

PANELIZED WALL SYSTEMS: MAKING THE CONNECTIONS



PANELIZED WALL SYSTEMS: MAKING THE CONNECTIONS

Prepared for:

U.S. Department of Housing and Urban Development
Office of Policy Development and Research
Washington, DC

Prepared by:

Steven Winter Associates, Inc.
Norwalk, Connecticut

August 10, 2006



Table of Contents

Acknowledgments	3
Disclaimer	3
Executive Summary	4
Context of Research	4
Research Methodology	5
Performance Standard Criteria	6
Application and Dissemination	18
Appendix A: Panel Connections Comparison Matrix	19
Appendix B: Panel Manufacturer Matrix	68

Acknowledgments

The authors would like to recognize the technical advisory group (TAG), which helped contribute to understanding the panel industry and provided review of materials generated in the research. The TAG included Randy Shackelford, Simpson Strong-Tie Company, Inc.; Harold Messenger, Oldcastle Precast; Jim LeRoy, Panel Pros, Inc.; Henry Walthery, Forest Homes, Inc.; Paul Johnson, Duo-Fast; Ron LaMont, Alpine Engineered Products, Inc.; Marc Olden, Mitek Industries; and Mark Daniels, Sika Corporation.

Thanks also to Eric Denny, Oldcastle Precast; Bob Stenzel, Sika Corporation; Lee Zinsle, Senco; John Kurtz, International Staple, Nail and Tool Association; Jeremy Bertrand, NAHB Building Systems Council; and Liza Bowles and Mark Nowak of Newport Partners.

The authors gratefully acknowledge the help and guidance provided by Luis Burray, David Engel, Michael Blanford, and Michael Freedberg of HUD.

Disclaimer

The statements and conclusions contained in this report are those of the authors and do not necessarily reflect the views or policies of the U.S. Department of Housing and Urban Development of the U.S. Government. The authors have made every effort to verify the accuracy and appropriateness of the report's content. However, no guarantee of the accuracy or completeness of the information or acceptability for compliance with any industry standard or mandatory requirement of any code, law, or regulation is either offered or implied. The products and systems described in the report are included only as examples of some available choices. No endorsement, recommendation, or evaluation of these products or their use is given or implied.

PANELIZED WALL SYSTEMS: MAKING THE CONNECTIONS

Executive Summary

The broad purpose of this research is to understand and document the connection systems of panelized home construction systems currently on the U.S. market with the goal of developing Performance Standard Criteria to help builders and manufacturers. Such criteria can also aid in the development of new panel systems and in the coordination among different types of panel systems.

The Performance Standard Criteria are based on a careful study of existing panel systems. Approximately 30 panelized construction systems were reviewed and 12 were selected for further study. The systems include concrete panels, metal panels, wood structural insulated panels (SIPs), and wood open-wall panels. Performance information on the 12 different systems was collected and then analyzed to develop the criteria. The criteria cite performance standards based on current codes as benchmarks for connections and system performance. Conventional construction practice is considered as the implicit performance baseline at the system level.

The criteria format makes it easy for builders or manufacturers to compare and contrast different system types and the performance of the various elements of the connection systems. A key to maximizing the use of the criteria is to provide builders and panel manufacturers with easy access to the information, through outlets such as the PATH website and trade organizations.



Panel/foundation connection point

Context of Research

HUD has been extensively involved in supporting research and development on building technology innovations, construction systems, products, standards, regulations, and code issues that affect the affordability, safety, and livability of the nation's housing. As the interrelationships between these topics grow increasingly complex, the continued need to conduct research and demonstrations becomes even more critical.

One of the most important of HUD's efforts in supporting research and pushing technological innovation has been the PATH program (Partnership for Advancing Technology in Housing). PATH has advanced state-of-the-art practices in the design and construction of affordable housing by accelerating the process of developing and introducing new and innovative technologies and new materials. One technology that has received particular attention is panelized housing construction, which has continued to gain market share, and now accounts for approximately 45 percent of the "building systems" activity in the U.S., according to *Automated Builder* magazine.

PATH devoted one of its five technology roadmaps (guides to helping the industry make decisions about research and technology development) to "Advanced Panelized Construction." This research project is in response to activities outlined in the panelization roadmap, to evaluate issues involving the panelization of building components and to develop strategies to better coordinate the use of panelized components currently on the market. A better understanding of the performance of panel connection systems is seen as a way of aiding builders in choosing the most effective panelized components in home construction. Developing "Performance Standard Criteria" for panel connections is one way of assisting builders in comparing different panel systems. Such criteria are also an aid to coordinating the use of different panel systems by builders. They can also serve as standards for new panel systems under development, and the future development of prescriptive connections and proprietary devices for connecting panelized components of differing sizes and materials.



Murus Cam-Lock panel connection system

Research Methodology

Panel System Types

The Performance Standard Criteria for panel connections is based on a careful study of existing panel systems now available in the U.S. Experimental systems were excluded from the study so that the performance criteria are based on panel systems that meet current codes and standards. Approximately 30 panelized systems were reviewed and 12 were selected for further study.

Definition of Performance Measures

The 12 panel systems represent the state-of-practice of connections being used today. The Panel Manufacturer Matrix (Appendix B) categorizes the 12 systems by 4 of the most popular types used by the U.S. homebuilding industry: concrete panels, metal panels, wood structural insulated panels (SIPs), and wood open-wall panels. The 12 systems are distributed among these 4 panel systems types as follows: concrete panels (2 systems); metal panels (3 systems); wood SIPs (4 systems); wood open-wall panels (3 systems).

Performance information collected on the 12 different systems is organized according to four broad categories: General Information; Physical Characteristics; Performance Characteristics; and Connection Interface. Within each of these categories, applicable information is presented for Panel-to-Panel Connections and Panel to Top/Bottom Plate Connections to understand how the connections interface within the panel system itself, and between the panel system and house subsystems such as roofs and foundations. The Panel Connections Comparison Matrix (Appendix A) presents all of the relevant information collected and documented for the 12 panel systems studied, which was then analyzed to develop the Performance Standard Criteria.

Performance Standard Criteria

The 11-page Performance Standard Criteria, which start on the next page, are based on the analysis of the information collected on the 12 panel systems. The Criteria are organized in the same way as the 12 systems of the comparison matrix found in Appendix A: General Information; Physical Characteristics; Performance Characteristics;

and Connection Interface. The criteria are also organized according to the four system types studied: Concrete Panels (which start on page 7); Metal Panels (page 10); Wood SIPs (page 13); and Wood Open-Wall Panels (page 16). Where specific metrics are helpful, they have been included throughout the criteria.

There are two levels at which performance is considered: (1) at the individual connection and (2) the effect it has at the system level. For the Criteria, acceptable performance is assumed to be at least as good as the minimum required conventional practice (which is not an engineered system although it implies the presence of acceptable engineering characteristics). For this reason, the Performance Standard Criteria cite performance standards based on current codes as benchmarks for connections and system performance, so as not to place an unfair burden or expectations of higher performance levels on panelized systems. Each of the four panel material types lists Performance Characteristics special to that particular material. For example, the Performance Characteristics for Concrete Panels starts on page 7, in the green-colored section.

Report text continues on page 18



Wausau Homes panel/top plate connection interface

Concrete Panels Performance Standard Criteria

General Information		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections	Rationale for Criterion
conc	Description	Solid precast concrete with rebar; precast concrete sandwiching insulation.		Investigation of and state-of-practice for two representative concrete panel systems.
conc	Panel Types	Closed-wall concrete panels.		Investigation of and state-of-practice for two representative concrete panel systems.
conc	Connection Types	Connections can be continuous or periodic.		Investigation of and state-of-practice for two representative concrete panel systems.
Physical characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections	Rationale for Criterion
conc	Connection materials	Weld plates, bolts, and cementitious grout.	A combination of structural steel and cementitious materials: rebar, grout, and bolted steel angles embedded in foundation.	Investigation of and state-of-practice for two representative concrete panel systems.
conc	Dimensions and physical characteristics	Weld plates are 8"x4"x3/8"; grout cross-section is approximately 6" wide in the insulation area.	HCA 3" plastic grout tube & #5 rebar; 5"x3-3/8"x4" angles & 1" thick layer of grout.	Investigation of and state-of-practice for two representative concrete panel systems.
conc	Connection tolerances (min/max)	Connections may yield tolerances up to 1/2". Erection crews must meet manufacturer's recommended tolerances to ensure that connection strength is not compromised.	Embedded bolts must align with angles, requiring precision. More latitude (1/4") is available with rebar in grout tubes than with embedded angles.	Investigation of and state-of-practice for two representative concrete panel systems.
conc	Connection method at corners	Corner connections may be mitred or butt joints, using the same materials as panel-to-panel connections.	Corner connections follow the same method to connect to top and bottom systems.	Investigation of and state-of-practice for two representative concrete panel systems.
Performance characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections	Rationale for Criterion
conc	Conformance with applicable building codes	Connections are part of a panel system that meets the criteria set forth in the International Residential Code (IRC) and the International Building Code (IBC). Code compliance of connectors may require testing performed in accordance with ASTM standards for strength, fire, mold growth, etc. Custom engineering may be required.		Typical practice/requirements in existing building codes, design standards, and product approval criteria.
conc	Structural strength (min)	Minimum strength of the connector system must be comparable to the strength of the wall panel as a unit. Assembly strength shall be determined in accordance with IRC/IBC or local code requirements (whichever is more stringent) by engineering analysis or structural testing.		Code intent.
conc	Number of connections (min/max)	Minimum of 2 connection points or more, depending on length and design of panel. Typical top/bottom plate connections pattern is four connections per 12' panel. Spacing may be determined by failure mode in high seismic conditions. Systems using a small number of connectors must have greater reliability (safety margin) at each connection point in case one connector fails. Grout or sealant at connections should be applied continuously.		Panel manufacturer's specifications for project-specific conditions.

conc	Connection durability over time	Connectors must be at least as durable as the panels themselves. Materials must be protected from foreseeable conditions (i.e. steel must be protected from corrosion) that would be encountered either with an exposed connection or with connections hidden within a wall cavity. Certain joints may require non-shrink grout.	Industry practice and materials science findings.	
conc	Connection fire resistance	Connection fire resistance need not necessarily match the resistance of the panels, but connections are part of panel "assembly" which must be tested to meet flame-spread and smoke-development ratings as defined by major building codes.	Code intent.	
conc	Acoustical separation/insulation at connection	Connection method should not reduce the STC rating of the whole panel assembly below that of a conventional wall framed with comparable materials. Continuous insulation at panel connections improves sound attenuation. If insulation is not continuous, acoustical performance at connections should be at least equal to that offered by conventional framing, or that required by code or ordinance (whichever is more stringent).	Typical building code sound attenuation criteria and test methods for wall systems.	
conc	Energy performance at connection	Panels must meet IRC/IECC minimum requirements and should not introduce air movement that may degrade the effective R-value. Thermal shorts should not degrade the performance below that of the effective R-value of a stick-frame wall with framing factors as used to develop the IRC/IECC code requirements. Thermal shorts should not produce cold spots that cause condensation or ghosting.	Building science, envelope improvement strategies.	
conc	Moisture/water resistance at connection	Panel connections must not create openings for bulk water intrusion. Where grout is not used, builder may apply foam, caulk, or mastic at panel joints as needed to improve performance. Where grout is used, certain joints may require non-shrink grout.	Building science, envelope improvement strategies.	
conc	Air infiltration resistance at connection	Panel connections must not interfere with the builder's ability to use air sealing techniques to achieve superior building envelope performance. Where grout is not used, builder may apply caulk, mastic, or other sealant. Where grout is used, certain joints may require non-shrink grout.	Building science, envelope improvement strategies.	
conc	Insect and vermin resistance	Connection materials must not be attractive to pests, and panel connections must be designed such that panels are not subject to insect/vermin infiltration. Adhering to air leakage requirements of IRC (N1102.1.10) will address many infiltration pathways.	General knowledge, envelope improvement strategies.	
Connection Interface		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections	Rationale for Criterion
conc	Required protection of panel connection system from factory to site	Shipment of panels must not compromise integrity or performance of connections or subject connection components to damage, deterioration, corrosion, or decay.	Concrete panel system manufacturer's recommendations.	
conc	Compatibility with other panel connection systems	Precasting and field bolting must support compatibility, where required by design. With adequate planning, concrete panels should be able to accommodate a variety of systems during the precasting phase.	Investigation of and state-of-practice for two representative concrete panel systems.	
conc	Compatibility with house subsystems	Connection tolerances must be compatible with foundation tolerances. Connections must not interfere with electrical, plumbing, communications, and HVAC systems. With adequate planning, concrete panels should be able to accommodate a variety of systems during the precasting phase. Utilities are not commonly integrated into concrete panels.	Concrete panel builders' state-of-practice.	
conc	Ability to accept interior finishes	Connections must not hinder the ability to effectively finish the interior of the panel. Where fasteners are used the connection head must be low-rising so the finish can be applied easily and smoothly. Connections must not corrode or degrade the interior finish.	Builders indicate that interior stud wall is the most common finishing application.	

conc	Ability to accept exterior finishes	Connections must not hinder the ability to effectively finish the exterior of the panel. Where fasteners are used the connection head must be low-rising so the finish can be applied easily and smoothly. Connections must not corrode or degrade the exterior finish.	Panel manufacturers' installation and finishing information.
conc	Method of access after assembly	Post-construction access must be comparable to that of non-panelized construction.	Irreversible connection methods are comparable to traditional technologies.

Metal Panels Performance Standard Criteria

General Information		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections	Rationale for Criterion
met	Description	Insulated metal panels combine metal structural support or metal skins (steel or aluminum) with EPS foam.		Investigation of and state-of-practice for three representative metal panel systems.
met	Panel Types	Both open- and closed-wall systems.		Investigation of and state-of-practice for three representative metal panel systems.
met	Connection Types	Panel edges can be formed, or can contain special framing. Connections can be either continuous or intermittent.	Panels must fit into metal tracks at top and bottom. Tracks must be screwed intermittently to both sides of the panel.	Investigation of and state-of-practice for three representative metal panel systems.
Physical characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections	Rationale for Criterion
met	Connection materials	Metal framing, formed edges for snap-lock connection, screws, and sealant.	Metal tracks, screws, and sealants.	Investigation of and state-of-practice for three representative metal panel systems.
met	Dimensions and physical characteristics	No standard dimension.		Investigation of and state-of-practice for three representative metal panel systems.
met	Connection tolerances (min/max)	Connection tolerances typical for screw/mechanical fasteners (1/8-1/4") must be expected. Continuous snap connection must align precisely for mechanism to engage.	Connection tolerances typical for screw/mechanical fasteners (1/8") must be expected.	Manufacturer-described practice; required spacing should depend on system specifics as well as application (e.g., in-fill wall vs. structural load-bearing panel, vs. shear wall).
met	Connection method at corners	Panels form butt joints at corners. Ends are capped using channels or studs and panels must be fastened with long screws or bolts.	Top and bottom tracks may overlap at corners to complete connection.	Manufacturers' installation guidelines.
Performance characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections	Rationale for Criterion
met	Conformance with applicable building codes	Connections are part of a panel system that meets the criteria set forth in the International Residential Code (IRC) and the International Building Code (IBC). Code compliance of connectors may require testing performed in accordance with ASTM standards for strength, fire, mold growth, etc. Custom engineering may be required.		Typical practice/requirements in existing building codes, design standards, and product approval criteria.
met	Structural strength	Minimum strength of the connector system must be comparable to the strength of the wall panel as a unit. Assembly strength shall be determined in accordance with IRC/IBC or local code requirements (whichever is more stringent) by engineering analysis or structural testing.		Code intent.
met	Number of connections (min/max)	Minimum of 2 connection points, depending on length of panel. Spacing for non-continuous connections is typically 12-24" at panel seams and 12-14" along top and bottom plates, as determined by panel composition, local conditions, and structural properties such as failure mode in high seismic conditions. Systems using a small number of connectors must have greater reliability (safety margin) at each connection point in case one connector fails. Sealants should be applied continuously.		Panel manufacturer's specifications for project-specific conditions.

met	Connection durability over time	Connectors must be at least as durable as the panels themselves. Materials must be protected from foreseeable conditions (i.e. steel must be protected from corrosion) that would be encountered either with an exposed connection or with connections hidden within a wall cavity.		Industry knowledge and materials science findings.
met	Connection fire resistance	Connection fire resistance need not necessarily match the resistance of the panels, but connections are part of panel "assembly" which must be tested to meet flame-spread and smoke-development ratings as defined by major building codes.		Code intent.
met	Acoustical separation/insulation at connection	Connection method should not reduce the STC rating of the whole panel assembly below that of a conventional wall framed with comparable materials. Continuous insulation at panel connections improves sound attenuation. If insulation is not continuous, acoustical performance at connections should be at least equal to that offered by conventional framing, or that required by code or ordinance (whichever is more stringent).		Typical building code sound attenuation criteria and test methods for wall systems.
met	Energy performance at connection	Panels must meet IRC/IECC minimum requirements and should not introduce air movement that may degrade the effective R-value. Thermal shorts should not degrade the performance below that of the effective R-value of a stick-frame wall with framing factors as used to develop the IRC/IECC code requirements. Thermal shorts should not produce cold spots that cause condensation or ghosting.		Based on state-of-industry and best known practices.
met	Moisture/water resistance at connection	Panel connections must not create openings for bulk water intrusion, air movement, or thermal shorts that lead to condensation. An appropriate sealant must be used where recommended by the panel manufacturer, and this sealant must be applied in accordance with both the sealant manufacturer and panel manufacturer's recommendations. Panels and connections must accommodate a weather-resistant barrier required on the exterior by IRC/IBC.		Based on manufacturer information and builder state-of-practice.
met	Air infiltration resistance at connection	Panel connections must not interfere with the builder's ability to use air-sealing techniques to achieve superior building envelope performance. An appropriate sealant (caulk, mastic, or other) must be used where recommended by the panel manufacturer, and this sealant must be applied in accordance with both the sealant manufacturer and panel manufacturer's recommendations. Air movement that could result in condensation inside the panel must be prevented.		Based on manufacturer information and builder state-of-practice.
met	Insect and vermin resistance	Connection materials must not be attractive to pests, and panel connections must be designed such that panels are not subject to insect/vermin infiltration. Adhering to air leakage requirements of IRC (N1102.1.10) will address many infiltration pathways.		Based on manufacturer information and builder state-of-practice.
Connection Interface		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections	Rationale for Criterion
met	Protection of panel connection system from factory to site	Shipment of panels must not compromise integrity or performance of connections or subject connection components to damage, deterioration, corrosion, or decay. Materials must be protected from moisture.		Panel system manufacturers' recommendations.
met	Compatibility with other panel connection systems	Proprietary connections need not be compatible, but field changes are facilitated if panels support a transition to traditional framing or other panel systems.	Tracks and screws can accommodate other panel systems or traditional metal framing.	State of practice.

met	Compatibility with house subsystems	Connections must not impede integration of subsystems into panels. Connections must accommodate utility chases located within the panels or components recessed into the panel's surface.	Tracks and other connection materials must be compatible with drilling where utilities run vertically through top and bottom connections.	Based on manufacturer data and builder state-of-practice.
met	Ability to accept interior finishes	Connections must not hinder the ability to effectively finish the interior of the panel. Where fasteners are used the connection head must be low-rising so the finish can be applied easily and smoothly. Connections must not corrode or degrade the interior finish.		State of practice.
met	Ability to accept exterior finishes	Connections must not hinder the ability to effectively finish the exterior of the panel. Where fasteners are used the connection head must be low-rising so the finish can be applied easily and smoothly. Connections must not corrode or degrade the exterior finish.		State of practice.
met	Method of access after assembly	Sealant may prevent access to interior of wall or assembly after installation.		Based on manufacturer data and builder state-of-practice.

