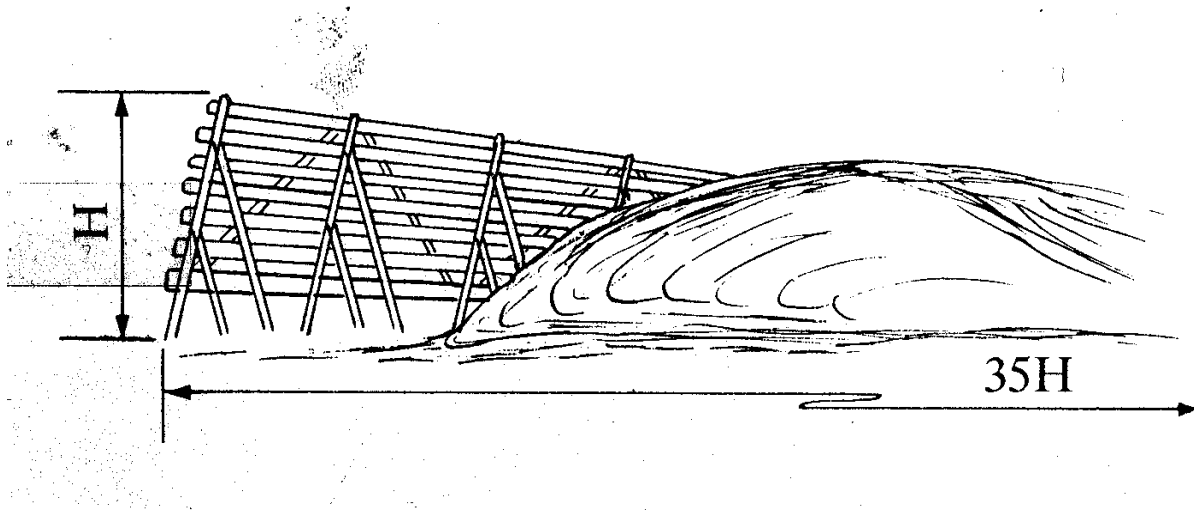


Snow Fence Guide



Ronald D. Tabler
Tabler & Associates



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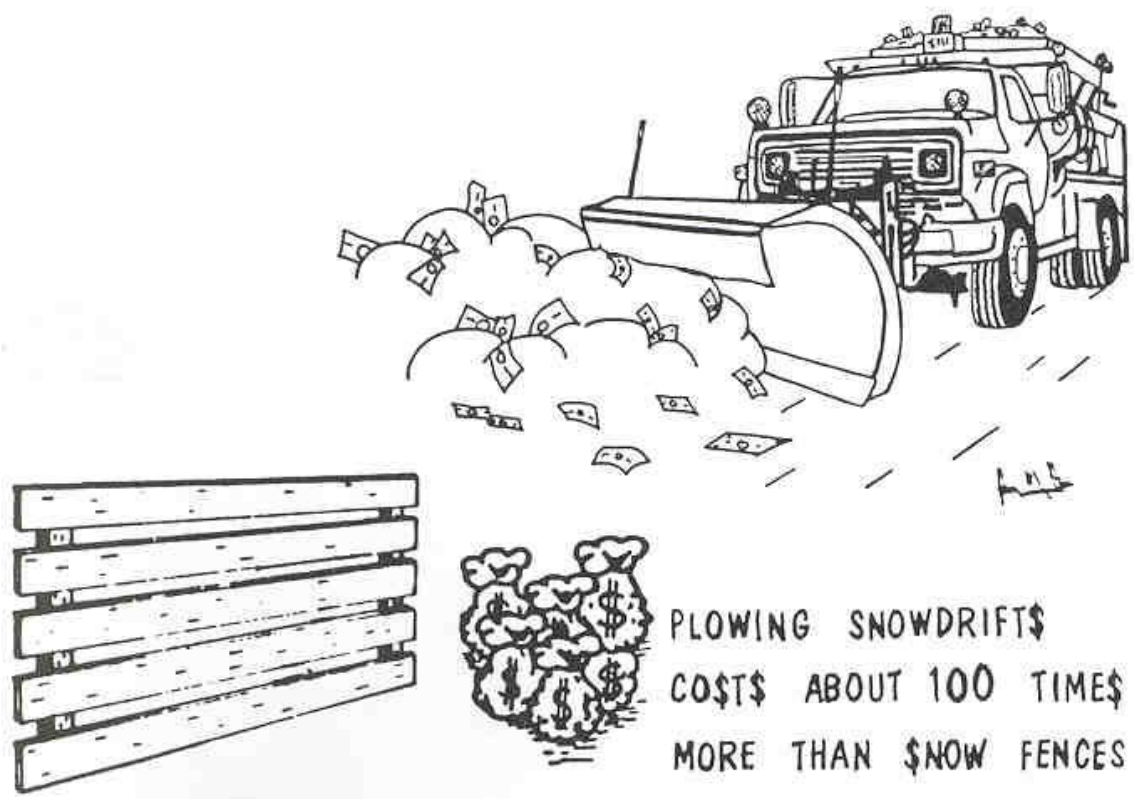
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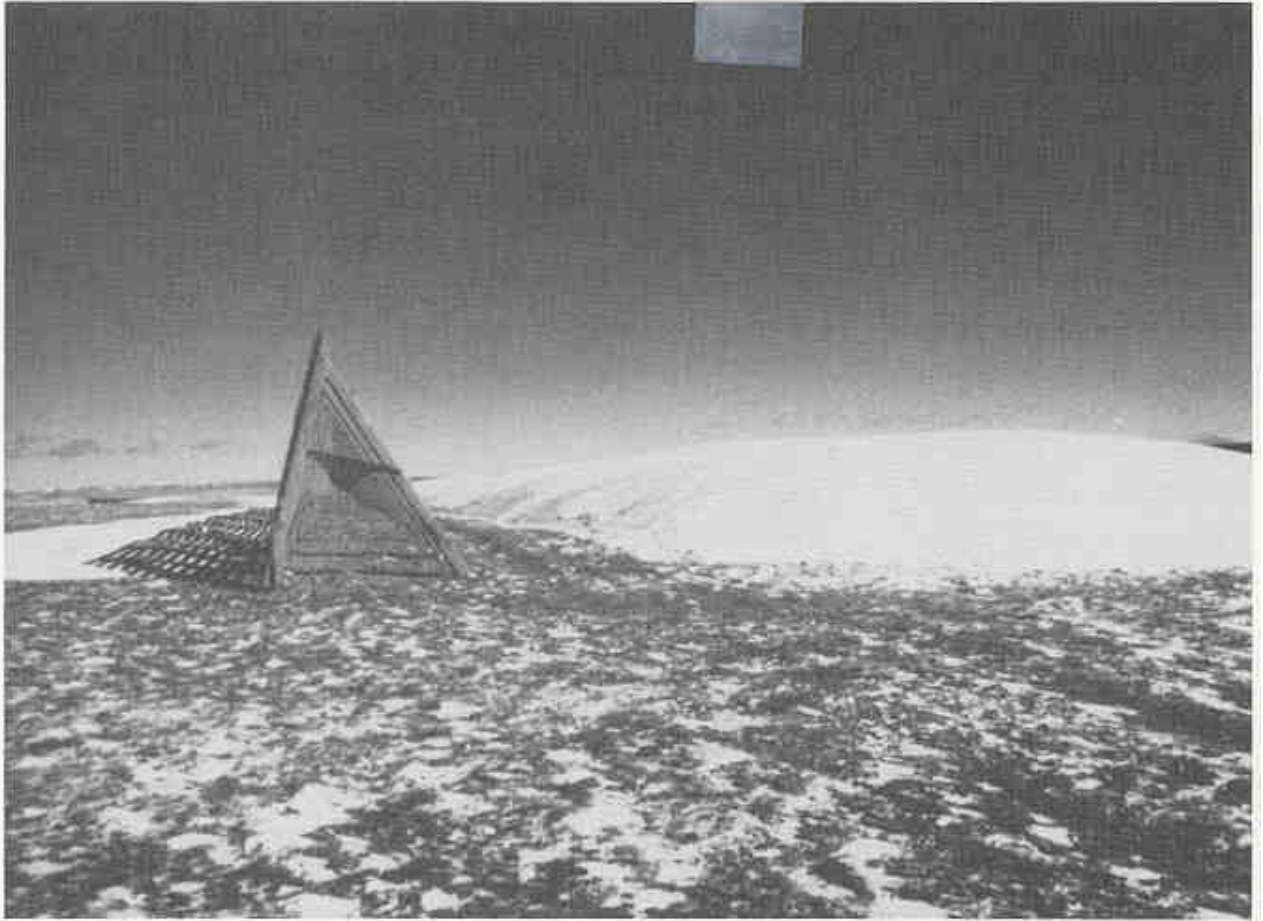
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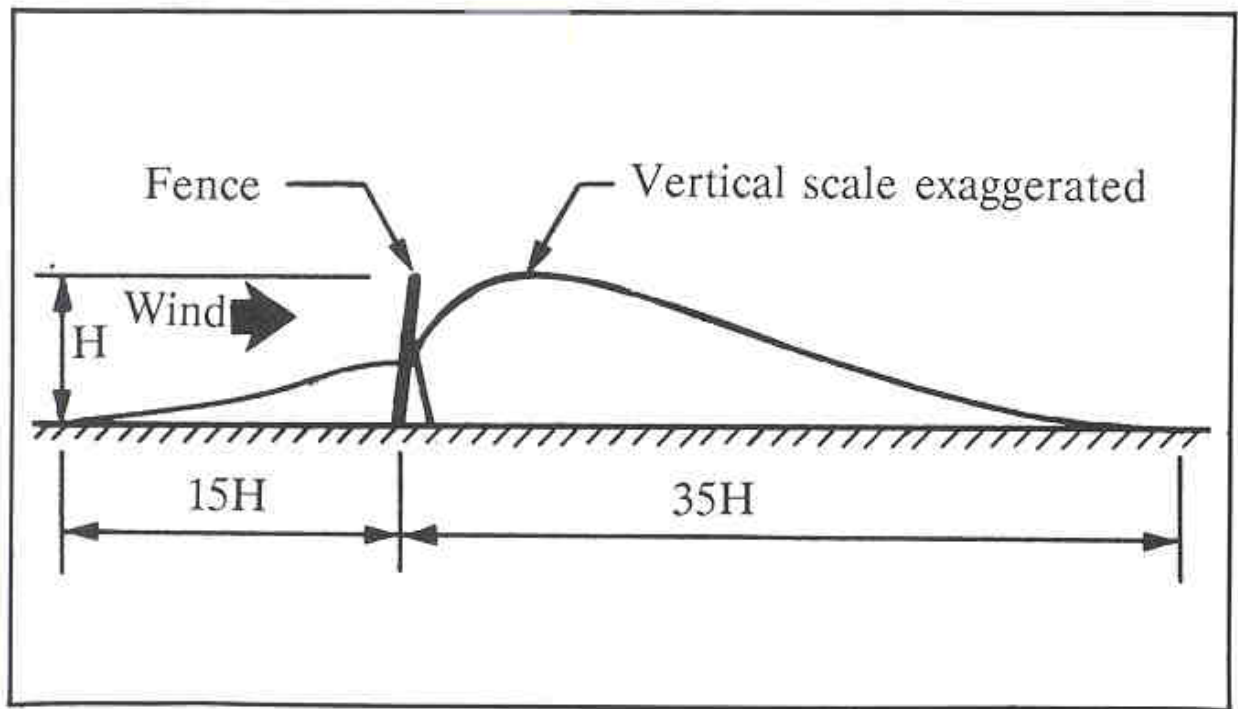
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Tips to Remember

1. Mechanical snow removal costs about 100 times more than trapping snow with fences.
2. The best fence porosity is 40% to 50%.
3. For effectiveness and economy, a single row of tall fences is always preferable to multiple rows of shorter fences.
4. One 6-ft. (1.8-m) fence = 2 rows of 4-ft. (1.2-m) fence
One 8-ft. (2.4-m) fence = 5 rows of 4-ft. (1.2-m) fence
5. Fences can improve driver visibility and reduce ice.
6. To improve driver visibility and to maximize effectiveness, fences should be 8 ft. (2.4 m) or taller.
7. Fences should be set back at least 35H from the road shoulder.
8. Extend fences beyond protection limits to an angle of 30° on either side of the prevailing wind direction.
9. Although fences should be perpendicular to the prevailing wind direction, departures up to 25° are permissible.
10. Leave a gap equal to 10% of the total fence height under the fence.

Purpose of This Guide

Snow fences can save lives and reduce maintenance costs. To be effective, however, snow fences must be designed and placed properly.

The modern snow fence is a giant step forward from the 4-ft. (1.4-m) picket fence so common 20 years ago. Placed in contact with the ground, the old-fashioned fence was an ineffective snow collector.

Properly designed and placed, taller fences are dramatically more effective than the traditional low picket fence. New lightweight plastics now allow the construction of portable fences up to 8 ft. (2.4 m) tall.

Fence projects can fail because the fences are improperly designed or placed. One common mistake is failure to design the fence for the capacity of snow it needs to hold over the season. Placing the fence too close to the road can actually make snowdrift problems worse, and is another common mistake.

To encourage more widespread use of this extremely cost effective snow fence technology, SHRP developed this *Snow Fence Guide* to cover everything maintenance personnel need to know in order to design and locate snow fences correctly.

The *Guide* summarizes the results of new research conducted by SHRP, as well as other research conducted over the last two decades. A 21-minute video, "Effective Snow Fences," supplements the *Guide*. Use the order form in the back of this book to order the *Guide*.

1. Benefits of Snow Fences

Blowing snow is a maintenance engineer's nightmare. It blinds drivers, causes accidents, and makes clearing the road difficult--at times impossible. When the snow melts, runoff seeps under the pavement, where water can cause cracking and heaving.

A well-planned snow fence program can provide a solution to blowing snow problems, and can be an excellent long-term investment. In the 1970s, the Wyoming Department of Transportation reduced snow and ice removal costs by more than one-third on a 45-mile stretch of I-80 where fences were installed (Figure 1). The fences have been remarkably effective in preventing drift formation over the 20 years they have been in place. Data available from the Wyoming study shows that storing snow with snow fences costs three cents a ton over the 25-year life of the fence, compared to three dollars a ton for moving it.

