# Wall Systems

Today, wood framing is the most common construction method for residential and small scale commercial buildings. However, environmental concerns, and volatile fuel and lumber prices are driving the quest for high performance building envelope systems such as Structural Insulated Panels (SIPs) and Insulated Concrete Forms (ICFs). In addition, natural disasters throughout the U.S. and large payouts for insurance companies are motivating builders to consider more robust and durable building materials. This fact sheet will outline the strengths and weaknesses of three alternatives to stick-frame construction, namely steel, SIPs and ICFs.

## Steel Framing

Wood frame construction has been the unchallenged norm for residential construction in North America for over a century. Over the last few years, however, volatile wood prices, declining quality of framing lumber and environmental concerns have led many builders to consider steel framing. A 1993 survey done by the National Association of Home Builders (NAHB) found that about 1% of new homes were framed entirely with steel, and that 5% used steel in non-load-bearing applications.

Since then, steel framing gained prominence primarily because it offers price stability and a simple piece-by-piece substitution for wood. Steel studs replace wood studs, steel joists replace wood joists, and steel channel sections replace wall plates and band joists. Builders can adjust to using the new material without worrying about learning a whole different approach to framing. In fact, contractors with experience in commercial buildings are usually already comfortable with steel-framed partition walls, so the switch is quite easy.

### Steel Framing Benefits

There are other reasons steel framing is attractive: steel is manufactured to exact specifications, without any of the twisting, warping, rotting and other defects that can plague framing lumber. Its lighter weight is also an advantage, making assembled walls easier to handle. Steel's inherent insect resistance is a big plus in termite-prone areas. Finally, advocates of steel framing cite performance advantages in fires and earthquakes, though these are challenged by the wood industry.

Environmentally, steel has a number of strong points. Steel isn't associated with the well publicized concerns about forest management and timber supply. It takes approximately one-fourth of an acre of mature trees to produce the wood framing for a typical house. The same house can be steel framed from the recycled steel in three or four junked cars. However, while overall the steel industry has a recycling rate of 66%, the average recycled content in steel framing is only 24%.

Indoor air quality: steel is inert, and releases no terpenes like wood or toxins like treated lumber. It is unattractive to insects and does not have to be treated for termites. Low-toxic or non-toxic products should be used on exposed metal requiring polishing, cleaning, or repainting.

Other benefits of steel framing include:

- Non-combustible - does not burn nor contribute fuel to the spread of a fire
- Dimensionally stable - does not expand or contract with moisture content
- Less scrap and construction waste (2% for steel vs. 20% for lumber)
- High strength results in safer structures, less maintenance and slower aging of structure
- Less probability of foundation problems - less weight results in less movement
- Lighter structure with stronger connections, screwed versus nailed

### Steel Framing Disadvantages

Steel has one glaring handicap, however, that has the potential to override all its advantages: thermal performance. Steel itself is over 400 times more heat conductive than wood. This high conductivity causes severe thermal bridging wherever steel spans from the inside to the outside of the building envelope. If appropriate measures aren't taken to control the thermal bridging, it can cause a number of problems:

 

excessive energy use for heating and cooling; the need for larger space conditioning equipment to handle the larger loads; and condensation of moisture on the warm side of a wall, leading to dust or mildew stains. In areas with significant heating or cooling loads, the energy penalty from using steel studs in exterior walls may be the single most important environmental factor to consider.

Many people are looking into potential solutions to the thermal bridging problem. To stop the heat transfer, contractors usually wrap steel framing with insulating board (or rigid insulation) in addition to placing conventional batts of insulation between the studs. On rare occasions and especially in colder climates, homes in which thermal bridges remain intact can have problems with condensation and mold. Adding insulation to the outside of the home usually solves this problem.

### Costs

Steel homes use nearly the same framing techniques employed in wood-framed buildings, and construction costs run about the same. Unlike wood, however, steel is impervious to termites. It provides added resistance to fire and earthquake. In addition, steel ceiling joists can span greater distances than wooden ones, allowing new design possibilities for architects and builders.

