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Some statistical characteristics of large deepwater waves around the Korean Peninsula

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ABSTRACT

The relationship between significant wave height and period, the variability of significant wave period, the spectral peak enhancement factor, and the directional spreading parameter of large deepwater waves around the Korean Peninsula have been investigated using various sources of wave measurement and hindcasting data. For very large waves comparable to design waves, it is recommended to use the average value of the empirical formulas proposed by Shore Protection Manual in 1977 and by Goda in 2003 for the relationship between significant wave height and period. The standard deviation of significant wave periods non-dimensionalized with respect to the mean value for a certain significant wave height varies between 0.04 and 0.21 with a typical value of 0.1 depending upon different regions and different ranges of significant wave heights. The probability density function of the peak enhancement factor is expressed as a lognormal distribution, with its mean value of 2.14, which is somewhat smaller than the value in the North Sea. For relatively large waves, the probability density function of the directional spreading parameter at peak frequency is also expressed as a lognormal distribution.

1. Introduction

During the last several decades, there has been a significant increase in the capability of generation, measurement, and analysis of random directional waves. The use of numerical and physical model tests using random directional waves has also been increased. Accordingly, the estimation of design waves and the design of coastal structures are carried out based on directional random wave spectra rather than using the linear regular wave theory and corresponding empirical formulas. On the other hand, reliability- or performance-based design methods are adopted in the design of coastal structures, in which the distributional characteristics of design variables (e.g. mean and standard deviation of a variable of normal distribution) are important. Therefore, it is necessary to provide the distributional characteristics of random design variables for reliable and optimal design of coastal structures.

There are a number of variables related to coastal structure design using directional random waves. In the present study, firstly we deal with the relationship between significant wave height and period. The statistical variation of significant wave period for a certain significant wave height is also investigated. Secondly, the statistical characteristics of the peak enhancement factor of a frequency spectrum are investigated. Thirdly, we deal with the statistical characteristics of the spreading parameter of a directional spreading function. Used wave data are the field data measured for 6 to 7 years at four locations around the Korean Peninsula, the field data measured for about 12 years along the coast of Japan by the NOWPHAS (Nationwide Ocean Wave information network for Ports and HArbourS) system, and the hindcasted data for 25 years in waters around the Korean Peninsula.

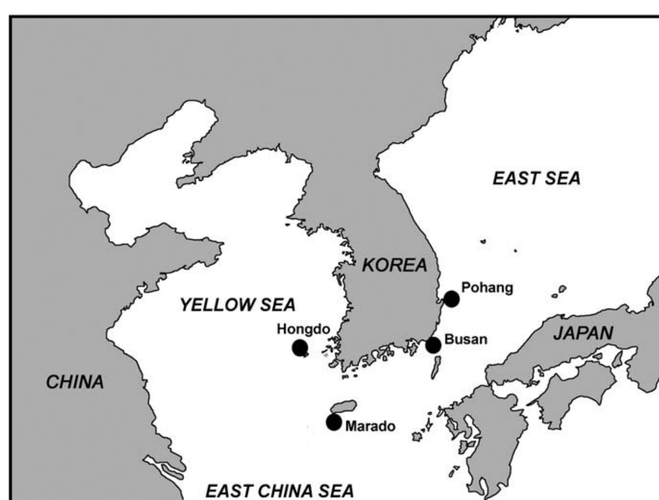

Fig. 1. Location map of wave measurement stations around the Korean Peninsula.

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Table 1
Details of wave measurement stations around the Korean Peninsula.

Stations	Latitude	Longitude	Water depth (m)	Significant wave height (m)	Significant wave period (s)	Peak enhancement factor	Directional spreading parameter at peak frequency	Measurement period	Percentage of data collection
Pohang	36°05′N	129°33′E	30	0.11–9.03	1.84–19.94	0.01–6.18	0.20–144.5	Jan 1, 1998–Jul 6, 2004	64.64
Busan	35°04′N	129°06′E	30	0.14–8.82	2.64–19.55	0.01–11.32	0.10–145.8	Aug 6, 1998–Jul 1, 2004	64.31
Marado	33°07′N	126°15′E	100	0.12–8.84	2.57–19.74	0.01–7.4	0.20–139.5	Apr 15, 1998–Dec 21, 2004	58.79
Hongdo	34°44′N	125°11′E	40	0.11–5.87	2.14–19.02	0.01–8.8	0.10–131.1	Feb 18, 1998–Jan 30, 2004	71.60

The statistical characteristics are analyzed for large waves comparable to design waves. Since rather various topics are dealt with in this paper, the previous studies are described at the beginning of each related section.

2. Relationship between significant wave height and period

In the design of coastal structures, the design wave height corresponding to a certain return period such as 30 or 50 years is often determined by statistical analysis of long-term measurement or hindcasting of extreme waves. Then a question arises as to what wave period should accompany the return wave height. The conventional practice is to prepare a scatter diagram of wave periods versus heights and to make a regression analysis.

