04.2020 and the specific requirement from IGTPL vide their mail dated 13.05.2020, the quantity as well as the Cost for the Capital Dredging under two Phases viz Phase-I to handle 16m Draught vessel and Phase-II to Handle 18m Draught vessel is furnished hereunder.

The dredging rate has been arrived as follows:

i. The rates determined based on CIRIA manual is adopted for estimation as per the minutes of the meeting dated 18.02.2020 (Annexure-I) and it works out to be ₹114 per cum. Accordingly the total dredging cost for Phase I is Rs 350 crores (excluding Mob & de-mob) and a incremental Quantity and cost required for handling 18m Draft vessel is Rs 210 crores (excluding Mob & De-Mob).

4.6 Part III: Feasibility Study for the additional Berth to the existing ICTT Berths, towards Vypin side (Western side) (“V4”)

4.6.1 Preparation of Preliminary layout of the additional Berth.

An additional Berth will be developed as an extension to the existing ICTT berths, towards Vypin side (Western side) (“V4”). The Berth will be of size 350m x 62m consisting of RC bored cast-insitu piles and beam and slab arrangements. Expansions joints will be provided at an intervals of 58.33m The Berth is designed to handle Neo panama vessels of 20,000TEU capacity (197300 DWT)

4.6.2 Re-running Hydrodynamic and Siltation model study for Estimation of Siltation and Maintenance Dredging requirements and impacts on Backwaters

On re-running the Hydrodynamic and Morphodynamic model for Estimation of Siltation and Maintenance Dredging requirements and impacts on Backwaters. The dredge quantity is estimated and shown below:

Sectors	Area	Dredge depth in meter/month	Quantity to be dredged
OAC1	572000	0.84	336336.00
OAC2	786500	0.52	247747.50
OAC3	1820000	0.80	728000.00
MCB	533434	0.20	55477.14
ECB	1106269	0.05	25886.69
IAC1	605109	0.26	119569.54
LNG	360000	0.84	226800.00
IAC2/ICTT BASIN	359316	0.89	243041.34
Proposed ICTT berth with approach area	56750	0.76	32347.50
Total(Mm^3/month)			2.02

Table 4.6.1 Estimation of dredge quantity in the ICTT proposed berth pocket

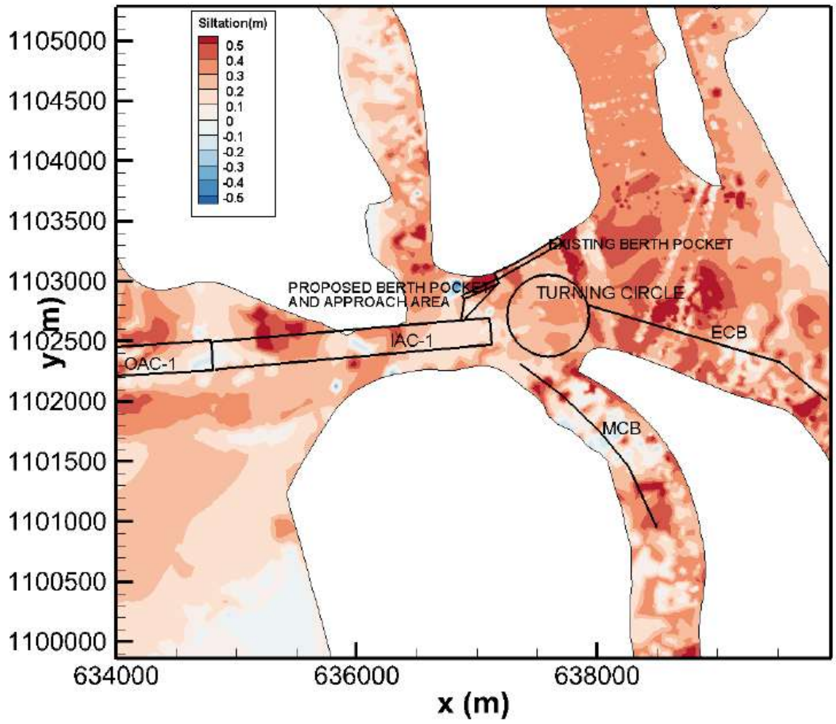


Fig 4.6.1 Bed level changes after 14 days simulation for ICTT-Proposed Additional berth

4.6 Assessment and preliminary design of bank protection measures for an extent of about 600m and assessment of stability of islands/land/shoreline within radius of 5kms,

The significant wave height is taken in seven different location along the berth for the present condition and after deepening up to -20m CD , shows that the there is no significant change in wave height even during the deepening of -20m.

4.6.1 Phase I - 16m Draft vessel:

From the hydrodynamic and wave propagation modelling results, it is understood that the ambient environmental forcing conditions such as wave and current, which dictate the shoreline stability will not significantly change in view of the proposed increase in the water depth in front of the ICTT jetty from existing to 20m. Hence, the stable shoreline around the ICTT jetty protected by the dense vegetation at present would continue to be stable for further deepening for accepting 16m draft vessels. In the vicinity of the jetty, on its east and west, the shoreline is already protected. However, the toe of the already existing shore protection units could not be analyzed unless the as built drawing could made be available. Hence, it is recommended not to disturb any vegetation around the shoreline to keep protecting the shoreline

4.6.2 Phase-II 18 m Draught Vessel

From the hydrodynamic and wave propagation modelling results, it is understood that the ambient environmental forcing conditions such as wave and current, which dictate the shoreline stability will not significantly change in view of the proposed increase in the water depth in front of the ICTT jetty from existing to 20m. Hence, the stable shoreline around the ICTT jetty protected by the dense vegetation at present would continue to be stable for further deepening for accepting 16m draft vessels. In the vicinity of the jetty, on its east and west, the shoreline is already protected. However, the toe of the already existing shore protection units could not be analyzed unless the as built drawing could made be available. Hence, it is recommended not to disturb any vegetation around the shoreline to keep protecting the shoreline.

4.7 Block cost estimate and cost-benefit analysis based on available traffic studies

As per the present scope of the study the Dredging quantity has to be worked out under two Phases viz Phase-I to handle 16m Draft Vessel of dimension 400(LOA)X 59(Beam)X16m (Draught) and Phase-II 18m Draft Vessel of dimension 400(LOA)X62(Beam)X 18m (Draught), requirement of width of the Channel to handle the above vessels has been assessed based on PIANC guidelines and ascertained the present width of the channel is sufficient to handle 16m draught vessel & 18m draught vessel.

However, when additional dredging is carried out to handle 16m draught vessel as well as 18m draught vessel, apart from the quantity of dredging arising out of deepening the channel to the corresponding depth, their will be some extra quantity for maintaining the side slopes.

Subsequent to the discussion held with CoPT , the mail confirmation from CE vide mail dated 31.03.2020, the response from NTCPWC vide mail dated 01.04.2020 and the specific requirement from IGTPL vide their mail dated 13.05.2020, the quantity as well as the Cost for the Capital Dredging under two Phases viz Phase-I to handle 16m Draught vessel and Phase-II to Handle 18m Draught vessel is furnished hereunder.

Without Prejudice to the observation and Tentative cost for Rehabilitation works contained in Chapter 2 of Part-I of this report and also considering the fact that an additional berth is proposed the Block Cost estimate for Structural Stability is not added hereunder. Notwithstanding the above, the Block Cost estimate for the other two components are as follows:

- Capital Dredging Cost
- Berth Construction Cost.

The rates determined based on CIRIA manual is Rs 897 crores (excluding Mob & de-mob) for Phase I including Berth construction and a incremental Quantity and cost required for handling 18m Draft vessel is Rs 140 crores (excluding Mob & De-Mob).

Part IV: Book of Drawings and Charts

The Drawings and Charts are being submitted as Part of the Hard copy of the Report

FEASIBILITY OF ACCEPTING VESSELS WITH LARGER DRAFT OF UP TO 18M AT INTERNATIONAL CONTAINER TRANSHIPMENT TERMINAL (ICTT) COCHIN

Final Report Part- I

Structural Stability and Adequacy of existing ICTT berth for larger Container Vessels

May 2020

Client

India Gateway Terminal Private Limited (IGTPL)

Consultant

Prof. K. Murali

Prof. S. A. Sannasiraj

National Technology Centre for Ports, Waterways and Coasts
New Academic Complex – 6th Floor
Indian Institute of Technology Madras
Chennai – 600 036

Contents of the Report

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PART-I Structural Stability and Adequacy of existing ICTT berth for larger Container Vessels

Chapter I

Design considerations

1.0 General design criteria

1.1 Structural Design

The main considerations for the design of structures are:

a. Structural safety, stability & durability.

b. Availability of material, equipment and expertise.

c. Constructability and ease of maintenance.

d. Maximum DWT of the ship, which will be berthed during lifetime of the structure.

1.2 Materials and Cover

1.2.1 Concrete

For all structural elements, M45 concrete is used.

(Referred from Design Criteria report for ICTT submitted by client)

1.2.2 Reinforcement

High yield strength deformed bars of grade Fe 415 conforming to IS 1786 are used.
Table 1.1 lists the concrete and steel grades used for piles and deck slab.

Table 1.1: Grade of concrete & steel

Structures	Materials	
	Concrete	Steel
Piles	M45	Fe415
Deck slab	M45	Fe415
Beams	M45	Fe415

(Referred from Design Criteria report for ICTT submitted by client)

1.2.3 Clear Cover provided

Following clear cover to the outer most reinforcement are provided for the structural members.

Deck Slab	:	50 mm
Pile	:	75 mm
Beam	:	50 mm

(Referred from Design Criteria report for ICTT submitted by client)

1.3 Vessel Specifications

Maximum size of container vessel considered for design 1, 97,300 DWT and 1, 45,000DWT. The vessel specifications are given in **Table 1.2.**

Table 1.2: Vessel specifications.

Description	Vessel size in DWT.	Vessel size in DWT.
Vessel capacity	1,97,300 DWT	1,45,000DWT
Draft	16 m	14.5 to 15 m
Overall Length	400 m	397.7 m
Beam	59 m	56.4m

(Referred from Design Criteria report for ICTT submitted by client)

1.4 Design Codes and Standards

The design was carried out in accordance with the applicable Indian codes. List of recommended codes and standards is given in **Table 1.3:**

Table 1.3: Indian Standards, Codes and Publications.

IS: 875 Part 3	Code of Practice for Design Loads for Building and Structures Wind Load
IS: 456	Code of Practice for Plain and reinforced Concrete
IS: 1893 Part 1	Criteria for Earthquake resistant Design of structures
BS EN ISO 19902-2007 + A1:2013	Petroleum and natural gas industries – Fixed steel offshore structures

IS: 4651 Part 3	Code of Practice for Planning and Design of Ports and Harbours-Loadings
IS: 4651 Part 4	Code of Practice for Planning and Design of Ports and Harbours-General Design Considerations
IS: 4651 Part 5	Code of Practice for Planning and Design of Ports and Harbours-Layout and Functional requirements
SP 16	Design aids to IS: 456
SP 34	Handbook on Concrete reinforcement and Detailing

1.5 Deflection

Deflection due to all loads including creep and shrinkage should not exceed span/250 as given in Clause 23.2 of IS 456:2000 and also as per Client requirements.

1.6 Crack width

Crack width is checked in accordance with IS 4651 (Part 4)-2014. As a guide, assessed surface width of cracks at points nearest to the main reinforcement should not exceed 0.004 times the cover of the main reinforcement or maximum crack width in different zones given in **Table 1.4,** whichever is minimum. Limit State of Serviceability load combinations is considered for crack width calculation.

Table: 1.4 Maximum Crack Width in Different Zone.

(*Clause* 8.3.4)
All dimensions in millimetres.

Sl No.	Exposure Zone	Maximum Crack Width	
		Sustained Load	Transient Load
(1)	(2)	(3)	(4)
i)	Atmospheric zone — above splash zone and where direct wave or spray impingement is infrequent	0.2	0.3
ii)	Splash zone — zone between the chart datum and the design wave height above the mean high water springs	0.1	0.2
iii)	Continuous seawater immersion zone — below splash zone upto seabed level	0.2	0.3
iv)	Below seabed level	0.3	0.3

NOTES

1 *Sustained load* — Dead load plus 50 percent of full uniformly distributed live load + earth pressure.

2 *Transient load* — Dead load plus berthing load and full crane load or full live load uniformly distributed + earth pressure.

1.7 Design loads

Indian Standard codes of practice are followed for loads combinations. Accordingly the following loads on the structure are considered.

1.7.1 Dead Loads

Dead loads consist of the weights of the structure. Unit weights of various materials used in the structural members are taken as follows:

a.	Water	-	10.0 kN/m3
b.	Seawater	-	10.25 kN/m3
c.	RCC	-	25 kN/m3
d.	Steel	-	78.5 kN/m3

1.7.2 Live load

Live load of 40kN/m^2 and 30kN/m^2 is considered for the design of the berthing structure.

(Referred from Design Criteria report for ICTT summited by client)

1.7.3 Seismic Force

Seismic force is calculated according to IS 1893-2002, considering 100 % dead load + 50 % live load acting on the structure. As per IS code, the site is under (Zone III) and the basic horizontal seismic coefficient is calculated accordingly. The seismic force calculations are given below.
Horizontal seismic Coefficient

Ah= Z I Sa/g

Where,

Z = 0.16, Zone factor (Table 2 of IS: 1893-2002)

I = 1.5, Importance factor (Table 6 of IS: 1893-2002)

R = 3.0, Response reduction factor (Table 7 of IS: 1893-2002)

Sa/g = Average Reponses accelerations coefficient

(Depends on the natural time period of the structure from STAAD Pro analysis)

Figure 1.1 shows the response spectra for rock and soil and sites for 5% damping.

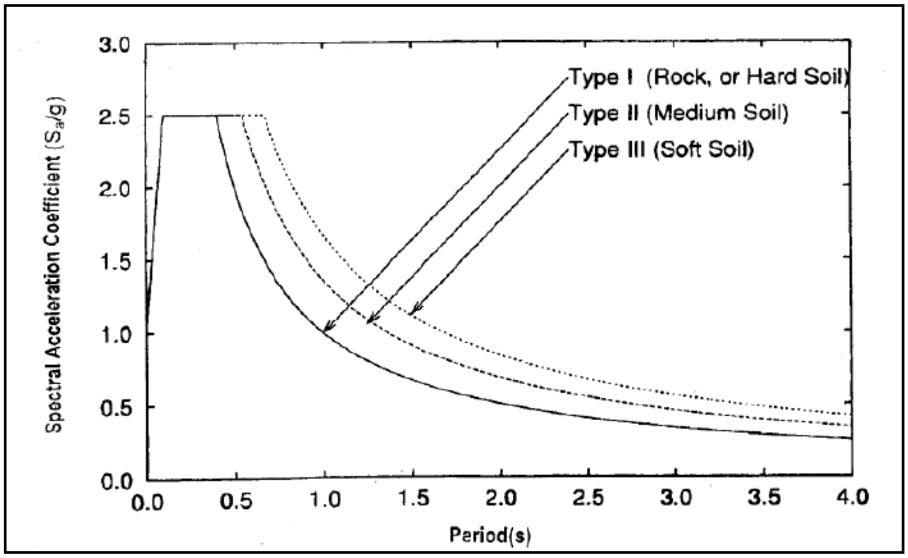


Fig 1.1: Response spectra for rock and soil and sites for 5% damping.

(Referred from Design Criteria report for ICTT submitted by client)

1.7.4 Mooring Load

Mooring loads are calculated in accordance with IS 4651 (Part III) –1974. Mooring force is calculated for the vessel of 1, 97,300 DWT. The mooring force is 200T bollard pull as per table below. However, as per IS 4651 manual calculation, the line pull works out to 100T and it is chosen for analysis.

Table 1.5: Mooring load.

Displacement(Tons) (DT)	Line Pull (Tons)
2000	10
10000	30
20000	60
50000	80
100000	100
200000	150
>200000	200

1.7.5 Berthing Force

It is proposed to handle 1, 97,300DWT vessel and the design of the berthing structure considers moderate berthing condition.

1.7.6 Mobile Harbour Crane and Rail mounted Crane

The dynamic loads are Mobile Harbour Crane and Quay Rail mounted Crane these loads are referred from **Design Criteria report for ICTT** submitted by client.

1.7.7 Load Combinations:

Load Combination factors for the analysis is in accordance with IS 4651(Part 4)-1989. The following load combinations have been considered in the analysis.

i. **Limit state of serviceability**

1DL+1.1LL+1.1DYN+1.0WF+1.0B.F

1DL+1.1LL+1.1DYN+1.0WF+1.0M.F

1DL+0.5LL+0.5DYN+1.0TEM

ii. **Limit state of collapsibility**

1.5DL+1.5LL+1.5DYN+1.2WF+1.5B.F

1.5DL+1.5LL+1.5DYN+1.2WF+1.5M.F

1.2DL+1.2LL+1.2DYN+1.0WF+1.0B.F

1.2DL+1.2LL+1.2DYN+1.0WF+1.2B.F

1.2DL+1.2LL+1.2DYN+1.0WF

0.9DL+0.9LL+0.9DYN+1.0WF+1.5B.F

0.9DL+0.9LL+0.9DYN+1.0WF+1.5M.F

0.9DL+0.9LL+0.9DYN+1.0WF+1.5S.F

Where,

D.L	-	Dead Load	DYN- Dynamic Force
L.L	-	Live Load	W.F- Wind Force
M.F	-	Mooring Force	
B.F	-	Berthing Force	
S.F	-	Seismic Force	

1.8 Geotechnical Data

The single Borehole data and the Fugro report subsequently made available by India Gateway Private limited were taken as the basis to arrive at the adequacy and capacity of the existing piles.

Chapter-II

Structural Stability of ICTT Berth including Strengthening Measures refit of berthing/mooring arrangements

2.1 Assessment/Validation of Structural Stability of Sub- Structure due to deepening and, proposed strengthening measures & refit of berthing /mooring arrangements based on available soil data

2.1.1.Based on the borehole data provided by the client vide mail dated 25th June 2019 and the Fugro report subsequently made available, the load bearing capacities of the piles in various grids were checked for different load combinations as per IS 4651(Part IV) of 2014 under serviceability condition for vessel of 197300 DWT and the results are furnished below. The allowable loads as per calculation of IITM and those indicated by ICTT in their report are also shown for comparison.

2,1,2.As per the Pile arrangement types, A&B constitute the front row (Fender Piles) and C,D,E & F inner/rear piles. It is seen that some of the piles do not have the required capacity compared to the Design vertical load and capacity of such piles for the relevant load combinations are shown in Chapter III.

The results are summarized as follows:

- Pile grid 1-20: all Piles types are safe
- Pile grid 21-34 : Pile Types A,B,C,D & E are not of adequate capacity
- Pile grid 35-51 : Pile Types C,D, E & F are not of adequate capacity
- Pile grid 52-68: Piles Types C,D & E are not of adequate capacity

2.2 Assessment/Validation of Structural Stability of Sub- Structure due to deepening and, proposed strengthening measures & refit of berthing /mooring arrangements based on available soil data

All transverse beams are found to be not safe for the critical load combinations considered in the analysis as per relevant Indian Standards. However, this could not be verified with the original design documents as they were unavailable. Further, Factor of Safety 2.0 has been considered for the design checks as per the IS codal provision currently in vogue. However, the original factor of safety as per prevailing guidelines at the time original design was 1.4. Due to this gap in the design aspects, it may be apt to parallelly explore the possibility of constructing an additional berth towards “Vypin Side” (V4) to handle vessel with capacity of 197300 DWT.

2.3 Outcome of the Structural Stability Analysis

For Structural rehabilitation, based on the present analysis with adopted data, the Block Cost estimate for dismantling of the Beams and Deck Structure, Strengthening of the existing Sub-structure by providing additional Piles and also reconstruction of the entire super structure of piles, beams and deck of the order of Rs 447 Crores the Cost Breakup is given below. It is assumed here that new Piles will be driven adjacent to the piles which are failing and connect it suitably with the existing Piles since, removal of piles up to founding level is time consuming in addition to the cost involved in it. Hence, an additional 20% number of piles are considered which may be necessary during detailed design stage. Also, it should be noted that if the loading conditions defined in the design basis adopted by IITM have been modified in the detailed design stage, there may be different requirements for Rehabilitation.

2.3.1 Cost for Rehabilitation Works

2.3.1.1. Following the detailed stability check of the present jetty, it is noticed that the structural members listed hereunder are failing under the given loading conditions.

1. 248 nos of piles
2. Transverse beams
3. Deck structure

2.3.1.2.Since it is not practically possible to dismantle a portion of the Structural components which are not safe for the adopted loading conditions, it becomes necessary to dismantle the entire deck structure and reconstruct the same and after adding additional Piles as detailed above. The Estimate is based on the following unit cost,.prevailing in the current market conditions.

1. Civil construction cost of jetty = Rs. 2,42,335/- per sq.m
2. Superstructure (deck and transverse) cost is adopted to be 30% of total cost
3. Pile costs for entire structure are adopted to be 70% of total cost
4. Demolishing cost is lump sum

2.3.2 Present ICTT berth details

- Area of ICTT Berth – 600m x 40.3m = 24180 Sq.m
- Total number of piles = 408

- Total number of piles to be rehabilitated = 248 Nos (206+ 20% extra considering the fact that rearrangement of pile spacing may warrant more number of piles)
- Entire deck and beams should be replaced

2.3.3 Cost estimate

1. Dismantling costs: Entire Deck structure & beams including cutting and removing 206 nos of piles upto seabed level = 24180 sq.m x Rs.9000/ sqm = **Rs. 21,76,20,000**
2. Construction cost of superstructure above pile head
   30% of (24180 x Rs.2,42,335) = **Rs.175,78,98,090**
3. A. Construction of 206 Nos of piles
   (206/408) * 70% of (24180 x Rs.2,42,335) = **Rs.207,09,87,780**
   B.Construction of 20% additional piles (42 piles) due to rearrangement of pile spacing= (42/206) * Rs.207,09,87,783 = **Rs.42,22,40230**

TOTAL COST FOR REHABILATION OF EXISTING JETTY = Rs.4,46,87,46,100/-

Say 447 Crores

.

CHAPTER-III PROOF CHECK FOR STABILITY ANALYSIS

Table 3.1: Estimated pile capacity for 197300DWT

Pile Grid	Pile type	Load combination as per IS:4651:Part-4:2014	Design Vertical Load (kN)	RL of pile tip with respect to Chart Datum	Q allow / pile (kN) (IITM)	Q allow / pile (kN) (ICTT)
1-20	**A, B**	1.0DL+1.1RMC+1.0LL+1.0MF	**6770**	(-)57 m	8071	8100
	C, D, E	1.0DL+1.1MHC+1.0LL+1.0MF	**6600**	(-)57 m	8301	8300
	F	1.0DL+1.1RMC+1.0LL+1.0BF	**12000**	(-)69 m	14338	13700
21-34	**A, B**	1.0DL+1.1RMC+1.0LL+1.0MF	**6770**	(-)63 m	**6072**	**6100**
	C, D, E	1.0DL+1.1MHC+1.0LL+1.0MF	**6600**	(-)56 m	**5065**	**5100**
	F	1.0DL+1.1RMC+1.0LL+1.0BF	**12000**	(-)69 m	13001	13000
35-51	**A, B**	1.0DL+1.1RMC+1.0LL+1.0MF	**6770**	(-)62 m	9947	9900
	C, D, E	1.0DL+1.1MHC+1.0LL+1.0MF	**6600**	(-)56 m	**5041**	**5000**
	F	1.0DL+1.1RMC+1.0LL+1.0BF	**12000**	(-)69 m	**11782**	**11200**
52-68	**A, B**	1.0DL+1.1RMC+1.0LL+1.0MF	**6770**	(-)65 m	12298	12300
	C, D, E	1.0DL+1.1MHC+1.0LL+1.0MF	**6600**	(-)52 m	**5075**	**5100**
	F	1.0DL+1.1RMC+1.0LL+1.0BF	**12000**	(-)67 m	13200	13200

3.0 Summary and Recommendations

Based on the borehole data provided by the client vide mail dated 25th June 2019 ,and the Fugro report subsequently made available, the load bearing capacities of the piles in the various grids were checked for different load combinations as per IS 4651(Part IV) of 2014 under serviceability condition for vessel of 197300 DWT and the results are tabulated above. In addition the allowable loads as per calculation of IITM and those indicated by ICTT in their report are also shown for comparison.

As per the Pile arrangement types, A&B constitute the front row (Fender Piles) and C,D,E & F inner/rear piles. It is seen that some of the piles do not have the required capacity compared to the Design vertical load and capacity of such piles for the relevant load combinations are shown in red.

The above results are summarized as follows:

- Pile grid 1-20: all Piles types are safe
- Pile grid 21-34 : Pile Types A,B,C,D & E are not of adequate capacity
- Pile grid 35-51 : Pile Types C,D, E & F are not of adequate capacity
- Pile grid 52-68: Piles Types C,D & E are not of adequate capacity

In addition, as detailed in the Interim Report dated June 2019, all transverse beams are not safe for the critical load combinations considered in the analysis as per relevant Indian Standards. However, this could not be verified with the original design documents as they were unavailable. Further, Factor of Safety 2.0 has been considered for the design checks as per the IS codal provision currently in vogue. However, the factor of safety then prevailed at the time of original design was 1.4.

Due to this gap in the design aspects, it may be apt to parallelly explore the possibility of constructing an additional berth towards “Vypin Side” (V4) to handle vessel with capacity of 197300 DWT.

(Prof.S.A.Sannasiraj) **(Prof.K.Murali)**

FEASIBILITY OF ACCEPTING VESSELS WITH LARGER DRAFT OF UP TO 18M AT INTERNATIONAL CONTAINER TRANSHIPMENT TERMINAL (ICTT) COCHIN

Final Report Part- II

Dredging, Marine & Bank Protection Measures

May 2020

Client

India Gateway Terminal
Private Limited (IGTPL)
Consultant

Prof. K. Murali
Prof. S. A. Sannasiraj

National Technology Centre for Ports, Waterways and Coasts
New Academic Complex – 6th Floor
Indian Institute of Technology
Madras Chennai – 600 036

Contents of the Report

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ASSESSMENT OF NAVIGATIONAL REQUIREMENTS, REDESIGN OF APPROACH CHANNEL AND TURNING BASIN AS PER PIANC & IS 4651

CHAPTER 1

ASSESSMENT OF NAVIGATIONAL REQUIREMENTS, REDESIGN OF APPROACH CHANNEL AND TURNING BASIN AS PER PIANC & IS 4651

1. Introduction

General, the approach and entrance channel for any Port including that of Cochin Port shall be designed as per PIANC guidelines. As per industry practice, the channel design shall serve as a conservative estimate as it accounts for all environmental, sea bed, navigational aspects. It provides for all variations and specifies safe allowances. However, the channel design may be reconfirmed by navigation studies in a bridge simulator for additional comfort and fine tuning. The design presented in the following sections, including environmental parameters used, basis of design and outcomes of design have been consulted with CoPT and approval of the same has been obtained as per emails of the Chief Engineer dt 30 & 31 Mar., 2020.

1.1 Present Channel Dimensions

In the design of channel for present study, the major design considerations are furnished hereunder:

i. The present channel has a straight approach from the initial 11km and has a mild change in course for a further stretch of 2km. This point is known as Cochin Gut (Ch 0.0m). The entrance channel to the port starts from here and has a length of 1489m prior to reaching the edge of Turning circle in front of ICTT. The layout is brought out below. The vessels take a change is course of about 11 deg. in the entrance channel till they reach turning basin.

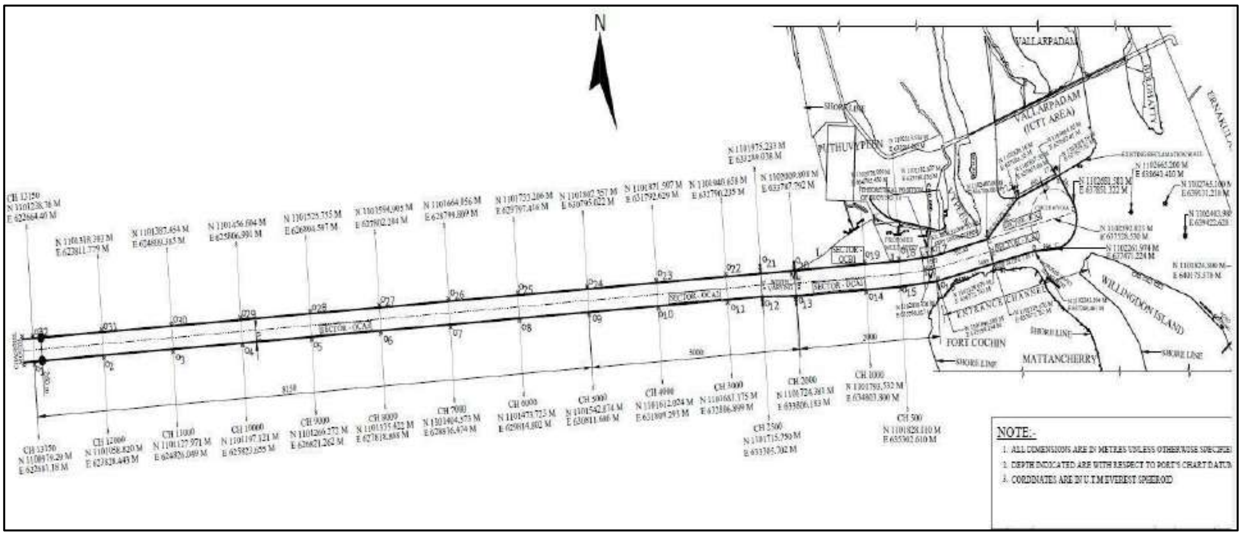


Fig 1.1: Alignment of the Present Channel

ii. The approach channel to the Port up to the Cochin Gut has a width of 260m for a length of 11km and 286m for the remaining length. The dredged depth is maintained by CoPT as (-)15.95m CD throughout the Channel.

iii. The basic design report of CWPRS (Report No. 4465, July 2007), is the guiding technical document available for the present channel.

a) The design is based on a maneuvering study. The report does not clearly indicate if the present channel was designed as a one way channel or a two way channel for a design vessel of 43m Beam. However, as interpreted by NTCPWC from the report and calculations, channel may have been designed as a two way channel due to the following reasons. The CWPRS report used a factor of two on maneuvering lane as two vessels will encounter similar conditions.

b) The design proposed a width of 320m in the first 2km section offshore (7.44 x Beam), 280m in the next 3km portion (6.5 x Beam), 250m in the next 6km section (5.8 x Beam). They proposed 286m in the Entrance channel of 1.489km.

c) However, the present channel has a width of 260m up to Cochin Gut but the Entrance channel portion has the 286m width. The 260m corresponds to 6.05 x 43m Beam.

iv. As per our interaction with CoPT the present width could not be comfortably used as a two-way channel for 43m Beam vessels. This could be because, the designed widths and depths are unavailable in the outer part. However, it is confirmed that a one-way channel is envisaged.

v. As per IS 4651, the minimum width for a one way channel is 3.3xBeam and two way channel is 5.1xBeam. However, IS 4651 is not specific about various allowances to be provided. Hence, the present design is based on PIANC guidelines. Where required, the minimum requirements of IS4651 shall be complied with.

1.2 Vessel Parameters

The present study relates to handling of large size container vessels with Draught 16m In Phase-I and 18m in Phase-II. For this purpose the following design vessels are considered as per the requirement of ICTT

Table 1.1: DesignVessel Size Specification

Vessel Dimensions	Length (m)	Beam (m)	Draught (m)	Dimensions of existing Berth	
				Length (in m)	Width(in m)
Phase-I	400	59	16	600	40
Phase-II	400	62	18	600	40

1.3 Under Keel Clearance

The usual UKC provision is 20% of the draft in the approach channel and could be reduced to 15% in the Entrance channel. NTCPWC recommends that dynamic UKC shall be adopted to optimize the dredging Quantity and further as the channel bed will be softer in CoPT channel. As per this, the UKC of 15% will be taken for Approach channel and 11% will be taken for Entrance channel. At the berths, it shall be taken as 8%.

1.4 Calculation of Channel Dimension for the Design Vessel (detailed in Para 1.2 above)

The following Environmental conditions are considered for the Channel design following CWPRS Report (No. 4465, July 2007) and approved by CoPT.

a) Wave height = 2m as that is the maximum wave height for Pilot Boarding
b) Wind speed = 15m/s
c) Cross Current = Variable as per Hydrodynamic model study
d) Vessel Speed = 8 kts in approach channel and 5kts in entrance channel

Accordingly, the relevant allowances for the above parameters are derived based on PIANC guidelines and listed in Table.1.2

Table 1.2 Various provisions / allowances for channel design as per PIANC guidelines.

Width	Factor (offshore)	Considerations	Factor (Inshore, Ch 2000 to TC)	Considerations
Basic Manoeuvring Lane, W_{BM}	1.5	Moderate manoeuvrability	1.5	Moderate manoeuvrability
Vessel speed, V_S	0	Mod (8 kts ≤ Vs < 12 kts)	0	Slow (5 kts ≤ Vs < 8 kts)
Prevailing cross wind, V_{CW}	0.4	Mod [15kts<Vcw < 33 kts] Beaufort 4-7	0.6	Mod [15kts<Vcw < 33 kts] Beaufort 4-7
Prevailing cross-current, V_{CC}	0.7	Mod (0.5kts< Vcc <1.5kts)	0.3	Low (0.2kts< Vcc <0.5kts
Prevailing longitudinal current, V_{LC}	0	Low (V_{LC} < 1.5kts)	0.2	Mod (1.5kts ≤V_{LC} < 3.0kts)
Beam and stern quartering wave height, H_S	0.5	H_S > 1m	0.3	H_S > 1m. Lower allowance taken as waves would have attenuated
Aids to Navigation	0.2	Good	0.2	Good
Bottom surface, h	0.1	Depth h <1.5 times draft (smooth and soft bottom)	0.1	Depth h <1.5 times draft (smooth and soft bottom)
Depth of waterway, h'	0.2	h'<1.25 times draft	0.2	h'<1.25 times draft
Cargo hazard level	0		0	
Width for bank clearance (W_{BR})	0.1	Gentle underwater channel slope (1:10 or less steep) Table 3.6, pg.89	0.3	Sloping channel edges and shoals. Table 3.6, pg.89
Width for bank clearance (W_{BG})	0.1		0.3	
Width of the channel	3.8	x Beam (of 59m)	4	x Beam (of 59m)
Width in Straight Channel (m)	224.2	Width in Straight Channel (m)	236	
		Allowance for bend (m)	30	As calculated by DC.
Width required in approach channel up to CH 2000	225m	Width required in 11 deg. turn inshore of CH 2000	266m	

Notes: (a) Lower cross current is only possible at entrance as currents are always in and out (See attached flow patterns); (b) Lower factor is taken as waves would have attenuated, PIANC gives only approx value; (c) Actually only lower allowance required as the requisite width of navigation will be within the present channel of 286m. However, we have taken higher value for safety.

1.4.1 Channel width required at straight portions (Up to chainage 0.0):

As per the above allowances, a single way channel IN THE STRAIGHT PORTIONS shall require a width of 3.8 x Beam. However, as per IS4651 the minimum width for a single way channel shall be considered as 3.3 x Beam.

1.4.2 Channel width required at bends.

Considering the present traffic numbers at CoPT & ICTT, it is recommended that it is apt to provide a Single way channel for the Design vessel above. **In this case, therefore, the channel width required for the proposed design vessel will be 225 m.** The width available presently is 260m up to Cochin gut which is more than the required width. Hence, the channel does not require widening. In the Entrance channel also, the width of 286m is available which is sufficient for catering for the mild change in course.

Therefore, the present channel does not need any widening to cater for single way traffic of the design vessel. However, while deepening the channel, the slope portion will become extended. This quantity will be taken for estimation purpose.

1.5 TURNING CIRCLE & APPROACHES

The Turning Circle will be of diameter of 800m and it is located in 1102681.581N and 637851.322 E, on the basis of 2 times length of the design ship as per IS 4651 Part-V considering partly unassisted maneuvering and future expansion. The area of the turning circle is 0.352km^2. The navigation channel is aligned with the turning circle such that the outer line of the navigation channel coincides with the center point of the turning circle. The width available presently is 260m up to Cochin gut which is more than the required width. Hence, the channel does not require widening. In the Entrance channel also, the width of 286m is available which is sufficient for catering for the mild change in course.

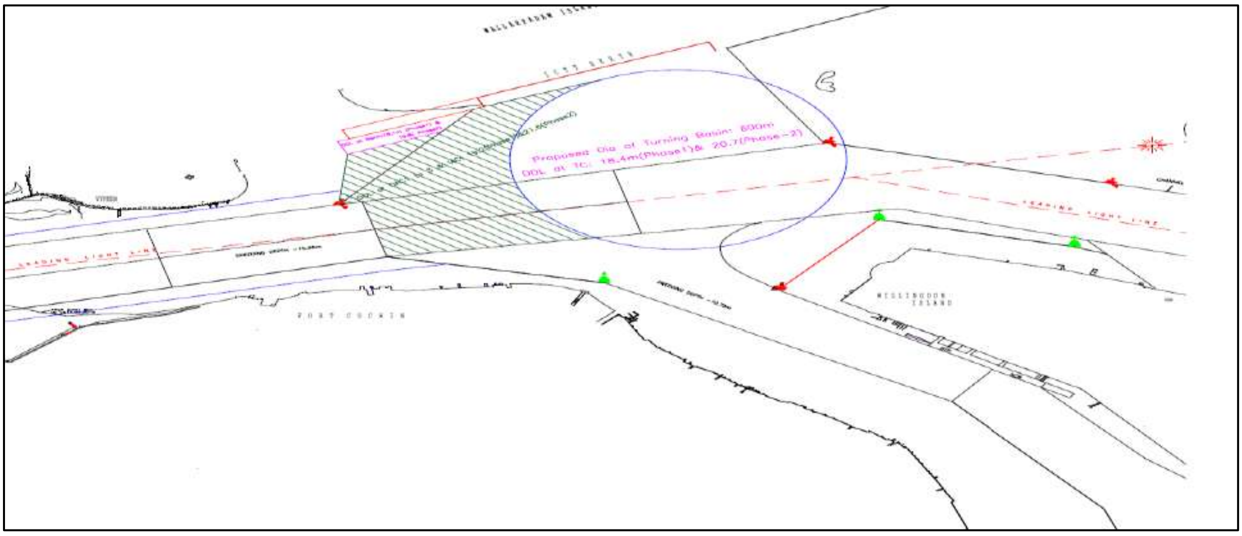


Fig 1.2: Turning Circle of Diameter 800m and Approaches

HYDRODYNAMIC AND SILTATION MODEL STUDY FOR ESTIMATION OF SILTATION AND MAINTENANCE DREDGING REQUIREMENTS AND IMPACTS ON BACKWATERS

CHAPTER-2

HYDRODYNAMIC AND SILTATION MODEL STUDY FOR ESTIMATION OF SILTATION AND MAINTENANCE DREDGING REQUIREMENTS AND IMPACTS ON BACKWATERS

2,0. Hydrodynamic & Morphodynamic Modelling

2.1 Objectives

The main objective of the tidal hydrodynamics study is to investigate the tide induced flow velocities and flow field. The study therefore brings out locations vulnerable to erosion and deposition of sediments. Accordingly, the scope of the study has been drawn and furnished below.

- Investigate the tide induced hydrodynamics in the ICTT basin of the Kochi harbour and to identify the possible locations of sediment deposition.
- Characterize the flow features during action oftides.

2.2 Methodology

Demarcation of the study domain is done to set up the extent of the model domain. Hydrodynamics modelling of the Kochi backwaters is executed using Ocirc circulation model. Modeling the bed evolution is performed using the morph dynamic routine of Ocirc. Both hydrodynamic and morph dynamic model will be simulated for a neap to neap condition, which covers all the astronomical aspects of tidal forcing. Estimation of the dredge quantity is based on the siltation simulation. It is conducted using the modelling approach by physical settings and domain considered with the mesh and measured bathymetry.

