National Association of Home Builders

Estimated Costs of the 2009 IRC Code Changes

Prepared by:

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TABLES

ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

AFCI	Arc fault circuit interrupter
Avg.	Average
Zone A[1]	Areas subject to inundation by the 1-percent-annual-chance flood event
Coastal A Zone	Areas landward of a V-zone or landward of open coast without mapped V Zone that are subject to inundation by the 1-percent-annual-chance flood event with additional hazards associated with storm-induced waves between 1.5 and 3 feet in height.
BFE	Base flood elevation
BPS	Builder Practices Survey—national survey conducted annually by Home Innovation Research Labs
Bsmt.	Basement
BWL	Braced wall line
BWP	Braced wall panel
CFM	Cubic feet per minute (a measure of flow)
CMU	Concrete masonry unit
CS-PF	Bracing method consisting of a continuously sheathed portal frame around a large door or window opening
CS-WSP	Bracing method consisting of continuous sheathing with wood structural panels
CZ	Climate zone, as defined by the International Code Council (ICC)
EA	Each
F.R.	Family room
GB	Gypsum board
GFCI	Ground fault circuit interrupter
G.R.	Great room
HVAC	Heating, ventilation, and cooling
IBC	International Building Code
ICC	International Code Council
IECC	International Energy Conservation Code
IRC	International Residential Code
LB	Pound/Pounds
LF	Linear feet
MAX	Maximum
MEP	Mechanical, electrical, and plumbing
MPH	Miles per hour
NAHB	National Association of Home Builders
OSB	Oriented strand board
O&P	Overhead and profit
PE	Professional Engineer

[1] https://www.fema.gov

PF	Portal frame
PFH	Portal frame with hold-downs
PSF	Pounds per square foot
RCD	Residential Cost Data 2014, RSMeans
SDC	Seismic design category
SF	Square feet
SHGC	Solar heat gain coefficient, a measure of the reflectivity versus the absorbed radiation of glass; the lower the SHGC number, the less radiation is absorbed by the glass unit
SQ IN	Square inch
SYP	Southern yellow pine
U-Factor	U-value; a measure of the conductance of building components like windows and doors; the lower the U-Factor the less conductive the component, or the higher the R-value, which is the inverse of U-value
WSP	Wood structural panel
Zone V	Areas along coasts subject to inundation by the 1-percent-annual-chance flood event with additional hazards associated with storm-induced waves

BACKGROUND

The National Association of Home Builders (NAHB) provided a list of code changes approved for the 2009 International Residential Code (2009 IRC).[2] Home Innovation Research Labs (Home Innovation) estimated the expected cost impact of these code changes on construction practices and materials for a number of reference houses sited in various cities nationwide. Cost estimates are aggregated in ranges of high to low based on various methods or components that might be used to comply with the code.

METHODOLOGY

National Construction Cost

Reference houses and their site locations were defined in an earlier report titled *Estimated Costs of the 2015 Code Changes.*[3] The four reference houses were selected for their similarity to new home offerings in the six metropolitan areas selected as site locations - Miami, Dallas, Los Angeles, Seattle, New York, and Chicago, and their size proximity to a national average of 2,607 SF.[4] Elevations and floor plans for these reference houses are provided in *Appendices C through F*. These single-family detached houses define the reference or base houses that provide the starting point for estimation of the cost (or savings) of each code change for the 2009 IRC relative to the 2006 IRC.

Cost impacts in this analysis have been developed primarily with data adapted from the following sources: (1) RSMeans' *Residential Cost Data 2014*,[5] (2) *ASHRAE 1481 RP*[6] and similar reports by Home Innovation Research Labs (Home Innovation), (3) U.S. government reporting from the Census Bureau[7] and the Bureau of Labor Statistics,[8] and (4) distributors' or big box retailers' websites. Where a source other than these is used in this report, it is cited in *Appendix A* when applicable to a specific code change.

The square-foot costs for energy efficiency features, which figure prominently in the 2009 IRC changes, have been comprehensively addressed in the May 2012 report *2009 IECC Cost Effectiveness Analysis*. The report reference is provided in *Appendix A*, and forms the basis for costs related to energy efficiency.

Costs are reported at the national level and can be modified for a region using builders' known bid prices or by applying a location factor adjustment shown in *Appendix B*. Costs reported are the cost to the builder and do not include the builder's gross margin, reported as ranging from 17 to 20 percent of construction cost per the *2014 Cost of Doing Business*[9] and prior year's versions. Therefore, the compiled costs do not reflect the consumer price.

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[2] International Code Council, www.iccsafe.org/Pages/default.aspx

[3] www.homeinnovation.com/trends_and_reports/featured_reports/estimated_costs_of_the_2015_irc_code_changes

[4] Taylor, Heather. 2014. *Cost of Constructing a Home* https://www.nahb.org/generic.aspx?sectionID=734&genericContentID=221388&channelID=311

[5] http://rsmeans.reedconstructiondata.com

[6] NAHB Research Center, 2009. Economic Database in Support of ASHRAE 90.2 1481 RP. https://www.google.com/#q=ashrae+1481+rp

[7] http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk

[8] http://www.bls.gov/oes/current/oes_nat.htm#47-0000

[9] Quint, Rose, 2014. What Has Happened to Builder's Profit Levels? http://eyeonhousing.org/2014/02/what-has-happened-to-builders-profit-levels/

Reference House Configurations

The four building designs (see *Appendices C-F)* used in this analysis are based on the data contained in the Census Bureau report, *Characteristics of New Single-Family Construction Completed*.[10] The report provides information about building foundation type (Table 1) and number of stories for new single-family detached construction over the previous nine-year period. (Table 2).

Table 1. New Construction Foundation Types

Foundation Type	Market Share
Slab	54%
Crawlspace	17%
Basement	30%

Table 2. New Construction Number of Stories

Number of Stories	Market Share
One-story	53%
Two-story	43%
Three-story	3%

The Census data supports defining the four reference houses as follows to encompass approximately 85 percent of the last decade's new single-family detached construction:

- One-story on slab foundation
- Two-story on slab foundation
- One-story on basement foundation
- Two-story on basement foundation

Table 3 covers the locations where each type of reference house foundation would be pragmatically constructed. All of these selected cities, except Chicago, lie within the top ten states for construction starts in 2013.[11] Chicago was selected to represent a Climate Zone 5 house.

Table 3. Sites for Reference Houses

Reference House	Climate Zone	1	2	3	4
Foundation		Slab	Slab	Basement	Basement
Miami	1	X	X		
Los Angeles	3	X	X		X*
Dallas	3	X	X		X*
Seattle	4	X	X	X	X
New York	4	X	X	X	X
Chicago	5			X	X

*For BWP analysis, only.

To accommodate results of an extensive braced wall panel (BWP) analysis, which is contained in *Appendix H*, the sites for the reference houses include reference house 4 (a low roof-slope, two-story house with basement) sited in both Los Angeles and Dallas.

House Size, Cost, and Features

Based on the data compiled by Home Innovation from the 2013 *Builder Practices Survey* (BPS),[12] a nationwide annual survey, the typical Heating, Ventilation, and Cooling (HVAC) systems used in new houses are summarized in Table 4. According to the BPS, 44 percent of new homes are cooled with a

[10] www.census.gov/construction/chars/completed.html

[11] www.census.gov/construction/bps/pdf/2013statepiechart.pdf

[12] www.homeinnovation.com/trends_and_reports/data/new_construction

central air conditioner. These results influenced the selection of a gas furnace with central (electric) air conditioner as the HVAC system in each of the reference houses.

Table 4. Typical HVAC Systems Supplied with New Houses

Feature	Quantity or % of Stock
Furnace or Boiler, natural gas or propane	48%
Central Air Conditioner, electric	44%
Standard Heat Pump with Backup Heat	41%
Geothermal Heat Pump	4%
Electric furnace, baseboard, or radiant	4%
Furnace or Boiler, oil	2%

Reference House Definition

The statistics presented in the foregoing tables support reference house features that are detailed in Table 5. These four houses, in compliance with the minimum requirements of the 2006 IRC, will serve as the baseline(s) for adding or subtracting costs to estimate the impact of the code changes approved for the 2009 IRC.

Table 5. Features of the Reference Houses

Reference House	1	2	3	4
Square Feet	2,607	2,607	2,607	2,607
Foundation	Slab	Slab	Basement	Basement
Number of Stories	1	2	1	2
Number of Bedrooms	3	4	3	4
Number of Bathrooms	2	2.5	2	3
Garage, attached	2-car	2-car	2-car	2-car
Heat, Gas Furnace	Yes	Yes	Yes	Yes
Cooling, (Electric) central air	Yes	Yes	Yes	Yes
Hot Water, Gas 50 gallon tank	Yes	Yes	Yes	Yes
9 ft. Ceilings, 1st	Yes	Yes	Yes	Yes
8 ft. Ceilings, 2nd	n/a	n/a	Yes	Yes
Energy Star appliances	Yes	Yes	Yes	Yes
Laundry Room	Yes – Mudroom	Yes	Yes - Mudroom	Yes - Closet
Walls, 2x4 (Zones 1&2)	Yes	Yes	n/a	n/a
Walls, 2x6 (Zones 3 thru 8)	n/a	n/a	Yes	Yes
Bsmt., Conditioned, Unfinished	n/a	n/a	Yes	Yes
Furnace Location	Attic	Attic	Basement	Basement
Water Heater Location	Interior	Garage	Basement	Basement
Window SF/% gross wall	360/18%	315/12%	360/18%	330/12%
Cladding	Brick, 4 sides	Brick, 4 sides	Brick, 4 sides	Stucco
Roof Pitch	12/12	6/12	9/12	4/12

The furnace location has been designated as a platform in the attic for both slab reference houses, a practice that is common in Florida and Texas, where the weather is temperate year round, and thus, the location is practical. A house built on a slab foundation in a cold climate zone would have the HVAC and water heating equipment located within conditioned space.

RESULTS

Estimated Cost of 2009 Code Compliance for Reference Houses by Location

Error! Reference source not found. summarizes the estimated cumulative impact of the 2009 code changes on the cost of constructing the reference houses. For the purpose of cost aggregation, it was assumed that reference houses were not built in coastal zones or subject to flooding. The aggregated costs are reported in ranges of "High" and "Low" impact based on the applicability of the changes to the features of the reference houses. The results are grouped into four climate zone categories to accommodate the extensive energy efficiency changes in this code edition.

Error! Reference source not found. summarizes the cost estimates of the code changes that do not apply to the selected reference houses and are not included in the aggregated summary. Those costs can be added or subtracted from the aggregated costs in **Error! Reference source not found.** as applicable to a particular location or a specific building. A detailed analysis of each individual code change is provided in *Appendix A*.

Cost estimates for the code changes that pertain to townhouses (e.g., reduced party wall fire resistance when a whole building sprinkler system is installed), foundation construction in Coastal A Zones, and treated lumber exterior decks have been produced as cost per square foot estimates because these changes are not directly applicable to the reference houses. These are shown in **Error! Reference source not found.**.