The remarkable effectiveness of properly designed snow fences is illustrated by Figure 2, which shows the conditions at a road cut before and after snow fences were installed.

In addition to their cost-effectiveness, snow fences make roads much safer. Snowdrifts can cause loss of vehicle control, reduce sight distance on curves and at intersections,

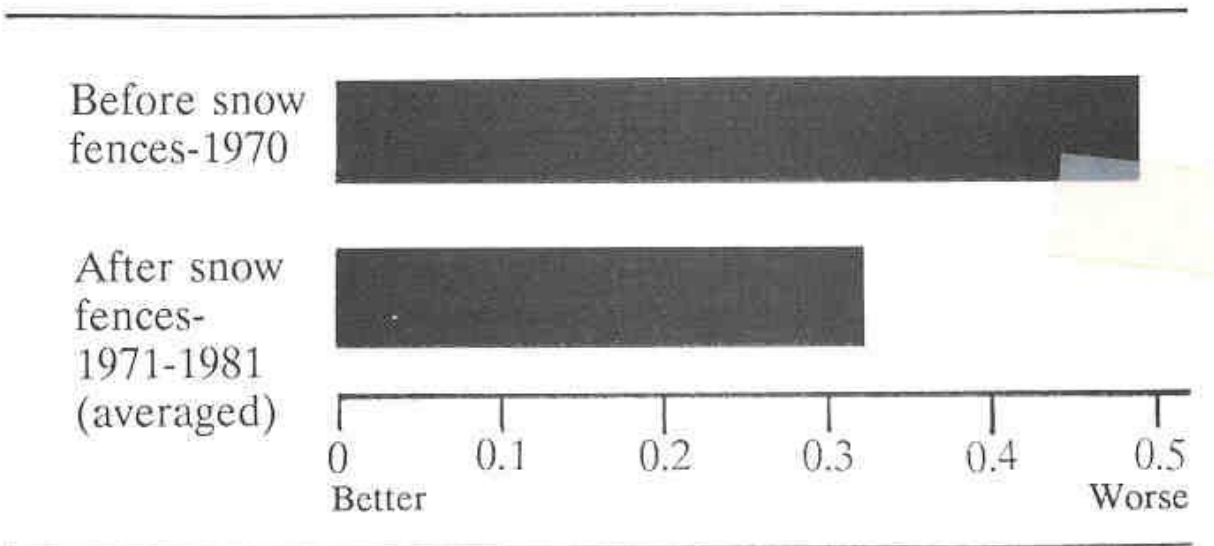


Figure 1. Snow removal costs before and after snow fences were installed on Wyoming I-80. Figures are based on the ratio between snow removal costs in the snow fence test section versus the remainder of the highways.

impair motorist visibility, promote ice formation, bury informational signs, and render safety barriers ineffective. By reducing the blowing snow crossing the road, snow fences improve visibility and reduce the formation of slush and ice (Figures 3 and 4).

The number of accidents caused by poor visibility was reduced by 70% where fences were constructed along I-80.

A final benefit of snow fences is that snow stays off the road, where runoff cannot damage the pavement or block drainage.



Figure 2. Snow conditions at a road cut before (top) and after (bottom) building snow fences. This cut has remained drift-free for the 20 years since the fences were built, and is representative of more than 25 other locations on this highway where drifts have been eliminated.

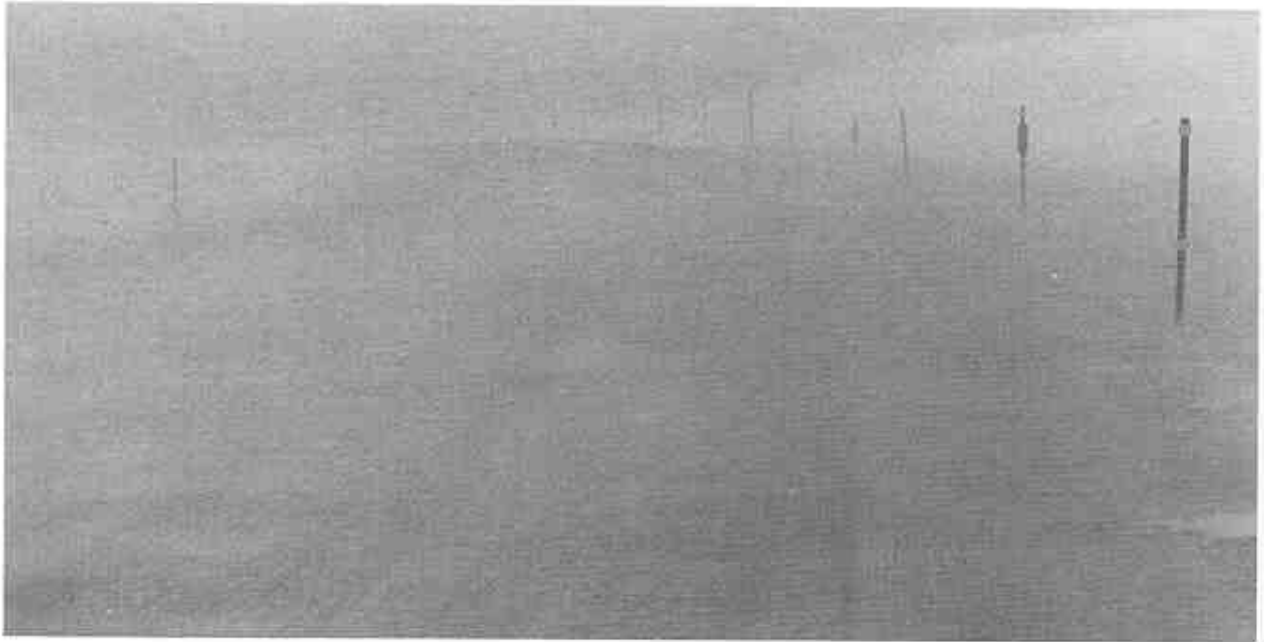


Figure 3. Improved visibility downwind of a 12-ft. (3.7-m) snow fence. The top photograph was shot 200 ft. (60 m) outside of the protected area. The bottom photograph was taken at the boundary of the protected area. (Photographs by Keith Rounds, Wyoming Department of Transportation.)

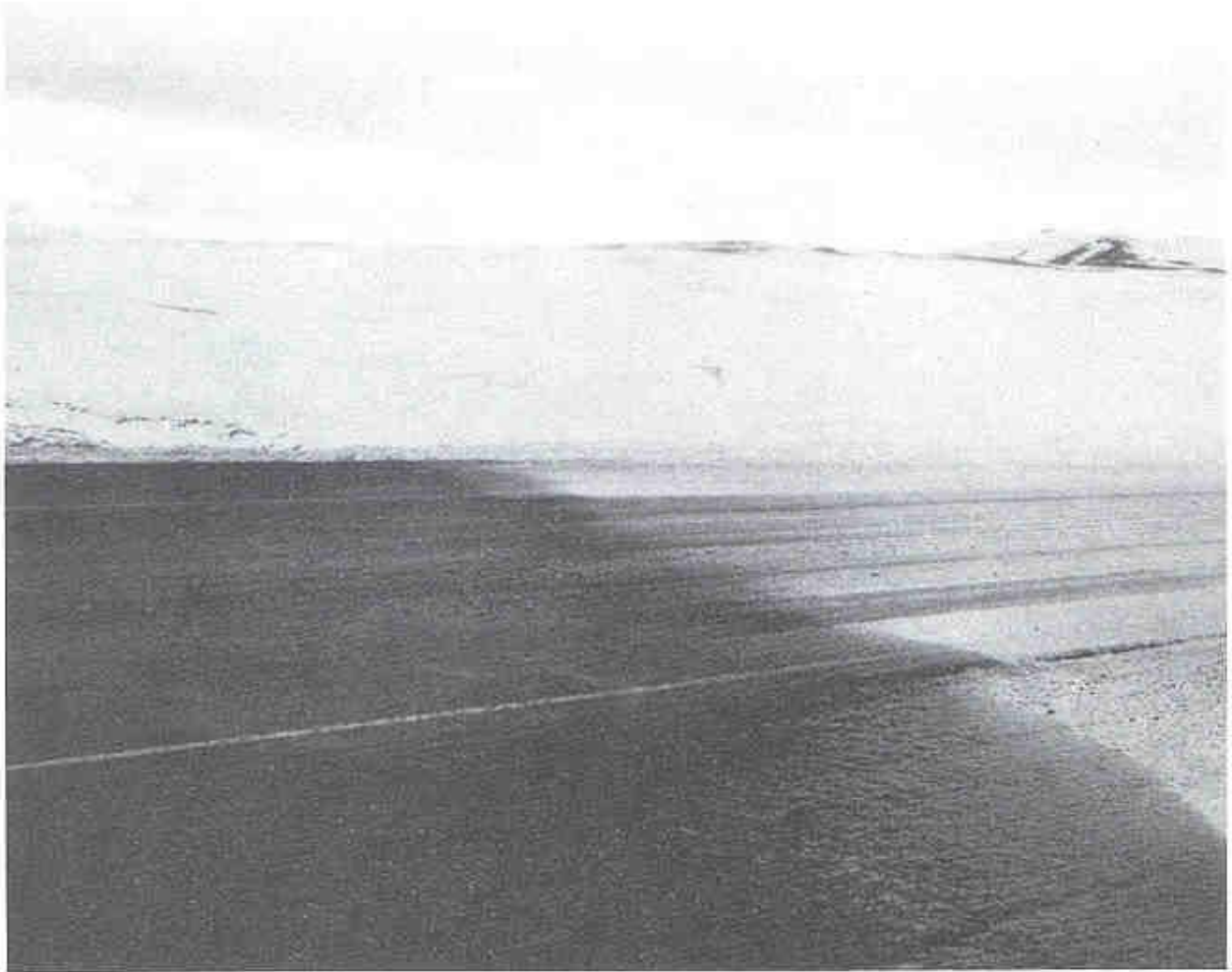


Figure 4. Transition from frozen slush to wet pavement caused by a 12-ft. (3.7-m) snow fence located about 500 ft. (152 m) upwind. The area on the right side of the transition was unfenced.

2. Introduction to Snow Fence Design

How Snow Fences Work

Blowing snow particles resemble tiny grains of sand. Snow particles that are too heavy to be suspended in the air move by bouncing or intermittently jumping (saltating) along the surface. If they are too heavy to saltate, particles roll or creep along the surface, forming "snow waves," or "dunes." Snow fences restrain the wind, reducing wind speed. This reduces the force of the wind on the surface of the snow, allowing the creeping and saltating particles to come to rest. Some of these particles are deposited on the upwind side of the fence because of the reduced wind speed that occurs ahead of the barrier. Most of the snow deposit occurs on the downwind side of the porous snow fence. Further information on how drifts form is given on p. 23, "The Four Stages of Drift Growth."

Designing the Fence

The most important factor in designing a snow fence--and one that often is disregarded--is capacity. Sizing a snow fence is similar to determining the required capacity for a culvert, detention pond, or storm drain. The first step is to estimate how much blowing snow must be stored, and the

second step is to design a fence system that has the capacity to store it.

To estimate the quantity of blowing snow, one must determine the distance (fetch) within which the wind can pick up snow and deposit it on the road, and the amount of relocated precipitation. Figure 5 illustrates the fetch concept. If the prevailing wind direction (or directions) is known, fetch can be measured on aerial photographs or topographic maps, or by direct observation during the winter.

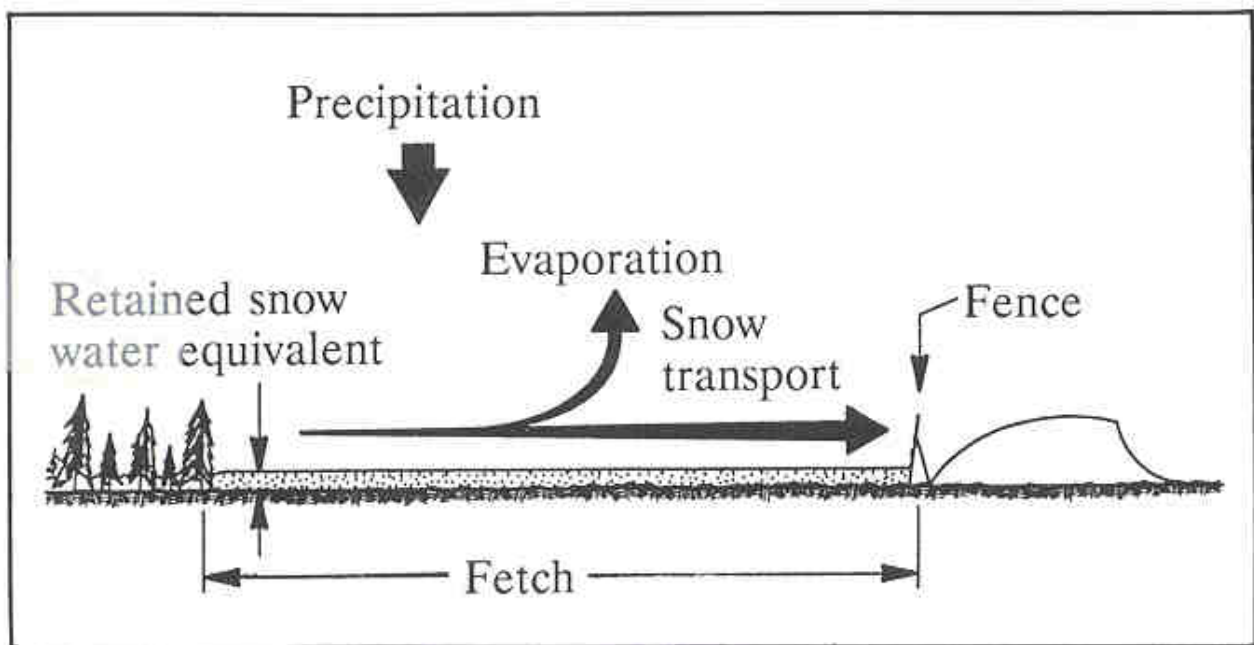


Figure 5. The fetch concept used to estimate snow transport.

