CHAPTER 92

PRESSURE UPON VERTICAL WALLS FROM OVERTOPPING WAVES

by

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A B S T R A C T

This paper is concerned with the study of wave pressures exerted upon breakwaters of the vertical type from overtopping waves.

The formulae for maximum wave pressure upon vertical walls and the wave crest elevation for overtopping waves are suggested by the author. The phase interval method for the maximum wave pressure is also given.

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INTRODUCTION

The following symbols are used in this paper:

h – wave height;

λ – wave length;

τ – wave period;

H – depth of water measured from the still water level (SWL);

Z_{sw} – elevation of wave crest above SWL for a standing wave at 90° ($t = 0{,}25\tau$);

Z_{max} – maximum elevation of wave crest from overtopping wave;

P_{sw} – wave pressure intensity for a standing wave at SWL;

P^{o}_{max} – maximum wave pressure intensity from overtopping wave at SWL.

Experimental model study shows that elevation of wave crest and wave pressures upon a vertical wall from an overtopping waves decrease in comparison with conditions without overtopping. Wave pressures upon vertical walls decrease with the loss of the wall elevation above SWL.

The construction of a breakwater for overtopping waves requires less expenses than for a full profile of walls, but it is necessary to take into consideration increasing degree of agitation in harbours.

Overtopping of waves over sea-walls is a very complicated hydraulic phenomenon which consists of partial standing waves (clapotis partial - French) and of periodical flow with a variable water discharge.

The trajectories of the four indicators small balls of bitumen and paraffin with the liquid specific weight are shown on fig.1. On fig.1 the two of the indicators namely I and II are to the left from the knot; and two other indicators III and IV are between the knot and

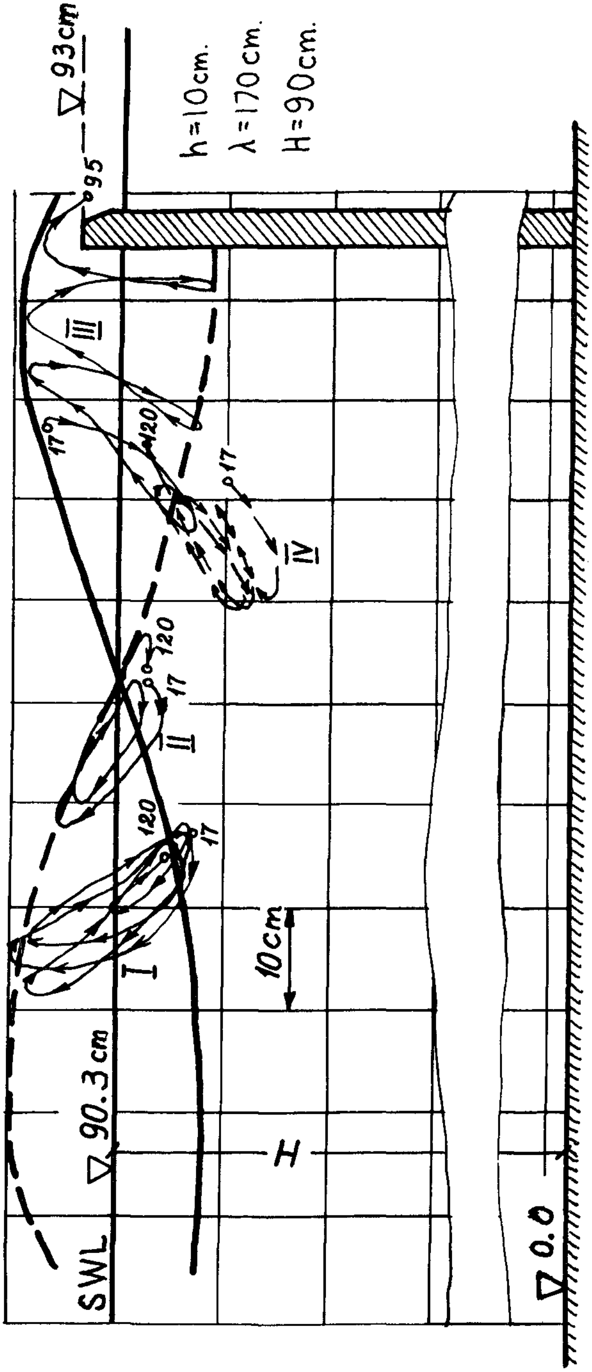


Fig.1. Movement of particles. (Film 24 cd/sec.)

the wall. The surface indicators I and II move along trajectories, which are typical curves of partial standing waves. There is no water current influence due to overtopping waves here.

