Alternative Construction Research Guide

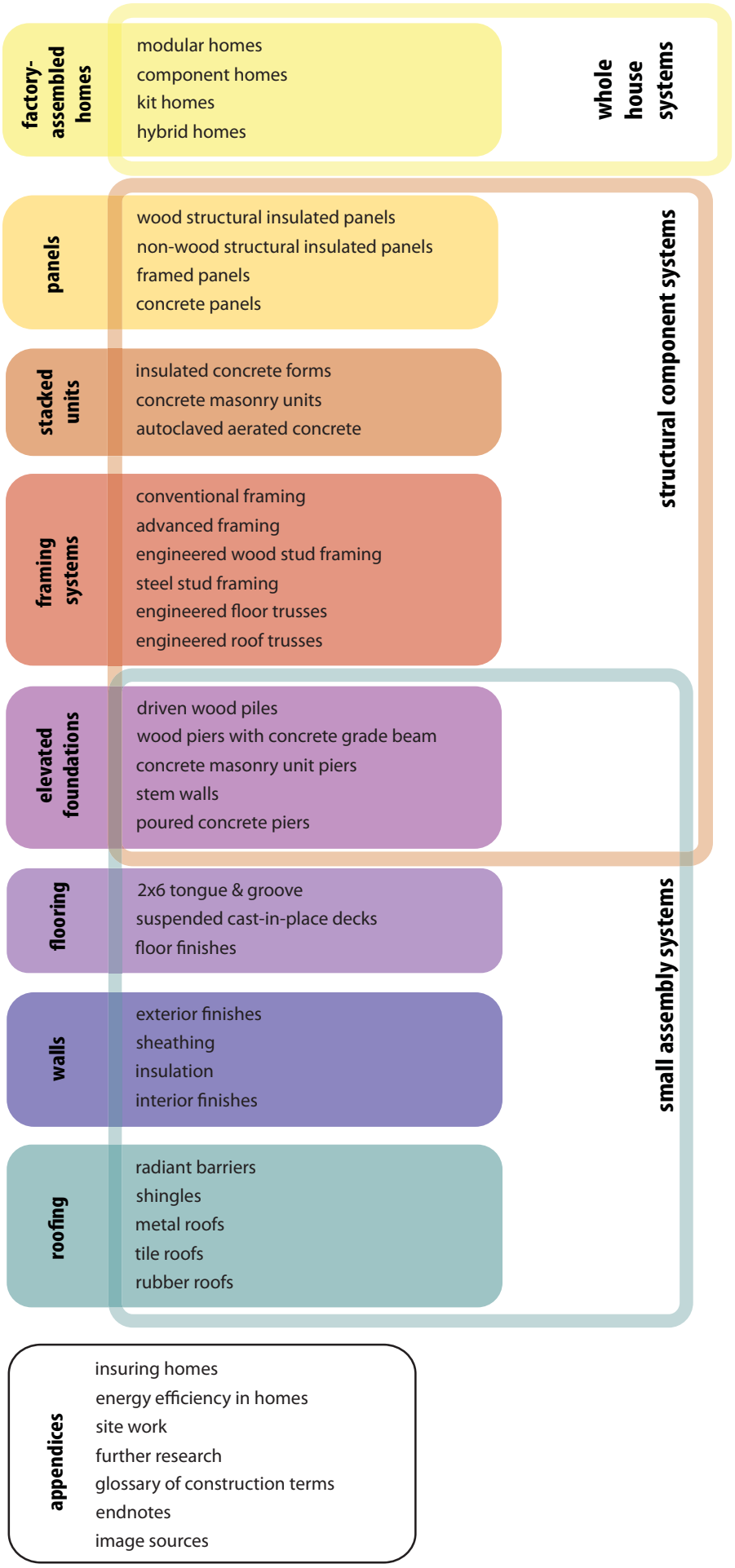
Methods for Building Communities
Gulf Coast Community Design Studio










factory-assembled homes
modular homes
component homes
kit homes
hybrid homes
whole house systems
panels
wood structural insulated panels
non-wood structural insulated panels
framed panels
concrete panels
stacked units
insulated concrete forms
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autoclaved aerated concrete
framing systems
conventional framing
advanced framing
engineered wood stud framing
steel stud framing
engineered floor trusses
engineered roof trusses
structural component systems
elevated foundations
driven wood piles
wood piers with concrete grade beam
concrete masonry unit piers
stem walls
poured concrete piers
flooring
2x6 tongue & groove
suspended cast-in-place decks
floor finishes
walls
exterior finishes
sheathing
insulation
interior finishes
roofing
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The Gulf Coast Community Design Studio hopes that this report will enhance the reader's awareness of alternative construction methods for residential systems. It must be emphasized that no specific product, material, technology, building system, or business practice included in this report is being endorsed by Mississippi State University, the College of Architecture, Art, and Design, or the Gulf Coast Community Design Studio. All research is provided in good faith, but accuracy is not guaranteed.

Before starting any construction it is important to consult with licensed architects, engineers, and contractors.

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GCCDS
Gulf Coast Community Design Studio
Mississippi State University College of Architecture Art + Design

Chapter Index

Introduction to the Alternative Construction Research Guide

PREFACE

Along the Gulf Coast, reduced volunteer labor, concern for structural stability, and increased awareness of environmental responsibility have caused many community builders to question their residential construction methods.

The Gulf Coast Community Design Studio (GCCDS), a research arm of Mississippi State University's College of Architecture, Art, and Design, is developing a series of tools to help those meeting housing needs in their communities. Our research will introduce housing providers to some alternative construction systems. Exposure to these systems will broaden the palette of construction choices housing providers use to build homes and communities.

This publication is a tool to help housing providers understand alternative construction systems. This continuing research is intended to inform community builders and housing providers of the variety of building choices available in the residential construction market place.

The GCCDS focused research on construction systems that have unusual performance capabilities and/or unique assemblies. We have tried to limit the discussion to building systems that seem reasonable for use regionally along the Gulf Coast, taking into consideration the availability, cost, performance, and suitability of a system. This is not meant to include all of the innovative construction systems that are available, and is merely an introductory guide to the alternative systems.

Our research is divided into categories based on the strategy of construction used, such as whole house systems, large structural component systems, or small assembly systems. Each strategy of construction is divided into smaller components that highlight a method or element of construction, such as panels, framing, floors, or roofs. These components are the basis for our chapters and the focus of our research. We have created an organizational system that can expand and accept new information as research or innovations make new construction products and methods available.

Each category is summarized, including common practices and some alternatives we find promising. A matrix on the back of each divider represents the advantages and disadvantages we see in sub-categories of the subject. We encourage housing providers to take this research guide as a starting point and add their own information and preferred products into the appropriate categories.

As availability and cost affect systems, or as new products become available, a document such as this could adjust and expand to include different content.

The GCCDS will be publishing both web and hard copy versions of this report and our continuing research on the web. For more information, please visit our web site at http://www.gccds.org/

RESEARCH CATEGORIES AND QUESTIONS:

Overview: Research in this guide does not directly rate one product or system against another. Many of the systems are too complex and the advantages and disadvantages too nuanced for a quantitative rating system. Instead, we have tried to ensure that we ask the same questions of each product or system. Across such a wide spectrum of material the same question has yielded many different answers. We have tried to cover important issues so that a reader can grasp the general strengths and weaknesses of each system. We also note when a system has met a certain bench mark, such as Energy Star or Wind-Resistant construction. We anticipate this will spur additional questions and research on the part of the user.

A list of categories and the questions asked:

INSTALLATION

Construction Process

How many people are needed? Are there a lot of steps? What is the general order of procedures? Are there a lot of details and measurements? What might be unusual about the way this product or system is put together?

Speed of Construction

How long does it take to complete this process? Does it take time to cure? How long does each step take? How does it compare to similar systems?

Delivery Method

How do the materials get to the site? What vehicles are used? Is it delivered from a warehouse or directly from a factory? Is it ready for installation or does it require on-site work after delivery?

Required Equipment

What specialized equipment is needed beyond typical construction tools? Are special cranes, machines, vehicles, or tools needed to lift, place, or secure the products or systems?

Specialized Labor

Are any specialized contractors or installers needed? Do the builders need to have any extra skills or training? Does it require other contractors to have a working knowledge of how their system works with it?

PERFORMANCE

Wind Load

What level of wind speeds can the material handle without damage? Does it qualify for insurance reductions? Is it more costly to insure than similar products?

Water Resistance

How well does the material handle exposure to water? Does it become damaged or stop working if it gets wet? Is it particularly susceptible to mold growth?

Fire Resistance

What is the fire rating for this system? Is it particularly resistant to fire? Is the smoke toxic when the material is burned?

Energy / Thermal

How well does this insulate a home? Does it act as a thermal bridge? Does it seal the house tightly? Does it help reduce the amount of energy needed to cool or heat the home?

Life Span

How long does this product last? Will it need to be replaced? How long does it keep working, and what happens to it after it is taken out of a home?

Common Failure

What are the likely problems one might have with this product? Where is it likely to fail? Under what conditions is it likely to fail? What are the warning signs? What happens when it stops working?

DESIGN

Environmental Impact

How does this product affect the environment in positive or negative ways? How can it be used to be least taxing on the environment? Does it create health concerns for the home owner?

Versatility/ Flexibility

What are the different ways one can use this product? Does it work well in connection with other products? Can it be used inside and outside? Can it be modified on site as the project changes?

Market Exposure

How available is the product? Is it available through suppliers, subcontractors, light manufacturers, or through special order? How easy is it to find people who can install this product? In what quantities does one have to order these products?

Code Approval

Which building code governs this product? During what inspections are systems checked? Is a special inspection required? Is there a particular professional needed to stamp or approve the use of this product?

Affordability

How much does the product cost to buy? How much does it cost to install? How much does it cost to maintain? How does it compare to other forms of construction? Does it provide lifetime savings to the homeowner?

Coastal Considerations

What about the climate might affect the performance of this building system? Can it handle the extremes of the climate? What about the local construction industry might affect the usability of this product? Is there a particular like or dislike of the product along the Gulf Coast?

GULF COAST AVAILABILITY / LOCAL MANUFACTURES

When choosing a manufacture/installer/contractor it is extremely important to research and get references. Do your due diligence. Check with your state and local licensing boards, ask for bonding and insurance. Always get more then quotes from more then one contractor.

Factory-Assembled Homes

Factory-assembled homes are sometimes called manufactured homes, modular homes, factory homes, or kit homes. All factory-assembled homes share a common strategy which moves as much of the construction process as possible from the building site into a factory environment. The concept is that building a structure under industrialized and controlled circumstances will allow for faster construction and better quality control. Production techniques used in the manufacturing of homes are modeled on durable goods industries such as auto, aviation, or maritime manufacturing.

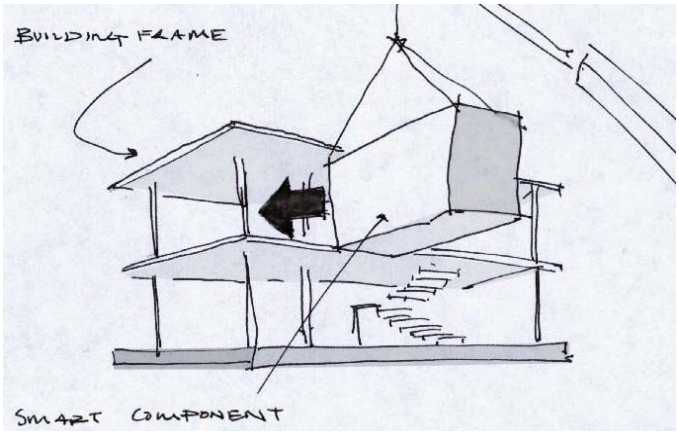
Strategies for manufacturing large parts of homes can be differentiated by the level of completion reached when the product leaves the factory. This can vary from being largely finished to being a group of parts not yet assembled. Examples are placed in the following order, one being the most finished and four the least.

1 Modular *- complete*
2 Component *- completed pieces*
3 Kit *- ready to assemble*
4 Hybrid *- additional material needed*

Most factory-assembled homes require specialized equipment to install them on the site. Often a crane is required, but in the cases of smaller products a "lull," which is a type of forklift, can be used to move products. Often a licensed contractor/installer is legally required to ensure job site safety, proper installation and qualify the product for manufacturer warranties.

It is difficult to categorize the performance of all factory-assembled homes because there is such a wide range of material qualities and manufacturing methods. Although it is important to compare the delivery method and manufacturing strategy, it is critical to remember that an innovative construction method does not ensure a quality product.

(FIG.A) MODULAR HOMES can be made of one, two, or more modules. Each module is typically completed in a factory, set in place, and finished on-site.



(FIG.B) COMPONENT BUILDINGS use a "plug in" strategy to place a pre-built element into a building. Typically these units are the more complex rooms to such as bathrooms.

(FIG.C) KIT HOMES are delivered on-site with various parts to assemble. Included in the kit should be all the pieces needed to assemble the home.

factory-assembled homes	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
modular homes	+	+	–	–	–							–	+	+	+	
component homes	+	+		–		–	+			+		+	–	–	–	–
kit homes	+	+		–	+							–	–		+	
hybrid homes	+	+	+	–	–							+	–	–	+	

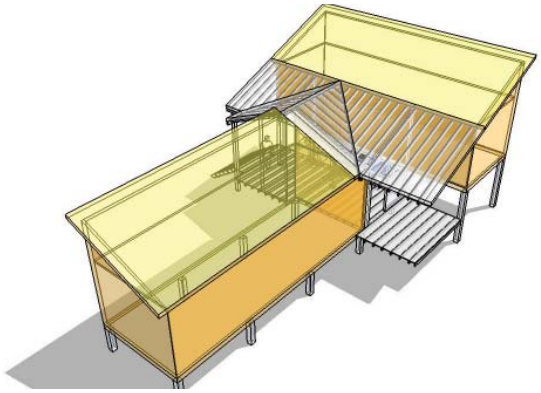
Modular Homes
Modular homes are common throughout the Mississippi Gulf Coast, and there are many manufacturers and several installers available to interested housing providers.

Component Systems
Component systems or "smart components" are currently only available for larger scale multi-unit residential and commercial projects. They may be an option as the quantity of components needed for a project increases. Typically components are kitchens or bathrooms.

Kit Homes
Kit homes come in a large variety of configurations, many of which are available on the Gulf Coast. Types of kit homes include panel, heavy timber, metal, or wood assemblies.

Hybrid Homes
Hybrid homes are not used very often on the Gulf Coast, as they are normally complex and require a good deal of pre-planning.

Most factory-assembled homes do not have as great of a cost- or time-advantage as manufacturers may claim. They do have the advantages of standardization and requiring less local skill in planning and construction. They are also increasingly economical and efficient as the number of housing units in a project increases.



(FIG.D) HYBRID HOMES use both large manufactured pieces and on-site construction. Each system is used for its own advantage to maximize speed and custom design.

FURTHER INFORMATION

- www.toolbase.org
- www.manufacturedhomesoure.com
- *Refabricating Architecture: How Manufacturing Methodologies Are Poised to Transform Building Construction* by Stephen Kieran and James Timberlake (McGraw Hill-Professional; 2003)

OTHER TYPES OF FACTORY-ASSEMBLED HOMES

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_____

Factory-Assembled Homes whole house system

1 FACTORY-ASSEMBLED SYSTEMS

subjects

Modular Homes

Overview: Built in large pieces in a factory, modular homes are most commonly delivered in two or more pieces to a site. In most cases the electrical, plumbing, drywall, and some flooring and cabinets have already been installed. These pieces are lifted into place on site with a crane and attached together with bolts. The roof is often hinged so that it can lay flat during transport and be swung into place. Work such as trim, painting and HVAC may or may not be factory completed, depending on the manufacturer.

INSTALLATION

Construction Process: Before the modules can be set on site all of the foundation work must be completed. Once the foundation is installed the modules are brought to the site, lifted into place, and bolted to each other and to the foundation. Finish work can begin at this point, which may or may not include trim work, finishing the cabinets, touching up dry wall, installing HVAC systems, and hooking up electrical and plumbing. Experienced installers can lift a house into place quickly and with ease.

Speed of Construction: A pre-approved plan can be built in a factory in about two weeks, but custom houses take longer. Shipping times depend on distances between the factory and the site, as well as the availability of trucks. Modular units can be set in one day and can be ready for certificate of occupancy inspections 3 or 4 weeks after being placed.[1]

Delivery Method: A modular unit will be trucked from factory to site. If the units are stored outside for any period before shipping, the unit should be properly protected from the elements. The size of trucks allowed on local roads is the limiting factor in the size of units available.

(Fig.1) Where two modules come together a "seam" wall is formed. It will need some finish work, and is often designed so that its thickness is used as an architectural element dividing two spaces such as a living and dining room.

(Fig.2) The size of the unit is determined by the size of truck allowed on local roads. Site access constraints should be carefully considered before a modular home is purchased.

Required Equipment: A crane and lifting rigging will be needed in addition to the trucks needed to transport the modular units. Standard construction equipment will be used on site for finish work.

Specialized Labor: Modular homes must be installed by state-licensed installers. Licensed installers will know how to properly lift and secure the house. Plumbers, electricians, and mechanical contractors are still needed to hook up the modular home, but in a reduced capacity. The ventilation system will most often require a full installation by an HVAC contractor.

PERFORMANCE

Wind Load: Units can be designed to meet local wind resistance requirements for most sites. It is not difficult to purchase a modular home designed to withstand winds from 140-160 mph or higher.

Water Resistance: Modular homes typically have a water resistance similar to site-built, stick-frame construction. Factory assembled construction exposes less of construction to weather, so fewer materials are likely to become damaged during the construction process.

Fire Resistance: Modular homes typically have fire resistance similar to site-built, stick-frame homes. It is typically not possible to get modular units made from more fire-resistant masonry materials.

Energy / Thermal: Modular units can be built to a variety of energy standards. It is possible to build to the standards of programs such as "Energy Star Homes" or "Coastal Electric Comfort Advantage". Most often batt insulation will be used in the factory built walls, while blown insulation will be used in the attic space once the roofs have been tilted up on site.[2]

Life Span: Modular homes typically have a life span similar to site-built stick-frame construction.

Common Failure: It is very important to create a strong connection between the modular units and the foundation. Weak connections could result in failure due to shifting or uplift. A mislaid foundation or the constrained movement of the lifting equipment can make connecting the modular unit to the foundation more difficult.

DESIGN

Environmental Impact: All factory-assembled homes share the environmental advantage of reduced waste, which can be achieved through factory-based efficiency. The factory building themselves take a certain amount of energy to condition and maintain. The environmental impact of transportation of modular home is no different than those of a site built home, because the material production network is connected at a national level in either case. More environmentally positive modular homes can be built, and several producers offer environmental upgrades at a cost.

Versatility / Flexibility: Units can be 900 sqft to over 3000 sqft, and normally have two or more bedrooms. Often the house has a porch built on site, which affects the sizing and shape of the roof. House manufacturers are becoming more accustomed to the market demand for custom built homes.

Market Exposure: Modular homes can be seen all over the Gulf Coast and the nation.

Code Approval: Modular units are inspected by employees in the factory and local officials on the site. The equivalent of a framing, electrical, and plumbing inspections will happen at a factory, while local officials will typically do a foundation inspection and a final inspection. A foundation is inspected before the house arrives. The strapping and connections between the house and the foundation is then inspected as part of a final inspection by a local municipal building office.

(Fig.3) The weight of modular units requires that they be lifted into place with a crane. Professional crane operators and modular installers must be used to ensure safety.

Affordability: Modular homes typically run $80-$105 per square foot at the lowest range, to bring the house to "turn-key", which means ready to be lived in. The price goes up with the quality of the finishes and size of the home.[3]

Coastal Considerations: Modular units should meet local wind resistance requirements, and should be attached to the foundation in a robust manner in order to handle coastal weather events.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

For lists of manufacturers, installers, and retailers go to the Mississippi Manufactured Housing Association web site at http://www.msmmha.com

Retailers in the Gulf Coast area include:

- Clayton Homes
- Meridian Homes
- New Gulf Homes
- Oak Creek Homes
- Palm Harbor Housing

Brands being installed in the Gulf Coast area include:

- Georgia Modular Systems
- Palm Harbor
- Lexington Homes
- Plantation Homes
- Modular One

Installers in the Gulf Coast area include:

- De Novo Mississippi Homes
- Precision, LLC
- Gulf South Homes, Inc.
- R.T. Bush Enterprises, LLC

(Fig.4) Two units bears on a concrete pier. They are bolted together and fastened to the foundation.

(Fig.5) Modular homes made in factories are made quickly with the help of specialized rigging and equipment.

Component Homes

Overview: Components, also called "smart modules" or "pods," can be thought of as single-function, semi-independent, factory-built chambers easily inserted into a building. Often these components are discrete elements of homes, such as a kitchen or bathroom, that are inserted into a structure. The idea of building in this way has developed from the naval construction industry where living/working units can be moved in and out of a ship's large hull.[4] Modular components' real advantage is that they can deliver complicated sections of a home ready for use, while leaving the less technical construction to be done on site. This can be helpful when there is a gap in the available skilled labor, or when construction time is a critical factor. Modular components are mostly used in high-volume buildings, like military bases, casinos, hotels, dorms, or apartments. It is difficult to find a company willing to produce components for residential use, let alone single family homes.

INSTALLATION

Construction Process: After being delivered to the site, components like bathroom pods are lifted onto the structure or platform and slid into place. Once in place, the pods are hooked up to the mechanical systems, such as ventilation, electrical, and water supply. Pre-positioning of some of these hookups is required. After installation most pods need to be protected from exterior weather. Some pods may come with a finished exterior, while others will need to be clad in an interior finish material. Avi Telyas CEO of Kullman Building Corp., a component producer, said while commenting on a 2008 project at Rice University that "typically, conventionally constructed bathrooms are one of the most inefficient components of a project during the construction phase of a new multi-family-type building...This is usually the result of up to 10 different trades required to work consecutively in such a

(Figs. 6-8) Component pods are delivered by truck and lifted into the structure.

confined area."[5]

Speed of Construction: Building components install very quickly compared to the typical time it would take to finish out a similarly programmed room. Some manufacturers claim dozens of bathroom pods (completely finished) can be placed and connected to mechanical systems in a single day.

Delivery Method: Components are delivered on a truck and hoisted into place using a crane with a carrying basket or a lull with a scope. Positioning the component into the right position is done with the help of dollies. Long shipping distances are common when using components due to the small number of manufactures.

Required Equipment: A crane or a lull is needed, and if the component will be moved across a floor some sort of dolly is needed, depending on the weight of the component.

Specialized Labor: Qualified operators are necessary for whatever transportation and lifting equipment is being used. Licensed plumbers, electricians, or HVAC contractors may be needed to hook up a component.

PERFORMANCE

Wind Load: Pod components are most often not part of the structure of a building. If using a pod, check to make sure that the rest of the structure will be strong enough to resist required wind loads without the bracing of the interior walls replaced by the component construction. An engineer should be used to insure proper wind load performance.

Water Resistance: Bathroom pods are built and sealed in the factory. Easy access to both the internal and external faces during fabrication allow for a greater seal and better water protection.

Fire Resistance: Bathroom pods are typically built from steel studs, or a composite shell. Both of these materials would slow the spread of fire compared to wood frame construction.

Energy / Thermal: Components are not often placed outside of the building envelope and are not meant to be an important part of a building's thermal strategy. Thus pods are designed without much thermal consideration. Interior placement means that pods typically don't have windows or natural light. Lack of windows means that passive ventilation, heating, and lighting strategies are much harder to use in the pod.

Life Span: A few of the manufacturers of bathroom pods will warranty their product for 50 years.

Common Failure: There is not much information on the common failures for component systems. However, it is likely that a bad connection between the electrical or water systems of the component and the building would be the most common failure.

(Fig.9) Pods can be easily wired and plumbed due to greater access and a factory setting which encourages quality and efficiency.

DESIGN

Environmental Impact: Off-site fabrication could allow for specialized environmentally responsible construction or systems, although this is not always the case. There are few manufacturers of smart components, so the shipment distances can be very long. There is little to no favorable environmental impact to be gained in this system.

Versatility / Flexibility: Production runs and deliveries normally must be of a high volume to be affordable. Some manufacturers will deliver several different models to meet the needs of a project.

Market Exposure: While common in hotels and casinos, and available for multi-unit residencies on the scale of a dormitory or an apartment, component modules are not used in single family construction. At the time of this publication most of the production and use of building components took place in Europe with some in Asia, and very little production in the Americas.

Code Approval: A house built with smart components should meet the same requirements as a modular home. It should also be inspected by local officials in a manner similar to the inspection of a modular house.

Affordability: Cost savings in smart components comes from time saved on the job site, economy of scale when ordering in quantity, and future flexibility. All of these cost-saving strategies are hard to achieve unless the scale of building is quite large. An example of scales is a new dorm built at Rice University which included an order of 176 bathroom pods shipped from New Jersey.[6] The reasons that pods were used in this project included cost savings and environmental performance.

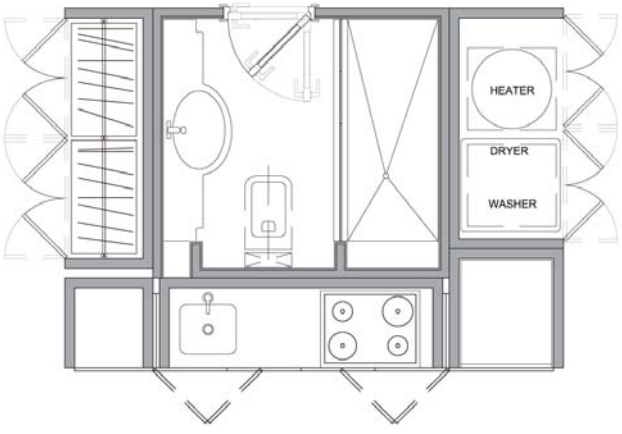
Coastal Considerations: Beyond the distance to manufacturers, there are no coastal considerations.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

There are no local manufacturers, but several manufacturers have good internet resources:

- Kullman Builders, New Jersey
- EggRock, Massachusetts KB Pods, Quebec Canada
- Axis Industrial, China
- Paddington Offsite, England
- Chrysalis Pod and Modular System, Europe

(Figs.10-11) High-end designers are using smart components to place kitchen/bathroom "service cores" into lofts. Components can be built in a variety of finishes on the interior and exterior and placed so as to divide larger spaces.



(Fig.12) A very tightly designed smart component in plan. All uses of home that require plumbing are pre-built in one component.

Kit Homes

Overview: A kit homes is a pre-designed house delivered to site with all the pieces needed for the home owner to complete the project. In some cases the interior finishes are not included in order to give the home owner a greater choice of finishes. Kit houses were popular at the beginning of the 20th century when they could be purchased out of catalogs like Sears Roebuck.[7] Today purchasing materials through mail-order has been replaced by the home construction mega-store. There are still kit homes available from different manufacturers. The four main types of kit homes are Log kits, Timber Frame kits (Post-and-Beam), Dome kits, and Panelized kits. Typically the pieces will be measured and cut or drilled to aid in the construction process.

INSTALLATION

Construction Process: Kit homes are often designed for easy construction with power tools and basic skills. However, because each piece is pre-cut, there is little margin for error during the construction process. Today, hiring a contractor to assemble a kit home is also a common option.

Speed of Construction: Speed of construction depends on the type of kit and the size of the structural and finishing materials it uses. The construction process is sped up by having most of the materials on site. For some kits, experienced contractors can dry-in a home in about a week after the foundation has been set.[8]

Delivery Method: Typically most of the needed material for construction will be brought to the site in a single delivery. Instructions and any specialized tools should be included in this delivery.

Required Equipment: Most kit homes will not need any unusual equipment. If any special tools are needed, they should be included in the kit. A crane might be needed to hoist pieces depending on the size of those pieces.

Specialized Labor: Plumbers and electricians are needed to hook up the home. Some kit homes will come pre-wired, but most will not. Typically a kit home is designed to be assembled without specialized labor.

THE COLLINGWOOD

FIVE ROOMS AND BATH

MODERN HOME
No. 3280
ALREADY CUT AND FITTED
PRICE $1497.00

FLOOR PLAN

HERE is an unusual bungalow, well suited for modern living conditions. The exterior is very practical and finds much favor on account of its simplicity. The lines of the hip roof are broken by the dormer on the front and bay projection over the dining room at the side. Living out of doors, as most of us do in summer, the front porch will be appreciated. The windows are very well designed and attractively arranged.

The Living Room. From the front porch we enter the living room, which is 12 ft. 9 in. wide by 18 ft. 5 in. deep. Note the convenient and attractively designed fireplace in the left wall, on each side of which is a window, and the triple window in the front wall.

The Dining Room. The dining room is located next to the living room and is lighted by two large windows contained in the bay projection.

The Kitchen. From the dining room we pass into the kitchen where considerable thought has been given to the placing of many built-in features and practical arrangement of other equipment. The kitchen sink is located underneath the double window on the left wall, on each side of which suitable kitchen cabinets are furnished at option prices. A place for brooms, mops, etc., is formed by the closet opening off the right wall. The built-in breakfast alcove occupies the space at the rear. Table and seats for this furnished at option price.

Bedrooms. A plastered arch is used in the opening between the dining room and hall which connects the two bedrooms and bath.

WHAT OUR PRICE INCLUDES

At the price quoted, we guarantee to furnish all material consisting of lumber, lath, millwork, flooring, shingles, building paper, hardware, metal and painting materials according to specifications. See attached price list for options.

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Modern Homes Division

(Fig.13) Sears sold mail order homes until the 1940s.

(Fig.14) The kit home construction observed as part of this research was a Deltec home. All the materials for the structure and the weatherproofing are included in the kit, but interior finishes are not.

PERFORMANCE

Wind Load: Kits can be designed to meet local requirements. Wind load performance depends on the specifics of the kit.

Water Resistance: Kits can be chosen to meet site requirements. Water resistance performance depends on the specifics of the kit.

Fire Resistance: Kits can be chosen to meet site requirements. Fire resistance performance depends on the specifics of the kit.

Energy / Thermal: Units can be built to a variety of standards. It is likely that they will be built to the standards of an energy program such as "Energy Star Homes" .

Life Span: Life span depends on the construction system and the materials used in the kit. Check for a warranty to get a sense of the product's lifespan - it may be up to 50 years.

Common Failure: Precut parts require each stage of construction to be executed to very small tolerances. This can be a problem in later stages of construction, particularly when the kit is assembled by less experienced home owners.

DESIGN

Environmental Impact: Environmental impact depends on the type of kit being purchased. Kit homes do reduce the amount of waste generated on site. Choosing a design with maximum insulation, quality windows, and other green characteristics will make the kit home as environmentally friendly as possible.

Versatility / Flexibility: There are a wide variety of sizes and performance types. Typically kit homes are over 1000 square feet and use lower quality materials for reasons of economy. Once the kit has been delivered any variance in construction from the plans will likely void any warranties.

Market Exposure: The wide variety of construction stores and the general availability of labor means that kit homes are not a needed or commonly used construction system on the Gulf Coast. There are several kit homes available on the internet.

Code Approval: Some cities will require a stamped set of construction documents. Make sure that the kit manufacturers can provide this if your municipality requires it.

Affordability: Most cost savings in a kit home will be proportional to the amount of labor the home owner puts into constructing the home. A kit home reduces the amount of construction skill or knowledge needed to construct the home, making an average homeowner able to use more of their own labor and thereby increasing their cost savings.

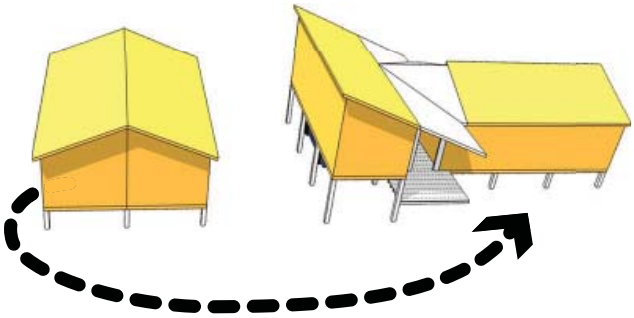
Coastal considerations: Kits designed for strong winds and increased moisture are preferable for coastal climates.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

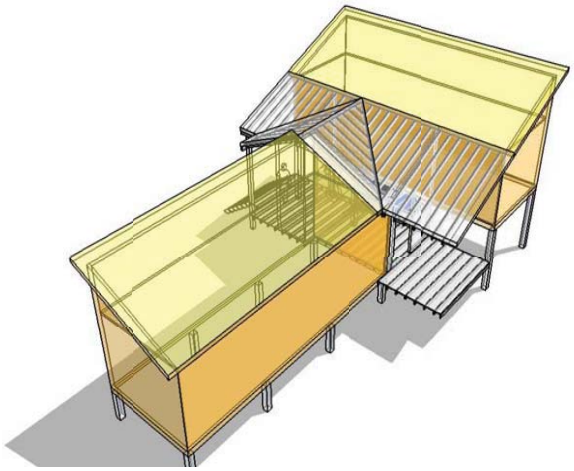
Deltec Homes of North Carolina makes a hurricane resistant kit home.

(Fig.15) Precut pieces make construction faster, but require greater precision.

(Fig.16) Panel segments are delivered to the site already sided and with openings for windows.



Hybrid Homes



(Figs.17-18) Pre-manufactured modules can be used in a variety of ways. They can also be combined with site-built construction to expand the possible forms the home can be built in.

Overview: A hybrid system will use factory-assembled elements in conjunction with site-built systems. The example of a hybrid home discussed here is a home built using two halves of a modular home with a traditional timber frame connection between the two. While all pre-manufactured systems (panel, modular, etc) require some on-site construction, a hybrid system attempts to use pre-manufactured elements of one or more types with site-built systems in a way that amplifies each system's strengths while mitigating its weaknesses.

INSTALLATION

Construction Process: Building a house that has more than one construction type or system can be difficult. With each system that is added the project becomes more complicated. Constructing a home that is a hybrid of on-site and off-site elements will require extra time for planning the connections between different assemblies. Time spent planning up front can yield advantages in the speed of construction in the field.

Speed of Construction: A hybrid strategy will normally be employed to shorten the construction time on a project by completing the parts that can be assembled most quickly off-site in a factory and adding the parts that can be built most quickly on-site once construction has begun.

Delivery Method: Whether panels or modules, the pre-manufactured elements will be delivered and installed the same way they would if used solo. Because different types of construction are combined in the building of a hybrid home, it is likely that the materials will need to be acquired from more then one source.

Required Equipment: The required equipment for a hybrid project is the same as the equipment needed to in-

(Fig.19) Auburn University's DESIGNHabitat students work on a project that is an example of how on-site construction can combine pieces of factory-assembled modular homes to create a hybrid home.

stall whatever the factory assembled system is; this might include cranes, equipment, lulls, and riggings.

Specialized Labor: The specialized labor needed for a hybrid project is the same as the equipment needed to install the pre-manufactured system; this might include crane operators, truck drivers, and licensed installers.

PERFORMANCE

Wind Load: Wind load performance depends on the specifics of the modules used and their connections to the site-built elements. An engineer should be consulted whenever using a pre-built modular or panel system in conjunction with structural site work, as an unusual use of a product might weaken it.

Water Resistance: Water resistance depends on the specifics of those modules used and their connections to the site-built elements.

Fire Resistance: Fire resistance depends on the specifics of those modules used and their connections to the site-built elements.

Energy / Thermal: Performance depends on the specifics of those modules used and their connections to the site-built elements. Enhancing a modular unit's thermal performance is something that might be done through on-site construction in a hybrid home.

Life Span: Life span is difficult to determine.

Common Failure: The most difficult aspect of building a hybrid home is the connection between the modular pieces of the building and the site-built pieces of the building. Incorrectly joining these two systems would likely be a common failure.

DESIGN

Environmental Impact: The environmental impact is difficult to judge. A hybrid building strategy could be used to increase a home's positive environmental impact while keeping costs or construction time down through the use of site-built elements.

Versatility / Flexibility: The hybrid strategy adds a great deal of flexibility to pre-manufactured products. It is important to check to make sure that the installation of the product is not so unusual as to void any warranty or cause a failure in product operation.

Market Exposure: This is not a common method of construction.

Code Approval: Unusual installation of pre-manufactured products might require a closer inspection before they are approved.

Affordability: The affordability is difficult to judge. A hybrid building strategy could be used to increase a home's affordability while keeping construction time down through the use of site built elements.

