SUPER SHELTERS

These eight unique homes showcase non-conventional structural systems, demonstrating the strength, efficiency and durability that will see them through whatever the next century holds.

BY SARAH LOZANOVA

SITE-BUILT, WOOD-FRAMED construction dominates the new homebuilding industry. And no wonder: it’s fast, inexpensive and standardized. But is it always the most sustainable and resilient choice? On the following pages we’ll examine the pros and cons of some “alternatives” to conventional stick frame construction including straw bale, structural insulated panels (SIPs), aerated autoclaved concrete block and modular methods. Some of these time-honored methods go back millennia; others are cutting edge but they’re all mindful of resources, promote energy efficiency and durability—the hallmarks of resilience.

In this issue we’ll also begin a year-long exploration of resilience. In the face of climate change and the accompanying uncertainty around resources, we need homes that can supply their own power and water and bounce back in the face of disaster—homes that are strong enough to withstand hurricanes, storms and floods, and that are prepared for fires and earthquakes and power outages. Like a healthy ecosystem, resilient homes have built-in redundancy: if one system fails there’s another one backing it up. Look for our “Keys to Resilience” throughout this story and in issues to come.
ARBORWALL COMBINES FACTORY EFFICIENCY, RAPIDLY RENEWABLE CEDAR AND A UNIQUE WALL SYSTEM TO CREATE DURABLE HOMES WITH FLEXIBLE DESIGN OPTIONS.

ARBORWALL BRINGS LONG-LASTING, energy-efficient log homes with a contemporary look to the custom built home market. Based in northern Maine, the company pairs solid log construction with a state-of-the-art precision custom manufacturing process that avoids human error and saves time on the construction site.

“We now have this proprietary building system that has all the benefits of the solid log construction—the structural element and the ability to use continuous insulation and be super energy efficient but not look anything like a log home,” says Gabriel Gordon, Arborwall’s managing director.

These innovative homes are constructed of northern white cedar, a material that naturally repels insects and protects against rot and mold, eliminating the need for chemically treated wood. At R-1.5 per inch, northern white cedar also has the highest insulative value of any tree species.

“If you are building anything that has to withstand the elements and you don’t want to chemically treat it, northern white cedar is superior to any other species of wood” says Gordon “That is why you see cedar shingles on coastal homes.”

A

The Log Home, Redux

The Modern Log Cabin. Each Arborwall home is custom designed and manufactured. One of the company’s first projects was for a family vacation home on Maine’s central coast.
The company uses Forest Stewardship Council–certified cedar from Katahdin Forest Products, Arborwall’s parent company. The cedar logs are milled into interconnecting 6” x 6” timbers, then air- and kiln-dried. During the manufacturing process, the cedar timbers are pre-drilled with holes for ¾” lag screws, using a computerized process. The hole locations are varied so screws don’t overlap. The finished walls are lined with a double layer of rigid foam insulation, eliminating thermal bridges and boosting comfort.

The exterior façade of shiplap or clapboard transforms the look of Arborwall log homes, eliminating the round accents that are typical of log construction. The interior can be finished for either a modern or rustic look, as desired.

Katahdin employs innovative no-waste strategies: all parts of the tree are used in a variety of products; in addition, sawdust powers a biomass boiler that heats the facilities, and ethanol from potato scraps sourced from nearby farms helps fuel mill vehicles.

Arborwall recently teamed up with Rockport-based Phi Home Designs, a well-established company that specializes in both advanced home design and interior finishing.

**Complete Package.** The Arborwall home kit includes everything needed to construct the home above the foundation, including floor framing, exterior and interior walls, windows, doors, trim, stairs and interior tongue-and-groove paneling.

**Arborwall System at a Glance**

**Pros:**
- Northern white cedar is renewable and naturally regenerating, growing faster in Maine than it is being harvested.
- Wood doesn’t require chemical treatment.
- Cedar provides natural rot and insect resistance.
- Solid log cabins are durable, withstanding many natural disasters.
- Each home is custom designed.
- Timbers are precut drilled labeled and bar coded in the mill.
- The construction process is quick with very little waste.

**Cons:**
- The timbers are milled in Northern Maine far from many population centers.
- Specialized materials are needed that are not stocked at lumber yards.
- The design must be finalized before construction and can’t be easily altered during construction.
- Solid wood is not the best choice for fire resistance.

