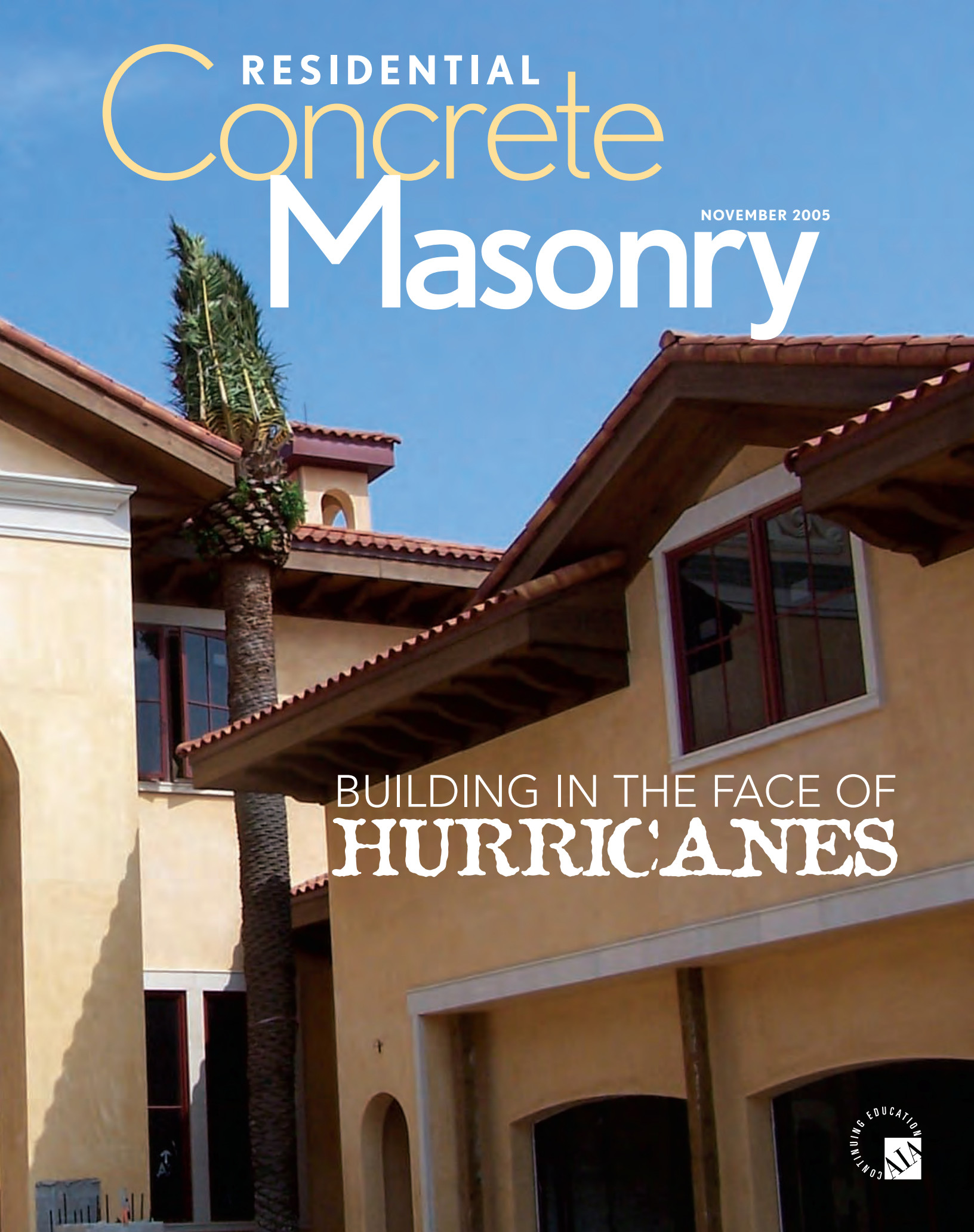
RESIDENTIAL Concrete Masonry

NOVEMBER 2005



BUILDING IN THE FACE OF HURRICANES

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RESIDENTIAL Concrete Masonry

NOVEMBER 2005

ON THE COVER:

The use of Concrete Masonry as a primary structural component in residential homes is on the rise.

FEATURES

DEPARTMENTS

PROJECT CREDITS

We would like to thank the following members for their assistance to CM Designs with providing project information: Block USA

Residential Concrete Masonry showcases the qualities of design and construction using concrete masonry.

Residential Concrete Masonry is devoted to design techniques using standard and architectural concrete masonry units; concrete brick; unit concrete pavers and segmental retaining walls; and other concrete masonry products around the world. We welcome your editorial comments, ideas and submissions.

