CHAPTER 12

WAVE FORECASTING FOR THE WEST COAST OF INDIA

J. DATTATRI *

AND

P S. RENUKARADHYA **

ABSTRACT

The applicability of the general Wave Forecasting procedures like the SMB and the PNJ methods, to the Indian coasts is studied. The study consisted in analysing the Synoptic charts to obtain the necessary wind characteristics. The computed wind characteristics were used in the above Forecasting methods to yield significant wave heights These were compared with the wave characteristics as recorded by a sub-surface pressure type recorder after suitable modifications to account for the attenuation of wave pressure with depth.

The predicted wave heights compare well with the recorded wave heights and the SMB method predicts wave heights better for the case studied.

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1. INTRODUCTION. Adequate foreknowledge of waves is essential for any coastal Engineering work. One of the ways of obtaining this necessary information about the wave characteristics is by installing wave recorders at suitable places along the coastline to obtain continuous records of waves. These records are statistically analysed to yield the required design wave height data. There are hardly any such recorders installed on the Indian coasts to the authors' knowledge. As such in the absence of any

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* Department of Civil Engineering, Karnataka Regional Engineering College, Surathkal, India.

** Formerly Post-Graduate student, Marine Structures Section, Karnataka Regional Engineering College, Surathkal, India.

recorded wave data, in most cases the only alternative will be Wave Forecasting to get the required design wave height.

The two commonly used methods of Wave Forecasting are the Sverdrup-Munk-Bretschneider method (hereafter referred as the SMB method) and the Pierson-Neumann-James method (PNJ method). These methods are based almost entirely on field data and as suoh can be used with confidence in areas from where the field data is taken. These methods cannot be directly used for the Indian coasts without verifying their applicability.

The primary aim of the present paper is to study the general applicability of these Wave Forecasting methods to Indian Coasts. For this purpose the South-West Monsoon period of 1968 was considered for the analysis, since it is during this season the strong monsoon winds generate the heavier seas. This work was possible thanks to the Wave Recorder installed near the Mangalore Harbour Project area situated 10 KM to the south of the College.

2. ANALYSIS: The analysis consisted in Hindcasting the waves by the SMB and the PNJ methods for the Mangalore area on the West Coast of India from known meteorological conditions and comparing the Hindcast waves with the recorded waves.

The study consisted of three stages, (i) analysis of weather maps (synoptic charts) to get the required meteorological data, (ii) wave Hindcasting (iii) analysis of wave records and comparison of recorded waves with Hindcast waves.

2.1 Meteorological Data:- The Indian Daily weather maps published twice a day by the Indian Meteorological Department, Poona, were used to obtain the required meteorological data (wind speed, direction, and duration, Fetch length and width and Decay distance). These weather maps are prepared with very scanty data, particularly over the Arabian Sea and the Bay of Bengal, which render any data based on them very approximate. The present analysis is subject to that limitation.

2.1(a) Wind characteristics:- The wind velocity over the generating area was determined by computing the Geostropic Wind velocity(5)* from the isobar spacings and applying the corrections for isobar curvature and the air-sea temperature differences as given in T.R-4(6) to yield the surface wind speeds.

The wind direction was assumed to be parallel to isobars and the wind duration was fixed by a study of the changes in the successive synoptic charts.

Comparison with a few observed wind velocities from ships' reports showed that the computed wind velocities were not much differing from the observed velocities.

The use of the geostropic wind equation over the generating area for the Mangalore Coast can be questioned. G.F. Taylor (5) recommends that the geostropic wind equation should be used for latitudes above 20°. The generating areas for the Mangalore coast generally lies between 10° and 18° latitude N. (Latitude of Mangalore is 12° 52' N) The equation therefore is likely to give inaccurate results with tendencies for the computed wind velocities being on the higher side. In the absence of any other method for finding the wind velocity, the Geostropic wind equation inspite of its limitations was used.

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* Numerals in parenthesis refer to corresponding items in the list of references given at the end.

2.1(b) FETCH:- The generating areas were demarcated on the synoptic charts according to procedures laid down in T.R-4(6). For most cases in the monsoon periods the isobars are straight and practically run East-West and the generating areas can be marked with a fair degree of accuracy The fetch length, width, decay distances and angles required for the PNJ method were directly scaled from the synoptic charts.

2.2 WAVE HINDCASTING: As mentioned earlier the SMB and the PNJ methods were used for wave hindcasting. The procedure for the SMB method was as that given in T.R-4(6) while that for the PNJ method was that given in Pierson et al (3).

The wave heights, periods and the time of arrival at the required hindcasting point were determined according to the standard procedures.