Table 6. Estimated Cost of 2009 Code Compliance

		Selected Cities		Miami, Los Angeles		Dallas, Seattle, New York		Chicago		Fairbanks		
		Climate Zones		1 & 2		3 & 4		5 - 7		8		
		Reference Houses		1 & 2		1, 2, 3, 4		3 & 4		3 & 4		
Ref #	Code Change	2009 IRC Chapter	2009 IRC Reference	Cost Range								Notes
				High ($)	Low ($)	High ($)	Low ($)	High ($)	Low ($)	High ($)	Low ($)	
R-1	Construction documents to include braced wall lines	Scope & Admin.	R106.1.1	750	436	750	436	750	436	750	436	All buildings
R-4	Residential fire sprinkler system required in one and two family dwellings, townhouses and manufactured homes	Building Planning	R303.2	6,649	4,430	7,671	4,430	7,671	6,136	7,671	6,136	All buildings
R-5	Carbon monoxide alarms(s) required for fuel-fired appliances and attached garages	Building Planning	R313.1.1	174	0	174	0	116	0	116	0	All buildings
R-8	Anchor bolts for interior braced wall panels	Foundations	R403.1.6	259	0	259	0	0	0	0	0	
R-9	Lateral support requirement for basement walls is removed	Foundations	R404	0	0	(1,200)	(1,605)	(1,200)	(1,605)	(1,200)	(1,605)	Buildings with basements
R-11	Wall bracing, 90 mph wind speed, low seismic	Wall Construction	R602	1,131	565	1,131	229	229	229	N/A	N/A	Buildings in wind zone ≤ 90 mph, low seismic
R-12	Connections to roof framing	Wall Construction	R602.10.5.2	394	394	506	47	47	47	460	460	All buildings w/truss heel 9-1/4" or less, wind zone ≤ 90 mph, low seismic
R-13	Braced wall panel support [on short foundation walls]	Wall Construction	R602.10.7	101	73	101	44	101	44	101	44	All buildings w/ masonry stem walls of ≤ 4' – typically garage front walls
R-14	Window fall protection required for large operable windows located 6 feet above grade [second story]	Wall Construction	R612.1	340	0	374	0	374	0	374	0	All buildings with operable windows located ≥ 6' above grade with a sill ≤ 2' off the floor
E-1	Posting of certificate identifying building energy efficiency factors required	Energy Efficiency	N1101.9	36	9	36	9	36	9	36	9	All buildings
E-2	Revised minimum insulation and fenestration requirements	Energy Efficiency	N1102.1	1,379	574	4,109	863	3,064	976	3,064	976	All buildings
MEP-2	Arc-fault circuit interrupters required	Power & Lighting Dist.	E3902.11	2,142	1,548	2,142	1,548	2,142	1,548	2,142	1,548	All buildings
MEP-3	Tamper resistant receptacles required	Devices & Luminaries	E4002.14	63	57	63	57	63	57	63	57	All buildings
Sub-Totals without Sprinklers				**6,769**	**3,655**	**8,445**	**1,628**	**5,723**	**1,741**	**5,907**	**1,924**	
Totals ($)				**13,419**	**8,085**	**16,117**	**6,058**	**13,394**	**7,877**	**13,578**	**8,061**	

Table 7. Additional Costs of 2009 Code Compliance not Attributed to the Reference Houses

		Selected Cities		Miami, Los Angeles		Dallas, Seattle, New York		Chicago		Fairbanks		
		Climate Zones		1 & 2		3 & 4		5 - 7		8		
		Reference Houses		1 & 2		1,2,3,4		3 & 4		3 & 4		
Ref #	Code Change	2009 IRC Chapter	2009 IRC Reference	Cost Range								Notes
				High ($)	Low ($)	High ($)	Low ($)	High ($)	Low ($)	High ($)	Low ($)	
R-2	Structural wood panels used as opening protection in windborne debris regions	Building Planning	R301.2.1.2	1,272	1,036	1,345	1,036	1,345	1,054	1,345	1,054	Opening protection in windborne debris areas (130 mph).
R-6	Flood hazard areas reclassified from A Zones to Coastal A Zones	Building Planning	R-322.2	8,720	0	8,720	0	8,720	0	8,720	0	Buildings constructed in Coastal A Zones
R-7	Certification required for flood opening design in enclosed areas below design flood elevation	Building Planning	R324.2.2	N/A	N/A	N/A	N/A	1,130	450	1,130	450	Building on crawl space foundations in flood zones
R-10	Deck ledger prescriptive connections & lateral load tension ties (based on typical deck sizes)	Floors	R502	260	227	260	227	260	227	260	227	Building with an exterior deck (20x8 or 20x14)
R-11	BWP - High wind zone 100/C, SDC A,B	Wall Construction	R602	N/A	N/A	4,789[a]	166[a]	N/A	N/A	N/A	N/A	Building in 100 mph wind zone
	BWP - Seismic design category D2, 85/B	Wall Construction	R602	(71)[b]	(71)[b]	N/A	N/A	N/A	N/A	711	711	Building in seismic D2
R-12	Connections to roof framing	Wall Construction	R602.10.5.2	N/A	N/A	654[a]	491[a]	289	289	491	491	Building w/truss heels 9-1/4" to 15 1/4"
R-15	Prescriptive method for masonry lintels supporting masonry veneer over garage door openings	Wall Covering	R703.7.3.2	0	(386)	0	(386)	0	(386)	0	(386)	All buildings with garage door openings ≤ 18'–3"
MEP-1	Makeup air is required for [kitchen] overhead exhaust hoods with flow rates greater than 400 CFM	Duct Systems	M1503.4	588	0	588	0	588	0	588	0	Kitchen range fan flow rates in excess of 400 CFM

a. Based on a site located in New York.
b. Based on a site located in Los Angles.

Table 8. Additional Costs of 2009 Code Compliance not Attributed to the Reference Houses

		Selected Cities		Miami, Los Angeles		Dallas, Seattle, New York		Chicago		Fairbanks		
		Climate Zones		1 & 2		3 & 4		5 - 7		8		
		Reference Houses		1 & 2		1,2,3,4		3 & 4		3 & 4		
Ref #	Code Change	2009 IRC Chapter	2009 IRC Reference	Cost Range								Notes
				High ($)	Low ($)	High ($)	Low ($)	High ($)	Low ($)	High ($)	Low ($)	
R-3	Duplex fire-resistant construction exception with whole house sprinkler system (1/2 hour-rated common wall) (per SF)	Building Planning	R302	(1.60)		(1.60)		(1.60)		(1.60)		Duplexes, only, per SF.
R-4	Residential fire sprinkler system required in townhouses (per SF)	Building Planning	R313.1	2.55	1.70	2.94	1.70	2.94	2.35	2.94	2.35	Townhouses per SF. (not additional to Table 6)
R-6	Flood hazard areas reclassified from A Zones to Coastal A Zones (per SF)	Building Planning	R322.2	3.34	0	3.34	0	3.34	0	3.34	0	Buildings constructed in Coastal A Zones, per SF.
R-10	Deck ledger prescriptive connections & lateral load tension ties (per SF of deck)	Floors	R502	1.42	0.93	1.42	0.93	1.42	0.93	1.42	0.93	Building with an exterior deck, per SF of deck area.

APPENDIX A:
DESCRIPTION AND COST IMPACT OF 2009 IRC CODE CHANGES

R-1

IRC Section R106.1.1 Information on construction documents.

Summary of Code Change:

The code change specifies that, where required by the building official, all braced wall lines, braced wall panels, and associated details and connections be identified on construction documents.

Cost Implication of Code Change:

The cost for detailing the braced wall lines and panels on the construction documents is based on the size and complexity of the design. Tables R-1-A and R-1-B indicate a range from $436 to $750 established for the reference houses based on two local engineers' accounts of services. The bid in Table R-1-A is from an engineer who works with a builder's architect/drafting team to document wall bracing. In this case, the engineer only provided the number of hours required to complete the task.

Table R-1-B is based on an engineer's estimate who provides the complete service of producing the documentation based on a set of floor plans. In this case, the engineer provided both the number of hours to complete the task and their standard rates.

Table R-1-A. Cost to Document Braced Wall Lines (Estimate #1)

Component	$/Hour	Hours[c]	Total ($)
Draftperson[a]	79	2	158
Professional Engineer[b]	139	2	278
Total ($)			**436**

a. http://www.bls.gov/oes/current/oes_nat.htm#17-3010

b. http://www.bls.gov/oes/current/oes_nat.htm#17-2000

c. Local engineers' estimated hours

Table R-1-B. Cost to Document Braced Wall Lines (Estimate #2)

Component	$/Hour[a]	Hours[b]	Total ($)
Draftperson	100	3	300
Professional Engineer	150	3	450
Total ($)			**750**

a. Local engineers' service rates

b. Local engineers' estimated hours

R-2

IRC Section R301.2.1.2 Protection of openings.

Summary of Code Change:

The code change adds a series of new prescriptive requirements to the exception for using wood structural panels for wind borne debris protection at openings in a building in lieu of hurricane shutters or impact-resistant glazing. These new requirements include: (1) predrilling the panels to accommodate anchorage so that they are ready for immediate installation when needed, (2) use of corrosion-resistant hardware, (3) permanent installation of anchors on the building, and (4) increased size and reduced spacing for the anchors. For masonry anchors, the minimum ultimate withdrawal capacity increased from 490 lb to 1,500 lb.

Cost Implication of Code Change:

The costs associated with the material and hardware represent the added cost to that of the panels, as per the existing exception in the 2006 IRC. This 2009 provision requires that the panels be pre-drilled so they are ready for the homeowner to install when needed. The labor cost, therefore, requires panel installation, as this is necessary to align the drilled holes for the permanent hardware, panel removal, and customizing the panels to the size of the window opening.

The hardware consists of #8 x 2.5" stainless steel screws fastened into plastic coated sheaths at a minimum 16" spacing surrounding the window, but windows between 4' and 6' wide require a 10" spacing and windows between 6' and 8' wide require an 8" spacing. This represents an increase in the quantity of #8 screws from the 2006 IRC, which allowed a 16” spacing for windows up to 6’ wide and a 12” spacing for windows up to 8’ wide. It is expected that a single fastening schedule will be used for the entire house based on the largest window so that panels can be interchanged if needed. The panels are installed vertically for all windows with the fasteners at the short edge of the panel. Based on the size of most windows in the reference homes, a 10-inch spacing is used for compliance with the 2009 code relative to 16 inch spacing for the previous code. The cost range is based on the costs for each house estimated in Table R-2-A. Because costs are based on the labor to install these pre-made panels, the estimate includes labor to allow for the removal of the panels and storage.

Table R-2-A shows the cost for the reference houses. Table R-2-A estimates are based on the window schedules shown in Table R-2-B and material, labor, & O&P costs in Table R-2-C. Note that opening protection is only required in windborne debris regions, e.g., Miami.

Table R-2-A. Cost of Using Wood Structural Panels for Windborne Debris Protection of Openings

Component	Unit	Cost/ Units	Reference House			
			1	2	3	4
Permanent Lag Screws & Sheaths	Qty	5.91	137	168	139	178
#8 Steel Screws (2006 code)	Qty	(0.20)	(86)	(105)	(87)	(111)
Added Cost to Install Permanent Hardware	$		791	972	805	1,027
Cost to Uninstall WSP	$	1.79	244	300	249	317
Total Cost ($)			**1,036**	**1,272**	**1,054**	**1,345**

Table R-2-B. Cost to Install Permanent Hardware in WSPs for Windborne Debris Protection of Openings

Component	Material ($)	Labor ($)	O&P ($)	Total ($)
1/4" x 2.5" Stainless Steel Lag Screw[a]	0.96	1.28	0.89	3.13
Plastic-coated Sheath	0.07	1.61	1.10	2.78
#8 x 2" Steel Screw (Credit)	(0.09)	(0.09)	(0.02)	(0.20)
Cost to Uninstall OSB	0.00	1.28	0.51	**1.79**

a. Home Depot.com

Table R-2-C. Window Schedules

	Reference House			
	1	2	3	4
Window Locations	1-Story Slab	2-Story Slab	1-Story Basement	2-Story Basement
Front	2-2060	2-3060	4-3060	1-3050
	1-3060	2-3050		1-4040
		1-2050		1-4040
Rear	3-3050	1-3060	3-3060	1-3050
	3-3060	3-3060	3-3050	1-3050
		2-3050		1-2050
		3-3060		2-3050
				1-2040
				2-3040
				2-4040
Right Side	1-3050	1-4050	2-2020	1-3040
	1-3050	1-3040	1-3050	2-3050
	4-2060	2-3050		
Left Side	3-2050	1-4060	2-3060	3-4040
	3-3060	2-3060	2-3060	
	1-3040	2-3050		
Basement			3-3019	4-3019
Total Quantity of Windows	22	23	20	23
Total Perimeter Length (LF)	358	392	305	328
Fasteners at Opposing Ends (LF)	**114**	**140**	**116**	**148**
Total Number of Fasteners at 10" Spacing	**137**	**168**	**139**	**178**
Total Number of Fasteners at 16" Spacing	**86**	**105**	**87**	**111**

R-3

IRC Section R302 Fire-Resistant Construction.

