



ACKNOWLEDGEMENTS:
BUILDING WITH STRUCTURAL INSULATED PANELS (SIPS)
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AMERIPANEL HOMES OF SOUTH CAROLINA

AmeriPanel Homes of South Carolina was established in 2002. The driving force behind the company is the desire to supply the customer with the best in the SIP's building process as well as the best product of its type in the industry. AmeriPanel of South Carolina strives to sell its product but also to educate the consumer on the benefits of the entire SIP's building system. Among the benefits are strength, durability and ease of construction. Energy efficiency coupled with the money savings are major selling points of the AmeriPanel system.

STRUCTURAL INSULATED PANELS (SIP'S)

A BREIF HISTORY

Some of the earliest examples of sandwich-panel technology can be found in the Usonian houses designed by Frank Lloyd Wright in the 1930's. These structures, innovative at the time were the result of Wright's attempt to incorporate beauty and simplicity into relatively low cost houses. Some of the walls in these houses consisted of three layers of plywood and two layers of tar paper as structural elements. Unfortunately, these prototype wall designs lacked any insulation, so they were never produced on a large scale basis.

Alden B. Dow, an architecture student of Wright and brother of the founder of the Dow Chemical Co., experimented further with the concept. Concerned about energy efficiency and dwindling resources, Dow was dismayed by the lack of insulation in the Usonian projects. In 1950, he developed a structural panel with an insulating core, thus he is generally credited with producing the first structural insulated panels or SIP.

Structural insulated panels or SIP's have been used since the 1950's. The SIP consists of two outer skins and an inner core of an insulating material to form a monolithic unit. Most structural panels use either plywood or oriented strand board (OSB) for their facings. OSB is the principal facing material because it is available in large sizes. The cores of SIP's can be made from a number of materials, including molded expanded polystyrene (EPS), extruded polystyrene (XPS) and urethane foam. The insulating core and the two skins of a SIP are pressure laminated together. This process produces incredible strength, versatility, stability. Structural stability with a SIP's constructed building far exceeds that of a traditional stick frame building.

NOT ALL BUILDING PANELS ARE SIP'S

Building panels come in many configurations, known variously as form-core panels.

WHY BUILD WITH SIPS?

The exterior envelope of a building creates a barrier from the elements for the comfort of the inhabitants. Many materials can be used to form that envelope, but none can do it as energy efficiently, as fast, as economically, and with as much design flexibility as SIP's. SIP systems technology offers a number of advantages over conventional framing methods.

SIP STRUCTURES ARE STRONGER

The structural integrity of a SIP building is significantly superior to a conventionally framed building in term of shear resistance, flexural strength, compressive resistance, and uplift resistance. All the major manufacturers are more than happy to provide National Evaluation Reports (NER) produced by the National Evaluation Service, Inc., for the BOCA, ICBO, and SBCCI code authorities.

Evidence of the superior performance of SIP's can be found in the real world, where SIP houses have survived earthquakes and hurricanes when the stick-built houses around them were destroyed.

To see how a SIP's building performs in a fire, tests were conducted in Illinois. In the study, the furniture in a 12-Ft. by 14-Ft. by 8-Ft. furnished room built with 5 ½ -inch core R-control panels was set on fire, and the door and windows were then shut. The fire brought the interior temperature of the room close to 2000 degrees F. This temperature quickly dropped in intensity without affecting the structural integrity of the room. No delaminating between the foam and the OSB facings underneath it was found, and apparently the fire resistance of drywall was dramatically increased by the OSB facing underneath it. The fire department's conclusion was that a tight SIP structure will quickly starve a fire of oxygen and that there is no air in the wall cavities to feed the flame.

SIP STRUCTURES OFFER BETTER THERMAL PERFORMANCE

Many side-by side comparisons of stick-built versus SIP houses have been conducted over the years. The results show that a SIP wall with a 3 ½ inch EPS core performed 31% better than the standard built 2x6 stick-built walls with fiberglass insulation.

SIP STRUCTURES GO UP FASTER

The faster erection time of a SIP building can cut one to four weeks from the construction cycle. This can be a significant factor at a site with difficult access or when bad weather presents a constricted window of building opportunity. The Energy Studies in Building Laboratory at the University of Oregon conducted extensive tests on stressed skin insulated core panels. (*Technical term for SIP's*) They found that their SIP house was completed in 161 fewer hours compared with industry standards for stick-framed houses and that a SIP house required 34% less on-site construction time.