## Structural Insulated Panels (SIPs)

Structural Insulated Panels (SIPs) have become another widely used alternative to conventional stick-frame construction. While many types of composite panel building systems have been developed, the acronym SIPs now refers to panels made from a thick layer of foam (polystyrene or polyurethane) sandwiched between two layers of Oriented Strand Board (OSB), plywood or fiber-cement. As an alternative to the foam core, SIPs are available with a core of agriculture fibers (such as wheat straw) that provides similar thermal and structural performance. The result is an engineered panel that provides structural framing, insulation, and exterior sheathing in a solid, one-piece component.

SIP construction is attractive in part because it allows very rapid erection of a building shell, helping to control labor costs while reducing dependence on skilled framing contractors. From an environmental perspective, SIPs offer superb energy performance due to both high R-value and excellent air-tightness.

### Installation

SIPs construction relies on careful planning and design prior to delivery and site assembly. Several companies offer pre-designed house packages with wall and roof panels of standardized dimensions to help control costs. For custom designs, a completely customized panel layout must be produced. Some panel manufacturers use computer controlled equipment that transfers panel cutting instructions directly from digital CAD (computer aided design) drawings.

Panels are shipped to the jobsite for assembly when the foundation and deck are in place. Ideally, panels are off-loaded and stacked in the exact reverse order needed, so that no sorting or shuffling is required. After the bottom plate is attached to the perimeter, placement of the wall panels begins. Panels weigh approximately three pounds per square foot, light enough to be carried and set by hand. Exterior walls for most houses can be erected in less than a day. Nails and adhesive foam are used to fasten the panels to top and bottom plates, and to make vertical connections. Gutter spikes or long screws are often used for SIP corner connections. Beams that carry roof loads may require stud supports incorporated into wall panels, to carry point loads downward. To take full advantage of SIPs insulating capacity, care must be taken to seal all joints properly, but the relatively small number of connections makes this easier to accomplish.

The installation of electrical wiring and plumbing lines may require special tools and techniques. Wiring is a simple task for the electrician because virtually all SIP makers pre-form wire raceways called chases into the panels. They are put in at the predetermined height for both switches and outlets. Typically, plumbing is installed in interior walls and floors. Where exterior wall vent pipes are necessary, chases can be formed in the foam cores. Since SIPs panel structures are more airtight, special attention should be paid to mechanical

 

ventilation design for proper sizing and avoidance of back-drafts. Gas appliances should be properly vented as well.

### SIPs Benefits

The ease and speed of assembly makes it possible for houses to be placed under roof within days rather than weeks. SIPs are compatible with any floor or foundation system. Once the floor is finished, the walls are ready to be tipped into place. The thing carpenters like about panels is that there are really no special tools to buy or new skills to learn. While basic carpentry skills are required, assemblers don't need to have the skill levels of conventional framing crews, which can further reduce costs to builders.

Framing is done with large pre-cut pieces. Once the walls have the top plate installed, the beams are set, so the roof has something to sit on. Then using a boom truck, the roof system is "flown" into place. The result of using roof SIPs is a true vaulted or cathedral ceiling. Since SIPs use rigid insulation, this is a very comfortable and cost effective space that can be used as either a second story or a loft. After the walls are in place, they can be finished with drywall or plaster inside and siding, brick, stucco, stone or any other appropriate exterior material on the outside.

The most important environmental feature of structural insulated panels is their superior energy performance. SIPs offer R-values ranging from R-15 to R-45, depending on the thickness of the panel. SIPs provide continuous insulation, without thermal bridges and have far fewer interruptions in the insulation. This makes SIP structures significantly more airtight, and in turn, makes a building more comfortable and energy efficient. The Florida Solar Energy Center found that SIP construction can account for household energy savings between 12 and 17 percent.

SIPs structures are highly resistant to wind damage, and suitable for areas with stringent wind shear or seismic codes. They are also fire resistant. SIPs have no "air" within their solid cores of insulation. The fire cannot propagate within the wall cavity. Builders also enjoy the benefits of less job-site waste and better utilization of material resources.