It is the policy of **Residential Concrete Masonry** magazine to provide the names of authors of articles appearing in the magazine upon request.

Residential Concrete Masonry is published quarterly by the National Concrete Masonry Association and distributed to advance and support the concrete masonry industry and the public interest through research and educational programs designed to meet the future needs of the industry.

Send address corrections to NCMA's Publications Department:

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NATIONAL CONCRETE MASONRY ASSOCIATION

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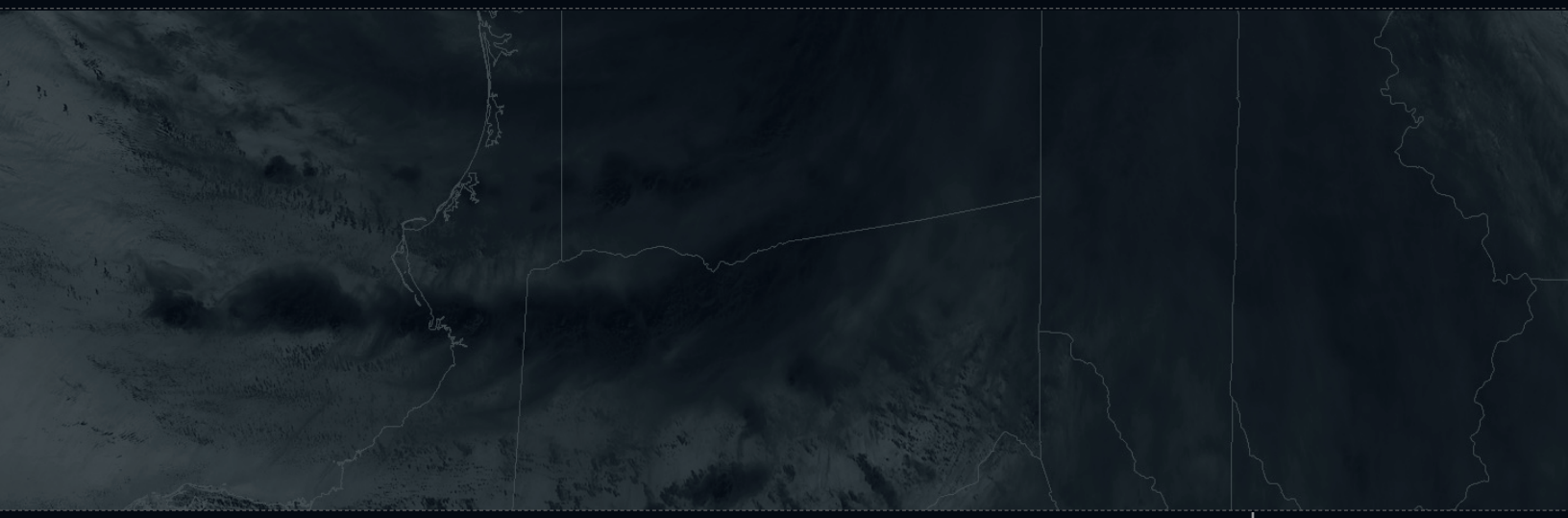
BUILDING IN THE FACE OF HURRIC



The catastrophic damage caused by Hurricane Katrina has driven home the vulnerability of residential construction under the onslaught of a natural disaster. But in Florida where hurricanes are more commonplace, building codes dramatically changed since 1992 after the massive destruction of Hurricane Andrew. Since then the use of concrete masonry as the primary structural component in residential homes is on the rise.

CANES

CONTINUING EDUCATION AIA

Concrete masonry's high mass gives it a better ability to withstand rain and the impact of flying debris. And when reinforced it withstands high force winds through increased flexural (bending) and tensile (uplift) capacity of the exterior walls which flex, and thus reduce structural shifting.

The proof of indomitable strength of concrete masonry can be seen first hand at two homes that have been under construction over the past year on Florida's coast. While the buildings were going up, one tropical storm (Arlene) and three hurricanes (Ivan, Dennis and Katrina) come through.

Builder Paul Hartzog, owner of Silver Sands Development and Decks N Such Marine, Inc. has been building a 22,000 square foot (2044 m2) reinforced concrete masonry home (the Adams residence) on a peninsula that juts out into Choctawhatchee Bay in Destin, Florida. Each time the weather prediction called for a hurricane he has prepared for the worst - scaffolding was disassembled and removed, materials were tied down or removed and equipment was put under cover. But as for the house itself Hartzog says it was never a worry.

