CHAPTER 45

MODEL STUDY ON THE IMPACT OF WAVES

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1. INTRODUCTION

The problem to be investigated is the structural strength of a sluice gate under the influence of wave attack. The gate was designed in view of the hydraulic forces in quasi permanent conditions.

The fact, however, that the gate is exposed to wave attack, necessitates an investigation of:

1) the transient forces due to impact,

2) the possibilities of modificating the shape of the gate in order to avoid, or at least to diminish, the chance on the occurrence of impacts.

As the mechanism of wave attack is influenced by the hydrodynamic properties of the oncoming waves, the tests are being carried out in a flume in which the waves are generated by wind in order to simulate the expected extreme natural conditions as close as possible.

Since the effects of impact are determined by the elastic properties of the structure, the final tests are being carried out by means of models with an elastic behaviour in accordance with the model scales. These tests have been designed in close cooperation with the laboratory of mechanics of solid materials.

The first phase of the model study deals with the way in which the impact is influenced by the angle of inclinatiom of the face of the gate.
The model tests have been carried out with three different positions of the gate, viz:

a) with forward inclined face,

b) with backward inclined face,

c) with vertical face.

Although the model study has not yet been concluded, it may be of interest to present already at this stage a brief report on the results obtained sofar.

The three positions of the gate are shown in figs. 1, 2 and 3 and part of the observations, recorded with each of these positions, are shown in figs. 4, 5 and 6. Fig. 7 gives four stages of a brea-

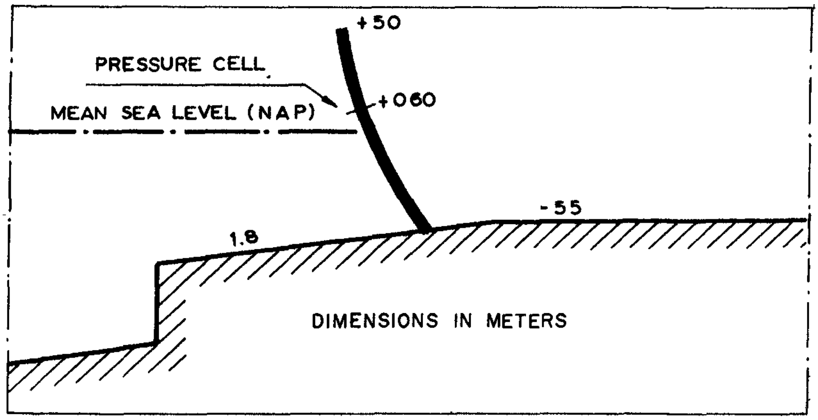

Fig. 1. Forward inclined face.

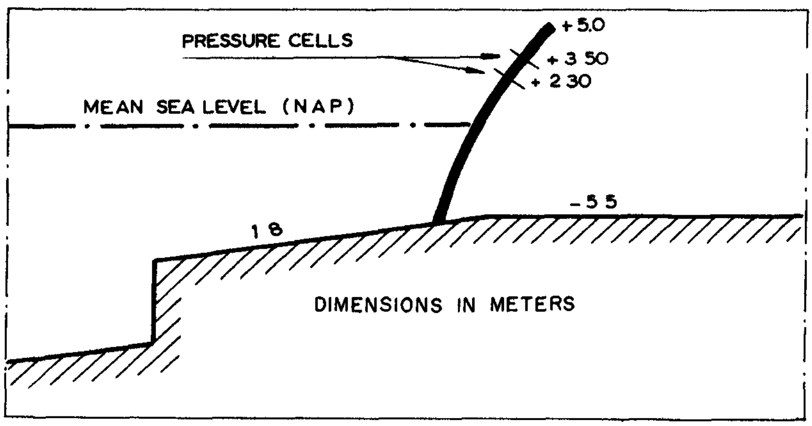

Fig. 2. Backward inclined face.

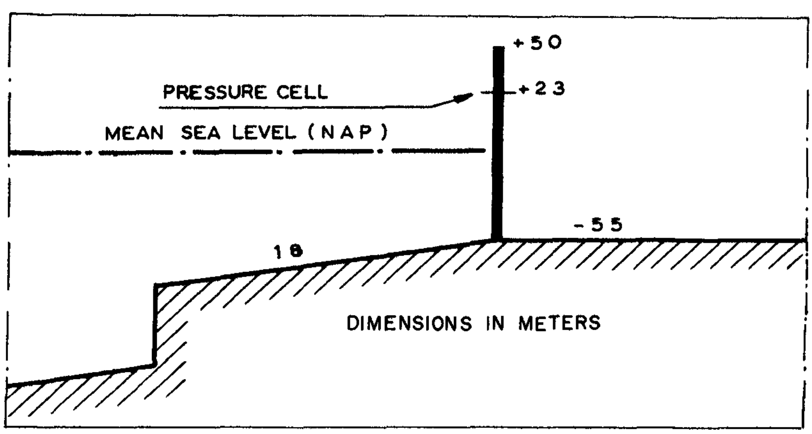

Fig. 3. Vertical face.