The indicators III and IV show a complicated simultaneous movement of particles is inherent in the partial standing wave and the flow with variable discharge. As a result the indicator III move along a loop-type trajectory.

The mathematical description of this phenomenon is very difficult. The author has decided to use a wave flume in order to clarify the questions with the help of hydraulic models within the given experimental parameters.

We use the standing wave theory and experimental data, giving the coefficients for computation of the maximum wave crest elevation and wave pressures upon a vertical wall from overtopping waves.

MODEL AND EQUIPMENT

This study has been carried out by the author in a wave flume of a rectangular cross-section 23 m in length and 0.50 m wide with a water depth of 0.90 m.

The wall model was represented by a concrete block with a wood screen. Seven wave pressure-gauges and one level-gauge were sunk into the screen surface. The installation scheme and the placing all the gauges is given on fig.2.

The crest wall elevation above SWL is equal a =2.7cm The investigation has been carried out for the following parameters (see tabl. 1).

Table 1

h cm	λ cm	τ sec	$\frac{h}{\lambda}$	$\frac{H}{\lambda}$	$\frac{a}{h}$
1	2	3	4	5	6
10	170	1,06	0,06	0,53	0,27
17	210	1,20	0,08	0,48	0,16

The wavegenerator of a flap type was used to generate regulars waves with different wave periods and wave heights.

The wave pressures were measured by tensemetric gauges having a frequency 140 cycles per second. The wave heights were measured by electrical gauges. A sample of an oscillograph record is given on fig. 2.

Phases of wave indulations and the movement of ball indicators were recorded on a 35 mm film at 24 frames per sec. A sample of a film record is shown on fig.1. The trajectories of indicators I, II and IV from 17 up to 120 frames and the trajectory of the indicator III up to 95 frames are seen on this figure.

