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3 August 1998

US Army Corps
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Technical Instructions

Commentary on Snow Loads

Headquarters
U.S. Army Corps of Engineers
Engineering and Construction Division
Directorate of Military Programs
Washington, DC 20314-1000

CEMP-E

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TECHNICAL INSTRUCTIONS

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This Technical Instruction supersedes EI 01S001, dated 1 October 1997.
(EI 01S001 text is included in this Technical Instruction and may carry EI 01S001 identification.)

FOREWORD

These technical instructions (TI) provide design and construction criteria and apply to all U.S. Army Corps of Engineers (USACE) commands having military construction responsibilities. TI will be used for all Army projects and for projects executed for other military services or work for other customers where appropriate.

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FOR THE DIRECTOR OF MILITARY PROGRAMS.

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Chief, Engineering and Construction Division
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COMMENTARY ON SNOW LOADS

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COMMENTARY ON SNOW LOADS

1. PURPOSE AND SCOPE. This document provides guidance for designing roofs subjected to snow loads. The primary discipline addressed in structural, but this guidance also applies to architectural, mechanical, and electrical issues.

2. APPLICABILITY. These instructions are applicable to all USACE elements involved with the design of buildings and other structures, including repairs and modifications as well as new construction.

3. REFERENCES.

a. Use the current edition of American Society of Civil Engineers (ASCE) Manual 7, “Minimum Design Loads for Buildings and Other Structures.” Copies are available from ASCE, 1015 15th Street, N. W., Suite 600, Washington, D.C. 20005-2605. ASCE’s phone number is (202) 789-2200. Users of this document should not use the mandatory provisions of the Standard itself without becoming familiar with the Commentary on Snow Loads appended to the Standard. The Commentary explains the rationale behind the provisions and contains examples that illustrate their use.

b. Site-specific ground snow loads for military installations and other places of interest to DOD are tabulated in TI 809-XX, “Load Assumptions for Buildings.” That information is based on a detailed snow load case study at each place. Occasionally, the case study answer differs from the value on the national snow load map in ASCE Manual 7. When a difference exists, the tabulated value in TI 809-XX should be used. A copy of each case study is maintained at CEMP-ET. Snow loads for foreign locations are also tabulated in TI 809-XX. Caution is urged when using these foreign values since each is based on local experience only, not an extreme-value statistical analysis of recent meteorological data. Wherever possible, host country expertise should be sought and host country snow loads compared to those tabulated in TI 809-XX.

c. In some areas of the United States extreme local variations in snow loads preclude mapping on a national scale. In such areas the national snow load map in ASCE Manual 7 does not present a ground snow load, but indicates that a snow load case study is needed. The data and methodology used to conduct snow load case studies are presented in Cold Regions Research and Engineering Laboratory (CRREL) report “Snow Loads for the United States.” Additional snow load case studies are available through CEMP-ET.

4. BUILDING CONFIGURAITON. The snow load provisions of ASCE Manual 7 indicate how dramatically the geometry of a building influences the snow loads on its roof. Problems can be avoided and more economical designs developed when snow load issues are considered by the design team as the show of the building evolves. Snow will drift into areas of “aerodynamic shade” (see figure 1). Figure 2 illustrates such places on the kinds of problems that are encountered.

5. UNBALANCED LOADS. Figure 3 shows a “saw-tooth roof” on which wind has moved snow from its upper portions into its valleys creating unbalanced snow loads. Such unbalanced snow loads are covered in ASCE Manual 7 for roofs with a slope of 15° or more. ASCE Manual 7 does not require consideration of unbalanced loads for lower slopes, but its Commentary warns that

such unbalanced loads are being observed on some large gable roofs with slopes less the 15°. That Commentary suggests that it may be appropriate to consider unbalanced loads for such roofs with slopes down to 5° (about 1 in./ft.).

6. METAL BUILDINGS. Many metal buildings are built with low-slope gable roofs (single- or multiple-gable). In cold regions for waterproofing reasons, it is appropriate to require a slope of at least 1 inch/foot (about 5°) for metal roofing systems. Metal buildings are designed with little structural “fat.” Many have failed where an unbalanced snow load in one area caused purlins to fall, initiating progressive collapse. Unbalanced snow loads should be considered on all metal buildings regardless of their slope.

7. INTERNALLY-DRAINED MEMBRANE ROOFING SYSTEMS. Such roofs usually have slopes much less than 15° and, thus ASCE Manual 7 does not require unbalanced loads to be considered. There is always the possibility that some unbalanced loads may develop. To reduce risks associated with this possibility, the depth of such basins should be as small as possible. The easiest way to do this is to reduce roof slopes to 1/4 inch/foot. Dead flat roofs are a design mistake. A l/8 inch/foot design slope can result in as-built flat areas. There is no real evidence that supports the contention that in cold regions a ½-inch/foot minimum slope should be used. Increasing the slope above ¼ inch/foot increases costs since higher walls are needed to account for the greater slope. Slopes of 1 inch/foot not only further increases the risk of unbalanced snow loads, but these slopes can be more expensive due to the additional attachments needed to hold roofing components in place on such slopes.

8. BUILDING ORIENTATION. ASCE Manual 7 requires designers to assume that the high winds which cause snow to drift could come from any direction. Nonetheless, information should be sought from “locals” on drift orientation. Where such information indicates strong preferential orientation of snow drifting, give thought to placing drift-prone features (e.g., loading dock roofs either upwind or alongside the building rather than at its downwind end. Design loads will not change, but the amount of drifting may be reduced significantly. An example is shown in figure 4. However, changing the orientation of buildings may not be possible. Sloping the roofs on the loading docks shown in figure 4 would reduce drift loads. However, that may introduce drainage, ice damming, and sliding snow problems.

