CHAPTER 3

WAVE RECORDING ON THE IJSSELMEER

P.W. Roest
Engineer, Zuiderzee Works
The Hague Netherlands

SUMMARY

The preliminary results of waverecording on the IJsselmeer are presented in this paper. The measurements have been carried out with a floating waverecorder (accelerometer on raft).

Wave heights and periods, windvelocity, fetch, depth, temperature of water and of the atmosphere and the siltcontent of the water have been determined.

The results have been compared with the diagrams of Thijsse and Bretschneider. The distribution of the wave heights is mentioned.

INTRODUCTION

The dimensions of the dikes in the IJsselmeer are mainly determined by wave-attack.

The dimensions of the waves as a result of the design gale are calculated with the diagram of the Hydraulics Laboratory at Delft (ref. 1). This diagram is based on data of Sverdrup for deep water and principally on laboratory studies for shallow water.

For a long time there has been a need of wave recordings on the lake in order to verify the calculated wave heights. A problem is the impossibility of maintaining a permanent recording station on the lake due to ice-drift in wintertime. Otherwise the IJsselmeer lends itself admirably to wave-research, because there are vast regions with only small variations in waterdepth. Another advantage is that frequently more or less stationary conditions will occur under the influence of winds of constant force and direction.

When Dr. Dorrestein of the Royal Dutch Meteorological Institute introduced his new floating waverecorder, it was possible to take observations in every place of the lake. Soon it appeared that this recorder has many advantages.

The equipment consists of an accelerometer mounted on a little raft of one meter each way, that follows the movement of the water surface. The signal of the accelerometer is transmitted by an electric cable to the ship, where it is double integrated and then recorded (ref. 3).

During the last winter several observations have been carried out with an instrument of this type. As a result of initial troubles with the electronic equipment the number of observations during gale-conditions has been limited.

The usual duration of each recording is about 15 minutes. The average period of the waves lies between three and a half and five seconds, so each diagram consists of 180 to 250 waves.

..ave height is measured as the difference in height between a trough and the next crest. The average period is determined by dividing the total recording time by half the number of zero-crossings.

OBSERVATIONS ON THE IJSSELMEER

In order to simplify the interpretation, observations were taken in places, where the fetch is measured over an area of nearly constant depth.

On fig. 1 - a map of the lake - the different places and their fetches are shown. In the southern part of the lake the depth is up to 4 meters; the northern part is somewhat deeper.

The velocity of the wind was measured on board a ship, three meters above sea-level. Besides the recordings of the meteorological station at Lelystad were available. There the wind is measured at 10 meters above sea-level. The temperature of the atmosphere and of the water and the silt-content of the water were also measured.

The appendix gives a summary of the results.

It appears that all distributioncurves of waveheights have the same shape and that they agree very well with the Raleigh distribution, just like deep water waves. Fig. 2 shows the cummulative distribution of the wave heights of several recordings. The scale has been chosen in such a way that Raleigh distributions become straight lines.

The distributions may have been slightly affected due to drifting of the raft.

The significant wave heights have been compared with the diagrams for shallow water waves of Thijsse and Bretschneider. It appears that almost all strong wind observations give smaller heights than those calculated with these diagrams, but that the only observation under gale conditions is comparable with the calculated one.

Fig. 3 shows the Delft diagram in which the observed wave heights have been plotted. As known the diagram is dimensionless. The height (H), fetch (F) and depth (D) are divided by twice the velocity head of the wind.

The dots are the calculated points from fetch, depth and windvelocity. The circles are giving the observed heights on the same dimensionless scale.

To use this diagram the observed windvelocity ought to be converted into the velocity W_o on a level proportional to the square of the windvelocity. This means, that with small windvelocities the observation height must be reduced to a lower level than with high velocities.

