will often be insufficient if only two of the bolts are assumed to be effective in shear resistance. To engage all four bolts (the typical number), some engineers specify welding tight-fitting heavy washers to the top of the base plate around the bolts, after they are installed. Others argue that this practice introduces bending in the anchors, since the force is now transferred *above* the base plate, and that the washers must be thick enough to avoid bearing failure. Another view simply assumes that the anchor bolts will be slightly bent out of alignment by the loaded column base plate, until all the bolts are engaged.

In pre-engineered buildings, anchor bolts are commonly pretensioned only to a "snug-tight" condition, which results in some modest clamping force normally neglected in design. A substantial amount of tightening is needed only for fixed-base columns which rely on clamping forces for moment transfer or for buildings where lateral drift is tightly controlled.

12.6.5 Common Anchor Bolt Locations

For buildings of moderate span and bay sizes with pin-base columns, the most common number of anchor bolts used to be four for sidewall (frame) columns and two for endwall (and sometimes interior) columns (Fig. 12.28). As just mentioned, OSHA regulations for steel erection now require a minimum of four bolts in *all* columns except for "posts" (see Sec. 12.6.1). As a result, some previously standard details may require revision, depending on the weight of the members.

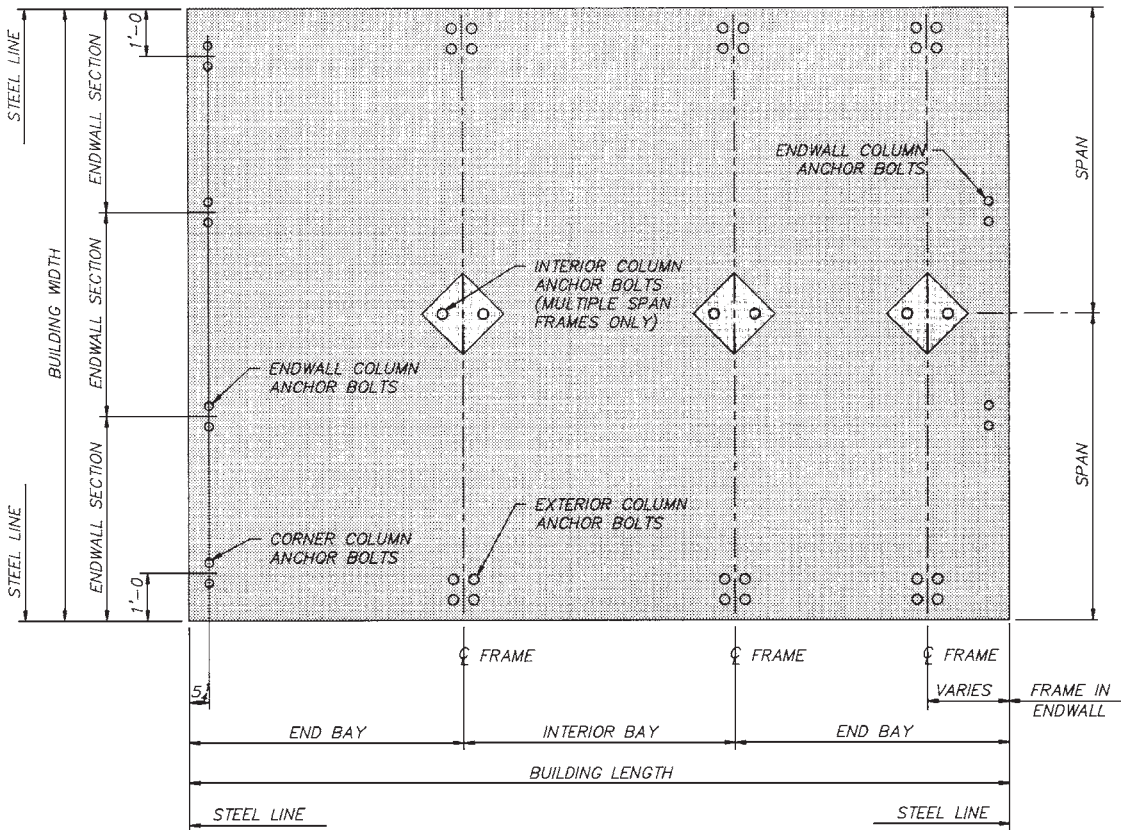

FIGURE 12.28 Typical anchor bolt layout. (Note that recently enacted OSHA Standards for Steel Erection require a minimum of four anchor bolts for all columns, except for "posts" as defined in Sec. 12.6.1.) (*Star Building Systems.*)

Each manufacturer has a standard set of dimensions for anchor bolt placement. The distance from the edge of concrete depends primarily on the type of girt inset (bypass, flush, or semiflush) and, for bypass girts, the girt size. Figure 12.29 shows one manufacturer's standard dimensions; the distances may be larger for other manufacturers, as shown in the illustrations that follow. Bolt spacing is also standard for each manufacturer.