Coastal Considerations: Like many construction systems the strength of the connections between elements is an important coastal consideration.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Any of the suppliers mentioned in the "Factory Assembled" or "Panelized" chapters are possible partners in constructing a hybrid home. There are no examples of contractors on the Gulf Coast doing this work at the time of this publication. Auburn University has an academic project working to develop hybrid homes in Alabama called DESIGNhabitat.[9]

(Fig.20) Auburn University's Design Habitat students work on a project that is an example of how on-site construction can combine pieces of factory assembled modular homes to create a hybrid home.

Panelized Systems

Panelized building systems use factory-made panels that are delivered by truck and assembled on-site by hand, sometimes with the aid of a light crane or lift. They may be used for all or part of the structural envelope (walls, foundations, floors, and roofs). Composite building panels can include structure, insulation, vapor barriers, and service chases in a single panel. Panelized systems combine the efficiencies and labor savings of factory-produced building components with the flexibility of a modular site-assembled system.

Structural Insulated Panels (SIPs)

Structural Insulated Panels (SIPs) are the most prevalent panelized systems in residential construction. SIPs are made by sandwiching a core of foam insulation between two structural skins. This system makes the panel structural without the need for additional framing members. Most SIP systems offer improved strength, insulation value, and air-tightness when compared to standard wood framing. This increases thermal performance and durability. In most cases, SIPs will be engineered and precut to the exact sizes needed, saving time and labor on site.

Wood SIPs

Wood-sheathed SIPs have a structural skin of oriented strand board (OSB) or, less commonly, plywood. The core may be expanded polystyrene foam (EPS), extruded polystyrene foam (XPS), or polyurethane foam. The material cost, although higher than standard wood framing, is lower than many other panelized systems. Wood-framed SIPs are relatively easy to assemble and limited on-site modifications are possible using regular tools.

Non-Wood SIPs

SIPs can also be manufactured using a variety of non-wood structural skins. These include metal (stainless or galvanized steel), fiber cement, and fiber-reinforced plastic (FRP). These materials, while more expensive than OSB, offer increased

(FIG.A) PANELIZED SYSTEMS are delivered to the site as a package. Builders familiar with SIP construction can erect the structure quickly, reducing labor costs.

(FIG.B) MANUFACTURERS can create custom-engineered designs based on architectural drawings.

(FIG.C) INSTALLING electrical, mechanical, plumbing, or other systems may require planning ahead. Coordinate with tradespeople to avoid delays or cost overruns.

panels	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
concrete panels		+	–	–	–	+	+	+	–	+	–	–		+	–	+
structural insulated panels	+	+		+	+	+	+	–		+	+	+				+
non-wood structural insulated panels	+	+				+	+	+	+	+	+	–	–		–	+
framed panels	+	+		+	+	+	+	+	+	+	+		–			+

resistance to moisture, water, insects, fire, and other threats. Overall, non-wood SIPs have excellent strength and durability. These SIPs may be used alone or in combination with wood framing or other building systems. Depending on the system, on-site modifications may be difficult or impossible.

Framed Panels

Framed panels are factory-built modular panels with structural framing elements built in. Some resemble site-built framed walls, but variations are possible. For example, Thermasteel Corporation produces EPS core panels with steel channel framing on the interior and exterior faces, creating a 2-1/2" gap that reduces thermal bridging. These panels are assembled using the techniques of light-gauge steel framing.

Concrete Panels

Concrete panels precast in a factory can be made to a higher strength than site-built block or cast-in-place walls, and without weather delays. In residential construction, concrete panels are most often used in below-grade foundation walls, but they can be used for part or all of the structural envelope. When used to create conditioned space insulation material will be a necessary addition to the system, as concrete itself has a poor R-value. Concrete panels can be manufactured with an insulating core made of EPS or other foam insulation, or cast with a layer of foam insulation on one side.

(FIG.D) FRAMED PANELS use techniques similar to standard wood or light-gauge steel framing but are built in a factory. Shown here is a steel-framed panel manufactured by Dynabilt.

FURTHER INFORMATION

- Structural Insulated Panel Association (SIPA) (www.sips.org)
- Toolbase (www.toolbase.org)
- Residential Advantage Building Systems - Jackson, MS (www.resadvan.com)
- General Panel - Grenada, MS (www.generalpanel.com)

NOTES ON PANELIZED SYSTEMS

2 PANELIZED SYSTEMS

subjects

(Fig.1) A typical wood structural insulated panel (SIP) is made of two oriented strand board (OSB) skins sandwiching an insulating foam core, most commonly expanded polystyrene (EPS) (shown).

Wood SIPs

Overview: Structural insulated panels (SIPs) are composite building panels that combine structure, insulation, and other elements in a single panel. The panels are made in a factory and shipped to the building site for assembly. They can be used to build floors, exterior walls, and roofs for residential and light commercial buildings. SIPs are manufactured by sandwiching a core of rigid foam insulation between two structural skins. In wood-sheathed SIPs, the structural skin is typically oriented strand board (OSB) or plywood. The insulating core may be expanded polystyrene (EPS), extruded polystyrene (XPS), polyurethane (PU), or polyisocyanurate (polyiso). Using SIPs, a strong, tight, well-insulated building envelope can be built quickly and efficiently.

(Fig.2) Panels laid out on a building site prior to erecting the walls. A partially assembled house is visible in the background.

INSTALLATION

Construction Process: In the factory, SIPs can be manufactured in the specific sizes and configurations necessary for the building. They are shipped to the building site to be assembled. Some on-site modifications, such as changes to door and window openings, can be made using simple tools. Panels are connected using dimensional lumber 'splines' or other methods. Roof panels are typically supported using a ridge beam or multiple rafters and beams as necessary. The skills and tools required are not very different from standard wood framing.

Speed of Construction: Builders familiar with SIP construction can frame a SIP house significantly faster than a standard wood-framed house. Time and labor savings will be highest in multi-unit developments. Learning to build with SIPs will not be difficult for builders familiar with standard wood framing.

Delivery Method: Panels will likely be shipped by flatbed trailer or truck (limiting the size of the panels) and offloaded with a forklift or crane.

(Fig.3) A crane may be needed to lift large panels into place.

Required Equipment: Beyond standard wood framing tools (such as a drill, reciprocating saw, circular saw, and router), little specialized equipment is required. According to ToolBase, a technical construction information resource, "panels weigh approximately 3 lbs per square foot, so 4-foot panels are light enough to be carried and set by hand."[1] Large panels may need to be lifted by crane or other means.

Specialized Labor: Certain contractors specialize in SIP systems. Contact your SIP manufacturer for a list of preferred builders. Learning to build with SIPs will not be difficult for builders familiar with typical wood construction techniques.

PERFORMANCE

Wind Load: Unlike standard framed walls, SIPs have OSB sheathing on both sides, which creates superior resistance to shear loads (wind and other lateral forces). Manufacturers claim that SIPs perform better than standard wood framing in most measures of strength, including axial loads (supporting the weight of the building) in addition to shear loads. SIP houses can be engineered to meet hurricane wind load requirements.

Water Resistance: Properly installed SIPs create a tight envelope that resists air and moisture infiltration. However, mold and mildew can grow if panel joints are not sealed properly. Most types of insulating foam are non-nutritive and do not contain cavities that might encourage mold, mildew, or insects. However, like any wood product, OSB is vulnerable to these threats. Panels should not be exposed to the elements for extended periods of time during the construction process. Pressure-treated plywood can be used for applications requiring greater resistance to decay, such as below-grade foundation walls.

Fire Resistance: OSB, and most foams, are combustible materials. EPS, the most common insulating foam, is nevertheless quite resistant to the spread of flame, and it gives off the same byproducts as wood when it burns. SIPs have a solid core and do not exhibit the chimney-like fire spreading tendencies of standard wood-framed walls.

Residential building codes require that foam insulation be separated from the interior of the building by a material that remains in place for at least 15 minutes of fire exposure, typically 1/2" drywall.

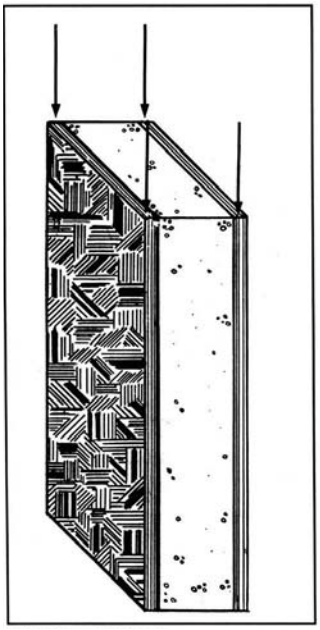
Energy / Thermal: SIP construction can create significant energy savings in two main ways:

First, SIP walls contain minimal amounts of thermal bridges between the exterior and interior of the building due to the reduced need for wood structural members and a more continuous layer of insulation.

Second, SIPs can create a very tight house, minimizing heat loss and gain due to air infiltration. According to industry estimates, "The amount of energy used to heat and cool a home can be cut by up to 50 percent."[2]

See the chart below for typical SIP insulation R-values. Most important, however, is the "whole-wall" insulation value. A wood-framed wall with R-13 fiberglass insulation may have an overall insulating value of R-6 to R-9, depending on how well it is built. By comparison, a SIP wall with R-17 insulation can have an overall insulating value of approximately R-15.[3]

The tight building envelope created by SIP construction does not allow sufficient air exchange for comfort. A properly designed fresh-air ventilation system is required to maintain interior air quality; a system that conditions the indoor air without bringing in fresh air will not be sufficient. Consult a mechanical contractor or engineer to design a system with sufficient fresh air ventilation.



(Fig.4) Vertical loads are carried by the panel skins. Continuous reinforcement by the foam core prevents buckling.

SIP R-Values (Calculated R-Values)

SIP Panel Thickness	4 1/2"	6 1/2"	8 1/4"	10 1/4"	12 1/4"
EPS	14.4	21.6	27.9	35.1	45.9
XPS	19.5	29.5	38.3	48.3	58.3
Polyurethane	21.7	32.9	N/A	N/A	N/A
Consult the panel manufacturer to verify R-values. R-values can vary between SIP manufacturers.					

(Fig.5) Base R-values for SIP insulation types. All listed R-values are at mean temperature of 75° F. Note that actual whole-wall insulation values may be lower.

Life Span: The OSB and wood members used are comparable to standard wood construction. However, when built properly, SIPs' lower air and moisture infiltration should reduce common sources of deterioration. Due to their strength and durability, SIPs can have a lifespan of many decades.

Common Failure: Failing to properly tape and seal seams can lead to moisture intrusion into the panel cavity, expansion of the underlayment at panel joints, and a decrease in the thermal performance of the structure. Long-term consequences could include serious mold and mildew problems and decomposition of the panel structure. Ridges might also become noticeable on the roof during hot weather.

Some roofing manufacturers will not warranty asphalt shingles over unvented SIP roofs because shingle temperatures may be higher (although typically only by a few degrees). Builders wishing to comply with the warranty can add a venting space under the shingles.[4]

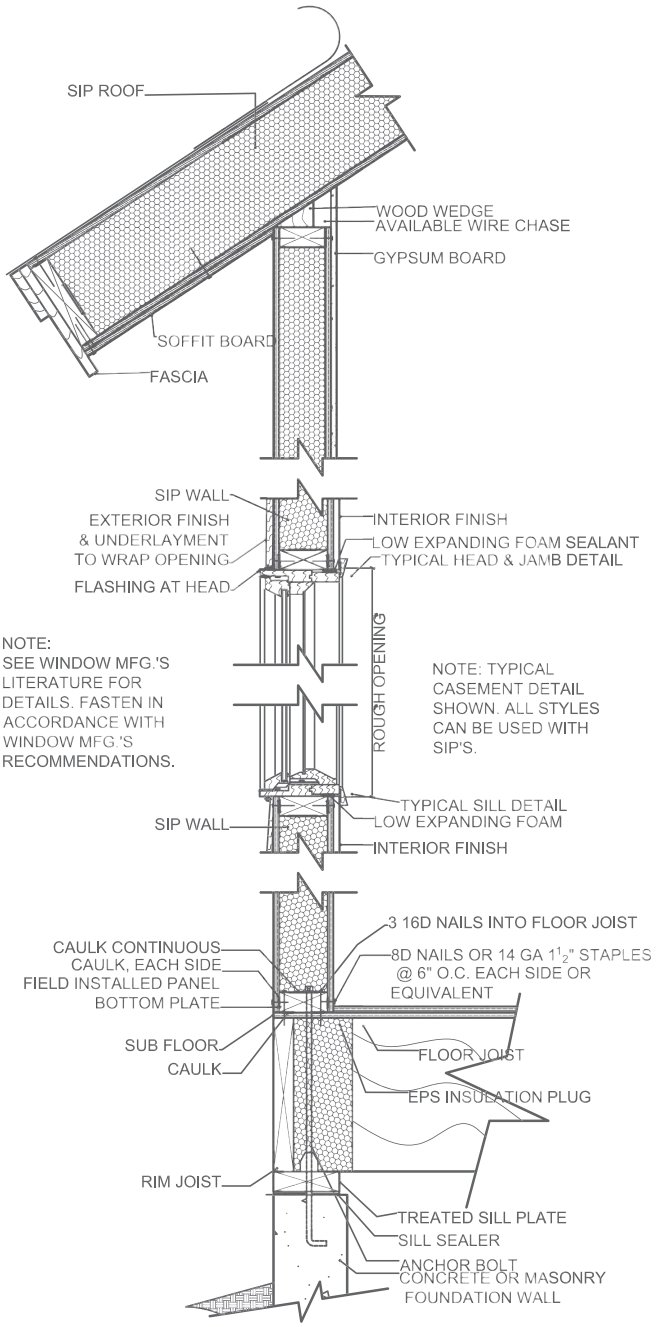
DESIGN

Environmental Impact: Factory construction reduces the amount of waste generated. On-site construction waste should be minimal.

EPS and some other types of insulation can be recycled, and can include recycled content. OSB is made using recycled wood scraps and small, renewable trees, so a SIP house requires fewer large trees to be cut for studs and other framing.

The increased thermal efficiency of a SIP house can lead to a reduction in the energy used for heating and cooling.

(Fig.6) Assembly of factory-made roof panels. FSU Zero Emissions House.



(Fig.7) This is an drawing of typical SIP wall and roof section. Most manufacturers will be able to provide the drawings necessary for code compliance and permitting. Many will design and engineer a custom SIP configuration based on the desired floor plan.

Versatility / Flexibility: SIPs come in standard panel sizes, and can also be custom manufactured to create whatever design or configuration is desired. Many manufacturers can use the construction documents to design a complete SIP package. This allows the panels to be assembled on site with few modifications. On-site modifications can be made using common tools. SIPs can work well with other building systems. For instance, interior partition walls are often built using standard wood framing.

Market Exposure: While SIPs are not as common as standard wood construction, they are among the most common alternative construction systems. They are relatively well known and understood within the building industry and are built in all areas of the country.

Code Approval: SIPs typically meet all building codes; however, building departments may not be familiar with the particular system in use. According to ToolBase, "the majority of manufacturers provide technical design and support services to ensure code acceptance."[5]

Affordability: The cost of a SIP house can be higher than or comparable to standard wood framing. Depending on material prices, demand, and level of customization required, the *material cost* for SIP framing versus standard wood framing will likely be higher. However, an experienced builder can frame a SIP house in days rather than weeks. Particularly with large numbers of units, the savings in time and labor costs can be significant.

Reduced operational costs (energy and maintenance) and a higher-quality finished product mean that a SIP house usually provides a better value than a standard wood-framed house.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

ThermaSAVE
- Gulfport, MS
- Eddie Hartwell

Residential Advantage Building Systems
- Jackson, MS
- Manufactures: EPS foam core SIPs with OSB skins. Panels fully customizable with thicknesses of 4.5", 6.5", 8.5", 10.5", or 11.5". Supplies fasteners and tools.
- www.resadvan.com / (601) 896-9623

General Panel Corporation
- Grenada, MS
- Manufactures: EPS foam core SIPs with OSB skins. Other types of panel are manufactured at their Tennessee plant (ICF, OSB/GWB, etc).
- www.generalpanel.com / (866) 774-0530

SIPS Team USA
- Bainbridge, GA
- Manufactures: EPS foam core SIPs with OSB skins. Panels fully customizable up to 8' x 24' and 2-10" thick.
- www.sipsteamusa.com / (229) 246-8880

PanelStar Custom Homes
- Columbus, GA
- Supplies: INSULSPAN SIPs, EPS foam core SIPs with OSB skins. Provides on-site supervision and consultation during construction.
- www.panelstar.com / (706) 315-4300

(Fig.8) Florida State University Energy & Sustainability Center's "Off-Grid Zero Emissions Building".

(Fig.9) Structural insulated panel components being made in a factory.

MM & I Construction & Design
- Nashville, TN
- Manufactures and builds: INSULSPAN SIPs, EPS foam core SIPs with OSB skins. Provides on-site supervision and consultation, full construction services, and design assistance.
- www.design101.tv / (615) 673-9294

Better Building Products LLC
- Salisbury, NC
- Manufactures: SIPTEX, polyurethane foam core SIPs with OSB skins. Wall panels come in 4' x 8' and 4' x 12' sizes and 4.5" thick.
- www.wabrown.com / (704) 636-5131

Superior Insulated Systems
- Palm City, FL
- Manufactures: EPS foam core SIPs with 7/16" OSB skins. Sizes up to 8' x 24' and 4-1/2" to 12-1/4" thick.
- www.sishomes.com / (800) 918-1430

Triton Building Systems, LLC
- Bay St. Louis, MS
- Builds: new construction, additions, and remodeling projects using SIPs.
- www.tritonbuildingsystems.com / (228) 220-4620

(Figs. 10-13) Process photos from Florida State University Energy & Sustainability Center's "Off-Grid Zero Emissions Building."

Non-Wood SIPs

Overview: Structural insulated panels can be manufactured using a variety of non-wood structural skin materials. These include metal (stainless or galvanized steel), fiber-reinforced cement, and fiber-reinforced plastic (FRP). Like wood SIPs, these panels are used to build floors, exterior walls, and roofs, and may be used alone or as part of a hybrid system that also uses steel framing, wood framing, concrete, or other building techniques.

Metal Panels:

Stainless Steel (SS) and G90 Galvanized are the most commonly used metal surfaces. Metal panels can be used for residences or residential roofs, but are more often used in industrial or commercial buildings that require the product's strength or non-corrosive properties. Stainless steel is essentially low carbon steel containing 10% or more chromium, which gives the steel its corrosion-resisting properties. Galvanized steel is coated with a thin layer of zinc that protects the steel from corrosion. Metal SIPs can be costly, but for the right application, the benefits may be worth the extra cost. Benefits include: corrosion-resistance, fire- and heat-resistance, hygiene, noise insulation, good strength-to-weight ratio; and impact resistance.

Fiber Cement Panels:

Fiber-reinforced cement ('fiber cement') is a mixture of cement, sand, cellulose fibers, silica, and additives, which are autoclaved (cured with pressurized steam) and molded into finished siding products. Fiber cement products such as those manufactured by the James Hardie Corporation are commonly used for siding, trim, and other exterior and interior applications. Panels can be made with fiber cement on one or both sides as a finished or unfinished surface. According to ToolBase, a technical homebuilding information, "manufacturers emphasize that fiber-cement siding is appropriate for hot and humid climates because it is resistant to rot, fungus, and termite infestation. They also state that it has excellent weathering characteristics, strength, and impact resistance."[6]

Fiber-Reinforced Plastic Panels:

Fiber-reinforced plastic (FRP) is a composite material made of a polymer reinforced by fiberglass or other fibers. FRP is typically used in combination with a polyurethane core. The manufacturing process uses synthetic composite materials and industrial processes similar to those of the marine and aircraft construction industries. This type of construction is most common in coastal areas.

INSTALLATION

Construction Process: Methods of construction vary depending on the manufacturer and system in use. In most cases, panels are mechanically connected using power-driven screws or cam-locks. In other cases, connections are made using glue, resin, and/or specialized tools. Most non-wood SIPs cannot be easily modified on site and must be manufactured to the dimensions required.

Many manufacturers offer a range of services, usually for a fee. Builder training, on-site supervision and assistance,

(Fig.14) A worker installs fiber cement panels in a house in Orlando, FL.

and full construction services are typical examples.

Speed of Construction: Claims vary from a fifty percent savings in time (particularly for experienced builders) to no appreciable difference compared to traditional construction techniques. Faster construction time and lower labor costs may offset higher material costs.

Delivery Method: Panels will likely be delivered by truck. A standard size for many manufacturers is 4ft x 8ft, but panels can be up to 30ft long, depending on the size of the truck available for delivery.

Required Equipment: Metal or fiber cement 4ft x 8ft panels can be handled by two people, but larger panels may require the use of a crane or forklift. Fiber-reinforced plastic panels are lighter and in most cases can be assembled by without the use of heavy lifting equipment.

Specialized Labor: Workers familiar with typical construction techniques can easily be trained to assemble many of these systems. Some systems, however, may require additional expertise. In some cases, electrical and plumbing work may require special expertise to install.

PERFORMANCE

Wind Load: Manufacturers of non-wood SIPs claim that they offer higher strength and better resistance to wind loads than either wood SIPs or standard wood framing. For instance, InnoVida claims its panels can withstand wind loads up to 186 mph. OceanSafe warrants its system up to 150 mph. The International Residential Code specifies design wind loads of 140 mph in most hurricane-prone coastal areas.[7,8,9]

Panels can often be engineered to meet the wind load required for a project. However, wind resistance will depend as much on the connections and configuration of the panels as it does on the strength of the panels themselves. Additionally, panels that perform well under one type of load, such as shear (wind load), may perform differently under other types of loads. Consult the manufacturer for strength information and instructions on correctly installing panels.

Water Resistance: Non-wood structural skins used in SIPs typically display superior water resistance. Stainless steel and galvanized steel are waterproof and resistant to corrosion. Fiber cement is highly resistant to moisture absorption. Fiber-reinforced plastic, which is also used in boat-building and marine applications, offers the best water resistance. It resists algae, fungi, water, and osmosis and has a high level of chemical stability against salt water. All of these systems offer advantages in flood-prone areas. However, any system can be weakened by improper installation.

Fire Resistance: Many non-wood systems offer excellent fire resistance. Steel and fiber cement are noncombustible materials. When used on the inside of a wall, fiber cement meets the code requirement for a 1/2" fire barrier. In the case of fiber-reinforced plastic, check with the manufacturer that it does not give off toxic chemicals when it burns.

EPS and polyurethane foam (PU), the insulation materials used in many non-wood panels, are not highly flammable materials. Given enough heat and air, they will burn, but are not prone to spread the fire.

Energy / Thermal: Energy and thermal performance is significantly better than standard wood framing and equal to or better than wood-sheathed SIPs, depending on the insulation material used. Many manufacturers claim insu-

(Fig.15) A worker installs wiring in a house built using InnoVida fiber-reinforced plastic panels in Dubai, UAE.

(Fig.16) Metal SIP corner showing window openings cased out using galvanized steel channels.

lating values of R-20 or better for standard thickness walls and R-30 or better for roofs and thicker walls.

Building tightness is a major factor in thermal performance, and most non-wood SIP systems offer the same improvements in building tightness as wood SIPs. When panels are properly installed, many manufacturers claim "equivalent R-values" of R-40 or better for the whole system, and energy savings of 30-70% for the occupant.

Life Span: Non-wood SIPs can be very durable. Materials like galvanized steel, stainless steel, and fiber cement offer exceptional strength and resistance to mold, moisture, insects, and other sources of decay, and will last significantly longer than wood SIPs or standard wood framing. InnoVida offers a long-term warranty of thirty years, and other manufacturers have similar warranties; however, actual product life span should be even longer.

Common Failure: Each system has its strengths and weaknesses. Panels must be designed to meet the expected load conditions. For instance, metal-skinned SIPs may fail under high compressive loads; fiber cement panels are more vulnerable to impacts. Most manufacturers can engineer their products to meet specific requirements such as hurricane wind loads.

The relative lightness of fiber-reinforced plastic panels means that the anchoring system is especially crucial to prevent wind and water damage. Additionally, these panels must be protected from the sun to prevent damage from Ultra Violet (UV) light. The manufacturer recommends painting the surface to avoid this damage.

DESIGN

Environmental Impact: The energy efficiency of a SIP home will be increased due to the reduction of air infiltration and insulating quality of the SIPs. The type of insulation has more impact on the insulating quality than the structural skin. Of the three most common SIP insulation types, expanded polystyrene (EPS) provides an R-value of approximately 3.2 per inch, while extruded polystyrene (XPS) provides 4.3 per inch and polyurethane (PU) provides the best insulating capacity with 4.8 per inch.

Factory production reduces on-site construction waste and, due to greater efficiency, can reduce overall construction waste. Some SIP materials, such as stainless steel, have high recycling value. Additionally, some SIPs can be made using recycled materials.

Versatility / Flexibility: Most manufacturers can make panels to specifications in any dimension and shape required, either in thicknesses standardized for walls and roofs or in custom thicknesses. However, non-wood SIPs are not generally designed for on-site modifications and must be manufactured in the exact sizes and shapes necessary for construction.

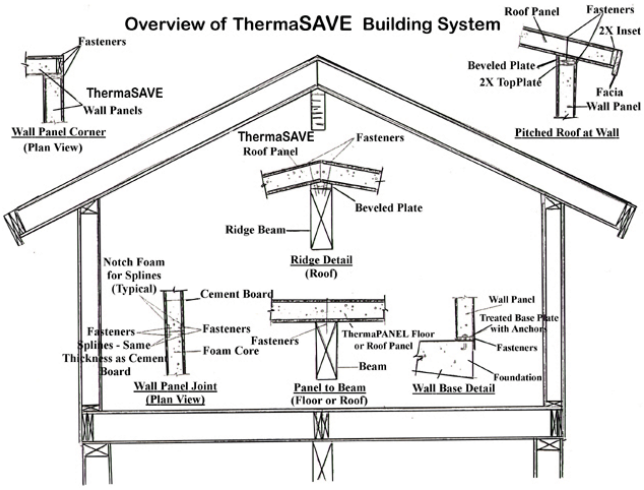
Market Exposure: Non-wood SIPs used in residential construction are most common in coastal areas that face threats from wind, flooding, and hurricanes.

Code Approval: Manufacturers may need to provide documentation for code approval.

Affordability: The initial material cost of non-wood SIPs will likely be higher than both wood-sheathed SIPs and conventional wood framing. However, an experienced builder can frame a SIP house quickly. Savings in time and labor costs can be significant, particularly in multi-unit developments.

Houses built using non-wood SIPs can have greatly reduced operational costs (energy and maintenance) and should last for many decades.

Coastal Considerations: Many non-wood SIP systems are designed for coastal applications and are highly resistant to wind, missile impacts, moisture, water inundation, insects, and other threats. Most manufacturers offer



(Fig.17) Most manufacturers provide instructions and drawings showing details and installation methods for their products.

some information about the strength and durability of their products. Check with manufacturers for design wind loads, hurricane loads, missile impact information, fire- and water-resistance, and other engineering data.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Ocean Safe
- New Orleans, LA
- Manufactures and builds: Houses using EPS foam core panels with galvanized steel skins.
- www.oceansafeinc.com / (504) 812-5519

Insulated Component Structures of Florida, Inc.
- Eustis, FL
- Manufactures: Polyurethane core SIPs with skins of OSB, fiber cement, fiber reinforced plastic, or metal.
- ics-sips-fl.com / (352) 483-7477

InnoVida
- Miami Beach, FL
- Manufactures and builds: Poluyrethane CSIPs (composite structural insulated panels), bonding materials, and additional components. Offers on-site training and supervision during construction.
- www.innovida.com / (786) 837-7200

Coastal Steel Homes
- Waynesville, NC
- Manufactures and builds: Steel structural insulated panels (SIPs), steel framing, insulated concrete forms (ICFs) exterior walls, and timber framing.
- www.coastalsteelhomes.com / (828) 545-3303

(Fig.18) SIPs can be manufactured to create custom designs.

Homefront SIP Systems
- Englewood, FL
- Manufactures: EPS foam core SIPs with James Hardie fiber cement skins for walls and water-resistant OSB skins for roofs.
- www.homefronthomes.com / (941) 475-6090

Marquis Construction & Development
- Holiday, FL
- Builds: Residential and commercial buildings using "Shadowline" steel SIPs manufactured by Kingspan Insulated Panels.
- www.southernsips.com / (727) 937-3090

(Fig.19) Construction photos from several homes built using steel SIPs by Marquis Construction & Development.

Framed Panels

Overview: Framed panels, like SIPs are modular panels that are built in a factory and assembled on site. Unlike SIPs, which rely on their stressed skins for strength, framed panels are made with framing members such as steel studs. Structurally, they perform like any other framed wall, floor, or roof, although factory production can ensure better and more consistent quality.

Many framed panels are made with rigid foam insulation, just like SIPs, and can deliver similar benefits in insulating value, building tightness, and durability. Like other factory-built panel systems, framed panels can reduce on-site labor costs. Most can be easily assembled using the techniques of light-gauge steel framing.

INSTALLATION

Panels are built in a factory to the sizes and specifications required. Rough openings for windows and doors and chases for electrical and plumbing are included. The panels are delivered to the site for assembly.

Steel-framed panels may be fitted into tracks and are typically installed using self-tapping screws. No specialized equipment is required. 4' x 8' panels weigh 45-50 lbs and can be handled by one or two people, while larger panels may require the use of a forklift or crane. Builders familiar with typical construction techniques or with light-gauge steel framing will be able to assemble the panels quickly.

Pre-installed chases allow electric wiring to be installed easily. A special foam-cutting tool may be used to place electric boxes and plumbing. In some cases, these can be installed in the factory instead, but this requires careful planning and coordination.

PERFORMANCE

Many framed panels can offer benefits similar to those of SIPs. Steel studs can create a thermal bridge that reduces the insulating quality of the panel, but some manufacturers have addressed this problem. For instance, Thermasteel Corporation produces panels framed with steel channels bonded to the insulation on the interior and exterior faces, creating a 2-1/2" gap in the center that reduces thermal bridging. A 5-1/2" Thermasteel wall has an R-value of 22; however, Thermasteel claims the "effective value" is closer to R-30 due to the tightness of the system.[10]

(Fig.20) These panels, manufactured by Dynabilt, combine galvanized steel framing with a polymeric insulated core.

(Fig. 21) The core adds structural strength and rigidity to the overall system.

The strength of framed panels comes from the steel studs reinforced by the rigid insulation. Panels can be engineered to meet hurricane wind loads. For instance, Dynabilt Technologies claims its panels are tested to withstand 170 mph wind loads.[11]

Most of the materials commonly used in framed panels, such as galvanized steel and EPS foam, display excellent durability. They resist fire, moisture, water, insects, mold, and other sources of damage and decay.

DESIGN

Framed panels have the same environmental advantages as SIPs: reduced waste, use of recycled and recyclable materials, increased durability, and an energy efficient building envelope.

Most manufacturers can make panels to achieve any house design that is desired. Some manufacturers offer pre-designed packages at affordable rates; for instance, Dynabilt Technologies "produces complete pre-designed house packages using Modutherm panels and steel truss roofing systems" for as little as $18.88 per square foot.[12,13]

Framed panels are well suited for coastal applications, and manufacturers located in coastal areas typically offer products engineered to meet hurricane wind loads and other requirements.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Dynabilt Technologies Corporation
- Miami, FL
- Manufactures: Galvanized steel-framed panels integrated with a structural polymeric insulated core.
- www.dynabilt.com / (305) 919-9800

Kokoon Homes
- Toccoa, GA
- Manufactures: Galvanized light-gauge steel framed panels with 1/2" OSB sheathing and closed-cell soy-based foam insulation.
- www.kokoonhomes.com / (706) 344-7528

Thermasteel Corporation
- Radford, VA
- Manufactures: EPS foam core panels with steel channel framing on the interior and exterior faces.
- www.thermasteelcorp.com / (540) 633-5000

(Fig.22) A framed panel house manufactured by Dynabilt.

(Figs. 23-24) Steel-framed panels manufactured by Thermasteel, in the factory (bottom) and being laid out on site (top).

> "The controlled temperature of the processing plant allows the manufacturer to work with concrete admixtures that focus on ultimate strength rather than cure time and temperature. Manufacturers are able to produce mixes that harden to 5,000 psi, which is stronger than concrete block or concrete walls formed and cast in the field. Better control of the concrete mixture and curing environment allows the use of low water/cement ratios that results in a dense material that prevents water penetration."[16]

Concrete itself has low thermal insulation values. However, panels can be cast with an integrated layer of foam insulation on one face. Alternatively, panels can be manufactured with an insulating foam core. When insulated, concrete panels are an excellent all-weather building material.

Concrete panels can bring other benefits as well. For instance, TMG International emphasizes the fire resistance and sound ratings of its panels.

Concrete Panels

Overview: Precast concrete panels first gained acceptance in commercial construction and have become a viable option in residential construction as well. In 2006, "precast reached an estimated 2.7% share of above-grade walls in single-family construction, equaling about 41,000 new homes, up from a zero share just a decade earlier by [the National Association of Home Builder's] count."[14]

Made in a factory, the panels can be made to a higher strength than block or cast-in-place walls, with no weather delays, and quickly assembled on site. The result is an extremely strong envelope that can offer good fire resistance, water resistance, durability, and, if well-insulated, thermal performance.

INSTALLATION

Panels are cast to specification in the factory. According to ToolBase, "Precast concrete foundation and wall panels can take many forms. Some consist of steel-reinforced concrete ribs that run vertically and horizontally...others are solid precast concrete panels."[15] Door and window openings and spaces for electrical, plumbing, and ducts, if necessary, must be pre-planned and built into the panels, because later modifications will be very difficult.

Once delivered to the site, the panels can be assembled in a matter of days or even hours. A crane is necessary to lift and position the panels in place, which may prove expensive for a single house. If a panelized foundation is used, it may be installed on concrete footers or directly on 4-6" of compacted stone, which eliminates the need for on-site poured concrete.

PERFORMANCE

While expensive, panelized concrete is particularly suitable for applications in hurricane- and tornado-prone areas due to its very high strength:

(Fig.25) A crane is used to lift panels into place.

(Fig.26) Precast concrete panels loaded on a trailer for delivery.

DESIGN

Typical panel sizes range between 2-12' wide and 8-12' high, but larger sizes may be available. "Walls may be customized during the order process to allow for door and window openings, steel beam pockets, and brick ledges."[17]

Concrete panels are common in foundation applications but less common in residential construction. They are recognized in the International Residential Code. At a cost of $55-$65 per linear foot, they are competitive with other foundation systems but more expensive up-front than standard wood frame construction. According to expert Rich Binsacca,

> "Custom builders like the system's performance aspects, but can't afford the one-time cost premiums for engineering, shipping, and crane-assisted assembly. Large-volume production builders, meanwhile, are generally too price-sensitive to consider anything out of their comfort zone of wood-based systems; on a per-foot materials basis only, precast might cost at least 20% more...
>
> "Another hurdle to acceptance for any builder is the system's requirement for exceptionally detailed planning for all openings and mechanical runs; simply, once the panels are cast, those placements are set, literally, in stone... It's a process [that] requires weeks of planning, engineering, and confirming specs–time that most builders are loath to spend when other structural systems are so easy to manipulate in the field to fix mistakes. "But, once the panels are in place, it takes all the guesswork and time out of where to locate those things."[18]

VARIATIONS:

Lightweight Aerated Concrete:

Some manufacturers build panel variations to better cater to the needs of residential construction. For instance, Precast Building Solutions in Louisiana uses lightweight aerated concrete to reduce the weight of its 8" wall panels, making them easier to transport and assemble.

ICS 3-D Panel:

The 3-D system arrives on site as a panel of modified expanded polystyrene (EPS) insulation with a welded wire mesh frame on both sides. Once the panels are assembled on site, concrete is applied to the reinforcing mesh using either shotcrete or troweled concrete. This system allows the lightweight panels to be assembled without the use of a crane and without sacrificing the strength of concrete. ICS claims R-values of 18 to 33 for its walls.[19]

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Precast Building Solutions
- New Orleans, LA
- Manufactures precast concrete panels and builds fully furnished houses using one of several standard designs. Can also design and manufacture panels for custom house designs.
- www.precastbuildingsolutions.com
- 504-250-7287 / 504-250-7115

StormFighter Precast Homes
- Pensacola, FL
- Manufactures precast concrete wall panels.
- precasthouse.com/index.html / 850-434-9588

ICS 3-D Panel Works
- Brunswick, GA
- www.greenfusiondesigncenter.com / 912-264-3772

(Fig.27) Far from creating a bunker-like feeling, precast concrete panels can be used to create designs with the same flexibility and aesthetic as any other house.

