CHAPTER 50

THE EFFECT OF STORM DURATION ON RUBBLE MOUND BREAKWATER STABILITY

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ABSTRACT

Experimental data are given to aid in the selection of the wave height for the design of a rubble mound breakwater as a function of the type and duration of the wave storm, and the allowed percentage of damage in the armour layers.

In these experiments the model breakwater was subjected to the attack of periodic waves of height and in number according with the known statistical distribution for actual swells.

Some noteworthy differences were found in the effects of different duration storms.

Observation of the destruction process of the breakwater with double layer of armour rocks, showed that the filter layers uncovering occurred always for armour damage percentages above 5% and thus this last value is suggested as the maximum permissible in case of a storm of very high recurrence period.

INTRODUCTION

Very often the engineer has to face the design of a rubble mound structure taking into account the strongest possible storm. Such a storm may have a peak lasting a few hours with very high waves. It may prove very costly to design a breakwater for that situation on the basis of no damage as defined by Hudson (1959). If some damage is allowed, then the storm type and duration become important.

THE DESIGN WAVE HEIGHT

Considering the experiments of Hudson (1959), Iribarren (1965) and those reported in the present paper, it may be concluded that the total breakwater failure occurs for wave heights from 1.5 to 1.8 times the design wave heights. All of these experiments were conducted with periodic waves breaking on the face of the structure. On the other hand the experiments of Rogan (1968) and Carstens, Torum and Traetteberg (1966) show that the effect of a locally wind generated wave storm is similar to that of a periodic wave with height equal to the significant wave height ($H_{1/3}$) of the storm.

A real storm may have waves with height up to 2.4 times the significant wave height and thus it is obvious that in the design wave selection the duration and the wave period spectrum of the storm must play an important rol. If a storm is such that some waves break before hitting the breakwater, then the wave period is determinant of the action of the waves on the structure. Very valuable are in this concern the experiments made by Carstens, Torum and Traetteberg (1966). They showed the remarkable difference between storms of the same significant wave height but of different kind of spectrum. As it is already known by experience swell waves are more deletereous to breakwaters than locally generated waves.

DESCRIPTION OF THE EXPERIMENTAL WORK

THE MODEL STORM.

The model storm was considered to be of the swell type and to have a wave height distribution as given by Putz (1954), with all waves breaking on the breakwater face. In this case the wave period may be considered irrelevant and thus it was held constant throughout the experiments.

It was also assumed that the effect of waves of different height may be added linearly and thus that there is no influence of the time secuence. This difference between the actual and the model storms will probably make a little conservative the experiments since in the model the largest waves act when the breakwater has been already weakened by the rest of the waves.

THE EXPERIMENTAL SET-UP.

See Fig. 1 for the description of the experimental set-up.

THE TESTS.

Waves and trains were calibrated before placing the model sections in the wave channel in order to select the needed height and duration. The model breakwater was subjected to the attack of regular waves of height and in number according with the statistical distribution above mentioned. The wave height was increased by steps of about one centimeter. The data were taken in terms of percentage of damage of the armour layers. The period was held constant for all of the experiments as well as the water depth. The period was 1.58 sec. and the depth 0.55 m.

CORRELATION OF DATA.

In Fig. 2 are summarized the results of the tests.

The symbol H_D refers to the wave height as computed from Hudson's formula for a given size of rock and breakwater slope. Thus:

$$H_D = \sqrt[3]{\frac{W \cdot K_D \cdot \cot \alpha}{\gamma_r}} \left(\frac{\gamma_r}{\gamma_f} - 1 \right)$$

W being the weight of the rocks and K_D the Hudson's formula coefficient taken equal to 3.2 and 2.8, depending on different techniques for placing the rocks as determined in previous tests.

The symbol n is equal to $t/T_{H_{1/3}}$ where t is the storm duration and $T_{H_{1/3}}$ is the mean period of the highest 33 per cent of the waves and, according to Sibul (1955), the most common period for the largest waves.

CONCLUSIONS

1. The experimental data show a scatter inherent to this kind of tests.

2. For the initial movement of the rocks it seems that the duration of the storm is not important. The duration becomes relevant for advanced damage.

3. In the experiments it was observed that the incipient destruction occurred in the way of sliding of isolated rocks. Eventually, for grater damage, several rows of rocks slide at the same time. Also, the filter layers uncovering occurred usually for damage in the range of 10% and always over 5%, therefore this last value is suggested as the maximum design damage allowable for a storm of recurrence period high enough as to assure that the breakwater will be repaired before it is affected by the next major storm.

4. The use of the wave breaking criteria combined with Fig. 4 of this paper may help to select the design wave for a critical storm. It is suggested that in future experimentation, related with the non-uniform waves effect on breakwaters, the relation between the significant wave height and the breaker height for the mean wave period at the depth of the structure be considered as a significant parameter. In the present experiments this relation was:

$$\frac{H_{1/3}}{H_b} = 0.3$$

H_b being the breaker height corresponding to the wave period and water depth of the tests as computed after the experiments of Danel (1952).

