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WIND GUSTINESS
RELATION TO LONG-PERIODIC WAVES

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ABSTRACT

Analyses of wind records from a 75 m (250 ft) high smokestack on the coast of Jylland, Denmark, is explained. Wind gustiness periods of 1 to 3 minutes averaging 2 minutes were found. This confirms that wind gustiness on the open ocean may be the main generating agent of long period waves within the same range of periods - as observed on the Danish West Coast at White Sands, at Sørvær in Norway, at Gufunes in Iceland and at other places as e.g. at the Table Bay Harbour in South Africa.

INTRODUCTION

Long period waves are affecting coastal harbours when the periods of the incoming waves match with the modes of the basin. The generating mechanisms of these waves cannot be said to be known. However, in order to develop forecasting procedures for harbour oscillations, the actual mechanisms should be better understood.

A careful study on the surge-action in Monterey Harbor, California, was published by B.W. WILSON et. al. in 1965. This report concluded that the harbour oscillations "were more likely to be a result of genuine long-period waves from the open ocean than from surf-beats generated locally by swells". They arrived at this conclusion basically on two arguments:

1. A lack of correlation between wind waves/swell on the site and long period oscillations were found. Harbour oscillations were reported, even when wind waves and swell were apparently absent.

2. Harbours exposed to the open ocean experience these oscillations only. "Although beats of waves pound all the coastlines of the world, there is singularly little evidence of serious harbor surging along any of the coastlines that lie in the lee of the land, relative to the movements of the large cyclonic storms of the temperate regions. On the other hand, one finds without exception that the coastlines that directly face the paths of extra-tropical and tropical cyclonic storm suffer acutely from long-period surging".

Recordings and analysis of harbour oscillations in Norwegian coastal waters support these conclusions. (VIGGOSSON and RYE 1971, E. GJERTVEIT 1973).

If harbour oscillations are caused by waves coming in from the open ocean, they must be generated in some way. Many possibilities exist: The wind and pressure fields above the storm sea and non-linear wave-wave interaction mechanisms are both potential sources of long period waves. To determine the actual generating mechanism, field measurements of the wind, pressure and wave fields from a storm area are needed. Such measurements are very difficult to conduct, however, due to the extreme operating conditions. In addition, the heights of long period waves are of order cm and are very difficult to separate from the much higher wind waves and swell. At present, material for such a study is therefore hardly available.

Until more sophisticated techniques are developed that operate under extreme weather conditions, different types of correlations in the wind and wave fields were considered instead in order to find the origin of these waves.

A correlation was found between the observed periods of harbour oscillations in general and the periods of the wind gustiness.

Consider the periods of harbour resonance frequently observed:

<u>Monterey</u> Harbour, California: 4, 2 and 1.2 minutes.

Table Bay Harbour South Africa: Generally less than 5 minutes, frequent period is 1.8 minutes.

Sørvær Harbour, Norway: Harbour oscillations of 4, 2 and 1.25 minutes.

White Sands, Denmark: 2 minutes. (Private communication with Dr. P. BRUUN).

Gufunes, Iceland: 5, 3.3 and 2 minutes. (See paper by Dr. T. KARLSON presented at the same session).

In general, harbours all over the world, facing the extra-tropical storm areas, seem to oscillate with periods between one and five minutes very frequently.

ANALYSIS

The present investigation will show that the average period of wind gustiness (that is, the average time duration between two wind gusts) falls within this period interval of one to five minutes. For design purposes, wind gustiness characteristics for storm conditions have been studied on land, showing the wind field to have a maximum of energy content in the vicinity of one minute. (WALLER, 1970). However, the wind field characteristics offshore may differ from the wind field onshore due to influence from topography. Because high-quality wind recordings offshore from a storm area are hardly available today, wind velocity recordings from a 75 m high smokestack on the coast of Jylland were analysed for wind gust characteristics instead. Fig. 1 shows the recording site at Skjærbek, Denmark. Due to the height of the recording instrument and the Danish landscape, which is flat, it was assumed that these recordings would contain offshore wind field characteristics when strong winds from west prevailed.

A "wind gust" was defined in the following way: Each time the recording showed a "distinct" maximum in the wind strength, it was a "wind gust". With this definition, the recordings had to be read off by hand, and the results were also dependent on the readers´choice of how distinct the wind maximum should be to be classified as a wind-gust maximum. Fig. 2 shows an example of the wind velocity recordings.

