ARTIFICIAL SNOW AND WIND BARRIERS AROUND OPEN FRONT LIVESTOCK BUILDINGS

by

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Ever since farming began in the more northerly latitudes of North America, farmers have been faced with the winter time problem of wind and snow. Snow-blocked roads and laneways have always been accepted by rural dwellers as a normal part of the price that must be paid for living in this region of the world during the winter months.

In recent years, the loose-housing system of livestock housing has gained wide acceptance, particularly with respect to the housing of beef and dairy cattle. This system centres around the use of open front buildings which serve as protection for the cattle from the severe phases of the weather. Two essential parts of this system are the bedded or resting area and the outside exercise yard. If these two areas are to function properly, they must be kept relatively free of both wind and snow during the winter season. Several research projects have supported the observations of practical experience and have shown that cattle comfort, and their feed efficiency, while being affected to only a minor degree by lower temperatures, are affected to a very major degree by drafts and dampness. This, then, points out the importance of keeping wind or drafts to a minimum in both the yard and open front buildings. In addition, snow must be kept out of the bedded area if the cattle are to remain clean and dry. Snow control with respect to the outside yard is equally important from two standpoints: (a) feeding operations in the yards can be greatly hampered by drifting snow; (b) the greater the amount of snow build-up in the yard, the greater the problem of trying to keep the yard relatively clean and dry during the spring thaw period.

Research and practical experience have indicated that the effect of wind and the amount of deposited or drifted snow are influenced by a number of different factors such as building arrangement, orientation, roof shape and height (4), and the location, type, height, and density of wind and snow barriers around yards and buildings.

Snow and wind barriers may be divided in two main types — natural or tree windbreaks, particularly with respect to snow control on roads and laneways. A limited amount of work has been done on the effect of shelterbelts on snow and wind around buildings. Likewise, considerable datum is known about the characteristics of a number of different types of artificial snow and wind barriers. However, very little has ever been done to relate this information to the use of the barriers around agricultural structures.

A tree windbreak will only begin to be effective in the control of wind and snow fifteen or more years after planting. For this reason, livestock men are particularly interested in the use of fence-type barriers to protect yards and open front buildings. Two types of fences are possible: (a) completely solid fences which allow no air to pass through; (b) fences with openings of various proportions (less than 100 per cent density) which allows varying amounts of air and snow to filter through. With respect to this latter type of fence, McPherson (2), in studying wind barriers for farmstead use, found that an 80 per cent density fence gave the best wind protection. However, it would seem from limited practical experience in Ontario that this type of barrier allows drifting snow to sift through the openings and cause an undesirable drift on the leeward side of the fence. This fact would seem to indicate that the open type fence is practical only in low snowfall areas.

Two important facts seem to be evident. Firstly, if any effort is made to prevent the movement of wind, consideration must also be given to the possible deposition of snow (especially in heavier snowfall areas). Secondly, the unwanted snow deposits in both yards and open front buildings are due primarily to the relocation of snow after it has fallen to the ground. The wind, in moving around the building fences, and other obstructions causes certain areas to be drafty due to eddy currents, while other areas remain relatively calm. As a result, the snow is moved from one area and deposited in another, often to the detriment of the operation carried on in and around the buildings. With the above-mentioned comments in mind, and because much of the Province of Ontario receives at least some snow during the winter season, a research project was initiated in 1962 by the Department of Engineering Science, Ontario Agricultural College, Guelph, to study the effect of a solid barrier or fence on wind and snow in the yard and in the open front building of a typical loose-housing system (1).

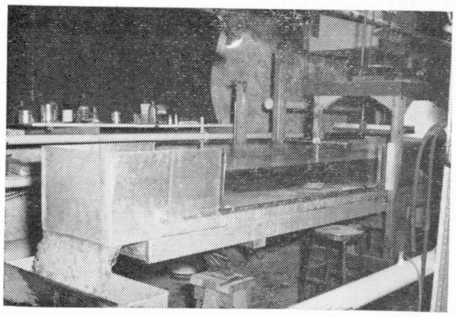

Figure 1. Water flume used to conduct this study (note sand shaker at upper end of flume, and model in position downstream between clear plastic sides).

