An obvious advantage of the tilt-up method is local fabrication, which avoids transportation costs and shipping limits on panel sizes; tilt-up panels can be as large as the available crane permits. A disadvantage is, of course, a loss of plant quality control and sophistication. While tilt-up panels are normally flat, a variety of reveals and surface treatments, such as exposed-aggregate and sandblast finishes, expands the designer's choices. As in precast construction, wall liners can simulate the appearance of brick or stone. To facilitate panel removal, the casting slab is sprayed with a bond breaker; slab curing compound is usually adequate for this purpose. Most tilt-up panels emerge with an uneven or splotchy appearance that improves somewhat over time; but the panels are frequently painted nevertheless, often with acrylic-based coatings.[26] Some architects seize on this opportunity and create a trompe l'oeil effect, a painted pattern that looks from a distance like a three-dimensional structure.

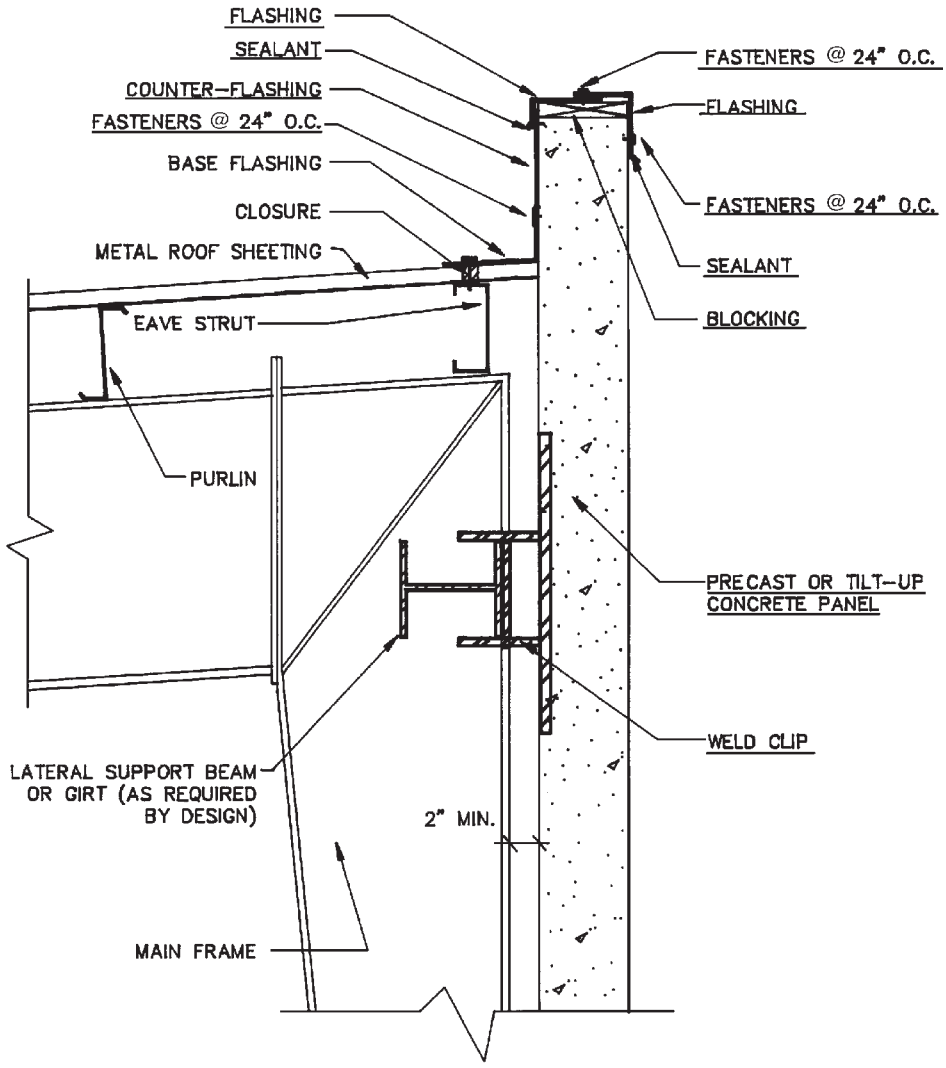

FIGURE 7.36 Connection at non-loadbearing precast panel. (*Ceco Building Systems.*)

