

HOME BUILDERS

GUIDE TO OFFSITE CONSTRUCTION



Thank You



Founded in 1987 by NAHB and a visionary group of leaders and icons in the housing industry, the National Housing Endowment works to 'build a foundation' to help make the American dream of homeownership a reality for present and future generations.

The National Housing Endowment

- ☑ The National Housing Endowment is dedicated to the development of the residential construction workforce through education, training and research. Supported programs include construction management in universities and two-year colleges; trades training programs in high schools, and activities introducing students at all levels to careers in home building.
- ☑ Is guided by a prestigious Board of Trustees representing various areas of the industry who provide a broad perspective on the diverse needs of the housing community.
- ☑ Is an important national vehicle for addressing industry concerns and has awarded thousands of grants totaling more than \$15 million in support of housing related projects nationwide.
- ☑ Attracts the financial support and leadership of prominent members of the building community and has passed the \$20 million mark in contributions and pledges.

We have more than fifty "Founding Advocates," an elite group of individuals and organizations who have pledged six-figure gifts in support of the Endowment's mission. In addition, 16 individuals and corporations have pledged gifts of over \$1 million.

Click here to learn more about [The National Housing Endowment](#)

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Building Systems Councils

The NAHB Building Systems Councils (BSC) is the voice of the systems-built housing industry — dedicated to promoting the benefits of systems-built construction to consumers and builders. Comprising six different councils, the BSC represents manufacturers, builders and suppliers of log, timber frame, modular, panelized and concrete homes.

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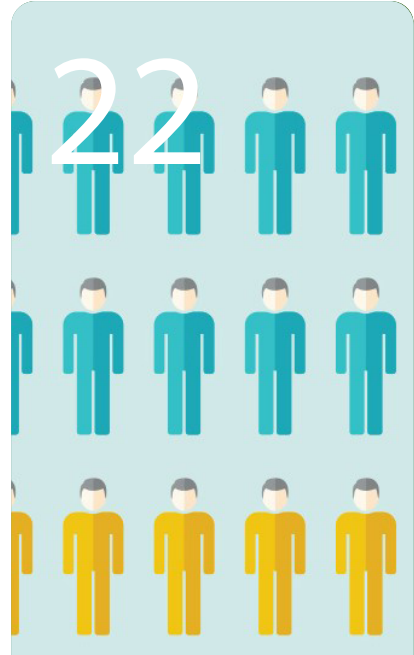
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OFFSITE
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Introduction to Offsite Construction

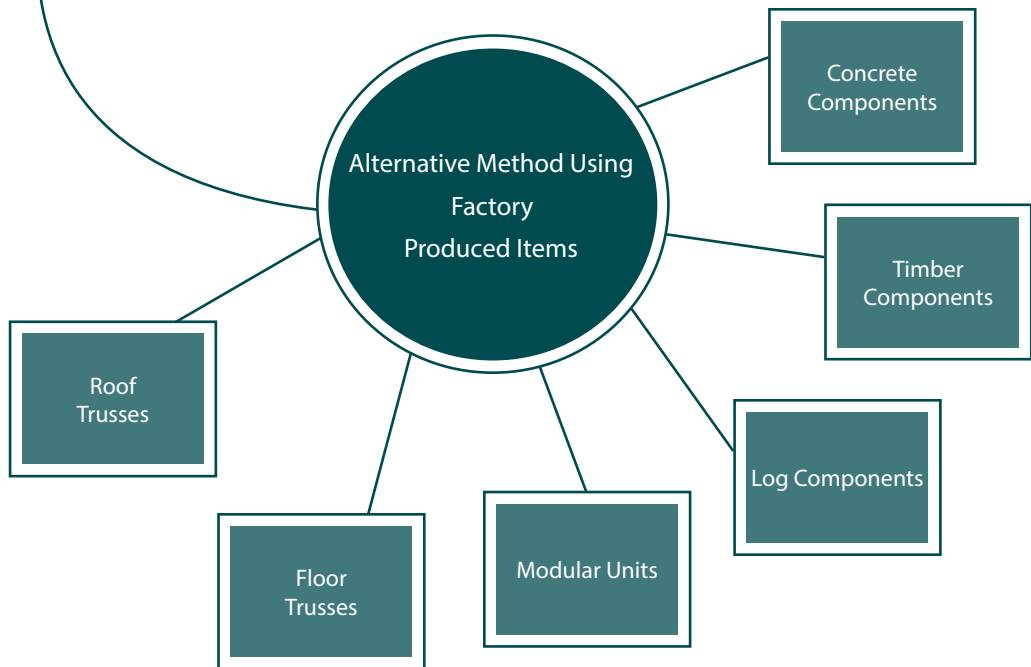
Home builders throughout the United States are using various forms of prefabricated components to streamline their building process. These builders range from giants of the industry to small-volume builders who are increasing their annual sales due to the inherent efficiencies of systems-built housing.

Building systems allow builders to increase their productivity and provide the same high-quality housing that is traditionally associated with stick building. In addition, systems-built housing appeals to builders because of the wide variety of available designs. Small, affordable houses and custom-designed luxury homes can all be built using building systems.



WHAT IS OFFSITE CONSTRUCTION?

Systems-built housing is built using alternative construction methods that utilize various forms of factory-produced items. These items range from simple components, such as roof and floor trusses, to volumetric modular units, to log, timber, and concrete components.





WHY IMPLEMENT OFFSITE CONSTRUCTION?

Systems-built construction appeals to builders for a variety of reasons. Labor management is simplified because required onsite labor decreases. For example, since more of the actual building is completed in a factory, builders using modular building systems don't worry about scheduling framers, drywallers, and some times painters. As a result, these builders pay fewer invoices because they need fewer subcontractors.

Additional reasons builders across the county have adopted offsite construction techniques:

- ☑ One of home builders' chief concerns is a lack of skilled labor. As most systems-built home manufacturing happens at the factory, building systems can greatly reduce your reliance on subcontractors and the volatile labor market.
- ☑ Onsite waste can be dramatically reduced as highly engineered, and precision cut components are delivered from the factory.
- ☑ Fewer subcontractors and fewer material orders enable builders to increase volume without increasing overhead or additional capital.
- ☑ Modular builders know over 90 percent of their site costs because the normal expenses associated with subcontractors are included in the fixed cost of the modular home.
- ☑ Project completion is subject to far fewer weather delays.
- ☑ The reduction of onsite construction material at the job site leads to a reduction in theft and vandalism at the site.
- ☑ Many manufacturers provide financing, management assistance, and marketing support to their associated builders.
- ☑ Depending on the manufacturing method, some systems-built housing relieves the builder of nearly all responsibility for building-code compliance and the scheduling of field inspections. (Modular homes and some panelized homes carry this benefit).

Types of Building Systems

PRECUT FRAMING SYSTEMS

Precut systems for framing has been shown to benefit builders with increased efficiency, less waste, and reduced risk. Precut framing may be the most like stick-built of our prefabricated delivery methods, as lumber is cut to length offsite but assembled onsite by the framing crew.

The process starts with the entire house framing package resolved in the design phase; floors, walls, and trusses. All structural and code compliance issues are reviewed and planned for, and then the materials are sent through the manufacturing line to be precut, marked, and bundled together. Then the entire precut framing package (including pre-assembled trusses) is shipped out to the job site, where the framers assemble the home. The job site slang term for the method is “frame by numbers.”



PRECUT WALL FRAMING



FRAME BY THE NUMBERS



PRECUT FLOOR SYSTEM



PANELIZED BUILDING SYSTEMS



PANELIZED WALL SYSTEMS

If you imagine modular housing as an assembled box, then panelized housing is like the unassembled parts of a box. Panelized buildings consist of wall panels that are generally eight feet high and range in length from four feet to 40 feet. Depending on the manufacturer, the panelized package may include doors, windows, and interior trim. The panels are designed for easy assembly. Panelized packages are loaded for delivery using a first off-first used system so that work on a structure can begin while unloading is still in process. A roof can be added to complete the exterior of the building in only a few days, and sometimes in only one day.



PANELIZED WALL SYSTEMS

Panelized building systems include precut packages, component systems (such as roof trusses and floor joists), and wall panel systems. Wall panels are available in two versions: open— and closed-wall. Open-wall panels consist of exterior sheathing only. Plumbing, wiring, insulation, and interior finishes are installed at the building site. Closed-wall panels are shipped from the factory as complete, insulated wall units. Interior and exterior sheathing are attached, and the electrical and plumbing systems are prepared for connection at the site.

Many stick builders already use building components, such as roof and floor trusses and prehung doors and windows. Usually, these components are purchased from a factory rather than site— built. Upon completion, panelized homes are identical to stick-built homes.



PANELIZED WALL SYSTEMS

SIPS BUILDING SYSTEMS

Structural Insulated Panels (SIPs) are high-performance building systems for residential and light commercial construction. The panels consist of an insulating foam core sandwiched between two structural facings, typically oriented strand board (OSB). SIPs are manufactured under factory controlled conditions and can be fabricated to fit nearly any building design. The result is a building system that is extremely strong, energy-efficient, and cost-effective. Building with SIPs generally costs about the same as building with wood frame construction when you factor in the labor savings resulting from shorter construction time and less job-site waste. Other savings are realized because smaller heating and cooling systems are required with SIP construction.



STRUCTURAL INSULATED PANELS (SIPs)

SIPS HOME



STRUCTURAL INSULATED PANELS (SIPs)



MODULAR BUILDING SYSTEMS



MODULAR BUILDING SYSTEMS



MODULAR BUILDING SYSTEMS



MODULAR BUILT HOME



MANUFACTURED HOUSING

Modular systems consist of one or more three-dimensional modules that are 90 to 95 percent complete when they are shipped from the factory. The modules can be thought of as assembled boxes. Of all systems-built housing, modules have the reputation of being the most structurally sound because they are sometimes transported as much as 250 or 300 miles and still must arrive in “factory condition.” The modules are towed on a flatbed trailer to the building site, where they are placed on a prepared permanent foundation. Two or more sections, a nominal 12 to 16 feet wide and up to 60 feet in length, are combined to create the finished building. Modules are often stacked to make two- or three-story structures. Styles of modular homes vary greatly, and many manufacturers can custom design packages for builders within certain limitations. Modular buildings are also used for multifamily housing, hotels, retail centers, and office buildings.

Both the industry and consumers are confused about the differences and definitions of Modular Housing vs. Manufactured Housing. According to the U.S. Department of Housing and Urban Development’s FAQs page, “A manufactured home (formerly known as a mobile home) is built to the Manufactured Home Construction and Safety Standards (HUD Code) and displays a red certification label on the exterior of each transportable section. Manufactured homes are constructed according to a code administered by the U.S. Department of Housing and Urban Development (HUD Code). The HUD Code, unlike conventional building codes, requires manufactured homes to be constructed on a permanent chassis.

Modular homes are constructed to the same state, local or regional building codes as site-built homes.” Many factories build both manufactured and modular homes in the same facility but Manufactured home have to meet the HUD Code, while the modular homes are built to the states currently accept year of the International Residential Code (IRC) (“Manufactured Housing and Standards- Frequently Asked Questions | HUD.gov / U.S. Department of Housing and Urban Development (HUD)”).



