



WAVE CHARACTERISTICS AROUND SITTWE PORT, MYANMAR

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ABSTRACT

This paper presents wave characteristics estimated around Sittwe port, which is located on the Paton Peninsula, Myanmar. Wind data recorded from January 1998 to December 2001 at Sittwe port was used for estimation of wave parameters. Offshore wave characteristics were estimated using the DOLPHIN Model. Thereafter, nearshore wave characteristics were estimated from the offshore waves using refraction-diffraction model. As there is a considerable fetch of around 5 km, for winds blowing from 20° to 180° , the waves will be locally generated apart from the refracted / diffracted waves. The locally generated waves were estimated using SPM84 method (USACE, 1984). Design wave height based on two-parameter Weibull distribution at 10 m water depth was estimated as 4.5 m for 1 in 100 year return period. Two cyclones passed near study region were collected for estimation of wind and waves. Estimation of cyclonic wave heights was carried out using a parametric hurricane wave prediction model.

1. INTRODUCTION

The Sittwe Port is located on the Paton Peninsula on the west side of the Myanmar at the confluence of river Kaladan into Bay of Bengal (Fig. 1). The wave characteristics are required for the planning of the jetty. Estimated design wave parameters have considerable importance in planning and operation of marine activities and design of coastal and offshore structures. The wave characteristics were estimated in the offshore location at 15 m water depth off Sittwe Port and that around the Sittwe Port covering all seasons of the year and that during the cyclone/storm.

2. METHODS

2.1 Offshore Waves

Wind data recorded from January 1998 to December 2001 at Sittwe Port area was used for estimation of the wave parameters. Wave characteristics were estimated using DOLPHIN model (Mandal, 1985). Numerical wave prediction model DOLPHIN is a deepwater hybrid point model, a combination of the parametric wind-sea and spectrally treated swells. This model is based on the study of directionally decoupled energy distribution of wind-generated waves. Inputs to the model were wind speed and direction, bathymetry and coastal boundary. Model outputs were the significant wave height (H_s) and the average wave period (T_z).

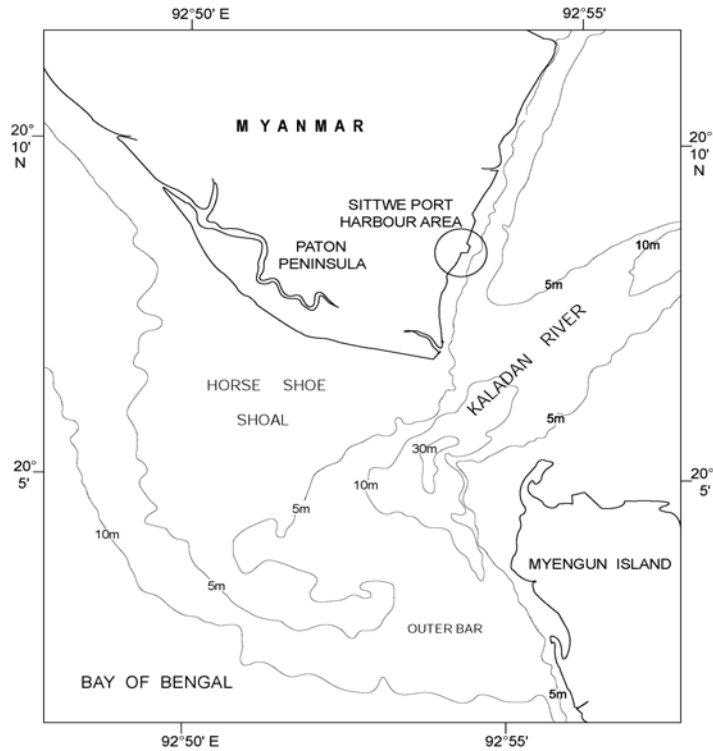


Fig. 1 Map showing study area

2.2 Near Shore Waves

Near shore wave characteristics were estimated from offshore waves using the refraction-diffraction program, REFDIR (Kirby and Dalrymple, 1994) and the TARANGAM wave refraction program (Chandramohan, 1988). For a given deep water wave characteristics (H_0 , T , α_0) and nearshore bathymetry, the model computes wave characteristics at any intermediate depth using small amplitude wave theory. It incorporates shoaling, refraction, bottom friction, bottom percolation and viscous dissipation. Wave transformation coefficient was estimated as the product of refraction, shoaling, bottom friction, bottom percolation and viscous dissipation coefficients.