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.

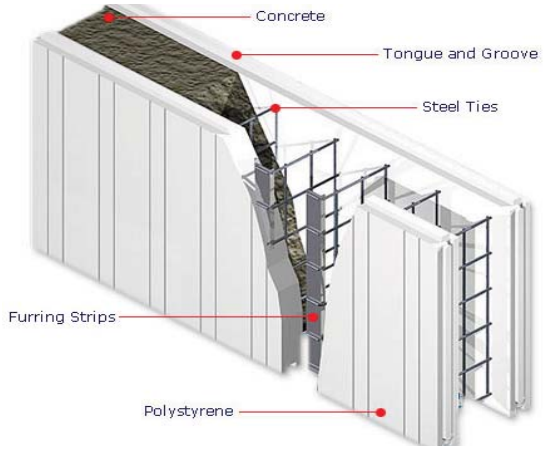
Common Failure: Common failures with ICF construction are: lack of fire-resistance in certain types of rigid foam, termite infestation, moisture problems, and difficulty adhering finish materials on the exterior or interior. [8]

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.

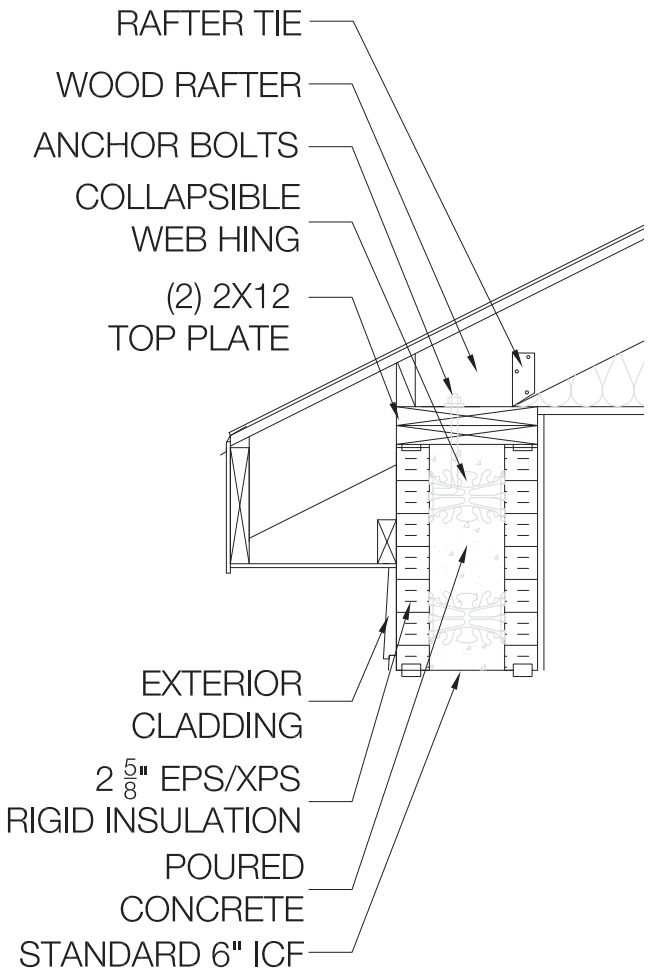
(Fig. 5) ICF walls offer superior acoustic insulation, making them a good choice for partition walls in multi-family projects.

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

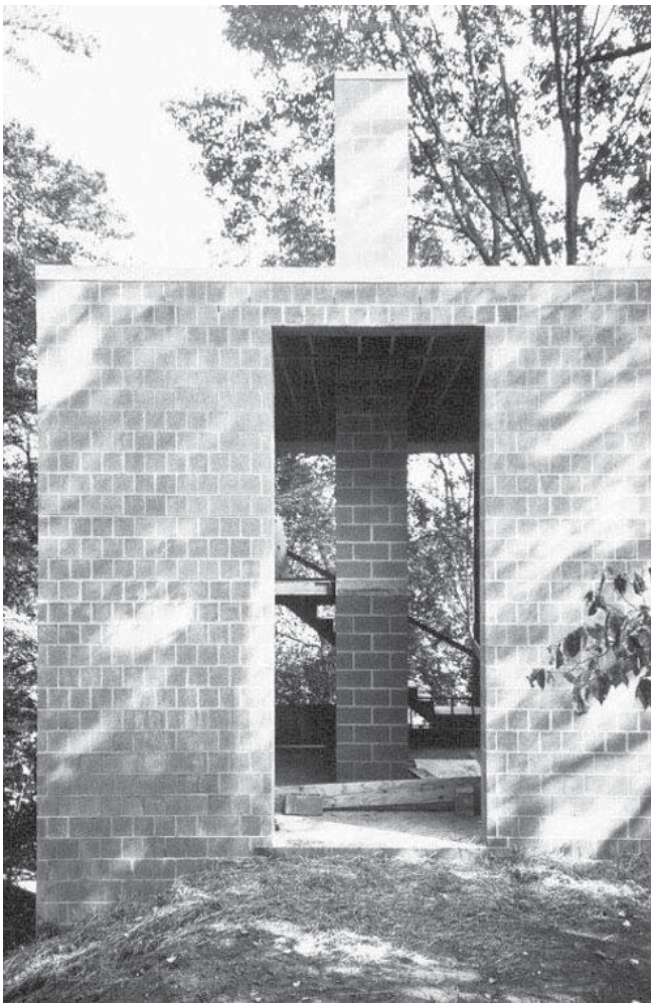
Wind Load: The design wind-load capacity of a CMU block wall is dependent on the amount of reinforcing (both horizontal and vertical).

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]

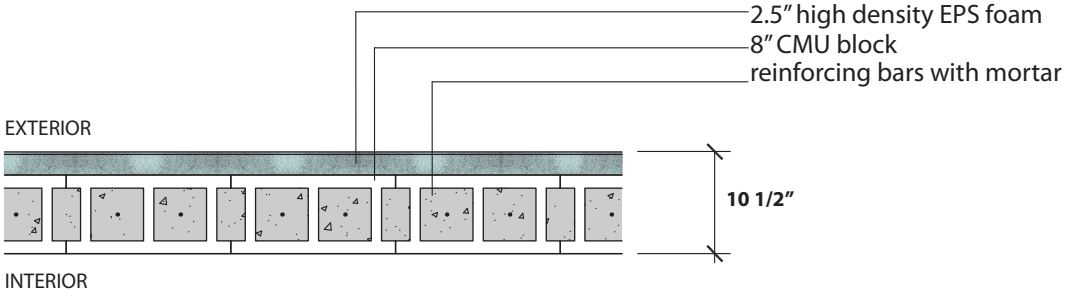
Energy / Thermal: CMU walls have low R-values, and therefore should be combined with an insulation method (see ch. 7: Insulation) in order to meet code. [15]

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.

Framing Systems

Framing systems are the basic structure used in the majority of new residential construction. Typically comprised of either wood or steel members, light frame construction provides a cost-effective, quickly assembled, and adaptable structure for building. Light frame construction can be used to build platforms, walls, ceilings, and roofs. The wood frame creates a skeleton for the house, which is stabilized using components such as sheeting and bracing.

Dimensional Lumber

Dimensional lumber is the most common material used for framing a building. Wood frame walls typically consists of 2x stud construction. As the most common mode of residential construction it is often the baseline against which alternative building techniques are measured, including in this document.

Advanced Framing

Advanced wood framing is a construction technique that uses a deeper stud (2x6 rather than 2x4) spaced 24" on center. Advantages in this system include direct load transfer, increased insulation depth, and reduced thermal bridging. The last two of these changes lead to greater energy savings. In some designs, the application of advanced framing techniques will decrease the overall amount of lumber need to frame a house.

Engineered Studs

Examples of engineered studs include laminated strand lumber, laminated veneer lumber, and parallel strand lumber. Most engineered studs are created from small, fast growing, easily replanted timber. To create an engineered stud, small pieces are bonded together with glues under compression and high heat. Studs are then milled into standard sizes and installed like dimensional lumber. Engineered lumber has a greater structural resistance than comparably sized dimensional lumber. The increased structural

(FIG.A) DIMENSIONAL LUMBER is the most typical material used in residential construction due to its ease of construction, familiarity, and relatively low cost.

(FIG.B) STEEL STUD FRAMING is a viable alternative to dimensional lumber framing and in large volumes can provide cost savings for the builder.

(FIG.C) TRUSSES offer a speedy alternative to traditional lumber joists in both floor and roof systems bridging larger spans and flexibility in the running of MEPs.

framing	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
conventional framing	+	+			+							+	+	+		
advanced wall framing						+			+							
engineered wood stud framing						+			+		+				−	
steel stud framing						+	+	+				−				
engineered wood floor trusses		+										−				
engineered steel floor trusses			+					+				+				
engineered wood roof trusses			+									+				
engineered steel roof trusses			+					+				+				

capability of engineered lumber is why it is often used when large beams or long spans are required.

Steel Studs

Another alternative to dimensional lumber framing is steel stud framing. While more typical in commercial construction, it is nonetheless a viable alternative in residential construction. When used in large volumes steel studs can provide cost savings for the builder. Although they require more precise methods of connection than wood framing, steel studs offer heightened structural capacity and other advantages.

Engineered Roof and Floor Trusses

Commonly used in residential development, engineered wood and steel roof and floor trusses can allow for greater spans than conventional lumber. Manufactured off site in a controlled environment, the precision and consistency of quality are viewed as major advantages. Additionally, open web trusses allow for utilities to run in either direction without cutting through lumber joists. Roof trusses can allow flexibility in form. Engineered wood floor trusses are typically constructed in an open-web design consisting of mostly 2x4 lumber connected at joints with metal plates.

Coastal builders must address the many challenges in making residential structures resilient in an environment with high winds and humidity. Ensuring that joints are properly sealed and connections strapped, regardless of the framing system used, is essential.

FURTHER INFORMATION

Energy Efficiency and Renewable Energy-Clearinghouse (EREC):
www.eren.doe.gov/buildings

Toolbase:
http://www.toolbase.org/PDF/DesignGuides/

OTHER TYPES OF FRAMING SYSTEMS

4 FRAMING SYSTEMS

subjects

Conventional Wood Framing

Overview: Dimensional lumber is by far the most popular wall framing material because it is readily available, easy to work with, and comparatively less expensive than other framing materials. Douglas fir and pine are some species frequently used to make framing lumber.

Materials such as steel and concrete are also used for framing. These materials can support more weight than wood framing, but are generally more costly and require special equipment and skilled professionals.[1]

INSTALLATION

Construction Process: Conventional wood framing is a process of construction where walls are framed on the slab or sub-floor, depending on the foundation and elevation of the house, and then tipped vertically into position.

Each exterior wall is laid out with a horizontal double top plate and bottom plate, and is most often framed with 2x4 studs spaced 16" on center. If openings for windows or doors are required, horizontal members are inserted at the proper width - a sill on the lower edge of the opening, and a deep load-bearing header on the upper edge of the opening.

Exterior walls are braced in position and then interior walls are framed and secured. At this point, walls should be strapped to the rim joist or foundation as well as at openings and at a regular interval along the wall in accordance with local code.

Finally, a roof will be framed in a similar manner using joists and ridge beams, or constructed using engineered trusses. This roof system will be strapped to the wall frame to complete the structural framework of the building.

Speed of Construction: Dimensional lumber framing is the most widely used method of wood residential construction and therefore provides a level of familiarity

(Fig. 1) A wall and doorway are shown framed in at a house on Mississippi's Gulf Coast

which allows for expedient construction. An experienced crew can frame a building in a matter of days.

Delivery Method: Dimensional lumber will typically be delivered to the site from the lumber distributor on a flat-bed truck in packages relating to the building sequence.

Required Equipment: Hammers or nail guns, nails, chop saw (or equivalent), any relevant hangers and/or straps.

Specialized Labor: Aside from basic carpentry knowledge, no specialized labor is needed for wood frame construction.

PERFORMANCE

Wind Load: Dimensional lumber, if properly spaced, sheathed and nailed, can be framed to withstand wind loads exceeding the 140 miles per hour required in hurricane-prone areas.

Water Resistance: Wood is prone to rot and mold and should be kept dry on site and inspected before walls are sealed, to ensure the elimination of any mold that may be present.

Fire Resistance: Wood is a combustible material and code mandates that fire blocking be installed if interior wall heights exceed 10 feet. Any vertical penetrations from electrical or plumbing lines must be fire-caulked.

Energy / Thermal: A typical wood wall that contains no insulation provides an R-value of around 3. Adding standard batt insulation to a 2x4 wall can bring its R-value up to 15.

Life Span: Despite many claims of conventional wood framing's shorter life spans, the life span of the building depends more heavily on the exterior cladding and construction of both interior and exterior walls, which protect the wood studs from moisture and exposure.

Common Failure: Failure in dimensional lumber framing arises mostly from problems of moisture exposure. Failure can also result from improperly connected joints or insufficient or incorrect fastening to adjoining members of the wall, roof, and floor systems.

DESIGN

Environmental Impact: After a long period of poor forestry practices, dimensional lumber production has moved toward more sustainable growing practices.

(Fig. 2) With an experienced crew, a house can be framed in a matter of days.

(Fig. 3) Basic carpentry knowledge is needed for wood frame construction.

(Fig. 4) It is important to ensure studs are properly strapped according to local building codes to prevent failure in a high wind event.

Lumber companies have begun branding many of their products to reflect the improved practices in the planting, harvesting, and nurturing of the trees associated with the milling process.

Versatility / Flexibility: Conventional wood framing techniques have been modified and adapted for centuries, and the flexibility and familiar nature of wood makes it versatile.

Market Exposure: As the prevalent material for residential construction, the market exposure of lumber framing is extremely high.

Code Approval: Conventional lumber frame construction complies with Residential Building Code.

Affordability: The affordability of dimensional lumber is one of the reasons it is the dominant framing material.

Coastal Considerations: The most critical factor in framing on the Gulf Coast is proper strapping and affixing of all fasteners. In a high wind situation, it is important to follow code requirements for additional sheathing, strapping, or framing.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Retailers in the Gulf Coast Area include: Nearly every building supply retailer carries dimensional lumber. These include major and local chains:

- Lowe's
- Home Depot
- 84 Lumber
- Home Town Lumber & Supply Incorporated
- Ocean Springs Lumber & Supply Co.
- McDonald W A & Sons
- Biloxi Lumber Co
- Bailey Lumber & Supply

(Fig. 5) Exterior walls are held plumb by bracing until interior walls are framed.

Advanced Wood Framing

Overview: Advanced wood framing is a technique that uses a deeper stud (2x6 rather than 2x4) spaced 24" on center in order to take advantage of direct load transfer, increase the insulation of walls to reduce energy loss, and decrease the overall amount of lumber used during framing.

INSTALLATION

Construction Process: Advanced wood framing is installed similarly to conventional wood framing but employs 2x6 studs at 24" on center, rather than 2x4 studs at 16" on center. One way in which it differs from conventional wood framing is the turning of a corner with a simpler two-stud construction. Additionally, there are techniques that must be implemented to adjust for the added depth of the wall and 24" spacing in relation to doors and windows.[2]

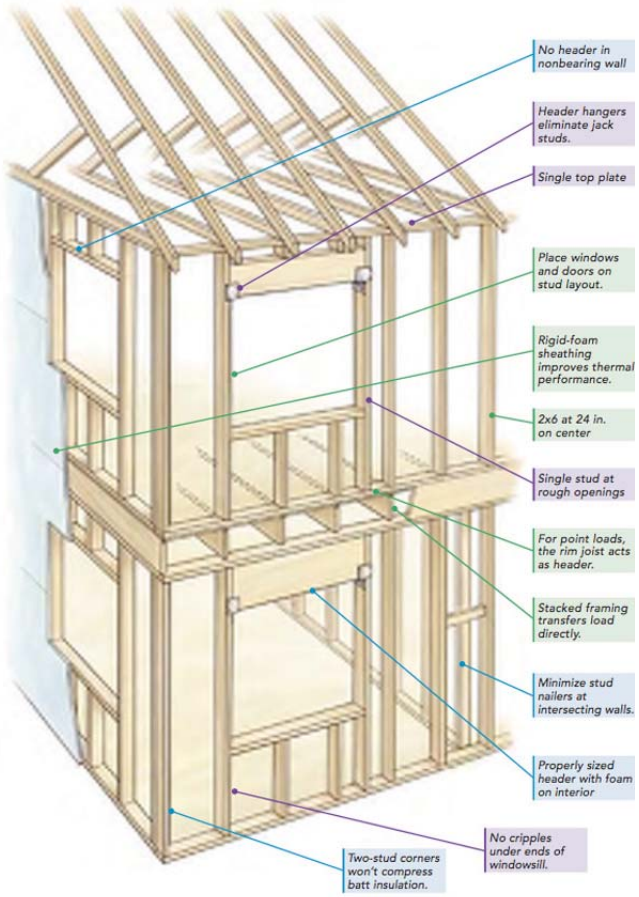
Beside the need to familiarize a crew with the code requirements, advanced wood framing is simpler than 16" spacing. It creates a house-wide 24" module that will align stud, joist, and rafter in a single line and ideally minimizes inaccuracies or missteps in the integrity of connections between the three.[3]

Speed of Construction: Advanced wood framing is not significantly faster than conventional lumber framing.

Delivery Method: Dimensional lumber is widely available and will typically be delivered to the site in packages as construction progresses.

Required Equipment: Hammers or nail guns, nails, chop saw (or equivalent), any relevant hangers and/or straps

Specialized Labor: Other than familiarizing a crew with the construction techniques, no specialized labor is necessary for advanced wood framing



(Fig. 6) Using advanced framing techniques increases the interval between studs from 16" to 24" O.C.

PERFORMANCE

Wind Load: Despite wider spacing, advanced wood framing's increased stud size results in similar wind performance as standard lumber framing.

Water Resistance: Wood is prone to rot and mold and should be kept dry on site and inspected before walls are sealed, to ensure the elimination of any mold that may be present.

Fire Resistance: Wood is a combustible material and code mandates that fire blocking be installed if interior wall heights exceed 10 (ten) feet. Any vertical penetrations such as electrical wiring or plumbing requires fire caulking.

Energy / Thermal: A typical wood wall that contains no insulation provides an R-value of around 3. Adding standard batt insulation to a 2x6 wall can result in a wall with an R-value of up to R-22.

Life Span: Despite many claims of conventional wood framing's shorter life spans, the life span of the building depends more on the exterior cladding and the construction of both interior and exterior walls to protect the wood studs from moisture and exposure.

Common Failure: Failure in advanced wood framing, as in dimensional lumber framing, arises mostly from the problems of moisture exposure. Failure can also result from improperly connected joints or insufficient or incorrect fastening to adjoining members of the wall, roof, and floor system.

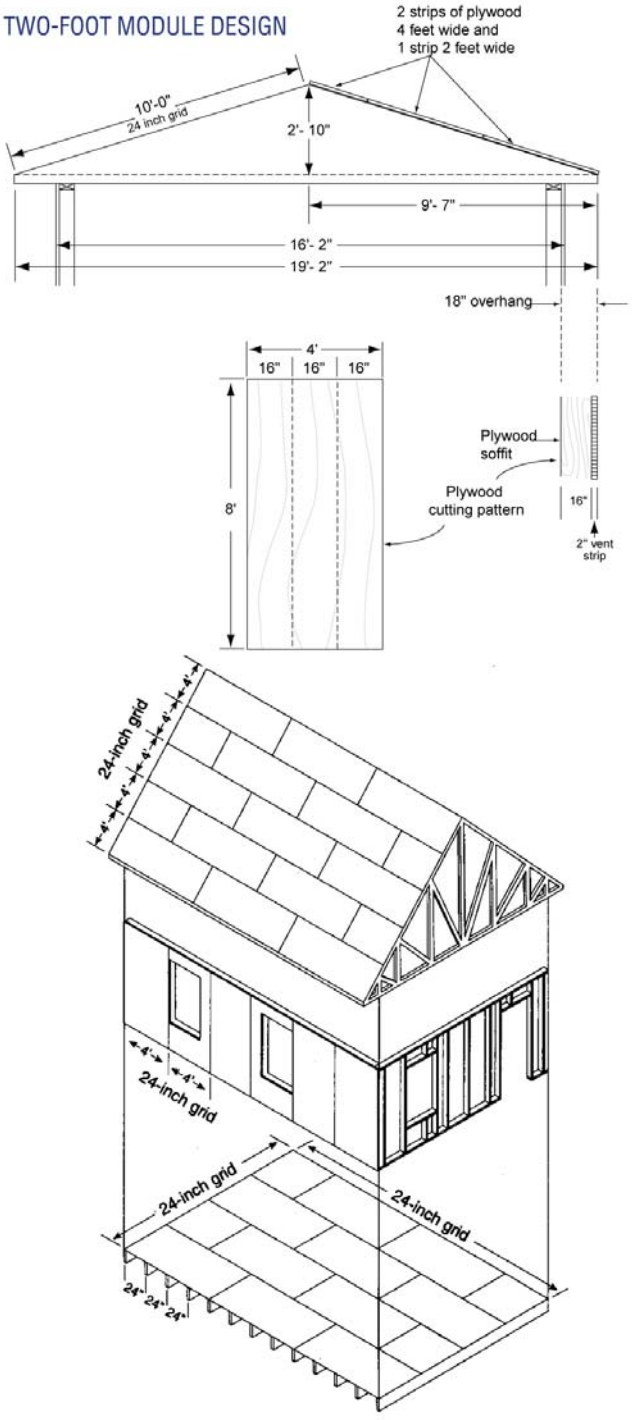
DESIGN

Environmental Impact: One of the main advantages of advanced wood framing is the increase in whole wall R-value. This is achieved with the greater wall depth and additional insulation, as well as reduced thermal bridging, all of which lead to energy savings for the home owner.

Versatility / Flexibility: As a lumber-based system, an advanced wood framing system is very flexible. However, the 24" spacing has more code restrictions, such as lateral bracing and strapping requirements. In addition, more planning is required in determining the framing layout in the field.[4]

Market Exposure: Advanced wood framing techniques are still not widely used. This system's popularity is likely to grow as the benefits of and differences from conventional wood framing are more widely understood.

Code Approval: Advanced wood framing is allowed by



(Fig. 7) The two-foot module allows the entire structural system to align. The consistent dimensions minimize waste.

residential building codes but may need to be introduced to, discussed with, and demonstrated to code officials to gain their confidence in this alternative system.

Affordability: Although the cost of a 2x6 is greater than a typical 2x4 used in conventional framing, the reduced material usage and energy savings may offset this drawback.

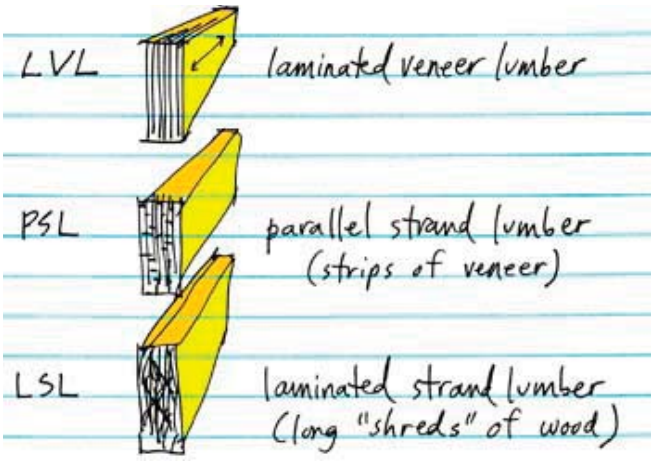
Coastal Considerations: A critical consideration for building on the coast is ensuring proper construction to withstand wind loads. In addition, local builders may face inspectors unfamiliar with this system.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS:

Retailers in the Gulf Coast Area include: Nearly every building supply retailer along the Gulf Coast carries dimensional lumber. These include:

- Lowe's
- Home Depot
- 84 Lumber
- Home Town Lumber & Supply Incorporated
- Ocean Springs Lumber & Supply Co.
- McDonald W A & Sons
- Biloxi Lumber Co
- Bailey Lumber & Supply

(Fig. 8) 2x6 studs on 24 inch centers, stack framed, single top plates, two stud corners, no jacks, no cripples. Almost 40 percent of the framing elements typical in traditional wood frame construction have been removed.



(Fig. 9) Engineered wood studs come in three main varieties that are delineated by the material and composition technique in the bonding process during manufacturing.

Engineered Wood Stud Framing

Overview: Engineered studs consist of Laminated Strand Lumber (LSL), Laminated Veneer Lumber (LVL), and Parallel Strand Lumber (PSL). They are made of small dimension, fast growth timber that can be easily replanted. The manufacturing process bonds wood components with glues and compression under high heat, and then mills them into standard dimensional lumber sizes. Because they are factory manufactured, their dimensions are more precise and consistent than standard dimensional lumber. Engineered studs are installed identically to standard dimensional lumber. [5]

INSTALLATION

Construction Process: Methods of construction are identical to standard dimensional lumber construction.

Speed of Construction: Although there may be a minimal amount of time saved due to the more regular nature of engineered studs, it is not significant in comparison to lumber framing.

Delivery Method: Methods of construction are similar to standard dimensional lumber construction.

Required Equipment: Hammers or nail guns, nails, chop saw (or equivalent), any relevant hangers and/or straps.

Specialized Labor: Methods of construction are identical to standard dimensional lumber construction.

PERFORMANCE

Wind Load: Engineered Lumber has the same structural resistance as comparably sized dimensional lumber

(Fig. 10) An LSL used as a header along with typical wood frame construction.

(Fig. 11) Finger jointed i-beam engineered studs arriving on-site in a lumber package delivery.

but can be designed to carry increased loads and spans if desired. This is often employed in beams or long span situations.

Water Resistance: Similar to dimensional lumber, engineered wood is prone to rot and mold. Additional water damage can occur when the glue is exposed to water if the lumber is not properly sealed. Engineered lumber should be kept dry on site and inspected before walls are sealed to ensure the elimination of any mold that may be present.

Fire Resistance: Engineered wood is a combustible material and code mandates that fire blocking be installed if interior wall heights exceed 10 feet. Any vertical penetration such as electrical wiring or plumbing requires fire caulk.

Energy / Thermal: Engineered wood provides no additional thermal advantages. With standard batt insulation builders can attain an R-value of 15.

Life Span: Due to its more precise construction, engineered lumber can reduce inconsistencies in the wall system. As a result, this system has been reported to reduce the possibility of mold growth inside the wall cavity.

Common Failure: Failure in engineered wood framing arises from the same problems as conventional framing: water and moisture exposure, improperly connected joints, and insufficient or incorrect fastening to adjoining members of the wall, roof, and floor systems.

DESIGN

Environmental Impact: Because engineered wood is manufactured using small dimension, fast growing trees such as aspen and poplar, it reduces depletion of old-growth forests.[6]

Versatility / Flexibility: Because components are formed to specification, engineered lumber is an extremely versatile building material.

Market Exposure: Although widely available, engineered lumber is typically viewed as a specialty product due to the cost differential between engineered studs and dimensional lumber.

Code Approval: Engineered lumber complies with typical residential building codes. A submittal consisting of load tables and specifications for installation and an evaluation report for building officials should accompany the construction drawings submitted for permitting.

Affordability: For wall framing applications engineered studs cost between 3 to 4 times more than dimensional lumber.

Coastal Considerations: Builders should follow code prescription for any additional sheathing, strapping, or framing needed to increase structural stability in preparation for high wind events.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

- Gulf Coast Components LLC
- Phillips Frame & Truss Inc.

Gulf Coast availability of engineered studs is limited but many stores are able to place orders to out of state manufacturers. The following are some manufacturers in the region:

- Louisiana Pacific, Nashville, TN: http://www.lpcorp.com/
- Boise Cascade, Memphis, TN/Milton, FL: http://www.bc.com/
- Georgia-Pacific, Atlanta, GA: http://www.gp.com/build

(Fig. 12) A close-up of an engineered wood stud.

Steel Stud Framing

Overview: Steel framing, while more typical in commercial construction than residential, is a viable alternative to conventional wood stud framing. In large volumes, steel framing can provide cost savings for the builder. Although it does require different installation equipment and training in layout and construction, steel framing provides more structural capacity than wood framing.[7]

INSTALLATION

Construction Process: Although it requires a different set of tools than wood stud framing, ease of construction is comparable to standard wood framing techniques. Due to the sharp edges of site-cut steel members, safety is a consideration. Installers should wear eye and hand protection at all times while framing.[8]

Speed of Construction: Speed is comparable to standard wood framing once a crew is properly trained.

Delivery Method: Steel studs arrive on site in packages along with ceiling and floor tracks.

Required Equipment: Screwdriver, c-clamp locking pliers, sheet-metal locking/duckbill pliers, tape measure, straight-cut metal snips, miter saw with metal cutting blade, screws (self-tapping preferred), level (with magnetic strip is convenient), work gloves, eye protection[9]

Specialized Labor: Individuals that do wood framing can be trained to do steel stud framing.

PERFORMANCE

Wind Load: Steel studs can be designed to withstand required lateral forces seismic loads derived from local conditions and requirements.

(Fig. 13) Steel stud walls are constructed with upper and lower guide tracks that are attached to the ceiling and floor.

(Fig. 14) After setting the guide tracks the studs are attached to create the walls.

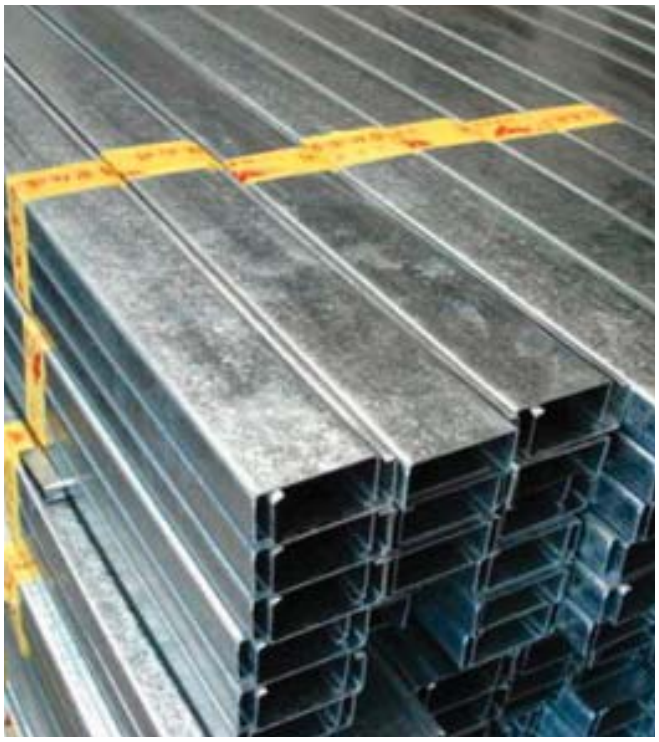
Water Resistance: Steel studs are typically coated with a water resistant material or galvanized in order to prevent rust and resist water damage.

Fire Resistance: Steel studs are fire resistant and non-combustible.

Energy / Thermal: The thermal properties of a steel wall are nearly identical to conventional wood framed walls. However, in northern states, different insulation practices may be required.

Life Span: Metal studs resist rot, insects, and mold, providing the possibility of a longer life span.

Common Failure: Failure can arise from improper connections to both roof and floor systems, especially in hybrid wood and steel systems.



(Fig. 15) Steel studs arrive on site in bundles similar to their wood counterparts.

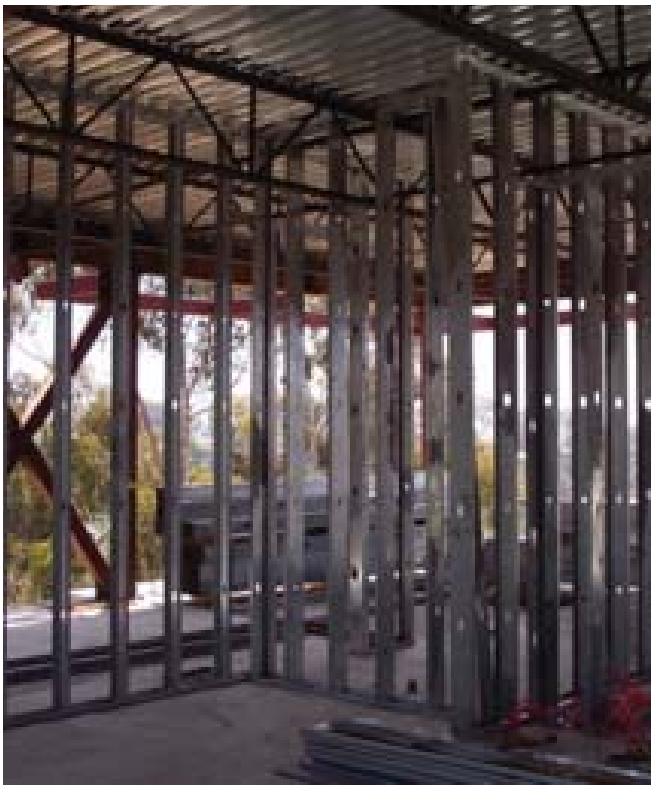
DESIGN

Environmental Impact: Steel studs are highly recyclable. Steel studs can be purchased at with varying amounts of recycled content. Some manufactures offer products with as high as 90% recycled content. A study cited by Whole Earth states that steel studs contain about 20% more embodied energy than dimensional wood lumber. [10]

Versatility / Flexibility: Steel-framed interior walls are typically not load bearing. If interior walls are to be load bearing, some planning is necessary, as larger or heavier gauge components are required. In general, steel framed walls are less flexible than their wood counterparts, as the 2-step process of laying track and infilling with studs makes sections more difficult to relocate on site than conventional wood framed walls. In addition, because wood blocking is needed where cabinets or other components are to be attached to the completed wall, preliminary planning is required to determine where these elements will go before walls are closed in.[11]

Market Exposure: Steel studs are sold in a variety of sizes comparable to dimensional lumber. Most home and lumber stores carry only the most typical 3 5/8" wide 25-gauge steel studs in 8-, 9-, 10-, and 12-foot lengths. These are used for framing non-load-bearing interior walls. Components in different widths and heavier gauges (for non-load-bearing and load-bearing exterior walls) can be special ordered through many larger retailers[12].

Despite increased availability and exposure of metal studs, wood remains the prevalent residential framing material in the United States. The American Iron and Steel Institute estimates that annually just two percent of new homes, or 27,000, are steel framed.[13]



(Fig. 16) A steel-framed wall system tied into steel floor trusses and steel pan flooring.

Code Approval: Steel stud construction complies with Residential Building Codes.

Affordability: Though the initial cost of the studs and tracks may be comparable to wood stud framing, there are additional costs to consider such as additional electrical costs to comply with code and the use of thicker drywall.

Coastal Considerations: One main issue can be the corrosion of the studs from contact with improper tools, which can cause chips or breaks in the protective coating. This can be avoided by using the proper installation tools and procedures.

(Fig. 17) Steel studs come in a variety of sizes, most of which are comparable to wood studs.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

- PowerBilt Steel Buildings, Inc.
- Universal Steel Corp.

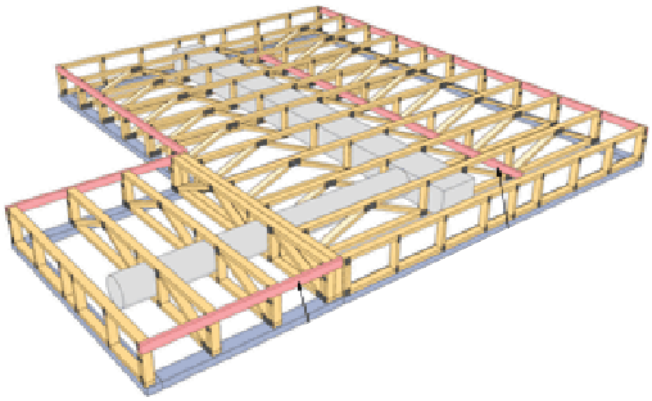
Gulf Coast availability of steel studs is limited but many stores are able to place orders to out of state manufacturers. The following are some manufacturers in the region:

- Allsteel & Gypsum Products Inc., Ft. Lauderdale, FL http://www.allsteelproducts.com/
- Craco Manufacturing, Inc. York, SC. http://www.cracometals.com
- Steel Construction Systems. Orlando, FL. http://www.steelconsystems.com
- Southeastern Stud & Components, Inc., Montgomery, AL.
- The Formetal Co., Inc., Forest Park, GA
- The Steel Network. Durham, NC. http://steelnetwork.com

Engineered Floor Trusses

Overview: Commonly used in residential construction, engineered wood floor trusses allow for much greater spans than conventional lumber. Manufactured off site in a controlled environment, their precision and consistent quality are major advantages. Additionally, open web trusses allow for utilities to run in either direction without the need for on-site cutting. Engineered wood floor trusses are typically constructed in an open-web design consisting of mostly 2x4 lumber connected at joints with metal plates.[14]

As a non-combustible alternative to the wood floor truss, engineered steel floor trusses are already being used in many commercial and multi-unit residential applications. They have yet to significantly infiltrate the single-family home market.