LOG HOME BUILDING SYSTEMS

The oldest form of systems-built housing in the United States is the log home. Precut log home kits have been in production since 1923. Builders can choose from a variety of log home styles, from traditional, rustic-looking houses to contemporary designs for commercial and retail structures, such as motels, restaurants, and gift shops. The log home industry has promoted the recognition of the energy efficiency of log buildings.



LOG HOME



LOG HOME



LOG HOME INTERIOR



LOG HOME FRAMING



CONCRETE HOME BUILDING SYSTEMS

Concrete is unquestionably one of the most durable building products available. Concrete homes have withstood fires, rains, floods, and hurricane-force winds with minimal or no structural damage. Homes built with insulated concrete walls effectively buffer the home's interior from the outside. The weight and mass of the concrete can reduce the amount of external noise entering the house by as much as two-thirds. Concrete construction can provide a tight thermal building envelope, which can reduce a homeowner's heating and cooling bills. The concrete, insulation, and steel in a concrete wall system are much more mold- and insect-resistant than traditional wood studs, joists, and wall sheathing.

The inert properties of concrete provide a good alternative for those concerned about unhealthy airborne solvents and product residues from other common building materials. Many insurance companies offer lower premiums for fire-resistant concrete constructed homes.



CONCRETE HOME



CONCRETE MASONRY WALL SYSTEM



POURED CONCRETE WALLS

Offsite Construction: A Brief History

1780's

Leonardo da Vinci wrote about the concept during the Renaissance in Italy. Two centuries later, the first real house in Australia was shipped there from England.

1880's

Thomas Edison had a house built in Maine, disassembled, shipped to Florida, and then reassembled. The house still stands today and is in use as a museum.

1900's

Sears, Roebuck and Company sold precut houses through their catalog.

1950's

Levittown Production was modeled on assembly lines in 27 steps with construction workers trained to perform one step. A house could be built in one day when effectively scheduled.

1970's

Operation Breakthrough - HUD Initiative to break through the barriers of financing, labor, material shortages, and codes that were limiting production and affordability of housing.

1980's

Professional Builder magazine became a cosponsor of a series of houses based on New Expandable Shelter Technology (NEST)

2020's

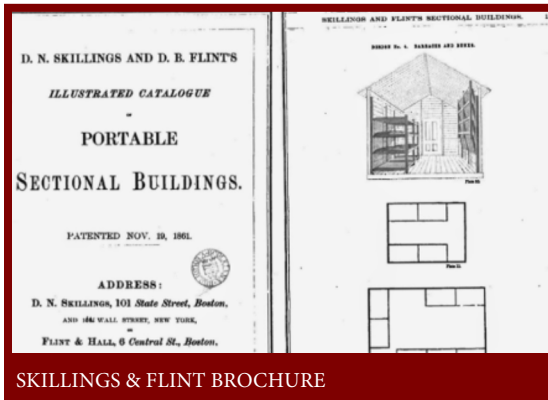
Due to labor shortages, supply chain issues, material shortages, and a global pandemic, offsite construction methods are at the forefront of the minds of home builders.



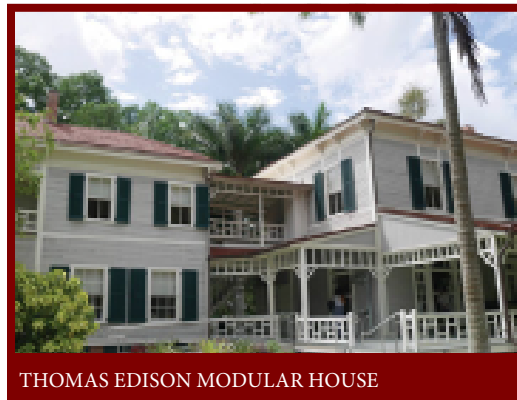
The idea of building shelter off-site and then transporting it to a permanent foundation dates back to Renaissance Italy when Leonardo da Vinci wrote about the concept. Two centuries later, in 1788, the first real house in Australia was shipped there from England.

U.S. DEVELOPMENT

Almost a century later in the United States, lumber dealers Skillings and Flint created buildings that could be assembled from a few standard panels and interchangeable parts. They said their houses could be assembled in three hours. In the late 1880s, inventor Thomas Edison had a house built in Maine, disassembled, shipped to Florida, and then reassembled. The house still stands today and is in use as a museum.



SKILLINGS & FLINT BROCHURE



THOMAS EDISON MODULAR HOUSE

SEARS HOUSE

Housing
pack-

century
through
that it
between

Illinois,
ordered
has the
order
United
of Sears

FOR LESS THAN \$2,500⁰⁰ YOU CAN BUILD THIS ELEGANT CONCRETE AND FRAME CONSTRUCTION NINE-ROOM \$4,000.00 HOUSE
BY USING OUR PLANS, SPECIFICATIONS AND BILL OF MATERIALS WHICH YOU CAN GET FREE, AS EXPLAINED ON PAGE 5.

MODERN HOME No. 111
The arrangement of this house is as follows:

FIRST FLOOR:
Music Room or Reception Hall, 13 feet 3 inches by 18 feet 6 inches.
Parlor, 15 feet 3 inches by 23 feet 6 inches.
Dining Room, 13 feet 3 inches by 16 feet 6 inches.
Kitchen, 8 feet 6 inches by 10 feet 6 inches.
Pantry, 8 feet by 8 feet 6 inches.
Entry and Front Entry, 6 feet by 24 feet.
Front Porch.

SECOND FLOOR:
Bedroom, 12 feet 3 inches by 12 feet.
Bedroom, 12 feet 3 inches by 12 feet.
Bedroom, 12 feet 3 inches by 12 feet.
Bath, 6 feet 6 inches by 6 feet 6 inches.
Halls, 6 feet 6 inches by 6 feet 6 inches.
Closets.

HOUSE SUCH AS WE LIST ABOVE ARE BECOMING MORE POPULAR EVERY DAY. MANY HOUSES, SIMILAR TO THE ABOVE ARE NOW BEING BUILT IN MANY OF THE BEST HIGH PRICED SECTIONS IN THE LARGER CITIES. THIS HOUSE IS BUILT TO ORDER AND IS AVAILABLE IN EVERY STATE. IT COSTS LESS THAN \$4,000.00. THE VALUE IS WELL OVER \$5,000.00. BE SURE TO SEND FOR THESE VALUABLE BUILDING PLANS. THEY ARE FREE TO YOU, AS LONG AS YOU ORDER ON PAGE 5.

THE LOW PRICES WE MAKE ON ALL HOUSES ABOVE IN THIS BOOK ARE ONLY MADE POSSIBLE BY OUR MAKING YOU THE MATERIALS AS MANUFACTURER'S SELL TO YOU, YOUR OWN

SEARS HOUSE BROCHURE

packages similar to today's precut houses gained popularity in this in 1908 when Sears, Roebuck, and Company sold precut houses their catalog. Sears estimates sold 100,000 mail-order houses 1908 and 1939.

Carlville, a town in downstate has a neighborhood of 152 homes from Sears. Carlville probably largest concentration of mail-houses, but other towns in the States also boast neighborhoods houses.

POST-WORLD WAR II



*Wish **YOU** lived here?*
A Home Like This is Well Within Your Means

For your family in this beautiful, friendly town... if you have married children... help...
can make either with your time, thanks to...
and Homes. The nation's largest producer...
may offer you a choice of dozens of smart...
designs and floor plans. The unique National...
way will save you thousands of dollars...
for a lifetime.

SEE YOUR LOCAL NATIONAL HOMES DEALER for details...
a member of the world's largest and most profitable...
National Homes Corporation, 1000 N. Salisbury, Indiana.



After World War II, the Lustron house was built. This steel-paneled home was shipped as a trailer with the panels and other parts on board. Although it was popular, production costs were high, and it never achieved the necessary sales volume to make it a financial success. Lustron houses are still in service today.

Also, about this time, in Lafayette, Indiana, Jim and George Price were fine-tuning factory panelization. Their company, National Homes (now National Enterprises), dominated the factory-built housing industry in the '50s and '60s. Although other manufacturers have eclipsed the company in size, the company is still active today.

Predecessor to the modular home was the mobile home or trailer. However, mobile homes were confined to trailer parks, and they developed negative connotations for people interested in purchasing an affordable home on their own piece of land. In the 1950s, '60s, and early '70s, this negative image was compounded by the fact that mobile homes were constructed of single sections with metal sides and flat roofs. They had serious aesthetic limitations.



MOBILE HOME



LEVITOWN

Levittown is the name of eight large suburban housing developments created in the United States and one in Puerto Rico by William J. Levitt and his company Levitt & Sons. Built after World War II for returning veterans and their new families, the communities offered attractive alternatives to cramped central city locations and apartments. The Veterans Administration and the Federal Housing Administration (FHA) guaranteed builders that qualified veterans could buy housing for a fraction of rental costs.

Production was modeled on assembly lines in 27 steps with construction workers trained to perform one step. A house could be built in one day when effectively scheduled. This enabled quick and economical production of similar or identical homes with rapid recovery of costs. Standard Levittown houses included a white picket fence, green lawns, and modern appliances. Sales in the original Levittown began in March 1947. 1,400 homes were purchased during the first three hours.



LEVITTOWN, PA - 1959

OPERATION BREAKTHROUGH

In 1969, the Department of Housing and Urban Development (HUD) announced a major initiative—Operation Breakthrough. HUD Secretary George Romney wanted to break through the barriers of financing, labor, material shortages, and codes that he believed were limiting production and affordability of housing.

Operation Breakthrough provided a big test for factory-built and prefabricated modular type homes. Nine prototype sites were selected. Although the housing at the prototype sites was not expected to be cheaper than conventionally-built housing, it was felt that if the housing systems reached production, the volume would bring costs down.

Though it was met with great fanfare, Operation Breakthrough eventually failed to live up to its promise. Wall Street investors ran out of enthusiasm, and corporate acquisitions of builders tailed off. Finally, during the early 1970s, the program was shelved when a moratorium was placed on all federal housing programs.

NEST HOUSES

The building systems concept was further developed in 1984 when Professional Builder magazine became a cosponsor of a series of houses based on New Expandable Shelter Technology (NEST). The NEST houses demonstrate the idea that the form of the house and the uses of living space can expand as needed by adding modules. These houses were all built off-site, disassembled, transported to the convention halls, and reassembled. The value of NEST was more to demonstrate the possibilities of modular housing than to suggest that manufacturers put the houses into production.



TECHNOLOGY

Side by side, systems-built houses look much like site-built houses when completed. However, while they are under production, they do, indeed, look different. Following is a scenario of what a visitor might find at a factory for systems-built housing.

Typically, the factory building is next to a railroad siding because factories buy materials by the carload. Manufacturers build primarily with wood, although some firms build with steel. (The volume of purchases permits the manufacturer to insist upon top-quality lumber. If it does not meet standards, manufacturers can reject—and get credit for—lumber that does not meet their specifications). This reduces expenses spent on waste materials.

