SNOW CONTROL FOR SLOPED GLAZING—AN ENERGY PENALTY

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ABSTRACT

The need to control sliding snow on sloped surfaces is discussed. Snow sliding mechanics and snowfall data are reviewed, and three basic approaches to the control of sliding snow are examined. A considerable energy penalty may be involved, depending on the snow control method, but proper design can eliminate any added energy requirement.

INTRODUCTION

In recent years the use of sloped glazed building faces has become an increasingly popular architectural feature. Interior space under glass takes on the character of a solarium making the space very desirable to tenants who enjoy naturally lit surroundings. In addition, because a great variety of shapes is made possible, resulting buildings tend to be more interesting.

In the early days of this trend, slopes were generally confined to entrance foyers and lobbies at lower levels of the building. Avalanches occurred, moving from the glazed surface to the ground, but they were generally cured by adding a small canopy over the building entrance.

In recent years, the trend has been to put sloped surfaces at the top of buildings to create what has sometimes been termed an "architectural event". However, there have been cases where large pieces of snow and ice have been blown or have fallen from these sloped surfaces at great heights creating a serious hazard for pedestrians. The building envelope must therefore meet a new performance criterion: to control sliding or falling snow.

While the control of sliding snow has nothing to do with energy itself, the typical methods of controlling sliding snow can range from completely passive to highly energy-intensive. In the following examples we hope to illustrate typical control methods, their impacts on energy use, and their applicability.

When and Where Snow Control is Needed

A common impression from any discussion of snow control is that snow control is far more important in the north than it is in the south. That may be true for snow control of sidewalks and parking lots, but the necessity of controlling sliding snow from buildings reaches as far south as Dallas, Texas.

In designing solutions for snow slides, we used the ten-year return period snowstorm for our calculations. This snowstorm has a 0.1 probability of occurring in any particular year. Put another way, it is the largest snowstorm to occur on average once in ten-years. The ten

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year return period is used in the National Building Code of Canada for the determination of wind loads on cladding.

Another step in preventing snow slides is determining the depth of snow above which a serious hazard is created. This is dependent upon the building, but generally if several pounds of snow are compacted into an icy mass before leaving the fortieth floor of a building, the effect of its impact could be fatal. It has been our experience, through both observation and laboratory tests, that hard, dense projectiles of this or greater weight commonly occur with snowfalls of three inches (75 mm) or more if the snow is held and compressed on a steep slope.

A sliding snow hazard may exist, then, whenever the ten-year return period snowfall is three inches or greater. Figure 1 is a graph of snowfall depth versus return period for a few selected cities. This information can be derived for any location where sufficient weather records are kept. It shows that even as far south as Dallas, sliding snow can be a hazard.

Of course, Figure 1 shows that northern cities have snowfalls of three inches (75 mm) or greater much more frequently than Dallas. This frequency affects the design of the control method since that method is likely to be used as much as ten times per year in the north but may only be used once in several years in the south.

The Problem

Snow sitting on a roof is not in itself a problem. However, a layer of snow on a sill, sloped roof, or other exposed building surface may harden after a time under exposure to wind and fluctuating temperatures. If it then manages to break free and is blown or slides from the building, glass damage or human injury may result.

The greatest potential for damage or injury occurs for buildings with sloping roofs where large quantities of snow can accumulate and eventually slide off. The snow will slide off as soon as its weight is sufficient to overcome the adhesion to the roof surface. If the snow is dry, the required weight can be quite high depending on the slope angle and the roof material. If the snow is not dry, and a liquid film exists between the roof surface and the snow layer, there will be very little adhesion. In that case, sliding will occur freely on most smooth surfaces, regardless of the slope angle and the weight of the snow layer. A liquid film will exist at the snow-roof interface only if the temperature there reaches 32 F (0^{o}C).

