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Snowdrift Around Antarctic Buildings — Effects of Corner Geometry and Wind Incidence

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ABSTRACT

Modelling of Antarctic snowdrifting was conducted in a turbulent boundary layer wind tunnel. A series of 7 models was designed, based on the extended dimensions of a shipping container. Tests were carried out to investigate the effects of varying the model corner geometry and the angle of wind incidence on snowdrift formation. The results were used to formulate design guidelines for buildings in Antarctica.

INTRODUCTION

Antarctic buildings have suffered from a range of problems caused by snowdrift accumulation, including blocked doors, windows, fire escapes, accessways and ventilation ducts, buildings being pushed off their footings and even complete inundation. Hence it is important that snowdrifting studies form part of the design process of proposed buildings in Antarctica.

To overcome some of the problems of on-site construction in the harsh Antarctic environment, a new modular elevated building system (the Loaf System) has been proposed (Rohde, 1990). The component buildings are based on the extended dimensions of a shipping container and may be constructed and completely fitted out in their country of origin. The buildings may then be shipped to Antarctica and transported to the site by sled or helicopter. Any number of modules may be linked together by covered walkways to form a small semipermanent station. The buildings are easily relocatable if the site is found to be unsuitable.

This study explores the effects of corner geometry and angle of wind incidence on snowdrift formation around component buildings of this modular elevated building system.

SIMILARITY OF MODEL AND PROTOTYPE

Snow particle movement in Antarctica is initiated and dominated by a turbulent boundary layer wind. Due to the relatively small size of the buildings to be modelled, it was found to be necessary to use the model scale of 1/50 in order to obtain reasonably sized model snowdrifts. Hence a 1/50 scale model of turbulent boundary layer wind flow over Category 2 open country terrain (AS.1170.2-1989) was generated in the Snowdrift Wind Tunnel (Kim et al., 1989). This flow simulates the summer conditions at a typical coastal site of Australian Antarctic Territory.

The model snow particle, viz. sodium bicarbonate, was selected from 12 different particles tested in the Snowdrift Wind Tunnel to ascertain which particle most accurately reproduced the snowdrift around the Observation Hut of the Japanese Shyowa Station in Antarctica (Kim et al., 1989). When the model snow was added to the wind tunnel, the modified flow characteristics closely resembled those of flow over a Category 1 exposed open country terrain (AS.1170.2-1989), thus simulating the winter conditions at a typical coastal site of Australian Antarctic Territory (Kim et al., 1989).

A 1/50 scale model of the Observation Hut was tested in the Snowdrift Wind Tunnel (Kim et al., 1991), and the results were found to be in good agreement with the prototype data collected by Mitsuhashi (1982). A number of similarity criteria were explored, including geometric similarity, similarity of surface and airborne particle motion, similarity of particle, fluid and inertia forces and time scaling. The conventional densimetric and geometric, and the threshold densimetric particulate and geometric Froude numbers were calculated (Kwok et al., 1991). There were good agreements between the model and prototype snowdrift shapes despite mismatches in all of the above Froude numbers. This appeared to confirm the general belief held by Anno (1984, 1989), Isyumov and Mikitiuk (1989) and Peterka and Petersen (1989) that strict Froude number scaling can be relaxed in the simulation of snowdrifting in some circumstances.

Iversen's (1979) proposed dimensionless time, which includes particle and fluid densities, Froude number, particle threshold speed, mean wind speed, time and length, produced a reasonable correlation between model and prototype snowdrift accumulation rates (Kwok et al., 1991).

EXPERIMENTAL ARRANGEMENTS

Seven elevated models with different corner geometries (see Table 1) were tested in the Snowdrift Wind Tunnel. All models were designed at 1/50 scale to fit within an envelope 56 mm high by 72 mm wide by 120 mm long. (Two of the full-size modules will occupy the space taken by three shipping containers.)

Approximately 80 kg of sodium bicarbonate was introduced into the wind tunnel. The internal temperature of the wind tunnel ranged from 27°C to 37°C and the relative humidity ranged from 48% to 65%. The snowdrift rate within the 0.6-m-high working section of the wind tunnel was determined by a vacuum trap apparatus to be 0.125 kg/m.sec. The wind velocity at a reference height of 10 m in prototype (200-mm height at 1/50 model scale) at the centre of the working section was maintained at approxi-

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KEY WORDS: Antarctic building, snowdrift modelling, turbulent boundary layer wind, wind tunnel.