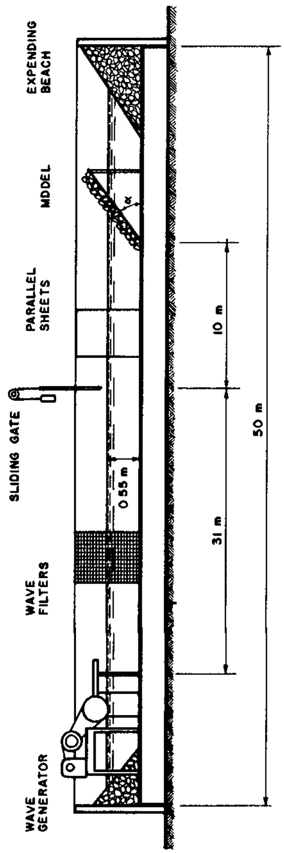

Fig. 1. Wave channel and experimental set-up

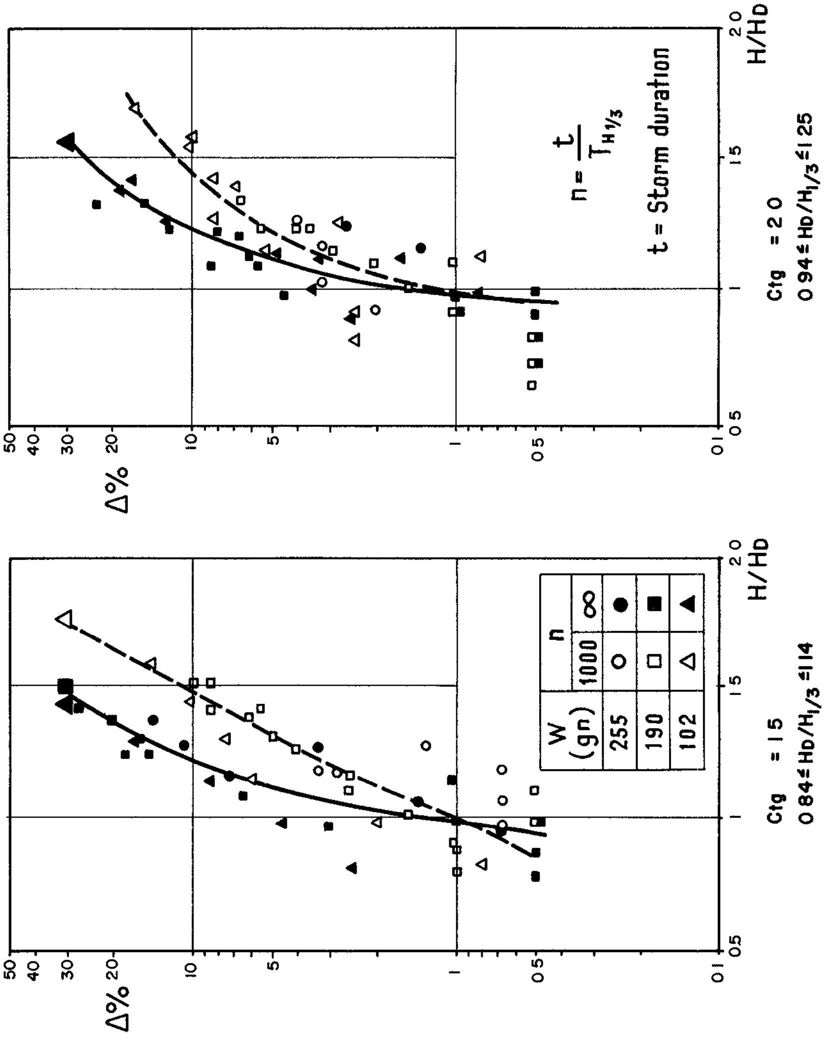

Fig. 2. Damage curves for different storm durations

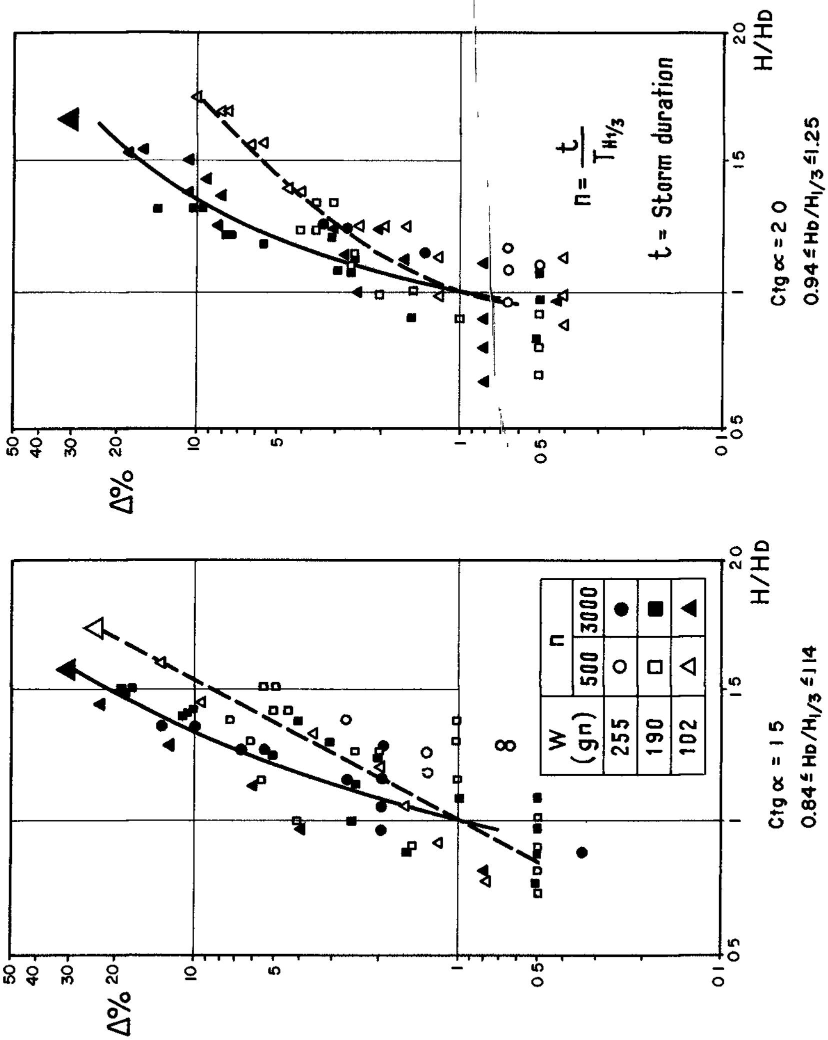