2.3 Hydrodynamic Modelling of the Study Area

The solution domain for the present problem is the ICTT basin of Cochin harbor which as an integral part of Cochin backwaters. Since an unstructured approach is being used in the present model, no hybrid meshing scheme is needed for capturing small features in geometry and flow. The domain of the study is represented by a number of bodies representing exterior coastal lines and interior islands. This is basically the geometric configuration of the coastal boundaries at Kochi. The computational mesh and bathymetry used for simulation is shown in **Fig.2.1.** and **Fig.2.2** respectively**.** The measured bathymetry interpolated with the GEBCO 30 arc second gridded bathymetry and adopted in this model . The final mesh has fine elements near the coastlines and shallower water depths. The size of mesh in the inlet near ICTT basin ranges from 30 to 50 m. The average mesh size is found to be about 20-100m which is very fine for a simulation such as the present problem. The mesh is coarser near the offshore boundaries, where the water depths are greater. The interpolated bathymetry on the mesh shows contours at regular intervals. The typical Representation of the bed profile in the computational model are shown in **Fig.2.3**. Detailed numerical model studies have been carried out to investigate the hydrodynamics of tides. It is to be noted that, considering such a time series for the 15 days period covers the spring-neap variations of the astronomical tide and addresses all variations in the astronomical tides. Typically the tidal amplitude and phase for the project site is extracted from TPXO data and the boundary conditions are implicated as a time varying tidal elevations. The bathymetry incorporated in the model with phase-II development is given in **Fig.2.2**

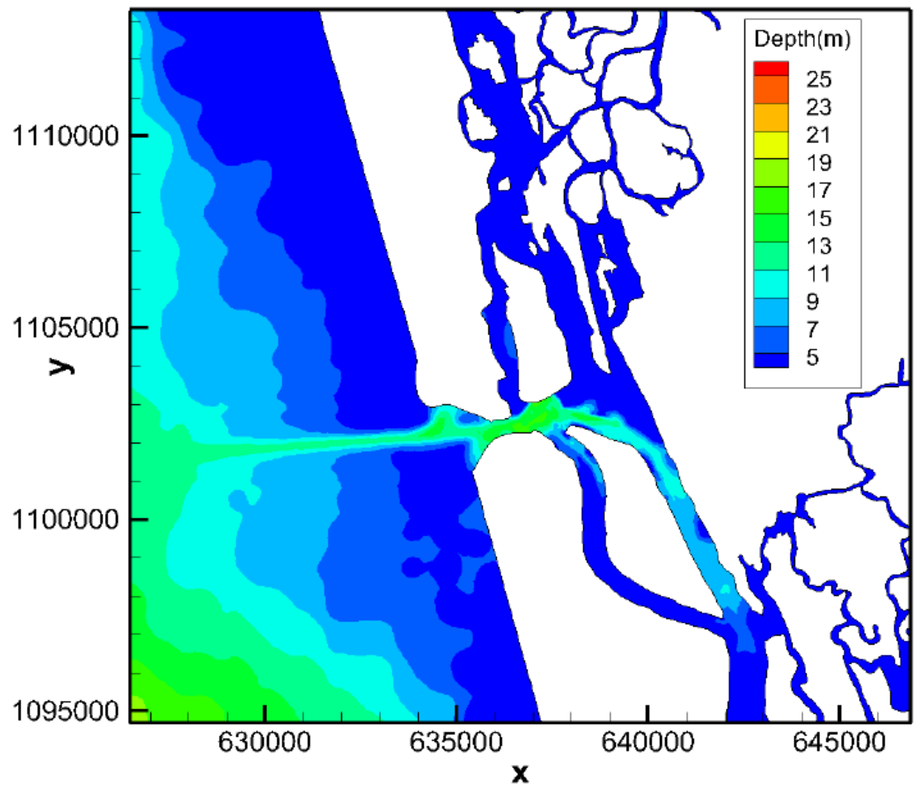


Fig.2.1 Bathymetry of the domain considered for simulation

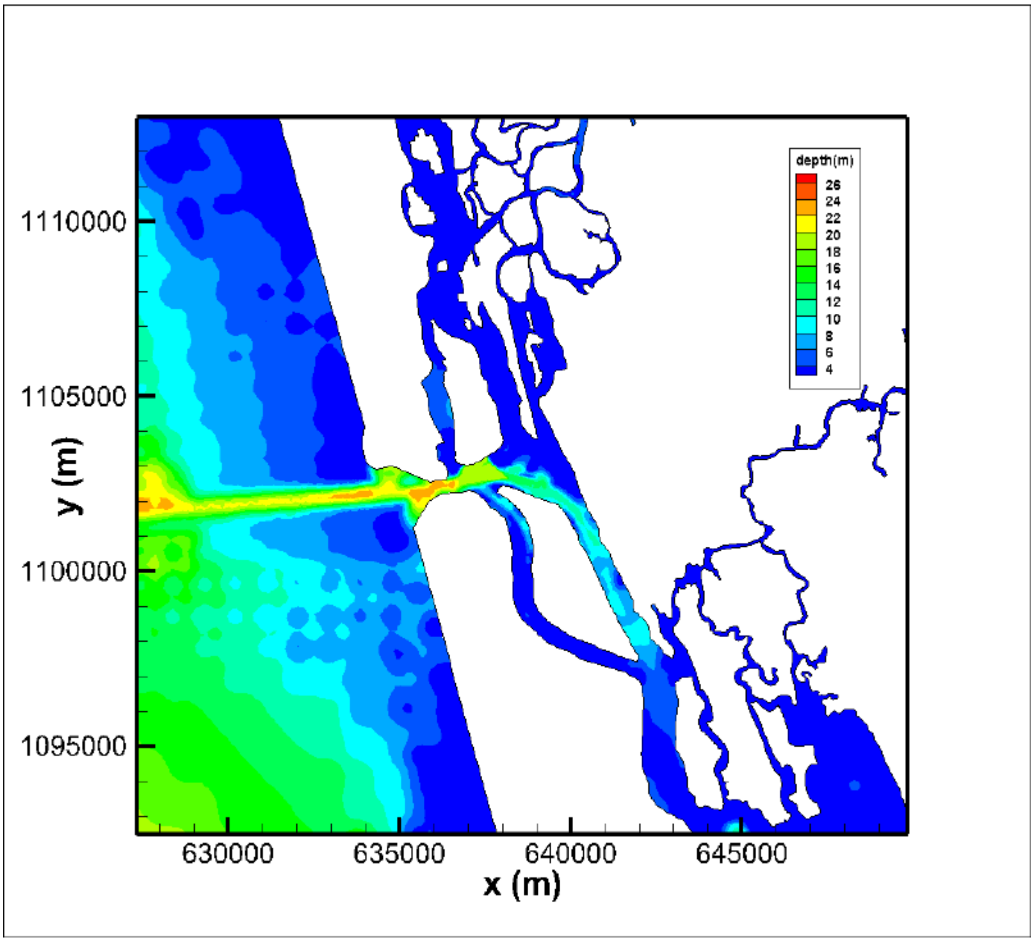


Fig.2.2 Bathymetry of the domain incorporated with phase-II changes considered for simulation

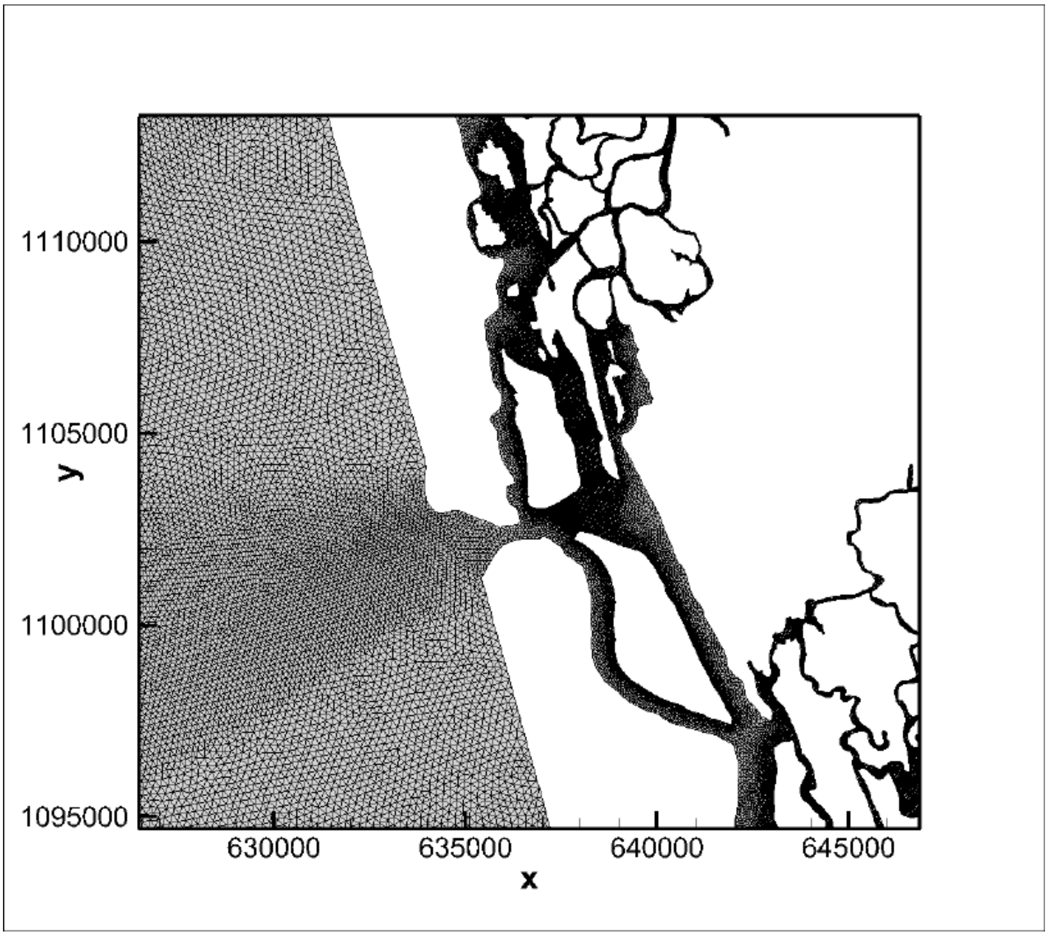


Fig.2.3 Typical meshing of the domain considered for simulation

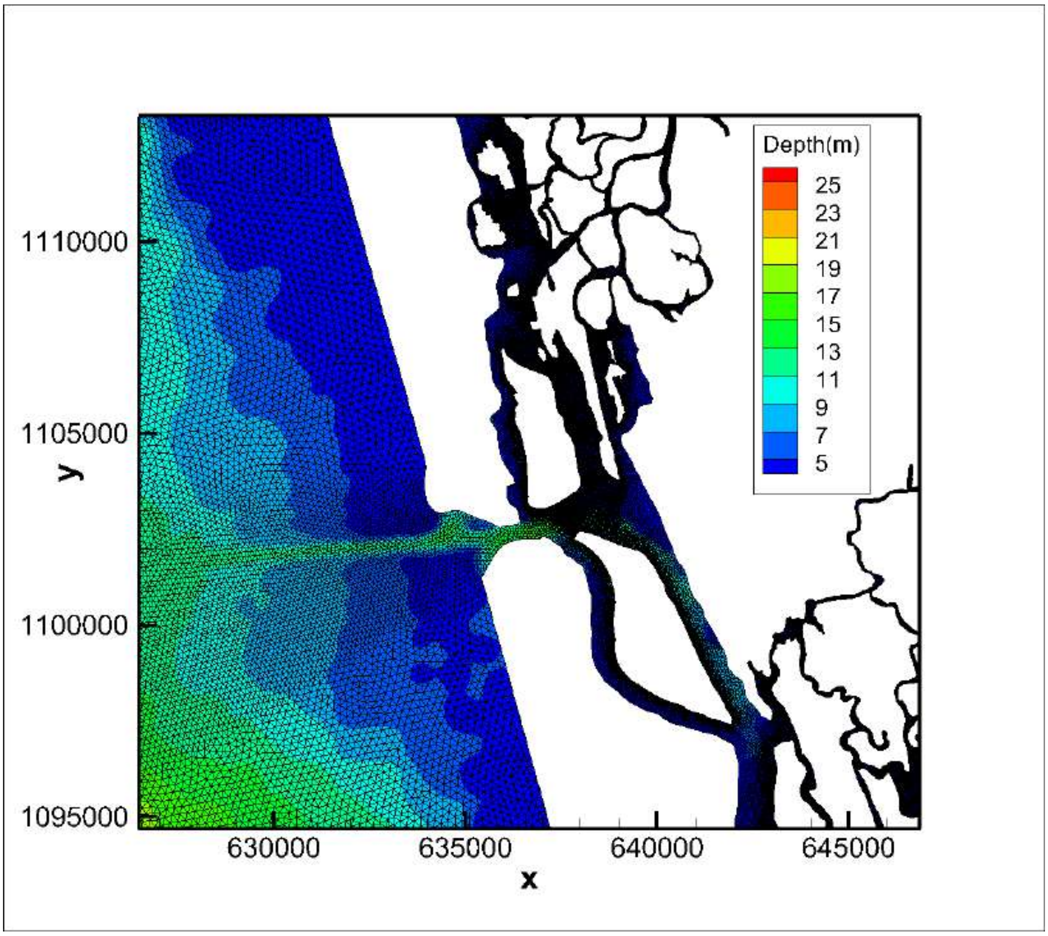


Fig.2.4 Typical bathymetry and computational mesh for simulation

2.3.1 Results and Discussion

General

Accurate simulation of the tidal hydrodynamics at Kochi ICTT, Kerala, depends on the kind of computational mesh generated for the simulations. An unstructured meshing scheme was selected in order to accurately capture the adjoining shoreline. The unstructured meshing scheme is capable of resolving all the boundary and bathymetry details in the study area. This typical computational mesh depicts the ability of the meshing algorithm to exactly discretize the study area. Ocirc is the hydrodynamic model used and details of which are given in Appendix- I

A suggestion was made to carry out a study of the Siltation rate in the Outer Approach Channel based on the existing CWPRS report. Prima-facie, the CWPRS report dated July 2007, shared by the Port, is related to Ship Manoeuvring to optimize the approach channel dimensions and this has no relevance to the Hydrodynamic Model. In addition, the report contains the data relating to wave, wind and current and not on Siltation rates. However, NTCPWC is assessing the Siltation rates based on its own independent Hydrodynamic model which is more scientific and reliable

Appendix-I

Simulated Tidal conditions

The present tidal hydrodynamic conditions at the site are mainly characterized by alternating northerly and southerly flow in the open sea and in the gulf. The directions of flow is west to east during flooding and the vice versa during ebbing at the mouth. Inside the backwaters the tide is reaching till the end of water metro route considered. For the purpose of easy referencing of the hydrodynamics with the tide levels, typical time instances at which flow patterns have been extracted, are shown in **Fig.1.5.** The origin is at mean sea level.

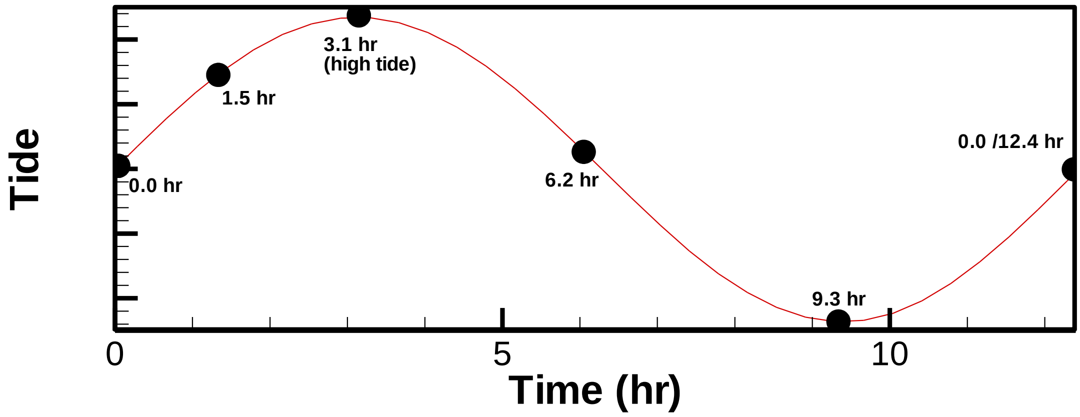


Fig.2.5 Times of tide at which results are plotted.

Flooding

This flow patterns during flooding condition in the ICTT is shown in **Figs.2.6 and 2.7.** The figures show a typical flow situation during the rising tide (at about 0 hr) from which, the magnitudes of current at various locations of the study area can be deduced.

The flooding phase of the tide is characterized with flow in the easterly direction to be precise in the ICTT basin of Cochin port and inside the inlet the flow is directed towards the river. The range of velocities around the region near the mouth of harbour is about 0.5-0.7m/s as shown in **Fig.2.6.** During the highest flooding event, the velocities around the location are about 0.6-0.8 m/s, shown in **Fig.2.7**. But during the above said phases of tide, the magnitude of velocity in the basin is about 0.2-0.3 m/s. This steep velocity gradient may lead to siltation. The above currents are disappearing during the high tide event in the harbor as shown in **Fig.2.8**, during which the velocities near the mouth is about 0.2-0.3m/s.

Ebbing

During the ebbing phase of the tide, which is followed by the occurrence of high tide, the tide starts to recede from the inlet and reversal of flow start to occur towards the sea as can be seen in **Fig.2.9.** As the tide start to recede, the currents in the inner channel of the harbor are more pronounced and the velocities immediately raises to 0.4-0.8 m/s during the ebbing event. During the peak ebbing event, the flow picks up to 0.9 m/s without changing the directional features as described earlier, in deeper parts like ICTT basin have low magnitude velocities as observed. The ebb flow magnitude is higher compared to flood flow as the river discharge contributes to this rise. During the low tide, the entire inlet regions become devoid of currents with some prominent reversal currents at the confluence regions in the domain and at locations near the entrance of the harbor. The velocity is about 0.2m/s as shown in **Fig.2.10** and both during high and low tides some strong eddies are observed in several parts of the harbor area which induces the potential for shoaling.

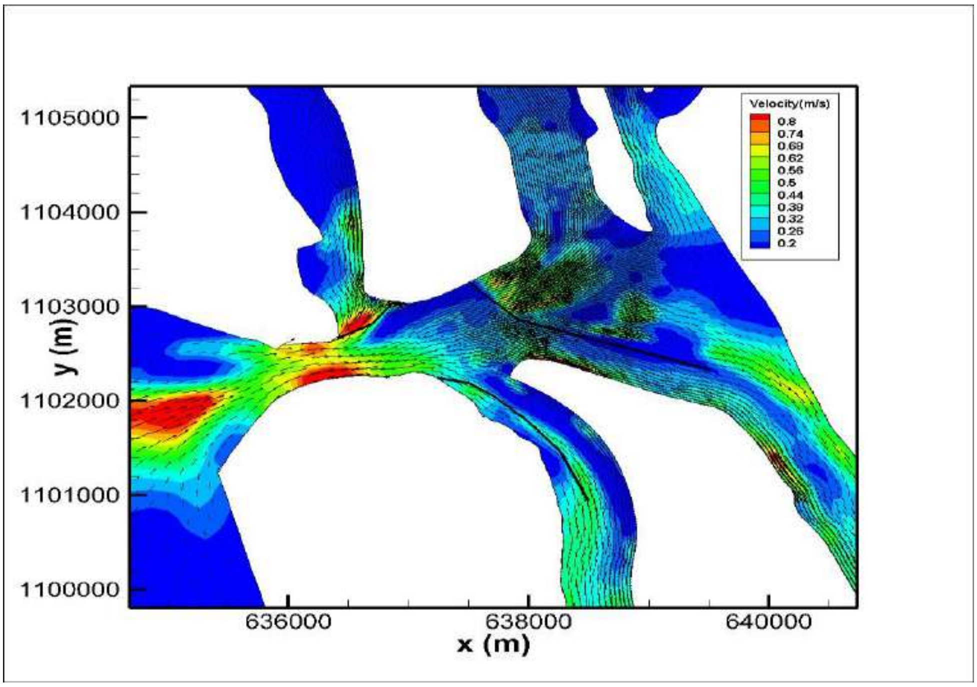


Fig.2.6 Velocity vectors and contour plots during flooding tide at 0 hours

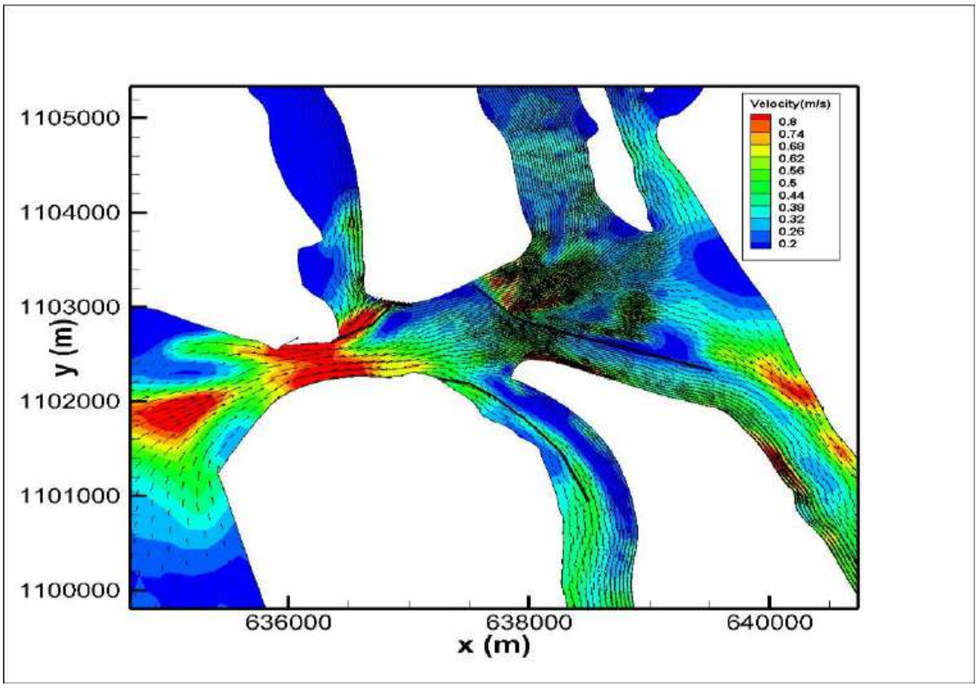


Fig.2.7 Velocity vectors and contour plots during flooding tide at 1.5 hours

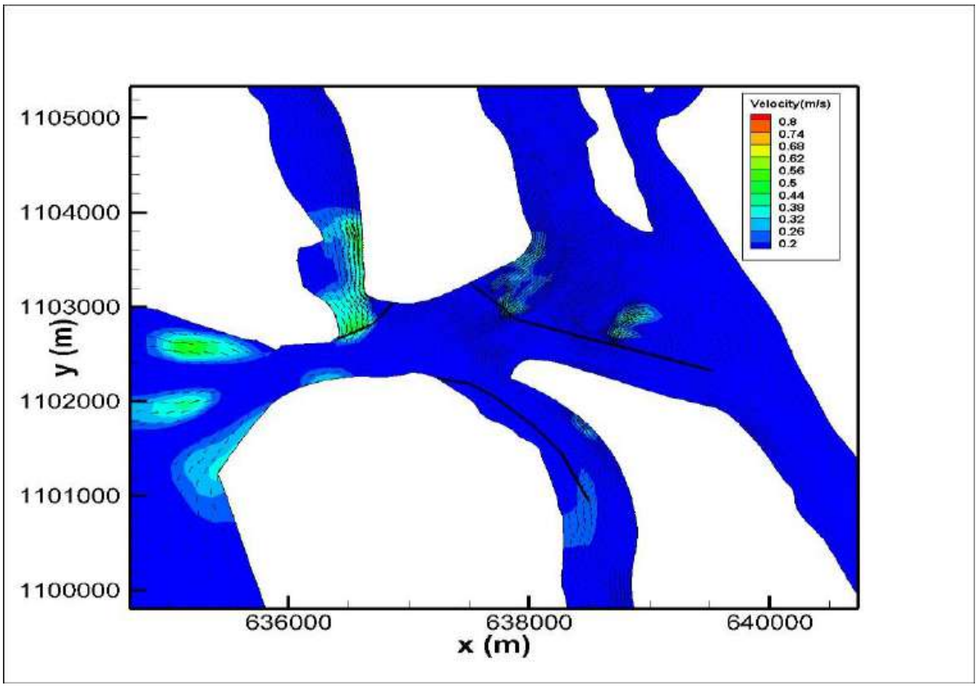


Fig.2.8 Velocity vectors and contour plots during high tide at 3.1 hours

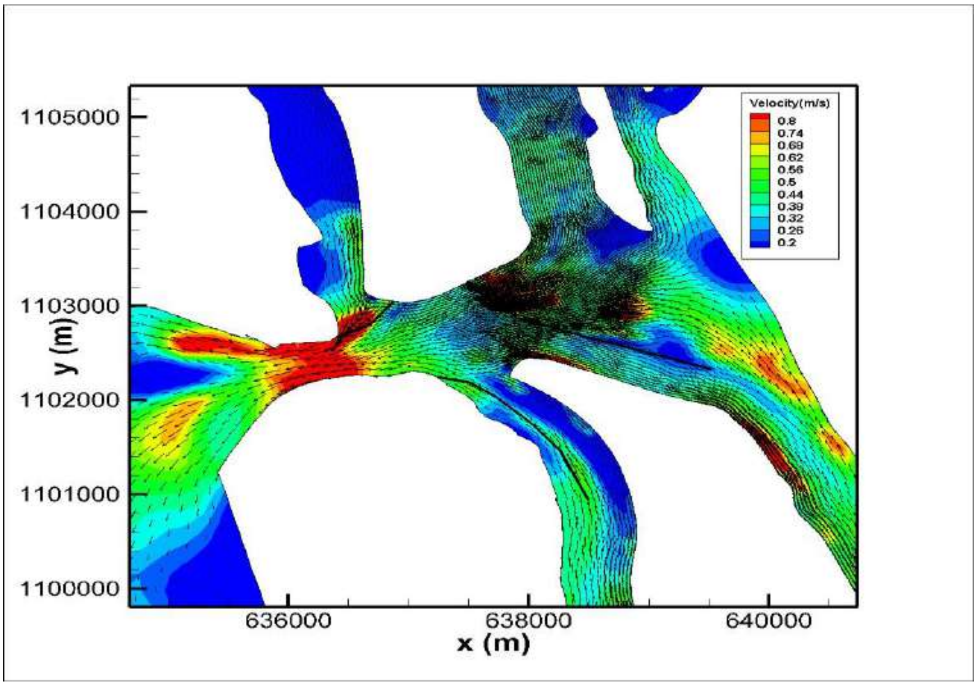


Fig.2.9 Velocity vectors and contour plots during ebbing tide at 6.2 hours

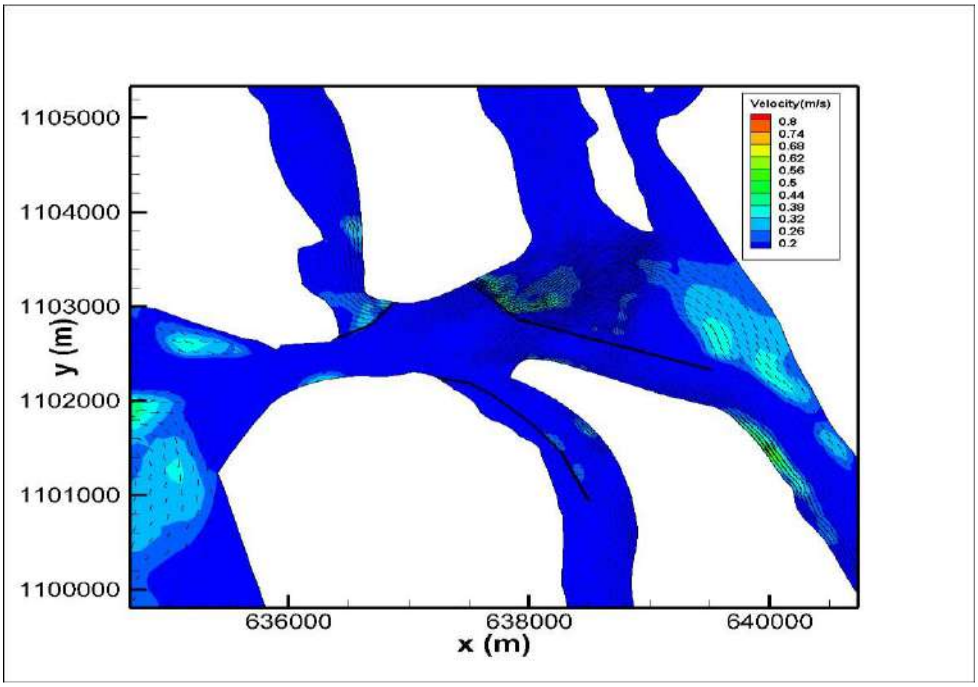


Fig.2.10 Velocity vectors and contour plots during low tide at 9.3 hours

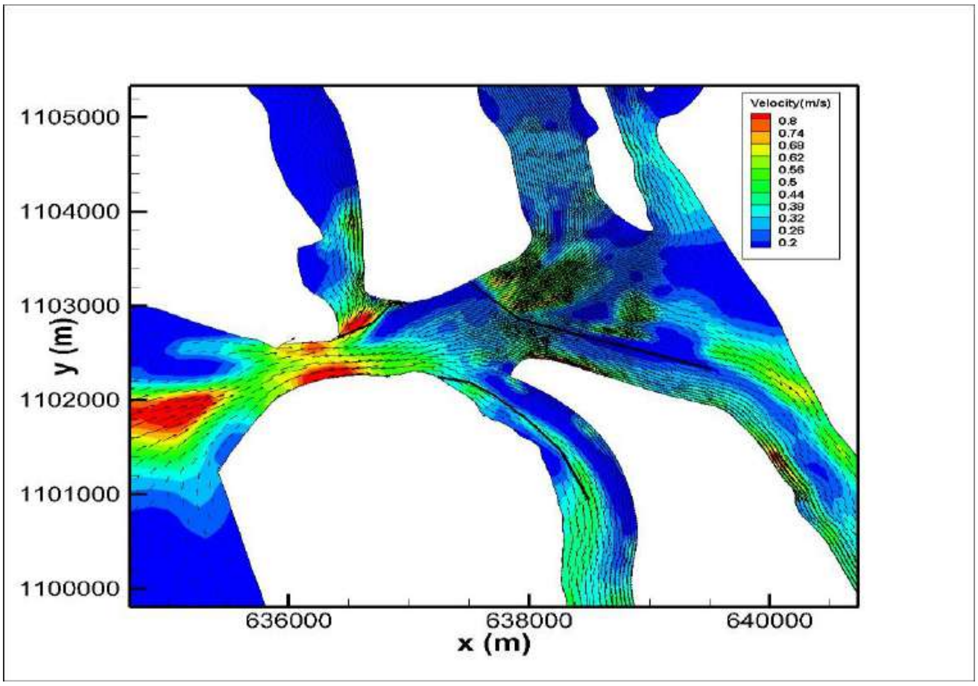


Fig.2.11 Velocity vectors and contour plots during flooding tide at 12.4 hours

2.4 Morphodynamic Modelling

2.4.1 Results And Discussion

Siltation study predicts the siltation rate in the ICTT basin of Cochin harbour. The average siltation rate is 0.04-0.05m/14 days. Based on the simulation the siltation is more in the approach channel which is of range, 0.05-0.06m/14days than near the turning circle and here the maximum siltation rate of siltation is 0.055m/14days. The siltation pattern is given in **Fig.2.13**. During monsoon season the rate of siltation increase by 60-80% with increased TSS as shown in **Fig.2.14**. The morph dynamic simulation is carried out implementing the phase-II changes in the bathymetry, and the same is incorporated in the numerical model. The details of the bathymetry with the proposed increased depths which are incorporated in the model, is given in **Table 2.1.**

Based on the morph dynamic results it was observed that, there is a 20-40% increase in siltation overall, on implementing the phase-II dredging. Some parts of the channel or the dredged areas show very low increase in rate of siltation by 5%. In some parts the rate of siltation remains the same. These details are observed in **Figs.2.14** and **2.15** for non-monsoon and monsoon respectively.

Table2.1: Channel, basin and berth requirements of ICTT for larger vessels at Phase-II

Description		Existing	Phase I	Phase-II
Navigational requirements	Depth at Berth(m)	15.95	17.28	19.8
	Depth at channel(m)	17.4	18.4	21.6
	Width of channel(m)	260	260	260
	Turning Basin Diameter (m)	670	800	800
	Turning basin draft(m)	16.68	17.76	20.7

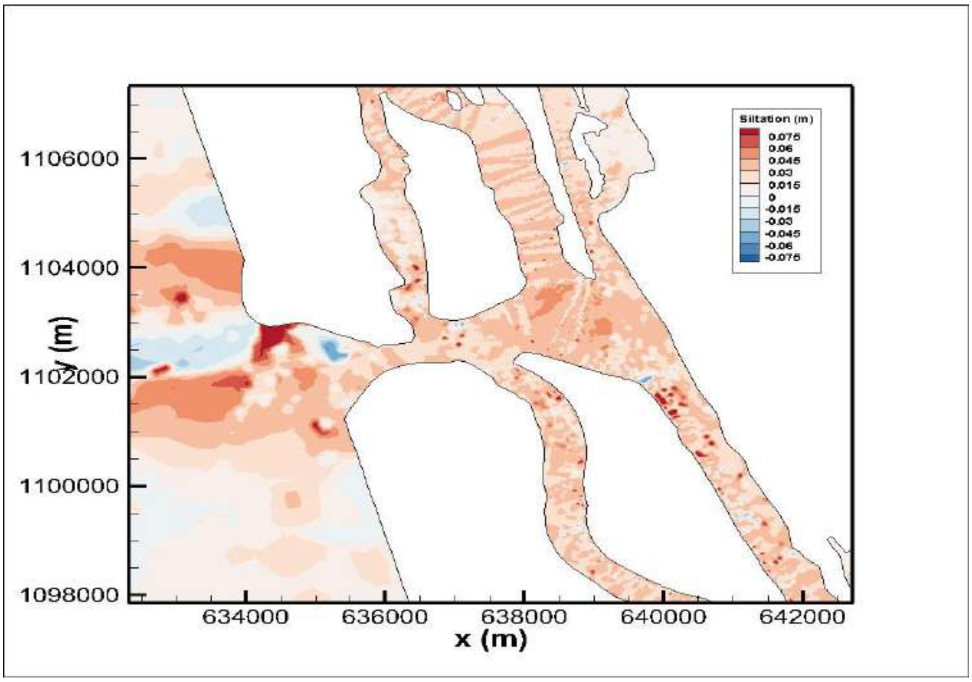


Fig.2.12 Typical bed level changes at the end of 14 days simulation for non-monsoon for existing condition

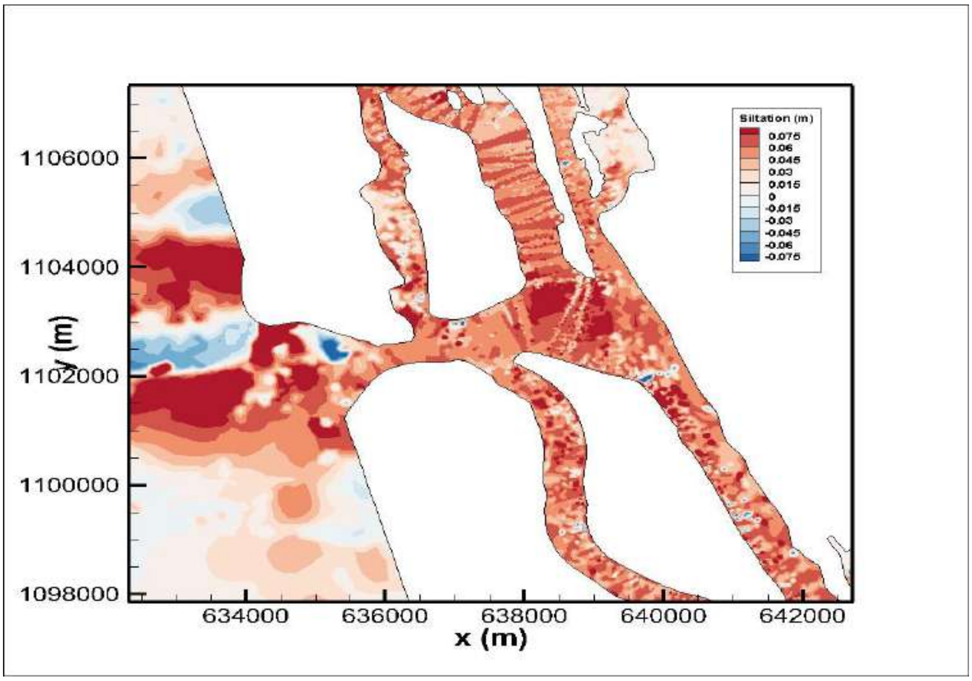


Fig.2.13 Typical bed level changes at the end of 14 days simulation for monsoon for existing condition

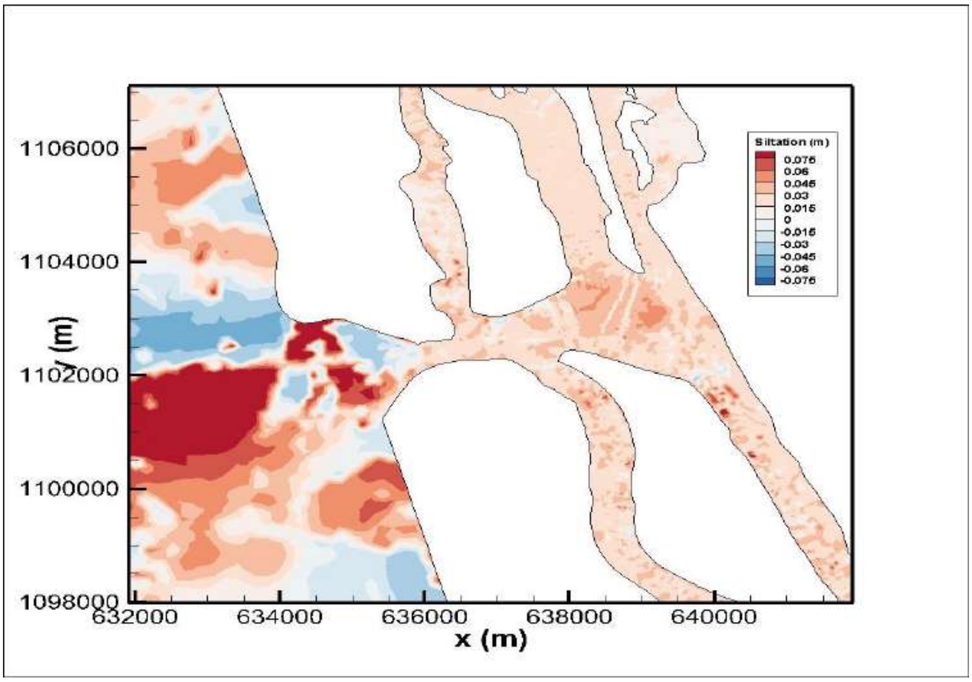


Fig.2.14 Typical bed level changes at the end of 14 days simulation for non-monsoon for phase-II condition

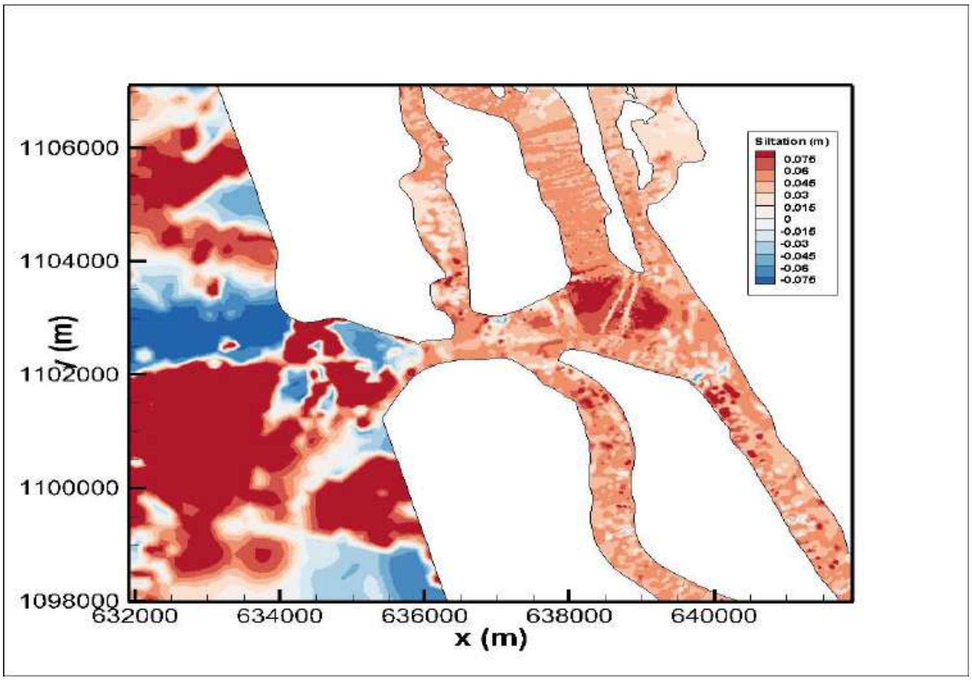


Fig.2.15 Typical bed level changes at the end of 14 days simulation for monsoon for phase-II scenario

2.4.2 Estimation of dredged quantity

The dredge estimation discussion is carried out for ICTT basin of Cochin harbour. Based on domain considered dredge estimation study is carried out for all locations of ICTT basin. The estimation of dredge quantity is discussed in **Table 2.2 and Table 2.3** for non-monsoon and monsoon respectively below. The total dredge quantity estimated for ICTT basin is 0.937 Mm^3/yr for phase-II dredge developments. The dredge quantity increased by 27% overall from the current situation due to phase-II development.

Table 2.2 Estimation of dredge quantity for non-monsoon season

Location	Approximate area to be dredged(m^2)	Siltation Rate for existing condition		Siltation Rate for Phase-II		Volume of Dredging (Mm^3)/242 days	
		(m/14 days)	(m/242 days)	(m/14 days)	(m/242 days)	Existing condition	Phase-II
ICA1	605109	0.045	0.81	0.050	0.89	0.490	0.540
MCB	533434	0.060	1.08	0.060	1.08	0.576	0.576
ECB	1106269	0.074	1.34	0.074	1.34	1.482	1.482
OCB1/LNG BASIN	360000	0.120	2.16	0.156	2.81	0.778	1.010
ICA2/ICTT BASIN	361734	0.065	1.04	0.078	1.40	0.376	0.507

Table 2.3 Estimation of dredge quantity for monsoon season

Location	Approximate area to be dredged(m^2)	Siltation Rate for existing condition		Siltation Rate for Phase-II		Volume of Dredging (Mm^3)/122 days	
		(m/14 days)	(m/122 days)	(m/14 days)	(m/122 days)	Existing condition	Phase-II
ICA1	605109	0.081	0.729	0.089	0.801	0.441	0.485
MCB	533434	0.096	0.864	0.096	0.864	0.461	0.461
ECB	1106269	0.133	1.199	0.133	1.199	1.326	1.326
OCB1/LNG BASIN	360000	0.204	1.836	0.270	2.430	0.661	0.875
ICA2/ICTT BASIN	361734	0.111	0.995	0.132	1.188	0.360	0.430

ASSESSMENT AND PRELIMINARY DESIGN OF BANK PROTECTION MEASURES FOR AN EXTENT OF ABOUT 600m AND ASSESSEMNT OF STABILITY OF ISLANDS/LAND/SHORELINE WITHIN RADIUS OF 5kms

CHAPTER 3

ASSESSMENT AND PRELIMINARY DESIGN OF BANK PROTECTION MEASURES FOR AN EXTENT OF ABOUT 600m AND ASSESMENT OF STABILITY OF ISLANDS/LAND/SHORELINE WITHIN THE RADIUS OF 5KM

3.1Extent of the area considered.

3.1.1 Area considered for Bank Protection measures within a radius of 600m as shown in sketch 3(a) & 3(b)

Fig 3(a)- Eastern side of Berth (600m area marked in red circle)

Fig 3(b)- Western side of the Berth (600m area marked in red ciecle)

3.1.2 Area considered for assessment of stability of Islands/Land/Shoreline within radius of 5 kms as shown in sketch 3(c)

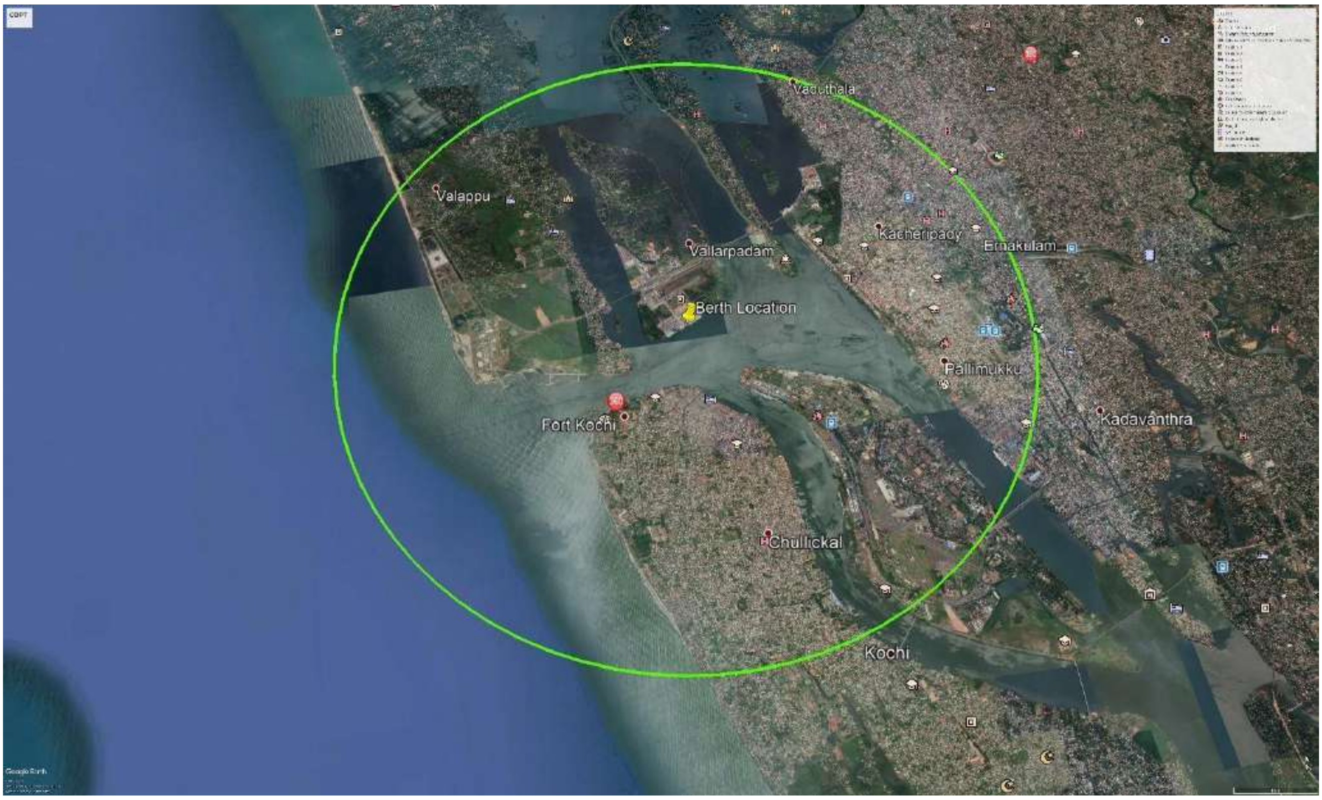


Fig 3(c) 5kms radius around the Berth

3.2 OFFSHORE WAVE CHARACTERISTICS

The wave characteristics such as significant wave height, mean wave period and mean wave direction at a deep-water location (10° 0'0.00"N, 76° 0'0.00"E) off Cochin have been extracted from the ECMWF (European Centre for Medium-Range Weather Forecasts) including the wind-wave modeling hind-cast studies. The data are sampled at every 6 hours. Basically, the wave field follows the wind pattern. It is noted that the spatial variability is closely related, the maximum of H_s are associated with maximum wind speeds. **Fig.3.1 to Fig 3.13** represents annual occurrence of wave climate. It is noted that the offshore wave climate of Cochin is predominantly from west. The waves are predominantly observed in 6s to 8s period with the significant wave height ranges between 0.5m to 1.5m. However, larger wave heights were also observed.

