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EFFECTIVENESS OF SLOPE-SHAPED SLIT CAISSON

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1. Introduction

Recently, the reduction of construction cost has severely been required in public works under the situation of the tight national budget in Japan. Hence, new technology has been developed to realize low cost and high quality in construction. Construction cost can be reduced by comparing various plans which have similar effects and choosing the optimal one. As for wave-dissipating structures, a slit-type and block-covered caissons are common harbor structures. When a wave-dissipating structure is constructed where it faces various wave conditions, a block-covered caisson is favorable because it copes with a wide range of wave frequencies. However, the process of production, shipment and placement of concrete blocks is costly itself, and moreover, the placement of concrete blocks costs a lot indirectly since it requires a wide mound as a foundation. This is more obvious in deep seas. On the other hand, a slit caisson is an economical structure because it does not need blocks to dissipate waves. That is, a slit caisson is designed to dissipate waves by a slit wall and wave chamber. A slit caisson is useful when aimed to dissipate specific waves for the safety of the vessels which sail outside the harbor, though it can not cope with a wide range of wave frequencies. In this paper, we propose a slope-shaped slit caisson, characterized by a sloped wall in the wave chamber, to reduce the construction cost of a wave-dissipating structure.

2. Slit-type caisson

2.1 Conventional slit caisson

A conventional slit caisson is shown in Fig.1. This caisson is designed to dissipate waves at the slit wall causing turbulence. At this point, large energy dissipation occurs when the horizontal velocity of fluid is large at the slit wall. The horizontal velocity becomes largest at a nodal point of waves when standing waves are acting. Therefore, the slit wall should be set at a nodal point of the waves to maximize the effect of wave dissipation. That is, the width of the wave chamber should be (wave length)/4. Considering the characteristics of a wave that wave length is short in shallow water, we can save the chamber width by letting water depth shallow in the chamber. It is denoted that wave reflection occurs significantly in front of the slit wall when water depth is too shallow in the chamber. Hence, in order to optimize the effects of the slit caisson, the width and depth of the wave chamber have to be determined properly.

A slit-type caisson is useful in terms of construction cost. If it is aimed to dissipate specific waves for the safety of vessels, it is superior to a block-covered caisson. However, since a conventional slit caisson has a vertical impermeable wall in the chamber, horizontal wave force is significantly large where it faces high waves. In this case, the construction cost increases because the caisson has to be wide for its stability, and accordingly, wide mound foundation is required.

2.2 Proposed slope-shaped slit caisson

To resolve the above cost problem, we propose a slope-shaped slit caisson shown in Fig.2. This caisson is characterized by the sloped wall in the wave chamber. At this point, the wave chamber is triangular in the cross-sectional view while that is square in a conventional slit caisson. In a slope-shaped type, the chamber width is defined at H.W.L.

We investigate wave dissipation by a slope-shaped type in comparison with a conventional upright type. An experimental and numerical analyses are carried out in a 1:60 scale to the scale shown in Figs.1 and 2. The slit interval is 2m, and the gap ratio (= slit width/slit interval) is 0.2 in the prototype. In the laboratory experiment, the prototype waves

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of H =2 (m), T =6, 8, 10, 12 (sec) for regular waves, and $H_{1/3}$ =2 (m), $T_{1/3}$ =8, 10, 12 (sec) for irregular waves were tested. Numerical analysis was carried out on the basis of the method of Kakuno et al.(1986) determining the head loss coefficient of the slit in comparison with the experimental results by Tanimoto et al.(1982).

Fig.3 shows the comparison between the experimental and numerical analyses for reflection coefficients. In this figure, the comparison is in good agreement, and the validity of the numerical analysis is confirmed. Fig.4 shows the comparison among the calculated results for different shapes of the chamber where BH denotes the chamber width. From this figure, we understand that a upright type copes with the wave period of 4.2-6.8 (sec) for the designed reflection coefficient of 0.4 while a slope-shaped type does with longer period of 4.6-7.5 (sec) under the same condition for the chamber width (BH=4m). It is confirmed that a slope-shaped type works with less chamber width having a similar ability to a upright type by comparing a conventional type and a slope-shaped type with less chamber width (BH=3.5m).

In addition, the following effects are expected by a slope-shaped slit caisson because of its design:

1) Horizontal wave force against the caisson is decreased due to the slope of the wall.

2) Vertical force is caused downward against the caisson by wave pressure and the slope of the wall.

3) The weight of the caisson increases because filling sands'in it increase as the volume of the wave chamber decreases.

The above three effects intensify the resistance of the caisson against sliding and overturning.

3. Conclusions

In this paper, we propose a new type of a slit caisson, called a slope-shaped slit caisson, to reduce the construction cost of a wave-dissipating structure. From the experimental and numerical analyses, we understand that the proposed type works with less chamber width to dissipate waves compared with a conventional upright type. In the proposed type, the widths of the caisson and mound foundation are required less, which implies that the improvement of the seabed foundation is required less too. Then, the total construction cost is expected to be less compared with a conventional type, though the structure of a slope-shaped type costs a little more.

Cost reduction can be realized retaining quality by continuous efforts to develop new technology.

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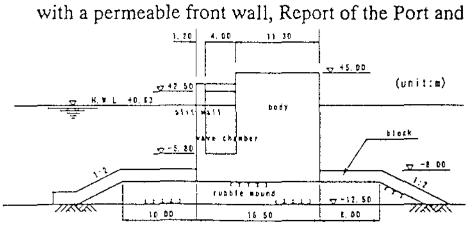

Fig.1 Cross-section of a conventional upright slit caisson.

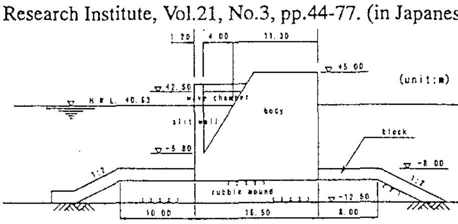

Fig.2 Cross-section of a slope-shaped slit caisson.

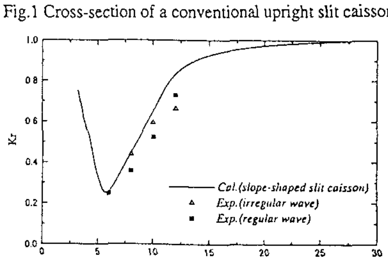

Fig.3 Comparison between experimental and numerical analyses for reflection coefficients.

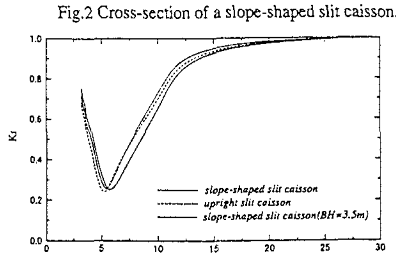

Fig.4 Comparison among the calculated results for different shapes of the chamber.