Stacked Unit Systems

Stacked unit systems refer to structural systems that employ manufactured components which are assembled and reinforced on the job site, using cement as a bond or fill. Some of these systems are used specifically for wall systems, while others can also be used for foundations. These concrete wall systems have traditionally been used in the commercial and industrial sectors. As builders, designers, and homeowners across the Gulf Coast have become increasingly concerned about the strength of homes, stacked unit systems have gained popularity in the residential sector. Three common types of stacked unit systems are insulated concrete forms (ICF), concrete masonry units (CMU), and autoclaved aerated concrete (AAC) construction. These wall systems, if properly installed and reinforced, may be classified as a wind-resistant system of construction. Homeowners using stacked unit systems may be eligible for a reduction in their wind, flood, or homeowner's insurance.

Most stacked unit systems are installed with methods familiar to experienced masons. Typically, block components are delivered to the job site where they are assembled and reinforced. These systems differ from site-poured concrete construction, which requires costly and time consuming temporary formwork. Stacked unit methods use factory pre-cast masonry components or formwork that is integrated into the final construction of the wall.

Stacked unit systems are typically a more expensive form of construction then stick framing. These systems always require project-specific engineering in order to pass inspections and meet codes. Most of these systems require at least one experienced or certified laborer and may also require special equipment, such as concrete pumps or masonry saws.

(FIG.A) INSULATED CONCRETE FORMS (ICF) is often manufactured with plastic vertical strips for adhering exterior finish material.

(FIG.B) CONCRETE MASONRY UNITS (CMU) are easy to stack by hand. Vertical reinforcement is set into the foundation and continues through the wall.

(FIG.C) AUTOCLAVED AERATED CONCRETE (AAC) has a uniform texture that can be left exposed for interior finishes. Exterior sides of walls should be protected from weather.

stacked units	construction process	speed	delivery method	required equipment	specialized labor	wind resistance	water resistance	fire resistance	thermal performance	life span	environmental impact	product versatility	market exposure	code approval	affordability	coastal considerations
insulated concrete forms		+		−		+			+						−	+
concrete masonry units	+	+			+			+				−				
autoclaved concrete	+		+	+	+			+			+	+	−	−		

Insulated Concrete Forms (ICF)
ICFs are used to build walls and foundations of monolithic concrete, at various thicknesses, sandwiched between layers of EPS or XPS foam insulation. The insulation is used as formwork for the concrete and remains part of the final construction. Plastic webs hold the insulation in place until the concrete bonds the wall together. The webs also replace standard stirrups for reinforcing bars. The ICFs interlock together and are grooved on the interior side for adhering to the poured concrete. ICF walls typically have high R-values, due to the double layer of insulation. The insulation is continuous on the exterior and interior of the wall, creating an extremely tight building envelope with nearly no thermal breaks.

Concrete Masonry Units (CMU)
CMUs are cast concrete blocks that are manufactured in uniform sizes. Their strength depends on the density of the block, which can be increased by using finer aggregate in the concrete mix. CMU block wall construction is typically used in commercial and industrial applications (i.e. car washes, garages, cafeterias, pools). Vertical reinforcement, in the form of a metal bar, is placed within the blocks. A bond-beam is often cast in place at the top of a CMU wall to add structural rigidity to the wall. In residential applications CMUs are typically used in combination with a brick exterior, which is often considered to be a more desirables exterior finish.

Autoclaved Aerated Concrete (AAC)
AAC blocks are cast blocks that are made of cement, lime, water, sand or flyash, and aluminum powder. Because blocks are made of natural and raw materials, the final product is non-toxic and is reported to generate no pollutants or hazardous waste during the manufacturing process. AAC is naturally non-combustible and resistant to mold, rot, termites, and moisture. The material has a high R-value, which depending on the width of the block may eliminate the need for additional wall insulation. Due to the manufacturing process, the blocks are incredibly lightweight, making them easy to assemble, cut, and transport.

