

Residential Tilt-up in Colorado

Pueblo, Colo., contractor successfully converts to tilt-up home construction

By RICHARD W. STEIGER

Energy-efficient concrete tilt-up homes are making news in Pueblo, Colo., where Castle Construction Co. is using insulated concrete sandwich panels to build two different home designs.

Castle Construction owner Joe Bullen has been involved with both wood-frame and concrete home construction for many years. Bullen began building concrete homes in 1970. These first homes were 1,200-square-foot monolithic boxes with post-tensioned walls and roofs. Though the homes were well received by local buyers, the designs were limited.

In the spring of 1993, Bullen attended a seminar on tilt-up construction in Denver. At the seminar, Bullen learned about an insulated sandwich-panel system that has helped him launch a promising home construction business.

Sandwich Panel Optimizes Energy Efficiency

In tilt-up construction, concrete wall and roof panels are cast in a horizontal position at the site, either on the building's floor slab or on casting beds adjacent to the slab.



All photos courtesy of Steve Eiler

Many lifting cables are needed to control and swing a large, heavy tilt-up panel into place. This wall for a three-story tilt-up home will be joined to a narrow vertical panel already in place. The outside surface will then be coated, covering the joint between the two panels.

The panels are raised and tilted by crane into final position using cables attached to each panel.

Tilt-up panels can be made of either solid concrete or two layers of concrete, with an insulating layer sandwiched in between. One sandwich-panel system shown at the seminar Bullen attended had a unique feature that captured his interest. Instead of using steel connectors, these sandwich panels are tied together with patented connecting rods made of a composite material combining a plastic resin with glass fiber for strength and durability. The connectors penetrate an expanded polystyrene core to join the two outer layers of concrete (Figure 1).

Using the composite connectors significantly reduces heat loss that would otherwise occur with the use of conventional steel connectors. This optimizes energy efficiency; panel R values range from 28 to 42 in the houses Castle Construction is building.

With their high tensile strength, low weight, and low thermal con-

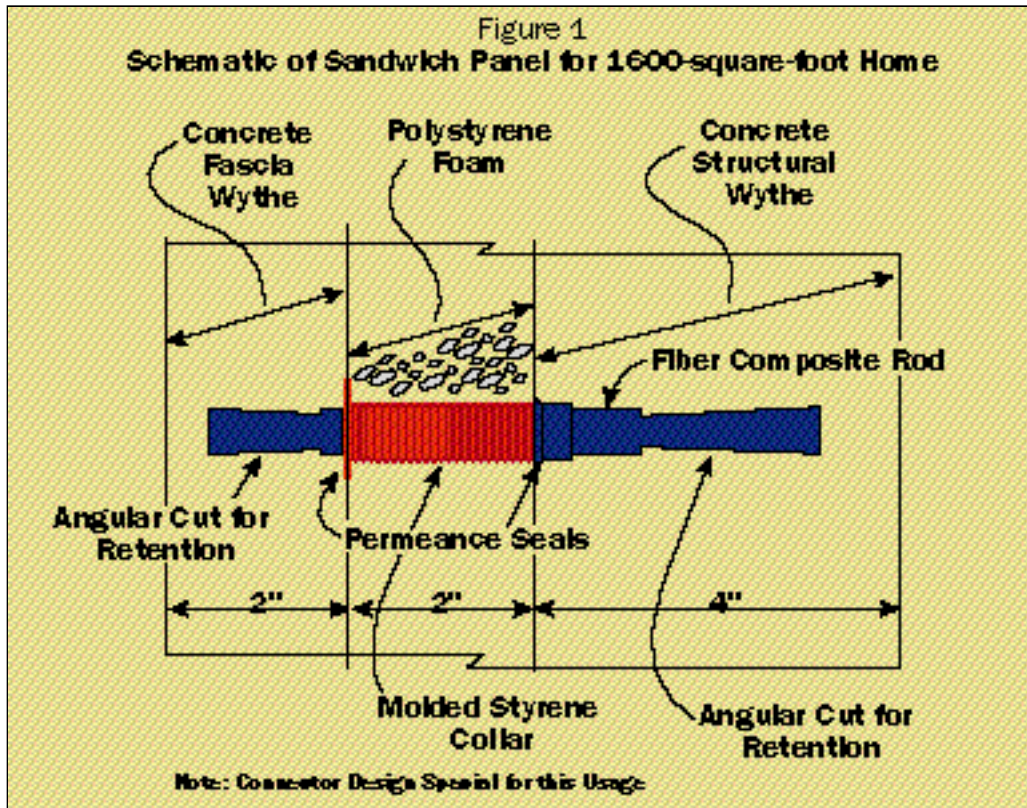


Figure 1. Typical cross section of a concrete-sandwich wall panel for the 1,600-square-foot home built by Castle Construction.