**Innovative Insulation.** An insulating 1/8 inch layer of sealed air space is created by applying strips of strapping to the inside surface of the double layer of rigid insulation. The interior finish material is applied to the furring strips.

**Solid Construction.** Arborwall homes are built with interlocking corners and tongue and groove joinery. The construction creates a continuous wall of solid cedar timbers around the entire perimeter of the home.
Sustainable Building Blocks

E2 HOMES USED AERATED AUTOCLAVED CONCRETE BLOCKS TO CONSTRUCT A NET-ZERO ENERGY HOME—AND “DOE CHALLENGE HOME WINNER”—IN A DIFFICULT SOUTHERN CLIMATE.
HVAC system to be downsized by 30 percent. AAC blocks are also mold resistant, an appealing attribute for Mr. Wilson who wanted to avoid moisture issues in the hot, humid climate where he lives.

As a residential construction firm specializing in custom luxury homes throughout Central Florida e2 Homes brings a thoughtful and flexible approach to green building. e2 is experienced in green certification programs and roughly half of its clients wish to pursue LEED certification for their projects.

AAC Blocks at a Glance

**Pros:**
- More fire resistant, lighter (1/3 percent lighter than clay blocks of the same size) and better insulator than conventional cement
- Durable
- Insect and rot resistant
- Sturdy; structures can be designed for earthquake and hurricane resistance
- Insulating and soundproofing qualities
- Recyclable and less material intensive than conventional cement using 15 percent less energy
- Simultaneously provide structure and insulation with low maintenance costs

**Cons:**
- R-value for 8-inch Aercon wall is 11.5 but with a greater thermal mass than for a stick frame home
- Non-allergenic material results in high indoor air quality; can be finished with non-toxic plaster and stucco
- Blocks may contain fly ash a by-product of coal combustion that is not always tested regularly for toxic contamination
- Most American contractors are unfamiliar with the product and so require training
- There are few AAC block manufacturers in the United States which boosts the cost of the product

**AAC Blocks Stack Up.** Aercon’s standard AAC blocks range in size from 4” x 8” x 24” to 10” x 8” x 24”. Low thermal conductivity combined with thermal mass effect make for an energy efficient building system.

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Healthy Homes, Naturally

THE ECONEST COMPANY COMBINES NATURAL MATERIALS AND FINISHES WITH THOUGHTFUL, HOLISTIC DESIGN TO CREATE HEALTHFUL AND NURTURING SPACES FOR ITS CLIENTS.

**EcoNest Clay/Straw and Timber-Frame System Sample Project**
- **Name:** Little Residence
- **Location:** Santa Fe, New Mexico
- **Size:** 1,300 square feet
- **Year Completed:** 2007

**HealthyHomes, Naturally**

**Above Customized Designs.** The Little residence overlooking the Sangre de Cristo foothills was built for two yoga teachers. It features a timber frame structure, clay/straw walls and a metal roof with large overhangs.

**AAC Blocks at a Glance.**

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The walls contain a mixture of liquefied clay and regional straw, which provides an R-24 insulation value. When the 12-inch exterior walls are load bearing, they include 2" x 4" Larsen trusses with a bamboo matrix, 24 inches on center, to support the clay/straw and reduce shear and settling. When a timber frame is used, the perimeter walls are not load bearing, eliminating the need for a double top plate.

Clay acts as a natural cement, gluing the mixture together and protects the straw from water, rot and insects, while the straw serves as insulation. The clay/straw combination form a dynamic system, both insulating and storing thermal energy. The typical EcoNest home contains 20 to 30 tons of mass, resulting in very stable indoor air temperatures.

“What makes clay straw walls so durable that 500-year-old structures are found throughout Europe and Asia?” asks Laporte. “Clay is the secret agent here—creating walls that are virtually non-combustible, rot and rodent proof, and humidity and temperature balanced.”