9. SLIDING SNOW. The ability of slippery unobstructed roofs to shed snow loads by sliding can be an advantage and a disadvantage. Loads on a roof can be reduced when snow slides off (figure 5), but loads will increase on any lower roofs onto which snow slides. If snow drops some distance, large dynamic loads can be imposed on a lower roof or on an object located below (figure 6). Snow can creep and glide slowly down slippery surfaces (figure 7), even those with very shallow slopes. The movement of snow can drag plumbing stacks (figure 8) and other roof penetrations with it, damaging them and creating holes in the roof (figure 9). If snow slides from roofs having gutters, they will probably be ripped off. Parapets and fascias can also be damaged (figures 10 and 11). Flow of snow down valleys can bend the standing seams of metal roofing (figure 12), reducing their strength and violating their waterproofing integrity. Several sliding snow issues are illustrated in figure 13. Large curling snow cornices can be created at eaves (figure 7). Such cornices can be quite heavy, and they may curl around enough to damage walls and windows. When they break off, piles of snow and ice are created on the ground. These piles may deflect falling snow sideways towards walls, damaging them. Meltwater that drips onto these piles can enter the building at the base of the wall if that base is not far above the finished grade outside. Figure 14 illustrates a number of these situations. Electrical service entrance cables located below eaves can be ripped loose by falling snow or damaged by the weight of ice that collects on them from roof meltwater (figure 15). Snow guards may be needed to hold snow

in place on slippery roofs. Internally drained membrane roofing systems with a slope of ¼ incj/foot avoid these problems. Switching from internal drains to scuppers can lead to problematic, dangerous icings (figure 16).

10. ICICLES AND ICE DAMS. Icicles and ice dams can form along the eaves of inadequately insulated and ventilated roofs of heated buildings that drain to cold eaves (figure 17). Where eaves are not present, such ice may form on the walls below (figure 18). Icings at eaves prevent snow load reductions by sliding until that ice warms up and either melts or breaks free. Falling ice is a hazard (figure 6). Icings at eaves can be avoided when attic ventilation systems are able to keep the temperature of the roof from rising above about 30° F when the temperature outside is about 22° F. When it is warmer outside, icings usually do not grow and when it is colder outside, less attic ventilation is needed. Equations for sizing attic ventilation systems are presented in CRREL Miscellaneous Paper “Ventilating Attics to Minimize Icings at Eaves.” The extra cost of adequately insulating and ventilating a roof to prevent icings is easy to justify since the water that ponds behind ice dams usually leaks into the building causing significant problems. Efforts to remove icings with hammers, axes (figure 19), chain saws, and such usually damage the roof. On existing buildings, electrical heaters may be needed to keep tunnels melted through small ice dams (figure 20). The tunnels prevent water from ponding on the roof and leaking into the building. Electric heaters are relatively easy to install along the eaves of a roof with asphalt shingles (figure 21). Installing electric heaters on standing seam metal roofs is more difficult. Guidelines are available in CRREL Miscellaneous Paper “Electric Heating Systems for Combating Icing Problems on Metal Roofs.” Essentially all new roofs should be designed so that they do not require electrical heaters.

11. SNOW GUARDS. Snow guards are objects used to hold snow on slippery roofs (figure 22). Many slate and metal roofs require snow guards to protect people and property. Snow guards may also be needed on barrel vaults and other such roofs with smooth membranes. Some snow guards are attached mechanically while others are adhered to the roof surface (figure 23). Design loads on snow guards should be based on the assumption that friction between the snow and the roof is zero. Multiple rows of snow guards spaced well apart up the roof (figure 24) are better at holding snow in place (i.e., avoiding the large dynamic loads created by sliding snow) than one row of last-resort snow guards placed near the eaves. A short snow guard on a long roof without other snow guards must be able to resist all the snow located within outward 45° angles up slope of its location. The loads at the ends of such a snow guard are about twice the average load on it. The design load on a snow guard should be less than half of any failure load reported by its manufacturer. In high risk situations, (e.g., entrances and emergency exits of schools) allowable loads on snow guards should be even lower. Design guidance, test, data, and performance standards on snow guards are limited so they should be used with caution.

