OCEAN WAVE HEIGHT PREDICTION

Muzathik AM[1] *, Ibrahim MZ[2], Samo KB[3], Azizi A[3] and Wan Nik WB[1]
[1] Maritime Technology Department; [2] Engineering Science Department; [3] Institute of Oceanography
University Malaysia Terengganu, 21030, Kuala Terengganu, Malaysia
* Corresponding author; e mail: muzathik64@yahoo.com

ABSTRACT: This paper presents and discusses the wave height prediction of the Terengganu Sea. It is based on 2008–2010 wave data collected from the study area. Rayleigh and Weibull density functions were used to model the significant wave heights (H_s). The Weibull expression is more prominent throughout the year. The Weibull scale and shape parameters of 0.69 and 1.49 respectively for the whole year can be utilized to predict the significant wave height for the study area. The results of this study will be highly useful for optimal design of ocean engineering projects.

Keywords: Rayleigh Probability Density Function; Weibull Probability Density Function; Significant Wave Height

1. INTRODUCTION

Establishing the design environmental condition such as wave height, wind speed, current speed, for different types of marine structures such as seawater intake structures, breakwaters, port and harbor structures, shore protection structures, submarine pipelines, open sea loading and unloading terminals, oil terminals, offshore platforms etc., are very essential from safety and economic point of view. A lack of correct information on the design environmental condition will result either in unsafe structures or with an over-designed and uneconomical structure. The concept of random and significant wave approaches provides convenient tools in ocean engineering activities [1]. Zero up-crossing wave height distribution follows Rayleigh distribution [2]. Prevosto et al. [3] have discussed various short and long-term probability models for ocean wave height distribution. The motivation for considering Weibull model for wave height distribution is highlighted in terms of the shape parameter and intensity function [4]. The importance of good estimate of wave climate for construction of shore and offshore maritime structures has been highlighted by many researchers [5]. The present study describes the modeling of significant wave heights at Terengganu sea of Malaysia.

2. STUDY AREA AND DATA

The area of interest in this study is at latitude 5 ° 35' N and longitude 102 ° 55.5' E. The investigation was based on one and two-hourly data collected at wave measurement point covering the period from 2008 to 2010. In order to give a better perspective on the representative wave conditions in the coastal area of Terengganu, a medium term analysis based on in situ measurements is presented. The datasets used for the wave analysis were acquired by the Department of Maritime Technology, University Malaysia Terengganu (UMT). The acoustic wave and current (AWAC) instruments belong to the Institute of Oceanography, UMT was deployed for continues measurement at the study area. The time series data consist of the significant wave height, the wave period, and wave direction.

3. MATHEMATICAL MODELING

Longuet-Higgins [2] had shown on certain basic assumptions that the probability density function of wave heights is represented by a typical Rayleigh density function as follows, where a-scale parameter, H-wave height, a, $H > 0$.

$$f(H) = \frac{2H}{a^2}.\exp-\left(\frac{H}{a}\right)^2 \tag{1}$$

The basic assumptions of Longuet-Higgins may not be met in all sea wave states. Hence we require a model that can accommodate Rayleigh distribution and fitting data under more general conditions. This requirement is supposed to be satisfied by Weibull probability density function (Equation 2). Rayleigh model is a special case of Weibull distribution for its shape parameter $b = 2$. In any case it is important to note that the concept of Weibull law does not contradict the Longuet-Higgins assumptions, which is readily satisfied in situation favorable to it, but only supplements it by extending the condition to more general situation.

$$f(H) = \frac{b}{a}\left(\frac{H}{a}\right)^{b-1}.\exp-\left(\frac{H}{a}\right)^b \tag{2}$$

where a-scale parameter, b-shape parameter, a, b, $H > 0$. The method of maximum likelihood estimate is applied to estimate the Weibull model parameters a and b.

4. RESULTS AND DISCUSSION

Rayleigh and Weibull model parameters were computed using equations (1) and (2) respectively, for the annual and monthly distributions of significant wave heights obtained from the study area (Table 1). The mean significant wave heights were estimated month wise for the same location by using Rayleigh and Weibull model and they are compared with computed mean values (Table 1). It is to be noted that Rayleigh expression is underestimating and Weibull expression is more prominent and almost equal to computed values through out the year. The Weibull scale parameter (0.69) and the shape parameter (1.49) are the average values for the whole year and can be utilized to significant wave height modeling for the study area.

Table 1. Shape (*b*) and scale (*a*) parameters of Weibull, scale parameter of Rayleigh, and computed and predicted H_s (*m*)

Month	a^* / Rayleigh mean H_s	a	b	Weibull mean H_s	Computed mean H_s
January	0.90	1.35	3.57	1.21	1.21
February	0.44	0.65	2.98	0.58	0.58
March	0.41	0.56	1.80	0.50	0.49
April	0.51	0.73	2.05	0.65	0.64
May	0.28	0.38	1.69	0.34	0.33
June	0.20	0.30	2.95	0.27	0.27
July	0.28	0.41	2.44	0.37	0.37
August	0.23	0.34	2.39	0.30	0.30
September	0.32	0.46	2.21	0.41	0.41
October	0.32	0.44	1.91	0.39	0.39
November	0.85	1.27	3.19	1.14	1.13
December	0.92	1.37	3.66	1.24	1.24
Annual	0.54	0.69	1.49	0.62	0.61

5. CONCLUSIONS

Rayleigh and Weibull density functions were used to model the significant wave heights. It is to be noted that Rayleigh expression is underestimating and Weibull expression is more prominent and almost equal to computed values through out the year. The Weibull scale parameter (0.69) and the shape parameter (1.49) are the average values for the whole year and can be utilize to significant wave height modeling for this study area.

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