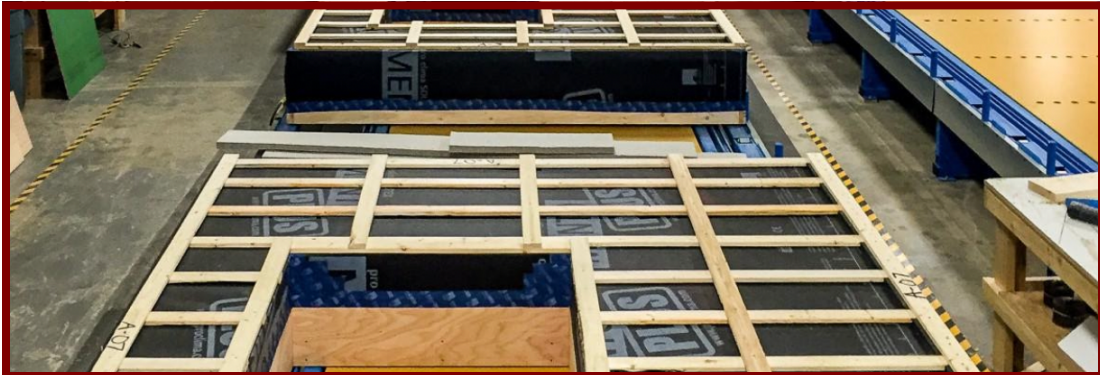
In the factory, the forklifts deposit their loads at various staging areas. At one area, for instance, multi-headed saws make simultaneous cuts on wood members to be used as truss webs. At another area, lumber is cut to length to be used as studs or plates. The odd lengths, which could be discarded as waste, are instead used as cripples or blocking. At the panel-making station, the precut lumber is laid in a steel jig to ensure that the panel will be square. The jig is tightened to press the members against each other, and then workers with pneumatic nailers fasten the members together. Other factories may use other procedures and methods.

From the framing jig, the panel might move on to a sheathing table. There, sheathing (or other insulating sheathings) is laid on top of the panel, and it then moves down a conveyor. Overhead, a jig holding pneumatic nailing machines comes down and fastens the sheathing to the wood members. From here, a crane carries off the panel to another staging area. At the assembly area for the floor and roof trusses, huge hydraulic or roller presses squeeze metal connector plates into truss members.

Much of what goes on in the factory is controlled by computer. Many manufacturers rely on the computer in the design and engineering of their homes and components, especially trusses. Computer-assisted drafting (CAD) devices have replaced draftsmen in many shops, and a computer may drive the wall-panel machine. Despite the importance of computers within the factory, manual labor still plays an active role in the assembly of both houses and components. Framing, drywalling, electrical, and plumbing tasks are all performed by humans.



FACTORY WALL PANEL LINE



FACTORY WALL PANEL LINE



WALL PANELS BEING DELIVERED



WALL PANELS ONSITE



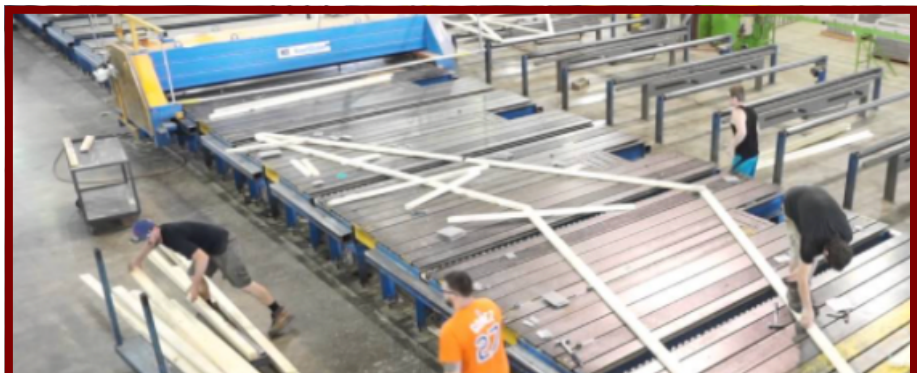
OPENING CNC CUTTER



WALL PANEL GANG NAILER



WALL SHEATHING NAILER



TRUSS LAYOUT LINE



MODULAR HOME FACTORY LINE

BUILDING CODES

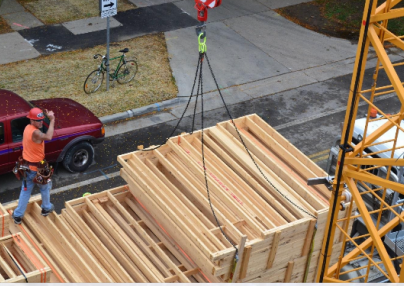
Modular homes are constructed to the same state, local or regional building codes as site-built homes. They are built to the states currently accept year of the International Residential Code (IRC) and the Internatioanl Enregy Conservation Code (IECC). Builders can achieve the same energy-efficient results using factory-built systems that are achieved during stick-building because the same materials are used whether the housing is built on- or off-site. Lumber, insulation, roofing, flooring, and finishes are identical.

Modular and panelized home manufacturers build in appropriate R-values based on the eventual geographic location and siting of the home. One panelized home factory that sells nationwide keeps data on the thermal performance of the houses it sells. This information has proven to be valuable to the company in improving its designs and construction techniques.

A challenge for modular homes can be local zoning codes that don't align with the factory's efficiencies and modular box dimensions or the state's Department of Transportation regulations that limit the width and length of the boxes being shipped. A local jurisdiction minimum downhome width of 18' is larger than the maximum DOT limits of 14'. This takes away the efficiencies gained in the factory and makes stick building the more efficient option.

“Everything is written for the site built world.”

-Tom Hardiman, Executive Director, Modular Home Builders Association



Profile of the Industry

AFFORDABLE HOUSING & LABOR SHORTAGES

Prohibitive housing policies paired with the lack of skilled labor are putting a huge strain on the affordability of housing. No matter which methods are being utilized for construction, they currently don't affect the appraisal value of the homes. Reducing regulatory barriers can have a significant impact on housing affordability. Yet, the industry cannot wait until widespread zoning or other regulatory changes are in place. Even if the cost of regulation decreases, the cost of skilled labor shortage has not shown indications of improvement. A shift in the dependency on skilled labor is required.

So why is the supply not keeping up with demand? There are many factors. Housing costs are rising faster than household incomes. And the land costs, permit costs, regulation fees, and costs of construction same as market-rate housing. There are also fewer government & financing regulations in market-rate housing, which makes market-rate housing more profitable for home builders.

“The development industry is... behaving exactly the way we would expect any industry to respond to an artificial cap on their production volume. The same thing would happen in the auto industry: if we limited Toyota to only 100,000 cars per year, they might as well choose to keep the Lexus and scrap the Camry, even though, at volume, the Camry is more profitable.”

RICK JACOBUS, SHELTERFORCE

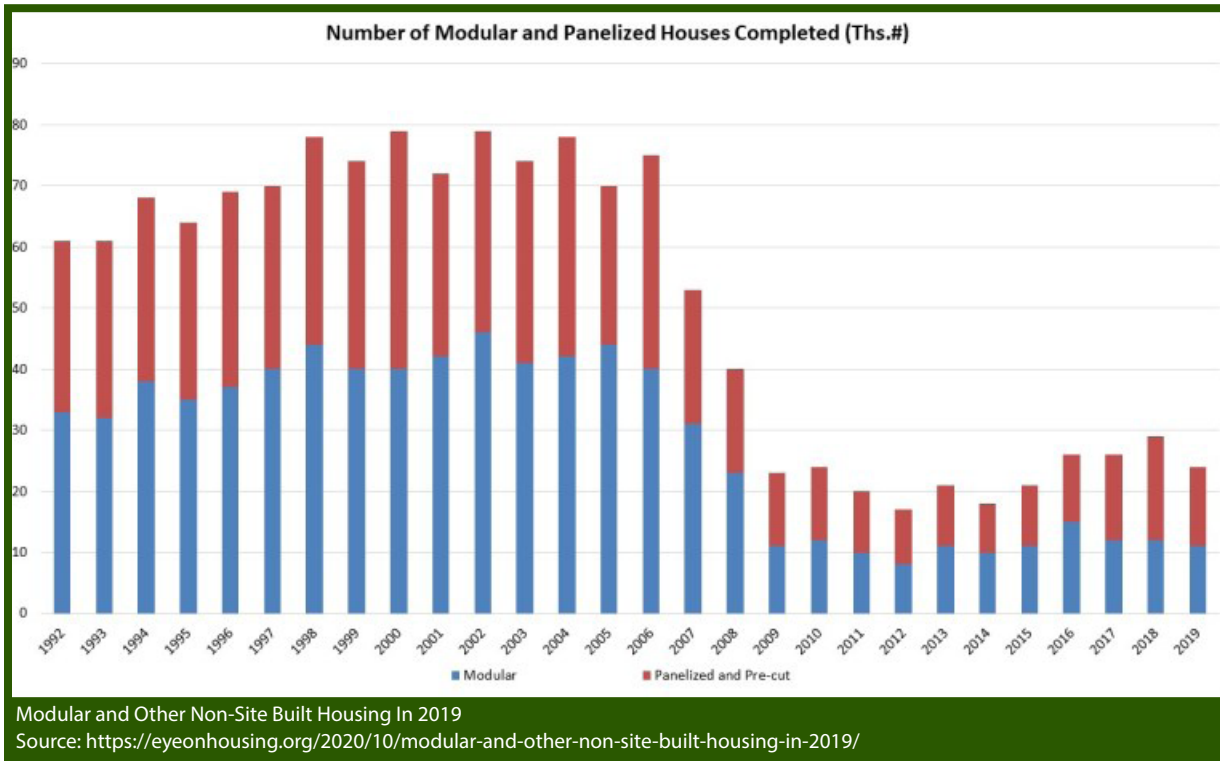
There is also a great labor shortage in the homebuilding industry. There are 434,000 vacant construction jobs in the United States - (Bureau of Labor Statistics, 2019). This lack of skilled labor is driving up the bid cost & cycle time.

Why is there such a labor shortage in construction? During the Great Recession, the Job Losses were 30% or higher – 1.2 Million workers. Coupled with the lack of vocational education, working conditions not appealing to younger generations, social perception of manual labor and trades, and the lack of career growth, competitive wages, and benefits, the construction industry labor shortage continues to grow. This is especially impactful for the framing trades since 76% of homes are light-frame construction. Seventy-three percent of home builders difficulty finding qualified carpenters for framing, and that framing cost has risen 9% to 43% across the nation.

The total market share of non-site built single-family homes (modular and panelized) declined to 3% of single-family completions in 2019, according to Census Bureau Survey of Construction data and NAHB analysis. This share is expected to rise moderately in 2020 and in the years ahead, due to the ongoing labor shortage in the residential construction sector and the need to lift labor productivity amid declining housing affordability.