The first step in determining relocated precipitation is to estimate water-equivalent winter precipitation, which may be calculated as 10% of the annual snowfall. A conservative estimate for relocated precipitation is 70%.

The fetch and relocated precipitation are used in the snow transport curve (Figure 6) to determine the amount

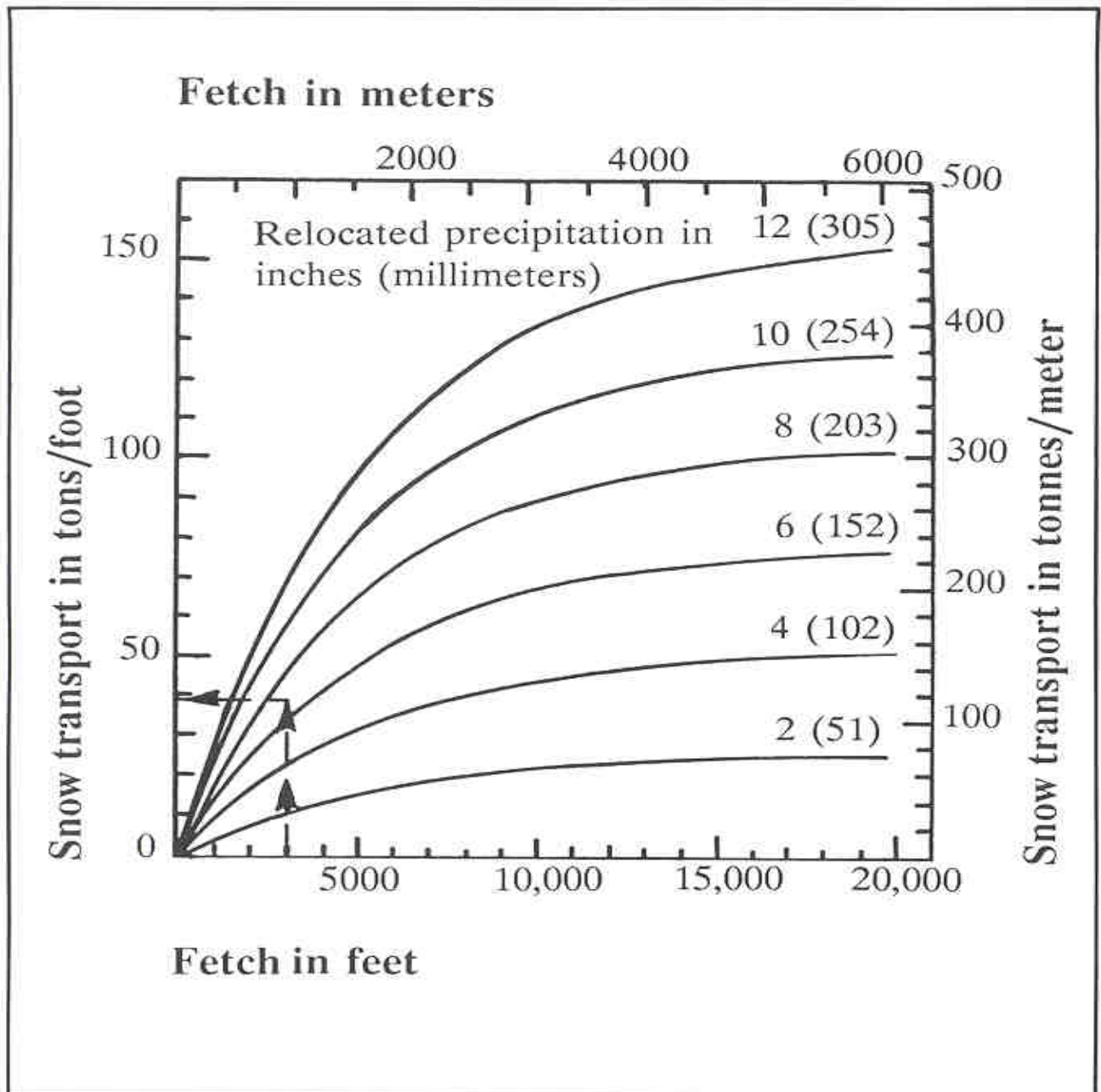


Figure 6. Variation of seasonal snow transport with fetch and relocated precipitation.
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of seasonal snow transport. The height of fencing (or number of rows of fence having a specified height) can be determined from the amount of snow transport (Figure 7).

For example, if the fetch upwind of the road is 3,000 ft. (915 m), and the average annual snowfall is 90 in. (2290 mm), then relocated precipitation would be $6.3 \text{ in.} = 90 \text{ in.} \times 10\% \times 70\%$ ($160 \text{ mm} = 229 \text{ cm} \times 10\% \times 70\%$). Enter Figure 6 at a fetch of 3,000 ft. (915 m), proceed vertically to intercept the relocated precipitation curve at 6.3 in. (160 mm), and then move to the y axis to determine that the snow transport would be approximately 38 tons/foot (120 tonnes/m). In this case, an 11-ft. (3.4 m) fence would be required, as shown in Figure 7.

Seven rows of 4.5-ft. (1.4 m) fences would be needed to provide the same snow storage. A single row of taller fence is always preferable to multiple rows of shorter fence. The taller fence not only traps more snow, but also much more effectively improves driver visibility, costs less, and requires less land. A rule of thumb is that fences should be at least 8 ft. (2.4 m) tall.

The fence should extend lengthwise far enough to cover the area to be protected, extended on either side by 20 times the height of the fence. The extension allows for variations in wind direction and for the reduced trapping efficiency and storage capacity near fence ends.

Fences should have a gap at the bottom equal to 10-15% of the fence height. Leave 40-50% of the fence surface area open to make the fence porous. Solid fences do not collect snow efficiently.

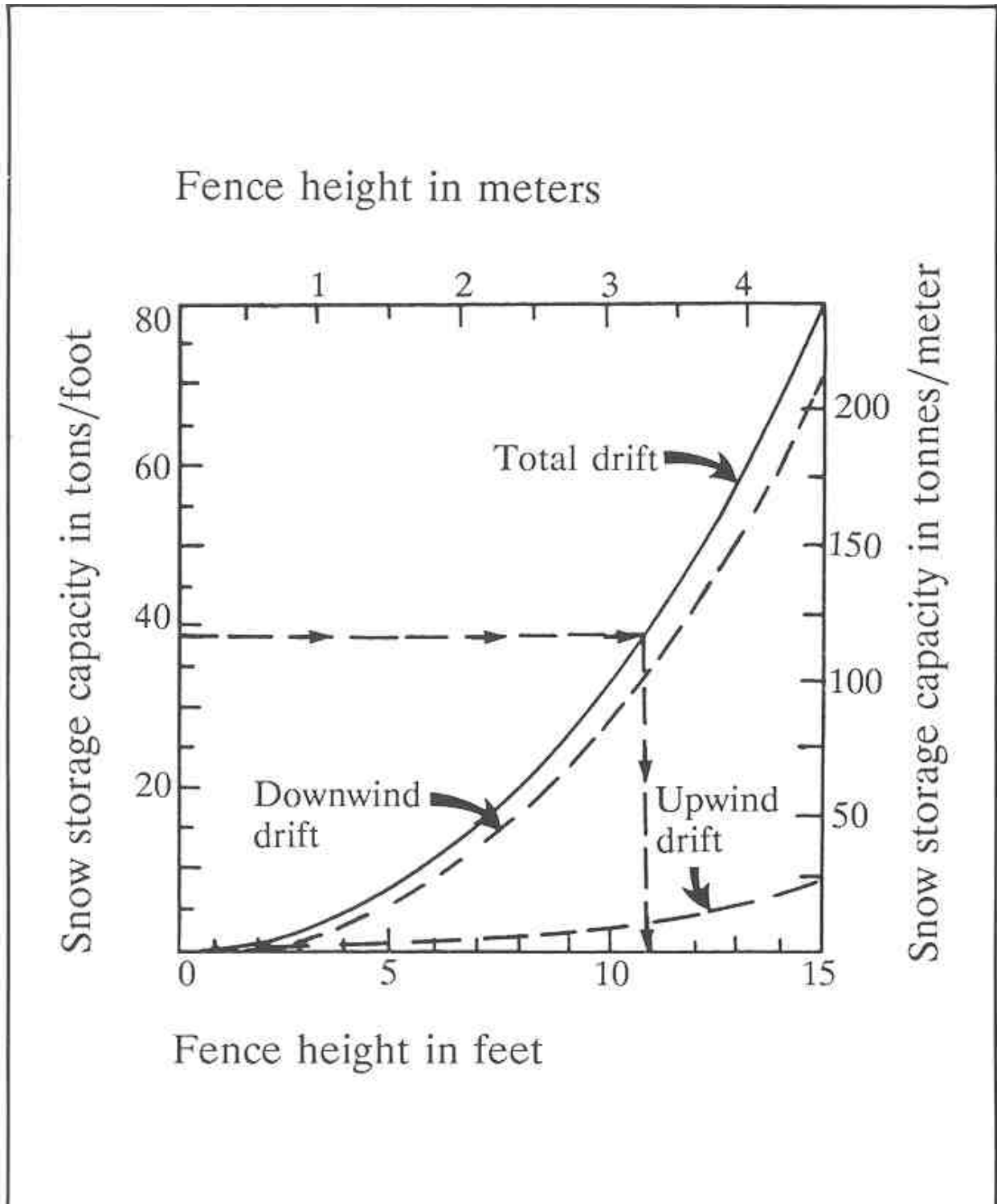


Figure 7. Snow Storage capacity in relation to fence height.
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Placing the Fence

Snow fences too close to the road can *increase* the amount of snow on the road! The distance between fences and the road should be at least 35 times the height of the fence.

Although fences should be perpendicular to the prevailing wind direction, the angle can vary by as much as 25° without affecting performance.

More detailed step-by-step guidance on designing and placing snow fences is provided in the next chapter.

3. Step-by-Step Guide to Snow Fence Design

Analyze the Snow Drift Problem

Identify *what* the snowdrifting problem is, *where* it is, and *why* it exists.

Is visibility poor? Are there drifts on the roads? Does ice form in some spots? Are there areas that seem to encourage accidents? Is it expensive to plow the snow? Or is the problem a combination of these things? Once you have determined what the problem is, the next step is to identify solutions.

Define the Area that Needs Fence Protection

Knowing *where* the problem is allows us to use snow fences where they are most needed. Define the area that needs snow fence protection by the mileposts or stations at the limits of the problem. Mark these locations on plans or aerial photographs. Observations should be made in the wintertime with the input of the local maintenance supervisor. Aerial photographs taken during the winter can show the problem boundaries, and also provide information on wind directions.

Determine Why the Problem Exists

Determining why a drifting problem exists can indicate the best possible solution to the situation. Road cuts, vegetation, buildings, guard rails, median barriers, or bridge abutments and their relationships to prevailing wind and snow conditions can cause snowdrifts. An important part of understanding the problem is to gain insight into how long the problem has existed, and the reasons that the problem has not been solved previously.

Determine the Wind Direction

Wind direction is the most important information for snow fence design. Wind direction determines the fetch, the snow transport, and fence orientation and placement.

The prevailing wind direction should be determined as precisely as possible. Methods to determine wind direction are to:

1. Analyze meteorological data from a representative weather station;
2. Determine direction of drift features in the field;
3. Determine direction of drift features using aerial photographs;
4. Note the orientation of wind-sculpted vegetation, such as flagged or bent trees, or snow-caused abrasion on wooden poles or posts.

The simplest procedure for determining wind direction is to use a hand-held compass to determine the direction of drifts

behind shrubs, trees, or other objects casting drifts. The streamlined shapes of drifts provide readily identifiable indicators for wind direction. The alignment of large drifts, measured late in the winter, represents the average direction of drifting. If only small drifts are available, measurements must be repeated several times over a winter to obtain a meaningful average. Because cuts and fills can alter local wind directions, it is important *not* to take measurements from drifts in road cuts or other locations where wind direction may be different from the wind direction at the snow fence site.

The direction of drifts formed by solitary objects is readily discernible on aerial photographs at scales up to 1:12,000 if the following requirements are met:

1. Black and white film must be used (color film does not provide sufficient contrast);
2. Photographs must be taken on bright, sunny days, preferably in the early morning when the sun is low;
3. Flights should be scheduled after major drifting events having typical winds, but not after a recent snowfall that can cover up drift features;
4. Photographs must be taken before melting begins, preferably near the time of peak snow accumulation.

Photographs also can be used to identify and delineate problem locations, measure the fetch, and help situate fences. The cost of aerial photographs may easily be repaid by the time saved in field measurements, design, and preparation of location maps.

Estimate the Snow Transport

Adequate capacity is the most important requirement for any snow fence system. Many snow fence projects fail because they are not designed for sufficient storage capacity. "Sizing" a snow fence is similar to determining the required capacity for a culvert, detention pond, or storm drain. First, estimate how much blowing snow must be stored. Second, design a fence system that can store it.

Snow transport is the mass of snow moved by the wind over a period of time within a specific width across the wind. It is usually expressed as tons per foot or tonnes per meter. The snow transport is related directly to the size of the fetch. The fetch is measured from the upwind side of the snow fence to the next upwind obstacle to snow transport. Obstacles include deep gullies or stream channels, trees, ice pressure ridges, and open water.

It is possible to calculate the snow transport from the fetch, from the amount of relocated precipitation, and from the evaporation that occurs when snow moves. Most blowing snow travels within 6 ft. (1.8 m) of the surface (Table 1). This is essential information for determining the height of the fence.

To estimate the snow transport at a prospective fence location, use Figure 7 (p. 13). The wind direction information from the previous section determines the fetch and hence snow transport. The fetch can be measured on aerial photographs or topographic maps, or measured in the field. An upper limit for the fetch is 4 miles (6 km), because most of the snow from further upwind evaporates.