Since, there is a considerable fetch of around 8 km, for winds blowing from 20° to 180° for generation of waves, waves will be locally generated apart from the refracted/diffracted waves. These locally generated waves may be the predominant waves around the Sittwe Port, than the refracted/diffracted waves in some cases. Locally generated waves were estimated using the SPM84 method (USACE, 1984).

2.3 Waves during Cyclone/Storm

The data on the 29-30th October 1962 cyclone and that during the 8-12th December 1965 cyclone, which passed near the study region, were collected for estimation of the wind and waves.

Winds

The storm variables viz. (i) central pressure, (ii) radius of maximum wind, (iii) storm speed, (iv) direction of storm movement, (v) latitude and (vi) longitude for the cyclones were extracted from the isobaric charts available with the archives of the Indian Meteorological

Department (IMD) at 6 hours time intervals. The method based on standard Hydromet pressure profile, presented by Varkey (1985) and Varkey et al. (1996), was used for the hindcast of storm wind fields.

Waves

Estimation of wave heights was carried out for the cyclones/storms using the Young's model which considers the moving wind field (Young, 1988). The Young's model was developed based on the concept of the equivalent fetch and the standard JONSWAP fetch-limited growth relationships (Hasselmann et al., 1973). Input parameters to the model were radius of maximum wind (R), maximum wind speed (V_{\max}) and speed of forward motion (V_{fm}). Using the JONSWAP fetch-limited growth relationship, the model estimates maximum significant wave height (H_s) and spectral peak period (T_p) of the maximum waves in the storm as given below:

$$\frac{gH_s}{V_{\max}^2} = 0.0016 \left(\frac{gF}{V_{\max}^2} \right)^{0.5} \quad (1)$$

$$\frac{gT_p}{2\pi V_{\max}} = 0.045 \left(\frac{gF}{V_{\max}^2} \right)^{0.33} \quad (2)$$

where, g is the acceleration of gravity and F is the fetch length, which was estimated from the speed of forward motion and radius to maximum wind.

3. RESULTS AND DISCUSSION

3.1 Offshore Waves

Wind speed and the direction used for the estimation of the waves are shown in Fig. 2. Wind speed varied from 1.8 m/s to 20 m/s with an average value of 5.5 m/s. 95% of the time the wind speed varied from 2 to 10 m/s and for 68% of the time the wind was from 180° to 300° .