2.3 WAVE CHARACTERSTICS - RECORDED: The observed wave heights were obtained from the analysis of the wave records, recorded by the wave recorder.

The Wave Recorder is of the frequency modulated pressure type. The Recorder is kept at a depth of 6.2 metres from the M.W.L. and the water depth at the place is 7.5 metres.

The wave heights as recorded need to be modified to account for the attenuation of wave pressure with depth. From theoretical Wave Hydrodynamics (7) the surface wave height H is related to H' obtained from a pressure recorder by the following equation.

$$H = H' \frac{\text{Cosh } 2\pi d/L}{\text{Cosh } 2\pi d/L\ (1-3/d)} \qquad \text{........(1)}$$

where z = distance below still water level to the reoorder

d = depth of water where the recorder is installed

L = wave length in water of depth d

In the above attenuation factor the wave length L, must be known. A close look at any wave record will show the wave heights and periods continuously changing. If the attenuation factor is to be applied for each individual wave heights based on its period, with no computer facilities available, the work is very tedius and time consuming. As an approximation it was decided to use the average period of the waves in the sample under consideration for computing the above attenuation faotor.

To investigate the probable error involved, some random samples of the wave records who selected, each of atleast 15 minutes duration. The significant wave height were calculated using attenuation factors based on the individual periods of each wave in the 15 minute record as well as the average period. The results of this investigations is shown in Table 1.

This random survey as summarised in Table - 1, shows that the percentage error involved if the average period is used to be less than 6% This is insignificant particularly in view of the findings that an additional factor together with the above attenuation factor may be required to get the correct surface wave heights from a sub-surface recorder. As such the attenuation factor is based on the average period only.

The attenuation factor as given by Equation - 1 has been recognised to be inaccurate to correlate the underwater wave pressure with the surface wave heights. Based on simultaneous surface and sub-surface observations many investigators have proposed an additional

TABLE - 1

Sample No.	Significant wave heights			Percentage error based on individual period attenuation factor
	Without attenuation factor Inches	With attenuation factor based on average period inches	With attenuation factor based on individual factor inches	
1	24.40	29.00	30.00	-3.3
2	28.40	34.00	36.00	-5.5
3	27 00	32.20	33.70	-4.45
4	43.60	53.00	53.20	-0.38
5	47.20	57.50	58.00	-0.86
6	44.76	55.60	59.00	-5.75
7	68.90	85.50	87.00	-1.73
8	64.00	78.50	81.20	-3.20
9	58.60	69.20	69.80	-0.86
10	50.89	63.50	63.10	+0.63
11	21.26	26.70	25.40	+5.1
12	18.60	22.70	23.80	-4.60
13	38.50	52.30	53.30	-1.87
14	26 60	34 80	37.00	-5.80
15	26.90	35.60	37.50	-5.00

factor to be used. As summarised by Masashi Homma etal (2) this factor designated n is normally taken as a constant for the analysis This modifies equation - 1 to equation - 1(a) as follows

$$H = n H' \frac{\cosh 2\pi d/L}{\cosh 2\pi d/L\ (1-z/d)} \qquad \ldots\ \ldots 1(a)$$

Seiwell (2) recommends a value of 1.35 for n, in Japan (2) a value of 1.3 to 1.5 is used, while laboratories National D'Hydraulique, France (2) recommends a value of 1.25, on the other hand Draper and Glukhovskiy (2) have presented formulas giving n as a function of relative water depth d/L. Cicslak and Kowalski (1) recommend a value of 1.25

In the absence of any definite criteria to fix this value of n, n = 1.25 is used in the analysis

3. REDUCTION OF DEEP WATER WAVES TO SHALLOW WATERS The waves as predicted by the Forecasting methods are deep water waves. Since the Wave Recorder is in shallow waters, the predicted deep water waves have to be reduced to shallow water waves to allow for refraction and shoaling. With the crests travelling parallel to coasts, the bottom contours also being practically parallel to the coast and the coast being a very flat one, the refraction and shoaling coefficient are very nearly unity so that the waves as predicted are directly compared with the recorded waves.

4. RESULTS OF THE ANALYSIS: Fig. 1 gives the significant wave heights as predicted by the SMB and the PNJ methods and the recorded significant wave heights over the active monsoon months of June and July. It is observed that the predicted wave heights are consistently smaller than the recorded heights for smaller wind velocities (upto 15 Knots). For wind velocities greater than 15 Knots there is a strong tendency for the predicted wave heights to be more than the recorded heights. Between the two methods, the SMB method appears to be closer to the recorded wave heights than the PNJ method.

