Use of Structural Insulated Panels (SIPs) in Seismic Design Categories

Date: December 12, 2011

Building with structural insulated panels (SIPs) in seismic design categories D, E and F is permitted when building code compliance is demonstrated through a manufacturer evaluation report.

Section R613 of the 2009 International Residential Code (IRC), Structural Insulated Panel Wall Construction, has limits for the use of SIPs. Section R613.2 Applicability Limits states that SIPs shall be limited to sites subjected to seismic design categories A, B or C. Some building code jurisdictions have interpreted this to mean that SIPs cannot be used in Seismic Design Categories D, E, and F. In order to clarify this, the ICC staff was asked for an interpretation of this section. The response from Larry Franks of the ICC staff follows:

> *In response to your question, per your e-mail of March 28, 2011, we offer the following opinion of the meaning and intent of the code on this subject. It is my understanding that your e-mail poses the following question:*
>
> *Q: Does the 2009 IRC permit structural insulated panel (SIP) wall construction beyond the applicability limits specified in Section R613.2?*
>
> *A: Yes. Section R613 is a prescriptive design for SIP wall construction based on the limits established in Section R613.2. In accordance with Section R301.1.3, a building that contains structural elements not conforming to the prescriptive limits of the code is acceptable if designed in accordance with accepted engineering practice. Also, Section R104.11 permits the use of SIP wall construction beyond the applicable limits of Section R613.2.*
>
> *This opinion is based on the information which you have provided. We have made no independent effort to verify the accuracy of this information nor have we conducted a review beyond the scope of your question. As this opinion is only advisory, the final decision is the responsibility of the designated authority charged with the administration and enforcement of this code.*

In order to show compliance to IRC Section 104.11 as noted above, additional information must be supplied by the SIP manufacturer. Most commonly a research report (evaluation report) obtained from a recognized agency such as ICC-ES or NTA is supplied to demonstrate the use of SIPs in Seismic Design Categories D, E, and F.

ICC-ES publishes evaluation reports in compliance with the ICC ES AC04 Acceptance Criteria for Sandwich Panels. AC04 Appendix A Section 4.5.1 says that structural insulated panels evaluated in accordance with the requirements set forth in Appendix A are permitted to be used as shear walls in all Seismic Design Categories. The basis of Appendix A is IRC Section R104.11.

In a similar manner, NTA publishes evaluation reports following NTA IM14 SEP01 to demonstrate the use of SIPs in Seismic Design Categories D, E, and F.

Therefore, SIPs can be used in seismic design categories D, E and F if the manufacturer obtains a recognized code report from ICC-ES or NTA.

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Fire Safety with Structural Insulated Panel Construction

Date: December 15, 2011

Fire safety is an important and potentially life-saving issue for homeowners, fire fighters, and building code officials. When constructed to the requirements of the applicable building code, homes built with structural insulated panels (SIPs) provide occupants with adequate protection in the event of a residential fire.

Building Code Compliance

The International Building Code (IBC) classifies buildings into various Types (I, II, III, IV, or V). Each Type has various construction limitations that include items such as building story height, square footage, and construction materials. Most wood frame buildings are classified as Type V.

Similar to conventional wood frame construction, SIPs with oriented strand board (OSB) facings are classified as Type V construction under the IBC. Type V construction permits the use of combustible materials such as OSB and wood framing. Both SIPs and conventional wood frame buildings present a manageable fire risk when their construction meets the fire precautions listed in the building code.

Fire precautions for SIP homes include:

- Application of a 15-minute fire-resistant thermal barrier on the interior, such as 1/2-in. thick gypsum board or a material of equivalent thermal performance
- Properly installed and protected electrical systems and appliances
- Properly installed and protected natural gas appliances
- Smoke alarms

In addition, fire safety is greatly improved when a number of precautions are taken by building occupants, such as the proper handling and storage of flammable materials as well as the safe use of both natural gas and electrical appliances.

Light commercial or multi-use buildings of Type V Fire Rated construction may require a one-hour fire rating and/or sprinkler systems. When a one-hour fire rated assembly is required, SIP manufacturers can provide tested assemblies for both walls and roofs that meet the one-hour fire resistance tests outlined in ASTM E 119. Check with your local manufacturer for available assemblies.