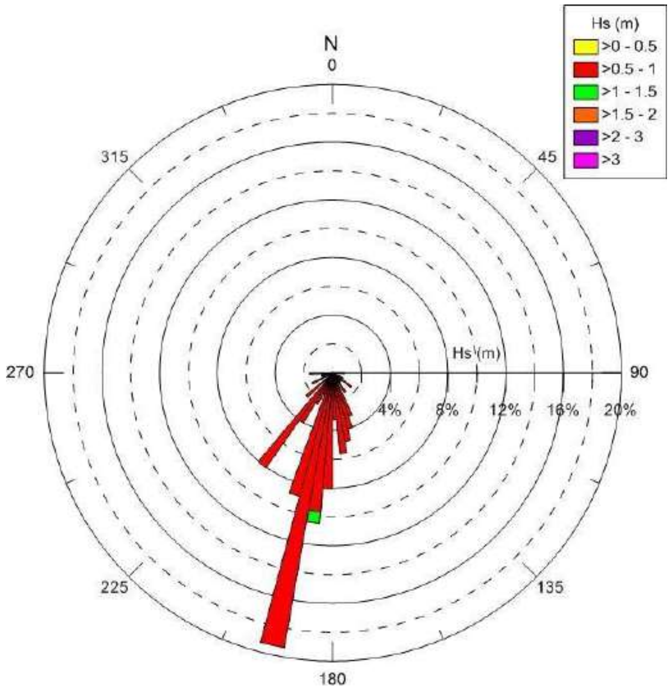


Fig3.1 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of january

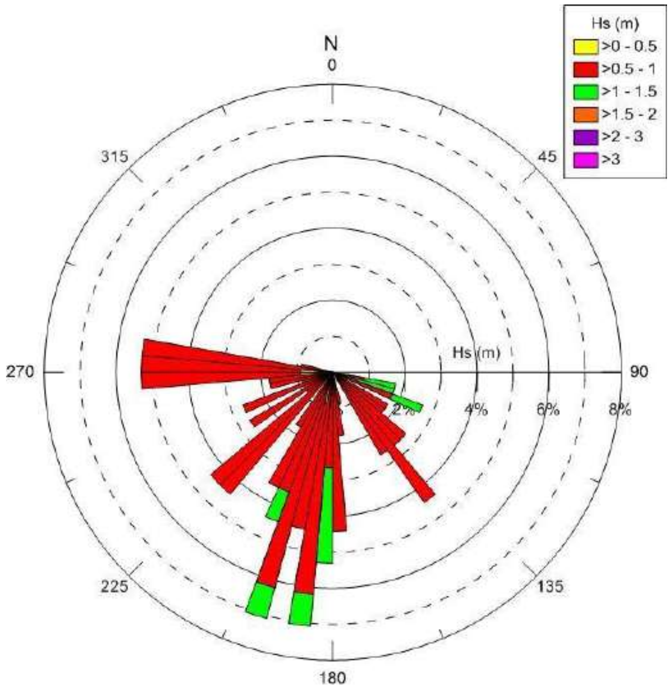


Fig3.2 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of February

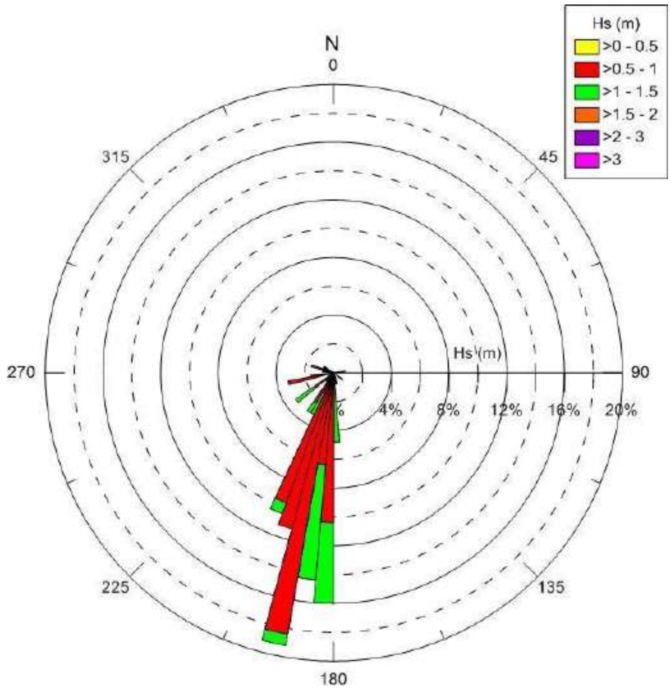


Fig3.3 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of March

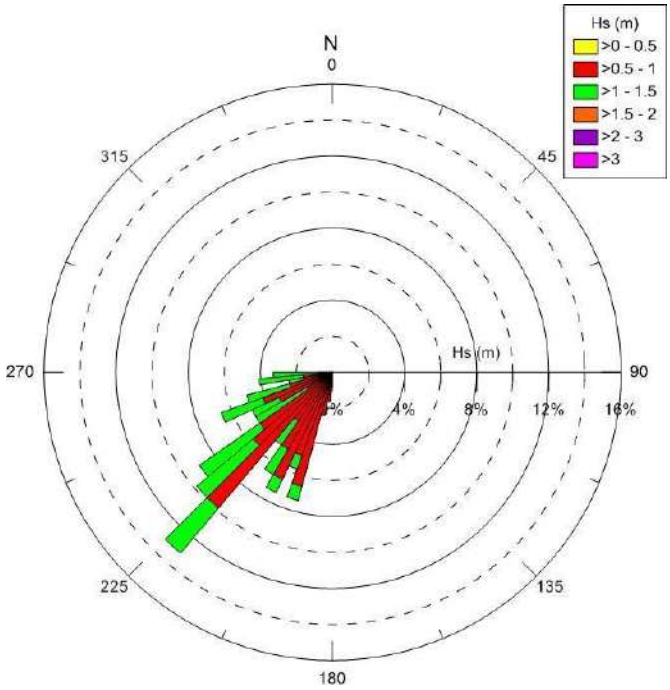


Fig3.4 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of April

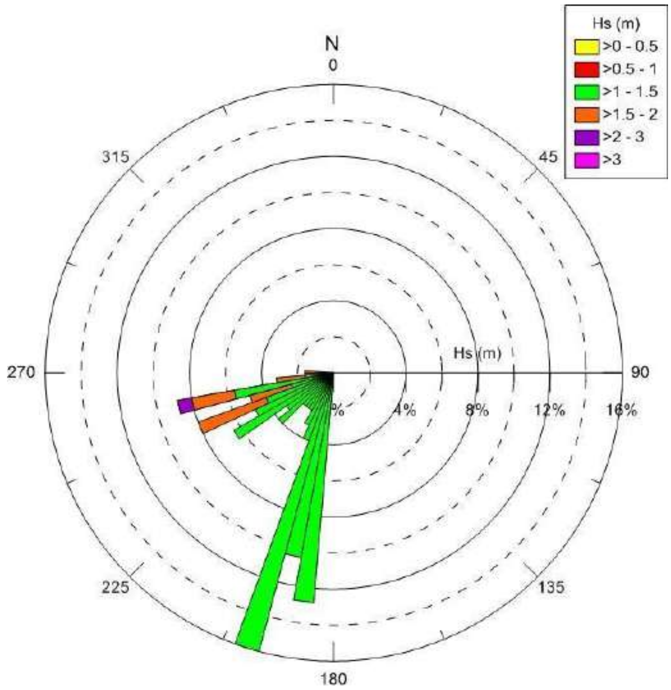


Fig 3.5 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of May

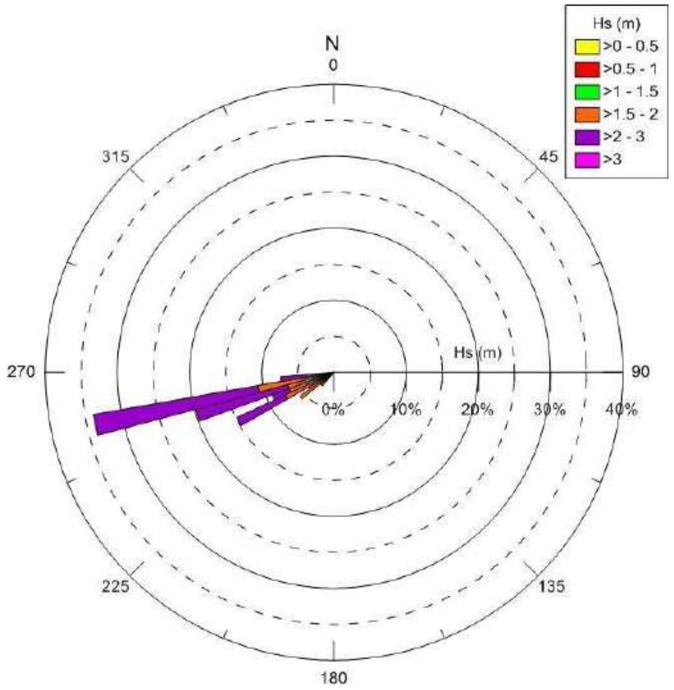


Fig 3.6 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of June

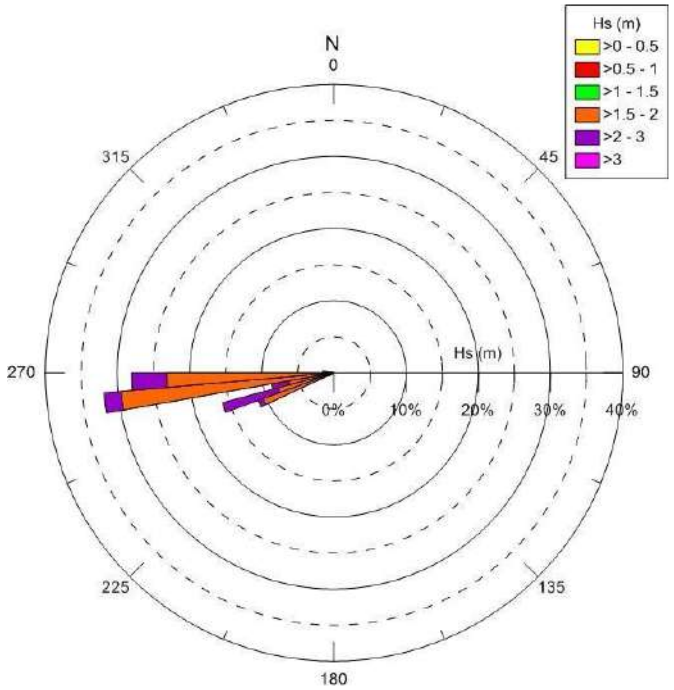


Fig 3.7 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of July

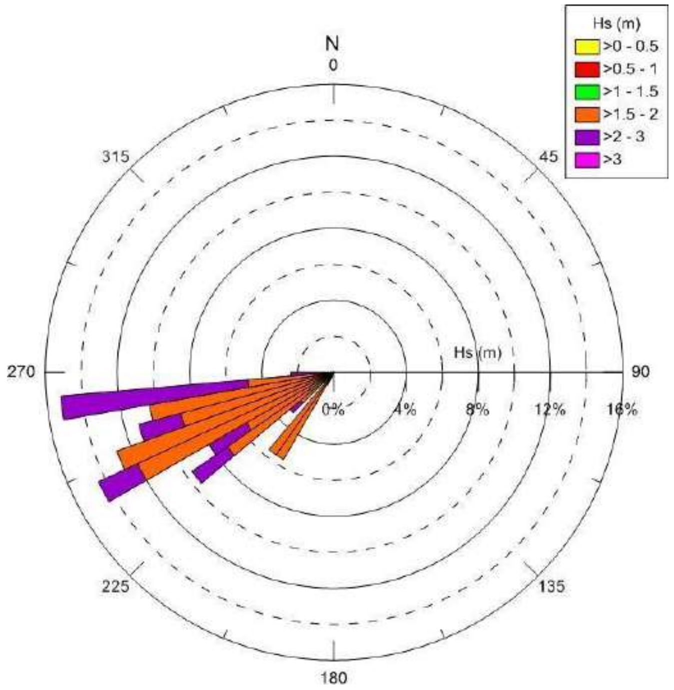


Fig 3.8 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of August

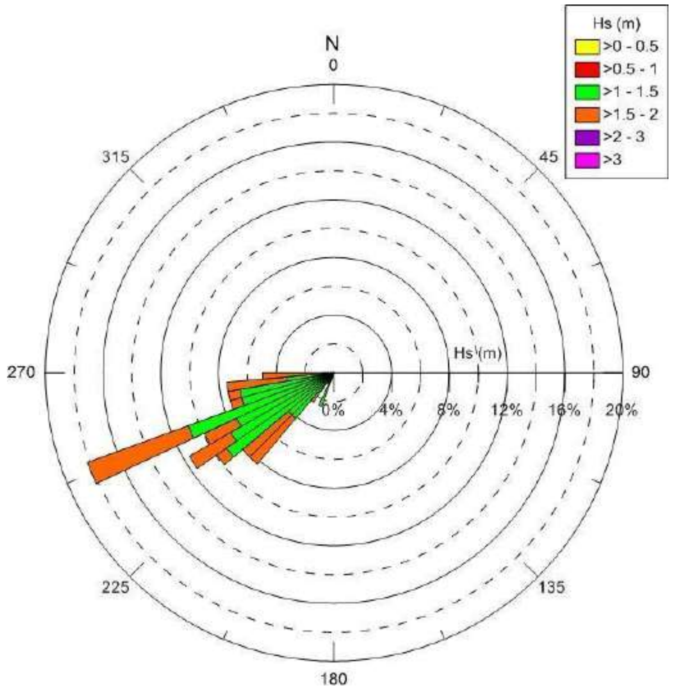


Fig 3.9 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of September

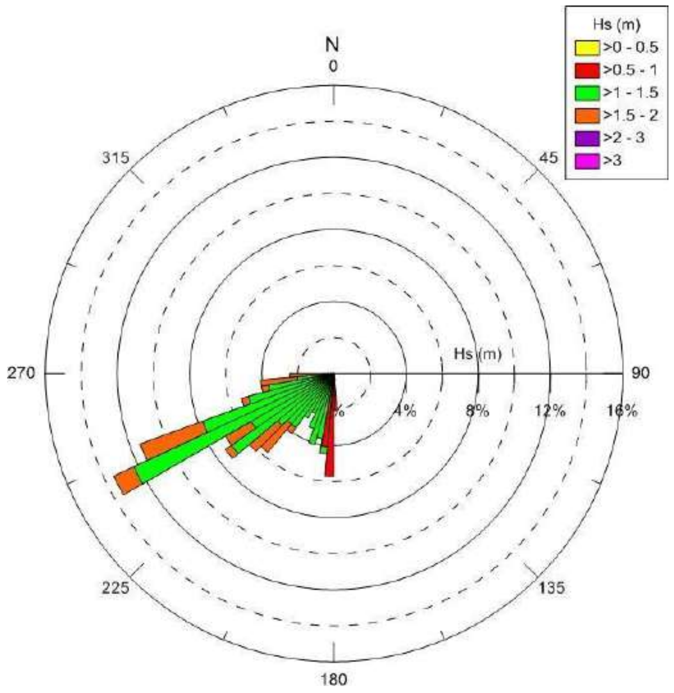


Fig 3.10 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of October

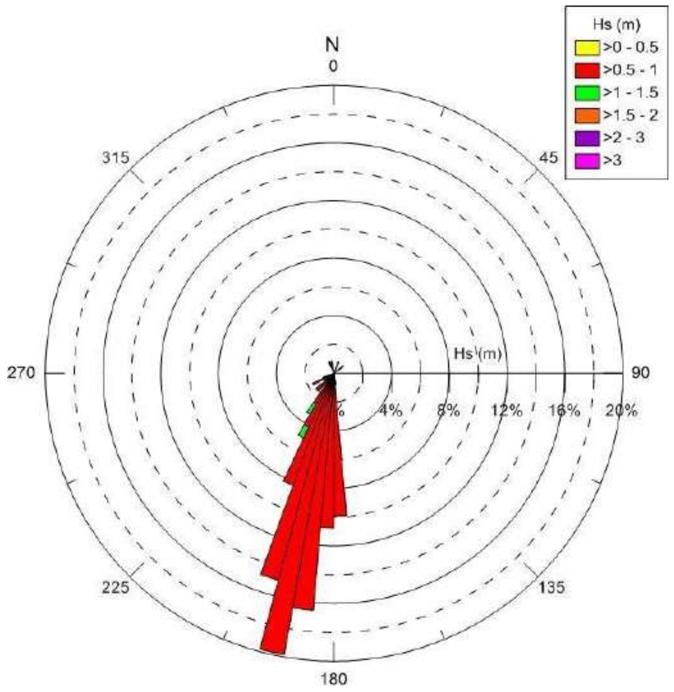


Fig 3.11 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of November

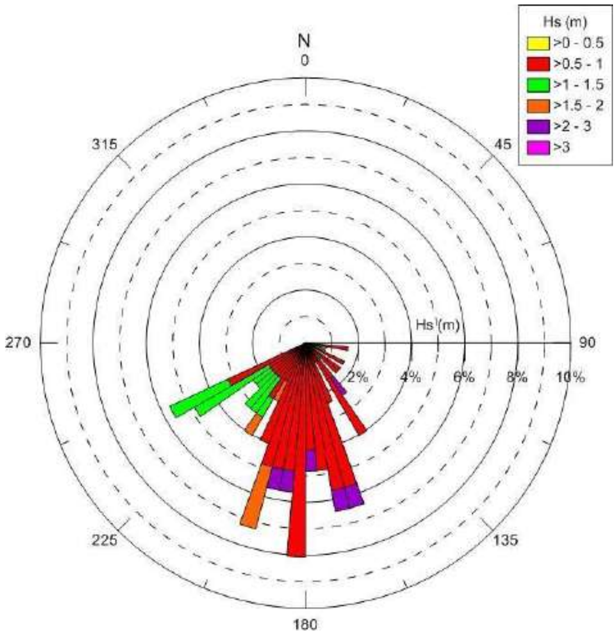


Fig 3.12 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of December

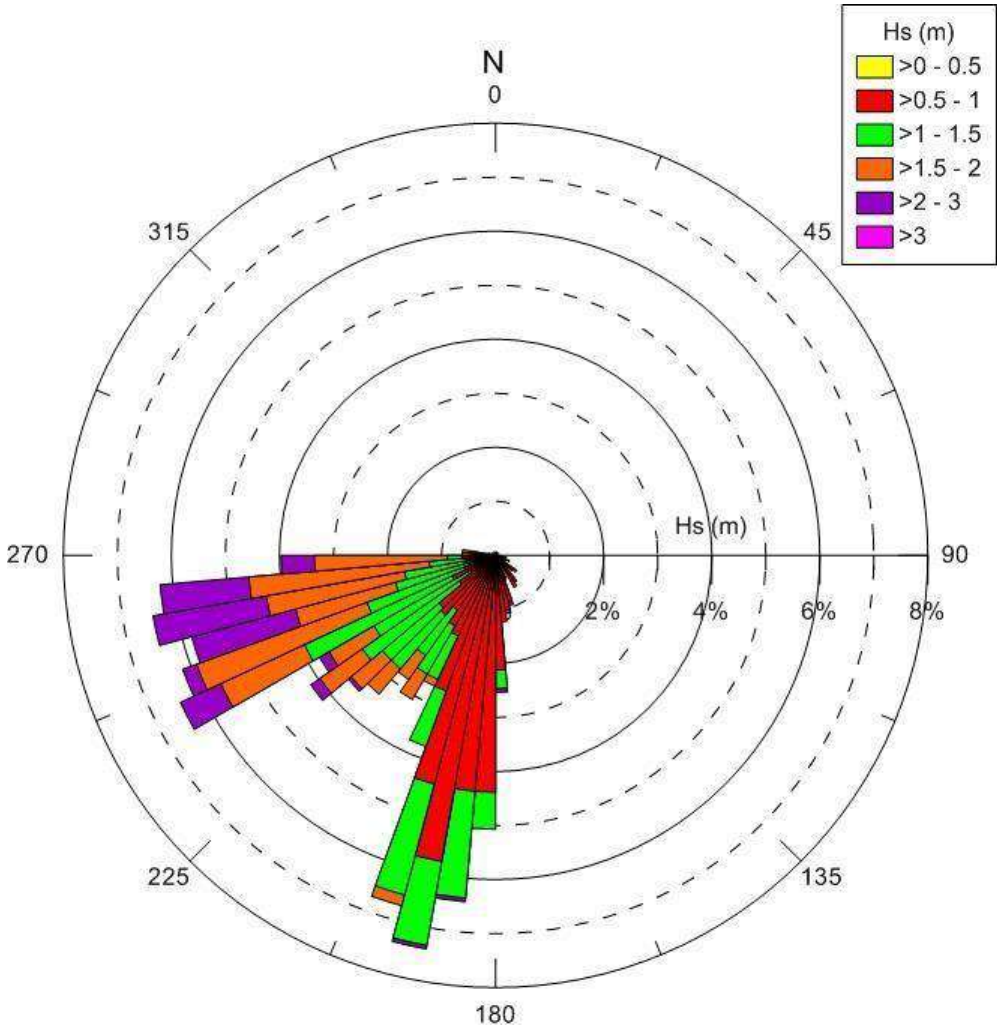


Fig 3.13 Wave rose diagram representing the significant wave height (m) along the particular direction for an annual year

3.2.1 Current Measurement for Present and Future conditions after Dredging of -20m

Demarcation of the study domain is done to set up the extent of the model domain. Hydrodynamic modelling is executed using Ocirc circulation model for ICTT vallarpadam Cochin port trust domain. The hydrodynamic modelling is executed for spring and neap condition, which covers all the astronomical aspects of tidal forcing. It is conducted using the modelling approach by physical settings and domain considered with the mesh and measured bathymetry is considered for simulation. The time series data is extracted for the present and future current conditions of the area which is shown in **Fig.3.14-3.21.**

Time series data is extracted for the present current condition with the depth of 14m along the shore of eastern and western side of the ICTT berth and is shown in **Fig3.14-3.17** below. The current extracted along the north western side and south western side of the ICTT berth is 1.0 m/s and 0.75 m/s respectively. The current extracted for north eastern side and south eastern side of the ICTT berth is 0.70m/s and 0.35m/s respectively. Time series data is extracted for the present current condition with the depth of 20 m along the shore of eastern and western side of the ICTT berth and is shown in **Fig.3.18-3.21** below. The current extracted along the north western side and south western side of the ICTT berth is 1.1 m/s and 0.73 m/s respectively. The current extracted for north eastern side and south eastern side of the ICTT berth is 0.72m/s and 0.33m/s respectively. There is no change in current measurement due to varying depth for present and future conditions.

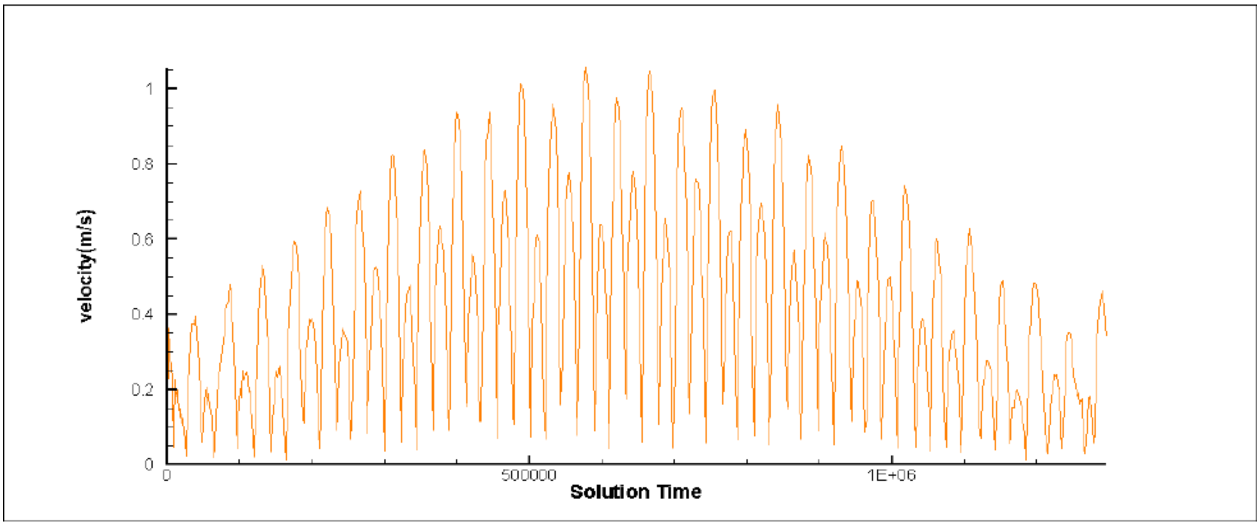


Fig.3.14. Time series data is extracted north western side of the ICTT berth at (14m) depth

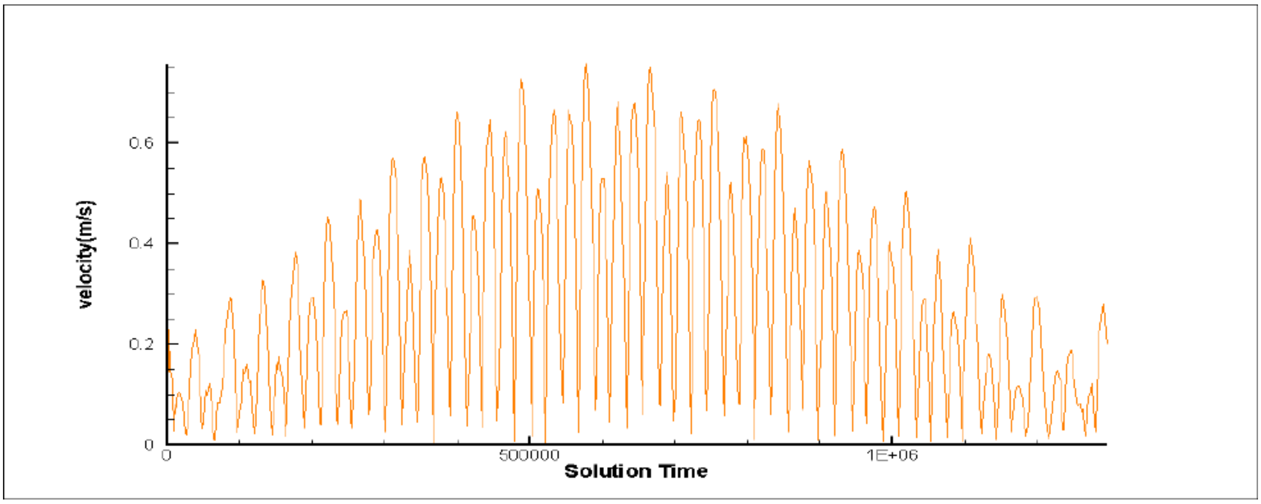


Fig 3.15 Time series data is extracted south western side of the ICTT berth at (14m) depth

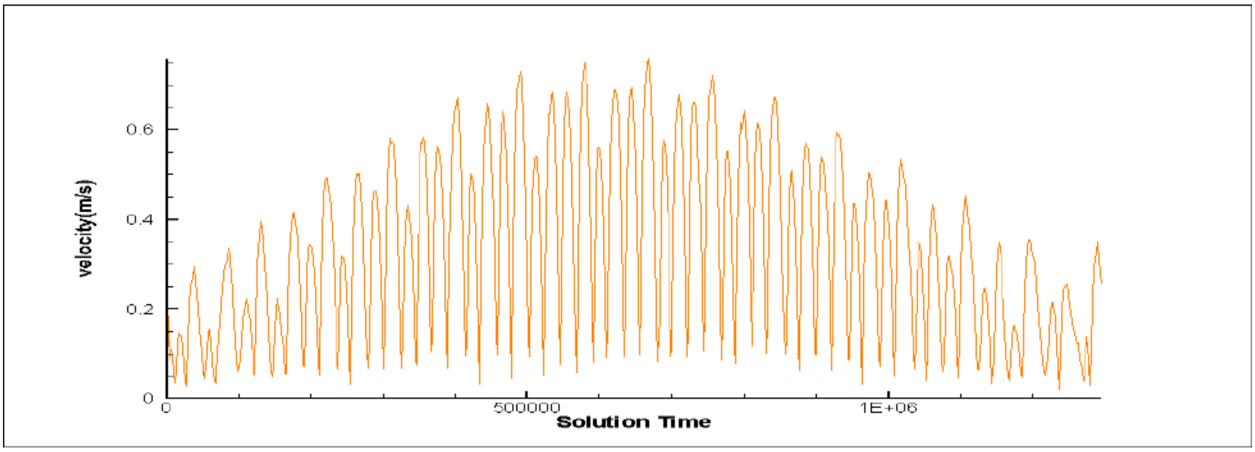


Fig 3.16 Time series data is extracted for north eastern side of the ICTT berth at (14m) depth

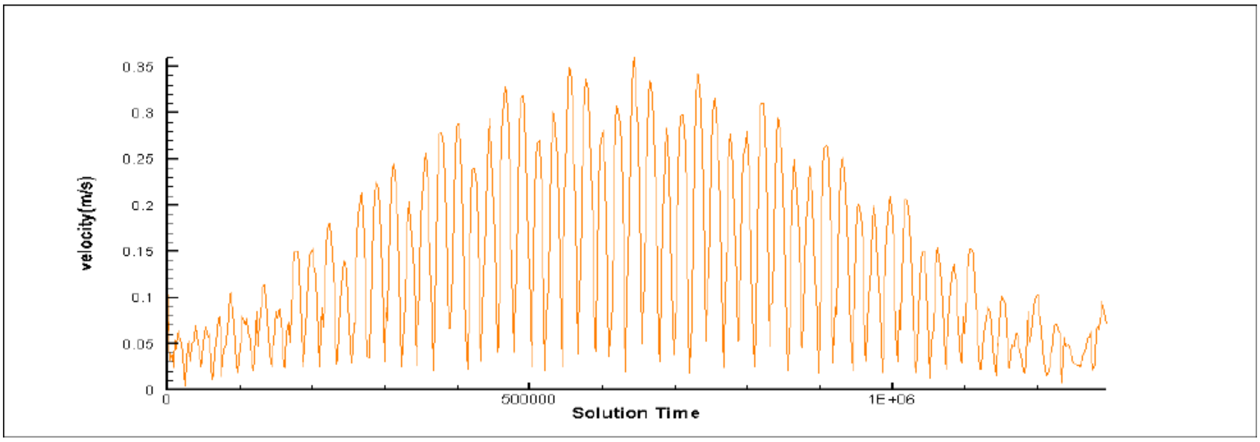


Fig 3.17 Time series data is extracted for south eastern side of the ICTT berth at (14m) depth

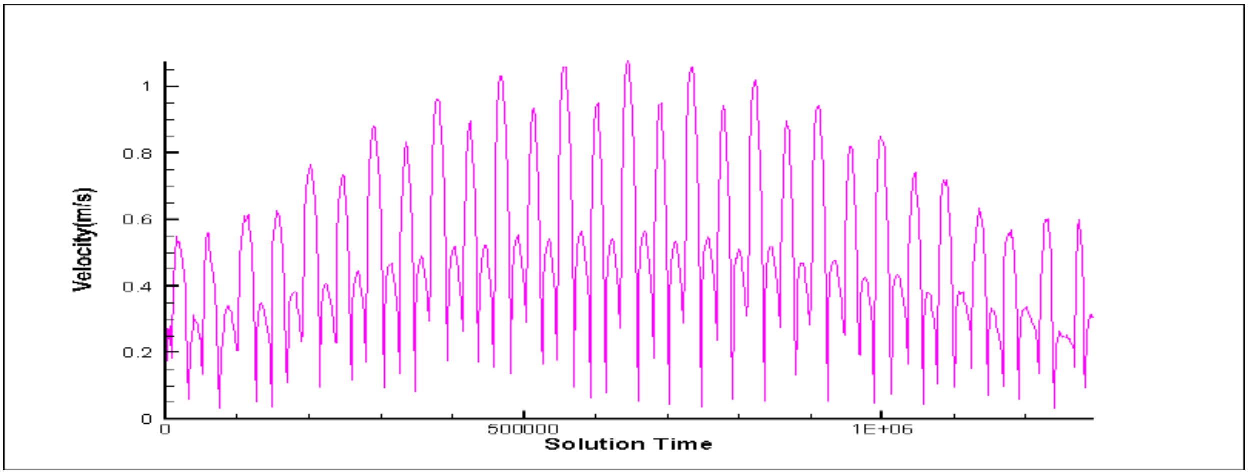


Fig 3.18 Time series data is extracted north westerly side of the ICTT berth at (20m) depth

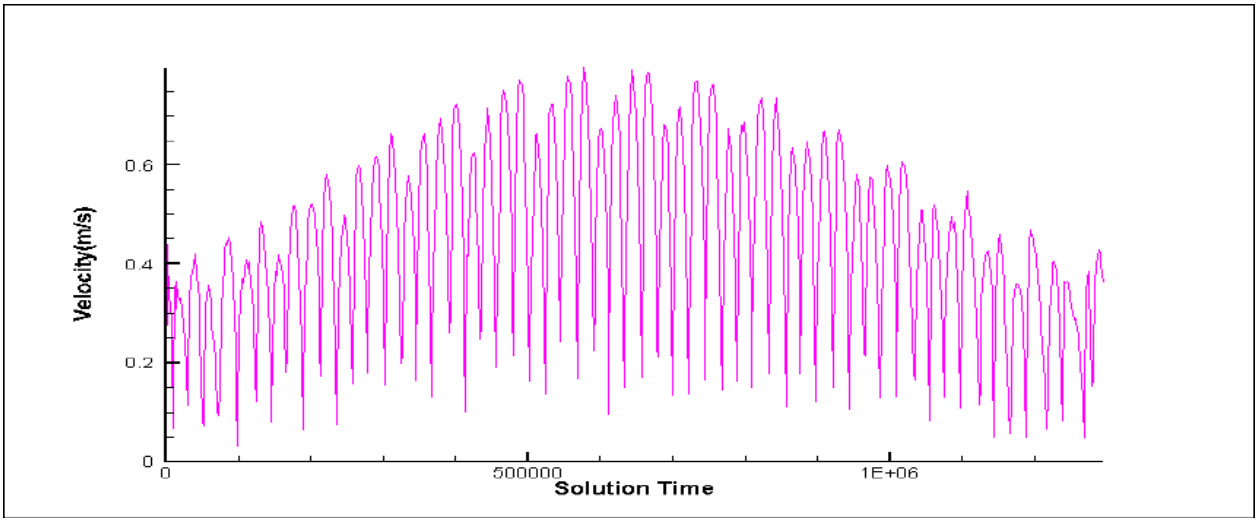


Fig 3.19 Time series data is extracted south western side of the ICTT berth at (20m) depth

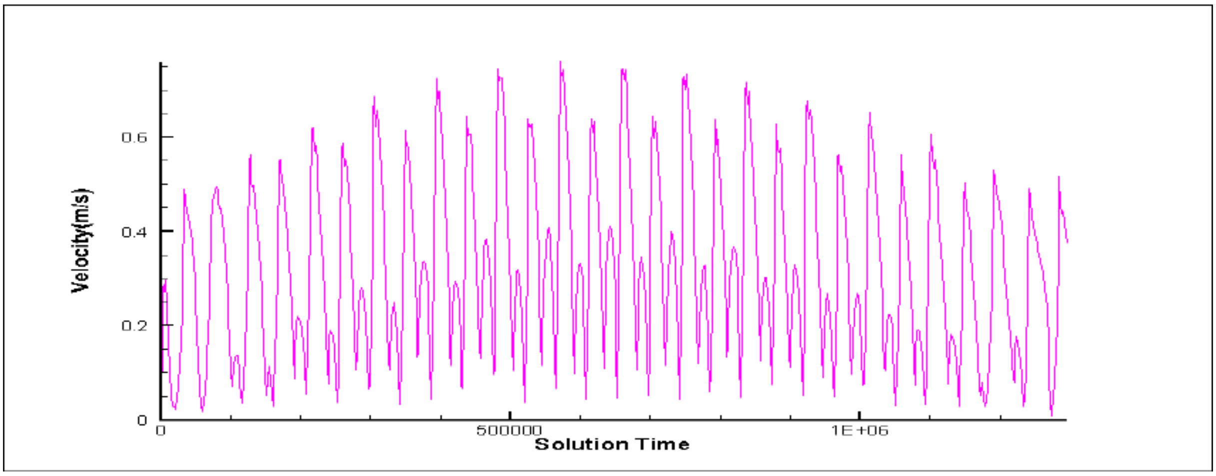


Fig.3.20 Time series data is extracted for north eastern side of the ICTT berth at (20m) depth

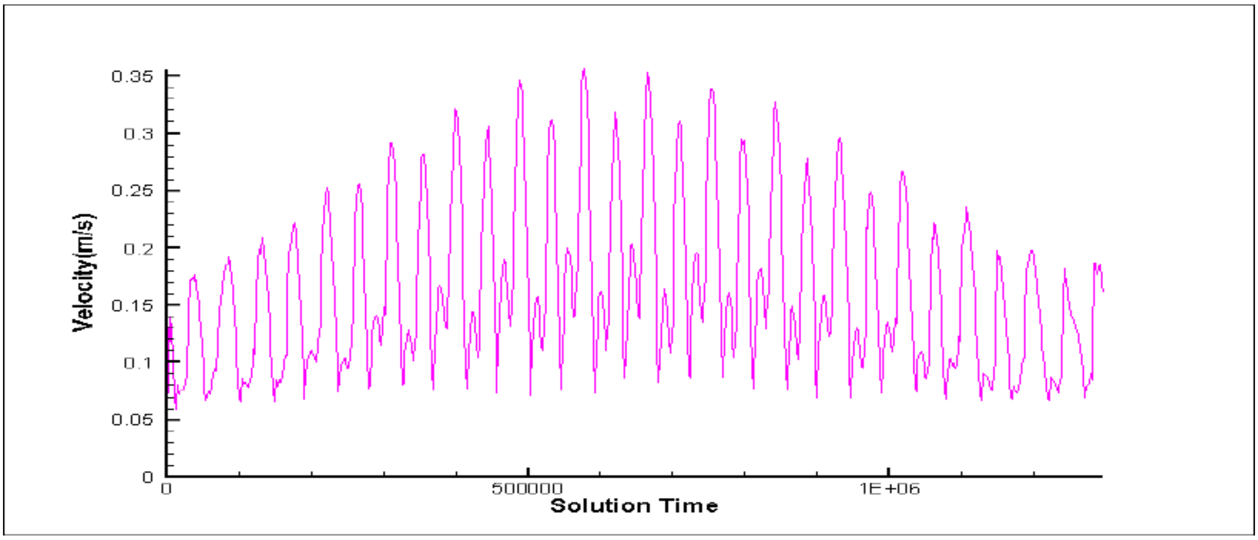


Fig 3.21 Time series data is extracted for south eastern side of the ICTT berth at (20m) depth

3.3 WAVE TRANQUILLITY STUDY

3.3.1 Numerical modelling

The study aims at providing an in depth analysis on the wave incidence on the neighborhood shoreline of ICTT berthing jetty due to the proposed increase in the water depth in front of the ICTT jetty. A suitable numerical model is required in order to carry out this task. For the present simulation, the phase resolving model based on mild slope equation has been used.
The nonlinear wave propagation associated with most of the observed phenomenon in offshore region (e.g., wave reflection, refraction and diffraction) is generally represented by the shallow water mild slope equation.

$$\nabla.\left(C_p C_g \nabla \eta\right) + k^2 C_p C_g \eta = 0 \qquad (1)$$

Where, C_p and C_g are the wave celerity and group celerity respectively. η is the water surface elevation. k is the wave number. For the computation of near shore wave field, this model, Eqn.(1) is subjected to the proper boundary conditions. This is provided by the bathymetry and the shore line.

The computational domain roughly approximates a semi circle of radius 10 km. **Fig 3.22** shows the domain where the computations are actually performed. The direction of the incident monochromatic wave is defined with respect to the geometric northern direction

3.3.2 Case 1- Present Bathymetry Conditions

In case 1, the computational domain roughly approximates a semi-circle of radius 10 km. **Fig.23** shows the domain where the computations are actually performed. The direction of the incident monochromatic wave is defined with respect to the geometric northern direction.

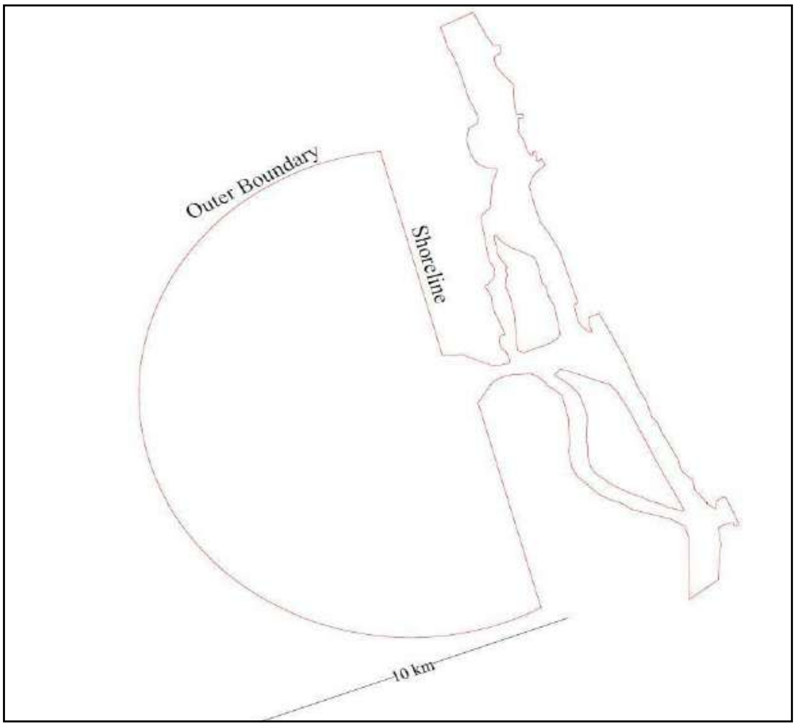


Fig.3.22 Computational domain for tranquility studies for Cochin

A numerical method is required to solve the above Eqn. (1) for wave elevation. In this study, Finite Element Method (herein after abbreviated as FEM) is employed. This requires creating a mesh structure in the given computational domain. Upon creation of such a mesh, the domain is represented by nodal points which are connected with each other through the created mesh. The numerical solution of Eqn. (1) is sought in those nodes. This mesh has been generated using the commercial package GAMBIT.

3.3.3 Detail of the mesh structure

The CGWAVE model utilizes triangular mesh units in the computational domain. Due to the complexity in the shoreline geometry (as can be seen in **Fig 3.22)** which includes both of the proposed breakwaters, an unstructured mesh is desired. Hence a triangular unstructured mesh is generated in GAMBIT, mesh generation software. In such a mesh the nodal spacing is optimized so as to adapt to the nearby portion of the shoreline boundary. The outer semi circular periphery is modeled by 1289 nodes with a spacing of 5 m and the inner shoreline is modeled by nodes with a spacing of 5 m. Then an unstructured mesh is created with an average spacing of 10m inside the domain. This leads to a total number of 186524 nodes with 393700 numbers of triangular elements. The mesh is shown in **Fig 3.23**

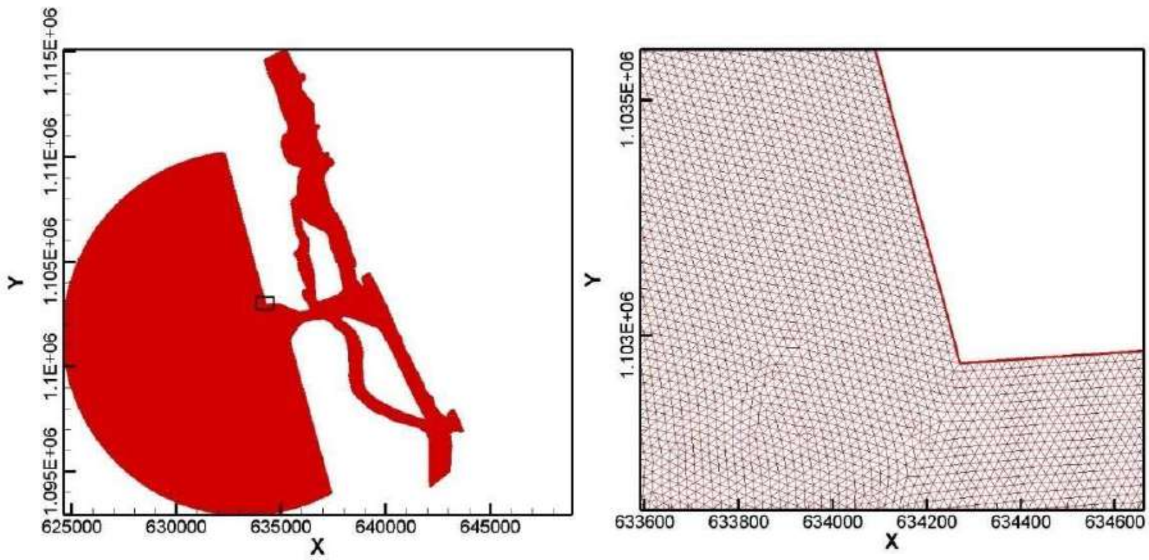


Fig 3.23 Mesh Structure adopted for the wave propagation modeling

3.3.4 Results and discussion

Different wave directions have been simulated in order to investigate the wave tranquillity inside the proposed jetty region. The wave directions are chosen such that these represent an annual year. The wave period of the computations is given as 8s to observe the wave climate. The incident wave angle is varied to simulate different wave directional scenarios.

The wave climates representing typical wave directions are presented. **Fig 3.24** to **Fig 3.29** present the wave phase diagram and the wave height distribution representing the wave crest propagation for the wave approach angles 180^{0} ,215^{0} ,225^{0}, 245^{0},270^{0} and 345^{0} respectively.

