Designing Roofs for Snow Loads

photo by T. Gilson

by Harris Hyman

At one time, dormers were added to attics to let in a little light. These dormers were rarely wider than four feet, and such small cutouts rarely broke up the integrity of a roof. But over the years, dormers became an element of style and grew. And grew.

Now it is common for a dustpan dormer to be nearly as wide as the roof, with lots of nice windows and no collar ties so that the owners can make better use of the space. Big dormers are wonderful for transforming a small Cape into a moderate-sized house.

But when the snow comes, they often are structural disasters.

The rafters over a dormer are at a low pitch, maybe 3 on 12, which holds the snow. And good insulation prevents the snow from melting (as it should). So the load builds up on the structure, which has been weakened by the removal of the ties.

In mid-March, the heavy, wet snowfall comes, and the dormer leans out a little—only a couple of inches if the owner is lucky. The house takes on a slightly seedy sag, giving it the flavor of a nice old house. The windows may jam and be impossible to open, but no big deal. After all, this is a nice old house.

Sometimes the owner isn't quite as lucky, and the wall sags out six inches or so. A pronounced sag in a wood-frame house probably won't cause a collapse, but most builders and home owners find the prospect frightening—and it probably doesn't do too much for the resale value. (However, I just saw a T-shirt declaring that beer bellies are *in* this season, so perhaps the beer-belly dormer could spell status in some circles.)

It is in March that the heavy, depressing snowfalls of New England usually do their worst damage, mostly ripping off porches and sometimes crushing buildings. The snow piles up, it's excessively wet and heavy, it clings to a layer of ice already on the roof, and it adds enough weight to break things. (This doesn't seem to happen much earlier in the season, although the roof of the Hartford Civic Center did collapse in January.)

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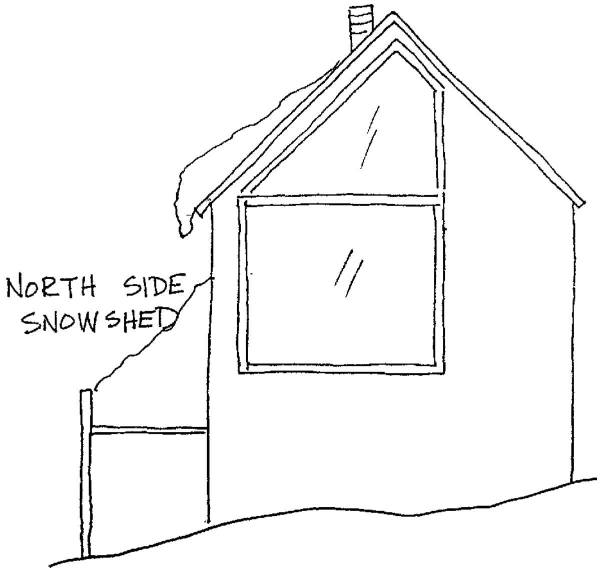
One day in mid-March, as I was writing this, I had an excess of curiosity and went outside to gather some of the wet, heavy, depressing snow for weighing. I scooped up a board foot (12"x12"x1") of the stuff and then couldn't find a scale, so I melted it down to a pint or so and estimated the weight at a little over a pound—not a lot.

But it adds up. There are places on buildings where the snow can pile up for most of the winter—and load up 30 or 40 pounds per square foot. These places are typically on the north side of a building: porches, dustpan dormers and roof valleys where the low winter sun does not hit.