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SIPs and ENERGY STAR v3

Date: January 30, 2012

The Environmental Protection Agency's ENERGY STAR for New Homes program provides guidelines and verification methods for new homes that are at least 15 percent more energy efficient than the 2004 International Energy Conservation Code (IECC).

Beginning on January 1, 2012, all new homes must follow the ENERGY STAR Version 3 guidelines that include higher insulation levels and an expanded thermal enclosure checklist. Building with structural insulated panels (SIPs) allows builders to meet these requirements faster and easier than with traditional wood framing by creating a well-insulated and airtight building enclosure in a single step.

Builders have the option of constructing a home to the prescriptive requirements of the ENERGY STAR Reference Design or demonstrating that their home meets the equivalent performance of the Reference Design through energy modeling. Both methods require inspection by a RESNET certified home energy rater.

Prescriptive Path

Insulation: The building enclosure must be insulated to meet the 2009 IECC. ENERGY STAR allows builders to demonstrate compliance using an alternative equivalent UA calculation that accounts for the lack of thermal bridging in continuous insulation assemblies like SIPs.

Air infiltration: ENERGY STAR qualified homes are subject to a blower door test that determines the amount of air infiltration. SIPs have a well-established track record of testing below 2 ACH50, and experienced SIP crews routinely build homes that test between 0.5 and 1 ACH50. Simply installing SIPs per the manufacturer's specifications will easily meet the ENERGY STAR air infiltration requirements without any of the additional air sealing measures typically needed on wood frame homes.

Air Infiltration Rates

Climate Zone	Air Infiltration Rate
1,2	6 ACH50
3,4	5 ACH50
5-7	4 ACH50
8	3 ACH50

Ductwork in conditioned space: Placing ductwork in the conditioned attic space created by a SIP roof bypasses the ENERGY STAR requirement of insulating ductwork. In hot climates, the Prescriptive Path requires a radiant barrier if more than 10 feet of ductwork is placed in an unconditioned attic. If both the ductwork and air handler are placed in conditioned space, duct leakage testing can be waived.

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Thermal Enclosure Checklist

All ENERGY STAR homes are subject to a visual inspection of the building enclosure following the Thermal Enclosure Checklist that examines common areas for thermal bypasses and air leakage. A complete SIP building envelope makes passing the inspection virtually automatic.

Insulation: All insulation must meet RESNET Grade I, meaning that cavity insulation must fill the entire cavity without any sizable gaps or compression. The exception is homes with insulated sheathing, where Grade II is permitted. SIPs deliver Grade I insulation every time, without relying on the work of subcontractors.

Fully-aligned air barriers: The checklist names a number of locations where a complete air barrier must be installed that is fully aligned with the insulation. This includes attic knee walls, skylight shaft walls, and installing wind baffles on attic eaves. With SIPs, the insulating foam core is fully encased in a code-compliant air barrier of oriented strand board (OSB), so no additional effort is needed to meet this requirement.

Air sealing: ENERGY STAR identifies several mandatory air sealing measures for wood framing, including sealing top and bottom plates, caulking sheetrock to top plates at attic-to-wall interfaces, sealing wiring penetration, and many others. SIPs require their own sealing measures per manufacturer's specifications, but because they are manufactured in large sections (up to 8' x 24') there are fewer gaps to seal.

Reduced thermal bridging: Builders using wood framing are required to implement a number of advanced framing methods to reduce thermal bridging. For conventional framing, the checklist requires insulated headers, insulation at corners, and reduced window and door framing. Alternately, builders can add insulated sheathing, use double wall construction, or build with SIPs.

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SIPs and the 2009 IECC

Date: Revised August 6, 2012

In January of 2009, the International Code Council released the 2009 International Energy Conservation Code (IECC). The 2009 version of the code marks a 12 to 15 percent increase in residential energy efficiency over the 2006 version. For residential builders, complying with the 2009 IECC may require changes in their current building practices as it is adopted by local jurisdictions across the country. Faced with these additional measures, more and more builders are looking at structural insulated panels (SIPs) as a simple solution for energy-efficient building enclosures. SIPs can save builders time and money when it comes to meeting the 2009 IECC.