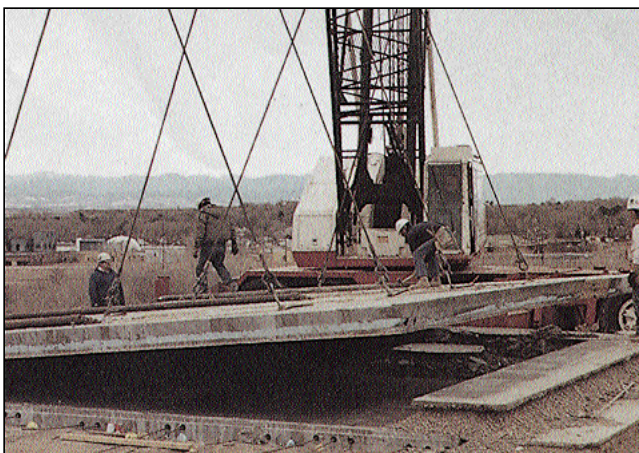
ductivity, glass-fiber composites offer many advantages. According to the manufacturer, the connectors allow the two concrete layers, which can vary from one another in temperature by as much as 80° F, to expand and contract independently without warping. Bullen thought this construction system would be ideal for the extremes of freezing and thawing on the high plains around Pueblo, where temperatures often range from zero at night to 60° F in the day.

“The insulated sandwich system using composite connectors produces a superior home for the same price per square foot as a traditional stick-built home,”

Bullen explains. “Additionally, I can offer buyers design flexibility with this system. Architects can design exteriors using a variety of treatments, including stucco, brick, and various textures and finishes. Interior walls are ready for application of paint or wallpaper.”

“Because of the efficiency of this tilt-up system, we plan to sell 1,600-square-foot homes, each with a two-car attached garage, in the range of \$115,000.” This price includes a concrete roof, but does not include the cost of the land. “We anticipate completing our 1,600-square-foot homes, from groundbreaking to finished product, in one week,” notes Bullen.

In addition to the basic 1,600-square-foot ranch-style house, Castle Construction offers a 3,000-square-foot three-story home designed by Bullen. Expected to sell for about \$250,000, not including land, the home has a three-car attached garage, walkout basement, great room with a 24-foot ceiling, four bedrooms, three full baths,



A 145-ton crane lifts a large wall panel out of the casting bed. Note the thinner 2-inch fascia layer of concrete that will be exposed to the elements, the 3-inch polystyrene foam layer, and the heavy 4-inch bearing layer that will be on the inside of the house. Post-tensioning tendons used for the slab extend from holes along the edge.

fireplace, 700-square-foot patio, and a red Spanish-tile roof. An experienced crew can erect the home in about two weeks.

These tilt-up concrete homes offer buyers many advantages, including durability, minimal maintenance, energy efficiency, and noise reduction. Their resistance to fire, hurricanes, tornadoes, earthquakes, termites, and rot usually results in lower home-insurance premiums.

Rising lumber prices and scarcity of good lumber also are reasons for choosing tilt-up concrete home construction over wood-frame construction. Many trees can be saved when a concrete home is built. And concrete is produced with abundant natural and recyclable materials.

taining 6½ sacks of cement per cubic yard. It is specified to achieve 4000-psi compressive strength.

