A Magazine for Specifiers and Engineers

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WINTER 2012

EXTREME WEATHER ISSUE

In this issue:

Energy-Efficient Precast Solar Home

Standing Up to Weather Extremes

Precast in Frigid Weather

Storm Shelters

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A Magazine for Specifiers and Engineers

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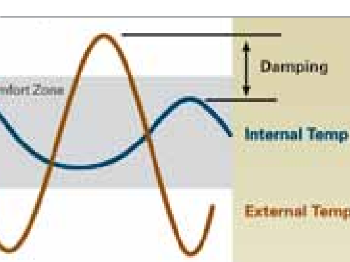

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Photo by Ron Hyink.

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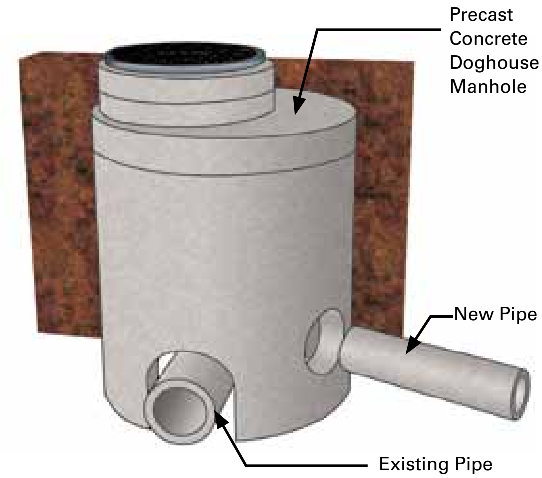
Precaster's Notebook:

Anatomy of a Doghouse Manhole

By Gary K. Munkelt, P.E.



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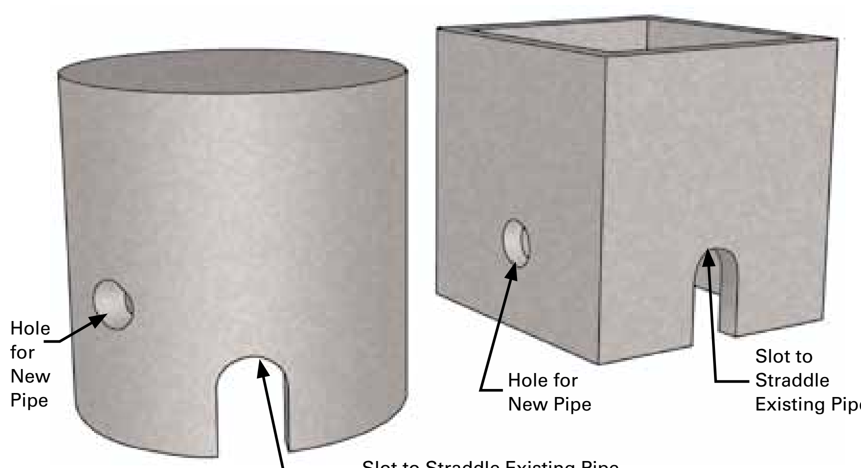

Fig. 2 and Fig. 3

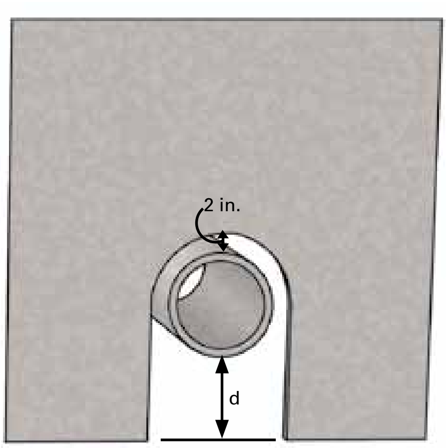

Fig. 4

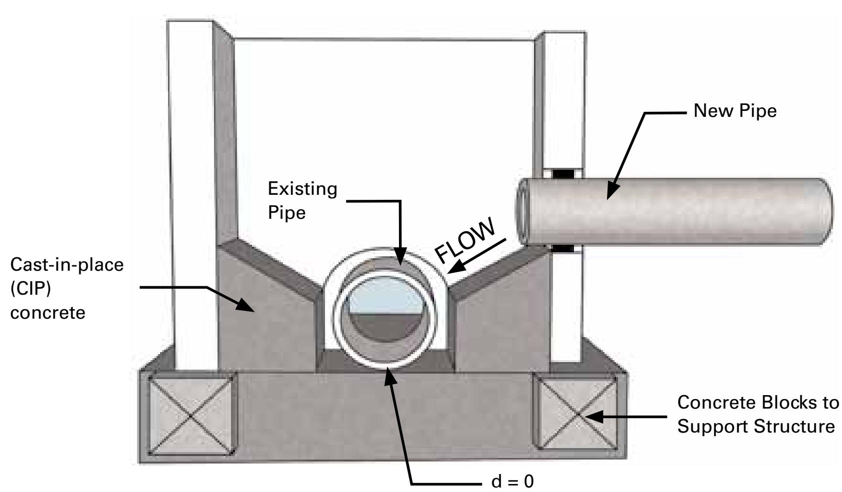

Fig. 5

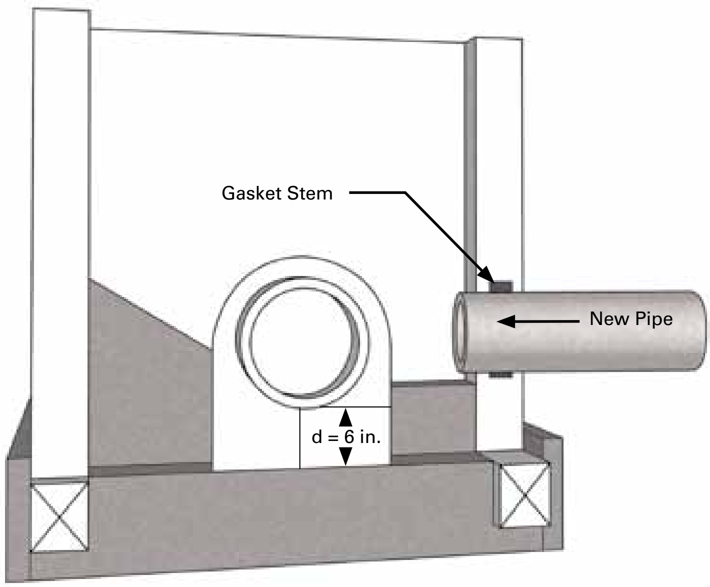

Fig. 6

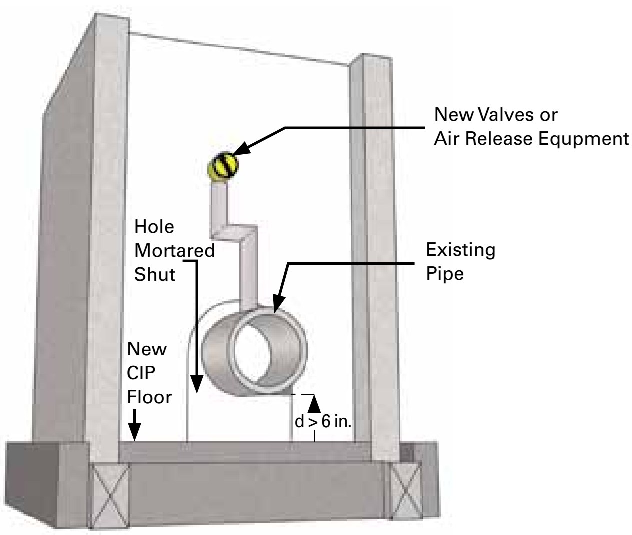

Fig. 7

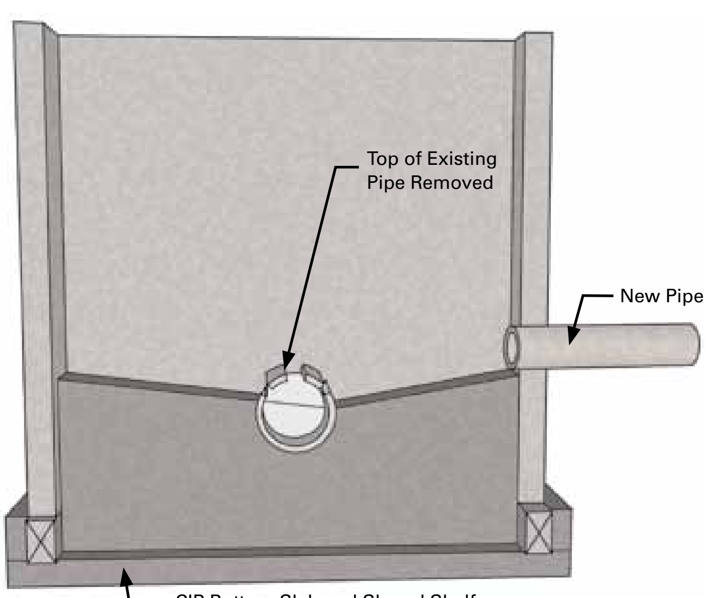

Fig. 8

Fig. 1

The doghouse manhole is commonly used to connect a lateral pipeline to an existing pipe in the ground. This type of manhole is widely used in gravity sewers where round structures are common. It is also used in rectangular structures where new equipment (i.e., blow off valves or air release valves) requiring access for maintenance is required by utility companies.