Residential Building Enclosures

The prescriptive building enclosure requirements in the 2009 IECC require more insulation and lower fenestration U-factors in some climate zones (Table 402.1.1). SIPs provide continuous insulation that can help builders meet these increased requirements through either the total UA alternative method (Section R402.1.4) or the simulated performance alternative (Section R405).

The total UA alternative method accounts for the thermal bridging in wood frame wall assemblies and in some cases allows builders to use SIPs with a nominal R-value lower than what is specified for cavity insulation (Section R402.1.4). Under the simulated performance alternative, energy modeling software is used to compare the energy use of a SIP home to the standard reference design.

2009 IECC Residential Code Compliance with SIPs

Climate Zone	2009 IECC Wood Frame Wall R-Value	SIP Wall Thickness (EPS/PUR/XPS)	2009 IECC Ceiling R-Value	SIP Roof Thickness (EPS/PUR/XPS)
1	13	4”/4”/4”	30	8” - 10”/6”/6”
2	13	4”/4”/4”	30	8” - 10”/6”/6”
3	13	4”/4”/4”	30	8” - 10”/6”/6”
4 except Marine	13	4”/4”/4”	38	10”/8”/8”
5 and Marine 4	20 or 13+5	6”/4”/4”	38	10”/8”/8”
6	20 or 13+5	6”/4”/4”	49	12”/8”/10”
7 and 8	21	6”/4”/4”	49	12”/8”/10”

R-values may vary by SIP manufacturer and will vary by actual SIP thickness. Table is based on minimum R-values. Please consult SIP manufacturers for individual product R-value information and code compliance. Calculations based on Total UA Alternative method (IECC, Section R402.1.4) using REScheck.

Building enclosure requirements under the residential performance path have also been increased in the 2009 IECC. Builders can no longer trade off efficient HVAC equipment for building envelope performance, and the assumed window area of the standard reference design has been decreased to 15 percent of the home’s floor area (Table 405.5.2). Under the performance path, the continuous insulation and airtightness of a SIP building enclosure offer builders a helpful boost towards meeting the required energy performance.

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Whole House Air Infiltration

A major addition to the 2009 IECC is the examination of whole house air infiltration by either blower door testing or a visual inspection of the building enclosure (Section 402.4.2). Builders opting for blower door testing must reach an air infiltration rate of 7 air changes per hour at 50 Pa (ACH50) or less. A SIP building enclosure that is installed to the manufacturer's specifications will easily meet this level of airtightness.

Alternately, a building inspector can visually verify proper air sealing at a number of locations listed in Table R402.4.2. Insulation must be in full alignment with an air barrier and properly installed in often ignored situations such as small cavities, knee walls, and behind showers. SIPs deliver continuous insulation that is fully enclosed with OSB—a code-compliant air barrier. With a full SIP building enclosure, many problem areas are inside conditioned space and do not require any additional effort.

Duct Insulation and Sealing

Supply ducts need to be insulated with R-8 duct insulation, and all other ducts need to be insulated with R-6 insulation unless they are located in conditioned space (Section R403.2.1). Placing ducts in the conditioned attic created by a SIP roof avoids this requirement. If the ducts and air handler are located in conditioned space, the builder can avoid the duct leakage testing requirement as well (Section R403.2.2).

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SIPs and the 2012 IECC

Date: Revised August 6, 2012

In May of 2011, the International Code Council released the 2012 International Energy Conservation Code (IECC). The 2012 version of the code contains a number of increased energy efficiency requirements, accounting for an approximately 30 percent rise in energy efficiency for residential buildings over the 2006 IECC and 15 percent over the 2009 IECC.

For residential builders, the 2012 IECC may require changes in their current building practices as it is adopted by local jurisdictions across the country. As energy standards increase, more and more builders are looking at structural insulated panels (SIPs) as a simple solution for energy-efficient building enclosures. SIPs can save builders time and money when it comes to meeting the 2012 IECC.

Insulated building enclosure

The 2012 IECC raises the required insulation levels for some climate zones. In extremely cold climates, exterior insulation is required (Table 402.1.1). By providing continuous insulation, SIPs allow builders to meet these requirements without the added step of installing exterior insulation. This adds to the labor savings gained with SIP construction, determined by a third party R.S. Means study to be over 50 percent faster than wood framing.