Height						
		22 (10)	34 (15)	45 (20)	56 (26)	
0.0-1.6	0.0-0.5	88.5	68.7	51.9	41.1	33.8
1.6-3.3	0.5-1.0	2.4	8.1	12.6	15.2	16.7
3.3-4.9	1.0-1.5	1.6	5.0	8.0	9.9	11.1
4.9-6.6	1.5-2.0	1.3	3.9	6.1	7.5	8.5
6.6-8.2	2.0-2.5	1.2	3.1	4.8	6.0	6.9
8.2-9.8	2.5-3.0	1.1	2.7	4.2	5.2	5.8
9.8-11.5	3.0-3.5	1.0	2.5	3.6	4.4	5.1
11.5-13.1	3.5-4.0	1.0	2.1	3.2	4.0	4.5
13.1-14.8	4.0-4.5	1.0	2.0	2.9	3.5	4.0
14.8-16.4	4.5-5.0	0.9	1.9	2.7	3.2	3.6

Table 1. Vertical distribution of snow transport as a function of wind speed. Values are percentages of total transport in the first 16 ft. (5 m) above the surface.

The next step is to determine the relocated precipitation by estimating water-equivalent precipitation over the snowdrifting season. For most purposes, it is sufficient to design for the *average* winter. Sources of precipitation data include climatological data published by the National Weather Service, or summaries published in climatological atlases. The average water-equivalent of newly fallen snow is about 10% of the snowfall. In the western states, the best estimate for winter precipitation is provided by records of the peak snowpack water-equivalent as measured on snow courses operated by the U.S. Soil Conservation Service. In Canada, snowfall data are available in the *Climatological Atlas of Canada*.

The proportion of precipitation relocated by the wind over the course of a winter varies with weather conditions,

vegetative cover, and topography, but seldom exceeds 70%. In the absence of specific measurements, 70% may be used as an upper limit for conservative design. If a closer estimate is desirable, snow retention may be measured over a winter and expressed as a percentage of average precipitation.

Determine the Fence Height and the Number of Rows Required

There are two ways to determine how much storage capacity is needed: by estimating snow transport as described above; or by trial-and-error. Estimating snow transport speeds up the determination, but for those who prefer to learn by experience, there is one simple rule that applies to most locations: *Start with a fence 8 ft. (2.4 m) tall.*

Given the snow transport (Figure 6, p. 11), however, the required height of fencing (or the number of rows of fence of a specific height) is easily calculated from Figure 7 (p. 13), which contains information about the storage capacity of fences.

For the example on p. 12 where the snow transport was estimated to be 38 tons/ft. (113 tonnes/m), an 11-ft. (3.4-m) fence would be required. Seven rows of fence 4.5 ft. (1.4 m) tall would be required to provide the same snow storage capacity. The 11-ft. (3.4-m) fence would be less expensive to build and install, would require less land area, and would trap snow more efficiently. For these reasons, a single row of taller fence is always preferable to multiple rows of shorter fence.

Determine Fence Placement

Layout Procedure

The following procedure is recommended for laying out fence systems:

1. Enlarge a topographic map or aerial photograph to a scale of 1 in. = 500 ft. (1 cm = 60 m) or larger;
2. Mark the required protection limits on the map;
3. Draw lines on the map parallel to the prevailing wind direction at protection limits;
4. Determine fence orientation and setback;
5. Draw tentative fence locations;
6. Make a field visit to determine if fence locations should be adjusted for topographic features and other conditions not apparent on the map or photograph.

Fence Orientation

The orientation of a fence is much less important than its proper extension on either side of the area to be protected. Fences should be parallel to the road if the prevailing wind direction is within 25' of perpendicular to the road. If winds are more closely angled to the road, fences should be aligned perpendicular to the prevailing wind direction. Departures from these guidelines of up to 25' may be made to avoid adverse terrain, or to take advantage of favorable

topography. Where fences are designed at an angle to the road, adding a parallel fence between the road and the angled fences affords the most complete protection.

If the average wind direction is nearly parallel with the centerline of the road, visibility can be improved by placing fences on both sides of the road in a herringbone pattern (Figure 8). To deflect the blowing snow away from the road, the fences should be aligned so that the outside end is farther downwind than the end nearest the road.

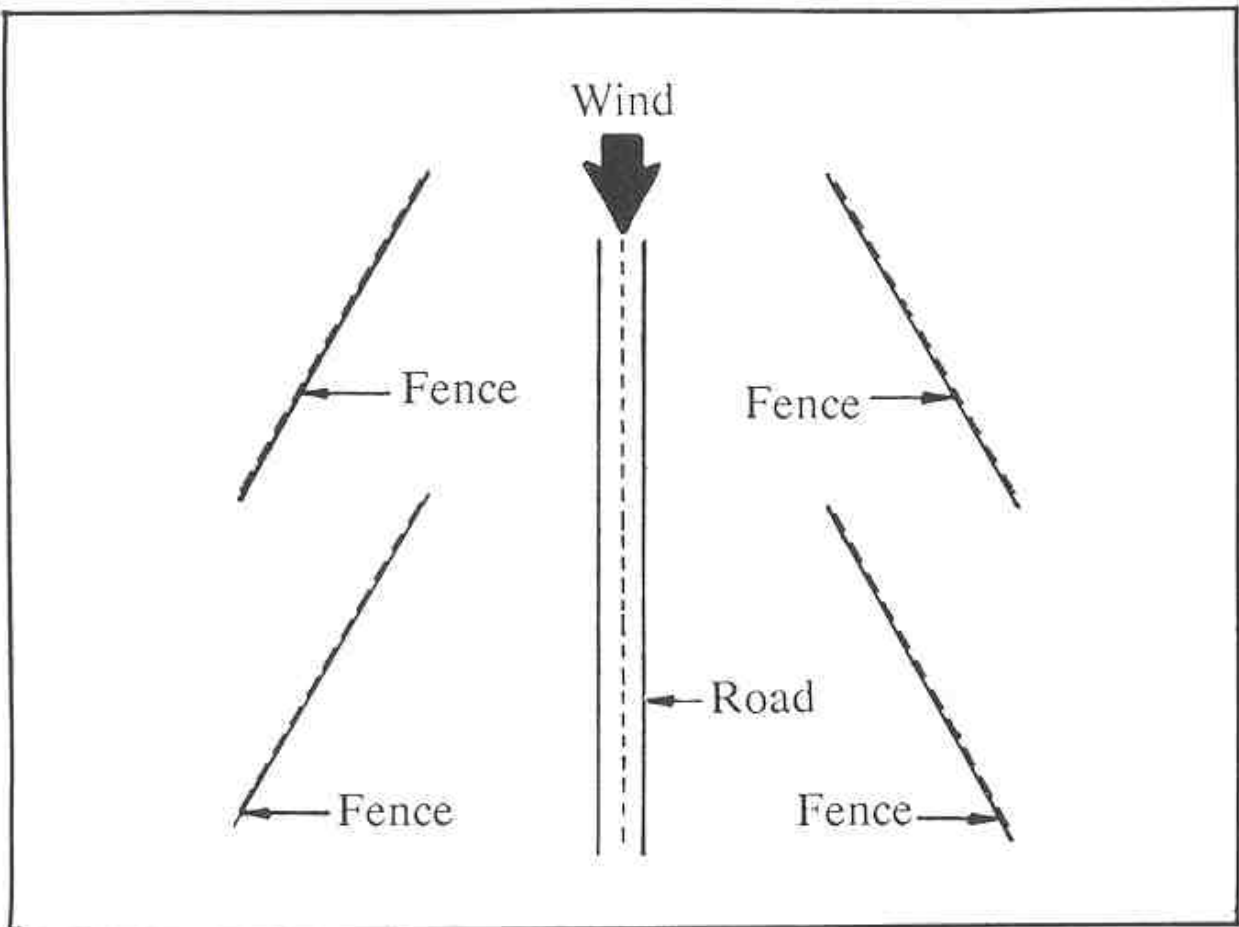


Figure 8. Herringbone snow fence pattern used to improve visibility with winds that blow down the road.

The Four Stages of Drift Growth

Snow fences slow down the wind and allow snow particles to stop or fall to the ground. Since the wind slows ahead of the snow fence, some snow deposits upwind of the fence. For a 50% porous fence on level ground, the upwind drift contains about 15% as much snow as the downwind drift, and grows in proportion to the downwind drift. Figure 9 shows the four stages of drift growth.

In the first stage, a lens-shaped drift forms as creeping and saltating particles are caught by the fence. The wind force diminishes for a distance equal to about 15 times the height of the fence ($15H$). Some blowing snow deposits on the ground, but the wind still carries some particles from the shelter of the fence.

This lens-shaped deposit becomes deeper until the wind no longer follows its curvature. At this stage, an eddy or recirculation zone forms at the downwind end of the lens, causing a slip-face to form. This is characteristic of the second stage of drift growth. At this stage, the drift adds significant resistance to the approaching wind. The recirculation zone helps trap particles blowing off the top of the drift.

During the second stage, the lens-shaped drift becomes deeper but not much longer (Profile 3, Figure 9). The efficiency of the fence may actually

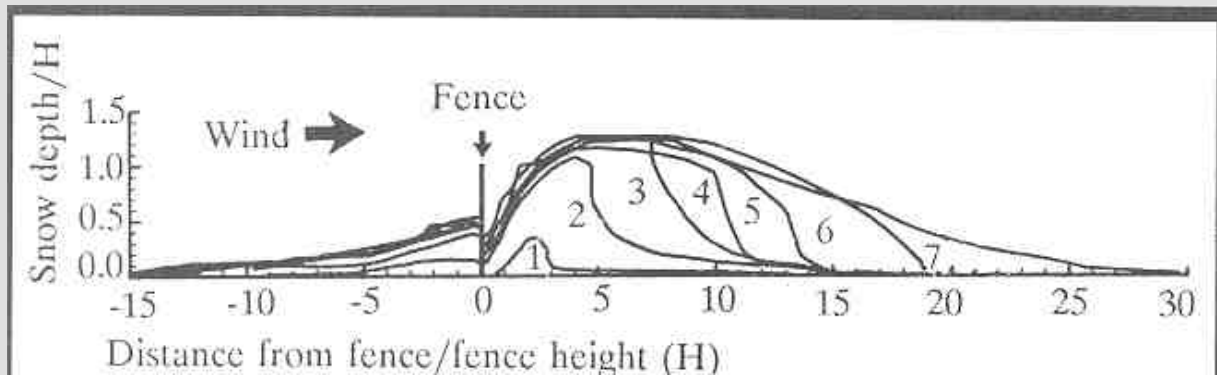


Figure 9. Stages of growth for a 50% porous snow fence, as illustrated by profiles on seven dates. ©1986 Tabler & Associates

increase as the drift adds resistance to the wind. The slip-face and recirculation zone that form in this stage trap some of the snow that blows off the top of the drift.

As the downwind drift approaches its maximum depth (for 50% porous fences, 1 to 1.2 times the height of the fence), the third stage of growth begins. The recirculation zone fills in as the drift lengthens downwind (Profiles 4-6, Figure 9). This stage is characterized by a decline in trapping efficiency as the recirculation zone diminishes in size.

The fourth stage of growth begins when the drift first assumes a smooth profile without the slip-face, marking the disappearance of the recirculation zone. At this stage, the drift is about $20H$ in length (Profile 6, Figure 9). Subsequent growth is slow as the drift elongates to its final length of 30 to $35H$ (Profile 7, Figure 9).

Minimum Setback Distance

Fences should be far enough from the road so that the downwind drift does not extend onto the road. On flat terrain, the minimum setback for 50% porous snow fences is $35H$. Minimum setback for a 6-ft. (1.8-m) fence, for example, would be $35 \times 6 \text{ ft.} = 210 \text{ ft.}$ ($35 \times 1.83 \text{ m} = 64 \text{ m}$). Snow fences may be set back farther to prevent their drifts from burying right-of-way fences, or if terrain will encourage longer drifts.

Maximum Setback Distance

Certain terrain features, such as a hill, a ditch, or a gully, may require a fence to be placed farther from the road than the minimum distance. The farther a fence is from the area to be protected, the less protection it affords.

The maximum setback distance depends on the nature of the drifting problem. At shallow road cuts where even a small amount of blowing snow can cause drift encroachment on the road, fences must be closer than in the case of deep cuts that store more snow before drifts reach the road.

The End Effect

Fences should extend far enough beyond the protection limits to intercept blowing snow from the anticipated range of wind directions, and to allow for the reduced trapping efficiency and storage capacity near the fence ends--the end effect.

To account for both the end effect and the natural variability in wind direction, fences should extend far enough on both

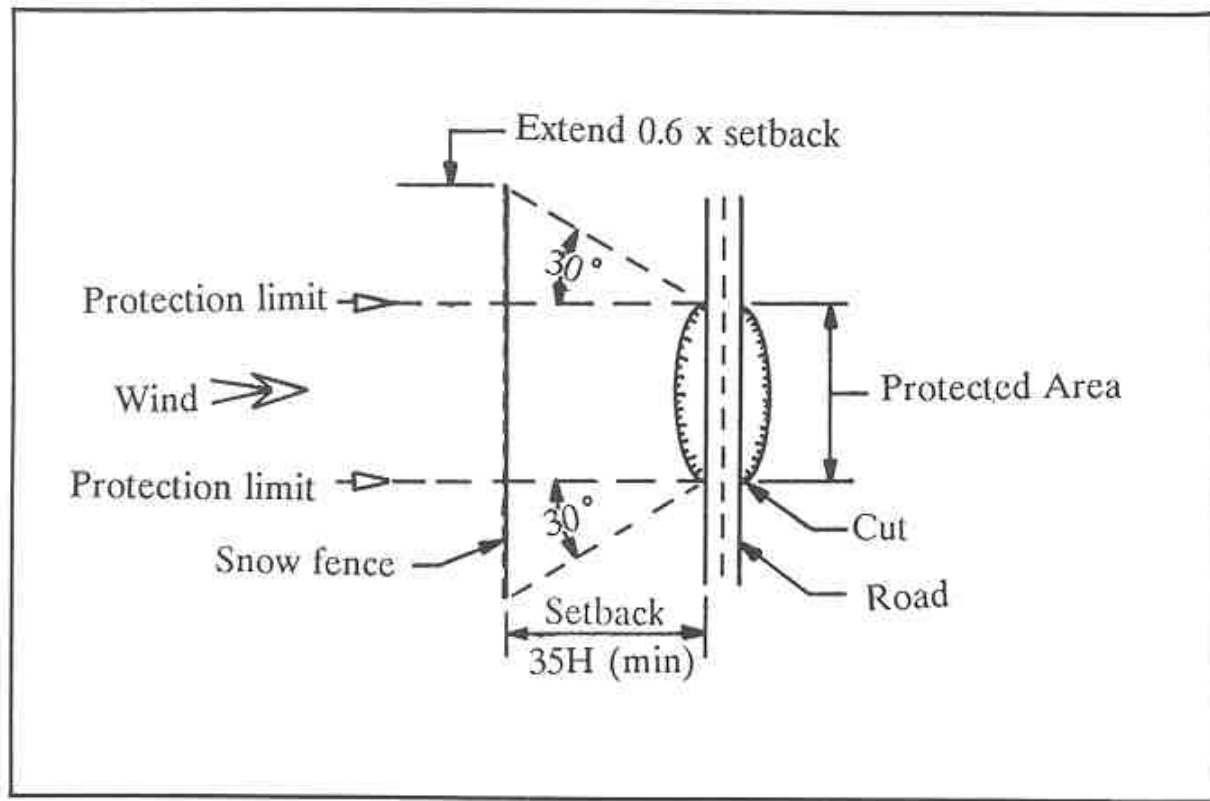


Figure 10. Setback and length of parallel fences. ©1986 Tabler & Associates

sides of the protected area to intercept winds that vary up to 30° on either end of the prevailing wind directions (Figures 10 and 11). The required overlap length for parallel fences is therefore equal to 0.6 times the setback distance.