For 2019, there were 24,000 total single-family units built using modular (11,000) and panelized/precut (13,000) construction methods, out of a total of 903,000 total single-family homes completed. While the market share is small, there exists the potential for expansion. Moreover, this 3% market share for 2019 represents a decline from years prior to the Great Recession. In 1998, 7% of single-family completions were modular (4%) or panelized (3%). This marked the largest share for the 1992-2018 period. One notable regional concentration is found in the Northeast, where 6% (3,000 homes) of the region's 62,000 units completed were due to modular construction, the highest share in the country.



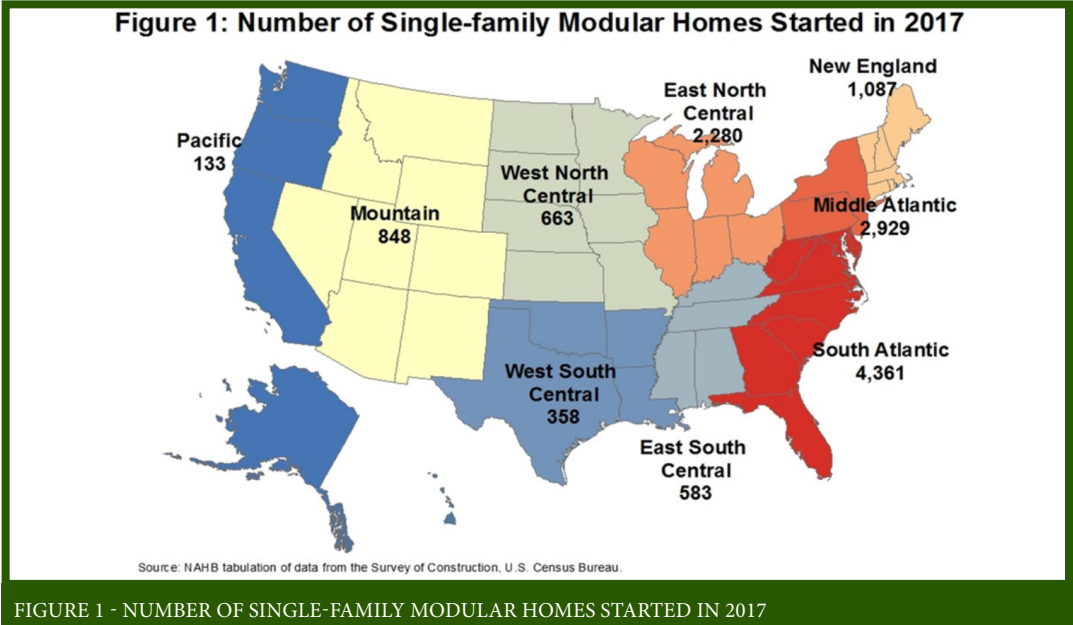
“As the market share increased alongside an increasing homebuilding market volume, modular and alternative framing methods are explored and implemented, but every time a recession happens, and the market cools off, builders seem to forget everything they have learned and revert back to the simplest form of stick-built onsite framing homes.”

- Ken Semler, Impresa Modular

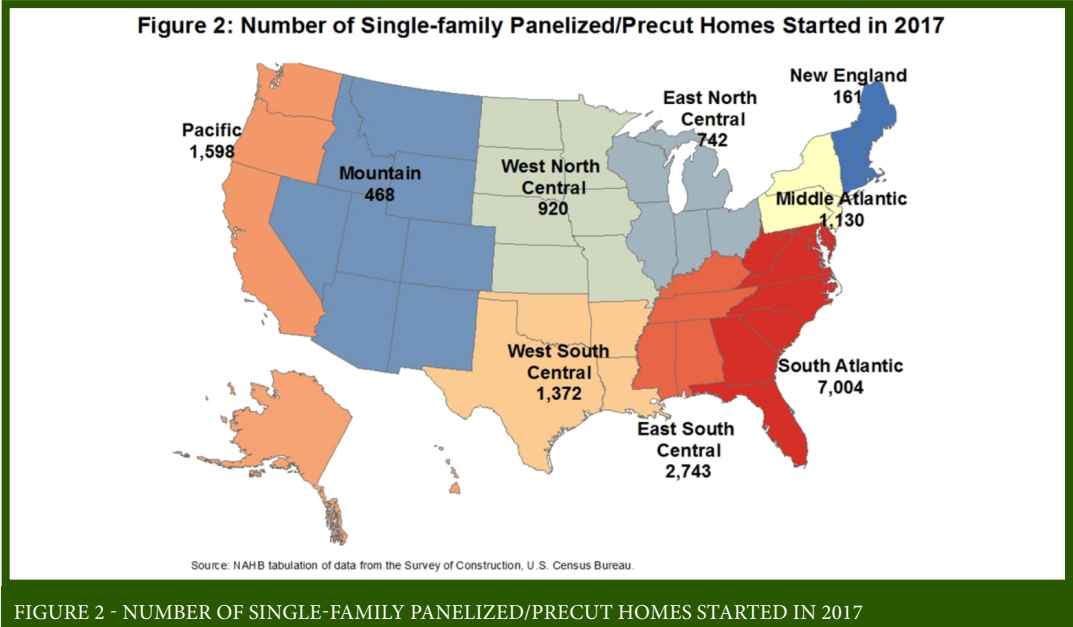


According to the U.S. Census Bureau, modular and precut* construction represented 4% of all single-family housing starts in 2017. An increasingly popular method of building multifamily projects, large companies like Marriott International and some of the country's biggest municipalities, including New York City, have specified bids using prefabricated components for their construction projects.

The total number of modular single-family homes started in 2017 was 13,254. More than 80 percent were east of the Mississippi River, with 33 percent in the South Atlantic division, 22% in the Middle Atlantic, and 17 percent in the East North Central (fig. 1).



In addition to the modular homes, a total of were 16,138 panelized/precut single-family homes were started in 2017. These also tend to be geographically concentrated, with 43 percent built in the South Atlantic and 17 percent in the East South Central (fig. 2).





Since 2017, the construction of panelized and precut homes increased substantially in three divisions. In the West North Central, panelized/precut single-family starts increased by 66 percent, and in the West South Central, they increased by 90 percent. However, in the East South Central, panelized/precut starts increased by nearly 400 percent. Moreover, this came on the heels of a 6,000 percent increase in 2016. *Includes panelized and precut units, including those that use concrete, log and timber frame construction.

In late July 2021, Home Innovation Research Labs conducted a survey of 348 home builders, repeating a question on offsite housing that was asked in similar surveys in August 2019 and September 2020: “Considering only the new homes your company builds, how often do you anticipate using the following construction practices in FIVE YEARS compared to the past year.”

Given a choice of responses – do not plan to use; use less than; use the same; and use more often – there is an overall increase in builder interest in offsite technologies. The chart below summarizes the percentage of builders choosing “more often” in each of the three yearly surveys.

Builders Expecting to Increase Use of Offsite Technologies in 5 years	AUG 2019	SEP 2020	JUL 2021
Roof trusses	15%	23%	22%
Turn-key framing services	7%	16%	19%
Pre-cut framing package	12%	16%	14%
Factory-built open wall panels	9%	16%	13%
Modular	7%	11%	13%
Precast concrete floor, wall, or roof panels	7%	8%	12%
Panelized, pre-assembled floors	7%	13%	11%
Factory-built closed wall panels	9%	10%	10%
Manufactured homes (HUD-code)	1%	4%	4%

Source: Home Innovation Research Labs Survey of U.S. Home Builders, July 2021

The July 2021 survey found that builder intention to increase roof truss usage continues at the top – signaling to truss manufacturers that now may be a great time to expand capacity to meet an anticipated increase in demand. Interest in turn-key framing services rose to the #2 spot in our 2021 survey, undoubtedly a beneficiary of the instability in the supply chain and the construction labor shortage. Interest in pre-cut framing packages and wall panelization followed in the #3 and #4 positions – slightly down from last year in intent-to-adopt, but still up considerably from 2019.

Research data shows that precut, panelization, and modular home building can be more efficient in labor, materials, and logistics savings. Builders will need to plan ahead, working with the lumber and manufacturer suppliers to resolve their plans structurally and for code compliance fully. Many production builders and developers are starting to think about home building in a controlled manufactured mindset to drive this industry change forward. This guide will help builders along the way.





PRECUT FRAMING SYSTEMS

Precut framing may be the most like onsite stick-built of the prefabricated delivery methods, as lumber is cut to length offsite but assembled onsite by the framing crew. The process starts with the entire house framing package resolved in the design phase; floors, walls, and trusses. All structural and code compliance issues are reviewed and planned for, and then the materials are sent through the manufacturing line to be precut, marked, and bundled together. Then the entire precut framing package (including pre-assembled trusses) is shipped out to the job site, where the framers assemble the home. The job site slang term for the method is “frame by numbers.”



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QUESTIONS TO ASK A PRECUT FRAMING SUPPLIER

- How long has the company been in business?

- What type of distributor agreement does the company offer?

- Does the manufacturer provide or arrange financing?

- What is the company's shipping area?

- Will the company let you tour the factory?

- Can the manufacturer accommodate changes to the standard plans?

- Will the manufacturer produce designs supplied by the builder?

- Does the company promote their products through a cooperative advertising program?

- Are special discounts available?

- Does the company provide training assistance for framing crews and/or sales training for builders and dealers?

- What is the current production schedule? Will the company be able to produce packages when you need them?

- Does the manufacturer have an established procedure for handling problems?

- What is included in the package? (Does the package meet your needs?)

- Is there a local subdivision or finished framing package that can be visited for a look at the installed product?

- Who supplies the crane and operator (if needed)?

- Do they provide framers/installed products?

- When does the transfer of responsibility/liability pass from the manufacturer to the builder?

- What kind of onsite supervision does the factory supply?



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Many stick builders have already recognized that they can save time-without sacrificing quality-by using panelized building systems in their onsite construction procedures. Like other building systems, panelized systems can allow a builder to increase volume and profits through maximized efficiency and control. Panelized building is a means for a builder to combat the problem of labor shortage because more work is completed in the factory, thereby decreasing the required onsite labor.

TYPES OF PANELIZED BUILDING SYSTEMS

Open Wall Panels

Open wall panels are delivered from the factory, most with only the exterior sheathing attached to stud walls. Although some companies provide a fully finished-sided exterior with windows and trim applied. Some panelized building system companies provide interior wall framing as well. As with pre-cut framing packages, panelized building systems are highly customizable and have far fewer restrictions than what can and cannot be done within the building system compared to other types of building systems.

Onsite, builders install plumbing, wiring, insulation, and interior sheathing. Similarly, floor and roof trusses are prefabricated in a factory environment before being installed on site. Some panelized companies also supply pre-cut TJI roof systems in addition to truss roof systems. Among many advantages, systems-built open wall panels can minimize the need for interior bearing walls and provide space for HVAC, plumbing, and electrical runs without field modifications. The most significant advantage to utilizing a panelized building system in your next build is that it reduces the time to get to the dry-in stage substantially. You don't need as many skilled framers or siding installers on your project compared to traditional stick frame methods. Money is also saved by not having as much onsite waste to dispose of or making trips to the lumber yard for mistakes. Many builders have reported that they can build several more homes a year using the same overhead using panelized building systems over the traditional onsite building.