The sides of tilt-up panels are usually formed with dimensional lumber, and panels $5\frac{1}{2}$ or $7\frac{1}{4}$ in thick are common. A rule of thumb limits panel thickness to one-fiftieth of the unsupported height. (This thickness is in addition to the depth of any reveals.)

In general, structural considerations for tilt-up panels parallel those for the precast. Calculations dealing with lifting loads and selection of embedded anchors are frequently performed by specialized engineers. A common panel design features a single reinforcement mat located at middepth with bars spaced 12 to 16 in on center.

Like precast panels, tilt-up concrete walls can be made with as much as 6 in of sandwiched-in insulation. A typical sandwich panel could be made of 2- to 3-in-thick exterior concrete layer, 2-in extruded polystyrene insulation, and an interior structural layer. Lately, fiber-composite connections between the panel layers, free from the disadvantages of thermal bridging endemic in the panels with traditional metal ties, have become popular.

Tilt-up construction imposes some specific requirements on the building slab-on-grade used for casting: The slab has to support the weight of the panels and the loaded crane (the erection is commonly done from inside the building). A minimum slab thickness of 5 to 6 in is recommended.[26] In addition, slab finishing requires special attention, as any surface irregularity will be reflected in the finished product. For best results, the slab joints are preplanned to coincide with the panel joints. The panel joints are usually $\frac{1}{2}$ to $\frac{3}{4}$ in wide; they are sealed at both faces after erection.

For further engineering guidelines, readers are referred to ACI 551R, Tilt-Up Concrete Structures[27] and to Brooks.[28]

Tilt-up construction can be quite economical for medium-size buildings with high sidewalls (20 ft+) and a repetitive appearance. Most tilt-up panels are used as loadbearing elements and shear walls. Tilt-up is especially popular in areas with good climate such as Florida and southern California. According to the Tilt-Up Concrete Association, this wall system accounts for over 15 percent of new industrial building construction.[29]

7.7.3 Cast-in-Place Concrete

For concrete buildings with intricate plans or profiles panelization may not be an option and concrete has to be placed on-site. Cast-in-place concrete exterior may also be needed to contain lateral pressures from the loose materials stored inside, as in most materials-recycling and resource-recovery facilities which require exterior concrete "pushwalls." Acting as cantilevered retaining walls, these pushwalls need to be rigidly connected to a horizontal base or to foundation walls; there are few alternatives to casting them in place.

Structural design and finishes of full-height cast-in-place concrete walls are similar to tilt-up construction, although cast-in-place walls are thicker to allow for concrete placement in a vertical position. For weather resistance of exterior walls, high-strength air-entrained concrete mixes are used. Control joints in cast-in-place walls are often made with rustication strips spaced 20 to 25 ft apart, perhaps coinciding with the bay spacing. To facilitate cracking at a joint, the amount of horizontal reinforcement passing through it may be halved.

7.8 OTHER WALL MATERIALS

7.8.1 Glass Fiber Reinforced Concrete (GFRC)

This relatively new material—it has been used in this country since the 1970s—is made by mixing glass fibers into a slurry of sand and cement and spraying the mixture onto molds. GFRC panels are thin (about $\frac{5}{8}$ in), lightweight, and durable, offering an appealing alternative to precast concrete and stone. Since the shape of the molds is limited only by the designer's imagination, a variety of striking forms can be achieved. GFRC affords an unmatched sharpness of detail due to smaller aggregate size. The available finishes include sandblasting and special decorative aggregate facing mixes ranging from $\frac{1}{8}$ to $\frac{1}{2}$ in in thickness.