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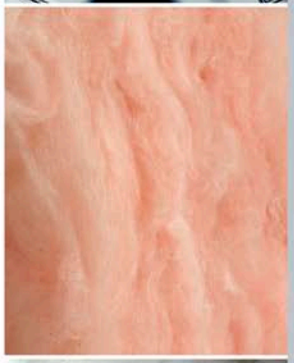

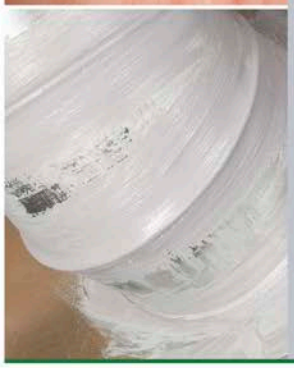

EXTENDED PLATE & BEAM WALL SYSTEM

CONSTRUCTION AND CODE ASSESSMENT

February 2018

DRAFT REPORT

Building AMERICA
U.S. Department of Energy

Extended Plate & Beam Wall System Construction and Code Assessment

Prepared for:

U.S. Department of Energy's Building America Program

Office of Energy Efficiency and Renewable Energy

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The work presented in this EERE Building America report does not represent performance of any product relative to regulated minimum efficiency requirements.

The laboratory and/or field sites used for this work are not certified rating test facilities. The conditions and methods under which products were characterized for this work differ from standard rating conditions, as described.

Because the methods and conditions differ, the reported results are not comparable to rated product performance and should only be used to estimate performance under the measured conditions.

Foreword

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Preface

This report was prepared by Home Innovation Research Labs for the U.S. Department of Energy/Office of Energy Efficiency and Renewable Energy/Buildings Technologies Office with industry cost-share support from Dow Chemical Company and the American Chemistry Council.

The aim of the Building America program is to develop market-ready solutions that improve energy efficiency, durability, quality, affordability and comfort for new and existing houses. Specifically, this study is intended to address the objectives of the Building America Moisture Risk Management and High-Performance Envelope Systems Roadmap by demonstrating and validating durability, constructability and cost-effectiveness aspects of the Extended Plate and Beam wall system for new construction housing projects using both field-framing and factory panelization methods.

Since 2012 the International Energy Conservation Code (IECC) has required an R-5 or R-10 layer of continuous insulation (c.i.) for all walls in climate zones 6, 7 and 8, and c.i. is one of two prescriptive solutions for climate zones 4 and 5. While foam plastic insulating sheathing (FPIS) as continuous exterior insulation has been used by a small cohort of high-performance builders for approximately two decades, by 2015 the practice had achieved only about 11% market penetration for all thicknesses of foam. Constructability challenges associated with exterior foam are presumed to be a barrier to adoption. Potentially, 60% to 80% of residential builders in the targeted climate zones are candidates for adopting the EP&B wall system, as local jurisdictions begin to require the most recent codes.

This report includes calculations indicating EP&B's thermal performance equivalency to 2015 IECC minimum code walls and laboratory test results indicating EP&B's structural performance equivalency to current IRC braced wall methods. The report presents proposed code language and other support documentation for submission of EP&B to the ICC for inclusion in the next code cycle as a prescriptive braced wall method and a prescriptive insulated wall system.

Acknowledgments

Home Innovation Research Labs acknowledges the U.S. Department of Energy Building America program, American Chemistry Council, and the Dow Chemical Company for their invaluable support.

Nomenclature

c.i.	Continuous insulation—generally a rigid or semi-rigid board insulation material installed exterior to the wall cavity.
CZ	Climate Zone, as defined by the International Energy Conservation Code
DOE	United States Department of Energy, a federal agency that conducts and solicits research on energy efficiency topics, and includes the Building America program
EPS	Expanded Polystyrene, a type of rigid foam sheathing suitable for use in the EP&B wall system with the addition of a film
EP&B	Extended Plate & Beam, a light frame wall system under development at Home Innovation Research Labs
FPIS	Foam Plastic Insulating Sheathing- a rigid foam board typically made from extruded polystyrene (XPS), expanded polystyrene (EPS) or Polyisocyanurate (PIC) and used to provide a layer of continuous insulation for house walls or other components. In this report, FPIS generally refers to rigid foam installed as continuous insulation exterior to the wood sheathing, or in place of the wood sheathing.
Rigid Foam	FPIS used primarily as an insulation material, rather than for the purpose of sheathing. In an EP&B wall, the rigid foam is installed between the framing and the OSB.
High-R	Building America program reference to wall systems with high thermal resistance, exceeding energy code minimum requirements
ICF	Insulated Concrete Forms
IECC	International Energy Conservation Code
IRC	International Residential Code
o.c.	On center – the measurement for lumber with dimension, e.g., studs, whose 1-1/2-in. width means that 16-in. o.c. installation leaves a 14-1/2-in. stud bay.
OSB	Oriented Strand Board, a manufactured wood sheathing product
PIC	Polyisocyanurate, a type of rigid foam sheathing suitable for use in the EP&B wall system
SIP	Structural Insulated Panel
R-value	Quantitative measure of resistance to conductive heat flow (hr·°F·ft2/Btu)
U-value	Quantitative measure of thermal conductance: Btu /(hr·°F·ft2) (the inverse of R-value)
WSP	Wood Structural Panel — the layer of wood sheathing (plywood or OSB) that provides shear and racking strength when properly attached to wall framing
XPS	Extruded Polystyrene, a type of rigid foam sheathing suitable for use in the EP&B wall system

Executive Summary

Home Innovation Research Labs studied the Extended Plate and Beam Wall system over a two-year period from mid-2015 to mid-2017 to determine the wall's structural and thermal performance, moisture durability, constructability, and cost-effectiveness for use as a high-R enclosure system for energy code minimum and above-code performance in climate zones 4 through 8.

The geometry of typical residential wall configurations was analyzed to determine the thermal bridging constituted by the extended plates of the EP&B wall. This ratio was used in ASHRAE parallel path calculations to determine the theoretical thermal performance of EP&B walls. The results were then compared to the theoretical performance of 2015 IECC walls constructed with the typical foam over-sheathing method of installing continuous insulation exterior to the wood structural paneling. The extended plates of the EP&B framing method constitute an area-based thermal bridge of approximately 4.6%, yet with typical materials choices and framing factors, EP&B meets the IECC *Table R402.1.4 Equivalent U-Factors.*

Laboratory tests based on AC269.1 confirmed EP&B walls' strength and stiffness performance for IRC intermittent and continuous braced wall equivalency. The calculated Allowable Design Racking Shear Load Value for EP&B walls is 256 plf (lbs/ft) for SPF framing. As a point of comparison, the minimum acceptable IRC-WSP braced wall is listed at 184 plf.

EP&B thermal transfer calculations and structural test results are presented here with suggested language, tables and figures to provide the basis for inclusion of the EP&B wall in the next ICC code cycle as a prescriptive IRC braced wall and prescriptive IECC insulated wall.

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Introduction and Background

The residential building industry has been searching to expand the list of available options for increasing the thermal resistance of walls for several decades. Although multiple high-R wall construction methods have been developed over the last 25 years, their market adoption rate remains low, due in part to their added complexity and variations from standard details. The EP&B wall system is a solution that can be appealing to a large swath of typical builders looking to improve their homes' thermal performance while minimizing many of the common risks and concerns associated with high-R envelope systems.