Example: Assume that a parallel fence 8 ft. (2.4 m) tall is used to protect a cut 500 ft. (152 m) in length.

Then:

Setback distance = $35 \times 8 \text{ ft.} = 280 \text{ ft.}$ ($35 \times 2.4 \text{ m} = 84 \text{ m}$)

Length of extension beyond protection limit = $0.6 \times 280 \text{ ft.} = 168 \text{ ft.}$ ($0.6 \times 84 \text{ m} = 50 \text{ m}$)

Total fence length = 500 ft. + (2 x 168 ft.) = 836 ft. (152 m + (2 x 50 m) = 252 m)

Spacing of Multiple Rows

Although a single tall fence is most efficient, there are situations where multiple rows are necessary, such as for temporary installations where fences are installed and removed on a seasonal basis. Proper spacing maximizes the storage and trapping efficiency of each fence and prevents structural damage.

The spacing guidelines given below are distances measured in the direction of the prevailing wind. On flat ground, 30 times the height of the fence ($30H$) is a satisfactory spacing. In other situations, proper spacing depends on terrain and a simple guideline is not possible.

Oblique, Staggered Fences

When the wind direction requires fences to be aligned at an angle to (obliquely with) the road, oblique, staggered rows of fence may provide the best protection. The required length of these rows depends on the angle between the road and the fence, the offset between rows, and the overlap required to compensate for the end effect and variations in wind direction. This latter requirement is determined by the 30° angle specified for the overlap at the end of a fence.

To avoid burial of staggered fences, the *minimum* spacing recommended between staggered rows is $25H$. For example, for 4-ft. (1.2-m) fences the offset should be 100 ft. (30 m).

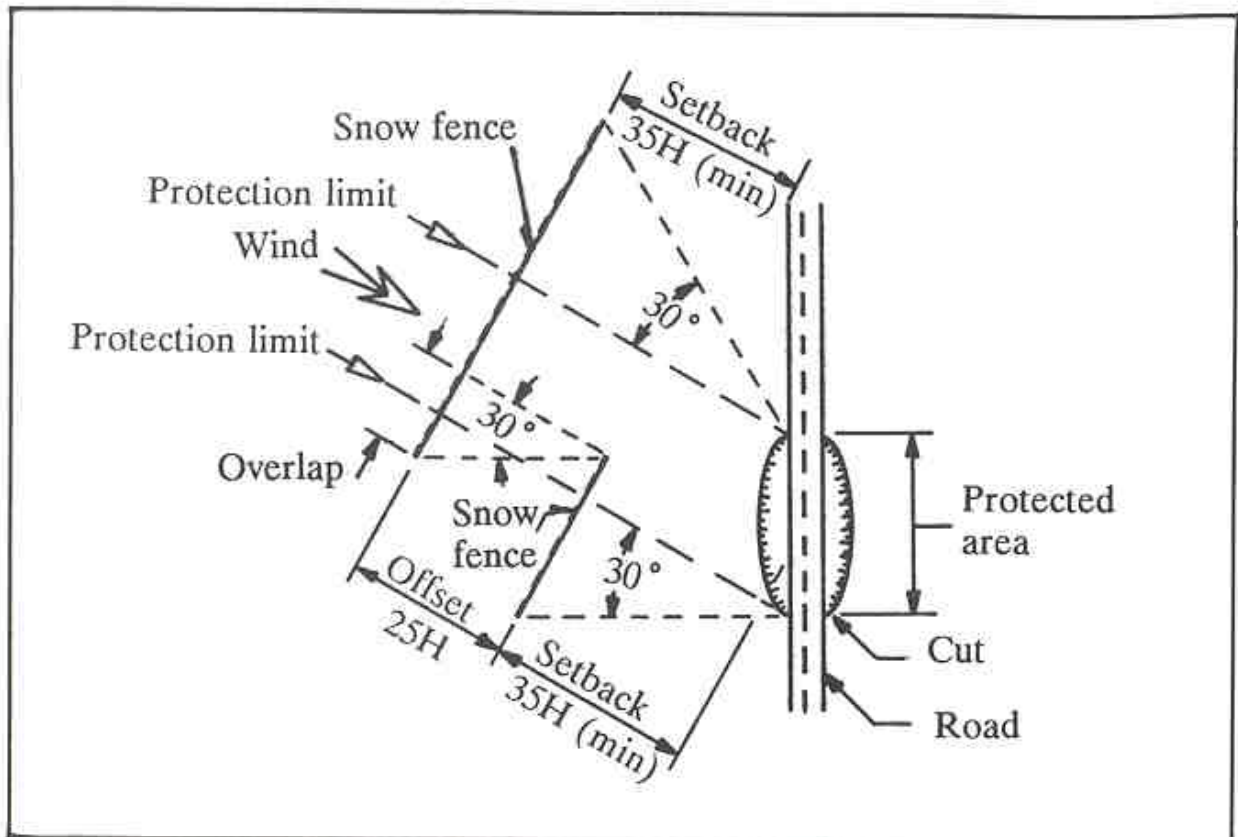


Figure 11. Setback, overlap, and extensions for oblique, staggered fences. ©1986 Tabler & Associates

Oblique, staggered fences should be overlapped a distance equal to 0.6 times the offset distance. For example, if fence rows are offset 100 ft. (55 m), the overlap should be 0.6 x 100 ft. = 60 ft. (0.6 x 30 m = 18 m).

Terrain Considerations

Favorable locations include the crests of ridges or hills, and sites upwind of stream channels or other topographic depressions that increase storage capacity. Fences should not be placed in locations where drifts form naturally, such as in depressions or on the downwind side of hills. Steep,

upwind-facing slopes reduce both trapping efficiency and storage capacity.

Fences should not be placed on embankment slopes, but instead should be located upwind of the toe of the slope. If placed too close to the shoulder of the embankment, a fence can cause a deep drift on the road.

Openings in Fence Lines

Fences should be as long as necessary, without gaps. This is because the acceleration of the wind through openings reduces snow deposition over an area much larger than the opening itself. Even leaving 6-in. (15-cm) spaces between panels of the Wyoming fence causes appreciable erosion and scalloping with significant loss of snow storage capacity.

The snow fence planner should resist giving in to the requests of landowners, wildlife officials, and others who think it necessary to leave openings for livestock or wildlife. Where openings are unavoidable, they should be closed off by overlapping the two sections or by building another fence upwind.

Design the Fence

After the height, length, and location of the fence system have been selected, the next step is to select the type of fence to be constructed and the materials to be used. The following discussion describes the basic requirements for an efficient snow fence, standard designs, and criteria for custom designs.

Height and Bottom Gap

Height is by far the most important factor in fence design because it has the greatest influence on snow trapping efficiency, storage capacity, and cost. By comparison, characteristics of the fencing material, such as porosity and size and shape of openings, are relatively unimportant. A 6-ft. (1.8-m) fence, for example, will store more than twice as much snow as a 4-ft. (1.2 m) fence. See p. 20 for the procedure to determine the required fence height.

Adding 6 in. (15 cm) to a 4-ft. (1.2-m) fence increases its capacity by 30%. A gap between the bottom of the fence and the ground increases the height and capacity of a snow fence. Partially or totally buried fences do not trap blowing snow effectively, are often damaged by snow settlement, and can develop abnormally long drifts. A bottom gap reduces snow deposition close to the fence.

The optimum bottom gap on flat ground is equal to 10% to 12% of the total vertical height. The gap should be measured from the lower edge of the fencing material to the top of the vegetation as it appears in winter. Although bottom gaps greater than 15% of total fence height significantly reduce snow storage capacity, it is sometimes desirable to leave larger gaps in locations where the fence may become buried as a result of deep snowcover, or where terrain contributes to deposition at the fence.

Recommended minimum bottom gaps are presented in Table 2. "Fencing height" refers to the width of the fencing material, and is equal to the total fence height less the bottom gap.

Fencing height		Bottom gap		Fence height	
feet	meters	inches	centimeters	feet	meters
4.0	1.2	6	15	4.5	1.4
5.3	1.6	8	20	6.0	1.8
7.1	2.2	11	28	8.0	2.4
8.0	2.4	12	30	9.0	2.7
8.9	2.7	13	33	10.0	3.0
10.7	3.3	16	41	12.0	3.7
12.5	3.8	18	46	14.0	4.3

Table 2. Minimum bottom gaps for common heights of properly designed snow fences.

Types of Fences

Fences may be supported by steel or wood posts set in the ground ("post-supported), or by a surface-mounted framework, anchored or counterweighted to resist overturning in the wind ("truss-type"). There are advantages and disadvantages to each of these two types.

Post-supported

Advantages:

- Occupies least land area.
- Suitable for any height of fencing.
- Less susceptible to damage by snow creep on steep slopes.

- Allows use of different fencing materials, such as plastics.
- Suitable for permafrost soils.

Disadvantages:

- Usually more expensive than truss-type.
- Fences taller than 6 ft. (1.8 m) are not easily relocated.
- More time is required for field construction. Supports must be custom-designed for each site.

Truss-type

Advantages:

- Least expensive to build in most locations.
- Relatively easy to remove or relocate.
- Can be prefabricated to reduce field construction time.
- Standard plans are available for most applications.

Disadvantages:

- Susceptible to damage by snow creep or glide on steep slopes.
- Occupies significant land area.
- Maximum practical height limited to about 14 ft. (4.3 m).

The Wyoming Truss-Type Fence

Basic design: The truss-type snow fence used by the Wyoming Department of Transportation since 1971 consists of horizontal 1- x 6-in. (2.5- x 15-cm) wooden boards fastened to wooden trusses, and is anchored with steel reinforcing bar (rebar) driven into the ground. The version

recommended here has an average porosity of about 45%, a bottom gap equal to 10% to 12% of the total height, a 15° layback angle, and a panel length of 16 ft. (4.9 m). Figure 12 shows dimensions for an 8-ft. (2.4-m) height, but the basic design is adaptable to heights up to 14 ft. (4.3 m).

Anchors: Steel rebar provides an inexpensive anchor with excellent extraction resistance in most soils. Number 6 rebar, with a diameter of 3/4 in. (1.9 cm), is best suited for this application. This diameter provides adequate extraction resistance, has adequate rigidity for driving, and is sufficiently flexible to deflect around stones in the soil. The anchors shown in Figure 13 are attached near both ends of each sill. In dry soils, 2-ft. (0.6-m) penetration is adequate to anchor 8-ft. (2.4-m) fences, and 4-ft. (1.2-m) penetration is sufficient for the 14 ft. (4.2 m) height. Where fences must be placed on wet or boggy soils, longer rebar or another type of anchor should be used. Rebar should be driven at an angle of 30° to 45°. Most failures of driven anchors are caused by improper attachment of sills to the rebar. The U-clamp shown is effective and inexpensive, but must be fabricated.

Service Life: Properly designed Wyoming fences can withstand winds of 100 mph (45 m/s), snow settlement pressures associated with complete burial on level terrain, and rubbing by animals. When built according to specifications and properly anchored, the Wyoming fence has proven to be durable and relatively maintenance-free for at least 25 years.

