CHAPTER 60

THE EFFECT OF WAVE CRESTS ON WAVE FORCES

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ABSTRACT

This paper deals with wave forces from short crested waves as compared with two dimensional waves. The investigation comprised measurements of wind wave forces on fixed pontoons in a model, and a comparison of wave crest characteristics of wind waves in model and prototype. The model tests showed that the wave crests have a marked influence on the wave forces. The investigation of model and prototype wave data showed that the crest characteristics of the model waves compared well with that of prototype sea.

INTRODUCTION

As known, wind waves are three-dimensional and short crested. When a structure, e.g. a pontoon, is exposed to short crested waves the total force at any moment is determined by the instantaneous water level along the entire length of the structure. If the structure is of approx. the same length as the wave crest, the resultant force will differ considerably from that of the two dimensional case.

The paper deals with an investigation conducted at the River and Harbour Laboratory at the Technical University of Norway to give some information of the effect of wave crests on wave forces as compared with two dimensional waves.

The investigation comprised measurements of wind wave forces on fixed pontoons in a model and a comparison of wave crest characteristics of wind waves in model and prototype.

MODEL TESTS

Model tests have been conducted in a channel with wind generated waves, and horizontal forces on a fixed pontoon were measured. The test arrangement is shown schematically in Fig. 1.

Four pontoons with different lengths (λ = 50-150-200 and 350 cm) in the crest direction were used. The resultant horizontal force was measured by use of strain gauges as indicated in Fig. 1. Practically no wave energy was transmitted to the lee-side of the pontoon, and pressures on the front wall in regular waves with periods in the range of periods of the wind wave spectrum, was found to be equal to the pressures on a vertical wall extended to the bottom.

Fig. 2 shows the energy spectrum and wave height distribution of the incident waves at the location of the front wall of the pontoon. The waves were generated over a fetch of 46 metres with a wind velocity of approximately 8 m/sec. The water depth of 108 cm was "deep water" for all waves present in the wave spectrum.

Fig. 3 shows the distribution of horizontal forces per unit length in the direction of the wave propagation for the four pontoons. The distribution is calculated on the basis of 200 successive force peaks.

The diagram, Fig. 4, shows the maximum force per unit length as a function of a relative pontoon length λ/L_o. L_o designates a characteristic wave length of the wave spectrum; the length of a sinusoidal wave with a frequency equal to the peak frequency of the wave spectrum. F_o is the interpolated maximum force for a relative pontoon length $\lambda/L_o = 1.0$.

As shown in Fig. 3 and 4, the crests of the wind waves in the model had a marked influence on the resultant forces on the pontoon.

COMPARISON OF WIND WAVES IN MODEL AND PROTOTYPE

In connection with the tests a comparison of wind waves in model and prototype has been made. The prototype data have been taken from the SWOP project (1) where stereo photographs of the water surface were obtained and maps of the instantaneous water surface were prepared. In the present investigation profiles of the water surface in the crest direction have been drawn on basis of these maps.

In the model profiles in the crest direction were obtained by photographing the waves as they passed through a finely meshed screen suspended across the channel in the crest direction.

The crest data have been treated as illustrated in Fig. 5. The moving average of the surface level along the crest profiles over a series of lengths, λ', has been calculated. In this manner, one gets the data in a form similar to the test results; λ' corresponding to the pontoon length, λ, and the mean water level, $\bar{\eta}$, corresponding to the resultant force per unit length.

The total length of crest profile used for the analysis was 100 L_o, and the moving average water level has been calculated for a range of λ' from 0,1 L_o to 10,1 L_o.

The results of the crest analysis are shown in Fig. 6, where the maximum values of $\bar{\eta}$ are plotted against the relative length λ'/L_o. The $\bar{\eta}_o$ is the maximum water level above still water level for $\lambda'/L_o = 1.0$.

In the model, the crest profiles have been investigated for two fetch lengths, 34 and 46 metres. In order to indicate the scatter for a profile length of 100 L_o, two sets of profiles for the fetch length of 46 metres has been treated.

COMMENTS

The results of the crest investigation as shown in Fig. 6 indicate that the wave crest distribution of the three dimensional SWOP sea is rather similar to that of the model sea. However, the prototype data used for the comparison are very limited and the results apply to deep water conditions only. While the test results must be used with reservation for prototype design, the test results demonstrate that the wave crest represents an important feature of wind waves in relation to the design of certain types of structures.

REFERENCE

Cote et.al.: The Directional Spectrum of Wind Generated Sea as observed from Data obtained by Stereo Wave Observation Project.
Meteorological Papers, Vol. 2, No. 6, New York University.

