EXPERIMENTAL STUDIES ON SNOW CONTROL AROUND FLOOR-ELEVATED BUILDINGS IN THE ANTARCTIC (EXTENDED ABSTRACT)

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1. Introduction

Antarctic observation stations frequently encounter heavy blizzards, leaving snowdrifts around the buildings. To control snowdrifts and to withstand gusty wind, floor-elevated buildings have been constructed in Antarctic stations including those at Syowa Station (69°00′S, 39°35′E).

In order to elaborate the design concept of floor-elevated buildings to be constructed in the future, snowdrifts around the two buildings (Observation Hut and Ionosphere Hut) and wind profiles near the Ionosphere Hut at Syowa Station were observed between February and November 1978. Furthermore, to interpret the observed results in detail, wind tunnel experiments of scale models were carried out.

2. Observations on the Snowdrift Development

The two isolated buildings, *i.e.* Observation Hut (floor-elevated by steel pipe trusses) and Ionosphere Hut (floor-elevated by concrete pillars) were selected as places for observation of snowdrifts.

The features of the topography surrounding the buildings are shown in Fig. 1. The Observation Hut was built on fairly flat ground in alignment with the prevailing

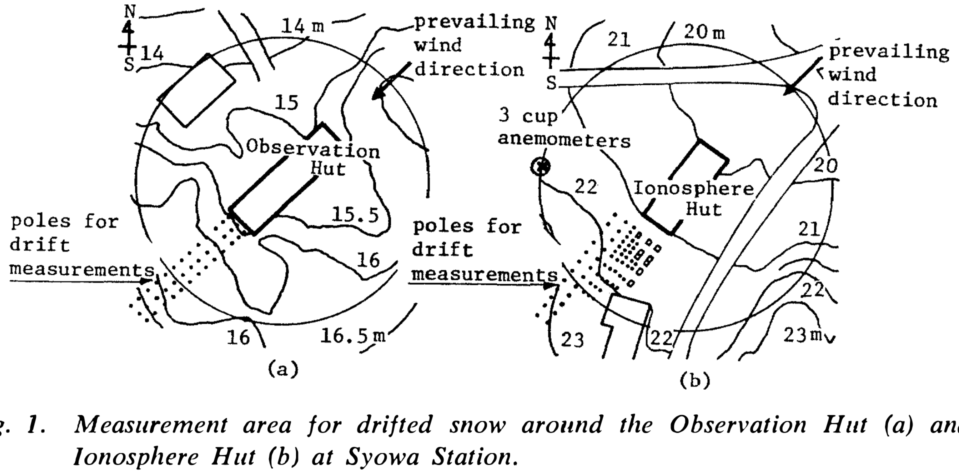

Fig. 1. Measurement area for drifted snow around the Observation Hut (a) and Ionosphere Hut (b) at Syowa Station.

wind direction (Fig. 1a), and the Ionosphere Hut was built on ground descending slowly to the NE (Fig. 1b). The difference between the wind directions and the alignment of the Ionosphere Hut was about 17°.

In order to observe the temporal change of snowdrifts, many bamboo poles were placed on the lee side. Behind the Observation Hut, the poles were set in three lines of 13 sticks over an area 24 m long and 4 m wide along the building alignment (Fig. 1a). Behind the Ionosphere Hut, 61 poles and 9 space frames (1×1×2 m) fabricated with L-shaped steel bars were placed over an area 25 m long and 10 m wide (Fig. 1b).

The elevation of the buildings is shown in Fig. 2.

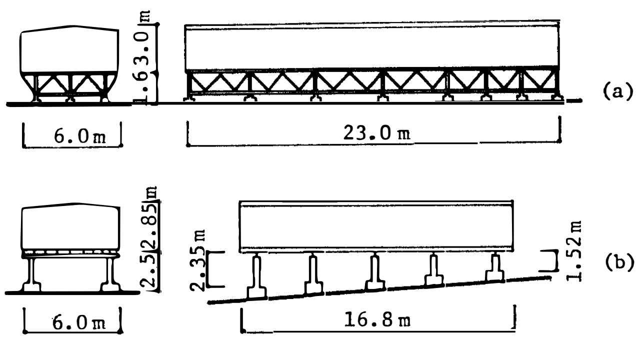

Fig. 2. Elevation of the buildings. (a) Observation Hut, (b) Ionosphere Hut.