Closed Wall Panels & Structural Insulated Panels (SIPs)

Closed wall panels are shipped from the factory with interior sheathing, exterior wrap, installed insulation, plumbing, and electrical systems prepared for connection on site. Structural Insulated Panels (SIPs) are prefabricated wall, roof, and floor panels made of a rigid foam core and sandwiched between structural skins, usually two pieces of oriented strand board (OSB). While the use of OSB is more well known, new technology includes panels created with metal framing, that can be used in both residential and commercial applications. While sharing the advanced benefits of clad SIPs which include strength, efficiency and the opportunity for mold, mildew or insect infestation being virtually eliminated, the metal framed panels also weigh less, meaning less labor and equipment are required.



CLOSED WALL PANEL SYSTEM



WALL PANEL DELIVERY

CHOOSING A MANUFACTURER

In shopping for a panelized home producer, a builder has to check out the panelizer's reputation, experience, and performance. Builders should determine at the outset what they want in terms of building material, price, and their relationship with the producer, and then look for manufacturers that meet their needs.

Study the manufacturer's business reputation and strength. To do this, check on the creditworthiness of the company. Companies with credit problems should be avoided for obvious reasons. Most importantly, talk to other builders who have dealt with the manufacturer, and learn as much as possible from them. Ask about their delivery schedules-are they dependable? Also, check on the quality of the package. Find out about the structural integrity of the materials and if the builders were pleased with the product upon delivery.

OPEN WALL PANEL BUILDING PROCESS

1. DELIVERY

In four to five weeks from the time of the order, the producer will deliver the home, typically in two or more deliveries. By this time, the builder will have prepared the foundation and the site. Some producers deliver in two shipments-framing lumber first and finish materials next. A three-installment shipment would be delivered in the following order: floor, shell, and finish materials (doors, windows, trim).

When the home package arrives at the site, the builder will have to supervise its delivery. One producer suggests that a builder have four to five workers on hand to help with the unloading. Builders should find out from their producers how much labor and time will be needed to unload. Some truck drivers will help unload; others will not. Regardless of who is to be involved in the unloading process, a builder should provide a clean, clear, and marked area to accept delivery of the floor system-10 feet by 20 feet should be adequate.

Exterior panels are sequence-loaded at the factory-the first panels needed are the first ones unloaded. Panels, too, are numbered to match the plans. Exterior panels come sheathed and ready for doors and windows. Some factories ship exterior panels with windows installed; others do not.

Trusses are also sequence-loaded at the factory. Gable components are labeled according to a numbering system. Usually, all pieces are cross-indexed to working drawings. This way, a builder knows what is on hand. Although they may ship under wraps, panels, and parts will be exposed after delivery. For that reason, builders should be prepared to protect the building components from the weather, dirt, and vandals.

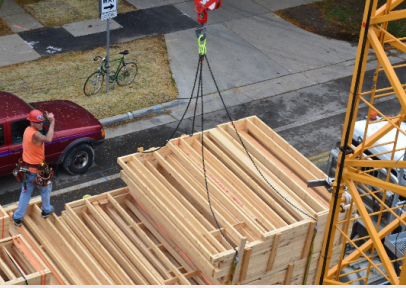


2. SETTING & FINISHING

Walls shall be positioned and installed in accordance with the construction documents consisting of the wall shop drawings provided by the wall designer and the building plans and specifications provided by the building designer.

Temporary bracing shall be provided, as required, to resist loads during the construction phase until a floor or roof diaphragm is constructed and attached to the walls according to the permanent fastening schedule specified by the building designer.

Any significant discrepancies between the as-built or field conditions and the construction documents shall be corrected. After consultation with the owner, constructor, and panel manufacturer, the building designer will produce a prescriptive correction. Corrective measures are implemented by the wall installer and inspected and approved by the local building authority.



SIPS BUILDING PROCESS

1. FOUNDATIONS

Working with SIPS requires attention to foundation tolerances. Although SIPS can be modified onsite to fit an out-of-square or non-level foundation, this process is laborious and can affect the air sealing capabilities of the panels. Make sure the foundation contractor is aware of the tolerance required with building with SIPS.



2. WINDOW AND DOOR OPENINGS

When the drywall is applied to SIPS, the total wall thickness may be slightly different than a stick-framed wall because SIPS have wood structural panels on both sides—window and door opening need to be sized accordingly and ensure window and door jam widths are ordered correctly.



3. SITE CONDITIONS AND MATERIAL HANDLING

Although 4x8-foot panels can often be unloaded and set by hand, jumbo 8x24-foot panels weigh up to 700 pounds and require the use of equipment to unload and install. To set jumbo wall and roof panels, an extending boom forklift, boom truck, or crane is used. Site conditions need to be taken into consideration when dealing with large equipment. High-wind conditions present the need for careful rigging and bracing to set large roof panels.

4. FLOOR SYSTEMS

Builders have two options for floor systems when constructing a home with SIPS. In a hanging floor system, high-efficiency SIPS are used in place of Rim Boards, and floor joists are attached using metal hangers; in a platform floor design, builders use traditional floor construction design and a Rim Board to connect wall panels to the foundation. Insulated SIP Rim Boards are available for many SIP manufacturers.



5. SEALING

All joints between panels need to be sealed according to the manufacturer's specifications. Sealing is typically done with specially designed SIP sealing mastic, expanding foam, and/or sealing tape. Sealing is crucial to achieving the potential envelope tightness capable with SIPS. An improperly sealed home is not only energy-inefficient but is also subject to moisture damage. Proper sealing is especially important when installing SIP roofs. The ridge detail is a critical construction detail that requires attention to sealing using methods as noted above.





6. EXTERIOR FINISHES

Exterior finishing materials can be applied easily to SIPS as they provide a uniform nailing surface for exterior finishes. A water-restrictive barrier must be installed between SIPS and siding in accordance with the code or the recommendation of the SIP manufacturer. They may be either building paper or house wrap. Siding should be attached to SIPS according to the siding manufacturer's specifications.



SIPS HOME - REGIONAL FINISHES CAN BE APPLIED INSIDE AND OUT

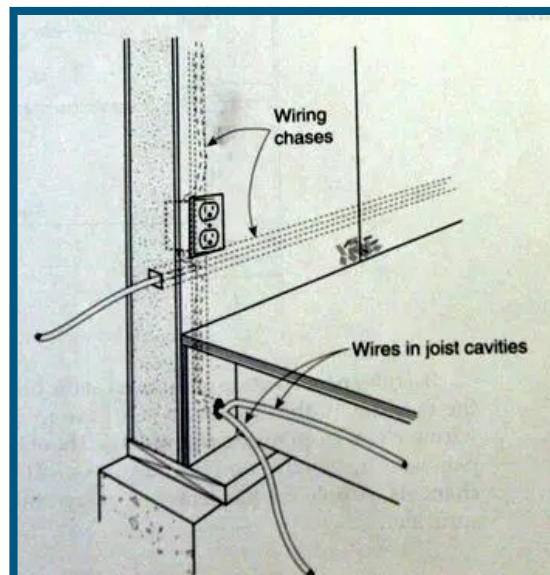
7. ROOFING

As with siding, roofing needs to be attached to SIP roof panels according to the roofing manufacturer's recommendations. Roofing paper needs to be placed beneath the finish roofing as with a lumber-framed roof, and roofing materials are specified in the same manner as over a conventionally framed roof.

8. ELECTRICAL

Electrical wires are pulled through precut channels inside the core of the panels called chases. Manufacturers cut, or form chases both horizontally and vertically during the fabrication process according to the electrical design of the home. Plug outlets and switch boxes can also be precut at the factory. Chases enable wires to be run through walls without compressing insulation or having to drill through studs. Electricians can access chases by drilling or cutting small access holes in the interior skin of the panel.

Another commonly used technique to run wires through baseboard raceways and in the cavity behind the beveled spacer on SIP roof-to-wall connections. Raceways can be created by using manufactured surface mount wiring mold, furring strips behind baseboards, or holding back drywall and the flooring to create space for wiring.



SIPS ELECTRICAL CHASE



9. PLUMBING

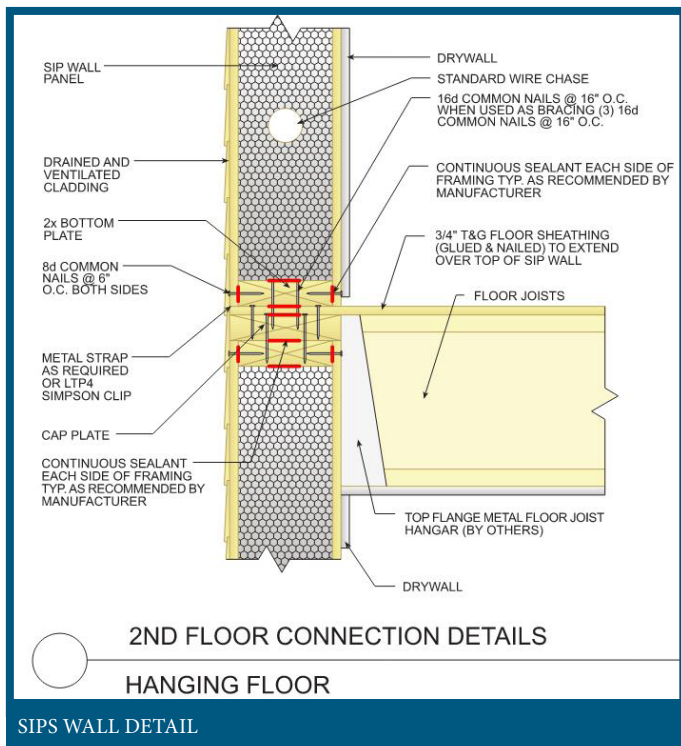
Plumbing should never be run horizontally or vertically in SIP walls. Penetrations through SIPs must be well sealed to prevent air leakage and moisture penetration. Plumbing should be run in the interior walls, so there will not be any chance of pipe freezing up.

10. HVAC

SIP buildings are extremely tight structures with levels of air infiltration lower than the average stick-built structure. When working with an HVAC contractor, make sure their calculations take into account the low air infiltration and higher R-values of a SIP home. An oversized HVAC system will fail to reach the steady operating rate for which the equipment was designed. Short-cycling HVAC equipment also leads to excessive humidity in structures during cooling seasons.

The increased insulation performance of SIP structures, in addition to their airtightness over conventional construction, almost always significantly reduces required HVAC demand beyond what typical contractors estimate. Reduced loads often allow for cost-saving ductless mini-splits in units. Superior SIP envelopes provide thermal consistency within multilevel homes, allowing for less expensive and complex single zone systems.