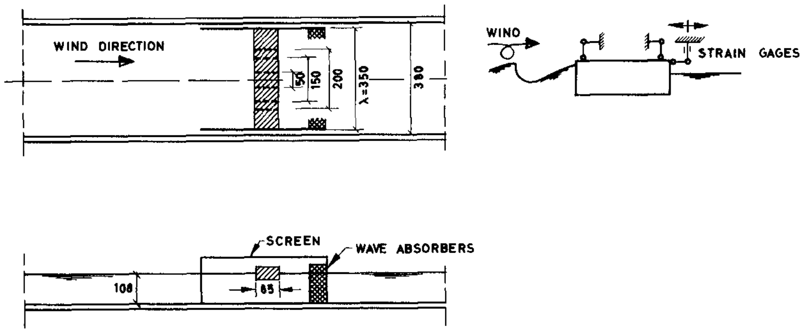

FIG 1 TEST ARRANGEMENT

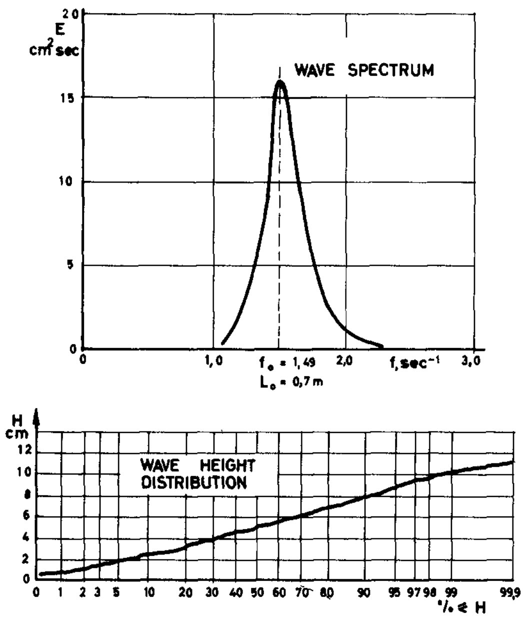

FIG 2 WAVE DATA FROM MODEL

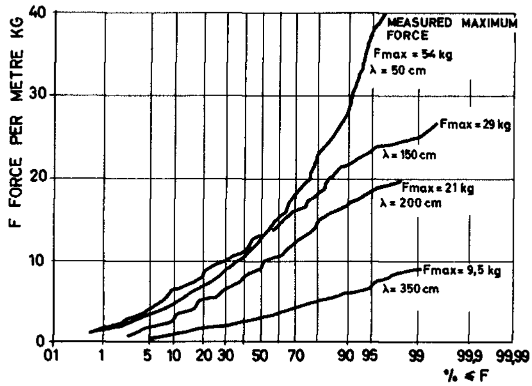

FIG 3 DISTRIBUTION OF RECORDED FORCE PEAKS DIRECTED INWARDS

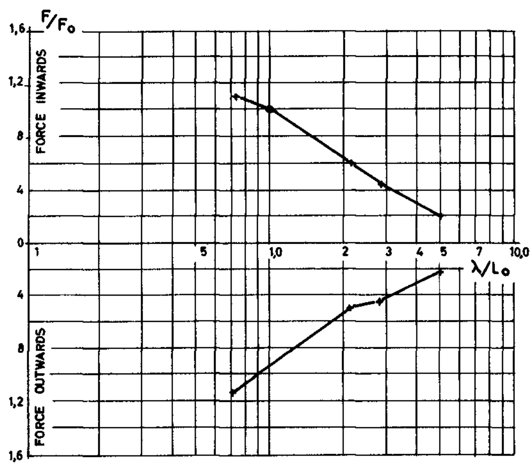

FIG 4 MAXIMUM FORCE PER UNIT LENGTH VS VALL LENGTH

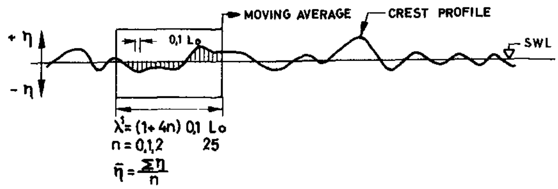

FIG 5 CALCULATION OF MEAN WATER SURFACE LEVEL DISTRIBUTION

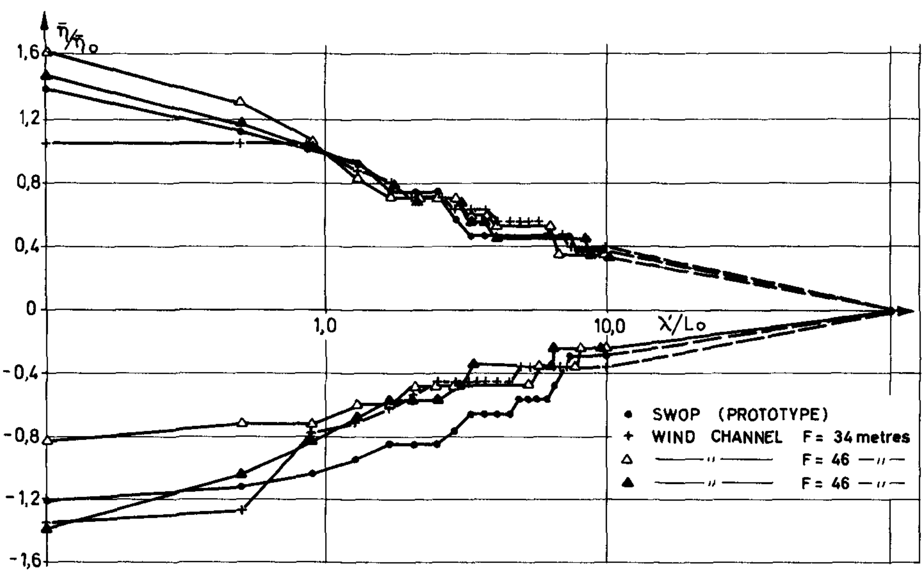

FIG 6 MAXIMUM MEAN SURFACE LEVEL IN CREST DIRECTION