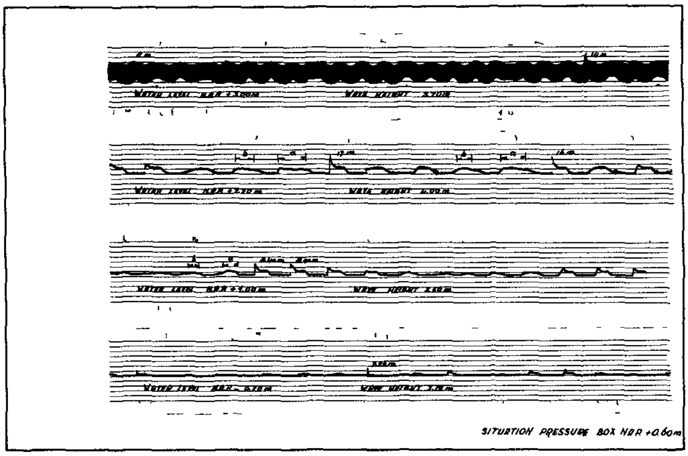

Fig. 4. Pressures on forward inclined face.

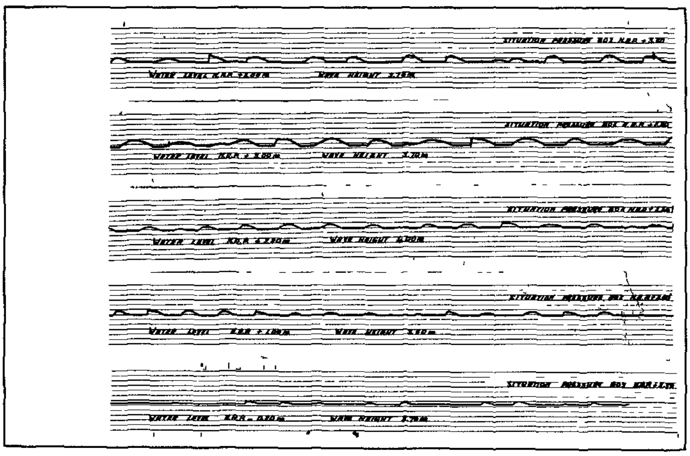

Fig. 5. Pressures on backward inclined face.

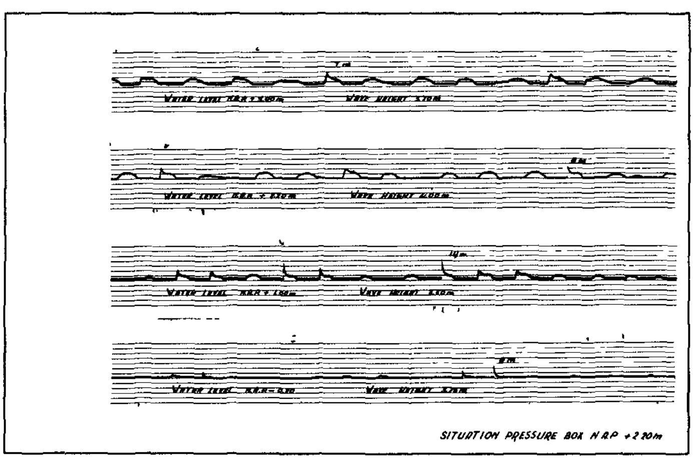

Fig. 6. Pressures on vertical face.

king wave in the case of a gate with forward inclined face.

During each of the three positions the height of the waves varied from 3.5 to 4 metres, while the water level varied from 0.2 m below to 3 m above Mean Sea Level (N.A.P.).

The tests have not advanced sufficiently far to determine th zone of impact and the magnitude of the areas struck by the pressu shocks.

2. APPARATUS AND PROCEDURE

The tests are being carried out in the 100 m long and 4 m wi wind and stream flume of the open-air laboratory at De Voorst (a subsidiary of the Delft Hydraulics Laboratory), in which flume wav can be generated by means of an air current blowing over the water surface, as well as by means of a wave machine.
A model of the sluice gate, on scale 40, was placed at the lower end of the flume and exposed to waves produced by the combined action of wind and wave machine.

Since a wave is a flow phenomenon with free surface, and sin the wave height can be expressed as a function of the square of th wind velocity, wave period and wind velocity in the model were tak in accordance with Froude's law.

The pressure fluctuations were measured by means of a pressu cell placed at different heights in the outer face of the gate. In order to eliminate the possibility of a reduction in magnitude of the pressure shocks resulting from a yield of the face of the gate the pressure cells were fixed in a block of concrete, thus obtaini a surface as rigid as possible.

As the pressure shocks are of a very short duration (increas from zero to maximum), viz. in the order of 1/500 sec., it is important that the natural frequency of the membrane of the pressure cell is very high compared to that of the forced displacement in order to minimize disturbance of the measurements by resonance. Fo this reason the membrane was given a frequency of 1.400 Hz.
The pressure cells are of the capacitance type. Displacement of th membrane causes a change in capacitance which is recorded on a film by means of an oscilloscope.