SIP BUILDINGS ARE MORE COMFORTABLE

Inhabitants of SIP homes and buildings report a high level of comfort. Heating and cooling is more evenly distributed in a SIP building, without the hot and cold spots found in conventional houses. SIP buildings are also much quieter inside and the sound deadening offers respite from a noisy world. This is a difficult-to-measure quality of a home but one that has a significant effect on the occupants.

SIPS ARE THE WAVE OF THE FUTURE

The SIP industry is in the midst of an expansion that many industry leaders predict will bring SIP technology to the forefront of residential and light commercial construction. The professional association that represents the industry is the Structural Insulated Panel Association (SIPA). The SIPA was formed in 1990 by SIP manufacturers. The mission of SIPA is to increase the use and acceptance of SIP's by demonstrating to professionals and homeowners their technical superiority.

Besides promoting SIP's to designers, contractors, regulators, and homeowners, SIPA also helps develop industry standards for manufacturing and testing SIP's and promotes standards of ethics among industry members. While not all SIP manufacturers and suppliers are members of SIPA, the group represents most of the production capability of the industry. A recent SIPA study shows that the industry has experienced a 24% yearly growth rate between 1991 and 1994. Since then the growth rate has been more than 35% a year. SIPA estimates that 85 million sq. ft. of SIP's will be produced yearly over the next several years, a figure representing about 0.5% of the buildings built per year in this country.

THE SIP INDUSTRY TODAY

In 2000, there were about 100 American manufacturers of SIP's. While SIP production is spread out over the country, the majority of manufacturers are located in the central and northeastern portions of the United States. There are also some manufacturing plants

outside the United States. Many domestic manufacturers are gaining footholds in international markets, particularly in countries with extreme climatic conditions or frequent earthquake activity, such as Japan. Countries that have limited wood resources or very high labor costs are also potential customers.

Manufacturers offer a wide range of services, which may include compatible foundation systems manufactured from foam-core panels or insulated concrete forms (ICF's). Engineering assistance for builders and homeowners is an important service, and on-site consulting and assistance are vital to help consumers get acquainted with this "new" technology. A number of the larger manufacturers offer precutting services and can send their own crews or subcontract out the erection work.

Another vital component in the industry is the custom fabricators/builders that typically shape the raw panels and install them for their customers. The customers here are likely to be high-end home buyers who demand a high level of service from the custom builder. These companies are the visible arm of the industry. Custom builders, along with architects and designers who specialize in SIP construction, are moving the industry forward, not with expensive ad campaigns but with customer satisfaction and solid word-of-mouth reputation. Finally, it will be the consumers who "get it" who will drive this industry. And educated public aware of energy efficient building possibilities will provide the biggest boost in production and sales.

Along with SIP manufacturers are the makers of the facings, cores, and adhesives used in the manufacture of SIP's. For example, the American Plywood Association (APA), now called the Engineered Wood Association, is the industry organization for engineered wood products. Its members produce the various skins for the SIP industry as well as the engineered products such as I-Joists and laminated beams that integral to a SIP house. There are also a number of manufacturers and suppliers of Panel related accessories and tools.

The SIP industry is heading into high gear. There will likely be some fallout as larger companies absorb some of the smaller ones, while some companies will be forced out of business altogether by competition. This is an inevitable part of growth and change, but right now the panel makers are enjoying this growth and its rewards. The companies that produce and fabricate panels with openings, rakes, and plumb cuts will likely get better at servicing their clients. At the same time, custom builders will be able to offer their customers more refined products and will keep that share of the market that needs its hand held tightly. And as with the construction industry in general, there will be production builders who will build commercial buildings, tract homes, and the like.

There is an unfilled niche in the industry for companies that specialize in erecting SIP structures. In the near future, we expect to see a group of mobile erection companies for the SIP industry that would be similar to the custom grain harvesters that roam the Midwestern plains like mechanized nomads. And there will always be a place for small contractors with non-mechanized crews; they will use SIP's because they want to offer a quality house to their customers. But, what will happen to the die hard stick-framers? There will always be a special place in the museum of technology for these guys-maybe right next to John Henry.

