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Anemometer Reading in the Presence of Nearby Obstacle

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Abstract

A three-cup anemometer and a combination wind vane and anemometer model are tested in wind tunnel as to their rotational speed in the presence of a cylindrical obstacle. Somewhat consistent and remarkable errors in reading, especially in the lee-side, are observed which should be taken into account in wind speed measurement at towers, pylons etc.

1. Object

Ground-based anemometry is often effected with anemometers installed at the side of towers, pylons etc. Especially, the gradient of wind speed is always measured with this installation. The present experiment is scoped to clarify the magnitude and correction of errors caused by this installation.

2. Method of experiment

The cup anemometer and the combination wind vane and anemometer model are set respectively according to the scheme illustrated in Figs. 1 and 2, around a circular cylinder of diameter d=150, 100 and 44.7 mm in case of cup anemometer, and d=100, 44.7 and 22 mm in case of combination anemometer model. The cylinder is placed vertically across the free air stream of the 1.5-meter wind tunnel of the Institute, the anemometer being set in the horizontal plane passing the mid-point of the cylinder.

The cup anemometer is of the standard type having three cups of diameter 100 mm and cup-center diameter of 200 mm. The

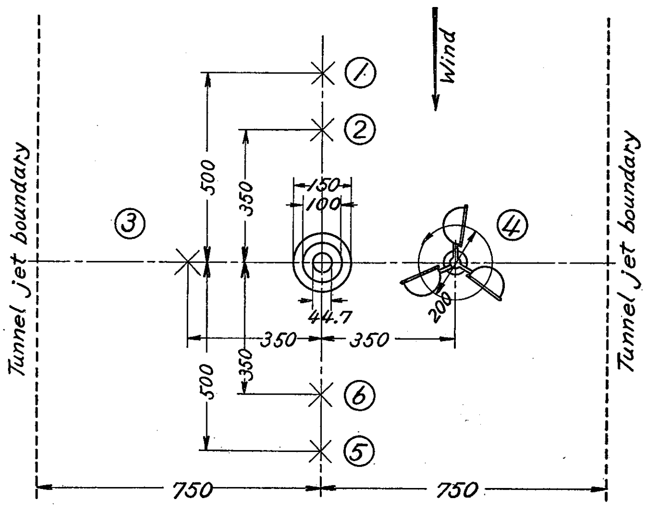

Fig. 1. Arrangement of the cup anemometer around the cylinder (plan view, unit in mm).

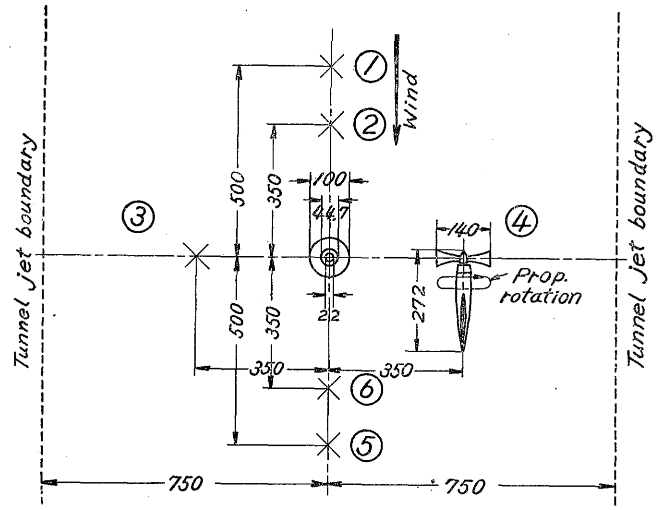

Fig. 2. Arrangement of the combination model around the cylinder (plan view, unit in mm).

combination anemometer is an 1 : 2.5 scale model of Speedovane (an experimental combination wind vane and anemometer, also Ref. [1]) having a windmill or a propeller of diameter 140 mm and total fuselage length of 272 mm.

The anemometer reading is first taken at the location of the cylinder with the cylinder removed. This reading is regarded as comparison base and other readings are expressed as its fractions.

For the combination model the deviation of the fuselage center line from the direction of the tunnel flow is also observed.

All observations are conducted in the steady state of the tunnel flow.

3. Experimental results

1) Cup anemometer

The most remarkable effect is found in the lee-side of the cylinder, as illustrated in Fig. 3, where N/N_0 stands for the ratio of anemometer readings with and without the presence of the cylinder. The abscissa represents distance measured windward or leeward from the cylinder center, expressed in multiple of cylinder diameter. This shielding effect is so conspicuous in the lee-side that the sole practical remedy is to install an anmometer with cup center diameter D larger than at least five times the cylinder diameter d (Fig. 3b). The windward stagnation effect is much milder and the anemometer reading at distances larger than four times the cylinder diameter will give sufficient accuracy (Fig. 3a).