How Does a Doghouse Manhole Work?

Fig. 2 & 3

I. The precast concrete structure is made without a bottom slab with a "U" shaped opening in the walls wherever the existing pipe will pass through. Gasketed holes or plain holes are placed wherever a new pipe will pass through a wall.

Fig. 4

II. The "U" shaped hole needs to be large enough to slide over the existing pipe without damaging it. One rule-of-thumb is to allow 2 in. around the pipe. The distance "d" from the bottom of the pipe to the bottom of the riser depends on jobsite conditions for the project:

Fig. 5

A. d = 0 when a new pipe enters a manhole at an invert elevation higher than the invert of the existing pipe.

Fig. 6

B. d = 6 in. when a new pipe enters the manhole at an invert elevation equal to the invert of the existing pipe. The 6 in. allows room for the gasket stem.

Fig. 7

C. d > 6 in. when structures will be used as an air release valve pit or valve vault and existing pipe must be above the floor.

Fig. 8

III. The doghouse manhole is installed to straddle the existing pipe. Concrete is then poured to form a bottom slab and invert shelf. The existing pipe can then be cut open to gain access and to provide a means for water on the shelf to run into a pipe. New pipes can be installed without interrupting service of the existing pipe. **PS**

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Taking Mother Nature's Worst

Precast concrete offers solutions for protecting people and places from nature's worst weather events.

BY DEBORAH R. HUSO

The people of Southeast Asia are no strangers to tsunamis, but no one was prepared for the one that followed the 9.0-magnitude earthquake just off the eastern coast of Japan in March 2011. In some places, waves reached well over 100 ft. Tens of thousands of people lost their lives despite the fact that Japan, when compared with the rest of the developed world, was relatively well-prepared for such an event. Many coastal structures survived the disaster, and many of those structures were concrete.

"Even older precast structures withstood the tsunami," says Clay Naito, Ph.D., associate professor with the Department of Civil and Environmental Engineering at Lehigh University in Bethlehem, Pa. He took a two-week trip to Japan in the wake of the natural disasters to study the damage from debris and to look at the country's precast buildings.

Naito says both precast and cast-in-place concrete survive these types of disasters better than most other structural forms, and indeed he saw a 40-story, total-precast building that survived the earthquake.

An Oregon community prepares for the worst

In Cannon Beach, Ore., engineers have designed a 9,800-sq-ft precast concrete Tsunami Evacuation Building (TEB) and city hall, which if constructed will cost the local government around $4 million – twice the

cost of a conventional building. But the 1,700 residents of Cannon Beach aren't balking at the price tag, because they know a tsunami is coming – they just don't know when.

Geologists at Oregon State University (OSU) in Newport say a massive earthquake is likely to occur in the Cascadia subduction zone off the Pacific Northwest coast within the next 50 years. "Cannon Beach was affected by the 1964 Alaska earthquake and a tsunami generated by it," says Kent Yu, Ph.D., principal branch manager with Degenkolb Engineers in Portland, Ore. He is among the members of a team, including professors from OSU, working pro bono to design a TEB for Cannon Beach.

Using OSU's Tsunami Wave Basin, the most advanced testing facility of its kind in the world, engineers have been evaluating the design of a proposed concrete TEB/city hall. "We want to make sure the building can sustain the shaking from a 9.2 earthquake," Yu explains. They also want to ensure the structure can bear the impact load from water and debris. That includes making sure the building can withstand storm surge water pounding into it and pushing upward against the floors.

The structure Yu's team of engineers has designed is rectangular in shape with a concrete frame, structural walls that run parallel to the water flow, and breakaway walls that will let loose to allow water and debris to flow through the building to prevent a damming up of debris at the front of the building. The proposed structure would be built on a deep-pile foundation with concrete beams. "I believe precast will perform better," says Yu, who points out that precast concrete performed well in seismic testing simulating a magnitude 8 earthquake in San Diego in 2008. The testing was a joint venture among the University of California, San Diego, the University of Arizona and Lehigh University.

The proposed TEB/city hall would be 30-ft tall, thus allowing for vertical evacuation of city residents, as geologists have estimated water depth from an incoming tsunami would be about 15 ft. Engineers have also proposed putting a sea wall in front of the building to further reduce the impact of tsunami waves.

"The key component is to know the inundation depth and how fast the water will come through the building," Yu explains. And that's where OSU's Department of Geology and Mineral Industries has come in, working up an inundation map to help engineers calculate water force to size the columns for the TEB.

Multiple risks of tsunamis

Cannon Beach isn't the only community in the Pacific Northwest at risk, of course. Every community from Northern California up to Canada's Vancouver

Architectural rendering of proposed tsunami evacuation building in Cannon Beach, Ore.

Graphic courtesy Ecola Architects (www.ecolaarchitects.com)

Precast concrete community center in Emory, Texas, designed by Speed Fab-Crete to withstand winds in excess of 250 mph (an F5 tornado).
Photo courtesy of Speed Fab-Crete, Forth Worth, Texas (www.speedfabcrete.com)

Island could be impacted by an earthquake in the Cascadia subduction zone. The city of Cannon Beach is currently seeking funding from the Federal Emergency Management Agency (FEMA) to help build the proposed TEB.

But a manmade TEB isn't always necessary. "An evacuation shelter is something you'd only put in where you have no higher ground to go to," says Lehigh University's Naito. He says in low-lying areas, he could see precast concrete as a cost-effective way to build elevated tsunami evacuation platforms at various distances along a whole beachfront, pointing out that precast concrete also has better durability than steel in areas that are persistently exposed to moisture and salt-laden air, like seaside towns.

The challenge with an earthquake-driven tsunami, however, is keeping the structure together. "You have to have failure mechanisms in place," Naito explains. "You have to allow for large joint openings to allow the structure to move in an earthquake." The challenge with precast, however, is its mass. "That hurts you in an earthquake, but it's good in a tsunami," Naito adds, noting that engineers face major challenges in designing buildings to withstand multiple natural hazards.

FEMA's P646, "Guidelines for Design of Structures for Vertical Evacuation from Tsunamis," promotes building strong structural systems that have the ability to resist extreme force; open systems that let water flow through without much resistance; ductile systems that resist failure in extreme weather conditions; and redundant construction systems that allow for partial failure without complete building collapse.

Defying deadly tornadoes and hurricanes

Tsunamis aren't the only severe weather events engineers are concerned about. In the wake of the deadly tornado that swept through Joplin, Mo., in May, more communities in Tornado Alley are looking at precast concrete as an option for building structures with high wind resistance (See "Precast Concrete Safe Rooms: Shelter from the Storm" on page 24).

This is an area in which David Bloxom, president of Speed Fab-Crete, a design-build contractor of precast building systems in Fort Worth, Texas, has been working for a long time. His company has been involved in precast concrete since 1963 and recently completed a precast concrete community center in Emory, Texas, designed to withstand an F5 tornado. That designation means winds in excess of 250 mph, similar to what residents of Joplin experienced.