Summary of Code Change:

The code change defines the continuity and fire resistance requirements for exterior and common walls of townhouses and duplexes and establishes parapet wall height and location at roofs. The code change adds language to this Section, relocates Section R317 on Dwelling Unit Separation to Section R302, and retitles the Section as Fire-Resistant Construction.

If fire sprinklers are installed, Section 302.2 allows townhouses to have one-hour-rated fire assemblies as common walls rather than two-hour rated assemblies. The one-hour rated common wall cannot have MEP system penetrations or be gravity load-bearing and must be continuous from foundation to underside of roof sheathing and tight to exterior walls.

Cost Implication of Code Change:

There are at least half a dozen assemblies that meet a one- or two- hour rating under UL263[13] or ASTM E119[14]. The wall selected to represent the cost savings allows one ply of 5/8" Type X gypsum board to be removed from each side of the assembly (the original design calls for 2 plies of 5/8" Type X on each face of a 2x4 stud wall at 16" o.c.) Referring to Table R-3-A, this code exception would reduce the cost of the described common wall by $1.60 per square foot (2 times $.80).

Table R-3-A. Potential Savings Switching from 2 Hour to 1 Hour Fire Rated Assembly

Component	Location	Unit	Material ($)	Labor ($)	O&P ($)	Total Cost ($)	Savings ($)
5/8" Type X	Wall	$/SF	0.34	0.26	0.20	0.80	**(1.60)**

Where non-combustible construction is prescribed, the code also requires draftstopping in crawl spaces and suspended ceiling areas when open web or perforated trusses are used for floor support. Because draftstopping between trusses at specific intervals has always been a best practice for areas exceeding 1,000 square feet, this is not treated as a code change. Cost was not calculated.

[13] UL Online Certifications Directory. http://database.ul.com

[14] See www.firefree.com/testing/standards-fire-resistant-coatings.php

R-4

IRC Section R313 Automatic fire sprinkler systems.

Summary of Code Change:

The code change requires the installation of automatic residential fire sprinkler systems in one- & two-family dwellings and townhouses. An exception is made for additions and alterations to existing buildings that do not have a fire sprinkler system installed (retrofit applications are outside of the scope of this cost evaluation).

For townhouses, Section R302.2 permits a firewall/party wall rating trade-off if a sprinkler system is installed. A one-hour rated party wall may be constructed in lieu of a two-hour rated assembly. The cost savings for townhouse party walls that are constructed with a one-hour rated assembly has been captured under *Section R302 Fire-Resistant Construction* (Appendix R-3).

Cost Implication of Code Change:

Based on the four prototype single-family homes and using RSMeans data, the cost of a residential fire sprinkler system will add between $4,430 and $7,671 to the cost of the reference houses, as per Table R-4-A.

Table R-4-A. Estimated Low End of Cost Range to Install a Whole House Sprinkler System

Component	Unit	$/Unit	Reference House			
			1	2	3	4
Meter and Controls	EA	654.00	654	654	654	654
Service Main	LF	2.61	196	196	196	196
Pipe Quantity	LF	3.85	192	268	262	296
Pipe Fittings Quantity	EA	32.67	30	50	50	60
Sprinkler Head Quantity	EA	97.95	19	32	27	38
Total Cost ($)			**4,430**	**6,649**	**6,136**	**7,671**
Cost per SF of home ($)			1.70	2.55	2.35	2.94

Table R-4-B. Cost Breakdown for Sprinkler Installations

Component	Material ($)	Labor ($)	O&P ($)	Total ($)
Backflow Preventer	445.00	19.00	56.00	**520.00**
Sub Meter	88.50	21.50	24.00	**134.00**
Increased Service Pipe	2.37		0.24	**2.61**
Pipe	1.62	1.25	0.98	**3.85**
Pipe Fittings				
Elbow	2.30	11.70	8.00	**22.00**
Tee	3.17	17.55	11.78	**32.50**
Cross	4.98	23.50	15.52	**44.00**
Coupling	2.21	11.70	7.59	**21.50**
Sprinkler Heads	29.33	21.05	16.33	**66.70**
Sprinkler Head Adaptor	5.85	5.85	4.35	**16.05**
Escucheon Plates	2.87	7.30	5.03	**15.20**

The National Fire Protection Association provided extensive data in support of this code change and estimates a 2013 cost per square foot of $2.47[15]. Multiplied by the 2,607 square feet size of the reference houses, this provides an estimate of $6,439 for the projected cost which is within the range of costs reported in Table R-4-A.

These numbers are also supported by a 2007 NAHB Research Center survey of builders who were constructing houses with fire sprinkler systems at that time. Sixty-five percent of builders surveyed with houses supported by public water systems reported whole system costs between $2,500 and $6,999. Costs were reported to escalate for houses on private water systems – 62 percent reported costs in the $3,500 to 8,999 range. The $2,000 added at the high end of the range is likely due to the added cost of a storage tank for water to supply the system.

To estimate the cost effect of implementation for townhouses, the same cost per square foot range as that developed for single-family dwellings was used.

[15] http://www.nfpa.org/research/fire-protection-research-foundation/reports-and-proceedings/suppression/home-fire-sprinklers/home-fire-sprinkler-cost-assessment-final-report

R-5

IRC Section R315.1 Carbon monoxide alarms.

Summary of Code Change:

The code change added a requirement to install a carbon monoxide (CO) alarm outside of each sleeping area in all dwellings containing fuel-fired appliances or an attached garage. CO alarms must be in compliance with UL 2034. The code change also applies to alterations to such dwellings requiring a building permit.

Cost Implication of Code Change:

The bedrooms in three of the four reference houses are located in more than one area, thus, each of these reference houses would require two CO alarms to comply with the new requirements. If an optional area were to be used as a bedroom, e.g., the study in reference house 1, a third CO alarm would be required. Table R-5-A shows the cost per CO alarm. The cost range, **$58 to $174**, represents installation of one to three alarms which would be required in the reference houses, however, CO detectors can be incorporated with smoke detectors in a single device for about the same cost as either device costs separately. These can be hardwired, as well, although the code does not currently require CO detectors to be hardwired.[16] For this reason, the low end of the cost range to comply has been set at zero.

Table R-5-A. Cost of Adding One CO Alarm

Component	Cost ($)	O&P ($)	Total ($)
Kidde CO Alarm (Plug-In Model with Battery Backup)	48	10	**58**

Homedepot.com

[16] www.homedepot.com/s/co%2520and%2520smoke%2520detector?NCNI-5

R-6

IRC Section R322 Flood Resistant Construction.

Summary of Code Change:

This code change makes several revisions to the flood-damage-resistant construction requirements.

For buildings in a Coastal A Zone and in Zone V, the mechanical and electrical systems are now required to be elevated an additional foot above the base flood elevation (BFE) with an exception that allows the lowest horizontal member oriented within 20 degrees of the direction of wave approach to be exempt (from the additional foot above BFE requirement). The location of combustion air openings and vents shall also meet the BFE plus one foot requirement.

Whereas in the 2006 IRC, flood damage-resistant materials were only required below the design flood elevation, the revised provisions of the 2009 IRC require flood damage-resistant materials to be used up to one foot above the BFE in Coastal A Zones and Zone V. A similar requirement applies to mechanical systems.

The combined effect of the new 2009 IRC requirements is that most buildings in Coastal A Zones and Zone V have to be elevated by one additional foot compared to the 2006 IRC. In jurisdictions where the design flood elevation already was at one foot or more above the BFE, there will be no change in the construction practice.

In addition, the code was revised to recognize the Coastal A Zone. The zone is defined as a flood hazard area subject to wave heights between 1 ½ and 3 feet. This results in portions of a Zone A adjacent to a Zone V condition being reclassified as a Coastal A Zone.

Cost Implication of Code Change:

The reference houses are assumed to be constructed outside of flood plains and coastal flooding areas, as none of the ascribed foundations would be practical in these areas. The estimated costs to comply with stricter elevation requirements in a Coastal A Zone or in Zone V are taken from **Error! Reference source not found.** in a 2006 FEMA publication, *Evaluation of the National Flood Insurance Program's Building Standards*[17]. Table R-6-A shows the added cost for a pier foundation that is an additional three feet long on pile-driven piers for a 1,500 square foot house. The $5,017 total cost divided by the area of the foundation results in a cost per square foot of $3.34 at the high end of the estimated range and zero at the bottom for those jurisdictions where the design flood elevation was already one foot or more above the BFE.

[17] www.fema.gov/media-library-data/20130726-1602-20490-5110/nfip_eval_building_standards.pdf

Table R-6-A. Cost to Construct a Three-Foot-Higher Pile Driven Foundation in a Coastal A Zone

Component	Unit	Material ($)	Driving ($)	Total ($)
Cost per LF of Pier	$/LF	11.48	6.73	18.21
No. Piers at 7' - 30'x50' Footprint	EA			31
Total added length of piling[a]	LF			276
Total Added Cost ($)				**5,017**

a. Allow 2' in ground for each 1' out of ground - 9' additional pole length.

R-7

IRC Section R322.2.2 Enclosed area below design flood elevation.

Summary of Code Change:

The code change adds a new requirement for the design of flood vents to be sealed by a registered design professional in cases where the designed amount of vent openings is below the minimum prescriptive opening ratio of 1 square inch of openings per 1 square foot of enclosed space.

Cost Implication of Code Change:

The cost will vary based on foundation type and degree of enclosure of the space below BFE. Typically, this would apply for a perimeter crawl space foundation in an A Zone. Table R-7-A shows the cost of flood vents on Reference House 3 (one-story with a basement). The area of the basement is the same as that of a crawl space foundation that would be built to support the house.

Table R-7-A shows costs developed for two options – standard ventilation vents used as foundation flood vents which are designed and sealed by a Professional Engineer (PE) and proprietary vents with FEMA and ICC-ES approval. The added cost range for code compliance is between the $450 for the PE and the net cost of the proprietary flood vents and ordinary foundation vents, $1,130.

Table R-7-A. Cost of Engineered Flood Vents in a Crawl Space Foundation Constructed in a Flood Zone

Component	Unit	Quantity	Cost/Unit ($)	Subtotal ($)
Foundation Vent (16"x 8")[a]	EA	20	16.20	340
Engineer's Review & Seal[b]	Hour	3	150.00	450
Option 1 Total				**790**
Smart Vent 1540-511[c]	EA	7	210.00	1,470
Option 2 Total				**1,470**

a. Homedepot.com

b. Rate established for PE by informal telephone survey.

c. Buysmartvents.com

Table R-7-B. Vent Requirement Calculation

Component	Unit	Quantity
Foundation Area	SF	2,607
Area of Vents Required	SQ IN	2,607
Foundation Vent (16"x 8")	SQ IN	128
Quantity of Vents Required	EA	20

R-8

IRC Section R403.1.6 Foundation anchorage.

Summary of Code Change:

The code change revises the provisions for sill and sole plate anchorage of exterior walls and interior braced wall panels. The primary substantive revision requires sill or sole plates of braced wall panels on interior braced wall lines (i.e. braced wall lines passing through the interior of the dwelling) to be bolted to monolithic slabs.

