Stability of a New Type Armor Protection Unit in High Waves

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Introduction

Powerful Unit (PU) is the name of the new type armor protection unit mentioned in this paper. It is composed of two parts: bag and inner filling. The bag material is a single-layer kind of raschel netting structure made from polyester fibers which is light in weight with outstanding durability and workability. Materials such as boulders, broken stones, rag stones and concrete chunks which are generated at the site can be utilized as the inner filling.

Due to the characteristics of PU, when the existing revetment is destroyed, it can be utilized to recover the destroyed part rapidly and effectively. So it is currently performing well in emergency situations, especially in flood and typhoon disaster protection. However, there are few examples of it to be applied as general foot protection works in common use. As a kind of relatively new type armor protection block, the stability of PU in various situations in coastal areas has not been adequately proved and verified yet. So this study aims to research the stability of PU as revetment construction of composite breakwaters in high coastal waves by model experiment.

Fig.1 PU applied in Kansai International Airport

Model Experiment

This model experiment is designed to simulate the situation that PU is utilized as all parts of the armor units forming the revetment of normal breakwater to protect the rubble mound from continuous coastal waves for an adequately long time, under a proportion of 1/50.

Table.1 Experimental conditions

Proportion	1/50
Simulated significant wave period $T_{1/3}$	1.13s (8s), 1.56s (11s), 1.98s (14s)
Random number of simulated wave N_R	500, 1013
Input significant wave height $H_{1/3i}$	5cm ~
Width of the offshore side of mound *B*	144mm (7.2m), 216mm (10.8m), 266mm (13.3m)
Distance from the water level *h'*	144mm (7.2m), 96mm (4.8m)
Number of layers of model units N_0	1, 2
Damage rate *r*	Limitation: 2%

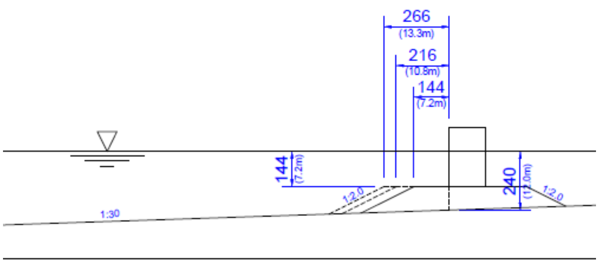

Fig.2 Section view of the model breakwater

Stability number is applied to estimate the stability. According to the Hudosn's formula, it is calculated by the following formula:

$$N_S = \sqrt[3]{\frac{\rho_r {H_{1/3c}}^3}{M(\rho_r/\rho_w - 1)^3}}$$

where

$H_{1/3c}$: critical significant wave height when damage rate is 2% (unit: m)

M: mass of Powerful Unit (8t)

ρ_r: density of Powerful Unit (2.6t/m^3)

ρ_w: density of water (1t/m^3)

Larger stability number means higher stability. After calculating the stability number of each experimental section, the relationship between the stability and the supposed influence factors can be shown easily.

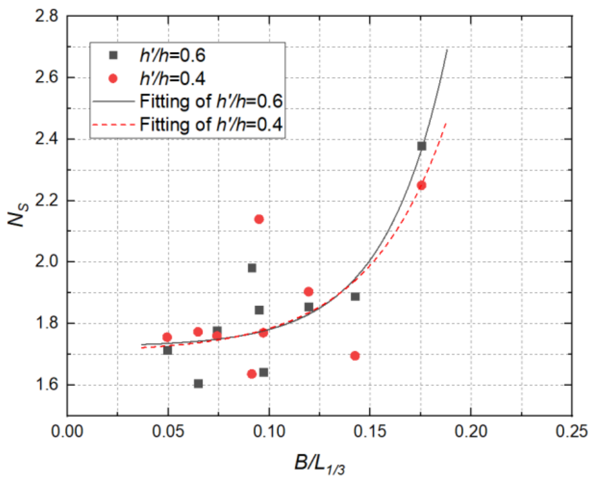

Fig.3 Fitting curves of two kinds of h'/h (h=12m; $L_{1/3}$: wavelength at h)

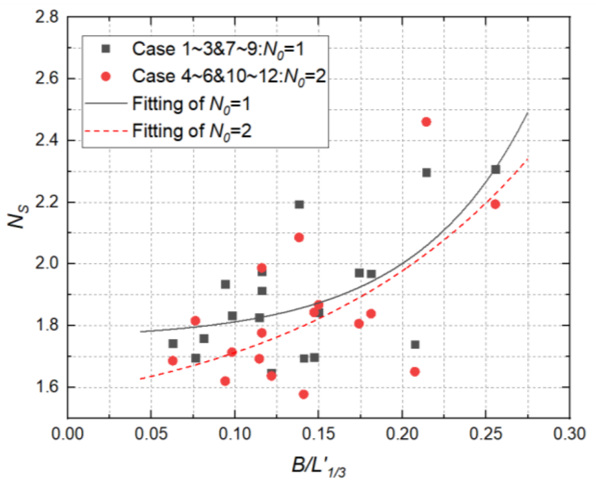

Fig.4 Fitting curves of two kinds of placement (N_0: number of layers; $L'_{1/3}$: wavelength at h')

Application

According to the Tanimoto's model, two empirical formulas have been established to estimate the stability number of PU:

$$N_S = a\frac{1-\kappa}{\kappa^c}\frac{h'}{H_{1/3}} + N_{S0}exp\left[-b\frac{(1-\kappa)^2}{\kappa^c}\frac{h'}{H_{1/3}}\right]$$

N_0= 1: N_{S0}= 1.5 a= 0.648 b= 0.369 c= 0.161

N_0= 2: N_{S0}= 1.45 a= 0.334 b= 0.038 c= 0.155

κ: environmental influence coefficient

$H_{1/3}$: design wave height

By using this empirical formula, this study has estimated the required mass of PU in different coastal areas in Japan under both the common situation and the situation where the possibly largest storm surge takes place.

Conclusion

(1) The wide type of mound will improve the stability of PU especially the type which can contain 5 lines of it. When $B/L_{1/3}$ is larger than 0.15, relatively long distance from water level may improve the stability.

(2) It is not effective to add a layer from the one-layer type. The one-layer type of placement is worth considering to be applied more commonly because it can save almost half of the cost of construction.

(3) If PU can be improved to contain 20 tons of inner filling, it will be able to serve almost all the coastal areas in Japan as the general revetment of breakwaters.

(4) It is hard for PU to resist the high coastal waves under the situations of supposed largest storm tides. The stability from other factors such as the structure and placement should be improved.