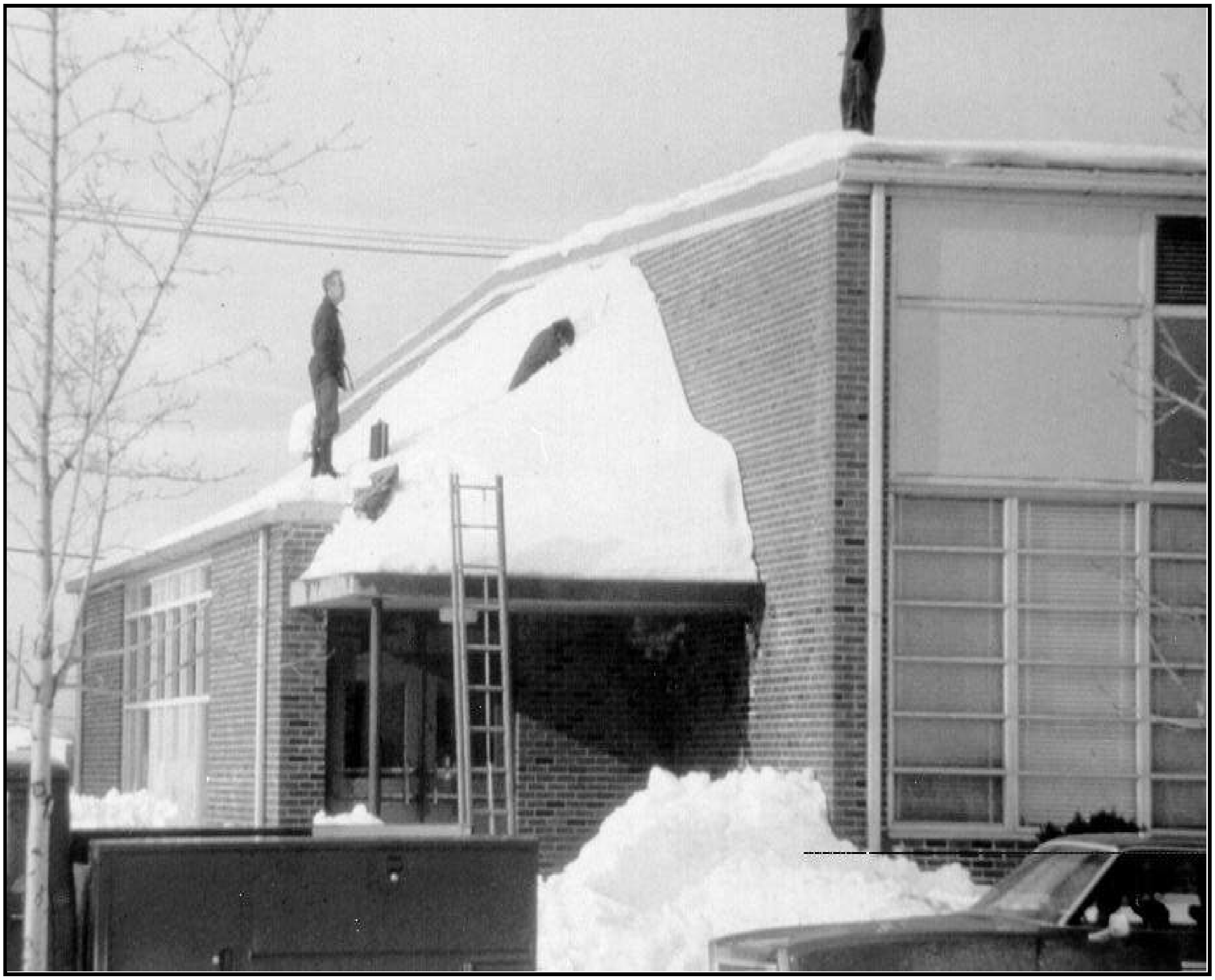

Figure 1. The peak snow load of this drift was 130 psf. The ground snow load then was 20 psf, and the snow load on the upper roof was 15 psf.

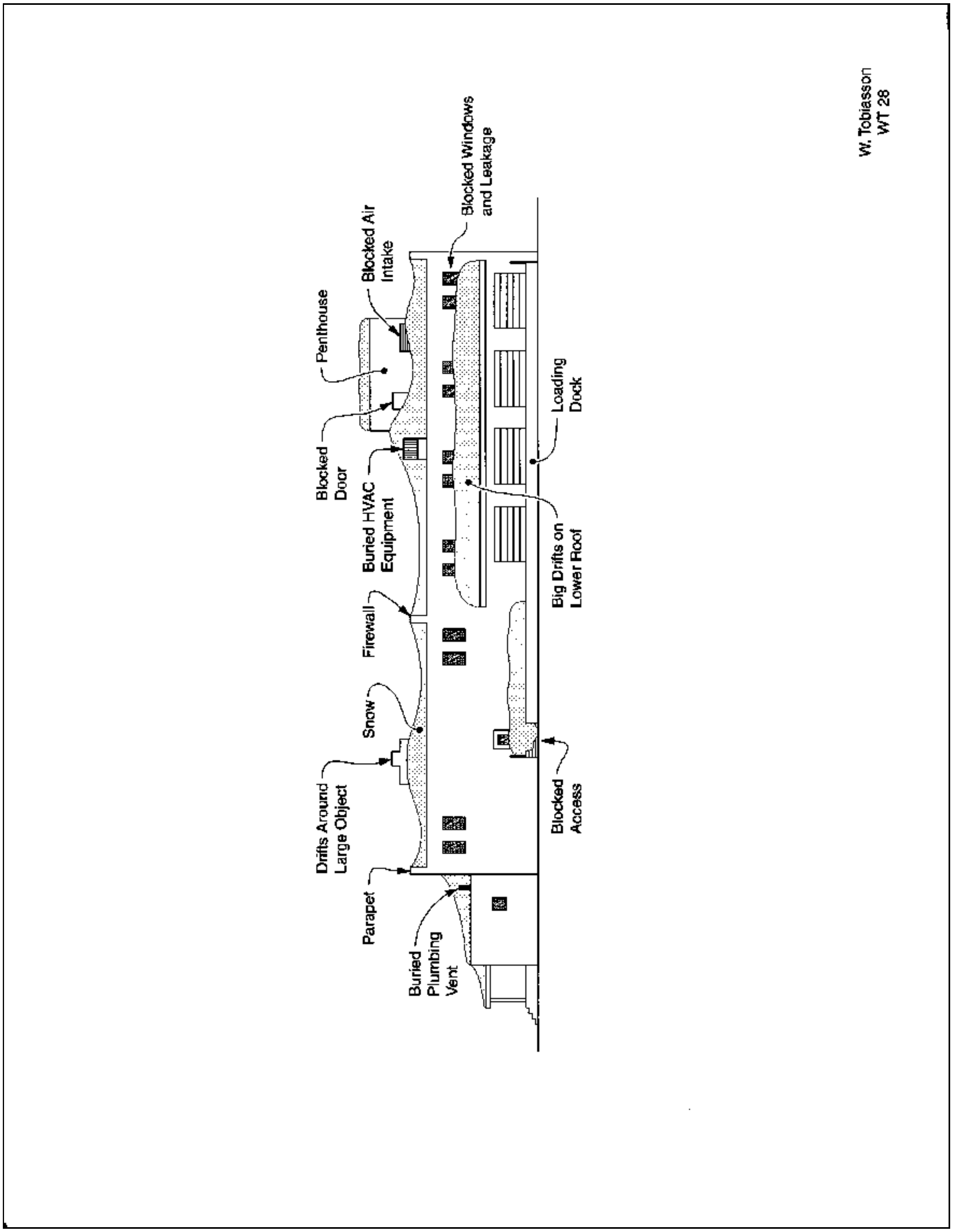

Figure 2. Snow drifts and their consequences.