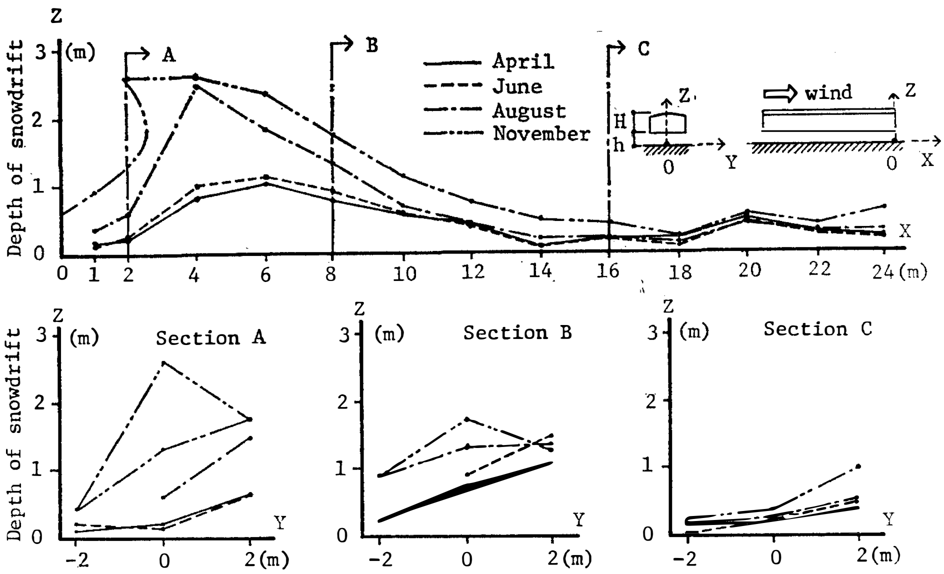

Fig. 3. Development of snowdrift in the lee of the Observation Hut.

At the beginning of the observation, there was little snow around the buildings. Observations were carried out after a blizzard in each case and quantities of snowdrift were recorded from the reading of the measuring poles. The forms of the snowdrifts were photographed. Figure 3 shows the development of snowdrift in the lee of the Observation Hut.

Figure 3 also shows the orthogonal coordinates taken from the ground level of the lee side of the building. Longitudinal profiles on the center line of the Observation Hut in April and June indicate about 1 m of deposition at a distance of about 6 m from the lee side of the hut and the drift deposition had a gentle slope.

In the early developmental stage, the drift had a U-shape, because the drifting snow passing under the floor was blown off and deposited on both sides (see Fig. 3, Section A, in April and June). Although the number of poles was not enough to observe the transverse profile of the drift, the formation of a U-shape was ascertained by photographic observations. The drift increased to a large extent in July and reached a peak in October and November. The height of the drift gradually approached the height of the hut with the increase of snow deposition. From July to August, the highest point shifted to a position about 4 m from the lee side of the hut and was about 2.5 m high. Furthermore, it shifted to a position about 2 m from the lee side of the hut and was about 2.7 m high in November.

However, there was no deposition within the range of about 2 m from the lee side of the hut. The form of the maximum drift in November had a sharp ridge to the windward. The length of the drift was about 5 times the maximum height of the hut $(H+h)$.