Cost Implication of Code Change:

The added cost is incurred in situations where an interior braced wall line is used and that interior braced wall line is not a loadbearing wall (gravity load). The added anchor bolts are required only at the locations of braced wall panels. The maximum bolt spacing is 6 feet with at least two bolts per plate section. The slab is thickened to 12 inches to allow for the minimum 7-inch anchor bolt penetration. This change only applies to slab-on-grade homes. The cost impact of the new anchorage is estimated for Reference House 1 (slab-on-grade) based on the braced wall analysis in R-11. Because the interior wall in the house is not a loadbearing wall, the cost increase includes added cost of anchor bolts with washers and nuts and the added cost of a thickened slab (Table R-8-A). For homes in SDC D2, 3”x3”x0.229” plate washers are added to the cost. Where the interior walls are loadbearing or where houses are designed not to require an interior braced wall line, there is no direct cost representing the lower bound estimate for this code change.

Table R-8-A. Foundation Anchorage for a Slab-on-Grade House

Reference House Location	Unit	$/Unit	90/B, SDC A/B	100/C, SDC A/B	85/B, SDC D2
Interior BWP	LF		5’+10.4’= 15.4’	5’+15’+6.8’= 26.8’	12’+5’+12’= 29’
					12.2’+12.2’+12.2’=36.6’[a]
Slab - thickened to 12"	LF	3.95	16.40	29.80	39.60
1/2" Anchor Bolts w/ Washer	EA	4.83	5	8	17
Plate Washers 3"x3"	EA	1.17	0	0	17
Total Added Cost ($)			**89**	**156**	**259**

a. all with 3”x3” plate washers

R-9

Section R404. Foundation and retaining walls.

Summary of Code Change:

The code change removes the requirements for added lateral support of basement walls: basement slab, joist to sill plate connections, blocking, and anchor bolts which were added in a 2006 IRC revision.

Cost Implication of Code Change:

For homes with basements (reference houses 3 & 4), this code change will result in cost savings. The cost implications have been evaluated as follows:

1. No savings are assigned to the removed slab provisions because a slab is installed in a typical basement.
2. Material and labor savings from removing the requirements for using hardware to attach floor joists to sill plates are estimated (steel angle segment for reference house 3 and 4).
3. Material and labor savings from restoring the maximum anchor bolt spacing to 6 feet (SDC A-C) from 12-inch (reference house 3) and 18-inch (reference house 4).
4. Material and labor savings from removing the requirement for blocking the entire length of the building in the direction perpendicular to the joists. An 8 foot on center spacing is assumed for the rows of blocking.

Results of the cost estimation are covered in Table R-9-A. Reference house 4 represents the low end of the range, while reference house 3 is used as the high end in Climate Zones 4-8 where basements are common. For slab foundations there is no savings.

Table R-9-A. Estimated Cost Savings by Removing Basement Wall Lateral Bracing Requirements

Reference House		Unit	3	4
Remove Hardware at Floor Joist/Sill Plates	Quantity	EA	(75)	(54)
	Unit Cost	$	7.80	7.80
	Subtotal	$	(583)	(419)
Increased Anchor Bolt Spacing on Sill Plate (1/2")	Quantity	EA	(150)	(123)
	Unit Cost	$	4.01	4.01
	Subtotal	$	(602)	(495)
Remove Blocking (2x4)	Quantity	LF	(228)	(140)
	Unit Cost	$	1.44	1.44
	Subtotal	$	(328)	(202)
Remove Blocking (2x10)	Quantity	LF	(31)	(28)
	Unit Cost	$	3.02	3.02
	Subtotal	$	(93)	(85)
Total Cost Savings ($)			**(1,605)**	**(1,200)**

Table R-9-B. Table R-9-B. Estimated Component Unit Cost

Component	Unit	Material ($)	Labor ($)	O&P ($)	Total ($)
1/4" Steel Angle	EA	2.04	0.92	0.82	**3.78**
1/2"x2" Bolts w/ Nut and Washers	EA	0.95	2.16	0.90	**4.02**
Blocking (2x4)	LF	0.50	0.54	0.40	**1.44**
Blocking (2x10)	LF	1.15	1.18	0.69	**3.02**
Anchor Bolt	EA	1.08	1.98	0.95	**4.01**

R-10

R502.2.2.1 Deck ledger connection to band joist.

Summary of Code Change:

The code change added a prescriptive table for fastener type and spacing for the attachment of an outdoor deck ledger board to a dimensional lumber band joist. The table specifies minimum 1/2" diameter lag screw or bolt with the spacing varying from 16 to 36 inches. Deck lateral load connections were also added with this change.

Cost Implication of Code Change:

The 2006 IRC required "positive anchoring" which could "not be accomplished by the use of toe nails or nails subject to withdrawal." Therefore, as a base case for estimating the added cost for compliance with the 2009 IRC, Table R-10-A assumes 3/8" lag screws spaced at 48 inches, staggered in two rows. Two deck joist span configurations compliant with the 2009 IRC are evaluated with 1/2" lag bolts spaced at 36 and 24 inches, staggered in two rows. These fastener schedules represent 8'-0" and 14'-0" maximum deck joist spans, respectively. Table R-10-A indicates the costs associated with the base case and the two joist spans reviewed under the new code change. The cost of the lateral load connection hardware and assembly is tallied in one line and summed to the cost of each deck. Subtracting the cost of the base case from the costs of the 2009 IRC compliant cases indicates a cost range to comply of $227 to $260, which includes the credit for the fasteners used in the base case.

Because the cost of the deck tension ties account for the majority of the total cost of this code change, and the example is based on two defined deck sizes, the cost is also reported as the cost per square foot of the 160 SF deck and the 280 SF deck at $1.42 and $0.93, respectively.

Table R-10-A. Cost to Fasten Deck Ledger Board to Dimensional Lumber Band Board

				20'-0" Deck Ledger			
				Quantity	Cost ($)	Quantity	Cost ($)
Component	**Detail**	**Spacing**	**Cost ($)**	**Max. Span 8'-0"**		**Max. Span 14'-0"**	
3/8" x 3.5" Lag screw	Base Case	48" - 2 rows	3.20	(12)	(38)	(12)	(38)
1/2" x 3.5" Lag screw	8' Deck	36" - 2 rows	4.55	15	84	N/A	N/A
1/2" Washer		36" - 2 rows	0.92	15	14	N/A	N/A
1/2"x 4" Lag bolt	14' Deck	24" - 2 rows	5.35	N/A	N/A	21	112
1/2" Washer		24" - 2 rows	0.92	N/A	N/A	21	19
Deck Tension Ties (pair)	Each Deck	2 Pairs/Deck	55.00	2 pair	110	2 pair	110
1/2"x36" Thread Rod	Each Deck	2 Per Deck	28.64	2	57	2	57
Low End of Range	8' Deck				**227**		
High End of Range	14' Deck						**260**
Cost per SF ($)					**1.42**		**0.93**

Table R-10-B. Unit Cost for Deck Components

Component	Material ($)	Labor ($)	O&P ($)	Total ($)
3/8" x 3.5" Lag screw	0.29	1.71	1.20	**3.20**
1/2" x 3.5" Lag screw	1.64	1.71	1.20	**4.55**
1/2" Washer[a]	0.33	0.34	0.24	**0.92**
1/2"x 4" Lag bolt	0.75	2.38	2.22	**5.35**
1/2" Washer[a]	0.33	0.34	0.24	**0.92**
Deck Tension Ties(2)[a]	16.71	16.05	22.24	**55.00**
1/2"x36" Thread Rod[a]	4.99	8.03	15.62	**28.64**

a. Homedepot.com for hardware & deck tension ties price. Labor and O&P interpolated from RSM *Residential Cost Data 2014* .

R-11

R602.10 Wall Bracing.

Summary of Code Change:

The code change resulted in a complete overhaul of wall bracing provisions including new requirements for braced wall lines and panels; increased wind bracing amounts with multiple adjustment factors, more options for alternate bracing methods and portal frames, continuous sheathing using fiberboard, mixed bracing allowances and limits, partial credit for intermittent braced wall panels less than 48" wide, wind uplift limits for braced wall panels, expanded support/blocking requirements, modified fastener table for structural members and completely reworked design and analysis of braced wall lines and braced wall panels.

Cost Implication of Code Change:

To develop relevant costs, a matrix of the components for code compliance were developed as summarized in the report titled *Code Comparative Bracing Analysis For Two Representative House Plans* by ARES Consulting (*Appendix H*). The associated costs are compiled in Table R-11-A through Table R-11-F by reference house, wind zone/exposure category, and seismic design category. Supporting costs are provided in Tables R-11-G through R-11-I. The cost tables show the incremental costs of adding or removing the specified feature relative the baseline construction practice.

Cost impacts were developed using the following assumptions about the reference houses:

1. In addition to the costs for sheathing, anchors, connections and other components required for compliance with the wall bracing provisions, each design required 4 hours of engineering analysis, shown in the cost tables following this section as *Wall Bracing Design Fee*. Note that the fee for documenting the wall bracing designs is covered in R106 (see R-1).
2. All base reference houses are fully sheathed with Method CS-WSP (continuous wood structural panel sheathing). (As early as 2006, 80 percent of the exterior sheathing market for single-family dwellings was wood structural panels.[18] Today, 3/8" and 7/16" plywood or OSB sheathing costs less than 1/2" intermediate or rigid foam sheathing, thus intermittent bracing with non-structural infill provides no cost savings over continuous sheathing.)
3. All window/door rough openings are at least 24" from an outside corner.
4. All braced wall panels are a minimum of 24" wide.
5. The analysis includes one house sited in SDC D2 and one house sited in a 100 MPH wind zone and exposure category C (open terrain with scattered obstructions).

The added cost for the two reference houses 1 and 4, assuming they are sited in suburban terrain that is not a high wind zone or high-seismic area, ranges from $229 to $1,131, as shown in Tables R-11-A and R-11-B. For a high wind zone of 100 mph and open terrain, the cost increase ranges from $166 to $4,789, as shown in Tables R-11-C and R-11-D. For construction in an SDC D2 region, the cost either remained about the same ($71 savings) or increased by $711 depending on the house configuration.

[18] Builder's Practices Survey, 2006. NAHB Research Center. Proprietary database.