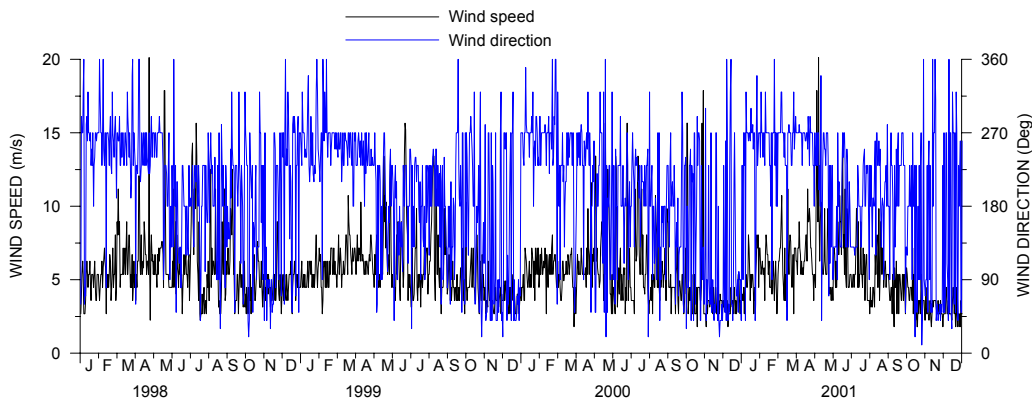


Fig. 2 Measured wind speed and wind direction at Sittwe Port

The estimated significant wave height and average wave period for the offshore location at 15 m water depth is shown in Fig. 3. Significant wave height varied from 0.1 to 3.7 m with an average value of 0.6 m. The average wave period was 3 s.

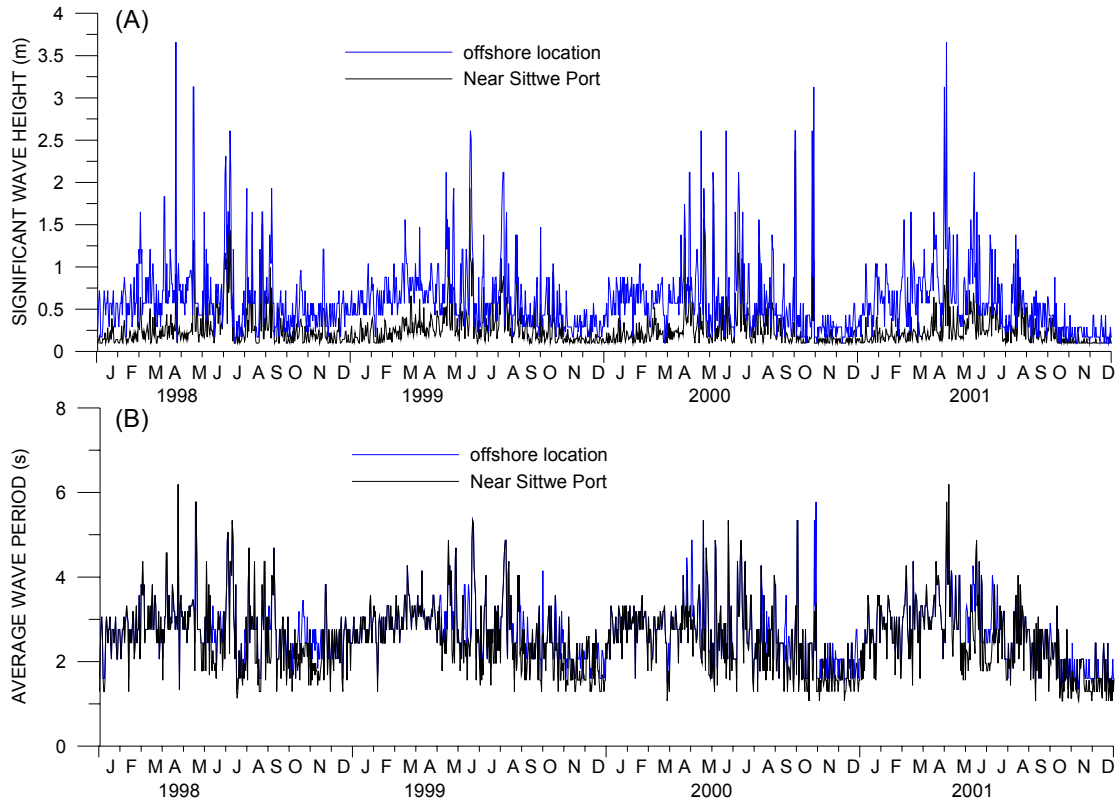


Fig. 3 Estimated (A) significant wave height and (B) average wave period at offshore location and near Sittwe Port

3.2 Near Shore Waves

The grid domain with depth profiles used in the wave transformation model for estimating the near shore wave is shown in Fig. 4. Here the depth profiles in channel and port areas were considered based on the existing data.