The fascia, or panel that is exposed to the elements, is poured first at a 2-inch thickness. Next comes installation of the rigid polystyrene-foam sheet, which has predrilled holes at 16-inch spacings in both directions to receive the composite connectors. The connectors are inserted through the foam sheet and pressed into the soft concrete underneath. Each connector has a molded-in permeance seal that also acts as a positioner (Figure 1). The connector's molded collar is the exact length of the foam thickness: 2 inches for the walls of the 1,600-square-foot house,

square-foot house weigh as much as 90,000 pounds (45 tons). To lift such a panel requires a 145-ton crane, the largest one available in Colorado. For the smaller house, panel weights are limited to 50,000 pounds, and a 75-ton crane can be used for lifting.

During erection, all the panels are connected together by weld plates positioned at the corners and edges. The roof also is attached to the bearing walls by weld plates. Workers install these plates during the pouring process. Lifting hardware, decorative form liners, window frames, and doorframes are positioned on the casting bed before the pour.

Interior Walls and Finishes

Steel studs, finished with standard drywall, are used to support each home's freestanding interior walls. Drywall makes painting, wallpapering, and picture hanging an easy task. The interior concrete bearing walls can be coated with plaster or texture spray, then painted or papered to match the freestanding walls.

A radiant hot-water heating system is installed in the walls or floors of each home. To circulate the hot water, Bullen uses a strong, long-lasting piping made of a material that resembles rubber. Hot water is supplied from a 40-gallon hot water storage system equipped with a small boiler and heat-exchange unit. Plenums and vents are cast into the slab and upper floors to provide air circulation. Because of the total mass of concrete in the floors, walls, and roof, constant temperatures are easily maintained within the home, summer and winter. Flexible electrical conduit also is cast into each home's walls and floors and connected to a central service.

Waffle-slab Concrete Roof

One important feature of Bullen's designs is a concrete sandwich roof with a layer of polystyrene that provides an effective R value of 42. The roof is a



The thickest panels, used for the roof, have an R value of 42. Here a large roof panel with the tiles already installed is being lifted from the casting bed.

Casting the Panels

Because of the soil conditions in this part of Colorado, the base slab for Bullen's homes is post-tensioned using ¾-inch tendons and supported by caissons to provide a solid foundation. Welded-wire fabric is used for reinforcement throughout. After completing the slab, workers pour a large casting bed next to it for producing panels for the walls, upper floors, and roof. Castle Construction uses a concrete mix con-

and 3 inches for the walls of the 3,000-square-foot house. Finally, the inside-wall portion of the sandwich is poured. The 4-inch-thick inside wall surrounds the connectors and permanently embeds them in the wall.

Because casting space is at a premium, the panels are stack-cast one on top of the other. A bond breaker is used to ensure separation of the panels. The very large tilt-up panels used for the 3,000-

two-way, post-tensioned waffle slab 12 inches thick. Foam 8 inches thick is used to form depressions in the roof slab during casting, creating beams with a span of 30 feet. This strong design improves the overall stability of the house. Red roof tiles enhance the roof's durability. According to Bullen, it only takes about two hours to install the tiles while the roof is still in the casting bed.

Cellular Concrete Planned for the Future

Not one to rest on its laurels, Castle Construction is now developing a new system of home construction that uses tilt-up panels made of lightweight cellular concrete. Cellular concrete flows more readily around forms for openings, integral hardware, and utility systems. This means minimal vibration is required for concrete compaction. With an estimated maximum unit weight of 70 pounds per cubic foot, the new panels require only a 35-ton crane for lifting.

Bullen sees many benefits in using lightweight cellular concrete:

- The material can be made without coarse aggregates. Lightweight aggregates can be added, when necessary, to increase strength.
- Precast cellular-concrete units are lighter to hoist and easier to install.

- Components can be mass produced.
- Lighter-weight panels reduce the need for extra-strong foundations.

By designing a system that allows crews to slipform eight panels at a time in vertical frames in only one day, Bullen estimates it will take only two days to complete the total number of panels required for the 1,600-square-foot home design.

Castle Construction plans to license other producers for the new system. With eight smaller homes on order and construction about to begin on seventeen town houses, the future looks very bright indeed for concrete home building and Castle Construction. 🏠

Credits

Ready mix supplier: Valco Inc., Pueblo, Colo.

Engineer: Douglas Stines, Denver

Acknowledgment

Thanks to Joe Bullen, owner of Castle Construction Co., for providing the information for this article. Steve Eller, owner of the first three-story concrete tilt-up home built by Castle Construction, supplied photos.

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