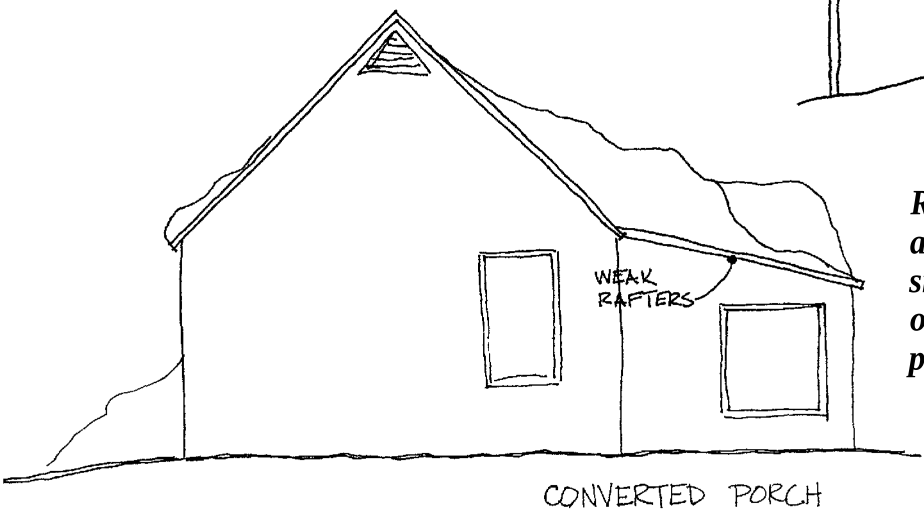
With an already heavy buildup, the March snowfall piles up evenly on the roof, then slides to the porches and valleys. Then there's a crunch and something breaks a little or comes loose a little, and we start to have problems.

The 50-Pound Standard

At one time, a design that would resist 30 pounds per square foot was considered reasonably safe. During the first ski booms of the 1960s, there was lots of innovative building and designing in the North Country. Exotic roof angles were used to give the houses distinction, and porches were situated to take in the view. Business was great, but



Roofs over former porches and those serving as snowsheds on the north side of a building are typical problem spots.



drawings by Harris Hyman

there were problems. Roofs caved in and porches fell off.

About that time, I left the corporate world of engineering and went into private practice. On receiving my registration certificate, I was invited to a dinner of the state engineering society with the other newly registered engineers. All of the talk at that meeting was of raising the statutory "safe" snow load from 30 to 50 pounds per square foot.

There was no building code in Vermont at that time, but the problems had shown themselves, and the state Department of

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Education had adopted 50 pounds as the design load for school buildings.

In a few years, 50 p.s.f. became standard throughout the Snow Belt. Today truss fabricators almost invariably build roof trusses to handle 10 p.s.f. dead loads and 50 p.s.f. live loads, and they become very nervous when the design specs call for a lighter load.

Well, 50 pounds per square foot is excessive for a lot of situations, but codes are somewhat like speed limits—they are set up so that if you follow them, you are exercising normal prudence and can keep out of trouble most of the time. So even though it usually is excessive, the 50 p.s.f. requirement follows this reasoning, and we usually design roofs this way.

I don't always, however. If it is easy enough to give a roof strength for 50 p.s.f. snow loads, I'll do it, but sometimes there are problems and special situations, for example, I do a lot of work on the coast, where there isn't much snow buildup, so roofs there usually are okay with the old 30 p.s.f. standard.

Design & Climate Considerations

Structural design involves three distinct acts: estimating the likely loads, inventing some sort of structural system that will hold up these loads, and then validating the system through calculation and experience. The 50 p.s.f. "standard" is not always a good estimate.

The shape and material of a roof also affect the amount of snow buildup and may argue against the 50 p.s.f. standard. Snow usually will not cling to a steep roof for a long time. (To me, "steep" means 8 or 9 on 12 for shingled roofs and 6 on 12 for metal roofs.) Roofs this steep generally will be clear within hours of a snowfall.

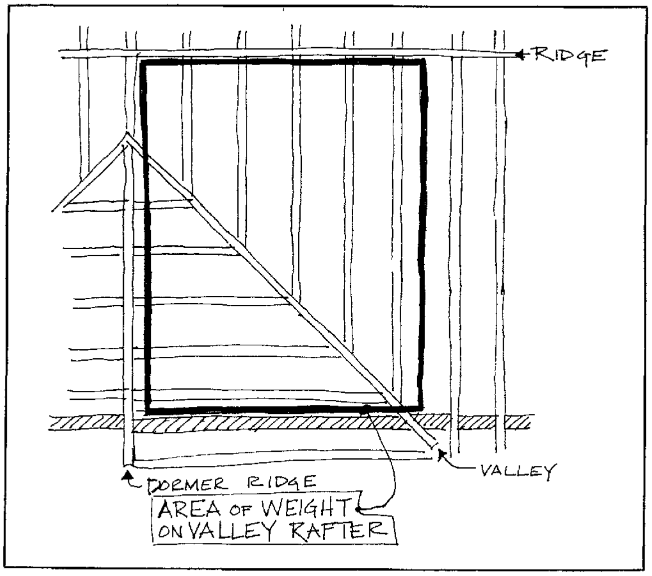
A lighter design load often can be used in windy areas, since wind will clear snow from roofs and porches. An exposed seashore site usually is blown clean. On the flip side, strong winds can create a different class of structural problems, so we don't get it all for free. Wind is also not always an asset.