SIP'S AND THE BUILDING COMMUNITY

A growing number of smart builders are switching to the SIP system to satisfy the demands of an increasingly knowledgeable consumer base. SIP projects have been featured on the shows of popular home improvement gurus Bob Villa and Norm Abram, generating considerable interest. All of these events hammer home the message that SIP's have finally arrived, offering more strength, more comfort, energy efficiency, and higher quality.

LARGE-VOLUME BUILDERS

Until now, the small custom builder has been the leading force in spreading the word about SIP's. However, there are now some major homebuilding companies that are using SIP's for housing developments involving hundreds of houses. For example, RJT Development Co. recently built 330 homes in the Crown Hills housing development in Alpine, California, on a site originally designated for mobile homes. The builder wanted to offer a more substantial product than mobile homes, but had to meet the state requirements for factory built components. Precut 6 ½" SIP walls helped meet these requirements, while the added volume given by vaulted ceilings and the homes' inherent energy efficiency helped attract buyers.

The development was begun in 1995, and by early 1998 all of the 1,200 sq.ft. homes (which cost between \$147,000.00 and \$182,000.00) were sold. According to RJT, some of the rapid sales were due to the fact that the homes used only half of the energy of the stick built competition. In addition, the vaulted ceilings were easier to build and offered more curb appeal. The hard costs for the project were between \$38 and \$45 per Sq. Ft., which was only about \$1 more per sq. ft. than conventional stick built construction. For large builders looking closely at the bottom line, changing to SIP's is not an easy decision. For the most part, potential home buyers are more interested in square footage and the bottom line than features that will save them thousands of dollars over the life of the building. However, the slight increase in production cost could easily be countered by energy savings and the power of "green" marketing. Success stories like the Crown Hills project always get attention from the builders, who do not want to miss any coming trends.

ANATOMY OF A STRUCTURAL INSULATED PANEL

A structural insulated panel starts with some wood strands, phenol-formaldehyde glue, and polystyrene beads the size of sugar granules. In this section we will examine the materials that go into a structural insulated panel and the process that turns these ingredients into a SIP. Then we will see how manufacturers try to crush, bend, rack, twist, and burn these panels, testing them to see if these products are good enough to build with.

The three main components of a SIP are the facings, the core material, and the adhesive agent that is used to bond the facings to the core. Pressure and setting time are also part of the equation and are used to help laminate those materials together. According to the Forest Products Laboratory branch of the U.S. Department of Agriculture, a SIP is "a layered structural system composed of a low-density core

material bonded to, and acting integrally with, relatively thin, high strength facing materials. When used as a wall, roof or floor system in housing, the sandwich panel provides exceptional strength for the amount of material used. In load-bearing wall, the two facings act as slender columns continuously supported by the core material to resist compression and buckling. In bending due to a live load or a wind load applied to a panel, the facings take most of the tensile and compressive forces and the core provides resistance to shear. The core and facings acting integrally provide exceptional stiffness to the member. Most of the SIP panels (85% to 90%) produced in the United States are composed of two 7/16 inch thick OSB facings and a core of EPS. This OSB-EPS-OSB panel is the bread and butter panel of the SIP industry and will likely continue to be the standard panel for the foreseeable future.

FACINGS

Foam-core panels can be manufactured with any number of materials bonded to the core to make a building component, but OSB is the main material currently used for facings. The trend toward using different facings for specific applications is likely to continue to evolve.

OSB Facings

There are two main reasons why OSB is the material of choice for SIP facings. First, it is an engineered wood product that has been extensively tested and found to be suitable for use as a load-bearing material. Second, it is readily available in the large sizes that are demanded by the SIP industry. OSB is not like any other glue and chip based panels, such as particle board, flakeboard, or waferboard. Since its invention in 1978, it has evolved into a high-tech panel that is changing to meet new demands.

Common thicknesses for OSB facings are 5/16 inch, 3/8 inch, 7/16 inch, 1/2 inch, 5/8 inch, and 3/4 inch. Theoretically, any of these thicknesses can be ordered for SIP's, but engineering test results aren't available for each panel thickness so the SIP's might not be covered under current code compliance reports. In addition, panels ordered in unusual thicknesses aren't as readily available as those ordered in standard thicknesses.

OSB panels used by the SIP industry have a fully waterproof bond and carry the Exposure 1 rating of the APA, meaning that they are designed for applications where long construction delays could result in significant exposure to the weather. Because of the tendency to absorb moisture on the edges and swell, many panels are treated with an edge sealant.