FURTHER INFORMATION

- Toolbase (www.toolbase.org)
- Portland Cement Association (www.cement.org)
- Insulated Concrete Form Association (www.forms.com)
- Autoclaved Aerated Concrete Products Association (www.aacpa.org)

OTHER TYPES OF STACKED UNIT SYSTEMS

3 STACKED UNIT SYSTEMS

subjects

Insulated Concrete Forms (ICF)

Overview: Insulated concrete forms are used to construct monolithic concrete walls and foundations of varying thicknesses that are sandwiched between two layers of EPS or XPS rigid insulation. The insulation acts as a form for the concrete and remains a part of the final wall construction. Before concrete is poured the insulation is held in place with hinged webs that are collapsible (for flat shipping) and that replace standard rebar. The form units are interlocking and grooved on the interior side for adhering to the poured concrete while it is curing. The form units also generally come with fastening strips on the exterior of the form for installing conventional exterior and interior finishes.

INSTALLATION

Construction Process: Foundations are installed similarly to typical poured concrete applications. Before the foundation wall can be installed, a footing of appropriate depth and dimension (per code) shall be poured, with the appropriate length of vertical reinforcement dowels left protruding, to be connected with the wall. ICFs are then centered on the footing. Vertical and horizontal reinforcements placed within the forms per code before pouring the concrete. Walls are typically poured at a rate of 4' of lift per hour. ICF walls and foundations can easily be integrated with other concrete or metal floor systems that are either stacked or hung from the walls. The walls are the same thickness as dimensional lumber and can be integrated with conventional stick-framing methods for top plates for floors and roofs. ICFs can also be used for lintels and beams. Window and door openings require casing with dimensional lumber or a manufactured casing. Interior and exterior finishes can be applied to the fastening strips that are generally spaced at 8" or 16" on-center. Electrical fixtures and wiring are installed by cutting channels in the EPS either on the exterior or interior of the wall. Plumbing walls should be designed so that they are not located on an exterior wall.[1]

Speed: Depending on the skill and experience of the installation contractor and the size of the project, the ICF form walls can be installed quickly. A typical wall and foundation system can be installed in a few days, and the concrete takes around 7 days to cure. The forms are premade by the manufacturer, which cuts down on the time that would be needed for typical site-cast methods.[2]

Delivery Method: Insulated concrete forms can be ordered through a local distributor. Shipping times vary between manufacturers and distributors.

Required Equipment: Required equipment for installation includes a cement mixer, concrete pump, concrete vibrator, cut-off machine/saw, pruning saw, electric chainsaw, rebar bender/cutter, hammer drill, reciprocating saw, in addition to standard framing and concrete hand tools.[3]

Specialized Labor: An authorized ICF contractor should do all of the installation for ICF walls and foundations, including the pouring of concrete. Other licensed contractors should be hired for mechanical, electrical, and plumbing systems. Coordination between the trades

(Fig. 1) Insulated Concrete Formwork is most commonly used in wall construction and combined with other systems, such as wood stick-framing for the roof structure, as shown above.

(Fig. 2) Manufactured exterior components are available from many manufacturers for installing custom detailing.

should be done carefully, as the construction sequence is slightly different than conventional stick-framing (i.e., plumbing vents need to be placed within the wall-forms before pouring).[4]

PERFORMANCE

Wind Load: Design wind-speed for most ICF systems is 150mph.[5]

Water Resistance: Manufacturers may provide a waterproofing membrane to be applied to the exterior of the ICF walls. Typical house-wrap can also be installed as a vapor barrier to the exterior walls. ICF walls are made of non-biodegradable materials, and therefore are not subject to rot.[6]

Energy / Thermal: ICF walls generally have higher R-values than a 2x4 or 2x6 stud wall, depending on the thickness of the EPS/XPS insulation. R-values typically range between R-17 and R-26.[7]

Lifespan: This system is not old enough to accurately assess the lifespan. Many manufacturers and installers offer a warranty of up to 50 years.