Several formulas have also been proposed for the relationship between significant wave height and period. Shore Protection Manual (U.S. Army, 1977, p. 3–73, abbreviated as SPM hereinafter) recommends estimating the significant wave period $T_{1/3}$ corresponding to the offshore significant wave height $H_{1/3}$ using

$$T_{1/3} = 3.85(H_{1/3})^{0.5} \quad (1)$$

where $T_{1/3}$ and $H_{1/3}$ are in seconds and in meters, respectively. Note that the coefficient has been changed from 2.13 to 3.85 due to the conversion of the height units of foot to meter. On the other hand, Goda (2003) proposed the following formula for design waves of a coastal structure:

$$T_{1/3} = 3.3(H_{1/3})^{0.63}. \quad (2)$$

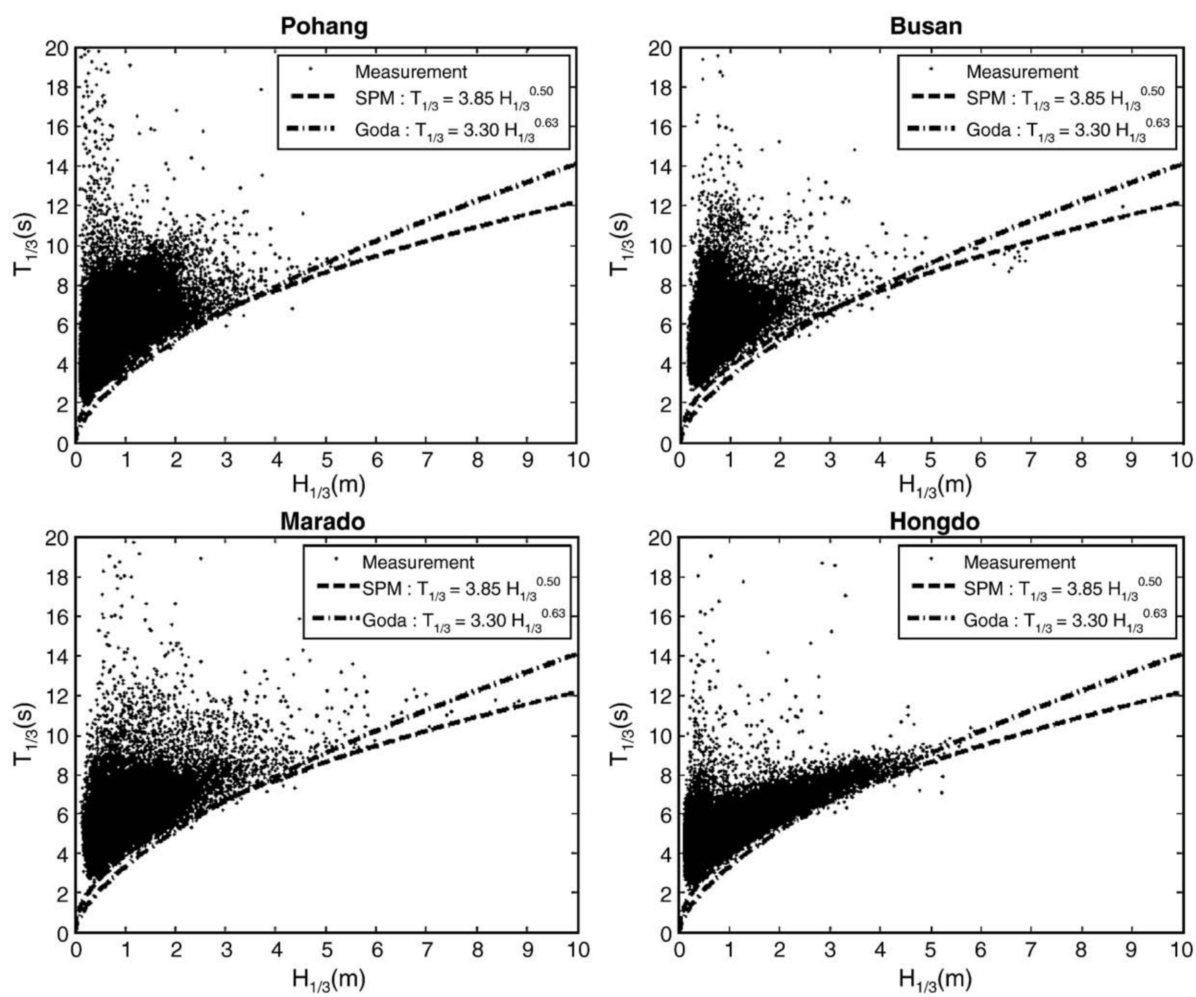

Fig. 2. Relationship between significant wave height and period at stations around the Korean Peninsula.