Table R-11-A. Change in Braced Wall Panel Costs for Reference House 1, 1-story, 90/B, SDC A/B

(1) Option without prefabricated shear panels that requires the maximum window size be limited to 28”

BWL#	Changes with Cost Implications (quantity)	Base (2006)	2009
	Engineer's Analysis (4 hours at $150/h)	0	600
1	CS-PF w/anchor bolts and washers (2 panels)	28	0
1	Gypsum Board at interior of garage wall (180 sf)	0	137
2	WSP at interior wall (180 sf)	187	0
2	GB with 7" edge fastener spacing (360 sf)	0	44
	TOTAL ($)	216	781
	Net Effect of Code Change ($)		**565**

(2) Option with prefabricated shear panels

BWL#	Changes with Cost Implications (quantity)	Base (2006)	2009
	Engineer's Analysis (4 hours at $150/h)	0	600
1	CS-PF w/anchor bolts and washers (2 panels)	28	0
1	Gypsum Board at interior of garage wall (180 sf)	0	137
2	WSP at interior wall (180 sf)	187	0
2	GB with 7" edge fastener spacing (360 sf)	0	44
3-Opt 3	Prefab. Shear Wall Panels (2 panels >16" wide)	1,131	0
3-Opt 3	Prefab. Shear Wall Panels (3 panels >16" wide)	0	1,697
	TOTAL ($)	1,347	2,478
	Net Effect of Code Change ($)		**1,131**

Table R-11-B. Change in Braced Wall Panel Costs for Reference House 4, 2-story, 90/B, SDC A/B

BWP#	Changes with Cost Implications (quantity)	Base (2006)	2009
	Engineer's Analysis (4 hours at $150/h)	0	600
B	Wood Structural Panel sheathing (288 sf)	300	0
B	GB with 7" edge fastener spacing (576 sf)	0	70
1	Portal Frame with hold-downs (PFH) (1 panel)	171	0
1	CS-PF w/anchor bolts and washers (2 panels)	0	151
2	WSP interior wall (153 sf)	159	0
2	GB with 7" edge fastener spacing (306 sf)	0	37
	TOTAL ($)	629	859
	Net Effect of Code Change ($)		**229**

Table R-11-C. Change in Braced Wall Panel Costs in High Wind Speed Zone for Reference House 1, 1-story, 100/C, SDC A/B

BWL#	Changes with Cost Implications (quantity)	Base (2006)	2009
	Engineer's Analysis (4 hours at $150/h)	0	600
1	CS-PF w/anchor bolts and washers (2 panels)	14	0
1	Prefab. Shear Wall Panels (4 panels >16" wide)	0	2,263
2	WSP interior wall (180 sf)	187	0
2	GB with 7" edge fastener spacing (482 sf)	0	59
3-Opt 1	WSP fully sheathed	0	(69)
3-Opt 3	Prefab. Shear Wall Panels (1-16" and 3-20+")	0	2,137
	TOTAL ($)	201	4,990
	Net Effect of Code Change ($)		**4,789**

Table R-11-D. Change in Braced Wall Panel Costs in High Wind Zone for Reference House 4, 2-story, 100/C, SDC A/B

BWP#	Changes with Cost Implications (quantity)	Base (2006)	2009
	Engineer's Analysis (4 hours at $150/h)	0	600
B	WSP interior wall (288 sf)	300	0
B	GB with 7" edge fastener spacing (498 sf)	0	61
1	Portal Frame with hold-downs (PFH) (1)	171	0
1	CS-PF w/anchor bolts and washers (1)	0	76
2	WSP interior wall (151 sf)	157	0
2	GB with 7" edge fastener spacing (464 sf)	0	57
	TOTAL ($)	627	793
	Net Effect of Code Change ($)		**166**

Table R-11-E. Change in Braced Wall Panel Costs in SDC D2 for Reference House 1, 1-story, 85/B

BWL#	Changes with Cost Implications (quantity)	Base (2006)	2009
	Engineer's Analysis (4 hours at $150/h)	0	600
B	GB with 7" edge fastener spacing (207 sf)	25	0
B	GB with 7" edge fastener spacing (144 sf)	0	18
C	Hold-down - 1,800 lb & 16-16d nails (1)	23	0
1	Portal Frame (PFH) with 4,200 lb hold-downs (3)	488	0
1	Gypsum Board (180 sf)	0	137
1	Bolts & 3"x3" washers at 6' o.c. (9)	0	36
5	Portal Frame (PFH) with 4,200 lb hold-downs (3)	488	0
5	CS-PF w/anchor bolts and washers (2 panels)	0	139
5	Bolts & 3"x3" washers at 6' o.c. (6)	0	24
	TOTAL ($)	1,025	954
	Net Effect of Code Change ($)		(71)

Table R-11-F. Change in Braced Wall Panel Costs in SDC D2 for Reference House 4, 2-story, 85/B

BWP#	Changes with Cost Implications (quantity)	Base (2006)	2009
	Engineer's Analysis (4 hours at $150/h)	0	600
B	WSP interior wall (378 sf)	393	0
B	GB with 7" edge fastener spacing (756 sf)	0	92
C	9,000 Hold-downs (2)	0	235
C	Engineer's Fee for GR hold-downs (2 h at $150/h)	0	300
B-2nd	WSP interior wall (191 sf)	198	0
B-2nd	GB with 7" edge fastener spacing (381 sf)	0	47
B-2nd	Joist blocking below interior BWLs (42 lf)	0	170
2-2nd	WSP interior wall (279 sf)	290	0
2-2nd	GB with 7" edge fastener spacing (558 sf)	0	68
2-2nd	Joist blocking below WSP (20 ft)	0	81
	TOTAL ($)	882	1,593
	Net Effect of Code Change ($)		**711**

Table R-11-G. Cost of BWP Components

Component	Unit	Material	Labor	O&P	Total ($)
WSP, 7/16", pneumatic nail	SF	0.50	0.29	0.25	1.04
GB, 1/2", glued & screwed[a]	SF	0.30	0.26	0.20	0.76
GB, 7" edge fastener spacing[a]	SF	N/A	0.09	0.03	0.12
GB, 7" edge & field fastener spacing[a]	SF	N/A	0.26	0.09	0.35
1,800# Hold-down LSTHD8[b]	EA	11.87	5.94	5.31	23.12
4,200# Hold-down , STHD14	EA	20.12	10.06	9.00	39.18
9,000# Hold-down HDU14-SDS2.5[b]	EA	60.23	30.12	26.96	117.30
Manufactured Shear Wall Panel (up to 16")	EA	304.00	32.00	104.00	440.00
Manufactured Shear Wall Panel (16"-48")	EA	400.00	32.00	133.71	565.71
Reinforced slab - 8" thickended	LF	2.76	0.26	0.93	3.95
Reinforced footing - 12" x 16"	LF	10.16	10.24	6.09	26.49
Anchor bolts & 3"x3" washers	EA	1.08	1.98	0.95	4.01
Joist blocking 2x12/Add Joist	LF	1.55	1.39	1.11	4.05
Threaded rod hold-down ATS-SR7[b]	EA	63.00	31.56	29.64	124.20

a. Based on 54"x12' sheets where GB would be installed; walls, no finishing, added labor for fastener spacing.

b. Connectorsonly.com for mat'l price. RCD14 for labor and O&P.

(Note: The tables summarizing the change of braced wall panel costs show the incremental costs of adding or removing the specified feature relative the baseline construction practice.)

Table R-11-H. Cost of Portal Frame Options

Schedule PFH - Double (single panel price)

Component	Quantity	Unit	Cost	Total ($)
WSP, pneumatically nailed	36	SF	1.27	46
Blocking (2) 2x4 (mid)	4	LNF	1.84	7
Blocking (2) 2x4 (bot plate)	4	LNF	1.84	7
5/8"x 8" J bolt	2	EA	5.83	12
Washers 3"x3"	2	EA	1.17	2
Metal strap 1,000# cap.	1	EA	5.95	6
Hold-down 4,200#, STHD14	2	EA	39.18	78
Total ($)				**159**

Schedule CS-PF - Double (Single panel price)

Component	Quantity	Unit	Cost	Total ($)
WSP, pneumatically nailed	36	SF	1.27	46
Metal strap 1,000# cap.	1	EA	5.95	6
Washers 2"x2"	2	EA	0.44	1
Blocking	4	LNF	1.84	7
1/2"x 8" J bolt	2	EA	4.83	10
Total ($)				**70**

(Note: The tables summarizing the change of braced wall panel costs show only the change from the standard construction practice of continuously-sheathed braced wall panels as applicable.)

R-12

IRC Section R602.10.6.2 Connections to roof framing.

Summary of Code Change:

The code change adds provisions for blocking between roof members at braced wall panels. An exception is provided for low-heel roof configurations (9 ¼" or less) constructed in Seismic Design Categories (SDC) A, B, or C and wind speed zones of less than 100 mph. In lieu of solid blocking, two prescriptive options are provided that use blocking panels braced with wood structural sheathing. (Note: high heel trusses are also known as trusses with energy heels because the height at the outside edge of the wall plane allows full depth coverage with attic insulation.)

Cost Implication of Code Change:

Tables R-12-A and R-12-B provide estimates of the costs that would apply to reference houses 1 and 4 (same houses used for braced wall analysis in *Appendix H*) if constructed in the selected locations. Schedule CC supports the aggregated costs in the cost tables. High heel trusses (9-1/4" to 15-1/4") are included only for locations in climate zones 5 and 6. Attachment details are only required to be applied above braced wall panels, which can be identified in the report in *Appendix H*. In concurrence with the roof uplift conditions related to wall bracing requirements analysis contained in *Appendix H*, the uplift connectors required to meet wall bracing requirements are also included. Based on the house configuration and location, the added cost ranges from $62 to $654.

Table R-12-A. Cost to Connect Trusses to Braced Wall Panels – Reference House 1

Locations	Los Angeles	Dallas	Seattle	New York[a]	Chicago	Miami
Components	**Heel < 9 1/4"**					
Number of Braced Wall Panels (4')	27	16	27	16	16	Special Design Required for 100 mph wind zone
Blocking (LF)	107	N/A	107	64	N/A	
440lb Strap H2.5ASS ($)	NR	NR	NR	279	NR	
360lb Uplift Connector HC520 ($)	NR	NR	NR	53	NR	
225lb Uplift ConnectorC RT5 ($)	103	62	103	NR	62	
Blocking	290	N/A	290	174	N/A	
Total ($)	**394**	**62**	**394**	**506**	**62**	
	Heel 9 1/4" to 15 1/4"					
Number of Braced Wall Panels	N/A	N/A	N/A	16	16	Special Design Required for 100 mph wind zone
Blocking (LF)	N/A	N/A	N/A	224	224	
Blocking ($)	N/A	N/A	N/A	323	323	
440lb Strap - H2.5ASS ($)	N/A	N/A	N/A	279	NR	
360lb Uplift Connector HC520 ($)	N/A	N/A	N/A	53	NR	
185lb Uplift Connector RT5 ($)	N/A	N/A	N/A	NR	62	
Total ($)	N/A	N/A	N/A	**654**	**385**	

a. Wind speed zone of 100 mph assumed for New York, exposure category C

Table R-12-B. Cost to Connect Trusses to Braced Wall Panels – Reference House 4

Locations	Los Angeles	Dallas	Seattle	New York[a]	Chicago	Miami
Components	**Heel < 9 1/4"**					
Number of Braced Wall Panels (4')	31	12	31	12	12	Special Design Required for 100 mph wind zone
Blocking (LF)	125	N/A	125	48	N/A	
440lb Strap H2.5ASS ($)	NR	NR	NR	209	NR	
360lb Uplift Connector HC520 ($)	NR	NR	NR	39	NR	
225lb Uplift ConnectorC RT5 ($)	120	47	120	NR	47	
Blocking	340	NR	180	131	NR	
Total ($)	**460**	**47**	**300**	**379**	**47**	
	Heel 9 1/4" to 15 1/4"					
Number of Braced Wall Panels	N/A	N/A	N/A	12	12	Special Design Required for 100 mph wind zone
Blocking (LF)	N/A	N/A	N/A	168	168	
Blocking ($)	N/A	N/A	N/A	242	242	
440lb Strap - H2.5ASS ($)	N/A	N/A	N/A	209	NR	
360lb Uplift Connector HC520 ($)	N/A	N/A	N/A	39	NR	
185lb Uplift Connector RT5 ($)	N/A	N/A	N/A	NR	47	
Total ($)	N/A	N/A	N/A	**491**	**289**	

a. Wind speed zone of 100 mph assumed for New York, exposure category C

Schedule CC. Cost of Blocking and Uplift Components

Component	Unit	Material ($)	Labor ($)	O&P ($)	Total ($)
2x4 Blocking	LF	0.50	0.54	0.40	1.44
2x8 Blocking	LF	0.87	1.05	1.92	2.72
225lb Uplift Connector RT5	EA	0.37	0.19	0.21	0.77
360lb Uplift Connector HC520	EA	0.79	0.40	0.46	1.64
185lb Strap - SSP	EA	0.75	0.38	0.43	1.56
440lb Strap - H2.5ASS	EA	2.80	1.40	1.62	5.82

R-13

IRC Section R602.10.7 Braced wall panel support.