The newly built, 6,000-sq-ft community and evacuation center was designed to meet the guidelines of FEMA's 361, "Design and Construction Guidance for Community Safe Rooms," for extreme wind events. The building's walls and roof are 8-in. thick. "The walls are staggered to withstand pressure from a severe storm," Bloxom explains. "One wall goes a little behind the

This precast concrete structure designed by Speed Fab-Crete withstood a direct hit from an F2 tornado in Forth Worth, Texas, even though the building next to it collapsed. Photo courtesy of Speed Fab-Crete (www.speedfabcrete.com)

previous wall." The precast wall panels are 18-ft tall and 15-ft wide, and the panels' overlap of 6-to-8-in. provides additional strength. Precast panels are welded to each other as well as to the building's foundation. The roof system consists of cap panels that go from a support panel in the building's center to the structure's outside walls.

Completed in the summer of 2011, the shelter hasn't had an opportunity yet to demonstrate its mettle, but Bloxom is confident it will survive an F5 tornado event – his company has designed countless buildings that have already withstood tornadoes and hurricanes from Brownsville, Texas, to central Oklahoma. A 10-story precast condominium Speed Fab-Crete built on South Padre Island on the Gulf of Mexico more than 20 years ago has weathered multiple hurricanes. "The building itself has never sustained structural damage," Bloxom says. In 2000, Fort Worth experienced an F2 tornado that tore through the city's downtown and devastated many buildings, including twisting a steel-frame high-rise building, but the five precast structures in the tornado's path built by Speed Fab-Crete had no structural damage. One of their projects, Evans Brake Service, sustained a direct hit without structural damage, even though a building next to it collapsed.

"One of the biggest problems in a tornado is flying debris," Bloxom says, "like flying bricks hitting people." His company has worked on several school construction projects. All of them, he says, have solid precast concrete walls with a concrete cap over hallways where children and faculty can take shelter in a tornado without worrying about structural collapse.

The goal for extreme weather-resistant precast structure isn't necessarily to avoid damage entirely but to avoid structural failure, thus saving property and people. "The trick is helping the whole building stay together," says Naito. "If designed correctly, precast is much more resilient to that purpose." **PS**

Deborah Huso is a freelance writer who covers home design and restoration, sustainable building and design, and home construction.

Extreme Precast: Freezing Out the

Five frigid project stories chosen by proud precast concrete producers.

BY SUE McCRAVEN

Precast concrete is not just a fair-weather friend. When the mercury drops below 50 F, cast-in-place (CIP) concrete is not a viable option as a construction material. Precast concrete, however, offers rapid on-site installation and cost effectiveness even in frigid weather. Here are the stories of five producers who supply clients with precast products in cold-weather states from Alaska to Wisconsin. These precasters proudly explain how precast concrete provides a better, more economical solution than CIP concrete construction, especially for extreme site and weather conditions. For really challenging jobs, precast concrete not only installs rapidly, but project engineers consider precast applications to be the best solution.

Mountain pass demands a rapid installation

Glacier Precast Concrete Inc., Kalispell, Mont.

No place to be caught in a snowstorm, Logan Pass is located on the Continental Divide in Glacier National Park in northwest Montana. At an elevation of 6,646 ft, the summit of the Going-to-the-Sun Highway was the unlikely construction site for Glacier Precast Concrete. Weather conditions at this elevation offer scant time for building during the off-season, and truck and equipment access on this historic highway is very restrictive.

"Glacier's challenge on Logan Pass was to construct a public vault toilet facility next to a historic visitor center during the 'shoulder season[1]' when plumbing is not available at the site," said Tom Anderson, owner of Glacier Precast Concrete. "The Visitor Center closes in late September. Our other challenge was to match the architectural design of the existing Visitor Center."

[1] Shoulder season is a travel period between peak and off-peak seasons.

© Sergey Pristyazhnyuk | Dreamstime.com

COMPETITION

At 6,650 ft, Logan Pass in Glacier National Park is no place for the timid. "It starts snowing in September and road access becomes very challenging," said Tom Anderson of Glacier Precast of Kalispell, Mont. Photo courtesy of Glacier Precast (www.glacierprecast.com)

"Our precast quality and strength will be far superior to anything poured outside ..." said Ryan Johnson of Fairbanks Precast and Rebar, North Pole, Alaska.
Photo courtesy of Fairbanks Precast & Rebar (www.fairbanksmaterials.com)

The Visitor Center on Logan Pass was completed in the 1960s and is listed in the National Register of Historic Places. The exterior walls were poured in place in 2-ft lifts that incorporated hand-picked stones from the area. A fairly dry concrete mix was placed and packed by hand in the forms. Crumpled newspapers were used to hold the stones away from the formwork so that the concrete would wrap partially around the stones and make them visible after stripping.

Fifty years later, Glacier Precast Concrete's project was to build a five-stall vault toilet facility with a maintenance room over an old existing septic tank. To match the 1960s architecture of the Visitor Center, the visible walls were poured face-down on a rough-cut lumber form liner using dry-cast concrete, and Glacier National Park employees hand-picked the stones at the site. Precast concrete was chosen because of the durability of concrete in a harsh environment, the ability of the precaster to match the architectural design, and the speed of installation in a very short building season. Because the U.S. National Park Service wanted to keep the Visitor Center open without disruption, park administrators did not want construction to begin on Logan Pass until after Labor Day. "This made the building season really short," said Anderson, "as it starts snowing in September and the road access becomes very challenging."

Glacier Precast manufactured the 16 panels needed for the project in about three weeks and the panels were erected in mid-September of 2010. "A rapid installation was critical, because the NPS carpenters needed all the time they could get to install the roof and porch before snow shut the road off completely in October," said Anderson. "By using a precast concrete assembly, the walls and floor panels were installed in just two days compared with a cast-in-place system, which would have required weeks of construction."

Luminous precast in the Land of the Midnight Sun

Fairbanks Precast & Rebar, North Pole, Alaska

"When the weather turns colder, precast has some big advantages," said Ryan Johnson, precast manager at Fairbanks Precast & Rebar in North Pole, Alaska. "Fairbanks supplies many small projects for Alaskan contractors who don't want to deal with pouring fresh concrete in the harsh elements or where the job site is located in a remote part of the state where ready-mix concrete delivery is not an option."

Examples of precast products manufactured by Fairbanks Precast & Rebar include orange security barriers for British Petroleum, and generator module foundations and pump station structures for the Trans Alaskan Pipeline. "We have the critical advantage of pouring concrete in a temperature-controlled environment where freezing concrete, adequate cure

"Concast's precast box pads ... make installation of wind turbine trasformers pretty painless even in extreme conditions," said Rob Duncan of Consulting Engineers Group (CEG), Farmington, Minn.
Photo courtesy of CEG (www.ceg-engineers.com) and Concast Inc. (www.concastinc.com)

time and extreme working conditions are not an issue," said Johnson. "Our precast quality and strength will be far superior to anything poured outside where the cold ground can prevent concrete from setting up properly or the wind can come up and destroy your enclosure, leaving you with a mess."

During the winter months in Alaska, Fairbanks Precast & Rebar uses extra measures in precast production, including a concrete accelerator, hot water, heated aggregates, and extra heating fuel to keep the shop warm. In the past, Fairbanks Precast & Rebar did not produce from November to mid March, because ready-mix suppliers in this region of Alaska are not typically open. In the summer of 2011, Johnson explained, "We were able to install and enclose a small batch plant from Mixer Systems. I'm not saying we will be pouring concrete inside at -50 F, but we should be able to extend our season on both ends and remain flexible throughout the winter."

Replacing CIP at snowy substations and remote wind farms

Concast/Fibercrete Inc., Zumbrota, Minn.

During Minnesota's harsh winters on the windswept plains, utility contractors are installing precast concrete trench systems and wind-turbine transformer box pads from Concast Inc.'s Zumbrota facility. For the trenches, U-shaped precast channels with removable covers are set in the ground at utility substations while the snow flies.

For the wind farm application, the 1,500-to-1,800-lb box pads have an integrated tunnel with custom conduit openings that connects with a specific wind turbine foundation. The 8-ft-square, 3-ft-deep pads support the turbine's three-phase transformer. The walls of the box pads are only ½-in-thick but very strong, as the internal ribs are made with glass fiber reinforcement. Wind turbine bases can be 16 ft in diameter and the transition duct tunnel from the precast box pad is designed to fit flush to the curved base.

The box pads are not standard designs. Concast receives a footprint drawing of the transformer, and from this a custom box pad with the required reinforcing is designed and produced. The transformers weigh up to 20,000 lbs, so the reinforcing must be adequate for structural support and for the openings that lead to the turbine base. The cable openings are usually specific to the transformer design. Precast shipments typically begin six weeks after receipt of the customer-approved drawing, and depending upon the size of the wind farm, final shipment is usually complete in 12 weeks. Concast's plant in Zumbrota can produce 10 to 12 box pads for delivery each week (per project), compared to about 50 precast units per week during the summer at peak season.