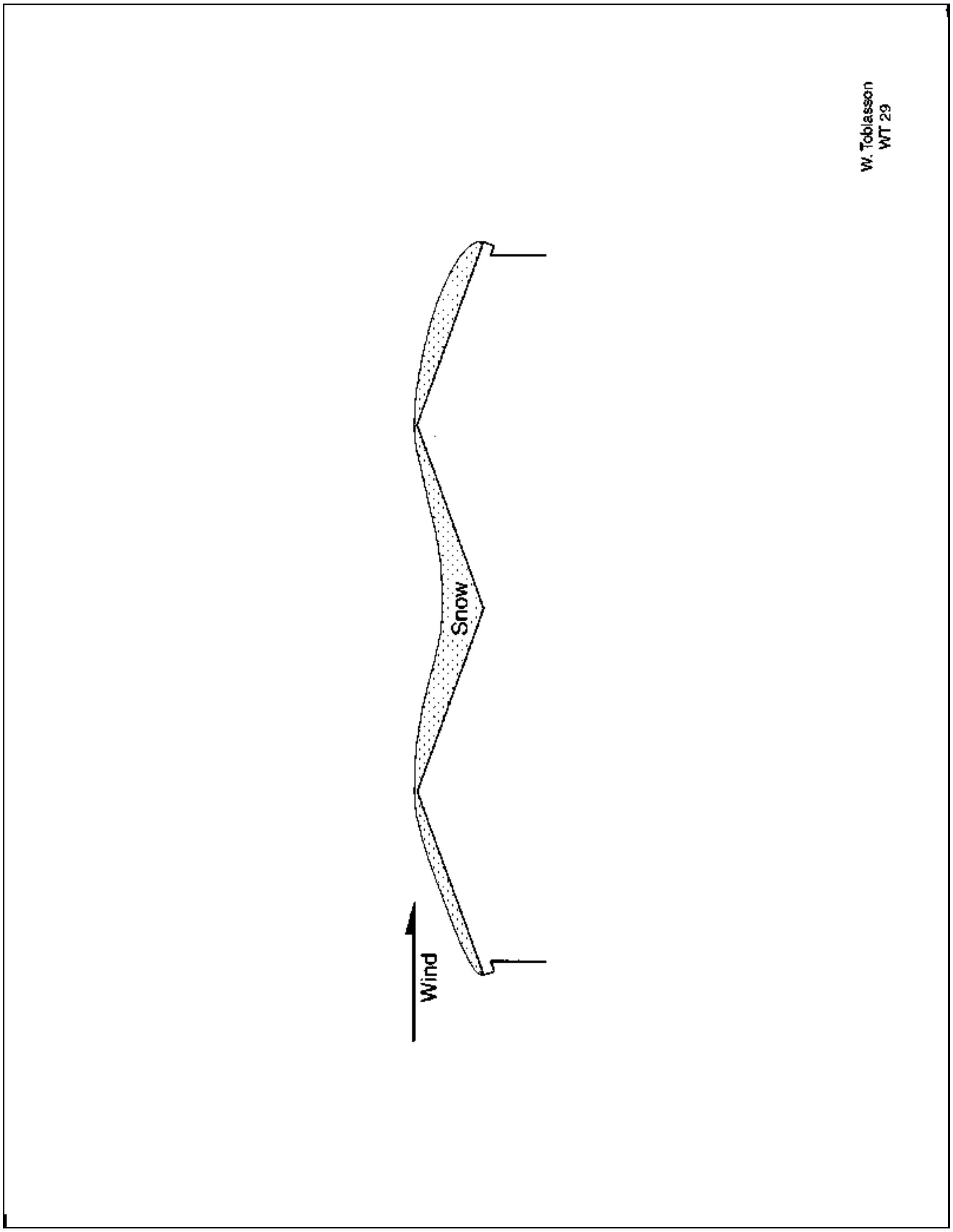

Figure 3. Unbalanced snow loads on a saw-tooth roof.

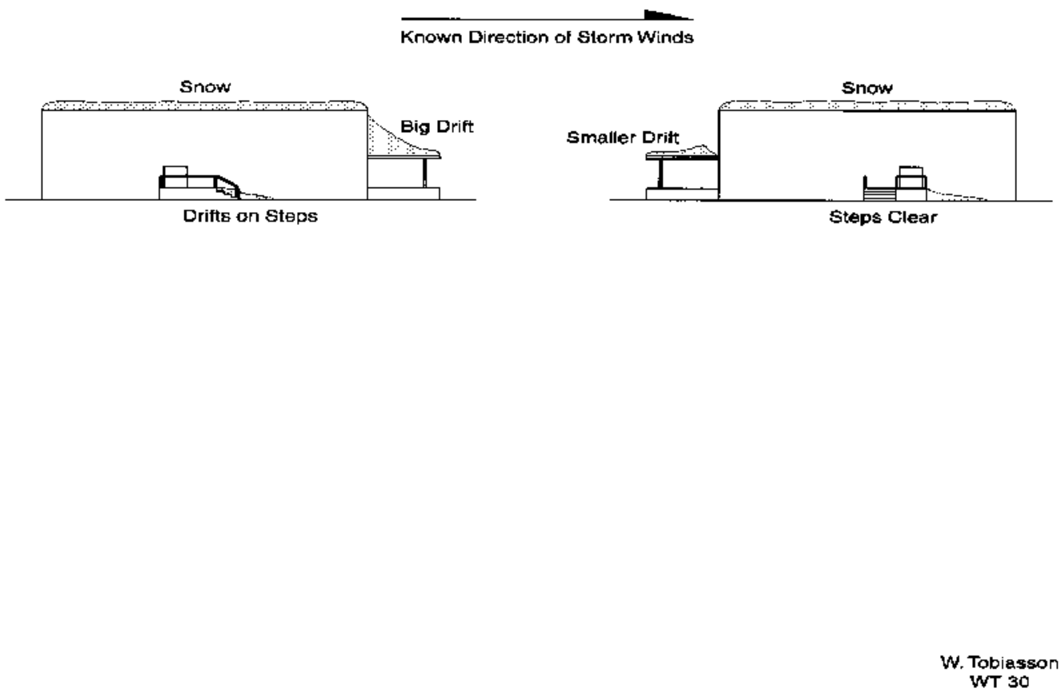

Figure 4. Orienting buildings with respect to the known direction of winter storm winds can reduce actual drifting even though design loads do not change.

Figure 5. Snow sliding off a metal roof.

Figure 6. Army van damaged by snow and ice that feel from a roof.

Figure 7. The creep and glide of snow down a slippery roof can create dangerous cornices.

Figure 8. Plumbing stack displaced by snow creeping down a slippery metal roof.