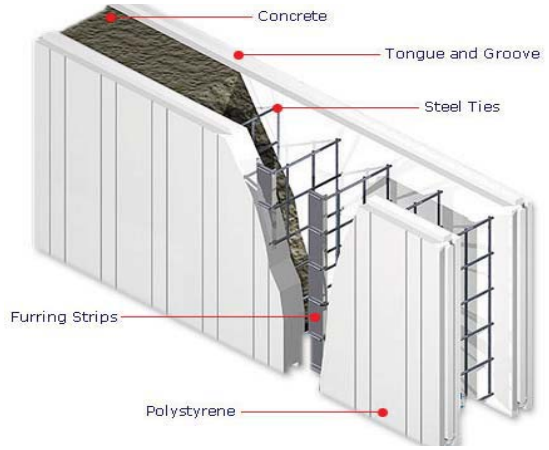
Common Failure: Common failures with ICF construction are: lack of fire-resistance in certain types of rigid foam, termite infestation, moisture problems, and difficulty adhering finish materials on the exterior or interior. [8]

DESIGN

Environmental Impact: Because the forms are used in the final product, there is less construction waste than in cast-in-place methods. The EPS or XPS insulation yields higher R-values than batt-insulation, leading to lower heating and cooling costs for the user. Concrete and foam insulation require high levels of energy in the production of the material.

Versatility / Flexibility: Walls are limited to 10' in height and foundations are limited to 12' for residential applications. The design should not exceed 2 stories above grade and one below grade. The maximum recommended building dimensions are 80' x 40'. ICF systems can be used with almost any floor or roof system, and most exterior and interior finishes can be used in combination with the ICF walls.[9]

Market Exposure: ICF systems are gaining exposure along the Gulf Coast due to their reputation for durability. The higher cost for materials is the main limiting factor for



(Fig. 3) Above shows the basic components of all ICF wall systems. Often, the steel ties are collapsible for flat shipping.

(Fig. 4) A small crew of just a few laborers is needed to stack the formwork.

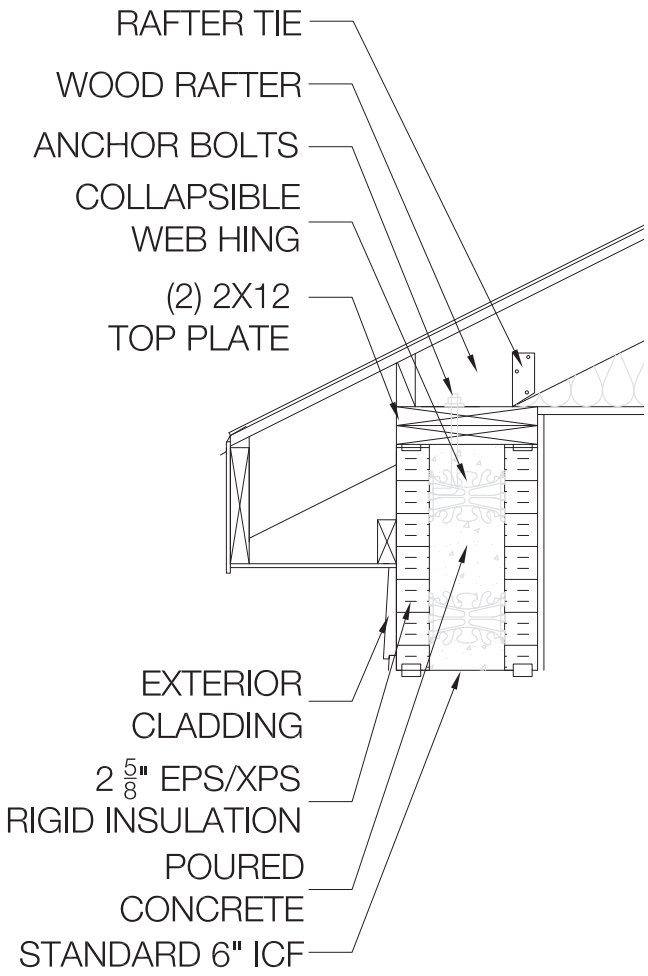
(Fig. 5) ICF walls offer superior acoustic insulation, making them a good choice for partition walls in multi-family projects.

the popularity of this product.