Fig. 3. Damage curves for different storm durations

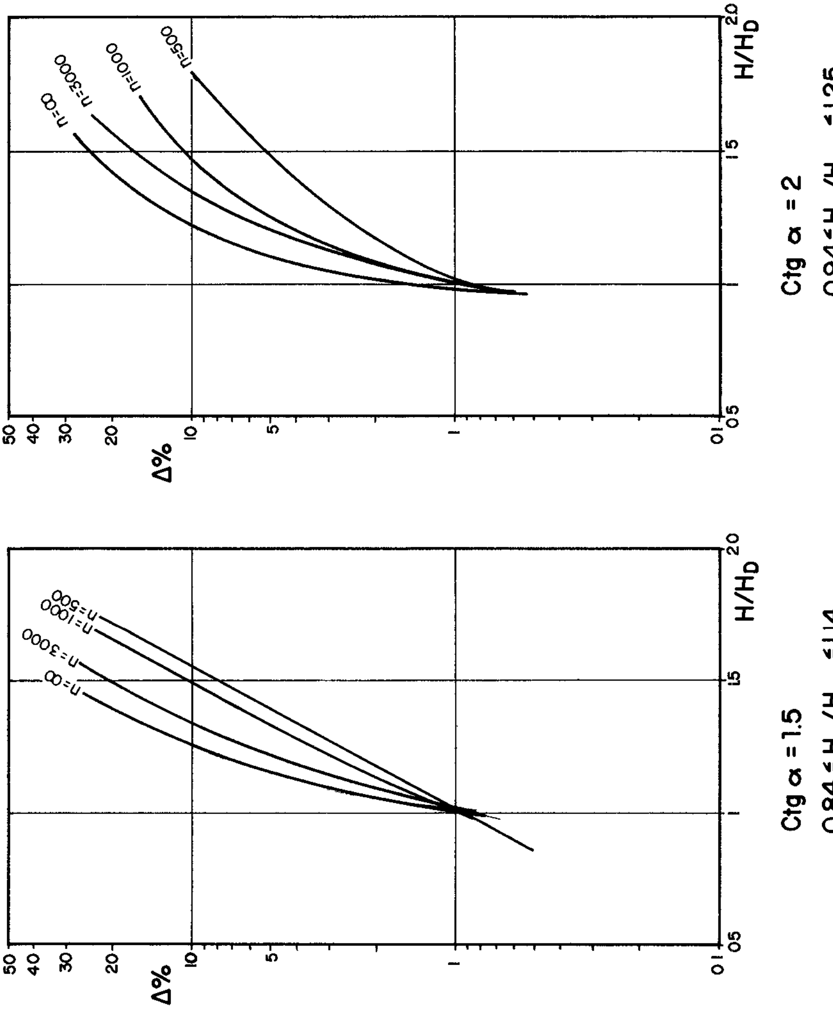

Fig. 4. Synthesis of experimental curves

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