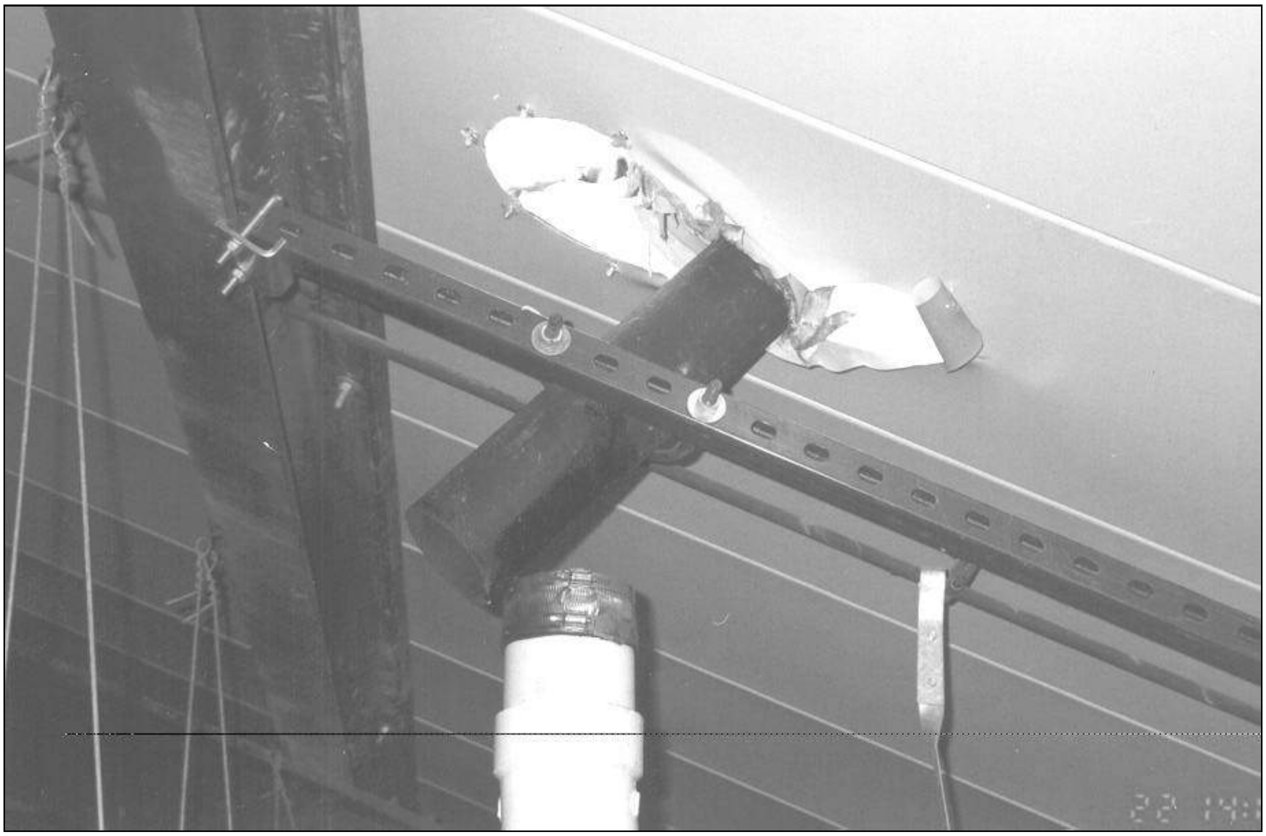

Figure 9. Tear in metal roofing caused by the plumbing stack displacement shown in figure 8.

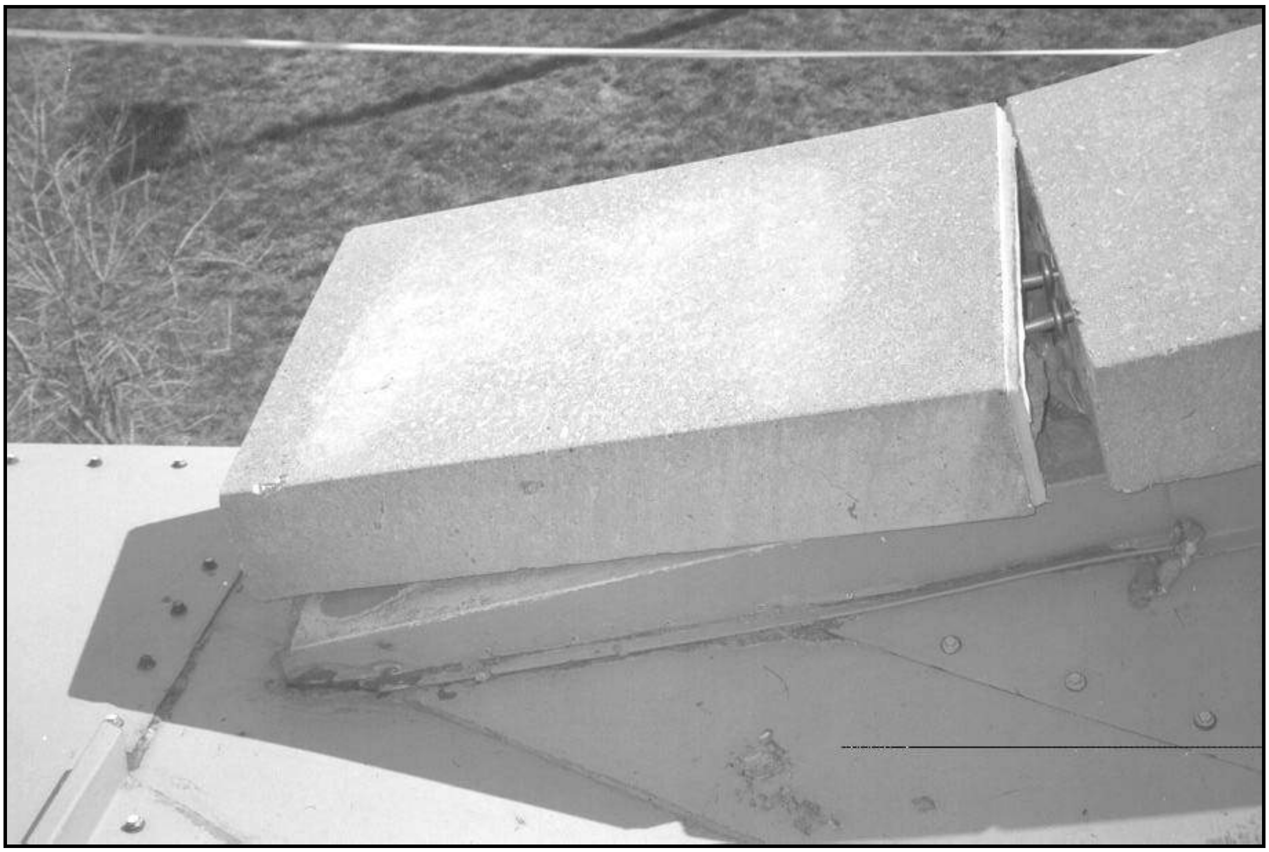

Figure 10. Parapet capstone displaced by snow moving down the adjacent roof valley.

Figure 11. Metal roof fascia torn by moving snow.

Figure 12. Metal standing seams broken and displaced by snow moving down a valley.

