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Wave overtopping of a vertical seawall with a wide submerged mound and a dike.

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Abstract

In this paper, the authors suggest a modification to vertical seawalls in order to reduce wave overtopping and discuss the results of a preliminary study on performance characteristics of such a structure. Laboratory investigations on irregular wave overtopping of the proposed structure were conducted for various wave conditions. The effectiveness of the structure on reducing overtopping was compared with that of a vertical wall.

Experimental procedure

Laboratory tests were conducted in a wave flume of 14.0m long, 0.7m high, 0.4m wide and with a horizontal bottom. Overtopping discharges were measured for four different configurations of seawalls shown in Figure 1-a,b,c and d.

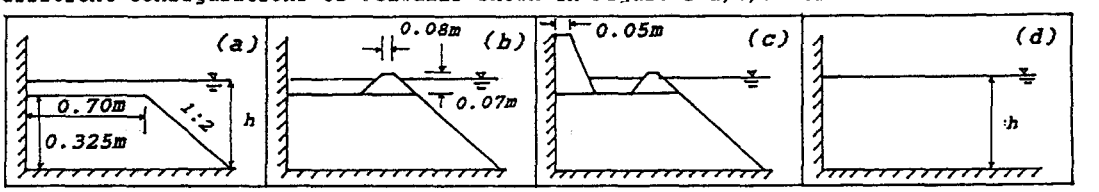

Figure 1

Irregular waves were generated by Bretschneider-Mitsuyasu type spectrum. The experiments were conducted for incident significant wave heights $H_{1/3}$, within the range of 0.07m to 0.14m and significant wave periods $T_{1/3}$ of 1.2, 1.6 and 2.0sec. Water depth h, water depth above the mound d and crest height h_c of the wall were kept constant at 0.375m, 0.05m and 0.1m respectively. Wave heights were measured by capacitance type wave gauges. Overtopped water for a fixed duration of 102.35sec was collected to a box fixed behind the vertical wall.

Experimental results

The non-dimensionalized rate of overtopping $q/(2gH_{1/3}^3)^{1/2}$ against relative crest height $h_c/H_{1/3}$ for all types of structures are shown in Figure 2-a,b,c and d.

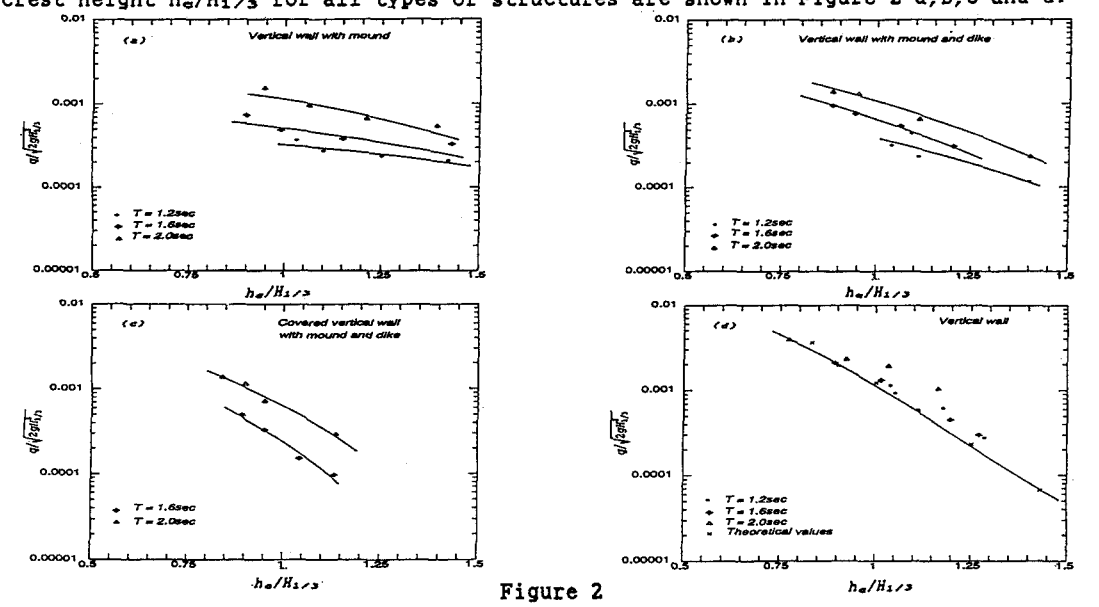

Figure 2

Results show that the average rate of overtopping of the vertical wall can considerably be reduced by the submerged mound. A further reduction was experienced by the dike and the cover of the crest of the wall, but the effectivity of the dike reduces as the wave height increases. The possible reduction of crest height of the vertical wall by the application of the mound and dike is arround 15%-20% on average.

The reflection coefficient of each structure was calculated for all experimental conditions and it was within the range of 0.2 - 0.4 for structures (a), (b) and (c) and 0.9 - 0.98 for vertical wall. Variation of reflection coefficient with wave period was not very significant.

The theoretical values of overtopping rates of vertical wall against irregular waves were calculated according to the equations given below (Goda et al.(1975).).

$$\frac{q_{exp}}{\sqrt{2g(H_0^1)^3}}=\int q^*(x)\,p(x)\,dx$$

$$where \quad q^*(x)=A_0\left(\frac{K}{K+1}\right)^{3/2}x^{3/2}\left[1-\frac{h_c}{H_0'}Kx\right]^{5/2}$$

p(x) is the probability density function of wave heights, H_0' is the deepwater equivalent significant wave height and x = H/H_0'

$$K=\frac{\eta_c}{H}=\min\left\{\left[1.0+ax\frac{H_0'}{h}+\frac{b}{K_{sb}}\left(x\frac{H_0'}{h}\right)^2\right],c\right\}$$

A_0, a, b and c are equal to 0.1, 1.0, 0.8 and 10.0 respectively. η_c is the crest height of the wave at the wall, h is the still water depth, h_c is the crest height of the vertical wall and K_{sb} is the ratio between $H_{1/3}$ and H_0'.

Since non-breaking wave conditions were maintained during the experiments, H_0' was taken as equal to $H_{1/3}$ and hence K_{sb} becomes equal to 1.

Calculated values of overtopping quantities are slightly lower than the experimental results as shown in Figure 2-d.

Conclusions

1) It is obvious that the rate of overtopping and hence, the crest height of the vertical wall could be reduced by the application of the mound and dike. The effectivity of the structure reduces for higher wave heights which may be due to the accumulation of water in between the dike and the vertical wall.

2) Upward splashing of water against the wall was experienced in the case of vertical wall with mound which seems to be a disadvantage. This situation was controlled to a certain extent by the dike and was completely prevented by covering of the wall crest. Eventhough the cover to the wall was effective in both reducing overtopping and upward splashing, the structure becomes bulky and hence uneconomical.

3) The overtopping rates for all types of seawall were found sensitive to significant wave periods except in the case of vertical wall, which might be a result of wave breaking on the submerged mound.

4) Since the experimental conditions are limited, it is not possible to formulate the experimental results at this stage. Further investigations have to be progressed.

References

1) Goda,Y., Kishira,Y., Kamiyama,Y., Laboratory investigation on the overtopping rate of seawall by irregular waves., Report of the Ports and Harbour Research Institute, Vol.14, No.4,(1975).