(Fig. 18) Floor trusses allow for utilities to run perpendicular within the confines of the structure.

INSTALLATION

Construction Process: Because they are built to specification, engineered floor trusses are delivered as an entire floor package. Trusses can save time and are relatively easy to install. Installation details provided by the manufacturers should be followed closely and will be familiar to a skilled construction crew. Steel trusses should be assembled by a crew with a knowledge of steel frame assemblies.

Speed of Construction: The main advantage of using a truss system is speed. With pre-cut and engineered steel trusses, the on-site labor for a house can be reduced greatly with a skilled construction crew.

Delivery Method: Floor trusses are ordered and delivered by a manufacturer to the site as a complete package, typically on a flatbed semi-trailer.

Required Equipment: Standard framing tools are the only tools necessary; larger trusses become unwieldy and

(Fig. 19) Trusses are assembled in a manufacturing plant.

may require a crane. This may be the case when using steel trusses or large wood trusses.

Specialized Labor: Although no specialized labor is required, construction crews should have a general understanding of the connections specific to the wood or steel truss packages.

PERFORMANCE

Wind Load: Engineered trusses are designed and manufactured to withstand wind loads based on geographical wind data and other factors such as specialized truss usage.

Water Resistance: As with all wood systems, engineered wood floor trusses are prone to rot and mold and should be kept dry on site. Steel trusses are typically coated with a water resistant material or are galvanized in order to prevent rust and maintain their water resistance.

Fire Resistance: Wood trusses have the same susceptibility to fire as other dimensional lumber. Steel roof trusses are fire resistant and non-combustible.

Energy / Thermal: The depth of engineered floor trusses, commonly 12, 14, 16, 18 or 24", provides adequate space for insulation to exceed residential building code requirements.

Life Span: Like any other wood system, wood floor trusses' durability depends greatly on the care used in construction to protect the trusses from moisture and exposure. In exposed and treated floor trusses, it is important to use properly treated nails and to protect the components from insects and small animals, which may be accomplished with screening. As is the case with steel studs, steel floor trusses resist rot, insects, and mold, which increases their life span.

Common Failure: Wood trusses typically fail due to moisture exposure, as well as in high wind events due to improperly connected joints or insufficient or incorrect fastening to adjoining members of the wall system. Failure can also occur in hybrid systems that are insufficient or improperly constructed.

DESIGN

Environmental Impact: All engineered floor trusses reduce on-site waste because they are manufactured. Steel trusses can be made of recycled material.

(Fig. 20) A truss used to create a platform-framed second floor. Gaps in the truss allow room for plumbing, electrical, and HVAC to run freely.

Versatility / Flexibility: Engineered wood floor trusses allow for long spans. The open web design allows for flexibility in placing mechanical, electrical, and plumbing systems. Additionally, a new industry development, trimmable wood floor trusses, allows the members to be shortened by creating either an I-joist on either end, or an end built of dimensional lumber and created separate from the existing truss plate.[15]

Market Exposure: The engineered open-web truss is the most common floor truss. Trusses are widely used in repeatable floor plans and houses built by developers and housing manufacturers, but are less common in individually contracted homes.

Code Approval: Engineered floor trusses comply with typical residential building codes. A submittal consisting of load tables and specifications for installation and an evaluation report for building officials should accompany the construction drawings submitted for permitting.

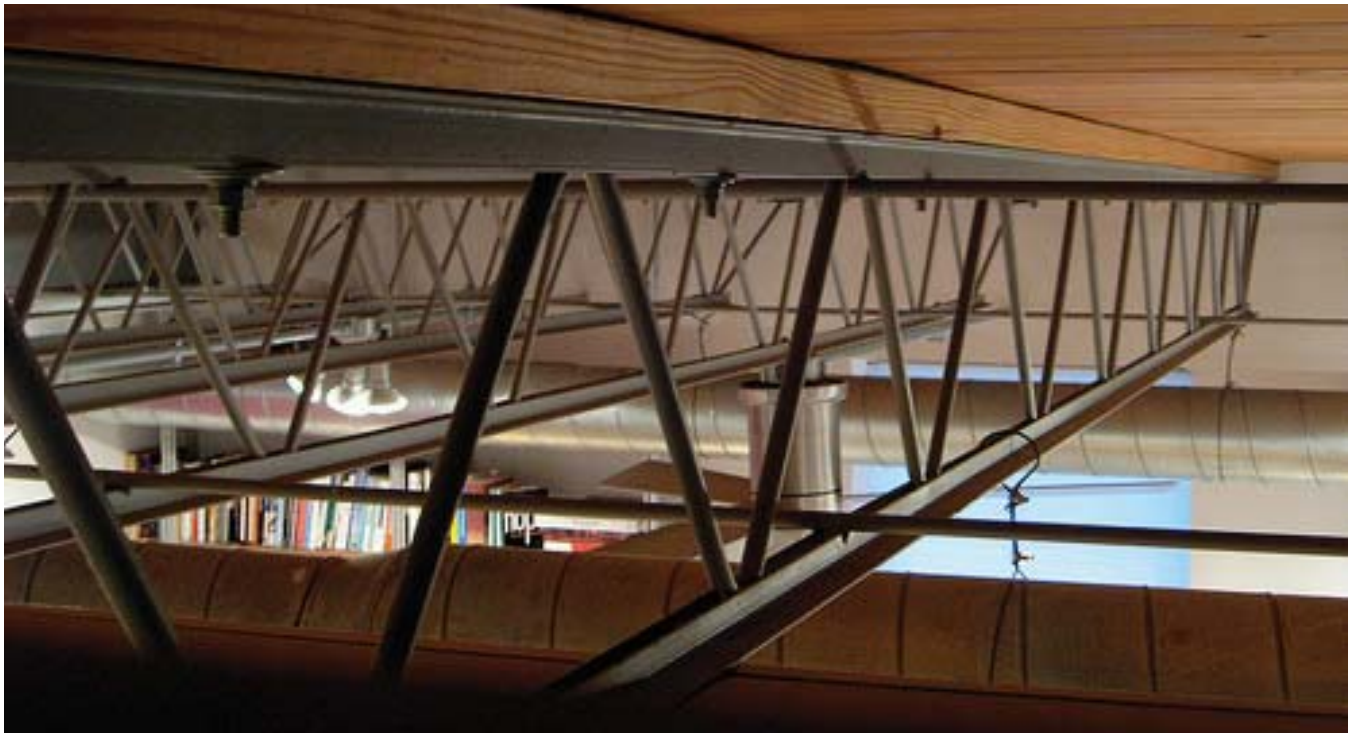
Affordability: Although trusses are more costly than conventionally framed roofs, they require less carpentry skill and save on overall cost of labor due to their relative speed of construction.

Coastal Considerations: Moisture is the biggest concern. Trusses should be properly covered to prevent mold growth and stored flat to prevent warping.

Like steel studs, steel trusses can corrode from contact with improper tools, which can cause chips or breaks in the protective coating. This can be avoided by using the proper installation tools and procedures.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

- Gulf Coast Components
- Gulf Coast Truss
- Phillips Building Supply
- Phillips Frame & Truss Inc
- Pine Belt Truss Company

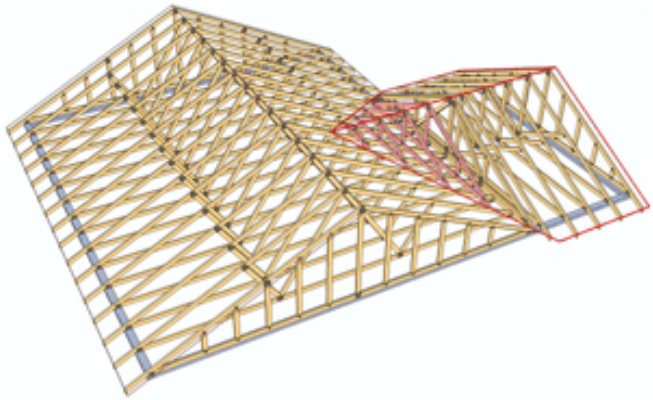


(Fig. 21) An engineered steel truss in a hybrid application.

Engineered Roof Trusses

Overview: Nearly all residential roofs are framed using one of two methods: standard dimensional lumber stick framing, or truss framing. Stick-framed roofs utilize individual rafters that span from the tops of exterior walls to the ridge. Truss-framed roofs are built from triangular-shaped, pre-made truss units. A truss is one continuous rafter/ceiling joist unit. Truss construction is as strong as stick framing, but is lighter weight and uses smaller components.[16]

Like wall studs and floor joists, rafters and trusses are spaced 16" or 24" on center. Most roofs utilize 24" spacings for strength and rigidity, while limiting the amount of material needed.



(Fig. 22) Trusses are cost effective. They save labor with fast installation, and can reduce job-site errors, cleanup, and waste. The open web design allows easy installation of plumbing, electrical, and HVAC.

INSTALLATION

Construction Process: Trusses offer a precisely manufactured, lightweight alternative to stick-framed roofs for simplified construction. Trusses are connected to the wall system, and blocking of a similar material is used to tie individual trusses together.

Speed: An advantage of truss construction is speed. Engineered trusses require less on-site labor than stick-framed roofs because the trusses are pre-assembled, easy to maneuver into place, and typically comprise both roof and ceiling construction.

Delivery Method: Roof trusses are ordered and delivered by a manufacturer to the site as a package, typically on a flatbed semi-trailer.

Required Equipment: Similar to floor trusses, standard framing tools are the only tools necessary; larger trusses may require a crane. This may be the case when using steel trusses or large wood trusses.

Specialized Labor: Although no specialized labor is

(Fig. 23) Blocking is nailed in place to tie the trusses together.

required, construction crews should have a general understanding of the connections specific to the wood or steel truss packages.

PERFORMANCE

Wind Load: Engineered roof trusses are designed and manufactured to withstand wind loads based on geographical wind data and other factors such as specialized truss usage.

Water Resistance: As with all wood systems, engineered wood roof trusses are prone to rot and mold and should be kept dry on site to avoid any mold growth. Steel trusses are typically coated with a water resistant material or are galvanized in order to prevent rust and maintain water resistance.

Fire Resistance: Wood trusses have the same susceptibility to fire as other dimensional lumber. Steel roof trusses are fire resistant and non-combustible.

Energy / Thermal: The depth of engineered floor trusses, commonly 12, 14, 16, 18 or 24", allows for insulation to exceed residential building code requirements.

Life Span: Like any other wood system, wood floor trusses' durability depends greatly on the care used in construction to protect the trusses from moisture and exposure. In exposed and treated floor trusses, it is important to use properly treated nails and to protect the components from insects and small animals, which may be accomplished with screening. As is the case with steel studs, steel floor trusses resist rot, insects, and mold, which increases their life span.

Common Failure: Failure may arise from improper connections to wall systems during high wind events when sudden uplift occurs.

DESIGN

Environmental Impact: Engineered roof trusses can reduce on-site waste because of their precise manufacturing. Steel trusses can be comprised of recycled material.

Versatility / Flexibility: Engineered roof trusses allow for longer spans. The open web design also allows for flexibility in placing mechanical, electrical, and plumbing systems.

Market Exposure: Trusses are widely used in repeatable floor plans and houses built by developers and housing manufacturers, but are less common in individually contracted homes.

(Fig. 24) Lightweight steel trusses allow for design flexibility and are resistant to corrosion.

(Fig. 25) Roof trusses are typically constructed with 2x4 or 2x6 lumber.

(Fig. 26) Wood roof trusses sit on an exterior bearing wall.

Code Approval: Engineered floor trusses comply with typical residential building codes. A submittal consisting of load tables and specifications for installation and an evaluation report for building officials should accompany the construction drawings submitted for permitting.

Affordability: Although trusses are more costly than conventionally framed roofs, they require less carpentry skill and save on overall cost of labor due to their relative speed of construction.

Coastal Considerations: Moisture is the biggest concern. Trusses should be properly covered to prevent mold growth and stored flat to prevent warping.

Like steel studs, steel trusses can corrode from contact with improper tools, which can cause chips or breaks in the protective coating. This can be avoided by using the proper installation tools and procedures.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

- Gatorback Truss Manufacturing
- Gulf Coast Components
- Gulf Coast Truss
- Modern Homes & Equipment Co. Inc.
- Phillips Building Supply
- Phillips Frame & Truss Inc.
- Pine Belt Truss Company

(Fig. 27) Roof trusses can be configured in many different ways to account for ventilation, storage, or mechanical systems.

(Fig. 28) Similar to other dimensional building systems, trusses are delivered from the builder in packages according to specification.

Chapter 5, *Elevated Foundations*, is currently undergoing revisions and will be reuploaded to the webpage and the document .pdf shortly. Please check back soon for updates.

Flooring Systems

Residential floors are typically an assembly of structural floor joists, overlaid with a subfloor sheathing and covered by any of a wide range of finish materials. Alternatively, floors can be constructed of a material that acts as both structural subfloor and finished floor. Materials such as concrete (both cast-in-place and pre-cast panels) and tongue & groove dimensional lumber can be used in this way.

Floor Finishes

Among the many floor finishes available are engineered (laminate) wood, bamboo, cork, vinyl, rubber, linoleum, natural- or synthetic-fiber carpet, tile, and stone. The choice of finish material will depend on many factors. Comfort and appearance are high priorities in the living areas of the house. Durability and ease of maintenance are important in high-use rooms and especially in wet rooms such as kitchens and bathrooms. Affordability and ease of installation are factors that vary greatly among floor finishes. Finally, the impact on the environment and the indoor air quality of the house should be considered.

Environmentally Preferable Products

A variety of environmentally preferable flooring products are available. Some, such as bamboo, cork, and other woods, are produced from fast-growing, renewable sources. Others, such as carpeting and tile, can include recycled content. Products that contain rubber, formaldehyde, harmful sealants, or other materials that off-gas should be avoided or used only in well-ventilated areas. Linoleum, which uses more renewable materials and off-gasses less, is an environmentally preferable alternative to vinyl. Carpeting should be avoided, as it collects dirt and mold, especially in moist climates, and adhesives and backers can off-gas; area rugs are a environmentally preferable choice.

(FIG.A) TONGUE AND GROOVE FLOORING This 2x6 southern yellow pine floor will be sanded and finished with a stain or sealer.

(FIG.B) FINISH MATERIALS are applied on top of the subfloor. In the past decade more sustainable finish materials have become widely available.

(FIG.C) SUSPENDED CAST-IN-PLACE DECKS can be used in combination with ICF walls and a concrete foundation system.

floors	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
subfloors w/ finishes			+	+	+							+	+			
2x6 tongue & groove	−	−	+			+					+		−			+
pre-cast panels		+	−	−	−	+		+		+		−	−		−	
cast in place floors	+	+				+		+		+		+			−	

Tongue and Groove Wood Floors
Tongue and groove floors are assembled using dimensional lumber with pre-routed tongues and grooves that allow the boards to be fitted together securely. These floors take longer to install than a plywood subfloor, but once sanded and sealed, the result is an attractive and comfortable finished floor. The strength of the continuously interlocked deck allows increased joist spacing and provides additional lateral strength to the house, an important consideration in hurricane- and tornado-prone areas.

Suspended Cast-In-Place Deck
Suspended cast-in-place decks are an elevated floor system that utilizes site-cast reinforced slabs supported by cold-formed steel joists. The steel joists are designed to house the formwork for the slabs above, so that formwork either remains a part of the structure after the concrete has cured, or is removed and re-used for other projects. This system is often used in combination with ICF walls and a concrete foundation system.

Pre-Cast Floor Panels
Pre-cast concrete panels are more common in multi-family units and commercial construction than in single-family homes. As concrete becomes common in residential construction, manufacturers are attempting to scale down the size and cost of these pre-cast panels in order to make them a more viable option for home construction.

(FIG.D) PRE-CAST FLOOR PANELS can be tensioned off-site and are often hollow. Pre-cast panels can be utilized for quickly assembled, strong and fire-resistant floor systems.

FURTHER INFORMATION

- *The Short and Long of Floors* (www.short-andlongofit.com/renovate/flooring.html)
- *GreenHomeGuide* (www.greenhomeguide.com/index.php/know-how/entry/803/C220/)
- Toolbase (http://www.toolbase.org)

NOTES ON FLOORING

6 FLOORING SYSTEMS

subjects

2x6 Tongue and Groove Decking

Overview: A tongue and groove floor system, assembled of pre-routed 2x6s of solid wood such as southern pine, is both subfloor and, after sanding and sealing, finished floor. The strength of a continuous interlocked 2x deck provides additional lateral bracing, making the system well-suited for hurricane zones. It also allows for a greater joist spans than a typical subfloor. Installation takes more time and care than a plywood subfloor but the end result is an attractive natural wood floor.

Like any other flooring material, tongue and groove decking must be well-insulated from below. A construction adhesive is applied to the joists before laying the 2x6s, and the tongues are nailed to every joist with 8 penny spiral-shank nails.

INSTALLATION

Construction Process: As the 2x6s will be the finished floor, care must be taken during installation to prevent surface damage. If the wood is of inferior quality or left exposed to the elements before installation, warping will most likely occur, making it difficult to align the boards and securely interlock them. The floor must be fully installed before contractors can frame walls on top of it.

Speed of Construction: The tongue and groove wood takes longer to lay out than a OSB/plywood subfloor, because care must be taken to provide a finish-quality installation. Once it is installed, however, no further flooring needs to be applied, saving time on finish work.

Delivery Method: Tongue and groove is readily available from most local lumber yards. If not in stock, it can be ordered quickly. Lumber is delivered on-site by the lumber yard.

Required Equipment: A nail gun and 8d spiral shank nails are required for installation, but no special equipment. Once flooring is installed, a floor sander can be rented to finish the floor.

Specialized Labor: No specialized labor is required, only the attention to detail required of a finish carpenter.

(Fig.1) 2x6 tongue and groove decking is simply stock lumber routed with tongues and grooves along its sides. Its additional depth makes it a strong and simple floor material.

PERFORMANCE

Wind Load: The 1½" thick interlocked flooring is twice the thickness of standard plywood subfloors, and adds minimal additional wind load resistance.

Water Resistance: No significant change in water resistance over conventional subfloors. With only one layer of flooring, no gutting is required to dry out component pieces in case of flooding.

Energy/Thermal: No significant change in thermal performance.

Life Span: When properly moisture-protected and insulated, the flooring will last at least as long as a traditional subfloor/finish-floor system. Gouges or dents in the surface of the wood can at any point be sanded down and refinished.

Common Failure: Flooring must be well-nailed and glued along the rim joists to prevent the floor system from becoming a weak point.

DESIGN

Environmental Impact: Wood is a renewable resource, if harvested sustainably. Locally sourced lumber is readily available, particularly pine. Construction adhesive can contain harmful gases, but products identified as "low VOC" can be used.

Versatility/Flexibility: This flooring system is adaptable to first floors or second floors, and is very strong.

Market Exposure: 2x6 tongue and groove flooring is not common in residential work. The tongue and groove is more often a roof deck visible to the floor below. Contractors may not have experience installing this system.

Code Approval: No known code approval issues.

Affordability: This system is slightly more expensive than a standard subflooring system, although homeowners save on the cost of a finish floor. Additionally, its strength allows joists to be spaced farther apart, which may save lumber costs.

Coastal Considerations: Additional strength from the thicker boards helps reinforce buildings against hurricane-strength winds.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

2x6 tongue and groove decking is available at several lumber yards along the Gulf Coast. Often it is carried in stock, but may also be special ordered.

(Fig.2-3) Workers can nail through the tongue or groove into joists at an angle, which results in a single smooth surface both above and below. Two-story houses are particularly well-suited to this system.

Suspended Cast-in-Place Decks

Overview: A suspended cast-in-place deck refers to an elevated floor system that utilizes site-cast reinforced concrete slabs that are supported by cold-formed steel joists. The steel joists are designed to house the formwork for the slabs above, so that formwork either remains a part of the structure after the concrete has cured, or is removed and reused for other projects. This system is most commonly used in combination with ICF walls and a concrete foundation system.

INSTALLATION

Construction Process: The ease of construction of a suspended cast-in-place deck is dependent on the steel joist and its assembly. The most commonly used system in residential construction is composed of a steel joist with punched holes that hold reusable lockbars in place. The lockbars support 4'x8' sheets of plywood or OSB that serves as the formwork for the slab. The steel joists also have a raised lip from which steel mesh reinforcement is hung.[1]

Speed: Installation of a suspended cast-in-place deck takes approximately the same time as a typical stick-framed floor system, if using a steel joist that is manufactured with the above features to eliminate the need for site built formwork.[2]

Delivery Method: Steel joists can be delivered to the site by a flat-bed truck.

Required Equipment: Standard concrete equipment and tools are needed for installation of the concrete slab. Manufacturers of the floor joists may suggest or require special hand tools for installing the joists properly.

Specialized Labor: An experienced builder familiar with standard concrete installation is preferable for pouring the slab. In addition, steel joist manufacturer warranties may require that a certified contractor perform the installation.[3]

(Fig.4) Reusable steel lockbars being set into the joists. These lockbars support the plywood while the concrete is being poured and are removed after installation.

PERFORMANCE

Wind Load: Lateral wind loads are generally not accounted for in floor systems. The resistance to uplift for a suspended cast-in-place system will be higher than typical stick-framed floor systems, although the ultimate strength of the system depends on the strength of the connection to the foundation system.

Water Resistance: Exposed steel joists are susceptible to moisture and salt damage, which will result in oxidation and corrosion. Periodic maintenance and cleaning will decrease oxidation. Concrete slabs are subject to damage if flooding occurs; elevating the structure at or above the base flood elevations will decrease the likelihood of flood damage.[4]

Energy / Thermal: Thermal resistance of concrete depends on the thickness of the slab, although a typical 3" suspended concrete slab has negligible R-values (below 0.5).[5] The floor may act as a thermal mass, moderating building temperatures throughout the year.

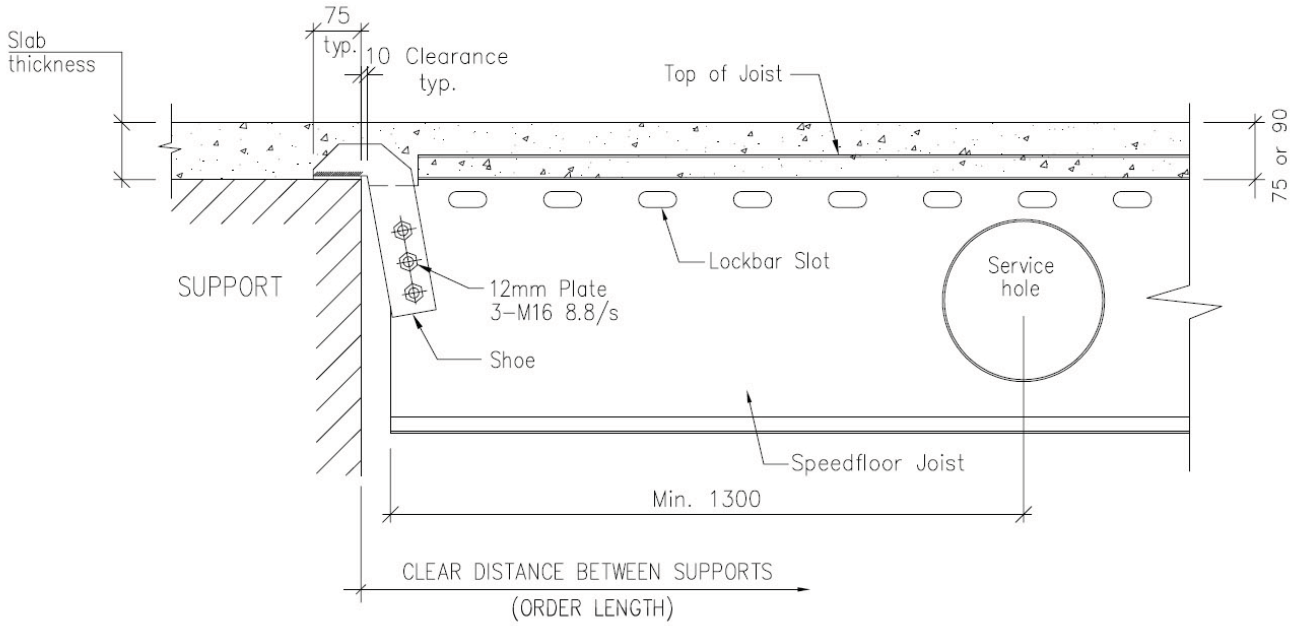
DESIGN

Environmental Impact: Forms and installation materials used for the steel joists and the concrete slab can be reused, reducing on-site waste. Concrete and steel production requires high levels of embodied energy. Steel can be recycled easily, while concrete recycling is more limited.

Versatility / Flexibility: The suspended concrete slab can be used as a finished floor material, eliminating the need for additional floor coverings. The concrete can be oiled, stained, or imprinted with textures for a variety of finished looks. The steel joists can support longer spans than wood, so fewer piers or piles are needed for foundation designs. Also, the steel joists can be manufactured with punched openings for running mechanical and plumbing systems through the joists. Typically, this system is used with concrete foundation systems and works well with ICF or masonry walls.[6]

Market Exposure: Suspended cast-in-place decks in the residential sector could serve an emerging market as designers and homeowners are seeking stronger and more rigid floor systems than typical stick-framed systems. Cast-in-place decks are used fairly often in large scale commercial applications.

Code Approval: Suspended cast-in-place systems should be engineered for specific projects to meet all code requirements regarding slab reinforcement and steel joist strength and installation.



(Fig.5) Steel joists are produced in a variety of sizes to accommodate longer spans.

Affordability: This system is one of the most expensive floor systems for residential construction. The cost for materials for a residential project is approximately $15.00 per square foot, not including labor. [7]

Coastal Consideration: This floor system qualifies as wind-resistant construction, and homeowners may be eligible to apply for a reduction in insurance rates in Mississippi.[8]

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Retailers in the Gulf Coast area include:

- Green Elephant Construction Supply
  4107 Popps Ferry Road
  D'Iberville, MS 39540

Manufacturers being used in the area include:

- Speedfloor USA
  299 Haskel Lane
  Batavia, Ohio 45103

Installers in the Gulf Coast area include:

- Bailey Homes
- Delta Builders

(Fig.6) Steel joists are anchored to foundation walls with an extended shoe (as shown above) that is then set into concrete.

(Fig.7) The steel joists are spaced 49" on center to allow for 4x8 sheets of plywood to slide in between. The plywood is removed after the concrete is cured.

(Fig.8) A professional concrete installer spreads concrete over the formwork. Here, rebar is used instead of steel mesh for reinforcement.

Floor Finishes

Overview: Most residential floors consist of a structural subfloor (such as a concrete slab or 3/4" plywood) covered by a finish flooring material that creates the finished surface. A wide range of flooring materials and floor coverings can be used to create a floor with the desired durability, appearance, environmental benefits, and other qualities.

Many types of floor finishes are available, including solid wood, engineered wood, laminate, vinyl, rubber, linoleum, natural- or synthetic-fiber carpet, ceramic tile, and stone. The choice of finish material will depend on many factors. Comfort and appearance are high priorities in the living areas of the house, while durability and ease of maintenance are important in high-use areas and especially in wet rooms such as kitchens and bathrooms. Affordability and ease of installation are key factors that vary greatly among floor finishes. Finally, the impact of the choice on the environment and on the indoor air quality of the house should be considered.

INSTALLATION

Construction Process: The finish floor is installed late in the process to protect it from damage during construction. Many finish floors are installed directly on top of the subfloor using a variety of methods including construction adhesive and nails. Laminate and engineered wood floors can be glued down or installed as a "floating floor" that is laid over a foam underlayment but not glued to the subfloor. Some tile floors may require an additional layer of a cement-based tile backer board to ensure durability.

(Figs.9-18) Shown at right are examples of typical floor finishes used in residential applications.

(Fig.9) Bamboo

(Fig.10) Cork

(Fig.11) Hardwoods: Oak

(Fig.12) Wood Laminate

(Fig.13) Wool Carpet

(Fig.14) Rubber

(Fig.15) Ceramic Tile

(Fig.16) Stone: Slate

(Fig.17) Vinyl

(Fig.18) Linoleum

Speed of Construction: Some flooring materials, such as laminate wood, carpet, and bamboo, are made to be installed quickly. Even unskilled workers may need only hours per room. Other materials, such as tile and hardwood floors, require more time and care for a high quality installation.

Delivery Method: A small truck can deliver most types of flooring. Depending on the material, weight can be a factor. Flooring ordered in quantity may come in pallets that can be lifted by a forklift. Carpet comes in large rolls that may require two or more people to handle.

Required Equipment: Flooring installed using construction adhesive requires little more than a caulk gun or trowel. Other installations may require a nail gun equipped with finish nails, per manufacturer's specifications. Tile requires simple tools such as trowels; a specialized tile saw may also be required.

Specialized Labor: Many types of flooring are suitable for homeowner installation. For instance, tile requires preparation and care, but can be done by unskilled workers. The same applies for many manufactured finishes. High-quality materials such as hardwood floors may require skilled professional installation to ensure proper installation and prevent damage to the flooring.

PERFORMANCE

Water Resistance: Resistance to stains and damage by water and other substances is a key factor to consider when choosing a flooring material. Unfinished wood floors (floors that have not been sealed) are easily stained by water and other liquids. Carpeting, especially light-colored carpeting, shows stains easily. Therefore, in wet rooms such as bathrooms, as well as kitchens, dining rooms, and other food areas, durable and stain-resistant flooring should be chosen. Ceramic tile, linoleum, and some vinyl, wood, or laminate products are good choices.

Life Span: Overall durability is another important consideration. Life span of flooring depends on the expected use. Flooring in hallways, living areas, and other high-traffic areas must be able to withstand heavy use. Resistance to scratching by heavy furniture and pets is another factor. Durable materials such as ceramic tile, engineered wood, hardwood, and linoleum can be expected to last for decades if cared for properly. Hardwood floors can often be refinished if worn or damaged, while laminate and engineered floors cannot. Carpeting and some vinyl and synthetic flooring materials are not as durable. Area rugs or carpet tiles are a better choice and much easier to replace than carpeting if stained or worn.

Common Failure: Floor finishes fail in different ways. Stone and ceramic tile, if not sealed and cleaned regularly, can accumulate grime and mildew. If not properly installed, they can also crack. Laminate and vinyl flooring can wear out with heavy use; inexpensive products may fail within a few years. Hardwood floors can scratch and, if not sealed properly, stain or discolor. Carpet can wear out, stain, and collect dirt and mold. Linoleum and vinyl can crack or peel. Flooring must be carefully selected and maintained to avoid common sources of failure.

(Fig.19) Tile flooring is a durable, easy to clean choice for kitchens, bathrooms, laundry rooms, entryways, and other areas.

(Fig.20) Tile can be installed by professionals or homeowners. Shown here, 12" ceramic tile is being installed by skilled and unskilled volunteers.

DESIGN

Environmental Impact: Materials used for flooring vary in both sustainability and their impact on the indoor air quality of a house. Rare or slow-growing woods, petroleum-based products such as vinyl, and certain types of stone, such as marble or granite, have environmental drawbacks.

A variety of environmentally preferable flooring products are available. Some, such as bamboo, cork, and other woods, are produced from fast-growing, renewable sources. Bamboo, however, is typically sourced from China, and the impact of shipping offsets some of its environmental benefit. Others, such as carpeting and tile, can include recycled content. The type and source of material should be carefully considered for its environmental impact.

Products that contain formaldehyde, harmful sealants, or other materials that off-gas, such as synthetic rubber and vinyl, should be avoided or used only in well-ventilated areas.[9] Linoleum is an environmentally preferable alternative to vinyl and can last 30-40 years. Carpeting should be avoided, as it collects dirt and mold, especially in moist climates; area rugs are a better choice.

Versatility / Flexibility: The wide range of products and materials available means that there is a flooring type for every application. Rarely will a single type of flooring be suited for all of the rooms of the house. At minimum, one type of flooring for wet rooms (kitchen, bathroom, laundry room) and one type of flooring for living areas (living, dining, and bedrooms) should be chosen. Additional types of flooring can be added for their aesthetic qualities or for special applications. While carpeting has its drawbacks, its comfort and quiet may be desirable for bedrooms. A high-quality, aesthetically pleasing hardwood, stone, or parquet floor could be chosen for an entranceway or main living area for design impact.

Market Exposure: While flooring materials are sold everywhere, local selections can be limited, particularly when it comes to environmentally preferable flooring. However, materials such as bamboo are increasingly common. Shop around and check specialty flooring stores as well as major building supply outlets for a greater selection of products.

Affordability: Flooring is subjected to a great deal of wear and greatly impacts the look and feel of a house. It makes sense to choose a high enough quality flooring to meet the expected need while still being affordable. For wood floors, consider, in addition to hardwood, the range of high-quality laminate and engineered wood floors (such as bamboo and cork). Softwoods, such as pine, can be used as well. In bathrooms and kitchens, consider linoleum, ceramic tile, and some laminate or engineered materials. Carpeting, although affordable, should be avoided in most cases; consider area rugs instead.

(Fig.21) Laminate flooring can recreate the look of many different types of wood. However, low-quality laminate flooring may wear out within just a few years.

(Fig.22) While hardwood flooring is more common, some soft-woods, like pine (shown here), can make warm, comfortable floors.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Most flooring is widely available at building material or flooring suppliers, including Lowe's, Hood's, and The Home Depot. The following is a partial list of suppliers that carry specialized and/or sustainable flooring materials:

Earth Weave Carpet Mills, Inc. (Dalton, GA)
- Carpet (Bio-floor)

Carpet Mart Gautier (Gautier, MS)
- Cork (USFloors Natural Cork)
- Bamboo (USFloors, Teragren)

Carpet Mill Connection (Gulfport, MS)
- Cork (USFloors Natural Cork)
- Bamboo (USFloors)

Bay Carpet & Interiors (Waveland, MS)
- Cork (USFloors Natural Cork)
- Bamboo (USFloors)

Stafford Tile & Stone (New Orleans, LA)
- Glass tile (Oceanside Glasstile)

Libbies Flooring (Biloxi, MS)
- Bamboo (Teragren)

Steve Nall Tile & Install (Ocean Springs, MS)
- Bamboo (Teragren)

Accent on Design (Ocean Springs, MS)
- Bamboo (Teragren)

King & Co., Inc. (Jefferson, LA)
- Carpet (InterfaceFLOR Carpet Tiles)

Dal-Tile (Ridgeland, MS)
- Tile (Quarry Tile Natural Hues Tile)

Rickert Tile (Metairie, LA)
- Tile (Terra Green Ceramics)

(Fig.23) Stone flooring, such as slate tile shown here, can be beautiful and durable. However, slate can be hard to clean and can stain if not properly sealed.

(Fig.24) Bedrooms are a good place for carpeting, which is quiet and comfortable. However, carpeting can collect dirt and mold, and can off-gas.

Wall Systems

Typical residential walls consist of an exterior finish material, sheathing material, structure, insulation, and an interior finish material. All of these wall components have specific roles that, combined, create a wall that is strong, resistant to weather, and durable. Structure is described in more detail under the Framing Systems Chapter in the Structural Component Systems category.

Exterior Finishes

Exterior finish materials are intended to protect the wall system from sun exposure, moisture, and wind. Beyond researching cost and appearance, it is important to learn the manufacturer's installation instructions in order to construct a wall that will withstand extreme weather and be compatible with other components of the wall. Some examples of exterior finish materials found in residential applications include board siding (vinyl, fiber cement, wood, masonite, asbestos), brick, corrugated metal, fiber-cement panels, stucco, magnesium-oxide panels, and fiberglass products.

Sheathing

Sheathing materials tie the framework together to create a structural diaphragm that resists lateral forces against the wall. Generally, the exterior finish materials are installed on top of a vapor barrier, such as Tyvec Housewrap or felt paper, both of which are attached to the sheathing. Typical sheathing materials are 4'x8' sheets of plywood or OSB (oriented strand board). Older homes along the Gulf Coast may have horizontal or diagonal sheathing made of dimensional lumber. Sheathing is usually nailed to stud walls, with a prescribed nail pattern engineered to withstand local wind loads.