SIP construction typically requires mechanical ventilation. Ventilation systems bring fresh air into the building in controlled amounts and exhaust moisture-laden and stale air to the outside. Ventilation systems can be designed to incorporate heat recovery ventilators or energy recovery ventilators. These advanced systems harness heat being exhausted from home and utilize it to heat the fresh air coming into the home for even more efficient use of energy. Proper ventilation is crucial in structures with low airflow to prevent condensation that can lead to mold growth.



SIPS WALLS

QUESTIONS TO ASK A PANELIZED WALL SUPPLIER



- How long has the company been in business?

- What type of distributor agreement does the company offer?

- Does the manufacturer provide or arrange financing?

- What is the company's shipping area?

- Will the company let you tour the factory?

- Can the manufacturer accommodate changes to the standard plans?

- Will the manufacturer produce designs supplied by the builder?

- Does the company promote their products through a cooperative advertising program?

- Are special discounts available?

- Does the company provide training assistance for erection crews and/or sales training for builders and dealers?

- What is the current production schedule? Will the company be able to produce packages when you need them?

- Does the manufacturer have an established procedure for handling problems?

- What is included in the package? (Does the package meet your needs?)

- Is there a local subdivision or finished home that can be visited for a firsthand look at the installed product?

- Are open and closed wall packages available?

- Who supplies the crane and operator (if needed)?

- Who will set the housing package?

- When does the transfer of responsibility/liability pass from the manufacturer to the builder?

- What kind of onsite supervision does the factory supply?

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MODULAR HOME FACTORY LINE

Today's modular homes are usually constructed of several modules mounted together, once delivered to their job site, which creates single or multi-story homes with a wealth of design options. The high-quality materials and building methods utilized in modular construction systems offer a fast and more cost-effective approach to homebuilding than traditional methods.

Builders experiencing scheduling difficulties due to a shortage of skilled labor can look to modular construction systems as a solution to much of their labor problem because modular home packages are the most complete of the factory-built housing systems. Typically, a modular house is 65% to 95% finished by the time they leave the factory.

DESIGN FLEXIBILITY AND VARIETY

Modular dwellings are available to suit the tastes and needs of a wide range of customers. All Modular producers offer standard housing plans, and many manufacturers will build custom-designed modules based on plans supplied by a builder or architect. Widely known national brands are available with many modular home manufacturers for all features within the modular building.

CHOOSING A MANUFACTURER

How does a builder select a modular home manufacturer? Like most selection processes, this one involves comparison shopping. The builder must make the final decision based on what is most important to their final product.

The factory's capacity is also a factor. Each factory has product offerings design to maximize efficiency. When the building type does not fit the factory line or meets the builder's needs, then using this type of methodology is no longer cost-effective.

REFERENCE CHECKING

Reference checking is a necessary part of the selection process. When shopping for a modular housing production firm, a builder should check into the firm's financial stability and check with other builders who have erected factory-built housing packages to see if they were satisfied with the product and the service. Also, look at the community in which the manufacturer is located and ask locals (who are not employed by the manufacturer) about the company's reputation. The community reputation is important and can be an indicator of problems or successes at the manufacturer's facility.



MODULAR BUILDING SYSTEMS

SITE WORK

Whether or not a house is factory-built or site-built has little bearing on the excavation and backfilling phase of site work construction. Site accessibility may require the clearing of a larger area if the building site is heavily wooded in order to provide access to the carriers for the modules. Additionally, some trees may have to be removed for crane operations.

Foundation construction for modular houses closely resembles site-built foundation construction, with the exception that dimensional accuracy of the foundation is more important for modular construction. The foundation must be built according to the design drawings to ensure a proper fit with the pre-constructed modules. Utility excavation and installation are similar to traditional site-built construction operations.



MODULAR BUILT HOME

WEATHER

All framing methods are affected by the weather, with modular being the most weather-sensitive. Stick, precut, and panel are in rough frame form: the lumber can handle getting wet (either snow or rain) during the construction process with minimal damage to the product, so the weather has a larger impact on labor productivity than the actual wood product. Modular, on the other hand, is a finished completed product. Any moisture intrusion of the boxes during the transportation or setting process can cause much product damage and rework. The advantage of modular is it is being built in a dry factory climate with no external factors. Coupled with the quicker set and dry-in time compared to other methods, if it is kept dry, modular can be an advantage to increasing the production time no matter what the weather is doing. Additional steps may be needed to mitigate the potential for weather related damage while unwrapping the module sections and preparing to place them on the foundation.



SHIPPING

After the modules are wrapped with weatherproofing material, they are loaded onto low clearance carriers by the manufacturer for shipment to the job site. Trucks are the most common means to transport modules to the site. Highway regulations limit the length, height, and width dimensions of the units over the road. Most manufacturers handle shipping and permits, or can assist the builder in finding proper shipping companies



MODULAR UNITS SHIPPING

The length, width, and height of the module allowed to be shipped are dictated by the Department of Transportation for each state. The cost of transportation/trucking from the modular factory to the site can vary greatly depending on the size, the number of modules, the state regulations, and the ease of site access. The travel route geography can add to the cost of the shipping. Large modular units must be mindful of road widths, hills, corners, and powerlines. The transportation cost can offset the factory efficiency savings and tip the scales from a cost-effective to costlier option over site-built. Though it can vary, a rule of thumb in the industry is around 350 miles from the factory is the maximum shipping cost-effectiveness radius.

Smaller one or two module plan manufactured units can be driven over the foundation and then jacked or slide into place, and larger and multi-story modular homes require a crane to set them, adding to the logistical cost and planning time needed. Due to the volumetric shipping of the complete boxes, many more trucks may be needed to complete the entire house.

Often, there are restrictions along local routes that do not allow for passage if the unit is being transported at its maximum height. Although most modular manufacturers are experienced in logistics, it is ultimately up to the builder to determine that no obstacles (low bridge underpasses, wires, tunnels, etc.) will prevent the delivery of the modules to the job-site.



MODULAR UNIT BEING SET IN PLACE



If the builder is aware of special height restrictions that may prohibit access to the site, modifications can be made to the design to reduce the effective height of the shipped modules. Alternatives include a “hinged” roof, assembling and raising a truss roof onsite, or stick building the roof onsite.

The difference from a cross-town shipment to across state lines or even across the country can create logistical difficulties. Finding a manufacturer that fits a builder’s strict criteria may require a larger sphere of influence, but manufacturer are more plentiful today than they have been in the past (“Off-site Heat Map | Alliance”). For a resource to determine manufacturers nationwide, please visit [Housing Innovation Alliance, Offside Heat Map](#). Each manufacturer firm is different in the geographical area they will ship to due to the complexities of shipping. There is no one size fits all when it comes to prefabricated shipping items. Be prepared to look past your individual market for manufacturers that best fit your needs. There are plenty of options for manufacturers overseas and in Canada. However, a local approach was assumed in this analysis, and constraints are based on a survey of manufacturers within the U.S. only. The variables of shipping constraints are as follows: state considerations, accessibility of the site, carrier characteristics, and shipping providers.

STATE CONSIDERATIONS

According to the U.S. Department of Transportation Federal Highway Administration, State classification of oversized/overweight thresholds may not meet the Federal standard, and each state dictates the dimensions and weight allowable for carriers classified as road compliant and oversized/overweight. For this reason, additional consideration and costs are associated with transporting over state lines. Trucking permits for oversized/overweight freight may be a non-issue, but permit costs vary widely. Each state oversees the issuance of its own permits (US DOT). This means that a cross country shipment will need to meet that state’s requirements individually. Application of trucking permits will need to be submitted for every state line crossed.

ACCESSIBILITY OF SITE

The most impactful constraint of modular shipping elements includes accessibility of the job site. Delivering modules to a job site accessed by a mountain road may require a shorter length of the carrier, immediately reducing the size of the module or may eliminate some larger closed box modular units from consideration altogether.

SITE CONSTRAINTS

Consideration of staging location on or off site may be required in dense urban neighborhoods or smaller lots, where space isn’t available to store units. Due to the new affordable housing concept, smaller lot sizes are trending, which amplifies this issue. As most cities do not allow materials to be delivered on the street, lots become crowded while not providing enough room for deliveries. Furthermore, topographical barriers or obstacles like powerlines become much more of an issue to overcome. Handling heavy roof trusses or setting a modular unit may require the use of specialized equipment, in most circumstances requiring a crane. Alternatively, the larger form factor of prefabricated elements has been shown to reduce job site theft. Access to the job site should also be considered, as it may dictate the carrier size of deliveries, ultimately affecting the design of the component being manufactured (Patel, Ghosh, Bigelow, & Lee, 2020).

“SETTING” THE MODULES

Installation of prefab elements on site continues to be a leading issue facing prospective builders. As this is an overarching dilemma addressed throughout this analysis, it is important to understanding the differing crews necessary for the specified prefabricated method after shipments have arrived onsite.



Manufacturers may provide their own set crew, have a preexisting relationship with a 3rd party crews, place the responsibility of install on the client. Panelized or precut elements will typically rely on the builders' chosen framing crew. The labor cost of framing crews fluctuates drastically between markets and should be addressed with the individual tradesman.

Set crews provided by an out of state Manufacturers may even travel with the shipments to the job site in limited circumstances. Depending on the complexity of install and square footage, modular set crews charge at a set box rate. In comparison, install of precut or panel elements is priced by labor hour or square footage rate. Manufacturers standardize framing rates more efficiently than other prefabricated methods. This is due to set crews becoming more familiar with the procedure of a specific product, most notably with modular construction.

Considerable skill and specialized knowledge are required when setting a modular house. Many modular manufacturers insist on providing their own set crews to ensure quality control. Other manufacturers rely on subcontractors who specialize in placing and erecting modular units.

The two methods commonly used to lift or place the modules on the foundation are (1) crane installation and (2) "rolling" the modules onto the foundation. Two story (and many single-story) houses require the use of a crane. Modules can weigh up to 15 tons or more and require the use of a large capacity crane depending on the condition of the site. During assembly, ground conditions must be able to support the weight of the truck and crane and to allow the crane to maneuver as close to the foundation wall as possible (generally, no more than 20 feet away). There can be no overhead obstructions. Utility and service hookups and site drainage must be in order.

In the "roll-on" operation, the carrier which the module has been transported to the site may have built-in hydraulic jacks that raise the unit off the carrier bed and place it on a set of steel tracks. The steel tracks are placed underneath the unit and extend to the top of the foundation wall. Additional tracks with jacks span the entire foundation. The units are then placed on the tracks and rolled into position. After the sections have been bolted together to form the modular house, it is raised by a series of jacks, the tracks are removed, and the house is lowered on its foundation. This procedure is limited to single-story houses placed upon relatively level sites.

The quality of the foundation plays an important role in the successful setting of a modular house. The foundation walls must be square and plumb. A foundation out of level by as much as one quarter (1/4") of an inch can pose serious problems. In addition, the surface the sill plates rest upon must be level.



CRANE INSTALLATION



"ROLLING" THE MODULES



FINISHING

The modules are typically 65% to 95% finished when delivered. After being set, the house can be finished within one to six weeks, depending upon its size and complexity.