OTHER FACINGS

The technology is available to laminate many materials, such as aluminum and steel sheet metal, fiber reinforced plastic (FRP), various types of cement board and many plywoods and finish wood products, to foam cores. Some manufacturers produce a panel that has drywall as the interior facing. None of these are rated as a structural panel nor do they have a code listing, but they can be used as curtain wall panels and partitions when used with timber frames or structural-steel frames.

More and more, secondary laminations of materials onto one or both of the structural facings are becoming available. The main impediment to a larger variety of facings becoming rated for structural use is that each different configuration of panel has to undergo extensive testing required for CABO and ICBO code acceptance. Manufacturers are not willing to put forth this expenditure without some real volume demand for a particular configuration.

Once the SIP industry becomes a major player in the building materials supply chain, it will be reasonable to imagine that the panel buyer will be able to fill out an order form that specifies the type and the thickness of exterior facing material with options for added laminations. The same selection of structural and finish elements will likely be available for interior facings, and there's no reason why the buyer won't also be able to select the type and thickness of the core material. So, for example,, a buyer might be able to specify a cement tile backerboard for the exterior facing (for direct application of stucco), a 5 1/2 inch urethane core (for an R-33 wall insulation), and a fire retarding finish over the OSB interior facing (to speed interior finishing).

CORE MATERIALS

There are three main categories of foam cores: EPS, XPS, and urethane foam. Each has unique properties, but all provide the structural and fire resistance characteristics required by the various building codes while offering the dramatic energy efficiency associated with the SIP construction system. Additionally, compressed straw cores have some potential in the industry.

EPS

The BASF Corporation patented the first expandable polystyrene in 1950. Today, 85% of SIP's have an EPS core. EPS foam has a closed-cell, moisture resistant structure composed of millions of tiny air filled pockets; it is manufactured from beads that are formed by the polymerization of a styrene monomer along with an expansion agent. EPS foam is produced using a multistage process. During the preexpansion phase, polystyrene beads are heated beyond the glass transition temperature of polystyrene (194 degrees F. to 212 degrees F), while the addition of the expansion or blowing agent causes a very fine cellular structure to develop within the polymer. Because the blowing agent is EPS is pentane, a hydrocarbon gas found naturally in the environment, the EPS manufacturing process uses no chlorofluorocarbons (CFC) or hydrochloro-fluorocarbons (HCFC) products than can deplete the ozone layer.

During the second intermediate stage of production, the beads expand, which forms a closed-cell foam structure. As the foam cools, the blowing agent dissipated and some condensation occurs, causing negative pressure in the cells. Aid diffuses through the cells, stabilizing the beads and dissipating moisture into the atmosphere. These stabilized, expanded beads are then blown into a mold, there more heat and steam are applied and the beads expand further into large blocks up to 4 ft. by 4 ft. by 2ft. The blocks are set aside to stabilize and release the moisture injected by the steam process. Some newer "block plants" use vacuum assisted molds that are more energy efficient and reduce the overall production time.

Next, hot wire cutters are used to slice the blocks to the thickness of the SIP core. The hot wire cutting method is ideal for making panels because the hot wire leaves a flat, melted surface that gives an increased surface area for the glue to bond to. Most of the EPS foam used for SIP's has a density of 1 pound per cubic foot (pcf), giving it an R-value of 3.85 per inch thickness. Extensive third-party testing has shown that EPS and the chemically similar XPS are not susceptible to thermal drift, the tendency of an insulating material to lose insulating value over time.

XPS

Extruded polystyrene has been used as a core material in SIP's but it costs more than EPS and is currently not being used by the major SIP manufacturers. XPS has greater compressive strength, slightly higher R values per inch of insulation, and more resistance to water vapor than EPS. The material is used extensively in the manufacture of refrigeration walls and as a surface attached insulation material.

XPS is formed from polystyrene pellets that are heated and extruded into sheets, typically with a density of 1.5 pcf. After the XPS has aged for several months, the outgassing of the blowing agent levels off and a consistent R-value of 5.0 per inch is achieved.

When comparisons are made regarding compressive strength, flexural strength, and shear resistance, XPS performs almost twice as well as EPS. Given these properties, panels that use XPS as a core material should have increased spanning and load carrying capabilities. Some of this may be attributed to the higher density of the XPS material.