(FIG.A) EXTERIOR FINISHES of walls should be well-secured in order to withstand a high wind load. Here, fiber-cement siding is nailed through the sheathing to the framing members, over a vapor barrier.

(FIG.B) SHEATHING creates a rigid building envelope, and helps resist shear forces. OSB sheathing is typically used on the Gulf Coast.

(FIG.C) INSULATION helps maintain the temperature of the conditioned area within a building. This photo shows spray foam insulation sprayed onto existing rigid foam insulation to increase the R-value of the wall.

insulation	required equipment	thermal performance	environmental impact	market exposure	affordability	coastal considerations
fiberglass batt				+	−	+
spray foam	−	+	−		−	+
rigid foam		+	−	+		

exterior finishes	wind resistance	water resistance	lifespan	environmental impact	affordability	coastal considerations
fiber cement siding	+	+	+			+
vinyl siding	−		−	−	+	−
brick	+		+		−	

Insulation
Insulation reduces heat transfer through walls. Insulation is one of the most important factors contributing to the energy efficiency of a building. The unit of measure to determine the performance of insulation is called the R-value. R-value is the rate of thermal resistance of an object or material. Generally, thicker insulation of any type will yield a higher R-value. Insulation is typically placed between vertical framing members. Insulation found in residential applications includes: fiberglass batt, sprayed fiberglass, closed and open cell spray foam, rigid foam, cotton batt, mineral wool, and blueboard.

Interior Finishes
Interior finishes protect the framing and insulation from moisture and damage inside the building. Interior wall finishes are susceptible to mold and rot, if not properly ventilated. As the interior finishes of the building are in close contact with people after construction is complete, it is important to consider the materials used to ensure high indoor air quality for users. Many interior finishes can off-gas VOCs (volatile organic compounds) that lead to respiratory illnesses. Many common interior finish materials are now available with low- or no-VOC options. Examples of commonly used interior finishes include painted drywall, ceramic tile, homasote, tongue and groove wood boards, bead board, polycarbonate panels, and plaster.

(FIG.D) INTERIOR FINISHES influence the comfort and versatility of walls. Tongue and groove pine boards (above) are durable and provide additional shear strength for the building. (photo © Alan Karchmer)

FURTHER INFORMATION

- Toolbase (www.toolbase.org)
- USGBC Green Home Guide (www.greenhomeguide.org)
- National Association of Home Builders (www.nahb.org)
- International Code Council (www.iccsafe.org)

OTHER TYPES OF WALL SYSTEMS

7 WALLS

subjects

Exterior Finishes

Overview: Exterior finish materials protect the structure from sun exposure, moisture, and wind. Beyond cost and appearance, it is important to research each material and the manufacturer's installation instructions in order to construct a wall that will withstand extreme weather and be compatible with other components of the wall system. Some examples of exterior finish materials found in residential applications that are discussed in this section include: board siding (vinyl, fiber-cement, wood, Masonite), brick veneer, corrugated metal, fiber-cement panels, and stucco.

INSTALLATION

Construction Process: Typically, finishes such as board siding, corrugated metal, and fiber-cement panels are applied to the exterior side of the sheathing material over a moisture barrier. Nail patterns are specified by the manufacturers to meet local wind loads. Stucco may be applied directly to a masonry wall or to a wood-framed wall using wire mesh or lath. Brick veneer is laid in courses with mortar joints and tied to the structure with steel ties.

Speed of Construction: The installation time of exterior finishes depends on the size of the project and the skill level of the builder. Typically, siding and panels can be installed relatively quickly. Brick installation time depends mostly on the experience level of the mason. Stucco may be the most time-intensive, as multiple layers must be applied, and the material is sensitive to humidity levels in the air.[1]

Delivery Method: Siding materials generally come in 8', 10', and 12' units, and can be delivered on a flatbed truck or trailer. Large quantities of brick may need to be delivered with commercial trucks or trailers. Stucco is mixed on site.

(Fig.1) Masonite siding should be painted every few years to protect from water damage, mold, and rot. Special attention should be paid to the bottom edge of the exterior lap, where damage often occurs.

(Fig.2) Vinyl siding is designed to mimic wood planks, and is easy to install.

(Fig.3) With an experienced mason performing the installation, brick can be laid in a variety of patterns.

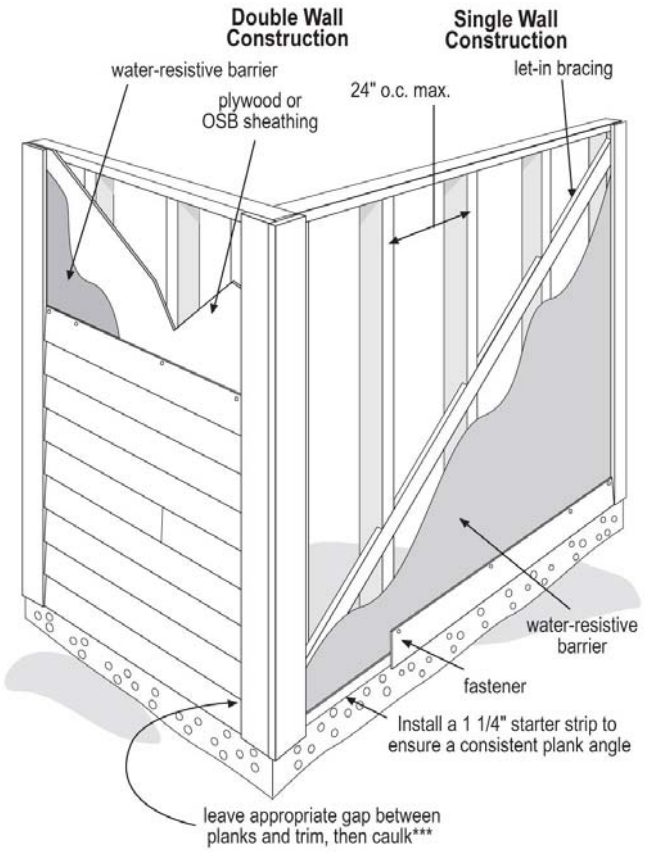
Required Equipment: Fiber-cement boards and panels can be cut on-site by scoring and snapping, using shears, or using a saw with a carbide blade or a blade designed for cement-fiber products.[2] Vinyl siding is easy to cut on-site with shears or utility blades. Wood and Masonite siding can be cut with regular framing saw blades. These exterior finishes can be installed using screws or nails, as per the manufacturer's instructions. A water-level or transit may be necessary for accurate siding installation. Brick finishes require typical masonry equipment (mixers, trowels, spades, and masonry saws). Stucco finishes require some form of reinforcement to reduce cracking, such as wire or plastic mesh. All exterior finish applications may require scaffolding for taller buildings.

Specialized Labor: No specialized labor is necessary for installation of siding. Masonry finishes may require experienced masons, depending on the pattern and size of the project. Stucco is difficult to apply evenly if the builder is not experienced in the trade.

PERFORMANCE

Wind Load: The wind load capacity of fiber-cement siding and panels are dependent on the nail pattern and type of nail used. Typically installed 8" fiber-cement siding can withstand wind loads between 110 and 150 mph.[3] Wood and Masonite siding have similar wind load capacities, if installed properly. Brick finishes, if tied to the frame properly, can withstand up to 150mph winds (when ties are spaced every 10" vertically and every 16" horizontally).[4] Vinyl siding has the lowest wind resistance, as the material is lightweight, prone to cracking and tearing, and adhered to the exterior surface of the building loosely.

Water Resistance: Manufacturers claim that fiber-cement siding is non-porous and is therefore resistant to mold and rot.[5] According to the 2000 ICC Legacy report, James Hardie fiber-cement products allow 1.54 perms, which is slightly less than wood siding.[6] Masonite siding, if properly painted and sealed, is similarly water resistant. Vinyl products are highly water resistant. However, because vinyl siding breaks and cracks easily, water can leak into the wall cavity and cause damage. Brick veneer is porous, necessitating a 1" gap between the veneer and the structure of the wall so proper ventilation can occur if water penetrates the exterior surface. In addition, weep holes (vents within the brick) and flashing must be properly installed so that moisture that does get in can escape the wall cavity.[7] Stucco has a very low resistance to water and is prone to mold and rot in humid climates.



(Fig.4) This drawing shows the preferred method of installation for HardiePlank siding, a fiber-cement siding product. Wood and vinyl siding are installed similarly.

(Fig.5) Stucco can be applied in a variety of textures. Above, a smooth finish is used for the exterior wall, while a rough finish is applied to the window trim.

Energy / Thermal: Generally, exterior finish materials provide negligible thermal resistance. Fiber-cement products, wood and Masonite siding have similar thermal properties, with R-values between 0.12 and 0.8. Stucco has an R-value of 0.2 per inch of thickness (most stucco applications are approximately 1/2"). Brick has an R-value of 0.11 per inch of thickness; common bricks are 4" thick. Vinyl products have an R-value of 0.61. Vinyl siding is available with an additional layer of insulation that can increase the R-value to 4.[8]

Life Span: Life spans of exterior finish materials vary greatly, depending on the level of maintenance and the local climate. Products like fiber-cement siding and vinyl siding come with a manufacturer's warranty of up to 50 years.[9] Masonite and wood siding must be painted every few years in order to seal the material from water damage. Brick, if properly installed and tied to the structure, has a long lifespan with little maintenance required.

Common Failure: Masonite siding and stucco have been known to rot and mold if not properly maintained (painted and sealed every 2-3 years).[10] Vinyl siding will most commonly fail in high-wind environments. Also, vinyl is extremely susceptible to failure in high heats, and emits toxic fumes when it burns.[11] The common failures of brick are related to poor installation of ties. Any exterior wall system will fail if moisture is allowed past the exterior surface and is not properly ventilated or wicked to the exterior.

(Fig.6) Fiber-cement vertical panels are used above in a cabin addition. 1x battens are used on the vertical joints between panels. Many fiber-cement products are primed at the factory.

DESIGN

Environmental Impact: The production of fiber-cement products and the raw materials for stucco (cement products) require high levels of embodied energy. If these products are manufactured with fly-ash, an industrial by-product, the impact is lower. Vinyl (polyvinyl chloride) products are particularly dangerous to manufacture; prolonged exposure during the manufacturing process is linked to certain cancers and respiratory problems. Additionally, vinyl releases VOCs during its lifespan and can also affect air quality if incinerated.[12] The impact of wood siding is dependent on the type of species used and where it was grown. Masonite siding has a fairly neutral environmental impact, as it is produced with wood by-products.

Versatility / Flexibility: All of the exterior finish materials described in this section can be used in combination with each other. Masonite, wood, fiber-cement, and vinyl siding are primarily designed to adhere to wood-framed buildings. Also, most alternative wall systems (SIPs, ICF, etc.) are designed to easily accept siding materials. Stucco is easier to apply and maintain if adhered to a masonry

(Fig.7) Fiber-cement lap siding has the finished look of wood siding. Here, it is used in combination with fiber-cement window trim.

wall. Brick can be coupled with most wall systems; however, it is difficult to change or remodel a brick wall after it is built.

Market Exposure: All of the above products are extremely common and easy to obtain in the United States.

Code Approval: Each of the exterior finish materials addressed here is accepted as an exterior cladding by the International Code Council (ICC) Evaluation Service. Code compliance is inspected by local building inspectors either during the framing or final phases of construction.

Affordability: Prices for exterior finishes vary, depending on location. In general, wood siding is more expensive than fiber-cement siding or masonite. Vinyl is generally the cheapest material. Brick and stucco have negligible differences in material cost, but usually cost more to install.

Coastal Considerations: High wind loads and prolonged exposure to heat and moisture are the most important factors to consider when choosing an exterior finish material on the Gulf Coast. With any siding application, check with the manufacturer and local building officials to determine the proper nailing pattern to reduce the risk of damage during a high-wind event (up to 140 mph winds). Materials such as stucco, Masonite, and brick that are particularly sensitive to moisture will likely require more maintenance and repair than in other parts of the country because of the humid climate.

(Fig.8) Cedar is a popular wood species used in siding. It is highly resistant to rot and moisture.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Retailers in the Gulf Coast Area include:

Nearly every building supply retailer along the Gulf Coast carries or can order any of these materials.

Manufacturers being used in the area include:

- James Hardie (fiber-cement)
- CemPlank, Inc. (fiber-cement)
- CertainTeed Corp. (fiber-cement)
- Dura-Bilt (vinyl)
- Georgia Pacific (vinyl)
- Masonite International Corporation (Masonite)

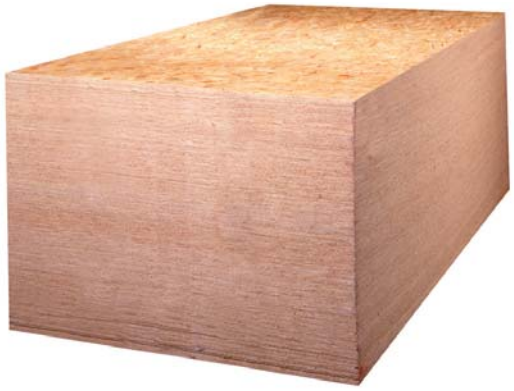
(Fig.9) Vinyl siding has a very low melting point. Here, a house fire caused the vinyl siding to melt, releasing toxic fumes.

(Fig.10) Brick is used to accent the cypress siding above. Cypress is another popular wood species used in siding because it is water resistant.

Sheathing

Overview: Sheathing is a material used to tie a building's structural framework together, creating a structural diaphragm that resists horizontal forces against the wall. Typical sheathing materials are 4'x8' sheets of plywood or OSB (oriented strand board), although sheets with 9' and 10' lengths are also available for higher ceilings. Sheathing is an essential component of construction.

In hurricane-prone areas, alternative sheathing materials include full-height OSB and sheets with pre-affixed weather barriers. Older homes along the Gulf Coast may have horizontal or diagonal sheathing made of dimensional lumber.



(Fig. 11) Plywood and OSB can be purchased at almost every building supply retailer and can be delivered on a trailer.

INSTALLATION

Construction Process: Sheathing is nailed to stud walls, with a prescribed nail pattern engineered to withstand local wind loads. Generally, the exterior finish materials are affixed to the sheathing, with a vapor barrier between them, such as Tyvec Housewrap or felt paper. Joints should be appropriately spaced at 1/8" or as defined by local code.

Speed of Construction: The process of sheathing is fairly swift once the framing is complete. An experienced crew can sheath a one-story house in a day. Sheathing can be further expedite by using full-height materials.

Delivery Method: Plywood and OSB can be purchased at almost every building supply retailer and can be delivered on a trailer. Boards should be kept flat to reduce warping before installation.

Required Equipment: Hammers and nails or nail guns, circular saw.

Specialized Labor: Aside from basic carpentry knowledge, no specialized labor is needed.

(Fig. 12) Aside from basic carpentry knowledge, no specialized labor is needed for sheathing a house.

PERFORMANCE

Wind Load: Sheathing is nailed to stud walls, creating a structural diaphragm that resists horizontal forces against the wall. It is affixed to the studs with a prescribed nail pattern engineered to withstand wind forces appropriate to the region, and should be carefully monitored to ensure proper installation.

Water Resistance: Wood sheathing is prone to rot and mold and should be kept dry on site and inspected before use to ensure quality.

Energy / Thermal: Sheathing itself has low thermal resistance. However, it can be a large determining factor in how the wall performs, based on proper installation and sealing of seams, and depending on the material used.

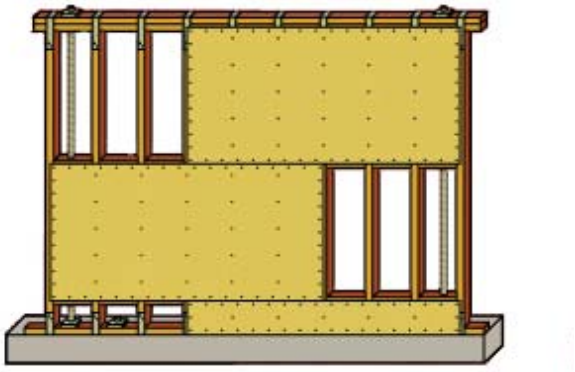
Common Failure: Failure in sheathing may result from improper nailing in the case of a high wind event. More likely is rot or decay from excessive moisture due to leaks in the building envelope. This can be prevented by properly sealing panel systems per manufacturer specification, as well as the proper application and installation of house wrap in the case of a conventionally sheathed OSB or plywood wall.[13]

DESIGN

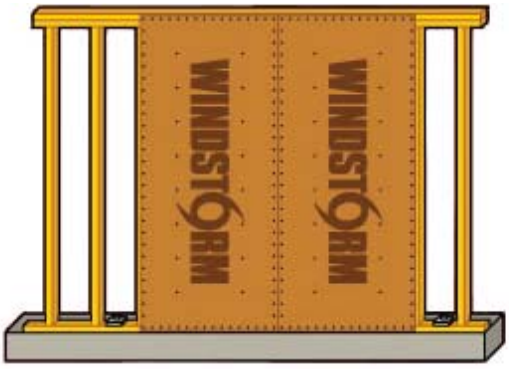
Environmental Impact: Plywood manufacture uses more mature wood than OSB or hardboard alternatives. The key to minimizing impact with plywood is to optimize material use and reduce waste.

OSB, in contrast, is made from short rotation or re-used chip products, but uses petrochemical binders in its manufacturing process. Builders can look for products with minimal binders and maximum recycled content.[14]

Versatility / Flexibility: Sheathing is manufactured in a variety of different material compositions and lengths and provides a wide array of choices for the builder. Increased lengths allow builders to connect the sill and top plate with one panel, resulting in increased resistance to uplift and wind shear.[15]



(Fig. 13) When not using full-height sheathing, panels should be properly spaced and overlapped, and affixed according to specified nailing patterns.



(Fig. 14) Full-height sheathing can increase the shear strength of the wall system.

(Fig. 15) Properly nailing and wrapping the sheathing with a moisture barrier is essential to prevent rot and mold in hot and humid climates.

Market Exposure: OSB and plywood remain the predominant materials for sheathing but a number of alternatives are available, including pre-wrapped panels such as Huberwood's ZIP System or Georgia Pacific's Nautilus wall sheathing.

Code Approval: Sheathing should be properly installed per manufacturer specifications and local building codes regarding nailing patterns. Structural sheathing should be used in coastal regions to provide proper shear strength.

Coastal Considerations: There are a number of factors to consider when sheathing on the Gulf Coast.

Proper nail patterns are essential in high wind areas. Without the required nail spacing and pattern, the sheathing wind resistance will be diminished, which can result in failure of the wall system.

Full-wall height sheathing is another option that is strongly encouraged. This increases strength by linking the top plate to the sill and rim joist with a continuous surface.

Sufficient moisture control is another essential element of coastal construction. This includes ensuring seams are properly sealed; ensuring house wrap is overlapped and wrapped at corners; using tools properly; and making sure nails are driven to proper depths to prevent puncturing the moisture barriers.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Retailers in the Gulf Coast Area include: Nearly every building supply retailer along the Gulf Coast carries or can order any sheathing material.

Additional Info and Further Reading:

- National Association of Home Builders Research Center, http://nahbrc.org/
- Toolbase Services, http://toolbase.org/
- Oikos Green Building Source- http://www.oikos.com/

Information on pre-wrapped panels can be found at:

- http://www.huberwood.com/ - ZIP System
- http://www.gp.com/ - Nautilus Wall Sheathing

Information regarding Windstorm OSB can be found at:

- http://www.windstormosb.com/

(Fig. 16) Nautilus wall sheathing by Georgia Pacific is an alternative to OSB and Plywood. It is produced with a moisture barrier pre-affixed and has begun to gain favor among builders.

(Fig.17) The ZIP system by Huberwood.

Insulation

Overview: Insulation is one of the most important elements contributing to the energy efficiency of a building. The unit of measure of insulation performance is called the R-value (the rate of thermal resistance of an object or material). Generally, the thicker the insulation, the more resistance it will have to heat flow, and the higher its R-value. Thermal bridges, which reduce the efficiency of a wall, occur wherever a material directly contacts both the interior and exterior finishes (for example, at every stud in a wood-framed wall). This creates a path for the conduction of heat or cold through the wall. The insulating performance of the wall decreases with each thermal break.

FIBERGLASS

Material: Fiberglass insulation is a composite material made of silica sand with additives such as boron and binders such as phenolformaldehyde. It is sometimes produced in rolls that are sandwiched between kraft paper for fire-proofing and vapor retarding. This is the most common type of insulation found in residential applications.[16]

Installation: Fiberglass insulation is manufactured to fit between studs and joists that are spaced 16" or 24" on center. Face-masks and gloves should be worn while handling the material, to avoid respiratory and skin irritation.

R-Value: Fiberglass batt insulation has an R-value of about 3.7 per inch.[17] This method of insulating creates many opportunities for thermal bridging, as the insulation is placed between studs.

Environmental Impact: Most fiberglass insulation is produced with a minimum of 20-30% recycled content. After the packaging industry, fiberglass insulation has the second largest market for recycled bottle glass. Glass fibers are potential human carcinogens, while formaldehyde is a confirmed human carcinogen. Most fiberglass insulation manufacturers have products certified as low-emitting by Greenguard, a third-party non-profit committed to improving indoor air quality.[18] Consumers should look for this certification when choosing fiberglass insulation.

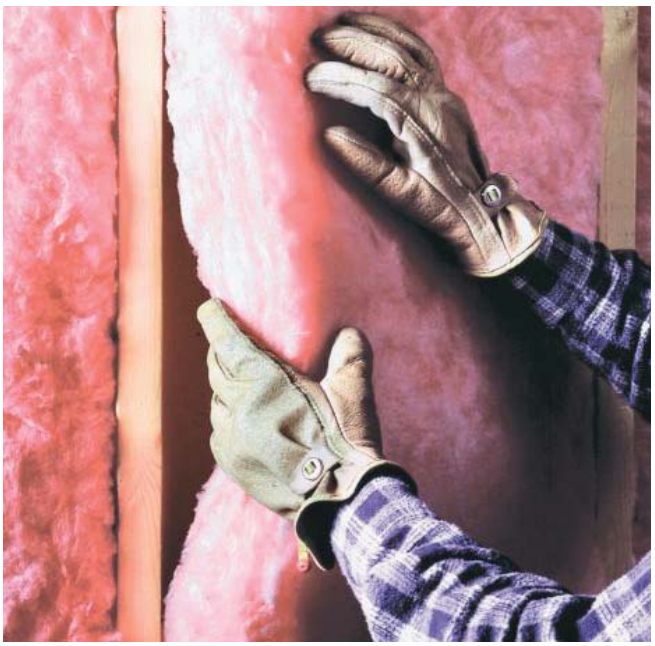
Affordability: Fiberglass batt insulation is approximately $0.70 per square foot of coverage(R-19). Skilled labor is not required for installation.[19]

Coastal Considerations: Fiberglass batt insulation is not water-resistant. Proper ventilation is required for roof and ceiling installation (by using ridge vents, attic vents, vented blocking, and vented soffits in the assembly of the house). Similarly, an elevated house with fiberglass insulation in the floor should have vented covering.

SPRAY FOAM

Material: Spray-foam insulation is a plastic product that is sprayed into cavities as a liquid and expands as it cures to create a tighter seal than typical batt insulation. There are two types of spray foam: open-cell (made of isocyanurate) and closed-cell (made of polyurethane).[20] Open-cell spray foam is more flexible than closed-cell and is less likely to crack or fail as a house expands and contracts.

Installation: A liquid polymer is combined with a foaming agent as the material is sprayed through a nozzle. A professional spray-foam contractor should perform installation to ensure personal safety and thorough application.



(Fig. 18) Fiberglass batt insulation should fit snugly between studs without any compression of the material.

After the foam dries, excess is trimmed from the cavity and a thermal barrier such as drywall or sheathing is installed as a covering.[21]

R-value: Open cell pray foam insulation typically yields an R-value of 3.8 per inch of thickness. Closed-cell polyurethane performs slightly better than open-cell applications.[22]

Environmental Impact: Installers of spray foam insulation have been required to reduce or eliminate the use of HCFCs (ozone-depleting gas). Many companies are producing soy-based spray foam insulation to reduce the risk of releasing VOCs over the lifetime of the product.[23]

Creating a tighter seal of insulation with spray foam applications will yield increased energy efficiency within buildings.

Affordability: Spray foam insulation costs between $1.25 to $2.25 per square foot (for material and installation).[24] This is one of the more expensive methods for insulating a building. However, many studies have shown that the initial cost is recovered over a few years of low heating and cooling costs associated with better thermal performance. Oftentimes, spray foam insulation is combined with fiberglass batt insulation to reduce the cost, while increasing the R-value of the wall.

Coastal Considerations: Spray foam insulation is typically more moisture resistant and mold resistant than fiberglass batt or other blown insulation materials.[25] Closed-cell spray foam is considered a vapor barrier, while open-cell is a vapor retardant. In residential construction, closed-cell foam being a vapor barrier can be problematic as its location traps moisture in the wall instead of keeping moisture from entering the wall.

(Fig. 19) Above, open-cell spray foam insulation is installed by a professional. The excess foam will be trimmed and discarded.

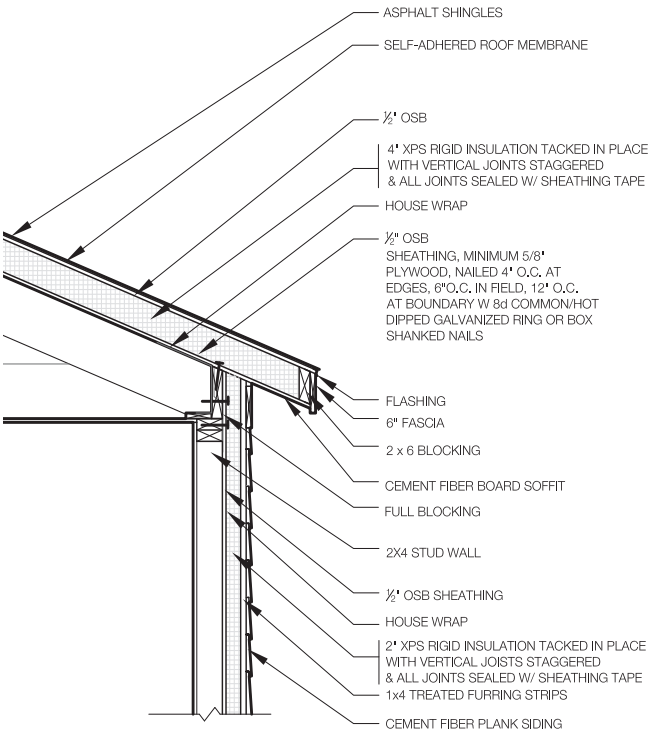
RIGID FOAM

Material: Rigid foam insulation refers to plastic foams made of either XPS (extruded polystyrene) or EPS (expanded polystyrene). The plastic is manufactured in sheets that vary in thickness. Rigid foam insulation can be used with stud walls, or to make ICFs (insulated concrete forms) and SIPs (structurally insulated panels).

Installation: Rigid foam insulation can be cut and installed between studs and joists. Alternatively, it can be adhered with screws or nails to the exterior or interior of a stud wall or masonry wall to create a seamless layer of insulation with little or no thermal bridging. Also, it can be used to supplement existing insulation in older homes. No skilled labor is required for installation.

R-value: XPS rigid foam has an R-value of 5 per inch of thickness; EPS rigid foam has an R-value of approximately 4 per inch of thickness.[26]

Environmental Impact: Both XPS and EPS are produced from petrochemicals. XPS foam is currently produced with HCFCs (ozone-depleting gas), while EPS is produced using pentane (non-ozone-depleting gas). There are health concerns related to the continued off-gassing of VOCs (residual monomers and brominated flame retardants may be released over time).[27] Code requires that all rigid foam insulation is covered with a material, such as drywall, to minimize this risk.



(Fig. 20) With proper detailing of the entire wall assembly, rigid foam can perform with little or no thermal breaks.

Affordability: The material costs for XPS and EPS foam are relatively comparable to fiberglass batt insulation. 2" XPS foam (R-10) is $0.54-$1.12 per square foot. 2" EPS foam (R-10) is $0.40-$1.12 per square foot.[28]

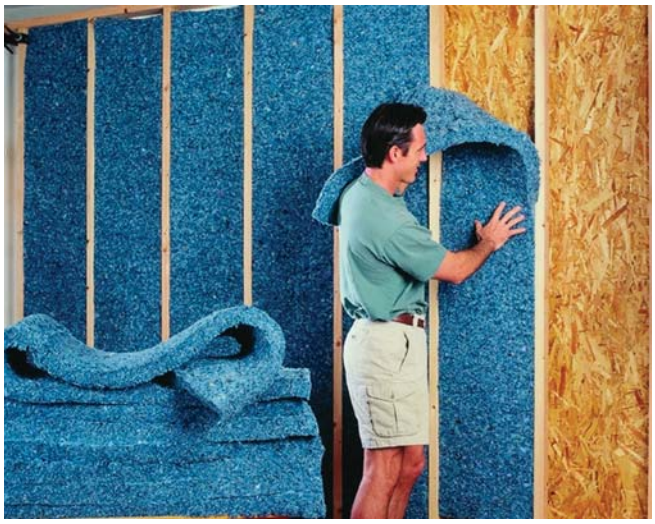
Coastal Considerations: If using EPS or XPS foam on the exterior of a stud wall, it is extremely important that the exterior sheathing and finishes are adhered firmly to the frame of the building because of high wind loads. Depending on the thickness of the insulation, higher gauge nails or screws may be required. Similarly, if using an ICF system, check the exterior finishes to ensure that they are compatible with foam for adhering.

COTTON BATT

Material: Cotton batt insulation is manufactured with 70-100% pre-consumer cotton, generally from recycled trimmings from denim factories. Boric acid (low-toxic) and/or ammonium sulfate is added to the insulation as a fire retarder and mold and insect repellant.[29]

Installation: Cotton batt insulation is installed in rolls between studs and joists, similar to fiberglass batt insulation. No skilled labor is involved in installation, and the material is safe to handle without any special protective equipment.

R-value: Cotton batt insulation is typically produced to yield an R-value of 3.7 per inch of thickness.[30] A 2x4 wall will have an R-value of 13, while a 2x6 wall will have an R-value of 19. Some manufacturers offer higher R-value cotton batts of up to R-21 for 2x6 applications. Like fiberglass batt insulation, cotton batt insulation creates many opportunities for thermal bridging, as the insulation is discontinuous at every stud within a wall.



(Fig. 21) Cotton batt insulation can be installed without any special equipment or specialized labor.

Environmental Impact: Because this insulation is made with plant-based, recycled material not known to off-gas harmful VOCs, cotton batt is considered to have very low environmental impact. Some question whether cotton is as safe as its manufacturer's advertise, because little research has been done regarding the use of pesticides during the manufacture of the raw material.[31]

Affordability: R-19 cotton batt insulation is about $1.20 per square foot.[32]

Coastal Considerations: Homeowners and builders should check with the manufacturer of any cotton batt insulation regarding the amount of mold and insect resistance the product provides.

MINERAL WOOL

Material: Mineral wool refers to either slag wool (a product made of iron-ore blast-furnace slag, an industrial by-product), or rock wool (a synthetic material made of basalt or diabase). Both are naturally resistant to fire, mold, and insects. Mineral wool can perform equally well when wet. Additionally, because of the high density of this type of insulation, both types offer high levels of acoustical insulation.[33]

(Fig. 22) Rock wool, as shown above, is extremely resistant to fire.

Installation: Mineral wool is produced in batts that are installed between wall studs and joists, or it is blown loosely into wall and ceiling cavities. Skilled labor is not necessary for installation; gloves and face-masks should be worn to lower the risk of temporary upper respiratory and skin irritation from loose fibers. As with any insulation described here, a material such as drywall should be installed over the insulation.

R-value: The R-value of mineral wool is slightly higher than fiberglass batt insulation; a batt designed for a 2x4 wall will have an R-value of 13.5.[34]

Environmental Impact: Mineral wool is made primarily (approximately 75%) of post-industrial recycled materials.[35] There is some debate as to whether mineral wool decreases the level of indoor air quality when installed; like any fibrous material, some fibers will enter the air. The North American Insulation Manufacturers Association (NAIMA) claims that there are no health risks related to the use of mineral wool.

Affordability: The cost of typical mineral wool insulation is approximately $1.07 per square foot.[36]

Coastal Considerations: Mineral wool, while very similar to fiberglass batt insulation, is naturally resistant to mold, which makes it a slightly better choice for the climate of the Gulf Coast.

CELLULOSE

Material: Cellulose insulation is made of post-consumer recycled paper products such as newspapers and telephone books, with borates and ammonia sulfates added for moisture, fire, and insect resistance.[37]

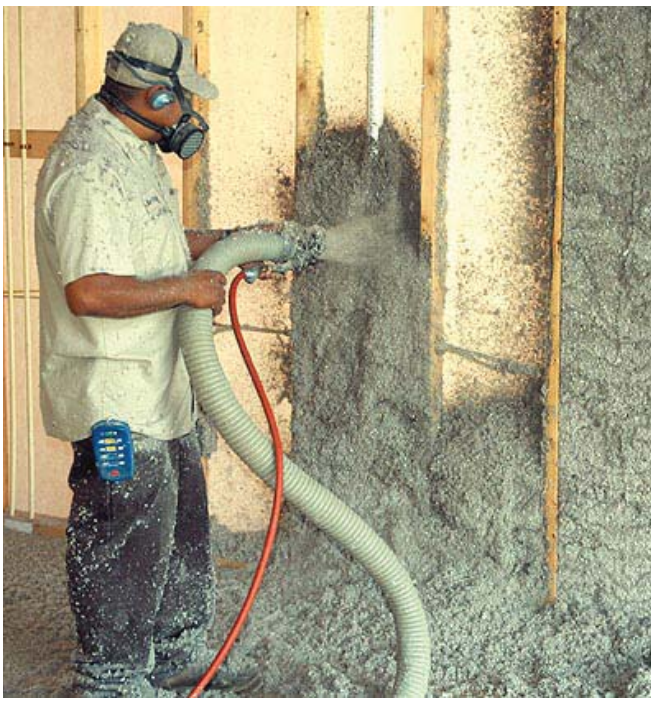
Installation: Cellulose insulation comes in four different forms: dry (loose fill), spray-applied (wet-spray), stabilized, and low-dust. Dry cellulose is typically used in retrofitting applications. Spray-applied cellulose is used for new construction. Water is mixed with the material and sprayed into the wall between studs. Stabilized cellulose is used in attic and high-sloped roofs. Small amounts of water and adhesive are mixed with the stabilized cellulose to create a lightweight insulation. Low-dust cellulose is used in applications where dust or paper-fiber allergies are a concern for the installers. This cellulose insulation has oil or some other dampener added to the mixture.[38]

R-value: The R-value of cellulose insulation is approximately 3.6-4.0 per inch of thickness. A 2x4 wall with cellulose insulation has an R-value of 13. Depending on the installation method, cellulose insulation has lower occurrences of thermal bridging.[39]

Environmental Impact: Cellulose insulation has low-embodied energy, as it is made with a high percentage of readily available post-consumer waste. A greater level of flame retardant is necessary compared to cotton batt or fiberglass insulation, as cellulose is inherently combustible. VOCs from printing inks were a concern in the past, but today most printed paper products use soy-based ink that does not release VOCs.[40]

Affordability: R-19 spray-applied cellulose insulation is approximately $1.20 per square foot.[41]

Coastal Considerations: Cellulose is considered a good choice for coastal applications because the performance of the material does not change if the insulation is wet. In studies done by the Cellulose Insulation Manufacturers Association (CIMA), cellulose-filled wall cavities remained mold-free after weeks of water saturation.[42]



(Fig. 23) A professional installs spray-applied cellulose insulation in the wall cavities. A relatively large amount of the material is wasted during this type of installation.

Interior Finishes

Overview: Many finish materials are available for the interior walls of a house. Finish materials are chosen primarily for their appearance and affordability; however, durability, environmental impact, and even acoustic qualities are important considerations. In the United States, gypsum board is the most common interior finish material; other panel materials available include fiber-reinforced plastic and magnesium oxide. Wood paneling is available in both modern and traditional styles. Plaster, tile (ceramic, glass, or porcelain), stone, and brick are additional options.

GYPSUM BOARD

Gypsum board, is used worldwide and is the most common interior finish in the United States. Also known as drywall or gypsum wallboard (GWB), gypsum board is "made of a layer of gypsum plaster pressed between two thick sheets of paper, then kiln dried."[43] When properly installed, gypsum board creates a smooth finish that is ready for painting or texturing.