EQUIPMENT AND PROCEDURE

A model study was conducted in the laboratory using the water flume technique developed by Professor F. H. Theakston to simulate the action of wind and snow around agricultural structures (3). It was found that very similar qualitative results to that actually observed in the field could be obtained using a model in a water flume, even though strict dimensional similarity was not adhered to.

For the study, a small plastic model of a commonly used open-front pole barn was constructed to scale and set in the water flume (figure 1). Model solid windbreak fences were also built and placed in various positions and arrangements around the yard formed in front of the open front building. Each different condition was studied with water flowing over the model in eight different directions (corresponding to the eight major wind directions). The building was oriented for reference purposes so that the open front faced south. In this study, fine, white silica sand was sprinkled into the water stream to simulate the action of snow, and a mixture of aluminum powder and detergent was injected into the water stream to study the currents set up (figure 2).

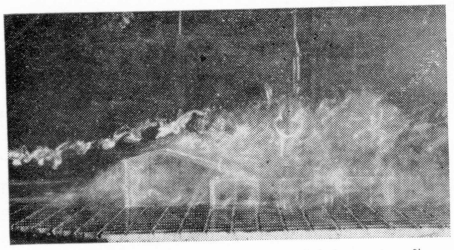

Figure 2. Side view of plastic model in water flume with aluminum powder being injected into water stream to show flow pattern.

The results of the various tests in this study were visual evaluations. These were recorded by written description, diagrams and photographs. Following this, the descriptive values were converted to numerical values in order to compare and evaluate the effects of fence position, arrangement and height, and wind direction.

RESULTS OF STUDY

Effect of Wind Direction with no Protective Fences

The effect of wind and snow on the inside of an unprotected open front building varied with the direction of the wind. The problems were the greatest with the wind blowing from the rear, diagonal direction (figure 3), and the least with wind blowing either straight at the rear of the building, or directly at the open front (figure 4).

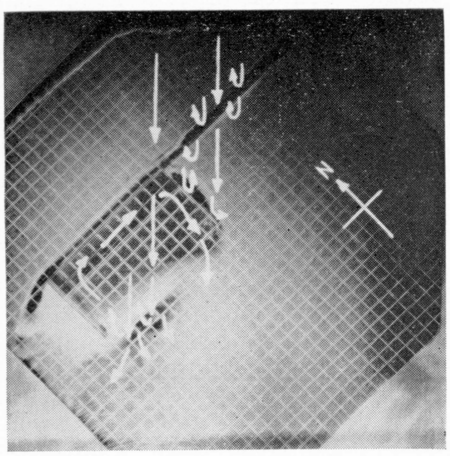

Figure 3. Typical wind and snow pattern with wind from north-east side of open front building.

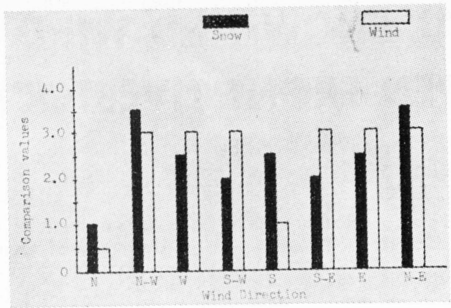

Figure 4. Comparison of snow and wind inside open front building according to wind direction (no fences present) (lowest value most desirable).

Effect of Fence Position

Method of attaching a windbreak fence to the corner of an open front building

It was found that if a windbreak fence was connected directly to the open corner of the open front building, it would cause air currents passing the open front to be diverted from the yard into the building, thus causing a drafty interior. At the same time, this wind would carry snow into the building where it would deposit out of the airstream in the form of a drift near the front of the building and/or as a thin covering over much of the interior (figure 5). This diverting effect was seen to be particularly evident with wind from both the rear and front diagonal directions, as well as with wind moving parallel to the open front, with the fence attached directly to the downwind corner of the open front.