Wood SIP Panels Performance Standard Criteria

General Information		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections	Rationale for Criterion
wsip	Description	Sheets of OSB sandwiching insulation made of EPS, urethane, or pressed agrifiber.		Investigation of and state-of-practice for four representative wood SIPs systems.
wsip	Panel Types	Closed-wall panels.		Investigation of and state-of-practice for four representative wood SIPs systems.
wsip	Connection Types	Intermittent connections made with splines, screws, or nails, and/or mechanical cam-lock connectors.	Intermittent connections made with dimensional lumber and screws or nails.	Investigation of and state-of-practice for four representative wood SIPs systems.
Physical characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections	Rationale for Criterion
wsip	Connection materials	Screws, nails, dimensional lumber, OSB splines, ABS plastic cam-locks, and sealant.	Screws, nails, dimensional lumber, sealant.	Investigation of and state-of-practice for four representative wood SIPs systems.
wsip	Dimensions and physical characteristics	Splines can be 2x2", 4x3/8", or dimensional lumber size and run the height of the panel. Continuous bead of sealant applied between panels.	Dimensional lumber (2x6 for a 6" panel) used for top and bottom plates. Continuous bead of sealant on both sides of plates.	Investigation of and state-of-practice for four representative wood SIPs systems.
wsip	Connection tolerances (min/max)	Connection tolerances typical for screw/mechanical fasteners (1/8") must be expected.		Manufacturer-described practice.
wsip	Connection method at corners	Panels form butt joints at corners. Ends are capped using studs, and panels must be fastened with long screws or bolts and washers.	Top and/or bottom plates must overlap adjoining panels at corners to complete connection.	Manufacturers' installation guidelines.
Performance characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections	Rationale for Criterion
wsip	Conformance with applicable building codes	Connections are part of a panel system that meets the criteria set forth in the International Residential Code (IRC) and the International Building Code (IBC). Code compliance of connectors may require testing performed in accordance with ASTM standards for strength, fire, mold growth, etc. Custom engineering may be required.		Typical practice/requirements in existing building codes, design standards, and product approval criteria.
wsip	Structural strength	Minimum strength of the connector system must be comparable to the strength of the wall panel as a unit. Assembly strength shall be determined in accordance with IRC/IBC or local code requirements (whichever is more stringent) by engineering analysis or structural testing.		Code intent.
wsip	Number of connections (min/max)	Minimum of 2 connection points or more, depending on length of panel. Screw and nail fasteners are typically spaced at 6-12" while specialty cam-lock connectors may be spaced at 24". Spacing is determined by panel composition, local conditions, and structural properties such as failure mode in high-seismic conditions. Top and bottom tracks may be considered part of panel-to-panel connection. Sealants should be applied continuously.		Panel manufacturer's specifications for project-specific conditions.

wsip	Connection durability over time	Connectors must be at least as durable as the panels themselves. Materials must be protected from foreseeable conditions (i.e. steel must be protected from corrosion) such that the panel system as a whole is at least as durable as conventional wood-framing assemblies. Connectors must be appropriate for the type of wood being connected (i.e. treated lumber sill plates require special connectors).	Industry knowledge and materials science findings.	
wsip	Connection fire resistance	Connection fire resistance need not necessarily match the resistance of the panels, but connections are part of panel "assembly" which must be tested to meet flame-spread and smoke-development ratings as defined by major building codes.	Code intent.	
wsip	Acoustical separation/insulation at connection	Connection method should not reduce the STC rating of the whole panel assembly below that of a conventional wall framed with comparable materials. Continuous insulation at panel connections improves sound attenuation. If insulation is not continuous, acoustical performance at connections should be at least equal to that offered by conventional framing, or that required by code or ordinance (whichever is more stringent).	Typical building code sound attenuation criteria and test methods for wall systems.	
wsip	Energy performance at connection	Panels must meet IRC/IECC minimum requirements and should not introduce air movement that may degrade the effective R-value. Thermal shorts should not degrade the performance below that of the effective R-value of a stick-frame wall with framing factors as used to develop the IRC/IECC code requirements. Thermal shorts should not produce cold spots that cause condensation or ghosting.	Based on state of industry and known best practices.	
wsip	Moisture/water resistance at connection	Panel connections must not create openings for bulk water intrusion, air movement, or thermal shorts that lead to condensation. An appropriate sealant must be used where recommended by the panel manufacturer, and this sealant must be applied in accordance with both the sealant manufacturer and panel manufacturer's recommendations. Panels and connections must accommodate a weather-resistant barrier required on the exterior by IRC/IBC.	Manufacturers' data and builder state-of-practice.	
wsip	Air infiltration resistance at connection	Panel connections must not interfere with the builder's ability to use air-sealing techniques to achieve superior building envelope performance. An appropriate sealant (caulk, mastic, or other) must be used where recommended by the panel manufacturer, and this sealant must be applied in accordance with both the sealant manufacturer and panel manufacturer's recommendations. Air movement that could result in condensation inside the panel must be prevented.	Manufacturers' data and builder state-of-practice.	
wsip	Insect and vermin resistance	Connection materials must not be more attractive to pests than conventional building products, and panel connections must be designed such that panels are not subject to insect/vermin infiltration. Adhering to air leakage requirements of IRC (N1102.1.10) will address many infiltration pathways.	Manufacturers' data and builder state-of-practice.	
Connection Interface		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections	Rationale for Criterion
wsip	Protection of panel connection system from factory to site	Shipment of panels must not compromise integrity or performance of connections or subject connection components to damage, deterioration, corrosion, or decay. Materials must be protected from moisture.		Panel system manufacturers' recommendations.
wsip	Compatibility with other panel connection systems	Panels are customized for a particular spline or cam-lock but may be field modified to accept other connection systems and traditional wood framing.	Top and bottom plate connection systems are interchangeable among most panel types, including some metal panels and both wood and steel stick-framing.	State of practice.

wsip	Compatibility with house subsystems	Connections must not impede integration of subsystems into panels. Connections must accommodate utility chases located within the panels or components recessed into the panel's surface.	Plates and other connection materials must be compatible with drilling where utilities run vertically through top and bottom connections.	Based on manufacturer test results and builder state-of-practice.
wsip	Ability to accept interior finishes	Connections must not hinder the ability to effectively finish the interior of the panel. Where fasteners are used the connection head must be low-rising so the finish can be applied easily and smoothly. Connections must not corrode or degrade the interior finish.		State of practice.
wsip	Ability to accept exterior finishes	Connections must not hinder the ability to effectively finish the exterior of the panel. Where fasteners are used the connection head must be low-rising so the finish can be applied easily and smoothly. Connections must not corrode or degrade the exterior finish.		State of practice.
wsip	Method of access after assembly	Sealant may prevent access to interior of wall or assembly after installation.		State of practice.

Wood Panels Performance Standard Criteria

General Information		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections	Rationale for Criterion
w op	Description	Manufactured wall panels using conventional wood-framing principles. Panels may arrive on site with exterior sheathing, cladding, and windows and doors installed. Insulation may also be factory applied.		Investigation of and state-of-practice for three representative wood panel systems.
w op	Panel Types	Open wall.		Investigation of and state-of-practice for three representative wood panel systems.
w op	Connection Types	Nails, screws, and bolts are used to connect framing, which consists of dimensional lumber studs and plates.		Investigation of and state-of-practice for three representative wood panel systems.
Physical characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections	Rationale for Criterion
w op	Connection materials	Screws, nails, dimensional lumber, sealants, optional gaskets.	Screws, nails, 2x top plate.	Investigation of and state-of-practice for three representative wood panel systems.
w op	Dimensions and physical characteristics	2x4 or 2x6 studs and chords, nails.	Panels have an existing bottom chord that can be attached directly to floor system, and top chord that acts as single top plate.	Investigation of and state-of-practice for three representative wood panel systems.
w op	Connection tolerances (min/max)	Connections may yield tolerances up to 1/2" (as with gaskets); or 1/8-1/4" typically expected with mechanical fasteners. Erection crews must meet manufacturer's recommended tolerances to ensure that connection strength is not compromised.		Investigation of and state-of-practice for three representative wood panel systems.
w op	Connection method at corners	Panels form butt joints at corners. Ends are capped using studs, and panels must be fastened with long screws or bolts and washers.	Top and/or bottom tracks must overlap adjoining panels at corners to complete the connection.	Investigation of and state-of-practice for three representative wood panel systems.
Performance characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections	Rationale for Criterion
w op	Conformance with applicable building codes	Connections are part of a panel system that meets the criteria set forth in the International Residential Code (IRC) and the International Building Code (IBC). Code compliance of connectors may require testing performed in accordance with ASTM standards for strength, fire, mold growth, etc. Custom engineering may be required.		Typical practice/requirements in existing building codes, design standards, and product approval criteria.
w op	Structural strength	Minimum strength of the connector system must be comparable to the strength of the wall panel as a unit. Assembly strength shall be determined in accordance with IRC/IBC or local code requirements (whichever is more stringent) by engineering analysis or structural testing.		Code intent.
w op	Number of connections (min/max)	Installer must follow manufacturer's recommendations, which must be designed for performance that is at a minimum equivalent to the performance of analogous connections in conventional construction.		Current industry standards.
w op	Connection durability over time	Connection durability must be equal to or greater than that of analogous connections in conventional construction. Connectors must be appropriate for the type of wood being connected (i.e. treated lumber sill plates require special connectors).		Current industry standards.

w op	Connection fire resistance	Connection fire resistance need not necessarily match the resistance of the panels, but connections are part of panel "assembly" which must be tested to meet flame-spread and smoke-development ratings as defined by major building codes.		Code intent.
w op	Acoustical separation/insulation at connection	Connection method must not reduce the STC rating of the whole panel system below that of a conventionally framed wall system using comparable materials.		Typical building code sound attenuation criteria and test methods for wall systems.
w op	Energy performance at connection	Panels must meet IRC/IECC minimum requirements and should not introduce air movement that may degrade the effective R-value. Thermal shorts should not degrade the performance below that of the effective R-value of a stick-frame wall with framing factors as used to develop the IRC/IECC code requirements. Thermal shorts should not produce cold spots that cause condensation or ghosting.		Code intent and builder state-of-practice.
w op	Moisture/water resistance at connection	Panel connections must not create openings for bulk water intrusion, air movement, or thermal shorts that lead to condensation. Builder may add sealant at connections for best moisture resistance, following the sealant manufacturer's recommendations for application. Panels and connections must accommodate a weather-resistant barrier required on the exterior by IRC/IBC.		Manufacturers' data and builder state-of-practice.
w op	Air infiltration resistance at connection	Panel connections must not interfere with builders' ability to use air sealing techniques to achieve superior building envelope performance. Builder may apply caulk, mastic, or other sealant according to both the panel manufacturer and sealant manufacturer's recommendations or best practices. Air movement that could result in condensation inside the panel must be prevented.		Manufacturers' data and builder state-of-practice.
w op	Insect and vermin resistance	Connection materials must not be more attractive to pests than conventional building products, and panel connections must be designed such that panels are not subject to insect/vermin infiltration. Adhering to air leakage requirements of IRC (N1102.1.10) will address many infiltration pathways.		Manufacturers' data and builder state-of-practice.
Connection Interface		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections	Rationale for Criterion
w op	Protection of panel connection system from factory to site	Shipment of panels must not compromise integrity or performance of connections or subject connection components to damage, deterioration, corrosion, or decay. Materials must be protected from moisture.		Panel system manufacturers' recommendations.
w op	Compatibility with other panel connection systems	May be joined to other framing like wood SIPs or metal framing by using conventional studs and fasteners.	Plates may be used to connect different panel types, or to connect panels to traditional stick framing.	State of practice.
w op	Compatibility with house subsystems	Connection compatibility with house subsystems must be equal to or better than traditional stick framing. Panels may provide a proprietary utilities chase at panel's base, to be covered by trim.		State of practice.
w op	Ability to accept interior finishes	Connections must not hinder the ability to effectively finish the interior of the panel. Where fasteners are used the connection head must be low-rising so the finish can be applied easily and smoothly. Connections must not corrode or degrade the interior finish.		State of practice.
w op	Ability to accept exterior finishes	Connections must not hinder the ability to effectively finish the exterior of the panel. Where fasteners are used the connection head must be low-rising so the finish can be applied easily and smoothly. Connections must not corrode or degrade the exterior finish.		State of practice.
w op	Method of access after assembly	Connectors must offer access to interior of the wall after assembly that is equal to access offered in a conventionally framed assembly.		State of practice.

Conventional construction practice is considered as the implicit performance baseline at a system level, as system-level performance is the key to having a competitive and efficient approach for panelized systems in a market that is defined by site-built system performance. Conformance to applicable building codes should be interpreted to mean that minimum performance for alternative systems should comply with the minimum implied performance of the minimum acceptable conventional (deemed to comply) system.

The criteria are presented in a format that makes it easy for builders or manufacturers to compare and contrast different system types and the performance of the various elements of the connection systems. The criteria are also easily referenced by those developing new panel technology as a standard of performance in the panelized home building industry as it currently operates in the U.S. (thus, it might also be valuable to foreign companies contemplating an entrance into the American market).

To use this tool, the builder can easily compare one system against the other. For example, if a builder has a work force with a very low skill level, it might be decided to select a panel system with as a generous amount of tolerance in making panel connections during site assembly. In reviewing the tolerance levels on a comparative basis, the builder will discover that concrete panel systems offer the greatest dimensional tolerance (1/2") for connections, compared to metal or wood systems (which are generally in the 1/8" to 1/4" range). The greater level of tolerance for concrete systems might lead the builder to choose such a system.

If a builder is shopping for a panelized system that will allow greater opportunity for on-site inspection by a building official, the

Performance Standard Criteria would indicate that a wood open-wall system would be the better choice over a closed-wall structural insulated panel.

In the case of an architect writing performance specifications, the Performance Standard Criteria can be useful in comparing how different panel systems conform to relevant codes and other performance measures. Language for writing performance specifications can be taken directly from the Performance Standard Criteria, allowing an unbiased comparison of one system to another.

Application and Dissemination

A key to maximizing the use of the Performance Standard Criteria for panel connections is to make them easily available to homebuilders and panel manufacturers. Posting this report on the PATH Website (pathnet.org) is a good starting point in this endeavor. The Criteria might also be posted on the PATH Website pages that deal specifically with panelized construction.

The National Association of Home Builder's Building Systems Councils (BSC), the trade organization that serves the building systems industries, including panelized housing, has expressed a strong interest in this project and in disseminating its results to its membership, and also in making it available on its own Website, through publications, conferences, and other communications with its membership and its members' customers. *Building Systems* magazine and *Automated Builder* magazine, the two leading trade journals in the field, are also good outlets for the dissemination of the results of this study.

APPENDIX A

PANEL CONNECTIONS COMPARISON MATRIX

The Panel Connections Comparison Matrix presents all of the relevant information collected and documented for the 12 panel systems studied, which was then analyzed to develop the Performance Standard Criteria. Performance information collected on these systems is organized according to four broad categories: General Information; Physical Characteristics; Performance Characteristics; and Connection Interface. Within each of these categories, applicable information is presented for Panel-to-Panel Connections and Panel to Top/Bottom Plate Connections to understand how the connections interface within the panel system itself, and between the panel system and house subsystems such as roofs and foundations.

OldCastle Precast - Concrete Panels

General Information			
Distributor Name		OldCastle Precast	OldCastle Precast
Description		Precast concrete panel with rebar (No insulation).	
Panel Type	<i>Is the panel open-wall or closed-wall?</i>	Solid concrete, most similar to a Closed wall system.	
Connection Type	<i>Do panel-to-panel and panel-to-top/bottom differ?</i>	Horizontal and vertical connections differ. In panel-to-panel connections, weld plates embedded in each panel are joined together.	On the bottom edge, panels are set over rebar imbedded in grout. Along top edge, panels have pockets (grout tubes) that are filled with grout and rebar, so that the next story of panels (or roof components) can be set over the rebar.