THE ECONEST COMPANY has innovated a unique light frame matrix that wraps timber-framed structures with one-foot thick claystraw walls. The company’s handcrafted heirloom homes begin with a holistic design by Paula Baker-Laporte, FAIA. Her designs make efficient use of space, maximize passive solar gains and fit the unique personality of the homeowner. She and President and Co-founder Robert Laporte take pride in creating customized homes that fit the homeowners “like a glove” and have very high air quality. “Green building falls short of the target unless it delivers a healthy living environment” says Laporte. “This is where EcoNest stands at the top of the scorecard. It does so because it uses 90 percent unprocessed natural materials sourced within a 50-mile radius.” The remaining 10 percent of the materials are closely scrutinized for toxicity.

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EcoNest Clay/Straw and Timber-Frame System at a Glance

Pros:

- Longevity: homes are built to last for centuries
- The building-system honors Old World craftsmanship and incorporates the 25 Principles of Building Biology for optimum health
- The systematic technology is easily adapted by mainstream conventional builders
- Non-toxic and natural building materials contribute to high indoor air quality
- Sound ecological practices promote environmental stewardship
- Materials are sourced locally, contributing to low embodied energy of projects

Cons:

- Continuous walls avoid thermal bridging
- This building approach was accepted into the International Residential Code
- Wet technique requires thorough drying before the application of finish materials
- Not a good option in areas that lack suitable clay
- Some building departments may be unfamiliar with the process making permitting more difficult
- The technique requires above-freezing temperatures for building
- Construction method is labor intensive

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Regional Materials, Local Labor. An elevated slip tank and a tumbler are used on the job site for the clay/straw mixture. The average 1,500-square-foot home uses seven tons of clay and three tons of straw to create dynamic insulation. CREDIT: COURTESY ECONEST

The National Fire Protection Association (NFPA) reports that in 2013, U.S. fire departments responded to 1.25 million fires, which resulted in 3,240 deaths, 15,925 injuries and $11.5 billion in property loss. The majority 99% of deaths were caused by home fires. While building to NFPA standards can improve a home’s resistance to fire and/or help ensure occupants can exit a burning building safely, installing fire sprinklers can preserve both lives and structures—the ultimate sustainable practice. Home fire sprinklers can control (and may even extinguish) a fire in less time than it would take the fire department to arrive on the scene. A collaborative study by FM Global and the Home Fire Sprinkler Association reports that installing home fire sprinklers can reduce the greenhouse gases released by a burning building by 98 percent. Fire sprinklers also prevent the release of polluted water into the environment.

www.nfpa.org

Fire Insurance. Uponor’s AquaSAFE residential fire sprinkler systems combine with a home’s cold water plumbing system.

www.uponor-usa.com
Enertia’s double shell mimics the earth’s atmosphere and its ability to capture and store heat. The temperature differential between the basement and attic creates a dynamic thermal current in the home’s outer shell. In the winter, cooler basement air is heated in the “sunspace” (a sunroom on the south side of the home) and circulates around the inner shell, storing the heat in its walls, ceilings, and floors. In the summer, when the angle of the sun is higher in the sky and strikes the roof, hot air is released through an attic vent or through the east and west gables. This causes cool air to be drawn in from the basement’s northern...
Enertia Double-Shell Building Systems at a Glance

Pros:
- Fast, economical construction method.
- Wood is pre-cut at the factory, minimizing waste.
- Heating and cooling costs are significantly reduced.
- Passive heating and cooling do not depend on electricity or fuel.
- Homes are constructed using natural, rapidly renewable resources.
- Solid wood construction is wood intensive.
- The double shell design boosts the price by 10 to 15 percent this can be partially offset when an HVAC system isn’t used.
- The design must be finalized before construction, and can’t be easily altered during construction.

Cons:
- Specialized materials are required that are not stocked at lumber yards.
- Solid wood construction is wood intensive.
- The double shell design boosts the price by 10 to 15 percent, this can be partially offset when an HVAC system isn’t used.
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Because of the massive structure the temperatures in the inner shell—including its walls, ceiling, floor—remain relatively constant despite abrupt changes in outdoor temperatures. The outer shell—which includes the basement, attic and sunspace—fluctuates more depending on weather conditions. In sunny climates, such as Colorado and Utah homes do not require an HVAC system. In climates with less winter sun a back-up radiant floor heating system is recommended. Enertia homes use rapidly renewable southern yellow pine for its solid wood walls. The tongue-and-groove wall elements are made by glue-laminating four pieces of wood, which are pre-cut in a factory. There, electric boxes are milled into the wall elements along with pre-drilled holes for wires. Plumbing lines are in the 2” x 4” partition walls. Extra insulation is added in extremely cold climates. “The wall elements are numbered, and they go together like Lincoln Logs,” explains Michael Sykes, founder of Enertia Building Systems. “People without any building skills can build a home just using an electric drill. If you have the time it can save a lot of money. The timbers are 100 percent renewable, and they are put together with screws—so they could be repurposed forever.”