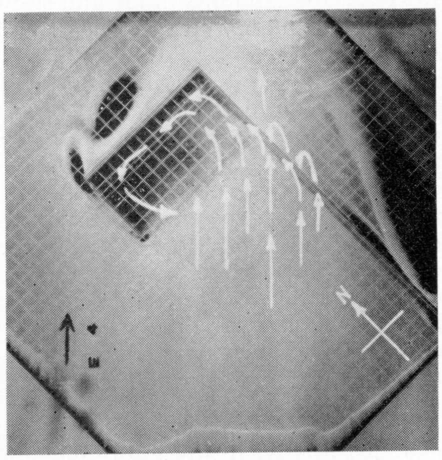

Figure 5. Wind and snow pattern with fence attached directly to corner of open front of building (wind from south-west).

In order to avoid this undesirable effect, it was found necessary to join the fence to the building by means of a "swirl chamber". This is a box-like arrangement formed by the fence and the end of the building when the windbreak fence is placed to one side and to the rear of the corner of the building.

In general terms, for all heights of fence, the larger the size of the swirl chamber, the less the interference caused by the windbreak fence to the natural flow of air by the open front of the building. The result was a decrease in both the speed of air movement and the amount of snow deposited inside the building (figure 6). This was particularly true with higher fences. The only wind direction where a larger swirl chamber was not advantageous was with wind from the south (blowing directly on the open front) where a wider swirl chamber seemed to funnel more wind

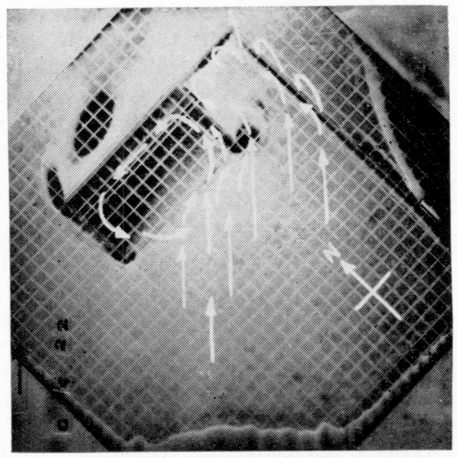

Figure 6. Wind and snow pattern with 48 feet wide by 48 feet deep swirl chamber (wind from south-west).

and snow into the building. In this situation, a deeper swirl chamber helped considerably. Depending on wind direction, certain turbulent or eddy areas were developed in the yard around the building. These would be drafty areas in actual operation and therefore undesirable. Here again, a larger swirl chamber tended to keep the size of these drafty areas to a minimum. In all fence arrangements the minimum size of swirl chamber to be of any practical benefit was 16 feet by 16 feet.

In cases where the yard was protected by a windbreak fence on one side only, larger swirl chambers sizes of 32 feet by 32 feet, and 48 feet by 48 feet gave even better results in the control of wind and snow in and around the open front building. Higher fences required larger swirl chambers to keep the wind and snow problem to a minimum. It seemed that the wider the swirl chamber, the less was the interference with the normal movement of wind and snow by the open front of the building. This was particularly true with winds from the side or diagonal direction. The deeper the swirl chamber, the less was the tendency for wind and snow to "bounce" back out of the chamber and enter the building. In addition, a deeper swirl chamber tended to decrease the adverse effect of wind coming over the building diagonally from the rear.

If the yard was totally enclosed by a windbreak fence (figure 7) the above mentioned statement with respect to the control of wind and snow inside the building still held true. However, the use of larger swirl chambers did cause some undesirable results. Because of the necessary increase in the size of the yard, large eddy areas were formed in the yard in front of the building, particularly, with wind from the diagonal direction. This effect tended to decrease the area of reduced velocity within the yard. Thus, it would seem that what was gained in the control of wind and snow inside the building by the use of larger swirl chambers, was at least partially offset due to the increased snow and wind problem in the yard.