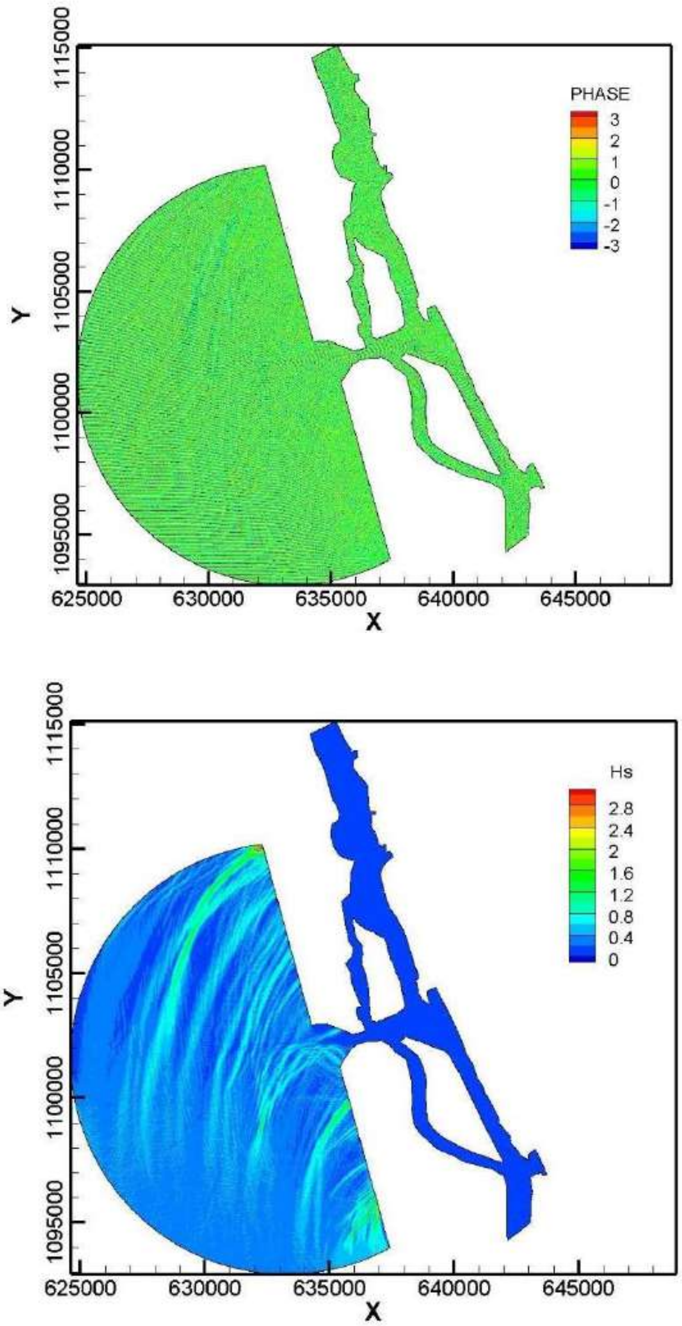


Fig 3.24 Phase distributions and Wave height distribution for the wave approach angle from 180^{0}

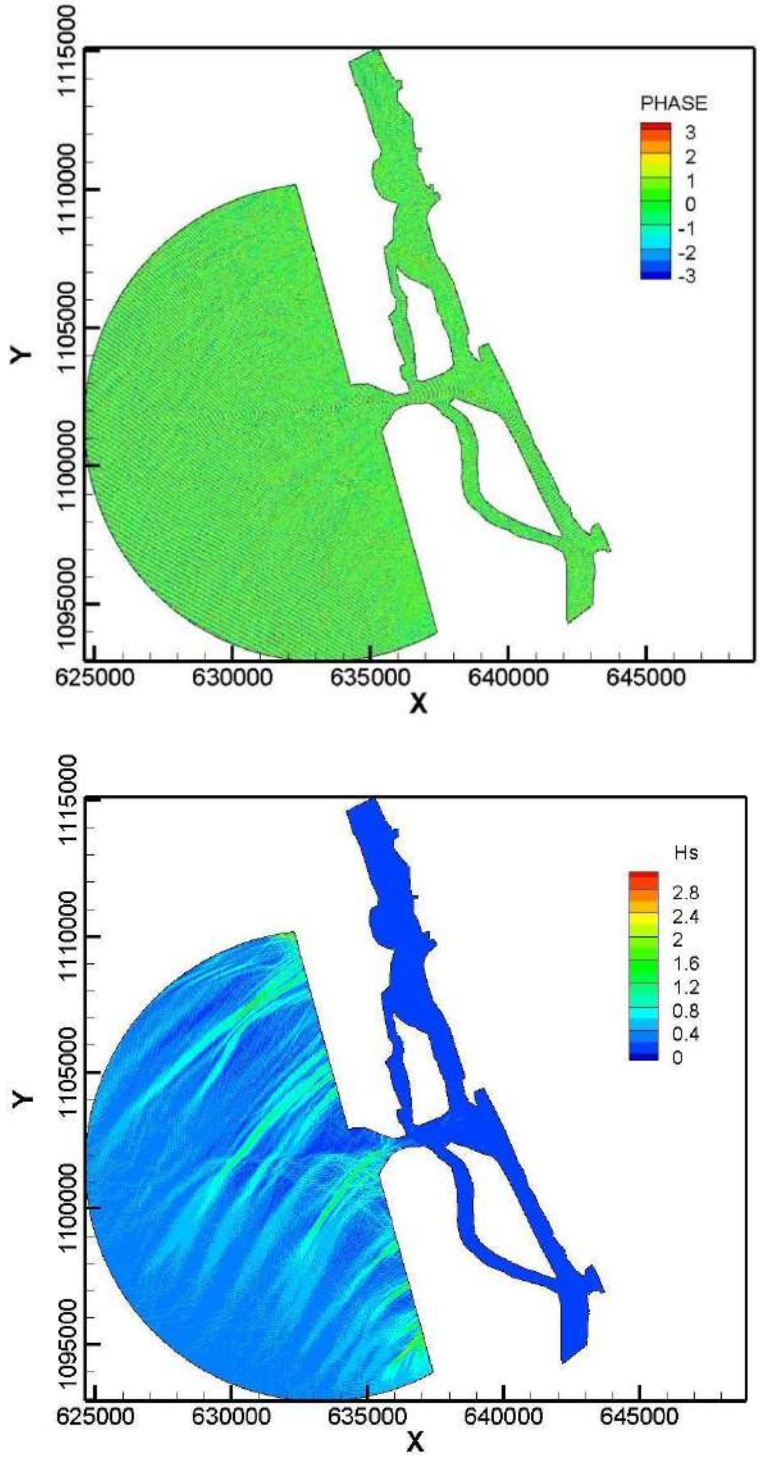
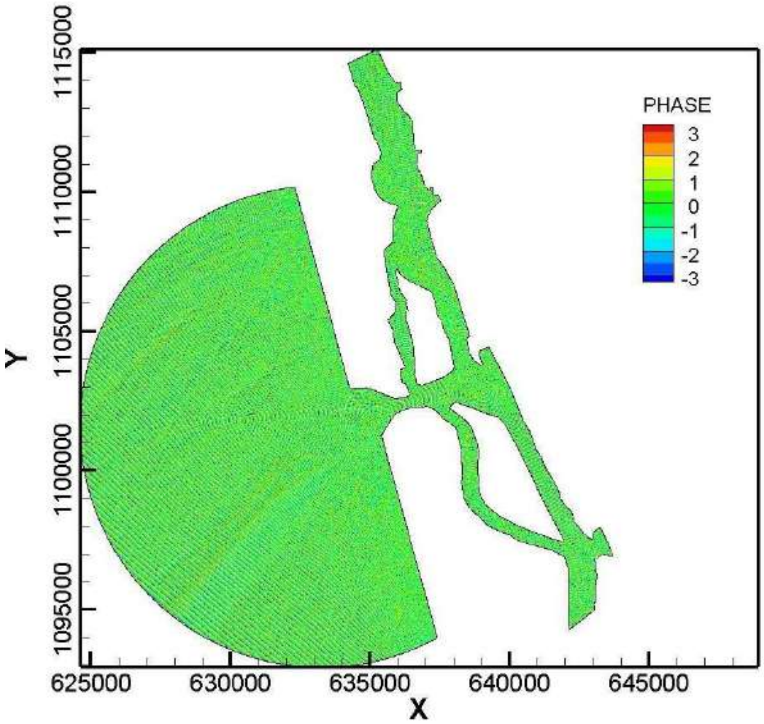


Fig 3.25 Phase distributions and Wave height distribution for the wave approach angle from 215^0



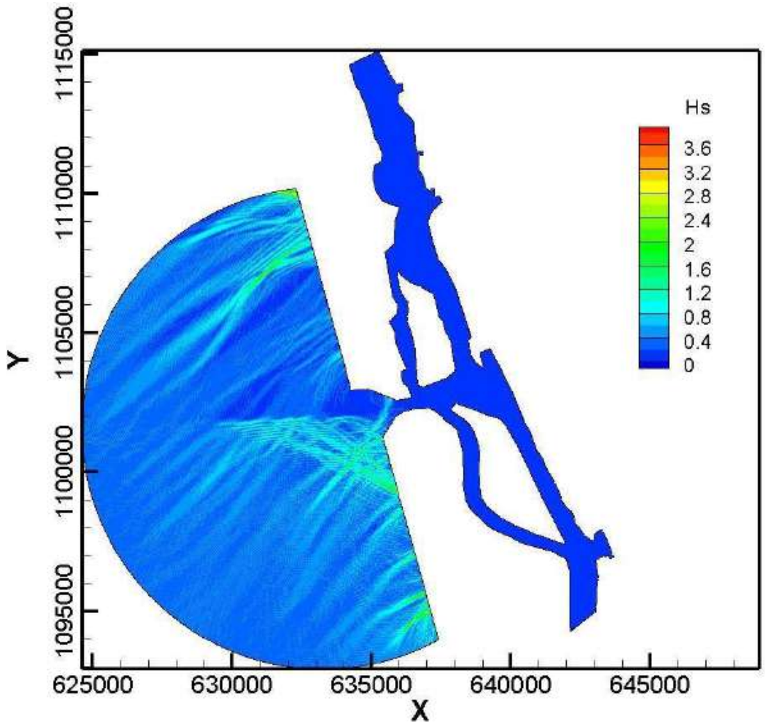
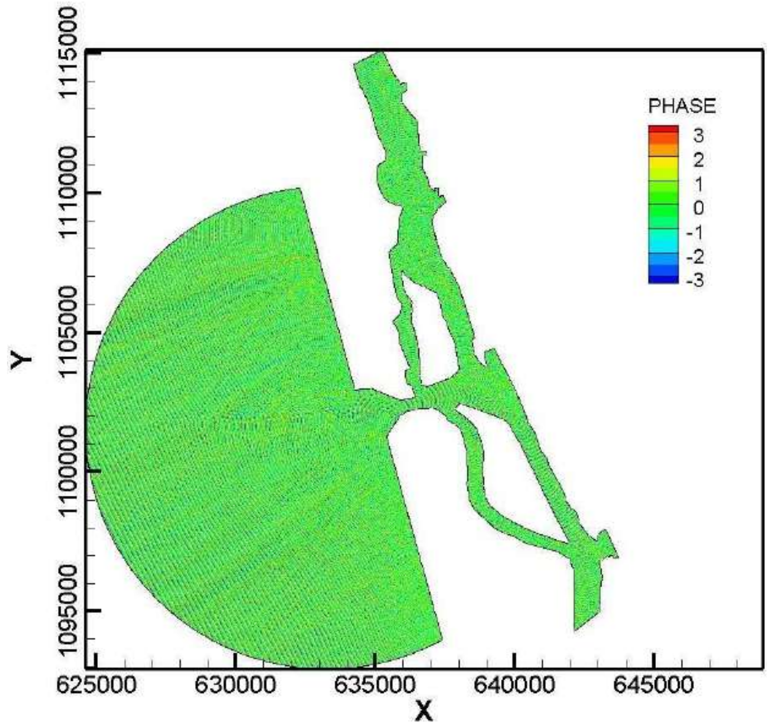


Fig 3.26 Phase distributions and Wave height distribution for the wave approach angle from 225^0



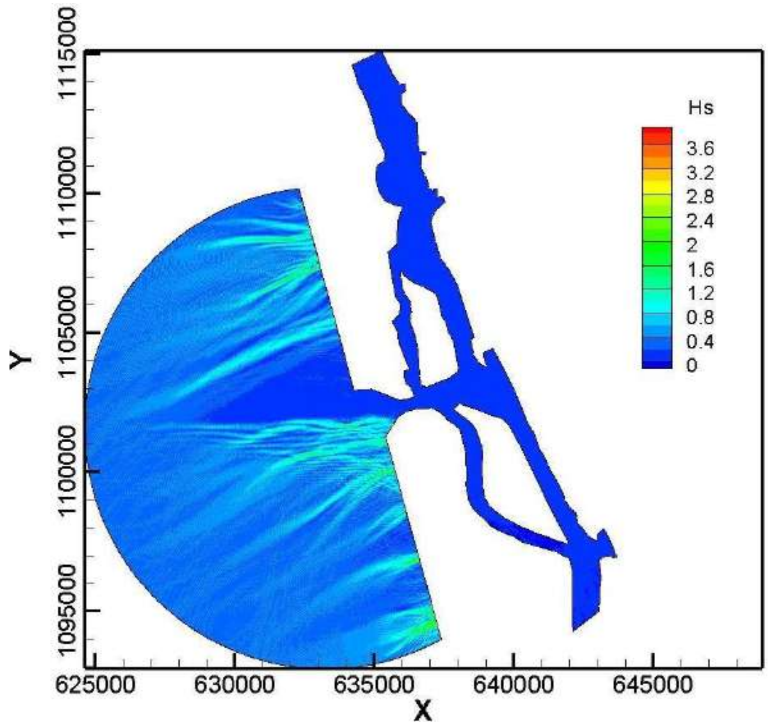


Fig 3.27 Phase distributions and Wave height distribution for the wave approach angle from 245^0

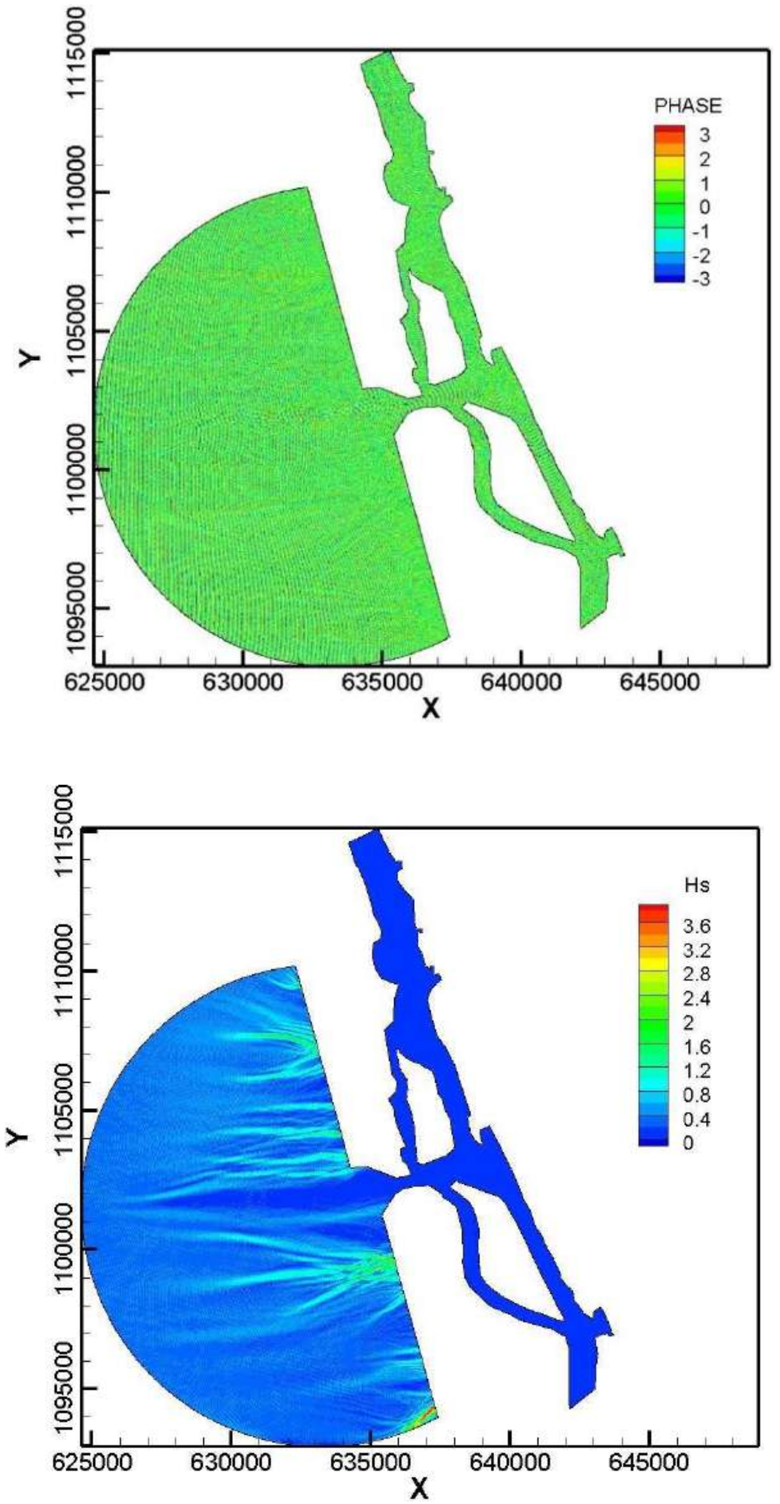


Fig 3.28 Phase distributions and Wave height distribution for the wave approach angle from 270^0

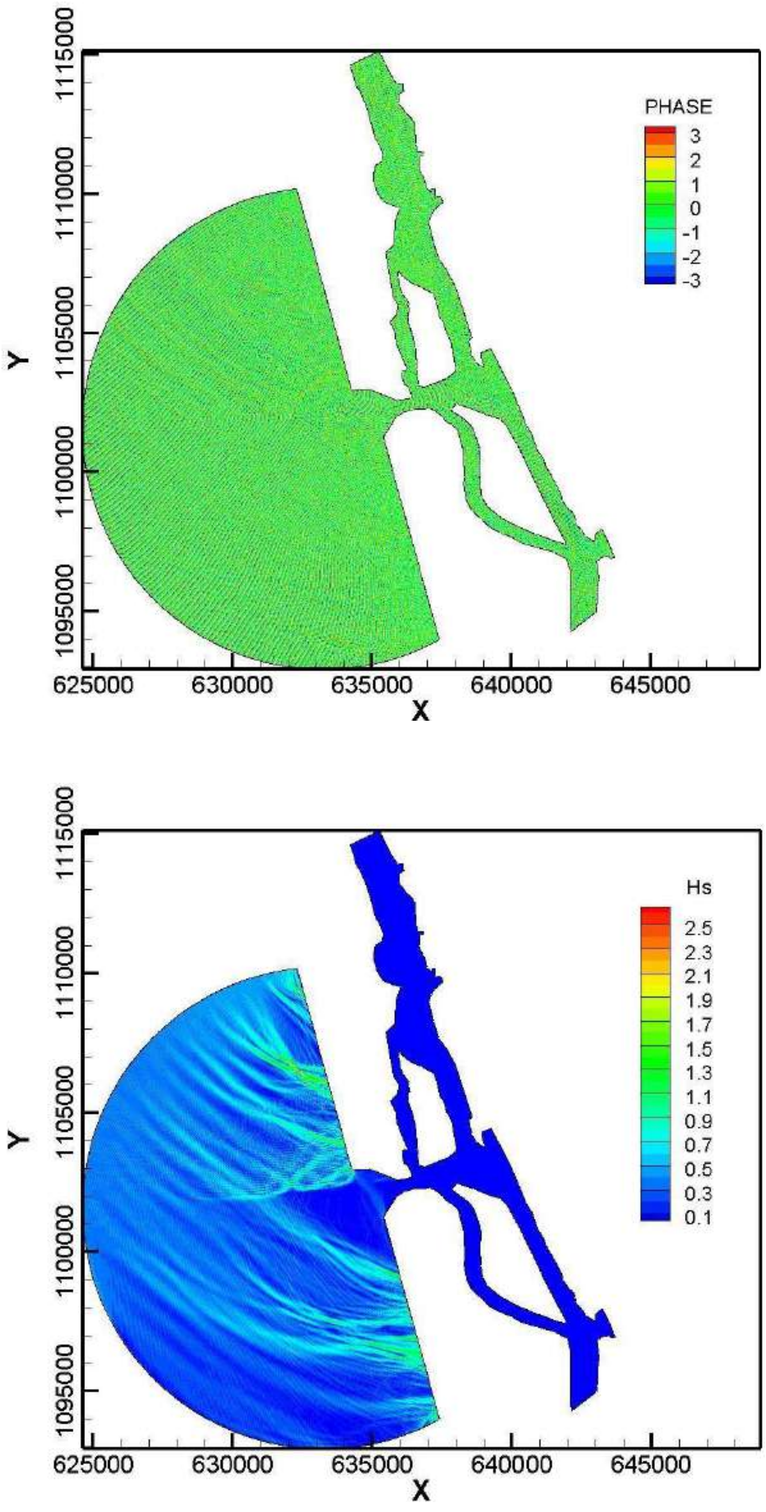


Fig 3.29 Phase distributions and Wave height distribution for the wave approach angle from 345^0

3.3.5 Summary

Further, in order have a closer understanding of the wave penetration upto the vicinity of ICTT jetty, a few nodal points around the channel on both sides of the ICTT jetty are selected, where, the wave height is monitored during the course of the simulations and averaged to find the wave amplitude at the location. The location of the output points is shown in **Fig.3.30.** The occurrence of waves in the location of output points is presented in **Table 3.1.** The average maximum wave climate has been obtained from the probability of occurrence of offshore wave climate penetration into the channel. It is to be mentioned here that the wave propagation model has been executed for both scenarios of water depth in front of the jetty as 14m and 20m. However, the variation of the wave climate off the channel near the shoreline is insignificant.

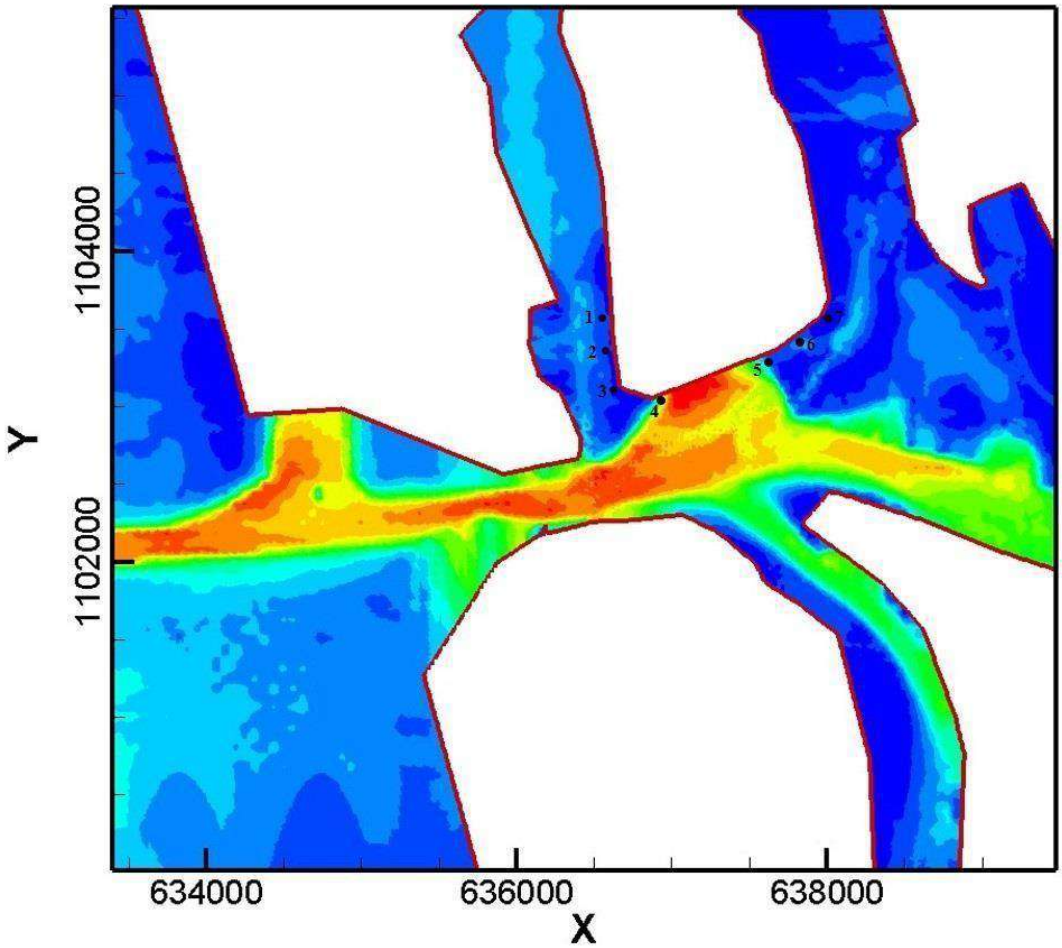


Fig 3.30 Points of measurement of the wave height

3.3.6 Case 2 – Bathymetry after dredging (20m)

In case 2, the computational domain roughly approximates a semi-circle of radius 10 km. **Fig 3.31** shows the domain where the computations are actually performed. The direction of the incident monochromatic wave is defined with respect to the geometric northern direction.

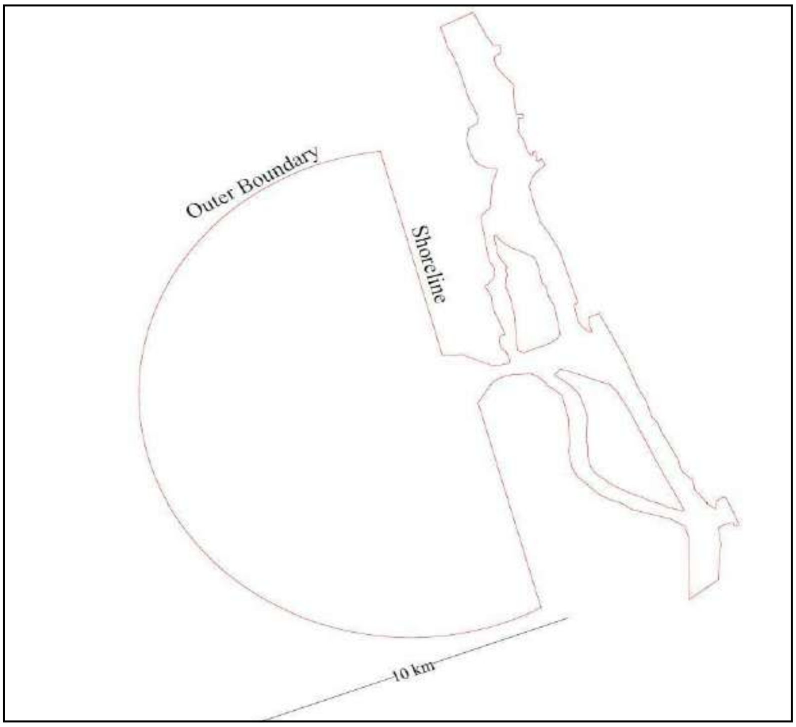


Fig.3.31 Computational domain for tranquillity studies for Kochi

A numerical method is required to solve the above Eqn. (7) for wave elevation. In this study, Finite Element Method (herein after abbreviated as FEM) is employed. This requires creating a mesh structure in the given computational domain. Upon creation of such a mesh, the domain is represented by nodal points which are connected with each other through the created mesh. The numerical solution of Eqn. (1) is sought in those nodes. This mesh has been generated using the commercial package GAMBIT. The procedure for generation of grid in GAMBIT as follows:

- Based on the region of the sea whose analysis is required add a path in Google earth software.

- Taking the two end nodes of the path draw a semicircle which would represent the domain for which the wave analysis is required.
- Choose the type of elements (tri/quad) and the sizing of mesh.
- Mesh will be generated from which we would be able to know significant wave height and phase at each node.

The computational domain with bathymetry is shown in **Fig.3.32**

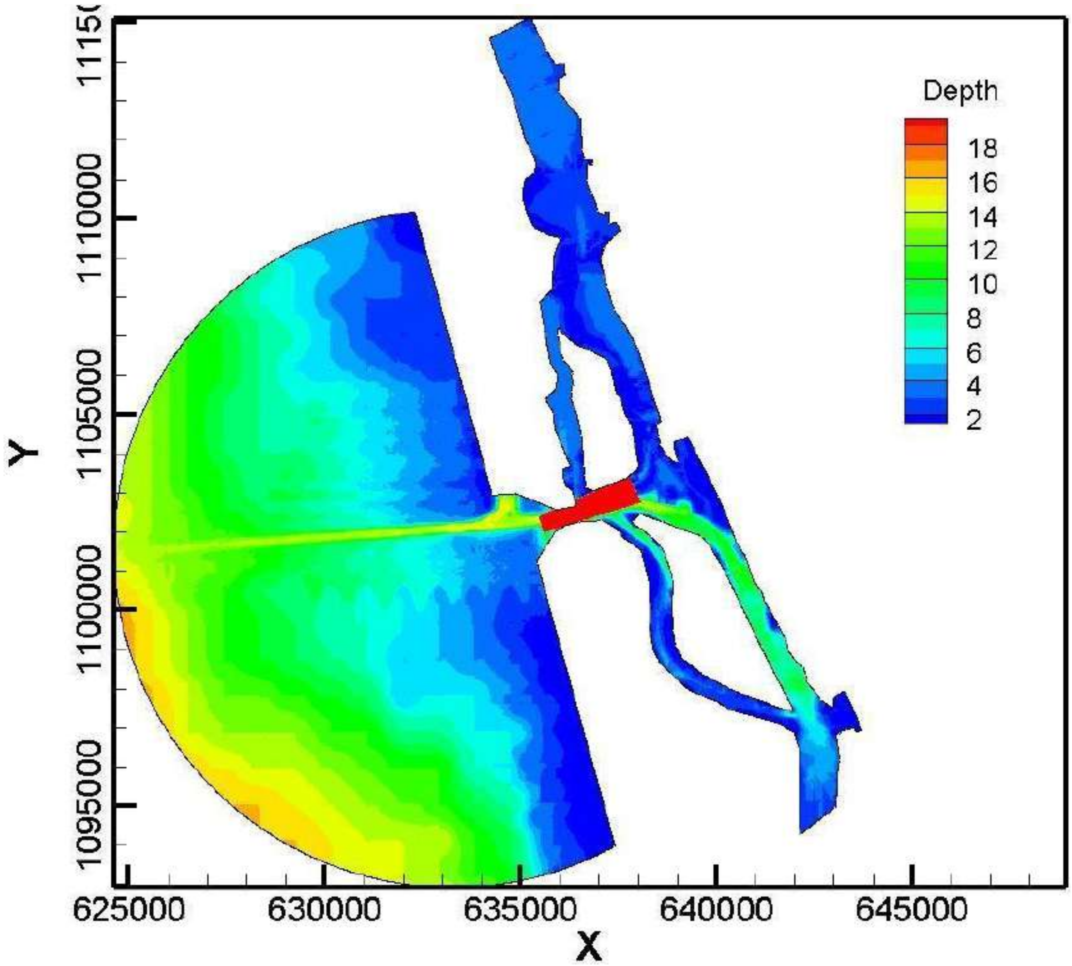


Fig. 3.32 Bathymetry for case 2

3.3.7 Detail of the mesh structure

The CGWAVE model utilizes triangular mesh units in the computational domain. Due to the complexity in the shoreline geometry (as can be seen in **Fig 3.32**), an unstructured mesh is desired. Hence a triangular unstructured mesh is generated in GAMBIT, mesh generation software. In such a mesh the nodal spacing is optimized so as to adapt to the nearby portion of the shoreline boundary. The outer semi-circular periphery is modelled by 1293 nodes with a spacing of 5 m and the inner shoreline is modelled by nodes with a spacing of 5 m. Then an unstructured mesh is created with an average spacing of 10m inside the domain. This leads to a total number of 186726 nodes with 394531 numbers of triangular elements. The mesh is shown in **Fig.3.35**

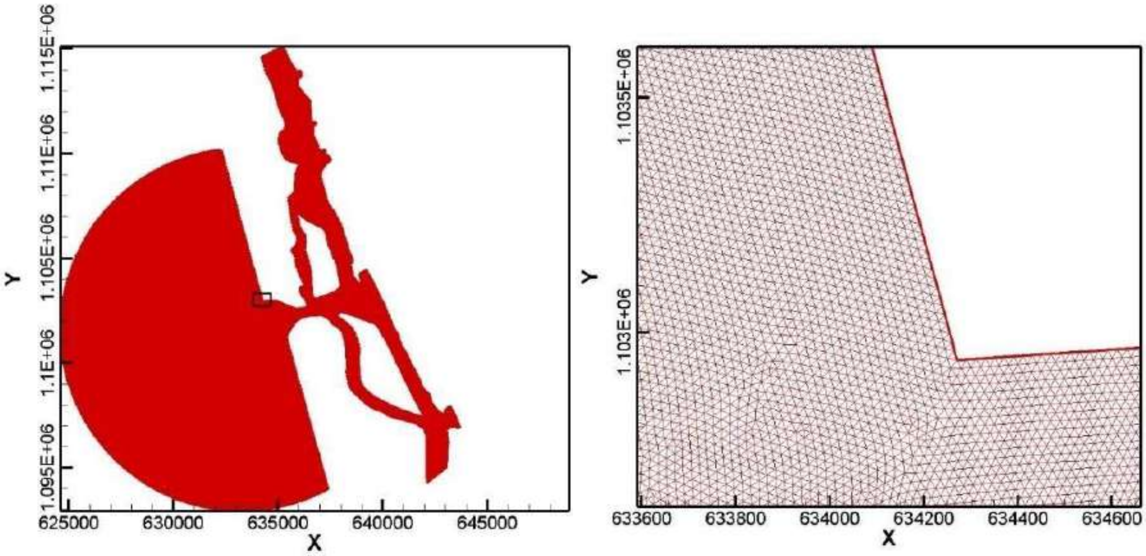


Fig.3.33 Mesh Structure adopted for the wave propagation modelling

3.3.8 Results and discussion

A total number of three wave directions have been simulated in order to investigate the wave tranquillity inside the proposed jetty region. The wave directions are chosen such that these represent an annual year. The wave period of the computations is given as 8s to observe the wave climate. The incident wave angle is varied to simulate different wave directional scenarios.

The wave climates representing typical wave directions are presented. **Fig.3.36** to **Fig.3.41** present the wave phase diagram and the wave height distribution representing the wave crest propagation for the wave approach angles 180^{0} ,215^{0} ,225^{0}, 245^{0},270^{0} and 315^{0} respectively.

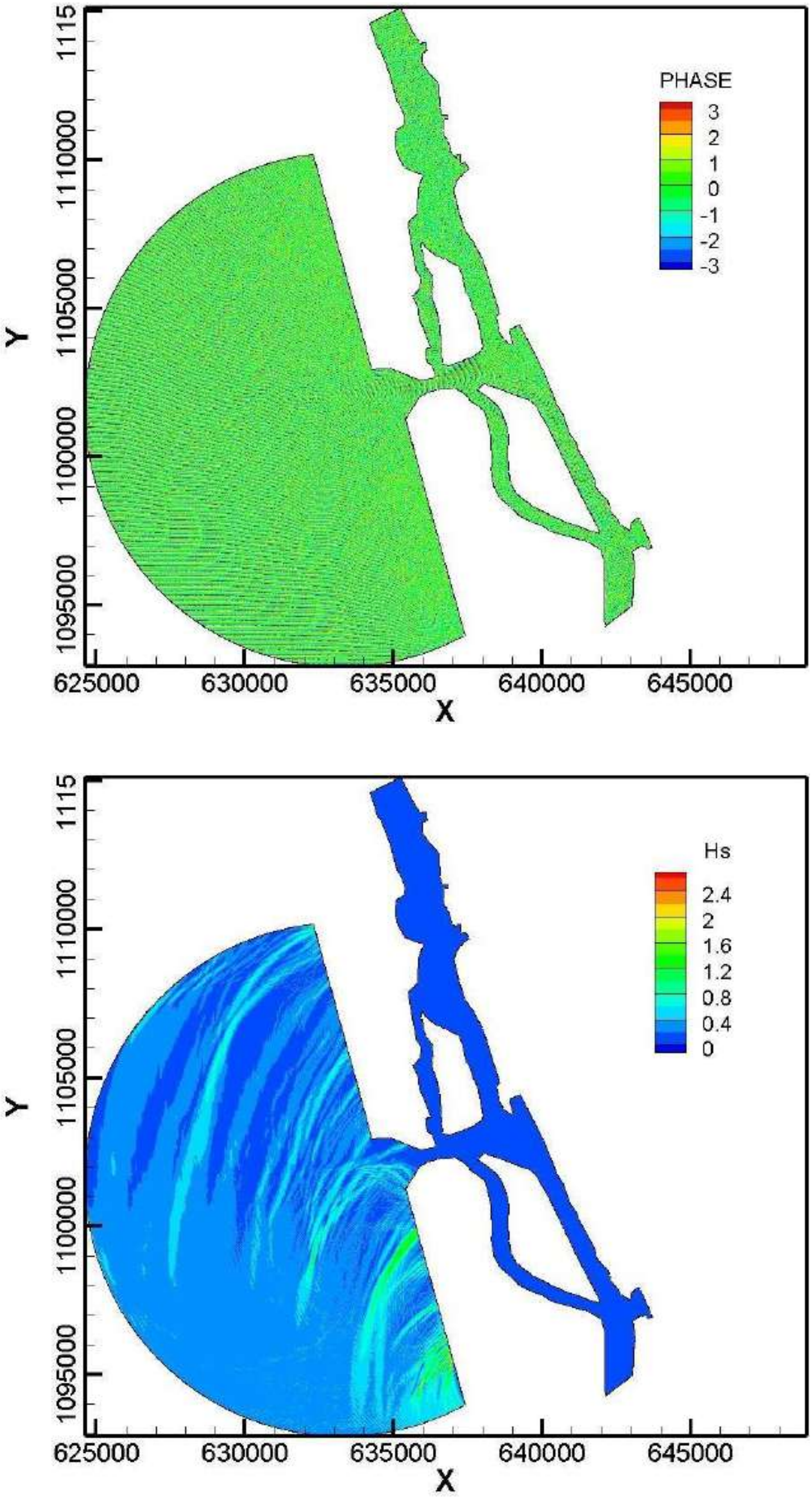
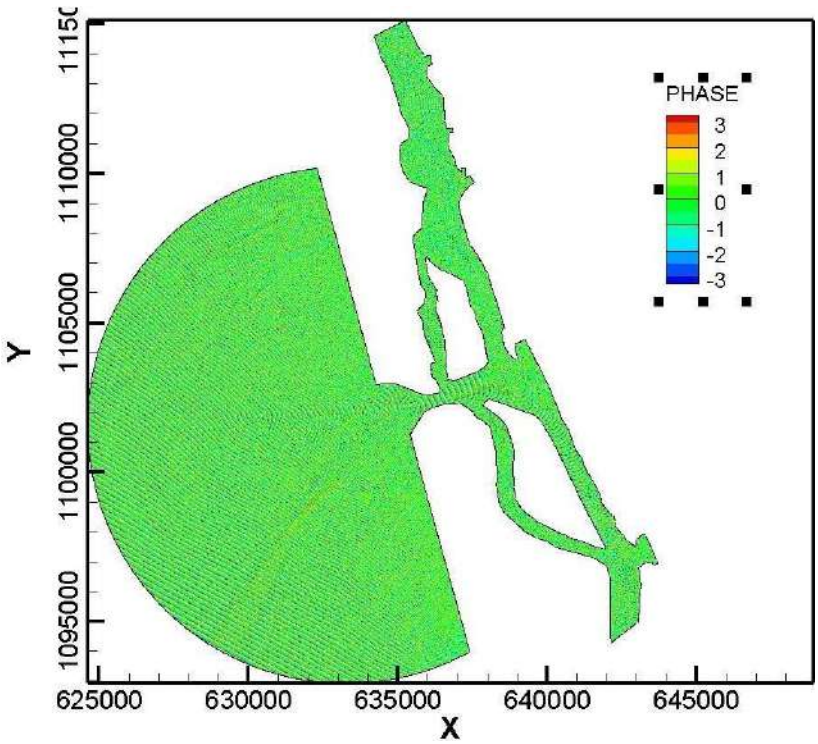


Fig3.34 Phase distributions and Wave height distribution for the wave approach angle from 180^0



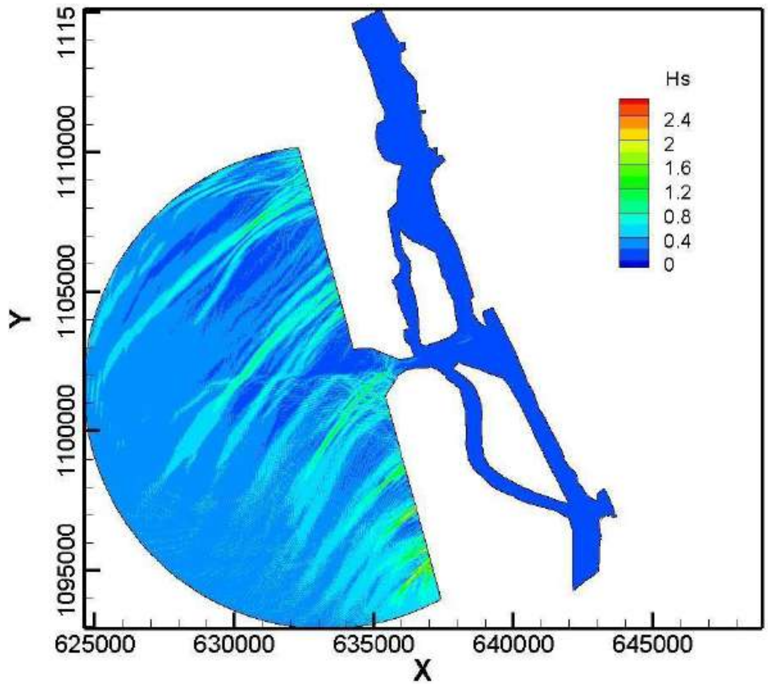


Fig.3.35 Phase distributions and Wave height distribution for the wave approach angle from 215^0

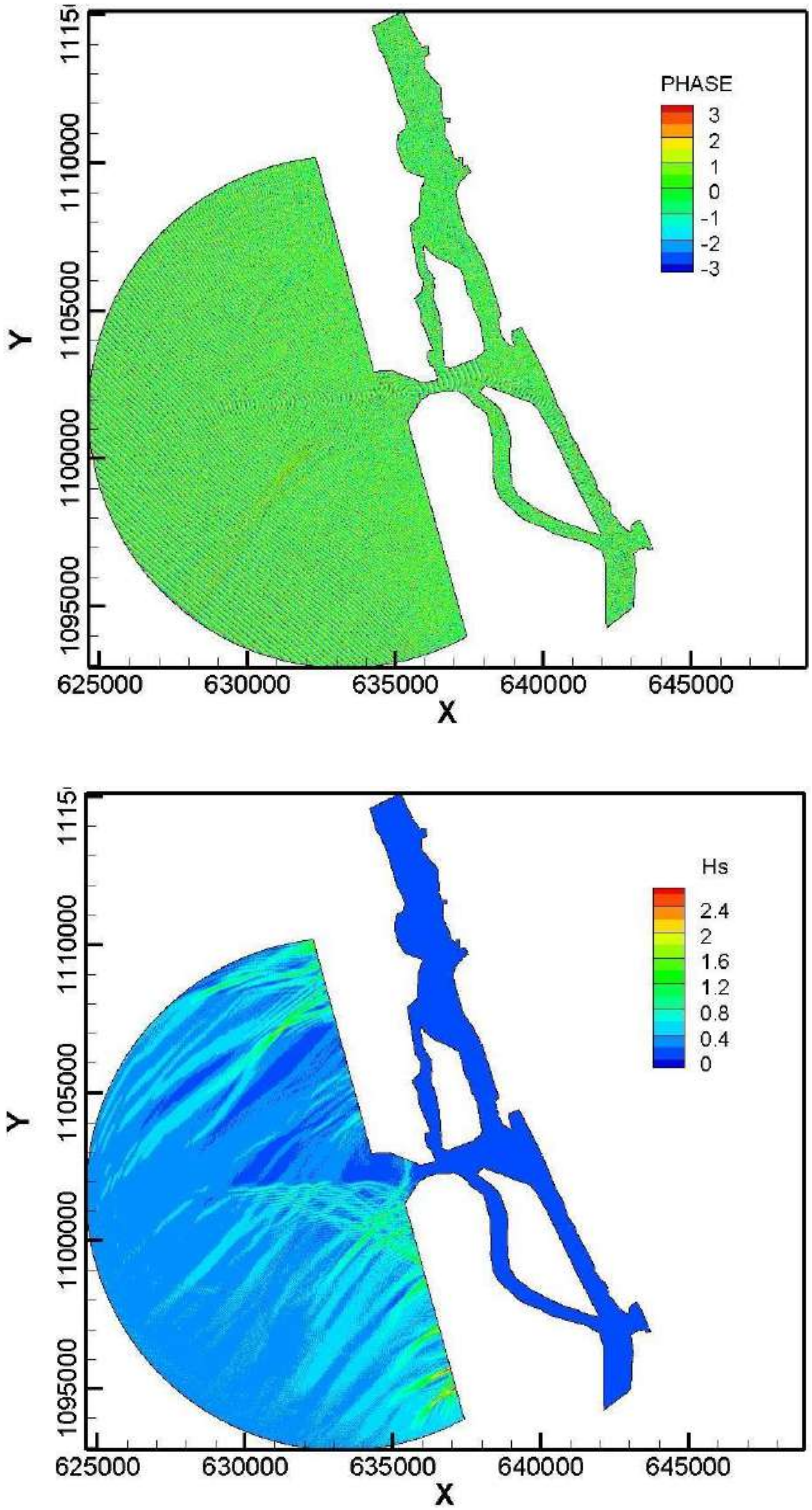
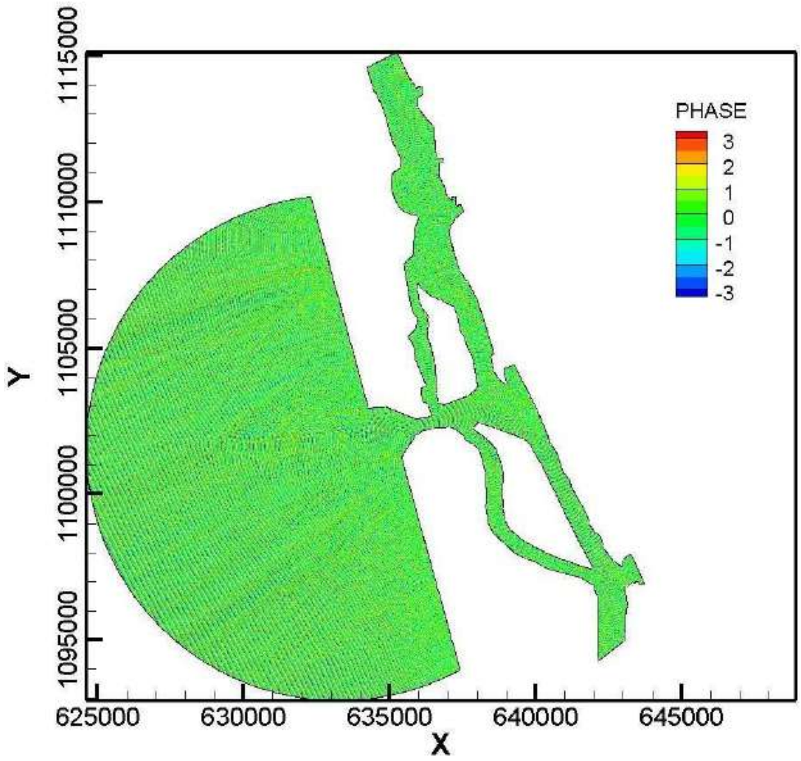


Fig.3.36 Phase distributions and Wave height distribution for the wave approach angle from 225^0



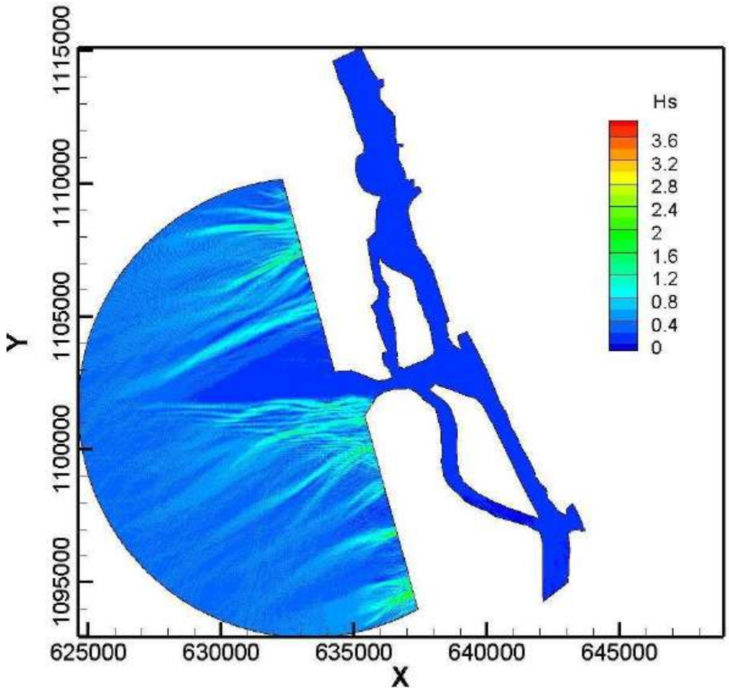
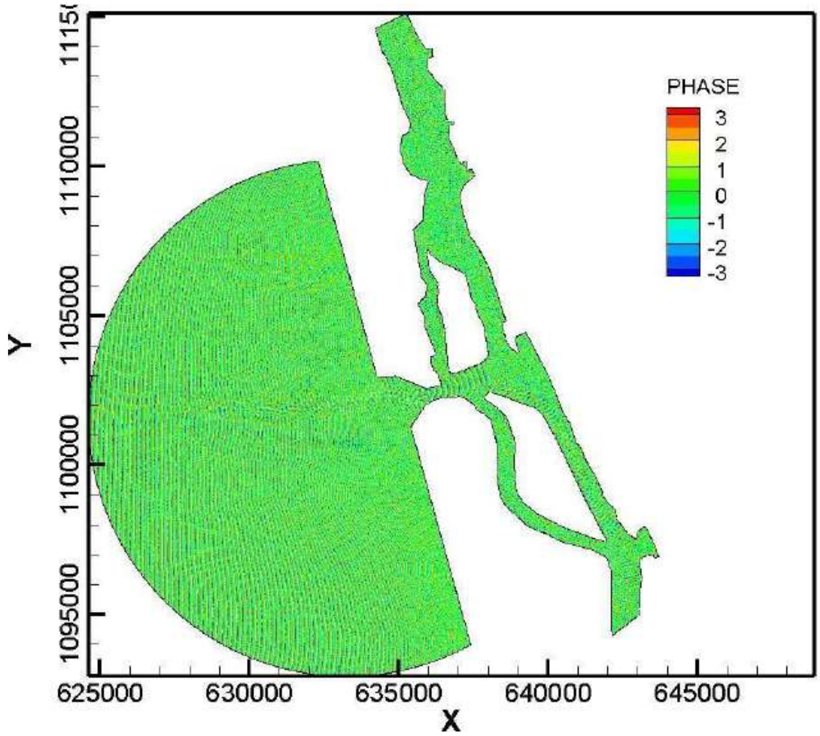


Fig.3.37 Phase distributions and Wave height distribution for the wave approach angle from 245^0