Any residential builder transitioning to a higher performing wall system will require construction details and methods that are based on common and accepted industry practices, and the validation of test results and code compliance. This is apparent based on the low diffusion of alternative wall systems such as Structural Insulated Panels (SIPs) or Insulated Concrete Forms (ICF) - wall technologies that have a long history of good performance in the building industry. The transition time for builders to make significant changes to construction practices is known to extend over dozens of years. The EP&B wall system was developed as an opportunity to reduce this long transition timeframe by maintaining industry accepted construction practices while employing design features that increase the thermal performance of the wall by over 50%, specifically by the inclusion of a layer of nearly continuous rigid foam insulation.

Beginning with IECC 2012, climate zones 6, 7, & 8 all require 2-in. c.i. with a 2x4 wall. In climate zones where 2-in of exterior insulation has not yet been incorporated as a prescriptive minimum thermal requirement it is estimated that 40% to 80% of builders who have not yet transitioned to high-R wall systems will soon need to make a decision about how to comply with new energy codes. That decision is likely to include 2-in continuous insulation; however, these builders have previously declined to choose from among a number of high-performing alternatives that have been available for the past decade or more.

A leading approach to increasing the R-value of walls is the prescriptive method of adding rigid insulation outboard of the sheathing, an approach that was demonstrated over 40 years ago but still remains underutilized with only about 11% nationwide market penetration as of 2015. The specific transition barriers to widespread adoption of this particular method include the lack of a nailing base to support the cladding, drainage plane and window flashing, and the concern with the possible creation of dual vapor barriers leading to moisture problems in colder climates.

EP&B walls integrate rigid foam sheathing with standard framing practices into a cost-effective system that preserves many conventional construction features and minimizes builder risk. The rigid foam insulation board is installed between the 2x4 framing and the wood structural panel (WSP), with top and bottom plates extending to the exterior plane of the rigid foam. This method keeps over 95% of the wall area free of thermal bridging and retains the WSP as an exposed nailing surface, maintaining common methods and materials for framing, air sealing, insulation, drainage plane and siding attachment. The extended plates in conjunction with the wood sheathing mounted at the exterior plane of the wall protect the foam during transit, making EP&B uniquely suited to factory wall panelization, in addition to field-framing.

Since 2013 EP&B walls have been the subject of several research projects which drove improvements to various details (rim design, fastening schedule, plate extensions and nail length), resulting in an optimized design which balances structural performance, first cost, energy efficiency and constructability.

EP&B Building Code Applicability

DOE's Building America program sponsored structural testing of EP&B walls based on ICC Acceptance Criteria AC269.1 as well as field tests for constructability. All structural testing was conducted on the final, recommended EP&B configuration of 3-1/2-in. nails in a 3/6 perimeter/field WSP nailing pattern using 2x4 studs and 2x6 bottom and double top plates. This configuration resulted from developmental improvements

based on current and previous research, culminating with the two field test houses of the current Building America research project.

Thus far, isolated local building inspectors in several jurisdictions where field tests have been conducted have approved the EP&B system as detailed. Structural P.E.s may now use the EP&B shear strength design value to develop engineered designs using EP&B in any climate zone. The inclusion of EP&B as a prescriptive IRC braced wall method per the International Residential Code and as a prescriptive solution for the IECC would be the strongest inducement to deep market adoption of the method, and would provide a legitimate, low-cost, low-risk alternative to the continuous insulation technique of over-sheathing with FPIS.

Research results confirm that the EP&B wall can be readily constructed using traditional methods, and can perform equivalently to or better than a standard IRC code-minimum wall with respect to structural, thermal and moisture performance.

This report provides language and rationale that can readily be incorporated in the International Residential Code (IRC) to identify and detail EP&B as a prescriptive approach for an IRC braced wall, and in the International Energy Conservation Code (IECC) to meet minimum thermal performance requirements.

EP&B Justification as a Prescriptive Code Solution

EP&B walls can be constructed in three framing configurations:

1. 2x4 studs with 2x6 plates, and a 2-in. rigid foam layer
2. 2x6 studs with 2x8 plates, and a 1-3/4-in. rigid foam layer
3. 2x6 studs with true 2x7.5-in. plates, and a 2-in. rigid foam layer (2x10's are vertically ripped to exact 7.5-in. width)

Intermittent Bracing

Section 4.1 of the acceptance criteria uses ASTM E72 testing for stiffness, deflection, and strength to qualify a wall for use as an intermittent braced wall. Three specimens must not exceed target deflections of 0.2 in and 0.6 in at 23% and 46% of peak load, respectively; must exceed 560 plf maximum unit shear; and must provide deflection of greater than 0.75 in. at the maximum shear load.

Further, to qualify for additional testing to determine potential use as an intermittent braced wall, the specimens must meet additional conditions of acceptance: no greater than 0.2 inches of deflection at a load of 200 plf, and no greater than 0.6 inches of deflection at a load of 400 plf. Table 1 shows that EP&B wall specimens met all criteria, individually and on average.

Table 1. EP&B Intermittent Bracing: AC 269.1 (ASTM E72) Conditions of Acceptance.

Wall Type	Max Shear Load (lb) (Peak	Net Deflection at Peak Load (in.)	Unit Shear, lbs/ft (plf)	Deflection at 23% load	Deflection at 46% load	Deflection at 200 plf	Deflection at 400 plf
AC269.1 Criteria 4.1:	>4,480	>0.75	>560	<0.2	<0.6	<0.2	<0.6
EPB-1	7,060	3.35	882	0.134	0.353	0.127	0.348
EPB-2	6,673	3.77	834	0.134	0.386	0.139	0.409
EPB-3	6,851	3.73	856	0.135	0.336	0.135	0.352
Average	***6,861***	***3.62***	***858***	***0.134***	***0.359***	***0.127***	***0.348***

Based on these results, the calculated Allowable Design Racking Shear Load Value for EP&B walls is 256 plf (lbs/ft) for SPF framing. As a point of comparison, the minimum acceptable IRC-WSP braced wall is listed at 184 plf (lbs/ft). See Appendix A for Acceptance Criteria test methodology, results and analysis.

Continuous Bracing

Section 4.2 of the acceptance criteria uses ASTM E564 testing for deflection and strength to qualify a wall for use as a continuous braced wall. A minimum of two 8x8 baseline wall specimens must not exceed target deflections of 0.2-in and 0.6-in at loads of 200 plf and 400 plf, respectively, and must exceed 560 plf maximum unit shear. See Table 2 for the passing results.

Table 2. EP&B Continuous Bracing: AC 269.1 Section 4.2 (ASTM E564) - Baseline

AC269.1 E564 Wall Type 1	Max Shear Load (lb) (Peak Horiz Racking Shear Load)	Net Defl at Peak Load (in.)	Max Unit Shear Lbs/Ft	Net Deflection at 200 plf	Net Deflection at 400 plf
Criteria 4.2:	n/a	n/a	≥ 560 plf	≤ 0.2 in.	≤ 0.6 in.
EPB Baseline 1-1	6181	2.62	773	0.148	0.506
EPB Baseline 1-2	5274	2.68	659	0.136	0.569
Average	***5728***	***2.64***	***716***	***0.142***	***0.537***

This average shear load is then used as a baseline reference for a set of one corner wall and five perforated wall types. Per AC269.1, a reduction factor is applied to each of wall types 2-7. See Table 3 for the passing results.

