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The Damage To The Armour Layer Due To Extreme Waves

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The sea waves are not regular but random and chaotic. In order to understand this randomness, it is common to make individual wave analysis in time domain or spectral analysis in frequency domain. Characteristic wave heights like H_{max}, $H_{\%2}$,$H_{1/10}$, $H_{1/3}$, H_{mean} are obtained through individual wave analysis in time domain. These characteristic wave heights are important because they are used in the design of different type of coastal structures. It is common to use significant wave height, $H_{1/3}$,for the design of rubble mound structures. Therefore, only spectrally derived or zero-crossing significant wave height is usually reported for the rubble mound breakwaters without any information on larger waves. However, even the values of $H_{1/3}$are similar; some train of irregular waves may exhibit a large fluctuation of instantaneous wave energy, while another train may not show such a fluctuation (Goda, 1998). Moreover, freak or rogue wave, simply defined as the wave exceeding at least twice the significant wave height may also occur. Those larger waves were called as extreme waves in this study and the effect of extreme waves on the damage to the armour layer of rubble mound breakwaters was investigated by means of hydraulic model experiment.

Rock armored rubble mound breakwater model with 1:1.5 slope was constructed in the wave channel of Hydraulics Laboratory of the Disaster Prevention Research Institute of Kyoto University, Japan. The model was consisted of a permeable core layer, a filter and armour layer with two stones thicknesses. Size of stones were same for both of the slopes as $D_{n50(armour)}$=0.034m, $D_{n50(filter)}$=0.021m and $D_{n50(core)}$=0.0148m for armour, filter and core layers, respectively.

Time series which are approximately equal to 1000 waves, with similar significant wave height but different extreme wave height cases were generated. In order to generate necessary time series in the wave channel, they were firstly computed by numerically. For the numerical computation of wave time series, Deterministic Spectral Amplitude (DSA) model with FFT algorithm was used. It is possible to get thousands of time series which have different wave statistics in DSA model by setting up the target spectrum and using random numbers for phase angles (Tuah et.al. 1982).

Multi-reflection in the wave channel was minimized by the absorption mode of wave generator. Incident wave energy spectrum was obtained by using the separation method introduced by Goda and Suzuki (1976). Three wave gauges in front of the model were used for the separation. Individual wave heights were determined by zero-up crossing method after obtaining incident wave train.

After each test, damage of the breakwater was calculated. Van der Meer's (1988) definition of damage level, S, was used in the calculations as:

$S= A_e/D_{n50}^2$ (1)

where; A_e= Eroded area, D_{n50}: nominal diameter of armour stone

In order to get eroded area, the profile of armour layer was measured by laser equipment through nine lines along the section.

Results of the experiments indicate that the higher the extreme waves are, the more destructive the wave train is, even the data is scattered. The damage was also calculated by using Van der Meer's formulae (1988) and compared with the experimental results. The comparison shows that the damages are more than the expected results in the

cases where at least one wave height in the train is higher than the twice of $H_{1/3}$. In fact, the damage results calculated by Van der Meer's formulae form the lower boundary for the higher extreme wave cases. It is also found that the damage is highly correlated to the ratios of characteristic waves like $H_{1/10}/H_{1/3}$ or $H_{1/20}/H_{1/3}$. Therefore, the parameter $\alpha_{extreme}$ covering the effect of all extreme waves is proposed.

References

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