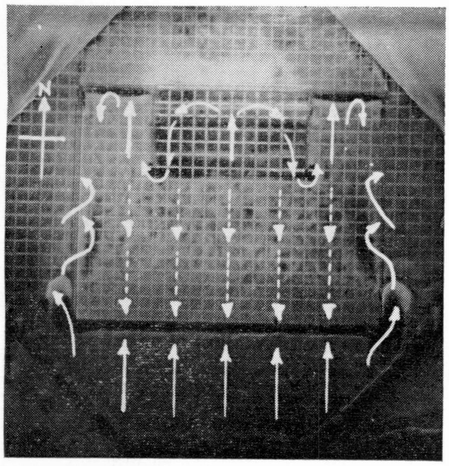

Figure 7. Wind and snow pattern with totally enclosed yard using large swirl chamber (48 feet wide by 48 feet deep (wind from south-west). Note large eddy area in corner of yard.

Position of open end of windbreak fence

If the yard in front of the open front building was not fully enclosed by a windbreak fence, the position of the open end of the fence on the windward side of the yard seemed to have particular significance with wind blowing from a diagonal direction toward the front of the building (Figures 8 and 9). Snow and wind problems in the building were reduced if the open end of the fence was kept outside a line which could be described as running from the front, windward corner of the building, across the yard at an angle of approximately 108 degrees with the front of the building.

Yard protection on side opposite open front of building

The presence of a windbreak fence on the side of the yard opposite the

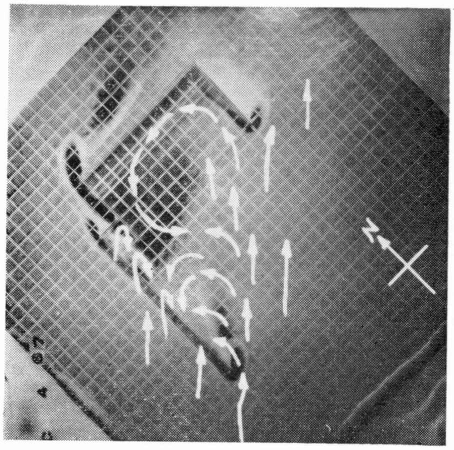

Figure 8. Snow and wind pattern with long fence (96 feet south of building) and narrow swirl chamber (16 feet wide by 16 feet deep (wind from south-west).

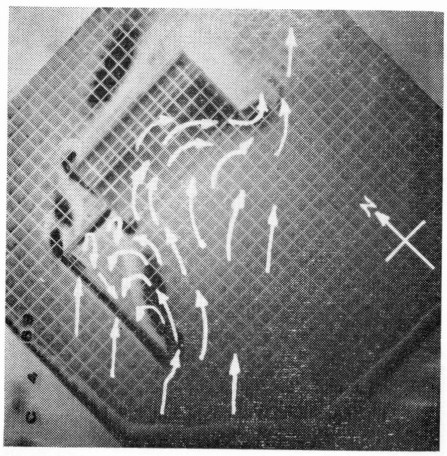

Figure 9. Snow and wind pattern with short fence (72 feet south of building) and wide swirl chamber (40 feet wide by 16 feet deep) (wind from south-west).

open front of the building afforded added protection to the interior of the building particularly with wind blowing directly on the open front. It was found that this windbreak fence should not be placed farther from the front of the building than eight to nine times the height of the fence to keep the wind and snow problems in

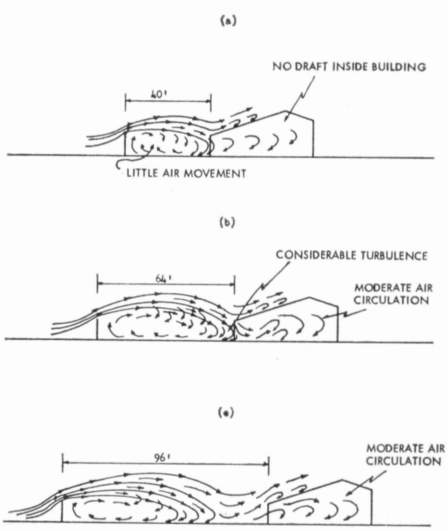

Figure 10. Effect of position of 10 foot fence south of open front of building.