If the roof surface is not smooth, but is fluted or has exposed muntins, then the presence of a liquid film does not guarantee that sliding will occur immediately. In fact, the snow layer may have to achieve a considerable weight before it can push itself over or break free of a muntin. The same holds true at the crest of a peaked roof where the snow layer is held in place by the weight of the snow on the other side of the peak. Once a layer of snow begins to slide, the rate at which it does so depends on the slope angle, the roof material, the weight of the snow layer, and the temperature at the snow-roof interface.

There are four basic scenarios for sliding snow on a sloped roof.

1. If the snow layer is dry or if the roof surface is not smooth, then the snow layer will build up until its weight is sufficient to overcome the surface adhesion or other forces holding it in place. In some cases, the snow may remain on the surface over the course of several snowstorms until it suddenly breaks loose.

2. If the outside air temperature rises to near 32 F, then a dry snow layer may develop a liquid film at the snow-roof interface and suddenly slide.

3. If the outside air temperature remains at or above 32 F and the roof surface is smooth, sliding occurs as soon as an appreciable amount of snow accumulates.

4. The outside air temperature may be below 32 F, but heat escaping from the building interior warms the roof surface. On a smooth surface, sliding will begin as soon as the snow depth is sufficient to provide the insulation necessary to achieve 32 F at the snow-roof interface.

In controlling sliding snow on sloped roofs, the object is to either keep the snow layer from becoming too deep and from hardening into a dense mass before sliding off the roof, or to keep the snow layer from sliding off the roof altogether. The three most commonly used techniques are (1) fencing off the bottom of the slope to prevent the sliding, (2) melting the snow before it has a chance to harden or become excessively deep and (3) maintaining a warm, smooth, obstruction free surface that allows snow to slide in small harmless amounts. Whenever melting is used, proper installation of gutters is required to avoid refreezing of melted water and icicle formation.

A COMPARISON OF CONTROL METHODS

Figure 2 shows a hypothetical, but realistic sloped building face. The shallow mullions are not deep enough to ensure that all of the snow stays on the roof, but they are deep enough to catch and hold snow long enough for it to become hardened and potentially dangerous. The slope is too steep to make a simple snow barrier effective in holding snow on the roof since it could be easily blown from the surface. Figure 3 shows three possible solutions.

The first solution requires building heat loss to melt the accumulated snow. To ensure sufficient building heat, single glazing has been used on the slope instead of double glazing. The energy penalty for this solution is fairly high since this reduces the insulating value of the entire sloped surface all year round. Using the sum of cooling and heating degree days, the added cost in energy for a north-facing slope of the size shown in Figure 2 would be approximately that shown in Figure 4 for the selected cities.

The second snow control solution also requires that all of the snow be melted, but the melting is done with electric heaters within the small gutter. The snow must be melted to keep the gutter clear since it does not have enough storage capacity to hold the snow from more than one large storm. In this case the energy needed is that required to melt the total snowfall for the location. Estimating how much snow will fall on the sloped surface is difficult since under some wind conditions the area will be scoured clean. Under other conditions, drifting could cause a magnified accumulation. In the face of this uncertainty we will assume a one-to-one ratio between snow falling on the ground and that accumulating on the sloped surface. Using a snow density of 6.4 lb/ft^3 (100 kg/m^3) the total energy requirement for the year for our hypothetical slope is shown in Figure 5.

The third solution shown in Figure 3 is the best from an energy standpoint, since it requires no additional heating. With this solution, sufficient setback has been provided to act as storage for more than one storm and will, in fact, hold the estimated ground snow depth, thus allowing natural melting to control the snow.

CONCLUSION

Climatic circumstances as well as building shape play an important role in the choice of snow control solutions for any particular situation. Sliding snow from sloped surfaces should be considered during the design of a building even as far south as Dallas.

Nearly all solutions have an inherent cost. Single glazing leads to a considerable energy cost and an electrical heating system entails a substantial equipment cost and additional energy penalty. The creation of a large storage area to which the snow may slide can have an associated loss of revenue due to reduced floor space.

