CHAPTER 101

THE INVESTIGATION OF THE WAVES AT THE BAY ON THE MODELS WITH FIXED BED AND THE ESTIMATION OF THE SCALE EFFECT

by

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SUMMARY

The wave model regime, in the given bay of the arbitrary outline, have been studing at the three scales 1:150, 1:300 and 1:450. The models had the fixed bed. The model of the scale 1:150 had been conditionally admited as the prototype at the investigation.

As a result of the study the scale effect for the present case have been found. The correction scale factors depend on the relative water depth.

The largest correction scale factors are $n = 1.5$ for the model scale 1:300 and $n = 2.1$ for the model scale 1:450. At these cases the relative water depth is less than $\frac{H}{\lambda} < 0.20$.

The correction scale factor is $n = 1$ for the model scale 1:300 and 1:450, if the relative water depth is more than $\frac{H}{\lambda} > 0.30 - 0.35$.

LIST OF SYMBOLS

h - wave height;

λ - wave length,

τ - wave period;

H - depth of water measured from SWL;

h_i - wave height at the point i;

λ - wave length at the point i;

$k_i = \frac{h_i}{h}$ - coefficient of the remaining wave height at the point i;

$n = \frac{K_{150}}{K_s}$ - correction scale factor (where S = 300 and 450)

INTRODUCTION

The determination of the model scale is one of the principal question at the study the port protection from waves. It is well known, that the model scales are applied from 1:40 up to 1:500 for such investigations in the practice of the hydraulic laboratories.

The relationship between the laboratory model figures and the same figures of the prototype is calculated by the Froud's law at any scale of the model. However, the loss of the wave energy is more at the models of the small scale than at the ones of the large scale. As a result we can have the underestimation of the wave heights. To avoid the underestimation of the wave heights some investigators (1,2) had proposed to introduce the correction scale for the wave heights at the port study on the models of the small scales. For example, T.Blu (3) takes notice that the relative wave heights at the model scale 1:400 are twice less than the ones at the model scale 1:100. We can find a lot of articles and research work (4-7) concerning to the dissipation of the wave energy at the model investigation.

The great interest to this problem is explained by natural desire to get reliable results at the least expenses and without wasting much time.

Indeed, at present time one can get the most reliable results for the estimation of the wave regime only with the help of the model study, as the analytical methods remain till now rather imperfect.

MODEL

The study of the wave regime had been carried out on the fixed bay model of the arbitrary relief. The general scheme of the bay model is presented in Fig.1. The situation of the wave generator and the points in which wave gauges were installed are also shown in the same Fig.1 and here you can see the direction of the wave fetch by the arrow, at which we have results presented in this paper.

The model of the bay was disposed on the concrete floor in the hangar. The bay isobaths had been drawn by the chalk on the concrete floor and according to the sheet iron strips of the appropriate size were placed. The space between the strips was filled up by sand, which had been moistened by water and had been rammed. The cement solution of 1,5 cm covered the sand model. After three-four days the model of the bay was prepared for the wave study. All models of the scale 1:150, 1:300 and 1:450 had been built in this way.

EQUIPMENT AND METHODS

The waves were generated by a flatter-type machine, driven by 10 kw- the direct current motor. The electric wave gauges