Physical characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Connection materials	<i>What are the connection materials?</i>	A36 weld plate	HCA 3" plastic grout tube and #5 rebar
Dimensions and physical characteristics	<i>What are the dimensional characteristics of the connection materials?</i>	8"x4"x3/8" plate	HCA 3" plastic grout tube and #5 rebar
Connection tolerances	<i>What are the connection tolerances?</i>	1/2" tolerance	1" tolerance
Connection points per panel type	<i>How often are the connections made?</i>	2 per edge	4 per panel at top and bottom each

Panel being lowered onto grouted-in-place rebar

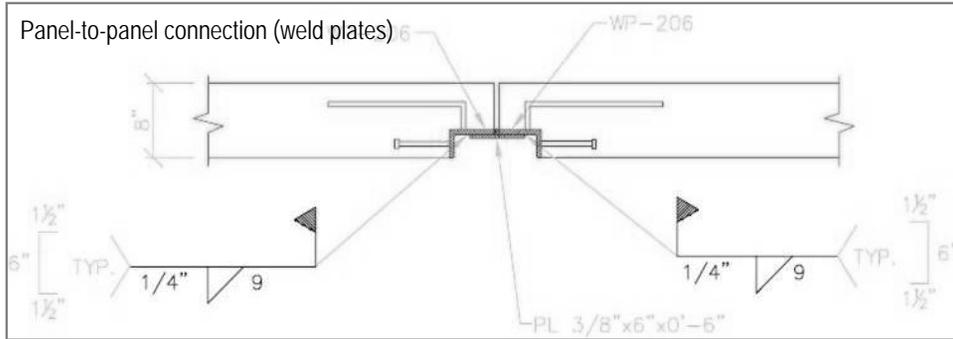


Panels erected



Panelized construction





OldCastle Precast

continued

Performance characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Conformance with applicable building codes	<i>What codes does the connection conform to?</i>	AISC and AWS	ACI 318
Structural strength	<i>What is the structural strength of the connector?</i>	14K shear	16K tension / 15K shear
Number of connections	<i>How many connections tie the panel to each other or other building parts?</i>	2 per edge	4 per panel
Connection flexibility	<i>Can the connection make angled joints?</i>	Panels can be cast in any shape, and weld plates can make angles. Corners are typically mitered.	Grout tubes and rebar can be installed as needed.
Connection durability over time	<i>Is the connection durable or subject to weakening under severe conditions?</i>	Must be protected from corrosion.	Must be protected from corrosion.
Connection fire resistance	<i>How does the connection perform when subjected to fire?</i>	Must be protected with fire proofing.	Must be protected by concrete/grout.
Connection fire resistance and panel performance	<i>How is panel performance compromised if connector is subjected to fire?</i>	Connection will lose strength.	Connection will lose strength, but rebar is embedded in the naturally fire-resistant concrete.
Acoustical separation/insulation at connection	<i>How does sound transmit through the panel at the connection?</i>	Overall panel sound insulation is equivalent to a concrete wall. At connections, the builder may apply caulk, mastic or foam to joints after construction to prevent air, sound, and water intrusion.	Overall panel sound insulation is equivalent to a concrete wall. At connections, the builder may apply caulk, mastic or foam to joints after construction to prevent air, sound, and water intrusion.
Energy performance at connection	<i>How does the connection perform thermally?</i>	Additional steel contributes to thermal bridging. Caulk, mastic or foam applied to joints post-erection to insulate.	Embedded rebar adds minimal thermal bridging. Caulk, mastic or foam applied post-erection to insulate.
Moisture/water resistance at connection	<i>How does the connection resist water and moisture?</i>	Subject to corrosion. Weld plates are located on interior side of wall panels, and caulk is generally applied to exterior of joint to limit water intrusion.	Subject to corrosion. Caulked exterior joint limits water intrusion.
Air infiltration resistance at connection	<i>How does the connection resist air infiltration?</i>	Connection provides No appreciable resistance to air infiltration. Joint should be sealed with caulk, mastic or expanding foam.	Connection provides No resistance to air infiltration. Joint should be sealed with caulk, mastic or expanding foam.
Insect and Vermin resistance at connection	<i>How does the connection resist insects and other vermin?</i>	Not affected by insects.	Not affected by insects.

OldCastle Precast

continued

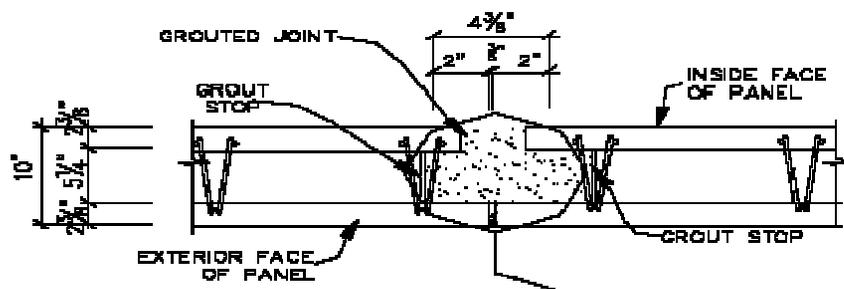
Connection Interface		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Installation of panel connection system in the factory	<i>What components of the connection system are factory applied?</i>	8"x4"x3/8" plate	HCA 3" plastic grout tube
Installation of panel connections system on the site	<i>What components of the connection system are site applied?</i>	A36 steel jumper plate or round slug	#5 dowel threaded into coupler
Protection of panel connection system from factory to site	<i>How are the factory-applied components protected during transport?</i>	Cast into concrete	Cast into concrete
Installation of damaged connections	<i>Is installation possible if a connector is damaged?</i>	Yes - through field repairs or redundant connections.	Yes - through field repairs or redundant connections.
Ease of installation	<i>What is the usual installation process?</i>	Set panels with crane. Weld jumper to plates in adjacent walls.	Set panels with crane. Field grouting #5 dowel into plastic tubes.
Tools required for connection	<i>What tools are required for the connection to be made?</i>	Welding torch, crane	Portable grout mixer, crane
Skill level required for installation	<i>What is the approximate skill required to make the connection?</i>	Requires multiple crew members. AWS certified welder.	Requires multiple crew members. Certified PCI erector.
Does the connection system support field changes	<i>If changes to the building are made, how does the connection respond?</i>	Depends on the change, but the nature of precast concrete and connections set in concrete limits ability accommodate field changes.	Depends on the change, but the nature of precast concrete and connections set in concrete limits ability accommodate field changes.
Compatibility with other panel connection systems	<i>Is the connection system compatible with other panel and wall systems?</i>	Yes, the panels could tie to other concrete panel systems or be field bolted to steel or other structural members.	Yes, the grout tubes could be used to imbed different types of connectors to attach to different structural systems.
Compatibility with house subsystems	<i>Are house subsystems accommodated by the connector?</i>	Connections are spaced widely and do not interfere with house subsystems, although very few systems are actually accommodated in the panel (steel stud wall on interior).	Rebar connections are widely spaced and do not interfere with house subsystems, although utilities are Not commonly run through the panels.
Ease of covering and finishing over connection, Interior	<i>Does the connection system hinder installation of interior finishes?</i>	Interior walls are insulated and framed before finishing, and flat weld plate does not interfere.	Connection is imbedded so does not affect finishing.
Ease of covering and finishing over connection, Exterior	<i>Does the connection system hinder installation of exterior finishes?</i>	Exterior receives no additional finishing other than caulking of joints.	Connection is embedded. Exterior receives no additional finishing other than caulking of joints.
Ease of accessing connection after assembly	<i>Can the connector be accessed after installation?</i>	Yes	No

Dukane Precast - Concrete Panels

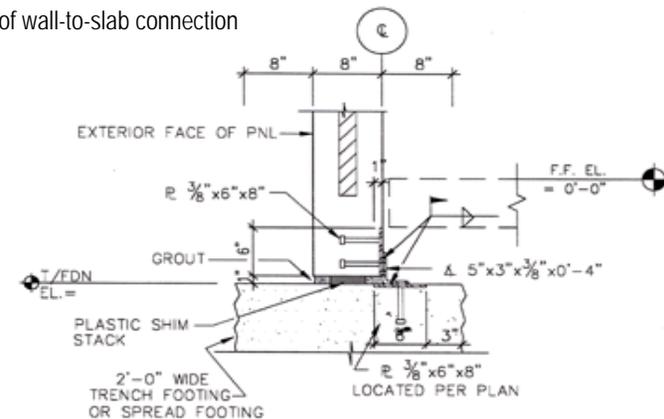
General Information			
Distributor Name		Dukane Precast Inc.	Dukane Precast Inc.
Description		Concrete Sandwich. A double wall of precast concrete, with insulation in the middle and steel trusses girders connecting two sides. The panel is insulated with various types of insulation.	
Panel Type	<i>Is the panel open-wall or closed-wall?</i>	Closed wall	
Connection Type	<i>Do panel-to-panel and panel-to-top/bottom differ?</i>	Panels are placed next to each other and grouted from the inside, and caulked from the outside. The connection is continuous.	Connection uses a layer of grout at the panel's top and bottom, plus a continuous steel angle on the interior fastened with bolts embedded in the panels, foundation, etc.

Physical characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Connection materials	<i>What are the connection materials?</i>	Cementitious grout	Cementitious grout
Dimensions and physical characteristics	<i>What are the dimensional characteristics of the connection materials?</i>	A recessed void is filled with grout from the interior side of the panel. Void dimensions are engineered for each panel/connection strength (typically 6").	Recessed void is filled with grout, void dimensions are engineered for each panel/connection strength (typically 6").
Connection tolerances	<i>What are the connection tolerances?</i>	The void space can accommodate latitude and the grout easily fills any dimensional discrepancies.	The void space can accommodate latitude and the grout easily fills any dimensional discrepancies. Embedded bolts must align with angles.
Connection points per panel type	<i>How often are the connections made?</i>	Continuous - this is a running connection.	Continuous - this is a running connection, although bolts are spaced at intervals.

Detail of panel-to-panel connection



Detail of wall-to-slab connection





Dukane Precast

continued

Performance characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Conformance with applicable building codes	<i>What codes does the connection conform to?</i>	Conforms with major building codes.	Conforms with major building codes.
Structural strength	<i>What is the structural strength of the connector?</i>	Structural strength of connector specifically is not available.	Structural strength of connector specifically is not available.
Number of connections	<i>How many connections tie the panel to each other or other building parts?</i>	Connection is continuously made, a running connection.	Connection is continuously made, a running connection.
Connection flexibility	<i>Can the connection make angled joints?</i>	Connection can make angled joints.	Panel may need additional support/bracing but can make angled connections
Connection durability over time	<i>Is the connection durable or subject to weakening under severe conditions?</i>	The connection of the panels is made in the interior of the wall system by pumping cementitious grout into the cavity created when two walls join, the grout fills the cavity and around the wall panel's reinforcement. Grout is a durable material.	The connection of the panels is made in the interior of the wall system by pumping cementitious grout into the cavity created when two walls join, the grout fills the cavity and around the wall panel's reinforcement.
Connection fire resistance	<i>How does the connection perform when subjected to fire?</i>	Concrete and cementitious grout are fire resistant, but at high temperatures the steel reinforcement in the panel fails.	Concrete and cementitious grout are fire resistant, but at high temperatures the steel reinforcement in the panel fails.
Connection fire resistance and panel performance	<i>How is panel performance compromised if connector is subjected to fire?</i>	Connector performs as well as panel in fire.	Steel is inclosed in concrete.
Acoustical separation/insulation at connection	<i>How does sound transmit through the panel at the connection?</i>	Performs well acoustically.	Performs well acoustically.
Energy performance at connection	<i>How does the connection perform thermally?</i>	Grout has thermal bridging like any concrete product, the panel is insulated at its core, the connection is un-insulated.	Grout has thermal bridging like any concrete product, the panel is insulated at its core, the connection is un-insulated.
Moisture/water resistance at connection	<i>How does the connection resist water and moisture?</i>	Continuous connection will not likely be susceptible to water infiltration.	Continuous connection will not likely be susceptible to water infiltration.
Air infiltration resistance at connection	<i>How does the connection resist air infiltration?</i>	Grouting fills the cavity fully and because it is a liquid fills any manufacturing defects which might have caused voids to form.	Grouting fills the cavity fully and because it is a liquid fills any manufacturing defects which might have caused voids to form.
Insect and Vermin resistance at connection	<i>How does the connection resist insects and other vermin?</i>	Grout forms a barrier that insects and vermin can not penetrate.	Grout forms a barrier that insects and vermin can not penetrate.

Dukane Precast

continued

Connection Interface		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Installation of panel connection system in the factory	<i>What components of the connection system are factory applied?</i>	The void or recesses for the grout, and the exposed reinforcement.	The void or recesses for the grout, and the exposed reinforcement.
Installation of panel connections system on the site	<i>What components of the connection system are site applied?</i>	Cementitious grout	Cementitious grout
Protection of panel connection system from factory to site	<i>How are the factory-applied components protected during transport?</i>	Because the panel connections made into the interior of the panel it is inherently protected, but because the connection is made with cementitious grout any defects or damaged areas are inherently fixed during installation.	Because the panel connections made into the interior of the panel it is inherently protected, but because the connection is made with cementitious grout any defects or damaged areas are inherently fixed during installation.
Installation of damaged connections	<i>Is installation possible if a connector is damaged?</i>	Yes, the grout should fill any void and is stronger than the concrete in the panel.	Yes, the grout should fill any void and is stronger than the concrete in the panel.
Ease of installation	<i>What is the usual installation process?</i>	The panels are set into place using a crane and braced. After all the panels are set and braced, concrete grout is pumped into the voids. After the concrete sets up the bracing can be removed.	The panels are set into place using a crane and braced. After all the panels are set and braced, concrete grout is pumped into the voids and steel angles are secured. After the concrete sets up the bracing can be removed.
Tools required for connection	<i>What tools are required for the connection to be made?</i>	Crane to set panels, concrete mixer and pump to pump grout into voids.	Crane to set panels, concrete mixer and pump to pump grout into voids.
Skill level required for installation	<i>What is the approximate skill required to make the connection?</i>	Crews must be trained to set panels and to install grout.	Crews must be trained to set panels and to install grout.
Does the connection system support field changes	<i>If changes to the building are made, how does the connection respond?</i>	While the grout itself when liquid is a flexible material, panels are difficult to alter if construction plans change. The concrete and the grout (once hardened) are both very difficult to cut and therefore field adaptability is extremely limited.	While the grout itself when liquid is a flexible material, panels are difficult to alter if construction plans change. The concrete and the grout (once hardened) are both very difficult to cut and therefore field adaptability is extremely limited.
Compatibility with other panel connection systems	<i>Is the connection system compatible with other panel and wall systems?</i>	While not inherently proprietary, the system limits possible successive connections that can feasibly be added -- all connections must be cast during the factory production.	While not inherently proprietary, the system limits possible successive connections that can feasibly be added -- all connections must be cast during the factory production.
Compatibility with house subsystems	<i>Are house subsystems accommodated by the connector?</i>	Utility accommodations must be cast at the factory and require careful coordination. Once grout is poured, changes to utilities through the connection area will Not be practical.	Utility accommodations must be cast at the factory and require careful coordination. Once grout is poured, changes to utilities through the connection area will Not be practical.
Ease of covering and finishing over connection, Interior	<i>Does the connection system hinder installation of interior finishes?</i>	Connection is recessed in the wall.	Connection is recessed in the wall.
Ease of covering and finishing over connection, Exterior	<i>Does the connection system hinder installation of exterior finishes?</i>	Connection is recessed in the wall.	Connection is recessed in the wall.
Ease of accessing connection after assembly	<i>Can the connector be accessed after installation?</i>	No access	No access

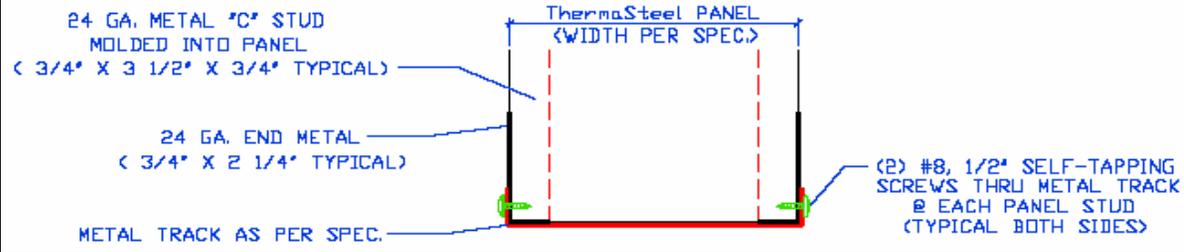
ThermaSteel - Metal Core Panels

General Information			
Distributor Name		ThermaSteel	ThermaSteel
Description		Steel Frame/Foam. A panel with a core of EPS framed with 24-gauge, G-90 galvanizing steel channels imbedded in the foam on either side of the panel for support.	In business for 30 years Now. Have been used in all 50 states and many countries around the world. Manufacturing plants in Virginia, Alaska, and Russia.
Panel Type	<i>Is the panel open-wall or closed-wall?</i>	Open Wall	
Connection Type	<i>Do panel-to-panel and panel-to-top/bottom differ?</i>	Shiplap joints are molded into the panel, and panels are connected to each other via many connection points, 16" o.c. Screws are driven through the joint to connect the panels.	Connects to foundation either sitting over wood 2x plate, or sitting in steel track. This analysis will focus on the steel track.

