Wind Field Distortion about Offshore Oil Platforms in Bass Strait

Daniel G. Crosby and Ian S.F. Jones
Ocean Technology Group
The University of Sydney

Introduction

There is currently much interest in the measurement of meteorological data over the open ocean. These measurements play an important role in general weather forecasting and in providing oceanographic data for the offshore oil industry. Approximate measurements may be made from boats or buoys as long as seas remain calm, however studies such as that of carbon dioxide flux over the open ocean often require wind measurements during periods of extremely high sea state. Oil platforms provide good stable structures from which these measurements may be taken, although it is not fully understood how the presence of these large structures distort the surrounding wind fields.

A number of studies have previously been undertaken on this topic. Thornthwaite, Superior and Field (1965) conducted a flow distortion experiment on Argus Island Tower, near Bermuda, in an effort to locate a suitable undistorted location at which to mount meteorological equipment on the tower. A reference anemometer was placed on a radio tower 14 metres above the deck of the platform to attempt to measure the free stream wind speed. A set of five anemometers was arranged along a 5 metre vertical pole which, together with the reference anemometer, simultaneously measured wind speed at various locations on the platform. The ratio of wind speed between these anemometers and the reference anemometer was thought to be a measure of the distortion of the free stream by the platform. However, when the data was collated and three-dimensional velocity contours drawn, it was discovered that the reference anemometer was in fact within the distorting influence of the platform. When attempting to place reference anemometers, it was deduced that due to the platform's size, it was very difficult to obtain undistorted wind measurements. In the case of the Argus Island Tower experiment, a process of trial and error and extrapolation of the contours resulted in an estimated increase in the mean wind speed of 5% at the reference position.

Attempts have been made in an effort to avoid the distorting effects of platforms by placing instruments on the end of long booms extending away from the platform. Wills (1984), in conjunction with the HEXOS Project (Humidity EXchange Over the Sea), placed a model of the Dutch Noordwijk Tower research platform in a wind tunnel in an effort to determine the level of distortion of the wind field at the end of a 10 metre and 16 metre boom. Wills concluded from model results that at 16 metres, levels of distortion of less than 10% occurred for both wind velocity and turbulence.

The Ocean Technology Group at the University of Sydney has, for a number of years, been performing experiments on oil platforms in Bass Strait to resolve issues such as the drag over the sea, for example Jones and Toba (1992). Measurements of the distortion of the wind field about a particular oil platform have been carried out with the aim of being able to correct past and future wind measurements. Unlike the previous experiments described above, these field measurements will be combined with wind tunnel studies.

Bass Strait Field Experiments

Field experiments were carried out in Bass Strait on Snapper Platform in order to measure the distortion around the platform relative to a reference anemometer placed high above the platform. Snapper is typical of the oil production facilities operated by ESSO/BHP in Bass Strait. The platform measures 63 x 27 metres in plan, with its main deck approximately 25 metres above mean sea level, as illustrated in Figure 1. Two series of experiments were carried out. The first series (October 1992) was carried out in order to check the feasibility of both the experimental method and equipment used, and to determine the best locations on the platform on which to concentrate further. Two R.M. Young propeller anemometers (Model No. 05305) were used for this experiment.

A reference anemometer was placed three quarters of the way up a radio mast located on the north-western corner of the main deck at a height of 27.5 metres above the deck of the platform. As the prevailing winds in this region are predominantly from the south-west and the platform was aligned exactly north-south, the reference anemometer was positioned on the south-western side of the radio mast. The second anemometer was attached to the end of a 2 metre rod which was clamped horizontally to a handrail and moved to various locations about the platform. The handrail and reference anemometers simultaneously measured wind speed and direction at each location for a period of 20 minutes, at a sample rate of 5 Hz. Both anemometers were connected via interfaces to a central computer. In order to obtain readings with as least distortion as possible, measurements were confined to wind directions 190° to 350°. Wind speed and direction ratios were recorded at a total of 61 locations throughout the platform as illustrated in Figure 2. This experiment revealed three practical locations at which future tests could be concentrated:

1. Location No. 3, South-west corner, Main deck
2. Location No. 69, North-west corner, Main deck
3. Location No. 73, Mid-west, Sea Deck

These locations were chosen for a number of reasons; they were on exposed sites on the platform, they were far enough away from any small objects that may have caused local disturbances, and they had distortion levels that were relatively small.