SIPs can help builders meet these increased requirements through either the total UA alternative method (Section R402.1.4) or the simulated performance alternative (Section R405). The total UA alternative method accounts for the thermal bridging in wood frame wall assemblies and in some cases allows builders to use SIPs with a nominal R-value lower than what is specified for cavity insulation. Under the simulated peformance alternative, energy modeling software is used to compare the energy use of a SIP home to the standard reference design.

2012 IECC Residential Code Compliance with SIPs

Climate Zone	2012 IECC Wood Frame Wall R-Value	SIP Wall Thickness (EPS/PUR/XPS)	2012 IECC Ceiling R-Value	SIP Roof Thickness (EPS/PUR/XPS)
1	13	4”/4”/4”	30	8” - 10”/6”/6”
2	13	4”/4”/4”	38	10”/8”/8”
3	20 or 13+5	6”/4”/4”	38	10”/8”/8”
4 except Marine	20 or 13+5	6”/4”/4”	49	12”/8”/10”
5 and Marine 4	20 or 13+5	6”/4”/4”	49	12”/8”/10”
6	20+5 or 13+10	6” - 8”/4” - 6”/6”	49	12”/8”/10”
7 and 8	20+5 or 13+10	6” - 8”/4” - 6”/6”	49	12”/8”/10”

R-values may vary by SIP manufacturer and will vary by actual SIP thickness. Table is based on minimum R-values. Please consult SIP manufacturers for individual product R-value information and code compliance. Calculations based on Total UA Alternative method (IECC, Section R402.1.4) using REScheck.

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Whole house air infiltration

The 2012 IECC requires that all homes undergo a blower door test to measure air infiltration. In climate zones 1 and 2, homes must test at 5 air changes per hour at 50 Pa (ACH50) or less, and at 3 ACH50 or less in all other climate zones (Section R402.4.1.2).

Whereas wood frame wall systems require extra air sealing measures, a SIP building envelope that is installed to the manufacturer's specifications will easily meet these air infiltration standards.

Complete air barrier

In addition to verifying air infiltration by blower door testing, Table R402.4.1.1 lists a number of locations where the air barrier and insulation are visually inspected. Insulation must be in full alignment with an air barrier and properly installed in often ignored situations such as small cavities, knee walls, and behind showers. SIPs deliver continuous insulation that is fully enclosed with OSB—a code-compliant air barrier. With a full SIP building enclosure, many problem areas are inside conditioned space and do not require any additional effort.

Duct insulation and sealing

Supply ducts need to be insulated with R-8 duct insulation, and all other ducts need to be insulated with R-6 insulation unless they are located in conditioned space (Section R403.2.1). Placing ducts in the conditioned attic created by a SIP roof avoids this requirement.

Duct leakage limits have been reduced in the 2012 IECC (Section R403.2.2). If the ducts and air handler are located in conditioned space, the builder can avoid the duct leakage testing requirement as well.

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Formaldehyde Emissions and Exemptions

Date: Revised August 6, 2012

Structural insulated panels (SIPs) are a popular option for sustainable construction. SIPs provide an energy-efficient and airtight building enclosure that helps maintain healthy indoor air quality for building occupants.

One of the primary components of most SIPs is oriented strand board (OSB). The following information from APA–The Engineered Wood Association addresses indoor air quality concerns related to OSB and explains why plywood and OSB manufactured to U.S. Product Standards PS 1 and PS 2 have such low emission levels that they are exempt from the leading formaldehyde emission standards and regulations.

What is Formaldehyde?

Formaldehyde is a simple chemical made of hydrogen, oxygen, and carbon. It occurs naturally, and is the product of many natural processes. It is made by our bodies and is in the air. Plants and animals also produce formaldehyde. It is in many fruits and vegetables, and is a byproduct of cooking certain vegetables, such as Brussels sprouts and cabbage. This chemical breaks down quickly and is metabolized to simple carbon dioxide. Our bodies readily break down the low levels to which we are exposed everyday.

Formaldehyde is also a product from combustion associated with the burning of kerosene and natural gas; automobile emissions; and cigarettes. It is an important industrial chemical used in the manufacture of numerous consumer products, including permanent press fabrics and even toothpaste.

How Much Formaldehyde is in Wood?