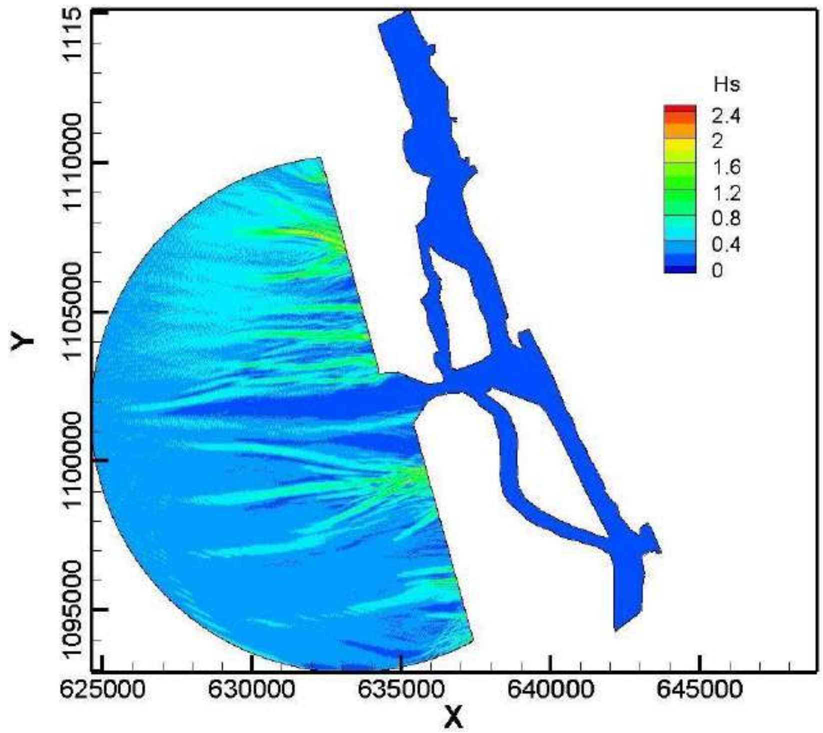


Fig.3.38 Phase distributions and Wave height distribution for the wave approach angle from 270^0

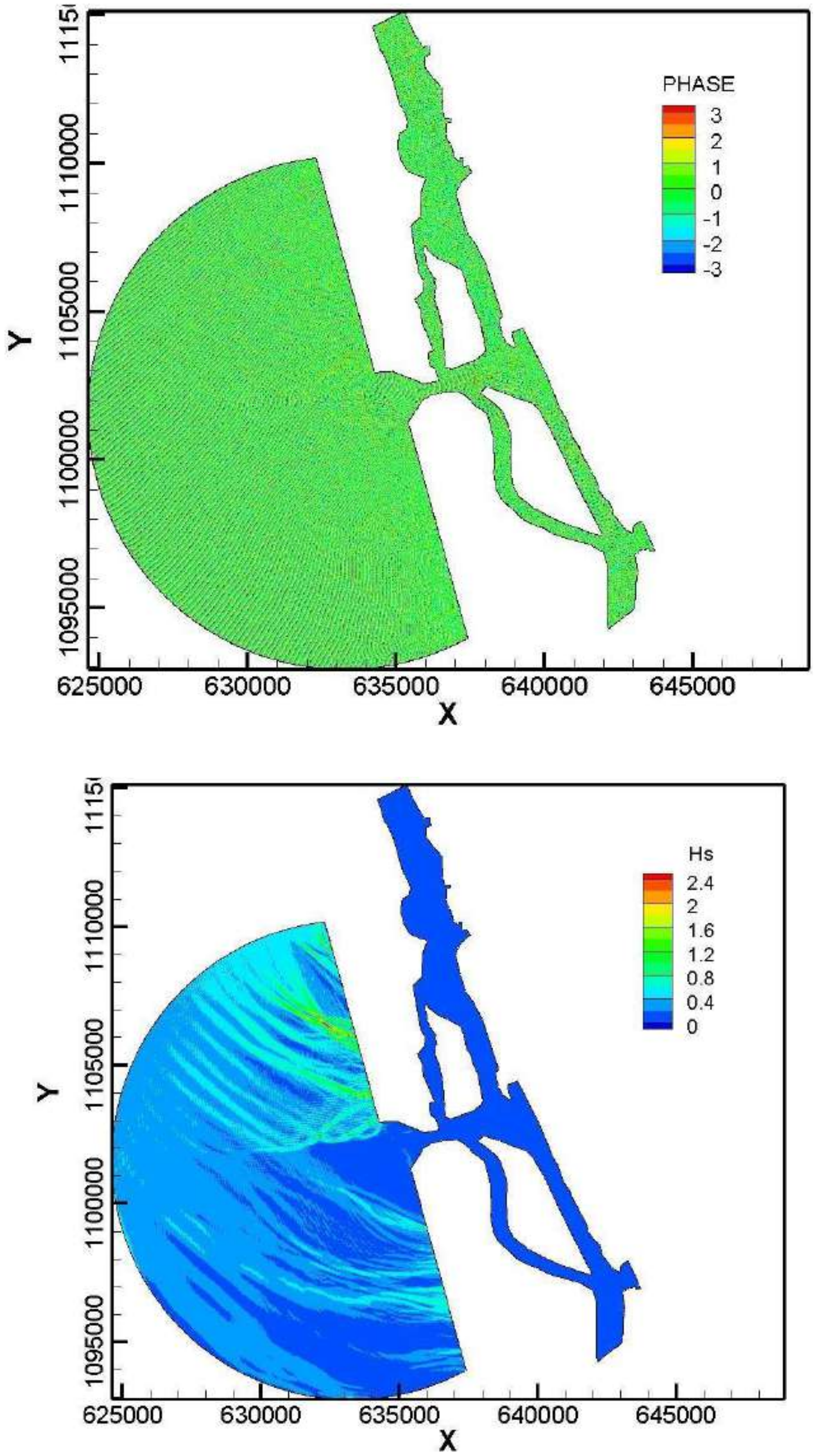


Fig.3.39 Phase distributions and Wave height distribution for the wave approach angle from 315^0

3.3.9 Summary

Further, in order have a closer understanding of the tranquility, a few nodal points near the channel are selected, where, the wave height is monitored during the course of the simulations and averaged to find the wave amplitude at the location. The location of the output points is shown in **Fig 3.42.** The occurrence of waves in the location of output points for case1 and case2 is presented in **Table 3.1 and Table 3.2.**

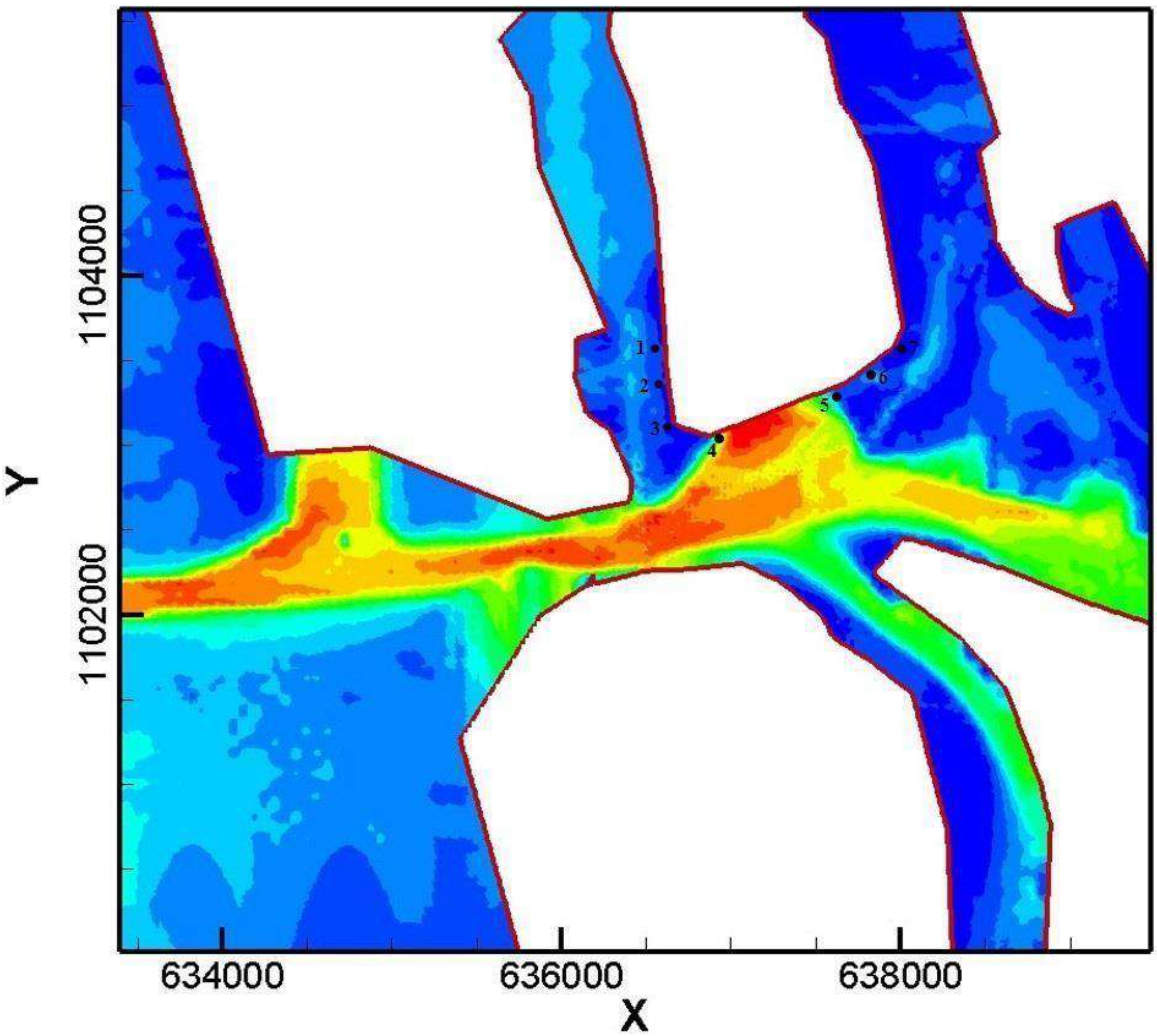


Fig.3.40 Points of measurement of the wave height

Table 3.1 Signification wave height at various locations (case 1)

Location	Hs (m)
1	0.272
2	0.211
3	0.286
4	0.483
5	0.461
6	0.302
7	0.247

Table 3.2 Signification wave height at various locations (case 2)

Location	Hs (m)
1	0.312
2	0.246
3	0.306
4	0.498
5	0.483
6	0.334
7	0.259

3.3.10 Results and Discussions

The significant wave height is taken in seven various location along the berth for the present condition and after deepening up to -20m shown in table 3.1 and table 3.2 of the Report., shows that the there is no significant change in wave height even during the deepening of -20m.

3.3.11 Summary and Recommendation

Phase-I 16m Draught Vessel

Based on the the above hydrodynamic and wave propagation modelling results, it is understood that the ambient environmental forcing conditions such as wave and current, which dictates the shoreline stability will not appreciably change in view of the proposed increase in the water depth in front of the ICTT jetty from existing to 20m. The shoreline presently are stable and not eroding. These are also protected by dense vegetation. Hence, the stable shoreline around the ICTT jetty protected by the dense vegetation at present would continue to be stable for further deepening for accepting 16m draft vessels. In the vicinity of the jetty, on its east and west, the shoreline is already protected. Even here also, as there is no significant change in the waves & current from present to future conditions, there is no requirement for providing additional shore protection.

Phase-II 18m Draught Vessel

Based on the the above hydrodynamic and wave propagation modelling results, it is understood that the ambient environmental forcing conditions such as wave and current, which dictates the shoreline stability will not appreciably change evenafter the proposed increase in the water depth in front of the ICTT jetty from existing to 20m. The shoreline presently are stable and not eroding. These are also protected by dense vegetation. Hence, the stable shoreline around the ICTT jetty protected by the dense vegetation at present would continue to be stable for further deepening for accepting 16m draft vessels. In the vicinity of the jetty, on its east and west, the shoreline is already protected. Even here also, as there is no significant change in the waves & current from present to future conditions, there is no requirement for providing additional shore protection.

PREPARATION OF BLOCK COST ESTIMATE AND COST-BENEFIT ANALYSIS BASED ON AVAILABLE TRAFFIC STUDIES FOR EXISTING ICTT BERTH

CHAPTER-4
PREPARATION OF BLOCK COST ESTIMATE AND COST-BENEFIT ANALYSIS BASED ON AVAILABLE TRAFFIC STUDIES FOR EXISTING ICTT BERTH

4.1 Introduction

As per the present scope of the study the Dredging quantity has to be worked out under two Phases viz Phase-I to handle 16m Draft Vessel of dimension 400(LOA)X 59(Beam)X16m (Draught) and Phase-II 18m Draft Vessel of dimension 400(LOA)X62(Beam)X 18m (Draught), requirement of width of the Channel to handle the above vessels has been assessed based on PIANC guidelines and ascertained the present width of the channel is sufficient to handle 16m draught vessel & 18m draught vessel.

However, when additional dredging is carried out to handle 16m draught vessel as well as 18m draught vessel, apart from the quantity of dredging arising out of deepening the channel to the corresponding depth, their will be some extra quantity for maintaining the side slopes.

Subsequent to the discussion held with CoPT , the mail confirmation from CE vide mail dated 31.03.2020, the response from NTCPWC vide mail dated 01.04.2020 and the specific requirement from IGTPL vide their mail dated 13.05.2020, the quantity as well as the Cost for the Capital Dredging under two Phases viz Phase-I to handle 16m Draught vessel and Phase-II to Handle 18m Draught vessel is furnished hereunder.

4.2 Capital Dredging Cost for handling 16m Draught vessel Phase-I

- Since CoPT channel bed is relatively softer having densities less than 1.18 t/cu.m, Low frequency Survey Data (31-33Khz) will be used for calculating the capital dredging estimates.
- The width available presently is 260m up to Cochin gut which is more than the required width. Hence, the channel does not require widening.
- In the Entrance channel also, the width of 286m is available which is sufficient for catering for the mild change in course.
- Therefore, the present channel does not need any widening to cater for single way traffic of the design vessel. However, while deepening the channel, the slope portion will become extended. This quantity is taken for estimation purpose.
- The Channel is extending to about 2kms to reach the 21m contour from Bouy No 1 of the present channel, the quantity is calculated by extrapolation from Buoy No 1 to reach the 21m contour as there is no Survey data available in that portion.
- The dredging rate has been worked based on **CIRIA** manual and same is adopted in the estimate.

4.2.1 Dredging rate based on CIRIA mannual.

As per guidelines on undertaking dredging at Major Ports issued by Ministry of Shipping in August2016, at para 5.13 it is stated that "The International/Indian standards for estimation of costs can be used". In line with the above, CIRIA method is used for estimating the Capital dredging work at CoPT.

A joint venture between International Association of Dredging Contractors (IADC) and Construction Industry Research and Information Association (CIRIA), the publication A guide to cost standards for dredging equipment 2009 offers a benchmark to establish the capital and related costs of various types of dredging plant and equipment commonly in use within the industry.

The 2009 publication is based on the experience and statistics from international dredging contractors who are members of the International Association of Dredging Companies. Prepared by IADC with data exclusively collected for this purpose, the reference gives the replacement value for several types of dredgers such as trailing suction hopper dredgers, cutter suction dredgers, etc. CIRIA's collaborative efforts included a study led by an independent steering group comprised of both clients and consulting engineers.

The financial costs associated with dredging activity are highly variable, depending on the dredging equipment being deployed and the type of dredging, viz.; capital / maintenance being executed, wear and tear of soil touching parts due to abrasive nature of soil, etc.

The guide presents the primary capital values and costs associated with a range of dredging equipment based on their technical specification. This publication is commonly used throughout the industry for a range of studies including capital expenditure estimations. Due to the high capital cost in the value of dredgers, the calculation of the depreciation and interest is paramount to arriving at the estimated operating cost per day. Further, day to day maintenance and repair of the dredgers need to be considered to arrive at the primary cost of the dredging equipment viz; trailer suction hopper dredger, cutter suction dredgers, etc. CIRIA costing does not provide details against other operational costs heads such as overheads and profit. However, in this estimation report, overheads and profit risk have been estimated conservatively at 3% and 8% respectively.

Dredging is a capital-intensive industry where only a few main marine equipment are deployed at each project. It is also a civil engineering or marine activity that frequently takes place in an inhospitable environment, where site investigation costs can be high and construction risks are elevated in relation to the working conditions and the potential difficulties of obtaining site information. As such many dredging works result in variation and some lead to disputes. Thus, the capital and related costs of equipment and contract values are crucial to the evaluation of these matters.

4.2.2 Based on CIRIA Guidelines explained above, following is the Dredging Rate work out shown in Table 4.1 below

Table 4.1 Dredging Rate

S.no	Description	Daily Production (A) ((A)=2.2x 10^6/30 = 73,300x0.8*= 0.586) (Lakhs CuM)	Daily Hire Cost of TSHD (Hopper Capacity 5500 cum) (C) (Lakhs)	Daily Hire Cost of TSHD (Hopper Capacity 7500 cum) (D) (Lakhs)
1	Capital Dredging of Channel, Approaches and Berth Pockets for handling vessels upto 18m Draft at ICTT Berth of Cochin Port Trust.	0.586	32	35
2	Dredging Rate	=(C)+(D)/(A)= **Rs 114/cum**		

Note: *In Capital Dredging only 80% can be achieved from the Monthly Production.

4.2.3 Dredging Quantity and Capital Dredging Cost for Phase I – handling 16m draft Vessel

Table 4.2: Dredging Quantity for Phase-I- For handling Vessels of Draft 16m

S.no	Description	Qty	Unit	Rate (₹)	Amount (₹) (Crores)
1.	Capital Dredging Quantity	30.66	Million m^3	114	349.52
	To Dredge Berth Pocket upto (-)17.28 m- 1.83				
	To Dredge theApproaches(-) 17.76 m- 2.58				
	Slope_1:6- _				
	To dredge the Channel upto (-)18.4 m in between 0 Chainage and 20m contour- 18.55				
	Slope 1:6- 5.64				
	To Dredge TC upto (-)17.76- 2.20				
	Slope_1:6 - 0.26				
2.	Mob and de-mob @10 % of the cost of item no 1	LS			34.95
	Sub – Total				384.47
	Contingencies & PMC Charges @ 5%				19.22
	GST @ 18 %				69.20
	Total				472.89

4.3 Capital Dredging Cost for handling 18m Draught vessel Phase-II

- Since CoPT channel bed is relatively softer having densities less than 1.18 t/cu.m, Low frequency Survey Data (31-33Khz) will be used for calculating the capital dredging estimates.
- The width available presently is 260m up to Cochin gut which is more than the required width. Hence, the channel does not require widening.
- In the Entrance channel also, the width of 286m is available which is sufficient for catering for the mild change in course.
- Therefore, the present channel does not need any widening to cater for single way traffic of the design vessel. However, while deepening the channel, the slope portion will become extended. This quantity is taken for estimation purpose.
- The Channel is extending to about 2kms to reach the 21m contour from Bouy No 1 of the present channel, the quantity is calculated by extrapolation from Buoy No 1 to reach the 21m contour as there is no Survey data available in that portion.
- The dredging rate has been worked based on **CIRIA** manual and same is adopted in the estimate.

4.3.1 Dredging rate based on CIRIA mannual.

As per guidelines on undertaking dredging at Major Ports issued by Ministry of Shipping in August2016, at para 5.13 it is stated that "The International/Indian standards for estimation of costs can be used". In line with the above, CIRIA method is used for estimating the Capital dredging work at CoPT.

A joint venture between International Association of Dredging Contractors (IADC) and Construction Industry Research and Information Association (CIRIA), the publication A guide to cost standards for dredging equipment 2009 offers a benchmark to establish the capital and related costs of various types of dredging plant and equipment commonly in use within the industry.

The 2009 publication is based on the experience and statistics from international dredging contractors who are members of the International Association of Dredging Companies. Prepared by IADC with data exclusively collected for this purpose, the reference gives the replacement value for several types of dredgers such as trailing suction hopper dredgers, cutter suction dredgers, etc. CIRIA's collaborative efforts included a study led by an independent steering group comprised of both clients and consulting engineers.
The financial costs associated with dredging activity are highly variable, depending on the dredging equipment being deployed and the type of dredging, viz.; capital / maintenance being executed, wear and tear of soil touching parts due to abrasive nature of soil, etc.

The guide presents the primary capital values and costs associated with a range of dredging equipment based on their technical specification. This publication is commonly used throughout the industry for a range of studies including capital expenditure estimations. Due to the high capital cost in the value of dredgers, the calculation of the depreciation and interest is paramount to arriving at the estimated operating cost per day. Further, day to day maintenance and repair of the dredgers need to be considered to arrive at the primary cost of the dredging equipment viz; trailer suction hopper dredger, cutter suction dredgers, etc. CIRIA costing does not provide details against other operational costs heads such as overheads and profit. However, in this estimation report, overheads and profit risk have been estimated conservatively at 3% and 8% respectively.

Dredging is a capital-intensive industry where only a few main marine equipment are deployed at each project. It is also a civil engineering or marine activity that frequently takes place in an inhospitable environment, where site investigation costs can be high and construction risks are elevated in relation to the working conditions and the potential difficulties of obtaining site information. As such many dredging works result in variation and some lead to disputes. Thus, the capital and related costs of equipment and contract values are crucial to the evaluation of these matters.

4.3.2 Based on CIRIA Guidelines explained above, following is the Dredging Rate work out shown in Table 4.1 below

Table 4.3 Dredging Rate

S.no	Description	Daily Production (A) ((A)=2.2x 10^6/30 = 73,300x0.8*= 0.586) (Lakhs CuM)	Daily Hire Cost of TSHD (Hopper Capacity 5500 cum) (C) (Lakhs)	Daily Hire Cost of TSHD (Hopper Capacity 7500 cum) (D) (Lakhs)
1	Capital Dredging of Channel, Approaches and Berth Pockets for handling vessels upto 18m Draft at ICTT Berth of Cochin Port Trust.	0.586	32	35
2	Dredging Rate	=(C)+(D)/(A)= **Rs 114/cum**		

Note: *In Capital Dredging only 80% can be achieved from the Monthly Production.

4.3.3 Additional Dredging Quantity and Capital Dredging Cost for Phase II – handling 18m draft Vessel

Table 4.4: Dredging Quantity and Cost for Phase-II- For handling Vessels of Draft 18m

S.no	Description	Qty	Unit	Rate (₹)	Amount (₹) (Crores)
1.	Capital Dredging Quantity	18.47	Million m^3	114	210.55
	To Dredge Berth Pocket upto (-) 19.44 m- 2.15				
	To Dredge Approaches upto (-) 19.98 m- 2.96				
	Slope_1.6- _				
	To Dredge Channel Upto (-) 20.7 m between 0 Chainage and 20m contour- 10.40				
	Slope 1:6- 0.48				
	To Dredge TC upto (-)19.98m- 2.23				
	Slope_1:6- 0.25				
2.	Mob and de-mob @10 % of the cost of item no 1	LS			21.05
				Sub – Total	231.6
				Contingencies & PMC Charges @ 5%	11.58
				GST @ 18 %	41.68
				Total	284.86

Note: The quantity and cost estimated and furnished in Table 4.4 above is a incremental Quantity and cost required for handling 18m Draft vessel over and above the dredging quantity required for handling 16m draft vessel as detailed in 4.2 above.

4.4 Way Forward

4.4.1 Geo physical Investigation and Magnetometer

Before Finalizing the estimate, it is necessary to carryout Geophysical Investigation and Magnetometer Survey to avoid any surprises during the dredging stage. Further, this survey will through light on any underwater obstructions such as metal parts, chains etc., likely to hinder the dredging activities. In addition, Bathymetry Survey has to carry out where no data is available. Both the above studies are part of the Phase-II studies in which Navigation simulations also would be taken up. The Phase-II studies shall be taken up by ICTT prior to finalization of full estimate of dredging.

(Prof.S.A.Sannasiraj) **(Prof. K. Murali)**

FEASIBILITY OF ACCEPTING VESSELS WITH LARGER DRAFT OF UP TO 18M AT INTERNATIONAL CONTAINER TRANSHIPMENT TERMINAL (ICTT) COCHIN

Final Report Part- III

Feasibility of Additional Berth towards Vypin side (Western side) ("V4")

May 2020

Client

India Gateway Terminal Private Limited (IGTPL)

Consultant

Prof. K. Murali

Prof. S. A. Sannasiraj

National Technology Centre for Ports, Waterways and Coasts
New Academic Complex – 6th Floor
Indian Institute of Technology Madras
Chennai – 600 036

Contents of the Report

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1

Introduction

1.0 General

Cochin Port viz,. Kochi Port is a Major Port on the Arabian Sea - Laccadive Sea – Indian Ocean sea-route in the city of Kochi and is one of the largest ports in India. The port lies on two islands in the Lake of Kochi-Willingdon Island and Vallarpadam, towards the Fort Kochi river mouth opening onto the Laccadive Sea. The International Container Transhipment Terminal (ICTT), part of the Cochin Port, is the largest container transhipment hub in India. The Cochin Port is governed by the Cochin Port Trust (CPT), under the administrative control of Government of India . This modern port was established in 1926 and has completed 94 years of active service. The Kochi Port is one of a line of maritime-related facilities based in the port-city of Kochi. The others are the Cochin Shipyard, the largest shipbuilding as well as maintenance facility in India; the SPM (single point mooring) facility of the Kochi Refineries, an offshore crude carrier mooring facility; and the Kochi Marina. The aerial view of the Cochin Port is shown in **Figure 1.1.**

Fig. 1.1: Aerial view of the Kochi Port.

India Gateway Terminal Private Limited (IGTPL) has entered into a License Agreement on 31st January 2005 with the Cochin Port Trust (CoPT) for the Development, Construction, Operation and Management of the International Container Transhipment Terminal and the Development, Operation and Management of the Rajiv Gandhi Container Terminal (RGCT).The International Container Transhipment Terminal (ICTT), which is India's first transhipment terminal and the first container terminal to operate in a SEZ, was inaugurated and dedicated to the nation by the then Honourable Prime Minister of India on 11th

February 2011. When fully developed, ICTT will be the largest single operator Container Terminal in India.

The main inward shipping channel of the Cochin Port comprises of Ernakulam and Mattancherry channels. The Ernakulum Channel is 4.90 Km long, with the width varying from 250 to 500 m and has a draft of 12.5 m up to the Oil Terminal & Q8 / Q9 and a draft of 9.14 m up to the wharves and the north & south tanker berths.. The 1024 m long Ernakulam Wharf has six alongside berths, five for general cargo and a fertilizer berth. Besides, there are three oil berths in the Ernakulum channel. The Mattancherry channel is 4.08 Km long, with the width varying between 180 and 250 m with a draft of 9.14 m except at Boat Train Pier where the draft is 10.0 m. On the Mattancherry Channel there are four alongside berths for general cargo, one Boat Train Pier and two jetties for miscellaneous cargo.

1.1 Objective and scope of the study

1.1.1 Objective of the Main Study

To Conduct a Detailed Study on the Feasibility of Accepting Larger Vessels with Draft upto 16m in the 1st phase and 18m in the 2nd phase at ICTT. The present study is to assess the structural stability of the existing ICTT berth while carrying out the additional dredging in front of the berth up to -17.28m CD in the phase and -19.44m 1st in the 2nd phase from the designed depth of 16m, in order to bring the larger vessels into the harbour basin as envisaged by the India Gateway Terminal Private Limited (IGTPL) without carrying out any major modification of the existing berthing structure. The scope covered under the present study is limited to Phase-I. **However, Phase-II studies shall be undertaken if required, at a mutually agreed cost, upon completion of the present scope of work.**

1.1.2 Scope of the Main study

Phase I- Feasibility study

- Assessment of navigational requirements and redesign of approach channel & turning basin as per IS 4651 & Buoy Requirements.
- Assessment / re-validation of structural stability due to deepening and proposed strengthening measures and refit of berthing /mooring arrangements based on available soil data.
- Hydrodynamic and siltation model study for estimation of siltation and maintenance dredging requirements & impact on backwater areas.
- Assessment and preliminary design of bank protection measures for a length of about 600m

& assessment of stability of islands/land/shoreline within a radius of 5km.

- Preparation of Bulk Cost Estimate and cost-benefit analysis based on available traffic studies for Existing ICTT Berth

Phase II- Detailed study

- Navigational simulation on a 360 deg. full Mission bridge.
- Assessment of stability of all berthing structures within a radius of 2 km.
- Dredging estimates in terms of quantity, cost & time. This includes cost of seabed geophysical investigations for obtaining dredging material properties and locating obstacles.
- Preparation of EIA Report using monitoring data.

1.1.3 Additional Scope of Work

As an alternative to the option of deepening the existing berth, ICTT is considering taking up development of V4 of their original plan for handling deep drafted vessels. To this effect, ICTT had issued an variation order for the development of a New berth of 350/400 M towards Vypin side (Western side) ("V4") in the ongoing study on feasibility of accepting vessels with larger draft upto 18m at ICTT, with the following additional scope:

- Preparation of preliminary layout of the additional berth.
- Re-running Hydrodynamic and siltation model study for estimation of siltation and maintenance dredging requirements & impact on backwaters areas
- Assesment of Bank protection measures for an extent of about 600m & assessment of staibility of islands/land/shoreline within a radius of 5km and preliminary design, if any.
- Preparation of Block Cost estimate only for additional berth

1.2 Organization structure of the report

The Report will be a draft report covering the additional Scope of Work as detailed in the variation order dated 3rd January 2020 as per the following sequence

Chapter 1: Introduction

Chapter 2: Preliminary layout of the additional berth.

Chapter3: Hydrodynamic and siltation model study for estimation of siltation and maintenance dredging requirements & impact on backwaters areas

Chapter 4: Assesment of Bank protection measures for an extent of about 600m & assessment of staibility of islands/land/shoreline within a radius of 5km and preliminary design

Chapter 5: Block Cost estimate

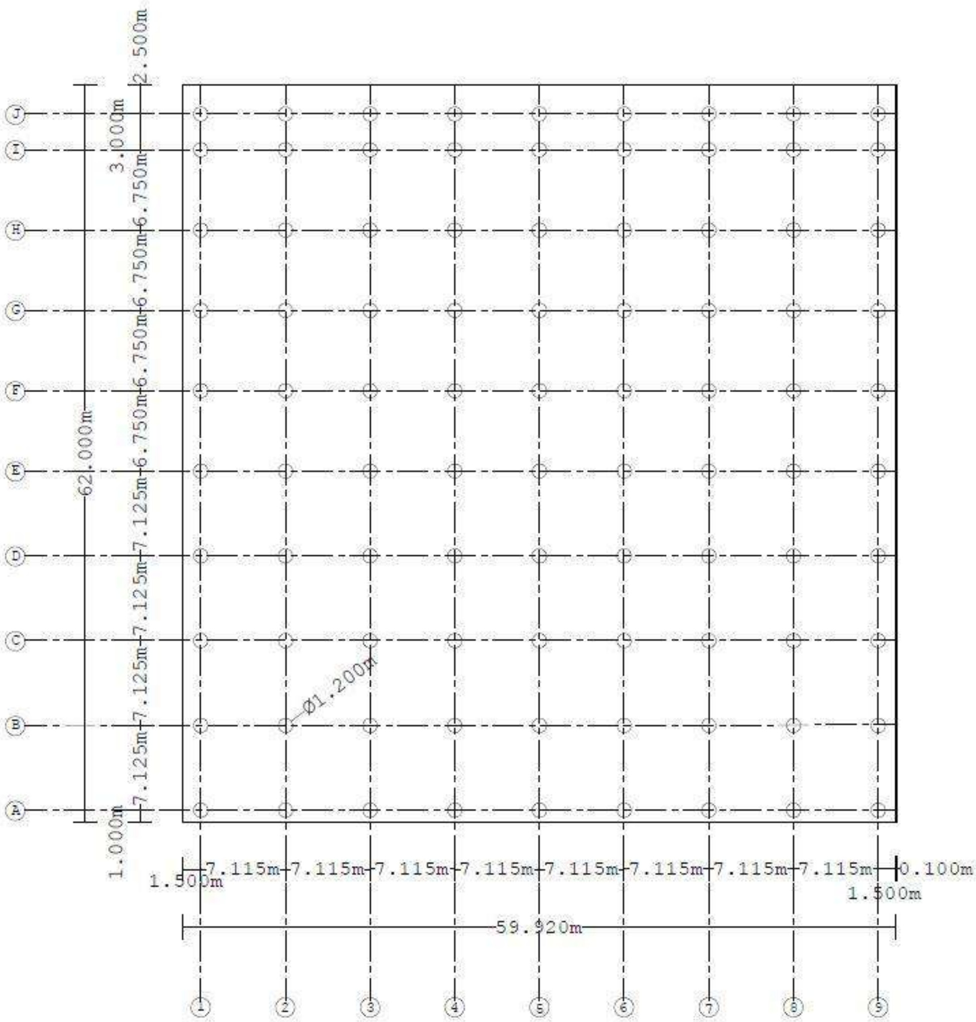
CHAPTER-2

Preliminary layout of the additional berth

2.0 Preliminary layout of additional Berth

The additional Berth will be developed as an extension to the existing ICTT berths, towards Vypin side (Western side) ("V4"). The Berth will be of size 350m x 62m consisting of RC bored cast-insitu piles and beam and slab arrangements. It is divided into 6 berthing dolphins Expansions joints will be provided at an intervals of 59.92m. The Berth is designed to handle Neo panama vessels of 20,000 TEU capacity a typical section of the berthing structure is shown hereunder.

Fig. 2.1 Typical layout showing a portion of additional Berth



CHAPTER-3

Hydrodynamic and siltation model study for estimation of siltation and maintenance dredging requirements & impact on backwaters areas

3.0 Salient features of the calibrated Hydrodynamic Model set up for Cochin Backwaters

3.1 Velocity time series plot for the location near Vallarpadam Bridge:

The time series plot for current is shown below in **Fig3.1** as the maximum velocity range is **0.45 m/s** near the Vallarpadam Bridge for 14 days simulation is shown below in **Fig3.1** and the modelled value is calibrated with the measured current values which is shown below in **Fig3.2.**The estimation of dredge quantity that gets accumulated in the proposed berth pocket based on the calibrated hydrodynamics is projected in the table.1.The dredge quantity in the proposed berth pocket and approach area is predicted to be 0.39 Mm^3/yr. The siltation rate contour plots is given in **Fig3.9.**

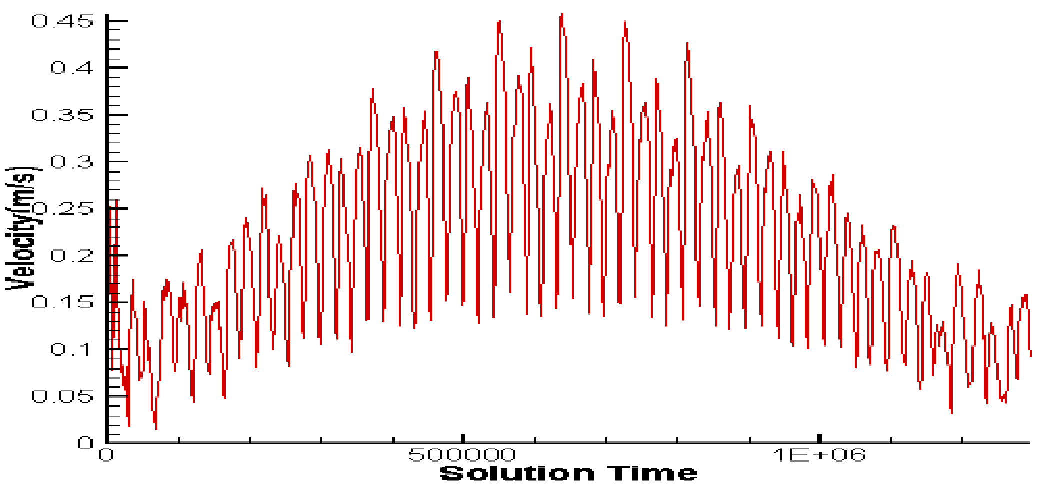


Fig 3.1 Modelled velocity range near Vallarpadam Bridge

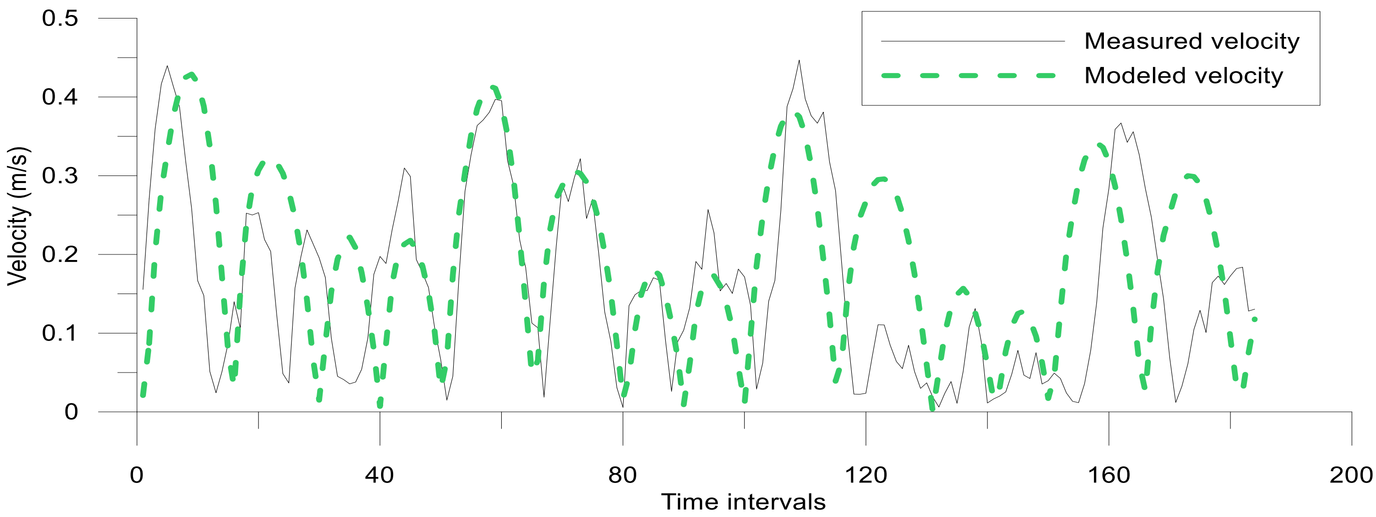


Fig 3.2 Validation of measured current with modelled values for location near Vallarpadam Bridge