In the second series of experiments (April 1993), only these three locations were concentrated on. The same equipment was used, however in an effort to avoid any local distortions due to any nearby objects, the second anemometer was attached to a 5 metre vertical pole. The results for each of these locations may be seen in Table 1. These results have not been corrected to take into account their relative position within the boundary layer profile, which is assumed to follow the classic logarithmic shape up to a height of approximately 100 metres. At each of these locations, a number of sets of readings were taken for varying wind directions and speed. The results appeared to be sensitive to the wind direction and insensitive to the wind velocity. This is illustrated in Table 1 where at location 69, two separate wind measurements 1 and 2 were recorded over different days and although the free stream wind speed remained relatively constant, the wind direction varied by approximately 100°, and resulted in a wind speed ratio of 1.081 for measurement 1 and 0.88 for measurement 2.

Wind Tunnel Tests

In accordance with the Argus Island Tower experiment, it is reasonable to expect that the reference anemometer in Bass Strait gave distorted readings due to either the influence of the platform or the radio tower. Indeed, if the Argus Island Tower results are to be proportioned according to the size of the platforms and relative heights of reference anemometers, then the Bass Strait reference

anemometer's mean wind speed readings may be as much as 8% faster than the free stream. A series of wind tunnel experiments on models of the Snapper platform is being conducted to investigate the wind flow distortion at the reference anemometer and to determine the absolute levels of wind distortion induced by the platform. The tests are currently being carried out in the Windtech Wind Engineering 2 x 2.6 x 15 metre boundary layer wind tunnel in Sydney.

A 1/200 scale model of Snapper platform, and a 1/10 scale model of the platform's radio tower have been constructed so they can be placed within the log-law boundary layer of the wind tunnel. The models will be used to determine whether the reference anemometer was in a zone of influence of the wind field due to either the platform or radio tower, and a correction factor will be determined. Tests will be carried out for a number of wind directions between 190° and 350°. With the platform model oriented to match the flow conditions in Bass Strait, ratios of wind speed and direction will be measured at locations 3, 69 and 73. If these ratios display good correlation with the relative distortion of the field results in Table 1, then at each of these locations we will assume the model is adequate for determining absolute flow distortion, and a number of measurements will be recorded for varying orientations of the model with respect to the wind. As Snapper platform, like most other platforms, is extremely porous, the platform model has been constructed such that a bulk of the model has a porosity of roughly 60%, a value determined from previous Bass Strait experiments. It is yet unknown how the porosity of the structure influences the wind distortion of these structures.

Conclusions

Wind measurements have been carried out on Snapper Platform in Bass Strait in order to determine the manner in which the presence of the platform distorts the wind field relative to a reference anemometer on a vertical radio mast. Three locations on the platform where the relative levels of distortion were minor were concentrated on. The mean wind speed at these three positions varied from that given by the reference anemometer by -12% to +8.1%. These results appeared to be sensitive to variation in wind direction, and insensitive to changes in the mean free wind stream speed, indicating Reynolds Number independence.

It is suspected that the reference anemometer used on the platform to measure the free stream velocities was in fact distorted to some degree due to either the platform or the mast. Scale models of the platform and the radio tower on which the reference readings were taken are currently in the process of being tested in a boundary layer wind tunnel in order to determine whether the reference anemometer was in fact measuring distorted wind flow, to determine the absolute distortion to the wind field due to the platform, and to extend these results to suit all wind directions such that in future undistorted wind measurements may be made on this platform.