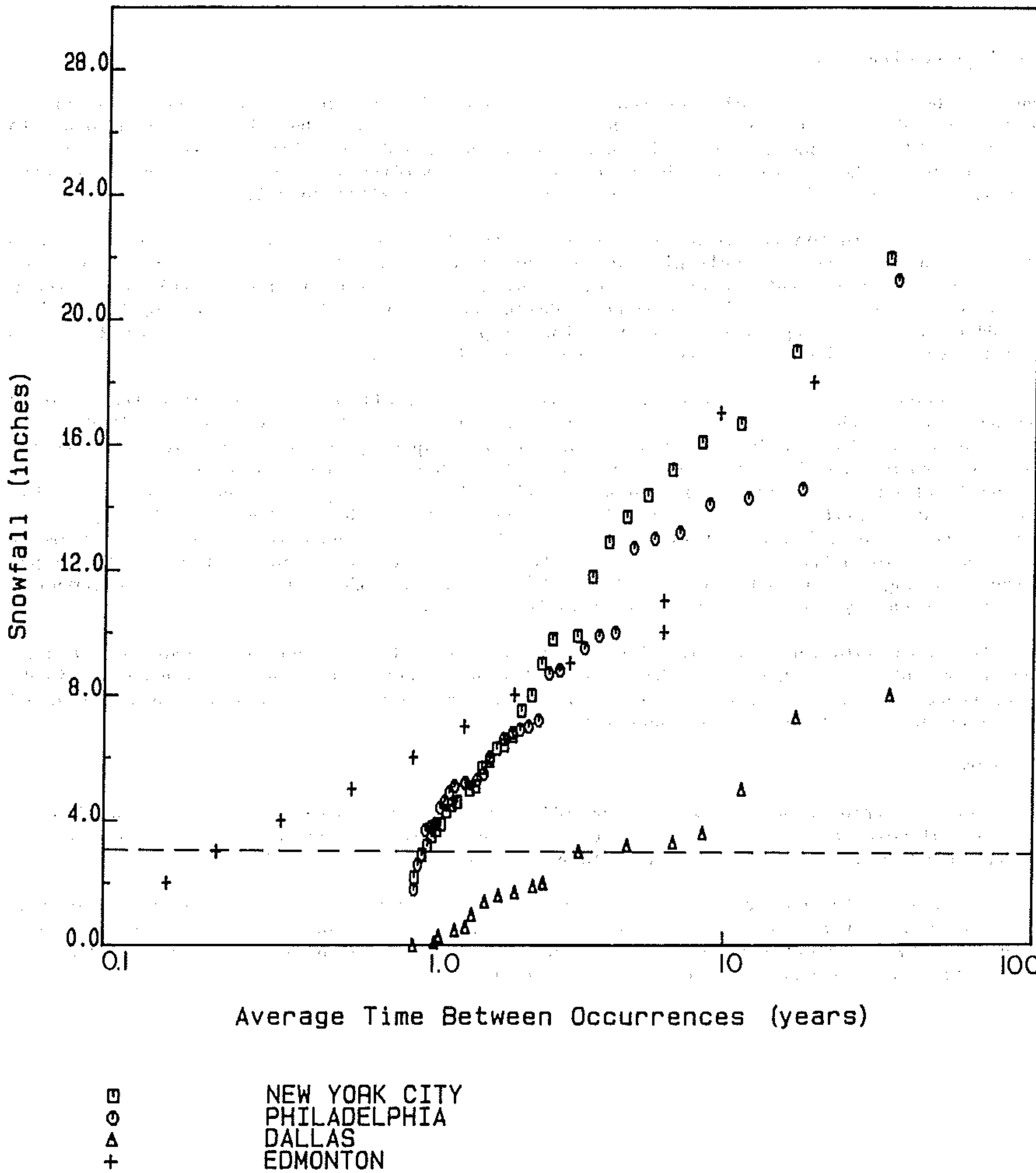

Figure 1. Depth of snowfall as a function of frequency of occurrence

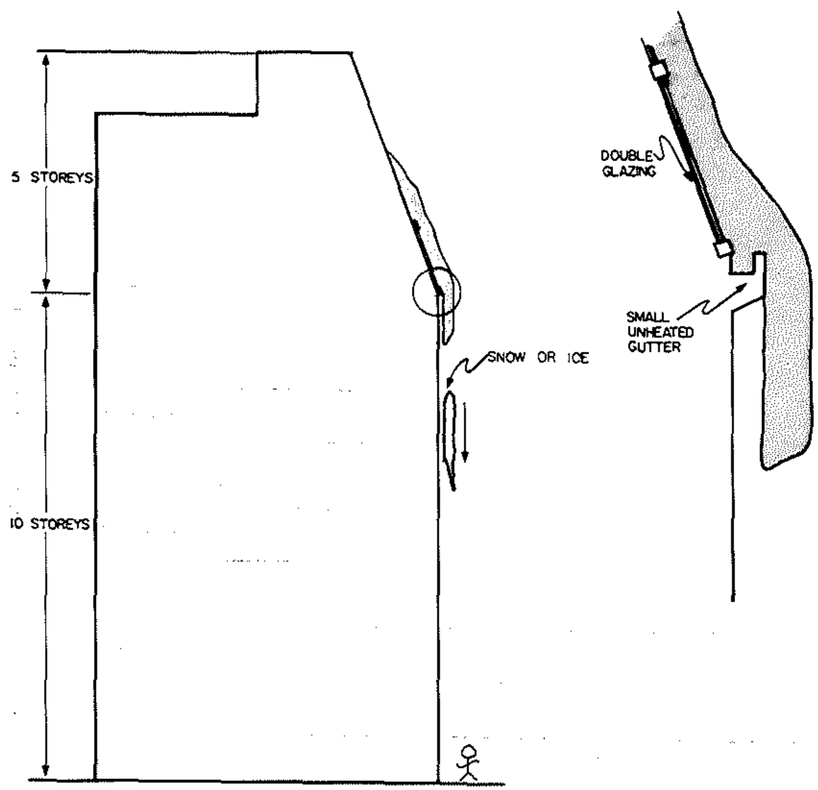