Concast uses a proprietary blend of glass fiber-reinforced concrete made with portland cement called Fibercrete®. According to Ben Olson, vice president at Concast, the slurry mixture, with chopped alkali-resistant Zircon (glass) fibers, is sprayed on the trench or box pad forms. A hand-held roller is used to compact and consolidate the material against the form, allowing for thinner sections and a high strength-to-weight ratio. After an overnight cure, the trenches or box pads are removed from the steel forms and the edges are tooled for a smooth finish. Field modifications are easily done with any masonry tool. Precast plant fabrication of the trenches and the box pads means that these systems

David Rasmussen and Aaron J. Ausen of Dalmaray Concrete Products of Janesville, Wis., said, "In Wisconsin winters ... with highs of 0 F and snow ... we turn products around a lot faster than CIP."

Photo courtesy of Dalmaray Concrete Products (www.dalmarayconcreteproducts.com)

can be installed in cold weather that would preclude on-site forms and CIP concrete placement. Precast systems are also less expensive.

"Concast's precast box pads with their unistrut leveling system make installation of wind turbine step-up transformers pretty painless even in extreme conditions," said Rob Duncan of Consulting Engineers Group (CEG) in Farmington, Minn. "A poured foundation would require us to frame and pour a foundation slab, pour a duct bank, and then dig out the dirt underneath the slab to install a ground sleeve. This would be a tough task in these extreme conditions, and we still wouldn't have the space for cable handling that we get with the Concast pad."

Cold-weather construction calls for precast solutions

Dalmaray Concrete Products Inc., Janesville, Wis.

For precast producers in the northern regions, winter winds can blow in opportunity. "When a project originally specifying 12 CIP utility vaults needed to begin construction in the fall," said Aaron Ausen, plant manager at Dalmaray Precast Concrete Products, "a good customer contacted us about doing the vaults with precast. Due mainly to quality and cost savings, this customer prefers precast over cast-in-place, and for this particular project, he was looking at a Midwest winter that would make construction of the project difficult with CIP."

The walls, floors and covers were originally specified with 8-in. and 10-in. wall thicknesses. "With precast, however," said Ausen, "we were able to redesign the vaults to have 6-in.-thick walls and satisfy the required loadings. This meant big cost savings to our client." After getting engineering approval, production time was two weeks with continuous delivery throughout the project. A short installation time was critical for the customer to meet the project deadlines, and they were able to complete the project at the beginning of week three.

Dalmaray cast everything in-house with controlled shop temperatures. "We used a small dose of accelerator along with an SCC admixture in order to create a beautiful, strong finish for the customer," said Ausen. "We also tested every batch to make sure each vault was shipped with a minimum 5,000 psi compressive strength. In Wisconsin winters, you cannot afford to ship product without adequate strength gain." The project was completed in February and March of 2011 under typical Midwest winter conditions. "(It was) very, very cold with highs of 0 F and snow," said Ausen. During most of the project, Dalmaray delivered the pieces to the job site so they would be ready for installation after the severe weather subsided.

Using temperature-controlled, in-plant production, precasters can use advanced mix designs and curing techniques to meet the needs of clients during severe weather months. "Precasters do not have to deal with elements as much as CIP construction does," said Ausen. "We can usually turn products around a lot faster than CIP, and for many projects, time is the deciding factor in winning a bid. Precast also achieves a much higher-quality product with controlled conditions. Pieces will come out better looking, stronger and faster than CIP.

In addition to moving a project along during winter months, minimizing worker exposure to the elements during extreme weather conditions is important to contractors. General contractors understand the limitations cold conditions pose for CIP construction and for on-site workers. Precast concrete solutions allow contractors to minimize worker exposure to the elements and thereby increase job-site safety.

"Dalmaray was able to take the complexity of our install and minimize our on-site labor in order to provide not only a quality product, but also assist in reducing exposure to the harsh environment," said Chris McGuire, Faith Technologies Purchasing Agent for the utility vault project.

"We continually pursue winter construction jobs and drive home the point to contractors that using precast has many advantages, making it the construction method of choice no matter what season," said Ausen.

"Sub-zero temperatures did not prevent a rapid 10-day installation," said Brian Seubert of County Materials Corp., Roberts, Wis. "If built as a CIP structure, the extremely cold weather would have not only delayed construction, but the project would have come to a standstill."
Photo courtesy of County Materials Corp. (www.countymaterials.com)

Sub-zero site conditions in Minneapolis

County Materials, Roberts, Wis.

Construction of the Solhaus Apartment[2] project in a triangular footprint on the University of Minnesota campus presented County Materials with a number of site-specific challenges during the fall and winter of 2010-2011.

County Materials supplied more than 18,550 sq ft of 8-in. and 12-in. hollowcore planks, 685 ft of beams (inverted-T, rectangular and L-shaped) and 170 ft of columns. The bottom story and parking structure of the 75-unit building is precast concrete and supports five floors of wood framing above. Erection of the precast took place in February 2011 with adverse weather conditions that kept the job site below freezing temperatures for much of the construction.

"There is a strong rationale to using precast over CIP concrete for the cold-weather construction season in the Midwest," said Brian Seubert, general manager at County Materials Corp., "because of precast's advantages, including cost, quality and accelerated construction." Seubert listed the following specific advantages of precast concrete solutions over CIP work:

- Product quality is controlled and monitored more easily at a precast production facility (with in-house testing labs) than in the field.
- In a precast plant environment, it is easier to control the concrete mix and ambient conditions for placement and curing.
- Precast plant process controls guarantee concrete strength and durability of the final product.
- Precasters offer clients cost savings, because plants order materials for multiple projects and one-time bulk-purchase costs are minimized.
- Severe weather is eliminated as a controlling factor for concrete quality, because precasters can cast product indoors for consistently high material quality.
- On-site, modular precast components can be installed rapidly without the delay required for CIP concrete to cure and gain adequate strength.
- Accelerated curing techniques in the precast facility mean a shorter project timetable between manufacturing and building erection.

"If the Solhaus Apartments were built as a CIP structure, the extremely cold weather would have not only delayed construction," said Seubert, "but the project would have come to a standstill."

Once production started, it took County Materials 10 working days to manufacture the required product and only one week to erect the entire lower level. The building's unusual triangular geometry presented many intricate angles for construction. "Complex geometry can substantially increase completion time and cost on any project," explained Seubert, "but because the precast pieces are made to specific dimensions in a controlled environment, they fit together like a complicated puzzle. On-site costs are reduced, and the structure can be erected rapidly in one seamless result."

County Materials Corp. has worked with several contractors on a number of projects where precast concrete systems (including prestressed hollowcore, and precast box culverts and pipe) have been preferred over CIP construction, because adverse weather conditions made on-site concrete placement impractical, uneconomical and time consuming. For the clients, precast concrete means a faster-moving job site, reduced cost, and higher quality as an end result.

When the going gets tough, the tough get going

These five chilly narratives say much about the advantages of precast concrete solutions in extreme weather conditions and remote locations. Precast concrete offers customers and contractors a more rapid installation than CIP construction, and for cold, icy job sites, less worker exposure to the elements means a safer project. When product quality and cost savings are added to the mix, not only is precast a smarter and more economical solution – but it doesn't leave you standing out in the cold. PS

Sue McCraven, NPCA technical consultant and Precast Solutions editor, is a civil and environmental engineer.

[2] Architect: Tushie Montgomery Architects, Minneapolis; Project engineer: Hanuschak Consultants Inc., Winnepeg, Manitoba; Canada; General contractor: Greiner Construction, LLC, Minneapolis.

Not Your Typical Beach House

Stunning precast concrete solar home incorporates latest technologies to provide superior energy savings and storm-proof strength.

BY RON HYINK

This beautiful high-tech precast concrete solar home is fireproof, termite-proof and offers everything from storm protection to energy savings.
Photo by Ron Hyink.

Throw off the yoke of conventional home design and start thinking forward. Wipe the slate clean and begin again with a completely sustainable design using currently available technology – and then build it!

A small group of architectural students did just that as they prepared for the U.S. Department of Energy's challenge to build energy-efficient homes for its biennial Solar Decathlon.