Installation: Gypsum board usually requires professional installation for the best appearance, although many homeowners can make small repairs or modifications themselves. Gypsum board comes in sheets, usually 4′ wide and between 8′ and 12′ long, although longer and wider sizes are available. These sheets are attached to the wall structure using drywall screws or nails.

The finished surface is created in a process known as "tape and float." Gypsum board can be finished to a level between 0 (no finish) and 5 (best finish). Typical residential gypsum board is finished to level 3 or 4: the joints between panels are sealed with drywall tape set in joint compound and concealed with 1-2 additional coats of joint compound, and nail or screw holes and any imperfections are concealed with 2-3 coats of joint compound. Once dry, the joint compound is sanded to create a smooth surface.[44]

Performance: Gypsum is a fire-retardant material; standard 1/2" drywall is rated as a 30-minute fire barrier, while 5/8" "Type X" drywall is rated as a 1-hour fire barrier.

Some homeowners dislike gypsum board's hollow feel and its lack of texture and character. Gypsum board is susceptible to damage, but can accept small nail and screw holes for hanging light objects. Heavier objects must be anchored to the wall structure (such as a stud).

Environmental Impact: According to the California Integrated Waste Management Board, "the U.S. produces approximately 15 million new tons of drywall a year... [and] approximately 12 percent of new construction drywall is wasted during installation."[45] The energy used in the manufacture of gypsum board, mostly in the form of natural gas, accounts for 1% of U.S. energy emissions.[46] Measures to reduce waste and encourage recycling can help reduce the environmental impact of gypsum board. Look for gypsum board made using a high percentage of recycled content. Gypsum can be up to 99% recycled while the paper facing can be up to 100% recycled from newspaper and other sources.[47]

Affordability: Gypsum board is an inexpensive material. However, cost estimates should include joint compound, tape, fasteners (screws or nails), corner bead (metal strips used to finish drywall corners), and the various tools used to hang and finish drywall. The cost of professional installation will vary depending on the size of

(Fig. 24) Gypsum board finishing (taping and floating) is the process in which panel joints, screw and nail holes, and other imperfections are concealed to create a smooth surface.

the job and the speed and skill of the workers. Estimates for materials and installation range from $0.85 to $1.15 per square foot to upwards of $2 per square foot in some cases.[48]

Coastal Considerations: Gypsum board's susceptibility to moisture is a significant disadvantage in coastal areas. If not protected from moisture, the paper facing of gypsum board can develop mold. Gypsum board exposed to leaks or flooding is prone to extensive mold growth and decay.

"Green board" is a type of gypsum board made with water-resistant paper facing and is suitable for use in areas subjected to some splashing (around sinks, for instance). However, green board is not suitable for showers, tubs, and other areas where it could be exposed to water for extended periods of time. Choose a water-resistant cement-based board for these areas.

Related System: Plaster

Plaster was widely used before World War II as an interior finish similar to gypsum board. Plaster was commonly applied over a series of wooden strips in a method known as "lath and plaster."[49] Alternatively, plaster can be applied over metal mesh to make a surface of any shape. Due to the ease and affordability of gypsum board, plaster is less common in residential construction today. Skilled plasterers may be hard to find. In some cases, its sculptural qualities are used to create architectural detailing.

NON-GYPSUM WALLBOARD

In addition to drywall, a number of other wallboard products are available today. Two of the most promising materials are magnesium oxide and fiberglass-reinforced plastic.

Magnesium oxide board (known as "MgO," after its chemical formula) is a durable, high-performance alternative to drywall, most commonly used in Asia, where the majority of magnesium oxide deposits are found.

Fiberglass-reinforced plastic (FRP) is made of high-strength glass fibers bonded with a resin. The result is a lightweight, strong, easy-to-clean board suitable for use in kitchens, bathrooms, and other sanitary areas.

Installation: Magnesium oxide board can be scored and snapped, cut, and drilled in much the same way as drywall, although it is a harder material and therefore somewhat more difficult to work. It is also heavy; a 4'x8' sheet of 11/16" MgO board manufactured by DragonBoard weighs 106 pounds.[50] MgO can be used in applications drywall cannot: as structural sheathing, tile backer board, exterior wallboard, fascias, soffits, and more.

FRP panels can be installed using adhesive, fasteners, or a combination of the two. Refer to manufacturer installation instructions.

Performance: Magnesium oxide board has numerous advantages over drywall. Its structural strength and impact resistance are greater. Therefore, thinner sheets can be used. For instance, a 3/8" MgO sheet can be used in place of a 5/8" drywall sheet.[51] Because it has no paper covering and magnesium oxide is not harmed by water, MgO board is resistant to moisture and mildew. When used in exterior applications, it should be painted, like

(Fig. 25) Gypsum Board with mold growth caused by flooding.

(Fig. 26) Magnesium oxide panels are considered to be more mold resistive then typical drywall.

cement board, to prevent water absorption. Finally, MgO is nearly impervious to fire. As with drywall, any penetrations through fire-rated walls must be firestopped.

Fiberglass-reinforced plastic has several advantages: it is strong, lightweight, water-resistant, and easy to clean, making it a suitable choice for kitchens, bathrooms, and other sanitary areas. FRP is more common in commercial and institutional construction.

Environmental Impact: Magnesium oxide is manufactured from magnesite, which is mined in China, the Middle East, and Canada. "Deposits in the US are negligible."[52] Due to its weight, the costs and emissions produced by transporting MgO or magnesite may be high. However, because MgO is manufactured at room temperature, little energy is consumed during production.[53] In addition, magnesium oxide board is highly durable and contains no VOCs or toxins.

Affordability: FRP and MgO panels are more expensive than drywall. For instance, a 4'x8' sheet of 3/8" MgO board can cost $35, whereas a 4'x8' sheet of 1/2" drywall can cost $7-8.[54,55]

Coastal Considerations: Based on their strength and resistance to moisture and mildew, both FRP and MgO have potential for use in coastal construction.

Gulf Coast Availability / Local Manufacturers:

Substance Distributing
- Austin, TX
- Sells "Dragon Board" magnesium oxide wallboard and "Strong-Enviro Board" magnesium oxide board.
- www.substanceproducts.com / (512) 385-4326

Dragonboard
- Dallas, TX; Miami, FL
- Sells "Dragon Board" magnesium oxide board for walls, subfloor sheathing, and more. Available thicknesses range from 1/8" to 3/4".
- www.dragonboard.com / (800) 214-4551

Magnum Building Products
- Tampa, FL
- Sells "Magnum Board" magnesium oxide board for interior wall and ceiling sheathing, underlayment, exterior sheathing, fascia, soffit, and more.
- www.magnumbp.com / (813) 314-2202

(Fig. 27) Magnesium oxide panels are used as the subfloor in this building.

(Fig. 28) Magnesium oxide panels are used as the exterior sheathing in this building.

(Fig. 29) Magnesium oxide panels are used as the exterior sheathing in this restaurant.

WOOD & WOOD PANELING

Wood can create an aesthetically pleasing finish for walls or ceilings. Wood finishes come in many forms, including solid wood and wood veneer. Veneer products imitate the appearance of solid wood using a thin layer of real wood or vinyl or paper facing bearing a printed pattern. Beadboad and other types of textured and patterned wood paneling are used for some applications. For instance, wainscoting is a traditional application in which wood paneling is used on the lowest 3′ - 5′ of a wall.

Installation: Solid wood boards and wood panels are often installed using interlocking tongue-and-groove joints. These boards can be cleanly installed using finish nails concealed in the joint. Larger pre-made wood panels may simply be installed flush with one another using finish nails, screws, or concealed fasteners.

Performance: Dents and damage in wood paneling can be difficult to repair. Some woods must be sealed to protect them from moisture and water damage. Low-quality veneers can warp or peel, especially if exposed to moisture or improperly installed.

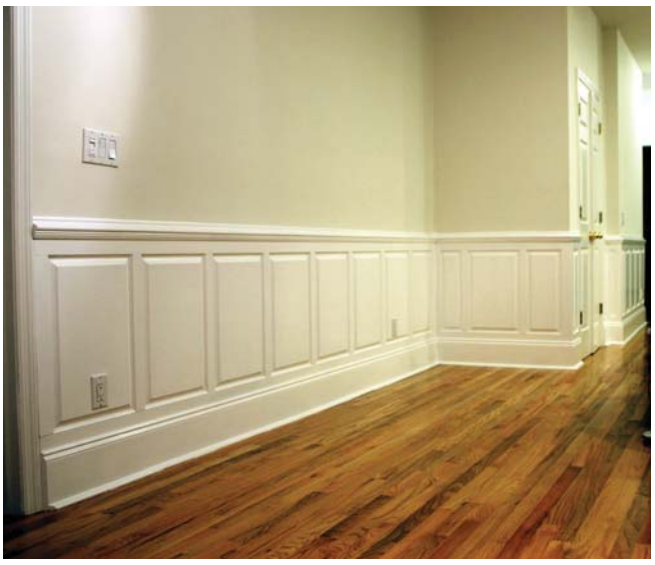
Environmental Impact: Wood veneer or imitation wood paneling are produced using a thin veneer applied over a substrate of plywood, medium-density fiberboard (MDF), or other composite wood materials. These materials can be manufactured using waste lumber, reducing the amount of raw lumber needed to produce wood paneling.

If stains or sealants are used to finish the wood or protect it from decay, select a product that will not off-gas and release harmful VOCs into the house.

Affordability: Wood paneling comes in a range of styles and prices, but can be an affordable option. MDF-based veneer with imitation wood grain is an inexpensive option but may be of low quality. Solid wood or high-quality veneers using real wood, while more expensive, offer better value due to their quality and durability. Wood paneling is generally more expensive than drywall and can be more costly to install.

Coastal Considerations: If using solid wood, consider durable, water-resistant woods such as cypress or cedar. Many woods must be stained or sealed to protect them from moisture. Termites can attack wood wherever it is used in the home; proper construction techniques should be followed to resist termite intrusion.

(Fig. 30) Wood paneling can add warmth to a residential interior.



(Fig. 31) Wainscoting is a traditional application in which wood paneling (often painted) is used on the lowest 3′ - 5′ of the wall.

(Fig. 32) Solid wood, such as this 2x6 tongue-and-groove southern yellow pine, is a durable and natural finish for a room.

TILE

Ceramic, porcelain, and glass tile can be used not only for flooring but also for walls, countertops, and other areas in bathrooms, kitchens, and elsewhere. Tile is highly durable, easy to clean, and can be used to create attractive designs that vary in their detail and complexity.

Ceramic tile is made primarily of clay. Regular ceramic is a porous material and ceramic tiles are usually glazed to make them waterproof and impart their finished color and appearance. Porcelain tile is a type of ceramic made with more refined clay and fired at higher temperatures. This makes porcelain denser, stronger, and much less pervious to water.[56] Glass tile is a third option that can come in a variety of styles.

Installation: Tile requires care and preparation to install, but it can be done by unskilled homeowners as well as skilled builders. The surface to be tiled is generally sheathed with a tile backer board, often a cement-based, water-resistant board. Tiles are set into a layer of mortar or other adhesive that has been spread on the wall using trowels. The joints between the tiles are filled with grout to create a finished surface.

Performance: Tile is a durable material which should last for many years. If not sealed and regularly cleaned, grout can accumulate grime and mildew. Extensive use of tile throughout a room can create unpleasant acoustic effects.

Environmental Impact: Because tile is heavy, it requires more energy to transport. Products that originate closer to the building site will require less energy to transport.

"Some manufacturers claim to use recycled materials," according to architect Cassandra Adams, "but those are mostly post-production (not post-consumer) wastes." One alternative is glass tile, which can include significant post-consumer recycled material.[57]

If grout sealer is used, select a product that will not off-gas and release harmful VOCs into the house.

Affordability: Ceramic tile comes in a range of styles and prices, but is generally an affordable option. Porcelain and glass tiles and specialty tiles may be more expensive.

Coastal Considerations: The warm, humid coastal climate can make maintenance especially critical. Sealing the grout will help reduce the development of mildew and grime.

(Fig. 33) Tile used for a kitchen backsplash creates a durable and attractive surface and protects the wall from grease and moisture.

(Fig. 34) A ceramic tile mosaic creates a artistic effect using small tiles or, in this case, broken pieces of tile in a random or pictorial pattern.

(Fig. 35) Ceramic tiles are set in a layer of mortar. In this case, magnesium oxide panels are used as the tile backer board.

MASONRY

Stone, brick, cast stone, and other types of masonry block can be used to create an attractive finish that adds character to the interior of a house.

Stone comes in nearly infinite varieties. Types of natural cut stone commonly used as decorative finishes include granite, marble, travertine, slate, limestone, and sandstone.

Cast stone is a manufactured concrete product, usually used as a veneer, that can replicate or nearly replicate the appearance of natural cut stone.

Brick is a ceramic block made of fired clay. Brick comes in a wide variety of shapes, textures, and colors.

Installation: Stone, brick, and other masonry finishes are most commonly installed as a non-structural veneer. The veneer layer can be applied directly to the structural wall using mortar or be attached by metal ties or other means. Individual masonry units are typically bonded to one another with a layer of mortar and the exposed joints filled with grout. The mortar joint between units can be reduced to create a "dry stack" look.

Performance: Quality brick or stone, professionally installed, is extremely durable.

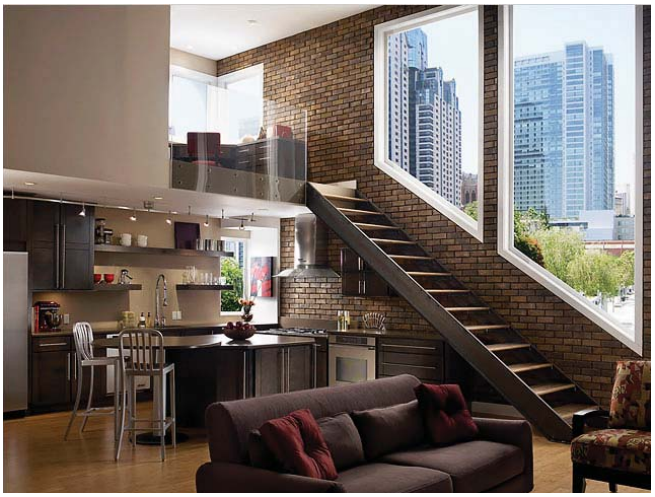
Environmental Impact: Depending on their source, brick, stone, and other earth-based materials can have a significant environmental impact. Additionally, they are heavy and therefore energy-intensive to transport. Choosing materials extracted and processed as close to the building site as possible can reduce the energy needed for transportation.

Affordability: The quality of workmanship and materials determines the cost of masonry. Stone can be very expensive, particularly hard, rare, or highly sought-after types such as marble. Cast stone can provide an affordable alternative to natural cut stone. Brick, too, can be affordable, although prices vary. In all cases, the skilled labor required can raise the cost of masonry finishes.

Coastal Considerations: Brick and stone are not prevalent in traditional coastal architecture. However, both are widely available and currently used in some coastal residential construction.

(Fig. 36) Cast stone is made to replicate the appearance of natural cut stone.

(Fig. 37) Natural stone and cast stone can provide attractive finishes for spaces such as fireplaces or outdoor spaces.



(Fig. 38) Faux brick adds texture and character, but is easily distinguished from real brick if not detailed right.

Roof Systems

Roof systems protect the house structure and interior from water penetration, wind and weather. In extreme weather situations, the roofing material also protects against wind-borne projectiles. Most roofing systems perform these tasks equally well, but each differs in life span, cost, and level of thermal protection.

Radiant Barriers

A radiant barrier can enhance the roof's thermal performance, regardless of the roof finish. Radiant barriers are installed in the attic space to reduce heat gain and loss, and can yield a savings of up to 15% on cooling bills. Radiant barriers comprise of a reflective metallic foil that can be attached to the underside of rafters or placed on top of the ceiling joists. Radiant barriers are also available as in a pre-installed layer on the underside of exterior sheathing material such as OSB or plywood.

Shingles

Shingles are manufactured using many different materials, including asphalt, metal, wood, and rubber. Regardless of material advantages, all shingle types are easy to handle. Installed in small units that overlap to form a water barrier, shingles tend to fail locally rather than as a system, which makes them easy to repair. Shingles are susceptible to failure in high winds. Most asphalt shingles are warrantied for 15 years, but hurricane resistant types are available. Most asphalt shingles absorb a great deal of heat, increasing the heat of the house and the bills to cool it.

Tiles

Tiles are commonly made from clay or concrete. Advantages of using clay/concrete tile instead of asphalt shingles include longer life, greater resistance to projectiles, decreased thermal gain, and greater fire resistance. However, if not properly attached, tiles are prone to dislodging in high winds and can become damaging projectiles. Traditionally tiles are attached with mortar, which

(FIG.A) Radiant Barriers are available for the underside of roof sheathing. Adding this inexpensive layer can reduce Mississippi cooling bills by 15%.

(FIG.B) Shingles, Sheet Metal, & Tile come in a variety of styles. Pictured here are asphalt shingles, metal, and clay tiles.

(FIG.C) Green Roofs are an unusual option in residential construction. The larger the area, the greater the insulative impact.

roofs	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
radiation barrier	+	+	+	+	+				+		+	+	+	+	+	+
shingles		+	+	+	+	−		−		−	−		+			−
tiles	−				−	−	+	+	+	+	+				−	
sheet metal		+		+	−				+	+			+			+
green roof	−	−			−	−	+	+	+	+	+	+	−	−		
rubber	−				−		−		−	−	−					−

often fails in hurricane zones. Instead, tiles can be secured with screws and/or a chemical bonding agent for greater performance. Tiles can be expensive, and their increased weight requires stronger structural support.

Sheet Metal

Sheet metal roofs is available in a variety of colors and profiles, although a galvanized finish with low ribs is the most common. Sheet metal is generally approved for roofs as low as 2:12, with special underlayment. More expensive standing-seam varieties can handle roof pitches of 1:12. Most sheet metal roofs are warrantied for 30 years or more, but can last much longer. Though historically as much as twice the price of asphalt shingles, the price can become comparable depending on larger market factors, such as the price of oil. A metal roof reflects more light than asphalt, saving on cooling bills. Sheets are very lightweight, and resist high winds better then shingles.

Green Roof

Green roofs comprise of a water barrier attached to the roof decking, over which planting medium such as soil and appropriate vegetation are placed. Green roofs collect rainwater and moderate interior temperatures. They must be detailed well to prevent water penetration. Green roofs are generally unused in hurricane zones or areas with heavy downpours, so further consultation and study is necessary.

Rubber

Rubber roofs, or EPDM membranes, consist of a wide rubber membrane glued to a substrate. Rubber roofs are common in commercial construction, but can be appropriate for flat or low-pitched residential roofs as well. If detailed properly, they will not leak, but precise installation is imperative. Rubber roofs can last more than 20 years. They are relatively inexpensive, but as they are usually black and absorb a significant amount of heat, increase cooling costs.

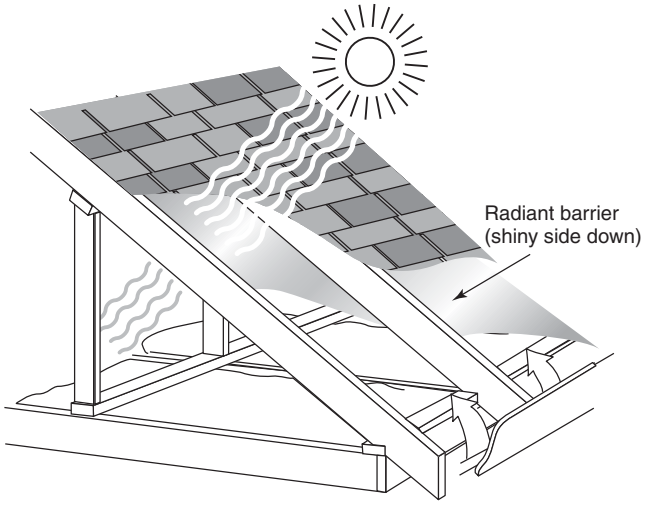
FURTHER INFORMATION

www.toolbase.org
www.gccds.org

OTHER TYPES OF ROOF SYSTEMS

8 ROOFING SYSTEMS

subjects



(Fig. 1) Radiant barriers reduce solar heat gain. It is best to install the barrier where it keeps the heat from entering the attic and the conditioned space.

Radiant Barriers

Overview: Most materials, particularly dark, matte ones, absorb much of the energy of radiant heat from the sun. In turn, they radiate this heat back into the immediate environment, including the house below, in the case of a roof material. Reflective and light-colored materials absorb and radiate less of this energy. Such reflective materials can be applied in attic spaces just below the roof, to act as radiant barriers.

Regardless of the roof finish, a radiant barrier can enhance the roof's thermal performance. Radiant barriers placed in the attic space drastically reduce heat gain, reducing cooling costs by up to 17%.[1] Radiant barrier products consist of a reflective metallic layer on a fabric or mesh back for stiffening, and can be attached to the underside of rafters or to the top of ceiling insulation or joists. There are also sprays which can be used to coat the underside of the roof sheathing. Some sheathing materials come with a factory-installed radiant barrier on the underside, which reduces installation time.

(Fig. 2) Foil backed sheathing can add radiant protection with no additional construction time. Note the shiny side faces the interior.

INSTALLATION

Construction process: Radiant barriers can be installed in several places in a home. If the goal is to reduce heat gain into the home, the most effective place to install radiant barriers is in the attic. The barrier can be placed above the ceiling insulation, where it will reflect the heat from the roof back into the attic space. Or it can be fastened to the underside of the roof or rafters, where it will reduce the amount of radiant heat entering into the attic space. Spray barriers can be applied to the underside of roof decking.

Speed: Installing a radiant barrier is a quick and easy process that does not require skilled labor. Using a product like TechShield, which is a foil backed roof sheathing,

(Fig. 3) Rolled-out foil covers the attic floor insulation. Little fastening is need to keep the product in place. Note the reflective side faces the interior.

adds no construction time. A spray barrier can be applied in 1-2 days.

Delivery Method: Radiant barrier products can be purchased at most construction stores or lumber yards and can be delivered to the site in a pick-up or flat-bed truck depending on the size of the order.

Required Equipment: No special equipment is required to install a radiant barrier beyond tools needed for basic carpentry or insulation installation. If a spray application is used, then special mixing and spraying equipment will be used by the installer.

Specialized Labor: No specialized labor is needed. Spray applications may require installation by a trained contractor.

PERFORMANCE

Wind Load: This product does not impact wind resistance.

Water Resistance: The product acts as a vapor barrier, which can be problematic when installed in locations where moisture may become trapped.

Energy / Thermal: Radiant barrier products are usually rated by their reflectivity and emissivity. Reflectivity is the amount of radiant heat reflected by a barrier, and emissivity is the measure of how much the material conducts heat. Most radiant barrier products have an emissivity rating of 0.05 or less and a reflectivity rating of 0.95 or greater.[2] A radiant barrier has no R-value, which means it cannot be used to replace insulation. Instead, radiant barriers should be used to improve the thermal barrier of a building envelope.

Life Span: There is insufficient information available on how long a radiant barrier will last. Barriers are fragile and can be easily damaged. Foil barriers will not last as long as sheathing or sprayed barriers.

Common Failure: There a two common failures for a radiant barrier. The first is a tearing of the very thin layers. Once there is a break in the barrier, it begins to trap heat.

The other common failure for a radiant barrier is due to dirt or dust.[3] Once a layer of dust has built up on the barrier, that dust will heat up and transfer heat through conduction. This is a particular problem for barriers that are installed flat on top of ceiling insulation. The best way to avoid this failure is to install a radiant barrier fastened to the roof or rafters where dust is less likely to collect.

DESIGN

Environmental Impact: Reducing the heat transfer into a house can greatly reduce the amount of energy needed to cool that home. The Department of Energy writes that the use of radiant barriers could "result in a 2 to 10 percent reduction in the summer portion of a utility bill... perhaps as large as 17 percent."[4]

Versatility / Flexibility: As noted, there are two locations where a radiant barrier can be installed in an attic, but there are many places a radiant barrier could be used to reduce the amount of heat transferred into a home. A radiant barrier will be effective as long as the reflective side of the material is facing out into an open space with an air space of at least 1" between it and the nearest surface.

Market Exposure: There are many different radiant barrier products available at home construction stores, both attached to sheathing and in rolls. The spray product is less common.

Code Approval: If installing a radiant barrier on top of the attic joists, ensure that the barrier does not cover any systems requiring inspection, such as mechanical or electrical equipment.

Affordability: The material cost of radiant barriers is between $0.15 and $0.75 per square foot. The cost is higher for products that combine insulation with reflective material.[5] The additional cost of foil backed roof sheathing relative to conventional sheathing is only a couple of hundred dollars depending on the size of the roof.

Coastal Considerations: A roof exposed to the sun for a prolonged period will absorb a great deal of heat,

(Fig. 4) A spray-coated radiant barrier can be applied to the underside of the roof decking.

sometimes reaching temperatures in excess of 170°.[6] Extreme heat and solar gains are common in the Gulf Coast climate. Because air-conditioning ductwork is located in the attic, it is subject to similar temperature extremes, increasing the energy required to cool a building. A radiant barrier reduces the temperature in an attic, the strain on the HVAC system, and the possibility of moisture and mold build-up in the ducts due to extreme temperature differences. The use of radiant barriers in roof construction is a sound building practice, particularly in a hot coastal climate.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Many construction supply stores will stock a variety of radiant barrier products to choose from. These selections should include radiant barrier backed plywood as well as various foils. Spray radiant barriers can also be ordered from suppliers and should be installed by experienced contractors.

(Fig.5) Radiant barriers come in a variety of forms. The main variable is the backing material.

(Fig.6) Radiant barriers are often installed between roof rafters. This is an example of a radiant barrier type that could be installed in an existing building.

(Fig. 7) Radiant barriers are commonly used in the attic, but can be installed in other locations. This image shows radiant barrier backed plywood being used inside a wall cavity.

Shingles

Overview: Shingles are small, easily handled units installed in overlapping layers to create a water barrier. Roofing shingles can be made of many materials: asphalt, wood, concrete, slate, rubber. Of these, asphalt is the most common, especially for residential construction.

Asphalt shingles are easy to install and repair, and are relatively inexpensive, although prices can vary with quality. They are also available in a variety of colors, styles, and textures, from a basic flat "three-tab" style to a more variegated "architectural" shingle.[7] Asphalt shingles often come with 15-year warranties, but can fail sooner. Higher quality shingles with longer life spans are available and preferable.

There are drawbacks to asphalt shingles. Inexpensive, low-quality shingles can blow off in high winds, and dark asphalt absorbs a great deal of heat, increasing energy costs.

If using asphalt shingles in the Gulf Coast region, homeowners should use a hurricane-resistant asphalt shingle with a longer lifespan, and install a radiant barrier to counteract the high heat absorption.

INSTALLATION

Construction Process: Asphalt shingles, like all shingles, are only appropriate for roof slopes of 3:12 or steeper. They require very little preparation for installation. To prepare a roof, the roof sheathing is nailed into place and then covered with an underlayment such as 30 pound roofing felt. Around the edges of the roof and at valleys, an ice and water shield is laid in lieu of felt for greater moisture resistance, as well as to strengthen the roof surface at its edges. Eave and gable flashing should be installed before laying out shingles.

Strips of asphalt shingles are laid in rows, beginning at the lowest roof edge and working up. Rows are chalked or marked on the roofing felt to facilitate parallel alignment and proper overlap.

Asphalt valley liners should be installed prior to shingling, and asphalt ridge caps should be nailed to any ridges after all shingles are in place. Nails are applied at the top of each shingle, which is covered by the next row, reducing leaks.

Speed of Construction: Even relatively inexperienced roofers can install asphalt shingles quickly. A 1,000 square foot house should take no more than a few days with a small crew of workers.

Delivery Method: Boxes of shingles and rolls of roofing felt are purchased and delivered from any building supply company. Higher quality or unusual styles may be special ordered.

Required Equipment: A nail gun increases the speed of installation but is not required. Galvanized Roofing nails should be used to attach the shingles to the roof.

Specialized Labor: Care should be taken with flashing details and proper valley detailing, but no particular specialized labor is required.

PERFORMANCE

Wind Load: Shingles may blow off in high winds or be damaged by wind-borne debris. Special high-wind-resistant asphalt shingles are available and recommended in coastal hurricane zones.

Water Resistance: When properly overlapped and installed, shingles should not leak, although their life span is relatively short and failure in valleys is more common. Mildew and mold may grow on shingles on north-facing or shaded faces of the roof.

(Fig. 8) A roofing installer nails down strips of asphalt shingles.

Energy/Thermal: Asphalt shingles absorb a great deal of heat from the sun, even when the applied aggregate is a light color. This makes them a particularly poor thermal choice for the Gulf Coast region, where cooling costs are already high. A radiant barrier below the roof sheathing is strongly recommended to reduce thermal impact.

Life Span: Most manufacturers warranty shingles for 15 years but many shingle roofs fail in less time. There are higher quality shingles on the market with 30 or 45 year warranties, which often last 25 years or more. Warranties are often voided due to imprecise installation.

Common Failure: Shingles are susceptible to mold and mildew on shaded parts of the roof. They can blow off in high winds and are easily damaged by debris. 15-year warranty shingles may not last a full 15 years, and are prone to leaking, especially in poorly detailed valleys or lower slopes.

Coastal Considerations: Asphalt shingles are a common choice on the Gulf Coast, but high winds and heat absorption are strong arguments against their use.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Asphalt shingles are available throughout the Gulf Coast. There is a great deal of experience working with shingles in the local work force. Most shingle types can be ordered from construction supply stores. Specialty types should be ordered in advance. Most shingles are shipped throughout the United States, but if a regional manufacturer is preferred, Tamko from Missouri is one option.

DESIGN

Environmental Impact: Asphalt shingles are derived from petrochemicals the manufacturing process of which is toxic. Some shingles will include recycled content in their base or their aggregate. Lower-quality shingles have a short life span and must be replaced more frequently than other materials. They are not recyclable.[8]

An asphalt shingle roof absorbs much heat from the sun, especially if dark in color. Even light-colored asphalt shingles have a dark underlayment that absorbs heat. Cooling costs for the life of the building are much higher with asphalt roofs than with a more reflective metal roof. If using asphalt shingles, lighter colors, higher-quality shingles, and a radiant barrier layered below the sheathing are all highly recommended.

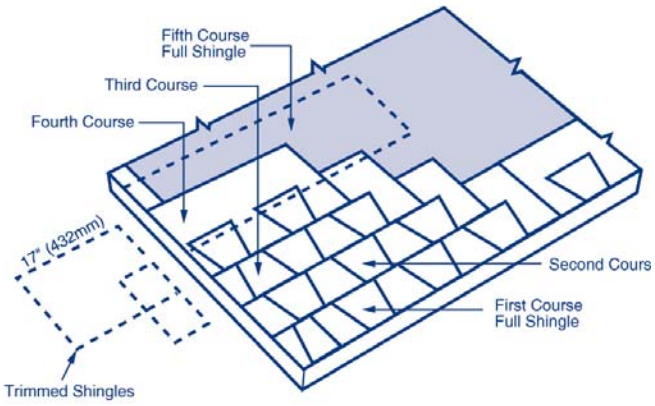
Versatility/Flexibility: Shingles can easily be adapted and installed around any roof vent or plumbing stack. They are very easily repaired because any damaged unit can be pulled out and replaced without disturbing surrounding units. They are easy to install on complicated roofs.

Market Exposure: Asphalt shingles are the most common choice for residential roofs, accounting for 80% of the market in the United States.[9]

Code Approval: Asphalt shingles are almost universally accepted and familiar to local building code officials.

Affordability: One of the main benefits of asphalt shingles are their relative affordability. Homeowners will need to resurface the roof much sooner than with more durable and wind resistant roofing materials, offsetting the initial cost savings.

(Fig.9) Architectural-style asphalt shingles are a more expensive, but more textured, alternative to a flat shingle.



(Fig.10) Diagram of shingle installation procedure.

Metal Roofs

Overview: Sheet metal roofs are lightweight, reflective, easily installed, and available in a variety of profiles, metals, and colors. Lead, zinc, and copper roofs are available, but are uncommon and expensive. Aluminum, galvanized steel, and especially galvanized aluminum ("galvalume") are more common.

Metal roofs generally have a long life span, with some varieties lasting more than 50 years. They do not rip off easily in high winds, and sheet metal can be installed on slopes as low as 1:12. Metal roofs can easily be installed over existing asphalt roofs, making them a good choice for renovations. The metal is often made of recycled content, and is completely recyclable, making metal roofs a sound ecological choice. Although sheet metal comes in various gauges, builders should avoid metal thinner than 26 gauge.

Standing seam metal roofs have no visible fasteners, and are installed by crimping together the seams between sheets. This system is unusual in residential applications in the Gulf Coast region. Corrugated metal roofs, also known as architectural panel roofs, have a number of profile styles, and are attached to the roof with waterproof gaskets and roofing screws. Panels are overlapped to keep out water. This is a more common system in the Gulf Coast region[10].

INSTALLATION

Construction Process: Roof decking is nailed according to building code and 30-pound roofing felt is applied on top. A layer of ice and water shield is then rolled along all roof edges, or over the entire roof, if the roof slope is less than 3:12.

Once the underlayment is in place, all low rakes are flashed. Standing seam roof panels are cut ahead of time to length, and butted up against each other with the seam side up. A crimper rolls down the doubled up edges of the panel and crimps the seam together tightly. A ridge cap is installed after the panels are in place.

If using a corrugated or architectural-panel roofing, 1x4 deck purlins are required to raise the panels above the surface of the roof to allow for air venting. Without this air space, condensation will build up below the surface of the metal and may cause leaks, mold, or other moisture damage. The purlins also provide more depth for the roofing screws. They are spaced at 2' on center, parallel to the ridge, and nailed into the rafters.

(Fig.11) After the sheet metal is in place, contractors install the top rake cap.

(Fig.12) Sheet metal roofs can handle slopes from 1:12 to nearly vertical, and are a good choice in sunny climates.

Because the screws are visible, the pattern of attachment should be considered. Rake caps and ridge caps are installed after the panels are in place.

To prevent corrosion, screws and other fasteners should be of the same metal as the roofing material. All exposed screws need some form of gasket or rubber ring to prevent leaks.

Speed of Construction: Panels on a small roof can be installed in a single day.

Delivery Method: Roofing supply companies will deliver packages with the panels, flashing, roll underlayment, and screws directly to the building site. Any purlins can be delivered from a lumber yard.

Required Equipment: If using standing seam panels, a specialized crimper should be used. No special equipment is needed for overlapping R-profile panels.

Specialized Labor: Standing seam roofs require professional installation. Architectural panels can be installed according to manufacturers' specifications without a professional, but extreme care should be taken and experienced installers are recommended.