Figure 2. Sliding snow hazard

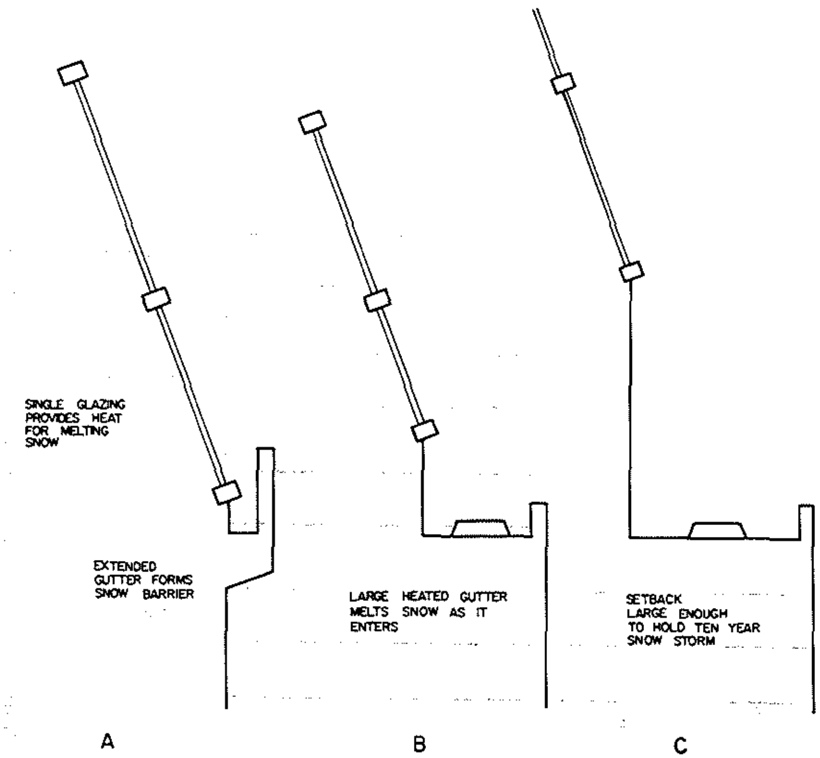

Figure 3. Three possible solutions

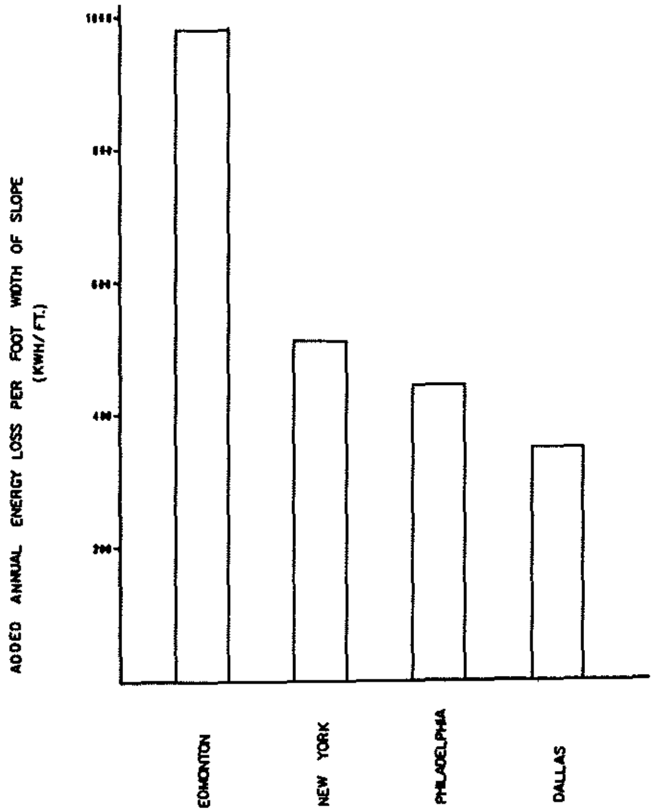

Figure 4. Added energy loss