"There were no problems with the house during the hurricanes. The first time - Hurricane Ivan - the block was just coming up on the foundation. The second time - Hurricane Dennis - we were dried in and just about to put the tile roof on. This last time - Hurricane Katrina - we were about 90% complete," said Hartzog adding that the house has come through all three without damage.

"We talked a lot about sustainable materials with the biggest threat being hurricanes," said architect Dennis Chavez, principal of Doughtery + Chavez Architects who designed the Adams residence. "When you design for structures to be built along water, you have to take into account the phenomenon of high winds and storm surge."

The foundation of the Adams home began by hammering pilings into the ground "In this particular design we have a footing that is constructed with 14 foot long (4.27 m) wood timber piles about every 10 feet (3.05 m) on center around

PROJECT
Adams House

Location Destin, Florida

Size 22,000 square feet

Contractor Silver Sands Development – Decks N Such Marine, Inc.

Architect Doughtery + Chavez Architects

Masonry Contractor
General Masonry

Total Cost of Masonry
(materials and labor)
$408,000

Completion Date
October 2005

said Hartzog. The exterior block was finished in stucco with soffits and corbels done in solid cypress.

The story of the Wilson house on Stallworth Plantation in Walton County, Florida reads much the same way as the Adams house, withstanding three hurricanes and a tropical storm while under construction. "It is usually not even a question about the type of material used directly on the Gulf - we build in concrete masonry because it can withstand anything," said Greg Tankersley, one of the principals of McAlpine Tankersley Architecture in Montgomery Alabama who designed the 6700 (622 m2) square foot (of heated space) house.

The Wilson house sits on 118 concrete pilings. The entire exterior is standard 8x8x16 inch (203x203x406 mm) concrete masonry units.

According to builder Tommy Norred of William T. Norred Construction who has been working on the house for two years, there have been no issues with the house during or after the hurricanes, not even water penetration. "This house is built like a fort," he said. "All the concrete blocks are solid grouted units reinforced No. 5 (No. 16 M) at 16 inch (406 mm) on center from bottom to top. So there is one bar in every concrete block and all those blocks are filled with grout. Then all around there are two courses of lintels with No. 5 (No. 16 M) like a belt around the house every 6 feet (1.8 m) vertically."

Tankersley says the choice to use concrete masonry was simply the history of common sense. "You go down to Florida and parts of the Panhandle where there are some structures that have been there forever and they are concrete masonry houses," he said. "So you look at what has been around and is still standing and that is concrete masonry, so we are not trying to reinvent the wheel."

Tankersley also says that using concrete masonry never limits his design capabilities. "The Wilson house which is far from a box house is on a fairly small footprint and made up of a bunch of out buildings. Using standard block material does not limit the design at all." The house is three separate structures-

the perimeter of the house. That was an extra precaution to resist scour - the wave action taking away dirt trying to undermine the foundation," said Chevez.

The foundation was completed using standard 8x8x16 inch (203x203x406 mm) CMUs laid in horizontal courses to bring the foundation up to 11.33 feet (3.45 m) above sea level. Every block course was reinforced with No. 5 (No. 16 M) bars that run vertically through it and every cell was filled with concrete grout forming the entire exterior envelope of the house. The only wood in the exterior of the house is on the second floor where a few parts of the walls are 2x6 framing.

In terms of design, Chevez says that they have never been limited by the choice to use concrete masonry in construction. "In some ways it is actually better because you have certain design parameters you want to achieve with block and you can do a lot of interesting things," he said.

The Adam's residence is anything but square with many curves and turns throughout the design. Some of the features achieved with concrete masonry in the house include a colonnade wall with columns, four fireplaces, a full vault ceiling, a safe room, a 90x60 foot (27 x 18 m) zero entry pool and a grotto with waterfalls. "We also have a sitting room with a dome that we did out of eight-inch (203 mm) block in a perfect radius with windows all the way around,"

"I have had more people asking me about concrete construction after these storms," said Hartzog.

AIA Learning Objective

After reading this article, you should understand the structural properties of concrete masonry.

the main house, a separate two bedroom apartment and a two car garage with a bedroom on top.

Like Hartzog, Norred has had to prepare the site each time a hurricane was forecast, policing the area to make sure everything has been picked up, having the dumpster removed and putting up plywood over the windows. He says they usually store a lot of the materials and equipment inside the house "because we know it will be safe there."

"As soon as we see it coming we treat it like it is coming right here. Unfortunately we have been right too many times," said Norred. "I just have had no concern about the structural capability of this building. My only concern is erosion. There is nothing we can do about rising water but in the wind rating it would survive a category Four or Five hurricane."