All wood species, and therefore all wood products, contain and emit small amounts of formaldehyde. Because formaldehyde occurs naturally in wood, there is no such thing as “formaldehyde-free” wood. An oak tree, for example, emits 0.009 parts per million (ppm) of formaldehyde. By itself, this is a very low quantity, but densely wooded areas can have much higher concentrations. It follows that any wood cut from that oak tree also contains small amounts of formaldehyde, as do all wood products.

Formaldehyde Regulations and Structural Wood Products

Structural wood products such as plywood and oriented strand board (OSB) are manufactured to meet stringent product standards, including Voluntary Product Standard PS 1-07 for Structural Plywood and Voluntary Product Standard PS 2, Performance Standard for Wood-Based Structural-Use Panels. Because wood products produced under these standards are designed for construction applications governed by building codes, they are manufactured only with moisture-resistant adhesives that meet Exterior or Exposure 1 bond classifications. These adhesives, phenol formaldehyde and diphenylmethane diisocyanate (MDI), are chemically reacted into stable bonds during pressing. The final products have such low formaldehyde emission levels that they easily meet or are exempt from the world’s leading formaldehyde emission standards and regulations:

- **U.S. HUD Manufactured Housing Standard**
  This standard specifies a 0.20 ppm emission limit for (non-structural) plywood using the ASTM E1333 method. Because of its extremely low formaldehyde emission levels, phenolic-bonded structural plywood is exempt from the testing and certification requirements of the standard. While there is no specific limit stated for OSB, it has been well accepted that the stated exemption for panels that use phenolic adhesives is applicable to OSB products meeting Voluntary Product Standard PS 2.

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- **California Air Resources Board (CARB) Air Toxic Control Measure for Composite Wood Products**
  This regulation, developed by a division of the California EPA and scheduled to take effect January 1, 2009, is considered the most stringent formaldehyde emissions regulation in the United States. In recognition of the different formaldehyde emission levels of different types of wood products, definition No. 8 of the regulation explicitly exempts "structural plywood," "structural panels," "structural composite lumber," "oriented strand board," "glued laminated timber," and "prefabricated wood I-joists."

SIPs and Formaldehyde Off Gassing

An independent test found that the amount of formaldehyde emitted by newly manufactured SIPs was below detectable levels, or less than 0.03 ppm. The test was performed by certified testing agency NTA, Inc. in accordance with ASTM E1333: Standard Test Method for Determining Formaldehyde Concentrations in Air and Emission Rates from Wood Products Using a Large Chamber.

References

1. *APA Technical Report: Structural Wood Panels and Formaldehyde*, Form SPE-1040

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Wall Aspect Ratios for SIPs

Date: Revised June 30, 2014

Question: A frequent question posed by design professionals is what wall aspect ratios are applicable to SIPs? A wall aspect ratio is defined as the ratio of the height of the wall segment to its length measured parallel to the wall line. For example a wall segment having a height of 8 ft. and a length of 4 ft. has an aspect ratio of 2:1. Similarly a wall with a height of 8 ft. and a length of 32 in. has an aspect ratio of 3:1. The length of the wall is also often referred to as the width of the wall.

Response: Aspect ratios applicable to SIP wall segments depend on whether the wall is being analyzed as a prescriptive braced wall in accordance with the 2012 IRC or as an engineered shear wall per the 2012 IBC. It is noted that the IRC and IBC provisions for SIPs only apply to SIPs with wood structural panel facers and a foam core.

Prescriptive Braced Wall Segments:

The 2012 IRC identifies 16 distinct wall bracing methods in Section R602.10.4 with minimum braced lengths of 48 in. for some panel-type methods or an aspect ratio of 2:1. Section R602.10.4.2 provides for a continuous sheathing bracing method using wood structural panel sheathing (the CS-WSP method) that allows a braced length of 24 in. or an aspect ratio of 4:1 for an 8 ft. wall. But there are some limitations to this 24 in. element such as being next to a garage door in Seismic Design Categories (SDCs) A-C. The CS-WSP method also permits a braced wall length of 24 in. in an 8 ft. wall next to an opening less than or equal to a 64 in. high such as a window, which is shown in Table R602.10.5. Placed next to an opening up to a height of 80 in., such as a door, the minimum length is 32 in. or a 3:1 aspect ratio.