A house to eNJoy

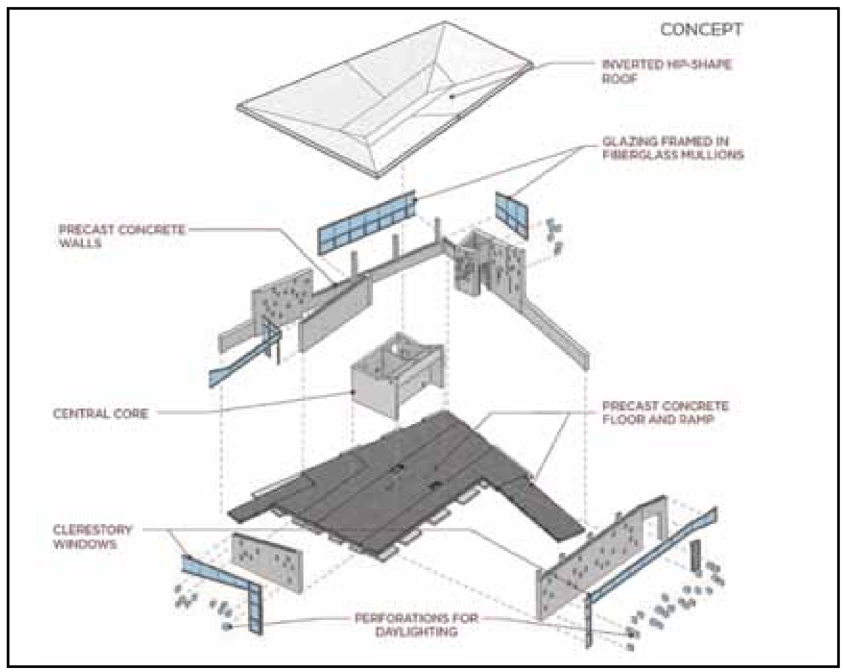
The "eNJoy house" – note the subtle New Jersey tag – is the concept of Team New Jersey, a collaboration of architectural students from the New Jersey Institute of Technology and Rutgers, The State University of New Jersey. The team not only designed an energy-efficient home made entirely of precast concrete panels - a first for the Solar Decathlon - but these students also helped manufacture and install the insulated walls.

"It's a beach home for a retiring couple," said Jennifer Switala, the student team leader for the project and recent graduate from the NJIT's architectural master's degree program. Presumably one of the inhabitants would be handicapped, and so there are entry ramps in the front and rear and no stairs, she said, adding that the home is completely compliant with the Americans with Disabilities Act. Even the kitchen countertop and sink, bathroom sink and shower are made of precast concrete, each of which will accommodate a wheelchair.

With the New Jersey beach in mind, the design takes into consideration a broad range of factors. First of all, the students wanted to work with a sustainable, energy-efficient building material that is relatively low in both cost and long-term maintenance. The easy answer for that was precast concrete, which naturally offers the utmost in thermal efficiency and lasts a long time without repairs or replacement (see the sidebar "Beautiful Design Plus All the Benefits of a Precast Concrete Home").

"In general, people are nervous about concrete homes; they don't think living in a concrete home can be comfortable," said Switala. "So that's what we wanted to try with this house – that it is comfortable and is much more cost-effective, more stable and, in the end, it works!"

While precast concrete's thermal mass dampens exterior temperature fluctuations on the interior, the students incorporated roof overhangs into the design at just the right angles and lengths that allow – as well as restrict – how much sunlight reaches the exterior surfaces. In summer, when the sun rides higher in the sky than in winter, the roof's overhang shades the southern exterior until evening. Operable windows can be opened to allow the coastal breezes to work with the integral cross-ventilation design and circulate air throughout the house. Impressively, on a hot, humid summer day, the home interior remains cool, and a slight air movement can be felt even if there is no breeze outside.



In winter, sunlight penetrates south-facing windows to help warm the interior; penetrating solar rays work in concert with radiant flooring to keep inhabitants comfortably warm.

No matter what the season, the concrete absorbs the sun's heat during the day and releases it inside at night, keeping the home's interior at a more consistent temperature (See "Thermal Mass: Precast Concrete can take the Heat," page 30).

To augment electric light, small perforations containing insulated glass are strategically placed along exterior walls to allow ambient light into the home without risking heat gain or loss.

The roof of the 960-sq-ft prototype home seems to float on top of the house, thanks to its clerestory windows, which make the structure seem much lighter in

A concept drawing offers a hint of the Jersey shore environment for which the solar home was designed

Illustration courtesy of Team New Jersey (www.solarteamnewjersey.com).

Page 18 photos: *Architectural students prepare the formwork for the inverted hip roof, known as "the boat." Workers install one of the insulated wall panels. An exploded view shows how the solar home can be disassembled for transportation and reassembled at a new site*

Photos courtesy of Northeast Precast LLC (www.northeastprecast.com), illustration courtesy of Team New Jersey (www.solarteamnewjersey.com).

Beautiful Design Plus All the Benefits of a Precast Concrete Home

Precast concrete offers much more than just strength and protection from high winds and extreme weather. Some of the more prominent benefits of the eNJoy home include:

- Low maintenance
- High durability
- No repair or maintenance
- Fireproof
- Extreme weather-resistant (tornados, tsunamis)
- Earthquake-resistant
- High thermal mass
- Lower utility bills
- Insect-proof (even against the formidable Formosan termite)
- Chemical-resistant
- Reduces air infiltration
- Resists airborne moisture
- Resists abrasion
- Contains natural materials and recycled industrial byproducts
- Reduced heat-island effect
- Quick installation
- Transportability
- Painting and integral colors are possible but not required for durability
- Stunning modern architectural design
- Wheelchair friendly

weight and roomier inside than it actually is. The inverted hip roof design – affectionately dubbed "the boat" – funnels rainwater toward the home's central core so that the water can be recycled for toilets and houseplants. The central core itself houses all the plumbing and electrical hookups and controls.

Throughout the house, technology abounds. From the roof with its solar panels to the floor with its radiant heating, the students designed the home to be self-sufficient (see the sidebar "Precast Concrete Design Makes the Most of Latest Energy Technologies").

Design/build concept on steroids

Since nothing like this project had ever been accomplished, there was a learning curve in all phases – from concept and design to manufacture and transport.

Rather than simply design the home and send the plans out to a contractor, Team New Jersey students traveled to Northeast Precast LLC in Millville, N.J., 90 minutes away, to help build the forms and pour the concrete themselves. From that, they learned firsthand a great deal about how their designs are brought into the manufacturing process. Some of the snags that surfaced drove them back to the drawing board,

Precast Concrete Design Makes the Most of Latest Energy Technologies

The Team New Jersey architectural students incorporated these energy-efficient technologies into the solar home design. All components are commercially available.

- Precast concrete (see the sidebar "Benefits of a Precast Concrete Home")
- Solar thermal technology
  - Roof-mounted system uses energy from the sun to heat water
  - eNJoy house uses a closed-loop drain-back system with an evacuated tube collector
- Photovoltaic technology
  - Roof-mounted system converts light to electricity
  - eNJoy home uses 40 solar arrays to match or exceed electricity draws
- Dual heat exchanger
  - Hot-water storage tank connects three systems in the house: the open domestic hot-water loop to the closed radiant floor and the solar thermal loops
  - Located in the central core, the system heats up the radiant flooring in winter
- Air handler
  - Used only when rapid space conditioning is necessary
  - Located in the central core, the six-row heating/cooling coil provides the surface area for air to come into contact with conditioned water provided by the reverse-cycle chiller
  - Also dehumidifies the air in extremely humid environments
- Energy-recovery ventilation
  - Located in the central core, the cross-flow membrane heat exchanger preconditions incoming fresh air
  - Incoming humidity is transferred to the stale exhaust stream, reducing humidity within the home
- Reverse-cycle chiller
  - An air-to-water heat pump located outside the house
  - Provides 45 F chilled water in summer
  - Reverses in winter to provide 120 F water to the radiant flooring
- Radiant concrete flooring
  - Concrete flooring contains coils filled with water used as a space heater in winter
  - Heating with water is 3,500 times more efficient than air in transporting heat
  - Delivers heat steadily, noiselessly and without hot spots
- Control systems
  - A central computer controls the house systems via low-voltage signals based on information received from sensors
  - Sensors monitor temperature, humidity, water and energy usage, user preferences and daily schedule
- Natural and artificial lighting
  - All lighting is recessed
  - Perimeter lighting imitates natural daylight and emphasizes the floating roof concept
  - Vertical lighting fixtures emit the correct amount of direct light into the space
  - A combination of low-E glass and suspended film technology gives the glazing system superior insulation over standard windows
  - Perforations filled with insulated glass are strategically placed to brighten the darker corners of the house with ambient light while accentuating the architectural design

but overall the house went together extremely well.