3.2 Detailed report of the Hydrodynamics and Morphodynamics Studies

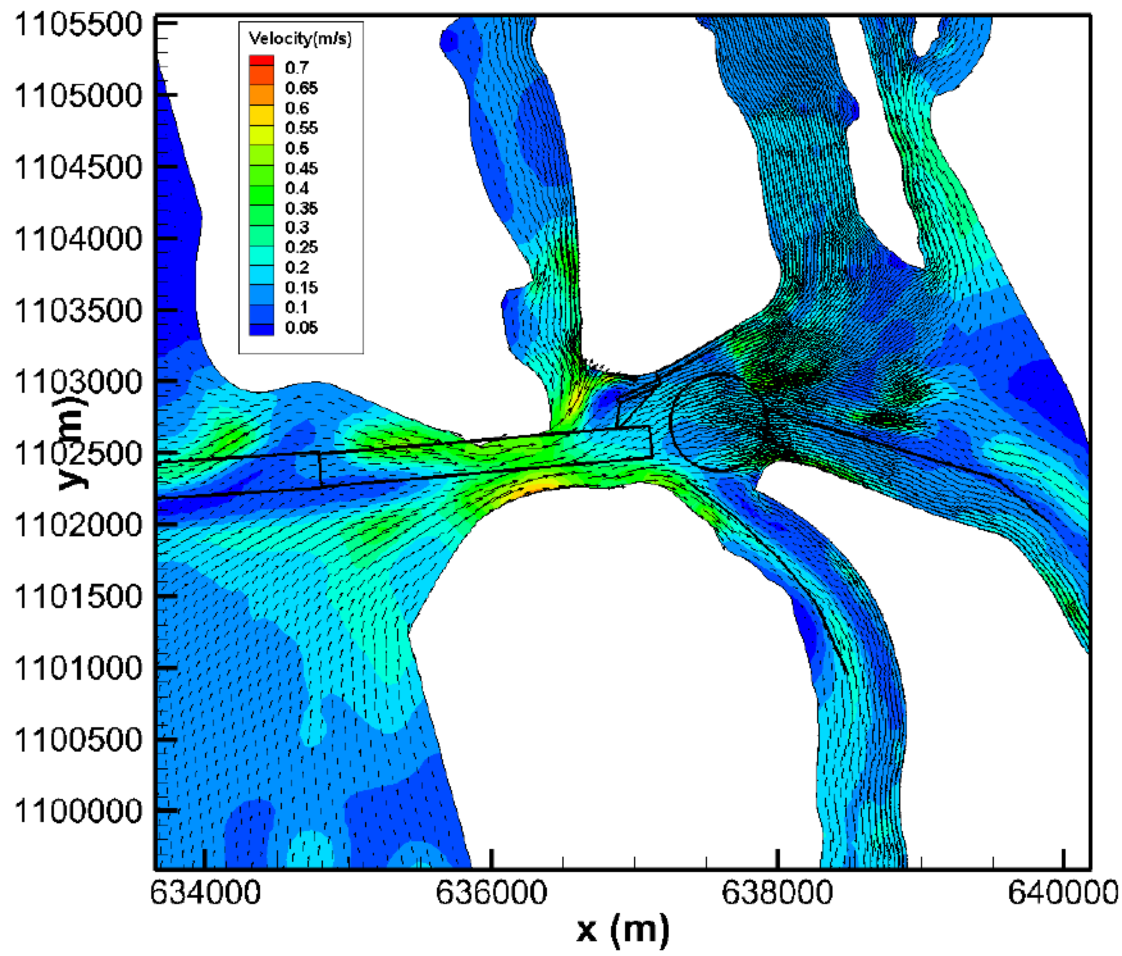


Fig 3.3 Velocity vectors and contour plots during flooding tide at 0 hours

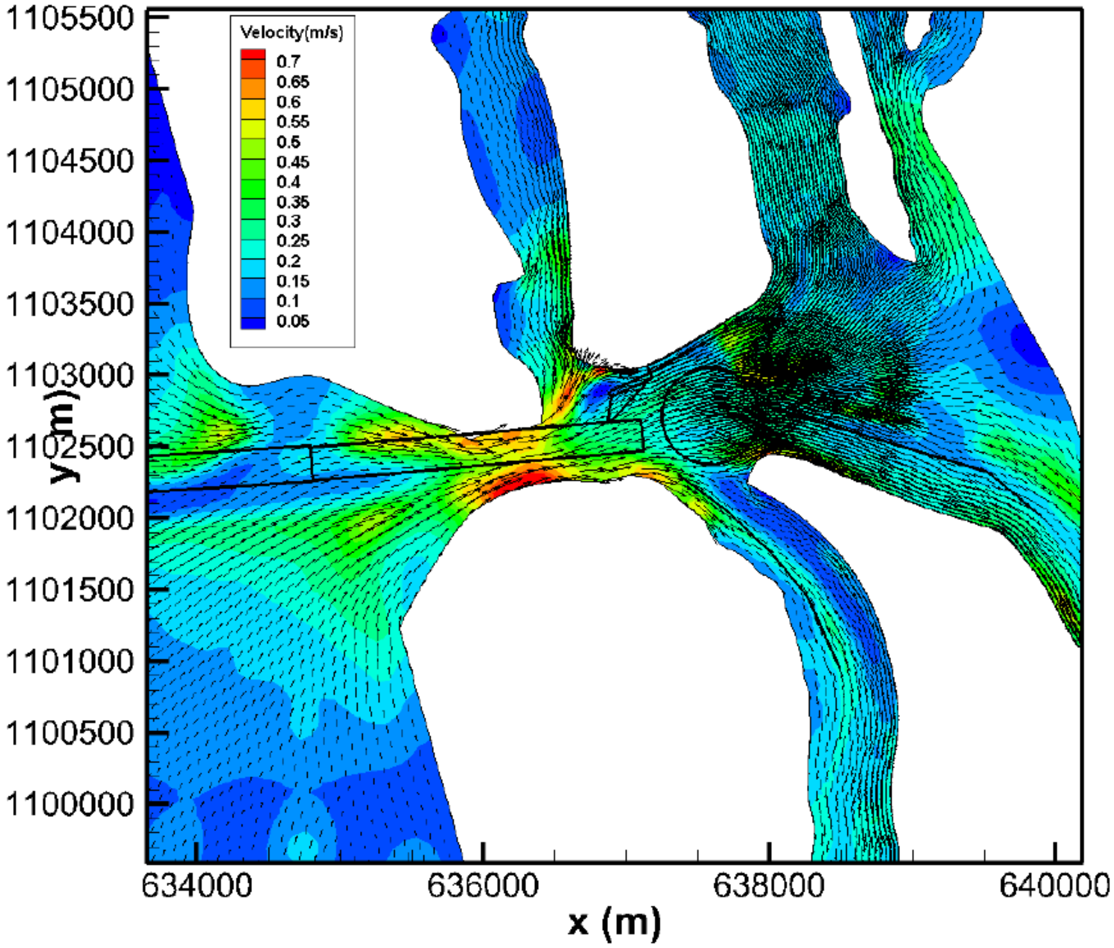


Fig 3.4 Velocity vectors and contour plots during flooding tide at 1.5 hours

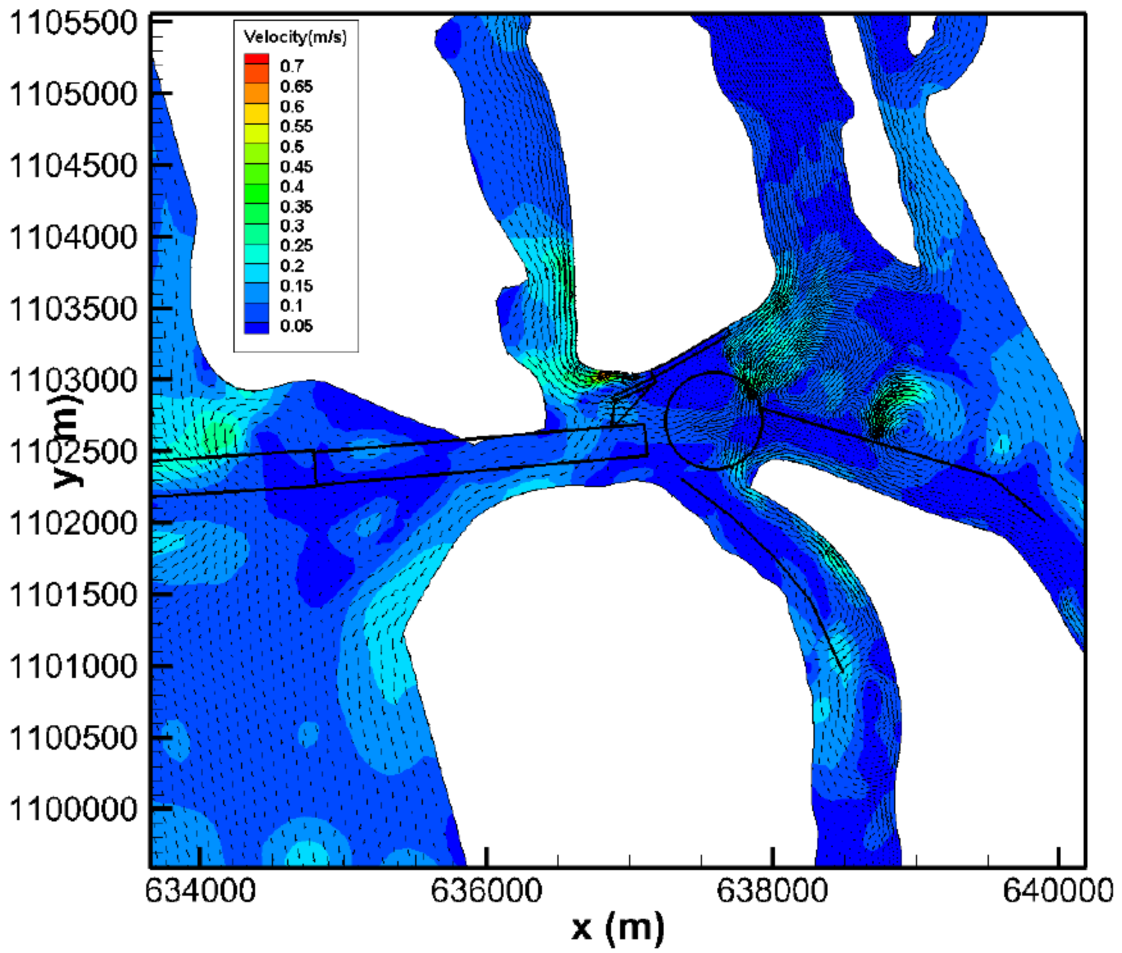


Fig 3.5 Velocity vectors and contour plots during high tide at 3.1 hours

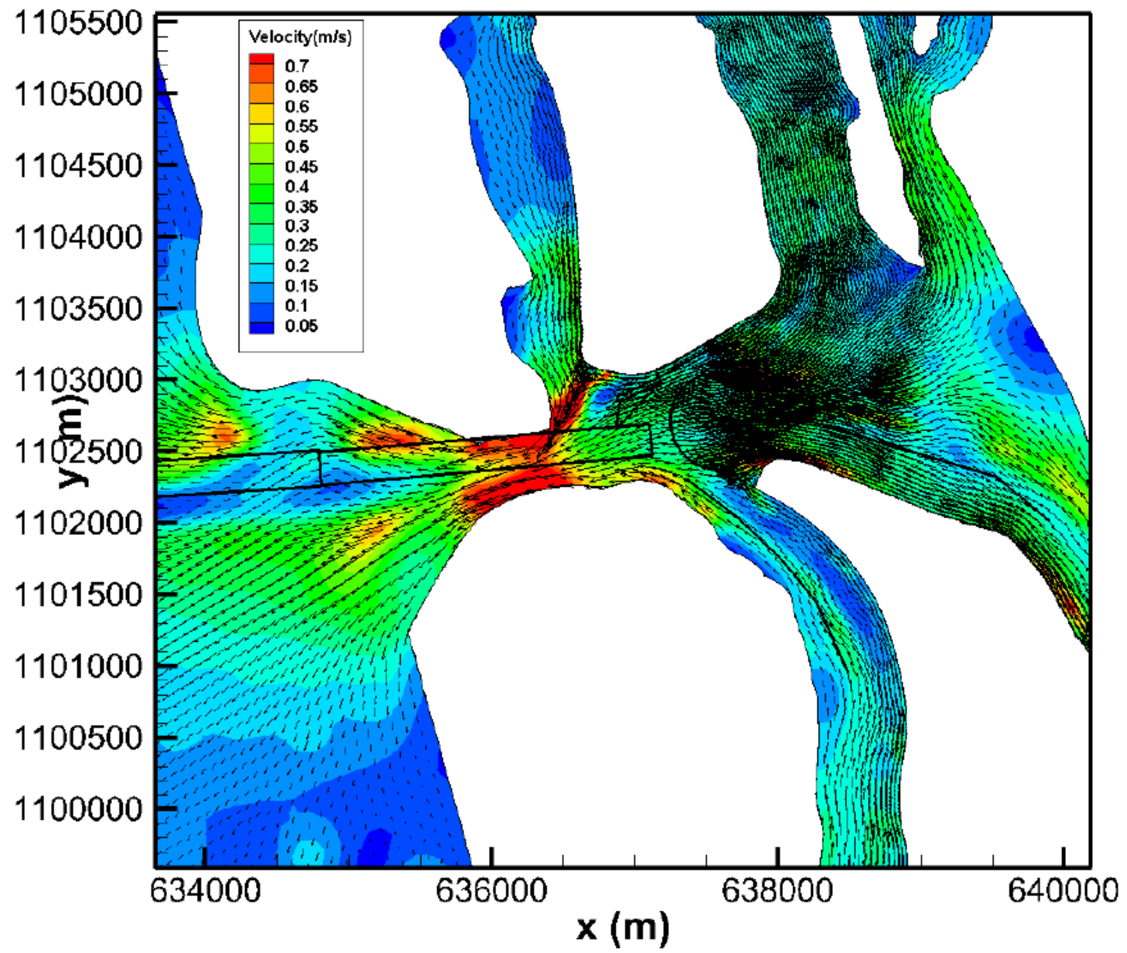


Fig 3.6 Velocity vectors and contour plots during ebbing tide at 6.2 hours

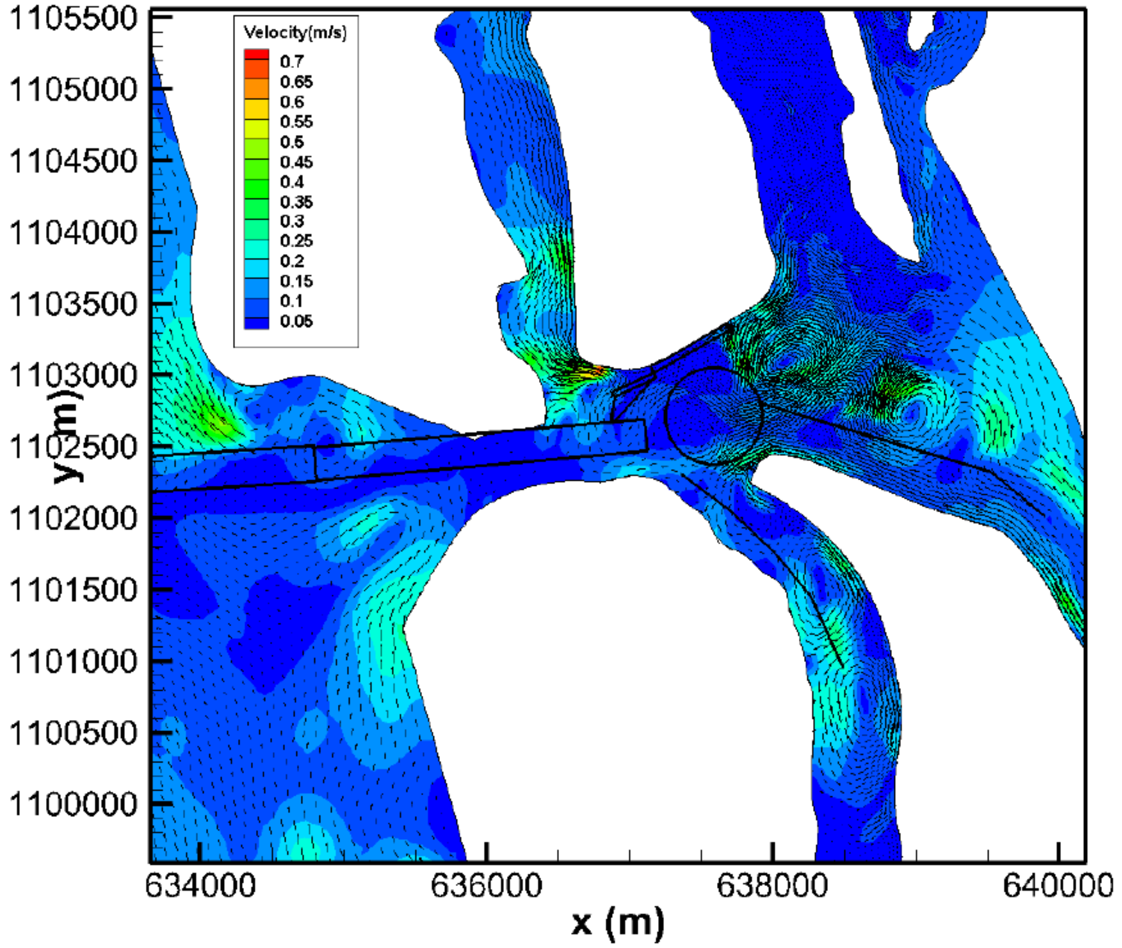


Fig 3.7 Velocity vectors and contour plots during low tide at 9.3 hours

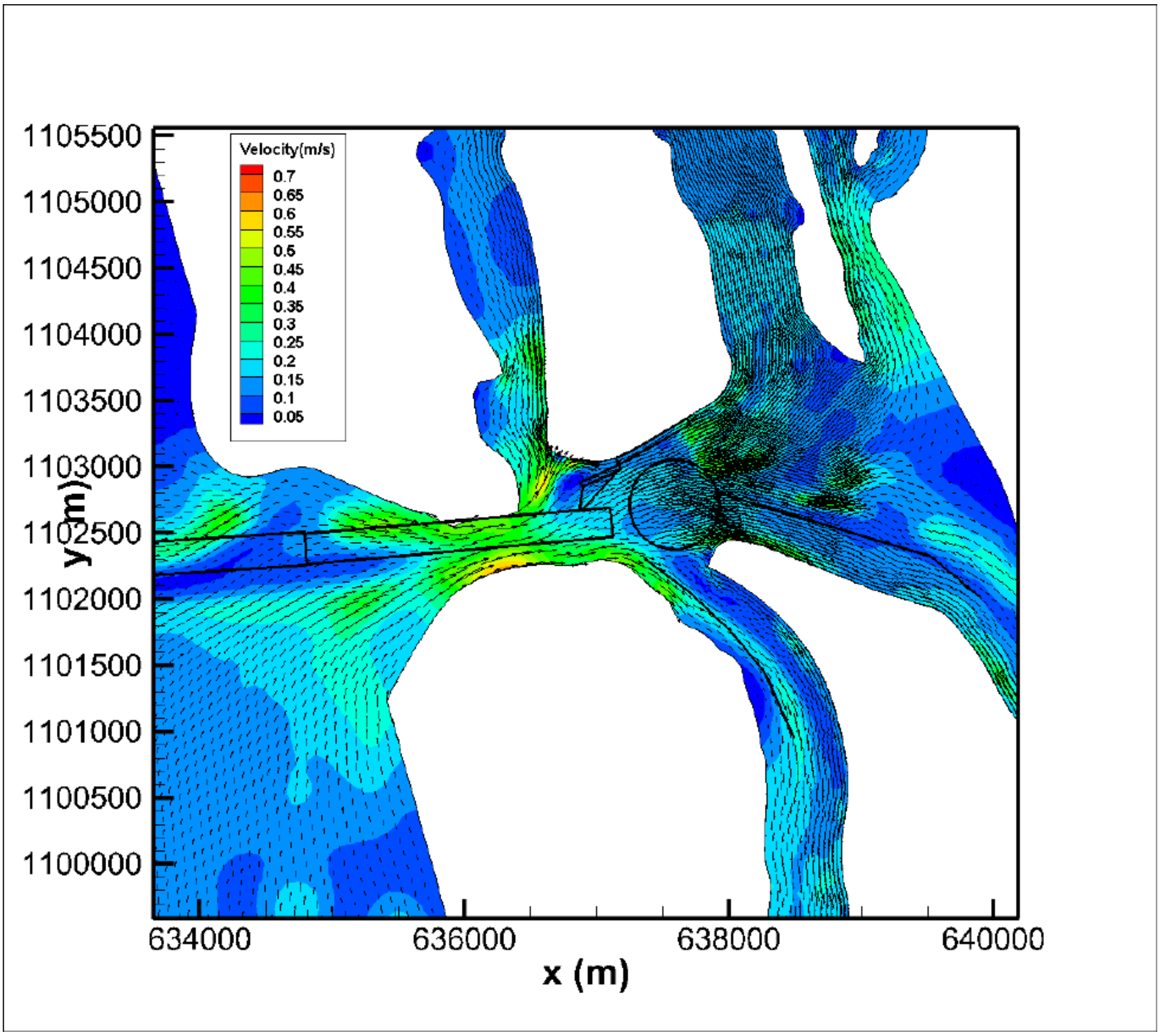


Fig 3.8 Velocity vectors and contour plots during flooding tide at 12.4 hours

Table 3.1 Estimation of dredge quantity in the ICTT proposed berth pocket

Sectors	Area	Dredge depth in meter/month	Quantity to be dredged
OAC1	572000	0.84	336336.00
OAC2	786500	0.52	247747.50
OAC3	1820000	0.80	728000.00
MCB	533434	0.20	55477.14
ECB	1106269	0.05	25886.69
IAC1	605109	0.26	119569.54
LNG	360000	0.84	226800.00
IAC2/ICTT BASIN	359316	0.89	243041.34
Proposed ICTT berth with approach area	56750	0.76	32347.50
Total(Mm^3/month)			2.02

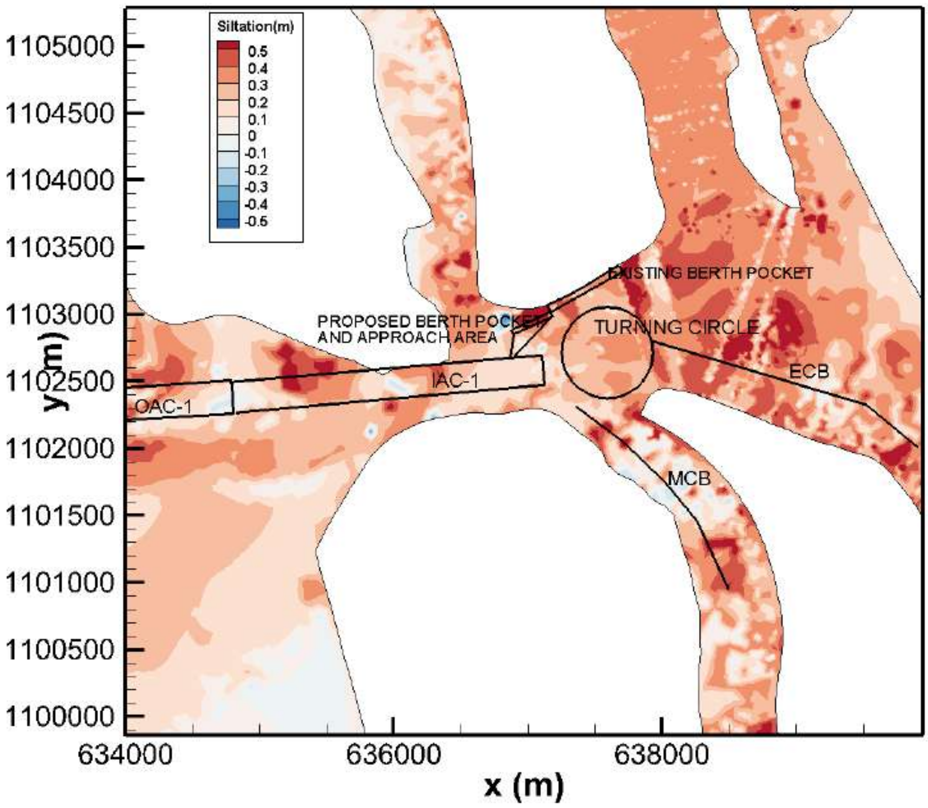


Fig3.9 Bed level changes after 14 days simulation for ICTT-Proposed Additional berth

CHAPTER 4

ASSESSMENT AND PRELIMINARY DESIGN OF BANK PROTECTION MEASURES FOR AN EXTENT OF ABOUT 600m AND ASSESSEMNT OF STABILITY OF ISLANDS/LAND/SHORELINE WITHIN RADIUS OF 5kms

4.1 Extent of the area considered.

4.1.1 Area considered for Bank Protection measures within a radius of 600m as shown in sketch 4(a) & 4(b)

Fig 4(a)- Eastern side of Berth (area marked in red circle**)**

Fig 4(b)- Western side of the Berth (area marked in red circle**)**

4.1.2 Area considered for assessemnt of stability of Islands/Land/Shoreline within radius of 5 kms as shown in sketch 4(c)

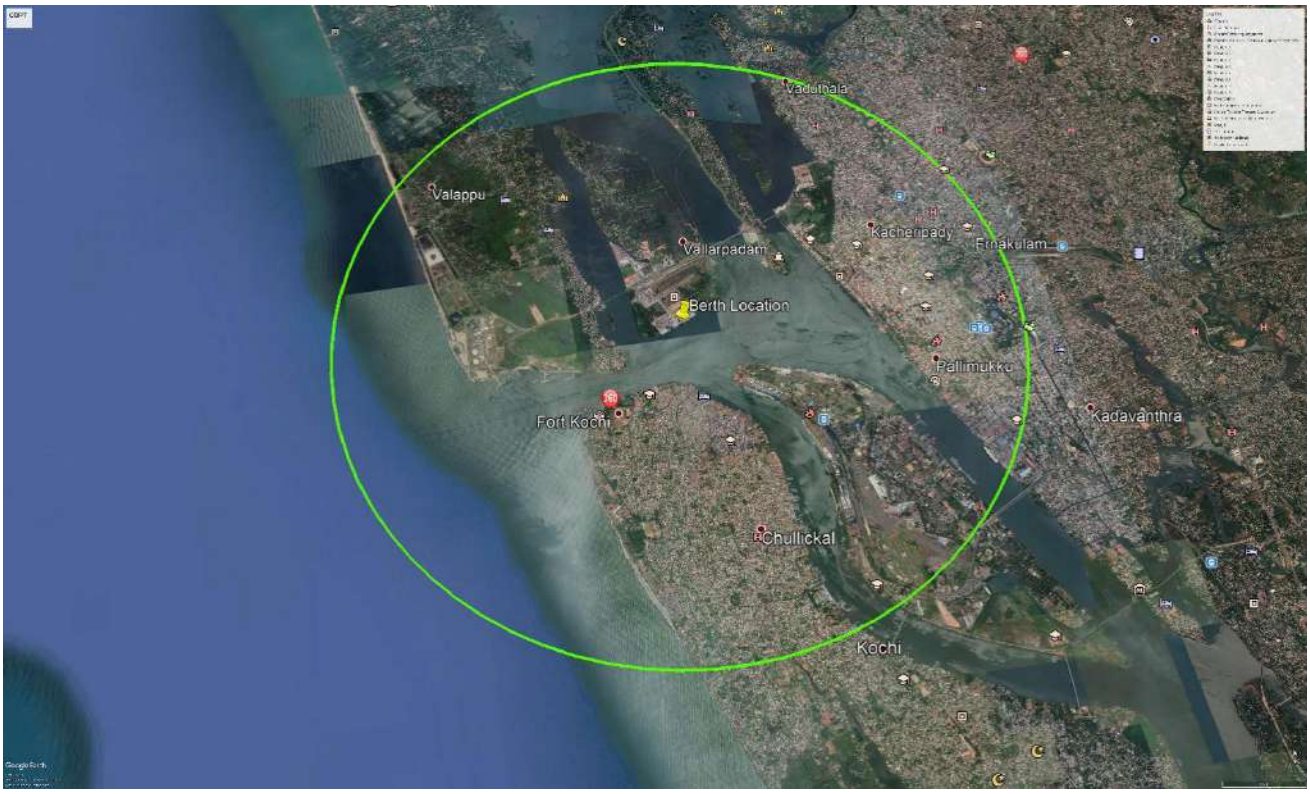


Fig 4(c) 5kms radius around the Berth

4.2 OFFSHORE WAVE CHARACTERISTICS

The off shore wave climate is same as previous case. However, for the sake of completeness, it is reproduced in this section also.

The wave characteristics such as significant wave height, mean wave period and mean wave direction at a deep-water location (10° 0'0.00"N, 76° 0'0.00"E) off Cochin have been extracted from the ECMWF (European Centre for Medium-Range Weather Forecasts) including the wind-wave modeling hind-cast studies. The data are sampled at every 6 hours. Basically, the wave field follows the wind pattern. It is noted that the spatial variability is closely related, the maximum of H_s are associated with maximum wind speeds. **Fig.4.1 to Fig 4.13** represents annual occurrence of wave climate. It is noted that the offshore wave climate of Cochin is predominantly from west. The waves are predominantly observed in 6s to 8s period with the significant wave height ranges between 0.5m to 1.5m. However, larger wave heights were also observed.

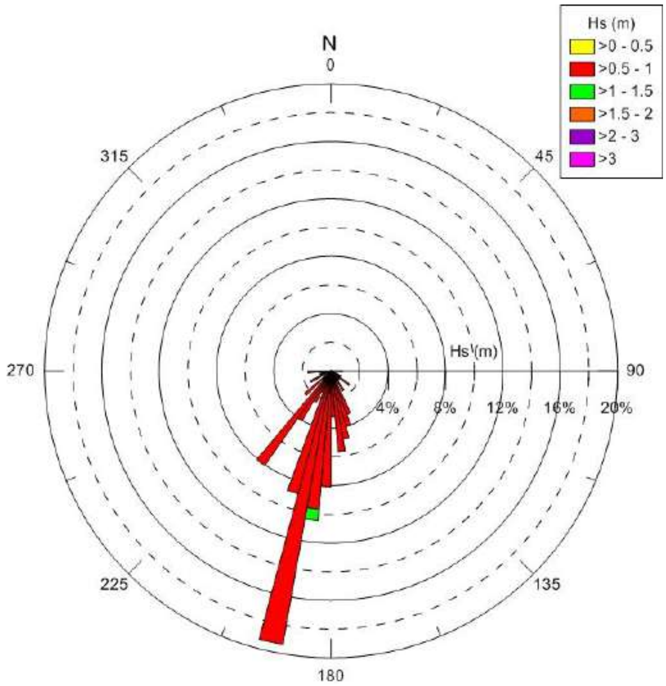


Fig4.1 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of january

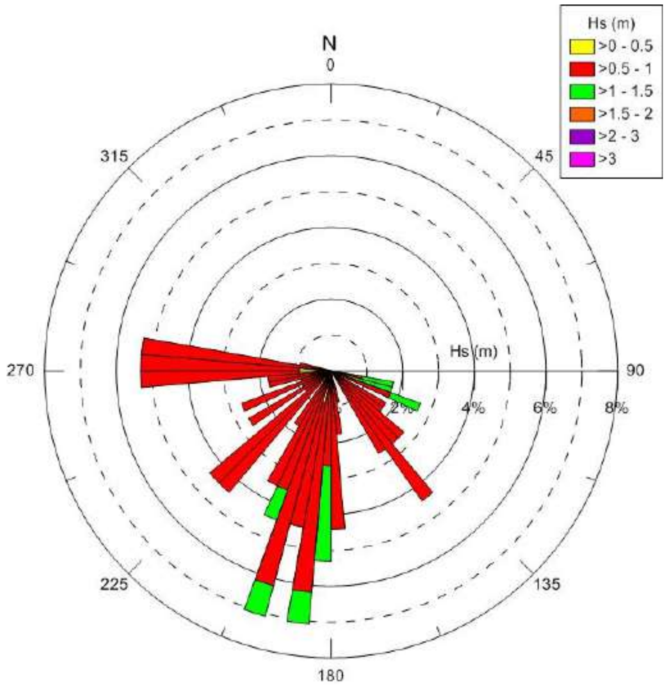


Fig4.2 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of February

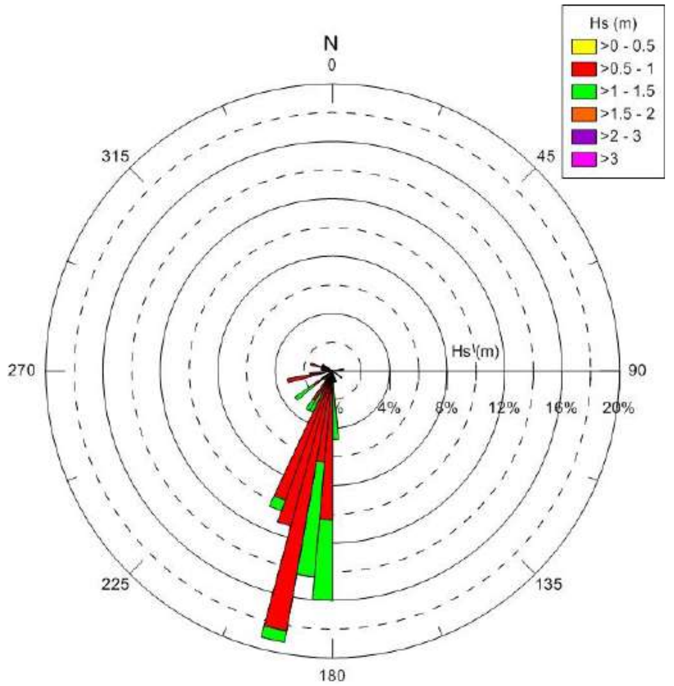


Fig4.3 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of March

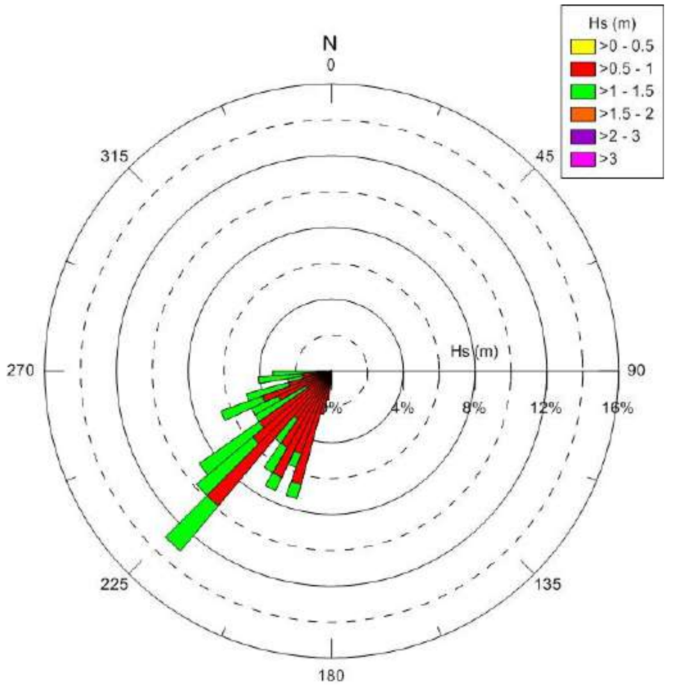


Fig4.4 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of April

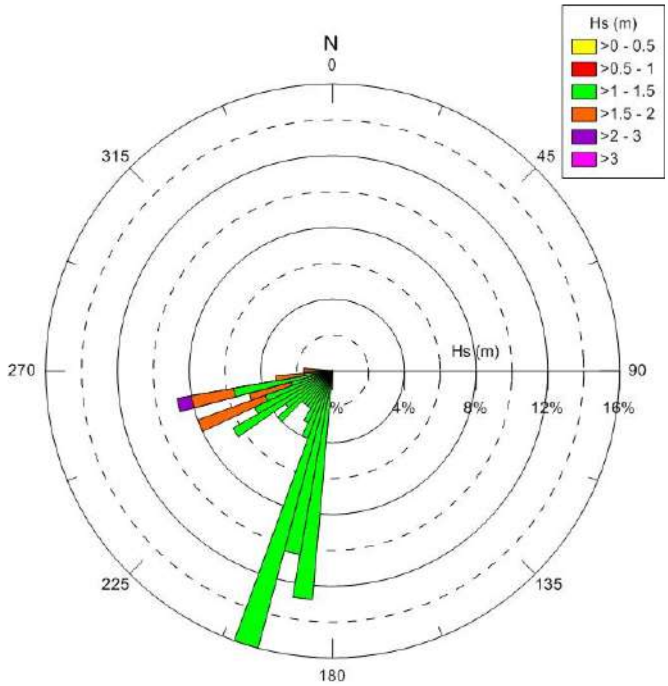


Fig 4.5 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of May

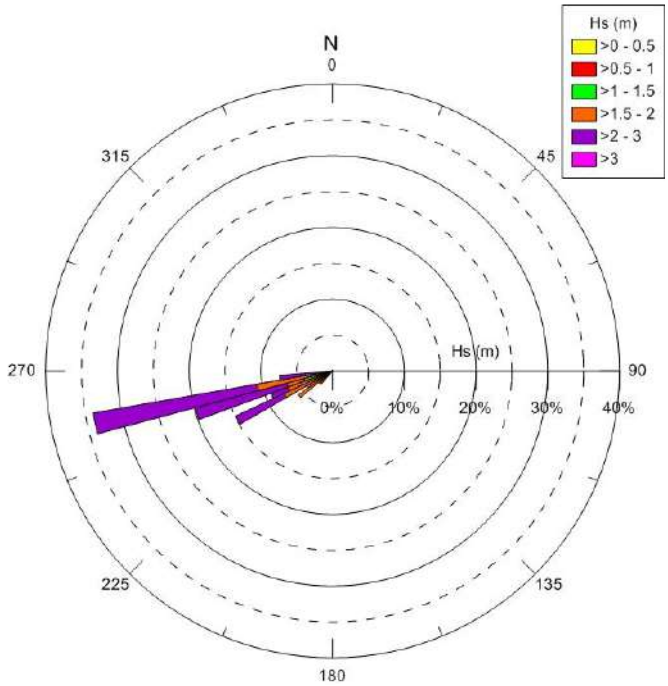


Fig 4.6 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of June

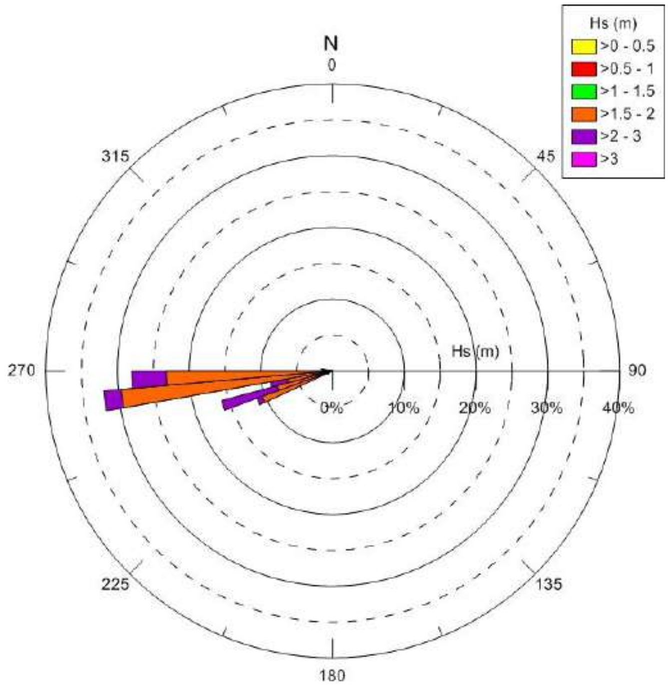


Fig 4.7 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of July

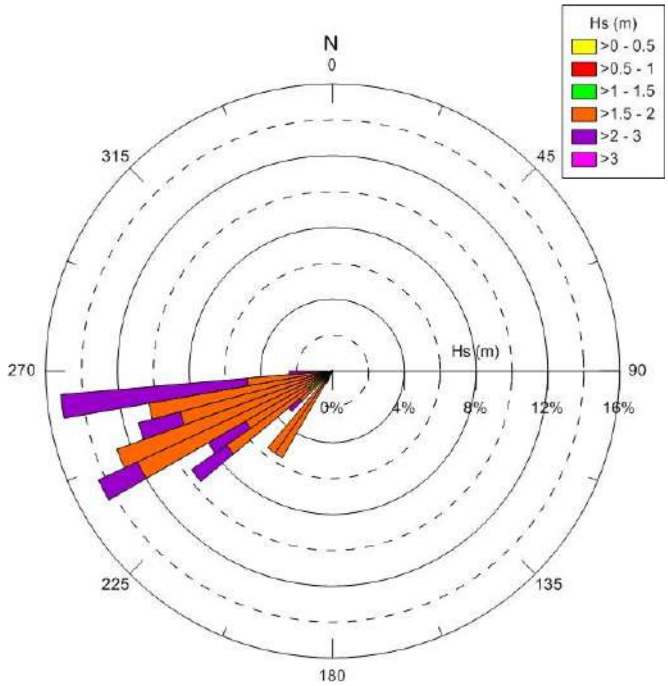


Fig 4.8 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of August

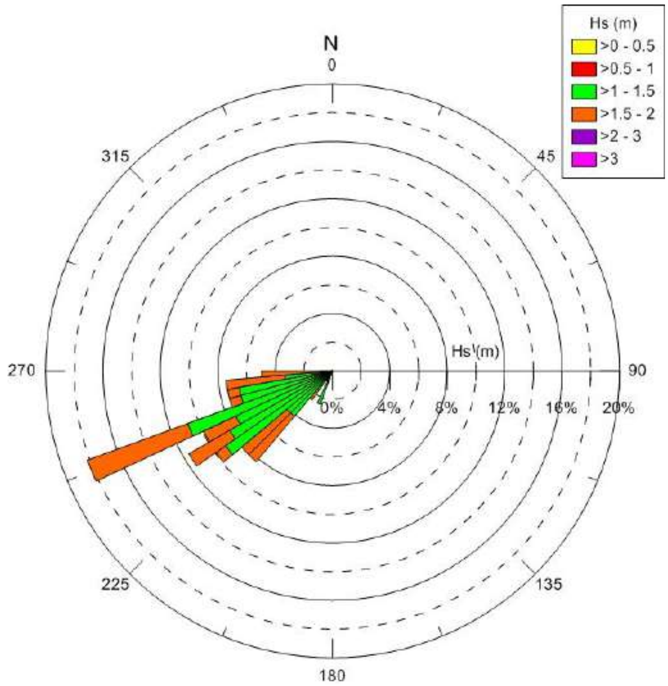


Fig 4.9 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of September

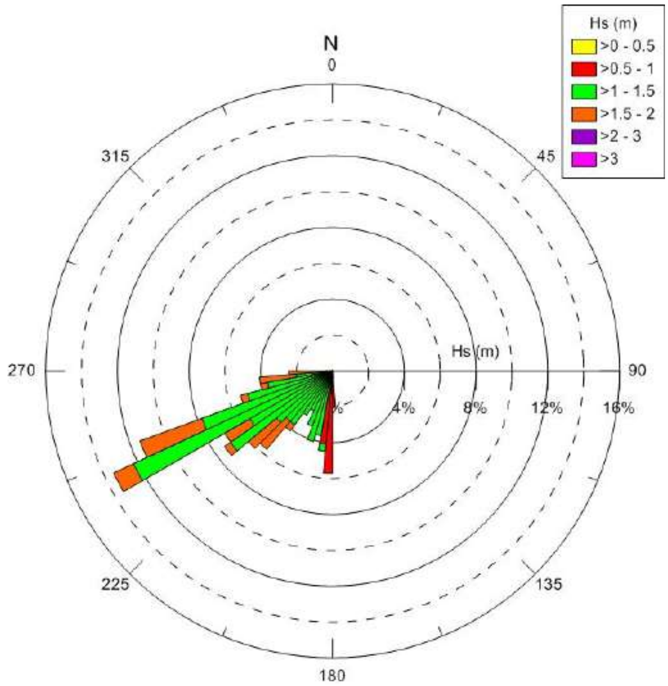


Fig 4.10 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of October

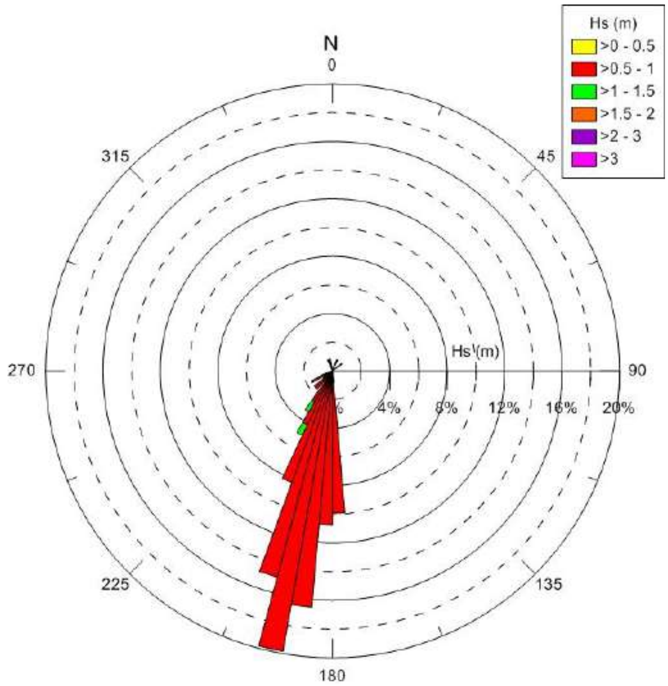


Fig 4.11 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of November

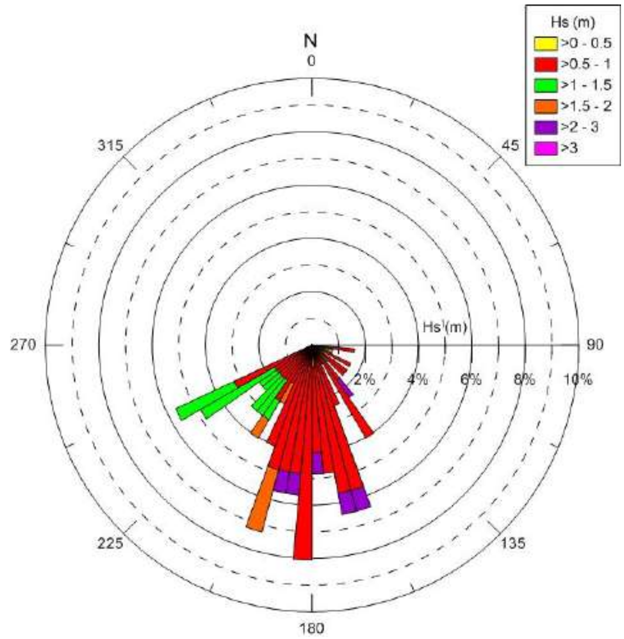


Fig 4.12 Wave rose diagram representing the significant wave height (m) along the particular direction for the month of December

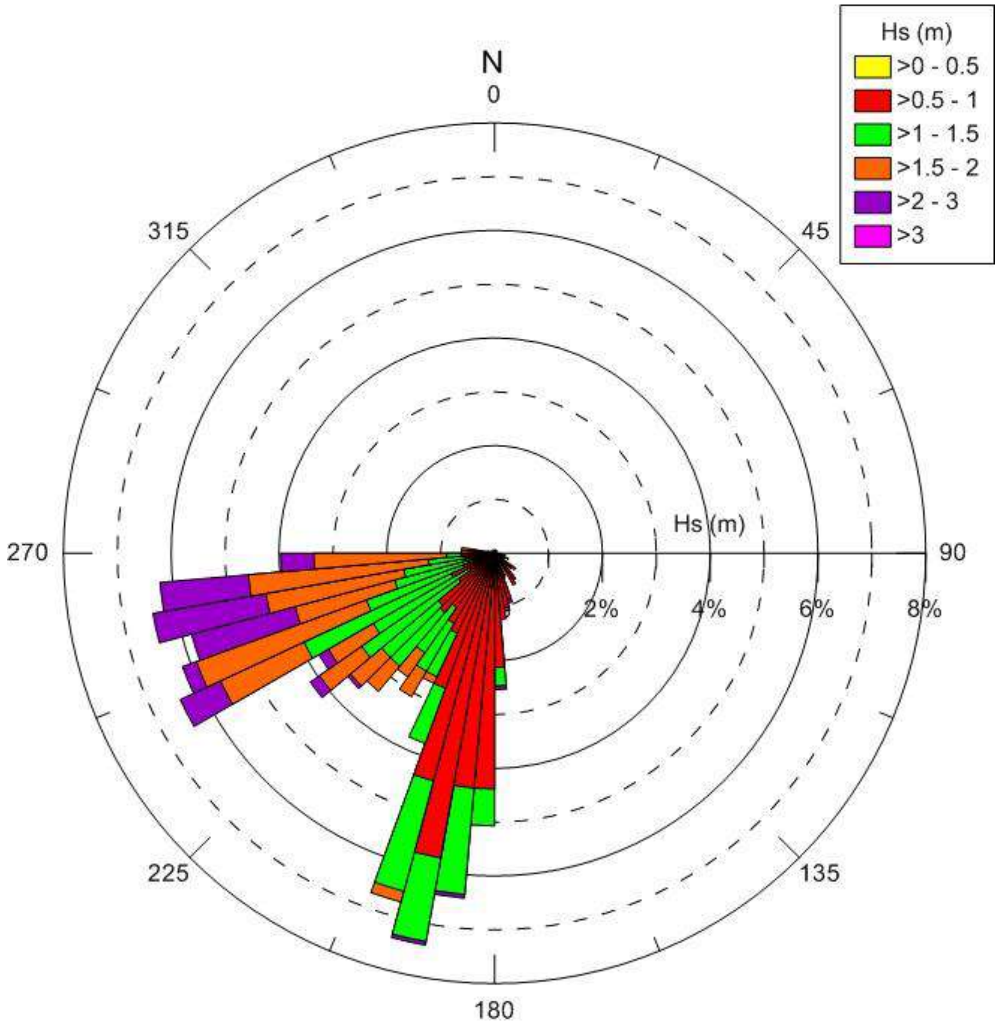


Fig 4.13 Wave rose diagram representing the significant wave height (m) along the particular direction for an annual year

4.2.1 Current Measurement for Present and Future conditions after Dredging of -20m

Demarcation of the study domain is done to set up the extent of the model domain. Hydrodynamic modelling is executed using Ocirc circulation model for ICTT vallarpadam Cochin port trust domain. The hydrodynamic modelling is executed for spring and neap condition, which covers all the astronomical aspects of tidal forcing. It is conducted using the modelling approach by physical settings and domain considered with the mesh and measured bathymetry is considered for simulation. The time series data is extracted for the present and future current conditions of the area which is shown in **Fig.4.14-4.21.**

Time series data is extracted for the present current condition with the depth of 14m along the shore of eastern and western side of the ICTT berth and is shown in **Fig4.14-4.17** below. The current extracted along the north western side and south western side of the ICTT berth is 1.0 m/s and 0.75 m/s respectively. The current extracted for north eastern side and south eastern side of the ICTT berth is 0.70m/s and 0.35m/s respectively. Time series data is extracted for the present current condition with the depth of 20 m along the shore of eastern and western side of the ICTT berth and is shown in **Fig.4.18-4.21** below. The current extracted along the north western side and south western side of the ICTT berth is 1.1 m/s and 0.73 m/s respectively. The current extracted for north eastern side and south eastern side of the ICTT berth is 0.72m/s and 0.33m/s respectively. There is no change in current measurement due to varying depth for present and future conditions.

