Under fire

Can tilt-up walls remain standing if the roof burns down? A fire in a Phoenix building proves they can.

By Jesse R. Wyatt

Fire fighters in the United States and other countries have expressed concern about the safety of putting out fires in tilt-up buildings. If the roof support system burns down, will the walls collapse?

They didn't in March 1986 when a severe fire in a Phoenix tilt-up building consumed the entire wood roof system. The walls could not be salvaged, but they did remain standing.

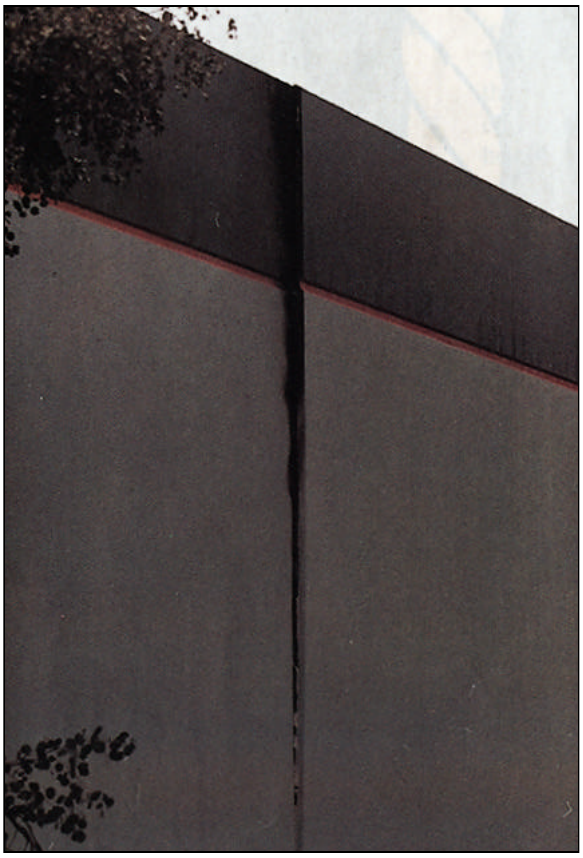
The building, a U.S. postal annex built around 1970, was 201x320 feet and had loading docks on its east and west sides. Construction was typical 5 1/2-inch-thick tilt-up concrete walls with a wood roof system. Wall panel height varied from 26 to 29 feet. The panels rose 24 feet above the floor and the distance from the floor to the top of the foundation varied from 2 to 5 feet. Panels were connected to the floor by #4 bars, 36 inches on center.

The plywood roof deck was connected to a ledger consisting of a 6x8.2 steel channel with a wood nailer attached. Interior columns made of steel pipe sections supported the roof's glue-laminated timber girders. Pilasters cast on some panels also supported the girders.

The fire

At the time of the fire, the building was being remodeled. Apparently workers turned off water to the fire sprinkler system during the remodeling work. The building suffered total burn out as a result.

All that remained of the roof system was the middle one-third cross section of the laminated girders. The steel pipe columns buckled, allowing the roof to collapse. The girders pulled loose from the pi-



Still standing after a severe fire, the concrete tilt-up walls of this building hide the devastation within (above). However, the fire's heat has deflected some of the panels as much as 8 inches (left).

Interior view of the building shows the extreme damage caused by the fire. Little remained of the plywood roof system except for the glue-laminated girders. Here two collapsed girders are leaning on the tilt-up wall panels. The steel pipe columns supporting the girders buckled in the intense heat. One such column appears in the left side of the picture.

lasters and were leaning against the tilt-up walls.

The walls deflected out 6 to 8 inches on the north, west, and south sides of the building. A canopy over the east loading dock limited deflection of the east wall. In a section of the north wall, differential deflection between adjacent panels was about 4 inches. The steel ledger broke at that location and at several other joints.

Aggregate popouts occurred in the panels, particularly those in the northwest corner of the building. These popouts and the large panel deflections suggested a very hot fire. Buckling of the steel pipe columns and sagging of the fire sprinkler piping were further signs of the fire's intensity.

The building's concrete floor, covered with 1/2-inch-thick asphalt planking, was still intact. The asphalt, which generated extensive smoke during the fire, was charred. The concrete showed only minor spalling.

The investigation

Before investigators could study the effects of the fire, the wall panels had to be stabilized. Ledger bolts were used in most cases to secure standard tilt-up braces to the walls. Expansion anchors secured the braces to the concrete floor. While stabilizing the walls, the contractor noted that many ledger bolts were loose and at least one had broken.

Cores were taken from the walls and pilasters 20 days after the fire. Problems encountered when drilling the cores gave investigators their first indication of the extent of damage caused by the fire. Expansion anchors securing the core drill to the walls would not set firmly. At a location on the west wall, the anchor almost pulled out before drilling was complete.

In most cases, the core drill cut into the concrete rapidly and with little resistance. However, a core taken from a pilaster near the southwest corner of the building was slightly harder to drill. The pilaster had been partially protected by gypsum board furring. The expansion anchors also set firmly at that location.

Because of the drilling problems, investigators took only seven cores instead of the intended 10 to 12 cores. Several cores contained reinforcing steel, but there were still five good samples for testing.

Before testing the cores for strength, investigators examined them carefully. The fire had discolored concrete near the fire side of the cores, indicating a chemical change due to the intense heat. Also, the surface of the cores on the fire side appeared chalky and contained many hairline craze cracks. Unit weights of the cores showed the concrete to be lighter than the average for local material. This further suggests that the heat of the fire chemically changed the concrete by lowering its water content.

Inspection of the cores after compression testing showed the failure

View of the top of a concrete pilaster shows where a girder pulled away from the pilaster before collapsing.

mode to be vertical splitting, indicating the fire had severely damaged the concrete. Compressive strengths of the five cores ranged from 2145 psi to 2778 psi. These values are low considering the age of the concrete and that the cores were tested dry. Also, most of the tests represented the interior of the concrete. Only one core included the face exposed to the fire in the tested portion.

Conclusions

Based on all the information obtained from site inspections and laboratory tests, investigators concluded that the tilt-up concrete walls were damaged beyond repair. But despite the large deflections in the walls and the extensive damage to the concrete, the walls did not collapse. An analysis of the wall panels as cantilevers from the floor showed they would resist lateral wind pressures of greater than 5 pounds per square foot in uncracked sections. If a panel was cracked at the floor, it would still resist at least 3 pounds per square foot. This resistance is limited by the bending capacity of the panel, not by its connection to the floor or the lateral friction resistance of the footing.

What does this mean to fire fighters? That in properly designed and erected tilt-up buildings the walls are likely to remain standing during a fire. But to ensure safety, fire fighters should position themselves and their equipment away from the walls a distance equal to wall height.

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