"You don't really hear of architectural students getting into that level of the fabrication process," said Richard Garber, associate professor with the NJIT's College of Architecture and Design. "They were all over it and were very excited about it." Garber, the faculty leader for the solar home project, explained that it added a twist in normal classroom procedures. "We teach a design studio, where all the students are given the same problem, and they all come up with individual solutions," he said. For this project, however, the students worked together toward the same common goal, much like the environment in a professional architectural firm.

It was a college education like no other. "Going through the process of doing all the design work, doing all the documentation, doing the shop drawings, working at the plant, being on site during the construction – these students are coming out with an architectural degree, but they have five or seven years of experience on people who go through the standard architectural education process at this point," said Garber.

John Ruga, owner of Northeast Precast, contributed all the precast concrete components for the project and provided the formwork and work space for the students at his Millville, N.J., plant. "It's really a cutting-edge design," said Ruga. "It was something that hadn't been done before."

Ruga said that he was fortunate to have grown up

working with his hands and probably takes things for granted that other people struggle with. "I really felt with the students that this was a great opportunity to work with them to give them an experience they would never get otherwise," he said. "They just wouldn't have had the opportunity at all to learn how to do this. That was the enjoyable thing for us."

Although Northeast Precast manufactures precast homes and commercial buildings every day with the patented THiN-Wall panel systems, it had its own learning curve for the solar home project. The most perplexing challenge was figuring out how to safely lift and handle the 30 precast panels, each of which was unique in shape, size and weight. Typically these insulated panels require lifting and handling systems that do not alter the thermal performance of the product, but none of the existing systems could eliminate thermal bridging.

To combat the problem, Ruga asked A.L. Patterson Inc. of Fairless Hills, Pa., to help create an entirely new lifting system. The new, patent-pending Quik-Lift Zero Series is a three-part lifting system that includes two wings cast into the panels and a reusable lifting plate. "After the panel is set, you reach in, remove the bolts and the lifter comes right out," explained Ruga. "It works extremely well. Then what we did was insert a foam piece in place of the lifting device to fill the cavity in."

"Mobile" home

The home also was designed with transportability in mind. It can literally come apart at the seams and be plugged back together, including the plumbing and electrical hookups. For example, the floor was cast in four separate, unique sections, and the roof in six sections. The entire home can be loaded up and strapped down on seven flatbed trailers.

The Team New Jersey students gained a rich learning experience from designing and building the solar home and felt their precast project could be used to help others as well. "We really felt that we should donate it to something, where it can be used for tours or a learning center or something like that," said Switala. With public service in mind, this precast home will "reside" at the Liberty Science Center, located in Liberty State Park in New Jersey. PS

Ron Hyink is NPCA's managing editor.

The solar home is shown assembled and fully furnished, complete with precast concrete shelving and counters.
Photo illustration by Ron Hyink and Deborah Templeton.

Plumbing and electrical fixtures can be added at the plant, saving installation time on site.

Precast Buildings:

Install Fast and Built to Last

By Kirk Stelsel

Photos courtesy J.E. Hill Precast, Leesburg, Fla. (jehillprecast.com)

Do you remember the qualities you were looking for the last time you set out to purchase a house?

For many homeowners, must-haves include curb appeal, move-in ready conditions and solid construction that passes a thorough inspection process. When it comes to utility buildings, engineers, city planners, contractors and DOT personnel should require the same.

Utility buildings that house restrooms, storage, mechanical or electrical equipment, offices and more may not be the flashiest part of a job site, but they can certainly be the easiest and most reliable when precast concrete is used. To construct a building on site requires delivery and storage of materials, days or weeks of construction, and additional work by specialists such as plumbers and electricians. Imagine this instead: When you're ready for it, a fully constructed precast concrete building is delivered, set in place and ready for use in less than a day. Precast concrete buildings offer this and more.

Looking for curb appeal? Any number of finishes can be applied, including brick, stone, acid-etched, exposed-aggregate, custom colors – and the list goes on. Precast concrete buildings can be made to any size and shape, including custom roofs, and they can be relocated if you need a change of scenery in the future.

Move-in ready conditions? Just as future homeowners don't want a long delay before the closing date, you don't want to delay any aspect of your project to take longer than needed. The precast manufacturer can pre-plumb and wire the structure, and interiors can be customized with everything from drop ceilings and drywall to carpeting and HVAC before it even arrives on site. If you opt for a built-in floor, foundations may not be needed either. All of this can save you countless days or weeks of construction costs and site disruption, which adds up to big savings in overall costs.

Solid construction? How about a building that can resist hurricane- and tornado-force winds, fire, floods

With a cast-in-place foundation already set, this precast restroom was installed in a Florida park in just a couple of hours.

and earthquakes; has a long service life; and is virtually maintenance free? Precast concrete stands up to natural forces better than any other building material, and your product is made in a controlled environment where it undergoes quality-control protocol throughout the manufacturing process.

With a precast concrete building, you can ensure a quality product, fast installation, savings in construction and logistical costs, and, best of all, you can keep your focus on other aspects of the project.

To learn more, or to find NPCA member precasters in your area, visit www.precast.org. **ps**

Kirk Stelsel is assistant director of NPCA's Communication Department and associate editor of Precast Solutions and Precast Inc. magazines.

Precast buildings can be customized at the plant and delivered to the job site ready to go to work.

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Precast Concrete Safe Rooms: Shelter from the Storm

Built to meet strict FEMA specifications, precast offers protection and peace of mind.

BY EVAN GURLEY

Every year the potential looms for a natural disaster involving extreme wind events. Tornadoes, hurricanes, tropical storms, typhoons and other extreme wind events strike with lethal force. For the United States, some years are far worse than others.

Hurricane Katrina of the 2005 Atlantic hurricane season was the costliest natural disaster, as well as one of the five deadliest hurricanes in U.S. history. At least 1,836 people died, and damages were estimated at $81 billion.

When we look back at the stories that made the headlines in 2011, we will certainly see mention of Tuscaloosa, Ala., and Joplin, Mo., where tornadoes devastated both cities and caused more than 400 deaths.

In the summer of 2011, the East Coast of the United States braced for the impact of Hurricane Irene with evacuations and the first mass-transit shutdown in the history of New York City. Irene was downgraded to a tropical storm by the time it made landfall in New Jersey and the Coney-Island area of Brooklyn, N.Y., but by then the hurricane had caused almost $15 billion in damage and had taken 56 lives.

When extreme wind events approach, we are warned to seek cover. Some communities, homes and buildings are equipped with shelters, basements or

rooms designated as safe areas during such events; however, many communities and individuals do not have storm shelters and remain at risk as a result. This article explains why certified and approved precast concrete safe rooms and storm shelters can help provide protection and peace of mind for families and communities when dangerous storms approach.

FEMA and ICC/NSSA
Safe Room Criteria

When extreme weather threatens, individuals and communities need a structurally sound safe room to provide protection. To ensure that safe rooms are structurally sound and will provide near-absolute protection from devastating storms, the Federal Emergency Management Agency (FEMA) has developed design, construction and operation criteria for architects, engineers, building officials, local officials, emergency managers and prospective safe room owner/operators. The two design guidelines developed are FEMA 320 and FEMA 361. FEMA 320 outlines the design criteria for the development of residential safe rooms (16 persons or less) located in residential basements, garages, interior rooms and stand-alone structures (buried or exposed). FEMA 361 designates the design criteria for construction and operation for both community and residential safe rooms (greater than 16-person capacity).

Using the FEMA guidelines as a pre-standard, design and construction professionals led by the International Code Council (ICC) and the National Storm Shelter Association (NSSA) have joined forces to produce the first ICC/NSSA Standard for the Design and Construction of Storm Shelters (ICC-500). Precasters who manufacture safe rooms meeting this standard assure prospective owners and occupants that precast concrete safe rooms will provide life-safety protection. While fully supporting this effort, FEMA has continued to promote its 320 and 361 guidelines to communities and individuals seeking further guidance on best practices.