Finally, SIPs are better for the environment as they use up to 65% less raw timber than wood-frame construction. The wood used in SIPs is typically either farmed wood or weed wood. This means that rapidly maturing second growth, not old growth, trees are harvested for the sheathing or "skins" of SIPs. Further, the entire tree is used, not just the inner core.

### SIPs Disadvantages

One potential weakness of foam insulation in general, and SIPs in particular, is that they make comfortable nesting chambers for carpenter ants, termites, and other destructive insects. Panel manufacturers generally recommend an aggressive pesticide treatment program both during and after construction to prevent infestation. This may mean significant exposure of the building occupants and the surrounding environment to toxic insecticides. Some manufacturers have issued guidelines to prevent these problems, including the following:

- Treating the ground with insecticides both before and after initial construction and backfilling
- Maintaining indoor humidity levels below 50%
- Locating outdoor plantings at least two feet away from the walls
- Trimming any over-hanging tree limbs

### Costs

SIPs can be slightly more expensive than the materials used in stick-frame construction. But by combining three stages of conventional shell construction – framing, sheathing, and insulation – into a single unit, a SIP structure can be erected much faster and with less specialized labor than conventional methods, cutting construction time and labor costs. Some manufacturers offer prefabricated SIPs home packages at costs approaching those for conventionally framed structures.

## Insulated Concrete Forms (ICFs)

ICFs provide all the benefits that have made concrete a popular building material worldwide:

 

solid, lasting energy efficient construction that resists the ravages of fire and wind. This gives an ICF home some sizable advantages over an ordinary stick-built home. ICF homes are beautiful, comfortable, quiet, solid, and built to last.

ICFs are permanent forms for cast-in-place concrete walls. By leaving the forms in place, a homeowner can reap extra benefits from the insulating materials. There are many ICF wall types. The three most common ICF systems are flat (ICF panels create uniformly thick concrete wall), grid (ICF waffle pattern creates concrete of varying thicknesses), and post-and-beam (ICFs create discrete horizontal and vertical concrete columns).

## Installation

Location of utility penetrations should be determined in advance to the extent possible. It is generally recommended to sleeve penetrations with PVC pipe before the concrete is poured and install the utilities later. In screen-grid and post-and-beam systems, it may be possible to put penetrations through solid form material and avoid penetrating the concrete altogether.

Large penetrations, such as those for vent stacks or ductwork, may need an engineer's structural analysis. Alternatively, large penetrations can be placed in interior walls or be framed out. Avoid placing ducts and plumbing in exterior walls, where possible.

In order to run wires and accommodate electrical boxes in ICF walls, grooves can be cut into the foam using a hot-knife or router. Some contractors have said they actually find this easier than drilling holes in studs. For electrical boxes, recesses can be cut to the exact depth required. Cutting foam will reduce the wall's thermal integrity. Therefore, groove depth should be minimized and spray-foam should be placed over any cut out sections.

Mechanical contractors need to calculate the expected peak heating and cooling loads because of ICFs higher R-values and lower infiltration rates. Sizing will also be influenced by the possible effects of thermal mass as there may be a time lag for heat transfer that affects peak load timing. Unfortunately, oversizing of equipment occurs often, and more efficient buildings may see even greater oversizing. Oversizing leads to reduced equipment efficiency, occupant comfort, and, possibly, shortened equipment lifespan. Field testing can determine air infiltration rates and help with proper HVAC sizing.