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References

1. Thornthwaite, C.W., W.J. Superior and R.T. Field, 1965: Disturbance of Airflow around Argus Island Tower near Bermuda. Journal of Geophysical Research, Vol. 70, No.24

2. Wills, J.A.B, 1984: HEXOS - Model tests on the Noordwijk Tower. HEXOS Report R184.

3. Jones, I.S.F and Y. Toba 1992: The Influence of Sea State on Atmospheric Drag. E.O.S, 73, p 306 - 307.

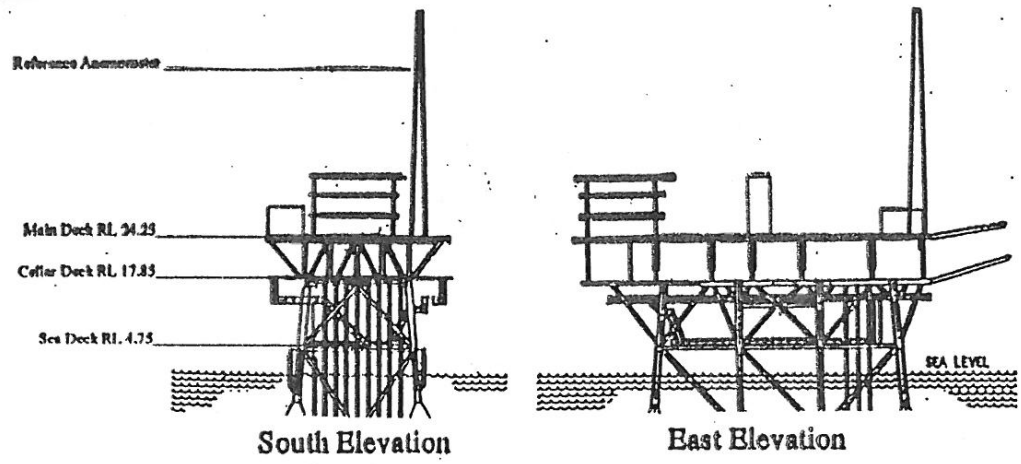

Figure 1. Snapper Platform, Bass Strait

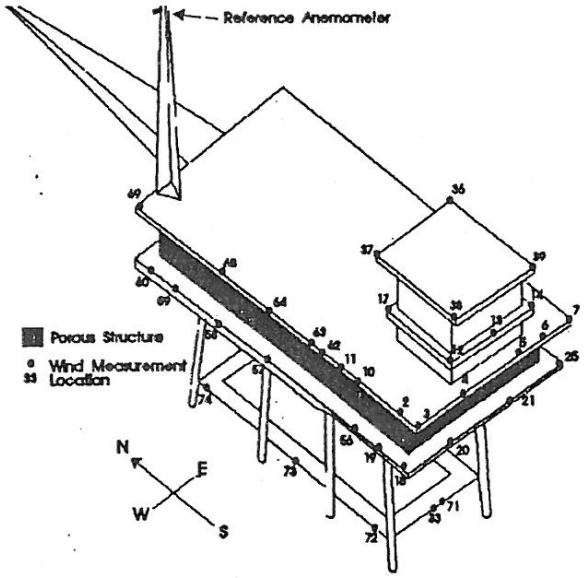

Figure 2. Locations of anemometer readings on platform.

Location	20 Minute Averages					
	Velocity Handrail	Velocity Radiomast	Ratio Handrail\ radiomast	Direction Handrail	Direction Radiomast	Difference Handrail
	m/s	m/s		Deg.	Deg.	Deg.
S/W Corner Location No.3	18.48	16.616	1.11	284.4	287	-2.6
N/W Corner Location No.69 Measurement 1	10.9	10.11	1.081	205.3	206.8	-1.5
Sea Deck Mid-West Location No. 73	11.55	11.59	0.996	273.5	273	0.5
N/W Corner Location No.69 Measurement 2	11.5	12.99	0.88	306	308.5	2.5

Note : Ratios are uncorrected for any distortions at the radio mast reference position and for relative position within boundary layer profile

Table 1. 20 minute mean wind speeds and directions as measured on Snapper platform.