On fig. 4 the observed wave heights have been plotted against the water depth. Only observations with a long fetch have been plotted. The solid line agrees with the Delft diagram. It appears,

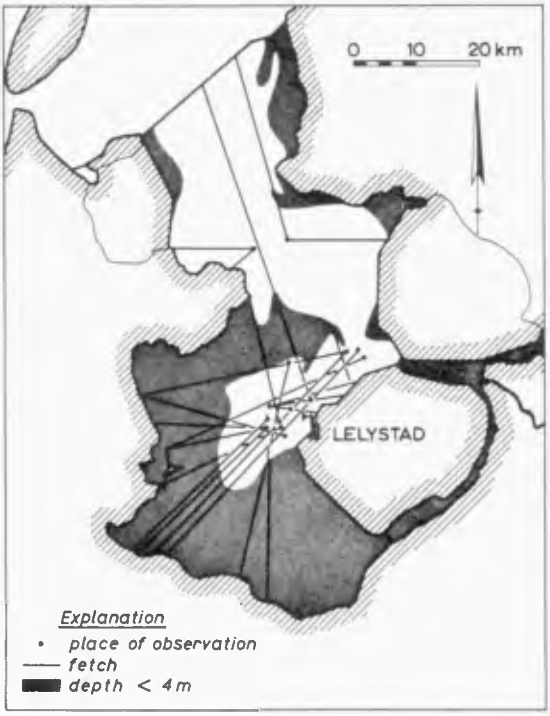

Fig. 1. The IJsselmeer.

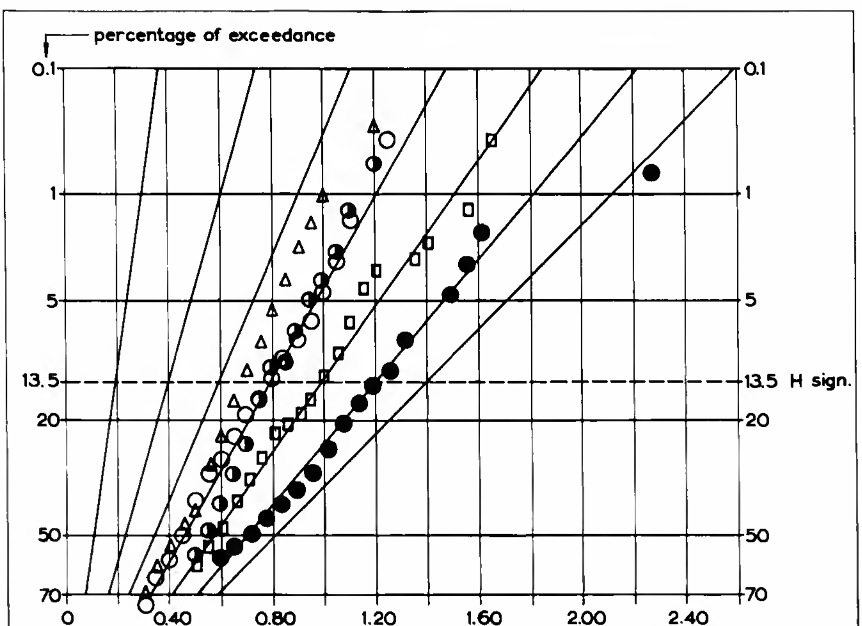

Fig. 2. Cumulative distribution of wave heights of 5 recordings.

that the observed values are systematically lower than this line.

Besides the results have been compared with a diagram of Bretschneider (ref. 2). This diagram gives smaller waves as the Delft diagram in the region of long fetch and shallow water. This leads in this region to a somewhat better agreement with the observations on the IJsselmeer.

DISCUSSION OF THE RESULTS

There is not yet a good explanation for the difference between the measured waveheights and the ones determined from the mentioned diagrams, based on observations elsewhere.

Some explanations have been considered.

The waverecorder. - In the first place there may be errors of the waverecorder e.g. due to the tilting of the raft (ref. 3). This has been examinated by comparing the floating recorder with a step-resistance recorder as well as with a recorder measuring with a float. Both recorders are suspended on poles off the coast in the Northsea.

Simultaneous recordings of both meters with the floating recorder have been carried out. The waves could not be compared individually. Only the statistical similarity of the recordings has been examinated.

The differences of the significant waveheights computed from simultaneous recordings of the stepresistance and the floating recorder were less than 10%. A comparison with the second type recorder gave exactly the same distributions of the waveheights.

For the present it may be concluded from these comparisons that the results of the floating recorder do not deviate appreciable from other known methods of observation.

The temperature. - Secondly there is the influence of the temperature. Most observations have been made while the temperature of the atmosphere was somewhat higher than that of the water. The observations under different conditions indicate a small influence of the difference of temperature between water and air.