An Economy Model: The member that rests on the ground (the sill) fixes the vertical inclination and provides rigidity to the frame. Because the sill must be in contact with the

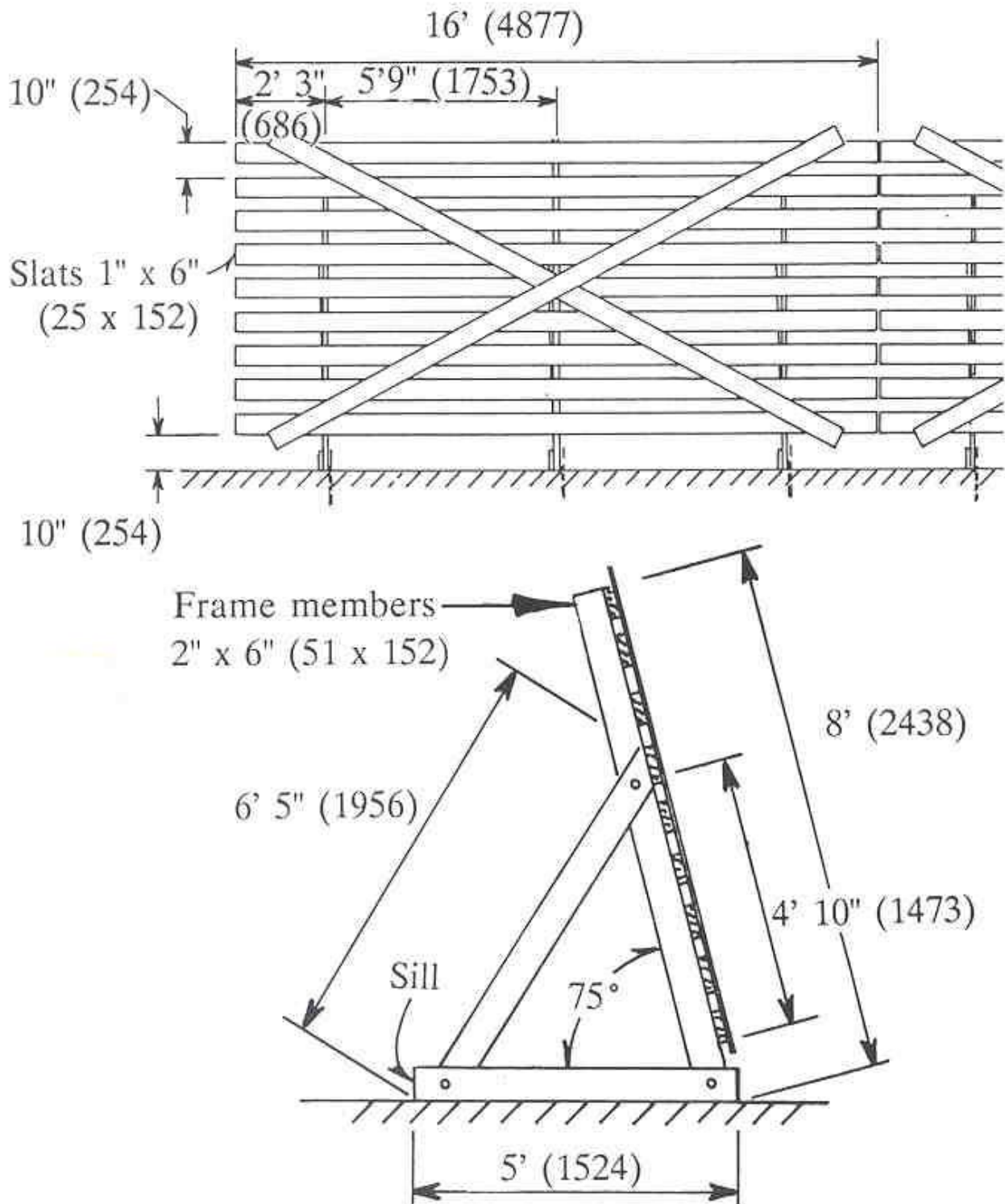
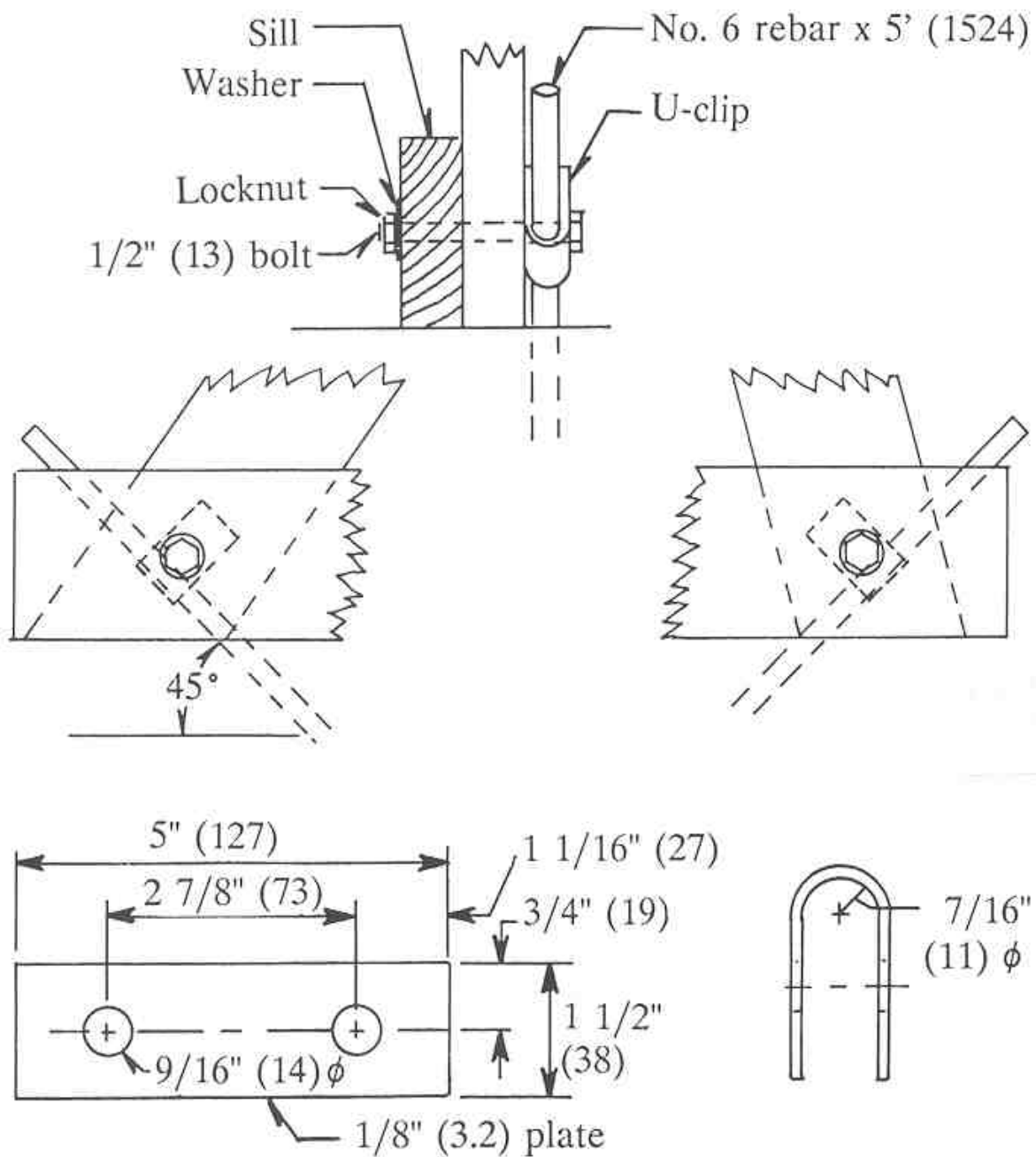


Figure 12. Dimensions of the 8-ft. (2.4-m) Wyoming snow fence. Dimensions in Parenthese are millimeters. ©1991 Tabler and Associates



U-clip plate before bending

Figure 13. Anchor detail for the 8-ft (2.4-m) Wyoming snow fence. Dimensions in Parenthese are millimeters. ©1990 Tabler and Associates

ground over its entire length, it is usually necessary to smooth off the ground under each sill. This "seating" process is often time-consuming on rocky or brush-covered sites, and adds significantly to construction cost. On such sites, the sill member can be eliminated for fence heights up to 8 ft. (2.4 m) or so without compromising structural strength. This modification significantly reduces construction cost, and also provides flexibility in setting the inclination angle, and hence the vertical height. It is important to maintain a constant layback angle.

Designing Post Supports

Posts can support wooden slats or a variety of synthetic snow fencing materials. The supports must be designed to withstand wind loads, and to allow proper tensioning of fencing materials. Because plastic fencing requires tensions as high as 250 lbf per foot of height (3.65 kN/m), posts at ends or corners must be braced longitudinally. Curved fence lines generally are undesirable because the tensioning forces would tend to pull down the fence.

The force that the wind exerts on a fence depends on the wind speed, density of the air, upwind topography and ground cover, and the height and porosity of the fence. Snow fences typically are designed for winds of 100 mph (45 m/s). The wind speed to be used for design of a snow fence varies with geographic location. Design wind speeds commonly required by local building codes for barns or storage buildings not intended for human occupancy can be used for snow fences.

The steel T- or U-posts commonly used to support 4-ft. (1.2-m) fences are spaced 8 ft. (2.4 m) apart to avoid bending

in strong winds. On a fence 6 ft. (1.8 m) tall, the bending moment exerted by the wind is about 65% greater than that on a 4-ft. (1.2-m) fence, so steel posts must be spaced about 4.5 ft. (1.4 m) apart if braces or guys are not used. Post supports are therefore usually impractical for temporary fences taller than 5 ft. (1.5 m) or so.

Transverse braces and guys are to be avoided for post-supported fences. When these supports become buried in the drift, they sustain large loads that can result in structural failure of the fence. This is particularly true on sloping ground where snow creep occurs. The vertical supports therefore must be sufficiently strong to resist bending or breaking under the design wind load, and they must be embedded deeply enough to keep the fence from overturning.

Table 3 shows an example of the size and embedment of wooden poles required to support various heights of snow fence in winds of 100 mph (45 m/s). This example is for supports placed 12 ft. apart, which is a common spacing.

Fencing Materials

Horizontal rails are best. Otherwise, there are no great differences among materials having 40% to 50% porosity.

There is a tendency for snow to be deposited close to the fence. With horizontal rails, even if the bottom gap does become plugged, the spaces between rails serve as gaps to slow the rate of burial. The small openings typical of most plastic fencing materials favor deposition near the fence. If the bottom gap remains open, however, there is little

Fence height		Diameter at butt		Embedment depth	
feet	meters	inches	centimeters	feet	meters
4	1.2	4.7	12	3.6	1.1
6	1.8	6.3	16	4.7	1.4
8	2.4	7.4	19	5.2	1.6
10	3.0	8.7	22	6.1	1.9
12	3.7	10.1	26	7.0	2.1
14	4.3	11.4	29	7.9	2.4

Table 3. Approximate post diameter and embedment required to support indicated heights of snow fence in 100 mph (45 m/s) winds. Values are for Douglas fir posts at 12 ft (3.7 m) centers in soil with an average bearing strength (2500 psf, 120 kPa) with compacted backfill. ©1986 Tabler & Associates

difference in snow storage capacity among materials having 40% to 50% porosity.

Wood, metal, plastic, and woven fabrics can be used. If *properly installed*, all of these materials are equally good investments.

Picket Fencing

The familiar picket snow fence consisting of slats 1.5 in. (4 cm) wide, held together with twisted wires, has a 10% lower snow storage capacity and trapping efficiency than other types of fencing, apparently because the slats are spaced too far apart. Although slat spacing varies from roll to roll and increases with repeated stretching, porosity is typically about 60%. If a bottom gap is provided under this

type of material for a permanent installation, the top of the fencing should be wired to a horizontal support, such as a two-by-four (5 x 10 cm). Even then, the individual slats tend to slip downward through the wire loops. For this reason, picket fencing is not recommended when several tiers of material are required for taller fences.

Synthetic Materials

Numerous types of synthetic fencing materials are available, ranging from woven fabrics to extruded plastic nets and polymer rails. Most of the plastic fencing materials are made from polyethylene. Specifications important for snow fencing include tensile strength, resistance to ultraviolet (UV) degradation, and size of openings. Black fencing is more resistant to UV degradation than other colors.

Although many synthetic fencing materials have high tensile strength, most are easily cut and susceptible to abrasion and therefore must be well secured at vertical supports. For tall, permanent fences, strips of elastomeric roofing membrane (EPDM) should be placed between the vertical supports and the fencing, and between the fencing and the batten. Battens should be rigid and secured tightly to vertical supports with steel banding. The fencing material should be tensioned to the manufacturer's specification before it is fastened to the intermediate posts. The end poles must be adequately braced to allow tensioning. This is typically accomplished by extending a diagonal brace from the top of the end pole to the ground line of the adjacent line pole.

A flexible polymer rail sold primarily for horse fencing also can be used to build snow fences. This product consists of a polymer strap 5 in. (12.5 cm) wide, in which three 12.5-gauge

wires are embedded. In addition to allowing fence height and porosity to be customized, this material conforms readily to irregular terrain.

Temporary Fences

Temporary fences often are necessary on cultivated land or where permanent fences are not compatible with summer land uses. It is now clear that taller fences are much more effective than the 4-ft. (1.2-m) picket fences used in the past.

The Tensar Corporation has a patent pending on a new design for portable fences 6.5 ft. (2 m) and 8 ft. (2.4 m) tall. This design uses a wooden frame of two-by-six (5 x 15 cm) members, bolted together at the corners, with a strip of plastic mesh fencing 4 ft. (1.2 m) wide pulled taut across the center (Figures 14, 15, 16). Tensioning is accomplished with threaded rods connected to a pipe woven through the plastic. The panels are 8 ft. (2.4 m) wide. They are connected by rebar pins that pass through U-clips like those used to anchor the larger, permanent fences. U-clips also attach the fence to rebar anchors driven into the ground. For most soils, 2 ft. (61 cm) is adequate penetration. The U-clip-and-pin connections allow rapid installation and disassembly, and add flexibility for proper installation on rough terrain. Panels can overlap at either the top or bottom to close gaps between panels. The U-clips rotate to accommodate irregular terrain. Only one U-clip must be tightened at each connection to prevent the pin from vibrating out. The U-clips can be made from either 1/8-in. (3-mm) steel plate or polyethylene. Each pair of adjacent panels shares a brace member 2 x 6 in. (5 x 15 cm) and one upwind anchor. Braces can be installed on either side of the fence.