One of the limitations of XPS is that the extrusion equipment can produce only 4 inch thick sheets of the material. In addition, XPS isn't as dimensionally stable as the wire cut EPS cores and does not provide as flat a gluing surface as EPS. This can create some irregularities and perhaps interfere with the bond between the facings and the core. This in itself is a major drawback for use in structural panels and is one of the main reasons so little XPS is currently used in SIP's.

POLYURETHANE AND POLYISOCYANURATE

Polyurethane and polyisocyanurate are generally referred to as urethane and isocyanurate foams are chemically similar, but their manufacturing processes differ, as do some of their properties. They are both closed-cell foams containing a low conductivity gas in the cells; isocyanurates are produced using the polymerization method with isocyanurate molecules, whereas urethanes are polymerized with equal parts of isocyanurate and polyol molecules. The 100% isocyanurate foam is expensive to produce and has a low thermal conductivity but tends to break down over time. The urethane foam is less costly to produce and less susceptible to breakdown but does not produce as high an R-value per inch as does isocyanurate.

ADHESIVES

The final key ingredient in a SIP is the adhesive that bonds the facings to the core. This glue has to resist the forces of buckling and racking, resist moisture penetration, and keep the panel from delaminating. Two of the major suppliers of adhesives to the SIP industry claim that their adhesives are water based, solvent free, and don't have a negative impact on the environment. The companies are working closely with panel manufacturers to

keep up with the rapidly changing environment. Adhesive manufacturers can now formulate different setup times into the adhesives to either accelerate or retard the pot life of these sophisticated products. Urethane adhesives can bond metal and various types of plastic skins to foam cores, in the case of a structural panel, bond these different facings to the OSB structural skins. Along with the rest of the ingredients in a SIP, the adhesives are tested and monitored for code compliance.

PUTTING THE PIECES TOGETHER

Now that we have taken a look at the components of a SIP, let's see how they are assembled. The cast majority of SIP's consists of two OSB facings pressure-laminated with adhesives to an EPS foam core. Various size presses are used to apply this pressure to allow the panels to cure properly.

Currently, the industry standard is an 8foot by 24 foot panel. But now there are machines that can produce 9 foot by 24 foot, 10 foot by 28 foot, and even 10 foot by 36 foot panels. In addition, there are designs for a new generation of roller presses will utilize fast set reactive hot-melt urethane glues that will essentially be able to produce a continuous panel. Of course, new fabrication technologies are moderated by the realities and limitations of material shipping, handling, and placement.

A typical sequence for producing a group of SIP panels isn't complicated. First, the bottom facing is laid out in the assembly area. The desired core thickness pieces are run through the glue spreading machine, where the adhesive is applied to both sides of the core pieces. These core sections are placed on the bottom facing and then the top facing is positioned. This assembly is aligned before being moved into the press, which can typically accept up to a 60 inch high stack of panels. The assembly sequence is repeated until the specific stack is in place in the press.

Most presses in use today are pneumatic, with the air pressure applied evenly to the top or bottom platens until the required pressure is applied to the stack of panels. Different adhesives have different setting times; which will determine how long the pressure is applied. Curing times are determined by temperature and humidity.

TEST RESULTS

One concern about a relatively new product like SIP's is the reliability of the finished product. Has this product been thoroughly tested? Will it stand up over time? The next section will examine the extensive testing that has been undertaken by SIP manufacturers and explain how to interpret the results. These tests are designed to see how these panels perform when subjected to forces found in the real world.

TRANSVERSE LOAD TEST

The transverse load is the applied load on a floor or a roof; it is the combination of the dead load (the weight of the assembly) plus the live load (people, objects, and snow, with

will vary, and a calculation of the wind load). The allowable load is determined by setting up the span to be tested, then uniformly loading the assembly to the point of failure. That figure, which is measured in pounds per square foot (psf), is divided by a safety factor of 3 to establish the allowable load for the assembly of that span.

The allowable deflection of the panel is measured by taking the length of the span and dividing by a deflection factor ($L/480$, $L/360$, $L/240$, or $L/180$, where L is the span). The larger the denominator in this equation, the stiffer the assembly. Typically, $L/360$ is used to calculate floor loads and $L/420$ to calculate roof loads. The test criteria is ASTM E-72, "Acceptance Criteria for Sandwich Panels".