PERFORMANCE

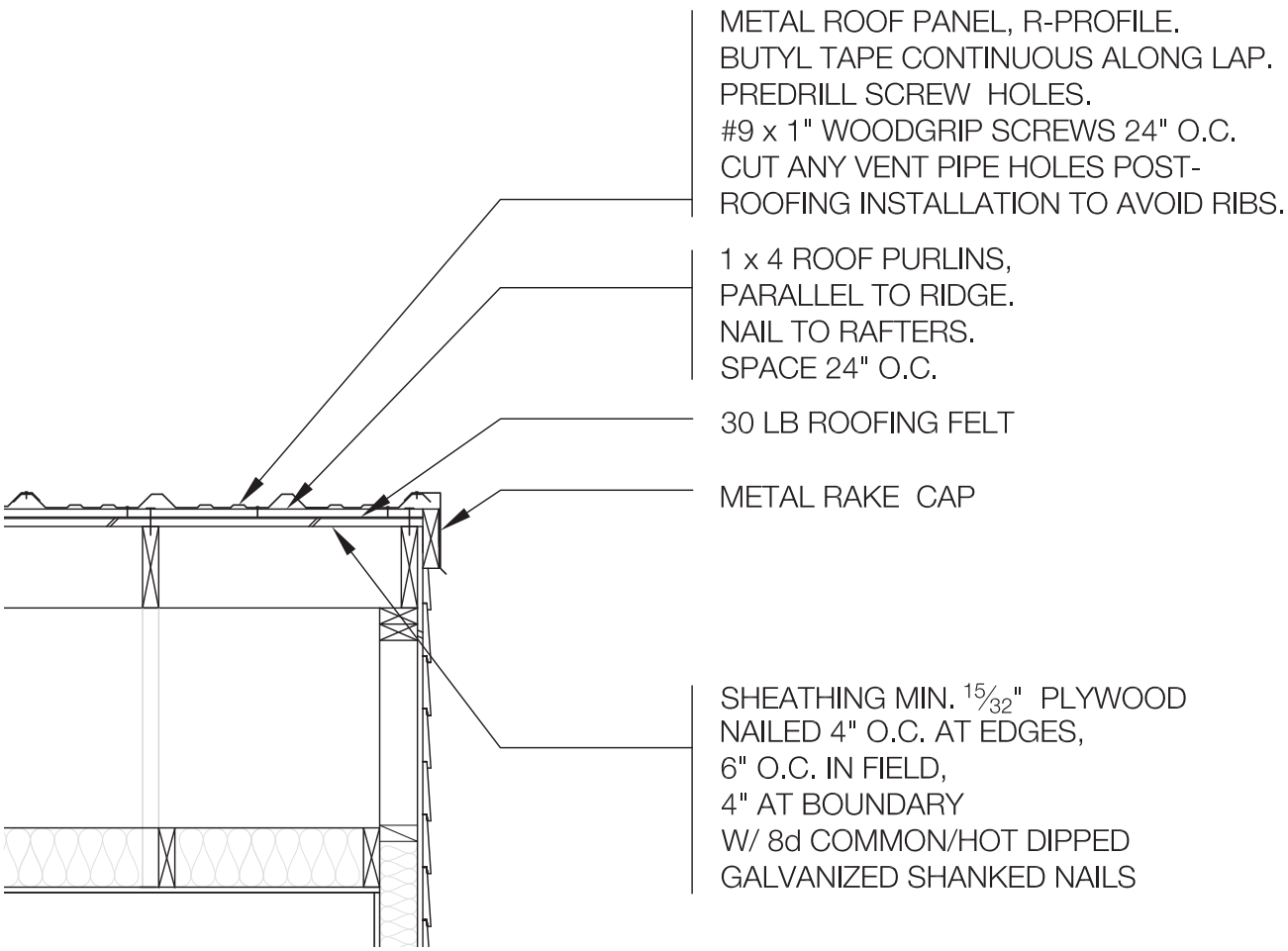
Wind Load: Sheet metal roofs are a smart choice in hurricane zones because their larger unit size and weight make them more resistive to uplift from heavy winds than smaller and lighter shingle systems.

Water Resistance: Metal roofs have fewer joints than shingles and are less prone to leaking when properly installed.

Energy/Thermal: Light colored and galvanized finish metal reflects light and heat, and thus is a smart choice for sunny coastal areas. Cooling costs are much lower with galvanized sheet metal roofs than with asphalt shingles.

Life Span: Most quality aluminum or galvalume coated metal panels will easily last 30 years, and some are marketed with a 50-year life span. Zinc or galvanized steel coatings can oxidize quickly in wet climates and therefore have a shorter life span.

Common Failure: Gaskets on roofing screws can become brittle over time, and may begin to leak. Low-quality metal will begin to rust over time[11].



(Fig.14) Metal roofs should be installed on 1x4 purlins and overlapped according to manufacturer's specifications.

DESIGN

Environmental Impact: Unlike asphalt shingles, metal roofs have a high recycled content. They are also completely recyclable.

In addition, lighter colored and galvanized roof finishes reflect sun and heat away from the house. Less energy is required for mechanical cooling systems, leading to lower energy bills for the homeowner.

Versatility/Flexibility: Metal panels are larger than shingles and should arrive on site pre-cut. Unusual or complicated roof profiles may be difficult to roof with metal panels. Metal roofs are appropriate for a wide range of slopes.

Market Exposure: Metal roofs are a traditional choice for the Gulf Coast region, and many historic or vernacular houses feature them.

Code Approval: Metal roofs are generally accepted by building code officials. In historic districts in the Gulf Coast region, they are encouraged over asphalt shingles.

Affordability: Metal roofs are becoming more affordable in the Gulf Coast region. A galvanized steel 26-gauge roof is generally no more than 150% the cost of a baseline asphalt shingle, and comparable in price to a higher quality or wind-resistant shingle. In addition, the material's longer life span will save the homeowner repeated installation costs over the life of the house, and its solar reflectivity will save the homeowner on monthly cooling bills.

Standing seam roofs are more expensive than corrugated panel roofs, and are more costly to install. However, they have an even longer life span.

Coastal Considerations: Metal roofs are a good choice for the Gulf Coast region. They reflect heat away from the house, lowering cooling bills. They withstand high winds well. They last much longer than asphalt shingles, and they are installed quickly.

(Fig.14) A variety of profiles and colors is available for sheet metal roofs.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Metal roofs are available throughout the Gulf Coast. The local workforce has a great deal of experience installing metal roofs. Most metal roofing types can be ordered from construction supply stores. Specialty types should be ordered in advance. Most metal roofs are shipped throughout the United States, but there are plenty of local manufacturers on the coast.

(Fig.15) Standing seam metal roofs are less common and more expensive, but have a longer life span.

Tile Roofs

Overview: Tiles are commonly made from clay or concrete. Advantages of using clay or concrete tile instead of standard asphalt shingles include longer life span, decreased thermal gain, and greater fire resistance. However, tiles are prone to dislodge in high winds and can become harmful projectiles. Traditionally tiles are attached with mortar, which often fails in hurricane zones. Instead, tiles should be secured with screws and/or a chemical bonding agent. Tiles can be expensive, and their weight requires stronger structural support.

INSTALLATION

Construction Process: Roof tile installation is similar to the installation of shingles or metal. Once the structure is in place, a layer of underlayment or felt paper is fastened to the sheathing to provide moisture protection. Tiles can be affixed to a roof in one of three ways: mechanically with a screw or fastener, chemically with epoxy, or with mortar.

Speed: Tile takes longer to install than other types of roofing such as shingles or metals. Aspects that can slow the installation of a clay roof include the weight of the product and the more complex fastening.

Delivery Method: Due to the heavy nature of the material, it is likely that material will be delivered to the site by truck in pallets.

Required Equipment: Some masonry tools may be needed to install tiles. Additionally, specialized clips, tracks, or fasteners may be needed.

Specialized Labor: An experienced contractor should install the tile roof.

PERFORMANCE

Wind Load: Tiles are very easily broken by wind-borne debris. Projectiles become a particular concern at wind speeds over 110mph. Where the expected wind speed is greater then 110mph, an additional clip is recommended to reduce the likelihood of failure due to uplift.[12]

Water Resistance: Higher quality tiles are kiln fired to high temperatures, creating a tile that is harder, less porous, and more water resistant. Less expensive tiles are often fired to a lower temperature and are less water resistant. When buying tile, look for an ASTM C1167 Grade 1 rating to insure a high level of water resistance.[13]

Energy / Thermal: Several tile products have received environmental ratings from various organizations, including a "cool roof" rating from the Cool Roof Rating Council (CRRC).[14] The color, material, and quality of a tile can greatly affect the amount of heat or radiation it absorbs and transfers into the house.

Life Span: Tiles have a much longer life span than common asphalt shingles. They can last 50 to 100 years, if they are well installed and not exposed to severe storms. The minimum warranty for a quality product is 50 years.

Common Failure: Tiles can have detrimental chemical reactions when used with fire-resistant subdecking. Walking on a clay tile roof can quickly damage it, and should be avoided. Common failure points in high wind situations occur along the ridges.

(Fig.16) Tile will be delivered to the site on pallets. The weight of tile makes them difficult to move around on site.

DESIGN

Environmental Impact: Both clay and concrete tiles are produced with relatively environmentally responsible materials. Neither requires chemicals that can off-gas harmful toxins, so long as the coloration uses lead- and VOC-free colors. The longer life of the product and the increased thermal performance are also possible environmental benefits of using clay or concrete tiles.

Versatility / Flexibility: Tile roofs require a stronger roofing system due to the extra weight compared to other roofing materials. When plywood is used, the National Roofing Contractors Association (NRCA) recommends the use of a minimum 5/8" thick nominal exterior-grade plywood.

NRCA does not recommend installing tile roof systems on roof slopes less than 4:12.[15]

Market Exposure: Nationally there are many producers and a good deal of market exposure. Suppliers in Mississippi can deliver any tile product given proper lead time. There are a few tile roofers in the Gulf Coast area, but any company making a tile product will likely be able to help locate a quality contractor.

Code Approval: Tiles do not require additional fastening in roofs shallower then 5:12. One clip per row is needed when the roof slope is 5:12 to 12:12, and one clip per tile is required when the slope is greater then 12:12.[16] These requirements do not include additional fasteners which may be required in high wind areas.

Affordability: Tile roofs can be more then twice as expensive as typical asphalt shingles.

Coastal Considerations: Due to the high wind loads along the coast, tile can be a dangerous material to use for roofing. However it performs well in rain.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Most home construction stores do not carry tile roof supplies. Some local contractors do advertise their experience with tile roofs, although it is best to inquire on a project by project basis.

(Fig.17) Tile roofs require a thicker roof deck to support the added weight of the tiles. These tiles are being installed using mortar to hold them in place.

(Fig.18) A preferred method for securing tiles in a high wind zone is to nail them to sleepers. This is a stronger connection that is less likely to fail over time and helps prevent uplift.

(Fig.19) Tiles ripped from a roof in a storm can become projectiles likely to damage other area of the roof. They can also cause damage to persons and structures.

Rubber Roofs

Overview: Low-slope (shallower than 3:12) or flat roofs require more detailing than steeper roofs. There are many options on the market for commercial or industrial products, but few are used for residential projects. Generally, low-slope residential roofs consist of an impervious sheet of material. Flat roofs have an increased vulnerability for water damage, and must be detailed and installed precisely in order to prevent leaks.[17]

Flat residential roofs fall roughly into three categories: built-up layers of bitumen or asphalt roofing felt applied with tar; a thin synthetic rubber called ethylene propylene diene monomer (EPDM), which is a large single-ply rubber membrane fully adhered to a subroof sheathing with a glue; or a fluid-applied membrane, which is usually used for unconventional geometric shapes or complex roofs.

An EPDM system, if installed properly, is more water resistant than a flat-roll built-up roof. EPDM roofs are a single piece of rubber, while built-up roofs comprise many overlapping pieces. Though EPDM roofs are relatively new, they have already proven to be more reliable and flexible than built-up roofs. They are also less messy to install and have a longer life span.[18] This guide will focus on EPDM roofs.

In general, hire an experienced professional to design and install a flat roof or roof deck. A well-installed EPDM roof can last more than 20 years, and is relatively inexpensive. However, rubber roof membranes are almost always black, increasing heat absorption into the house and increasing cooling costs.[19]

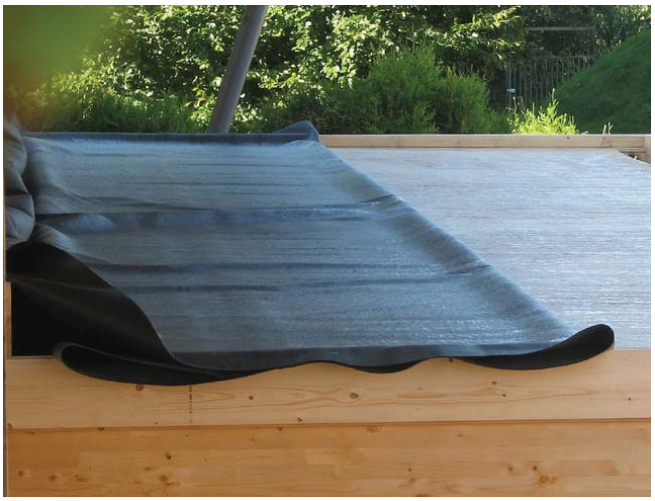
INSTALLATION

Construction Process: EPDM membranes are much easier and less messy to install than traditional built-up roof systems, but still require precise detailing and proper component pieces, adhesives, and fasteners. To prevent ponding, in which water collects and causes deflection in the structure, flat roofs must be sloped at least 1:48 (1/4" per 12"), although a steeper slope is recommended. Large surfaces should also have some form of internal drainage, especially if there are parapets.

An additional layer of plywood is added to the existing roof sheathing. This acts as an underlayment for the EPDM. This layer must be completely smooth, clean and dry before the EPDM can be laid.[20]

The EPDM membrane is rolled out and dry fitted in position, with an extra 3" hanging over roof edges and turned up walls and vertical projections at least 12". After the membrane is trimmed to size, it is folded back upon itself for the adhesive application. A specialized bonding adhesive is applied with a paint roller in a smooth thin layer across both the plywood and the underside of the membrane. When the adhesive is tacky, the rubber is smoothed into place. Care should be taken to avoid wrinkles or air pockets, as adhesives bond quickly. A push broom is used for final smoothing.[21]

In high-wind zones, mechanical fasteners should be applied in addition to the adhesives. Such fasteners can be component pieces that screw on over underlaying knobs, some form of fastening bar, or simply a gasket and screw covered with a strip of membrane and sealed at edges. There are many variations depending on the manufacturer. These will act as a backup, in case the adhesive fails in hurricane-force winds.



(Fig.20) An EPDM membrane is first laid out and trimmed for application.

Speed of Construction: Most small flat roofs can be applied in less than a day.

Delivery Method: EPDM membrane is sold in sheets of up to 50′ x 100′, available through roofing supply companies. Various thicknesses are available, although a minimum of 0.060″ is recommended. Depending on the supplier, the material can be picked up by the installer or dropped off on-site by the supplier.

Required Equipment: No required equipment is needed beyond the component pieces and adhesives.

Specialized Labor: Installers should have experience with EPDM and the specific product used, and follow all manufacturers' installation instructions.

PERFORMANCE

Wind Load: Homebuilders in coastal regions should not simply rely on adhesives or even ballasts, but use mechanical fasteners to keep the membrane in place.

Water Resistance: With the minimum roof slope, and no tears in the rubber, EPDM roofs are very watertight.

Energy/Thermal: EPDM products, like built-up roofs, are almost always dark or black materials that soak up a great deal of heat in the sun, raising cooling bills. There are some white EPDM products on the market. These generally have poor life spans and poor performance.

Life Span: Most manufacturers guarantee their products for 20 years. There is not enough evidence to show whether these roof systems last that long.

Common Failure: If not properly sealed, or if mechanical fasteners are not installed correctly, EPDM membranes may bubble, leak, or pond, especially over time as they become brittle.

(Fig.21) Installing an EPDM roofing membrane is a relatively straightforward task, but requires care and the appropriate adhesives.

DESIGN

Environmental Impact: Many rubber and synthetic membrane systems are produced using toxic chemicals and are laid with toxic adhesives. Most EPDM membranes are not recycled, and also not recyclable.

In addition, the high solar gain from a black flat roof will raise homeowners' heating bills substantially.

Versatility/Flexibility: Rubber roofs are a very flexible option for flat roofs or roof decks. The large sheets of rubber are pliable and easy to smooth into place and cut on site, making the material a good choice for complicated roof shapes.

Market Exposure: EPDM membranes are not as well known as built-up roofs, and builders may have to search to find knowledgeable suppliers and installers.

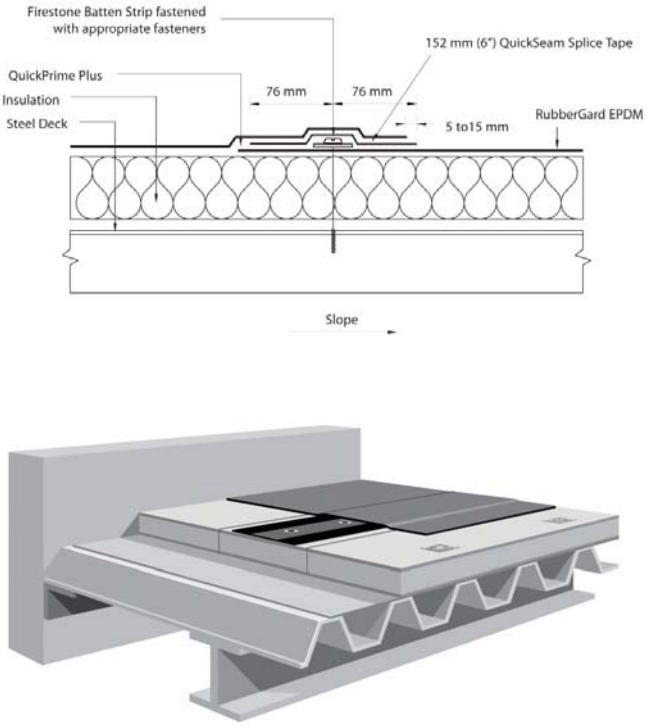
Code Approval: EPDM membranes are fairly new for residential use. Builders and homeowners should check with their local building code officials before committing to this system.

Affordability: One of the main benefits of rubber roofing is its affordability. Generally membranes cost no more than $1/ft for the rubber, plus materials for adhesives and fasteners. Rubber roofs have inconsistent life spans, so homeowners may have ongoing maintenance costs. The high thermal gain will raise homeowners' cooling bills.

Coastal Considerations: Generally, flat roofs and rubber roofs are not the best choice for coastal areas High winds, torrential rains, and high solar heat gain are all problematic for rubber roofs. However, if a project calls for a flat roof or a roof deck, EPDM membranes are a better choice than built-up roofs.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Many construction supply stores will stock a variety of rubber roof products. Because this construction method is often used in commercial buildings, commercial contractors will be more familiar with the process.



(Fig.22 - Fig.23) A mechanically fastened EPDM system uses gasketed screws to hold a sheet of EPDM in place. Some systems employ a second sheet overlapped at the joint or a separate strip of membrane to cover the fasteners. This ensures no water penetrates the hole created by the fastener.

9 APPENDIX

subjects

I. Insuring Homes

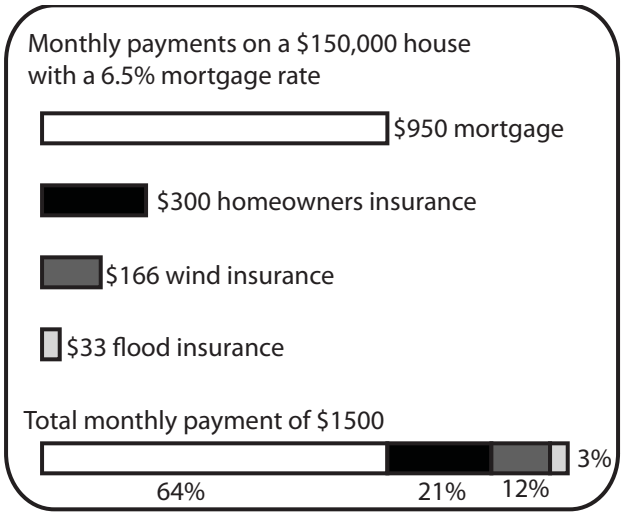
This research is only a small introduction to the issues of insuring a home in the Gulf Coast. Insuring a home is a complex and costly activitly. Anyone purchasing insurance must seek the advise of a trussed insurance professional before doing so. Anyone designing a home to take advantages insurance policies described here must seek the advise of a trussed insurance professional before doing so.

There are 3 common types of insurance for homes: flood insurance, wind insurance, and homeowners insurance. Along the Gulf Coast, homeowners insurance is typically the most expensive on a monthly basis, followed by wind insurance and flood insurance. The cost of insuring a home can be prohibitive for many people. In some cases, monthly rates for the 3 policies can add up to as much or more than a mortgage payment on a home. If this happens the actual cost of home ownership can effectively double, leaving many people unable to meet the expenses of even modest homes.

Homeowners insurance covers damage and liability in a private residence. It can cover either just the home, or the home and its contents, but will not cover flood damage. Mortgage lenders and most recovery grants require that homeowners get homeowners insurance. There are few construction strategies to lower the homeowners insurance rate. Reducing the risk of sudden peril through loss mitigation can lead to lower insurance rates. Sudden peril risks covered by typical homes owners include fire and theft. The more robust the fire protection (hard-wired smoke detectors or sprinklers), the greater the deduction for insurance. Similarly, the installation of a theft alarm or extra locks on doors and windows should reduce the insurance rate.

Other discounts are available, but they are largely based on owner characteristics or habits. Discounts are sometimes offered for non-smokers, seniors, or people with good credit. Homeowners can also leverage their role as a consumer to lower the cost of insurance by purchasing more then one type of insurance from the same provider (auto and homeowner), or by raising their deductible on any claims.

Wind insurance can be purchased from few private providers along the Gulf Coast. This leaves state mandated insurance pools. Each state has its own program, including the Louisiana Citizen Property Insurance Corporation's Citizens Insurance, the Mississippi Windstorm Underwriting Association's Wind Pool, and the Alabama Insurance Underwriting Association's Beach Pool. The Mississippi Wind Pool was established in 1987 to provide wind and hail insurance policies for high risk properties in the 6 Mississippi coastal counties. Today it is the insurer of last resort for more then 43,000 Mississippi residents.[1]



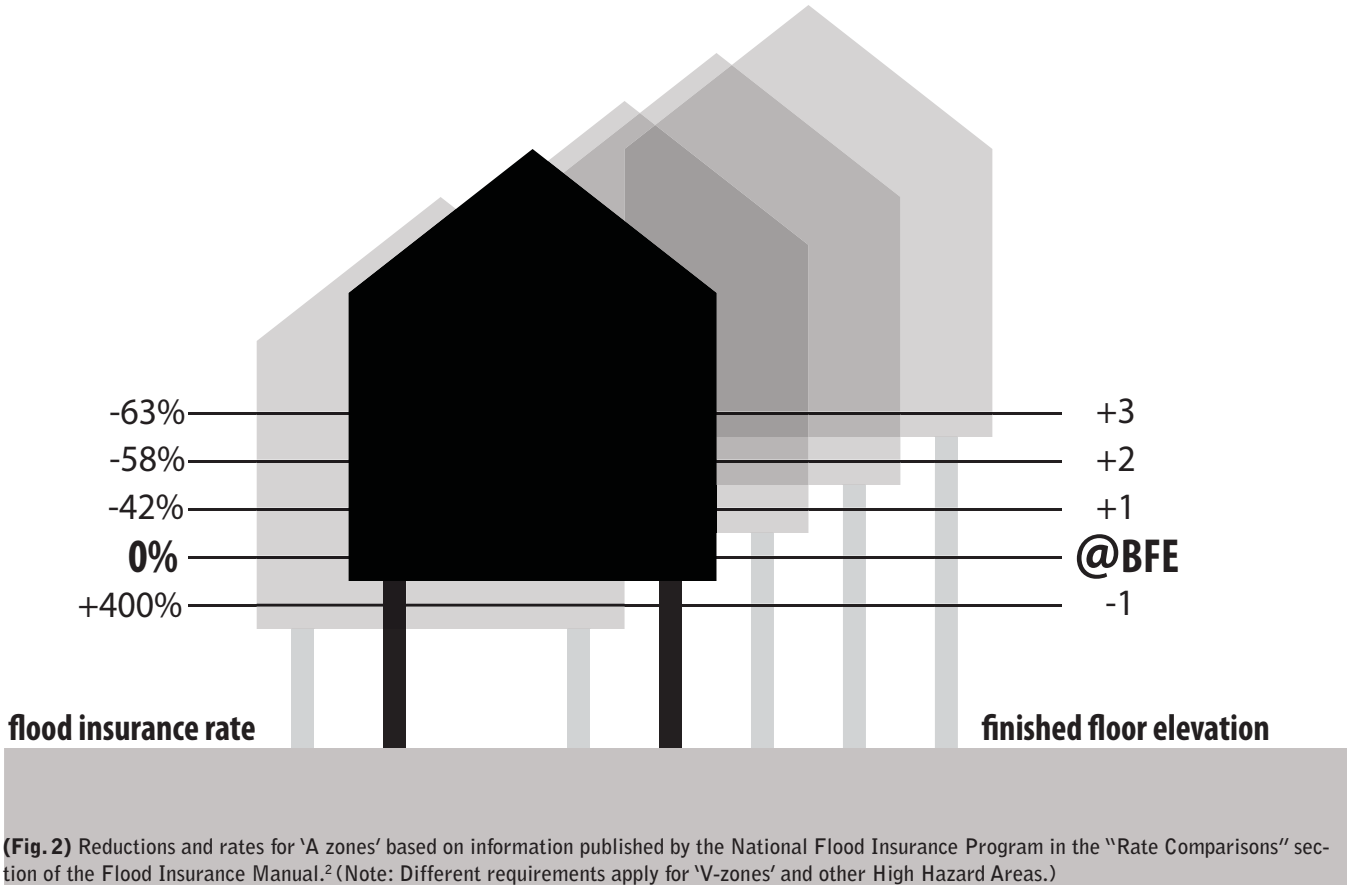
(Fig. 1) Costs and amounts developed from a hypothetical situation for an average home in Biloxi. Estimates based on anecdotal knowledge from GCCDS, Hope CDA, and local insurers and realtors.

Reducing the cost of wind insurance is difficult. The Mississippi Wind Pool offers reduced insurance rates for structures that meet one of two levels of construction standards: wind-resistive or semi-wind-resistive. The Mississippi Wind Pool also recommends the Institute For Business and Home Safety's (IBHS) fortified home program in lieu of its own semi-wind-resistive standard. The IBHS provides for more flexibility in construction and has proven to be an effective program for creating stronger houses and lower insurance costs. If IBHS standards are met, the homeowner qualifies for a reduced insurance rate. The rate credit for meeting the IBHS standards is close to that given for meeting the wind pool's semi-resistive standards. In the first year of insurance, a 55% reduction is awarded. In the second year a 50% reduction is awarded. In the third year a 45% reduction is awarded, and every year afterwards a 40% reduction is awarded. For information on the construction methods used in the IBHS see their website (www.ibhs.org) or "Fortified…for safer living," their builders guide for the standards.

Flood insurance is funded through a federal program called the National Flood Insurance Program (NFIP), which is managed by the Federal Emergency Management Agency (FEMA). The NFIP offers flood insurance to homeowners, renters, and business owners in communities that have adopted and enforced ordinances that meet or exceed FEMA requirements to reduce the risk of flooding. The insurance policies are sold and serviced by private companies but backed by the federal government through FEMA. The NFIP sets rates and requirements that dictate the cost of flood insurance.

The cost of flood insurance is based on the year of construction, the building occupancy, the location of immobile contents, flood zone classification, lowest level in relation to the base flood elevation (BFE), the deductible, and the amount of coverage. Most of these factors are not easily manipulated to achieve lower rates. The most effective way to reduce flood insurance rates is by elevating the building. Raising a home one foot above the BFE can yield a 42% reduction in the cost of flood insurance. Raising the home a total of 3 feet above the BFE can reduce the cost of flood insurance by 63%.

The Gulf Coast Community Design Studio has begun to research flood proof construction for commercial or mixed-use buildings. In some cases, these buildings can be floodproofed below the BFE (or the appropriate design flood elevation) to meet regulatory and flood insurance requirements. Residential spaces must be elevated above the BFE whether or not they are flood proof. Check the community floodplain management ordinance, the applicable building codes, and other federal, state, and regional codes for additional requirements.



(Fig. 2) Reductions and rates for 'A zones' based on information published by the National Flood Insurance Program in the "Rate Comparisons" section of the Flood Insurance Manual.[2] (Note: Different requirements apply for 'V-zones' and other High Hazard Areas.)

II. Energy Efficiency in Homes

Topics relating to energy efficiency are some of the most widely discussed issues in the building industry today. A broad scope of information relating to techniques, technologies, and products, while useful, at times undermines the clarity of the core concepts of energy efficiency. This inundation of information can be intimidating to builders who may choose to maintain their current standard of energy performance rather than risk being overwhelmed by the quantity of information. Understanding some of the core concepts of energy efficiency and synergies between lowering energy consumption and human and environmental health can help an energy-consious builder harness the relevant information and find productive methods from the larger discussion.

BACKGROUND

Ideas relating to increasing the energy efficiency of equipment and buildings was first popularized during the oil crisis in the early 1970s, when demand for energy began to outstrip supply. The notion that Americans could meet their energy needs by increasing efficiency rather than increasing energy production was presented as a means to reduce our foreign dependence on fossil fuels (which remains our main source of energy, accounting for 71% of our energy production today[3]). Conservation of energy was effective in both decreasing the nation's energy demand and lowering the energy costs in buildings.

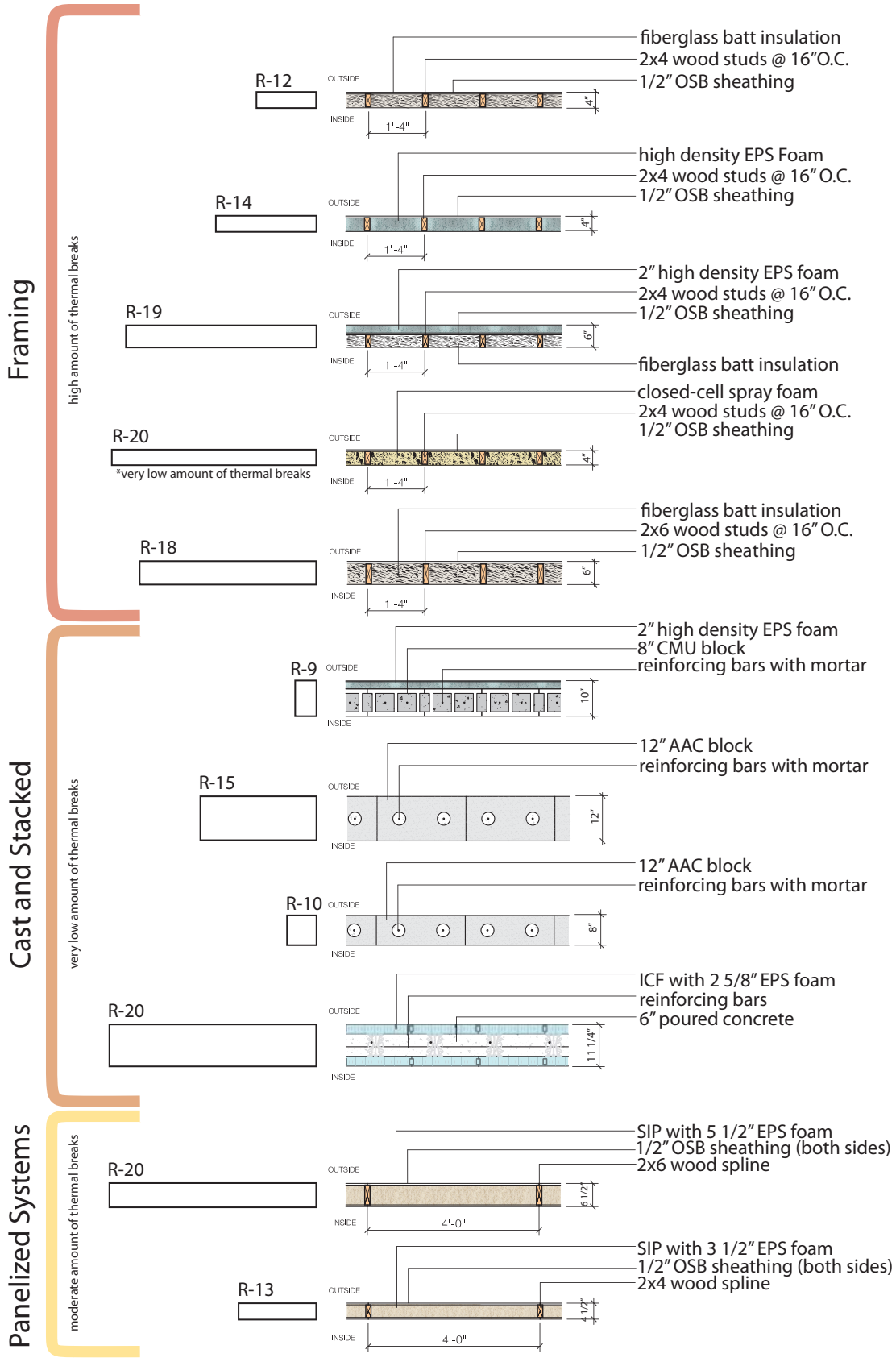
More recently, a second position has emerged that promotes energy-efficiency for reasons other than lowering net energy costs for buildings. This position endorses energy-efficient measures as a way to cut down on the environmentally dangerous emissions from fossil-fueled power plants that contribute to global warming and ozone depletion. Buildings currently use 73% of the electricity produced in the United States[4], so even minor reductions in the quantity of energy demand can have significant effects on the health of humans and the environment related to carbon dioxide levels, airborne pollutants, and environmental contamination. Additionally, a reduction in fossil fuel demand could translate into decreased mining and drilling activity in environmentally sensitive areas and nature preserves.

It has been shown that many measures that seek to increase energy efficiency also have quantifiable benefits for the health and comfort of building occupants. Locating windows with adjustable shades near work areas in offices, for example, can lower energy bills by decreasing lighting demand and increase occupant well being by providing direct lines of sight to the outdoor environment, which has been shown to increase both worker productivity and satisfaction.

STRATEGY

Regardless of whether developers, architects, and builders choose to seek energy-efficiency for reasons of cost, human health, or environmental impacts, the strategies are largely the same. The 2 main strategies to decrease energy consumption are reducing demand and increasing efficiency. Reducing demand means lowering the need for energy consumption by using preventative measures. For instance, roof overhangs can reduce solar heat gain and lessen the demand for mechanical cooling. Increasing efficiency means installing equipment that uses less energy during operation. For instance, some air-conditioning systems use less energy than conventional models.

It is important to understand how the strategies of reducing demand and increasing efficiency work together. For example, the most effective way to reduce negative impacts from automobile use is to reduce demand by driving less and increasing efficiency by making cars that use less fuel when in use. When these strategies are not used together, they are significantly less effective. For instance, to install an energy-efficient air conditioner but then keep the building overly cooled by running the unit unnecessarily would undermine the goal of energy efficiency.



(Fig. 3) Comparing the thermal performance of different wall sections shows that thickness and material affects the R-value of an assembly. Despite their thickness concrete walls do not have high R-values, highlighting the need to insulate if the performance of a framed or panel wall is going to be matched.

TACTICS

Although it would be impossible to outline all of the tactics used to implement the stratigies of energy efficiency in a brief appendix, the following are several measures that can have quantifiable impacts on the consumption of energy. New tactics and technologies are becoming available every day, and ongoing research is recommended.

The following measures are broken into the 2 main strategies of Reducing Demand and Increasing Efficiency, although there is some overlap between the tactics.

Reduce Demand

Shading Building Surfaces: Blocking buildings, particularly windows, from excessive amounts of direct sunlight can have a dramatic impact on the amount of solar heat gain on buildings. Shading can be accomplished by placement of trees, roof overhangs, louvers, vertical shades, and other buildings. The southern and western sides of the building are the most important to shade. Additional information can be found in the Environmental Appendix III.

Adequate Ventilation: Thermal comfort is affected by a combination of radiant temperature, air movement, and humidity. By inducing air movement through buildings, occupant comfort can be improved considerably without the use of a air conditioner. In particularly hot and humid climates like the Gulf Coast, these measures can extend the number of days per year when mechanical air conditioning is not required. Ventilation can be increased by capturing air flow through windows with cross-ventilation, or exhausting air from the building via vents, thermal chimneys, or whole-house ventilation fans. It can be achieved more simply through the generous and thoughtful placement of ceiling fans.

Building Envelope: An efficient building envelope can help maintain desired temperatures and prevent swings in temperature as exterior conditions change. Windows with low solar heat gain coefficients (SHGC) and low U-values, proper insulation of walls, and comprehensive sealing of all joints can create an envelope that helps maintain a consistent temperature inside the building envelope while lowering loads on HVAC systems. Additionally, employing advanced framing techniques (such as 2x6 studs at 24" on center) allows for a more continuous insulation barrier and thicker insulation in wall cavities. Addional information on insulation can be found in Chaper 7.3 and in Chapter 4.2

Rainwater Collection: Collecting rainwater in holding tanks for irrigation or for non-potable uses (i.e. flushing toilets, washing clothes, etc) can lower the amount of energy used to harvest, treat, and transport water from municipalities facilities. Additional information can be found in the Environmental Appendix III.

Efficient Floor Plans: Perhaps the most overlooked aspect of energy-efficient construction is space-efficient floor plans. By avoiding excessive square footage and underutilized spaces, heating and cooling loads for a building can be dramatically reduced.

Durability (materials, flashing, protection, water/vapor barriers): Durability is perhaps the most critical aspect of sustainability. Buildings with low quality materials and construction have great potential to be destroyed during hazardous weather or be a source of homeowner dissatisfaction, which can lead to the buildings' deliberate demolition. The materials that once comprised buildings ends up in landfills or pollutes landscapes and bodies of water upon demolition. The production of new materials often involves highly environmentally detrimental manufacturing processes using toxic chemicals and large amounts of energy.