## ICFs Benefits

- Strength – the strength of any ICF wall system comes from the combination of the concrete itself and the reinforcing steel utilized. An engineer should be used to design the ICF walls. The walls of a properly-constructed ICF home are exceptionally resistant to loads imposed by high winds and can be designed for all seismic zones. Shear wall testing is needed to verify compliance of ICF home designs in earthquake-prone areas.
- Energy efficiency and comfort – Energy savings and comfort are built into every ICF system. The combination of high R-values, low air infiltration, and high thermal mass account for the energy savings of ICFs compared to wood- or steel-framed homes. ICF walls have higher R-values (between R-18 and R-35) than typical wood frame construction (typically R-12 to R-20) and steel frame construction (R-7). A recent study, Energy Comparisons of Concrete Homes versus Wood Frame Homes quantified energy savings due to ICFs. The average combined heating and cooling energy savings were 42% (range: 34-50%) and cost savings averaged 21% (range: 17-25%). Annual cost savings averaged $250.
- Noise Suppression translates to Peace & Quiet – Due to the insulating capabilities of ICFs and the properties of concrete, ICF walls reduce noise transmission. ICF walls have a Sound Transmission Coefficient (STC) of 50+. Comparable wood systems have an STC of 37, and steel an STC of 40. STC measures the resistance of a material to the transmission of sound.
- Superior Fire Rating – In fire wall tests, ICFs stood exposure to intense flame without structural failure longer than common frame walls. The polystyrene foam used in most

 

ICF forms is treated so it will not support combustion. Many insurance carriers are now offering a discount on a homeowner's policy for an ICF home.

- Improved indoor air quality – ICF walls resist moisture, mold, and mildew and contribute to a healthier indoor environment.
- Durability – ICF walls are more rot-resistant and durable than wood-framed walls and that means less repair and maintenance. Concrete homes also have a proven track record of withstanding the ravages of hurricanes, tornadoes and fires, when the stick-build houses around them are in ruins.
- Sustainable Construction – by minimizing the number of different building products involved in construction and by reducing the amount of waste generated on site.

### ICFs Disadvantages

- Potential for Moisture Problems – Tighter construction means fewer air changes and less opportunity for drying out. Dehumidification is essential and should be done independent of temperature controls.
- Susceptibility to Insects: Similar concerns with SIPs for carpenter ants, termites and other insects. An effective method for termite protection is the use of uniformly-sized, course-grained sand barriers. The individual grains are too large for termites to push out of the way but the inter-grain spaces are too small for them to get through. This method has been used successfully in Australia, Hawaii, Texas and California.

### Costs

ICFs are so efficient to build, that many builders claim the cost of building an ICF house is comparable to that of an ordinary 2 x 6 wood-framed house. According to an NAHB Research Center study, ICF homes cost about one to five percent more than wood-framed construction.

Over the last ten years, concrete prices have been remarkably stable. Recent price increases in other materials have generated interest in concrete building systems as never before. Labor savings and readily available materials make ICFs, feature for feature, one of the most cost competitive wall systems in the U.S. housing market. ICF material costs range from about $1.75 per square foot to about $3.50 per square foot in addition to installation labor, reinforcement, bracing, and concrete.

### Which wall is the best choice?

It depends. If your site is exposed to traffic noise and you know you want a high R-value wall with an earthen clay finish on the interior and stucco for the exterior finish, an ICF wall might be your best choice. If construction speed and high R-value is the most important factor, then having large SIPs with pre-installed lumber delivered to the site might be your best bet. With sustainable living as the goal, green construction practices and energy conservation are only part of the larger picture. There is no perfect building material – only more appropriate products to match your set of parameters, requirements and goals.

## For more information

- **BuildingGreen.com.** Independent company committed to providing accurate, unbiased, and timely information designed to help building-industry professionals and policy makers improve the environmental performance, and reduce the adverse impacts, of buildings. Publishers of the Environmental Building News - www.buildinggreen.com
- **Partnership for Advancing Technology in Housing** (PATH) is a public-private initiative dedicated to accelerating the development and use of technologies that radically improve the quality, durability, energy efficiency, environmental performance, and affordability of America's housing. The PATH Technology Inventory is accessible at www.toolbase.org/TechInventory
- Search Build It Green's **AccessGreen Directory** to find local suppliers and services: www.builditgreen.org
- For more information about Build It Green, visit our web site at www.BuildItGreen.org or call us at 510-845-0472.

 

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