Sustainable Structures

By Micah Baginski

Historically the most prominent material found in a region drives the construction methods and materials used for housing. Egyptians used limestone, Central Europeans used straw and clay, Northern Europeans used stone, and other cultures dug right into the earth or the sides of canyons to make their dwellings. As the United States was developed, the most readily available building material was timber.

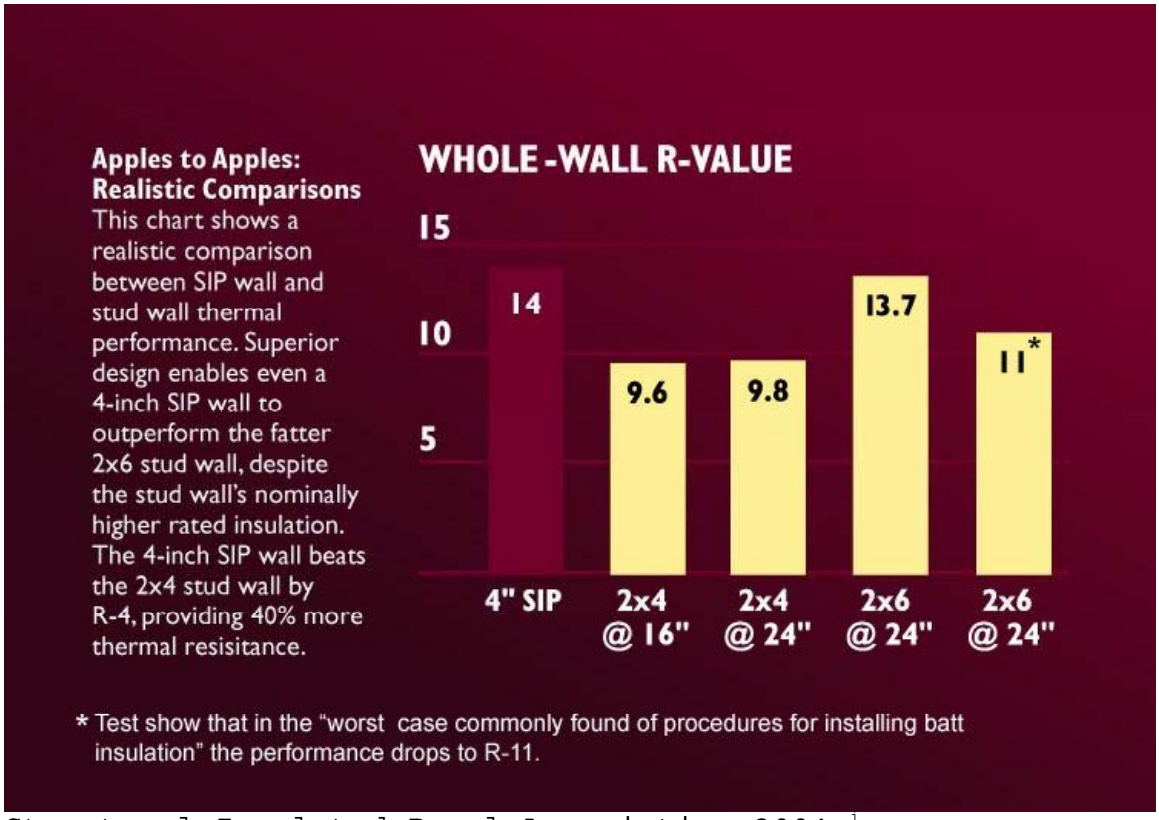
Wood has inherent problems associated with its sustainability. It can warp, twist, mold, swell and shrink. Problems are surfacing due to the use of modern building materials that can exacerbate these qualities. In the quest of energy efficiency buildings have become so airtight that they foster moisture when not ventilated properly. If lumber is not dried properly it can lead to deformations that can cause anything from drywall cracks to plumbing leaks. Poorly constructed wood structures have very short life spans that make them very unsustainable.

The following is an analysis of current alternate structural systems that are primarily dependant upon concrete for their strength and durability. They are SIPs (Structural Insulated Panels), Precast Concrete Panels, ICFs (Insulated Concrete Forms), Thermal Mass Walls and SCIPs (Structural Concrete Insulated Panels). Each system will be compared based on its heat resistive R-value (ability of heat to transfer through a material), thermal mass (ability of a material to retain heat or cold), sustainability (reused or recycled content), and durability. All of these systems do provide significant energy reductions for the end-users. However, no analysis was undertaken to specifically compare the energy usage.