Norred and Tankersley both are pleased with the masonry aspect of the home and how it has withstood the onslaught of hurricane force winds. So far it has gone virtually unscathed. "It is more a matter of trying to aesthetically keep it from being beat up, than of being blown away," said Tankersley.

Natural disasters are probably the ultimate barometer of a building's mettle because they represent some of the most extreme conditions to which a structure will be subjected. But as hurricanes continue to ravage the coastline of America, more and more homebuyers are choosing concrete masonry construction. "A lot of these houses are really high end custom homes and people are spending a lot of money to buy a sliver of Gulf front so if you are building in such a place with such a high property value it does not make sense to skimp on building a house not only for hurricane winds but durability over the years," said Tankersley.

"I have had more people asking me about concrete construction after these storms," said Hartzog. "I think it depends on where you are building and the type of structure you are building as to what material they like. As for me, I would much rather build out of block."

Tankersley relates the story of a home he designed in Rosemary Beach Florida. "It was much further inland and the client wanted a wood-frame/wood-sided house. We designed the house and then the owners decided to sell and move somewhere else. They had a ton of people look at the lot and the house but every sale fell through because it was not concrete. They would have sold it five times over if it had been a concrete masonry design."

PROJECT
Wilson House

Location Fort Walton Beach, Florida

Size 6700 square feet (622 m^2) of heated space

Contractor William T. Norred Construction

Architect McAlpine Tankersley Architecture

Masonry Contractor General Masonry

Total Cost of Masonry (materials and labor) $250,000

Completion Date Expectation May 2006

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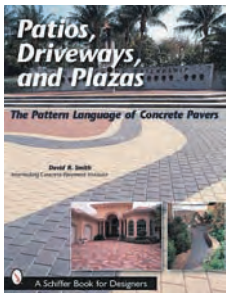

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- The following two HUD documents
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  – Building Concrete Masonry Homes: Design and Construction, both with details prepared by the National Association of Homebuilders Research Center
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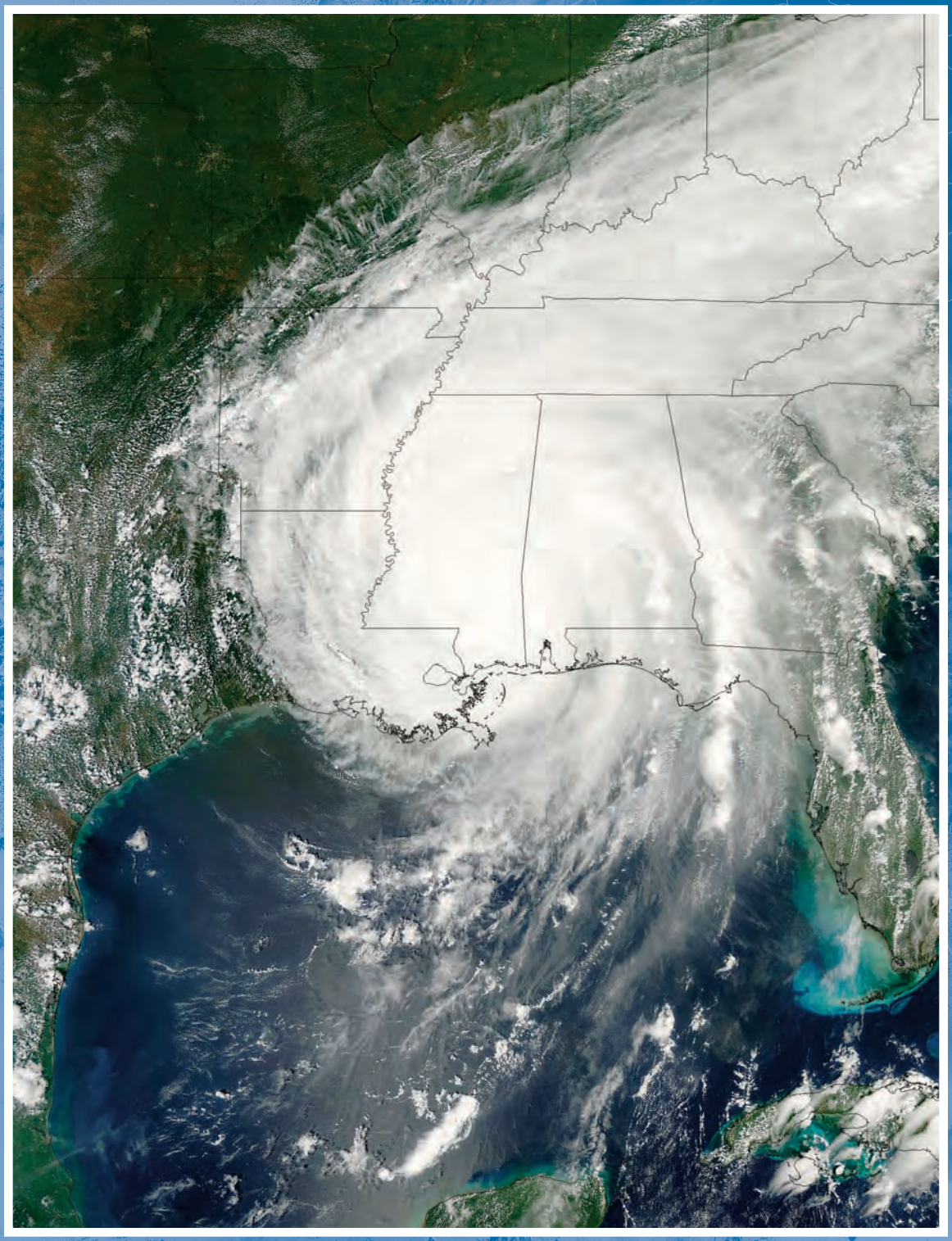
NCMA's TEK series and details are available online FREE to architects, engineers and specifiers. The TEKs include more than 130 technical bulletins on various topics related to concrete masonry with a new TEK published monthly. In addition, many others are revised and updated to reflect code or building design changes as necessary.