Code Approval: Depending on the location of the project, a licensed architect or engineer may need to approve the project design before construction. ICF walls and foundations should be inspected according to municipal requirements.

Affordability: ICF walls and foundations are more expensive than traditional wood framing. The material cost (for the forms) ranges from $1.75 to $3.50 per square foot. This does not include the cost for bracing, rebar, and concrete (which currently is approximately $100 per cubic yard). Additional labor costs may occur, depending on the installation contractor. Also, there may be additional labor costs for mechanical, electrical, plumbing, framing, and finishing contractors if they are unfamiliar with the product and have to change their methods of working to accommodate the ICF walls. Because of the increased thickness of the walls, there may be additional costs for materials for window and door openings.[11]

Coastal Considerations: A homeowner may be approved for reduced insurance rates through the Mississippi Wind Pool Reduction program.[12]



(Fig. 6) Typical wall and roof connection between an ICF wall and wood-framed roof system.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Retailers in the Gulf Coast area include:

- Green Elephant Construction Supply
- Build Block of South Mississippi
- Coastal Polysteel, LLC
- ECO Specialty Systems, Inc.
- Mississippi Green Built

Manufacturers being used in the area include:

- Nudura Integrated Building Technology
- AMVIC Insulated Concrete Forms
- ECO-Block
- Mississippi Green Built

Installers in the Gulf Coast area include:

- Bailey Homes
- Millennium Walls, Inc.
- Delta Builders

(Fig. 7) ICF walls are poured with concrete in 4′ lifts, horizontally, with a concrete pump.

Concrete Masonry Units

Overview: Concrete Masonry Units (CMU) are cast concrete blocks that come in uniform sizes. A typical CMU block (United States) is 8x 8x16, with these dimensions including the 3/8 of an inch mortar joints between blocks. Their strength depends on the density of the block, which increases as finer sand and gravel is used as the aggregate in the concrete. CMU block wall construction is typically used in commercial, industrial, and institutional applications (i.e. car washes, garages, cafeterias, pools). CMU walls in residential applications are typically a structural wall with a brick exterior.

INSTALLATION

Construction Process: CMU block walls are typically stacked, similar to bricks, in overlapping horizontal courses. Because of their weight, CMU block walls usually are placed on slab-on-grade foundations, or on CMU block stem walls. Vertical rebar is set into the foundation, which then runs through the blocks with structural mortar poured into the cavities after the blocks are set. Ties and hold-downs can be set into the wet mortar at the top of the wall for connecting to roof structures. Horizontal reinforcement can be laid between courses, and steel ties are used to connect CMU block walls to exterior brick walls.

Speed: The speed at which a CMU block wall can be installed is dependent on the amount of labor available.

Delivery Method: CMU blocks can be delivered to the jobsite in a truck. A larger, flatbed truck may be necessary, depending on the amount of block needed for the project.

Required Equipment: Required equipment for installation includes a cement mixer, concrete pump, concrete vibrator, cut-off machine/saw, pruning saw, electric chainsaw, rebar bender/cutter, hammer drill, reciprocating saw, in addition to standard concrete hand tools.[13]

(Fig. 8) A stringline is used to lay the first course of a CMU wall.

(Fig. 9) CMU wall construction is commonly found in institutional applications, such as this school shown above.

(Fig. 10) Reinforced lintels are used to span window and door openings in walls. Above, the CMU blocks are turned vertically so rebar can be set horizontally through the cavities.

Specialized Labor: Any experienced mason should be able to work with CMU block walls, as this is the most typical and standard form of concrete wall and foundation system.