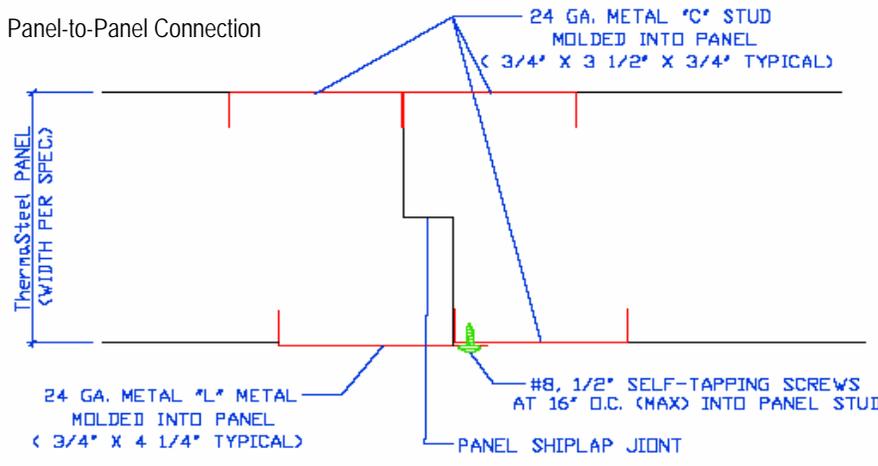
Physical characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Connection materials	<i>What are the connection materials?</i>	Panels are pre-shaped to form shiplap joint, and connection is made using caulk and screws.	Metal track, screws.
Dimensions and physical characteristics	<i>What are the dimensional characteristics of the connection materials?</i>	Interior panel spline: Shiplap joints tie into top plate and bottom plate, #8 self tapping screws every 12".	#8 self tapping screws every 12-14" o.c. to tie system into top and bottom plate.
Connection tolerances	<i>What are the connection tolerances?</i>	1/4"	Track must be level; panels should not be shimmed.
Connection points per panel type	<i>How often are the connections made?</i>	Connect to next panel sequence, and to sheathing material every 12"-14" o.c.	Connections made to top and bottom plates 12-14" o.c.



Detail of connection at bottom track (same at top)



Panel-to-Panel Connection



ThermaSteel

continued

Performance characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Conformance with applicable building codes	<i>What codes does the connection conform to?</i>	Panels conform to all codes including Dade County, ICCES #42-16, BOCA, SBCCI, and HUD. Has also passed hurricane projectile test (11 studs on exterior side of hurricane panels).	Panels conform to all codes including Dade County, ICCES #42-16, BOCA, SBCCI, and HUD. Has also passed hurricane projectile test (11 studs on exterior side of hurricane panels).
Structural strength	<i>What is the structural strength of the connector?</i>	N/A	N/A
Number of connections	<i>How many connections tie the panel to each other or other building parts?</i>	9 panel-to-panel connections - 12" o.c. along shiplap.	16 connections for each panel-to-track connection (assuming 16" o.c.). 2 screws at each stud.
Connection flexibility	<i>Can the connection make angled joints?</i>	Panels can make angled joints but would use some sort of plates or channels to secure, rather than the shiplap.	Yes, track is easily adaptable.
Connection durability over time	<i>Is the connection durable or subject to weakening under severe conditions?</i>	Screws and metal channels are durable.	Screws and metal channels are durable.
Connection fire resistance	<i>How does the connection perform when subjected to fire?</i>	Meets 1-hour fire rating but teel is Not fire resistant, so an additional layer of protection is needed.	Meets 1-hour fire rating but teel is Not fire resistant, so an additional layer of protection is needed.
Connection fire resistance and panel performance	<i>How is panel performance compromised if connector is subjected to fire?</i>	Flame spread of panel is 5+++ for 4" thick (see UL flame spread test results). Connection will fail during a fire at the same rate a the rest of the panel.	Metal channel will fail during fire.
Acoustical separation/insulation at connection	<i>How does sound transmit through the panel at the connection?</i>	Steel is primarily on the surface of the EPS foam, so sound does not transmit	Minimal sound transmission.
Energy performance at connection	<i>How does the connection perform thermally?</i>	Metal studs do not go through the panel, so thermal bridging is eliminated. Screws could potentially conduct heat and cold but are not expected to compromise thermal performance of panel.	The metal tracks at the top and bottom of the panel will be the weak point thermally, as the steel will transmit temperatures between interior and exterior.
Moisture/water resistance at connection	<i>How does the connection resist water and moisture?</i>	Poor if water accumulates on metal components and rusts. Relies on finishes for water protection.	Poor if water accumulates on metal components and rusts. Relies on finishes for water protection.
Air infiltration resistance at connection	<i>How does the connection resist air infiltration?</i>	Possible at joint if no sealant is used, but foam shiplap edge makes air travel difficult.	Possible at joint if no sealant is used, but shape of metal track makes air travel difficult.
Insect and Vermin resistance at connection	<i>How does the connection resist insects and other vermin?</i>	Steel resists insects but they can easily bore through foam.	Steel resists insects but they can easily bore through foam.

ThermaSteel

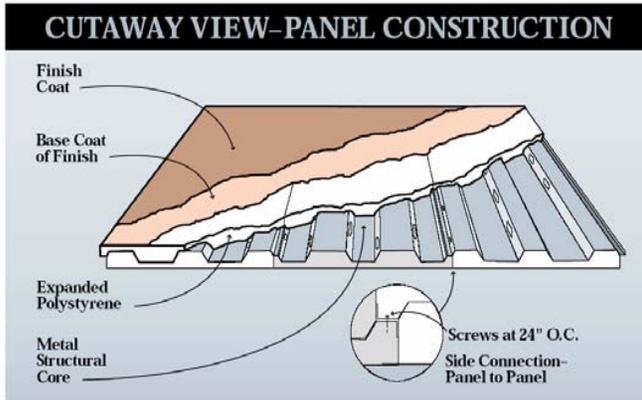
continued

Connection Interface		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Installation of panel connection system in the factory	<i>What components of the connection system are factory applied?</i>	Shi lap edges are formed in the factory.	Tracks are manufactured in the plant and shipped with the panels.
Installation of panel connections system on the site	<i>What components of the connection system are site applied?</i>	All screws are installed onsite.	All screws are applied on site including panel-to-panel, panel-to-track, and track-to-sill plate.
Protection of panel connection system from factory to site	<i>How are the factory-applied components protected during transport?</i>	No special protection.	Metal tracks can be bent if stepped on but can be either reshaped in the field, or replacement materials are readily available.
Installation of damaged connections	<i>Is installation possible if a connector is damaged?</i>	Screw should be replaced if it is damaged. If shi lap edges or metal studs become damaged, they could be field repaired using metal framing.	Metal tracks can be either reshaped in the field, or replacement materials are readily available.
Ease of installation	<i>What is the usual installation process?</i>	Panel is placed into bottom track, aligned next to subsequent panel, and locked together by top plate and interior screws at connections.	Panel is placed into bottom track, aligned next to subsequent panel, and locked together by top plate and interior screws at connections.
Tools required for connection	<i>What tools are required for the connection to be made?</i>	Drill, screws	Drill, screws
Skill level required for installation	<i>What is the approximate skill required to make the connection?</i>	Low skill level sufficient.	Low skill level sufficient.
Does the connection system support field changes	<i>If changes to the building are made, how does the connection respond?</i>	Yes, because the construction is similar to SIPs in detail and similar to steel framing it is easy to adapt panels and connections system in the field.	Yes, because the construction is similar to SIPs in detail and similar to steel framing it is easy to adapt panels and connections system in the field.
Compatibility with other panel connection systems	<i>Is the connection system compatible with other panel and wall systems?</i>	The panels could be used in conjunction with other panel types, but the shi lap joint would not transfer to the next panel. A flush ThermaSteel panel could be installed next to another flush panel.	Because either wood or metal tracks/plates can be used, the panels can tie into wood framing, wood SIPs, metal framing or metal SIPs.
Compatibility with house subsystems	<i>Are house subsystems accommodated by the connector?</i>	Chases are included. Although screws enter into the center of the panel, the connectors are spaced 12" or more so the connection does not interfere with utilities.	No penetration expected through top and bottom connections.
Ease of covering and finishing over connection, Interior	<i>Does the connection system hinder installation of interior finishes?</i>	Drywall is installaed directly over the panel. Unlike some other panel sytems, finishing crews must be sure to hit the metal studs in the panel to secure cladding.	No hindrance for interior finishes.
Ease of covering and finishing over connection, Exterior	<i>Does the connection system hinder installation of exterior finishes?</i>	Unlike some other panel sytems, finishing crews must be sure to hit the metal studs in the panel to secure cladding.	No hindrance for exterior finishes.
Ease of accessing connection after assembly	<i>Can the connector be accessed after installation?</i>	Screws can be removed but caulking at foam shi lap joint may cause panels to be damaged if torn apart.	Screws can be removed from tracks but sealant may make it difficult to remove panels intact.

Acsys - Metal Core Panels

General Information			
Distributor Name		Acsys Panel System	Acsys Panel System
Description		Steel Frame/Foam. An insulated steel-core wall panel made of 16-20 gauge galvanized corrugated structural core welded to a top and bottom 18 gauge galvanized steel track. Steel tracks are embedded in expanded polystyrene skin using a specialized molding process.	Acsys is the residential line but is identical to Koreteck, the version more widely used in light commercial construction. System is often used by Wendy's and Taco Bell and works particularly well with a stucco finish. Systems is most often used as in curtainwall (not structural) applications.
Panel Type	<i>Is the panel open-wall or closed-wall?</i>	Hybrid - Neither a skin nor a stud panel, uses a perforated steel core with foam on either side.	
Connection Type	<i>Do panel-to-panel and panel-to-top/bottom differ?</i>	Segments of steel core overlap like a shiplap joint and are screwed together. Corner and angled connections are made using formed metal channels screwed to the steel core.	Panels are fitted with factory-installed metal channels at top and bottom, which in turn fit into steel bottom tracks and top caps and are fastened with screws.

Physical characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Connection materials	<i>What are the connection materials?</i>	The panels are connected together using #14 x 3/4" galvanized self-drilling hex head screws. Zee channels are used at corners, attached 12" o.c.	18-gauge galvanized steel top and bottom channels are integral to panel. Framing fits into a track over continuous bead of sealant. panels screwed to track.
Dimensions and physical characteristics	<i>What are the dimensional characteristics of the connection materials?</i>	#14 self tapping screws every 24" o.c. panel to panel through shiplap joints. Shiplap = 1.5"; 3/4" to centerline.	#14 1/4" x 3/4" self-drilling screws used min. 12" o.c., except where structural member must fasten to the core - then use screws 2-1/2" long. Shaped channels (zee, etc.) used to stack panels and at intersections.
Connection tolerances	<i>What are the connection tolerances?</i>	Accommodates about 1/8" of "give".	Accommodates about 1/8" of "give".
Connection points per panel type	<i>How often are the connections made?</i>	24" o.c. minimum, along panel seams, and 12" o.c. at corners.	Minimum of 12" o.c.



Panels being tipped up into bottom track

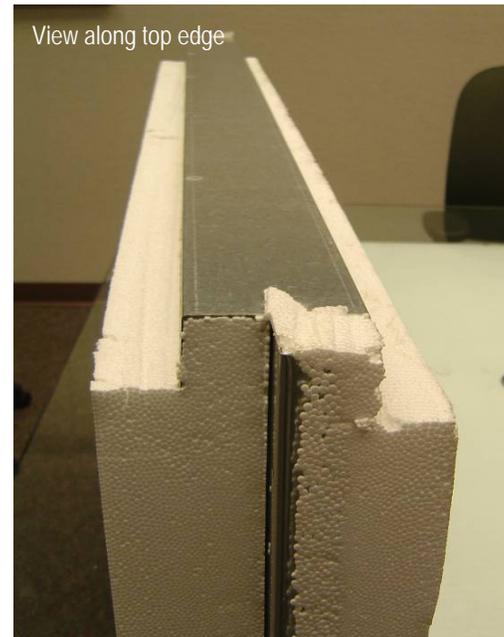


Panel is screwed into bottom track



Acsys

continued



Acsys

continued

Performance characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Conformance with applicable building codes	<i>What codes does the connection conform to?</i>	ICC for building materials; Underwriters Laboratories for fire tests; ASTM for steel, mold growth, and water vapor transmission.	ICC for building materials; Underwriters Laboratories for fire tests; ASTM for steel, mold growth, and water vapor transmission.
Structural strength	<i>What is the structural strength of the connector?</i>	N/A	N/A
Number of connections	<i>How many connections tie the panel to each other or other building parts?</i>	Fasteners are all screws, tied to steel core of panel or to shaped channels - track, corner, zee.	Fasteners are all screws, tied to steel core of panel or to shaped channels - track, corner, zee.
Connection flexibility	<i>Can the connection make angled joints?</i>	Track and panels can be easily adaptable to all angles.	Track and panels can be easily adaptable to all angles.
Connection durability over time	<i>Is the connection durable or subject to weakening under severe conditions?</i>	Metal screws and channels are durable.	Metal screws and channels are durable.
Connection fire resistance	<i>How does the connection perform when subjected to fire?</i>	Metal fasteners will eventually fail in a fire and must be protected with finishes.	Metal tracks and fasteners will eventually fail in a fire and must be protected with finishes.
Connection fire resistance and panel performance	<i>How is panel performance compromised if connector is subjected to fire?</i>	Panels and connections meet fire requirements. Greater portion of metal at connections than in panels may cause connections to fail first in a fire - not tested specifically.	Panels and connections meet fire requirements. Greater portion of metal at connections than in panels may cause connections to fail first in a fire - not tested specifically.
Acoustical separation/insulation at connection	<i>How does sound transmit through the panel at the connection?</i>	Insulates sound well. Connections have no significant increase in sound transmission.	Metal track transmits sound but top and bottom tracks are blocked by min. 1" thick EPS block.
Energy performance at connection	<i>How does the connection perform thermally?</i>	Thermal bridging minimal - 3/4" long connectors 24" o.c. imbedded in the foam	EPS filler block added after connections are complete.
Moisture/water resistance at connection	<i>How does the connection resist water and moisture?</i>	Galvanized steel resists rust. EPS resists mold. Connectors are galvanized also. Sealant helps stop moisture transmission.	Galvanized steel resists rust. EPS resists mold. Connectors are galvanized also. Sealant helps stop moisture transmission.
Air infiltration resistance at connection	<i>How does the connection resist air infiltration?</i>	Connections are imbedded in foam.	Sealant and EPS blocks limit air infiltration.
Insect and Vermin resistance at connection	<i>How does the connection resist insects and other vermin?</i>	Foam could be susceptible to vermin but should Not be appealing. Screws not affected.	Foam could be susceptible to vermin but should Not be appealing. Screws not affected.

Acsys

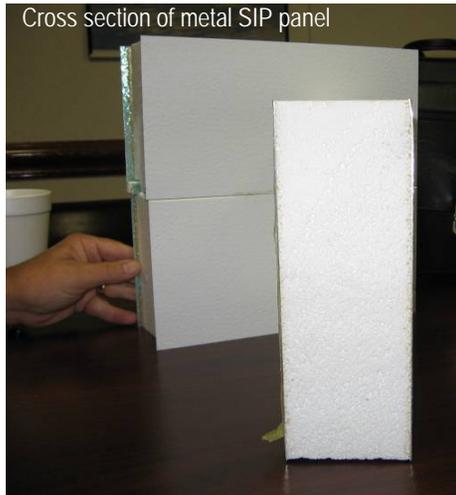
continued

Connection Interface		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Installation of panel connection system in the factory	<i>What components of the connection system are factory applied?</i>	Panel connection is inherently installed in the fabrication of the panel system.	Track mounted onsite.
Installation of panel connections system on the site	<i>What components of the connection system are site applied?</i>	Screws and channels (where needed) added onsite.	Screws, sealant and channels (where needed) added onsite.
Protection of panel connection system from factory to site	<i>How are the factory-applied components protected during transport?</i>	Wrapped in plastic for moisture protection. Only susceptible to dents in foam, which don't compromise performance much.	Wrapped in plastic for moisture protection. Only susceptible to dents in foam, which don't compromise performance much.
Installation of damaged connections	<i>Is installation possible if a connector is damaged?</i>	Yes, metal can likely be straightened. Unlikely to damage beyond repair.	Yes, metal can likely be straightened. Unlikely to damage beyond repair.
Ease of installation	<i>What is the usual installation process?</i>	Easy to set and tie panels together. Training takes about 4 hours.	Mount track, add sealant, place panel, fasten to bottom, fasten shiplap.
Tools required for connection	<i>What tools are required for the connection to be made?</i>	Drill, screws	Drill, screws
Skill level required for installation	<i>What is the approximate skill required to make the connection?</i>	Foam is marked to indicate where to drill (high and low sides of corrugation). One experienced crew member (familiar with order and layout) can direct crew with low skill level.	Foam is marked to indicate where to drill (high and low sides of corrugation). One experienced crew member (familiar with order and layout) can direct crew with low skill level.
Does the connection system support field changes	<i>If changes to the building are made, how does the connection respond?</i>	Easy to modify plan designs, panels can be modified on site to some degree but may need to special order channels, which can not easily be site fabricated.	Yes: Easy to modify plan designs, panels can be modified on site to some degree but may need to special order channels, which can not easily be site fabricated.
Compatibility with other panel connection systems	<i>Is the connection system compatible with other panel and wall systems?</i>	Metal channels could potentially connect to other metal-based panel connection systems. Can connect with metal stud wall.	Metal channels could potentially connect to other metal-based panel connection systems. Can connect with metal stud wall.
Compatibility with house subsystems	<i>Are house subsystems accommodated by the connector?</i>	Yes - because foam is on the outside, utilities can be imbedded using a hot knife without interacting with the connection.	Yes - because foam is on the outside, utilities can be imbedded using a hot knife without interacting with the connection.
Ease of covering and finishing over connection, Interior	<i>Does the connection system hinder installation of interior finishes?</i>	Requires longer drywall screws.	Requires longer drywall screws.
Ease of covering and finishing over connection, Exterior	<i>Does the connection system hinder installation of exterior finishes?</i>	Designed to work with stucco finish. Use of siding would require additional drainage and support measures.	Designed to work with stucco finish. Use of siding would require additional drainage and support measures.
Ease of accessing connection after assembly	<i>Can the connector be accessed after installation?</i>	Difficult to locate screws imbedded in foam.	Sealant and added blocks of EPS interfere.

