International Conference in Ocean Engineering COE '96
IIT Madras, India, 17 - 20 Dec. 1996

ENGINEERING PARAMETERS FOR EXPANSION OF MPT BERTHS, GOA

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SYNOPSIS : Comprehensive program for a harbour development and management requires general and detailed information on the coastal environment including engineering characteristics in addition to physical, chemical and biological parameters. Mormugao Port Trust has envisaged to expand the existing bulk cargo berths. Field measurements on currents, seabed sediment characteristics and suspended sediment load in the nearshore waters were carried out. Studies on wave refraction and diffraction were also carried out. The results of the field measurements and laboratory analysis are discussed in the paper to assess the feasibility of the expansion of existing bulk cargo berths.

INTRODUCTION

Mormugao Port Trust (MPT) is located at latitude 15°25'N and longitude 73°47'E. It is a semi-natural estaurine port situated on the southern bank of Zuari river mouth adjoining the Arabian Sea (Fig. 1). There exists three quay berths, one deep-drafted oil berth, one specialised mechanical ore berth and two multipurpose general cargo berths. MPT has planned to develop dry bulk cargo berths by extending the two existing berths. The proposed berths would be on piles with slope of 1:2 underneath and they would be in line with the existing oil and ore berths. The western face of reclamation near the basin formed by existing breakwater and mole would also be in slope of 1:2 and would be used in future for berthing small crafts. The comprehensive program for a harbour development and management requires general and detailed information on the coastal environment including the physical and engineering characteristics of the marine ecosystem.

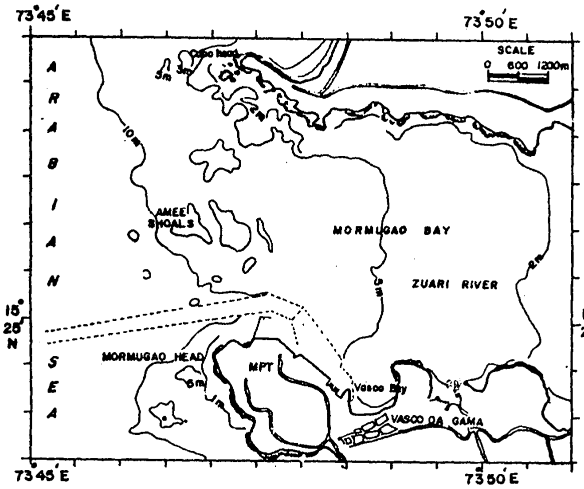

Fig. 1. Location map.

MORPHOLOGY OF THE REGION

The neighbouring coastline of the Port from Tiracol to Kali river consists of beaches, sea cliffs, promontories, estuaries, spits, dunes, weathering rocks, wave cut platforms etc. The prominent landform along the Goa coast consists of laterite capped mesas often extending 25 to 30 km inland. Average height of the cliffs vary from 40 to 100 m from the mean sea level. Wave cut terraces are seen at the base of the cliffs and headlands during the low tide time. Laterite beds are reported in the estuaries of Chapora, Mandovi and Zuari at 20, 27 and 34 m respectively below the level of chart datum. Seabed off Goa mostly consists of silty clay till 50 m water depth, sandy silt from 50 to 100 m water depth, clayey silt from 100 to 150 m water depth and sandy silt from 150 to 200 m water depth. Beach sediments mainly consist of quartz along with feldspars and other heavy minerals. They are represented by medium to fine sand, well to moderately sorted, and negative to very negatively skewed (Wagle, 1987). The Zuari river joins the sea, forming a large bay, and it encloses submerged Amee shoals over the entrance of the Mormugao Bay. The oceanographic conditions of this region is dominated by three seasons, i) south west monsoon from June to September, ii) north east monsoon from October to January and iii) fair weather period from February to May.

METHODS

Field measurements on currents, seabed sediment characteristics, and suspended sediment load in the nearshore waters were carried out in May 1995 at locations shown in Fig.2. Variation of current speed and direction was measured by deploying self recording current meter manufactured by Aanderaa Instruments, Norway, at 3 locations in May 1995. At one station currents were measured for 7 days, covering one spring to neap tidal cycle and at two stations, they were measured for 4 days each. Seabed sediments were collected at 9 locations and sieve analysis was carried out for silt and higher fractions and pipette analysis was carried out for finer fractions. The surface, mid depth and bottom sea water samples were collected at 9 locations using Niskin water samplers to estimate the suspended sediment load. Laboratory studies on wave refraction and diffraction were carried out. Available information on waves was compiled.