per unit width of slope due to use of single glazing

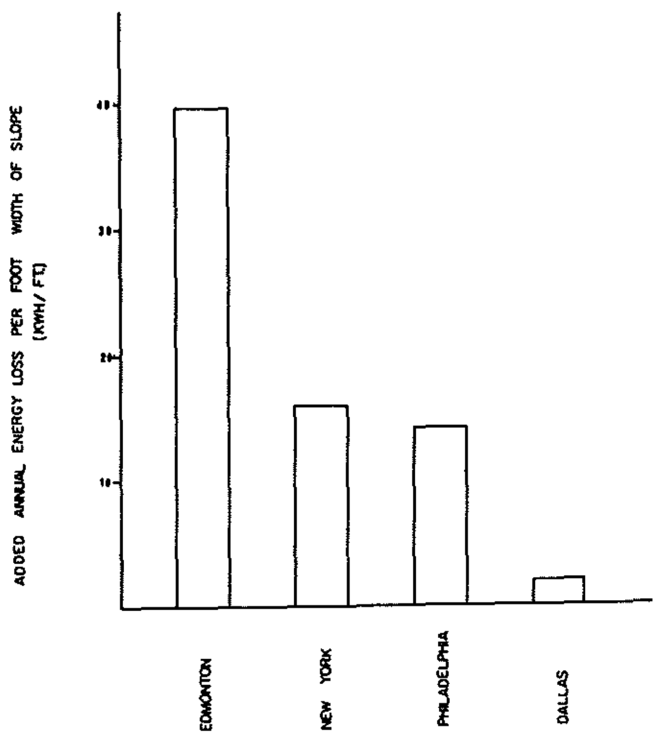

Figure 5. Added energy loss per unit width of slope due to snow melting