Section R613.5.3 of the 2012 IRC states that SIP walls shall be considered as “continuous wood structural panel sheathing” (CS-WSP method) for purposes of computing required wall bracing. Therefore, a SIP wall following the prescriptive requirements of the 2012 IRC can have a braced length as narrow as 24 in. or an aspect ratio of 4:1 under certain circumstances such as garage doors in low SDCs or applications next to windows up to and including 64 in. in height, or an aspect ratio of 3:1 adjacent to full height door openings up to 80 in. without limit.

Engineered Shear Walls:

The 2012 IBC refers designers to the 2008 ANSI/AF&PA Special Design Provisions for Wind and Seismic (SDPWS) for requirements on the design of lateral force resisting systems including wood frame shear walls and wood frame diaphragms. Table 4.3.4 of the 2008 SDPWS provides maximum shear wall aspect ratios for 7 different wall sheathing types.

For blocked wood structural panels, the aspect ratio can be as high as to 3.5:1. For designs resisting seismic forces, the shear wall aspect ratio shall not exceed 2:1 unless the nominal unit shear capacity is multiplied by 2b/h where b is the length of the shear wall segment and h is the height.

There is no specific mention of SIPs as a wall sheathing type in Table 4.3.4 and an interpretation whether the SIP can be considered as a blocked wood structural panel system is necessary.

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Recent Shear Wall Research:

To further evaluate the performance of a SIP shear wall with openings, a study was completed at the Home Innovation Research Labs (formerly the NAHB Research Center). This study addressed the aspect ratio limitations imposed on the SIP shear walls by product evaluation agencies. The NTA listing reports limits the aspect ratio to 2:1 for low seismic risk areas and 1:1 for high seismic risk areas. Many ICC-ES evaluation reports currently limit the aspect ratio for SIP shear walls to 1:1. These limitations have significant implications for engineered shear walls in nonresidential and residential construction where narrow aspect ratio segments are common as a result of doors and windows closely spaced or placed near building corners.

The 2013 study evaluated a series of walls with various openings and aspect ratios in 2013 and the results were reported in HIRL Report "SIP Shear Walls: Cyclic Performance of High Aspect Ratio Segments and Perforated Walls." Testing was conducted in accordance with general provisions of ASTM E 2126-11 "Standard Test Methods for Cyclic (Reversed) Load Test for Shear Resistance of Walls for Buildings."

A key objective of this study was to determine the applicability of applying the perforated shear wall (PSW) method to SIP shear walls based on an initial limited set of perforated shear walls with high aspect ratio segments. The PSW method is a widely used design method in the 2008 ANSI/AF&PA Special Design Provisions for Wind and Seismic (SDPWS). For the walls evaluated in this study the results confirmed that perforated SIP shear walls closely follow the overall PSW method trend for both strength and stiffness.

Summary:

For residential construction, SIPs used in accordance with the wall bracing provisions of the 2012 IRC can be considered as being equivalent to continuously sheathed wood frame walls with aspect ratios as high as 4:1 under certain circumstances and 2:1 without limit.

For nonresidential construction governed by the 2012 IBC an interpretation is required as to whether the maximum shear wall aspect ratios of Table 4.3.4 of the 2008 ANSI/AF&PA SDPWS apply to SIPs. However, the results of the HIRL study reported above strongly support the use of the PSW method for the design of SIP shear walls.

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Durability of SIPs Exposed to Moisture

Date: November 8, 2012

Question: As with all construction materials, structural insulated panels (SIPs) are occasionally subjected to moisture exposure during the construction process. The construction process includes transportation of the SIPs to the jobsite, temporary storage prior to erection and exposure to the elements prior to being protected with the appropriate wall or roof covering. Virtually all product standards for wood-based products acknowledge that the products may be exposed to moisture during the construction process but must resist this exposure without a negative impact on their structural performance.

While it is well documented that oriented strand board (OSB) sheathing exposed to moisture during construction will perform as intended after it has been allowed to re-dry and reach an equilibrium moisture content, research on the performance of SIPs exposed to moisture is limited. To address this concern, SIPA contracted APA to conduct a series of tests to evaluate the effects of exposure to moisture on OSB-faced SIPs.

Test Program: APA conducted three series of tests subjecting SIPs to various moisture exposure conditions at its Research Center in Tacoma, Washington. These included transverse load tests, lateral load tests and axial load tests as described below.