Table 3. EP&B Continuous Bracing: AC 269.1 Section 4.2 (ASTM E564) – Wall Types 2-7

Description	Max Shear Load (lb) (Peak Horiz Rack-ing Shear)	Net Defl at Peak Load (in.)	Max Unit Shear lbs/ft	Reduction Factor	Drift at Ref Shear Load ≤ 0.6 in.	Drift (Stiffness) Pass/Fail	Predicted Peak Racking Unit Shear Strength lbs/ft	Shear Strength Pass/Fail (max shear load > pred. peak)
Baseline AVG	5728	n/a	716			n/a		
Corner Rtn	6874	1.46	573	0.79	0.2224	Pass	566	Pass
Full-ht	5255	1.74	438	0.43	0.2571	Pass	308	Pass
Window	6480	3.65	540	0.65	0.3793	Pass	465	Pass
door	3281	3.18	246	0.29	0.4982	Pass	208	Pass
2 windows	5105	4.49	365	0.41	0.4527	Pass	294	Pass
wind & dr	4776	4.36	311	0.38	0.3590	Pass	272	Pass

Appendix A describes the equipment, methodology and details of the EP&B structural lab testing.

Thermal Performance

The rigid foam in EP&B walls can be any FPIS with minimum 15 psi compressive strength; typical R-values range from R-4 per inch to over R-6 per inch. These R-value market choices are the same as for the application of FPIS as exterior continuous insulation (the current prescriptive method.) EP&B walls do not quite meet the definition of “continuous insulation” due to the extended top and bottom plates which constitute a thermal bridge of 4.6% for any length wall (additional or redundant framing takes the form of 2x4 cripples, king and jack studs, and headers and sills.)

Framing factors (FF) vary widely. For standard light-frame wall construction with 16-in. o.c. stud spacing, the accepted FF range is from 15% to 25%.[1] Using R-10 c.i. and conservatively assigning 14.4% for stud framing and 4.6% for plate framing (total 19% FF), the ASHRAE parallel path thermal transfer calculation results in U-0.045 for the 2x4/2x6 framing configuration of EP&B, satisfying IRC *Table 402.1.4 Equivalent U-Factors*. Even using a more conservative framing factor of 23% (the value used in the energy simulation calculations of both REM/Rate and EnergyGuard) the U-factor is 0.46. All other EP&B framing configurations using R-10 c.i. exceed IECC minimums. See Appendix B for calculations.

Example Building Code Prescriptive Requirements

(Note – the name of the wall system has been modified from the Extended Plate and Beam to the Extended Plate Wall system. This was done to avoid confusion of a beam design or a beam requirement. Based on further laboratory testing, the original beam concept has been shown to be a non-critical part of the system design and thus is not required as part of the definition or code requirements.)

A draft example set of prescriptive IECC and IRC provisions for the EP&B wall system, based on the 2015 Codes, are outlined below, demonstrating how the EP&B wall system might be incorporated into the code. These examples indicate where EP&B prescriptive requirements would fit into the existing IRC and IECC code and how these example provisions might modify other sections of the IRC and IECC.

IRC

Add new definitions to Section R202

EXTENDED PLATE WALL (EPW). A wood framing method for constructing exterior walls using top and bottom plates that are wider than the width of the studs such that rigid foam sheathing can be inset between the top and bottom plates, and between the studs and the exterior wood structural panel sheathing. Sheathing is fastened directly to the bottom and top plates and through the rigid foam sheathing to the studs.

FOAM PLASTIC INSULATING SHEATHING (FPIS). A rigid foam board typically made from extruded polystyrene (XPS), expanded polystyrene (EPS) or Polyisocyanurate (PIC) and used to provide a layer of continuous insulation for house walls or other components. In this report, FPIS generally refers to rigid foam installed as continuous insulation exterior to the wood sheathing, or in place of the wood sheathing

Add new abbreviations

EPW Extended Plate Wall

FPIS Foam Plastic Insulating Sheathing

Add new section to IRC Chapter 6.

602.13 Extended Plate Wall (EPW). Framing, wood structural panel sheathing, connections, wall bracing, and anchorage for the EPW shall be in accordance with all applicable provisions of Sections R602.1 through R602.12 as modified by the provisions of Section R602.13. EPW shall be limited to Seismic Design Category A, B, and one and two-family dwellings in C. EPW shall be constructed by one of three framing combinations per Table R602.13.1.

[1] See page 23: "Assessment of Commonly-Used Code Compliance Simulation Software Relative to Cold Formed Steel Framing," Newport Partners

Table R602.13.1 Braced Wall Wood Framing Construction Requirements for EPW

EPW Configuration	Nominal Lumber Dimensions		Thickness Rigid Foam[2]
	Studs	Plates	
2x4/2x6	2x4	2x6	2-in.
2x6/2x8	2x6	2x8	1-3/4-in.
2x6/2x7.5[1]	2x6	2x7.5[1]	2-in.

[1]Actual 7.5-in. width plates are available as engineered lumber.

[2] Rigid foam thickness is achieved by installing one or more layers of foam.