The builder is responsible for the majority of the finish work that can not be completed prior to shipping the home to the site. The first task is to weatherproof the house by sealing the roof. Most two and four box modular houses are manufactured with hinged roof trusses, which are partially shingled at the factory. Installing the ridge vent (if required) and shingling the roof peak is done onsite by the set crew. Drying in the roof of most modular homes can take place the same day as the module units are placed on the foundation

Once the exterior is water-tight, attention can shift to the interior. A modest amount of remedial taping and spackling is invariably required. Hairline cracks appearing in the drywall due to racking during transportation or setting must be repaired. Some manufacturers intentionally leave off short segments of the drywall on ceilings and walls between adjacent boxes so that field applied segments can cover the joint and create a smooth surface transition.

Additional site finish work that the builder may be required to perform includes:

- » Connecting electrical service to the dwelling
- » Installing miscellaneous light fixtures and testing the electrical system
- » Connecting sewer and water service to the dwelling (which may include drilling a well and installing an elevated sand mound if the lot is not using public utility hookups)
- » Installing miscellaneous plumbing fixtures and performing pressure tests
- » Completing the HVAC system (possibly installing a furnace in the basement, installing central air conditioning, and/or connecting ductwork)
- » Installing steps
- » Completing miscellaneous trim work
- » Touch-up painting

Installing exterior cladding if the material was not installed at the factory. This may include vinyl siding, wood siding, stucco, stone-work, or brick-work.

Additionally, exterior work will have to be performed similarly to that experienced when completing a traditional site-built house. These items may include:

- » Pouring concrete slabs, patios, sidewalks, and curb crossovers
- » Building wood decks
- » Final grading of the lot
- » Installing grass and landscaping
- » Paving or pouring a concrete driveway



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MODULAR HOME EXTERIOR FINISH



MODULAR HOME INTERIOR FINISH



QUESTIONS TO ASK A MODULAR HOME SUPPLIER

- How long has the company been in business?

- What type of distributor/builder agreement does the company offer?

- Does the manufacturer provide or arrange financing?

- What is the manufacturer's shipping area?

- Will the manufacturer let you tour the factory?

- Will the manufacturer supply custom designs from its department or produce designs supplied by the builder?

- Does the company promote their packages through a cooperative advertising program?

- Are special discounts or rebates available?

- Does the company provide training assistance for erection crews and/or sales training for builders and dealers?

- What is the current production schedule? Will the company be able to produce packages when you need them?

- Does the manufacturer have an established procedure for handling problems, or service/warranty issues?

- What is included in the package? (Does the package meet your needs?)

- Does the product meet the state and local code requirements for the states in which you build?

- Do the homes qualify for FHA and VA financing?

- Is there a local subdivision or finished home that can be visited for a firsthand look at the installed product?

- Who supplies the crane and operator: the builder or the manufacturer?

- Who will set the housing package?

- When does the transfer of responsibility/liability pass from the manufacturer to the builder?

- What kind of onsite supervision does the factory supply?



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The log cabin is perhaps the quintessential American building. Formerly built by frontiersmen and serving as the birthplace of presidents, log and timber homes today barely resemble their early American ancestors. Modern-day log and timber homes incorporate the latest building technologies and products. They are durable, energy-efficient, and professionally designed and engineered.

Log homes are built in one of two ways: they are either handcrafted or produced in factories as log home kits and packages. Handcrafters select individual trees and fell them. Then, often using only hand tools, the handcrafters cut, peel, and shape the logs. The logs are temporarily fitted on-site, disassembled, and then transported to the building lot, where they are erected.

This chapter will focus on log homes that are factory-produced and sold in kits and packages. Log home packages and kits are designed by architects and designers. The production of these kits and packages is highly automated. High-speed planers and saws shape the logs into building parts. Trained inspectors grade each log in terms of structural soundness. Visual grading for knots, color, grains, and straightness is also performed. Logs may be rejected if they lack structural integrity or if they are warped or have too many knots. The finished packages are shipped to builders, dealers, and consumers.

LOG BUILDING VS. STICK BUILDING

Any builder can learn to build a log home. Differences exist between the two building styles and log walls differ from stud walls in a number of ways. However, manufacturers agree that a builder of stud walls can learn to handle log walls.

The big difference between 2x4/2x6 stud walls and log walls is that the erection of a log wall takes care of six construction steps simultaneously. When a builder erects a log wall, they also complete the framing, outside siding, sheathing, insulation, and interior wall finish. Because these steps are handled by the erection of a single log wall, the wall does not need vertical studs, batt or foam insulation, or drywall (although it can be added). Logs need to breathe so insulation or drywall covering a log wall may cause mold or moisture problems in the future. Unlike a stud framed wall cavity, logs are an honest wall which means when there is a problem such as leaks at a window or bugs somewhere, it can be seen and fixed before it becomes an issue. The wall are mechanically fastened uses large screws, tension rods, or spikes instead of nails. The electrical outlets are sometimes installed with surface-mounted chases, but most packages allow for the concealment of all wiring. Log builders install windows and doors and do interior stud work just like stick builders. The logs are the element that changes the procedure. Because of this difference, first-time log builders are encouraged to work closely with their manufacturers throughout the building process to ensure that proper procedures are being followed.

Another difference between log building and a stick framing is in the scheduling. Because the entire log package may arrive at the building site at one time, building with logs requires more coordination on the part of the builder. The builder also must arrange for proper storage of materials that will not be used right away.

CHOOSING A MANUFACTURER

With over 200 companies producing log and timber frame home packages, choosing a manufacturer can be a dizzying experience. However, the choice can strongly determine a builder's success. When choosing a manufacturer, consider experience, customer service, design flexibility, market coverage, and price.



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LOG HOME UNDER CONSTRUCTION



LOG HOME EXTERIOR FINISH



LOG HOME INTERIOR FINISH



THE LOG AND TIMBER HOME BUILDING PROCESS

THE CREW

A log home builder needs an experienced production manager to keep the job moving and on schedule, at least one worker skilled in building log homes, and an inside carpenter with experience in working on log homes. Still, the labor demands are lower than stick-building because erecting the exterior walls completes many steps at one time.

TOOLS AND EQUIPMENT

Perhaps the most noticeable difference between building log homes and conventional construction is the log itself. Logs are heavy and shaped differently from studs. Handling them requires different procedures. The tools and equipment required at the log home building site include the same tools that are necessary at a stick-building site, plus a few additions.



LOG HOME TOOLS OF THE TRADE



Even precut log kits occasionally need onsite modifications, so a chain saw is recommended onsite. A forklift or crane can aid in off-loading the logs from the delivery truck and lifting in place. In addition, a builder will need a heavy-duty drill to screw fasteners through the logs. Some producers also recommend a wrecking bar or a crowbar for straightening logs and pushing them into alignment. In addition, a steel brush is often needed to clean off the tops and bottoms of logs to ensure gasketing material will adhere properly, especially on handcrafted logs.



PREPARING FOR DELIVERY

As with any building material, the builder should be prepared to keep the logs clean, dry, and safe from vandals. Before accepting a log or timber frame package, the builder should check that water, electric, and sewer or septic systems have been approved for the homeowner's building site. If the systems are available, the builder can begin the foundation. Log homes can be built on a slab, crawl space, or full basement foundations. It is recommended to build log homes on a crawl space or basement rather than a slab for ease of wiring and mechanicals. Log homes are also compatible with all-weather wood foundations, which can be important for builders in northern climates because it means foundations can be installed and buildings can be continued throughout the year. Although the foundation and subfloor does not have to be completed when the log package arrives at the site, it is a preferred construction method. Otherwise, the logs will sit at the job site longer, increasing the risk of damage.



DELIVERY OF THE PACKAGE

Log homes are delivered from the mill to the building site on trailers after the foundation and construction drive is prepared. Most of the factories require approximately six to nine weeks' notice for delivery of a log home kit or package.



When the manufacturer delivers the log package, be sure to account for all of the items as they are unloaded. A factory produced inventory list should accompany the order. What comes off the trailer should match the inventory list. Manufacturers generally require that any items not delivered be reported promptly to headquarters. Then the manufacturer will ship a replacement product. In addition to accounting for materials as they are unloaded, check the condition of the logs. Damaged logs should not be accepted.





Builders may have to arrange for the return of any damaged or unacceptable logs to the factory for replacement products; the delivery driver may not be returning directly to the factory, so the driver may be unable to return the logs.

PUTTING THE HOUSE TOGETHER

Assembling the log home depends in part on the manufacturer selected. It also depends on whether a builder buys a precut package or a kit that requires onsite cutting of logs. The importance of taking inventory when the kit is delivered is underscored at this point. If a builder has all the necessary materials, he or she can begin construction.

LOG PROFILES

Logs come in a variety of profiles:

- » Round log: round inside and out.
- » D-logs: flat on the inside and round on the outside.
- » Square logs : flat on both sides.

Logs are connected in a variety of ways, also. Fastening may include any combination of screws, spikes, nails, splines, tongue, and grooves, or tension rods. A spline is a tongue or wooden strip that fits into grooves cut in a log.

Some logs are milled with a tongue on top and a groove on the bottom. When the logs are laid on top of one another, the tongue fits into the groove and a foam gasket is used. In another fastening method, a concave cut is made in the bottom of the log. This is known as the Swedish cope design. These logs are stacked on top of each other. Still other logs are flat on top and bottom. A spline or tongue may or may not be used. Most log home manufacturers use timber screws to fasten logs. This is much quicker and easier compared to pounding spikes with a sledgehammer. Additionally, screws allow the builder to remove a log after it was installed if needed

Some log systems run steel tension rods through the log walls. Tension rods pull the logs together. Foam gasketing, caulk, or chinking systems help reduce air and water infiltration. Some log systems require no chinking, but homebuyers may request it anyway because they want their houses to have a rustic look. These sealants move with the house. That is, as the house acclimates and the logs moisture stabilizes, the sealants expand and contract with changes in heat and humidity.

Once the shell is up, the full-service builder begins finishing the roof and interior. Some builders install plumbing, electrical, and other interior finish work, but many builders subcontract this work, just as conventional builders do. Generally, the bulk of the wiring is run in the subfloor framing below the log wall and then into predrilled wiring holes in the logs connecting to switches and receptacles. When possible, wiring is placed in interior wall framing.



D-LOGS



ROUND LOGS



QUESTIONS TO ASK A LOG AND TIMBER HOME SUPPLIER

What services does a builder receive for his/her money?

Does the manufacturer provide or sponsor a log construction training program?

Will the company help erect the first home?

Does the manufacturer grant a protected territory?

What do dealers in neighboring territories think about the company?

How quickly can the company fill an order?

Does the company make the kinds of log home kits and packages that appeal to consumers in the builder's territory?

What is included in the standard log home package?

Can builders request changes in packages (window substitutions, for example)?

Does the manufacturer have a hotline to answer a builder's urgent questions?

What type of guarantee or warranty is included?

Is the manufacturer a member of the Log and Timber Homes Council?

Does the manufacturer grade logs under an approved grading system?

Does the manufacturer provide a detailed construction manual?