The siltcontent. - A single remark on the influence of the silt content of the water may be made. The top layer of the bottom of the southern part of the lake consists mainly of clay. During a long stormy period the silt content of the water may increase to about 1 gram per liter. Boatmen familiar with the lake state a reduction of the waveheight when the siltcontent of the water increases and as a result of this, navigation seems to be easier according as a windy period lasts longer. The wave recordings did, however, not show any clear influence of the siltcontent on the height of the waves.

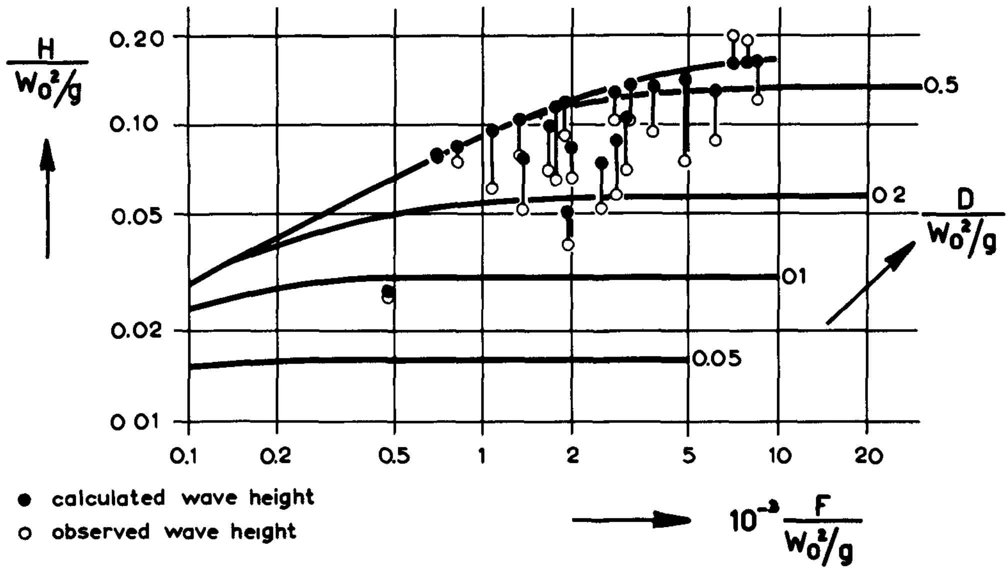

Fig. 3. Measured and calculated wave heights plotted in the Delft diagram.