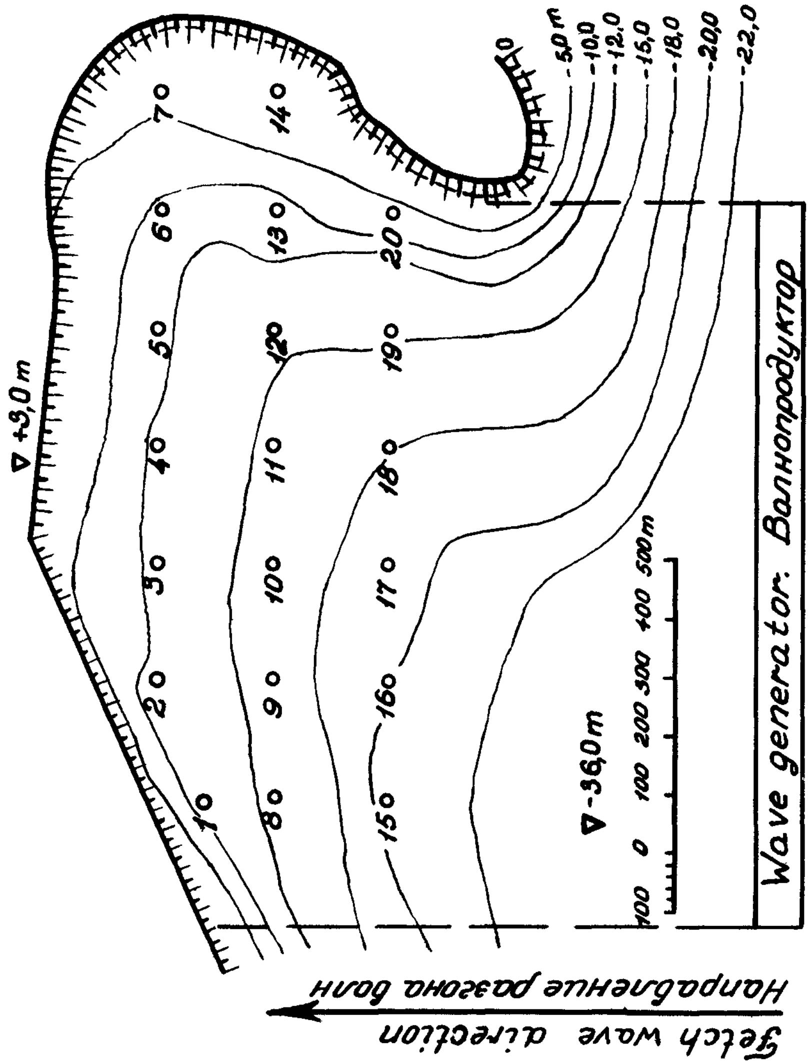

Fig. 1. Scheme of the bay
Рис.1. Схема бухты

of the ohm resistance were used to measure the wave heights.

The wave trains consisted up to 30 waves by 3 times and they were continiously recorded by the oscillograph on the photopaper belt.

We calculated the mean wave heights from $\frac{1}{3}$ of the largest wave height for any point. The relation of the mean wave height calculated by the above method, to the height of the initial wave, measured at the open sea, determined the coefficient of the remaining wave height at the given point $k_i = \frac{h_i}{h}$. If one knows the coefficient of the remaining wave height at every point it is possible to plot the isolines of the coefficients of the remaining wave height.

ANALYSIS OF RESULTS

The wave regime is shown for the three scale models in Table 1.

Table 1

NN	Name		Unit of measur.	Scale of model		
				1:150	1:300	1:450
1	Wave height	h	cm.	4.2	2.2	2.0
2	Wave length	λ	cm.	66	25	20
3	Wave period	τ	sec.	0,65	0,40	0,31
4	Wave depth in the open sea	H	cm.	24	12	8
5	Wave slopness	$\frac{\lambda}{h}$		15,6	11,2	10,0
6	Relative water depth	$\frac{H}{\lambda}$		0,36	0,48	0,40
7	Mean water depth in the bay	H_1	cm.	12	6	5,5

As shown in Table 1 the waves were of considerable steepness and they were generated at rather great water depth. According to the Froud's law the wave characterisations of the prototype are following: h = 4,5 m, λ = 70 m and τ = 7 sec.

The estimation of the automodelity of mean wave regime in the bay for the all three scale models was made by Reynolds' number according to Mich's and Ofitzerov's formulas

$$R_m = \frac{U_g H_1}{\gamma} \qquad (1)$$

where $U_g = \dfrac{\pi h}{\sqrt{\dfrac{\pi\lambda}{g}\, sh \dfrac{4\pi H_1}{\lambda}}}$ – bottom velocity

γ = 0.011 (t = 15°C) kinematik viscosity of water

$$R_o = \frac{U_n h}{\gamma} \qquad (2)$$

where $U_n = h\sqrt{\dfrac{\pi g}{2\lambda}\, cth \dfrac{2\pi H_1}{\lambda}}$ – orbital velocity

Table 2 schows the Reynolds' numbers for the all three models

Table 2

	1:150	1:300	1:450
R_m	14200	4200	3500
R_o	8500	3620	3450

In Table 2 on can see that the Reynolds' numbers for all the models appeared to be more than 2000.