Does the manufacture provide code approved and or engineer sealed drawings for the locality?



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CONCRETE HOME BUILDING SYSTEMS



From driveways and walkways to segmental retaining walls and pools, concrete has been an essential home building material for the past century. Recently, concrete construction has risen to new heights. With increasingly unpredictable weather in some areas and rising costs in heating and maintenance, concrete has quickly become a primary building material for many homes.



And it's no surprise the trend is sticking. Concrete homes offer solid, disaster-resistant construction, greater comfort, and security, lower energy bills, lower maintenance, as well as a home that is healthier to live in and easier on the environment.

TYPES OF CONCRETE BUILDING SYSTEMS

INSULATED CONCRETE FORMS



Choosing to build with Insulated Concrete Forms (ICF) for your next project provides you with one of the most advanced building envelope products available in the construction industry. ICF's can be used for a variety of building types, residential homes, commercial buildings, schools, hospitals, and multi-story buildings.

Insulated Concrete Forms provide a fast, easy, cost-effective, and energy-efficient solution for residential and commercial structures. ICFs combine six building steps into one easy building solution: Form system, air barrier, wall structure, vapor barrier, Insulation, Interior/exterior finish anchorage, which replace wood studs. Compare that to wood, where a multi-step construction process is needed, requiring multiple trades. ICF's are a cost-effective alternative.



CONCRETE HOME



CONCRETE MASONRY WALLS

Concrete masonry is one of the most familiar building materials used today and one of the most common concrete systems of building walls. Concrete masonry has been used successfully for decades in foundation walls and above-grade walls alike.

Concrete masonry units are generally hollow units that are manufactured with a dry-cast process in a plant. The most common masonry is a gray unit that is eight inches tall and 15 inches long. However, concrete masonry is available in many different sizes, finishes, and colors.



THE INSULATED CONCRETE FORM BUILDING PROCESS

PLANNING

Preconstruction planning is crucial in ICF construction because the features that make ICF homes attractive





to buyers are the same ones that make field adjustments to the structure difficult. This phase is particularly important if the blueprints were originally designed for wood framing. Since the exterior walls of ICF are thicker, the overall dimensions of a wood-framed design would be increased to avoid shrinking the interior floor plan. Also, pre-determine the location of utility penetrations, exterior and interior finishes, and appropriate attachment details for the roof, floors, and interior partition wall framing. Changes made after the concrete has set will result in greater labor costs.



UTILITIES

Utility penetrations for ICF construction should be determined in advance. Unlike a wood-framed wall, making a hole through a full-thickness concrete wall requires tools not readily available on the typical job site. It is generally recommended to sleeve penetrations with PVC pipe before the concrete is poured and install the utilities later. Larger chases, such as for vent stacks or ductwork, may need an engineer's structural analysis, especially if significant concrete is displaced by the chase. Temporary bracing during the pour may also be required if too much foam is cut away.

DOORS AND WINDOWS

Openings for doors and windows also need pre-planning. A permanent pressure-treated window frame is frequently installed to provide an attachment surface for the window or the door frame. Sizing this permanent frame is key to the efficient installation of the windows and doors. Whether the windows have "masonry-style" window frames or frames with nailing flanges, the permanent window frame should be sized appropriately to accommodate the actual size of the window. Strong, temporary bracing of all openings in an ICF wall is important to keep the opening square during the concrete pour and to support the weight of the concrete until it achieves its desired strength. The thickness of the wall is rarely a concern with wood framing when hanging a door; however, for ICF walls, like other masonry walls, the depth should be considered. The door should be installed so the hinges are located at the outside of the opening. The door will not open all the way if it is improperly mounted. For example, an inward opening door will not open if it is flush to the exterior wall surface; and an out-swinging door will not open if it is installed flush to the interior of the wall. Windows can be set at any depth in the ICF wall. Windows that are flush-mounted with the exterior face will have deep interior window sills and few problems with exterior moisture. Extended jambs may be needed on the inside of windows and doors because of the thickness of the ICF walls. These



may not be available from the window manufacturer and may require extra work by the installer or finish carpenter. Deep interior window sills are perceived as a benefit to many home buyers who like window seats or window display areas.

CORNER DETAILS

There are several different types of ICF form corners. Each ICF manufacturer has specific recommendations for the corner assembly of their product. However, in most systems, the corner blocks should be placed to stagger leg lengths for every other course. This allows the foam edges to be offset so that there is not a continuous vertical seam at the corner.



JOISTS AND BRACING

Floor joists are either hung from ledgers or are embedded in the concrete. The ledger and anchor bolts are embedded or secured into the ICF forms before the concrete is placed. Joist hangers secure the joists once the concrete has set. Embedded joists are firecut and require cutting out the foam and inserting wood spacers before the pour to create a pocket in which to seat the joist. Temporary bracing is needed at corners, window and door openings, periodically along the length of walls, and at the top of the forms. Top braces square the forms and provide a surface to check wall height and cut uneven blocks. When beginning the layout of forms, the first course is laid flush with metal angles, wood cleats, or wood studs placed along the length of the foundation to secure the forms. Blocks can be set in green concrete foundations. The courses should, in general, have staggered vertical joints. Foam sealant can be used along joints to secure blocks until the concrete is poured. This is especially handy during windy conditions. Most ICF systems have interlocking edges to reduce or eliminate the need for gluing.



FINISHED SURFACES

Attaching wall sidings requires adjustments when using ICF construction. The changes depend on the type of system used. Most manufacturers use plastic or metal ties built into the ICF blocks and panels into which siding material can be directly screwed. Although rare, if the spacing of the ties is not suitable for the siding material, furring strips may be attached to the ties.



On the interior, drywall is screwed to the ties and glued to the foam. Metal angles can be placed around the interior perimeter to screw in trim. Cabinets will require additional bearing support to remain attached to the wall. Plywood or 2 x 4 studs can be nailed into the green concrete and then used to hang cabinetry. Electrical boxes and wiring chases are cut into the foam. The foam is cut away using a hot wire cutter or a saw. The boxes and cable sit into the foam and are taped or sealed into place. The finished electrical outlets and switches sit flush against the drywall. Because the insulation is removed, thermal losses increase when the foam is cut away. This can be seen in the thermography testing of the demonstration homes. Foam cutaway for electrical boxes and wiring should be minimized. Sealants and tapes can be added around electrical boxes and wiring to reduce thermal losses.





MODULAR HOME INTERIOR FINISH

THE CONCRETE MASONRY WALLS BUILDING PROCESS

PLANNING

Before installing any units, the crew transfers measurement from the building plans to the foundation below, which is usually a footing or floor slab. This begins with marking the locations of the corners. Lines are drawn between the corners. This establishes the line to which the face of the unit will be laid. The location of openings and control joints are also marked. The masons may set the units of the first course in position without mortar to ensure the measurement is correct. The crew may install poles called “story poles” at each corner to ensure that the units there are correctly aligned and stacked in a precise vertical position. These are often marked at the course heights, so the mason can stretch a line between them to show the correct top of each course.

SETTING

The first course is set on the foundation in a bed of mortar. The foundation is usually fitted with dowels, which are positioned to be in cavities that will be grouted. Set precisely level, the mason places mortar on the ends of each unit as well and butts the units together. The upper course goes over the one below in much the same way. In a running bond, the position of the units is shifted at least one-quarter block on each course.

When the wall reaches the height of the bottom of the window opening, the masons begin to set the masonry up to the sides of the opening and continue laying units. When they reach the top of the opening, a lintel goes across the top to bridge from one side to the other. The lintel may consist simply of a lintel unit that will be filled with grout and reinforcement later to create a structural beam. In this case, the opening will likely have a buck or blackout installed to support the masonry temporarily. The lintel may also be formed out of a steel angle with conventional units set on top or a precast concrete beam set over the opening.

After the masons set all units to the top of the wall, they drop the vertical reinforcement down the cavities with dowels. Horizontal reinforcement goes around the top course to form a bond beam. The reinforcing bars are wired in position. With the



bars in place, the cavities are filled with grout. This may be done when the wall is laid to the top, a process called high lift grouting. It may also be done when the wall is only four feet tall or less, a process referred to as low lift grouting.



The masons typically check for correct alignment by placing a straightedge diagonally across the wall. They also check all the mortar joints to ensure that there are no holes or gaps. When the mortar has achieved adequate stiffness, workers will use a jointer to press the mortar inward, improving the seal and making a stronger bond between the mortar and unit. Temporary bracing may also be installed to guard against high winds from toppling the wall.



CONNECTIONS TO THE FLOOR AND ROOF

Frame floor decks may be attached with the ledger method. The anchor bolts may be embedded in a bond beam. The crew installs the bolts in holes in the face of the masonry before grouting the beam. There are also special bolts that are designed to be attached to a hollow unit in an ungrouted area.

An alternative for connecting a frame floor is with the pocket method. In this method, notches are cut in the inner face of the units. The floor joists are set directly in those notches. Extra measures are necessary to secure the joists in those pockets.



Frame roofs are usually attached by the top plate or hurricane strap method. The connectors are generally embedded in the grout of the bond beam on top. If the top of the wall is not grouted, there are various metal connectors that join to the masonry directly or to anchors in the joints.

Interior walls, fixtures, and wallboard may be connected directly to the masonry with concrete nails or screws. If the interior of the wall is insulated, fixtures may also be attached to the furring or studding.



CONNECTIONS TO DOORS AND WINDOWS

Doorframes are often attached by way of a buck. The doorframe is nailed or screwed to the buck just as it is to wood framing. Some doors are designed to attach directly to the masonry. In this case, no buck would be installed. There are also windows designed to be nailed to wood. For these, a buck is installed. Others are designed to be attached to masonry with self-tapping masonry screws through the frame. In this case, there is not buck. In some areas, special masonry windows are popular. These are sized to fit precisely into a standard masonry opening. They leave a vertical groove on the inside edges, and the windows have flanges that slide into the groove.

FINISHED SURFACES

The most popular and least expensive finishes for masonry are plain paint or stucco. In an area where stucco is common, it has been raised to something of an art form. Foam molding may be formed first, and stucco is applied over the foam to create relief on the wall. The stucco may be integrally pigmented or painted to create any color.



On the interior of the wall, furring and wallboard are most common. When the masonry is left exposed, its natural finish is perfectly functional. However, it may also be painted.





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ICF FOUNDATION



ICF HOME



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- What services does a builder receive for his/her money?

- Does the manufacturer provide or sponsor a concrete construction training program?

- Will the company help erect the first home?

- Does the manufacturer grant a protected territory?

- What do dealers in neighboring territories think about the company?

- How quickly can the company fill an order?

- Does the company make design packages that appeal to consumers in the builder's territory?

- What is included in the standard ICF home package?

- Can builders request changes in packages (window substitutions, for example)?

- Does the manufacturer have a hotline to answer a builder's urgent questions?

- What does the ICF home kit or package include?

- Does the manufacturer provide engineering for the ICF package?



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NATIONAL READY
MIXED CONCRETE
ASSOCIATION
BUILD WITH
STRENGTH

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