rigid-frame action is either partially or completely transferred from the frame knee to the column base. In the first approach, the frame knees remain rigid, but, in addition, the columns are fixed at the base. The second approach relies solely on column fixity; in essence, each fixed column becomes a flagpole-type structure. The flagpole approach allows the manufacturer to eliminate not only the expensive rigid frames but the wall and roof bracing as well—and submit a lower price.

Why doesn't everybody design that way? The answer is simple: This kind of design, while allowing the manufacturer to realize some savings, penalizes the foundations by subjecting them to high bending moments that would be absent under a pinned-base scenario. Whether fixed-base design results in a higher or a lower overall building cost depends on the project specifics. *If anticipated from the beginning,* it may be a viable option in cases where the foundation capacity can be increased at a low cost. Havoc might result, however, if such fixed-base framing is proposed for a building where the foundations have already been designed—or worse, built—based on a pinned-base assumption, as we will see in Chap. 10.

Another problem with fixed-base columns: Base fixity is easy to assume, not easy to achieve. For example, a widespread industry practice of not providing grouted leveling plates under column bases and not tightening the anchor bolts often leaves the base plates bearing only on one edge and allows for some "play" between steel and concrete. Moreover, the details used by the metal building manufacturers to accomplish base fixity rarely follow the details found in heavy structural steel buildings, such as that of Fig. 4.17.

In Fig. 4.17, anchor bolts transfer their forces via rigid brackets (also known as *bolt boxes* or *boots*) into the column flanges, bypassing the base plate itself. The simple base plate shown in Fig. 4.18*a* will also develop some moment, but it requires a very substantial plate thickness to avoid rotation under load. The type of deformation illustrated in Fig. 4.18*a* would bring the base plate much closer to pinned than to fixed condition, as many experienced engineers agree.[3]

A typical manufacturer's detail for fixed base shown in Chap. 12 uses eight anchor bolts and a relatively thin base plate. This design can decrease, but not fully eliminate, plate deformation under load (Fig. 4.18*b*) and probably provides less than full column fixity.

Still another issue that makes achieving column fixity difficult is the fact that even the best-detailed fixed-base columns bear on foundations that tend to move under load. As discussed in Chap. 12, these foundations often consist of shallow spread footings. However large, these moment-resisting or tied footings require that some soil deformation—and therefore rotation under load—occur, in order for them to become effective. The geotechnical engineers understand this well.[4]

Each of the factors discussed above will introduce perhaps a minor amount of base rotation. Taken in combination, however, they could provide a degree of rotation significant enough to make a fixed-base assumption in many cases simply unrealistic.

4.9 A ROLE OF FRAME BRACING

Every structural system we have considered, except perhaps Butler's Delta Joist, requires lateral bracing of the rafter's compression flange for full structural efficiency. Under downward loads (dead, live, and snow), the top flange of primary members is mostly in compression. Fortunately, this flange carries roof purlins, which provide the necessary bracing. Under wind uplift, however, it is the bottom flange that is mostly in compression. Lacking any help from secondary members, the bottom flange needs to be stabilized against buckling by flange bracing, consisting usually of bolted angle sections (Fig. 4.19).

Similar bracing is needed at interior flanges of rigid-frame columns that are normally in compression under downward loads. The bracing connects the interior flange to the wall girts (Fig. 4.20).

Locations of the flange bracing are determined by the metal building manufacturer and need not concern the specifiers. An absence of any flange bracing at all, however, warrants further inquiry.

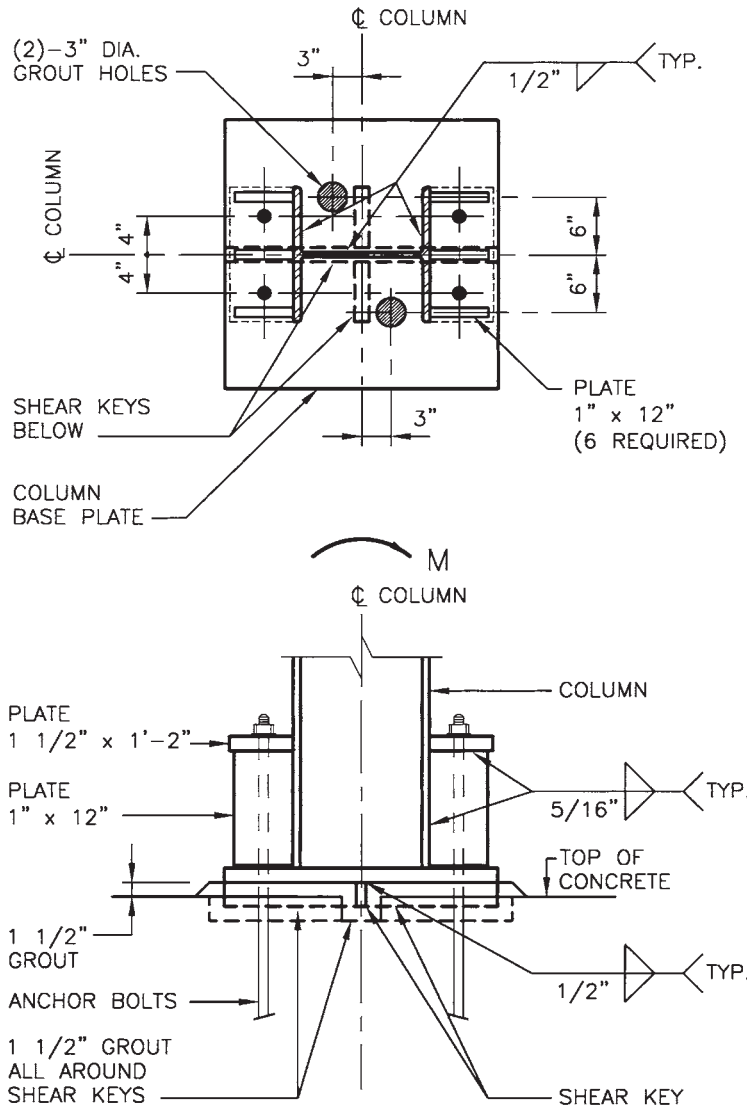

FIGURE 4.17 Typical detail for column fixity used in heavy structural steel buildings.

4.10 CHOICES, CHOICES

Any large manufacturer can provide most of the primary framing systems discussed above. Which one to specify? Hopefully, the information provided in this chapter, as well as in Chap. 3, will be helpful. (The dimensions and details shown in the illustrations should be considered preliminary, as each manufacturer has its own peculiarities.) Also, Fig. 4.21, adapted from *Means Building Construction Cost Data 1995,*[5] provides material and total cost per square foot for various types of