Due to the implementation of the ICC-500 standard and other national, state and local protection initiatives, FEMA identified a need to distinguish between a "safe room" and a "shelter," as the terms have been used almost interchangeably in the past. While FEMA and ICC criteria are both designed to ensure life-safety protection, only precast concrete units meeting FEMA criteria provide "near-absolute" protection from extreme wind events. Therefore, FEMA coins the term "safe room" as all shelters, buildings or spaces that are designed to the FEMA criteria. Buildings, shelters or

▲ *Families can depend on precast concrete safe rooms during severe weather.*
Photo courtesy of Michael L. Tidwell, SURESPEC Vaults, a division of Bartow Precast Inc. (www.surespecvaults.com and www.bartowprecast.com)

FEMA 320

Residential safe rooms that are designed to meet FEMA 320 criteria comply with the following guidelines:

- Located in an area that is accessible as quickly as possible
- Built in an area where flooding will not occur
- Readily accessible from all parts of a home, business or critical facilities (building or facility occupied by large numbers of people)
- Free of clutter and obstacles
- Adequately anchored to resist overturning and uplift (if specified by design) wind forces
- Connections that can resist failure
- Walls and roof that can withstand windborne missiles (designed @ 250 mph for tornado hazards)
- Designed to resist a 15-lb, 2-in. x 4-in. wood board missile traveling horizontally at 100 mph and vertically at 67 mph (ASCE 7-05)[2]

FEMA 361 (Additional criteria to FEMA 320):

- Designed for all cases as partially enclosed buildings
- Special life-safety protection elements when there is occupancy of 50 and greater

[2] SEI/ASCE 7-05, Minimum Design Loads for Buildings and Other Structures

spaces designed to the ICC-500 standard are termed "shelters," so all precast concrete safe rooms designed to the FEMA criteria meet or exceed the ICC-500 requirements.

Specifying precast concrete safe rooms

Precast concrete safe rooms and shelters are classified according to their location: above-ground (stand-alone) or in-ground (internal safe room). There are inherent advantages to each type of structure.

When specifying a safe room, the structural integrity of the unit itself is the primary consideration. While additional occupant life-safety and health requirements are also a fundamental part of the selection process, the first consideration when selecting a safe room is to verify that the unit can withstand the direct and secondary forces of wind and wind-borne debris.

FEMA 320, FEMA 361 and ICC-500 outline the requirements for the main wind-resisting structural system, components and cladding of these units. FEMA provides requirements for occupant life-safety and health requirements including: lighting; ventilation; sanitation; fire safety; means of egress; and minimum floor space for occupants. Precast concrete safe rooms provide many advantages – not only with the heightened structural integrity of the unit itself – but also meet the requirements for occupant life safety and health requirements.

Flood protection

It is extremely important to conduct a thorough flood hazard analysis on the proposed site for a safe room. The possibility of flooding from a hurricane event is very high, and as occupants might be in the safe room for an extended period of time (perhaps longer than 24 hours), the scenario of saving people from death or injury caused by extreme winds only to cause them harm by flooding must be avoided. Residential safe rooms should not be located in an area subject to storm-surge inundation.

Six advantages of precast concrete safe rooms

1. Structural integrity.

Structural integrity is the philosophy behind the engineered design of sound structural components that comply with, or exceed, applicable standards and codes. Structural integrity implies that the strength of the structure will be greater than the maximum anticipated

Photos courtesy of Michael L. Tidwell, SURESPEC Vaults, a division of Bartow Precast Inc. (www.surespecvaults.com and www.bartowprecast.com)

service stresses or storm loading. The structural integrity of a precast concrete safe room makes it capable of supporting service loads independently, without relying on adjacent support materials or soils. If the designed strength of a precast concrete safe room is greater than the expected maximum applied stresses by an appropriate factor of safety and meets the additional FEMA 320 and FEMA 361 requirements, the structure is considered to be adequate to fulfill its function. Structural integrity of a safe room is essential to provide dependable shelter from extreme wind events, and precast concrete safe rooms do just that. Precast concrete safe rooms can provide life-safety protection for occupants for durations of two hours or more for tornado events and more than 24 hours for hurricane events.

2. Extreme wind protection.

Extreme winds created by tornadoes, hurricanes and other such events are anything but constant. Wind speeds are continually fluctuating and changing direction, increasing the pressure and stresses on the parts of a structure. A safe room structure will also be affected by wind forces acting on both sides (inside and outside) of the structure.

While swirling winds from the vortex of a tornado or hurricane are thought to produce the most damage, much of the damage actually done to the building envelope is due to straight-line winds rushing toward, and being pulled into, the tornado itself.

Other stresses that winds project on safe rooms include:

- Airflows that can cause structural separation at surfaces near sharp edges and at points where the structural geometry changes
- Localized suction or negative pressures at ridges, edges, eaves, and the corner of roofs and walls that are caused by turbulence and flow separation
- Wind pressures and the impact of windborne debris on windows, doors and other openings.

If wind speeds reach a certain threshold level, there is even the potential for the swirling winds to launch objects through the air like missiles with enough force to penetrate a structure's building components and harm the occupants within. FEMA 320 and FEMA 361 address windborne missiles with numerous design minimums.

Precast concrete safe rooms designed to meet the FEMA 320 and FEMA 361 requirements will be able to withstand all extreme wind forces including projectiles, and

Photo courtesy of Eric Barger of C. R. Barger & Sons Inc., Kingston, Tenn. (www.bargerandsons.com)

will provide complete security for safe room occupants. Seeking shelter from an extreme wind event in a structure that is not made with a FEMA-compliant precast concrete design can prove to be a life-altering choice.

3. Access and entry

Access points in safe rooms are an important factor to consider when specifying a safe room. An access point (a door or window) must be easily accessible, able to withstand missile-type forces and be properly attached to a structural backing material; all requirements that are easily met in a precast concrete design. Access and entry points designed for approved precast concrete safe rooms are effectively designed to withstand tornado events as follows: doors compliant with ICC-500, Section 306.3.1; windows compliant with ICC-500, Section 306.3.2; and all other openings compliant with ICC-500, Section 306.4.

4. Safe room transportation & installation

Precast concrete safe rooms can be manufactured well in advance of site installation. They are fully cured prior to delivery to the site, so there is no need to wait for cast-in-place concrete structures to set or cure. Precast concrete safe rooms are ready for service upon delivery, are competitively priced and in ready supply. These precast benefits can save valuable days, weeks or even months on a project compared with other materials.

Manufacturers of precast concrete safe rooms that are NSSA-approved (meet FEMA 320 and/or FEMA 361) are located throughout North America, and precast concrete safe rooms can be ordered and shipped to any city or region at a moment's notice. In addition to ample supply, convenient delivery and readiness for service, inclement weather at the installation site does not pose a problem for precast (See "Extreme Precast: Freezing out the Competition" on page 10). Precast concrete safe rooms can be installed in extreme weather conditions and in remote locations.

5. Thermal mass

Thermal mass is used in the building industry to define the inherent property of a material to absorb heat energy. A wall material with a high thermal mass can moderate daily temperature variations in the building's interior spaces. Precast concrete has a high thermal mass, which means a lot of heat energy is required to change its temperature (See "Thermal Mass: Precast

Concrete can take the Heat" on page 30). Wood or metal walls, by comparison, have a lower thermal mass (relative to precast concrete) and transfer heat more readily. High thermal mass precast concrete walls act as thermal sponges, absorbing heat during the day and then slowly releasing the heat during the cooler nighttime hours.

So, why is the thermal mass of a safe room important? Precast's ability to moderate temperature fluctuations is important, because safe rooms are designed to hold a number of people for a duration of time, and the ventilation and the temperature inside play a critical role in assuring occupant health and safety. Extreme outside temperatures can adversely affect the living conditions in safe rooms constructed with alternative materials. Materials with a low thermal mass can act like ovens when sitting out in the hot sun for a long duration of time. Precast concrete safe rooms help keep the temperature inside safe rooms moderated and manageable.