Source: Earthquake Safety
Modular Marvels

INSPIRED BY THE NOTION OF STREAMLINING SUSTAINABLE BUILDING, SEATTLE-BASED GREENPOD DEVELOPMENT CREATES ENERGY-EFFICIENT, LOW-MAINTENANCE MODULAR HOMES WITH HEALTHY INTERIORS.

GreenPod Sample Project
Name: WaterHaus
Location: Port Townsend, Washington
Size: 450 square feet
Year Completed: 2012
www.greenpoddevelopment.com

Whole Package. GreenPod’s model Waterhaus includes all of the “ingredients” for sustainable, resilient, energy-efficient, small, flexible living: healthy, indoor finishes, local funding and craftsmanship.

Concept House. GreenPod’s award-winning Waterhaus features a graywater system and a vertical garden and waterfall.

continued on next page
**Key to Resilience: Energy**

Evere Weather is the number one cause of power outages in the US. The Department of Energy recognizes the imperative of creating a more resilient grid is key in the face of climate change which is spawning more intense storms. We can make our homes more resilient too by making them more energy efficient and incorporating on-site energy generation.

- **Renewables**: On-site energy systems such as solar PV - solar thermal and wind can help protect a home from rising electricity costs and power outages.
- **Reduced energy**: Multiple strategies - from tighter envelopes and high-performance windows to efficient appliances and energy management systems can reduce energy demand - making homes more self-sufficient.
- **Back-up power**: Having a back-up fuel tank or generator in case of power outages for grid-tied homes or prolonged cloudy weather for off grid homes with solar PV systems ensures a home can continue functioning.

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**GreenPod Modular Homes at a Glance**

**Pros:**
- Sustainable - chemical-free - socially responsible and traceably sourced materials are used for interior and exterior construction.
- Effortlessly designed homes have a small footprint.
- The homes maximize natural daylighting.
- The homes are ideal for simple living, but their small sizes may not appeal to all homeowners.
- The homes are designed to fit a variety of budgets.
- The homes are pre-cut when they come out of the factory.

**Cons:**
- Availability is currently limited.
- Current building codes require airtight construction; therefore, diligence regarding toxic finishes and furnishings is important.
- Reducing plug loads and creating healthy neutral zones.
- Clay wall finishes, all-organic textiles, a biofilter refrigerator and the absence of combusting products promote superior indoor air quality.

**Finishing Details**

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**GreenPod Development** offers interior furnishing packages including furniture maximizing the utility of these small homes and helping people to downsize - while maintaining a high standard of living. The company currently serves Washington State and California but Raab says they are focusing on exporting concepts rather than the actual GreenPods so that other communities can develop networks to support sustainable healthy homes.
HEN RICKY CAPPE, a green building consultant, wanted to build a home on a modest budget. He started wondering how someone could build an affordable sustainable home. He found it impractical for each homebuilder to hire an architect and research the myriad of options on the market. He found the process very time consuming and expensive which inspired him to create sustainable, affordable kit houses.

Cappe’s Sustainable Affordable Kit (SAK) Houses are customizable contemporary green-home packages. Ranging from $5,900 to $9,500, they include a complete set of building plans, material recommendations, supplier contact information, a detailed building timeline and technical support from Cappe. Homebuilders simply hire the contractor and select the model and finishes saving tens of thousands of dollars in architectural fees and many hours of research—streamlining the process and saving time.

The SAK House has five customizable building plans to choose from which can be modified to suit specific geographical regions. All feature generous insulation, natural lighting, passive solar designs, and intelligent floor plans, reducing the cost of building a green home.