The Web site-accessible e-TEK and e-Details service can be reached through NCMA's member Web sites that sponsor the program. A listing of sponsors with hot-links to their sites can be found at www.ncma.org. Click on the "Select Your State" pulldown menu and then select your local concrete masonry producer. Click on "Technical Details" for e-Tek or "Technical Manual" for e-Details. e-Details has all drawings downloadable in various electronic formats including DWG for AutoCAD and DXF. This service allows viewers to be supplied with the latest up-to-date information on concrete masonry. For those who still prefer the hard copies, they are available from NCMA at www.ncma.org or by calling the publications department at 703.713.1900. ■



The Nature of High Wind Events

When they strike, hurricanes can subject buildings to winds over 150 mph (241 km/h), imposing extraordinary forces, lateral and upward vertical. The impact of high winds on a particular building depends on a number of factors, including the wind speed and duration; building height (wind loads increase with height above grade); how exposed the building is to the prevailing winds (a building on an open plain is subjected to higher loads than one surrounded by buildings or other obstructions); the building shape; as well as sizes and locations of openings such as windows and doors.

PHOTO COURTESY OF EARTH SCAN LABORATORY, COASTAL STUDIES INSTITUTE, LOUISIANA STATE UNIVERSITY, BATON ROUGE, LOUISIANA

Residents of New Orleans and the entire Gulf Coast Region of the United States were subjected to not only high wind events through Hurricane Katrina and Hurricane Rita in the Fall of 2005, but also the severe and highly destructive effects of storm surges that wiped buildings completely off their foundations and tore gaping holes in the sides of others.

A team of structural engineering investigators arrived in the Gulf States area shortly after Hurricane Katrina left devastation in its path to investigate the effects of both high wind and storm surge. The four-man team included trained volunteers from the engineering, construction, materials, and forensic communities, and focused on the ability of modern building codes and recommended construction practices to protect structures and their inhabitants from design events such as hurricanes. Beginning their work in Mobile, Alabama, the team moved westward across the gulf coast of Mississippi through the hurricane-ravaged areas of Pascagoula, Biloxi, Long Beach, and Gulfport and into parts of Louisiana.

hurricanes damage structures, it is important to commence with investigations quickly before clean-up efforts are begun to collect forensic data and determine how well the structures performed. Quick-response field studies conducted following major disasters are vital to identify knowledge gaps where further research and building code revisions are most needed. Such investigations also offer opportunities to make recommendations regarding mitigation measures, disaster preparedness, and emergency responses for better preparing communities for future disasters.

The team noted a vast improvement over structures built as recently as the past ten years. Clearly, the knowledge gained from prior investigations of other high wind and storm surge events provided experts with basis to recommend construction improvements. Each event of this type, studied thoroughly, adds to an ever-growing body of knowledge that forms the basis for recommending newer code provisions and building practices needed to protect occupants and property.

> "To combat the threat of progressive failure, the buildings must be designed and constructed to maintain structural integrity during high winds."