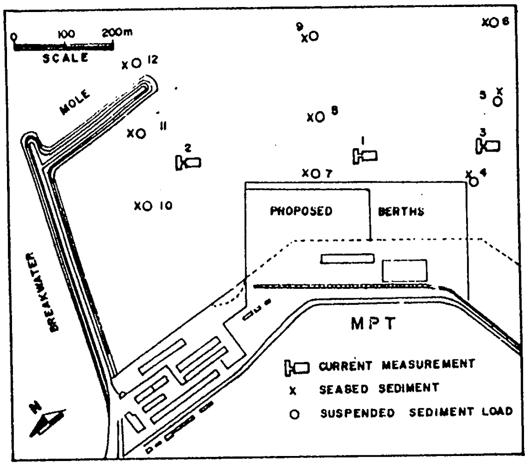

Fig. 2. Location of measurements.

RESULTS

Waves At Open Sea

Historical wave data: The deep water ship reported wave data have been compiled from the Indian Daily Weather Reports published by the India Meteorology Department for the period 1968 to 1986 for the Goa region (Anonymous, 1990). Significant wave heights vary predominantly between 0.5 m and 1.5 m from January to May, 0.5 m and 4.5 m from June to August, 0.5 m and 2.5 m in September, 0.5 m and 1.0 m in October, and 0.5 m and 1.5 m from November to December. The zero-crossing wave period varies between 5 s and 7 s from January to May, 5 s and 14 s from June to August, 5 s and 8 s in September, 5 s and 7 s during October and 5 s and 6 s during November and December. The distribution of deep water wave direction shows that the predominant wave direction persist between 270° and 360° from January to April, 180° and 320° in May, 220° and 290° from June to October, and the wave direction is variable from November to December.

Measured waves: The variation of monsoon wave characteristics measured at 8 m water depth off Cabo Headland using Datawell wave rider buoy from June to August, 1981 is shown in Fig. 3. It shows that the significant wave heights varied between 1.9 and 4.0 m and the maximum wave height varied between 2.8 and 6.5 m. The zero crossing wave period predominantly persisted between 8 and 10 s.

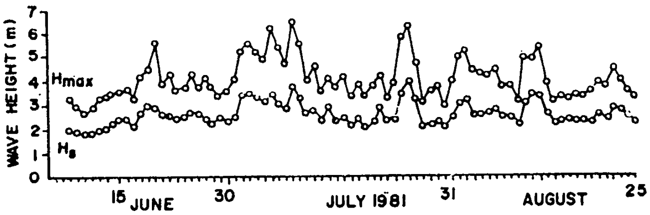

Fig. 3. Variation of monsoon wave characteristics off Cabo Headland.

Wave Refraction

Nearshore wave refraction study for the Goa region was studied using the computer model TARANGAM (Chandramohan, 1989). Nearshore bathymetry was adopted from the Indian Naval Hydrographic Charts. Based on the wave roses, it is seen that the representative deep wave directions off Goa are: 238° for southwest monsoon, 284° for northeast monsoon and 220° for fair weather period. Considering also the bathymetric variation, the refraction analysis has been done for 250° to represent southwest monsoon and fair weather period, and 284° to represent the northeast monsoon period. The 8 s wave period was considered for analysis.

The refraction of wave orthogonals for above parameters are shown in Figs. 4 and 5. The waves during March to September (southwest monsoon and fair weather period) undergo relatively more refraction before approaching the harbour breakwater. It shows that the waves of 250° at deep water, refract to 300° close to mole connected to breakwater. Further, due to wave refraction and wave shoaling, 1 m wave in deep water transforms to 1.07 m close to breakwater. Waves having 284° at deep water (during October to February), refract to 0° close to mole, and due to wave refraction and wave shoaling, 1 m wave in deep water transforms to 0.95 m close to breakwater. Based on the refraction studies, it

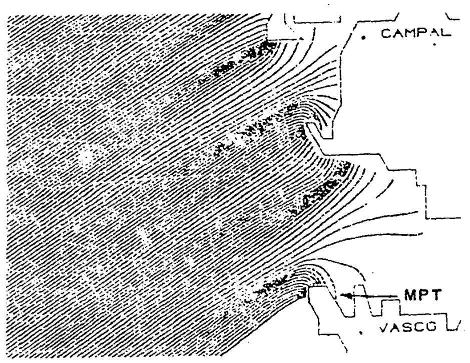

Fig. 4. Refraction diagram for wave direction-250°;
wave period-8 s.