Material Use (reused, reclaimed, salvaged, recycled, rapidly renewable, engineered wood): Tremendous amounts of energy are used in the production of construction materials. Material lifecycle processes such as harvesting, manufacturing, transportation, installation, use, and disposal all have economic, environmental, and human health impacts that should be understood and considered during the material selection process. Materials should be chosen that have fewer negative effects on human and environmental health and less energy embodied in there production.

Regional Materials: Buying local products increases demand for building materials and products that are created within the region, supporting the use of indigenous resources and reducing the enegry used in transportation.

Solar Water Heating: The sun's heat can meet much of a home's water heating needs without using electricity or gas. Solar water heating systems are typically used in combination with an electric or gas-fueled backup system, thus reducing the amount of energy required to heat the water while maintaining a consistent hot water supply.

Motion Sensors or Occupancy Sensors for Lights: Automatically shutting off lights can reduce the process loads for lighting in a building, which can be quite significant.

Light-Colored Roofing: Light-colored and reflective roofs can reduce the solar heat gain absorbed by a building. The most common type of metal roof comes in sheets made of galvanized aluminum and can reflect much of the heat that would be absorbed by other materials, such as asphalt shingles. Additional information on metal roofing can be found in Chapter 8.4.

Radiant Barriers: Radiant barriers are reflective sur-

faces that can be installed in attic areas to significantly reduce heat gain from radiation from the exterior. Additional information on radiant barriers can be found in Chapter 8.1.

Venting Attics: Venting hot air from attic spaces reduces the amount of heat transfer from hot attics into homes, which lowers cooling loads. It also provides a route for moisture to escape from attic spaces, preventing problems associated with moisture buildup in warm attics. There are mechicanical and passive methods for expelling air from an attic, both with advantages and disavantages. Information on venting attics can be found in Chapter 8.1.

Increase Efficiency

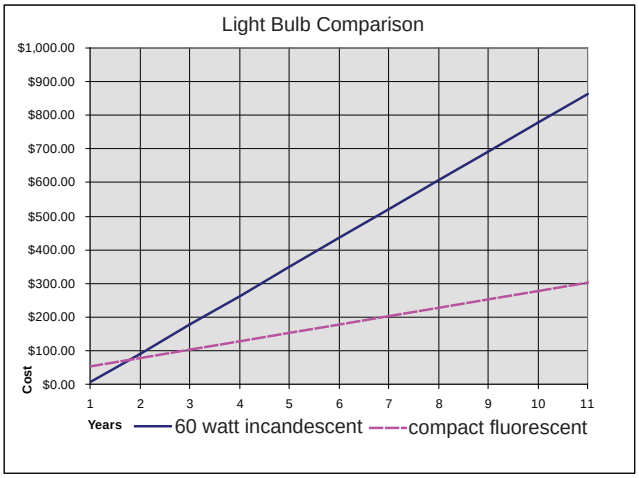
CFL Bulbs: Compact fluorescent light bulbs are perhaps the easiest way to reduce energy costs in buildings. Each light provides an estimated $62 savings over the life of each bulb, and lasts 6-15 times longer than an incandescent bulb.[5]

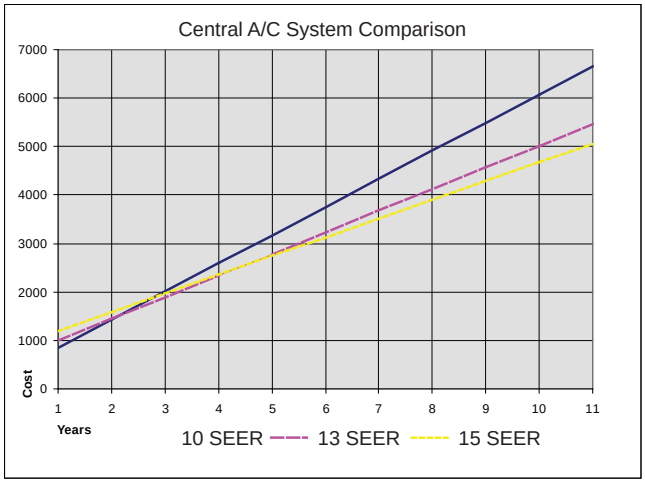
HVAC SEER Rating: The seasonal energy efficiency ratio for HVAC systems measures the efficiency of heating and cooling systems during their heating and cooling cycles. As of January 2006, no HVAC system with a SEER rating of less than 13 can be sold in the United States. Systems are currently available with SEER ratings up to 22.

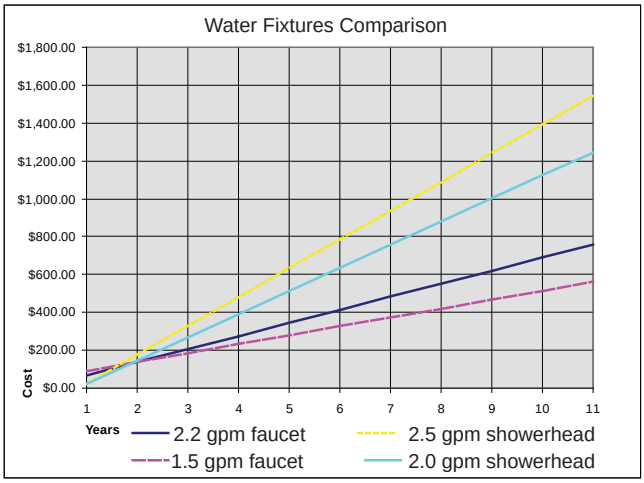
Water Fixtures: Fixtures that exceed the United States Energy Policy Act of 1992 requirements for flow and flush rates can help save tens of thousands of gallons of water over their lifetime. Using less water lowers both utility bills and the amount of energy used to harvest, treat, and transport water for municipalities.

Tankless Water Heaters: Tankless water heaters (also called instantaneous, inline, flash, on-demand, or instant water heaters) eliminate the standby heat loss of conventional water heaters by heating water instantly as it flows through the device. This differs greatly from conventional water heaters, which heat a large quantity of water to a certain temperature and maintain that temperature indefinitely until the water is used.

Energy Efficient Appliances: Appliances that have the Energy Star label have demonstrated a quantifiable energy savings over comparable appliances, often yielding a savings of up to 20-30% over their conventional counterparts.[6]







(Fig. 4-6) Cost comparisons, over time, of various energy efficiency products. Data based on market research by GCCDS.

III. Site Work

There are many systems to consider when designing and integrating a building into its site. The following systems deal with environmentally sound approaches to two major factors that affect the Mississippi Gulf Coast, storm water and heat.

Porous Paving

Porous paving systems provide surface stability and allow storm water to filter through the material into the ground rather than sheeting off the site at a high velocity. This takes advantage of the natural capacity of the soil to filter out pollutants and return the filtered water to the water table, reducing pollution and the need for expensive stormwater management infrastructure such as culverts and drains.

Porous paving materials include gravel, shells, stone fines (various rocks crushed to a size smaller than gravel), unit pavers of various materials, porous asphalt, porous concrete, flexi-pave, and grass pave, among others. Porous paving can be as sturdy as non-porous paving and offer additional advantages. Porous paving often will have lower surface temperature and less glare than non-porous paving. Porous paving has the added value of being more attractive and environmentally preferable than materials like asphalt.

Porous paving systems can cost more than conventional paving systems due to their slightly longer preparation and installation processes. Conventional concrete paving, once poured, can set in a few days and be ready for use, whereas porous concrete has to set for up to a week. Because porous concrete has a low water content, it must be misted and covered while curing to ensure full hydration.

It is important to prepare a sub-base that is appropriate for the porous paving being installed. The sub-base should not be compacted, as it must be more porous than the final paving material in order for water to penetrate through to the soil.

Rain Gardens and Bioswales

Rain gardens and bioswales use simple site grading, vegetation, and minimal infrastructure to passively manage stormwater on site. As a result, they reduce the need for expensive constructed infrastructure such as concrete and metal culverts, and they reduce the amount of water entering a municipality's treatment system. Bioswales, which are vegetated channels, and rain gardens, which can take many forms, are inexpensive and simple to build with typical site forming machinery as part of the overall site grading process.

By creating depressions in the ground that hold rainwater and allow it to be absorbed by plants or gradually percolate into the ground, rain gardens and bioswales reduce the quantity and velocity of water runoff. They keep stormwater from overloading local water bodies, especially within urbanized areas, thus reducing flooding. They also provide habitat for birds, insects, and small animals.

Existing low-lying areas can easily be converted into a rain garden. The soil in the area must be able to absorb water and provide nutrients for the plants. If a low-lying area drains into an area drain, that area can be converted into a rain garden as well, by raising the drain pipe. The height above grade of the drain pipe will determine how large the rain garden is, depending on the site's topography. For plant choices, consult your local university extension agency for a native plant species list that will be appropriate for a rain garden or bioswale.

(Fig. 7) Porous paving systems are available in many different forms and materials, which allows for flexibility in choosing the right paving system for each project.

(Fig. 8) Rainwater collection systems are used to store rainwater for irrigation, and for reuse with building greywater systems.

Rainwater Collection

A third strategy for managing storm water runoff on site is to install rainwater collection systems. Rainwater collected from the roofs of buildings can be stored and later used for things like flushing toilets or irrigating plants. Rainwater collection systems hold this "grey water" above ground in a cistern or below ground in a vault. Above-ground cisterns work well for irrigation because they use gravity to force the water out. However, the system should be enclosed to reduce potential mosquito breeding. Cisterns vary in price and size and are easy to install. Below-grade vaults are better for the use of internal systems that require a pump. They can be expensive but because they are installed below grade they do not interfere with other site uses. Installation of a rain water system requires an up-front investment that will pay off with use. It is important to properly calculate the amount of water that will be used and to consider available space when sizing a water collection system. Average rainfall amounts and the amount of water that can be collected should also be considered and a proper runoff strategy should be designed to handle large rainstorms. Check with governing municipalities before installation, as many along the Gulf Coast limit or ban the use of these systems.

Planting Screens

Planting screens are vertical screens of vegetation that provide shade, privacy, and security. These systems are usually made of a metal mesh or wire along which vines grow. By using deciduous vines, which lose their leaves in winter, a planting screen can provide shade from the summer sun and still allow warm light to pass during the winter, helping to lower energy bills year round.

There are a number of products on the market that are made specifically for creating planting screens. They can be attached to a building or be freestanding and can be made to fit most any form. There are also a number of climbing plant species that can be used to create a planting screen including climbing roses, ivy, jasmine, grapes, and beans.

Native Plants

A native plant is one that grows in the habitat from which it originated. Just because a plant is growing in the forest or field does not mean that it is native. Many plant species that grow in this area were introduced and are invasive, such as Chinese Privet, Kudzu, and the Chinese Tallow Tree. It is best to refrain from using invasive species, as they can choke out other desired species. Even if an invasive species is in a yard, wind, water, and animals will spread the seeds to other areas where the invasive species can take over and result in native habitat loss.

When developing a site plan it is important to identify what plants exist on a site and which of those plants should be salvaged. Native plants require less irrigation and provide healthy habitats for local animal species. Taking an inventory and striving to reuse existing plants in a new design can lead to cost savings. Many nurseries will have native species in stock. These plants, which have often been grown locally, are already adapted to the local climate and therefore more likely to survive after being planted.

The local extension agency can provide both native and invasive species lists.

(Fig. 9) Planting screens provide shade, beauty, and security for structures and can either be attached to the structure or stand independently. (photo: Jakab®)

site work	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
porous paving	+		+	+	−					+	+	+	−			
rain gardens & bioswales	+	+	+	+	+					+	+				+	+
rain water collection	+	+	+	+	+				+	+	+	+		−		
planting screens	+	−	+	+	+						+				+	
native plants										+	+		−		−	

IV. Further Research

Gulf Coast Community Design Studio
www.gccds.org
A digital version of this document as well as updates and additional information are available for download on the Gulf Coast Community Design Studio web site.

Materials / Products

Toolbase
www.toolbase.org
A resource for technical information on building products, materials, new technologies, and housing systems. Researched by the NAHB with funding from HUD and PATH.

PATH
www.pathnet.org
PATH is a public-private partnership for the advancement of housing technology. Funded by HUD and industry partners, PATH provides technology guides, studies, and other housing technology resources.

Building Science Corporation
www.buildingscience.com
A resource for information on building performance of all types. Web site contains reports and studies, as well as information on books, seminars, and consulting.

Porous Paving Systems
www.perviouspavement.org
www.uni-groupusa.org
www.invisiblestructures.com
Resources for information on porous paving systems. Web sites contain reports and studies, as well as information on appropriate product applications.

Rainwater Collection Systems
www.invisiblestructures.com
www.harvesth2o.com
www.ecofriendlyhouses.net
Resources for information on rainwater collection systems for small to large applications. The sites also contain information on specific products and manufacturers.

Planting Screen Systems
www.greenscreen.com
www.jakob.ch
Companies that manufacture planting screen systems for small to large applications. The sites also contain information on specific products and how and where to apply specific systems.

Native Plants
www.msucares.com
This website provides lists of Mississippi native plant species as well as invasive species to avoid.

Builders Guide to Hot Climates
Joseph Lstiburek, Building Science Press, 2005. This book is a particularly good resource for coastal construction.

DESIGNhabitat
www.cadc.auburn.edu/soa/design-habitat/index.html
A resource of the ongoing program at the College of Architecture at Auburn University investigating new methods for using manufactured housing to build high quality affordable housing.

Safety Standards

International Code Council
www.iccsafe.org
The International Code Council is a membership association dedicated to building safety and fire prevention. The building codes developed by the ICC are adopted (often with modifications) in the majority of United States cities, counties, and states. The ICC is also in the process of developing energy and environmental standards.

The Coastal Construction Manual
www.fema.gov/rebuild/mat/fema55.shtm
The Coastal Construction Manual is intended to help design professionals, state and local officials, and builders mitigate the impact of natural hazards on one- to four-family residential buildings in coastal areas.

Recommended Residential Construction for the Gulf Coast
www.fema.gov/library/viewRecord.do?id=1853
FEMA published the Recommended Residential Construction for the Gulf Coast, a design manual available online that provides recommended designs and guidance for rebuilding homes destroyed by hurricanes on the Gulf Coast. The manual also provides guidance in designing and building new homes to reduce the risk to life and property.

National Flood Insurance Program
www.floodsmart.gov
This web site contains information on the National Flood Insurance Program. It also has answers to frequently asked questions and links to more resources. Technical definitions used for the NFIP can be found at http://www.fema.gov/business/nfip/19def2.shtm

Environmental Standards

Southface Energy and Environmental Resource Center
www.southface.org
Southface is a nonprofit providing environmental education and outreach. A resource for home rating systems such as EarthCraft and other efficiency testing.

The U.S. Green Building Council
www.usgbc.org
The U.S. Green Building Council is an organization that certifies buildings, products, and professionals according to their level of environmental practices. The main program of the USGBC is the LEED program. There is also a "LEED for Homes" program.

NAHB National Green Building Program
www.nahbgreen.org
The National Association of Home Builders is an industry group. They have developed a green building program that includes competitions and awards for home builders meeting the NAHB green building standards.

National Green Building Standards 2008
NHAB/ICC, Builderbooks.com, 2009.

U.S. Department of Energy
www.eere.energy.gov/
The clearinghouse for the Department of Energy's programs on energy efficiency and renewable energy. A source for home technologies, practices, and grants relating to better energy efficiency in the home.

U.S. Environmental Protection Agency
www.epa.gov
The Environmental Protection Agency has several programs relating to construction materials and their effects on the environment as well as programs and information for ensuring that site work is responsive to the local environment.

Mississippi State University Extension Service
www.msucares.org
This web site offers extensive information on environmental issues and solutions for residents of Mississippi, including information on local weather, animals, plants, and habitats.

Green Home Guide
www.greenhomeguide.org/
Another program from the USGBC aimed at environmentally friendly buildings. Green Home Guide is a resource more focused on living and maintaining a home in an environmentally positive way.

Earth Craft House
www.earthcrafthouse.com/Earth
Earth Craft is a certification program based out of Atlanta.

V. Glossary of Construction Terms

Air Barrier: *Air barriers control the movement of air, which helps limit the movement of moisture, but they are not impermeable to water. Air leakage through a building envelope (wall) is controlled by an air barrier.*

Base Flood: *The base flood is defined as a flood having a one percent chance of being equaled or exceeded in any given year. Also known as the '100-year flood,' it is the standard used by the National Flood Insurance Program to determine flood insurance and floodplain development requirements.*

Bearing Capacity: *In geotechnical engineering, bearing capacity is the capacity of soil to support the loads applied to the ground. This is a measure of how much pressure between the soil and the foundation can be supported without a shear failure in the soil.*

BFE: *The Base Flood Elevation is shown on the Flood Insurance Rate Map (FIRM) for Zones AE, AH, A1-A30, AR, AR/A, AR/AE, AR/A1-A30, AR/AH, AR/AO, V1-V30, and VE, indicating the water surface elevation resulting from a flood that has a one percent chance of being equaled or exceeded in any given year. The relationship between the structure's elevation above grade and the BFE determines insurance rates.*

Black/Blacked In: *"Blacked in" typically means that the house is structurally complete and covered in a weather protective layer. Historically, the housing paper that was applied to house once the structural and framing work was complete was made with tar and black in color, hence the term "blacked in."*

C.O.: *The certificate of occupancy, referred to as the C.O., is the final inspection and certification that allows the completed building to be occupied.*

Coastal Comfort Advantage: *Comfort Advantage is an energy-efficient home program offered by the Coast Electric Power Association, providing homeowners with the latest energy efficiency standards and cash rebates when they sign up and qualify.*

Compression: *Physical compression is the force pushing on an object or squeezing it. In residential construction, compression normally happens along the vertical axis, as with the weight of a roof structure loaded onto a wall.*

Continuous Load Path: *A method of construction that ties a building together from the roof to the foundation provides a continuously tied path for load forces to be transmitted through the building. A building built with a continuous load path can withstand forces from high winds.*

DFIRM: *Digital Flood Insurance Rate Maps are an online resource for base flood information and other information related to FEMA's National Flood Insurance Program.*

Dry In: *A level of completion during construction. Once the exterior windows and doors have been installed and the roofing is complete the house is considered "dried in." This is because the interior of the house is secure and protected from the weather.*

Energy Star: *ENERGY STAR is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy that promotes energy-efficient products and practices. Appliances and fixtures with an ENERGY STAR rating consume less energy than comparable non-ENERGY STAR products. An entire house can be ENERGY STAR certified through the purchase of these appliances and additional energy saving construction practices.*

Embodied Energy: *Embodied energy refers to the amount of energy used to create a product, transport it to the site, and install it. This is more comprehensive way of measuring the environmental impact of a product.*

Fill: *Often referred to in foundation work, "fill" refers to the soil, stone, or other material used for building up the level of grade at a site.*

Finished Floor Elevation (FFE): *A measurement from the finished grade to the top of the first finished floor surface.*

Footing: *The lowest part of a subgrade foundation system. Footings are wider than the foundation structures they support in order to distribute the load effectively and to resist uplift.*

Form work: *Form work is the structure (often wood or cardboard) into which concrete is poured and allowed to set. It gives concrete its final shape and surface texture.*

Freeboard: *In addition to the base flood elevation, some municipalities choose to require additional elevation, called freeboard, as an additional safety factor. Freeboard is typically described in number of feet above the base flood elevation. Adding freeboard can lead to lower flood insurance rates for an individual building and for the community at large.*

Grade: *The finished surface of the soil or ground layer on a site.*

Grade Beam: *A grade beam is a reinforced concrete beam installed on or at grade, often used to provide horizontal support to piles or deep foundations.*

Gravel: *Aggregate composed of hard and durable stones or pebbles, crushed or uncrushed, often mixed with sand.*

Grout: *In masonry, grout is a thin, coarse mortar poured into cavities and cracks in masonry to fill and join the blocks into a solid. When referring to tile, grout is a thin fluid mortar used to fill the spaces between the tiles and create a finished surface.*

HVAC: *Heating, ventilation, and air conditioning are the mechanical systems that handle climate control and movement of air in a building.*

IBC: *The International Building Code. Most municipal building authorities adopt some version of this document to ensure buildings are constructed to a safe standard. There is also an* **IRC,** *International Residential Code, which is written specifically for small residential construction.*

LFE: *The lowest floor elevation is the measured distance of a building's lowest floor above the National Geodetic Vertical Datum (NGVD) or other datum specified on the FIRM for that location, and defining the topographical grade of a site.*

Life Span: *The life span of a product refers to its time of use and its time as waste. Its important to know how long a product will be of use when comparing cost and installation times.*

Load: *Structural loads are physical forces on a structure such as weights or natural forces . The weight of the building itself is called the dead load; the weight of people and objects in a building is called the live load; and other forces, such as environmental or wind loads, are called dynamic loads.*

Load-Bearing: *A load-bearing element is one that transfers a building's live- and dead-load forces to other parts of the structure. A load-bearing wall, for instance, transfers the weight and forces resting atop the wall to the floor structure and foundation. By contrast, non-load-bearing walls simply form partitions between spaces and are not integral to a building's structure.*

Load Bearing: *Generally refers to structural walls in a home. Walls which support the roof or floor above them and cannot be removed or reduced without consideration for the houses ability to stay stable. "Non-load Bearing" refers to the walls which can be removed without danger of the house falling down.*

Lowest Floor: *The lowest floor of the lowest enclosed area (including a basement). An unfinished or flood-resistant enclosure, usable solely for parking of vehicles, building access, or storage in an area other than a basement area, is not considered a building's lowest floor provided that such enclosure is not built so as to render the structure in violation of requirements.*

Mechanical Systems: *Refers to the HVAC systems in a building.*

Moisture Barrier: *A moisture barrier is similar to an air barrier, but is used to resist the diffusion of moisture through a wall.*

Mortar: *Mortar is a mixture of lime and cement with sand and water, used as a bonding agent between bricks and stones.*

Offgassing: *The evaporation of volatile chemicals in materials at normal atmospheric conditions. Building materials can release chemicals into the air through evaporation continuously for years after the products are initially installed. Materials such as paints, stains, varnishes, carpet, insulation, flooring, kitchen cabinets, countertops, plywood, particleboard, and paint strippers can be prone to offgassing. Absorbent materials like drywall and carpet can absorb these gases.*

Overturning: *Lateral forces from wind can cause buildings or parts of buildings to rotate, overturn, off their foundation.*

Porous Paving: *Paving constructed from materials that permit percolation of storm water to the soil below.*

Pressure Treated Wood: *Wood treated with chemicals applied under pressure to reduce decay in the field. Types of pressure treated wood include; ACQ (Alkaline Copper Quaternary), MCQ (Micronized Copper Quat), CCA (Chromated Copper Arsenate), and CAB (Copper Azole).*

R-Value: *R-value is the measure of the thermal resistance of a material. The higher the number, the better a material insulates. R-value is used to measure the insulative effectiveness of individual components such as windows and insulation as well as whole wall or roof assemblies. Local energy codes require construction to meet certain R-values.*

Racking: *Lateral forces such as wind acting on the frame of a house can cause deformation called "racking" in which a rectangular shape is tilted into a parallelogram with oblique angles.*

Rebar: *Steel bars or rods used to reinforce concrete. As concrete can only handle compressive forces, rebar is necessary to absorb any tensile forces applied to a concrete element.*

Runoff: *The amount of precipitation carried away from the area on which it falls.*

Shear: *A force acting parallel to a surface.*

Shear Wall: *Walls braced to counter the lateral forces on a building. Typically if a building is a rectangle, the shear walls will be the short sides, braced in a way to keep the long side from deforming. They can be bearing or non-bearing, exterior or interior.*

Sliding: *Wind exerts horizontal pressure which can cause a home to slide off its foundation if not properly anchored.*

Stick Framing: *Light wood framing using dimensional lumber is a construction method commonly called stick framing. It is a common form of residential construction.*

Sonotube: *Sonotube is a brand name of cardboard concrete formwork. It is used as a formwork for concrete when pouring foundations. The product can be easily removed from the concrete once it has hardened.*

Stone Fines: *Stone that is crushed into pieces smaller than gravel and larger than sand. Stone fines are normally used as paving in low volume traffic areas such as park pathways or residential drives and paths.*

Subbase: *The layer of aggregate material between the subgrade and the final layer of paving.*

Tension: *Tension is the measure of a force pulling on a object. It is the opposite of compression. Tension can be applied to cables, chains, and rods, but it is also a force in action when a beam spans between two points.*

Thermal Bridge: *Materials with low thermal resistance conduct heat. When these materials make contact with both the interior and exterior faces of a building, like the studs in a typical stud wall assembly, they create a bridge through which heat is transferred between the interior and exterior of the building. This can considerably reduce the insulative performance of a wall and make the interior more expensive to condition.*

Thermal Break: *A material of low thermal conductivity placed in an assembly between two materials of high conductivity is called a thermal break. Thermal breaks are used to stop the transfer of heat through a thermal bridge.*

Turn Key: *The stage of construction at which a house is ready to be occupied.*

Tyvek: *Tyvek is a registered trademark of DuPont. It is a water intrusion barrier that allows vapor, but not water, to pass through. It is often used to wrap houses once the sheathing has been installed, but before exterior siding has been installed.*

Unit Pavers: *Manufactured pavers that are made to interlock to create a patterned, paved surface. Unit pavers can be laid in various ways to create either porous or impervious surfaces.*

Uplift: *The force of the wind pushing and pulling a building or its components upward. This force causes roofs to lift off of buildings and houses to lift off of foundations.*

Vapor Barrier: *A layer of material, such as plastic, used to prevent condensation inside a wall by retarding moisture transmission.*

V.O.C.: *Volatile organic compounds are harmful gases that are emitted from a material. The term volatile refers to the fact that these compounds vaporize, entering the air, under normal conditions.*

Wind Load: *The force created by the wind on the vertical surfaces of a building.*

VI. Endnotes

Chapter 1: Factory Assembled Systems

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Chapter 5: Elevated Foundations

Fig.A *Image from the Gulf Coast Community Design Studio*

Fig.B *Image from the Gulf Coast Community Design Studio*

Fig.C *Image from the Gulf Coast Community Design Studio*

Fig.D *Image from the Gulf Coast Community Design Studio*

Fig.1 *Diagram from the Gulf Coast Community Design Studio*

Fig.2 *Image from the Gulf Coast Community Design Studio*

Fig.3 *Drawing from the Gulf Coast Community Design Studio*

Fig.4 *Image from the Gulf Coast Community Design Studio*

Fig.5 *Image from the Gulf Coast Community Design Studio*

Fig.6 *Drawing from the Gulf Coast Community Design Studio*

Fig.7 *Drawing from the Gulf Coast Community Design Studio*

Fig.8 *Image from the Gulf Coast Community Design Studio*

Fig.9 *Image from the Gulf Coast Community Design Studio*

Fig.10 *Image from the Gulf Coast Community Design Studio*

Fig.11 *Image from The Old House Web, http://www.oldhouseweb.net/how-to-advice/concrete-floor-slabs-on-ground.shtml*

Fig.12 *Image from the Gulf Coast Community Design Studio*

Fig.13 *Image from the Gulf Coast Community Design Studio*

Fig.14 *Image from the Gulf Coast Community Design Studio*

Fig.15 *Image from Alan Richardson*

Fig.16 *Image from Architecture for Humanity*

Fig.17 *Image from the Gulf Coast Community Design Studio*

Fig.18 *Drawing from Architecture for Humanity*

Chapter 6: Flooring

Fig.A *Image from Gulf Coast Community Design Studio*

Fig.B *Image from Gulf Coast Community Design Studio*

Fig.C *Image from The Owner-Builder Book, http://www.ownerbuilderbook.com*

Fig.D *Image from http://ballutblocks.com*

Fig.1 *Image from Architecture for Humanity*

Fig.2 *Image from the Gulf Coast Community Design Studio*

Fig.3 *Image from the Gulf Coast Community Design Studio*

Fig.4 *Image from The Owner-Builder Book, http://www.ownerbuilderbook.com*

Fig.5 *Image from SpeedFloor USA, http://www.speedfloorusa.com*

Fig.6 *Image from Advanced Construction Concepts, Inc., http://www.accproducts.com*

Fig.7 *Image from Advanced Construction Concepts, Inc., http://www.accproducts.com*

Fig.8 *Image from Advanced Construction Concepts, Inc., http://www.accproducts.com*

Fig.9 *Image from Green Fever, http://greenfever.wordpress.com/2008/09/09/just-to-make-things-a-little-more-clear/*

Fig.10 *Image from U.S. Floors, http://www.usfloorsllc.com/*

Fig.11 *Image from Lumber Liquidators, http://www.lumberliquidators.com/*

Fig.12 *Image from Lumber Liquidators, http://www.lumberliquidators.com/*

Fig.13 *Image from Woolshire Carpet Mills Inc., http://www.woolshire.com/*

Fig.14 *Image from ECOsurfaces, http://www.ecosurfaces.com/*

Fig.15 *Image from Photoshop Textures, http://www.photoshoptextures.com/floor-textures/floor-textures.htm/*

Fig.16 *Image from BuildDirect, http://flooring.builddirect.com/*

Fig.17 *Image from Lowe's, http://www.lowes.com/*

Fig.18 *Image from Forbo, http://www.forbolinoleumna.com/*

Fig.19 *Image from Vincent Baudoin, Gulf Coast Community Design Studio*

Fig.20 *Image from Vincent Baudoin, Gulf Coast Community Design Studio*

Fig.21 *Image from the Gulf Coast Community Design Studio*

Fig.22 *Image from Vincent Baudoin, Gulf Coast Community Design Studio*

Fig.23 *Image from Vincent Baudoin, Gulf Coast Community Design Studio*

Fig.24 *Image from Vincent Baudoin, Gulf Coast Community Design Studio*

Chapter 7: Walls

Fig.A *Image from the Gulf Coast Community Design Studio*

Fig.B *Image from the Gulf Coast Community Design Studio*

Fig.C *Image from http://www.pghsprayfoam.com*

Fig.D *Image from © Alan Karchmer*

Fig.1 *Image from House-Painting-Info, http://www.house-painting-info.com*

Fig.2 *Image from Escape Estates, Inc., http://www.escapeestates.homebuilders.com*

Fig.3 *Image from WE Masonry, http://www.wemasonry.com*

Fig.4 *Image from James Hardie, http://www.jameshardie.com*

Fig.5 *Image from Carol Mattson, http://www.surfpix.net*

Fig.6 *Image from Picasaweb user at http://www.picasaweb.google.com*

Fig.7 *Image from the Gulf Coast Community Design Studio*

Fig.8 *Image from Picasaweb user at http://www.picasaweb.google.com*

Fig.9 *Image from Berwyn Fire Company, http://www.berwynfirecompany.org*

Fig.10 *Image from Morris Farms Cypress Sawmill, http://www.morrisfarmscypresssawmill.com*

Fig.11 *Image from Lowe's Home Improvement Online, http://2.bp.blogspot.com/_XEQbaTzjzsw/SQEg_Z3FDYI/AAAAAAAAC70/UV7OPYQjOR8/s320/ZIP+system+sheathing+and+taped+joints.jpg*

Fig.12 *Image from the Gulf Coast Community Design Studio*

Fig.13 *Image from Windstorm OSB, http://windstormosb.com/images/methodbig/diag01.png*

Fig.14 *Image from Windstorm OSB, http://windstormosb.com/images/methodbig/diag01.png*

Fig.15 *Image from the Gulf Coast Community Design Studio*

Fig.16 *Image from Georgia Pacific, http://www.gp.com/build/images/products/nautilus_wallsheathing.jpg*

Fig.17 *Image from Directory M Articles, http://2.bp.blogspot.com/_XEQbaTzjzsw/SQEg_Z3FDYI/AAAAAAAAC70/UV7OPYQjOR8/s320/ZIP+system+sheathing+and+taped+joints.jpg*

Fig.18 *Image from Construction Links, http://www.constructionlinks.ca*

Fig.19 *Image from the Gulf Coast Community Design Studio*

Fig.20 *Image from Southwest Mobile Storage, http://www.swmobilestorage.com*

Fig.21 *Image from L&D Adhesives, http://www.adhesives.com*

Fig.22 *Image from Tianjin Huali Thermal Insulation Building Materials Co., Ltd., http://www.tradew.com*

Fig.23 *Image from M&D Insulation, http://www.mdinsulation.net*

Fig.24 *Image from Vincent Baudoin, Gulf Coast Community Design Studio*

Fig.25 *Daniel Friedman, InspectAPedia, http://www.inspect-ny.com/sickhouse/Green_Mold_Pictures.htm].*

Fig.26 *Image from Magnesiacore Inc., http://www.magnesiacore.com/*

Fig.27 *Image from Magnesiacore Inc., http://www.magnesiacore.com/*

Fig.28 *Image from Magnesiacore Inc., http://www.magnesiacore.com/*

Fig.29 *Image from Magnesiacore Inc., http://www.magnesiacore.com/*

Fig.30 *Image from Build LLC., http://www.buildllc.com/*

Fig.31 *Image from The Wood Whisperer, http://thewoodwhisperer.com/*

Fig.32 *Image from Alan Karchmer, http://www.alankarchmer.com/*

Fig.33 *Image from Earth and Wood Creations, http://www.earthandwood.bix/work/kitchen.html/*

Fig.34 *Image from Vincent Baudoin, Gulf Coast Community Design Studio*

Fig.35 *Image from Magnesiacore Inc., http://www.magnesiacore.com/*

Fig.36 *Image from Stonecleft LLC., http://www.earthrox.net/*

Fig.37 *Image from ArchiExpo, http://www.archiexpo.com/prod/cupamat/natural-stone-veneer-facing-interior-and-exterior-51785-125329.html*

Fig.38 *Image from Tim McKeough, New York Times, http://www.nytimes.com/2008/02/28/garden/28room.html*

Chapter 8: Roofing Systems

Fig.A *Image from www.flickr.com member "Christopher.johnson"*

Fig.B *Image from www.flickr.com users "Chubfisherman","Vinylindustries", and "Korrynne"*

Fig.C *Image from www.delafleur.com. the 168 elm "one drop at a time" project.*

Fig.1 *Image from "Radiant Barriers: Energy Fact Sheet," Southface Energy Institute, www.southface.org*

Fig.2 *Image from www.flickr.com member "van wagner_skzat"*

Fig.3 *Image from promotional web site for BTU Busters, http://www.btubusters.com/04RADIANT-BARRIER-PRODUCT.html*

Fig.4 *Image from promotional web site for Efficient Attic Systems, http://www.btubusters.com/04RADIANT-BARRIER-PRODUCT.html*

Fig.5 *Image from www.flickr.com member "van wagner_skzat"*

Fig.6 *Image from www.flickr.com member "van wagner_skzat"*

Fig.7 *Image from www.flickr.com member "van wagner_skzat"*

Fig.8 *Image from www.flickr.com member "pointnshoot"*

Fig.9 *Image from Austin Roofing Inc., http://www.austinroofing.ca/*

Fig.10 *Image from GAF Materials Corp., http://www.gaf.com/*

Fig.11 *Image from the Gulf Coast Community Design Studio*

Fig.12 *Image from Architecture for Humanity*

Fig.13 *Drawing from the Gulf Coast Community Design Studio*

Fig.14 *Image from Mueller, Inc. http://muellerinc.com*

Fig.15 *Image from 5-A Enterprises, Inc., North Carolina*

Fig.16 *Image from www.flickr.com member "editor B"*

Fig.17 *Image from www.flickr.com member "pizzodisevo"*

Fig.18 *Image from Hans RoofTile. http://www.construction.com*

Fig.19 *Image from "Tile Roofing for High-Wind Areas" Technical Fact Sheet 21. FEMA*

Fig.20 *Image from www.flickr.com member "sverjans"*

Fig.21 *Image from London Flat Roofing, http://www.london-flat-roofing.co.uk/EPDM-Rubber-Roofing/EPDM-Rubber-Roofing.htm*

Fig.22 *Image from Firestone Building Products, http://www.firestonebpe.com/roofing/rubbergard/_en/*

Fig.23 *Image from Firestone Building Products, http://www.firestonebpe.com/roofing/rubbergard/_en/*

Appendix

Fig.1 *Image from the Gulf Coast Community Design Studio*

Fig.2 *Image from the Gulf Coast Community Design Studio*

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Fig.7 *Image from http://www.flickr.com*

Fig.8 *Image from http://www.flickr.com*

Fig.9 *Image from Jakab®*