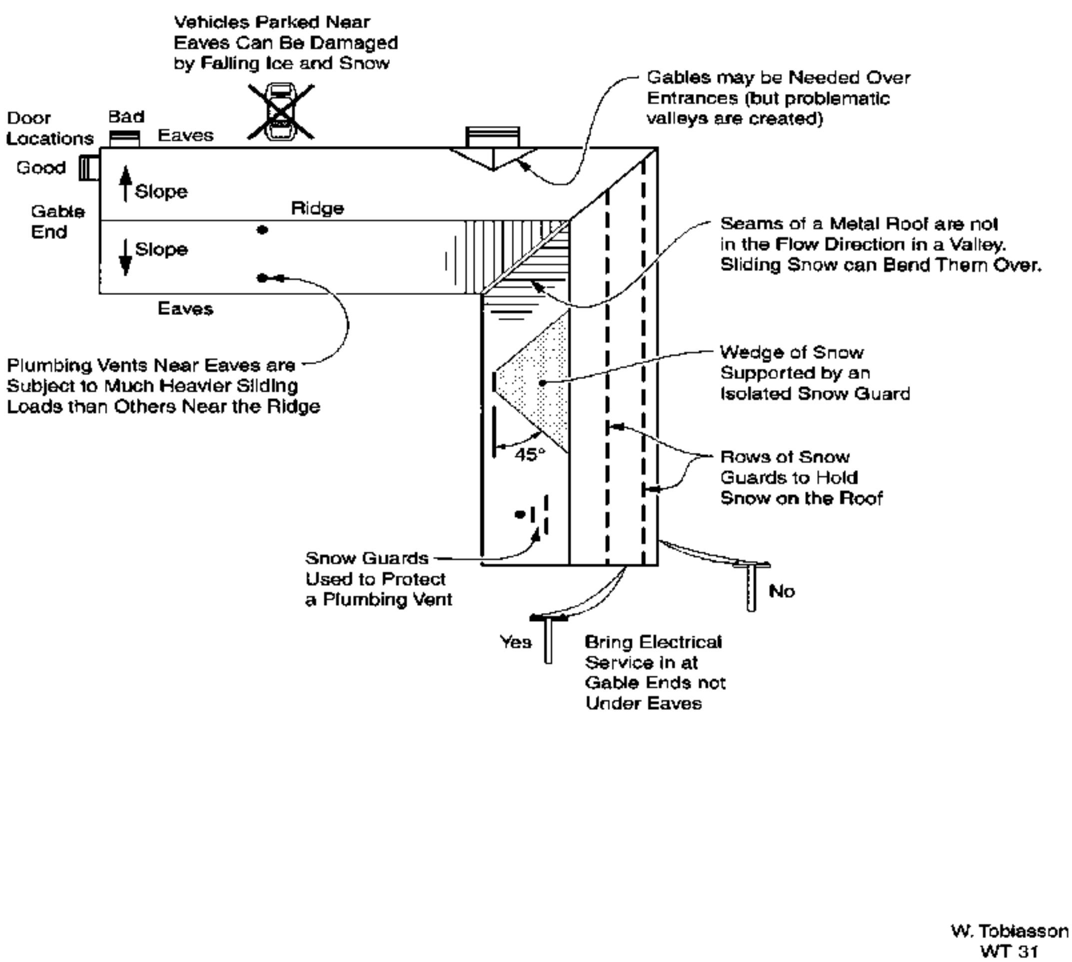

Figure 13. Plan view of a gable-roofed building showing some sliding snow issues.

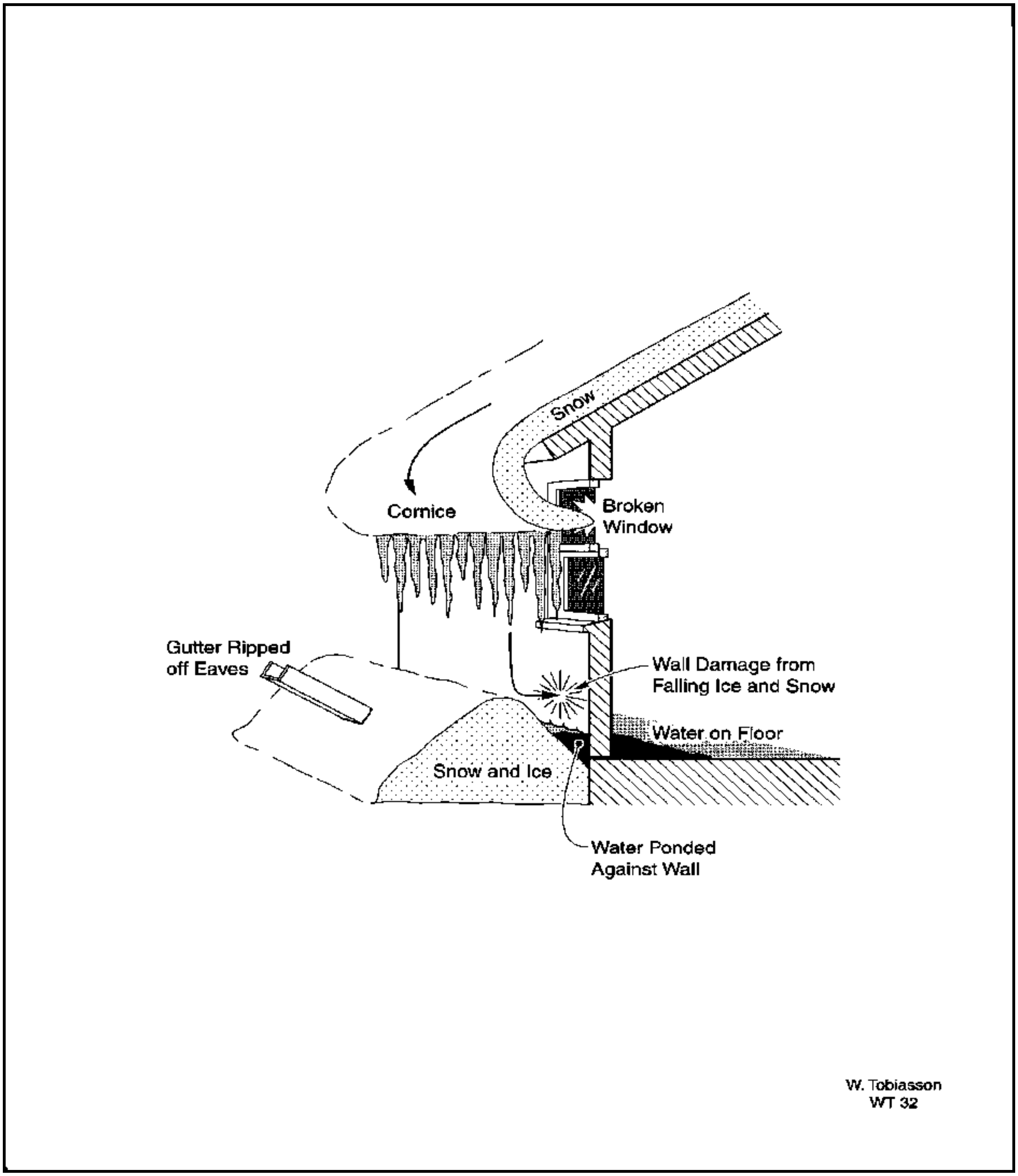

Figure 14. Snow creep can create cornices that cause several problems.