Summary of Code Change:

The code change provides prescriptive designs for short masonry walls (four feet in width or less) supporting braced wall panels. (Typically, these walls are at garage vehicle entry door openings.) New provisions require steel reinforcement tying minimum 8" concrete masonry unit (CMU) to the supporting concrete footing and from the CMU cores filled with grout to the braced wall panel.

Cost Implication of Code Change:

The added cost of the material and labor to install the specified reinforcement is shown in Table R-13-A. Masonry pier construction is standard practice that would have been used for compliance with 2006 IRC, except that often 4" CMU and 4" brick veneer provided the base of these walls. In that case a larger footing and minimum 8" CMU would add more cost which has been added to reference houses 1, 2, and 3, Table R-13-B.

An estimate for a 24-inch and a 48-inch tall pier was developed. The range of extra cost will include both wall heights.

Table R-13-A. Braced Wall Support at CMU Garage Walls (Reference House 4)

Component	Unit	24" x 24" Wall			24" x 48" wall		
		Quantity	Cost ($)	Total ($)	Quantity	Cost ($)	Total ($)
#4 Rebar	LB	14	1.24	17	26	1.24	32
Bond Beam	LF	4	2.52	10	4	2.52	10
Grouting	SF	4	4.08	16	8	4.08	33
Total ($)				**44**			**75**

Table R-13-B. Added Braced Wall Support at CMU Garage Walls with Brick Veneer (Reference House 1, 2, & 3)

Component	Unit	24" x 24" Wall			24" x 48" wall		
		Quantity	Cost ($)	Total ($)	Quantity	Cost ($)	Total ($)
#4 Rebar	LB	12	1.24	15	26	1.24	32
4" CMU	SF	8	6.10	(49)	16	6.10	(98)
8" CMU	SF	8	7.60	61	16	7.60	122
Bond Beam	LF	4	2.52	10	4	2.52	10
Grouting	SF	4	4.08	16	8	4.08	33
Footing	cu. yd.	0.10	350.00	35	0.10	350.00	35
Total ($)				**73**			**101**

Table R-13-C. Component Unit Cost Breakdown

Component	Unit	Material ($)	Labor ($)	O&P ($)	Total ($)
#4 Rebar	LB	0.50	0.26	0.23	**1.24**
4" CMU	SF	1.66	2.57	1.87	**6.10**
8" CMU	SF	2.45	2.95	2.20	**7.60**
Bond Beam	LF	1.04	0.86	0.62	**2.52**
Grouting	SF	1.13	1.77	1.18	**4.08**
Footing	cu. yd.	198.00	78.50	73.50	**350.00**

R-14

IRC Section R612.2 - R612.4.2 - Window sills. Window fall prevention devices.

Summary of Code Change:

The code change provided additional definition to window fall prevention requirements where the sills of operable windows are located less than 24" from the floor and more than 6' from the grade outside. The revision included the addition of emergency escape operation provisions, for window hardware, that are contained in ASTM F2090, Specification for Window Fall Prevention Devices with Emergency Escape (Egress) Relief Mechanisms. The ASTM standard is referenced in both the previous and current code versions (IRC 2006 and IRC 2009).

Cost Implication of Code Change:

This requirement will primarily apply to the upper story of two-story houses (or the middle and upper stories of three-story houses). The requirement would only apply to a one-story house or the first story of a two- to three-story house if the house has an elevated foundation, a walk-out basement, or the exterior grade drops off steeply. The simplest method of compliance, known as a vent latch or sash limiter, is an integral feature to the high end window series of many manufacturers which will define the low, or zero, end of the cost range. Table R-14-A shows the cost to install sash limiting devices, based on the number of applicable windows for each of the reference houses as shown in Schedule W. Basement windows are omitted because they would not require fall prevention devices. The cost to comply ranges from 0 to $374.

Table R14-A. Cost to Install Sash Limiters on Vinyl Windows

Reference House	# Devices	Material ($)	Labor($)	O&P ($)	Total ($)
1	N/A	12.45	12.85	8.73	0
2	10	12.45	12.85	8.73	**340**
3	N/A	12.45	12.85	8.73	0
4	11	12.45	12.85	8.73	**374**

Schedule W

Reference House	1	2		3	4	
	1-Story Slab	2-Story Slab		1-Story Basement	2-Story Basement	
		Floor 1	Floor 2		Floor 1	Floor 2
Front	2-2060	2-3060	2-3050	4-3060	1-3050	1-4040
	1-3060		1-2050			1-4040
Rear	3-3050	1-3060	3-3060	3-3060	1-3050	1-2040
	3-3060	3-3060		3-3050	1-3050	2-3040
		2-3050			1-2050	2-4040
					2-3050	
Right Side	1-3050	1-4050	2-3050	2-2020	2-3050	1-3040
	1-3050	1-3040		1-3050		
	4-2060					
Left Side	3-2050	1-4060	2-3050	2-3060		3-4040
	3-3060	2-3060		2-3060		
	1-3040					
Basement				3-3019	4-3019	
Quantity	22	13	**10**	20	12	**11**

R-15

IRC Section R703.7.3. [Masonry] Lintels.

Summary of Code Change:

The code change provides prescriptive design details for a composite steel angle and masonry lintel supporting masonry veneer over garage door openings up to 18'-3" in width with zero stories above.

Cost Implication of Code Change:

The change was meant to allow a less costly approach to supporting the brick veneer above a garage vehicle door opening by providing a prescriptive design for a steel angle lintel that accounts for the strength of the brick over the opening. Table R-15-A indicates the potential savings that can be recognized by using the prescriptive detail, which specifies an L5x3-1/2"x5/16" and three courses of 3/16" horizontal joint reinforcing, in lieu of a pair of L6x3-1/2x5/16" (reference houses 1, 2, and 3). The modification has been estimated as $386, dependent on whether the design change is employed.

Table R-15-A. Cost Savings Using a Masonry Lintel over 18'-3" Garage Door Opening

Component	18' - 3" Opening						
	Quantity	Material ($)	Labor ($)	O&P ($)	Total ($)	L6x4 Cost ($)	L5x3.5 Cost ($)
L6"x3.5"x3/8"x20' lintel (double)[a]	2	557.80	35.40	195.76	788.96	1,578	N/A
L5"x3.5"x1/4"x20' lintel[a]	1	365.07	17.70	126.31	509.08	N/A	509
Double-wire reinforcement (10')[b]	7.5	4.92	53.10	19.15	77.17	N/A	579
Shoring (7 day)[c]	1	25.00	53.10	25.77	103.87	N/A	104
Cost Savings ($)							(386)

a. Fastenal.com ASTM A36 Hot Rolled Steel Angle

b. Hohmann & Barnard

c. RSM *Residential Cost Data 2014*

E-1

IRC Section N1101.9 Certificate.

Summary of Code Change:

The code change adds a requirement that all thermal systems (e.g., insulation and windows), HVAC system, ducts in unconditioned space, and water heating equipment have R-value and efficiency factors itemized on a list on or near the electric panel box. The information can be provided by the builder or registered design professional.

Cost Implication of Code Change:

The code change can be accommodated with a report that has been incorporated into many of the energy efficiency simulation programs or on a form developed by the builder (if a prescriptive design approach is taken). The added cost would involve the administrative function of either compiling or printing the specifications and posting the form on the panel box. The job superintendent would be a logical point person for this responsibility.

The cost range of $9 - $36 assumes the task takes between 15 minutes and an hour to be completed by the Superintendent. An alternative approach, for builders employing a 3rd party Energy Rater, would be to incorporate the certificate and the posting of the certificate into the scope of the Rater's responsibility at the close-in inspection. According to the US Department of Labor, Superintendents have a higher hourly income than Energy Raters[19].

Table E-1. Cost to Produce and Post the Equipment Efficiencies and Thermal System Specifications

Component	Hourly ($)	Employer Benefits ($)[a]	Total ($)	1/4 Hour ($)
Median Wage for First-Line Construction Superintendents[b]	29.03	8.97	38.00	**9.50**
Median Wage for an Energy Rater/ Inspector[c]	24.95	11.09	36.04	**9.01**

a. www.bls.gov/news.release/ecec.t10.htm

b. www.bls.gov/oes/current/oes471011.htm

c. www.bls.gov/oes/current/oes474011.htm

[19] http://www.bls.gov/oes/current/oes_nat.htm#47-0000

E-2

IRC CHAPTER 11 ENERGY EFFICIENCY.

Summary of Code Change:

A number of major changes were made from the 2006 IECC to the 2009 IECC (see list below), with corresponding changes to Chapter 11 of the IRC. For the first time, performance testing of whole building tightness and duct tightness testing are now part of the IECC. In addition, lighting has been added to the scope along with updates of R-value and U-factor requirements. An full itemization of the code changes by Climate Zone and associated costs can be accessed in the NAHB Research Center's report, *2009 IECC Cost Effectiveness Analysis* (2009 Report), published in May 2012.[20]

- **Windows:** Window requirements were changed in the southern climate zones. The SHGC was reduced from 0.40 to 0.30 in Climate Zones 1 through 3 and reductions were made in the U-factor in Climate Zones 2 through 4. Based on incremental cost estimates from a 2010 Building Codes Assistance Project study[21], the changes resulted in a $0.50/ft^2 cost increase for all window changes except Climate Zone 3 where the cost increase was $1.00/ft^2.

- **Window Area:** The window to conditioned floor area percentage was reduced from 18 to 15 percent in the 2009 IECC. This change will result in either reduced window area or additional requirements that will need to be traded off against the more conductive windows. It is assumed for this report that no construction cost change will result from this code change.

- **Frame Walls:** The wood-frame wall R-values increased from R-19 to R-20 in the prescriptive table. The lowest incremental cost to go from R-19 to R-20 is $0.20/ft^2.

- **Mass Walls:** Although the mass wall U-factors did not change in the 2009 IECC, the assumed location of the insulation moved to the outside of the structure. Since the majority of mass walls in southern climates have insulation installed on the inside surface of a block wall, this change effectively increased the requirement. The cost increase associated with this change included the increase in insulation required for insulation located on the inside walls. Cost increase was $0.10/ft^2 in Climate Zone 1 and 2, and $0.41/ft^2 in Climate Zone 5.

- **Basement/Crawlspace Insulation:** Basement insulation was not previously required in Climate Zone 3. The new requirement is now R-5 continuous insulation or R-13 when installed within framing when a home is north of the Hot-Humid line in Climate Zone 3 (see Figure 2). Based on the foundation distribution by climate zone, it is believed that very few basements exist south of the Hot-Humid line; therefore, the calculation assumes all homes in Climate Zone 3 with basements will either need floor insulation or basement wall insulation. The incremental cost for basement wall insulation is $1.87/ft^2 of basement wall. Basement and conditioned crawlspace insulation levels increased in Climate Zones 6 through 8 from R-10 to R-15 at a cost of $1.05/ft^2 of wall.

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[20] Home Innovation Research Labs, May 2012. *2009 IECC Cost Effectiveness Analysis.* www.homeinnovation.com/~/media/Files/Reports/Percent%20Energy%20Savings%202009%20IECC%20Cost%20Effectiveness%20Analysis.PDF

[21] http://energycodesocean.org/sites/default/files/resources/Cost%20Increment%20Project-FINAL_0.pdf

- **Duct Systems:** Ducts are required to be either entirely within conditioned space or sealed and tested. The assumption for the energy simulation model is that ducts are outside conditioned space and additional sealing and testing is required when the house has a slab foundation or vented crawlspace. The associated cost is $259 to seal the ducts and $165 to test.

- **Air Sealing:** Building air sealing special inspection or testing to 7 ACH_{50} was introduced in the 2009 IECC. The majority of new homes would meet the 2009 IECC tightness requirement, but to avoid having to re-test, it is expected that additional air sealing will be performed. The associated cost is $0.12/ft^2 to seal the house and $165 to test.