A more commonly used definition of "wind gust" is based upon the exceedance of some preset level of wind strength. (MONAHAN & ARMENDARIZ 1971). With this definition, the period of wind-gustiness would be dependent on the specific choice of level of exceedance. It was therefore decided not to use this definition.

The present method of examining the recordings for wind gust characteristics was chosen because the time resolution of the recording was not large enough to allow for spectral analysis. To avoid that the investigation was based upon the impression of one single reader, two students read off the strip-charts for wind-gustiness periods, independent of each other. Recordings containing strong wind velocities from west were considered only. The recordings selected were therefore expected to contain wind-gust characteristics from weather conditions usually resulting into harbour oscillations.

Eleven cases with strong winds recorded during the autumn 1970 were selected for analysis, covering a time range of 160 hours all together. The number of wind gusts was counted for each of the eleven cases, and the average period of wind gustiness was found by dividing the duration of the recording with the number of wind gusts counted.

RESULTS

The results are shown on Fig. 3. The vertical shows the average time period between two wind gusts, and the horizontal shows the average strength of the wind gusts, normalized to the average wind strength. Fig. 3 shows the average wind gusts to appear with intervals between one and three minutes, approximately, averaging about two minutes. Also, the results differ from one student to the other. This is probably due to the students' different choices of definition of wind gust.

A trend in Fig. 3 is present: When the average period of wind gustiness is large, the strength of the gusts is larger. This is probably due to the fact that the student who selected only a few of the wind gusts, will select the strongest ones. In this way, the average wind gust strength becomes larger. (Student no. 2).

CONCLUSION

Wind gustiness seems to appear with time intervals between one and three minutes, on the average. This time interval falls within the period interval of severe harbour oscillations reported from different parts of the world, that is, one to five minutes. Consequently, wind gustiness may be responsible for the long period waves generated on the open ocean.

It should be mentioned that no firm conclusion can be drawn from this count. The count merely suggests where the generating mechanism of these waves might be found. A more careful study, based upon high-quality field data, is necessary to prove what the generating mechanisms of the long period waves actually are like.

REFERENCES:

1. H.H. MONAHAN & M. ARMENDARIZ: Gust Factor Variations with Height and Atmospheric Stability.
   Journ. Geoph. Res. Vol. 76, No. 24, 1971.

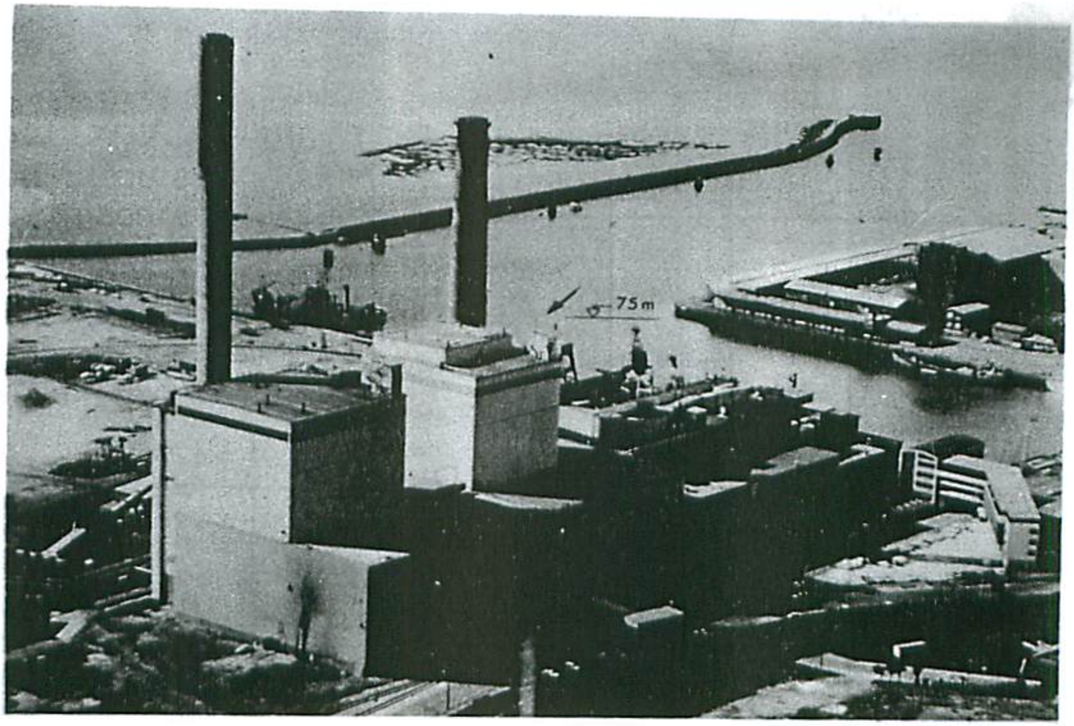
2. E. GJERTVEIT: Numerical Calculations of Long-Periodic Oscillations at two Norwegian Harbours.
   Proceedings, Second International Conference on Port and Ocean Engineering under Arctic Conditions.
   University of Iceland 1973. POAC 1973.