SIPbLOC - Metal SIP Panels

General Information			
Distributor Name		SIPbLOC	SIPbLOC
Description		SIP- Steel/Metal Sheet/Foam Core - made of expanded polystyrene (EPS) foam insulation sandwiched between two structural steel skins. Finished with embossed aluminum coil, or embossed galvanized steel composite, in stucco, cedar wood grain, or smooth patterns.Snap-N-Lock system used to connect panels.	
Panel Type	<i>Is the panel open-wall or closed-wall?</i>	Closed wall	
Connection Type	<i>Do panel-to-panel and panel-to-top/bottom differ?</i>	Fits over bottom plate. Connected at many points.	

Physical characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Connection materials	<i>What are the connection materials?</i>	Metal sips rest in a track anchored into the foundation, and metal edges are formed with a special lip on vertical edges so panels next to each other snap together.	
Dimensions and physical characteristics	<i>What are the dimensional characteristics of the connection materials?</i>	Snapping joints are manufactured into each panel, which uses EPS foam and skins of either aluminum or steel.	A steel C-channel is used to anchor the wall system to the foundation or slab, and another C-channel acts as the top cap. Screws connect panel skins to the channels.
Connection tolerances	<i>What are the connection tolerances?</i>	Horizontal latitude is minimal because snap connection pulls panels tightly together.	The snap connection would allow for some vertical latitude.
Connection points per panel type	<i>How often are the connections made?</i>	Continuous snap connection.	Connections are made on each side of the panel with screws.





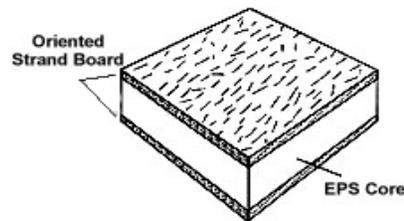
Performance characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Conformance with applicable building codes	<i>What codes does the connection conform to?</i>	International Building Code, California Building Code, Florida Building Code.	International Building Code, California Building Code, Florida Building Code
Structural strength	<i>What is the structural strength of the connector?</i>	Structural strength is available for the panel system as a whole.	Structural strength is available for the panel system as a whole.
Number of connections	<i>How many connections tie the panel to each other or other building parts?</i>	One continuous connection is made between panels.	Screws spacing is dictated by loads and conditions, 6"-12" o.c.
Connection flexibility	<i>Can the connection make angled joints?</i>	Track and panels can be easily adaptable to all angles.	Track and panels can be easily adaptable to all angles.
Connection durability over time	<i>Is the connection durable or subject to weakening under severe conditions?</i>	Track is easy to install, and panel to panel connections are embedded into each other.	Track is easy to install, and panel to panel connections are embedded into each other.
Connection fire resistance	<i>How does the connection perform when subjected to fire?</i>	Steel is not fire resistant, so an additional layer of protection is needed. Left unprotected, connection will fail during a fire.	Test samples meet UBC 26-3.
Connection fire resistance and panel performance	<i>How is panel performance compromised if connector is subjected to fire?</i>	Metal warps, yet stays intact. The snap connection is likely to perform the same as the wall.	Metal warps, yet stays intact.
Acoustical separation/insulation at connection	<i>How does sound transmit through the panel at the connection?</i>	Foam meets foam inside skins for continuous insulation.	Sound transmission is minimal.
Energy performance at connection	<i>How does the connection perform thermally?</i>	Foam meets foam for continuous insulation.	Thin metal track is only conductor.
Moisture/water resistance at connection	<i>How does the connection resist water and moisture?</i>	Entire panel is formed with moisture resistance.	Entire panel is formed with moisture resistance.
Air infiltration resistance at connection	<i>How does the connection resist air infiltration?</i>	Panel to panel connections snap together and sealed with sealant.	Sealant at bottom track helps prevent air infiltration, and track shape limits airflow.
Insect and Vermin resistance at connection	<i>How does the connection resist insects and other vermin?</i>	Panel connections are tight and resist insect infiltration.	Panel connections are tight and resist insect infiltration.

Connection Interface		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Installation of panel connection system in the factory	<i>What components of the connection system are factory applied?</i>	Panel connection is inherently installed in the fabrication of the panel system.	Metal tracks are shipped with panels.
Installation of panel connections system on the site	<i>What components of the connection system are site applied?</i>	The sealant is applied on site.	Tracks, screws and sealant are site-applied.
Protection of panel connection system from factory to site	<i>How are the factory-applied components protected during transport?</i>	Plastic film protects the metal finish. Panels are covered on the shipping truck.	Metal channels are galvanized and are Not protected.
Installation of damaged connections	<i>Is installation possible if a connector is damaged?</i>	Installation is difficult and can be impossible if damaged.	Metal track can be repaired or replaced with common metal framing materials.
Ease of installation	<i>What is the usual installation process?</i>	Installation process is straight forward and can be performed by a lower skill level.	Installation process is straight forward and can be performed by a lower skill level.
Tools required for connection	<i>What tools are required for the connection to be made?</i>	Drill, screws.	Caulking gun, drill, screws.
Skill level required for installation	<i>What is the approximate skill required to make the connection?</i>	Low	Low
Does the connection system support field changes	<i>If changes to the building are made, how does the connection respond?</i>	Easy to modify plan designs, might be difficult to modify panel size/shape.	Easy to modify plans, more difficult to move panels but it is easy to cut in windows, doors, and walls.
Compatibility with other panel connection systems	<i>Is the connection system compatible with other panel and wall systems?</i>	Can be used in conjunction with other wall systems with preplanning.	Can be used in conjunction with other wall systems with preplanning.
Compatibility with house subsystems	<i>Are house subsystems accommodated by the connector?</i>	House wiring can run uninterrupted through the foam at connection points.	House wiring can be accommodated by prefabricated wiring hole, but builder often fir out interior walls to house electrical.
Ease of covering and finishing over connection, Interior	<i>Does the connection system hinder installation of interior finishes?</i>	The connection system does not interfere or inhibit Interior or Exterior finishes.	The connection system does not interfere or inhibit Interior or Exterior finishes.
Ease of covering and finishing over connection, Exterior	<i>Does the connection system hinder installation of exterior finishes?</i>	The connection system does not interfere or inhibit Interior or Exterior finishes.	The connection system does not interfere or inhibit Interior or Exterior finishes.
Ease of accessing connection after assembly	<i>Can the connector be accessed after installation?</i>	Theoretically possible to disassemble, except for sealant.	Theoretically possible to disassemble, except for sealant.

Insulspan - Wood SIP Panels

General Information			
Distributor Name		Insulspan	Insulspan
Description		Wood SIP. Panels are made of an expanded polystyrene (EPS) core bonded between two outer layers of rugged oriented strand board (OSB). Several typical SIP connections are possible including 2x lumber spline, but analysis focuses on double OSB surface spline.	
Panel Type	<i>Is the panel open-wall or closed-wall?</i>	Closed	
Connection Type	<i>Do panel-to-panel and panel-to-top/bottom differ?</i>	Strips of OSB are used to spline two adjacent panels together.	Panels fit over a 2x bottom plate and are nailed at many points. Top plates overlap adjacent panels.

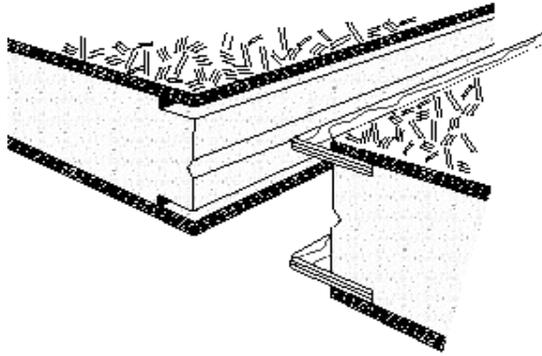
Physical characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Connection materials	<i>What are the connection materials?</i>	Many different details are available; however, this analysis focuses on OSB splines fitting into grooves just behind the panel sheathing. Sealant, nails, and screws are used to complete the connection. 2x lumber is used for panel ends at corners.	Foam is recessed to accommodate top and bottom plates made of dimensional lumber. Connect with nails/screws and sealant. Trusses/joists rest in hangers nailed to OSB.
Dimensions and physical characteristics	<i>What are the dimensional characteristics of the connection materials?</i>	Plywood splines are 7/16" x 3" and run the height of the panel. Two are used at each panel-to-panel connection, fastened with 1-5/8" drywall screws or nails. At corners or where panels meet dimensional lumber, use 8" spikes or screws for a 6" panel. Foam keyway is 3/4" x 3/4".	For 6" panels, used 2x6 lumber for top and bottom plates.
Connection tolerances	<i>What are the connection tolerances?</i>	There is some measure of latitude that can be taken up by the panels (perhaps 1/8") but any gaps must be filled with foam sealant. Gaps larger than 1/8" require special IFS sealant.	There is some amount of latitude.
Connection points per panel type	<i>How often are the connections made?</i>	Nailing pattern is typically 6" o.c. with 1-5/8" drywall screws or nails on either side of the seam between panels. Expanding foam sealant is applied to a central channel through holes spaced 12-18" to create a continuous bond. At T-intersections or corners, use use long (8" for 6" panel) screws w/ 2" dia. washers to drive through panel into a 2x end plate in the intersecting wall.	2x sill plate is nailed or bolted to foundation or trusses (pattern varies, 16" to 4' o.c.) and OSB panel skins are nailed to the sill and top plates at 6" o.c. on both sides. Roof panels are screwed to top plate at 8" o.c. w/ 2" dia. washers.



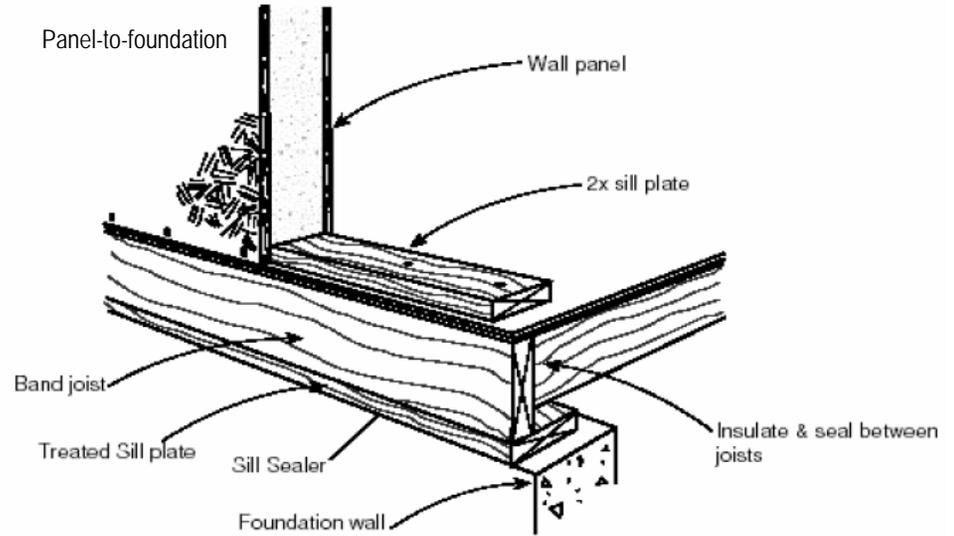
Insulspan

continued

Sketch of double OSB spline at panel-to-panel connection



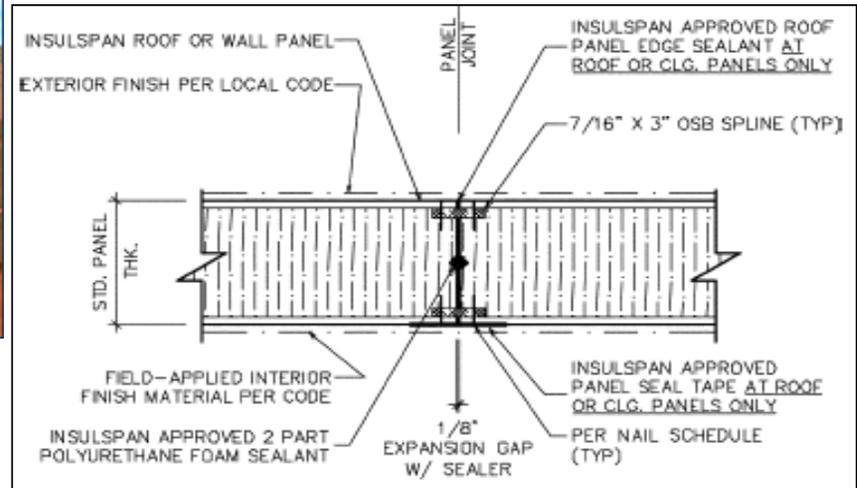
Panel-to-foundation



Insulspan SIP Installation



Architectural detail of panel-to-panel connection



Insulspan

continued

Performance characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Conformance with applicable building codes	<i>What codes does the connection conform to?</i>	Panels conform to BOCA, ICBO, SBCCI, and ICC. Tested for structural properties including racking load, surface burning characteristics, fire resistance, compressive strength tests, sound transmission, water vapor transmission.	Same as panel-to-panel.
Structural strength	<i>What is the structural strength of the connector?</i>	Maximum allowable racking load for stapled surface splines is 208 PLF; for nailed 2x wood splines it is 385 PLF.	Same as panel-to-panel.
Number of connections	<i>How many connections tie the panel to each other or other building parts?</i>	Top and bottom plates, OSB splines, nails and sealant. Nailing pattern is as described above.	Top and bottom plates connect to foundation/roof assemblies. Hangers for trusses/joists can be nailed directly to panel skins.
Connection flexibility	<i>Can the connection make angled joints?</i>	Panels can be easily adaptable to all angles, but 2x lumber may be needed to make these splines.	Top and bottom plates can make a variety of angles.
Connection durability over time	<i>Is the connection durable or subject to weakening under severe conditions?</i>	OSB splines perform well in most conditions but could potentially weaken under intense racking, steam, fire, etc.	Durability of connections at top and bottom is compatible to that of stick-frame construction.
Connection fire resistance	<i>How does the connection perform when subjected to fire?</i>	Test results from a National Evaluation Report show that OSB or plywood surface splines may be used "when spline studs [2x] are Not required for structural capacity or to meet fire resistive assembly details."	Dimensional lumber is susceptible to fire but connection is comparable to stick-frame construction.
Connection fire resistance and panel performance	<i>How is panel performance compromised if connector is subjected to fire?</i>	Once connection fails, whole wall failure will follow close behind.	Connections at top and bottom are less likely to fail than the spline connections.
Acoustical separation/insulation at connection	<i>How does sound transmit through the panel at the connection?</i>	Only 7/8" less insulating foam occurs at panel-to-panel connections.	Acoustical performance equals that of 2x lumber.
Energy performance at connection	<i>How does the connection perform thermally?</i>	Whole-wall R-value of 6-1/2" wall is R 23.3 with with surface splines; R 22.3 with a solid 2x6 spline.	Thermal performance equals that of 2x lumber.
Moisture/water resistance at connection	<i>How does the connection resist water and moisture?</i>	Expanding sealant helps limit moisture infiltration. Panel Seal Tape can be used to add another layer of protection. Inert foam insulation is not affected by moisture.	Sealant on both sides of bottom plate helps obstruct water path. Panel Seal Tape recommended at all panel-to-roof connections.
Air infiltration resistance at connection	<i>How does the connection resist air infiltration?</i>	Expanding sealant in central keyway helps limit air infiltration. Panel Seal Tape can be used to add another layer of protection. Inert foam insulation is not affected by moisture. Surface splines block direct path from interior to exterior.	Sealant on both sides of bottom plate helps block air. Panel Seal Tape recommended at all panel-to-roof connections.
Insect and Vermin resistance at connection	<i>How does the connection resist insects and other vermin?</i>	OSB can be treated with borate. EPS is penetrable but not particularly attractive to pests.	Similar to traditional stick frame construction.

Insulspan

continued

Connection Interface		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Installation of panel connection system in the factory	<i>What components of the connection system are factory applied?</i>	Foam is routed to fit splines and foam keyway. Splines cut to length.	Foam is routed to accommodate top/bottom plates.
Installation of panel connections system on the site	<i>What components of the connection system are site applied?</i>	Surface splines, expanding foam sealant, nails/fasteners.	Plates, hangers (if needed), sealant, nails/fasteners.
Protection of panel connection system from factory to site	<i>How are the factory-applied components protected during transport?</i>	Occasionally OSB panel edges can get damaged during shipping - makes installation more difficult, not impossible. Panels and connectors must be kept dry.	None.
Installation of damaged connections	<i>Is installation possible if a connector is damaged?</i>	Splintered edges may be OK but broken surface splines need to be replaced - easy to cut more onsite.	If damaged, plates are easily replaced onsite and foam can be hot-scooped out to accommodate connections.
Ease of installation	<i>What is the usual installation process?</i>	Attach bottom plate to foundation or floor, set panel over plate and nail. Pound in splines, set next panel, and screw/nail together. Top plate overlaps. Drill holes and spray in foam.	Same as panel-to-panel.
Tools required for connection	<i>What tools are required for the connection to be made?</i>	Hammer, foam sealant, nails, long screws, washers.	Hammer, foam sealant, nails, long screws, washers, Panel Seal Tape.
Skill level required for installation	<i>What is the approximate skill required to make the connection?</i>	Low	Low
Does the connection system support field changes	<i>If changes to the building are made, how does the connection respond?</i>	Yes: Panels can be modified and new connection points added but cutting panels and molding foam can be messy. New splines can easily be created onsite.	Same as panel-to-panel.
Compatibility with other panel connection systems	<i>Is the connection system compatible with other panel and wall systems?</i>	Product should interface with any other wood SIP system or wood framed construction.	Same as panel-to-panel.
Compatibility with house subsystems	<i>Are house subsystems accommodated by the connector?</i>	Surface splines allow utilities to run continuously through the center of the panels.	Plates can be drilled out to accommodate utilities.
Ease of covering and finishing over connection, Interior	<i>Does the connection system hinder installation of interior finishes?</i>	Very easy, no need to find studs and surface is very even.	N/A
Ease of covering and finishing over connection, Exterior	<i>Does the connection system hinder installation of exterior finishes?</i>	Very easy, no need to find studs and surface is very even.	N/A
Ease of accessing connection after assembly	<i>Can the connector be accessed after installation?</i>	SIPs can be modified or removed after they are installed by cutting the panels, but sealants and frequent nails/fasteners will make getting panels apart intact difficult.	N/A

Precision Panel - Wood SIP Panels

General Information			
Distributor Name		Precision Panel	Precision Panel
Description		Wood SIP. Panel are made of an expanded polystyrene (EPS) core bonded between two outer layers of rugged oriented strand board (OSB). Several typical SIP connections are possible including 2x lumber spline, but analysis focuses on 2x4 lumber spline.	
Panel Type	<i>Is the panel open-wall or closed-wall?</i>	Closed	
Connection Type	<i>Do panel-to-panel and panel-to-top/bottom differ?</i>	Panels fit over bottom 2x plate. 2x studs run vertically between adjacent panels. Nails are used to secure panel skins to plates and stud/spline.	