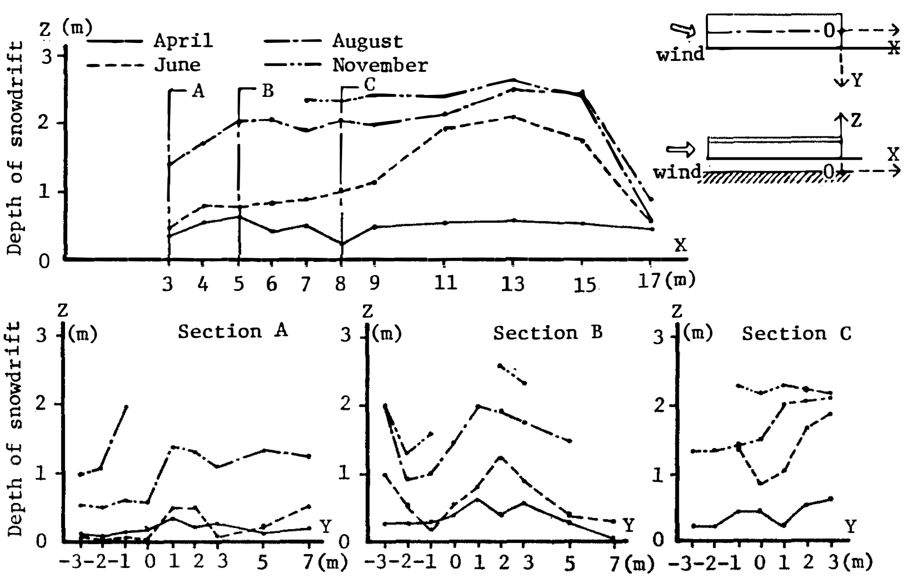

Fig. 4. Development of snowdrift in the lee of the Ionosphere Hut.

Figure 4 indicates the development of snowdrift in the lee of the Ionosphere Hut. The origin of the Cartesian coordinates is at the ground level on the lee side of the building on its center-line and the X-axis is in the building alignment. In this case, the hut covered a larger area and disturbed the wind flow, and drifts were formed over a wide area. The drift increased remarkably in June and reached a peak in October as in the case of the Observation Hut. The drift formed a sharp ridge line along the prevailing wind direction (see the Sections A and B in June and August). The temporal change of the form of the snowdrift was similar to that at the Observation Hut.

The relation between the duration of a snowstorm and the quantity of snowdrift was examined. In this observation, the time of snowfall and blowing snow were counted as the duration of a snowstorm. In the case of the Observation Hut, the annual duration of snowstorms was 2433.3 hours, and the quantity of snowdrift in the observation area ($4\times24=96.0\ m^2$) was $78.3\ m^3$. In the case of the Ionosphere Hut, on the other hand, the duration of snowstorms was 2322.4 hours, and the quantity of snowdrifts in the observation area ($6\times8+2\times6+4\times2=68.0\ m^2$) was about $181.7\ m^3$.

3. Measurement of Wind Profiles near the Building

Using three-cup anemometers, mean wind velocities at 5 levels up to 8 m were measured near the Ionosphere Hut. The measurement position is indicated in Fig. 1b.

Most of the measured wind profiles are expressed with the logarithmic formula:

$$u_z=(u_*/k)\cdot\ln(z/z_0)\,, \tag{1}$$

where u_z is the mean wind velocity at the height of z, u_* the surface friction velocity, k the Kármán's constant (about 0.4), z the height above the suface and z_0 the surface roughness length, being in a range from 1 m to 10^{-4} m with a mean of 2.2×10^{-2} m.

The following exponential formula was used to calculate the power indices n:

$$u_z/u_1=(z/z_1)^n\,, \tag{2}$$

where u_1 is the mean wind velocity at z_1 and n was in a range from 1/2.9 to 1/7.2 with an average of 1/4.9.

4. Wind Tunnel Experiments

A 1/50 scale-model simulating the Observation Hut and a 1/40 scale-model simulating the Ionosphere Hut including terrain configuration within a radius of about 40 m were used. Two experimental methods were used to estimate the drift development around the buildings, and the results were compared with observations at Syowa Station. The first method, Method (a), is to estimate the deposition from the difference of transport of blowing snow calculated from wind profiles and blowing snow density profiles.

The amount of snow Q, transported by the wind flow, is:

$$Q=\int_z U_z\cdot n_z\cdot \mathrm{d}z\,, \tag{3}$$

where U_z is the mean wind velocity at z and n_z is the mass of snow particles in a unit volume, or the so-called drift density. According to the turbulent diffusion theory, the drift density n_z is expressed by the following:

$$n_z/n_1=(z/z_1)^{-w_0/k\cdot u_*}\,, \tag{4}$$

where n_1 is the drift density at z_1, and w_0 is the falling velocity of snow particles. Then, the snowdrift increment ΔQ, over a finite interval $\Delta x(=x_2-x_1)$, may be estimated by