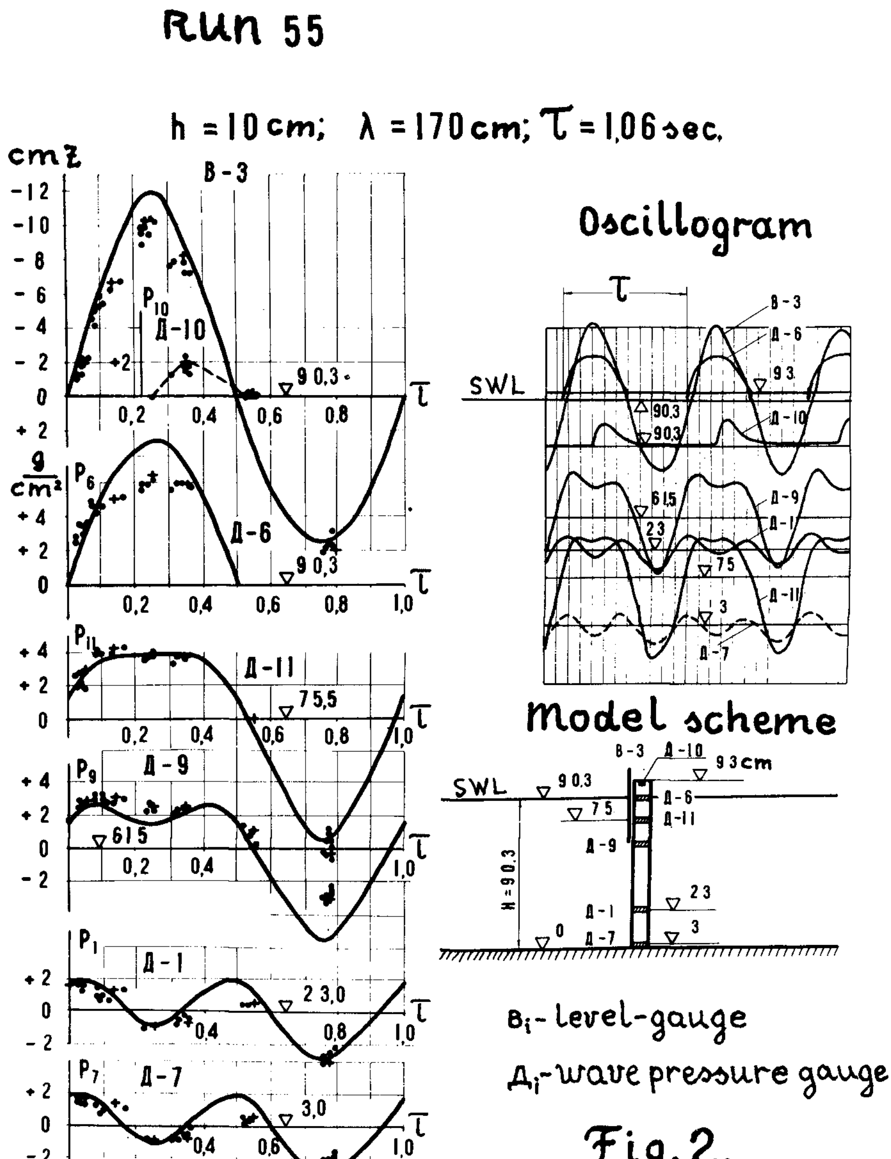

RUN 55
h = 10 cm; λ = 170 cm; τ = 1,06 sec.
Oscillogram
Model scheme
SWL
B-3
Д-10
Д-6
Д-11
Д-9
Д-1
Д-7
93 cm
90,3
75
61,5
23
3
H=90,3
Bi - level-gauge
Дi - wave pressure gauge

Fig. 2.

RESULTS

On fig.2 graphs of water level oscillation and wave pressure are shown by a continuous line according the calculation by the standing wave theory (1, 2 and 3) at condition without overtopping. Experimental data are also shown by points.

The decreases of water level elevation (see B-3) and wave pressures in the vicinity of still water surface (see Д-6) are clear from these graphs for overtipping waves in comparison with waves without overtopping.

Within the scope of experimental parameters:

- maximum wave crest elevation Z_{max} from overtopping waves is given by formula

$$Z_{max} = 0{,}8\ Z_{sw}$$

- maximum wave pressure at still water level from overtopping waves will be

$$P^{o}_{max} = 0.8\ P_{sw}$$

Values of wave pressures equal and below the level of 75 cm (see fig.2) up to from the bottom are practically equal to values calculated by the standing wave theory. Thus the decrease of wave pressures up to 20% due to wave overtopping are only noted from the still water level down to a depth about $(1.0 \div 1.5)\ h$.

Maximum resultant of wave pressures occurs at phase intervals from $0.10\,\tau$ to $0.15\,\tau$ (zero phase corresp-