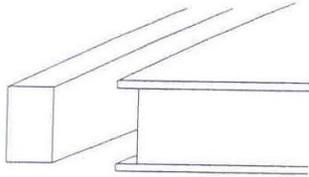
Physical characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Connection materials	<i>What are the connection materials?</i>	Many different details are available; however, this analysis focuses on 2x lumber splines fitting into grooves just behind the panel sheathing. Sealant, nails, and screws are used to complete the connection. Expanding foam sealant completes the connection.	Foam is recessed to accommodate top and bottom plates made of dimensional lumber. Connect with nails/screws and sealant. Trusses/Joists rest in hangers nailed to OSB.
Dimensions and physical characteristics	<i>What are the dimensional characteristics of the connection materials?</i>	2x splines are typical studs and run the height of the panel. One is used at each panel-to-panel connection, fastened with 8d nails.	For 6" panels, use 2x6 lumber for top and bottom plates.
Connection tolerances	<i>What are the connection tolerances?</i>	There is some measure of latitude that can be taken up by the panels (perhaps 1/8") but any gaps must be filled with foam sealant.	There is some amount of latitude.
Connection points per panel type	<i>How often are the connections made?</i>	Nailing pattern is typically 6" o.c. on either side of the seam between panels. Expanding foam sealant is applied down the middle of the foam core before panels are placed against spline.	2x sill plate is nailed or bolted to foundation or trusses (pattern varies, 16" to 48" o.c.) and OSB panel skins are nailed to the sill and top plates at 6" o.c. on both sides. Roof panels are screwed to top plate at 8" o.c. with 2" dia. washers.



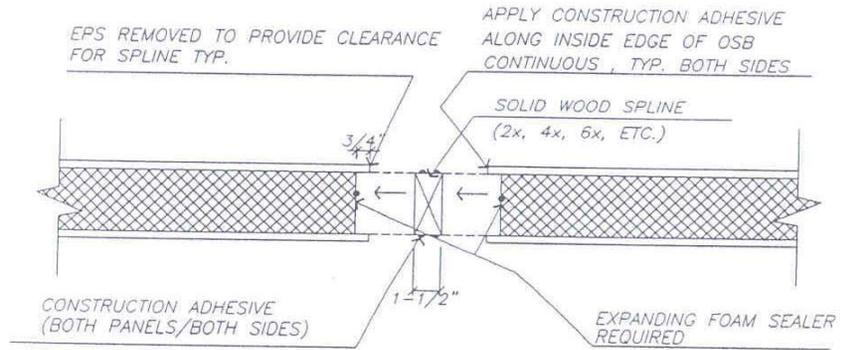
Precision

continued

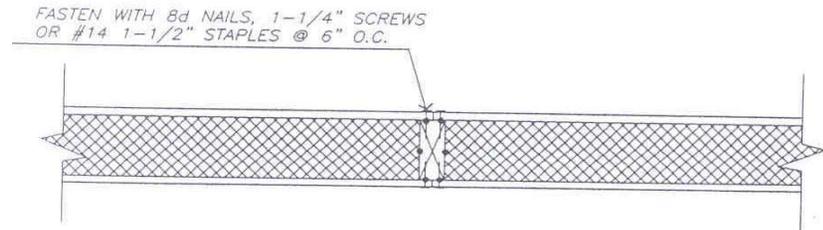
Details of 2x wood spline connection for panel-to-panel



Solid 2x blocking joint. A single groove for inseting 2x4, 2x6, 2x8 or 2x10, or 2x12. This blocking is required at corners and framing rough openings for windows, doors, etc. With doors and very large windows, inset 2x blocking running the full length of the panel (from bottom plate to top plate or header) may be required for strength.



HORIZONTAL SECTION PANELS BEFORE ASSEMBLY AND SOLID WOOD SPLINE



HORIZONTAL SECTION PANELS ASSEMBLED WITH SOLID WOOD SPLINE

Precision

continued

Performance characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Conformance with applicable building codes	<i>What codes does the connection conform to?</i>	Panels conform to BOCA, ICBO, SBCCI, and ICC. Tested for structural properties including racking load, surface burning characteristics, fire resistance, compressive strength tests, sound transmission, water vapor transmission.	Same as panel-to-panel.
Structural strength	<i>What is the structural strength of the connector?</i>	Maximum allowable racking load for stapled surface splines is 208 PLF; for nailed 2x wood splines it is 385 PLF.	Same as panel-to-panel.
Number of connections	<i>How many connections tie the panel to each other or other building parts?</i>	Top and bottom plates, OSB splines, nails and sealant. Nailing pattern is as described above.	Top and bottom plates connect to foundation/roof assemblies. Hangers for trusses/joists can be nailed directly to panel skins.
Connection flexibility	<i>Can the connection make angled joints?</i>	The 2x spline is easily adaptable.	Top and bottom plates can make a variety of angles.
Connection durability over time	<i>Is the connection durable or subject to weakening under severe conditions?</i>	Lumber splines are more durable (under racking load, etc).	Durability of connections at top and bottom is compatible to that of stick-frame construction.
Connection fire resistance	<i>How does the connection perform when subjected to fire?</i>	Dimensional lumber is susceptible to fire but connection is comparable to stick-frame construction.	Dimensional lumber is susceptible to fire but connection is comparable to stick-frame construction.
Connection fire resistance and panel performance	<i>How is panel performance compromised if connector is subjected to fire?</i>	Solid lumber connection is unlikely to withstand exposure to fire.	Connections at top and bottom are less likely to fail than the spline connections.
Acoustical separation/insulation at connection	<i>How does sound transmit through the panel at the connection?</i>	Only 7/8" less insulating foam occurs at panel-to-panel connections.	Acoustical performance equals that of 2x lumber.
Energy performance at connection	<i>How does the connection perform thermally?</i>	Whole-wall R-value of 6-1/2" wall is R 23.3 with surface splines and R 22.3 with a solid 2x6 spline.	Thermal performance equals that of 2x lumber.
Moisture/water resistance at connection	<i>How does the connection resist water and moisture?</i>	Expanding sealant helps limit moisture infiltration. Panel Seal Tape can be used to add another layer of protection. Inert foam insulation is not affected by moisture.	Sealant on both sides of bottom plate helps obstruct water path. Panel Seal Tape recommended at all panel-to-roof connections.
Air infiltration resistance at connection	<i>How does the connection resist air infiltration?</i>	Expanding sealant in central keyway helps limit air infiltration. Panel Seal Tape can be used to add another layer of protection. Inert foam insulation is not affected by moisture. Surface splines block direct path from interior to exterior.	Sealant on both sides of bottom plate helps block air. Panel Seal Tape recommended at all panel-to-roof connections.
Insect and Vermin resistance at connection	<i>How does the connection resist insects and other vermin?</i>	OSB can be treated with borate. EPS is penetrable but not particularly attractive to pests.	Similar to traditional stick-frame construction.

Precision

continued

Connection Interface		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Installation of panel connection system in the factory	<i>What components of the connection system are factory applied?</i>	Foam is routed to fit splines and foam keyway. Splines cut to length.	Foam is routed to accommodate top/bottom plates.
Installation of panel connections system on the site	<i>What components of the connection system are site applied?</i>	Surface splines, expanding foam sealant, nails/fasteners.	Plates, hangers (if needed), sealant, nails/fasteners.
Protection of panel connection system from factory to site	<i>How are the factory-applied components protected during transport?</i>	Occasionally OSB panel edges can get damaged during shipping - makes installation more difficult, not impossible. Panels and connectors must be kept dry.	None
Installation of damaged connections	<i>Is installation possible if a connector is damaged?</i>	Splintered edges may be OK but broken surface splines need to be replaced - easy to cut more on-site.	If damaged, plates are easily replaced onsite and foam can be hot-scooped out to accommodate connections.
Ease of installation	<i>What is the usual installation process?</i>	Set panels over bottom plate and adhesive and nail off. Apply foam to spline, pound spline into edge of panel, set next panel, foam and fasten to spline.	Same as panel-to-panel.
Tools required for connection	<i>What tools are required for the connection to be made?</i>	Hammer, foam sealant, nails, long screws, washers.	Hammer, foam sealant, nails, long screws, washers, Panel Seal Tape.
Skill level required for installation	<i>What is the approximate skill required to make the connection?</i>	Low	Low
Does the connection system support field changes	<i>If changes to the building are made, how does the connection respond?</i>	Panels can be modified and new connection points added but cutting panels and molding foam can be messy. New splines can easily be created on-site.	Yes
Compatibility with other panel connection systems	<i>Is the connection system compatible with other panel and wall systems?</i>	Product should interface with any other wood SIP system or wood framed construction.	Use of 2x top and bottom plates is consistent with other SIP panels and traditional stick framing.
Compatibility with house subsystems	<i>Are house subsystems accommodated by the connector?</i>	Surface splines allow utilities to run continuously through the center of the panels.	Plates can be drilled out to accommodate utilities.
Ease of covering and finishing over connection, Interior	<i>Does the connection system hinder installation of interior finishes?</i>	Very easy, no need to find studs and surface is very even.	Same as stick framing.
Ease of covering and finishing over connection, Exterior	<i>Does the connection system hinder installation of exterior finishes?</i>	Very easy, no need to find studs and surface is very even.	Same as stick framing.
Ease of accessing connection after assembly	<i>Can the connector be accessed after installation?</i>	SIPs can be modified or removed after they are installed by cutting the panels, but sealants and frequent nails/fasteners will make getting panels apart intact difficult.	Accessible except for sealant.

Murus Company - Wood SIP Panels

General Information			
Distributor Name		Murus Company	Murus Company
Description		Wood SIP. Panels available as polyurethane (PUR) panel with unique tongue and groove edge profile and patented Cam-Lock connectors. Also available is the expanded polystyrene (EPS) panel. Both panel types are available in various thicknesses, lengths and skin configurations. Both panels are sheathed with OSB.	
Panel Type	<i>Is the panel open-wall or closed-wall?</i>	Closed wall, wood SIP	Closed wall, wood SIP
Connection Type	<i>Do panel-to-panel and panel-to-top/bottom differ?</i>	Non-uniform connection made with Cam-Locks.	Non-uniform connection made with top and bottom plates and nails/screws.

Physical characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Connection materials	<i>What are the connection materials?</i>	Proprietary Cam-Lock, 6-7-8-9" galv. Ring shank or Ardox nails, or panel screws at corners	OSB panels slip over a treated 2x plate, are glued, sealed (with sealant) and nailed
Dimensions and physical characteristics	<i>What are the dimensional characteristics of the connection materials?</i>	Cam-Lock unit is approximately 6" tall and is imbedded into the panel approximately 4". The "tongue" of the cam is about 1/2" wide and 1/4" thick.	8d nails 6" o.c.
Connection tolerances	<i>What are the connection tolerances?</i>	Vertical tolerance is as much as a half inch; horizontal is a couple of sixteenths (1/8").	Latitude can be taken up with the setting of the panels, therefore it is minimized, but the connection can adapt to site variables.
Connection points per panel type	<i>How often are the connections made?</i>	24" intervals, beginning 12" from top or bottom of panel. At corners, screw or nail 8" o.c.	Continuous, every 6" o.c.





Panel connected over bottom plate



Panel-to-roof connection via angled top plate



Cam-lock and special wrench

Murus

continued

Performance characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Conformance with applicable building codes	<i>What codes does the connection conform to?</i>	Conforms to ICC and BOCA. Detailed tests performed for adhesion, cyclical aging, wind loads, and racking. Racking is the only test that specifically tests connections.	Conforms to ICC and BOCA. Detailed tests performed for adhesion, cyclical aging, wind loads, and racking. Racking is the only test that specifically tests connections.
Structural strength	<i>What is the structural strength of the connector?</i>	Racking test results, sheetrock screws 8" o.c. Full Panel assemblies 430 lbs, 53.75 plf Panel w/ Door opening 400 lbs, 50 plf Panel w/ Window opening 430 lbs, 53.75 plf Compare camlocks to 2x4 (or 2x6) wood splines showed Cam-Locks only 10% weaker.	Racking test results, sheetrock screws 8" o.c. Full Panel assemblies 430 lbs, 53.75 plf Panel w/ Door opening 400 lbs, 50 plf Panel w/ Window opening 430 lbs, 53.75 plf Compare Cam-Locks to 2x4 (or 2x6) wood splines showed cam locks only 10% weaker.
Number of connections	<i>How many connections tie the panel to each other or other building parts?</i>	Cam-Locks 2 at every panel joint	6" o.c.
Connection flexibility	<i>Can the connection make angled joints?</i>	Cam-Locks cannot accommodate irregular joins. Substitute 2x or other splines.	Yes
Connection durability over time	<i>Is the connection durable or subject to weakening under severe conditions?</i>	Cam-Locks are durable ABS plastic. OSB is much more subject to weakening under cyclical aging - ice, heat, steam.	Durable mechanical fasteners
Connection fire resistance	<i>How does the connection perform when subjected to fire?</i>	Plastic potentially melts but is protected in the wall.	Equivalent to traditional stick framing.
Connection fire resistance and panel performance	<i>How is panel performance compromised if connector is subjected to fire?</i>	When the connection fails, the interior panel is exposed to the fire and produced noxious gas when burned.	
Acoustical separation/insulation at connection	<i>How does sound transmit through the panel at the connection?</i>	Expect little or no change in sound transmission at connection.	Sound transmission equivalent to that of dimensional lumber.
Energy performance at connection	<i>How does the connection perform thermally?</i>	Plastic surrounded by foam. After locking, foam up the Cam-Lock through a small access hold.	Thermal bridging as with lumber.
Moisture/water resistance at connection	<i>How does the connection resist water and moisture?</i>	Adhesive applied as panels are joined, then foam sprayed in through small holes after connection is complete helps keep water and moisture out. Plastic not susceptible to water.	Adhesive helps seal, and blocking increases travel distance water would have to travel to inner building.
Air infiltration resistance at connection	<i>How does the connection resist air infiltration?</i>	Limited air infiltration thanks to good installation details and foam added to connection cavity after connections are made.	Limited air infiltration thanks to good installation details (bottom plate causes increase travel and caulking fills any voids).
Insect and Vermin resistance at connection	<i>How does the connection resist insects and other vermin?</i>	Susceptible to any pests that destroy wood but OSB can be treated with borate. EPS is not attractive to pests.	Sealant helps keep pests out, but wood is susceptible to pests that destroy wood.

Murus

continued

Connection Interface		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Installation of panel connection system in the factory	<i>What components of the connection system are factory applied?</i>	Cam-Locks are factory-installed during the foam expansion process. Foam sealant is added onsite.	The recess for the top and bottom plates are factory fabricated.
Installation of panel connections system on the site	<i>What components of the connection system are site applied?</i>	If a non-Cam-Lock connection is used, it is installed onsite - typically surface splines, or 2x dimensional corner connectors.	Slip panel over the bottom plate and nail onsite.
Protection of panel connection system from factory to site	<i>How are the factory-applied components protected during transport?</i>	Plastic wrapped for moisture protection. OSB edges can get damaged and slow but not prevent installation.	Plastic wrapped for moisture protection. OSB edges can get damaged and slow but not prevent installation.
Installation of damaged connections	<i>Is installation possible if a connector is damaged?</i>	Murus reports that all Cam-Locks are not really necessary once top and bottom plates are in place; they report that you only need one or two working cam-locks for sound construction.	Good: bottom plate is easy to install, panel to panel connections are easy some edges may be worn and impede installation.
Ease of installation	<i>What is the usual installation process?</i>	Panel set over plate, glue and foam applied within the recess. The next panel is set and builder uses a special key to engage the Cam-Locks. Foam squirted into Cam-Locks to finish.	Caulk and adhesive is applied to the bottom plate, and a panel is set on top of the plate. Nailed 12" o.c. around the perimeter of the panel. Top plates overlap panels.
Tools required for connection	<i>What tools are required for the connection to be made?</i>	Hammer, cam-lock wrench, nails, caulk or construction adhesive, foam insulation.	Hammer, chalk, glue, nails.
Skill level required for installation	<i>What is the approximate skill required to make the connection?</i>	Easy to set and lock into place; relatively low skill.	Easy to set and fasten into place; relatively low skill.
Does the connection system support field changes	<i>If changes to the building are made, how does the connection respond?</i>	Cam-Locks cannot be added in the field but panels are modifiable and substitutions (i.e., surface splines) can be used. Cam-Locks can be sliced through with a circular saw.	Panels can be modified in the field with a panel router and 16" circular saw.
Compatibility with other panel connection systems	<i>Is the connection system compatible with other panel and wall systems?</i>	Easy to tie other system into SIPs, similar to wood frame construction.	Easy to tie other system into SIPs, similar to wood frame construction.
Compatibility with house subsystems	<i>Are house subsystems accommodated by the connector?</i>	Plumbing and electrical cannot run through the Cam-Locks, but the locks are only about 6" high and spaced 24" o.c. leaving room for chases. One chase per panel is standard.	Yes, in some cases plumbing and electrical can make cuts into the bottom plate.
Ease of covering and finishing over connection, Interior	<i>Does the connection system hinder installation of interior finishes?</i>	Smooth surface, no need to search for studs.	Smooth surface, no need to search for studs.
Ease of covering and finishing over connection, Exterior	<i>Does the connection system hinder installation of exterior finishes?</i>	Smooth surface, no need to search for studs.	Smooth surface, no need to search for studs.
Ease of accessing connection after assembly	<i>Can the connector be accessed after installation?</i>	SIPs can be modified post-installation by cutting and the Cam-Locks themselves are reversible, but foam/adhesive impedes separation.	Difficult to actually disassemble the panel so it remains intact. Construction adhesive sealing panels to top and bottom plates complicates disassembly.