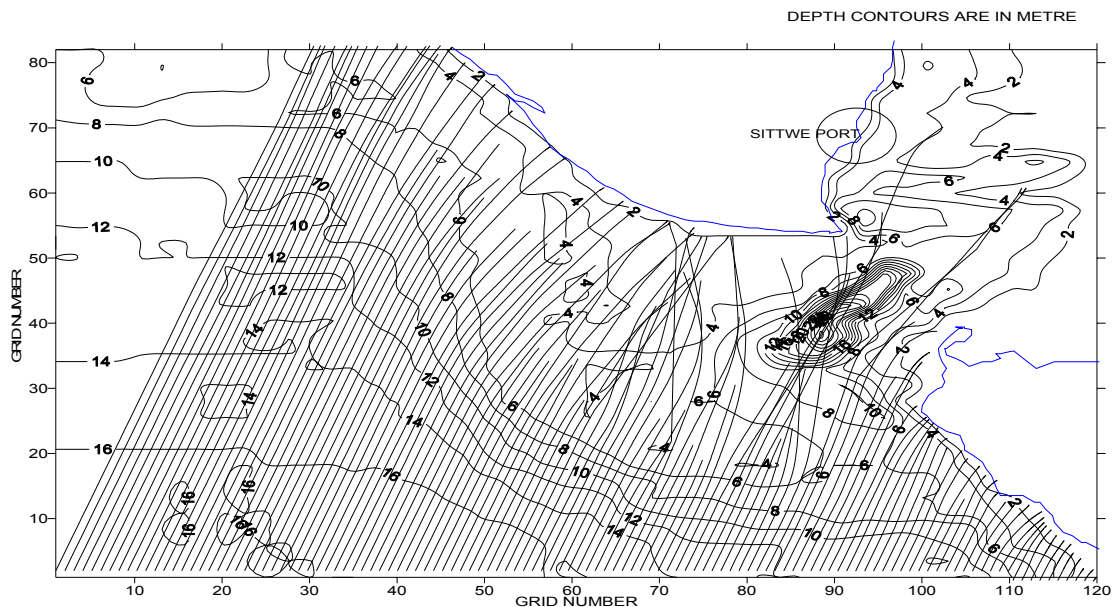


Fig. 4 Typical wave refraction diagram with grid domain and depth contour

Estimated significant wave height and average wave period near the Sittwe Port is shown in Fig.3. Significant wave height varied from 0.1 to 2.4 m with an average value of 0.3 m. 88% of the time the significant wave height was less than 0.5 m. Only 2% of the time H_s exceeded 1 m. The average wave period varied from 1 to 6 s with an average value of 3 s. Coastal inclination at the study region is 20° with respect to north. The wave direction will vary from 90° to 130° for the study region due to refraction.

3.3 Design Wave

Based on the estimated wave data for 4-years, the design waves for 5, 10, 25, 50 and 100 year return period were estimated for 10 m water depth using the two-parameter Weibull distribution. The design significant wave height are 2.5, 2.9, 3.5, 4 and 4.5 m for 5, 10, 25, 50 and 100 year return periods.

3.4 Waves during Cyclone/Storm

a) 29 - 30 October 1962: Storm variables and estimated maximum wind speed are presented in Table 1. Maximum wind speed during the period was 21.6 m/s on 30.10.1962 at 2330 hrs, when the cyclone was over the land. The times referred are the Indian Standard Time (IST). Maximum wind speed when the cyclone was over the sea was 20.9 m/s on 30.10.1962 at 1130 hrs and the estimated wave height and wave period were 3.63 m and 8.1 s respectively at 20.6° N, 89° E.

