

Modelling of Snowdrift Around Prismatic Buildings for Antarctic Environment

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ABSTRACT

Modelling of snowdrift was conducted in a purpose-built turbulent boundary layer wind tunnel. A number of similarity criteria, in particular time scaling, for the physical modelling of snowdrift in a wind tunnel were examined. Iversen's (1980) proposed dimensionless time, which includes scaling of particle and fluid densities, Froude number, particle threshold speed, mean wind speed, time and length, was found to produce a reasonable correlation of snowdrift accumulation rate between model and prototype. Tests were also carried out to investigate the relationships between different dimensions of prismatic building and snowdrift. The results were used to formulate design guidelines for buildings in Antarctica.

INTRODUCTION

Antarctic buildings have perennially suffered from a range of problems including inconvenience around accessways, and windows and ventilation ducts being snowed in. Snowdrifting has also caused the more dangerous problems of blocked fire-escapes, buildings being pushed off their footings and stations even having to be abandoned when inundated completely (Mosley, 1986). The cost in terms of safety, wasted labour, maintenance, high energy consumption, damaged, destroyed or abandoned buildings and stations, environmental degradation, political embarrassment and so on, is enormous.

The development of buildings and structures in Antarctica should include extensive studies of snowdrifting. However, field tests and observations are not only time-consuming and expensive but also the necessary environmental control cannot be readily achieved. Although a perfect simulation of the various aspects of snowdrifting has been regarded as extremely difficult to achieve, model testing remains the most practical and cost-effective method for investigating and predicting snowdrifting problems.

Extensive reviews of the similitude requirements for scaled modelling of snowdrift and experimental works have been carried out by Strom et al. (1962), Mellor (1965), Isyumov (1971), Kobayashi (1972), Dyunin (1974), Kind (1976), Iversen (1980), Irwin and Williams (1983), Anno (1984), Isyumov and Mikitiuk (1989) and others. Most of the experimental works have been associated with scaled model experiments using artificial snow in water flumes and wind tunnels.

This paper does not attempt to provide an extensive review of similitude requirements, nor does it propose radically new similitude requirements. Attempts were made to compare experimental results with field study results obtained by Mitsuhashi (1982) and to explore relevant similarity parameters suggested by other

researchers. The major aim of this paper is to provide design guidelines for Antarctic buildings which can be used in practice to minimise the problems caused by snowdrift accumulation.

SIMILARITY CRITERIA OF SNOWDRIFTING

It is extremely difficult to fully simulate the behaviour of snow, and at the same time satisfy all similitude criteria at a reduced geometric scale. In particular, the simulation of inter-particle forces, which are mainly dependent on temperature, is difficult to achieve. Hence it becomes a challenge for the experimentalist to determine which similitude parameters can be relaxed without undue consequences.

Model Particle Selection

Prototype snow presents difficulties for modelling because its ability to sinter increases the steepness of the faces it forms. The term angle of repose was used by Kind (1976) to describe the angle of this steepness. Snow is known to form very steep faces, often having an angle of repose greater than 90°. Kind (1976) and Anno (1984) suggested that the angle of repose of model snow and prototype snow should be approximately equal if snowdrift patterns are to be simulated. Anno (1984) also suggested that this requirement is the most important and difficult modelling requirement for the achievement of a realistic snowdrifting simulation.

Strom et al. (1962), Iversen (1980), Kind and Murray (1982), Anno (1984), Da Matha Sant'Anna (1986) and others used various model snow particles in wind tunnels. Anno (1984) has achieved the highest angle of repose, 40°-50°, by using activated clay particles. To the best of the authors' knowledge, none of the previous model snow particles achieved a desirable angle of repose. Therefore, the adopted approach was to find a suitable model snow particle by testing various particles until one produced the correct snowdrift shape.

A number of different particles were investigated (Kim et al., 1989), viz., acrylamide copolymer, cornflour, calcium carbonate, kaolin, crystalline silica, magnesium silicate, sodium bentonite, calcium oxide and sodium bicarbonate. These particles were tested in the Snowdrift Wind Tunnel at the School of Civil and Mining Engineering of the University of Sydney, in the search for

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