As with other hurricanes, the team noted that building failure during high winds often begins with a relatively minor failure. For example, if one roof fastener pulls out or breaks, the load on the surrounding fasteners increases, often leading to the progression failure of the system. A portion of the roof can be pulled away from the walls in this way, leaving unsupported walls that were designed to be supported at the roof. In fact, the most common source of failure in high-wind events is wind uplift on the roof.

To combat this threat of progressive failure, buildings must be designed and constructed to maintain structural integrity during high winds. This requires that buildings incorporate continuous paths that allow structural forces to be transferred from the roof to the underlying soil, where the forces are dissipated. Designed continuous load paths allow wind forces on the roof to be distributed to the walls, then to the foundations. Structural continuity relies heavily on properly sized, located and installed connectors between the building's various structural elements.

How are opportunities for improvements in building practices identified? When catastrophic events like

In the Gulf Coast Region, examples of masonry homes left standing while other adjacent homes were washed away were documented. In other cases, the storm surge wiped out all structures in its path. A concrete masonry K-Mart store in Gulfport, Mississippi was left intact with the exception of its glass entrance while the steel-stud structure of the attached adjacent strip mall shops was stripped clean of its siding material. Those modern masonry structures that did not perform as desired often appeared to not be constructed to code requirements highlighting the need for both education and inspection.

HIGH-WIND CONNECTIONS

Connections between structural elements must be strong and durable enough to transfer loads during high winds, maintaining the continuous load path through the home and into the ground below. Critical connections include: roof to floor; and walls to walls; and walls to foundation. Connectors in each of these applications must be strong enough to transmit design loads, be properly installed and be adequately protected from corrosion for long-term durability.

CONTINUING EDUCATION

AIA Learning Objective

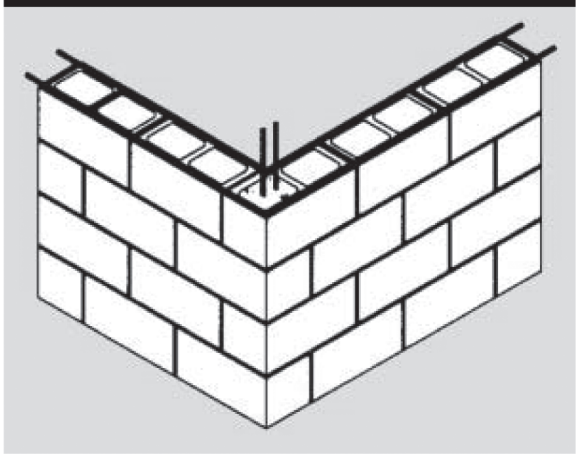
After reading this article, you should understand the design issues and solutions for concrete masonry in hurricane prone areas.

Designer should carefully review manufacturers' data when choosing connectors for buildings subjected to high winds. Manufacturers' specifications will include structural ratings for the various connectors, usually in the form of ultimate capacities for resisting shear, uplift and gravity forces (for connections to wood elements, these values typically vary with the wood species used). The manufacturer will also include specific information on the appropriate number and type of fasteners to be used with each connector.

Hurricane clip manufacturers provide allowable uplift and lateral loads for the clip, based on the clip being installed using eight 8dx11/2 nails to fasten it to the roof truss, and eight more to fasten it to the top plate. Connectors are then spaced as needed to carry the design uplift and lateral loads. Anchor bolts at 32 inches (813 mm) are used to attach the double 2x8 top plate to the concrete masonry wall.

Wall to wall connections, such as at outside corners of the home, are provided by interlocking block coursing as shown in Figure 1. Two continuous No. 5 (M # 16) reinforcing bars are grouted into each corner to provide increased continuity between the intersecting walls, as well as provide a vertical load path between roof and piers. Horizontal joint reinforcement overlaps at all corners as well.

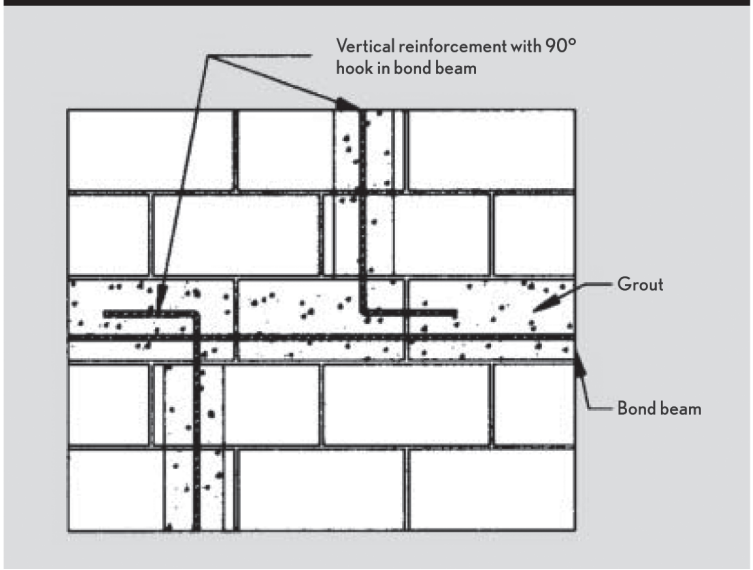
Figure 1 – Building Corner Using Interlocking Masonry Bond



