

Extreme Wave Prediction in Markov Chain Condition

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Abstract

This paper discusses the effect of statistical dependence of the daily maximum significant wave heights assuming they are subjected to Markov chain condition. The formula of extreme wave prediction using daily maximum significant wave heights subjected to Markov chain condition is derived as a function of joint probability distribution of successive daily maxima, marginal distribution of daily maxima, correlation coefficient between successive daily maxima and sample size for which the extreme value distribution is studied.

The extreme wave height is predicted for two cases: wave data fitted to weibull distribution and fitted to log-normal distribution. Importance sampling procedure (ISP) is used for simulation of multivariate joint probability distribution. Analytical method also is used for bivariate log-normal distribution.

Based on the observed wave data in Northern North Sea and Atlantic the 100yrs. and 10yrs. wave heights are predicted by proposed method with Markov concept and traditional method. Predicted results show that 100yrs. wave height with the Markov concept is about 10% less than those predicted by traditional method.

Key words: Extreme Wave, Markov Chain, Prediction, Simulation

Introduction

There are three kinds of methods used for extreme wave prediction in the design of marine structures:

1. Maxima method

The maximum value taken from consecutive periods of equal time length, for example, year, month or day, can be selected as annual maxima, monthly maxima and daily

maxima wave heights, which can be used for extreme wave prediction.

2. Peaks over threshold method (POT method)

All wave heights above a predetermined threshold level H_0 are selected for extreme wave prediction.

3. Initial distribution method

All three hourly observations are used for extreme wave prediction.

Mentioned above three kinds of method is based on the assumption that the data samples are considered to be statistically independent. Up to now, only a few papers studied extreme wave prediction of daily maxima, even more about their statistical dependence of the successive daily maxima. So that, It is important to study on effect of the statistical dependence of the successive wave data samples for the extreme wave prediction. As the first step, this paper has been made on extreme wave prediction assuming the daily maxima are subjected to the Markov chain condition, because previous method to extreme wave prediction using daily maximum significant wave heights with assumption of statistical independence of data (Liu, 1986; Ochi, 1986).

Theoretical derivation

1. Definition of Markov chain

The state of a system invariably changes with respect to some parameter, for example, time or space. The transition from one state to another as a function of the parameter, or its corresponding transition probability, may generally depend on the prior states.

If the transition probability depends only on the current states, the process of change may be modeled with the Markov process. If the state space is a countable or finite set, the process is called a Markov chain.