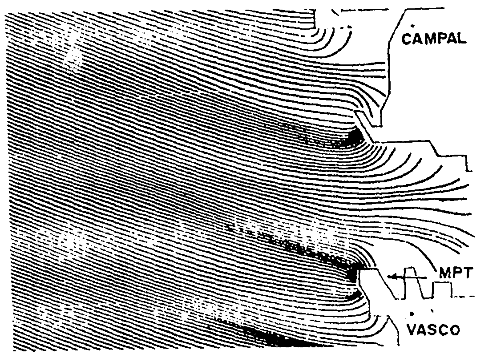

Fig. 5. Refraction diagram for wave direction-284°;
wave period-8 s.

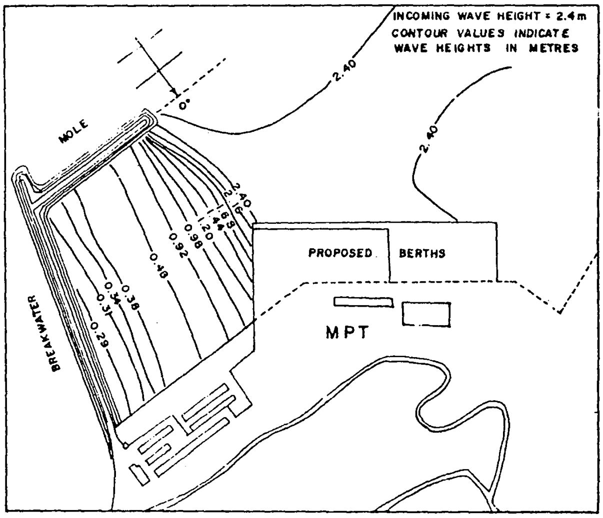

Fig. 6. Diffracted wave heights in front of proposed berths.

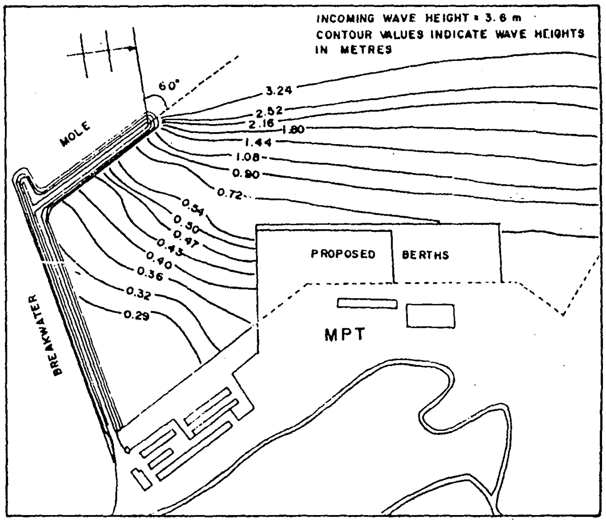

Fig. 7. Diffracted wave heights in front of proposed berths.

is observed that, the waves will have the crest angle with respect to alignment of mole as 60° during March to September and 0° during October to March.

Wave Diffraction

The diffraction studies were carried out for the incoming wave directions of 0° and 60°. The distribution of the ratio of diffracted wave height and incident wave height in front of the berths is shown in Figs. 6 and 7. The design waves near the mole were considered as 3.6 m for westerly waves (March to September) and 2.4 m for northwesterly waves (October to February). Accordingly for westerly waves, the wave height in front of the proposed berths would vary from 0.9 m to 3.24 m.

For northwesterly waves, the wave height in front of the proposed berths does not undergo much diffraction and it mostly remains as 2.4 m only.

Tides

The tides in this region are semi-diurnal with average spring tidal range of about 2 m and neap tidal range of 0.25 m.

Currents

The typical variation of current speed and direction measured at surface at st. 1 is shown in Fig. 8.

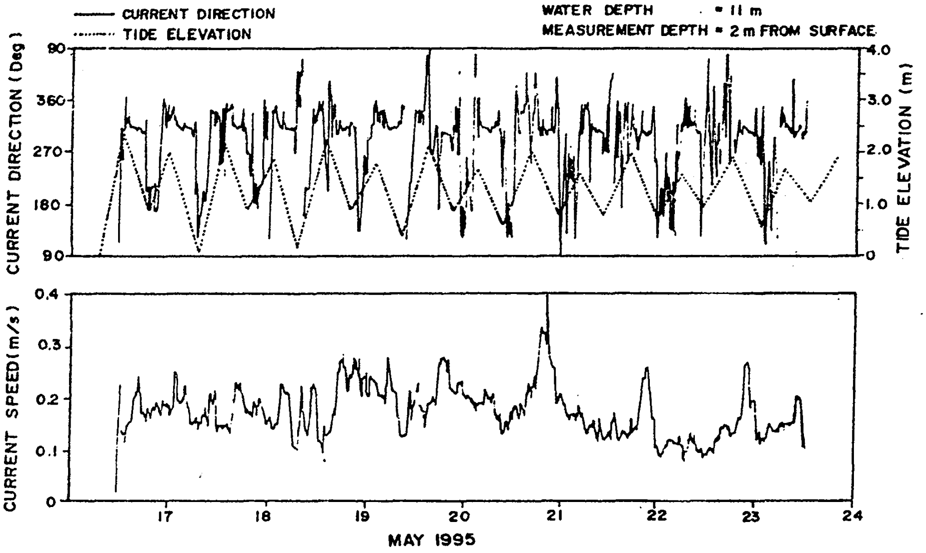

Fig. 8. Variation of current speed and direction at station 1.