Walls are connected to the concrete masonry foundation piers by extending vertical wall reinforcement into the piers. The reinforcing bars are extended a full 3-feet (1 m) into the piers to provide adequate anchorage.

The concept of the continuous load path requires not only that individual elements are tied together, but also that loads are easily transferred from one element to another. This is most directly accomplished by placing the various connections in a direct line from the roof to the foundation. For example, when considering a typical wall elevation, the roof truss to top plate connection should be directly above the top plate to wall and wall to foundation connections. When structural elements must be offset, reinforcement should be detailed such that it is structurally continuous, as shown in Figure 2 for changing the location of vertical reinforcement.

Figure 2 – Changing Vertical Reinforcement Location



Steel connectors must be protected from corrosion to help ensure long-term strength. Coastal environments not only subject connectors to corrosive salts, but they are also more likely to be exposed to water due to wind-driven rain. For masonry connectors, the Specification for Masonry Structures (ACI 530.1/ASCE 6/TMS 602) requires carbon steel joint reinforcement, anchors and ties to be protected from corrosion by means of mill or hot-dipped galvanizing or epoxy coatings (the Specification contains specific minimum coating thicknesses based on the type of coating and the steel element to be protected). As an alternative, stainless steel connectors can be used. In fact, FEMA recommends the use of stainless steel connectors, or thicker-than-required corrosion protection coatings, for connectors in highly corrosive environments.

Residential Concrete Masonry's AIA Continuing Education Learning Program

Learning Units Reporting Form

To receive one learning unit, read "Building in the Face of Hurricanes" (page 4) and "The Nature of High Wind Events" (page 11) and complete the following questions on both articles. Return this form to the National Concrete Masonry Association. Only original forms will be accepted for learning unit credit.

Forms received after November 2006 will not be accepted for learning unit credit.

❑ I am a non-AIA architect or design professional. Please send me a certificate stating the learning units earned that I can use for documentation to fulfill other continuing education requirements.

Send completed Report Form to: AIA CES, National Concrete Masonry Association, 13750 Sunrise Valley Drive, Herndon, VA 20171-4662. If you have questions, please contact NCMA at 703.713.1900.

November 2005

AIA Questions:

1. Authors of the articles identified each of the following as critical to effective post disaster sight investigations except

- ☐ Expedient response
- ☐ Building code improvements
- ☐ Identification of need for education and inspection
- ☐ Thorough investigation
- ☐ Corrosion resistance

2. All the following were identified as possible methods to protect carbon steel anchors, joint reinforcement, and connectors for structures built in coastal environments except

- ☐ Aluminum
- ☐ Zinc protection
- ☐ Epoxy
- ☐ Thicker connection
- ☐ Stainless steel

3. Articles in this issue of CM Designs identified all of he following as building design issues that become important for buildings subjected to hurricanes except

- ☐ Shape and height of building
- ☐ Location
- ☐ Fasteners
- ☐ Occupancy
- ☐ Progressive failure

4. Each of the following were identified as material attributes for concrete masonry except

- ☐ Size
- ☐ Color
- ☐ Surface treatment
- ☐ Shape
- ☐ Cost

5. Select the one item from the following that is not identified in this issue of CM Designs as a reason to build homes of concrete masonry

- ☐ Excellent resistance to wind
- ☐ Superior aesthetics
- ☐ Safe
- ☐ Excellent resistance to water
- ☐ Resistance to mold

