



Photo courtesy Federal Emergency Management Agency.
Photo Mark Wolfe

Solutions for Natural Disasters

Using concrete and plastic insulation for safety and energy efficiency in residential design

With each passing year, weather extremes seem to become more a part of our daily lives. Natural catastrophes have recently captured public attention with California wildfires on the West Coast, Hurricanes Isabel and Juan on the East Coast, and a series of tornadoes in between. The cost of cleanup alone is in the billions, once the price of home and public infrastructure repairs, debris removal, and temporary housing is included. Many millions more are spent on less obvious items, such as medical/dental care, small business loans, water, and ice—the list goes on.

Natural catastrophes lead to higher costs of living. Food becomes costlier when supply is destroyed, damaged, or unable to get to market. Damaged buildings suffer electricity, computer, and telecommunications losses, effectively shutting down businesses inside and resulting in some unemployment.

Architects/engineers (A/Es) are looking to newer materials in an effort to build more durable, higher quality residential projects to better withstand some of the effects of natural disasters. One technique growing in popularity involves the use of concrete in the home's exterior shell. While, both precast and poured-in-place concrete walls have been used in the non-residential construction for over 50 years, applying this technology to residential projects is a relatively new idea.

Clearly the need exists for residential homes that limit the impact of nature's destructive effects, without sacrificing comfort, energy efficiency, and aesthetics. Along with plastic insulation, concrete may provide the answer.

By Cecile Mutton, P.Eng



Photo courtesy Federal Emergency Management Agency. Photo Andrea Booher



Photo courtesy Federal Emergency Management Agency. Photo Mark Wolfe



In August 2004, Hurricane Charley wreaked havoc in cities such as Punta Gorda, Florida (above and preceding page). At left, the roof of the Denmark Elementary School was torn off by the West Tennessee F4 tornado. While using insulated concrete and plastic insulation is far from a guarantee structures remain standing, the combination could mean additional safety and durability during natural catastrophes.

Plastic and concrete solutions

As its name implies, an integrally insulated concrete wall system has insulation embedded within the wall, sandwiched between two facing concrete slabs. The core insulation not only offers a consistently high insulation R-value, but also resists moisture movement through the wall. Usually, a connector ties both concrete slabs together so the wall works as a structural panel. However, integrally insulated wall panel systems should not be confused with insulated concrete forms (ICF), where the insulation is on the outside of a vertically cast concrete core.

Integrally insulated concrete panels are usually manufactured using one of two different techniques—precast or poured-in-place. Precast panels are produced in-plant, and shipped to the site and erected by trained installers. Poured-in-place walls, on the other hand, are prepared using conventional forms at the job site. Typically, the forms are set,

the insulation and connectors installed, and the concrete poured into the forms with equal amounts on either side of the insulation.

Increasingly, plastic insulation is being used within these precast walls. For example, one proprietary system comprises either 50.8-mm (2-in.) extruded polystyrene (XPS) or 50.8-mm (2-in.) polyisocyanurate (polyiso) sandwiched between two 101.6-mm and 50.8-mm (4-in. and 2-in.) reinforced concrete wythes, and held together with a fiber-reinforced composite connector. Some companies also offer pour-in-place systems that require similar components as the precast system, but allow above/below-grade walls to be poured on-site using conventional forms.

According to the Portland Cement Association (PCA), more than 14 percent of all single-family U.S. homes built in 2002 had concrete or masonry walls. This amount is projected to grow to an estimated 22 percent in 2006—and the use of insulating plastics can help these structures face weather extremes.



Photo courtesy Federal Emergency Management Agency. Photo Michael Raphael



Photo courtesy Federal Emergency Management Agency. Photo Bob McMillan

Whether dealing with wild fires in San Bernadino County, California, or tornadoes in Hallam, Nebraska, using precast insulated concrete walls with extruded polystyrene (XPS) or polyiso insulation can provide some protection.



Withstanding wildfires

The destruction caused by this summer's West Coast wildfires heightens the need to design fire-resistant housing. The Institute of Business and Home Safety (IBHS) has released recommendations on how homeowners can recover from—and proactively address—future fires. For example, in extreme fire areas, (IBHS) recommends exterior wall assemblies have at least a one-hour fire resistance rating with non-combustible exterior surfaces, such as brick veneer, concrete block, or concrete.¹

The majority of wildfire destruction is caused by firestorms or hot embers blown by high winds in and around the fire. These embers alight on combustible material, adding fuel to the fire, so to speak. When building a new home or retrofitting a fire-damaged one, A/E's may wish to consider specifying integrally insulated concrete walls, as they provide a non-combustible fire barrier. In this system, the plastic insulation is protected by the concrete and does not contribute to the fire load. For example, one proprietary brand of integrally insulated concrete panels has a fire endurance of greater than 3.5 hours when tested to the *Uniform Building Code (UBC) Vol. 3 Standard 7-7, Methods for Calculating Fire-resistance of Steel, Concrete, Wood, Concrete Masonry, and Clay Masonry Construction*.

Since integrally insulated concrete walls are structural panels with rigid corners, the exterior building envelope typically remains in place during and after a fire. When necessary, officials can enter the home during the fire, knowing the concrete walls minimize the potential for collapse. So integral insulation may provide an answer.

Hurricanes and tornadoes

For a home to survive a high wind event, it must not only account for the lateral forces on the walls and roofs, wind-driven rain, and storm surges along the coast, but also flying debris. In fact, the impact of 'missile' debris (*i.e.* tree limbs or wood torn from damaged homes) causes great damage since it can puncture the home's outer shell, allowing wind/water ingress.