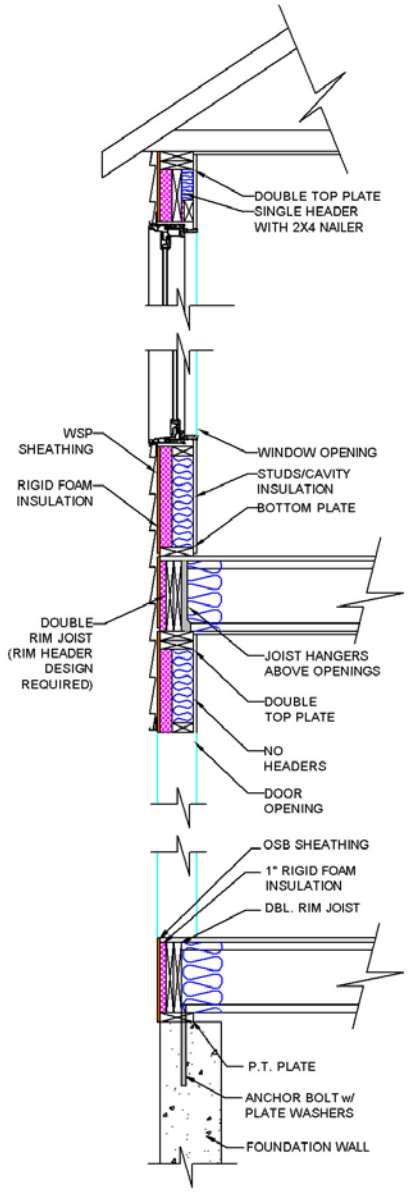

Figure R602.13.1 Extended Plate Wall (EPW) System, section view

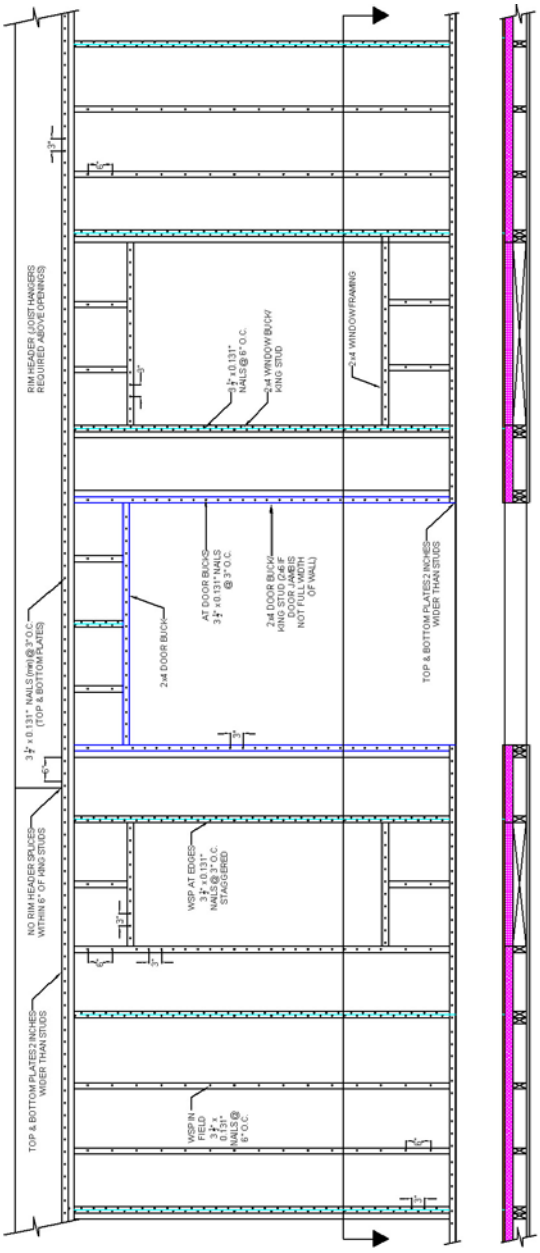

Figure R602.13.2 EP&B Wall, Interior Elevation View

602.13.1 Plates. The bottom and double top plate shall be wider than the width of the studs by not more than 2 inches, in accordance with Table R602.13.1 and Figure R602.13.1 and Figure R602.13.2.

602.13.2 Wood structural panel sheathing attachment. Wood structural panel (WSP) sheathing of thickness from 3/8-in. to 15/16-in. shall be installed vertically and attached to wall plates and studs per Table R602.13.4.

602.13.3 Horizontal joints in wood structural panels. Where used as part of wall bracing, each wood structural panel shall be continuous between the extended top and bottom plates. Blocking of panel edges shall not be an acceptable alternative to continuous vertical wood structural panels for the EPW. The vertical joint between two wood structural panels shall occur only at the location of a stud.

602.13.4 Wall Bracing. Wall bracing shall be in accordance with the WSP Bracing Method in Table R602.10.4 except the fasteners' diameters and spacing shall be in accordance with Table R602.13.4. All provisions applicable to the use of the WSP Bracing Method, including provisions for mixing bracing methods, shall be applicable to EPW.

Table R602.13.4 Braced Wall Fastener Requirements for EPW

Minimum nail length and diameter	Maximum Fastener Spacing	
	At Perimeter of WSP	In Field of WSP
3-1/2-in. x 0.131 in.	3-in. oc	6-in. oc

602.13.4.1 Simplified Wall Bracing. With the exception of Section R602.12.2 Item 2 and Section R602.12.3 Item 1, provisions of Section R602.12 shall be applicable to the EPW. The fastening schedule for wood structural panels shall be in accordance with the additional requirements of Table R602.13.4.

602.13.5 Rim joist. Rim joists (band joists) supporting an EPW shall be single or double-member solid-sawn or engineered lumber. Single member rim joists shall be inset by 1 inch. Double member rim joists are permitted to be installed flush to the exterior face of the wall, or inset by 1 inch from the exterior face of the wall to provide space for exterior rigid insulation. Rim joists are permitted to be inset by 2 inches from the exterior framing surface to provide space for exterior rigid insulation only if the WSP sheathing spans from the top plate all the way to the sill plate and is fastened to the sill plate in accordance with schedule of Table R602.13.4. The aspect ratio for braced wall panels in this case shall be based on the entire length of the WSP sheathing from the top plate to the sill. The minimum bearing length requirements for the floor joists shall be satisfied or joists shall be supported with metal hangers.

602.13.6 Rim joist used as rim header. Solid-sawn or engineered lumber single or double member rim joists (band joists) are permitted to support EPW above openings as rim board headers in accordance with the provisions of R602.7.2 or an equivalent alternative and no additional headers are required at openings. Rim headers shall not have splice joints over an opening and the first splice joint to each side of the opening shall occur a minimum of 6-in. away from the opening edge and past the outermost king studs. Floor joists above such openings shall be supported with metal hangers selected by a licensed professional based on design loads.

602.13.6 Headers. Where the rim joist is not used as a header, construct headers in accordance with Section R602.7.

602.13.7 Door bucks. Where door jamb depth is less than the thickness of the EPW, the rough opening of the door framing shall be constructed using extended studs of width equal to the top and bottom plates of the EPW to allow full attachment of the door jamb to the framing. Where door jamb depth equals the thickness of the EPW, no changes in framing are required, as shown in Figure R602.13.2. All other provisions of IRC Section R609 shall be applicable to the EPW.

602.13.8 Foam plastic sheathing. Foam plastic insulative sheathing (FPIS) shall comply with ASTM C578 or ASTM C1289, with a minimum compressive strength of 15 psi.

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602.13.8.1 Foam plastic sheathing installation. Foam plastic sheathing with a maximum total thickness of 2 inches shall be cut to stud length and installed flat against the exterior stud plane of the EPW, between extended top and bottom plate(s). Total combined permeance of FPIS and any attached vapor retarder film shall not exceed 1.5 perms. Any one-sided vapor retarder FPIS film shall be oriented to the interior side. Spray foam with maximum permeance of 1.5 perms at the installed thickness is permitted to be applied to the interior cavity side of the foam plastic. FPIS shall be installed vertically, and the vertical joint between two panels of rigid foam sheathing shall not occur at the same stud where there is a joint between wood structural panels; vertical FPIS joints must be offset from vertical WSP joints by at least one stud bay.

602.13.9 Cold-Formed Steel Wall Framing. EPW is not an approved framing method for cold-formed steel framing members.

602.13.10 Wall Coverings. Interior and exterior coverings and wall finishes for the EPW shall be in accordance with all applicable provisions of Sections R701 through R703 as modified by the provisions of Section R602.13.

602.13.11 Interior Wall Coverings - Vapor Retarder. A vapor retarder on the interior side of the EPW frame shall be in accordance with Section R702.7 except:

1. Class I vapor retarder shall not be permitted.
2. Class II vapor retarder shall be kraft paper or an approved equivalent.
3. Vapor retarders for EPW shall be installed in accordance with Table R602.13.1.
4. Where spray foam is installed to the interior cavity side of the foam plastic sheathing, it is permitted to use combined rigid foam and spray foam R-value for use with Table R602.13.1.