When designing for load spans in different parts of the country, span charts that are representatives of results for the EPS panel industry can be very useful. SIP's are engineered products, and it's important to work with the panel manufacturer or an engineer when calculating the actual loads of your building. For example, in the Midwest there is a moderate snow load factor, so the design should for 50 psf of total load. If there is a span of 10 ft. from ridge to eave and the R-value of R-30, then calculate with the roof load chart for a 7 1/4 inch core (r-30) panel at $L/240$ and follow the 10 foot span row to see that this assembly will give an extra load capacity of 68 psf. The span could even be extended to 12 foot and still have an allowable load of 56 psf.

AXIAL LOADS

The compressive force that puts load on a wall is called the axial load. This is measured in pounds per linear foot (plf). The standard test that panel manufacturers have to comply with is ASTM E-72. Section 9, amended by ICBO "Acceptance Criteria for Sandwich Panels," section 4.4. Loads are measured by situating four "compressometers"- two on each side to measure deformation in a vertically oriented panel. The load is applied uniformly in 100-ound increments along the top of the panel being tested until either the panel deflects 3/4 inch or the panel fails.

In one example, that is representative of SIP performance, PFS Corporation testing service conducted a series of tests on a 4x20x49/16 thick with a urethane form core manufactured by Winter Panel. The average load to 3/4 inch deflection was 10,300 lb. The average maximum load to fracture point was 23,000 lb. Dividing this figure by the 4ft. of panel width gives a figure of 5,750 plf. Dividing that number by the safety factor of 3 gives a working allowable load of 1,917 plf.

When conducted on panels from different manufacturers with different core thicknesses and core materials, this same axial loading test resulted in similar allowable loads in the range of 2,000 plf. That load rating would be the equivalent of a typical bearing-wall loading for a three story building.

RACKING RESISTANCE

Racking or Shear Resistance is the ability of an assembly to withstand horizontal forces applied to a structure by earthquakes and high winds. This is where the most important differences between SIP construction and conventional framing methods show up. The standard ICBO and BOCA approved test is ASTM E-72-80. "Conducting Strength Tests of Panels for Building Construction," section 14. In this test, 2 4x8x 41/2 inch SIP's are

assembled and locked into place. Then force is applied to the top corner, in a series of tests conducted in 1995 by PFS Corporation on panel manufactured by W.H. Porter Inc., assembly failure occurred at an average load of 10,700 lbs. Here, failure is defined as the point where the fasteners pulled out of the bottom edge of the panel and along the center seam. Dividing this figure by the safety factor of 3 gives 3,566 lb. This figure is again divided by 8 (the length of the assembly) to arrive at an allowable load of 446 plf before failure. The average allowable racking resistance for the tested panels was about 400 plf.

As a comparison, the APA-Engineered Wood Association offers test results for the following assembly, which is the standard wall construction currently used. It consists of an 8x8 foot wall composed of 2x4 bottom and top plates, double end studs, and studs, 16-in. o.c. along the assembly. Using 8d nails, ½ inch plywood was applied at 6-in. spacing around the perimeter and at 12-in. spacing throughout the field; this assembly reached the failure point at 4,744 pounds of applied pressure. When this figure is divided by the safety factor of 3 and the length of 8 ft., an allowable load for this type of wall is calculated to be 197 plf.

So, right off the truck and installed in the basic configuration, a SIP has an allowable load factor of 446 plf compared with the standard wall value of 197 plf. This difference is clearly evident in a SIP structure that is exposed to high winds: the absence of creaks and groans is very noticeable. This is also why a SIP building has few or no drywall callbacks due to cracking or fasteners backing out. The failure locations along the bottom edge of the panel assembly also point out that the addition of steel strapping or other holding down methods will add significantly to the lateral resistance to shear forces in the structure.

TENSILE STRENGTH

SIP manufacturers subject their products to another test to determine the strength of the lamination and of the core material itself. The accepted ASTM C-297 test for dry tension determines how much force it takes to pull the SIP apart in the cross section. Selected 2 in. by 2 in. cross sections are carefully removed from various parts of a test panel. These samples are then surface attached to the testing equipment and pulled until either the core shears or the facings delaminate. The dry tension result on a Inter Panel Corporation SIP with a 3, 9/16th inch urethane core was an average of 87 lb. In all of the 10 tests performed on these samples, the core sheared before the skins delaminated, clearly demonstrating the structural integrity of these panels.