Agriboard - Wood SIP Panels

General Information			
Distributor Name		Agriboard	Agriboard
Description		Wood/Straw SIP. A panel system with a core made of compressed agricultural fibers (wheat, rice, straw) and an OSB skin. The fiber board incorporates a natural mineral to resist termites, carpenter ants, and other pests. The board provides up to a 2.5-hour fire protection.	
Panel Type	<i>Is the panel open-wall or closed-wall?</i>	Closed wall	
Connection Type	<i>Do panel-to-panel and panel-to-top/bottom differ?</i>	Panel-to-panel connections are the same as the panel-to-foundation or panel-to-ceiling connections. The panels are routed to accommodate a 2x2" "key" (track or plate) made of OSB.	

Physical characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Connection materials	<i>What are the connection materials?</i>	Mechanical fasteners and OSB keys and sealant.	Same as panel-to-panel connection.
Dimensions and physical characteristics	<i>What are the dimensional characteristics of the connection materials?</i>	Varies from connection type to connection type.	Same as panel-to-panel connection.
Connection tolerances	<i>What are the connection tolerances?</i>	1/8"	Same as panel-to-panel connection.
Connection points per panel type	<i>How often are the connections made?</i>	Screws at 12" o.c.	Same as panel-to-panel connection.

Agrifiber material



Panels stacked in plant with formed keyways



Panel samples

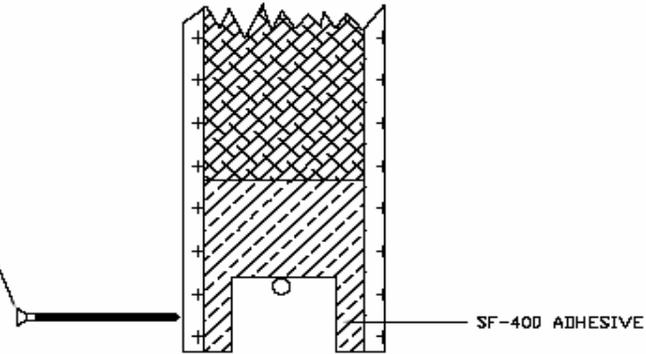


Detail applic
vertical conr

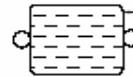
AGRIBOARD INDUSTRIES

KEYWAY TO PANEL CONNECTION

Install Approved Fasteners
on 12" centers on both
sides of the Panel.
Offset sides by 6"
on center.



TYPICAL KEYWAY TO
PANEL ATTACHMENT
USE A 3/8" BEAD OF
PL400 ADHESIVE ON
ALL SIDES OF "C"
CHANNEL. PLACE APPROVED FASTNERS
AT 12" INTERVALS STAGGERED
ON EACH SIDE OF THE PANEL.



Approved Keyway



Agriboard
Industries

1 Stage Adhesive	Keyway to C Channel Joist
Agriboard Industries CONSTRUCTION EQUIPMENT REPAIR DIVISION	
DATE	REV
04/20/03	04/20/03
REV	REV
	1 of 3

Agriboard

continued

Performance characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Conformance with applicable building codes	<i>What codes does the connection conform to?</i>	International Building Code, International Residential Code, Florida Building Code.	International Building Code, International Residential Code, Florida Building Code.
Structural strength	<i>What is the structural strength of the connector?</i>	Structural strength of overall panel system is known.	Structural strength of overall panel system is known.
Number of connections	<i>How many connections tie the panel to each other or other building parts?</i>	12" o.c.	12" o.c.
Connection flexibility	<i>Can the connection make angled joints?</i>	Panels can be easily adaptable to all angles.	Panels can be easily adaptable to all angles.
Connection durability over time	<i>Is the connection durable or subject to weakening under severe conditions?</i>	Keys and panels are durable but OSB is subject to weakening under racking load over time.	Top and bottom plates are durable.
Connection fire resistance	<i>How does the connection perform when subjected to fire?</i>	Connections hold up well under fire testing.	Connections hold up well under fire testing.
Connection fire resistance and panel performance	<i>How is panel performance compromised if connector is subjected to fire?</i>	Connections fire resistance comparable to that of whole panel resistance.	Connections fire resistance comparable to that of whole panel resistance.
Acoustical separation/insulation at connection	<i>How does sound transmit through the panel at the connection?</i>	Wall filled with agrifiber insulation. Test results available.	Wall filled with agrifiber insulation. Test results available.
Energy performance at connection	<i>How does the connection perform thermally?</i>	Same as whole-panel insulation values.	Same as whole-panel insulation values.
Moisture/water resistance at connection	<i>How does the connection resist water and moisture?</i>	Relies on finishes for moisture and water resistance. Borate helps resist mold.	Relies on finishes for moisture and water resistance. Borate helps resist mold.
Air infiltration resistance at connection	<i>How does the connection resist air infiltration?</i>	Sealant is used to fill voids.	Bottom plate causes increase travel and caulking fills voids.
Insect and Vermin resistance at connection	<i>How does the connection resist insects and other vermin?</i>	Borate used to provide insect barrier.	Borate used to provide insect barrier.

Agriboard

continued

Connection Interface		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Installation of panel connection system in the factory	<i>What components of the connection system are factory applied?</i>	Some panels are manufactured with the spline installed, or it is shipped to be installed at the job site.	Panel and connectors are shipped to site together.
Installation of panel connections system on the site	<i>What components of the connection system are site applied?</i>	Adhesive, nails.	Adhesive, nails, key bolted to foundation.
Protection of panel connection system from factory to site	<i>How are the factory-applied components protected during transport?</i>	Connections are packaged and sent with panels in shipment.	Connections are packaged and sent with panels in shipment.
Installation of damaged connections	<i>Is installation possible if a connector is damaged?</i>	Installation is possible. Replacement keys can be made on-site.	Installation is possible.
Ease of installation	<i>What is the usual installation process?</i>	Panels set over bottom key, then adhesive is applied to vertical key, placed in panel keyway, adjacent panel is placed and both are nailed off on both sides of the seam.	Bottom key is bolted to foundation, and bead of adhesive is applied to its top before panels are placed over it and nailed off.
Tools required for connection	<i>What tools are required for the connection to be made?</i>	Hammer, chalk, glue, nails.	Hammer, chalk, glue, nails.
Skill level required for installation	<i>What is the approximate skill required to make the connection?</i>	Low	Low
Does the connection system support field changes	<i>If changes to the building are made, how does the connection respond?</i>	Easy to modify plan designs, might be difficult to modify panel size/shape.	Easy to modify plan designs, might be difficult to modify panel size/shape.
Compatibility with other panel connection systems	<i>Is the connection system compatible with other panel and wall systems?</i>	Easy to tie other system into SIPs, similar to wood frame construction.	Easy to tie other system into SIPs, similar to wood frame construction.
Compatibility with house subsystems	<i>Are house subsystems accommodated by the connector?</i>	Four standard chases are cut during the manufacturing process.	Four standard chases are cut during the manufacturing process.
Ease of covering and finishing over connection, Interior	<i>Does the connection system hinder installation of interior finishes?</i>	It is actually easier to install drywall to the panel as compared to stick-built (connection is hidden in the panel).	It is actually easier to install drywall to the panel as compared to stick-built (connection is hidden in the panel).
Ease of covering and finishing over connection, Exterior	<i>Does the connection system hinder installation of exterior finishes?</i>	The connection system does not hinder installation of exterior finishes. It works well with a variety of finishes.	The connection system does not hinder installation of exterior finishes. It works well with a variety of finishes.
Ease of accessing connection after assembly	<i>Can the connector be accessed after installation?</i>	Connection is not easily accessed after assembly.	Connection is not easily accessed after assembly.

Bensonwood - Wood Open Wall Panels

General Information			
Distributor Name		Bensonwood Panels	Bensonwood Panels
Description		Wood. The OSB panel has a 16" o.c. stud framing. Features a unique larger wiring chase, and manufacturer-installed boxes and conduits. These panels are custom-made and can be structural or not. Often used in conjunction with timber framing, where timbers bear the load rather than the panels.	
Panel Type	<i>Is the panel open-wall or closed-wall?</i>	Work with several types of panels but this research focuses on a closed-wall panel that uses OSB sandwiching 2x studs with blown cellulose insulation.	
Connection Type	<i>Do panel-to-panel and panel-to-top/bottom differ?</i>	Panels have a 2x tongue-and-groove connection with gaskets for sealing, all connected with nails like conventional framing.	Panels have 2x top and bottom plates, nailed connections.

Physical characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Connection materials	<i>What are the connection materials?</i>	Nails and lumber similar to stick framing; Trelleborg gaskets (EPDM) for gaps tight to 1/2"; combination of chinking rod and PUR foam for 1/2" to 1" gaps.	Trelleborg gasket ST87 and construction adhesive (all tight joints), ringshank nails.
Dimensions and physical characteristics	<i>What are the dimensional characteristics of the connection materials?</i>	2 @ 1/2" and 3/4" dia. spaced 2"	2 @ 1/2" dia. spaces 2"
Connection tolerances	<i>What are the connection tolerances?</i>	Good tolerances due to air sealing gaskets and foam.	Similar to conventional wood framing.
Connection points per panel type	<i>How often are the connections made?</i>	every 6" o.c.	Every 4" o.c.





Cutout for wire chase at panel's base. Receives baseboard cap later.



Bensonwood

continued

Performance characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Conformance with applicable building codes	<i>What codes does the connection conform to?</i>	BWC	National Building Code
Structural strength	<i>What is the structural strength of the connector?</i>	Unknown	Unknown
Number of connections	<i>How many connections tie the panel to each other or other building parts?</i>	Nails, tongue and groove joints.	Nails, headlocks.
Connection flexibility	<i>Can the connection make angled joints?</i>	Many angles possible.	Yes
Connection durability over time	<i>Is the connection durable or subject to weakening under severe conditions?</i>	Comparable to wood framing.	Comparable to wood framing.
Connection fire resistance	<i>How does the connection perform when subjected to fire?</i>	Comparable to wood framing.	Comparable to wood framing.
Connection fire resistance and panel performance	<i>How is panel performance compromised if connector is subjected to fire?</i>	Comparable to wood framing.	Comparable to wood framing.
Acoustical separation/insulation at connection	<i>How does sound transmit through the panel at the connection?</i>	No different than wood-framed construction; not tested, minimal airborne sound transmission.	Not tested, minimal airborne sound transmission.
Energy performance at connection	<i>How does the connection perform thermally?</i>	Performs well due to gaskets and sealing, not superior.	Performs well, not superior.
Moisture/water resistance at connection	<i>How does the connection resist water and moisture?</i>	Performs well; gaskets make better connection than wood-frame construction.	Sealing and gaskets contribute to good water resistance.
Air infiltration resistance at connection	<i>How does the connection resist air infiltration?</i>	Performs very well; gaskets make better connection than wood-frame construction.	Performs very well; gaskets make better connection than wood-frame construction.
Insect and Vermin resistance at connection	<i>How does the connection resist insects and other vermin?</i>	Same susceptibility as wood-frame construction.	Same susceptibility as wood-frame construction.

Bensonwood

continued

Connection Interface		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Installation of panel connection system in the factory	<i>What components of the connection system are factory applied?</i>	Gaskets applied in factory and fastened on site.	Gaskets at top plate factory installed fasteners site installed.
Installation of panel connections system on the site	<i>What components of the connection system are site applied?</i>	Fasteners, gaskets, chinking rod, and sealant applied in field.	Adhesive, gasket, and fastener applied on site(bottom plate).
Protection of panel connection system from factory to site	<i>How are the factory-applied components protected during transport?</i>	Gaskets fastened with staples. Other components need no special protection.	Gaskets fastened with staples. Other components need no special protection.
Installation of damaged connections	<i>Is installation possible if a connector is damaged?</i>	Yes	Yes
Ease of installation	<i>What is the usual installation process?</i>	Panels are prepped on ground (fasteners) Trelleborg gaskets are stapled to panel; combination gets installed later.	Panels are set in place; fasteners driven after.
Tools required for connection	<i>What tools are required for the connection to be made?</i>	Screw gun, hammer, hammer stapler.	Screw gun, hammer, hammer stapler.
Skill level required for installation	<i>What is the approximate skill required to make the connection?</i>	Low	Low
Does the connection system support field changes	<i>If changes to the building are made, how does the connection respond?</i>	Field changes will likely need to be framed and connected like typical wood-frame construction.	The top and bottom plates are easily adjustable.
Compatibility with other panel connection systems	<i>Is the connection system compatible with other panel and wall systems?</i>	Yes, no different than wood framing.	Yes
Compatibility with house subsystems	<i>Are house subsystems accommodated by the connector?</i>	Yes - a recess at the panel's base allows for utilities, and can be covered with baseboard later on.	No
Ease of covering and finishing over connection, Interior	<i>Does the connection system hinder installation of interior finishes?</i>	Additional sheathing makes hanging drywall easier; no need to hit studs.	Comparable to wood framing.
Ease of covering and finishing over connection, Exterior	<i>Does the connection system hinder installation of exterior finishes?</i>	Comparable to wood framing.	Comparable to wood framing.
Ease of accessing connection after assembly	<i>Can the connector be accessed after installation?</i>	Yes	Yes

Wausau Homes - Wood Open-Wall Panels

General Information			
Distributor Name		Wausau Homes	Wausau Homes
Description		Wood Open Wall. Interior wall panels are open frame. Exterior wall panels are open-frame on the inside surface. The outside surface has plywood, OSB, or foam sheathing and house-wrap plant applied, windows and entry doors plant installed with weatherization flashing. Wausau makes floor panels and roof trusses for Whole House design.	
Panel Type	<i>Is the panel open-wall or closed-wall?</i>	Open Wall	
Connection Type	<i>Do panel-to-panel and panel-to-top/bottom differ?</i>	Connections made using nails and fasteners, identical to wood stick-frame construction.	

Physical characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Connection materials	<i>What are the connection materials?</i>	Dimensional lumber, nails, sheathing.	Dimensional lumber, nails, hangers.
Dimensions and physical characteristics	<i>What are the dimensional characteristics of the connection materials?</i>	Dimensional lumber studs, overlapping top and bottom plates, and overlapping sheathing are used with nails to attach the panels to each other.	Dimensional lumber top plates connect panels to each other and to floor. Hangers connect top plate to roof/joists.
Connection tolerances	<i>What are the connection tolerances?</i>	Connections have a great deal of latitude, limited primarily by the difficulty of installing finish systems over uneven panelized construction.	Same as panel-to-panel.
Connection points per panel type	<i>How often are the connections made?</i>	Nailing patterns vary depending on design loads: 8" - 32" o.c., 1 nail per joist, etc. Typical detail is 3 16D nails where top plates overlap adjoining panels. 2 16D nails 32" o.c. at corners.	Wall to floor and top plate: 2 16D nails ever 16" o.c. Truss and joist anchors w/ hanger nails for second story floor and roof.





Panels installed with plates and ladder blocking



Panelized Wal Systems: Making the Connections

Wausau Homes

continued

Performance characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Conformance with applicable building codes	<i>What codes does the connection conform to?</i>	Panel connections meet same requirements as a site-built home.	Same as panel-to-panel.
Structural strength	<i>What is the structural strength of the connector?</i>	N/A	Same as panel-to-panel.
Number of connections	<i>How many connections tie the panel to each other or other building parts?</i>	Top plates overlap and are nailed. At corners, sheathing overlaps and is nailed. Adjoining studs are nailed together.	Bottom plate is nailed to floor. Top plates connect adjoining panels, and hangers are used to connect joists.
Connection flexibility	<i>Can the connection make angled joints?</i>	Yes, this type of panel is highly flexible.	Same as panel-to-panel.
Connection durability over time	<i>Is the connection durable or subject to weakening under severe conditions?</i>	Durability comparable to traditional wood framing. Factory precision contributes to long-lasting construction.	Same as panel-to-panel.
Connection fire resistance	<i>How does the connection perform when subjected to fire?</i>	Wood plates and studs used to connect panels are susceptible to fire and must be covered with drywall or other finishing material to meet fire codes.	Same as panel-to-panel.
Connection fire resistance and panel performance	<i>How is panel performance compromised if connector is subjected to fire?</i>	Connections are no more susceptible to fire than the whole wall.	Same as panel-to-panel.
Acoustical separation/insulation at connection	<i>How does sound transmit through the panel at the connection?</i>	Acoustical performance equals that of dimensional lumber.	Same as panel-to-panel.
Energy performance at connection	<i>How does the connection perform thermally?</i>	Thermal performance equals that of dimensional lumber.	Same as panel-to-panel.
Moisture/water resistance at connection	<i>How does the connection resist water and moisture?</i>	Wood is typically susceptible to moisture, and is protected by exterior and interior finish systems. At customer's (builder's) option, the manufacturer will add waterproofing products.	Same as panel-to-panel.
Air infiltration resistance at connection	<i>How does the connection resist air infiltration?</i>	At customer's (builder's) option, the manufacturer will add airsealing measures (foam, etc).	Same as panel-to-panel.
Insect and Vermin resistance at connection	<i>How does the connection resist insects and other vermin?</i>	Wood is typically susceptible to insects and vermin, and is protected by exterior and interior cladding. At customer's (builder's) option, the manufacturer will add Borate treatment.	Same as panel-to-panel.