Fig 10.

the building to a minimum as well as to prevent large eddy areas from developing in the yard to cause a draft problem (figure 10). Beyond this distance the snow and wind in both the yard and building increased, especially with wind blowing from a diagonal direction. For maximum yard and building protection with winds from all directions, the fence opposite the open front should be placed as close to the building as is practical in the functional use of the yard.

Degree of yard protection

When winds from all directions were considered, the snow and wind problems in both yard and building were kept to a minimum if the yard was fully protected by a windbreak fence, especially if the depth of the yard was kept within the limits set forth above (figure 11).

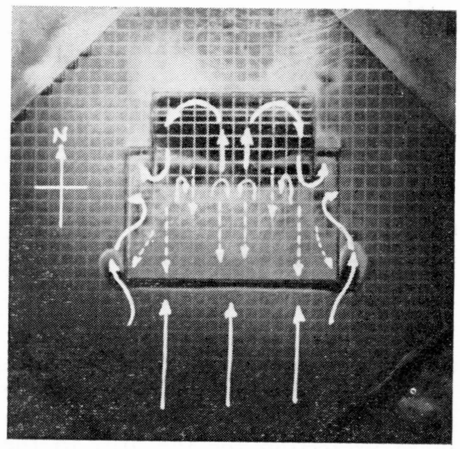

Figure 11. Wind and snow pattern with totally enclosed yard using 10 foot fence (south fence 64 feet out from open front of building—wind from south).

Fence Height

This study did not show any conclusive evidence in favour of one height of fence over any other. The results varied considerably depending on the situation. In general, it seemed that higher fences caused greater interference with normal air flow, and although a greater area of influence for velocity reduction resulted, increased eddy action also took place, causing drafty areas in the yard. With small swirl chambers, a six foot fence gave the best results, while the large swirl chambers, a 14 foot fence gave the greatest degree of protection. However, a higher fence, especially with a larger, totally enclosed yard, tended to create larger eddy areas within the yard, and this in turn, adversely affected the snow and wind situation in the building.

Wind Direction

The nature and extent of the wind and snow problems in the open front building and in the yard, were influenced by the direction of the wind. Wind from a rear, diagonal direction caused the greatest problem with wind and snow in the building, while wind blowing directly on the back or front of the building caused the least problem (figure 12). The same general situation was true with or without the presence of windbreak fences around the yard. Although wind from a front, diagonal direction did increase the wind problem in the yard if it was fully protected, still a windbreak fence, placed in the optimum position, did reduce the size of the wind and snow problems in the building for each wind direction over that encountered if no protection was provided at all.

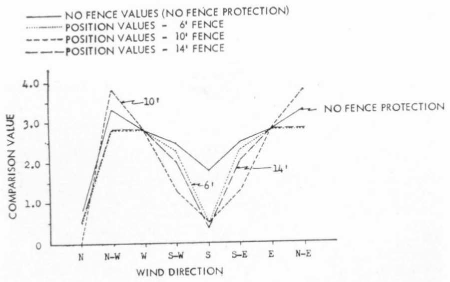

Figure 12. Effect of wind direction on amount of snow and wind inside open front building using different height of fence (yard totally enclosed—16 feet by 16 feet swirl chamber—south fence 32 feet from building).

An additional observation made during this study was that a windbreak fence placed at right angles to the direction of the wind resulted in more protection for the area to the leeward, than a fence placed diagonally to the wind. In this latter case, the wind tended to roll over the fence and continue with very little velocity reduction on the leeward side.