In the wave troughs the water level falls below the elevatio of the pressure cell, thus indicating on the film the zero positio (atmospheric pressure) of the pressure observations.

3. THE TEST RESULTS

a) GATE WITH FORWARD INCLINED FACE

During the model tests with forward inclined face (figs. 1 and 4) the pressure cell was placed at a height of 0.6 m above M.S.L.. The pressure shocks occurred with wave heights exceeding 2.5 m, independent of the water level.

As may be seen from fig. 4, pressure shocks were also recorded, with the pressure cell at + 0.6 m, at high water levels (3 m above M.S.L.). This is not much higher than the level of the trough of the wave. Evidently pressure shocks may be expected over the full height from wave trough to wave crest.
The maximum pressure recorded was 1.8×10^5 newton/m^2 (25.5 psi).

Visually it was observed that the waves showed a beat phenomenon caused by the wind.
The first breaking wave fills up a trough; the second one may cause a pressure shock. This is shown in fig. 4 by a prolongation of the wave pressure preceding the pressure shock ("a" is longer than "b").

Each pressure shock is followed by a "pressure ridge", which indicates that the shock occurs at the front of a wave: the pressure ridge is the remainder of the wave which is partly reflected and partly overtopping the gate.

Fig. 7 gives four pictures of such a breaking wave. The simultaneously recorded pressure did not show a shock, nor did the wave break in a trough (the pressure cell did not reach below the trough preceding this wave).

b) GATE WITH BACKWARD INCLINED FACE

During the model tests with backward inclined face (figs. 2 and 5) the pressure cell was placed at heights of 2.3 m and 3.5 m above M.S.L.

As may be seen from the pressure fluctuations shown in fig. 5, not a single shock was recorded. As a result of lesser reflection, the waves were in this case less steep than in the case of a gate with forward inclined face.

c) GATE WITH VERTICAL FACE

During the model tests with vertical face (figs. 3 and 6) the pressure cell was placed at a height of 2.2 m above M.S.L.

The pressure diagram of fig. 6 shows that the pressure fluctuatuions are about the same as in the case of a gate with forward inclined face.

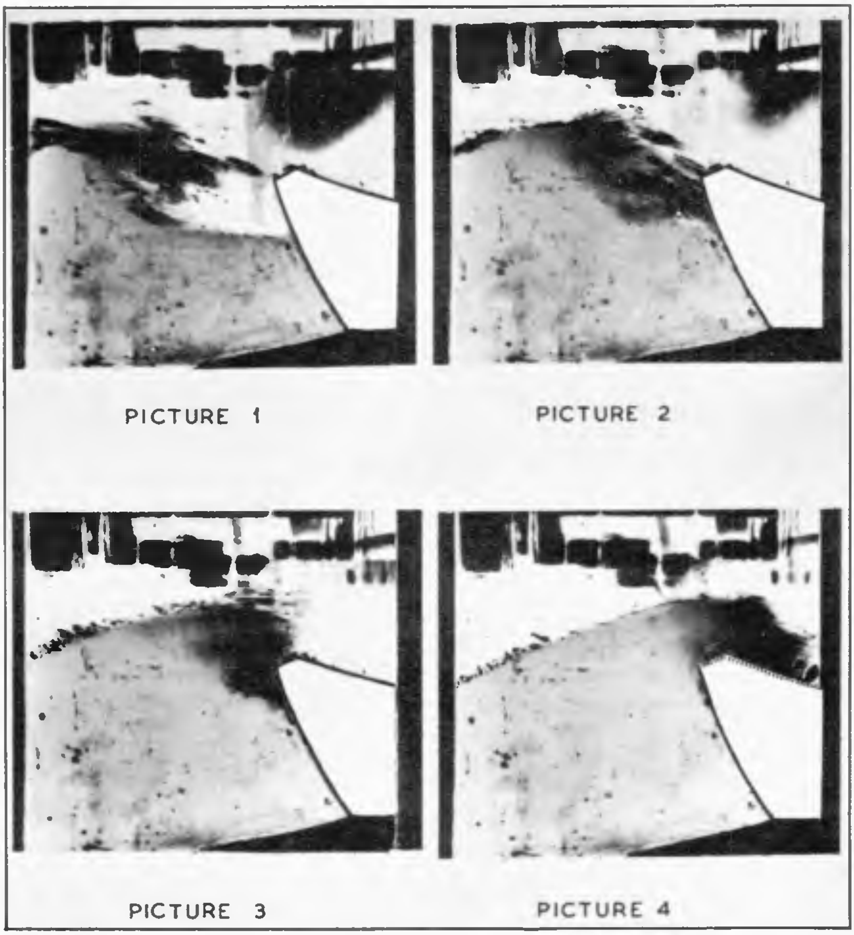

Fig. 7. Photograph of breaking wave.

The observations indicate a tendency of the pressure shocks to decrease in strength with increasing height of the water levels (3 m above M.S.L.). The crests of the breaking waves overtop the gate, resulting in less reflection, less steepness, and less breaking of the waves.

However, the possibility should not be excluded that (though with a lesser degree of frequency) the combination mentioned under a) may occur.

ACKNOWLEDGMENT

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