studs, and brick ties needs to be made. Such finite-element analysis and investigation performed by Gumpertz and Bell[19] have found the BIA's limit of $L/600$ to be reasonable. The investigation has also discovered that the wind-force distribution among various brick ties along the height of the wall is not uniform: two or three ties located at the top and at the bottom of a stud carry a significant fraction of the total wind force. Thus the total wind load tributary to a stud should be divided into four or six, and the resultant should serve as the basis for design wind loading on all the ties.

BIA Note 28B recommends that one masonry veneer tie be placed for each 2.67 ft^2 of wall area. The ties should not be spaced more than 18 in vertically and 32 in horizontally. They should be embedded not less than 1.5 in into the veneer, but still provide at least $^{5}/_{8}$ in of mortar cover from the outside brick surface.

As noted above, this information just scratches the surface of the complex issues that involve brick veneer. Those involved in specifying brick in metal building systems are wise to educate themselves about the latest relevant code provisions and the ever-improving standards of design and detailing brick veneer walls.

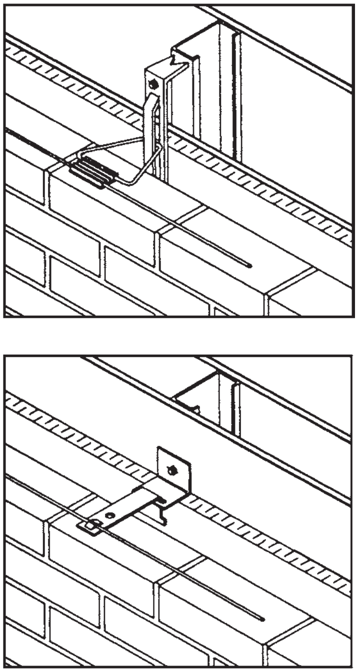

FIGURE 7.31 Brick reinforcement for areas of high seismicity. (*Used with permission of the Brick Industry Association, Reston, VA, www.brickinfo.org.*)

7.6 COMBINATION WALLS

Metal building systems allow plenty of opportunities to combine different materials in the same wall. For example, exterior masonry can be provided only at the bottom, where potential for physical abuse is the greatest. Masonry may also be selected as a wall-base material for aesthetic reasons, to add depth and interest to an otherwise flat or ribbed facade.

Partial-height masonry walls present some design challenges with respect to their lateral support at the top. As mentioned already, typical cold-formed wall girts are not usually appropriate for lateral support of masonry because of stiffness incompatibility. The best way to stabilize a partial-height ("wainscot") masonry wall is to cast vertical reinforcing bars into the foundation wall, so that a cantilever action is effected. Making such walls taller will result in a dramatic increase of the reinforcing bar size, so it is better to keep partial-height walls relatively short (Fig. 7.32). The most expensive and difficult design is to run the CMU almost all the way up to the eave and terminate it in a ribbon window. If a situation like this arises, consider adding a few discrete windows at the top rather than a continuous one. If the ribbon-window design is unavoidable, structural steel girts may be provided above and below the windows. The girt design is similar to that of Example 7.2.

A common wall combination is that of a partial-height CMU with metal panels above. Panels can be attached to CMU with a sill channel or a sill angle (Fig. 7.33*a* and *c*), in which case the masonry should be structurally designed for an additional wind load imposed by the panel. In another possible solution, siding is laterally supported at the bottom by its own girt (Fig. 7.33*b*).

Metal wall panels of different profiles can be combined to create accent bands and to enliven the facade (Fig. 7.34). In this design, the bottom panel can be not only metal but also masonry (self-supporting, as noted above) or even precast concrete.

Occasionally, a combination of various wall materials can be avoided when metal panels are able to play a role of other building components, such as louvers. On a project in Puerto Rico, custom louvers were made of 18-gage metal liner panels bent to a louver-like configuration and spanning horizontally. The resulting product not only blended in well with the surrounding wall panels but was also much less expensive than standard extruded metal louvers.[21]

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FIGURE 7.32 This partial-height CMU wall faces a hill and provides a measure of protection against rolling rocks and sliding debris.

7.7 CONCRETE MATERIALS

7.7.1 Precast Concrete Panels

Precast concrete offers some of the advantages of masonry, such as impact and sound and fire resistance, without the handicap of slow construction. Loadbearing and shear-wall applications of precast panels are especially popular in metal building systems. Nonstructural precast wall panels can add depth to the building (Fig. 7.35). To develop a distinctive wall texture, precast panels can be designed with deep horizontal or vertical grooves, perhaps with varying groove spacing; panels with projecting fins can also add visual interest. Even such unlikely elements as precast double-tee roof units have been successfully used as economical long-span curtain walls.

One of the main disadvantages of precast concrete is its low thermal insulation value, but this problem can be overcome. Rigid insulation can be attached to the panel's interior face and covered with gypsum board or can be enclosed as a sandwich between a thick structural part and a thin exterior course. For example, a 12-in insulated panel can consist of an 8-in solid or hollow-core structural part, 2.5 in of expanded polystyrene, and 1.5 in of exterior exposed-aggregate concrete. Such panels are commonly supplied in 8- to 12-ft widths.

Many engineers neglect any structural contribution of the exterior layer and make it totally independent of the structural part. Interconnecting the two layers may ease concerns about panel delamination but may also lead to panel bowing and some loss of *R* value.

Insulated wall panels seem to be especially popular in food processing plants, where strict cleanliness requirements call for hard and smooth interior finishes without any crevices, pinholes, and horizontal ledges. For this application, panels are examined with binoculars to detect the most minute surface flaws that could become harbors for dust and bacteria.[22]

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