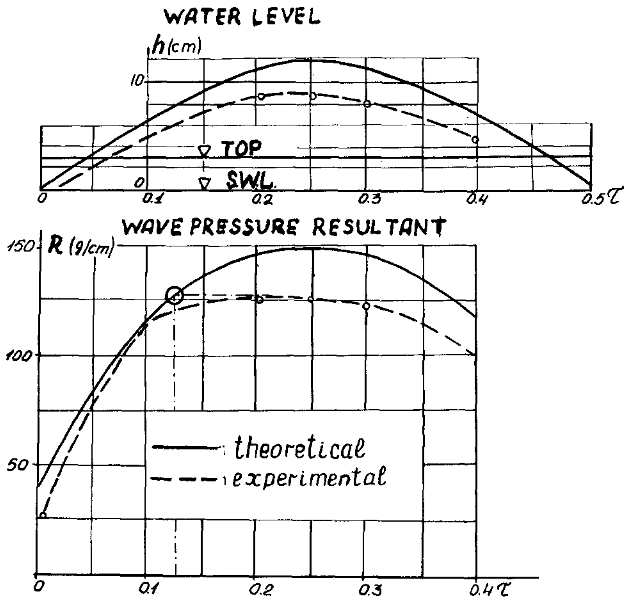
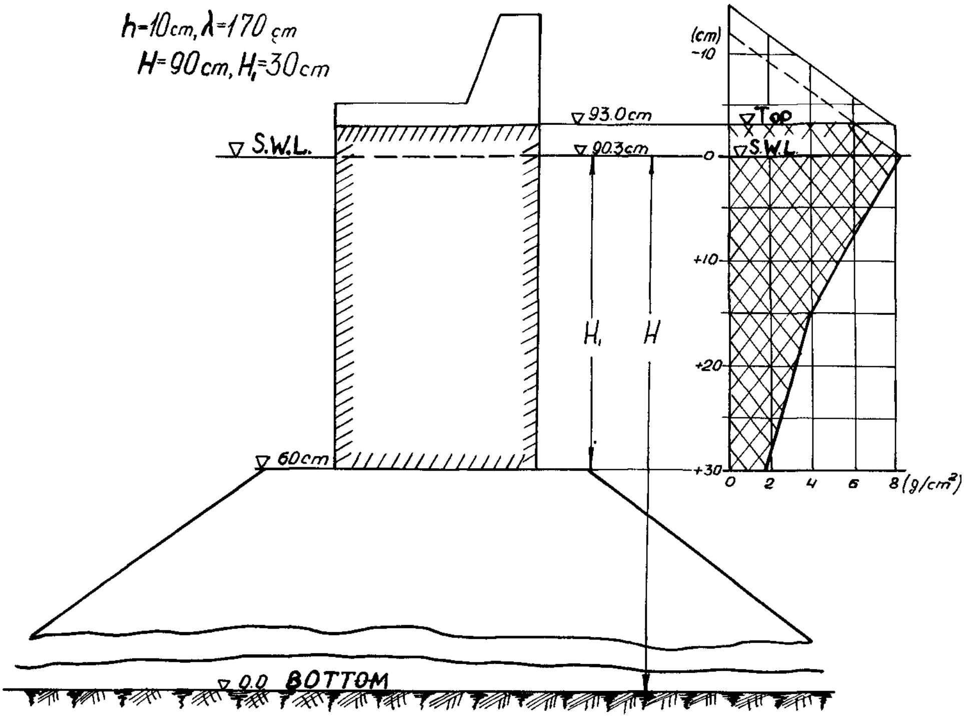

WATER LEVEL
h (cm)
10
0
TOP
SWL
0
0.1
0.2
0.3
0.4
0.5 τ
WAVE PRESSURE RESULTANT
R (g/cm)
150
100
50
theoretical
experimental
0
0.1
0.2
0.3
0.4 τ

Fig. 3.



h=10cm, λ=170 cm
H=90cm, H1=30cm
S.W.L.
93.0cm
90.3cm
H1
H
60cm
0.0 BOTTOM
(cm)
-10
Top
S.W.L.
0
+10
+20
+30
0
2
4
6
8 (g/cm²)

onds to the coincidence of the upsurging wave surface with SWL).

Computation of the maximum resultant of wave pressure may be carried out by a graphical method based on the standing wave theory for 4-5 phases values of the resultant in a phase interval from 0.10 τ up to 0.15 τ

The graphs of change the water level and the wave pressure resultant for semiperiod of wave calculated by the standing wave theory and by experimental data are given on fig.3. These curves of the wave pressure resultant are in corresponding to the wave pressure scheme indicated above on fig.3.

CONCLUSION

Wave crest elevationd and wave pressures upon vertical walls decrease from overtopping waves in comparison with a full wall.

Decrease of wave pressures occur only from SWL down to depth of about $(1.0 \div 1.5)$ h.

Maximum resultant of wave pressures due to overtopping waves occurs at a phase interval from $0.10\,\tau$ up to $0.15\,\tau$ for the scope of our experiments.

R E F E R E N C E

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