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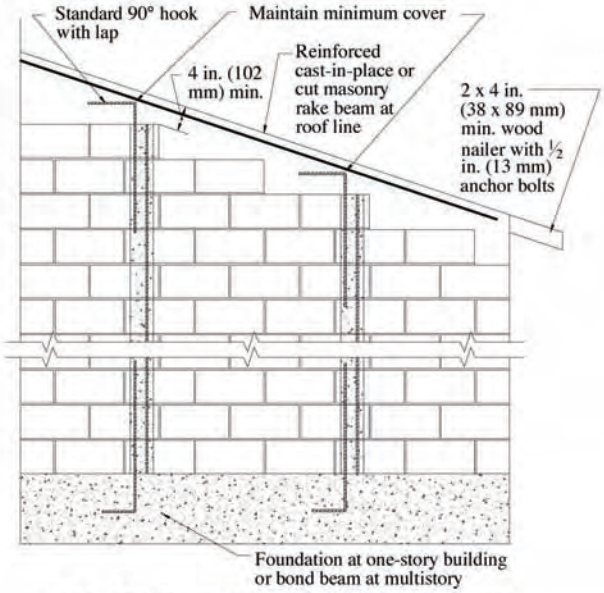
Gable End Wall Detail for High Wind Areas

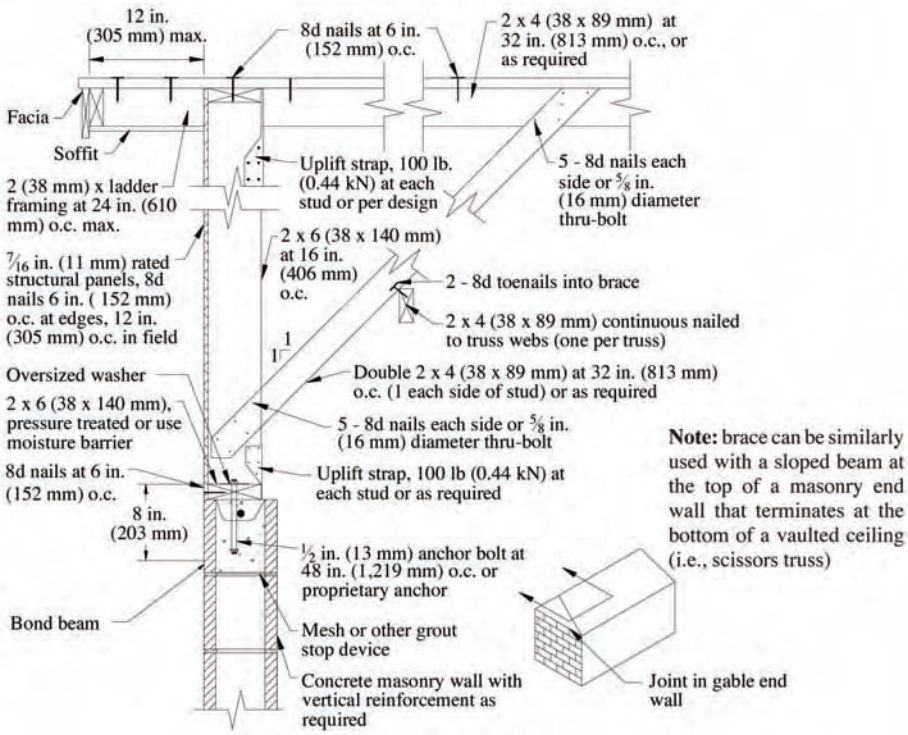
The most efficient roof system for high wind areas is a hip roof as the roof diaphragm is brought down to the top of the wall and provides support at that point much the same as at the sidewall. The hip roof is also more aerodynamic and as a consequence results in lower overall loading on the structure. However, oftentimes gable ends are needed for aesthetic or functional reasons such as an attic. With a gable end wall in conventional construction, the masonry is usually stopped at the eave height and the space between the top of the wall and the roof is framed via either a gable truss or conventional framing. This results in a joint or "hinge" in the wall that has little lateral support and is relatively weak in resisting wind loads – particularly suction forces on the leeward side of the building.

The "hinge" can be addressed and/or strengthened in several ways. One is to completely eliminate the joint as shown in the adjacent figure by constructing the masonry gable end wall continuously from the floor to the roof. Reinforcement is required in the wall and rake beam The sloped portion of the gable is formed using either a raked concrete bond beam or a cut masonry bond beam.

Another alternative, the top of the hinge in the gable end wall can be supported by running diagonal braces from the hinge location up to the roof diaphragm. The number and spacing of braces depends on design wind speed, roof slope and roof span. See TEK 5-11 Residential Details for High Wind Areas for a detail and information on high wind resistance. TEK 5-11 and all other 140+ TEK are available free on line on NCMA member company web sites. A listing of companies that sponsor NCMA TEK and links to their e-TEK sites can be found at www.ncma.org.



6a—Continuous Gable End Wall Reinforcement



Note: brace can be similarly used with a sloped beam at the top of a masonry end wall that terminates at the bottom of a vaulted ceiling (i.e., scissors truss)

6b—Braced Gable End Wall

Figure 6—Gable End Wall Construction

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