3. T. KARLSSON: Long Period Oscillations at Gufunes, Iceland.
   Proceedings, Second International Conference on Port and Ocean Engineering under Arctic Conditions.
   University of Iceland 1973. POAC 1973.

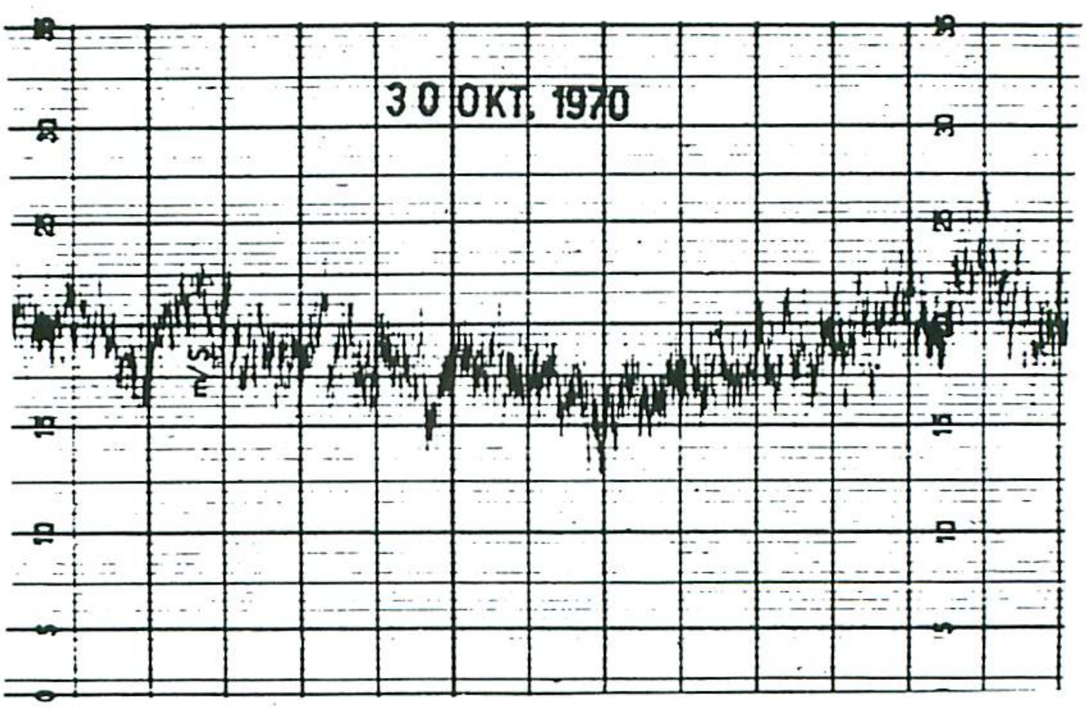
4. G. VIGGOSSON & H. RYE: Long Periodic Oscillations in Sørvær Harbour, Finnmark, Norway.
   Proceedings, First International Conference on Port and Ocean Engineering under Arctic Conditions.
   Technical University of Norway, Vol. II, 1971. POAC 1971.

5. R.A. WALLER: Design Techniques for Practical Wind Problems.
Proceedings from "Dynamic Waves in Civil Engineering".
Conference held at Univ. College of Swansea, July 1970.
Ed.: Howells, Haigh and Taylor.

6. B.W. WILSON et al.: Feasibility Study for a Surge Action Model
of Monterey Harbour, California.
Contract Rep. no. 2-136. Corps of Engineers, Vicksburg,
Miss. Contract no. DA-22-079. October 1965.