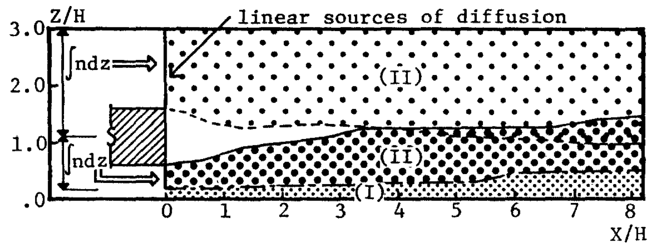

Fig. 5. Classification of the domain for drift density profile at the lee of the floor-elevated building.
Domain I: $n_z/n_1=(z/z_1)\exp(-w_0/k\cdot u_*)$, Domain II: n_z=constant.

$$\Delta Q=(\mathrm{d}Q/\mathrm{d}x)\cdot\Delta x=-(Q_{x1}-Q_{x2}), \tag{5}$$

where Q_{x1} is the blowing snow transport at x_1, and Q_{x2} is at x_2. In order to calculate the snowdrift increment ΔQ, the wind profiles in the tunnel were measured and drift density profiles in the lee of the building were assumed. Two domains, (I) and (II), were tentatively considered in the lee of the building as shown in Fig. 5. Domain (I) is the area expressed by eq.(4), and in domain (II), in which diffusion begins with the linear sources in uniformly turbulent flow, n_z is assumed to be constant.

The second experiment, Method (b), to estimate the drift formation is based on the wind profiles. The form of snowdrift may be predicted from isolines of threshold wind velocities from the mean wind velocity in the wind tunnel, provided that the drift density n_z is constant in the lee of the building where the turbulent energy becomes larger and there is a weak wind region near the ground surface. It is assumed that the form of snowdrift in the lee of the building will be the same as that of the isoline of wind velocity which is 40% of the mean velocity at the maximum height of the building ($H+h$ in Fig. 6).

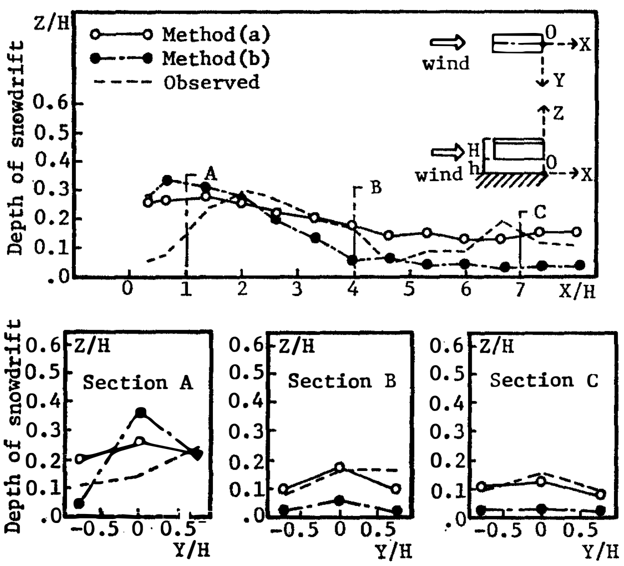

Fig. 6. Comparison of wind tunnel experiments and observations for the Observation Hut. Observations were in April 1978.

Figure 6 shows the experimental results compared with the observed data for the Observation Hut. The formation of snowdrift and the significant zone of deposition were estimated from these wind tunnel experiments. In Fig. 6, the experiments agreed fairly well with the observations. But in the case of the Ionosphere Hut, the wind tunnel experiments did not agree well with the observations. This might be because the wind flow around the hut had three-dimensional characteristics, since there was an angle of about 17° between the prevailing wind directions and the building alignment.

It was found from the scale-model experiments and observations that the highest drift in the experiments was closer to the hut and the significant area of drift was somewhat shorter than the actual measurements at Syowa Station. Wind tunnel experiments indicated a remarkable decrease of drifts when the floor height h became larger than 0.44 H (where H is the height from the floor to the ridge of the roof), and the drift showed a gentle slope in the lee. This suggests that the optimum floor height of a floor-elevated building should be about 44% of H.

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