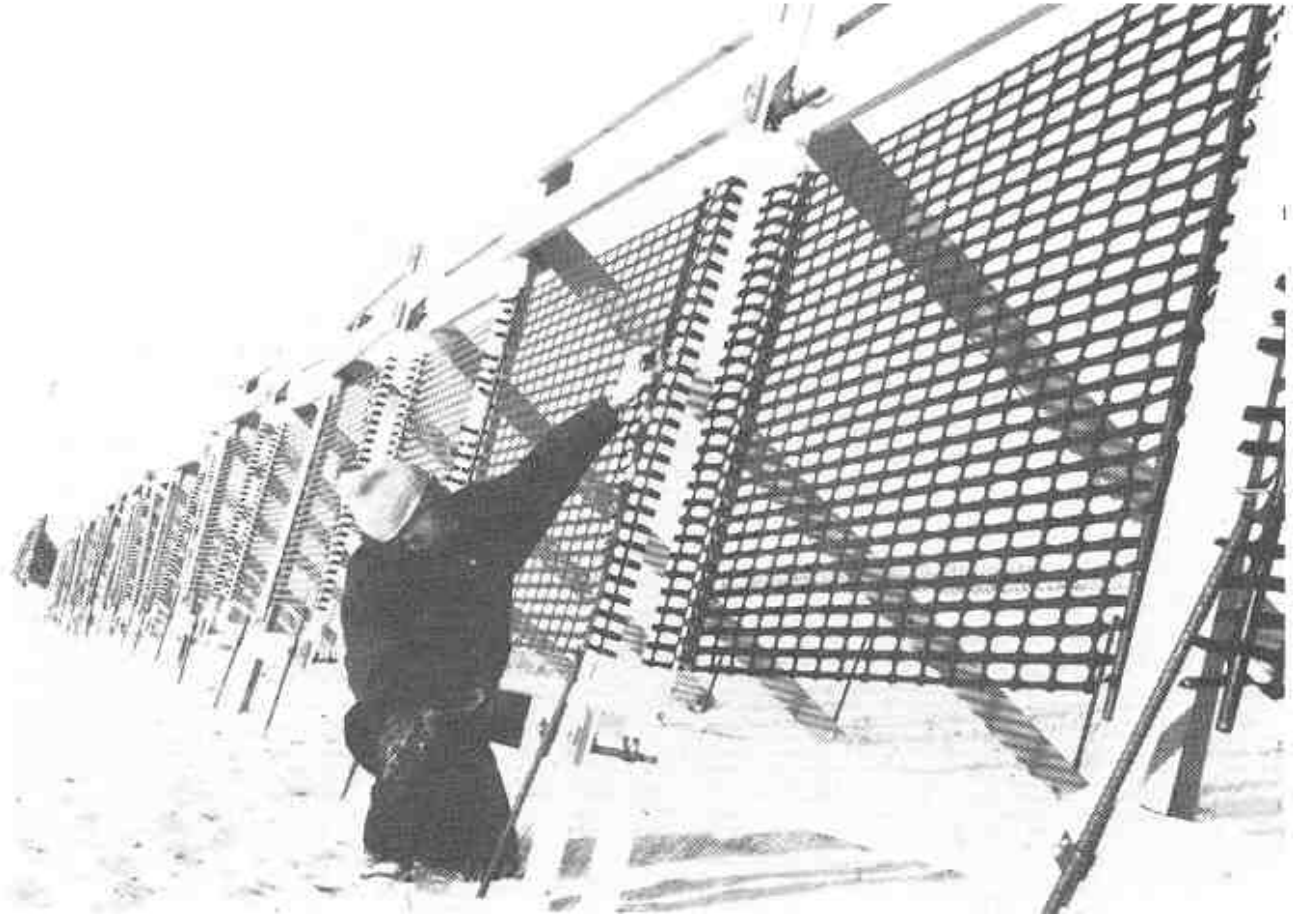
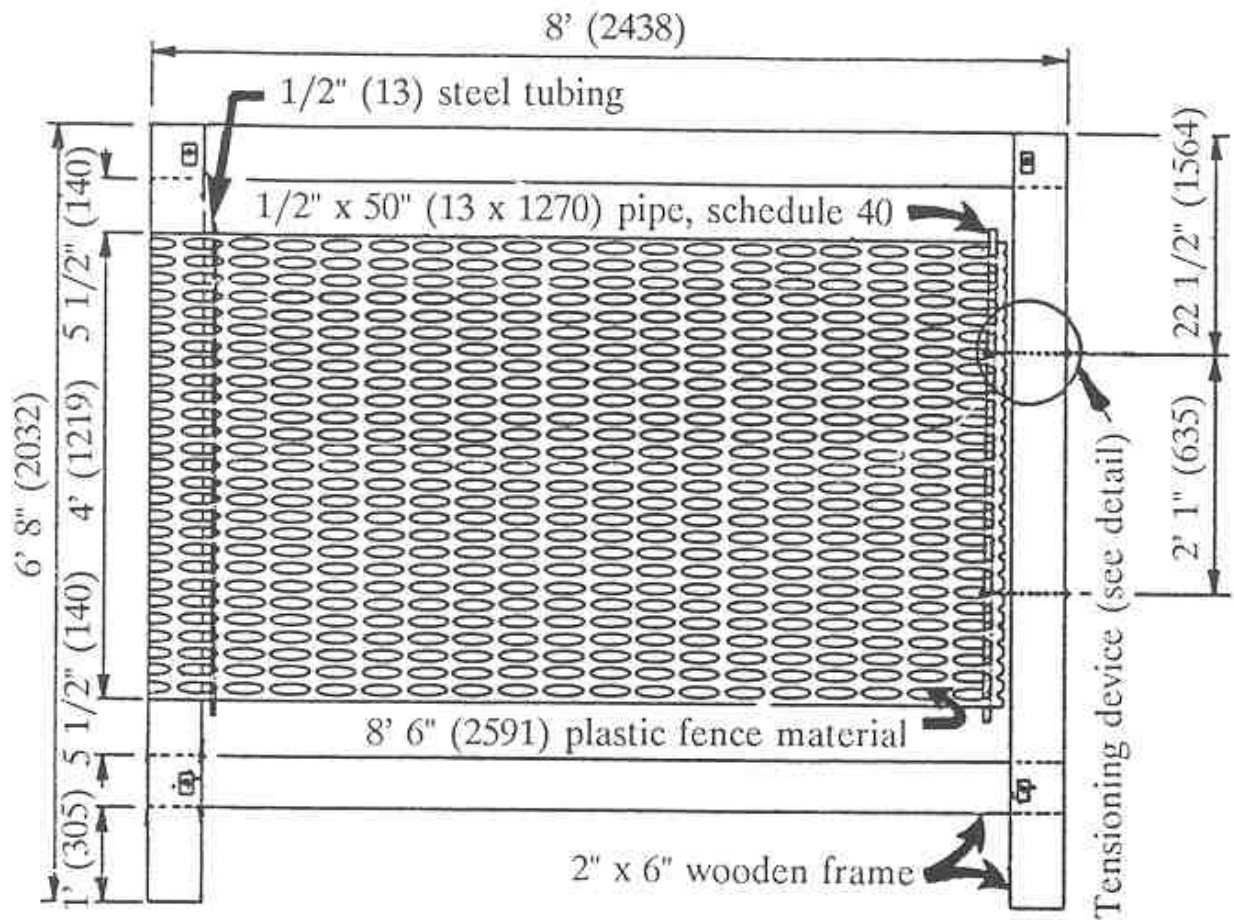


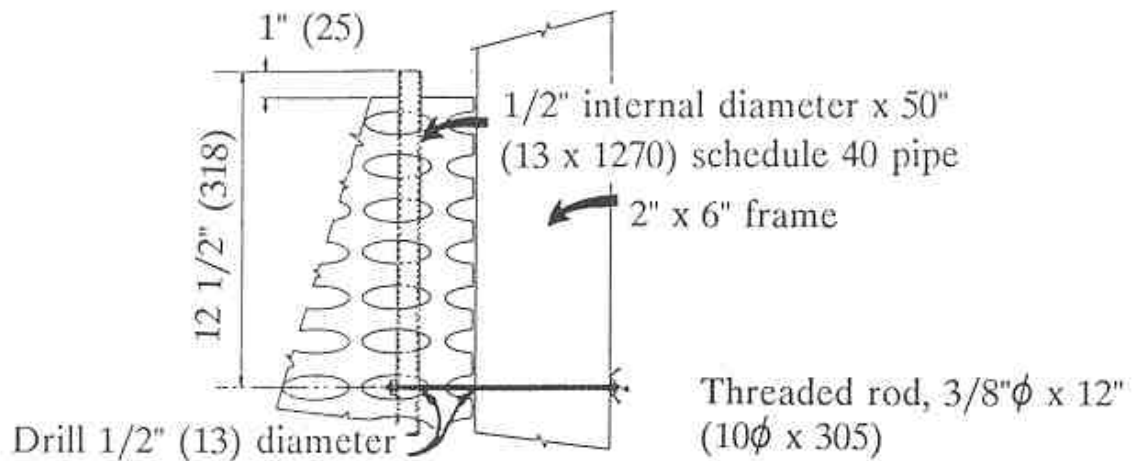
Figure 14. A design for temporary fences 6.5 and 8 ft. (2 and 2.4 m) tall by the Tensar Corporation uses wooden frames to support plastic fencing connected with rebar pins and U-shaped anchor clips described in Figure 13. ©1990 Tabler & Associates

Field installation of prefabricated panels requires approximately three person-hours per 100 ft. (30 m) of fence. It takes less time to install the 8-ft. (2.4-m) fence than to build a series of conventional 4-ft. (1.2-m) fences of the same storage capacity. Material and fabrication costs are comparable to costs for permanent fences.

A portable fence 6.5 ft. (2 m) tall stores three times as much snow as a conventional 4-ft. (1.2-m) fence.
A portable fence



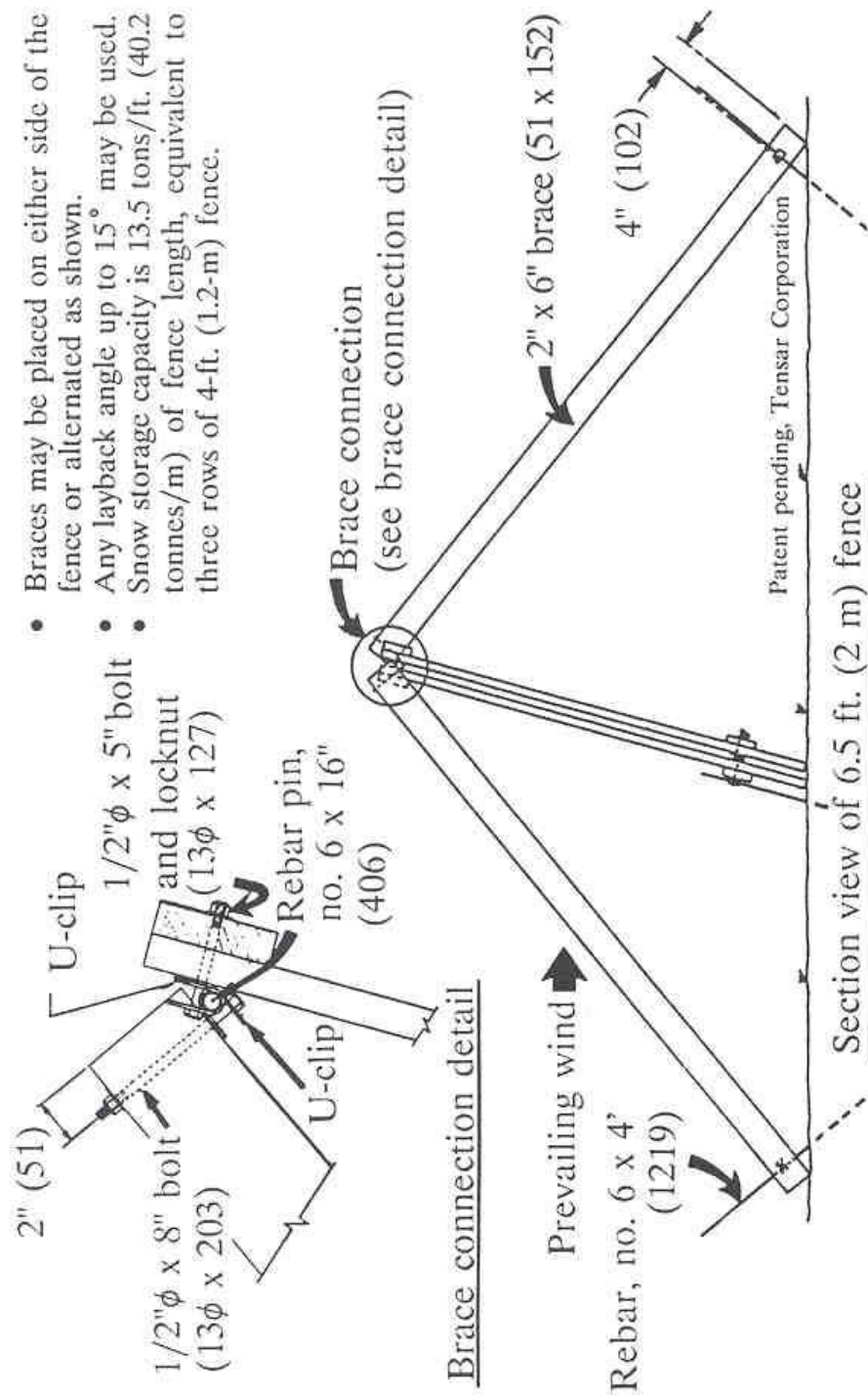
Elevation of 6.5 ft. fence



Tensioning device detail

Patent pending, Tensar Corporation

Figure 15. Framing details for the temporary fence. © 1990 Tabler & Associates



- Braces may be placed on either side of the fence or alternated as shown.
- Any layback angle up to 15° may be used.
- Snow storage capacity is 13.5 tons/ft. (40.2 tonnes/m) of fence length, equivalent to three rows of 4-ft. (1.2-m) fence.

Figure 16. Framing details for the temporary snow fence. ©1990 Tabler & Associates

8 ft. (2.4 m) tall stores 4.6 times as much snow as a 4-ft. (1.2-m) fence.

Guidelines for Fences 4 ft. (1.2 m) Tall

Where taller fences cannot be used, the following guidelines should be used for 4-ft. (1.2-m) fences:

- Fences should be as long as possible, and placed at least 160 ft. (49 m) from the road shoulder, assuming a 6-in. (15-cm) bottom gap.
- A bottom gap of 6 in. (15 cm) should be left under the fence.
- Steel posts should be on 8 ft. (2.4 m) centers. End posts should be 6 ft. or less from the adjacent post to facilitate bracing.
- The end post should be braced with a steel post driven into the ground at an angle so as to extend from near the top of the end post to the ground line of the adjacent post and wired in place.
- If picket fencing is used, it should be pulled taut to at least 250 lbf (1.1 kN) for a 4-ft. (1.2-m) width. Synthetic fencing material also should be pulled taut, at tensions specified by manufacturer, typically 500 to 1000 lbf (2.2 to 4.5 kN).
- Plastic fencing material should be sandwiched between two 2- x 2-in. (5- x 5-cm) boards wired tightly to the steel post at the center and at 6 in. (15 cm) from each edge. A better but more expensive method is to slip a piece of

foam insulation for 1-in. (2.5-cm) pipe around the post to replace the inner 2- x 2-in. (5- x 5-cm) board.