CONCLUSION AND SUMMARY

Solid windbreak fences can be used to advantage to control, at least to some extent, the undesirable movement of wind and accumulation of snow, both inside open front buildings, as well as in the yards in front of them. A considerable amount of drifting snow can be prevented from entering an outside yard, as shown in figure 13, of an actual situation. The amount of snow on the outside of the 10 foot fence is very much greater than that shown on the inside or yard side of the fence as shown in figure 14.

Solid windbreak fences can also reduce the problem of unwanted snow

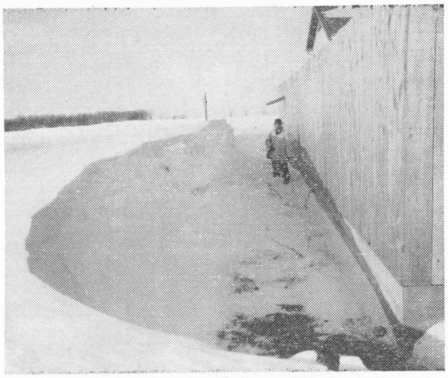

Figure 13. Snow accumulation outside a yard protected by a 10 foot high, solid board fence.

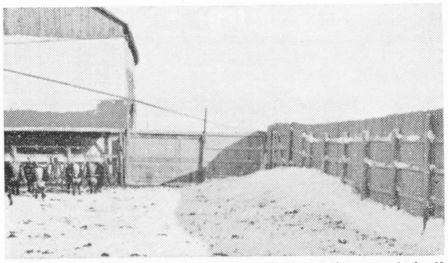

Figure 14. Snow accumulation inside the yard indicated above (both pictures taken at the same time).

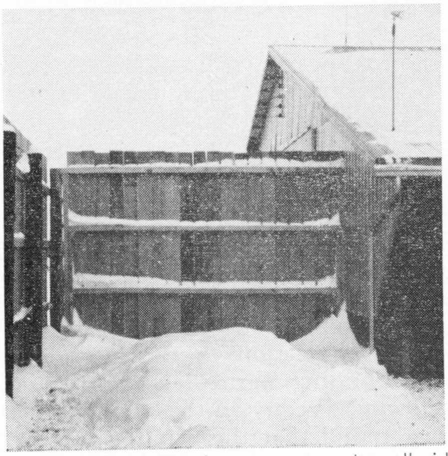

Figure 15. A box-like fence arrangement or "swirl chamber" used to connect a windbreak fence to the end of an open front building.

inside an open front building, as well as affecting considerable velocity reduction in the wind moving in and around the yard and building, if they are used in the proper position or arrangement. The importance of this fact has been brought out by this report of a model study using the water flume technique.

The following major facts have been revealed:

1. A windbreak fence should not be joined directly to the corner of an open front building. Instead, a "box-chamber" should be used to prevent funneling of wind and snow into the open front. Figure 15 shows a swirl chamber in actual operation. A minimum size for this swirl chamber, to be effective, is 16 feet by 16 feet, with somewhat larger dimensions being advantageous.

2. If the yard is not protected by a windbreak fence on the side opposite the open front of the building, the open end of the windbreak fence on the windbreak side should be outside a line running from the front windward corner of the building across the yard, and at an angle of approximately 108 degrees with the front of the building.

3. A windbreak fence on the side of the yard opposite the open front of the building will help protect the building interior as well as the yard, if it is placed closer to the open front than eight to nine times the height of the fence. For maximum yard and building protection, a fence position close to the open front is desirable.

4. If the depth of the yard is kept within the limits set forth above, a fully enclosed yard gives the best control of wind and snow in both yard and building.

5. Although not definitely determined by this study, it would seem that fence height should be approximately 10 feet; less will not give adequate wind and snow protection; more will cause undue eddy currents and winds inside the yard and building.

6. A windbreak fence is much more effective if placed at right angles to the wind than at an angle. Less wind and snow problems are encountered inside an open front building or a totally enclosed yard, if the wind blows directly at the back, side, or front of the building; a diagonal wind causes the greatest problem.

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