Table R602.13.1 VAPOR RETARDERS FOR EPW

Climate Zone	Minimum Required Vapor Barrier	Rigid Foam Insulation Minimum R-Value		
		2x4/2x6 EP&B	2x6/2x8 EP&B	2x6/2x7.5* EP&B
CZ 1, 2, 3	None required.	0	0	0
CZ Marine 4 and Non-Marine 4	Class III	2.5	3.75	3.75
CZ 5	Class III	5	7.5	7.5
CZ 6	Class III	7.5	11.25	11.25
	Class II*	0	7.5	7.5
CZ 7	Class III	10	15	15
	Class II*	7.5	7.5	7.5
CZ 8	Class III	12.5	20	20
	Class II*	7.5	7.5	7.5
*See Table R702.7.1 to determine if vented cladding may be installed to allow the use of a Class III vapor retarder.				

Commented [PG4]: Note reformatting to more closely match existing IRC table.

602.13.12 Exterior Wall Coverings. EPW shall provide the building with a weather-resistant exterior wall envelope and shall include Water Resistance as described in Section R703.1.1, Wind Resistance as described in Section R703.1.2, and a Water Resistive Barrier as described in Section R703.2.

602.13.13 Flashing. Flashing for EPW shall comply with the provisions of Section 703.4. Fluid applied membranes for pan flashing at exterior window and door openings shall not be installed in EPW. Mechanically attached, self-adhered flexible membrane pan flashing shall be installed as described in Section R703.4 item

1.1. and shall span from framing across both the rigid foam layer and the WSP layer, and extend to the surface of the exterior wall finish or to the water-resistive barrier for subsequent drainage.

602.13.14 Cladding Attachment. Cladding attachment over EPW shall comply with the provisions of Section 703.3 including Table R703.3.2.

Commented [PG5]: Deleted table title

IECC

Add new definitions to Section R202

EXTENDED PLATE WALL (EPW). A wood framing method for constructing exterior walls using top and bottom plates that are wider than the width of the studs such that rigid foam sheathing can be inset between the top and bottom plates, and between the studs and the exterior wood structural panel sheathing. Sheathing is then fastened directly to the bottom and top plates and through the rigid foam to the studs.

FOAM PLASTIC INSULATING SHEATHING (FPIS). A rigid foam board typically made from extruded polystyrene (XPS), expanded polystyrene (EPS) or Polyisocyanurate (PIC) and used to provide a layer of continuous insulation for house walls or other components. In this report, FPIS generally refers to rigid foam installed as continuous insulation exterior to the wood sheathing, or in place of the wood sheathing

Add new abbreviations

EPW Extended Plate Wall

FPIS Foam Plastic Insulating Sheathing

Add new section to IECC Chapter ~~2~~4

R402.1.6 Extended Plate Wall (EPW). EPW wall systems constructed in accordance with all applicable provisions of IRC Sections R602.1 through R602.13 and utilizing a layer of rigid foam shall satisfy the prescriptive minimum cavity and continuous insulation R-value requirements of Table R402.1.2 for wood frame walls. Use FPIS manufacturer's technical specifications for both cavity insulation and continuous insulation to determine the associated R-value per inch for meeting the thermal resistance minimum requirement of each layer according to the configurations of IECC Table R602.13.1.

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Add footnote to IECC Table R402.1.2

j. EPW exterior wall systems utilizing cavity and continuous insulation of the required R-values shall satisfy the prescriptive minimum insulation requirement for Climate Zone (CZ) 3-8.

TABLE R402.1.2
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE	MASS WALL *R*-VALUE[i]	FLOOR *R*-VALUE	BASEMENT[c] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c] WALL *R*-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.35	0.55	0.25	38	20 or 13+5[h, j]	8/13	19	5/13[f]	0	5/13
4 except Marine	0.35	0.55	0.40	49	20 or 13+5[h, j]	8/13	19	10 /13	10, 2 ft	10/13
5 and Marine 4	0.32	0.55	NR	49	20 or 13+5[h, j]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.32	0.55	NR	49	20+5 or 13+10[h, j]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.32	0.55	NR	49	20+5 or 13+10[h, j]	19/21	38[g]	15/19	10, 4 ft	15/19

For SI: 1 foot = 304.8 mm.

a. R-values are minimums. *U*-factors and SHGC are maximums. When insulation is installed in a cavity which is less than the label or design thickness of the insulation, the installed *R*-value of the insulation shall not be less than the *R*-value specified in the table.

b. The fenestration *U*-factor column excludes skylights. The SHGC column applies to all glazed fenestration. Exception: Skylights may be excluded from glazed fenestration SHGC requirements in climate zones 1 through 3 where the SHGC for such skylights does not exceed 0.30.

c. "15/19" means R-15 continuous insulation on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. "15/19" shall be permitted to be met with R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulation on the interior or exterior of the home. "10/13" means R-10 continuous insulation on the interior or exterior of the home or R-13 cavity insulation at the interior of the basement wall.

d. R-5 shall be added to the required slab edge *R*-values for heated slabs. Insulation depth shall be the depth of the footing or 2 feet, whichever is less in Climate Zones 1 through 3 for heated slabs.

e. There are no SHGC requirements in the Marine Zone.

f. Basement wall insulation is not required in warm-humid locations as defined by Figure R301.1 and Table R301.1.

g. Or insulation sufficient to fill the framing cavity, R-19 minimum.

h. The first value is cavity insulation, the second value is continuous insulation, so "13+5" means R-13 cavity insulation plus R-5 continuous insulation.

i. The second *R*-value applies when more than half the insulation is on the interior of the mass wall.

j. EPW exterior wall systems utilizing cavity and continuous insulation of the required R-values shall satisfy the prescriptive minimum insulation requirement for CZ 3-8.

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Appendix A
EP&B Structural Lab Testing

Equipment and Methodology

EP&B wall testing was begun in the fall of 2015, and proceeded under the version of AC269.1 that had been approved as of February 2013. Analysis was also done against the updated criteria of AC269.1 2017. Home Innovation Research Labs regularly performs construction testing using ICC published Acceptance Criteria. HI's equipment is calibrated and audited in accordance with ISO 17025:2005.

Figure 1. Reference Wall in Testing Apparatus Prepared for ASTM 72 Test

Test Methods and Materials

Tests were executed in general conformance with the provisions of ICC-ES AC269.1 Acceptance Criteria for Proprietary Sheathing Attached to Wood Light-Frame Wall Construction Used as Braced Wall Panels Under the IRC (IRC Evaluation – prescriptive bracing tables) as applicable to the specific objectives of this study. AC269.2 Acceptance Criteria for Proprietary Sheathing Jobsite-Attached to Wood Light-Frame Wall Construction Used as Shear Walls (IBC evaluation – engineered design values) procedures were used to develop the Allowable Design Racking Shear Load Values.

Racking shear performance testing of the EP&B wall system was conducted in two phases. Phase I of the test plan applies ASTM E72 Section 14 procedures per AC269.1 Section 4.1 to qualify the wall system for intermittent bracing. Phase II of the test plan applies ASTM E564 procedures per AC269.1 Section 4.2 to qualify the wall system for continuous bracing.