6. Ventilation

Ventilation in approved precast concrete safe rooms complies with the building codes or ordinances adopted by the local jurisdiction; the 2006 IBC and IRC codes[1] are applicable if the local jurisdiction has not adopted a building code. Ventilation is provided either through the floor or the ceiling of precast concrete safe rooms. A protected shroud or cowling meeting the missile-impact criteria testing is mandatory to protect any ventilation openings. If the safe room is designed for occupancy of more than 50 people, the room must be ventilated by mechanical means, a requirement that is conveniently met when specifying a precast concrete safe room. Ventilation openings are easily fabricated during the precast manufacturing process and can be installed to custom specifications.

Conclusion

While there are many options in the marketplace from which to select when looking for a safe room for a residential home or community setting, only one safe room option stands out for quality, structural soundness, versatility, strength and protection – and that is an approved, precast-concrete quality, life-saving unit designed to resist even extreme wind conditions. **PS**

Evan Gurley is a technical services engineer with NPCA.

[1] IBC is The International Building Code and IRC stands for The International Residential Code.

Thermal Mass

Precast concrete can take the heat.

BY CLAUDE GOGUEN, P.E., LEED AP

Seven billion people on a planet with limited resources means that energy conservation is not optional. Our planet's growing population creates an ever-increasing demand for limited power resources. In today's world, every engineer and architect involved in the design of new structures is looking for ways to increase building heating and cooling efficiencies. And because buildings' HVAC[1] systems use about 30% of all U.S. energy, there is an increased demand for sustainable, energy-efficient building designs.

Newer and greener energy technologies like solar panels, wind turbines and geothermal systems are gaining in popularity, but one method of conserving energy has been around for a very long time: using a building envelope material with a high thermal mass. Energy demand is not just about using energy, it is about having a comfortable indoor temperature when and where we want it. Designs that take advantage of precast concrete's exceptional thermal properties can provide a high level of service and occupant comfort with less energy input.

Precast is a heavyweight for power efficiency

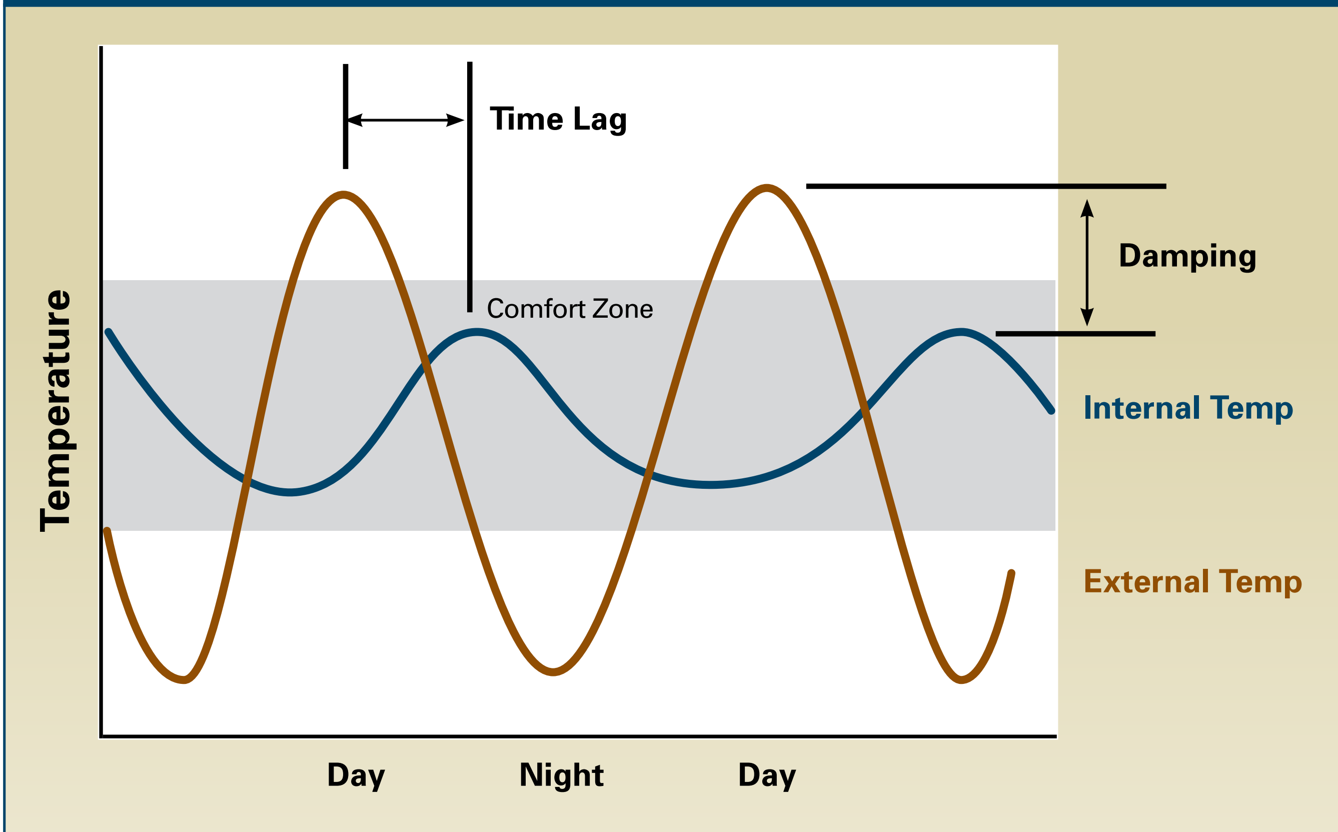
What is thermal mass? It's defined as the inherent property of a material to absorb heat energy. Precast concrete has high thermal mass, because a lot of heat energy is required to change its temperature. Lumber products are much easier to heat and therefore have lower thermal mass. High thermal mass materials, like precast concrete, act like thermal sponges, absorbing heat during the summer to keep the building's interior cool, and storing heat from the sun to release it slowly at night when outdoor temperatures fall.

Precast concrete's thermal mass serves to flatten daily interior temperature differentials and thereby reduce energy demands on a building's HVAC system. The more we can minimize, or flatten, a building's interior temperature differential, the more energy we conserve.

When outdoor temperatures are at their summertime peak, a precast concrete building's interior remains cool, because it takes time for heat to penetrate concrete with its high thermal mass. This heat transfer results in a time lag shown in the accompanying diagram. As that heat is transferred, the temperature is also reduced, an effect referred to as "damping." The naturally lower nighttime temperatures cool the precast concrete mass (building envelope) and allow the precast to absorb heat again the next day. Precast concrete's high thermal mass effectively delays and minimizes the impact of outside temperature variations on the indoor climate. Consequently, this improves a structure's energy efficiency, which is mandated by the national Energy Policy Act of 1992 for commercial buildings.

[1] HVAC stands for heating, ventilation and air conditioning.

Thermal Mass



Measuring thermal mass

So how is thermal mass – the ability of a material to absorb, store and release heat energy – quantified? The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1-2010, "Energy Standard for Buildings Except Low-Rise Residential Buildings," quantifies thermal mass effects based on a wall's heat capacity. Heat capacity is defined as a wall's weight per square foot multiplied by the specific heat of the material.

Specific heat describes a material's ability to store heat energy, or the amount of heat energy (in Btu) required to raise the temperature of one pound of a material by one degree Fahrenheit. The specific heat of concrete and masonry is generally assumed to be 0.2 Btu/lb·F.

Thermal mass is not to be confused with R-value, also known as thermal resistance. R-value is expressed as the thickness of the material divided by the thermal conductivity. The coefficient of thermal conductivity, ***k***, is a measure of the rate at which heat is conducted through a unit area of homogeneous material of unit thickness for a temperature difference of one degree.

R-values and U-factors (thermal transmittance) do not take into account the effects of thermal mass, and by themselves are inadequate in describing the heat transfer properties of construction assemblies with significant amounts of thermal mass such as precast concrete buildings.

The thermal mass properties of precast concrete can also help projects obtain LEED credits. The LEED-NC[2] Energy & Atmosphere (EA) Credit 1 on optimizing energy performance can potentially provide up to 10 points for energy cost savings beyond ASHRAE Standard 90.1-2010.

Precast concrete's high thermal mass is but one of its many benefits; but it is an important asset for designers who are looking to cut energy costs associated with HVAC systems and still keep building occupants comfortable. For more information on the thermal mass of precast concrete, contact the NPCA technical staff at technical@precast.org or call (800) 366-7731. **ps**

Claude Goguen, P.E., LEED AP, is NPCA's director of Technical Services.

[2] LEED-NC stands for Leadership in Energy and Environmental Design for New Construction.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