Structural Insulated Panels

SIPs are constructed using oriented strand board or cement fiberboard and polystyrene or polyurethane in a sandwich that creates a web and flange structural member. These panels are typically designed as a system and constructed offsite. Then the panels are brought onsite erected and attached. Most of the tilting of the panels can occur by hand or with the use of a forklift.

The heat resistive quality of SIPs, or R-Value, is 40% greater than the conventional framing and batt insulation of a like-sized wall. If the SIP wall thickness is increased the value rises exponentially. SIP panels with oriented strand board have very little thermal mass. Due to the lack of thermal mass the structures do not inherently stay cool or warm, and they must be mechanically conditioned.



Structural Insulated Panel Association 2004 [i]

"Unlike steel or concrete, OSB is made from a completely renewable resource--small-diameter, fast-growing trees." [ii] The OSB does include formaldehyde in a concentration of .1 PPM and the polyurethane cores in the panels are made from petrochemicals, which may offset the environmental benefit of using renewable harvested wood products. Although the number of trees used to produce a conventional wood-framed home is far greater than that of a SIP home.

SIPs are just as durable as conventionally framed houses assuming similar exterior treatments. In fact, due to the lack of wood studs that have the potential to deform from moisture, the SIP structure will retain its shape better. This will lead to fewer warranty issues. The SIP system is a mildly sustainable product due to its increased energy efficiency.

Precast Concrete

The use of precast concrete in residential construction has been limited to mid- and high-rise buildings typically but is beginning to be used in small multifamily projects. Precast concrete panels are constructed much like

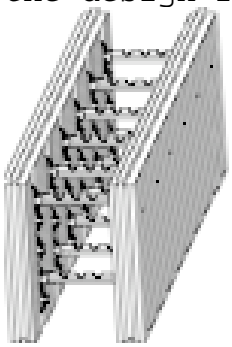
conventional concrete slabs. The panels are engineered to either act as a curtain over a steel structure or in more recent cases as the actual structure itself. Typical precast panels are constructed by the assembly of a steel rebar mat, embedded steel brackets, and concrete poured within a form. The panels are designed and formed offsite and then trucked to the building site and erected by crane.

Precast concrete does not have a high R-value as a stand-alone system. Concrete is a decent conductor of heat energy. It is 20 times more conductive to heat transfer than wood.[iii] As a side note steel is 62 times more conductive than concrete. To resolve this heat loss precast construction requires an interior wall system that is either furred out directly attached to the precast or separated and framed as an individual wall. Concrete does have a very high thermal mass coefficient however. This is useful in absorbing the summer heat at the exterior of the building and retaining it there. The problem is that the interior of the structure does not get the benefit of this thermal mass to stabilize the interior temperatures.

Concrete and steel both contain recycled content. Precast walls are very durable and have the longest life expectancy of any of the systems being analyzed herein. Due to the duplicity of the exterior precast structure and the interior framed walls precast is considered a mildly sustainable product.

Insulated Concrete Forms

ICFs can be likened to Styrofoam Legos because of their design and assembly. They are typically four feet wide by 16 inches tall and come in various thicknesses dependant on the design requirements of the structure.



ECO- Block LLC. 2006[iv]

The blocks are constructed of expanded polystyrene (EPS) walls two inches thick with plastic or metal spread bars to hold the block together. The building slab is poured with vertical steel rebar protruding from the perimeter. The blocks are stacked around the perimeter and more vertical

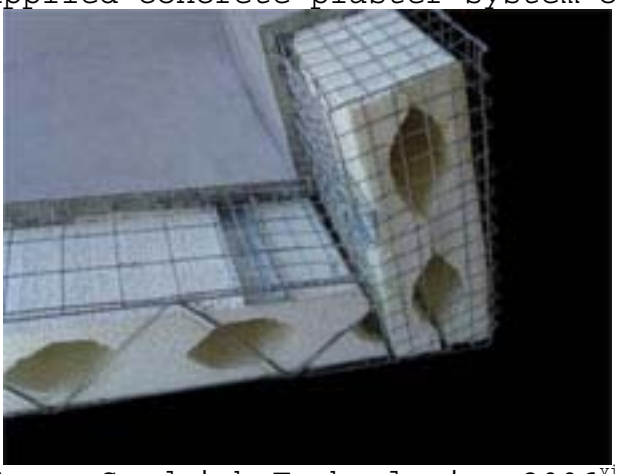
rebar placed within the walls is tied to the rebar in the slab. The blocks are then supported with wood cribbing and bracing to prepare for the installation of concrete. Concrete is poured in the walls in lifts predetermined by the contractor.