Table 1 Storm, wind and wave parameters of October 1962 cyclone

Duration (hrs)	Day	Month	Year	Time (hrs)	Latitude (ON)	Longitude (OE)	Central pressure (mb)	Radius of max. wind (m)	Speed of forward motion (m/s)	Direction of movement (deg)	Wind speed (m/s)	Significant wave height (m)	Wave period (s)	Fetch (m)
0	29	10	1962	530	14.8	84.5	995	1E+05	6.33	13.6	19	4.5	9.58	219377
6	29	10	1962	1130	16	84.2	995	90000	6.33	13.6	19	4.4	9.52	214530
12	29	10	1962	1730	17.5	84.5	995	95000	7.83	349	18	3.8	8.7	166359
18	29	10	1962	2330	18	85.7	995	65000	6.42	294	19	4.3	9.33	198696
24	29	10	1962	530	19.4	86.7	995	55000	8.68	326	19	3.4	7.91	119439
30	30	10	1962	1130	20.6	89	990	95000	12.73	299	21	3.6	8.07	116206
36	30	10	1962	1730	22.2	91.3	990	95000	13.75	307	21	4.9	9.83	213267
42	30	10	1962	2330	23	93	990	60000	9.07	297	22	- *	- *	- *

b) 08 - 14 December 1965: The storm variables and the estimated maximum wind speed are presented in Table 2. Maximum wind speed during the period was 27.1 m/s on 14.12.1965 at 0530 hrs and estimated wave height and wave period were 5.91 m and 10.2 s respectively when the cyclone was at 17.0° N, 88.5° E.

The above estimated wave characteristics during the cyclone is for the offshore region on the open coast at the centre of the cyclone. Wave characteristics will be modified due to the refraction/diffraction when it reaches the Sittwe port area. If this cyclone/storm approaches the port area (10 m water depth) from 180° to 210° , then the maximum significant wave height around Sittwe port will be 4.4 m. Since only two data sets were available on

cyclone/storm for the study area, a realistic design estimate of the wave characteristics could not be estimated for the cyclone/storm condition.

Table 2 Storm, wind and wave parameters of December 1965 cyclone

Duration (hrs)	Day	Month	Year	Time (hrs)	Latitude (ON)	Longitude (OE)	Central pressure (mb)	Radius of max. wind (m)	Speed of forward motion (m/s)	Direction of movement (deg)	Wind speed (m/s)	Significant wave height (m)	Wave period (s)	Fetch (m)
0	8	12	1965	1730	12	89	995	80000	3.59	316	19	4.8	9.99	240859
6	8	12	1965	2330	12.5	89.5	992	83000	3.59	316	21	5.4	10.5	255195
12	9	12	1965	530	13.5	89	992	91000	5.71	26.1	21	5.2	10.3	245987
18	9	12	1965	1130	13.5	89	993	87000	0	0	20	4.3	9.13	174737
24	9	12	1965	1730	14	89	992	90000	2.56	0	21	5.3	10.3	248449
30	9	12	1965	2330	14	89	994	90000	0	0	19	4.1	8.98	172447
36	10	12	1965	530	14.5	89	995	89000	2.56	0	19	4.7	9.84	235457
42	10	12	1965	1130	14.3	89.5	995	90000	2.7	248	19	4.7	9.88	237882

4. CONCLUSION

Significant wave height varied from 0.1 to 2.4 m with an average value of 0.3 m. 88% of the time the significant wave height was less than 0.5 m. Only 2% of the time H_s exceeded 1 m. The average wave period varied from 1 to 6 s with an average value of 3 s.

The estimated design significant wave heights for 10 m water depth based on the two-parameter Weibull distribution are 2.5, 2.9, 3.5, 4 and 4.5 m for 5, 10, 25, 50 and 100 year return periods.

5. ACKNOWLEDGEMENTS

The authors acknowledge the Director of the institute for permission to publish the paper. We thank RITES, New Delhi for funding the work and acknowledge the help given by Shri A. Rajagopalan, General Manager, P & WR, RITES and Shri K.G.S.Sarma, Deputy General Manager, P & WR, RITES.

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