Note that AC269 criteria are developed for evaluation of proprietary sheathing materials; OSB-braced walls were used as the basis for developing most of the evaluation criteria for AC269. The EP&B wall system as tested used OSB as exterior structural sheathing. The purpose of this evaluation is not to verify the performance of OSB sheathing. The purpose is to verify that the EP&B assembly with a modified nailing schedule continues to meet the established strength and stiffness performance criteria for a minimum code

shear wall. Three dry specimens were tested for Section 4.1 conformance; wet tests were not necessary because the sheathing as a material is not the focus of the evaluation.

Per AC269.1, "Framing members receiving sheathing fasteners shall have a measured average specific gravity (oven-dry basis) not exceeding the nationally specified value plus 0.03 for the species of framing member in accordance with NDS Table 11.3.2A." All lumber was pre-qualified by estimating the specific gravity based on moisture content measured with a hand-held moisture meter, with appropriate species adjustment. Following destructive testing, multiple lumber samples from each specimen were weighed and dried in the oven to confirm average specific gravity. All lumber was within the specified range.

Intermittent Braced Wall: Test Protocol and Results

Testing for Intermittent Braced Walls follows Section 4.1 of AC269.1 in accordance with ASTM E72 regarding specimen construction and loading protocol using the testing apparatus described above.

Standard 2x6 (SPF) IRC CS-WSP reference walls were constructed in conformance with ASTM E72 and tested for comparison, only; these reference values are not required for AC269 equivalency. The 2x6 configuration was selected to match the framing material and finished wall thickness of the EP&B walls to allow for direct comparison. Sheathing for the 2x6 Standard Reference wall was attached using collated 2-3/8-in. clipped head nails with 6/12 in o.c. nail spacing. IRC reference walls were constructed with Spruce-Pine-Fir (SPF) lumber.

Shear test results are summarized in Table 4 for the three E72 EP&B specimens.

The averaged result of two 2x6 IRC reference walls having the same width as the tested EP&B specimens is included in for comparison only (not an Acceptance Criteria requirement).

Table 4. Maximum Unit Shear: AC 269.1. ASTM E72 – EPW and IRC 2x6 Walls

E72 Shear Capacity Comparison	Target	2x6 IRC Comparison Wall (SPF)	EPB (DFL)
Unit Shear (lbs/ft) min (set)	560	618 / 652	834 / 856 / 882
Unit Shear (lbs/ft) (average of set)		635	858
Unit Shear Avg (lbs/ft) Normalized to SPF		n/a	767
Ultimate Load (SF=3)		206	256
Drift Limit		284	268
Allowable Design Racking Shear Load Value, psf (lesser value: Ultimate Load vs Drift Limit)		206	256

All tested EP&B walls exceed the required shear strength criteria. The average maximum unit shear load in lbs/ft for the 3/6 EP&B walls as tested exceeds the 560 lbs/ft unit shear requirement by 298 lbs, 53%. The EP&B species-adjusted unit shear exceeds the requirement by 37%. For comparison, the average maximum unit shear load in lbs/ft for the 2x6 IRC reference walls exceeds the 560 lbs/ft requirement only by 75 lbs/ft, 13% (this test was for general reference only, and is not required by AC 269.1).

The calculated Allowable Design Racking Shear Load Value is 256 lbs/ft, the lesser of the loads determined based on the ultimate load limit and the drift limit, in accordance with Sections 4.2.3.1 and 4.2.3.2.

Columns 2 through 6 in Table 7 show that all tested EP&B walls exceed the AC 269.1 Conditions of Acceptance; each criterion's minimum and maximum is shown in italics below each column's header.

Although *AC 269.1 Table 1 Deflection (Stiffness) Criteria* are permitted to be reduced (per the species-reduced nominal unit shear value) to achieve compliance with the listed deflection limits for 23% and 46% load, this allowable adjustment was not required for the extended plate and beam walls.

The two columns at the right side of the tables show that the EP&B walls also meet the additional requirements necessary to be permitted to be evaluated as an alternative to the continuously sheathed wood structural panel bracing method (CS-WSP) per ASTM E 564.

Table 5. EPW Intermittent Bracing: AC 269.1 Section 4.1 (ASTM E72)

Wall Type	Max Shear Load (lb) (Peak	Net Deflection at Peak Load (in.)	Unit Shear, lbs/ft (plf)	Deflection at 23% load	Deflection at 46% load	Deflection at 200 plf	Deflection at 400 plf
AC269.1 Criteria 4.1	>4,480	>0.75	>560	<0.2	<0.6	<0.2	<0.6
EPB-1	7,060	3.35	882	0.134	0.353	0.127	0.348
EPB-2	6,673	3.77	834	0.134	0.386	0.139	0.409
EPB-3	6,851	3.73	856	0.135	0.336	0.135	0.352
Average	***6,861***	***3.62***	***858***	***0.134***	***0.359***	***0.127***	***0.348***

Figure 2 shows the deflection curves for the three EP&B baseline walls.

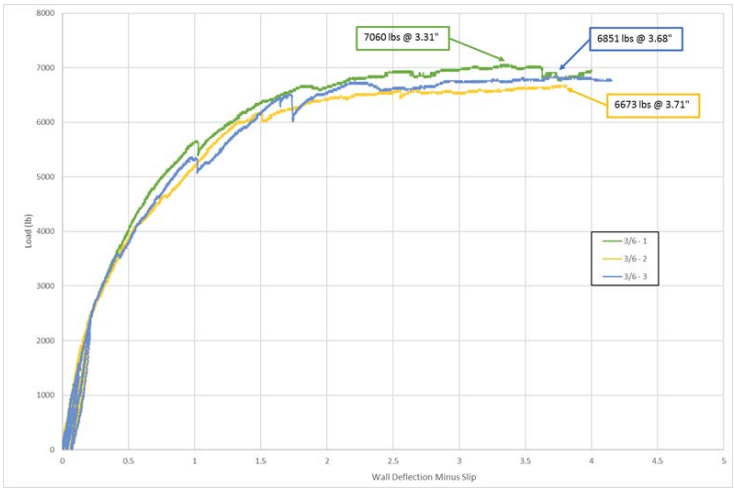

Figure 2. Maximum Loads: E72 Test – EPW Baseline

Continuous Braced Wall: Test Protocol and Results

Testing for Continuously Sheathed Braced Walls follows Section 4.2 of AC269.1 regarding specimen construction, wall type test matrix and loading protocol. The racking shear tests were conducted in accordance with ASTM E564. Loading was applied in a single, continuous phase using the test apparatus described above.

Based on E72 qualification, the E564 baseline tests were performed on EP&B wall samples for types 1 (baseline), wall type 2 (12-ft. wall section with corner returns) and wall types 3-7 (perforated walls having various combinations and sizes of window and door openings.)

Table 6 summarizes the E564 test results for the Extended Plate wall type 1, the baseline, including maximum recorded (peak) shear load, net deflection at peak shear load, maximum unit shear and the maximum net deflections at two target loads: 200 plf and 400 plf. The column headers for the last three parameters show the

thresholds required by the acceptance criteria. If only two tests are performed, each specimen must pass all criteria. When three or more tests are performed, the average of all specimens must pass all criteria.