Living Snow Fences

Advantages

If properly designed, plantings of trees and shrubs can make effective snow fences (Figure 17). Vegetative plantings offer many benefits in addition to drift control:

- Living snow fences are more pleasing in appearance than structural fences.
- Habitat is provided for wildlife.
- Little maintenance is required after plants are established.
- Living snow fences can be a part of the roadside beautification plan, but be cautious about placing plants too close to the road.

Disadvantages

- On some sites, climate, soil type, and other environmental conditions make the establishment of trees difficult.
- Several years are required before plants become tall enough to intercept snow.
- Barrier height and porosity, and hence drift length and storage capacity, change with time.



Figure 17. Living snow fences. The top photograph shows a Colorado spruce snow fence along I-35 near Owatonna, Minnesota. The bottom photograph shows the snow fence in a triangular area of a right-of-way adjacent to a separation structure across I-35. (Photographs by the Minnesota Department of Transportation.)

- Vegetative barriers are subject to damage by such things as insects, disease, and wind. Using a variety of plants helps counter the negative effects of such occurrences.

Minimum Setback Distance

Because living snow fences' mature height will usually exceed that required to store the design snow transport, trees often can be planted closer to the road than 35 times their mature height. Snow deposition behind a porous barrier extends for a distance of about 15 times the barrier height throughout the early stages of drift growth. This suggests that the minimum setback distance for a living snow fence should be 15 times the height of the trees (or shrubs) at maturity. The planting should not cast a drift on the road *at any stage* in its growth. This can only be determined if the seasonal snow transport is known. Therefore, the basic guideline is:

The setback distance for a living snow fence should be 15 times its height at maturity, or 35 times the required height of structural snow fence, whichever is greater.

For very tall trees, such a spacing may prove excessive during the many years required for the trees to reach maturity. A solution is to plant two or more rows of fast-growing shrubs having a height at maturity of 6 to 8 ft. (1.8 to 2.4 m) at a distance from the road equal to 35 times their mature height.

Snowbreak Forests

Living snow fences consisting of only a few rows of trees or shrubs behave like porous snow fences. Plantings on the order of 200 ft. (60 m) in depth, however, behave as solid barriers regardless of the kinds of trees planted. Deep

plantings will therefore accumulate snow on the upwind side of the barrier first, and deposition on the downwind side will be restricted to within 5H of the trees until the upwind drift reaches the top of the trees. If the trees are sufficiently tall, the snow storage capacity on the upwind side will never be exhausted.

Although planting such wide belts of trees is frequently impractical, the lesson from the snowbreak forest is that the most effective plantings consist of numerous rows of trees-not just two or three--to encourage more deposition on the upwind side. A snowbreak forest should be placed no closer to the road shoulder than five times the height of the mature trees.

Interim Drift Control

Where possible, structural fences should be used to provide snow control while the trees or shrubs are growing. Structural fences should be placed so that the downwind drift does not bury the trees or shrubs, because snow settlement breaks branches. In addition to providing interim control, structural fences provide some protection for the young trees. The additional water provided by the drift also can encourage faster growth.

Pruning

Pruning has been recommended as a way to reduce deposition within the trees. Removing lower branches has the same effects as widening the bottom gap under a structural fence. Pruning reduces snow deposition on the upwind side and elongates the downwind drift. Because pruning increases wind speed and snow transport under the

canopy, this practice may not be in the best interest of wildlife. A better way to improve habitat is to *increase* the density of the leading edge of the planting, using a dense structural fence if necessary, to encourage snow deposition upwind of the trees.

Other Guidelines

Guidelines for species, spacing, and planting vary with geographic location. For specific information on these important aspects of living snow fences, a competent landscape architect should be consulted. An alternative is to consult with local extension agents for help in the selection of plants and planting specifications to insure proper growth.

There are two conceptual guidelines that are generally applicable. First, avoid leaving holes and openings in the planting, for the reasons explained in the discussion of structural fences. A minimum of three rows should be used, with a staggered planting pattern. Trees should be planted close enough to form an unbroken row at maturity, but not so close that trees do not have room to grow. Second, the layout should avoid burying trees in deep drifts formed by rows farther upwind. The minimum spacing depends on the estimated snow transport and the height of the upwind trees.

Standing Corn

At least two states have experimented with leaving a number of rows of corn standing in fields adjacent to the highway right-of-way. Experience has shown that this strategy is economically viable. The number standing corn rows varies with the size of the harvester and the harvesting pattern used by the farmer, but to be effective, the minimum is six to

eight rows. The most effective strategy is to use two strips of corn rows separated by 150 to 200 ft. (45 to 60 m). The minimum setback from the road shoulder should be 35 times the height of the standing corn. Figure 18 illustrates the effectiveness of such fences.

Owners receive payment for the corn left standing in the field based on the market value for the crop on the day of harvest. Some corn left standing can be salvaged in the spring. Costs for such a program in 1984 in one state averaged \$1,300/mile (\$810/km).



Figure 18. Standing corn living snow fences. Two strips of standing corn are shown in each photograph. Note that the first strip (about six rows, farther from the road) trapped more snow than the second strip (closer to the road). Photographs by the Minnesota Department of Transportation.

4. Working With Landowners

Existing public rights-of-way usually are too narrow to accommodate effective snow fencing, and the difficulty of obtaining easements on private land often discourages highway agencies from implementing a snow fence program. One strategy that can be used to obtain community support for a snow fence program is to start with one or more "demonstration" projects. Initial projects could focus on locations having maximum benefit and minimal conflicting land uses, or where landowners are most likely to be receptive.

One of the concerns commonly expressed by farmers is that the snowdrifts will delay tillage or planting in the spring. It helps to have some information ready on this subject when approaching landowners for snow fence easements. A useful rule of thumb is that snow melts at the rate of 0.22 in. for every degree-day above 32°F (1 cm of depth for every degree-day above 0°C). A drift 6 ft. (1.8 m) deep, for example, would persist until 327 °F-days (182 °C-days) had accumulated. Climatological information published by the National Weather Service can be used to determine the probable melt-out date. This information can be useful in easement negotiations, particularly when it can be shown that the delay would be minimal. It is not unusual to find that the drifts formed by the proposed fences are comparable to

naturally occurring drifts in the same or nearby fields, providing a persuasive argument in favor of the fences.

The following negotiation strategy can help highway agencies secure cooperation of landowners.

The Initial Contact

- The initial contact with landowners should be made by local highway officials known to the landowner, and should be made soon after a major snowstorm. A chance meeting at the local coffee shop or post office is better than an arranged meeting.
- Bring up the subject of snow fences casually by inquiring about problems the landowner might be having with snowdrifts on the property, on farm-to-market roads, or in getting to town.
- Suggest that new ideas about snow fences might be useful to the landowner, and incidentally would help improve conditions at the location where the road or highway department wants to build fences.
- Arrange for a later meeting at the site.

The Second Meeting

- Explain the importance of the snowdrifting problem at the location in question. Photographs of drift conditions or accidents in previous years, if available, can support

this point. If actual accident data and/or information for the specific site are available, explain how snow fences could help reduce accidents.

- Present information about the effectiveness of fences.
- Describe the fences that need to be built and the area they will occupy. If pertinent, also discuss living snow fences, such as the corn snow fence.
- Point out advantages to landowner, if any other than contribution to safety and other transportation benefits. Living snow fences, for example, can create food and habitat for wildlife, including pheasants, deer, and songbirds. Snow fences can sometimes provide wind protection for livestock or can provide a source of water.
- Respond to the landowner's concerns about the negative effects of the fences, and ask the landowner to share specific concerns or objections.
- Thoroughly discuss each of the landowner's concerns, providing specific information (such as probable melt-out dates for snow fence drifts) to help the landowner realistically evaluate the impact of the proposed fences.
- Ask if the landowner would be willing to participate in a snow fence demonstration project. Discuss the possibility of limited compensation for indirect costs of the snow fence.
- Work toward a permanent installation to avoid the costs of installation and removal. This point is particularly

valid if the land is not in high-production agriculture. If one high fence can do the work of several rows of shorter fence, this is an argument in favor of a permanent installation.

- Where the fence needs to be located in a field dedicated to agricultural use, a temporary installation may be the only acceptable alternative, even though more than one row is required. The new 8-ft. (2.4-m) temporary design will reduce the need for multiple rows in many locations.

Glossary

Blowing Snow Terms

Wind speed: The rate at which the wind blows. Since wind speed increases with height above ground, this *Guide* refers to the wind speed at the standard height of 33 ft. (10 m).

Blowing snow: Snow that has been relocated from the surface by the wind, excluding falling, new snow.

Saltating particles: Snow particles too heavy to be suspended in the air that move by bouncing or intermittently jumping along the surface. Although most saltating particles are contained in the first 2 in. (5 cm) or so above the surface, most of the blowing snow is transported in this way at wind speeds below about 45 mph (20 m/s).

Creeping particles: Snow particles too heavy to saltate that roll along the surface, forming "snow waves" or "dunes."

Suspended particles: Snow carried by the wind for extended distances. Suspended particles reduce visibility.

Snow transport: The quantity of snow moved by the wind over a period of time and space. The concentration of blowing snow above 16 ft. (5 m) in height is negligible.

Fetch: The length of the area upwind of the snow fence. The upwind end of the fetch is a topographic or vegetative boundary with no snow transport (forest margins, deep gullies or stream channels, ice pressure ridges, or shorelines of unfrozen bodies of water).

Relocated precipitation: Snow that is blown from its original location, excluding snow that stays in place due to gullies, ditches, brush, melting, or compaction.

Precipitation: Water that falls from the sky as rain, sleet, hail, or snow. Precipitation is measured in water equivalent regardless of the form in which it falls.

Snow fence: A barrier that prevents snow from drifting onto a specific area.

Bottom gap: A space between the ground and the bottom edge of the snow fence that helps to keep snow from drifting in the fence.

Porosity: The holes or spaces in the fencing material. Porosity is expressed as a percentage, and does not include the bottom gap. Fences of 40 - 50% porosity are most effective in slowing the wind and trapping snow.

Fence height. The vertical height of a fence, measured from the ground to the upper edge of the fencing. It is represented in this text by the letter *H*.

Throughout this Guide, a numerical value followed by H represents a dimension expressed as multiples of fence height.

Fencing height: The vertical height of the Porous fence material. Fencing height is equal to the height of the fence minus the bottom gap.

Fence inclination: The angle, expressed in degrees from vertical, that the fence tilts either upwind or downwind. The top of a fence can be inclined in the downwind direction up to 15° from vertical without affecting performance adversely.

Snowdrift Terms

Upwind drift: The snow that collects on the side of the fence that faces the wind.

Downwind drift: The snow that collects on the side of the fence that faces away from the wind.

Slip-face: An abrupt drop-off that forms near the end of a downwind drift during intermediate stages of growth.

Recirculation zone: A region of recirculating wind formed immediately downwind of the slip-face, or any solid barrier.

Equilibrium drift: When a fence has filled to capacity, the drift is said to have reached equilibrium. At this stage, the fence has no more effect on blowing snow.

End effect: The lack of snow deposition near the ends of a snow fence caused by wind scouring.

Trapping efficiency: The amount of blowing snow caught by the fence, in relation to the incoming snow transport over the height of the fence.

Storage capacity: The amount of snow a drift contains when the fence is filled with snow. Because drifts are roughly triangular in cross-section, their cross-sectional areas are approximately proportional to the *square* of the fence height. Although this suggests that an 8-ft. (2.4-m) fence would hold four times as much snow as a 4-ft. (1.2-m) fence, the taller fence will actually store 4.6 times as much snow on a weight basis, because the density of drifted snow increases with depth. In mathematical terminology, storage capacity is proportional to height raised to the 2.2 power.

Parallel fences: Fences that are equally distant from the road along their length. Parallel fences require a shorter total fence length, have fewer openings to detract from trapping efficiency, and are more effective because of the reduced space between the fence and the area to be protected.

Oblique fences: Fences aligned at an angle to the road.

Offset distance: The distance, measured perpendicularly to the fences, between rows of staggered, oblique fences.

Setback distance: The distance between the fence and the road shoulder, as measured in the prevailing wind direction.

Fence Placement Terms

Protected area: A section of road that has a snow fence to reduce or eliminate snow drifting or visibility problems.

Protection limits: The boundaries of the protected area, typically marked by survey stations or mile markers.

Fence orientation or alignment: The compass bearing of a fence or its alignment with respect to either the prevailing wind direction or the road alignment.

Departure angle: The angle between the prevailing wind direction and a line drawn perpendicular to the alignment of a snow fence. Storage capacity per unit length of fence decreases as the wind becomes more oblique to the fence. However, the capacity per unit of width across the wind is not appreciably affected by a moderate departure angle. Trapping efficiency may decline as winds become more oblique to the fence, especially for departure angles greater than 45°.

Order Form

Use the order form below to obtain copies of the *Snow Fence Guide* and the 21-minute video, "Effective Snow Fences." SHRP's publications are sold through the Transportation Research Board (TRB), which, like SHRP, is a unit in the National Academy of Sciences. *Please do not send order forms to SHRP. Make checks payable to TRB.*

Please send me _____ copies of the Snow Fence Guide (SHRP-W/FR-91-106)
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Return this form to: Transportation Research Board, National Research Council; 2101
Constitution Avenue, N.W., Washington, DC 20418; (202) 334-3214.

Tips to Remember

1. Mechanical snow removal costs about 100 times more than trapping snow with fences.
2. The best fence porosity is 40% to 50%.
3. For effectiveness and economy, a single row of tall fences, is always preferable to multiple rows or shorter fences.
4. One 6-ft. (1.8-m) fence = 2 rows of 4-ft. (1.2-m) fence
One 8-ft. (2.4-m) fence = 5 rows of 4-ft. (1.2-m) fence
5. Fences can improve driver visibility and reduce ice.
6. To improve driver visibility and to maximize effectiveness, fences should be 8 ft. or (2.4 m) or taller.
7. Fences should be set back at least $35H$ from the road shoulder.
8. Extend fences beyond protection limits to an angle of 30° on either side of the prevailing wind direction.
9. Although fences should be perpendicular to the prevailing wind direction, departures up to 25° are permissible.
10. Leave a gap equal to 10% of the total fence height under the fence.