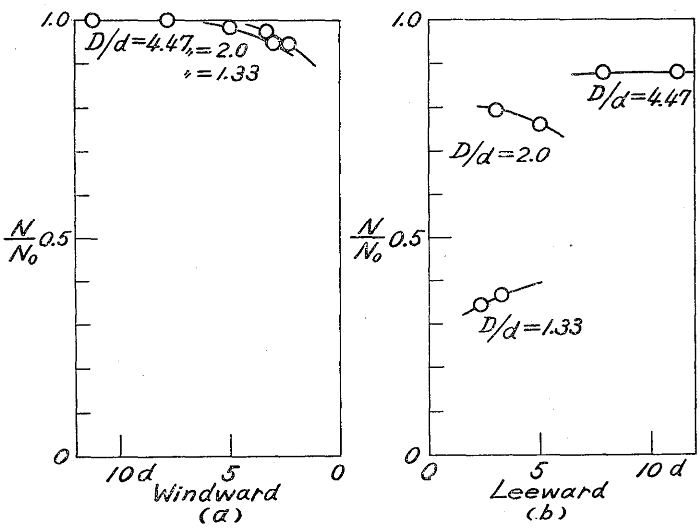

Fig. 3. Cup anemometer reading at various distances windward and leeward of the cylinder (d: cylinder diameter, D: cup center diameter, M. R. I. wind tunnel).

The anemometer

reading at both sides of the cylinder gives only minor deviations, amounting $N/N_0=0.99$ at position 3 in Fig. 1 and 1.02 at position 4, for three sizes of cylinder. This unsymmetry is caused by the direction of anemometer rotation as illustrated in Fig. 1, as the near flow to the cylinder is more accelerated than that at the far side. The resulted effect has the tendency to accelerate the anemometer at position 4 more than that at position 3 owing to the fact that the driving cup (recessing in the wind) of the former is closer than that of the latter. The wind tunnel free bouudary has nothing to do with this unsymmetry, as is ascertained from a separate experiment.

The results in Fig. 3 are tested up to wind speed of 20 m/s and it is found that the wind speed has very little effect on them.

2) Combination anemometer

The results are illustrated in Fig. 4. The shielding effect is similar to the

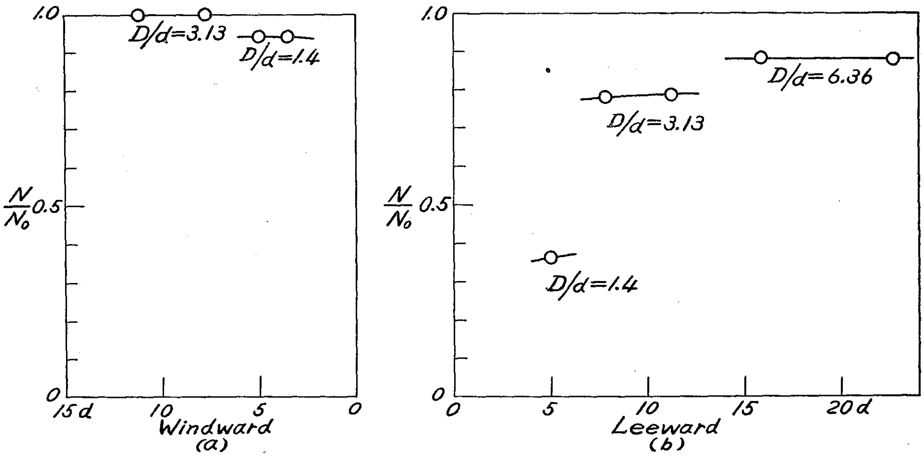

Fig. 4. Combination anemometer reading at various distances windward and leeward of the cylinder (d: cylinder diameter, D: propeller diameter, M. R. I. wind tunnel).

case of cup anemometer, and the propeller diameter D should be taken not less than six times the cylinder diameter d, if the anemometer reading is effected in the lee-side. In the windward side a propeller diameter larger than three times the cylinder diameter will be satisfactory. In both cases the location of the anemometer should probably be taken at distances larger than five to ten times the cylinder diameter.

The deviation of the fuselage center line from the tunnel flow direction is most fierce at position 6 in case of cylinder diameter 100 mm, where speed measurement is hardly possible. Other positions give deviations of from several degrees to 10° right or left, even in case of the smallest cylinder diameter 44.7 mm, except windward locations.

The anemometer reading at both sides of the cylinder gives $N/N_0=0.95$ for $d=100$ mm, and $N/N_0=1.0$ for $d=44.7$ and 22 mm. No unsymmetry is observed in these cases.

All the tests are conducted up to wind speed of 10 m/s.

4. Conclusions

1) The cup center diameter of a cup anemometer should be taken larger

than at least five times the diameter of the obstacle, in order to obtain satisfactory reading. This is more essential than the distance of the anemometer location which will be taken not less than four times the obstacle diameter.

2) The propeller diameter of a combination anemometer should be taken larger than at least six times the diameter of the obstacle. This is more important, here again than the installation distance, which need not exceed five to ten times the diameter of the obstacle.

Reference

[1] Sanuki, M. and Kimura, S., 1954: Experiments on a Marine Combination Wind Vane and Anemometer in Pitching or Rolling Motion, Pap. Met. Geophys., 3, p. 35.