Currents at st. 1 predominantly persisted around 0.1 - 0.2 m/s for 90% of the time at all three levels. For about 65% of the time, current direction was between 270° and 330° (with respect to north). At st. 2, at all three depths, the currents were below 0.2 m/s for 98% of the time. Predominant current direction was between 300° and 330°. In general, current speed at st. 2 was low compared to the current at st. 1, due to the presence of breakwater and mole. At st. 3, the current speed persisted around 0.1 - 0.2 m/s for 80% of the time. Compared to surface and mid depth currents, relatively stronger currents of the order of 0.2 - 0.3 m/s were observed at the bottom. The predominant current direction was between 300° and 330°.

Table 1. Sea bed sediment characteristics

St.	Sand %	Silt %	Clay %	Specific gravity	Remarks
4	2.50	81.77	15.73	2.45	clayey silt
5	1.95	79.03	19.02	2.28	clayey silt
6	1.85	82.72	15.43	2.49	clayey silt
7	3.12	83.53	13.35	2.54	clayey silt
8	3.60	71.18	25.22	2.27	clayey silt
9	2.53	70.89	26.58	2.53	clayey silt
10	2.50	76.22	21.28	2.44	clayey silt
11	3.45	58.34	38.21	2.49	clayey silt
12	46.01	39.78	14.21	2.54	silty sand

Seabed Sediments

The classification of seabed sediments at different locations is shown in Table 1. Clayey silt was found at all places except at st. 12, where it was found as silty sand. The proportion of silt was high showing about 80 per cent at sts. 4 to 7, about 70 per cent at sts. 8 and 9, about 76 per cent at st. 10 and about 58 per cent at st. 11. The sand fraction was more for about 46 per cent at st. 12. It shows that the seabed close to mole consists predominantly of sand and thereafter the silt fraction increases with the distance inside the harbour basin.

Suspended Sediments

Suspended sediment concentrations measured at different stations are presented in Table 2. The concentration of the suspended load increases from surface to bottom. In general the concentration varied 30 - 60 mg/l at sts. 4, 5 and 9 to 12. The concentration was relatively high about 100 - 400 mg/l at sts. 6 and 7. The study shows that the water is relatively turbid with significant suspended sediment load.

DISCUSSION AND CONCLUSION

Based on the wave refraction studies, it is observed that the waves will have the crest angle with respect to alignment of mole as 60° during March to September and 0° during October to March.

Table 2. Suspended sediment concentration in the nearshore water

St.	Water depth (m)	Concentration (mg/l) top	middle	bottom
4	13	22.4	42.9	61.5
5	14	28.7	32.3	57.0
6	8	35.5	40.0	308.4
7	10	19.8	21.6	471.4
8	11	34.4	75.9	109.2
9	12	34.1	50.1	54.9
10	8	23.0	13.0	30.3
11	8	21.4	30.1	78.0
12	9	24.4	16.7	61.4

Diffraction study, shows that for the westerly waves the wave height in front of the proposed berths would vary from 0.9 m to 3.24 m and for the northwesterly waves, it remains as 2.4 m.

The current pattern at the measured locations off the Port showed a parabolic trend with the flow parallel to the existing berths with direction between 270° and 330° without appreciable reversal of current with tidal variation. Though the estuarine region, far away from the mole, is influenced by the tides, the region close to proposed berths is well protected by the breakwater and mole, and hence only ebb flow pattern exists in this region. The currents are not in phase with the tides showing predominantly unidirectional between 270° and 330°. Seabed sediments are mostly of clayey silt with the silt portion of about 60% to 80%. The nearshore waters are found to be turbid. This may be attributed to the disturbance caused by the maintenance dredging carried out inside the basin.

The study shows that, at the proposed locations for the expansion of berths, the waves does not undergo much diffraction. And the region is subjected to very low currents which are not subjected to change in direction. Therefore, the expansion of the existing berths may not considerably alter the oceanographic processes.

ACKNOWLEDGMENTS

Authors thank Director, National Institute of Oceanography, Goa for encouragement. They also thank Sri. Ganesh N. Naik for help in field data collection.

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