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Characteristics of Wave Grouping and Freak Wave Observed by Two Typhoons

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Abstract

Two large typhoons destroyed a concrete detached breakwater on the Suruga Coast, Shizuoka Prefecture, Japan in 2013. Although the Typhoon Man-yi, recorded a lower wave height than the other Typhoon Wipha, significant damage to the structure was observed by Typhoon Man-yi. It appeared that the significant wave height alone cannot describe the extreme wave field caused by typhoon appropriately. This study investigates typhoon wave characteristics with an objective to extract essential wave parameters influential to the stability of coastal structures. The relationships among various parameters were examined regarding the nonlinearity and the irregularity of nearshore waves, such as power spectrum, occurrence of freak waves, skewness and kurtosis, wave grouping and distribution of wave height. It is concluded that the occurrence of freak wave had strong correlation with the kurtosis μ_4 and the groupiness factor GF. The nonlinearity parameter $\Pi_{1/3}$ was found to be a good parameter in the early detection of catastrophic wave field.

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Keywords: Typhoon wave characteristics; wave grouping; freak wave; skewness; kurtosis; groupiness factor; catastrophic wave field;

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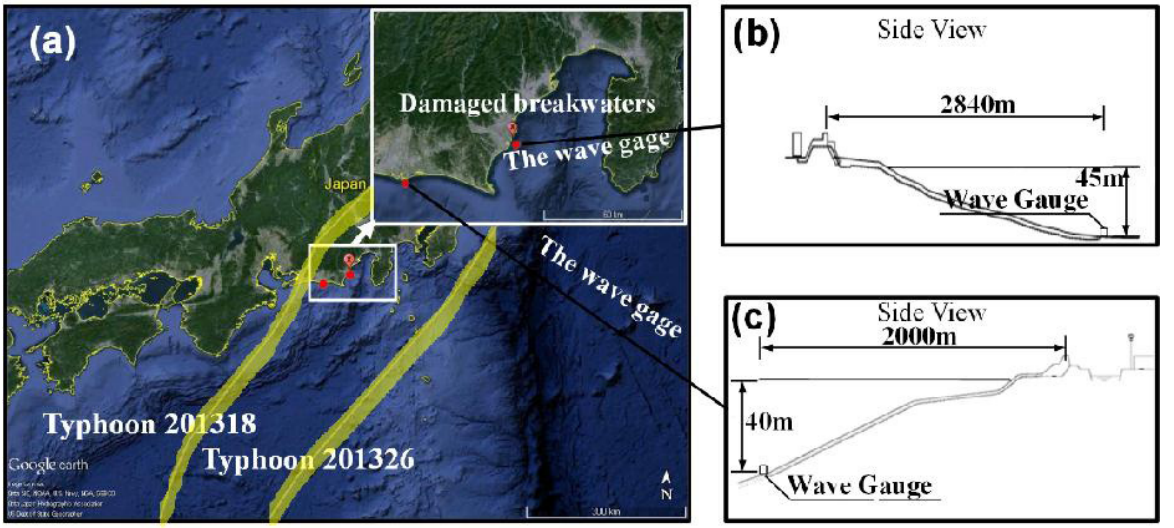

Fig. 1. Study area: (a) Location of two observation point; (b), (c) setup of sensors ((b): Suruga Bay; (c) Tenryu. Coast).

1. Introduction

The characteristics of ocean waves are most crucial for the design of the maritime structure. Semi-empirical statistical methods based on random wave theory have already developed extensively after decades. However, the mechanism of structure failure due to the effects of the extreme wave field, i.e., typhoon-caused wave field has not yet been fully investigated.

A pile-supported concrete breakwater was partially damaged by two typhoons in 2013. The structure was located at Suruga Bay, Japan at the depth of 7 m. A stationary wave gauge was installed nearby at the depth of 45 m (Fig. 1). It is noted that Typhoon Man-yi, Typhoon 18 in the Japanese nomination on September 15, 2013, had exerted more damages to the structure than Typhoon Wipha, Typhoon 26 on October 15, 2013, although the latter typhoon recorded a higher wave height. In general, the breakwater being partially damaged by the first typhoon would be vulnerable to confront the second typhoon. Still, the expected significant damage have not been observed from the second typhoon. The wave height in front of the breakwater was computed on the basis of nearby wave gage and listed in Table 1. It appeared that the significant wave height alone cannot appropriately describe the extreme wave field caused by typhoons. This study investigates typhoon wave characteristics with an objective to extract essential wave parameters influential to the stability of coastal structures.

Table 1. Wave parameters of typhoon peak at Suruga Bay

Wave parameters		Design	Typhoon Man-yi	Typhoon Wipha
Incident wave (inferred)	Angle (°)	------	N168°	N168°
	H_o (m)	11.30	7.02	7.02
	T_o (sec)	16.0	11.5	15.1
	L_o (m)	399.36	206.31	355.70
Observed wave at the depth of 45m	$H_{1/3}$ (m)	------	6.46	5.97
The wave in front of the targeted structure at the depth of 8m (inferred)	Angle (°)	------	N132°	N127°
	$H_{1/3}$ (m)	**5.84**	**5.10**	**5.93**
	H_{max} (m)	**7.86**	**6.85**	**7.83**