PERFORMANCE

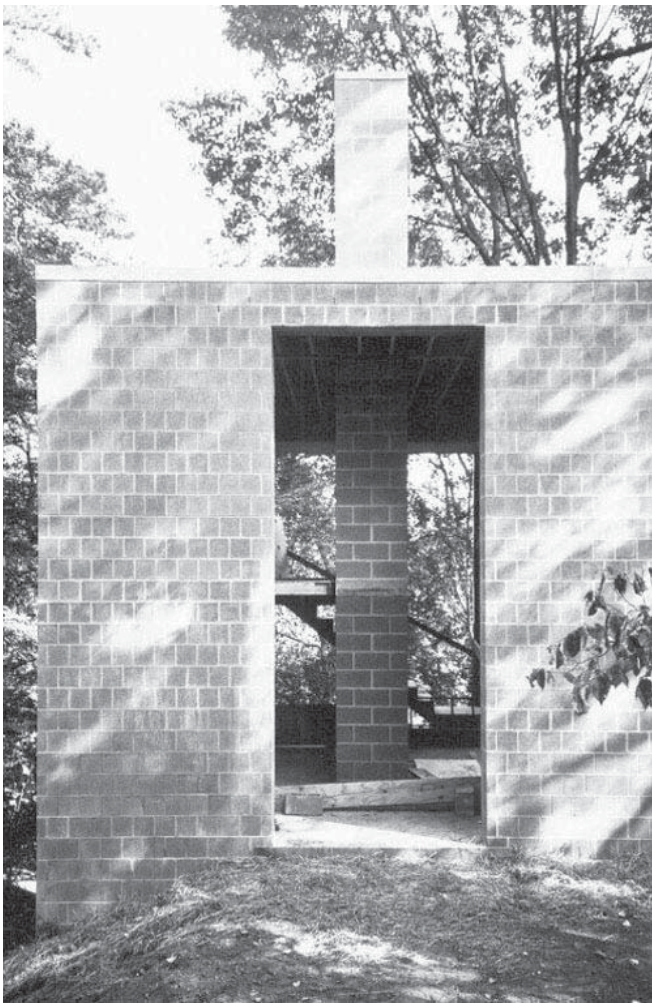
Wind Load: The design wind-load capacity of a CMU block wall is dependent on the amount of reinforcing (both horizontal and vertical).

Water Resistance: CMU walls are water absorbent. Exterior walls need to be sealed with a water repellent , or covered with a moisture barrier and exterior finish materials.[14]

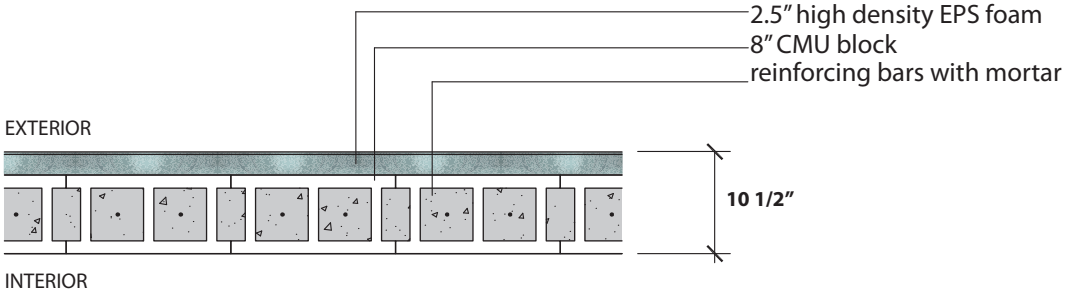
Energy / Thermal: CMU walls have low R-values, and therefore should be combined with an insulation method (see ch. 7: Insulation) in order to meet code. [15]

Lifespan: CMU construction has a long lifespan, if installed correctly and maintained. Because of the durability of this material, homeowners may apply for a reduction in insurance rates through the Mississippi Wind Pool Reduction.[16]

Common Failure: Common failures in CMU construction typically are a result of water and temperature damage. Expansion and control joints should be properly placed within the courses of the wall (see local building code requirements). Vertical and horizontal cracks within the mortar joints are signs that there is structural damage within the wall, and should be inspected by an expert to determine the correct method of repair.[17]



(Fig. 11) Above, the CMU blocks are turned sideways to show variation in the course pattern.