Fig. 2 and Fig.3 show the comparison between the predicted wave heights and the recorded wave heights for the two methods. No doubt there is scatter since we are dealing with data which are subject to errors but the reasonable agreement cannot escape the attention.

The other results of the study reported elsewhere (4) can be summarised as;

(1) the generating areas for the waves that reach the Mangalore area on the West Coast of India, lie between 10° and 18° latitude North and 64° and 74° E longitudes

(2) the fetch lengths in the monsoon period lies between 200 to 600 NM

(3) the maximum calculated wind velocity is about 40 Knots while generally it is around 25 Knots

(4) the general direction of wave travel is between S 35°W and N 65°W since the range of wind direction is found to be between these limits. The predominant direction is from west.

5. CONCLUSIONS·- The planning, design and construction of any Coastal Engineering structure requires knowledge of wave characteristics. At present on the Indian Coast in most places the required design wave height is obtained from Wave Forecasting.

In this study undertaken at the Coastal Engineering Section of the Karnataka Regional Engineering College, Surathkal, India the primary aim was to investigate the applicability of the general Wave Forecasting methods like the PNJ and the SMB methods to Indian Coasts.

The present analysis indicates that the predicted wave heights compare well with the recorded wave heights and between the two methods used, the SMB method predicts wave heights which are nearer to recorded wave heights.

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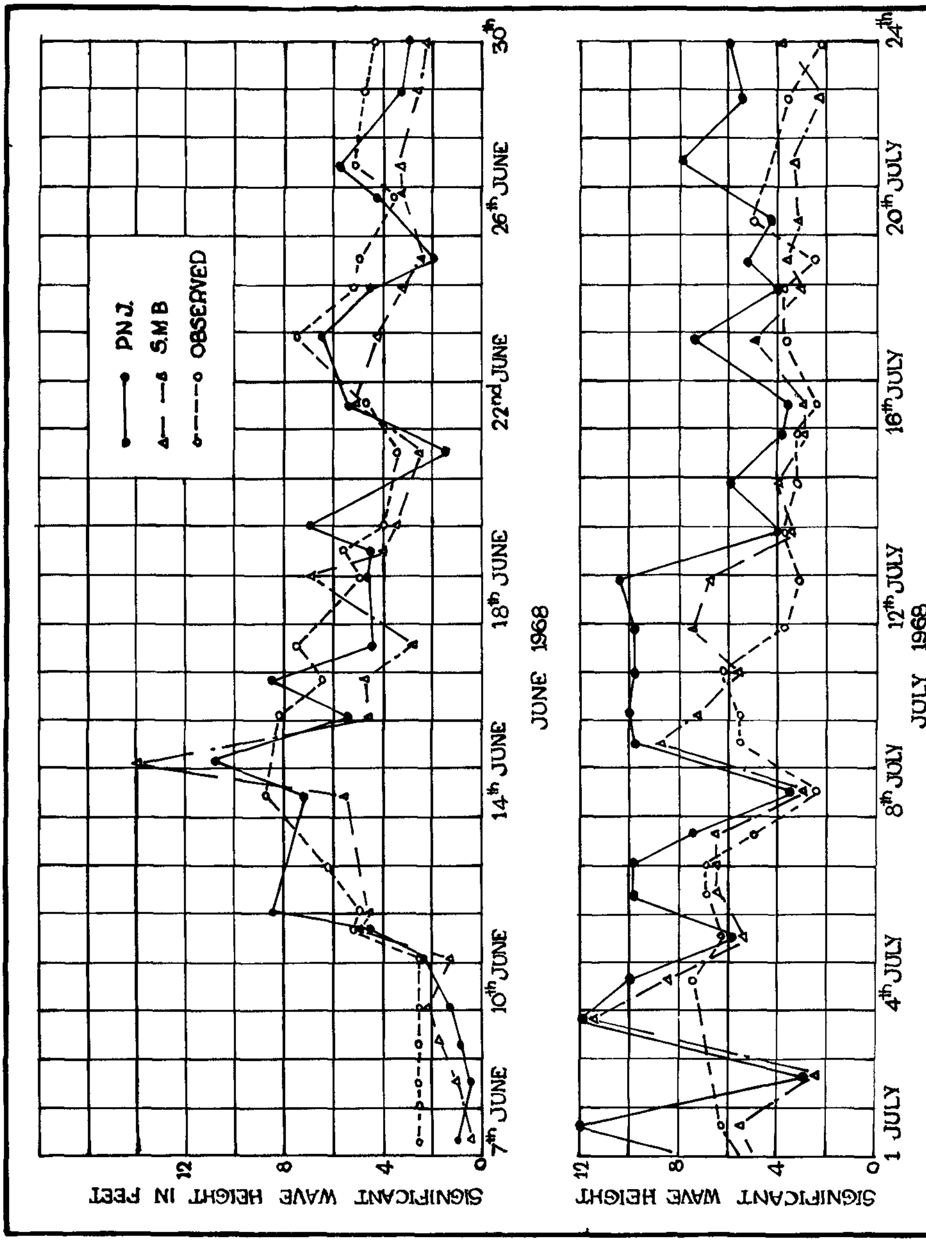