Transverse Load Tests: Six SIPs, 4-1/2 in. in thickness and 4 ft. by 8 ft. in overall dimension were supplied to APA by a SIPA member manufacturer. The SIPs were manufactured under an approved quality assurance program. The SIPs included 7/16 in. OSB facings trademarked to meet the APA PRN-610 specification. The expanded polystyrene foam core was 3-5/8 in. thick meeting the requirements of ASTM C578 Type I. The adhesive used to bond the facings to the core conformed to ASTM D2559 for adhesives specifically intended for the lamination of SIPs. Each 4 ft. by 8 ft. panel had a single 1-1/2 in. diameter vertical electrical chase and two horizontal chases through the foam core. In addition, two 4-3/4 in. by 4-3/4 in. cutouts for electrical boxes were routed in one face of each specimen.

Three SIPs were tested in the as-received condition (dry) and three were tested after exposure to moisture cycling in accordance with Section 15.3 of ASTM E72 for wet/dry specimens. The ASTM E72 wetting cycle is 6 hours of exposure to a water spray on both faces of the SIP followed by 18 hours of drying with the cycle repeated three times. The SIPs exposed to the moisture cycling were then dried under laboratory conditions until they achieved their as-received weight, which took approximately 30 days.

Transverse load testing was conducted in accordance with Section 11 of ASTM E72 using a third point loading set-up. The cutouts for the electrical boxes were positioned on the tension face.

The results showed that the mean ultimate load for the moisture cycled specimens was approximately 98 percent of the as-received specimens. The load at a deflection limit of L/360 for the moisture cycled specimens was approximately 97 percent of the as-received specimens. These results indicate that the SIPs retained their transverse load capacity after exposure to simulated construction cycle moisture and drying (see Table 1 below for results).

Lateral Load Tests: A set of six SIPs manufactured as described above for the transverse load testing were supplied to APA and tested under cyclic lateral loading. Three SIPs were tested in the as-received condition (dry) and three were tested after exposure to moisture cycling in accordance with Section 15.3 of ASTM E72 for wet/dry specimens. For the SIPs exposed to the moisture cycling, two SIPs were dried for two weeks and one SIP was dried for four weeks under laboratory conditions to simulate varying degrees of drying.

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The lateral load testing was conducted in accordance with ASTM E2126, Method C, CUREE loading protocol. The reference deformation was set at 2.4 in. and the term α was 0.5. Displacement cycles were added such that the maximum displacement was ± 4.8 in. The top and bottom of the OSB sheathing on all SIPs was restrained with a nominal 2 in. by 6 in. SPF full SIP width cap plate and a 2 in. x 6 in. SPF full SIP width bottom plate.

The average OSB facing moisture content at time of testing was 5.1 percent for the three as-received SIPs, 7.4 percent for the two-week dried SIPs and 6.6 percent for the four-week dried SIPs, indicating the moisture cycling did result in a slightly increased moisture content of the OSB.

The results showed that the peak load for the SIPs exposed to simulated construction cycle moisture and re-drying was approximately 2 percent higher than the as-received specimens. There was no difference between the peak load results for the specimens re-dried for two weeks versus those re-dried for four weeks. Based on this testing, the SIP cyclic performance was insensitive to the wet-dry cycling and there was no distinguishable difference of the cyclic performance after a two-week or four-week drying (see Table 1 below for results).

Axial Load Tests: A set of six SIPs as described above for the transverse load testing were supplied to by APA and tested under axial (compression) loading. However, to simulate a more extreme exposure to moisture as may occur during a flood situation, three of the SIPs were soaked under tap water for 72 hours based on the National Evaluation Service (NES) protocol for determining flood resistance properties. This is considered to be a more severe moisture exposure than the ASTM E72 protocol. The SIPs exposed to the simulated flood soaking were dried under laboratory conditions until they achieved their as-received weight which took approximately 30 days.

The axial load testing was conducted in accordance with Section 9 of ASTM E72. The cutouts for the electrical junction boxes were positioned on the compression face.