Wausau Homes

continued

Connection Interface		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Installation of panel connection system in the factory	<i>What components of the connection system are factory applied?</i>	Panels are complete with top and bottom plates, ladder blocking, and overhanging top plates and sheathing (at corners) for panel-to-panel connections.	Plates are factory installed.
Installation of panel connections system on the site	<i>What components of the connection system are site applied?</i>	All nailing is performed on-site.	All nailing and hanger installation is performed on-site.
Protection of panel connection system from factory to site	<i>How are the factory-applied components protected during transport?</i>	Panels are primarily shipped vertically and are carefully loaded to protect the pre-installed doors and windows. Sheathing overhangs are probably most vulnerable.	Panels are primarily shipped vertically and are carefully loaded to protect the pre-installed doors and windows. Sheathing overhangs are probably most vulnerable.
Installation of damaged connections	<i>Is installation possible if a connector is damaged?</i>	Problems can be fixed on-site with traditional wood-frame building materials.	Problems can be fixed on-site with traditional wood-frame building materials.
Ease of installation	<i>What is the usual installation process?</i>	Builder sets panels with equipment or by hand, beginning in a corner and nailing panels into place. Bracing is used to support the panels during installation.	Builder sets panels with equipment or by hand, beginning in a corner and nailing panels into place. Bracing is used to support the panels during installation.
Tools required for connection	<i>What tools are required for the connection to be made?</i>	Nailgun, hammer.	Nailgun, hammer.
Skill level required for installation	<i>What is the approximate skill required to make the connection?</i>	Less skill than traditional wood framing.	Less skill than traditional wood framing.
Does the connection system support field changes	<i>If changes to the building are made, how does the connection respond?</i>	Highly flexible panel connection system accommodates changes easily using traditional building materials. Factory-installed windows, doors, and exterior cladding may limit changeability.	Highly flexible panel connection system accommodates changes easily using traditional building materials. Factory-installed windows, doors, and exterior cladding may limit changeability.
Compatibility with other panel connection systems	<i>Is the connection system compatible with other panel and wall systems?</i>	These panels can be joined to other panelized systems, for instance SIPs, using a dimensional lumber spline to transition between panels.	These panels can be joined to other panelized systems, for instance SIPs, using a dimensional lumber spline to transition between panels.
Compatibility with house subsystems	<i>Are house subsystems accommodated by the connector?</i>	Compatibility is identical to that of traditional stick framing.	Compatibility is identical to that of traditional stick framing.
Ease of covering and finishing over connection, Interior	<i>Does the connection system hinder installation of interior finishes?</i>	Similar to stick framing, although factory quality control tends to make for straighter walls and easier finish application, including areas over connections. When installed, connections perform the same as the rest of the panel.	Similar to stick framing, although factory quality control tends to make for straighter walls and easier finish application, including areas over connections. When installed, connections perform the same as the rest of the panel.
Ease of covering and finishing over connection, Exterior	<i>Does the connection system hinder installation of exterior finishes?</i>	Exterior finishes are factory-installed except for trim, which can be easily applied over the panel connections at corners and joists.	Exterior finishes are factory-installed except for trim, which can be easily applied over the panel connections at corners and joists.
Ease of accessing connection after assembly	<i>Can the connector be accessed after installation?</i>	Access is identical to that of traditional stick framing. Nails can be removed.	Access is identical to that of traditional stick framing. Nails can be removed.

Strong-Wall Shearwall - Wood Open-Wall Panels

General Information			
Distributor Name		Simpson Strong-Wall Shearwall	Simpson Strong-Wall Shearwall
Description		Simpson makes a variety of fasteners and shearwall products. This research focuses on the wood Strong-Wall Shearwall.	
Panel Type	<i>Is the panel open-wall or closed-wall?</i>	Wood open-wall panel reinforced with additional framing and metal channels. Typically used in conjunction with Simpson tie-downs for maximum shear resistance for high design loads.	
Connection Type	<i>Do panel-to-panel and panel-to-top/bottom differ?</i>	The panel-to-panel connections and the panel to top/bottom plate connection differ. Shearwall panels are typically set next to other wood framing or wood open wall panels, mainly in garage portals. Shearwall panels connect to adjacent studs (posts) or panels using nails and rectangular straps or nailing plates.	The panel-to-panel connections and the panel to top/bottom plate connection differ. Connect to roof or framing at the top with nailed straps. Connect to foundation anchor bolts and foundation bolts, secured with nuts.

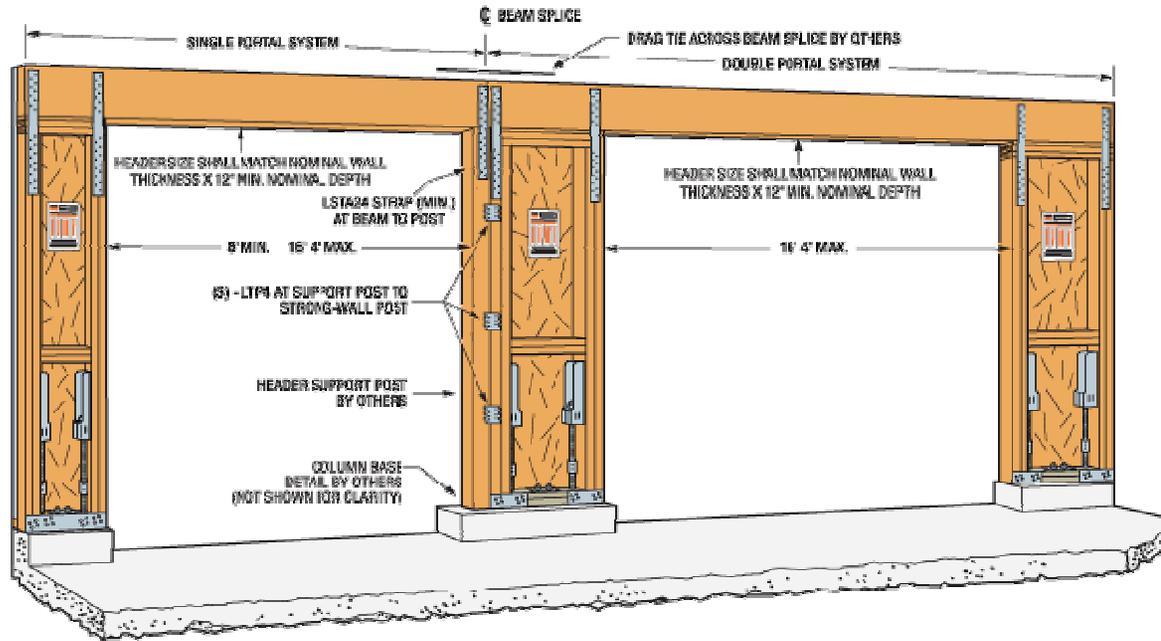
Physical characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Connection materials	<i>What are the connection materials?</i>	Straps, nails, screws.	Hold-down anchor bolts, straps, foundation bolts.
Dimensions and physical characteristics	<i>What are the dimensional characteristics of the connection materials?</i>	Specific fastener used vary widely based on building design and conditions. Simpson makes a wide variety of fasteners.	Two SSTB28 anchor bolts (SSTB34 for 2 pour applications) and minimum 5/8" x 12" foundation bolts into template a maximum of 1" above template, secured with nuts.
Connection tolerances	<i>What are the connection tolerances?</i>	Precision is important for safety. Templates accompany panels and fasteners to ensure precise installation.	Precision is important for safety. Templates accompany panels and fasteners to ensure precise installation.
Connection points per panel type	<i>How often are the connections made?</i>	Depends upon loading, but typically two straps plus nailing.	Typically 2 straps at top and 2 bolts to anchor bottom.



Strong-Wall

continued

Typical garage portal application



Strong-Wall

continued

Performance characteristics		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Conformance with applicable building codes	<i>What codes does the connection conform to?</i>	Conforms to the IBC and the UBC, California Building Code and various other building codes, ICC, State of Florida.	Conforms to the IBC and the UBC, California Building Code and various other building codes, ICC, State of Florida.
Structural strength	<i>What is the structural strength of the connector?</i>	All Simpson connectors are engineered. Strengths are given for the wall as a whole, including the specified connectors.	All Simpson connectors are engineered. Strengths are given for the wall as a whole, including the specified connectors.
Number of connections	<i>How many connections tie the panel to each other or other building parts?</i>	Depends upon loading, but typically two straps plus nailing.	Typically 2 straps at top and 2 bolts to anchor bottom.
Connection flexibility	<i>Can the connection make angled joints?</i>	While connections are not limited, shearwalls are typically installed square to the building for greatest strength.	While connections are not limited, shearwalls are typically installed square to the building for greatest strength.
Connection durability over time	<i>Is the connection durable or subject to weakening under severe conditions?</i>	The shearwall was creating to withstands heaving loads without weakening.	The shearwall was creating to withstands heaving loads without weakening.
Connection fire resistance	<i>How does the connection perform when subjected to fire?</i>	Unknown	Unknown
Connection fire resistance and panel performance	<i>How is panel performance compromised if connector is subjected to fire?</i>	Unknown	Unknown
Acoustical separation/insulation at connection	<i>How does sound transmit through the panel at the connection?</i>	Where additional studs or posts are used, acoustical transmission will increase.	Anchor bolts and takeup devices contribute to sound transmission, as do additional top and bottom plates.
Energy performance at connection	<i>How does the connection perform thermally?</i>	Where additional studs or posts are used, thermal bridging will increase.	Anchor bolts and takeup devices contribute to energy transmission, as do additional top and bottom plates.
Moisture/water resistance at connection	<i>How does the connection resist water and moisture?</i>	All fasteners are galvanized to resist rust.	All fasteners are galvanized to resist rust.
Air infiltration resistance at connection	<i>How does the connection resist air infiltration?</i>	No special resistance.	No special resistance.
Insect and Vermin resistance at connection	<i>How does the connection resist insects and other vermin?</i>	No special resistance.	No special resistance.

Strong-Wall

continued

Connection Interface		Panel-to-Panel Connections	Panel-to-Top/Bottom Plate Connections
Installation of panel connection system in the factory	<i>What components of the connection system are factory applied?</i>	Panels and connectors are shipped to the site together.	Panel and connectors are shipped to the site together.
Installation of panel connections system on the site	<i>What components of the connection system are site applied?</i>	All connectors are field-installed.	The anchors must be set in concrete prior to installation.
Protection of panel connection system from factory to site	<i>How are the factory-applied components protected during transport?</i>	Panel and connectors are packaged for protection during shipment.	Panel and connectors are packaged for protection during shipment.
Installation of damaged connections	<i>Is installation possible if a connector is damaged?</i>	This wall cannot be installed with damaged connectors.	This wall cannot be installed with damaged connectors.
Ease of installation	<i>What is the usual installation process?</i>	Simpson provides a fool proof system for installation by including installation instructions attached to the wall during shipment. They have provided the builder with a product that doesn't require a high skill level for installation.	Simpson provides a fool proof system for installation by including installation instructions attached to the wall during shipment. They have provided the builder with a product that doesn't require a high skill level for installation.
Tools required for connection	<i>What tools are required for the connection to be made?</i>	No special tools required.	No special tools required.
Skill level required for installation	<i>What is the approximate skill required to make the connection?</i>	Low/medium skill level required.	Low/medium skill level required.
Does the connection system support field changes	<i>If changes to the building are made, how does the connection respond?</i>	This wall system was not created for change after installation.	This wall system was not created for change after installation.
Compatibility with other panel connection systems	<i>Is the connection system compatible with other panel and wall systems?</i>	This wall system is compatible with other wall systems including SIPs and wood open wall, as well as conventional wood framing.	This wall system is compatible with other wall systems.
Compatibility with house subsystems	<i>Are house subsystems accommodated by the connector?</i>	It offers multiple prefabricated holes for electrical and wiring.	House subsystems are accommodated including several spaces for wiring or different types.
Ease of covering and finishing over connection, Interior	<i>Does the connection system hinder installation of interior finishes?</i>	The system is set up for the future installation of interior and exterior finishes.	The system is set up for the future installation of interior and exterior finishes.
Ease of covering and finishing over connection, Exterior	<i>Does the connection system hinder installation of exterior finishes?</i>	The system is set up for the future installation of interior and exterior finishes.	The system is set up for the future installation of interior and exterior finishes.
Ease of accessing connection after assembly	<i>Can the connector be accessed after installation?</i>	The strap tie connections are easy to access.	The connections are easy to access, except the anchors set in concrete.

APPENDIX B PANEL MANUFACTURER MATRIX

This matrix includes the 12 panel systems studied, which represent the state-of-practice of connections being used today. The matrix categorizes the 12 systems by 4 of the most popular panel types used by the U.S. homebuilding industry: concrete panels, metal panels, wood structural insulated panels (SIPs), and wood open-wall panels. The 12 systems are distributed among these 4 panel systems types as follows: concrete panels (2 systems); metal panels (3 systems); wood SIPs (4 systems); wood open-wall panels (3 systems).

<i>Concrete Panels</i>	
OldCastle, NY	A concrete panel with carbon fibers (TEchFab) and rebar for support. The panel is backed with expanded polystyrene. For residential interior and exterior walls and floors. Vertical connections use a NMB Splice Sleeve System. Most horizontal panel to panel connections are made through embedding weld plates into the panel during the casting phase; then making a welded connection during installation.
Dukane Precast Inc., IL	Concrete Sandwich. A double wall of precast concrete, with steel trusses girders connecting two sides. The panel is insulated with various types of insulation. For exterior residential and commercial walls and floors. Panels are grouted together inside and caulked outside. Floor and ceiling are cemented in.
<i>Metal Panels</i>	
Acsys Panel System, ThermaSteel, VA	Steel Frame/Foam. A panel with a core of EPS framed with 24-gauge, G-90 galvanizing steel studs, typically finished on interior with appropriate gypsum composite although any type of cladding may be field applied to the interior and exterior. For residential and commercial interior and exterior walls. Connected with shiplap joints and self-tapping tech screws. Preferred method: metal tracks for top and bottom plate.
Acsys Inc., ID	Steel Frame/Foam. An insulated steel-core wall panel made of 16-20 gauge galvanized corrugated structural core welded to a top and bottom 18 gauge galvanized steel track. Steel tracks are embedded in expanded polystyrene skin using a specialized molding process. For residential and commercial exterior walls. The product is supplied with mounting track, fasteners, and corner connectors.
SIPbLOC, Metals USA Building Products, TX	SIP- Steel/Metal Sheet/Foam Core. The panel is made of expanded polystyrene (EPS) foam insulation sandwiched between two structural skins of steel or aluminum. The unique feature of this system is the mechanism used to lock the panels together. For residential and commercial exterior walls and roofs. Connected via integrated snap-and-lock system with sealant.
<i>Wood SIPs</i>	
Insulspan	Wood SIP. Expanded Polystyrene (EPS) core bonded between two outer layers of Oriented Strand Board (OSB). For residential and commercial walls, roofs, and floors. Panels sit on 2x plating, which in turn sits on a treated sill plate anchored to foundation. Connect panels w/ double OSB surface splines (most common), nails or screws, and sealant. Other spline types can be used including 2x4 lumber splines.
Precision Panel	Wood SIP. Expanded Polystyrene (EPS) core bonded between two outer layers of Oriented Strand Board (OSB). For residential and commercial walls, roofs, and floors. Panels sit on 2x plating, which in turn sits on a treated sill plate anchored to foundation. Connect panels w/ either 2x4 lumber splines, OSB surface splines, or insulated "superspline" resembling a mini-panel. Connections also use sealant and nails or screws.
Murus, PA	Wood SIP. Polyurethane (PUR) or EPS insulation core w/ OSB sheathing. Unique tongue and groove edge profile and patented cam-lock connectors with Urethane panels. For residential and commercial exterior walls, roofs, floors. Once one or two of the cam locks are engaged, the panel is supported correctly in place and is ready to be secured to the framing members. Sealant is added to the panel-to-panel connection. Top and bottom plates provide majority of connection strength.
Agriboard, Raytheon Engineers & Constructors, TX	Wood/Straw SIP. A panel system with a core made of compressed agricultural fibers (wheat, rice, straw) and an OSB skin. The fiber board incorporates a natural mineral to resist termites, carpenter ants and other pests. The board provides up to a 2-hour fire resistance. For residential exterior walls, roofs, floors. Connected using 2x2 wood 'keys' fitted into keyways along panel edges. Connections completed with sealant and nails.
<i>Wood Framed Panels</i>	
Bensonwood Open-Wall Panels, NH	Wood. The OSB panel has a 16" o.c. I-flange framing and is insulated with urethane. Features a unique larger wiring chase, and manufacturer-installed boxes and conduits. These panels are custom-made and can be structural or not. Often used in conjunction with timber framing, where timbers bear the load rather than the panels. For residential exterior walls. Connected with shiplap joints, gaskets, and foam.
Wasau Homes, WI	Wood Open Wall. Interior wall panels are open frame, while exterior wall panels are open frame on the inside surface. The outside surface has plywood, OSB or foam sheathing & house-wrap plant applied, windows & entry doors plant installed with weatherization flashing. Panels are for residential and light commercial floors, walls, and roofs. Connected with nails, spikes, plates, hangers and other conventional mechanical fasteners. Meets requirements for high wind load design and foundation anchorage.
Strong-Wall Shearwall, Simpson Strong Tie, CA	Wood Open Wall. This panel is an open wall prefabricated wood shear wall. The panel achieves high design loads proven by cyclic testing. For residential exterior walls and garages, when the area requires high load and/or shear load bearing capability. Templates are used to place the required holdown and mudsill anchor bolts accurately in the foundation. The wall panels cover the anchor bolts, followed by top and bottom plate attachment.