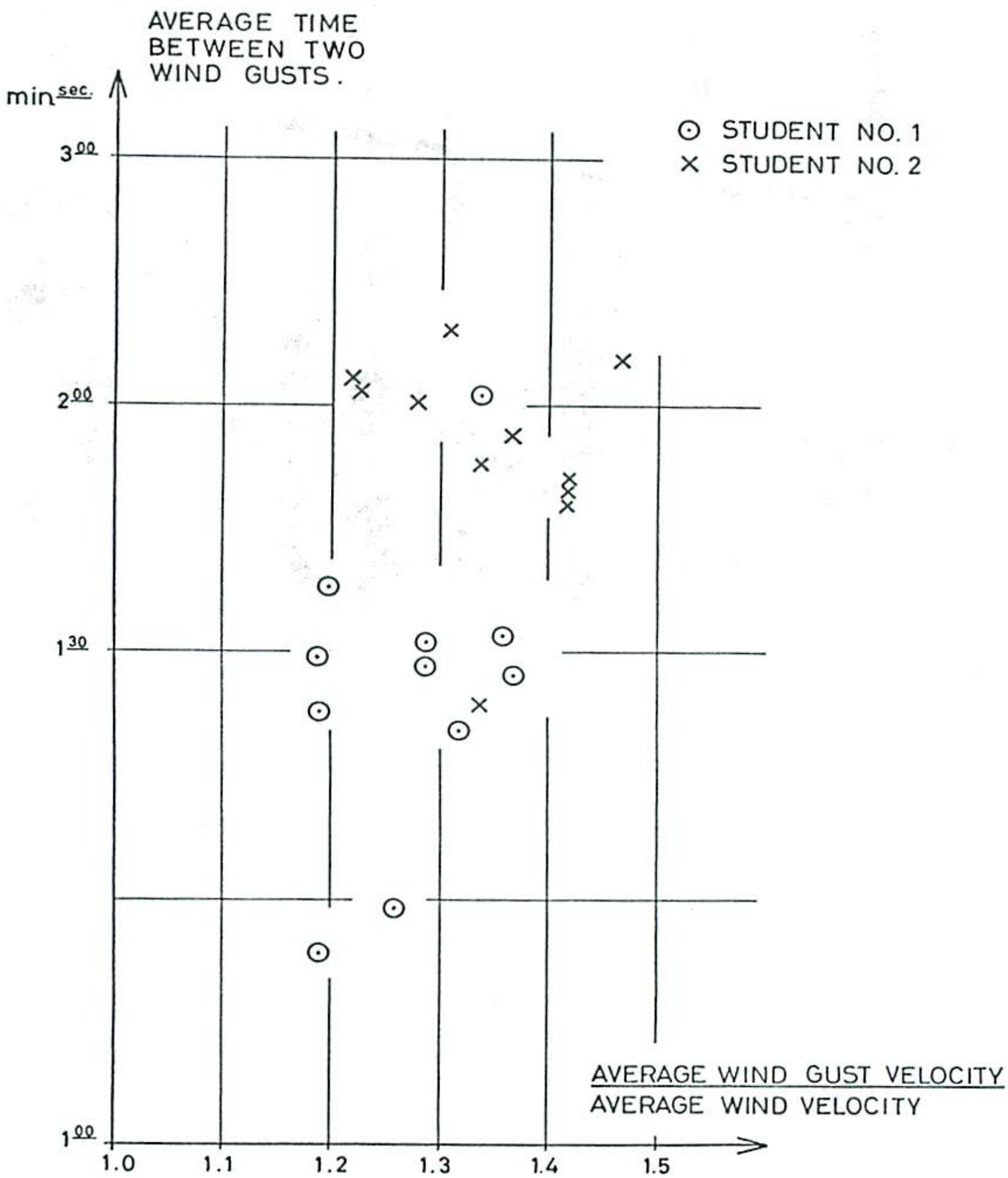


- FIG. 1 -



1 hour

- FIG. 2 -


AVERAGE TIME
BETWEEN TWO
WIND GUSTS.
min sec.
3 00
2 00
1 30
1 00
STUDENT NO. 1
STUDENT NO. 2
AVERAGE WIND GUST VELOCITY
AVERAGE WIND VELOCITY
1.0
1.1
1.2
1.3
1.4
1.5

- FIG. 3 -