relationships with a few manufacturers who could be called upon to help. Another option is to engage a specialized engineer who is intimately familiar with metal building design and renovations.

There are a number of techniques for strengthening primary and secondary framing. Perhaps the most straightforward method is to add additional primary frames between the existing ones. This way, the loading on the existing frames is halved, and the purlin span is reduced by one-half, meaning that the purlin capacities are quadrupled. Naturally, the primary frames will require their own foundations. To fit under the existing purlins, the new frames can be placed slightly lower than the existing frames, and the purlins can be attached to them by bearing clips. The clips will not only make up for a slight difference in the frame elevations, they will also guard against purlin web crippling at supports.

Another method of frame strengthening involves adding additional columns. This method is less desirable, not only because it introduces new obstructions into the building, but also because it requires a careful analysis of the resulting stress redistribution.

It is also possible to strengthen primary and secondary framing by welding continuous plates or angle sections to their flanges. These and other methods of strengthening are discussed in detail in another book by the author, *Structural Renovation of Buildings: Methods, Details, and Design Examples.*[6] The book also contains a comprehensive case study of renovating an existing pre-engineered building.

14.5 EXPANSION OF EXISTING METAL BUILDINGS

One of the often-stated advantages of metal building systems is the ease of expansion. True, it is relatively easy to extend a pre-engineered building by adding several more bays of matching framing to its expandable endwall and cutting in a door in the wall. The complications begin when anything more than that is attempted.

A case in point concerns removal of the old endwall framing to unify the new and the existing spaces. As was discussed in Chap. 3, this task is easy only if the building had been programmed for expansion and a moment-resisting frame installed in each expandable endwall. Otherwise, the elimination of an old endwall requires some engineering gymnastics such as temporarily shoring the purlins and girts that bear on the endwall framing, removing the latter, and erecting a new clear-spanning moment frame in its place—hardly an easy chore, as illustrated in the Case Study in Sec. 14.6.

Expansion alongside the existing building is even more treacherous. In northern regions, two gable buildings sharing a common wall create a valley likely to be filled with drifted snow (Fig. 14.11). The resulting design roof snow load will probably exceed the design load for the original building. While the addition can certainly be designed for the larger loading, the existing building could be in serious danger. In fact, the losses from failures attributable to this very condition are measured in hundreds of millions of dollars.[3] Unless a costly structural upgrade is contemplated, it is better to avoid building expansion in this manner.

A similar problem arises whenever the addition has a higher roof elevation than the original building. Again, the snow drifted onto the lower existing roof can result in overstress and failure.

In some cases, the only way to expand is up. Second-story additions are not very common in metal buildings, but they can be built in situations where site constraints leave no other option. Rather than supporting the second-story columns on top of the existing ones, it is often better to locate the new supports outside the building. The offset between the new and existing columns is dictated largely by the distance needed to allow the new foundations to clear the existing ones (Fig. 14.12).

A similar approach can be taken in cases where it is necessary to keep the existing operations going while the new building is being constructed. Indeed, some metal building manufacturers produce replacement systems intended to span over the existing building (or several small buildings). One example is Coronis Building Systems, Inc., already mentioned in Chap. 4, which markets its *Retroframes** for this purpose (Fig. 14.13). According to the manufacturer, *Retroframes* have been used successfully in a number of applications.

*Retroframe is a registered trademark of Coronis Building Systems, Inc.

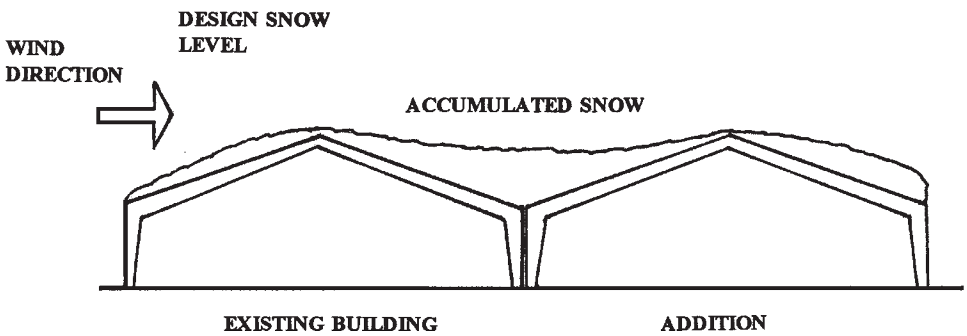

FIGURE 14.11 Building addition alongside an existing structure can result in its overstress.

14.6 CASE STUDY: ADDITION TO PRE-ENGINEERED BUILDING*

14.6.1 Project Background

A public agency desired to make an addition to its 10-year-old warehouse, constructed in the early 1990s. The existing pre-engineered building was approximately 100 ft long, 60 ft wide, and had an eave height of 20 ft. It was a basic gable building with the ridge running in the long direction and single-span rigid frames spaced 25 ft on centers. The existing structural and architectural contract drawings were available.

According to the drawings, the building lateral stability was provided by a two-bay-wide horizontal roof diaphragm made of steel rods extending from eave to eave. Cross bracing was provided at all four walls. The standing-seam metal roofing, with a pitch of 1:12, was supported on continuous Z purlins. The roof was insulated with fiberglass blanket insulation draped over the purlins. The field-insulated metal siding was carried by Z girts of bypass design. The endwalls were nonexpandable, with endwall columns spaced at 20 ft on center. There were 12-ft-wide overhead doors in the middle of each endwall.

The building had a 6-in-thick slab on grade, reinforced with welded wire fabric. The foundations consisted of 12-in-thick foundation walls on 20-in-wide wall footings. The walls were partly exposed for 3 to 4 ft and continued down below grade to the frost line for a minimum of 3.5 ft. The drawings indicated no vertical wall reinforcement and no wall footing reinforcement, but did show two horizontal #5 bars at the top and bottom of the walls. The walls were tied to the slab on grade with #5 dowels spaced at 2 ft o.c. Frame columns were supported on integral piers and column footings. A tie rod (1.5-in-diameter threaded rod) in thickened slab was provided at each pair of frame columns to resist their lateral reactions.

The proposed addition measured 34 × 60 ft. It was to be fully integrated with the existing building, so that one of the existing endwalls had to be removed.

14.6.2 The Design Criteria

The design criteria are listed below.

Governing building code: BOCA 1996

Roof snow load: 30 psf

*This case study is based on a project by Maguire Group, Inc., which supplied the accompanying illustrations (Figs. 14.14 to 14.19).