- **Lighting:** The 2009 IECC introduced a new, mandatory 50 percent high-efficacy lighting requirement. The baseline assumption is that 10 percent of hard-wired lighting is already high efficacy. The cost to increase lighting to 50 percent is $1 per percent change, or $40.

- **Thermostats:** The 2009 IECC has a new programmable thermostat requirement for gas furnaces. Nearly all thermostats are now electronic, however, there is still a cost added for the programmable feature. A survey of a big box retailers indicated that the additional cost to upgrade to programmable is roughly $25 per thermostat.

Cost Implication of Code Change:

The cost implications of the code changes for energy efficiency (Chapter 11 of the IRC or Chapter 4 of the IECC) were evaluated in the 2009 Report using a different reference house from those selected for this analysis. Specifications unique to the reference houses in Appendices C through F have been factored by costs developed in the 2009 Report to provide a direct basis for comparison. Results are summarized in Table E-2-A. Schedules A and B support costs for window-related changes in Table E-2-A. Table E-2-B estimates the cost of the duct insulation upgrade (from R-6 to R-8) that is required by an approved code change and not included in the 2009 Report.

Table E-2-A. Cost of Energy Efficiency Code Changes by Component

Prescriptive Changes		Reference Location		Miami, Los Angeles		Dallas, Seattle, New York		Chicago		Fairbanks	
		Climate Zones		1 & 2		3 & 4		5-7		8	
		Reference House		1 & 2		1, 2, 3, & 4		3 & 4		3 & 4	
				Cost Range							
Code Ref.	Component	Avg. SF/Qty.	Cost Per ($)	High ($)	Low ($)	High ($)	Low ($)	High ($)	Low ($)	High ($)	Low ($)
N1102.1	Window SHGC	300	Sched A	7	11	20	0	0	0	0	0
N1102.1	Window U-Factor	300	Sched B	300	0	300	300	0	0	0	0
N1102.1	Basement Wall Insulation[c]	1,448	1.87	n/a	n/a	2,708	0	n/a	n/a	n/a	n/a
N1102.1	Basement Wall Insulation[d]	1,448	1.05	n/a	n/a	n/a	n/a	1,520	0	1,520	0
N1102.1	Wall Insulation	3,439	0.18	n/a	n/a	n/a	n/a	619	619	619	619
N1102.1	Floor Insulation[e]	360	0.25	n/a	n/a	n/a	n/a	90	0	90	0
N1102.4	Visual Inspect[a, b]	1-2 Hours	44.00	88	44	88	44	88	44	88	44
N1102.4	Leakage Test[a]	1	165.00	77		77		77		77	
N1102.4	Air Seal (7ACH50)	2,607	0.12	313	313	313	313	313	313	313	313
N1103.1	Programable Thermostat	1	25.00	25	0	25	0	25	0	25	0
N1103.2	Sealed Ducts (8cfm/100SF)	2,607	0.11	287	0	287	0	287	0	287	0
N1103.2.1	R-8 Ducts			247	206	247	206	0	0	0	0
N1104.1	CFLs (50%)	36	1.11	36	0	44	0	44	0	44	0
Total ($)				**1,379**	**574**	**4,109**	**863**	**3,064**	**976**	**3,064**	**976**

Note: All costs were developed in the report *2009 IECC Cost Effectiveness Analysis* , May 2012 unless otherwise noted here.

a. An optional visual inspection by an approved independent party is prescribed in lieu of a leakage test (blower door test).

b. Cost developed in the report *Estimated Costs of the 2015 IRC Code Changes* , February 2015.

c. The cost of basement insulation does not apply to reference houses 1 and 2, as these have been specified as slab foundations.

d. Additional basement insulation is not required in Zone 5.

e. Does not apply to reference house 3. Reference house 4 has conditioned space above the garage, thus, that floor would be insulated.

Schedule A - Differential SHGC Cost Increase per Square Foot

Climate Zone	1	2	3	4	5, 6, 7[a]
SHGC Cost per SF ($)	0.50	0.50	1.00	0.50	n/a

a. Climate Zone 5-8 did not change requirements

Schedule B - Differential U-Factor Cost Increase per Square Foot

Climate Zone	1	2	3	4	5, 6, 7
U-Factor Cost per SF ($)	n/a	0.50	1.00	1.00	n/a

Table E-2-B. Cost of Additional Duct Insulation

Reference House		1	2	3	4
Duct Insulation	Cost/LF ($)	Estimated Duct Length Outside of Conditioned Area (LF)			
R-6[a]	0.62	216	180	0	0
R-8[b]	1.76	216	180	0	0
Added Insulation Cost		**247**	**206**	0	**0**

a. Material cost from homedepot.com. Labor and O&P estimated to cost the same for either insulation.

b. Material cost from Global Industrial because the big boxes do not stock R-8. Globalindustrial.com

MEP-1

IRC Section M1503.4 Makeup air required.

Summary of Code Change:

The code change adds a requirement for providing makeup [outdoor] air equal to the flow rate of the exhaust hood when the system is capable of exhausting more than 400 CFM. The makeup air systems are required to be equipped with a means of closure and automatic controls that synchronize with the exhaust hood system.

Cost Implication of Code Change:

Under-cabinet-mounted ducted exhaust range hoods are available in the $200 to $300 range for a 30" drop-in range (stove and oven combination). Many of these have fan flow rates from 280 to 390 CFM, several speeds, and can be ducted to the outside. These will provide exhaust ventilation without reaching the 400 CFM capacity that triggers a code requirement for makeup air and these type of fans are typically installed as standard features in new houses. (The code requires that 100 CFM in exhaust ventilation be provided in kitchens. Range or cook top manufacturers may require additional capacity.) Most premium kitchen fans and hoods tend to have flow rates higher than 400 CFM, thus this code change would add the cost of providing a system of equal flow rate in makeup air to these higher end kitchens.

Compliance with makeup air requirements involves providing ducting sized for the maximum fan flow capacity of the range hood behind a filtered grille. The interior of the ducting should have a control that is triggered to open a damper in the duct when the range hood is switched on or reaches a set point equal to or greater than 400 CFM.

The estimated cost for the additional duct installation and a motorized damper required to provide the matching makeup air is shown in Table MEP-1-A. The cost would be zero if installing equipment with less than 400 CFM of exhaust air capability. Range hoods in excess of 600-800 CFM could require a larger diameter duct than the one shown in Table MEP-3-A, or two 6"-8" ducts may be required; this application would double the cost shown in Table MEP-1-A.

Measures for mitigating potential comfort issues associated with bringing unconditioned outdoor air (cold or hot or humid) directly into the kitchen for the duration of the fan's use would require commercial-type equipment and would add several thousand dollars in direct costs depending on the specific system. These types of solutions are not commonly used in residential applications and are not applicable to the reference houses.

Table MEP-1-A. Cost of Makeup Air Supply in Kitchens with Range Hoods in Excess of 400 CFM

Component	Quantity	Unit	Material ($)	Labor ($)	O&P ($)	Cost ($)
8" Flexible Duct, Insulated	15	LF	3.49	2.89	2.27	130
Control	1	EA	46.50	38.50	176.00	115
Duct Wall Cap[a]	1	EA	84.38	8.67	33.11	126
Motorized Damper	1	EA	82.00	12.05	15.95	110
Boot	1	EA	11.99	8.67	5.41	26
Grille, with filter	1	EA	37.40	24.10	19.50	81
Total Cost for Makeup Air Supply ($)						**588**

a. Online cost for a Broan 8" duct cap and shutter at Home Depot. Homedepot.com

Labor and O&P cost derived from RCD duct labor and time estimate of 15 minutes for 2 person team for each assembly.

MEP-2

IRC Section E3902.11 Arc-fault circuit-interrupter protection.

Summary of Code Change:

The code change specifies that all residential branch circuits (15 and 20 amps), except for those that supply a fire alarm system or have a ground fault circuit interrupter (GFCI), shall have an arc-fault circuit interrupter (AFCI) at the head of the circuit. These include circuits that service, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, and similar rooms, which are required to be protected by a combination type AFCI circuit breaker.

Cost Implication of Code Change:

This change adds the cost of arc-fault circuit breakers to the cost of each reference house. The quantity of AFCI's was calculated assuming two 15 amp circuits to each room, garage, hallway, and bath. Kitchens were assumed to have three 20 amp circuits requiring AFCIs. Full baths were assumed to have one 20 amp GFCI circuit which are used instead of AFCIs, plus two 15 amp circuits. Schedule E-Circuits shows the quantity of affected circuits attributed to each house. Table MEP-2-A indicates the high and low ends of the cost range to provide AFCI's in lieu of standard breakers.

The code does allow an exception whereby the first outlet in the branch can contain the combination AFCI as a receptacle. In this case the wiring from the panel box to the outlet containing the AFCI must be wired with rigid metal conduit (RMC), intermediate metal conduit (IMC), electrical magnetic tubing (EMT) or steel armored cable, Type AC. An AFCI outlet costs about $29 rather than the $51 to $53 shown in Table MEP-2 for AFCI circuit breakers, however, the cost of metal sheathed or conduit-encased wire costs between $5.25 and $9.80 per linear foot. Thus, for rooms/branches further than approximately 8' from the panel box it would be more cost effective to outfit the panel box with two AFCIs.[22]

Table MEP-2-A. Cost to Install Arc-Fault Circuit Interrupters

Breaker Size	Quantity	Material ($)	O&P ($)[a]	High ($)	Low ($)
20 amp	See schedule E-Circuits	11.36	18.05%	(536)	(375)
15 amp		5.54	18.05%	(20)	(20)
20 amp AFCI		53.28	18.05%	2,516	1,760
15 amp AFCI		51.57	18.05%	183	183
Total				**2,142**	**1,548**

a. RCD for O&P. Rexel USA for circuit breaker cost.
https://www.rexelusa.com/power-distribution/circuit-breakers/circuit-breakers-classified/arc-fault-replacement-breakers/category/3844

Schedule MEP-Circuits

Reference House	1	2	3	4
#Rooms x 2, 15 amp	28	40	36	40
Kitchen - 3, 20 amp	3	3	3	3

[22] RSMeans® 2014. *Light Commercial Cost Data*.

MEP-3

IRC Section E4002.14 Tamper-resistant receptacles.

Summary of Code Change:

The code change requires that all 125-volt, 15-, and 20-ampere receptacles be tamper resistant.

Cost Implication of Code Change:

The National Electrical Code (NEC) has included this code provision for residential housing since 2008 and as a result many manufacturers produce tamper-resistant receptacles. The added cost is calculated in Table MEP-3-A based on the average number of receptacles estimated using a six foot distance for receptacle spacing. Based on a review of retailer web sites, the average difference in cost between standard and tamper-resistant receptacles was estimated to be 75 cents.