Table 6. EPW Continuous Bracing: AC 269.1 Section 4.2 (ASTM E564) – Baseline

E564 Wall Type 1	Max Shear Load (lb) (Peak Horiz Racking Shear Load)	Net Defl at Peak Load (in.)	Max Unit Shear Lbs/Ft	Net Deflection at 200 plf	Net Deflection at 400 plf
AC269.1 Criteria 4.2:	n/a	n/a	≥ 560 plf	≤ 0.2 in.	≤ 0.6 in.
EPB Baseline 1-1	6181	2.62	773	0.148	0.506
EPB Baseline 1-2	5274	2.68	659	0.136	0.569
Average	***5728***	***2.65***	***716***	***n/a***	***n/a***

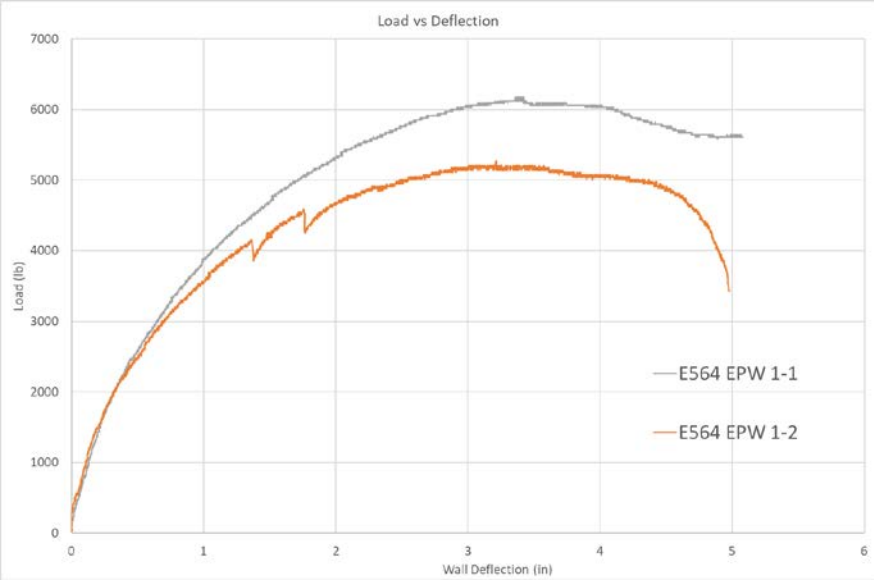

Figure 3. Shear Load Deflection Curves: E564 Test – Baseline EP&B Walls

The AC269.1 Section 4.2 ASTM E564 criteria are self-referencing, i.e., the average maximum shear for wall type 1 specimens is used to develop the wall type 2-7 reference values for racking shear strength, per the AC protocol. All EP&B walls were constructed with SPF lumber; per 4.2.1, so that no species adjustment is required for comparison to target performance values.

Figure 4 graphs the load deflection curves for the EP&B wall specimens of the ASTM E564 tests for IRC continuous braced wall equivalency. Tested values for wall types 3-7 meet all target performance values for both strength and stiffness (drift at reference shear load) per AC 269.1. See Table 7.

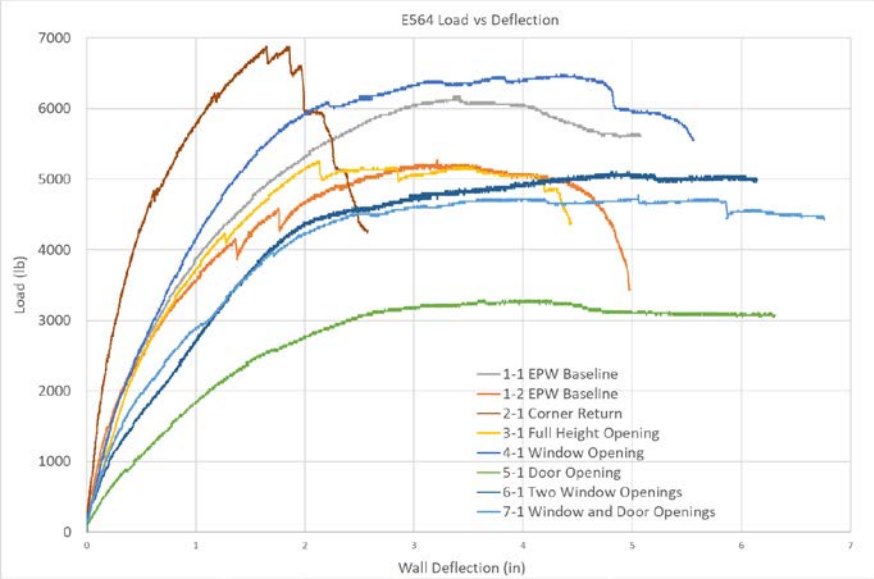

Figure 4. Load Deflection Curves: E564 Test – EP&B Walls

Table 7. EP&B Continuous Bracing: AC 269.1 Section 4.2 (ASTM E564) – Wall Types 2-7

Description	Max Shear Load (lb) (Peak Horiz Rack-ing Shear)	Net Defl at Peak Load (in.)	Max Unit Shear lbs/ft	Reduction Factor	Drift at Ref Shear Load ≤ 0.6 in.	Drift (Stiffness) Pass/Fail	Predicted Peak Racking Unit Shear Strength lbs/ft	Shear Strength Pass/Fail (max shear load > pred. peak)
Baseline AVG	5728	n/a	716	n/a	n/a	n/a	n/a	n/a
Corner Rtn	6874	1.46	573	0.79	0.2224	Pass	566	Pass
Full-ht	5255	1.74	438	0.43	0.2571	Pass	308	Pass
Window	6480	3.65	540	0.65	0.3793	Pass	465	Pass
door	3281	3.18	246	0.29	0.4982	Pass	208	Pass
2 windows	5105	4.49	365	0.41	0.4527	Pass	294	Pass
wind & dr	4776	4.36	311	0.38	0.3590	Pass	272	Pass

Both E564 baseline walls exceeded the 560 lbs/ft minimum shear strength requirement of Section 4.1 by 18% to 38%, respectively; the average shear strength for the specimen set was 28% above code minimum. This resulted in predicted ultimate racking shear capacity values for wall types 2-7 that are much higher than required for a minimally compliant wall to meet IRC braced wall equivalency.

The EP&B wall is intended to be used in the same fashion as a code-minimum IRC wall, yet there is no acceptance criteria other than AC269.1 to utilize for equivalency testing. When the racking shear load performance of EP&B wall types 2-7 is judged in relation to an IRC code-minimum wall, with nominal unit shear of 560 plf, wall types 2-7 exceed the shear strength targets by a range of 30% to 82%.

Table 8. EPW Continuous Bracing: Wall Types 2-7 with 560 plf (Code-Minimum) as Baseline

Description	Max Shear Load (lb) (Peak Horiz Racking Shear Load)	Max Unit Shear Lbs/Ft	Reduction Factor	Predicted Peak Racking Shear Strength at IRC minimum 560 plf	Shear Strength Pass/Fail (max shear load must exceed predicted peak)	Compare Net Shear Strength to IRC minimum 560 plf
Code Minimum	4480	560	n/a	n/a	n/a	n/a
Corner Rtn	6874	573	0.79	*442*	*Pass*	*129.5%*
Full-ht	5255	438	0.43	*241*	*Pass*	*181.8%*
Window	6480	540	0.65	*364*	*Pass*	*148.4%*
door	3281	246	0.29	*162*	*Pass*	*151.5%*
2 windows	5105	365	0.41	*230*	*Pass*	*158.8%*
wind & dr	4776	311	0.38	*213*	*Pass*	*146.4%*

Appendix B
Thermal Transfer Calculations

Framing Factors

Geometries of a typical 8-ft. x 12-ft. wall were examined to determine likely framing factors and the proportion of thermal bridging constituted by the extended top plates in the EP&B wall. (Table 9 - Table 11) The calculated values were then referenced against typical framing factors used in the industry.