Three SIPs were tested in the as-received condition (dry) and three were tested after exposure to the flood soaking and laboratory drying. The results of this testing showed that the mean ultimate axial load for the moisture cycled specimens was approximately 6 percent higher than the as-received specimens. The load at 1/8 in. deflection for the moisture cycled specimens was approximately 98 percent of the as-received specimens. These results indicate that there is virtually no axial strength loss for the SIPs after simulated flood soaking and this would also be applicable to typical construction cycle moisture exposure (see Table 1 below for results).

Summary: The results of these three test programs indicate that there is no significant loss in strength (transverse, lateral or axial) for SIPs subjected to typical moisture exposure during the construction process.

Table 1: Summary Test Results [a]

	Lateral (cyclic)		Transverse		Axial	
	Peak Load/3.0	Deflection at Peak Load	Peak Load/3.0	Load at 1/8 in. Deflection	Peak Load/3.0	Load at 1/8 in. Deflection
Control	407 plf	2.5 in.	42 psf	26 psf	3,100 plf	3,340 plf
After Moisture Cycling	416 plf	2.6 in.	41 psf	25 psf	3299 plf	3,273 plf
Ratio	1.02	1.06	0.98	0.96	1.06	0.98

(a) All control and moisture cycled values are the average of 3 tests

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Use of SIPA Test Results

Date: February 18, 2013

Question: SIPA frequently sponsors research testing on behalf of the SIPA members. In these testing programs the SIP assemblies are supplied by a SIPA manufacturing member, often based on logistics to the testing laboratory. The question is then posed as to whether or not the test results achieved are applicable to SIPs manufactured by other SIPA members?

Response: When SIPA sponsors a test program, the details associated with the SIP assemblies are clearly defined before the SIPs are manufactured and supplied to the testing laboratory. This includes the requirements for (a) the OSB facers, (b) the foam core, (c) the adhesives used to bond the foam core to the facers and (d) any construction details pertinent to the testing procedure.

For example, assume that an expanded polystyrene (EPS) foam core that must meet the requirements of ASTM C578 Type I and have a minimum density of 0.90 lbs per cubic foot is specified for a specific testing program. The specification for the facers requires that they be 7/16 in. thick OSB meeting the requirements of APA PRN-610 and that the adhesives must meet the requirements of Type II, Class 2, conforming to ASTM D2559 recognized for bonding OSB to EPS foam.

During the manufacturing of the SIP test specimens, an accredited third party inspection agency must verify these component requirements have all been met.

If, subsequent to the testing, another SIPA manufacturer wants to apply the test results achieved to SIPs that they produce, they would then be required to demonstrate that the SIPs they manufacture use equivalent components and include a third party verification of this equivalence.

Specific Example of the Use of SIPA Test Results

In December of 2011, APA conducted a series of moisture resistance tests for SIPA. The results were reported in APA Report T2011P-73 issued on January 15, 2012. The purpose of this testing was to determine the impact of moisture cycling on the axial and transverse load capacity of SIPs manufactured with APA PRN-610 facers. The testing in this report supplements the durability study reported in APA Report T2011-43, where cyclic shear testing was conducted on both dry and moisture-cycled SIP assemblies.

The SIPs were manufactured by a SIPA member and the SIPs bore a third party inspection agency trademark. The facers were 7/16 in. thick OSB meeting the requirements of APA PRN-610 and trademarked with the APA PRN-610 designation. The core of the SIPs was composed of EPS foam meeting the requirements of ASTM C578 Type I with a minimum density of 0.90 lb/ft^3. The thickness of the core was 3.5 in. (89 mm).

The adhesive used to structurally laminate the EPS foam core material to the OSB facers conformed to ASTM D2559 specifically intended for use as an adhesive for the lamination of structural insulated panels using OSB facers and an EPS foam core.

Each 4 ft. by 8 ft. SIP contained a single 1-1/2 in. diameter vertical chase and two 1-1/2 in. horizontal chases in the EPS core. Two holes (4-3/4 in. by 4-3/4 in.) to simulate a double gang electrical box opening were routed in one face of each SIP specimen. The results of this study showed a minimal impact on the panel's axial and transverse load capacities due to 72 hour water soak and ASTM E72 moisture exposure respectively when tested after the assemblies were re-dried.

SIPA considers these results to be applicable to SIPs manufactured by any SIPA member using components and SIP construction equivalent to those used to manufacture the original test specimens.

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