Figure 15. Electrical service entrance cables should not be located below cold eaves.

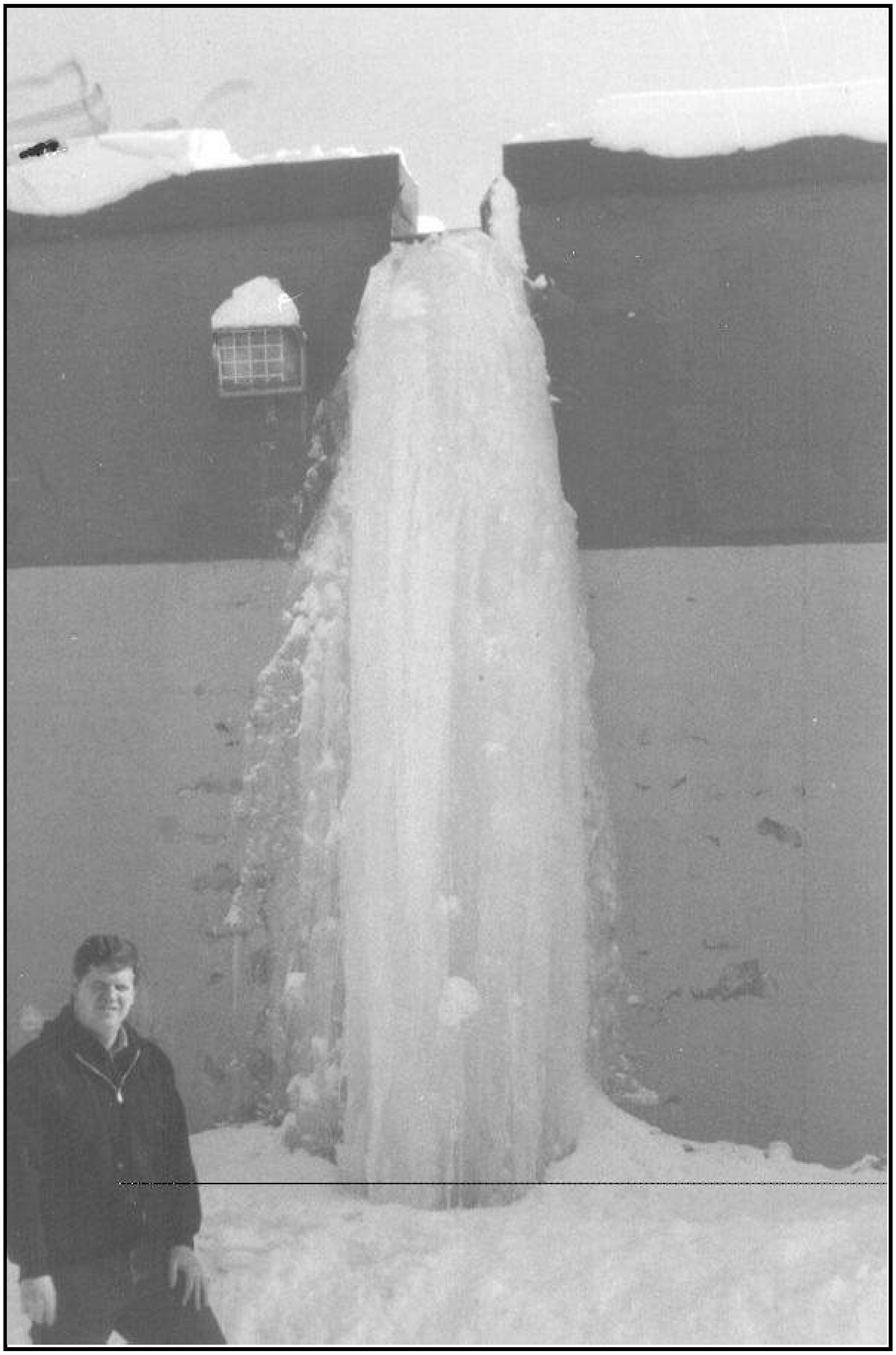

Figure 16. Scuppers are often not appropriate as primary drains for low slope roofs in cold regions.

Figure 17. Massive icings along a metal roof over a warm attic.

Figure 18. When a cold eave is not present, ice may form on building walls.

Figure 19. Removal of snow and ice is dangerous and often damages the roof.