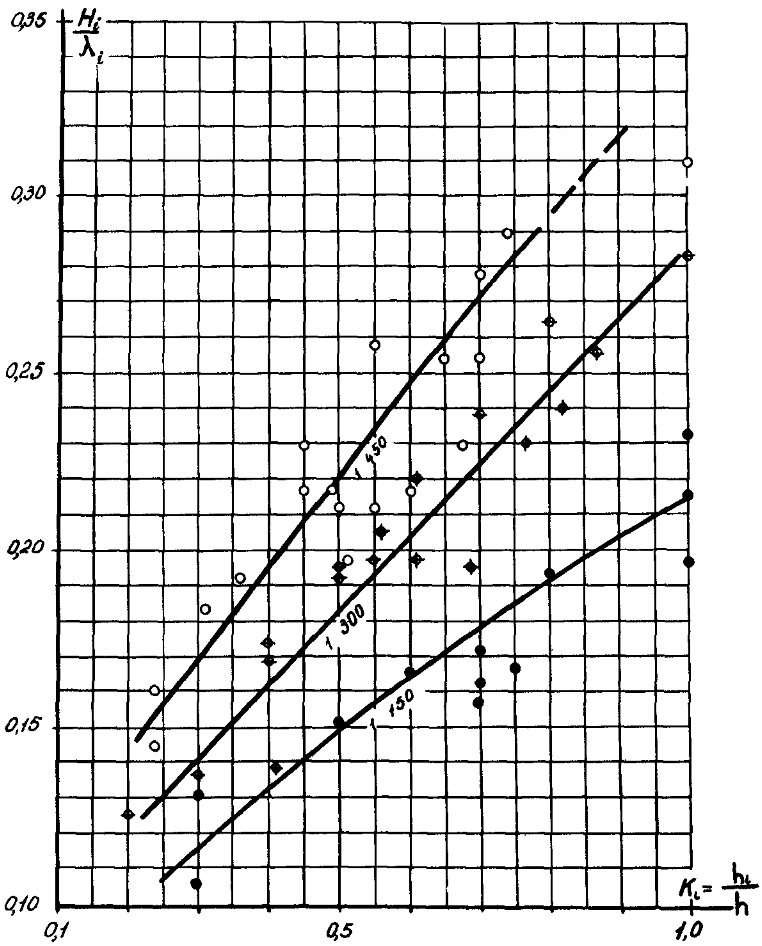

Fig.2 Relationship between K and $\frac{H_i}{\lambda_i}$ to three model scales

Рис.2. Зависимость коэффициента остаточной высоты волны от относительной глубины воды

It allows to believe that the wave regimes in all our models are within the limits of the same automodel zone.

The values of the coefficient of the remaining wave height and the relative water depth to any point were calculated. The values were then marked on the paper and by them one drew the three curves (Fig.2). The curves are in entire confirmity to each other.

The less the scale of the model - the more the curve steepness and therefore, for the same relation of the water depth to the wave length $\frac{H_i}{\lambda_i}$ the coefficient of the remaining wave height K_i is appeared to reduce with the decreasing of the model scale.

The dissipation of the wave energy results from the turbulent viscosity of the water and the bottom friction. The less the relative water depth $\frac{H_i}{\lambda_i}$ the more the loss of the wave energy because of the bottom friction.

I.Stepanov (8) notes in his work, that the information about the influence of the turbulent viscosity upon the decreasing of the wave height is very contradictory.

The dependency between the relation of the coefficients of the remaining wave heights of the studied models $n = \frac{K_{150}}{K_s}$ and the relative water depths $\frac{H_i}{\lambda_i}$ are given in Fig.3 The Fig.3 is based on Fig.2.

In Fig.3 one can see that the correction scale factor $n = 1$ for the models with the scale 1:300 and 1:450 when the relative water depths are $\frac{H_i}{\lambda_i} \geqslant 0.30 - 0.35$, but when the relative water depths are $\frac{H_i}{\lambda_i} < 0.20$ we have $n = 1.5$ for the scale 1:300 and $n = 2.1$ for the scale 1:450.

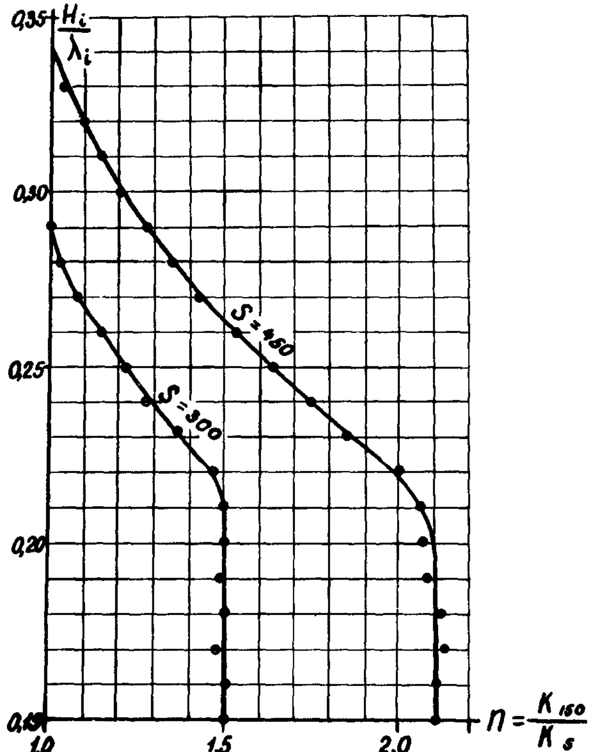

Fig. 3 Relationship between $n = \frac{K_{150}}{K_s}$ and $\frac{H_i}{\lambda_i}$ (where S = 300 and 450)

Рис. 3. Зависимость отношения $n = \frac{K_{150}}{K_s}$ от относительной глубины воды (где S = 300 и 450)

As the relative water depth $\frac{H_i}{\lambda_i}$ decreases from 0,30 up to 0.20 the correction scale factor increases.

CONCLUSION

The investigation carried out can not claim to establishment the correction scale factors in all possible cases. However, these investigations display great importance of the problem, which can be solved more completely by the investigation of the scale series including wave research in field conditions.

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