(Fig. 12) Above is a typical wall section of a CMU wall with rigid insulation. The R-value for this wall is approximately 13.

DESIGN

Environmental Impact: Concrete masonry units are fairly innocuous products, but they are not renewable resources like wood. They can incorporated reused material that would be otherwise landfill-bound, such as flyash. Adding a small amount of flyash, a by-product of coal combustion, improves workability and also helps reduce corrosion from salt air and moisture in the concrete mix.

Versatility / Flexibility: CMU blocks are typically 8" high, 8" deep, and 16" wide (including 3/8" mortar joints). CMU walls are difficult to construct on elevated foundations, as they are heavy and require overlapping reinforcement between the foundation or floor and wall. CMU blocks come in a variety of finishes and textures.

Market Exposure: CMU construction is typical in commercial and industrial applications. For residential applications, CMU is typically used in foundations, not in walls. The material is easy to find at any building supply retailer.

Code Approval: CMU masonry construction is accepted by the ICC as a construction material.

Affordability: CMU block walls cost approximately $3.00 per square foot. This is comparable to AAC block walls, and about 10% more expensive than wood framed walls.[18]

Coastal Considerations: Due to the porosity of this material and susceptibility to water damage, mold and indoor air quality issues are a concern when using CMU as a construction material on the Gulf Coast. Appropriate sealing, covering, and venting of the material should be designed. Additionally, an architect or engineer should approve reinforcement schedules and installation methods, in order to ensure a wall system that is strong enough to withstand high wind loads. A homeowner may be approved for reduced insurance rates through the Mississippi Wind Pool Reduction program.[19]

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Retailers in the Gulf Coast area include:

Any building supply retailer should carry CMU blocks.

Installers in the Gulf Coast area include:

Most construction contractors should be able to perform installation of CMU walls. Some local contractors specifically working with masonry walls are:

- Benefield Masonry
- Brothers Masonry
- Duke Masonry
- Jones Masonry Contractors Inc.
- Magee's Masonry
- Sky Masonry
- Smith Stoneworks
- Tiger Masonry

(Fig. 13) CMU walls are often used for exterior walls, in combination with interior wood stud walls.

(Fig. 14) Many split-face textures and colors are available for CMU blocks.

Autoclaved Aerated Concrete

Overview: Autoclaved Aerated Concrete (AAC) is a pre-cast block wall component made of a mixture of cement, lime, water, sand or flyash, and aluminum powder. During the manufacturing process, the aluminum and concrete react together, forming tiny hydrogen bubbles that expand the concrete up to five times the original volume. After the hydrogen evaporates, the closed-cell aerated concrete is formed by steam curing in an autoclave, or pressurized chamber. The final product is non-toxic and is reported to generate no pollutants or hazardous waste during the manufacturing process. In addition to being used for wall components, AAC can be formed for lintels as well as floor and roof panels.[20]

INSTALLATION

Construction Process: Typically, AAC walls are laid in a running course, with a layer of structural mortar beneath the first course to bond to the sill. The top side of each course is serrated with a hand tool during construction in order to adhere better to the thinset adhesive that is applied between each course. Blocks are pre-drilled with vertical holes for reinforcing bars to be placed within the walls, according to local codes. These holes are then filled with structural mortar. U-shaped blocks are typically used for lintels above windows and as bond-beams at the top of walls, so that ties and bolts can be set into the mortar.[21]

Speed: In a study done by Hughes Construction of Lexington, NC in December of 2005, AAC walls took 5.5 times longer to construct compared to typical wood-stud framed walls.[22]

Delivery Method: AAC blocks can be delivered in any size truck, depending on the quantity desired. Because the blocks are lighter in weight than CMU blocks, shipping costs may be lower.