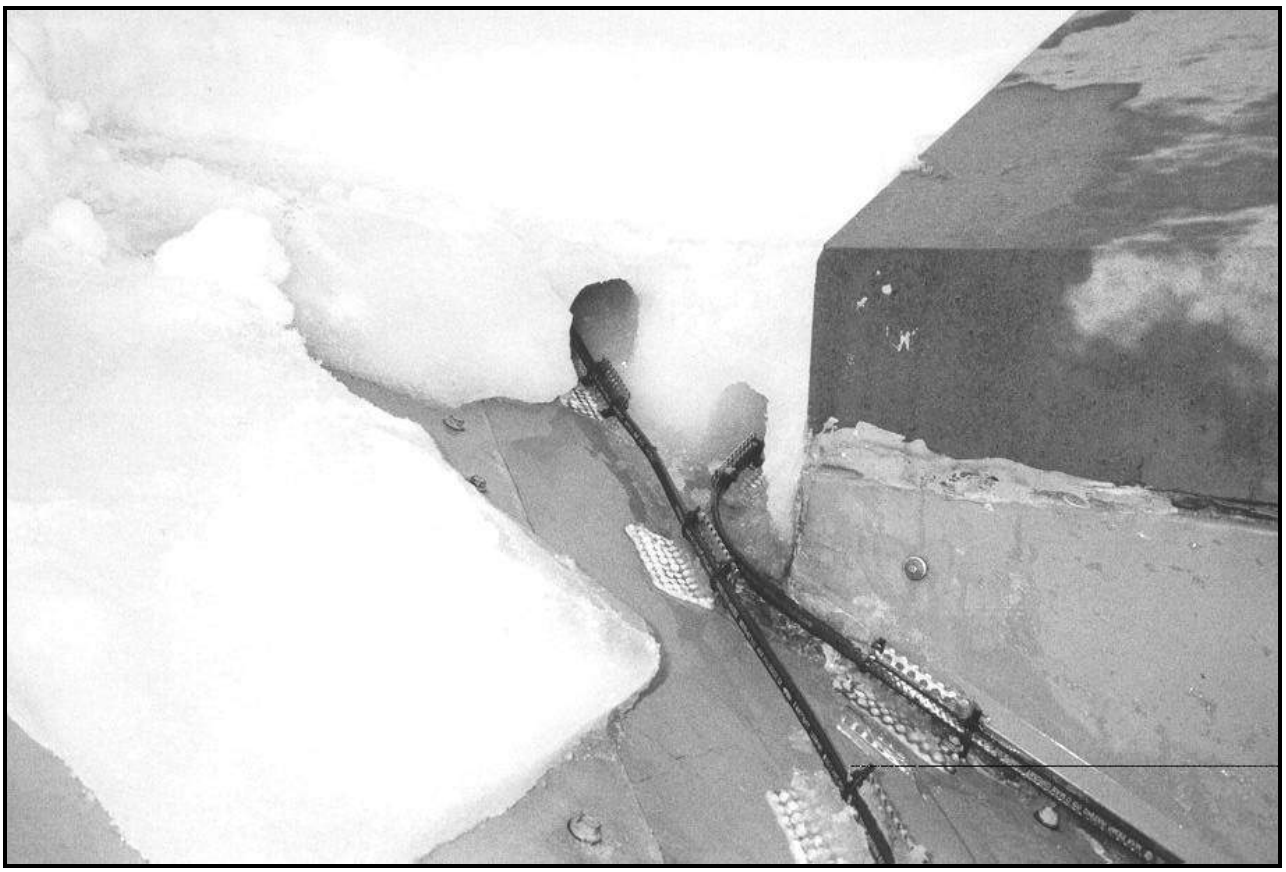

Figure 20. Electric heaters can create tunnels which prevent ponds from forming on roofs behind ice dams.

Figure 21. Electric heaters zigzagged along the eaves of a residence to prevent ponding of water behind ice dams.

Figure 22. Fence type snow guards installed on a metal roof.

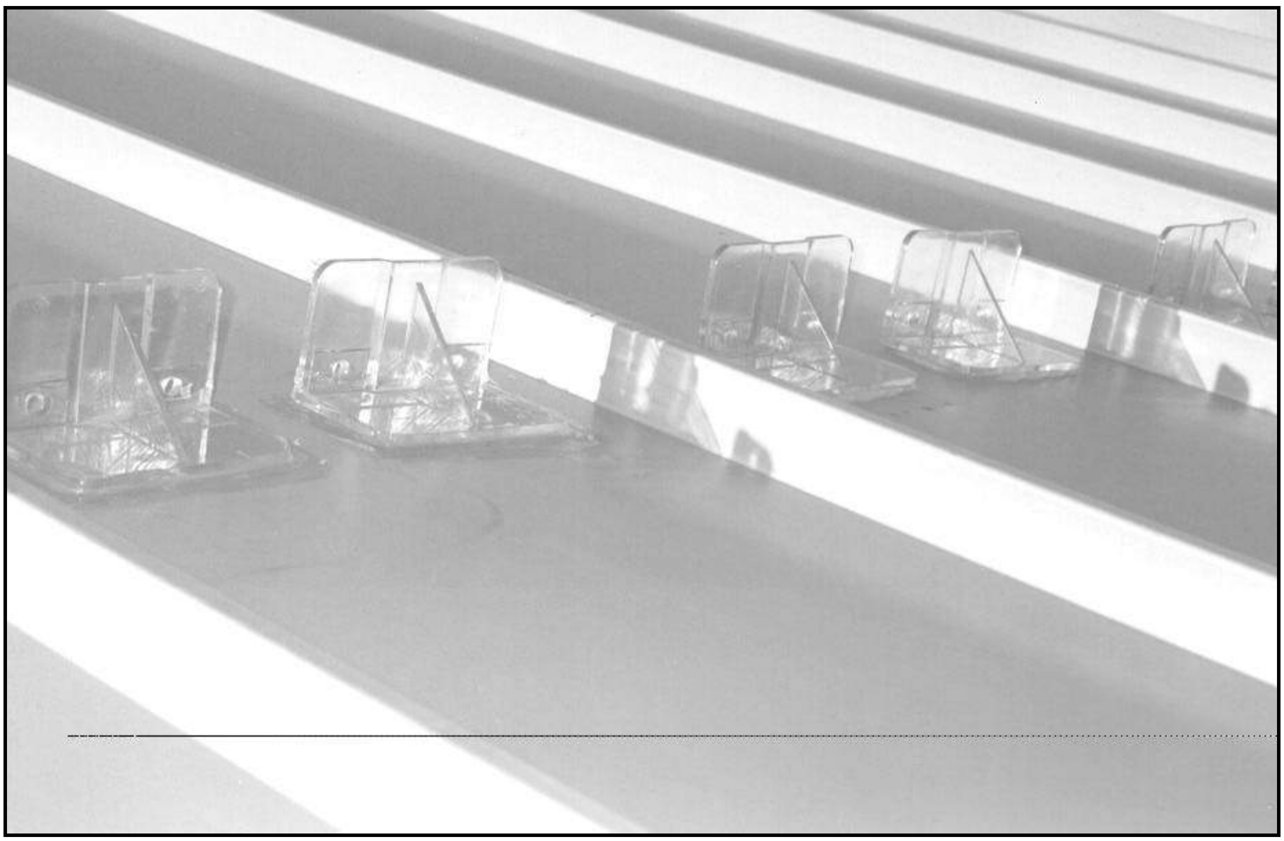

Figure 23. Plastic snow guards adhered to a metal roof.

Figure 24. Two rows of aluminum angle snow guards spaced well apart up a metal roof.