And on turbulent sites, with moderate winds and a lot of trees, there can be some drifting and piling of show. So the presence of wind should not be taken as an automatic license to violate convention.

Snowsheds

Another design factor is whether a portion of a building is a snowshed—the north side of a house with an east-west ridge line, for example. Snow lands on the north pitch, then it slides off and piles up for the whole winter out of the sun. A flat porch or garage roof on this north side gets the winter accumulation of the whole north pitch, which can be quite heavy—even greater than the statutory 50 p.s.f.

A low pitch on the roof of a former porch that has been converted into a room also can act as a snowshed. A porch often has a much lighter roof than the main roof of the house, but a few years after the conversion the



original character of the roof may be forgotten. A couple of years of heavy snow loads can weaken the structure and lead to a messy surprise.

In construction, the trickiest snowsheds are valleys on the north and east sides of a roof. The valley rafters carry all of the snow loads of all of the rafters nailed into the valley, with the loads increasing at the lower end.

Often the valley rafter is just a single stick, and this single stick supports the jack rafters on both sides. Peculiarly, this condition frequently occurs on buildings that are generally overbuilt.

Valley rafters usually should be doubled—and sometimes tripled—and it's a good idea to work a supporting wall in under the valley. Hip rafters have the same support problems (a single stick holding up many jack rafters), but snow doesn't collect on the hips; it slides down into the valleys.

The worst of these valleys are found on oversized dormers. The design trend of the past few years, toward exaggerations of the Victorian and Shingle styles, brings out the oversized doghouses. Architecturally, they work extremely well, creating style, interesting spaces and excellent attenuations of daylight, but they also create structures that need careful attention.

Here, the dormer valley rafters must carry not only the structure of the enlarged

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dormer, but also snow that slides down and piles up out of the sun. More potential for rude surprises. I've worked on a few neo-Victorian houses with lots of fancy woodwork and steel valley beams hidden in the roof structure.

And flat roofs. Gaaahhhh! Problems all the way. Many of the flat roofs are on school buildings, with parapets all around to keep the snow from blowing off. The snow melts and the deformed roof no longer drains properly on the 1/16" per foot design pitch, so there's a skating rink to be held up as well as some leaking to be stopped. Fortunately, we don't do this much anymore.

Other Factors

Super-insulation has produced an interesting side effect in building for snow loads. Much heavier rafter sections are used—not for strength, but to accommodate insulation. In most residential cases, 2x8 rafters are strong enough, but if we want a roof blanket, 2x12s are just about right for R-30 fiberglass and some air space.

The rafters are *always* overstrength, just to make the building sufficiently tight. This shifts the engineering problem away from the design of the roof to the proper care of the snowshed areas, accentuating the valley problems.

Some specifics might be useful. Chapter 6 of *Architectural Graphic Standards* (7th edition), by Ramsey and Sleeper, has an excellent set of load tables giving allowable spans for various rafter and joist sizes.

For construction-grade spruce—the stuff generally sold in the lumberyards, with the really gross pieces culled out on site—an extreme fiber-bending stress of 1,200 pounds per square inch is about right for evaluating strength. Floor-joist tables can be used for rafters, and the word "span" should be taken to mean horizontal span, not pitch length.

(Incidentally, although *Standards* is a moderately expensive item, it should be a part of *every* builder's library.)

Snow is heavy, but not that heavy. It is one of those inevitable facets of our life in New England. We must work with it and treat it with respect, and realize that dealing with it isn't all that difficult. Like most of our work, all it takes is some care and understanding. ■

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