Required Equipment: A mason's level is used for plumbing the corners of walls, and a serrated edge application tool is needed to apply the thinset adhesive. Also, a heavy-duty drill with a 3-1/2 inch sized bore and extended bit is typically used to drill holes for reinforcement bars. If AAC panels are used for wall construction, a crane for lifting the panels into place may be necessary. No other special equipment is necessary for installation.[23]

Specialized Labor: A typical residential project can be completed with 2 experienced masons and one general laborer.[24]

PERFORMANCE

Wind Load: Wind load capacities vary depending on the grade of AAC used and the amount of reinforcement within the walls. AAC walls need to be engineered to meet minimum local wind load requirements.

Water Resistance: Because AAC blocks are made of closed cells, they are relatively resistant to water. A moisture barrier is recommended for the exterior of the wall to limit the amount of water that may infiltrate the envelope.[25]

Energy / Thermal: The R-value of AAC units is approximately 1.25 per inch, with variations due to the density of the concrete. An 8" AAC wall used in combination with an applied wall insulation will result in high thermal resistance. A 12" AAC wall has a high enough R-value that wall insulation is not necessary.[26]

Lifespan: Due to the inherent qualities of the material,

(Fig. 15) Tiny hydrogen bubbles are created when the concrete is combined with aluminum powder.

AAC is naturally resistant to termites, water, and fire, which inevitably may lead to a longer lifespan than other materials. Because the quality of construction using this material is dependent on proper installation and engineering, there is little data regarding life span of the product, and most manufacturers do not offer a warranty on the material.

Common Failure: Unprotected AAC deteriorates when exposed to extreme cycles of freezing and thawing while saturated, making this material a poor choice for northern climates.[27]

DESIGN

Environmental Impact: AAC is made of entirely natural, raw materials. It does not produce pollutants, nor does it off-gas. It is also recyclable and has an extremely low-impact manufacturing process.[28]

Versatility / Flexibility: AAC block units are between 4" and 16" thick, 8" high, and come in 24", 32", and 48" long units. Panels are typically available between 8" and 12" thick, 24" wide, and up to 20' long. Because the panels and blocks are easy to cut on-site with a hand or power saw, this material has good versatility in design. Exterior and interior walls can be incised to create reveals, signage, bas relief, or textures. AAC can be used in combination with most floor, foundation, and roof systems. AAC is also lightweight, and may be a good material choice for building on sites that do not allow vehicular access.[29]

Market Exposure: AAC wall systems have been popular in Europe for over 50 years, and most notably in Sweden, where AAC was invented. Only within the last 20 years has AAC emerged in U.S. markets.

Code Approval: Currently, prescriptive AAC construction methods are not mentioned in conventional building codes, such as the IRC. Some experts recommend submitting the product ICC-ES report with architectural plans to local municipalities for code compliance and enforcement.[30]

Affordability: AAC block walls cost approximately $3.00 per square foot. This is slightly more than CMU block walls, and about 10% more expensive than wood framed walls.[31]

Coastal Considerations: Because this material's strength depends on the construction methods and amount of reinforcement, we recommend hiring an engineer to determine the density and strength of AAC walls if building in an area that is susceptible to high winds. This material is extremely resistant to rot and mold as well as heat transfer, therefore (depending on the quality

(Fig. 16) This AAC constructed house survived a wildfire. AAC blocks are highly fire-resistant.

(Fig. 17) AAC blocks are easily cut on-site without the need for special saws or blades.

(Fig. 18) Vertical holes are drilled through the blocks for reinforcing bars. After the bars are set, the holes are filled with structural mortar.

of interior finishes) this material may be one of the best choices if indoor air quality is a priority for construction. A homeowner may be approved for reduced insurance rates through the Mississippi Wind Pool Reduction program.[32]

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Manufacturers being used in the area include:

- AERCON Florida, LLC
- Omnicrete Development, Inc.
- Safecrete
- Hebel, USA
- Xella
- ACCOA

(Fig. 19) AAC blocks are easily brought to a site with lower shipping costs because they are lightweight.