The R-Value of the block varies depending on the manufacturer's literature. The Eco-Block 2006 product specification sheet states, "The steady state insulating value of the wall is R-22. Additional insulation credits can be obtained from the thermal mass effect of the concrete."[v] The drawback to this system is the lack of thermal massing at the interior and exterior of the wall. The thermal mass is captured and insulated inside the foam shell and therefore cannot radiate the heat or cool efficiently. They (ICFs) make more sense in colder parts of the country, where the thermal mass effect is minimized.[vi]

As with SIPs, ICFs contain petrochemicals, which are not sustainable. Similar to precast panels the concrete and rebar used in the process contain recycled materials. The long-term durability of this product is not yet known. If not properly protected the exterior foam could be subject to moisture intrusion and degradation. Although this is true of the conventional wood materials used in housing also.

Structural Insulated Concrete Panels and Thermal Mass Walls

SCIPs consist of a polystyrene or biomass core surrounded with a steel wire cage encased with concrete plaster. The panels are erected by hand, tied together and then a spray-applied concrete plaster system or shotcrete is applied.



Green Sandwich Technologies 2006[vii]

Thermal Mass Walls or T-Mass Walls, while similar to SCIPs, are built using precast techniques. "Thermal mass walls consist of 4 inches of concrete facing the interior, 2 inches of concrete on the exterior and 2 inches of Styrofoam

extruded polystyrene board insulation sandwiched in between. Fiber composite connectors, spaced 16 inches on center, hold the assembly together." [viii] These panels are constructed and installed exactly like precast concrete panels discussed above.

Both systems maximize the thermal mass effect. The presence of concrete surfaces on the interior and exterior of the structure separated by an insulating core allows a thermal flywheel behavior to take place. When interior of the house is heated or cooled the wall system absorbs that heat or cool. When the temperature in the house changes the walls will begin emitting the retained heat or absorbing it as the case may be. The exterior skin behaves in the same manner by preventing the heat or cool to radiate inward. Their energy efficiency is maximized in warmer climates, especially those with large temperature differences between day and night, like the deserts of the southwest, where homes built with thermal mass walls (including traditional adobe structures) have been most popular.[ix] Structures built using these technologies can be designed to require a significantly smaller heating and cooling system or possibly no cooling system at all.

The Green Sandwich SCIP panel utilizes very sustainable materials. Green Sandwich panels are made from 40% recycled material content by weight, and 60% by volume. All waste is 100% recyclable. They use BASF's environmentally friendly Styropor EPS foam in the panels. "The wire mesh is 40% recycled steel (Mostly from the auto industry), and the shotcrete skins are a minimum of 40% fly ash (A byproduct of coal burning). Green Sandwich Panels can be fabricated with a core of 100% locally harvested biomass. The source of this bio-mass can include "rapidly renewable" content, such as orchard trimmings, road-side weed growth, straw and stalk mowings." [x] Thermal Mass Walls on the other hand contain similar materials to the ICF product discussed above. Both systems claim to be able to be constructed in half the time of a conventional wood framed house.

From the standpoint of durability these systems rival that of a precast concrete system. The insulation materials are isolated within the concrete envelope and therefore are not as susceptible to moisture, termites, or physical damage.

The SCIP and T-Mass structural systems appear to be the most holistically sustainable option for construction of residential housing. The Green Sandwich panel exceeds the renewable and recycled material content of all of the systems analyzed. Either system if used broadly would reduce lumber consumption, energy consumption, carbon production, and building waste.

[i] Structural Insulation Panel Association – Website www.sips.org 10/17/06

[ii] Structural Board Association – Website www.osbguide.com 10/17/06

[iii] Thermal Conductivity Chart – Website http://230nsc1.phy-astr.gsu.edu/hbase/tables/thrcn.html 10/20/06

[iv] ECO-Block LLC – Website http://www.eco-block.com/product/CAD.aspx 10/20/06

[v] ECO-Block LLC – Website http://www.eco-block.com/product/specs.aspx 10/20/06

[vi] Professional Builder –Website www.housingzone.com/probuilder/article/CA6275261.html 10/20/06

[vii] Green Sandwich Technologies – Website www.greensandwichtech.com/company/panels.php 10/20/06

[viii] Professional Builder –Website www.housingzone.com/probuilder/article/CA6275261.html 10/20/06

[ix] Professional Builder –Website www.housingzone.com/probuilder/article/CA6275261.html 10/20/06

[x] Green Sandwich Technologies – Website www.greensandwichtech.com/company/what.php 10/20/06