SAK House Kits Sample Project
Name: Cappe Residence
Location: Nelson, British Columbia
Size: 2,300 square feet
Year Completed: 2012
www.sakhouse.com

SAK House Kits at a Glance
Pros:
- Homes are energy and resource efficient
- Homes promote high indoor air quality by using building materials that don’t off-gas
- Plans maximize natural lighting
- Designs are modified for specific geographical regions
- Turnkey building plans material lists and construction timelines streamline the process making it easier to navigate the myriad of green building options

Cons:
- There are only five designs to choose from and the homes are not highly customizable
- Homes don’t “breathe” as an earthen home does
- The traditional construction industry is resistant to using SIPs

Streamlined Green
Sustainable Affordable Kit (SAK) Houses provide the homebuilder with a complete set of plans, material recommendations and supplier referrals.
“Architects alone take months and months of planning and redesign,” explains Cappe. “Why do we need to reinvent the wheel every time we build?”

The time and cost savings continue through the construction phase of the project. “The walls and roof are made of SIPs (structural insulated panels) which is almost like a puzzle but it comes with a map for how they fit together,” says Cappe. “The SIPs come in four-foot panels and the SIPs manufacturer builds in the headers for windows and doors and pre-drills electrical openings. When you put it together a lot of the work has already been done. It even cuts down on the time that some of the subcontractors put in.”

The walls on the first floor of the prototype SAK House were up in one day, the second floor took a day and a half, and the roof was up in a day. The SAK House designs utilize standing seam metal roofs because they allow harvesting of clean rainwater and are durable and recyclable.

Inspired by the motto “build it once and build it right,” Cappe is meticulous in selecting materials that require little or no maintenance. “All the materials that I selected were recycled, reclaimed or of really high quality,” says Cappe. “I tried to source materials from within 500 miles of the building site. No matter where the building site is, we source as many materials within that region as possible.”

Saving Resources: SIPs panels are nailed to studs that are four feet apart on center using less wood to frame the house compared to conventional stick-frame construction.

Smart Sting All SAK House models feature passive solar design including ample south-facing windows with generous overhangs.

Above: Energy Saver: The Jennings residence is a two-story home featuring a rammed earth first floor, passive solar design and virtually airtight construction. The forced air furnace is one quarter the size of what is typically required.

Earthen Elegance

RAMMED EARTH WALLS ARE NOT ONLY UNIQUELY BEAUTIFUL, THEY’RE HIGHLY INSULATED, DURABLE AND DON’T REQUIRE ANY FINISHING MATERIALS.

continued on next page
Rammed Earth at a Glance

**Pros:**
- The walls are termite resistant, noncombustible and good for soundproofing.
- It uses low-cost, widely available building materials.
- The building system has a very low environmental impact and is non-toxic and biodegradable (depending on the binders used).
- These high thermal mass homes absorb heat and slowly release it when the ambient temperatures are lower.
- Interior humidity levels are controlled by the earthen walls.

**Cons:**
- Construction is labor intensive without machinery (power tampers, mixing equipment, etc.).
- Homes are susceptible to water damage without proper protection and maintenance.

The finished walls are 18 inches thick in total with 6 inches of Roxul Mineral Wool insulation sandwiched between two layers of rammed earth. "The walls have an R-value of 27 with lots of thermal mass," Schmidt says. "If we have passive solar gain and [thermal] mass we have what you need to create a cycle for cooling and heating." The walls have an R-value of 27 with lots of thermal mass.

Schmidt says finalizing the plumbing and electrical plans before constructing the walls is imperative. "There are gang boxes, conduit and hose bibs that are designed into new homes or retrofitted inside or outside existing homes."

Schmidt says finalizing plumbing and electrical plans before constructing the walls is imperative. Gang boxes, conduit and hose bibs are placed during wall construction, as holes aren't drilled in the exterior walls afterwards. "Rammed earth construction does seem like a long procedure but it’s also a finished product," he says. It’s a simple system, and I can reuse the formwork again and again and again.”
IONEERS IN THE Nebraska Sandhills lacked trees and even good sod for home construction, so they used the material they had widely available: straw bales. A revival of this building method is underway, with homebuilders seeking the desirable qualities of these highly insulated, attractive and renewable homes.

Straw-bale homes are often finished with interior and exterior plaster or stucco. Once plastered, the walls are typically around 21 inches thick and about three times as energy-efficient as conventional stick-framed walls.