FIRE HAZARD

The issue of how a material performs in the presence of fire is a primary concern to the code authorities as well as to the manufacturers of products that are used in the construction of homes and other buildings, there are a number of ways to test both the cores themselves and the panels as wall and roof assemblies.

Before considering SIP panels for your project, contact the manufacturer for fire safety test results. Reputable companies will be happy to provide you with an extensive array of information about testing procedures and results. Test results indicate that a SIP system can be designed to meet current codes for fire resistant wall assemblies.

A SIP wall with ½ inch drywall on the interior surface will meet the mandated 15 minute resistance required for residential structures. A 1/10 inch thick, factory applied “fire finish” coating will also meet the 15 minute fire requirement. A two layer surface of 5/8 inch type X drywall or one layer of type C drywall will meet the requirements for a one hour rated wall assembly. Tests indicate that a SIP structure performs safely in a fire situation because the walls have no air cavity to spread the fire and the airtight construction will quickly starve a fire of oxygen. Another concern in a fire situation is the toxicity of the burning material. Current BOCA codes have deleted requirements for combustion toxicity because there is no acceptable test protocol simulating actual fire conditions. But some studies that have been done on combustion toxicity suggest that most SIP core materials are no more hazardous than other common building materials.

In all testing categories, SIP’s performed above the standards set by the governing bodies. It is clear that manufacturers and others involved in the SIP industry strongly believe in their products and are dedicated to making SIP’s the building material of the future.

DESIGN CONSIDERATIONS AND OPPORTUNITIES

Many people unfamiliar with new building technologies confuse SIP building systems with prefab or modular construction methods. This confusion can lead to the mistaken impression that the SIP system is “cheap” construction and that the type of style of buildings constructed with SIP’s are limited. Actually, modular production and SIP’s are two very different approaches. In this section, we will compare approached to factory built components, take a look at the advantages for designers using SIP’s and show how SIP’s can be used in various types of buildings.

SIP’s: AN INTEGRATED SYSTEM

Modular buildings are mass produced to take advantage of the cost savings realized by producing a great number of the same thing. Modular building sections are prefabricated in a controlled factory setting, then transported to the job site and erected. This approach shortens the erection time, but any savings realized here are offset by the difficulty of making a tight building because there is no way to wrap a building/vapor membrane around corners that have completed trim and siding.

In fact, modular buildings are virtually identical to stick built structures constructed onsite, having the same problems of making them straight, level, and airtight during construction and with the additional problem of transportation to the site that can result in loosened joints and out of square conditions. This cookie-cutter, mass-production approach limits the design choices available to potential homeowners and all too often results in the repetitive houses commonly seen in urban America.

SIP design and construction, on the other hand, take advantage of the modern approach to production, where communication between the design team, sales team, and the production team are all linked horizontally. When an order comes into the design department is a SIP manufacturer/fabricator, the time line starts. If the plans have been drawn with SIP’s in mind, then the job goes directly to the production department for

scheduling. If the plans need to be modified to work with the SIP system, the design department takes the job and works with the engineering department to make the job compatible. This usually won't affect the look of the project, although some details may need to be modified to work with the SIP system. When a project is designed with SIP components from the start, the size and spanning capabilities of SIP's can be fully utilized. The flexibility of the CAD design process can be conceived, designed, modified, delivered, and built in significantly less time than a conventional structure.

This rapid communication means that each SIP project can be uniquely designed and custom built to architect or designer provided specifications. At the other end of the scale, production speed and fabrication capabilities mean that high quality, energy efficient components are available with which to build affordable housing. Design flexibility and production capabilities inherent in the SIP system make it attractive for both custom buyers and those interested in affordable housing.

SELLING SIPS TO THE DESIGN COMMUNITY

Given the benefits of building with SIP's, you may well ask why the design community has been slow to utilize them in the design of residential and light commercial buildings. Many architects simply don't know about this class of products and their capabilities. Some share a misconception with the general public that the use of SIP's is limited to simple shapes and that they aren't flexible enough to be used for innovative or unusual designs. Many architects want to see a product establish a track record in the working world before incorporating that product into their design work. But the number of architect designed residences nationwide is relatively small: only about 5% of all houses built. Why haven't builders themselves embraced SIP's, considering the inherent advantages of building with this system? For one, innovations in construction practices traditionally come into the industry from the top down, that is, architects and designers rather than contractors and home buyers incorporate the new ideas that result from new technologies, which then filter down and are adapted by the general public.

