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.

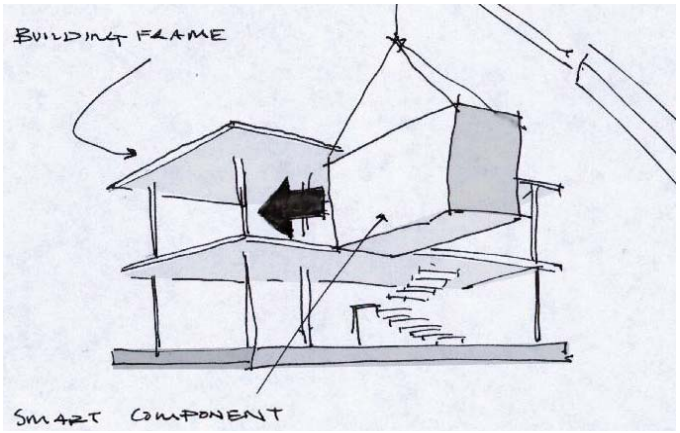
Strategies for manufacturing large parts of homes can be differentiated by the level of completion reached when the product leaves the factory. This can vary from being largely finished to being a group of parts not yet assembled. Examples are placed in the following order, one being the most finished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

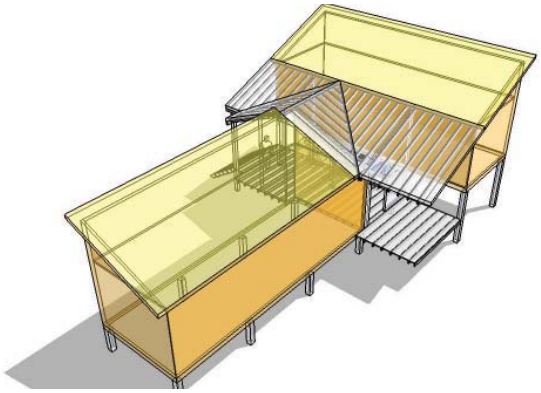
Modular Homes
Modular homes are common throughout the Mississippi Gulf Coast, and there are many manufacturers and several installers available to interested housing providers.

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

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.

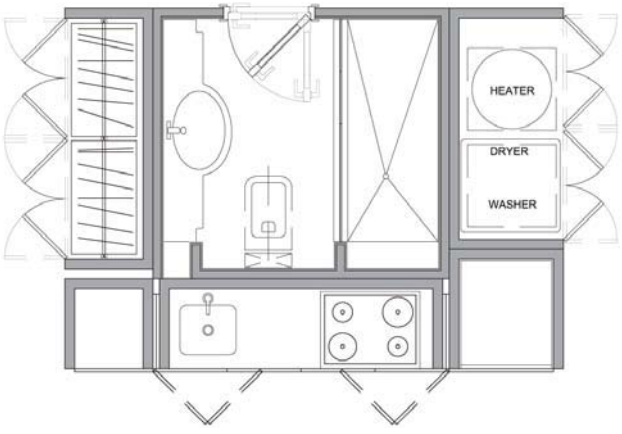
Market Exposure: While common in hotels and casinos, and available for multi-unit residencies on the scale of a dormitory or an apartment, component modules are not used in single family construction. At the time of this publication most of the production and use of building components took place in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

(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.

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

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.

Page 42 642

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.

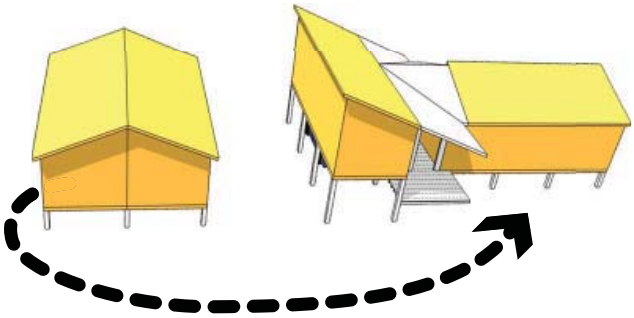
Coastal considerations: Kits designed for strong winds and increased moisture are preferable for coastal climates.

GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

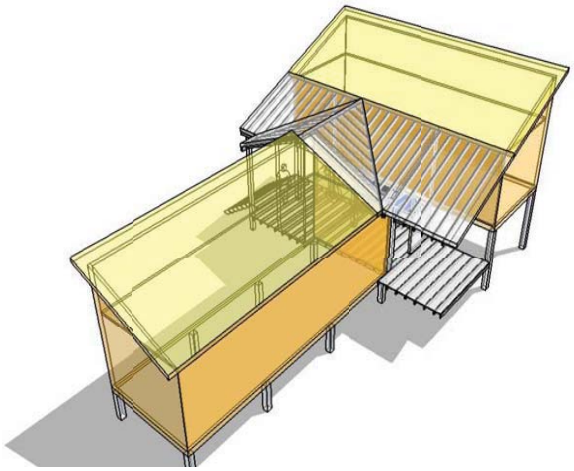
Deltec Homes of North Carolina makes a hurricane resistant kit home.

(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.