Straw-bale homes can be either load-bearing or non-load bearing. Load-bearing structures have straw bales serve as the structure for the home; these are typically simpler to build. Non-load-bearing structures, such as the Lamy residence in Jacksonville, Oregon, built by master straw-bale builder and teacher Andrew Morrison, feature a post and beam frame. Straw bales are infilled between the beams and serve as backing for the plaster.

Straw-bale construction requires a few tools that aren't common on a traditional construction site: a three-foot needle for sewing and resizing the bales and a weed whacker to clean them up. A tamper is used to straighten out the bale walls.

Reduced Heating Requirements.

The Lamy residence is heated with a modest radiant floor system, which runs through the attractive acid-stained concrete floor.

Straw-Bale Showcase.

Chris Keefe of Organic Forms Design collaborated with Andrew Morrison on the Lamy residence, a straw bale townhome in Jacksonville, Oregon.

Enduring Appeal

A HOME IN SOUTHERN OREGON SHOWCASES THE STRENGTHS OF STRAW-BALE CONSTRUCTION: ORGANIC, COMFORTABLE AND ENERGY EFFICIENT.

Straw-Bale Construction Sample Project

Name: Lamy Residence
Location: Jacksonville Oregon
Year Completed: 2006
Size: 1,800 square feet
www.strawbale.com
Straw-Bale Construction at a Glance

**Pros:**
- Straw is a low cost material
- Continuous insulation from straw bales avoids thermal bridging
- Straw is renewable, regenerates quickly and is widely available
- Compressed and plastered walls are naturally fire resistant
- Walls help stabilize and regulate humidity levels
- Bales can provide both insulation and structural support for the structure
- Plaster applied to bales adds thermal mass to the walls
- Construction method allows for curved walls, niches and window seats

**Cons:**
- Financing may be difficult
- Diligence is needed to avoid rotting in the bales from water damage
- Thick walls take up space
- Obtaining insurance for the home may be difficult

“Mesh provides backing for cabinetry and electrical work,” he explains: “It adds out of plane and in plane shear resistance to the wall. Plumbing lines are kept out of contact with the bales either in water isolation walls or in boxes. For the exterior finish, Morrison uses three coats of a lime plaster containing sand with the final layer containing pigment if requested. He doesn’t recommend using cement in the plaster. “Cement—although it is very strong—doesn’t breathe at all and tends to trap moisture in the walls” he explains “It has a brittleness to it which produces more cracks over time. Cracks become a potential issue for moisture intrusion into the house.”

Despite having straw bale walls with a high R-value, Morrison says many homebuilders overlook insulating the ceiling sufficiently. When he set out to build the Lamy residence he ensured that there was generous insulation in both the floor and the ceiling.

In the aftermath of a hurricane or flooding, spray foam insulation is an investment in future preparedness and protection. As the industry leader, Icynene drives a cutting-edge evolution of insulation with a comprehensive and innovative portfolio of high performance spray foam insulation. Our next-generation closed cell product, Icynene ProSeal™, sets a new benchmark in performance, applicability, range to help protect homes from extreme weather events. Learn more at: www.icynene.com
Boral® is Your Single Source for
Endless Design Possibilities.

Boral Roofing
Boral Roofing leads the industry in environmentally sustainable clay and concrete roofing products. Boral Roofing is the nation’s largest clay and concrete roof tile manufacturer. Included in our comprehensive portfolio of products are the only line of clay roof tile certified Cradle to Cradle®, cool roof reflective colors, clay tiles containing recycled content of up to 59%, Energy Star certification, and the revolutionary new concrete “Smog Eating Tile” with BoralPure® technology.

Cultured Stone® by Boral®
Cultured Stone® by Boral® has been at the forefront of innovation for over half a century. Proudly made in the USA, with over 100 colors and 20 textures that capture the beauty of natural stone, Cultured Stone® is an industry leader in manufactured stone veneer. Cultured Stone® is in a class by itself when it comes to building and thinking Green. We were the first manufactured stone veneer to receive an NAHB Green Building Product Certification and the only product to receive the GREENGUARD Children & Schools certification.

Build something great™
For more information visit www.Boral America.com