In addition, many builders won't work with architects, feeling that money spent on design fees is money out of their pockets. They see no added value in having involved when they have built the same house over and over and can still sell those houses as fast as they can build them. But that situation is changing as designers and builders alike are learning about SIP's and incorporating them into projects that are successful and profitable.

The question is how to educate architects about SIP technology. One step in that direction is a requirement for continuing education for practicing architects adapted by the American Institute of Architects (AIA) in 1993, which is intended to encourage them to embrace new technologies that come into the marketplace. Some SIP suppliers are tapping into this program as a way to get their message out to professionals. For example, the Associated Foam Manufacturers (AFM) recently subsidized the development of a CC-Rom about the history and use of SIP's using this as a part of presentations for architects and other professionals in the design community. While programs like this help keep architects abreast of current materials and practices, the real

key is for builders and suppliers to establish relationships with architects and help them to incorporate SIP's into their work, simply because it is a better way to build buildings.

DESIGN ADVANTAGES OF SIP'S

When polled, builders and architects experienced in the SIP construction process responded with the knowledge that SIP's offers numerous advantages to clients. Some mentioned that building with SIP's is a resource efficient building. Others liked the speed of SIP erection. But almost all these professionals pointed out that SIP's are only one component in the overall design of a building. To fully utilize the benefits offered by these panels, they must work in conjunction with siting, HVAC requirements, windows, and the other components used in the making of a building.

SIPS ARE AN ENGINEERED SYSTEM

A SIP house is a tighter, more energy-efficient house than a stick-build one because it is engineered more precisely. While straight walls and roofs are taken for granted by home buyers, they are more and more difficult to produce with today's erratic lumber supply and conventional framing systems. But CAD drafting systems help detail the SIP fabrication process, allowing precise instructions to be sent to the SIP manufacturer for foam relief and spline setup. The result is a SIP package that is built to 1/8 inch tolerances, this precision makes for well built houses, a refreshing approach when the industry standard today for framing tolerances is 1 in. A straight and true building shell gives every other trade a better chance to do their best work too.

SIP's can be used to form an excellent structural and thermal envelope that allows other aspects of energy efficient design to be utilized. SIP's should be considered the core material for building a home, while all the technology and components in the marketplace are worthy add-ons. If clients are interested in an energy efficient building, they will likely want better windows, more efficient heating and cooling systems, and insulated concrete form basement, and good passive solar design.

In addition to the relatively high insulating values per inch of EPS and urethane cores there is another thermally related advantage of SIPs that translated into energy efficiency. The moisture permeability of a SIP panel is very low, which changes a number of design aspects, especially the roofs. For example, the old question of cold roof versus hot roof doesn't need to have a definitive answer in a SIP system. Here's why: Buildings, especially residences produce a large amount of moisture daily from cooking, from showers, and from the breathing of the inhabitants. As that moisture migrates through the wall and roof of a conventional structure, it gets trapped by the exterior vapor barrier, condensing when it contacts any surface with a much different temperature. This, in turn, causes mildew, dry rot, and premature failure of building components. This is a big problem that is often ignored in conventional construction, with predictable, disastrous results.

One answer to moisture control has been elaborately designed, expensive ways to vent this moisture outside. The difficulty of venting is compounded in a roof with hips and valleys because there is no straight, open channel from eave to ridge to create an airflow path. A SIP roof system eliminates these problems.

Even though the SIP's themselves having low moisture permeability, the differential pressure generated within a building tries to force moisture through joints in their panels. This accelerated moisture concentration can cause deterioration of the exterior facings of the panels and has led to some replacement of roof panels. This approach to keeping moisture away from the roof is very different than typical venting of a stick built roof. It simplifies both the construction and the detailing because no vents are necessary at the eaves or ridge.

Of course, the moisture is still inside a SIP building. A well built SIP house can have air change per hour rates of less than 1.0. So, the best way to control moisture is to use an air-to-air heat exchanger that allows a constant air change to take place in the house, removing stale and humid air while retaining some of the inside air temperature before it exhausts.