The most difficult-to-estimate dimensions are those for corner columns. For nonexpandable endwalls, a representative detail is shown in Fig. 12.30. Figure 12.31 shows a detail at an expandable endwall frame.

Fixed-base columns require a large number of anchor bolts, typically eight, to develop end fixity (Fig. 12.32). Full fixity cannot realistically be provided with closely spaced anchors of Fig. 12.33.

As already mentioned, these "standard" dimensions can be readily changed if required. They should not be considered sacrosanct, as the manufacturers acknowledge—see, for example, a note to this effect on Fig. 12.29. The author's practice is to provide the minimum bolt edge distances on the contract drawings, warning the manufacturers that their "standard" details will not be accepted.

12.6.6 Minimum Pier Sizes

Do not skimp on column pier sizes. The pier should be large enough not only to accommodate the column base plate, perhaps of yet unknown size, but also to provide ample space for concrete placement around anchor bolts, ties, vertical bars, and formwork. Pier congestion can lead to improper concrete placement and structural failure.[3]

Whenever foundations are designed before the metal building, the contract drawings should indicate the largest acceptable sizes of column base plates. Such restrictions do not indicate paranoia: on one project, the manufacturer submitted shop drawings showing a 6-ft-wide column that was to bear on a 2-ft-wide pier, apparently to make a point about the stringent lateral drift criteria specified in the contract documents.

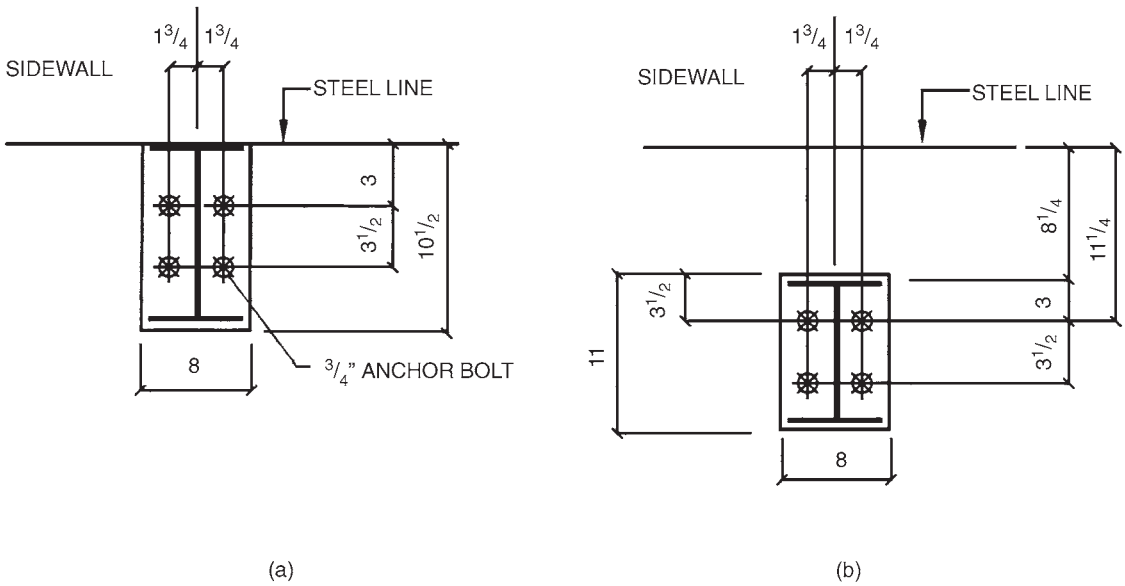

FIGURE 12.29 Sample anchor bolt locations at sidewall columns: (*a*) with flush girts; (*b*) with bypass girts. (*A&S Building Systems.*)