There are measures to minimize the effects of hurricanes on homes. The key is making the home strong and airtight. Using storm shutters over exposed glass can help prevent high winds from entering the house, while specifying robust anchors (*i.e.* hurricane straps) at the walls' intersection with both the foundation and roof can reduce blow-offs.

Integrally insulated concrete walls offer many design solutions to combat high hurricane winds and wind-driven rain forces. The 50.8-mm (2-in.) outer concrete slab of an integrally insulated wall can provide excellent protection from any flying debris during high winds. Plates, designed to withstand high uplift forces, are cast into the upper and lower portions of the concrete panel, which allow the panels to be connected to the foundation and roof. Additional hurricane straps can be installed on-site for further security. Provided there is proper detailing at the panel joints and around windows/doors, the concrete panels can be impenetrable to wind-driven rain. Even when the roof blows away, the exterior building walls typically remain standing.

Although hurricanes may be more of a coastal phenomenon, almost every part of the country has experienced tornadoes.

Designing homes in tornado-prone areas (such as the Tornado Alley corridor running north from Texas into Indiana) is much like designing in hurricane regions—one of the key measures taken is to make connections between the roof and foundation strong enough to resist high winds/pressures.

Integrally insulated concrete walls provide a measure of protection for homes in places exposed to high winds, according to Kim Seeber, a professional engineer from Pensacola, Florida, who has been involved with designing (non)residential precast and poured-in-place walls for years and received four awards of merit from the Precast/Prestressed Concrete Institute (PCI).

"Because the structure is stiff, the exterior walls of a precast concrete wall home can withstand high wind loads, which, depending on where the home is being built, can be in the [225 km/h to 258 km/h] 140 mph to 160 mph range," he explains. "In addition, the corners, with connectors at the top and bottom, are rigid so even in high winds the walls are generally stable."

Although homes in the direct path of a tornado may not survive, the exterior walls of concrete wall homes located further away could suffer less structural damage.

But is it a 'home'?

While a concrete home may sound like a gray concrete bunker, the reality is far from that. With the ability to convert conventional blueprints to integrally insulated wall panels with XPS or polyiso insulation, builders can adapt the exterior shell without compromising performance or aesthetics. Both precast and poured-in-place walls can be



Photos courtesy Dow Chemical Co.

Insulated concrete need not mean the 'bunker look.' The exterior shell can be adapted to provide various looks, including brick masonry.

offered with various exterior/interior finishes. Concrete homes can be made to look like a conventional frame home, but with some noticeable advantages.

John Stoll of Iowa City, Iowa, is in the business of financing homes, and has investigated all types of home construction. About three years ago, Stoll was out house-hunting and toured a 418-m² (4500-sf) bungalow, constructed of integrally insulated precast panels.

"My heating bills are about the same as my old 186-m² (2000-sf) house—and my air conditioning bills are about the same as my son's 84-m² (900-sf) apartment" he says. "Even my home insurance rate is lower; I figure I am saving around 20 percent per year just because of the fire reduction savings."

Conclusion

There are no single, quick fix solutions to building catastrophe-resistant homes. However, specifying an integrally insulated concrete wall system with plastic insulation in residential projects could be a step in the right direction. In addition to potentially reducing overall ownership costs, it offers great strength both within the wall panel and at the connection points, protection against flying debris and burning embers, and a structure less likely to collapse on occupants and rescuers. ☺

Notes

¹ For more information, visit IBHS's Web site, www.ibhs.org, and search for Fortified Home Buyer's Guide.

About the Author

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Benefits of Insulated Precast Concrete Wall Homes

- *Design flexibility*

Almost any conventional home's blueprints can be translated into an integrally insulated concrete home. A range of exterior/interior finishes, such as brick, siding, and stucco, are available for a custom look.

- *Fewer specialized trades required on-site*

Since much of the finishing surfaces, electrical rough-ins, opening framing, etc., are cast-in-place at the factory, fewer on-site trades are required. Additionally, gypsum wallboard is not required on most interior surfaces—just a paint coating.

- *Construction time*

Once the precast panels are shipped to the site, the home can be erected quickly—up to twice the rate of some conventional frame houses.

- *Structural integrity*

Precast concrete panels are structural panels that are mechanically fastened to the foundation, roofs, and other panels to form a robust building envelope that can outperform conventional frame construction in high winds. Even after a fire or when the roof has been swept away, the precast panels typically remain in place, helping to protect emergency workers and home contents.

- *Thermal performance*

The high R-value per inch of the extruded polystyrene (XPS) or polyisocyanurate (polyiso) insulation core reduces thermal movement through the wall in any season, and the mass of the concrete moderates the effect of outside temperature extremes during the day. Thermal mass effect can greatly enhance the overall effective R-value of a home, depending upon geographic region. In addition, the insulated core is continuous over the wall with no thermal bridging, allowing for lower air-conditioning and heating bills. Certain concrete wall/plastic insulation designs also meet third party energy ratings, such as the U.S. Environmental Protection Agency's (EPA's) Home Energy Star® rating criteria.

- *Sound barrier characteristics*

Concrete wall mass makes it an effective barrier to exterior/interior sound.

- *Fire resistance*

Concrete is a non-combustible material. The material does not burn, soften, or distort, so concrete homes are more likely to remain standing after a fire.

- *Maintenance costs*

Insurance costs for precast homes can be more than 15 percent lower than conventional framed homes.

- *Longevity*

Concrete requires less maintenance. Termites and other pests are not problems for concrete walls, as they are denied their food source and/or warm nesting cavities.

- *Sustainability*

Concrete homes typically outlast similar conventional structures. For example, a home using integrally insulated technology uses up to 40 percent less wood in its construction.