Table 9. EP&B Framing Factor Calculations for Standard 16-in. o.c. Framing

Std. 16-in. o.c., double top plate	o.c.	qty	L	W	tot in2	tot ft2	tot wall area, ft2	framing portion
studs	16	10	92.625	1.5	1389.375	9.65	97.125	0.099
plates		3	144	1.5	648	4.50		0.046
Jacks		2	92.625	1.5	277.875	1.93		0.020
header & sill		2	48	1.5	144	1.00		0.010
Kings		2	66	1.5	198	1.38		0.014
connections, corners, bracing		2	92.625	1.5	277.875	1.93		0.020

Std. 16-in. o.c., double top plate	Plates	Non-Plates	Cavity	Reference
	4.6%	16.4%	79.0%	calculated
	4.6%	20.4%	75.0%	ASHRAE
	4.6%	18.4%	77.0%	REM/Rate, EnergyGauge

Table 10. EP&B Framing Factor Calculations for Standard 24-in. o.c. Framing

Std. 24-in. o.c., double top plate	o.c.	qty	L	W	tot in^2	tot ft^2	tot wall area, ft^2	framing portion
studs	24	7	92.625	1.5	972.5625	6.75	97.125	0.070
plates		3	144	1.5	648	4.50		0.046
Jacks		2	92.625	1.5	277.875	1.93		0.020
header & sill		2	48	1.5	144	1.00		0.010
Kings		2	66	1.5	198	1.38		0.014
connections, corners, bracing		2	92.625	1.5	277.875	1.93		0.020

Std. 24-in. o.c., double top plate	Plates	Non-Plates	Cavity	Reference
	4.6%	13.4%	82.0%	calculated
	4.6%	17.4%	78.0%	ASHRAE
	4.6%	15.4%	80.0%	REM/Rate, EnergyGauge

Table 11. EP&B Framing Factor Calculations for Advanced Framing 24-in. o.c. Framing

OVE 24-in. o.c., double top plate	o.c.	qty	L	W	tot in^2	tot ft^2	tot wall area, ft^2	framing portion
studs	24	7	92.625	1.5	972.5625	6.75	97.125	0.070
plates		3	144	1.5	648	4.50		0.046
Jacks		2	92.625	1.5	277.875	1.93		0.020
header & sill		1	48	1.5	72	0.50		0.005
Kings		2	66	1.5	198	1.38		0.014
connections, corners, bracing		1	92.625	1.5	138.9375	0.96		0.010

OVE, 24-in. o.c., double top plate	Plates	Non-Plates	Cavity	Reference
	4.6%	11.9%	83.5%	calculated
	4.6%	11.4%	84.0%	Building Science Corp, etc.

U-Factor Calculations

The total assembly U-factors of all three EP&B wall configurations were calculated using 4.6% for the thermal bridge of the extended plates. A cavity ratio of 77% (total framing factor of 23%) was used for all walls, including the five 2015 IECC code minimum walls for all climate zones. Table 12 shows the ASHRAE Parallel Path method calculation for the baseline 2x4/2x6 EP&B wall as an example.

Table 12. EP&B 2x4/2x6 Wall Calculated Thermal Performance, ASHRAE Parallel Path Method

EP&B 2x4/2x6 w/ XPS	Layer R-Value		Nominal	Actual
		Stud:	2" x 4"	3.5
		Plate:	2" x 6"	5.5
		Path 1	Path 2	Path 3
		Cavity	Studs	Plates
Int. film resistance	0.68	0.68	0.68	0.68
Gyp drywall, 1/2"	0.45	0.45	0.45	0.45
FG, 3.5" R-13	13	13.0		
Lumber, SPF	1.25		4.38	6.88
XPS, 2"	10	10.00	10.00	0.00
OSB, 7/16"	0.62	0.62	0.62	0.62
None	0	0.00	0.00	0.00
Airspace (behind diag-slat sid)	0.62	0.62	0.62	0.62
Siding - vinyl	0	0.00	0.00	0.00
Ext. film resistance (winter)	0.17	0.17	0.17	0.17
PARALLEL PATH nominal:	23.00			
Path Thermal Resistance, R		25.54	16.92	9.42
Path Thermal Conductivity, U (1/R)		0.0392	0.0591	0.1062
Percent of Assembly		77.0%	18.4%	4.6%
Total Assembly U-value	0.0459	0.04591	0.01088	0.00489
Total Assembly R-value (1/U)	21.8			

Table 13 compares the calculated U-factors and R-values for all the wall assemblies.

Table 13. EP&B 2x4/2x6 Wall Calculated Thermal Performance, ASHRAE Parallel Path Method

Wall System[a]	U-Value[b] Calc'd[c]	R-Value[d] Calc'd[c]	Framing Factor by path			
			cavity	cavity/c.i.	Lumber	Lumber (bridge)
2x4 Std. R13	0.083	12.0	77%	n/a	n/a	23%
2x4 Wall R13+5	0.057	17.6	0%	77%	23%	0%
2x6 Std. R20	0.059	17.0	77%	n/a	n/a	23%
2x4 Std. R13+10[e]	0.044	22.9	n/a	77%	23%	n/a
2x6 Std. R20+5	0.044	22.8	n/a	77%	23%	n/a
2x4/2x6 EP&B R13+10	0.046	21.8	n/a	77%	18.4%	4.6%
2x6/2x8 EP&B R20+8.75	0.039	25.8	n/a	77%	18.4%	4.6%
2x6/2x7.5* EP&B R20+10	0.037	27.0	n/a	77%	18.4%	4.6%
2x4/2x6 EP&B R13+10	*0.045*	*22.2*	*n/a*	*81%*	*14.4%*	*4.6%*

[a] Vinyl siding, #2 SPF lumber, 7/16 in. OSB, 1/2 in. gypsum drywall

[b] R-value in hr·°F·ft2/Btu

[c] Includes all layers, interior/exterior finishes and film factors

[d] U-value in Btu/(hr·°F·ft2)

[e] One layer of 1.5 in. rigid foam, with 1/2 in. foam layer alternating with 1/2 in. furring strips

References

Newport Partners, (2007). *Assessment of Commonly-Used Code Compliance Simulation Software Relative to Cold Formed Steel Framing*, Steel Framing Alliance. Website accessed December 20, 2017: http://www.steelframing.org/PDF/energy/SFASoftwareReviews-September10.pdf

Bibliography

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Provide two sections (or one section with two subsections)

1) Not used as rim header
    a. Double 1-1/8-in.
    b. Double 1-1/8-in. inset by 1 inch
    c. Single 1-1/8-in. inset by 1 inch
    d.
2) used as rim header
    a. in accordance with IRC rim header requirements

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