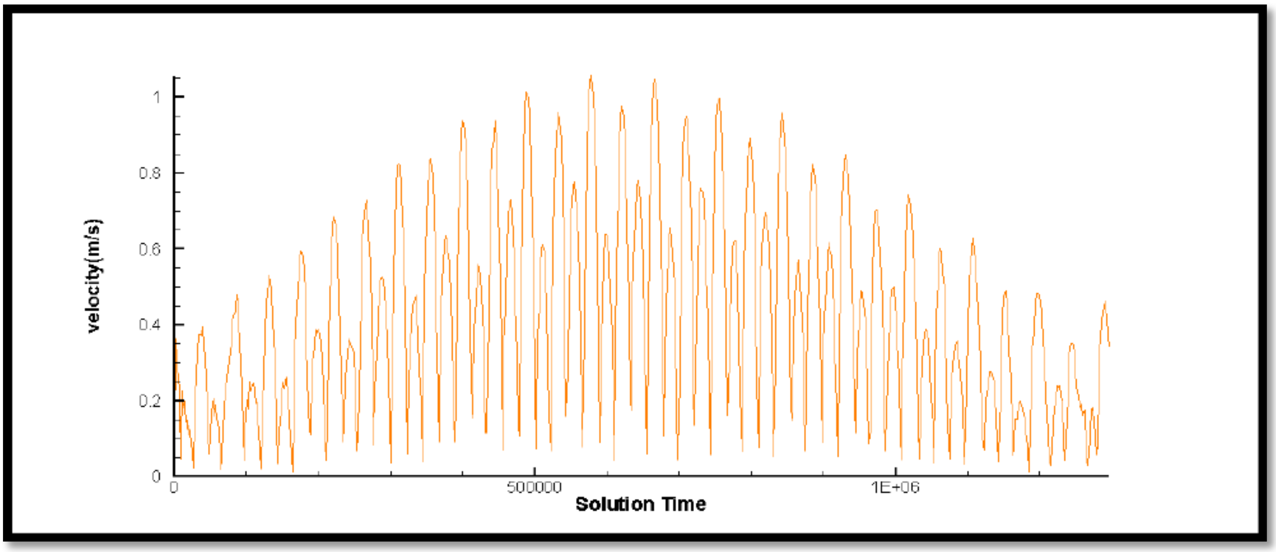


Fig.4.14. Time series data is extracted north western side of the ICTT berth at (14m) depth

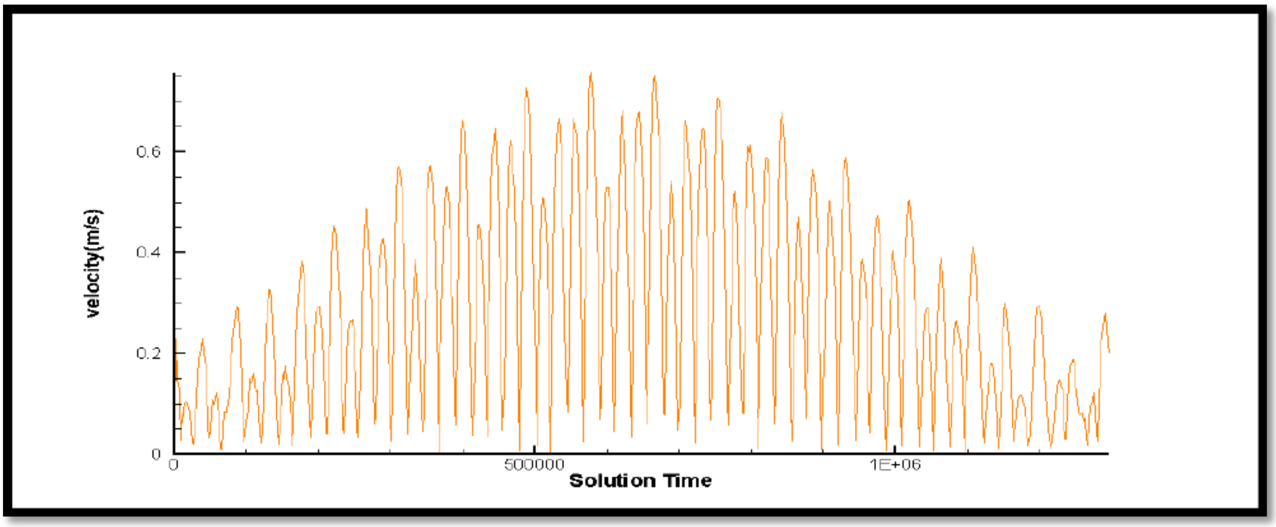


Fig 4.15 Time series data is extracted south western side of the ICTT berth at (14m) depth

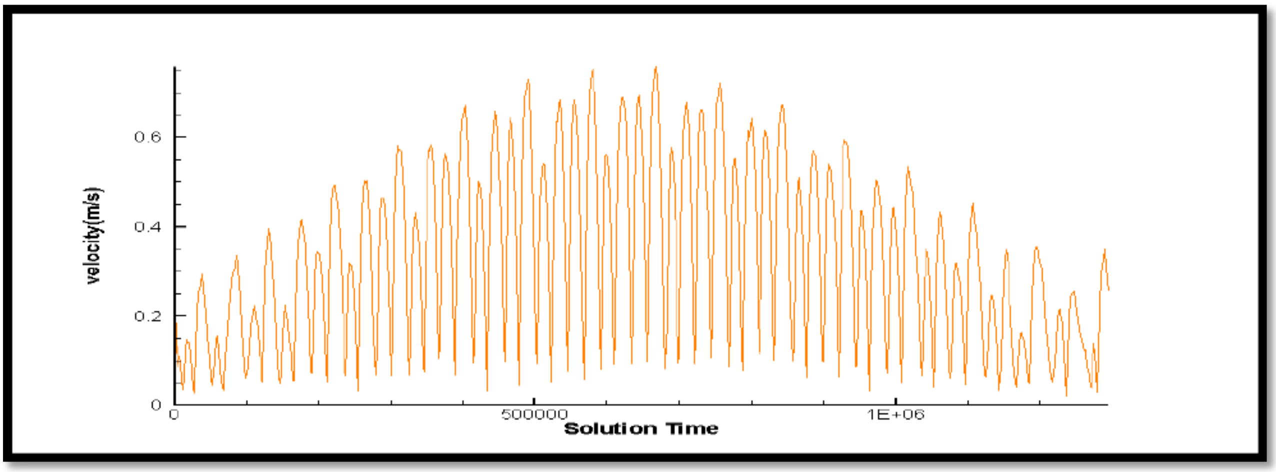


Fig 4.16 Time series data is extracted for north eastern side of the ICTT berth at (14m) depth

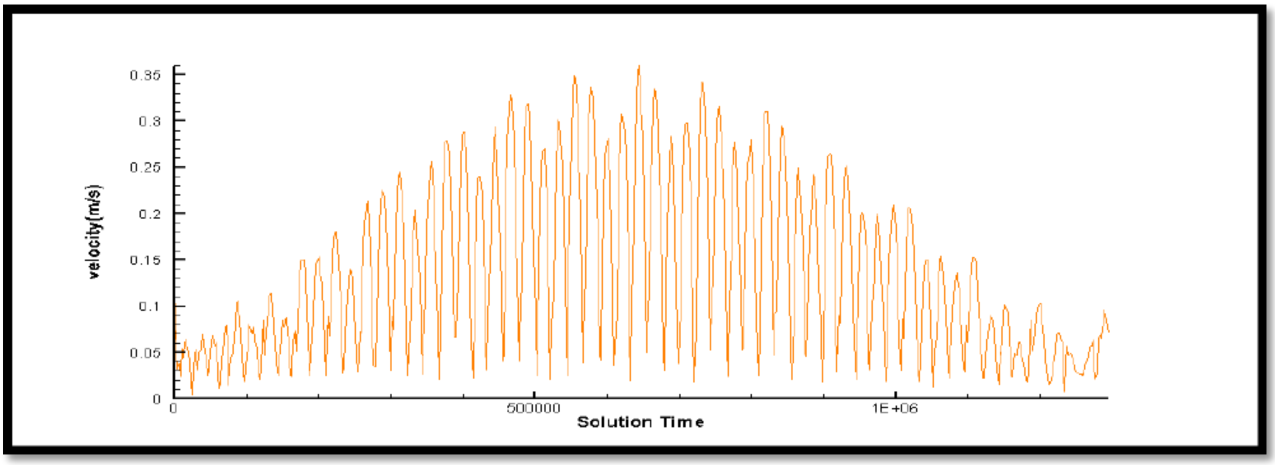


Fig 4.17 Time series data is extracted for south eastern side of the ICTT berth at (14m) depth

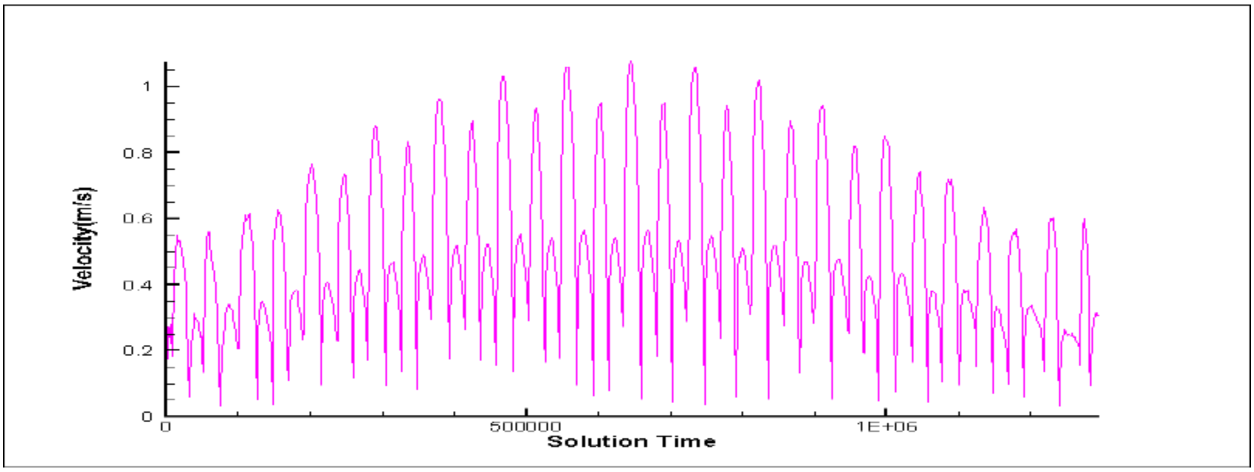


Fig 4.18 Time series data is extracted north westerly side of the ICTT berth at (20m) depth

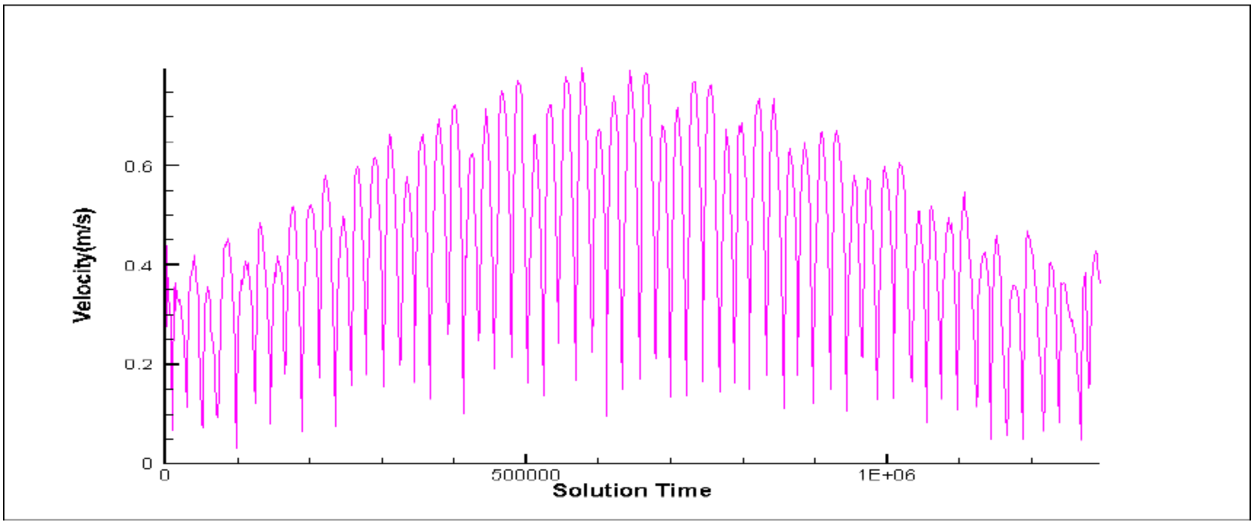


Fig 4.19 Time series data is extracted south western side of the ICTT berth at (20m) depth

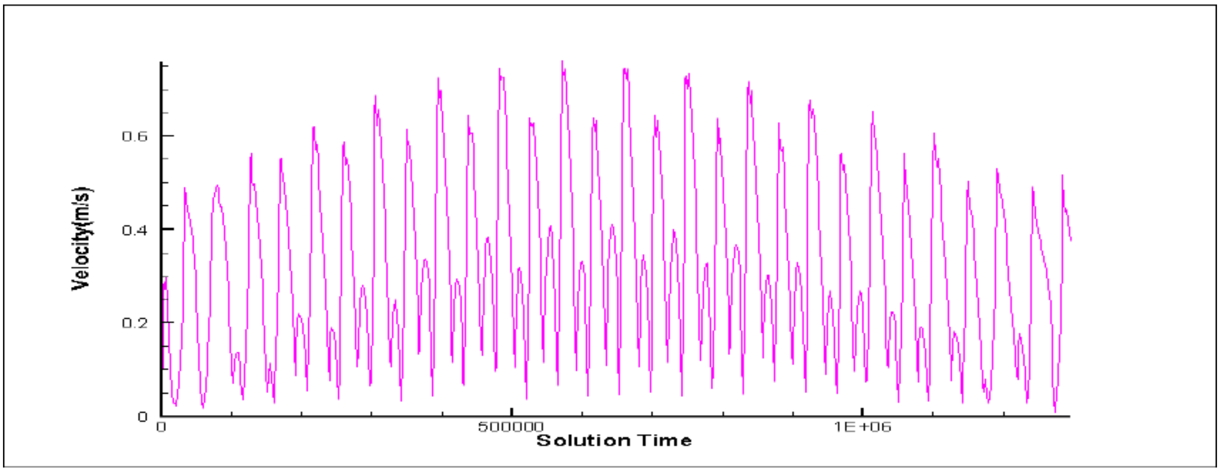


Fig.4.20 Time series data is extracted for north eastern side of the ICTT berth at (20m) depth

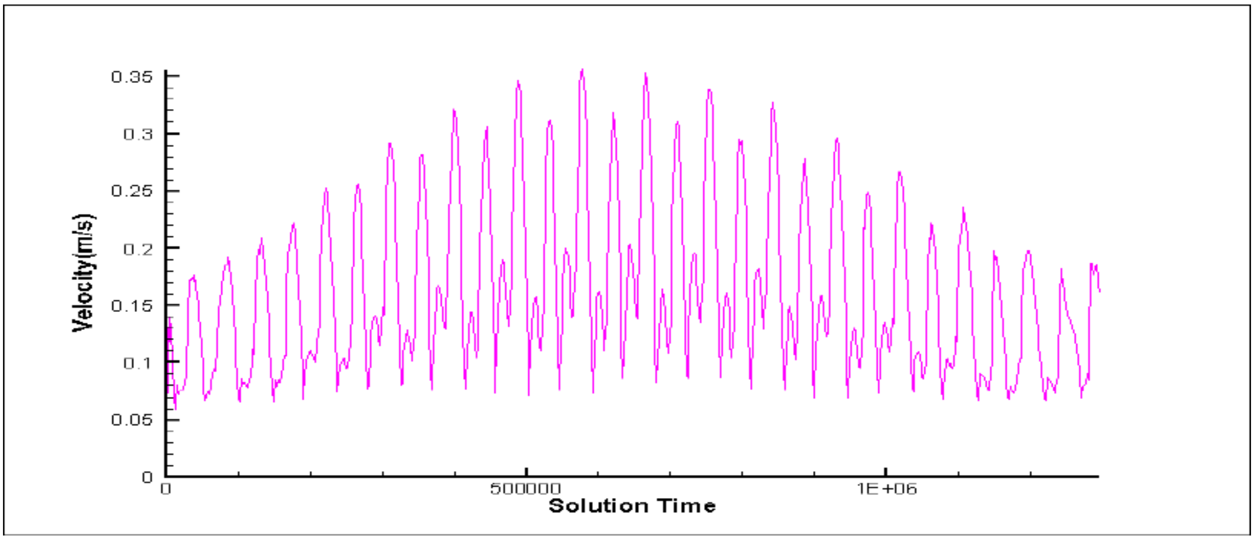


Fig 4.21 Time series data is extracted for south eastern side of the ICTT berth at (20m) depth

4.3 WAVE TRANQUILLITY STUDY

4.3.1 Numerical modelling

The study aims at providing an in depth analysis on the wave incidence on the neighborhood shoreline of ICTT berthing jetty due to the proposed increase in the water depth in front of the ICTT jetty. A suitable numerical model is required in order to carry out this task. For the present simulation, the phase resolving model based on mild slope equation has been used.

The nonlinear wave propagation associated with most of the observed phenomenon in offshore region (e.g., wave reflection, refraction and diffraction) is generally represented by the shallow water mild slope equation.

$$\nabla.\left(C_p C_g \nabla \eta\right) + k^2 C_p C_g \eta = 0 \qquad (1)$$

Where, C_p and C_g are the wave celerity and group celerity respectively. η is the water surface elevation. k is the wave number. For the computation of near shore wave field, this model, Eqn.(1) is subjected to the proper boundary conditions. This is provided by the bathymetry and the shore line.

The computational domain roughly approximates a semi circle of radius 10 km. **Fig 4.22** shows the domain where the computations are actually performed. The direction of the incident monochromatic wave is defined with respect to the geometric northern direction

4.3.2 Case 1- Present Bathymetry Conditions

In case 1, the computational domain roughly approximates a semi-circle of radius 10 km. **Fig.23** shows the domain where the computations are actually performed. The direction of the incident monochromatic wave is defined with respect to the geometric northern direction.

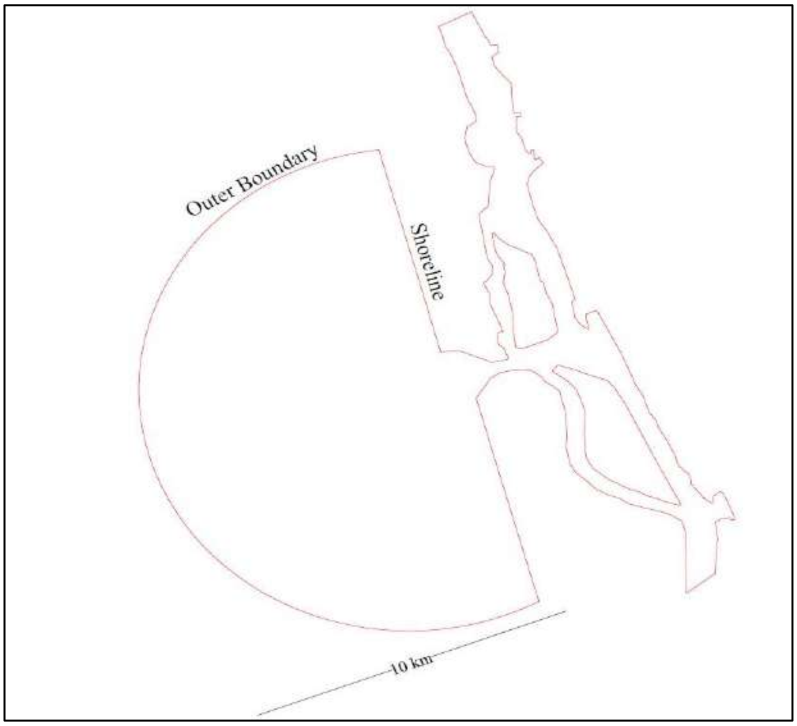


Fig.4.22 Computational domain for tranquility studies for Cochin

A numerical method is required to solve the above Eqn. (1) for wave elevation. In this study, Finite Element Method (herein after abbreviated as FEM) is employed. This requires creating a mesh structure in the given computational domain. Upon creation of such a mesh, the domain is represented by nodal points which are connected with each other through the created mesh. The numerical solution of Eqn. (1) is sought in those nodes. This mesh has been generated using the commercial package GAMBIT.

4.3.3 Detail of the mesh structure

The CGWAVE model utilizes triangular mesh units in the computational domain. Due to the complexity in the shoreline geometry (as can be seen in **Fig 4.22)** which includes both of the proposed breakwaters, an unstructured mesh is desired. Hence a triangular unstructured mesh is generated in GAMBIT, mesh generation software. In such a mesh the nodal spacing is optimized so as to adapt to the nearby portion of the shoreline boundary. The outer semi circular periphery is modeled by 1289 nodes with a spacing of 5 m and the inner shoreline is modeled by nodes with a spacing of 5 m. Then an unstructured mesh is created with an average spacing of 10m inside the domain. This leads to a total number of 186524 nodes with 393700 numbers of triangular elements. The mesh is shown in **Fig4.23**

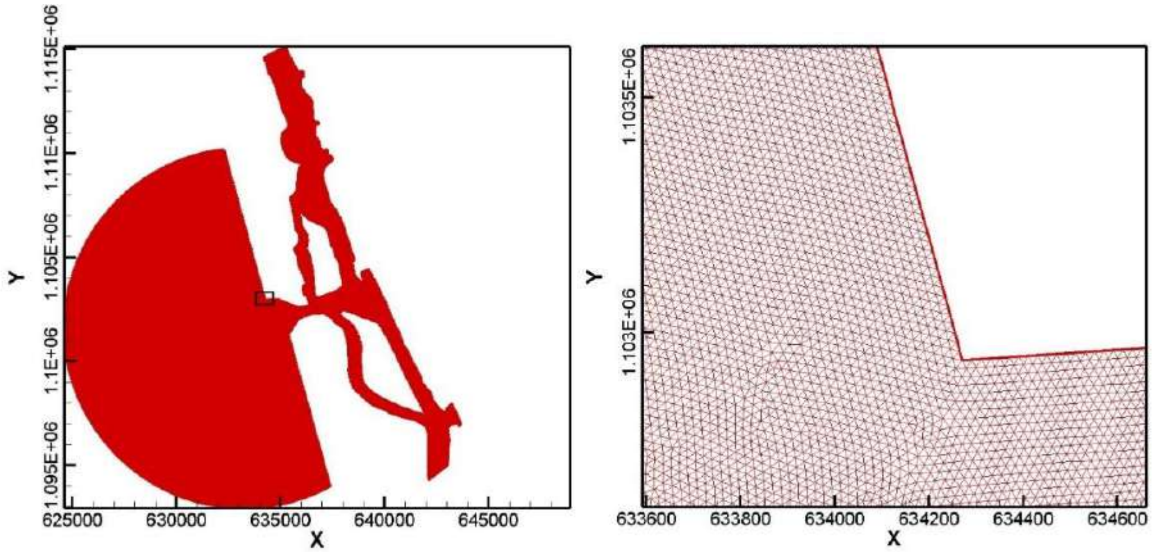


Fig 4.23 Mesh Structure adopted for the wave propagation modelling

4.3.4 Results and discussion

Different wave directions have been simulated in order to investigate the wave tranquility inside the proposed jetty region. The wave directions are chosen such that these represent an annual year. The wave period of the computations is given as 8s to observe the wave climate. The incident wave angle is varied to simulate different wave directional scenarios.

The wave climates representing typical wave directions are presented. **Fig 4.24** to **Fig 4.29** present the wave phase diagram and the wave height distribution representing the wave crest propagation for the wave approach angles 180^0 ,215^0 ,225^0, 245^0,270^0 and 345^0 respectively.

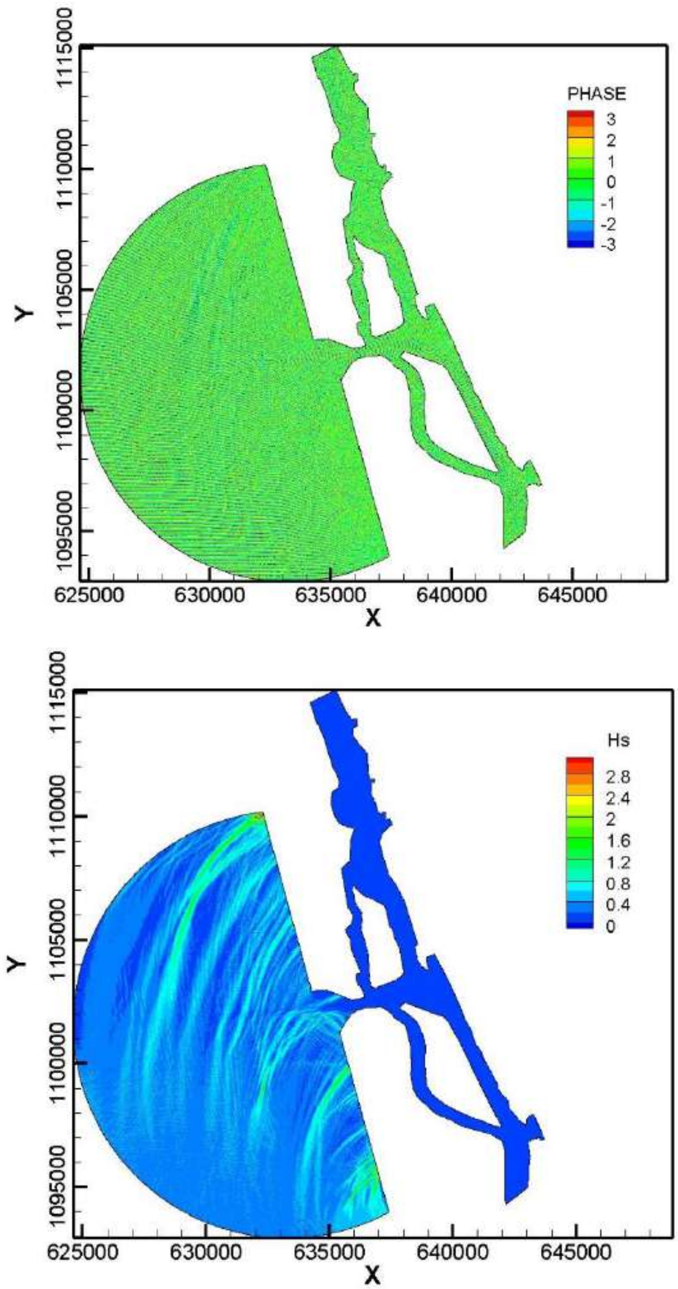
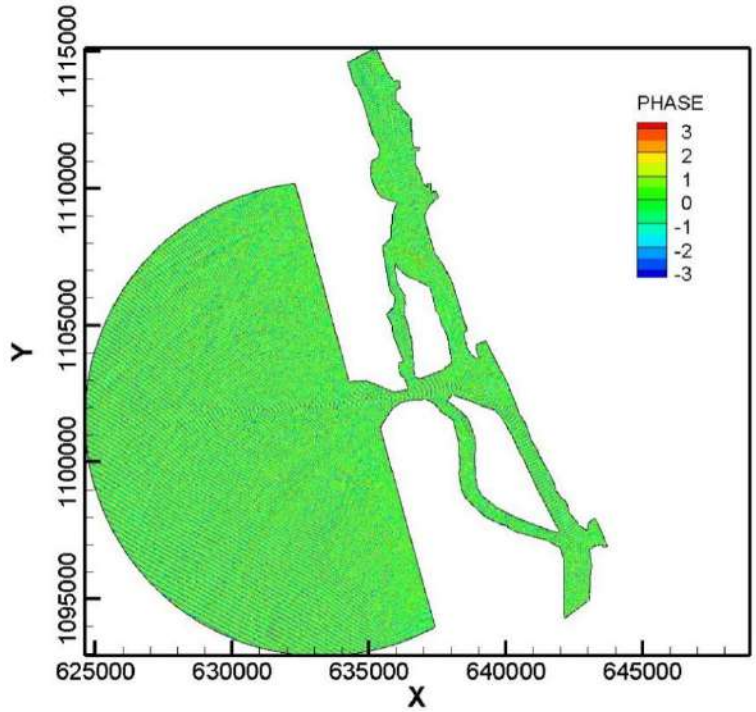


Fig 4.24 Phase distributions and Wave height distribution for the wave approach angle from 180^0



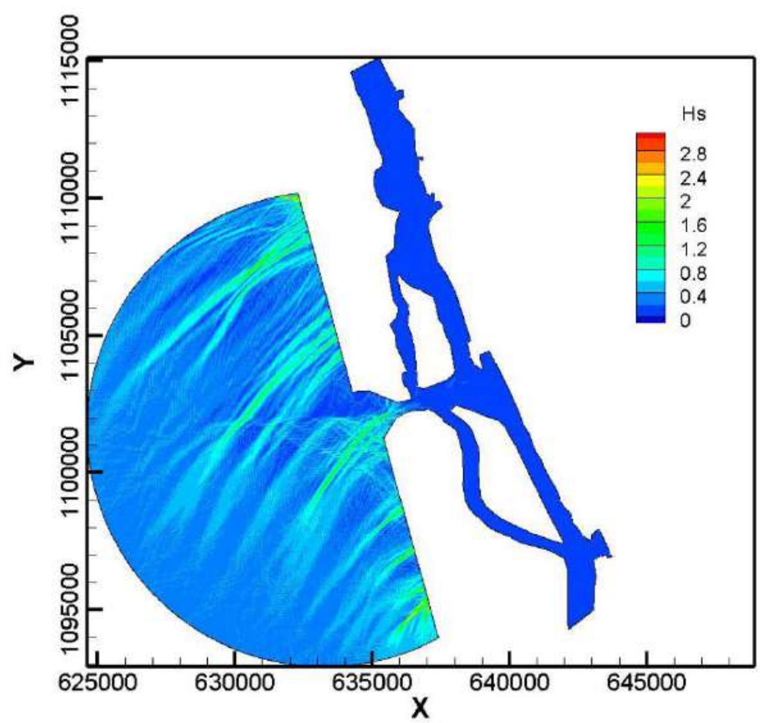


Fig 4.25 Phase distributions and Wave height distribution for the wave approach angle from 215^0

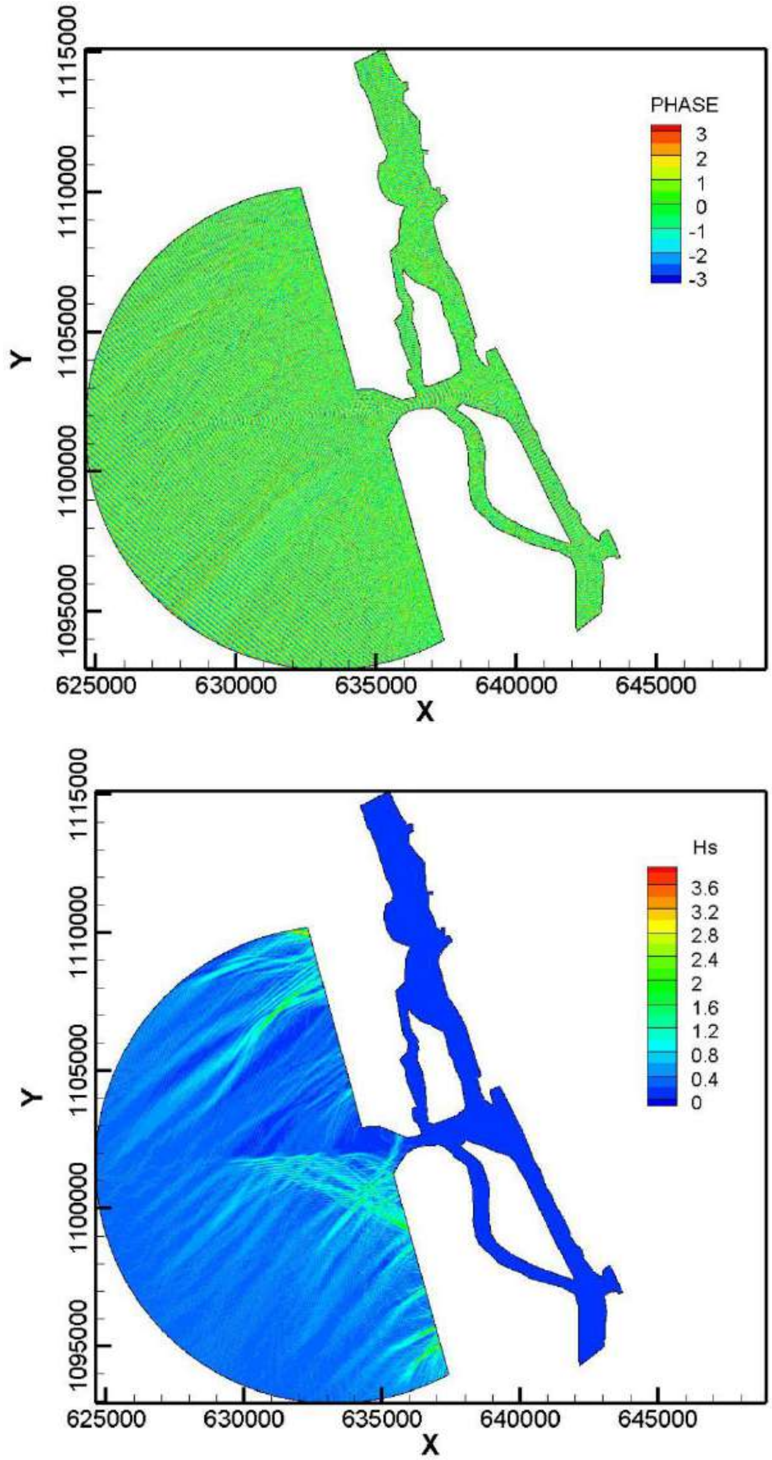


Fig 4.26 Phase distributions and Wave height distribution for the wave approach angle from 225^0

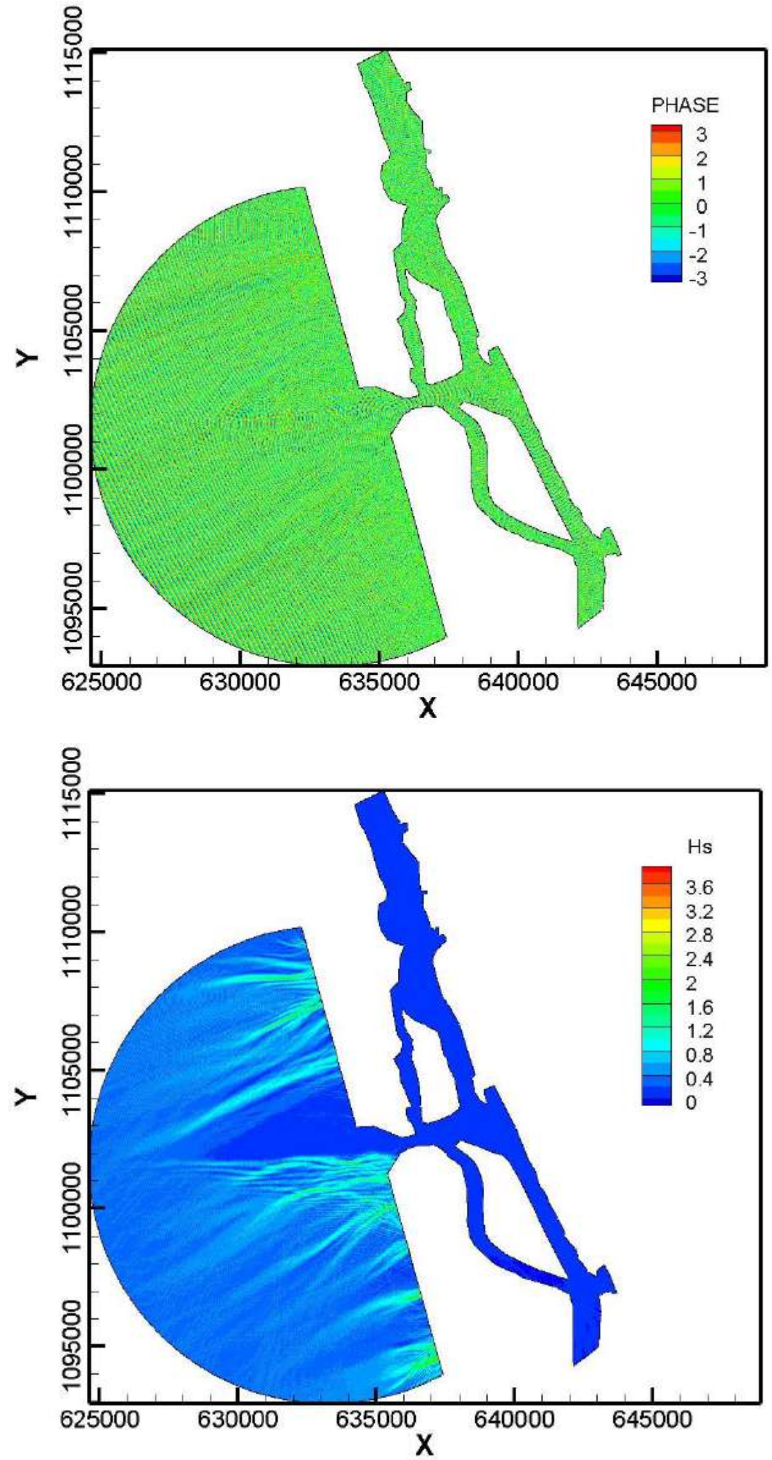


Fig 4.27 Phase distributions and Wave height distribution for the wave approach angle from 245^0

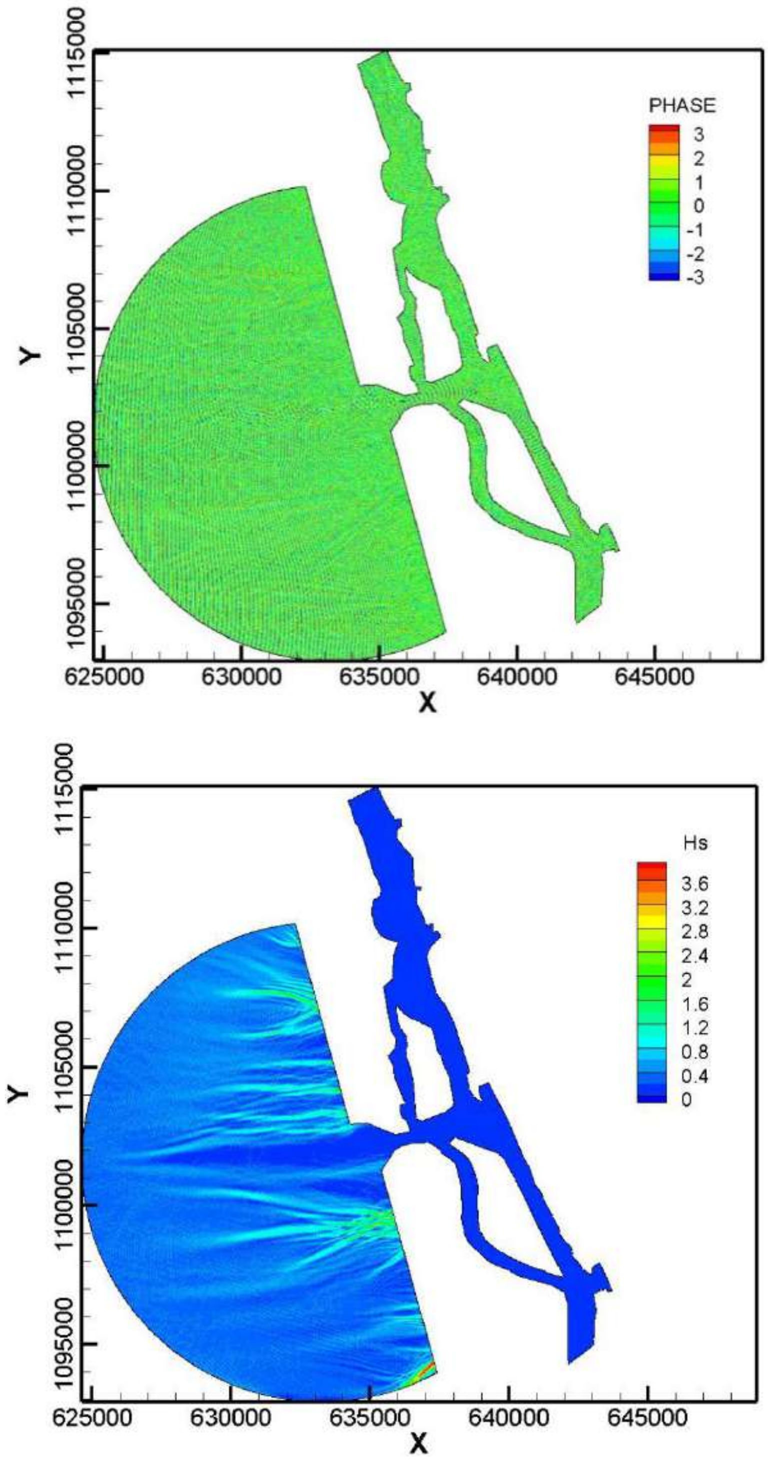


Fig 4.28 Phase distributions and Wave height distribution for the wave approach angle from 270^0

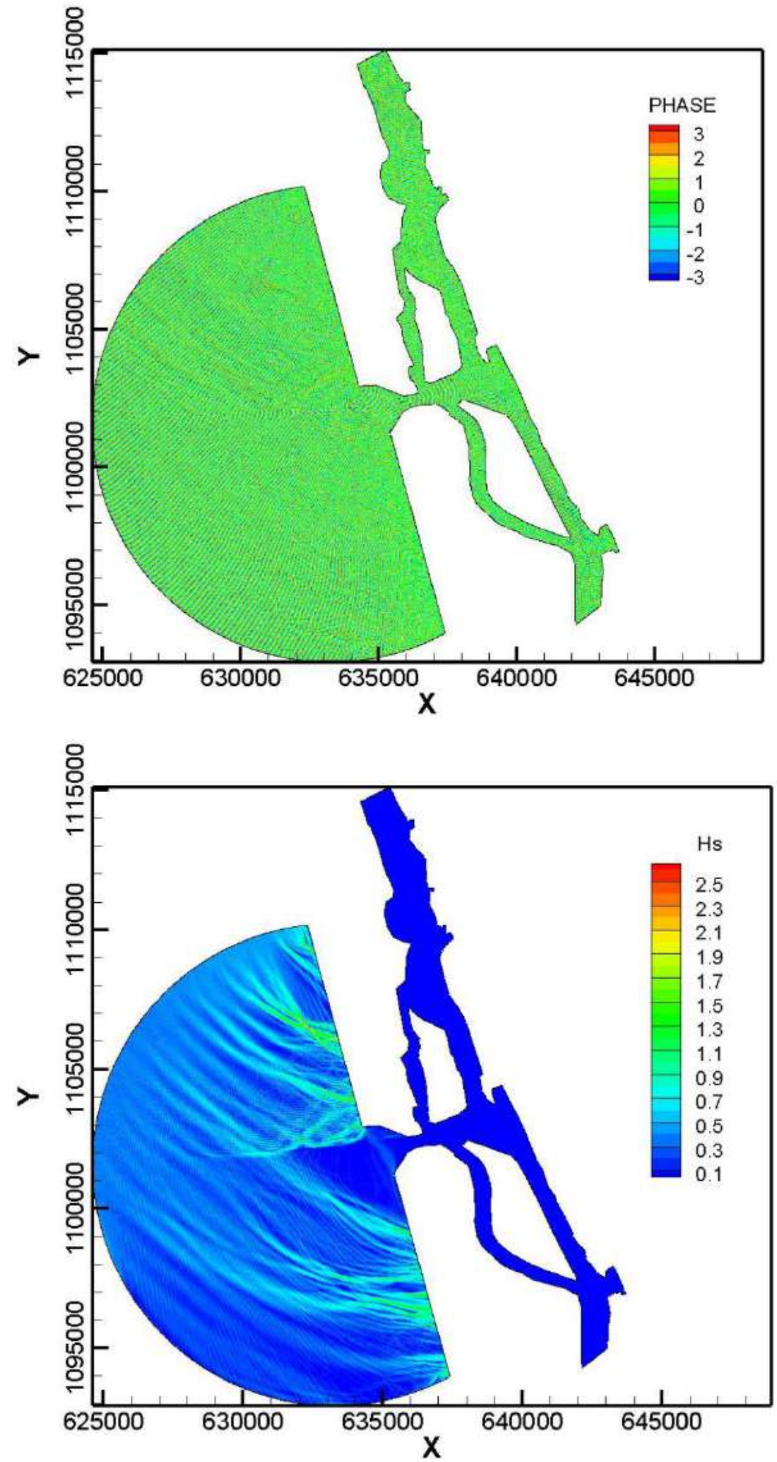


Fig 4.29 Phase distributions and Wave height distribution for the wave approach angle from 345^0

4.3.5 Summary

In order have a closer understanding of the wave penetration upto the vicinity of ICTT jetty, a few nodal points around the channel on both sides of the ICTT jetty are selected, where, the wave height is monitored during the course of the simulations and averaged to find the wave amplitude at the location. The location of the output points is shown in **Fig.4.30.** The occurrence of waves in the location of output points is presented in **Table 4.1.** The average maximum wave climate has been obtained from the probability of occurrence of offshore wave climate penetration into the channel. It is to be mentioned here that the wave propagation model has been executed for both scenarios of water depth in front of the jetty as 14m and 20m. However, the variation of the wave climate off the channel near the shoreline is insignificant.

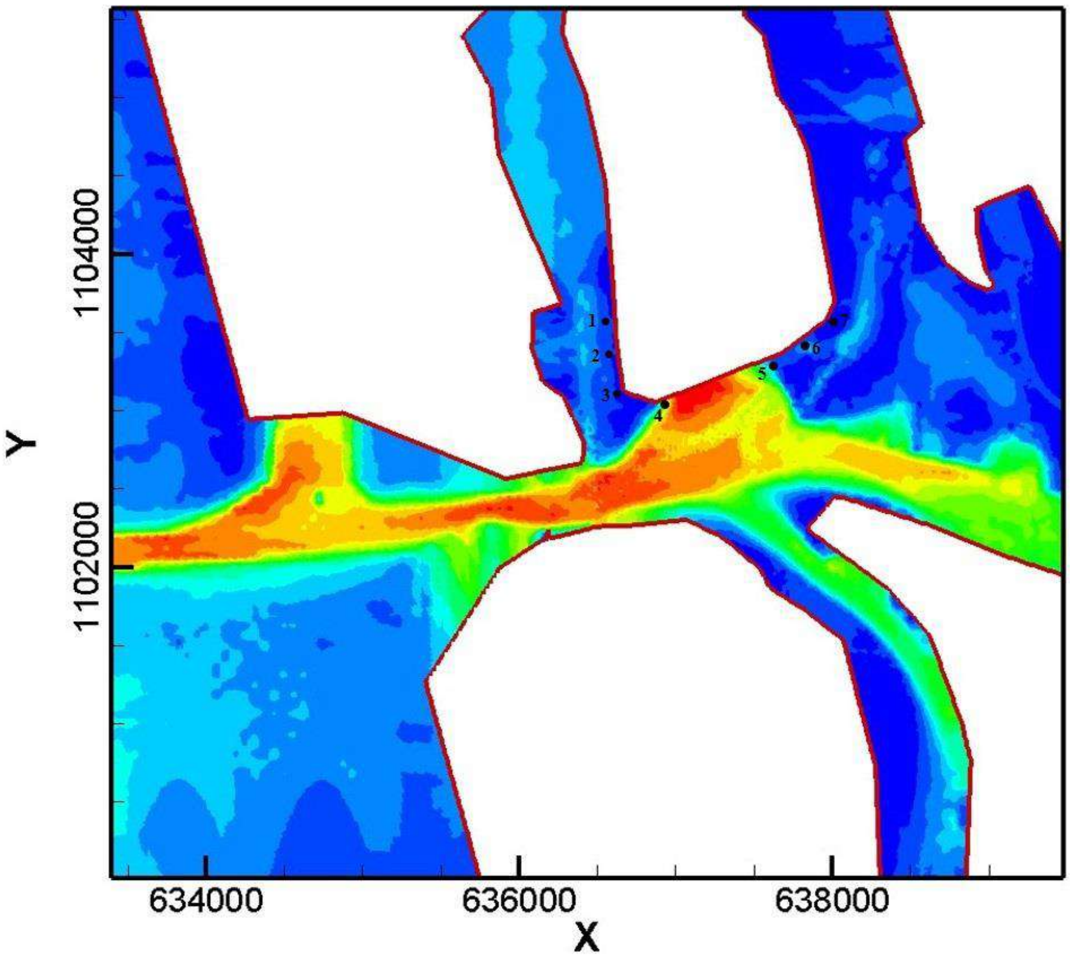


Fig 4.30 Points of measurement of the wave height

4.3.6 Case 2 – Bathymetry after dredging (20m)

In case 2, the computational domain roughly approximates a semi-circle of radius 10 km. **Fig 4.31** shows the domain where the computations are actually performed. The direction of the incident monochromatic wave is defined with respect to the geometric northern direction.