FIG 1 OBSERVED AND 'HINDCAST' SIGNIFICANT HEIGHTS FOR JUNE-JULY 1968

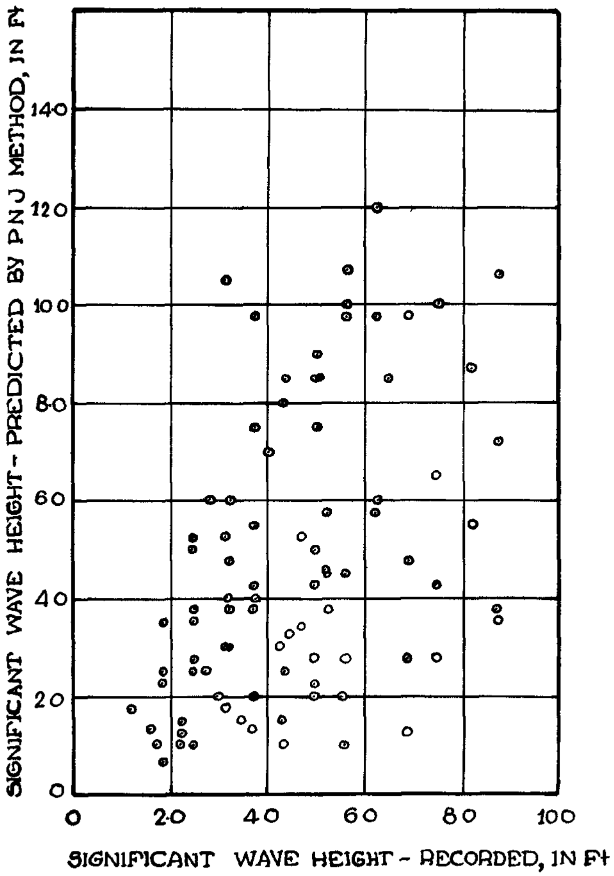

FIG 2 SIGNIFICANT WAVE HEIGHTS PREDICTED [PN J METHOD] VERSUS RECORDED

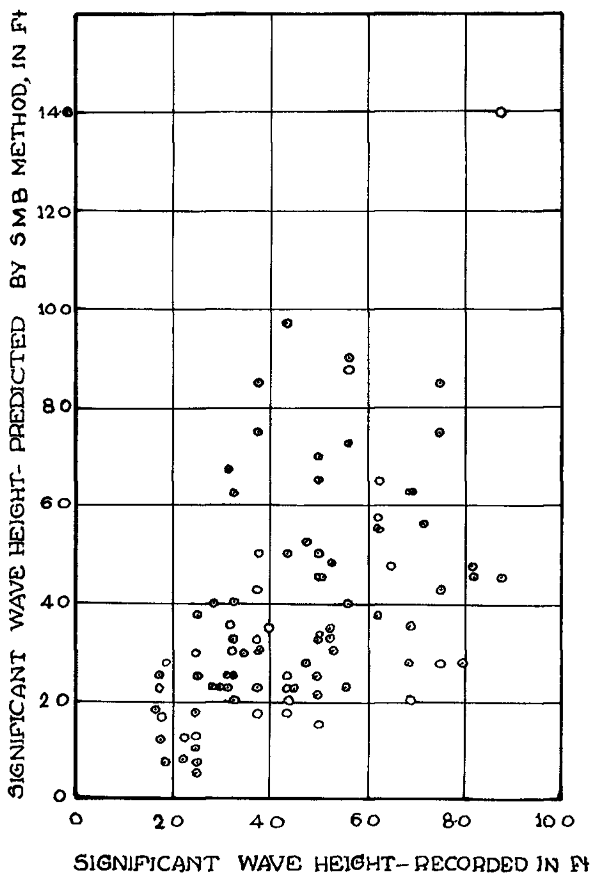

FIG 3 SIGNIFICANT WAVE HEIGHTS PREDICTED [S M B METHOD] VERSUS RECORDED