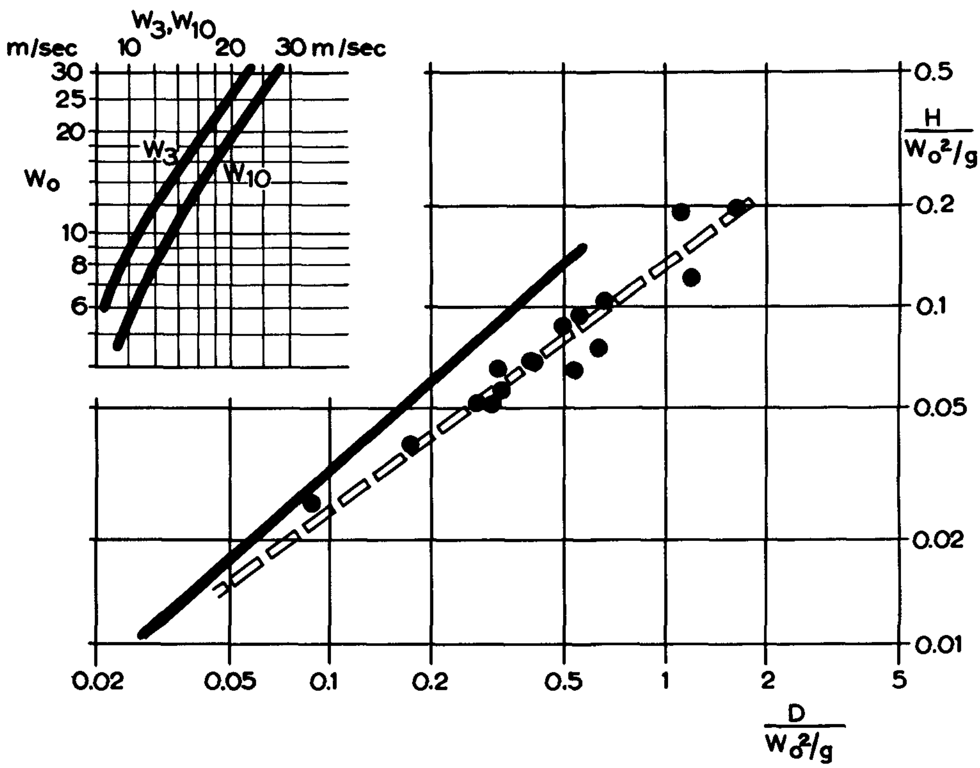

Fig. 4. Measured wave heights (shallow water and long fetch).

All things considered, it does not appear that the results are affected by local circumstances. The dashed line in fig. 4 may have a more general significance. Further wave observations will have to prove this.

REFERENCES

1. Thijsse, J.Th. "Dimensions of wind-generated waves". Assembly I.U.G.G. Oslo,1948. International association of scientifical hydrology.

2. Bretschneider, C.L. "Revisions in wave forecasting, deep and shallow water". Proceedings of sixth conference on Coastal Engineering, 1957.

3. Dorrestein, R. "A wave recorder for use on a ship in the open sea". Proceedings symposium. On the behaviour of ships in a seaway. Wageningen, 1957.

APPENDIX

Summary of the results

Date	D	F	W_3	W_{10}	t_w	t_a	Silt	Hsign	H_{50}	Period
	m	10^3m	m/sec	m/sec	°C	°C	mg/liter	m	m	sec
6- 1-'58	3,50	9	-	11	2,6	4	-	0,43	0,26	3,4
6- 1-'58	4,30	32	-	12	2,6	8	-	0,46	0,28	3,5
7- 1-'58	4,10	22	-	21.5	3,3	5	1033	1,21	0,71	5,0
29-10-'59	4,35	54	11	12	9,9	11	64	0,77	0,45	3,6
9-11-'59	3,15	20	12	11	6,1	5	250	0,65	0,42	3,4
9-11-'59	3,95	35	13	11	6,6	5	163	0,69	0,39	3,5
4- 3-'60	4,05	19	9	12	5,8	7	248	0,64	0,38	3,5
4- 3-'60	4,60	32	8	11	4,7	7	50	0,45	0,28	3,2
7- 3-'60	4,35	7	11	12	3,5	1	297	0,64	0,38	3,5
8- 3-'60	4,20	14	11	11	3,1	-2	242	0,51	0,30	3,8
9- 3-'60	4,20	12	11	12	2,7	3	398	0,68	0,43	3,8
9- 3-'60	3,65	17	9	10	2,7	6	196	0,66	0,39	3,4
11- 4-'60	4,20	19	12	14	9,3	9	284	0,70	0,46	3,8
11- 4-'60	5,70	12	11	14	8,4	9	109	0,66	0,40	3,8
12- 4-'60	4,15	18	8	9	9,4	10	185	0,50	0,28	3,0
12- 4-'60	5,90	5	11	10	9,2	11	96	0,58	0,36	3,2
13- 4-'60	4,35	29	11	11	9,3	10	245	0,73	0,44	3,8
13- 4-'60	3,95	45	16	13	9,3	12	372	0,89	0,58	4,2
14- 4-'60	4,15	17	11	13	9,3	10	294	0,70	0,44	3,6
14- 4-'60	3,75	34	12	14	9,3	10	181	0,71	0,43	3,7
6- 7-'60	4,35	30	-	10.5	15,3	15	160	0,72	0,46	3,8
18- 7-'60	4,30	21	10	12	17,1	18	125	0,76	0,49	3,6
18- 7-'60	4,55	35	12	12.5	18,2	19	159	0,79	0,53	3,8

Explanation

W_3 Windvelocity at 3 m ebova sealeval (place of observation)

W_{10} Windvelocity at 10 m above sealevel (Lelyatad)

t_w temperature of the water

t_a temperature of tha atmosphere

Heign significant wave height

H_{50} height exceaded by 50% of the waves