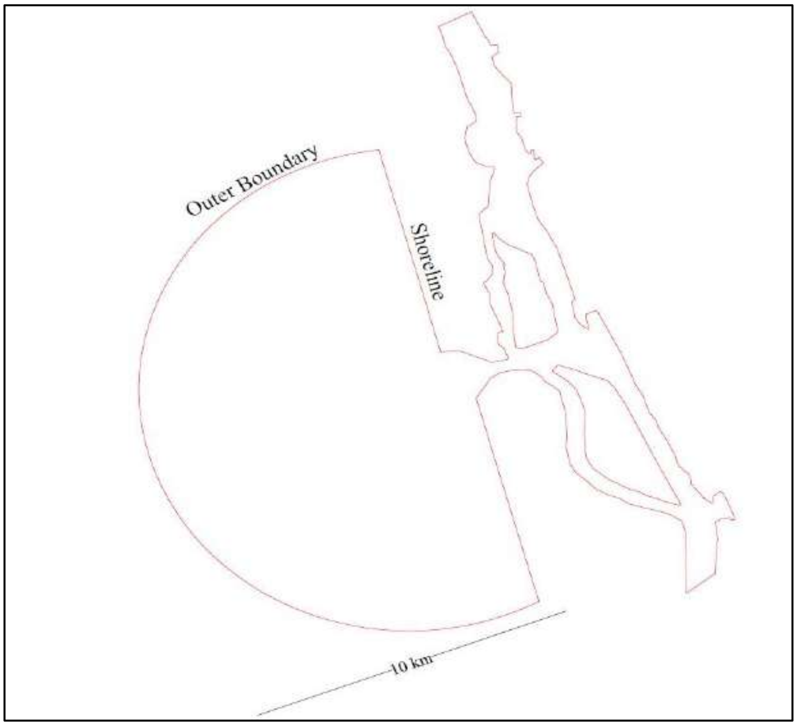


Fig.4.31 Computational domain for tranquility studies for Kochi

A numerical method is required to solve the above Eqn. (7) for wave elevation. In this study, Finite Element Method (herein after abbreviated as FEM) is employed. This requires creating a mesh structure in the given computational domain. Upon creation of such a mesh, the domain is represented by nodal points which are connected with each other through the created mesh. The numerical solution of Eqn. (1) is sought in those nodes. This mesh has been generated using the commercial package GAMBIT. The procedure for generation of grid in GAMBIT as follows:

- Based on the region of the sea whose analysis is required add a path in Google earth software.
- Taking the two end nodes of the path draw a semicircle which would represent the domain for which the wave analysis is required.
- Choose the type of elements (tri/quad) and the sizing of mesh.
- Mesh will be generated from which we would be able to know significant wave height and phase at each node.

The computational domain with bathymetry is shown in **Fig.4.32**

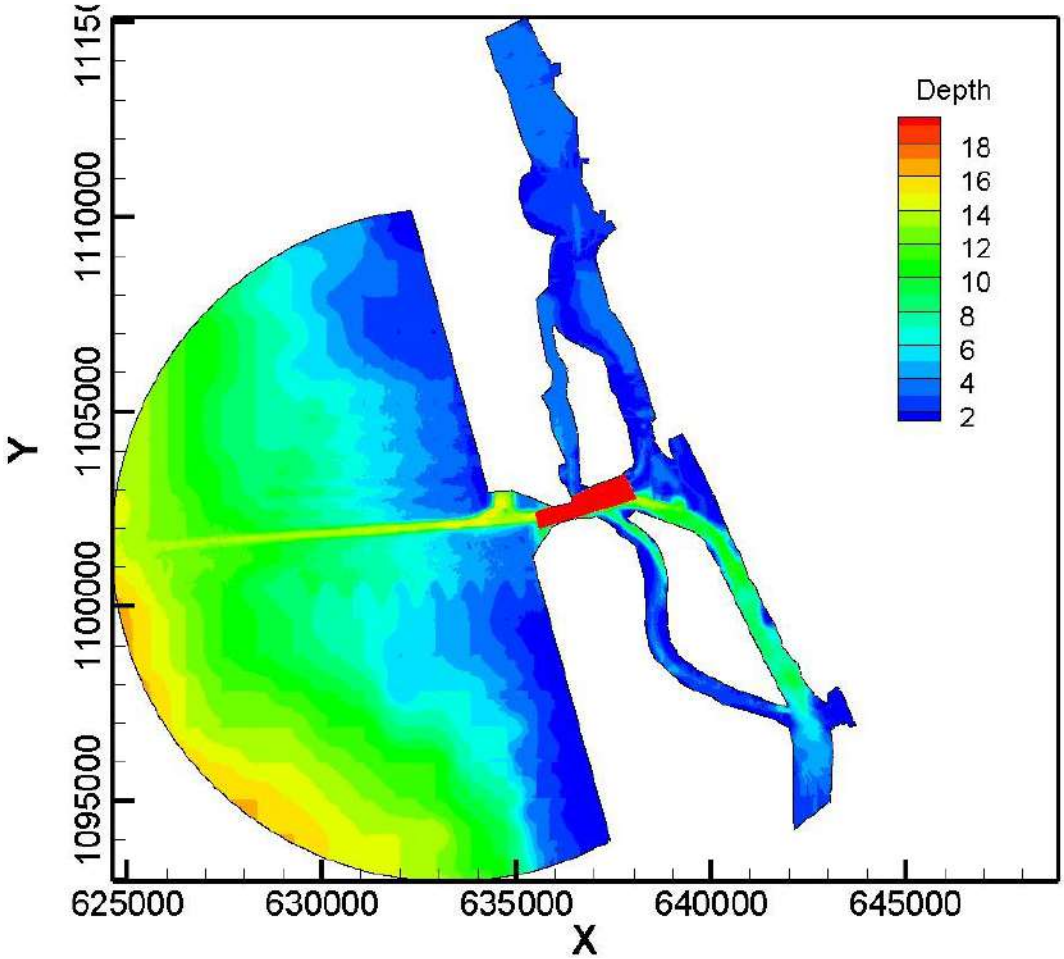


Fig. 4.32 Bathymetry for case 2

4.3.7 Detail of the mesh structure

The CGWAVE model utilizes triangular mesh units in the computational domain. Due to the complexity in the shoreline geometry (as can be seen in **Fig 4.32**), an unstructured mesh is desired. Hence a triangular unstructured mesh is generated in GAMBIT, mesh generation software. In such a mesh the nodal spacing is optimized so as to adapt to the nearby portion of the shoreline boundary. The outer semi-circular periphery is modeled by 1293 nodes with a spacing of 5 m and the inner shoreline is modeled by nodes with a spacing of 5 m. Then an unstructured mesh is created with an average spacing of 10m inside the domain. This leads to a total number of 186726 nodes with 394531 numbers of triangular elements. The mesh is shown in **Fig.4.35**

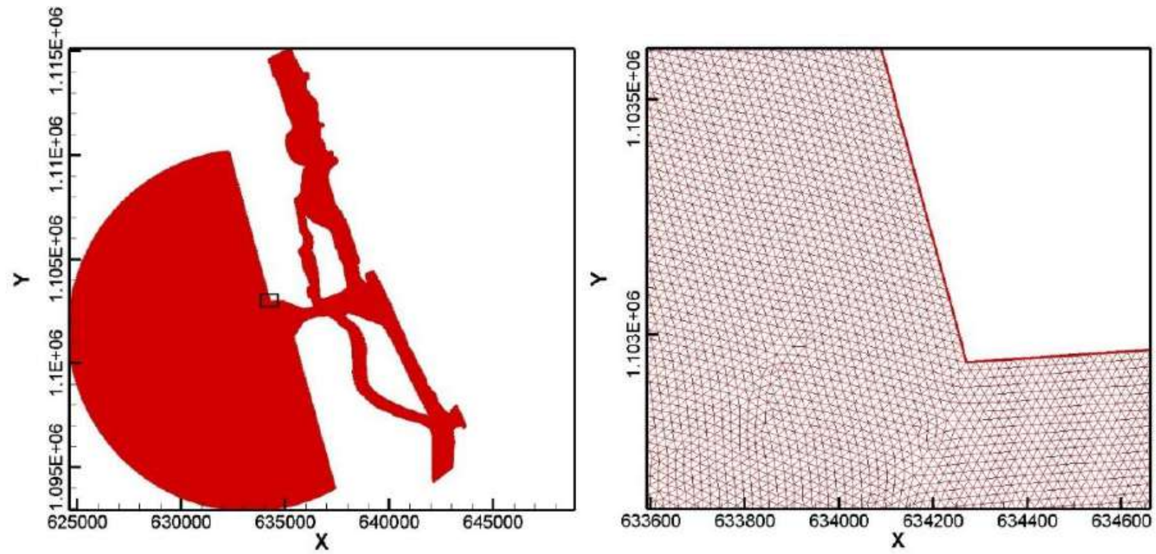


Fig.4.33 Mesh Structure adopted for the wave propagation modeling

4.3.8 Results and discussion

A total number of three wave directions have been simulated in order to investigate the wave tranquility inside the proposed jetty region. The wave directions are chosen such that these represent an annual year. The wave period of the computations is given as 8s to observe the wave climate. The incident wave angle is varied to simulate different wave directional scenarios.

The wave climates representing typical wave directions are presented. **Fig.4.36** to **Fig.4.41** present the wave phase diagram and the wave height distribution representing the wave crest propagation for the wave approach angles 180^0 ,215^0 ,225^0, 245^0,270^0 and 315^0 respectively.

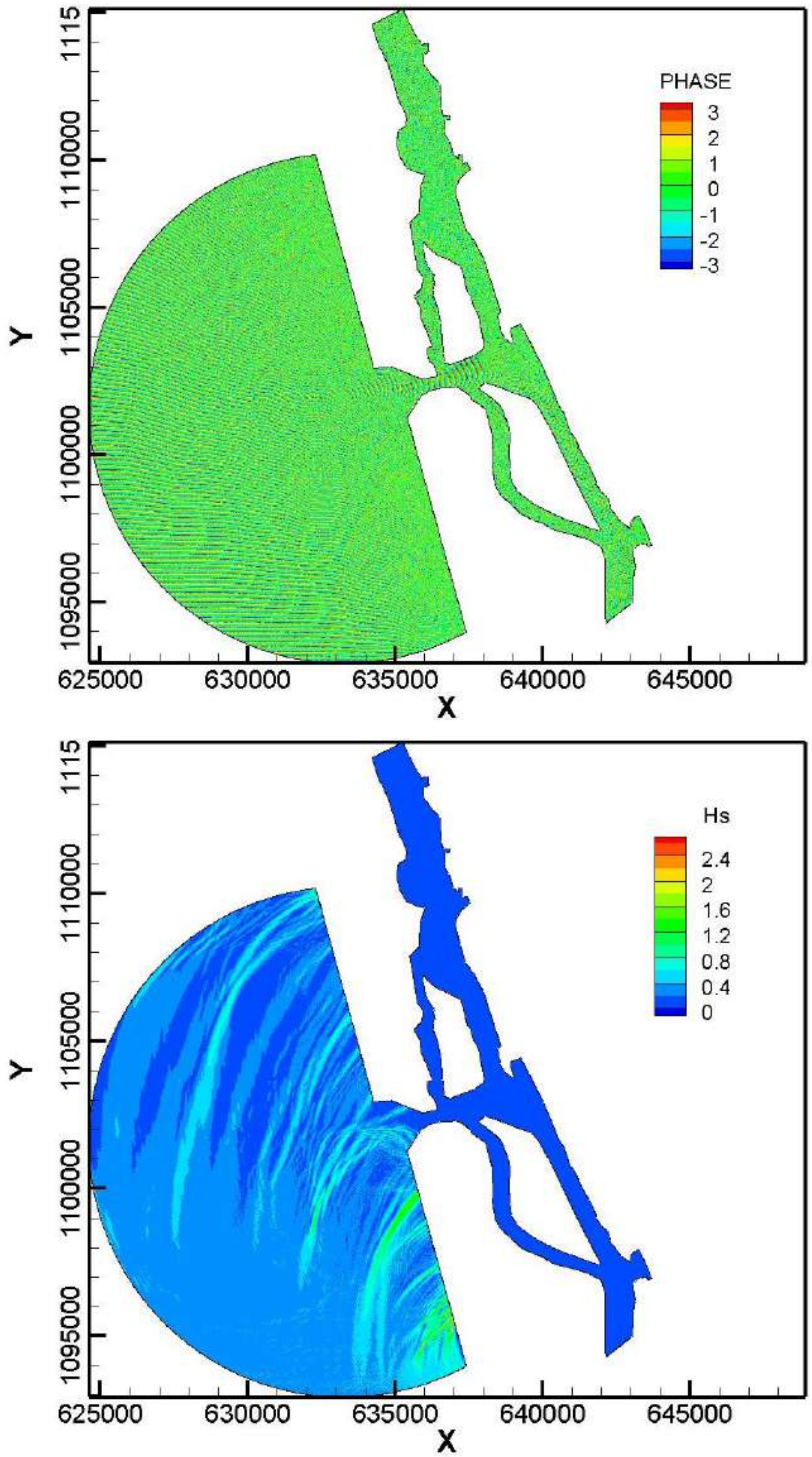


Fig4.34 Phase distributions and Wave height distribution for the wave approach angle from 180^0

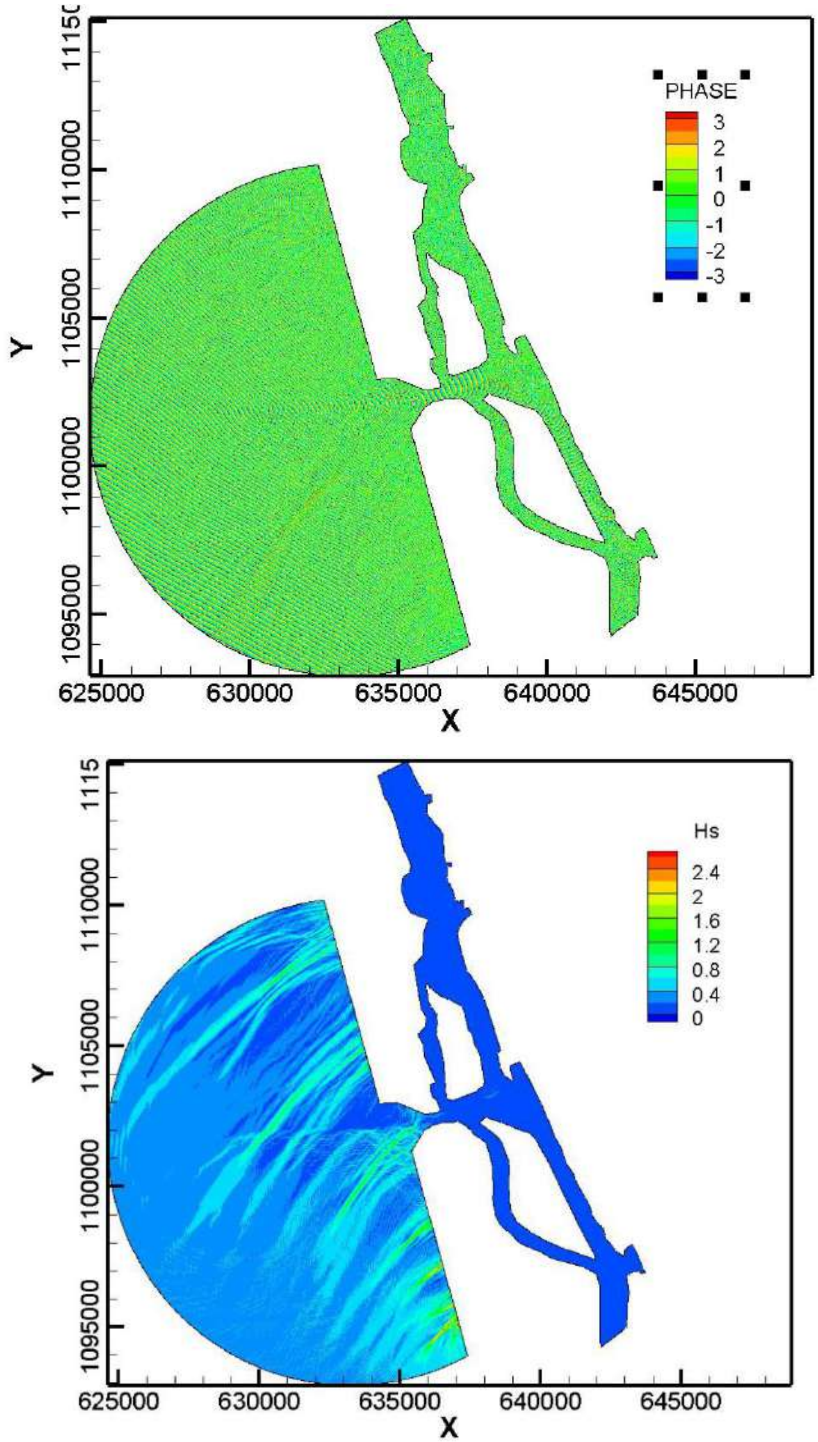
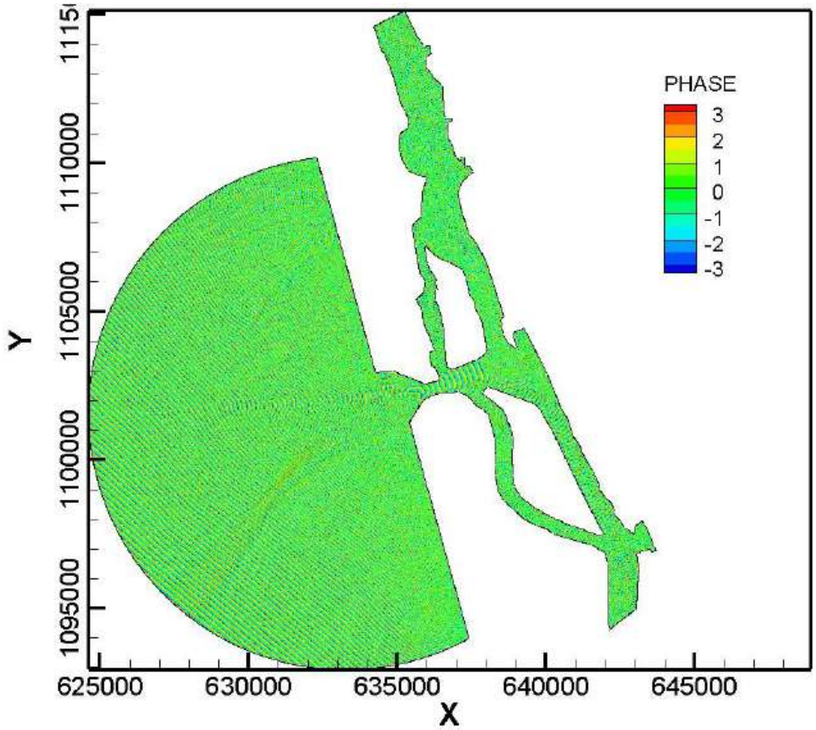


Fig.4.35 Phase distributions and Wave height distribution for the wave approach angle from 215^0



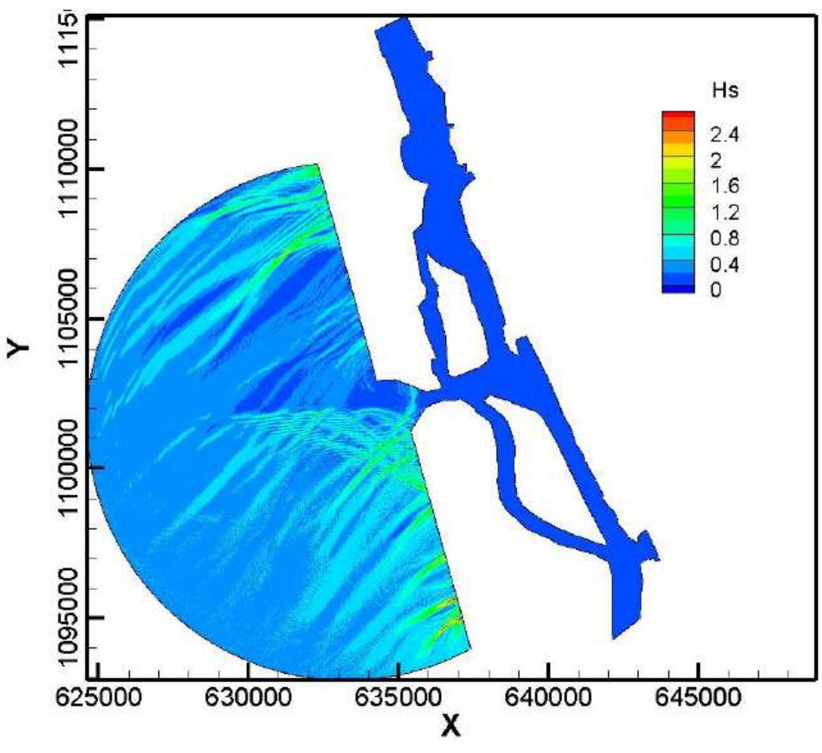


Fig.4.36 Phase distributions and Wave height distribution for the wave approach angle from 225^0

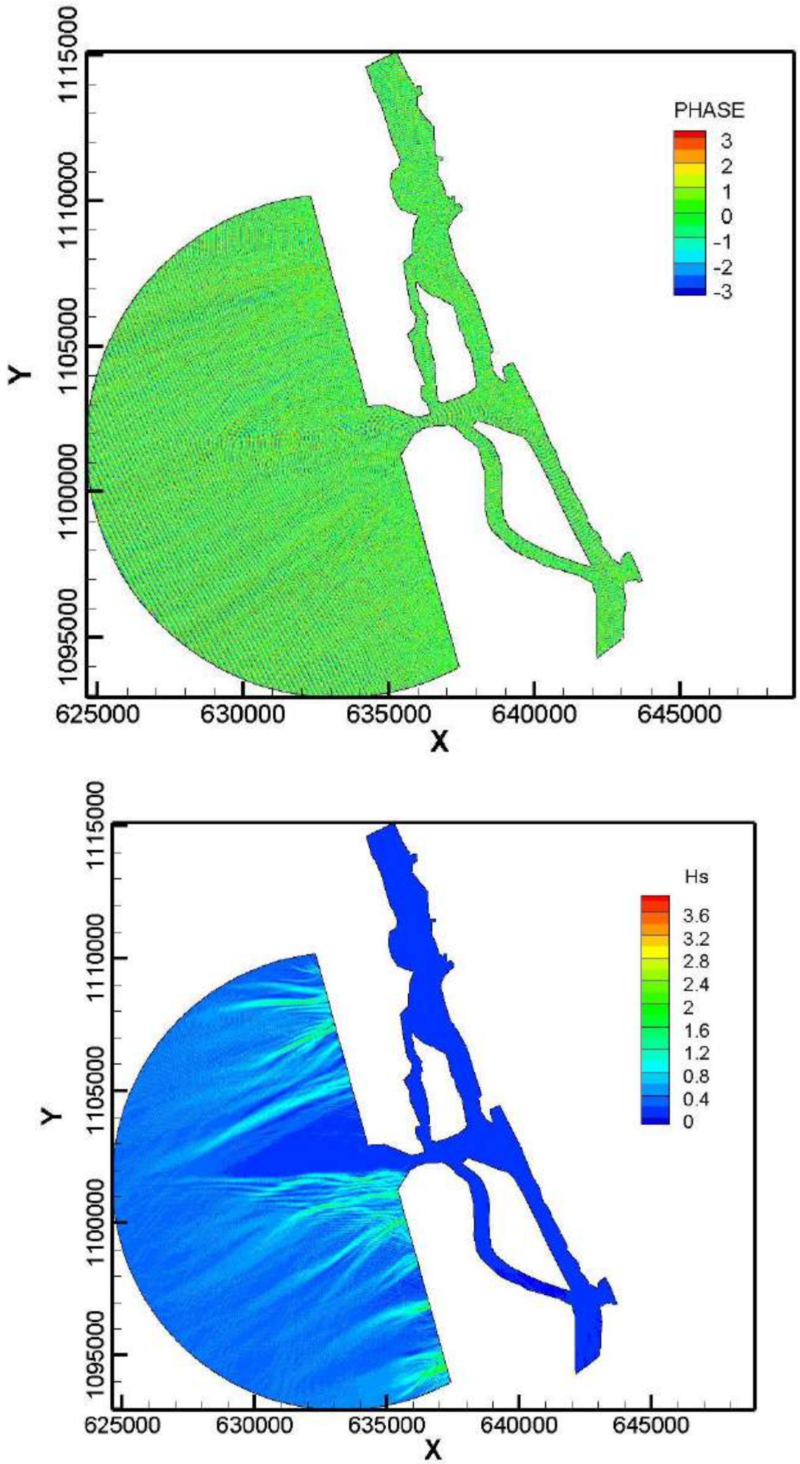


Fig.4.37 Phase distributions and Wave height distribution for the wave approach angle from 245^0

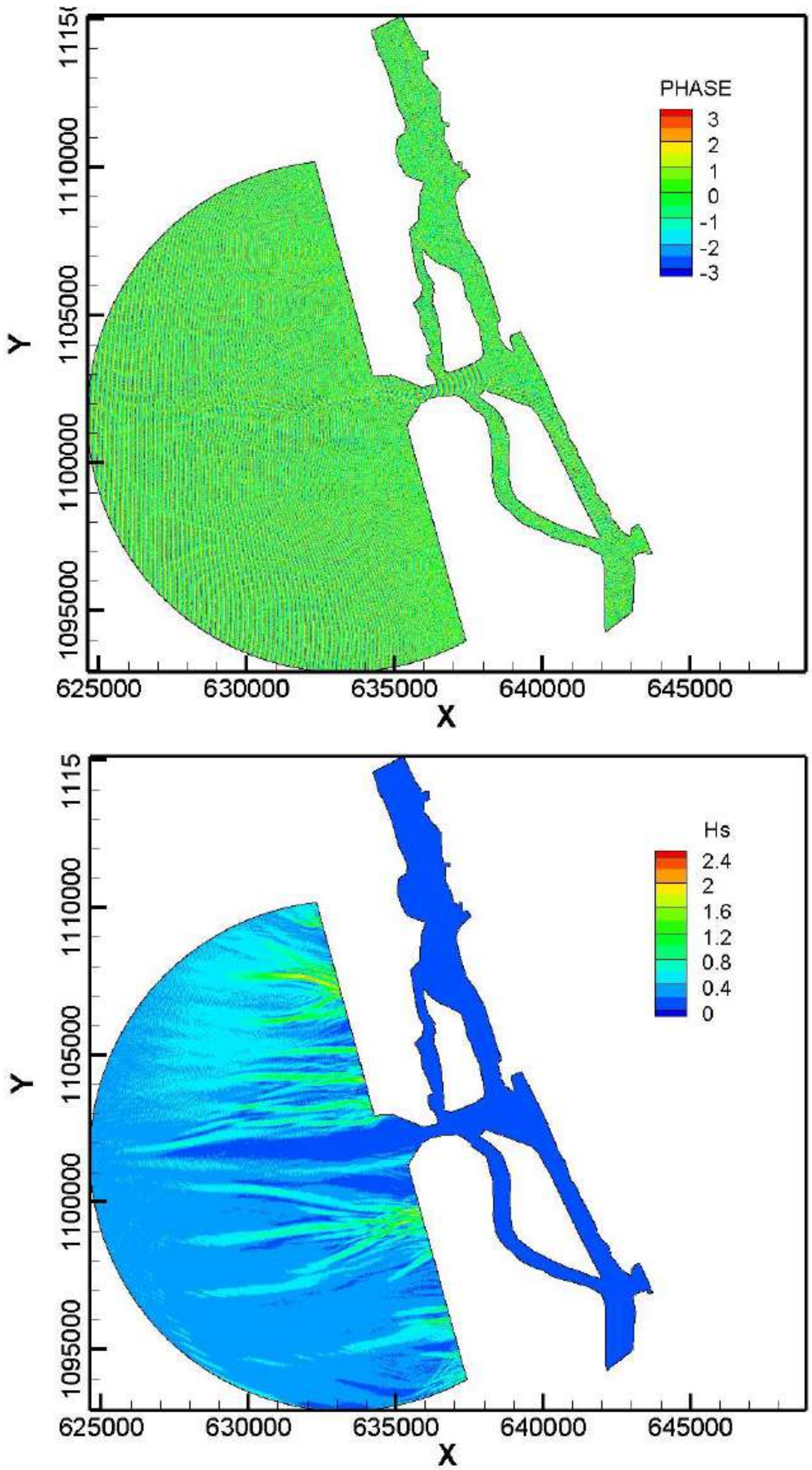
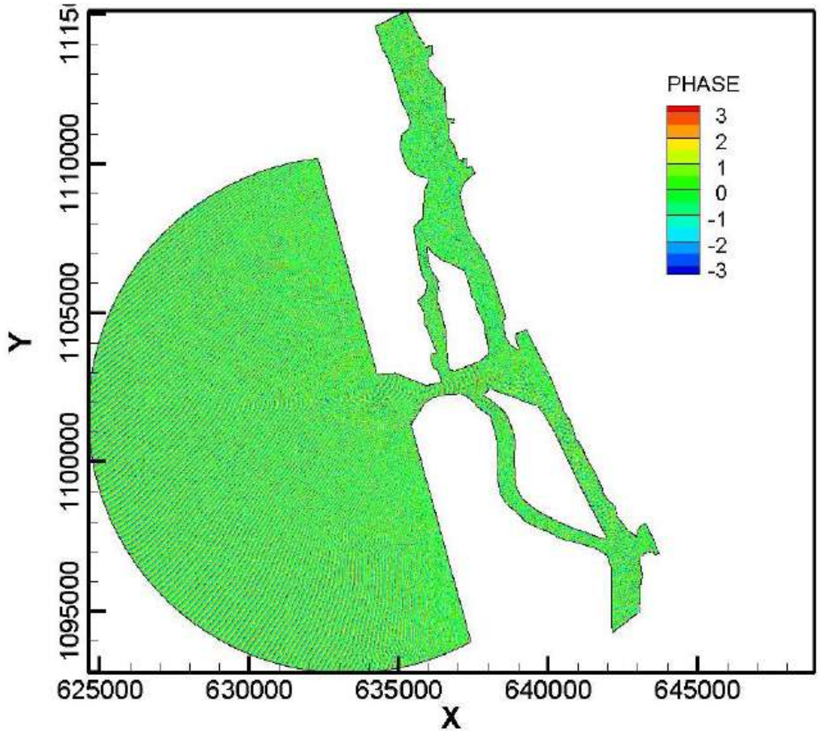


Fig.4.38 Phase distributions and Wave height distribution for the wave approach angle from 270^0



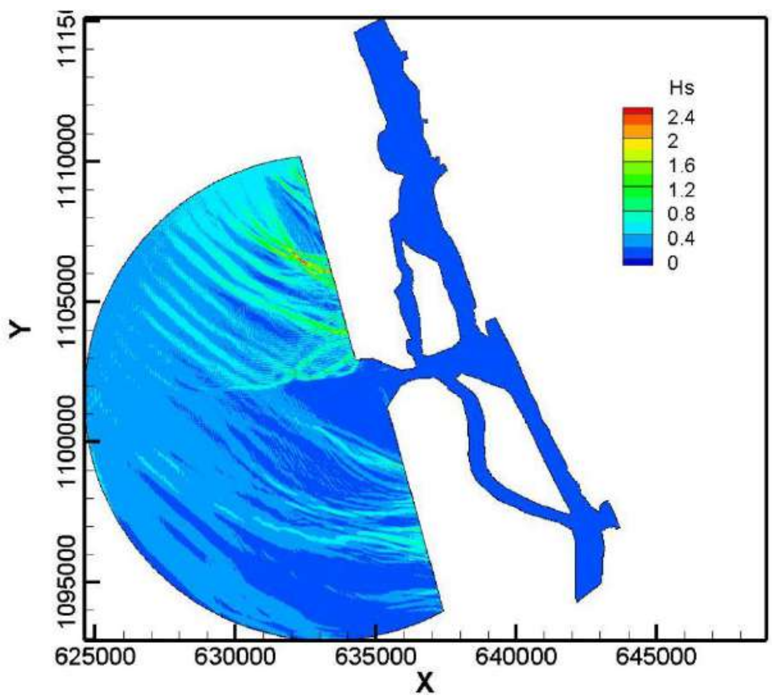


Fig.4.39 Phase distributions and Wave height distribution for the wave approach angle from 315^0

4.3.9 Summary

In order have a closer understanding of the tranquility, a few nodal points near the channel are selected, where, the wave height is monitored during the course of the simulations and averaged to find the wave amplitude at the location. The location of the output points is shown in **Fig 4.42 .**The occurrence of waves in the location of output points for case1 and case2 is presented in **Table 4.1 and Table 4.2.**

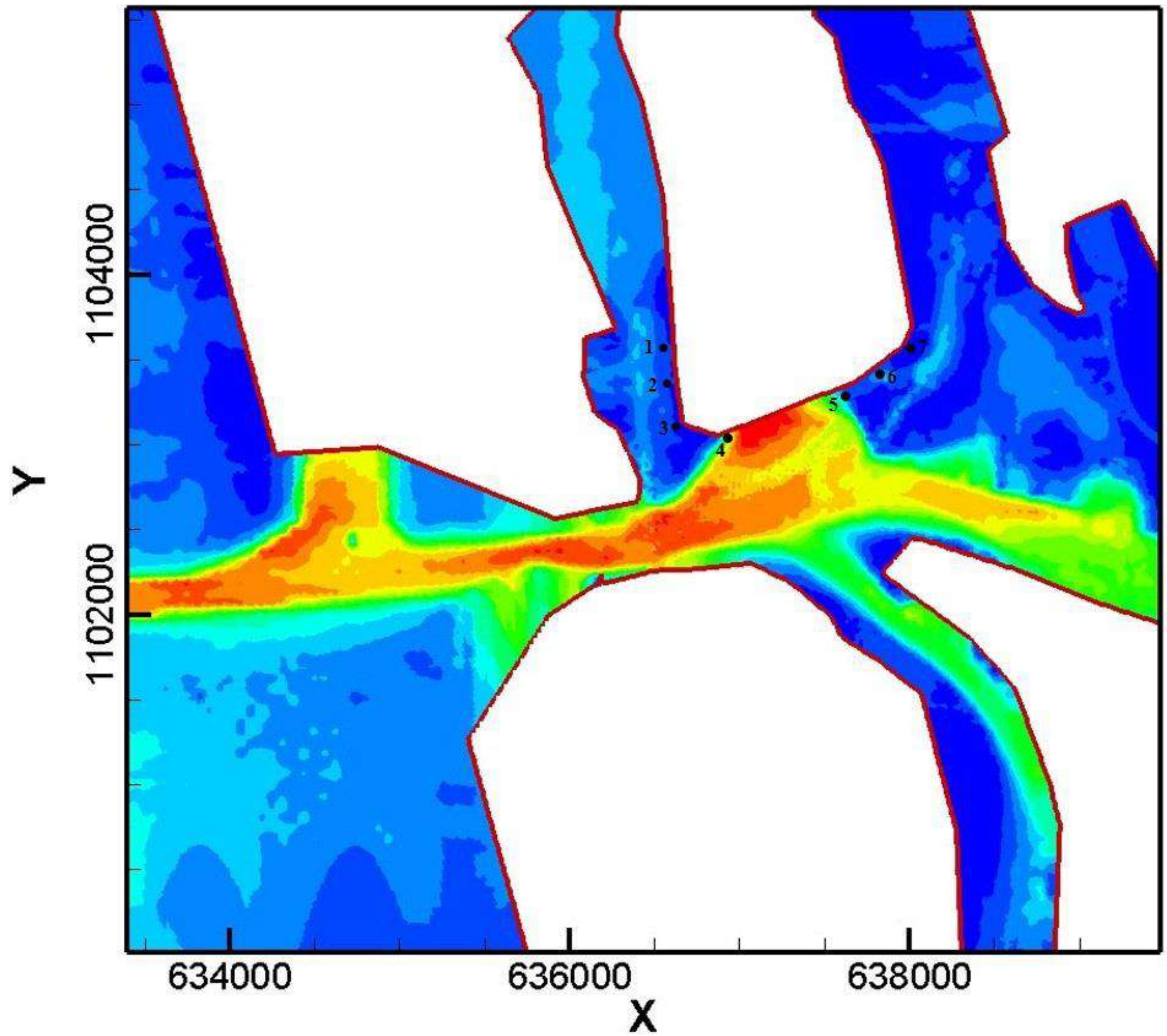


Fig.4.40 Points of measurement of the wave height

Table 4.1 Signification wave height at various locations (case 1)

Location	Hs (m)
1	0.272
2	0.211
3	0.286
4	0.483
5	0.461
6	0.302
7	0.247

Table 4.2 Signification wave height at various locations (case 2)

Location	Hs (m)
1	0.312
2	0.246
3	0.306
4	0.498
5	0.483
6	0.334
7	0.259

4.3.10 Results and Discussions

The significant wave height is taken in seven various location along the berth for the present condition and after deepening upto -20m shown in table 4.1 and table 4.2, shows that the there is no significant change in wave height even during the deepening of -20m.

4.3.11 Summary and Recommendations

Phase-I 16m Draught Vessel

From the hydrodynamic and wave propagation modelling results, it is understood that the ambient environmental forcing conditions such as wave and current, which dictate the shoreline stability will not significantly change in view of the proposed increase in the water depth in front of the ICTT jetty from existing to 20m. Hence, the stable shoreline around the ICTT jetty protected by the dense vegetation at present would continue to be stable for further deepening for accepting 16m draft vessels. In the vicinity of the jetty, on its east and west, the shoreline is already protected. However, the toe of the already existing shore protection units could not be analyzed unless the as built drawing could made be available. Hence, it is recommended not to disturb any vegetation around the shoreline to keep protecting the shoreline.

Phase-II 18 m Draught Vessel

From the hydrodynamic and wave propagation modelling results, it is understood that the ambient environmental forcing conditions such as wave and current, which dictate the shoreline stability will not significantly change in view of the proposed increase in the water depth in front of the ICTT jetty from existing to 20m. Hence, the stable shoreline around the ICTT jetty protected by the dense vegetation at present would continue to be stable for further deepening for accepting 16m draft vessels. In the vicinity of the jetty, on its east and west, the shoreline is already protected. However, the toe of the already existing shore protection units could not be analyzed unless the as built drawing could made be available. Hence, it is recommended not to disturb any vegetation around the shoreline to keep protecting the shoreline.

CHAPTER 5

PREPARATION OF BLOCK COST ESTIMATE FOR ADDITIONAL BERTH

5.0 Introduction

As per the present scope of the study the Dredging quantity has to be worked out under two Phases viz Phase-I to handle 16m Draft Vessel of dimension 400(LOA)X 59(Beam)X16m (Draught) and Phase-II 18m Draft Vessel of dimension 400(LOA)X62(Beam)X 18m (Draught), requirement of width of the Channel to handle the above vessels has been assessed based on PIANC guidelines and ascertained the present width of the channel is sufficient to handle 16m draught vessel & 18m draught vessel.

However, when additional dredging is carried out to handle 16m draught vessel as well as 18m draught vessel, apart from the quantity of dredging arising out of deepening the channel to the corresponding depth, their will be some extra quantity for maintaining the side slopes.

Subsequent to the discussion held with CoPT , the mail confirmation from CE vide mail dated 31.03.2020, the response from NTCPWC vide mail dated 01.04.2020 and the specific requirement from IGTPL vide their mail dated 13.05.2020, the quantity as well as the Cost for the Capital Dredging under two Phases viz Phase-I to handle 16m Draught vessel and Phase-II to Handle 18m Draught vessel is furnished hereunder.

5.1 Capitak Dredging Cost for handling 16m Draught vessel Phase-I

1. Capital Dredging Cost
2. Berth Construction Cost

5.1.1 Basis for arriving Dredging Cost

The dredging rate has been worked based on **CIRIA** manual and adopted in the estimate, The extract of Methodology adopted for calculation of Dredging rate from the CIRIA manual is detailed in Chapter 4 of Part II - Dredging, Marine & Bank Protection of this report.

5.1.2 Basis for arriving Berth Construction Cost

Cost of Construction Additional Berth = 266569/- **Say Rs. 2,70,000/-*/sqm**

Note: *Based on the rates adopted in a similar work proposed in the vicinity with an addition of 10% towards for provision of Crane Rails, end stoppers, anchor pit, etc.

Table 5.1 Dredging and Berth construction Cost for handling 16m draft vessels

S.no	**Description**	**Qty**	**Unit**	**Rate (₹)**	**Amount (₹) (Crores)**
1.	Capital Dredging	27.44	Million m^3	114	312.81
	To Dredge Berth Pocket upto (-)17.28 m - 0.24				
	To Dredge Approach upto (-)17.76 m - 0.76				
	Slope_1.6 -_				
	To Dredge Channel upto (-)18.4m between 0 chainage and 20m contour - 18.31				
	Slope_1:6 -5.64				
	To Dredge TC upto (-)17.76m - 2.23				
	Slope_1:6 - 0.26				
	Add extra for Mob and de-mob (@10 % of the Capital Dredging Cost)	LS			31.28
2	Cost of Construction Additional Berth	21,700	M^2	2,70,000	585.90
	Sub – Total				930
	Contingencies & PMC Charges @ 5%				46.5
	GST @ 18 %				167.40
	Total				1,143.90

5.2 Capital Dredging Cost for handling 18m Draught vessel Phase-II

1. Capital Dredging Cost

5.1.1 Basis for arriving Dredging Cost

The dredging rate has been worked based on **CIRIA** manual and adopted in the estimate, The extract of Methodology adopted for calculation of Dredging rate from the CIRIA manual is detailed in Chapter 4 of Part II - Dredging, Marine & Bank Protection of this report.

Table 5.2 Additional Dredging Cost for handling 18m draft vessels

S.no	Description	Qty	Unit	Rate (₹)	Amount (₹) (Crores)
1.	Capital Dredging Quantity	12.26	Million m^3	114	139.76
	To Dredge Berth upto Pocket (-)19.44- 0.019				
	To Dredge Approach upto (-) 19.98 m- 0.18				
	Slope_1.6- __				
	To Dredge Channel upto (-)20.7m between 0 Chainage and 20m contour - 10.40				
	Slope_1:6- 0.48				
	To Dredge TC upto (-)19.98m- 1.18				
	Slope_1:6- 0.01				
2.	Mob and de-mob @10 % cost of item 1	LS			13.9
	Sub – Total				153.66
	Contingencies & PMC Charges @ 5%				7.68
	GST @ 18 %				27.65
	Total				189

Note: The quantity and cost estimated and furnished in Table 4.3 above is a incremental Quantity and cost required for handling 18m Draft vessel over and above the dredging quantity required for handling 16m draft vessel as detailed in 4.2 above.

5.2 Typical arrangement of dredging area connecting new Berth basin to channel

A typical graphical representation of the Appraoches and Channel connecting the new Berth Basin of the new Additiona Berth (V4) 350m X 62m on the Vypin side of the existing ICTT berth is shown in Figure 5.1 below

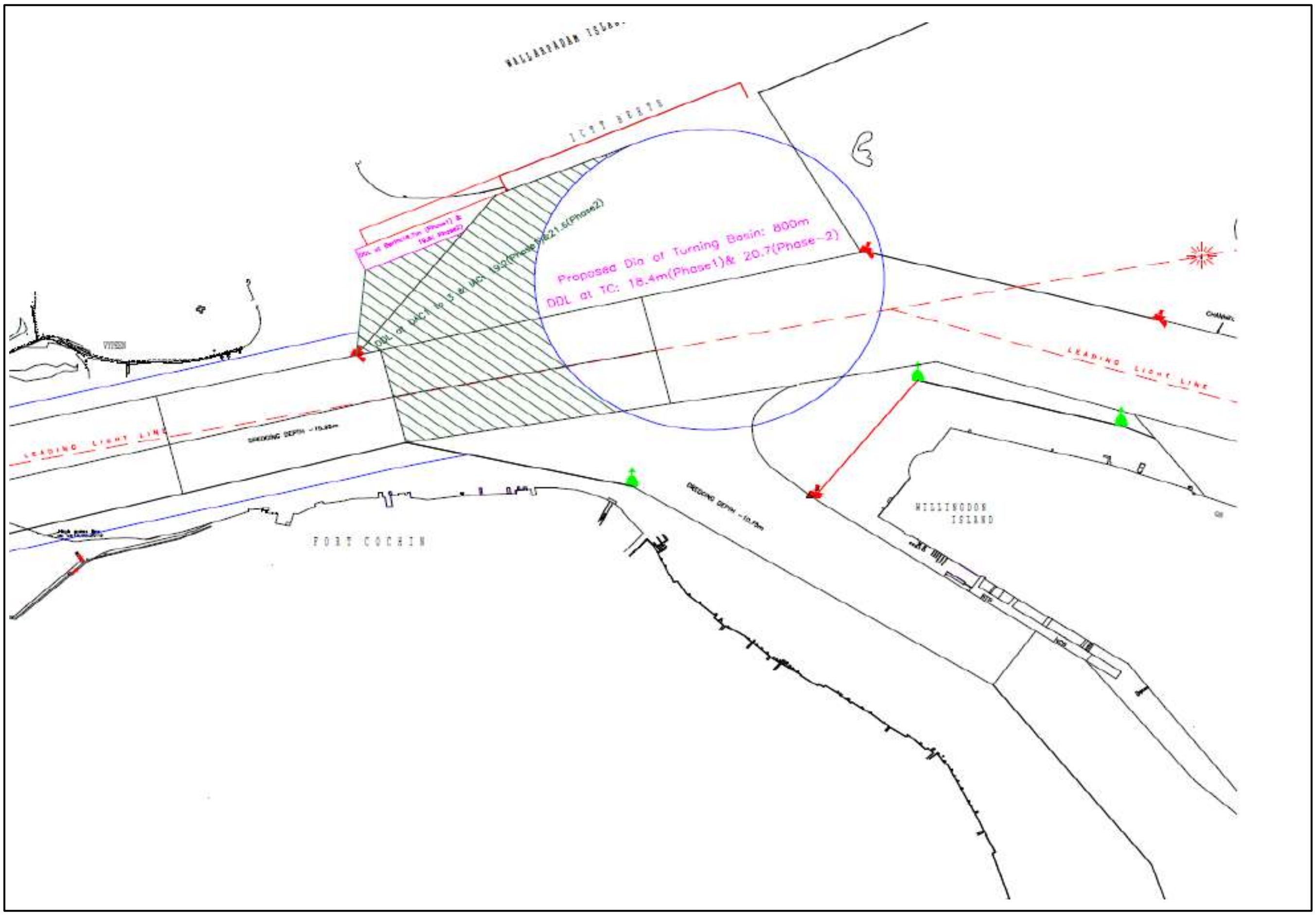


Figure 5.1 Typical arrangement of dredging area connecting new Berth basin to channel

(Prof.S.A.Sannasiraj) **(Prof.K.Murali)**