Table MEP-3-A. Cost to Install Tamper Resistant Receptacles

Component	Cost ($)	
	High	Low
Quantity of Receptacles	71	64
Avg. Cost Difference per Receptacle ($)[a]	0.75	0.75
Subtotal ($)	53.25	48.00
Subcontractor's O&P ($)	9.61	8.66
Added Cost for Tamper Resistant Receptacles ($)	**63**	**57**

a. Home Depot showed a cost difference of $.51. Homedepot.com
Lowes showed a cost difference of $.68. Lowes.com
Rexel showed a cost difference of $1.08. Rexelusa.com

Schedule MEP-B. Receptacles per House

Reference House	No. of Receptacles
1	71
2	75
3	64
4	69

APPENDIX B:
LOCATION ADJUSTMENT FACTORS

State	City	Cost Adjustment Factor	State	City	Cost Adjustment Factor
Alabama	Birmingham	0.86	Montana	Billings	0.90
Alabama	Mobile	0.81	Nebraska	Omaha	0.90
Alaska	Fairbanks	1.24	Nevada	Las Vegas	1.03
Arizona	Phoenix	0.86	New Hampshire	Portsmouth	0.97
Arizona	Tucson	0.84	New Jersey	Jersey City	1.13
Arkansas	Little Rock	0.8	New Mexico	Alburquerque	0.83
California	Alhambra	1.08	New York	Long Island City	1.33
California	Los Angeles	1.09	New York	Syracuse	0.98
California	Riverside	1.07	North Carolina	Charlotte	0.86
California	Stockton	1.11	North Carolina	Greensboro	0.85
Colorado	Boulder	0.91	North Carolina	Raleigh	0.86
Colorado	Colorado Springs	0.86	North Dakota	Fargo	0.79
Colorado	Denver	0.89	Ohio	Columbus	0.95
Connecticut	New Haven	1.11	Oklahoma	Oklahoma City	0.82
Deleware	Dover	1.01	Oklahoma	Tulsa	0.78
District of Columbia	Washington, D.C.	0.94	Oregon	Bend	1.00
Florida	Fort Meyers	0.86	Pennsylvania	Norristown	1.10
Florida	Miami	0.86	Pennsylvania	State College	0.91
Florida	Orlando	0.87	Rhode Island	Providence	1.10
Florida	Tampa	0.90	South Carolina	Greenville	0.85
Georgia	Atlanta	0.87	Tennessee	Memphis	0.84
Hawaii	Honolulu	1.22	Texas	Austin	0.78
Idaho	Boise	0.88	Texas	Dallas	0.84
Illinois	Carbondale	1.02	Texas	Houston	0.85
Indiana	Indianapolis	0.93	Texas	San Antonio	0.80
Iowa	Des Moines	0.91	Utah	Ogden	0.79
Kansas	Wichita	0.79	Utah	Provo	0.79
Kentucky	Louisville	0.92	Utah	Salt Lake City	0.80
Louisiana	Baton Rouge	0.82	Vermont	Burlington	0.95
Maine	Portland	0.97	Virginia	Fairfax	1.02
Maryland	Baltimore	0.90	Virginia	Winchester	1.01
Michigan	Ann Arbor	1.03	Washington	Tacoma	1.01
Minnesota	St. Paul	1.11	West Virginia	Charleston	0.97
Mississippi	Biloxi	0.80	Wisconsin	La Crosse	0.96
Missouri	Springfield	0.89	Wyoming	Casper	0.75

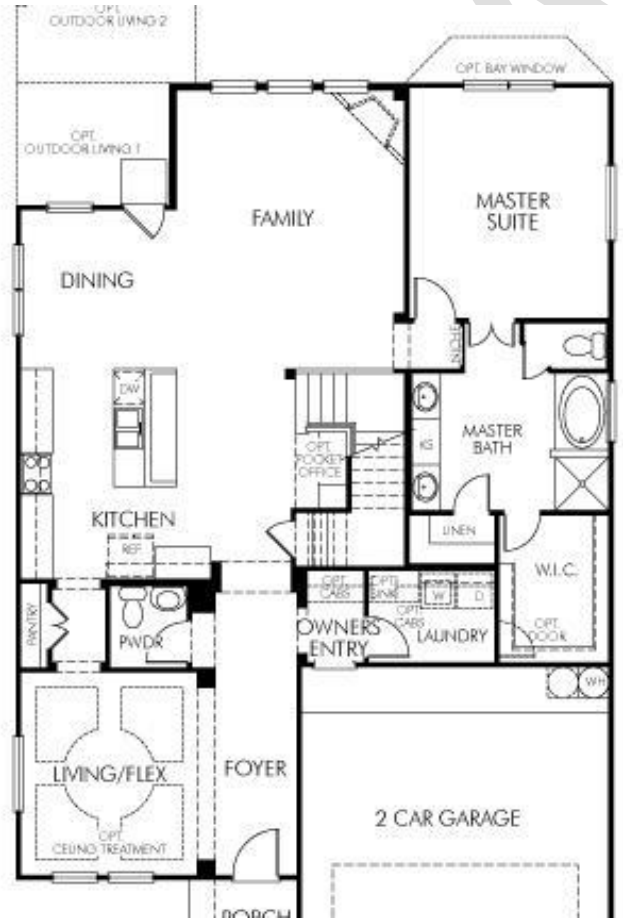
Source: RSMeans® *Residential Cost Data 2014*.

APPENDIX C:
ONE-STORY HOUSE WITH SLAB FOUNDATION (REFERENCE HOUSE 1)

Courtesy: LionsGate Homes at The Creekside

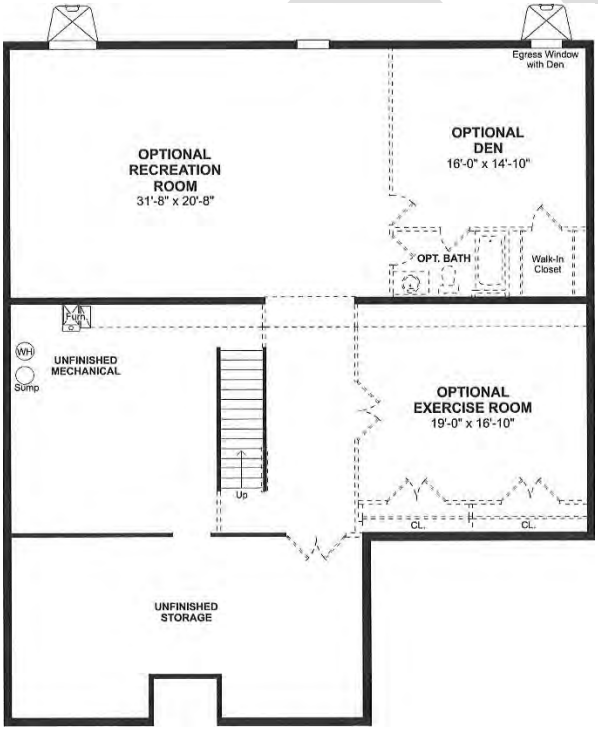
APPENDIX D:
TWO-STORY HOUSE WITH SLAB FOUNDATION (REFERENCE HOUSE 2)

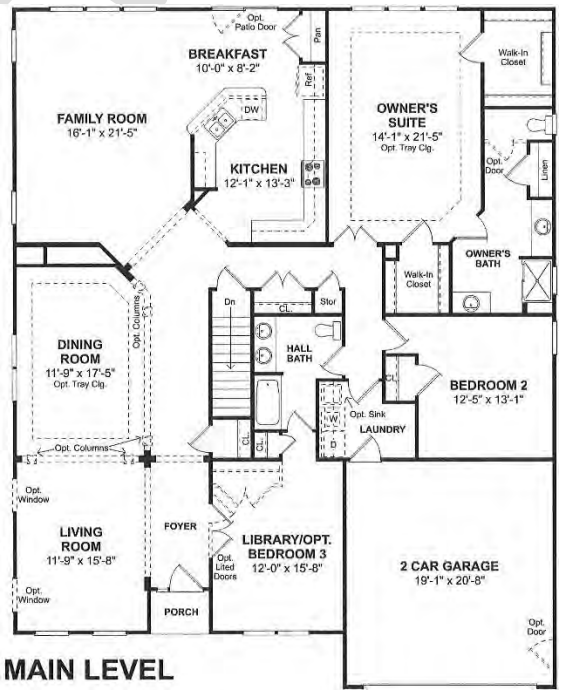
Courtesy: Meritage Homes at Riverstone



APPENDIX E:
ONE-STORY HOUSE WITH BASEMENT FOUNDATION (REFERENCE HOUSE 3)

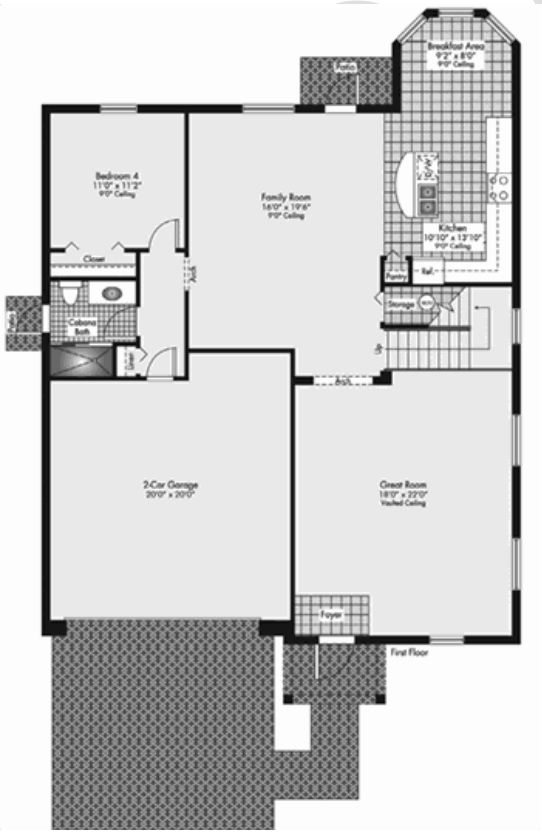
Courtesy: K Hovnanian Four Seasons at New Kent Vineyards

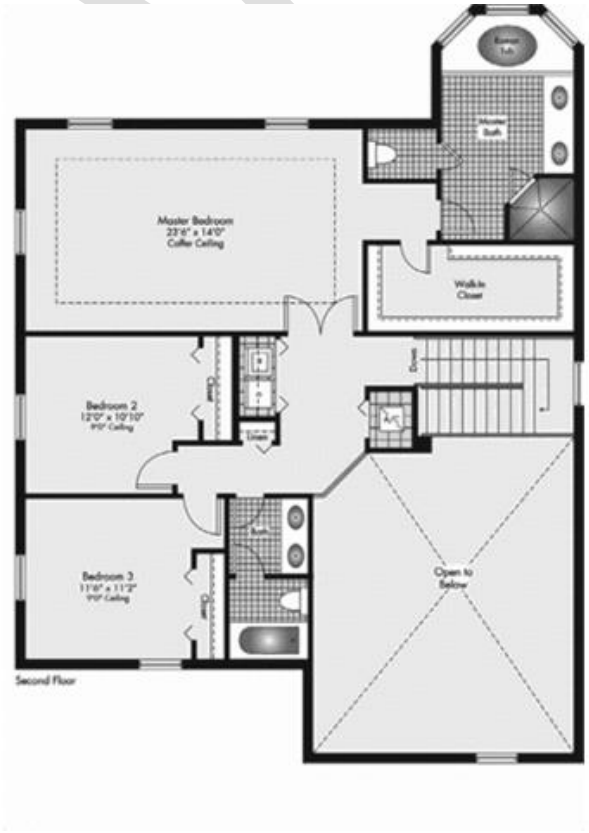




APPENDIX F:
TWO-STORY HOUSE WITH BASEMENT FOUNDATION (REFERENCE HOUSE 4)

Courtesy: Lennar at Sorento Estates





APPENDIX G:
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APPENDIX H:
ARES CONSULTING BRACING REPORT

CODE COMPARATIVE BRACING ANALYSIS FOR TWO REPRESENTATIVE HOUSE PLANS

Prepared for
Home Innovation Research Labs
Upper Marlboro, MD

Prepared by
Jay H. Crandell, P.E.
ARES Consulting
www.aresconsulting.biz

May 4, 2015
FINAL REPORT
(REVISED September 4, 2015 – SDC D2 Analyses Only)

Introduction:

This report provides data in the form of bracing design solutions for two representative house plans. The data is intended to support a cost impact analysis of changes to prescriptive wall bracing provisions in the 2006, 2009, and 2012 editions of the International Residential Code (IRC).

Approach:

The following approach was taken in conducting the bracing analyses for this study:

- Start with 2006 IRC as the "baseline code" and repeat analysis for 2009 and 2012 editions.
- Evaluate intermittent bracing (wood structural panels) as baseline bracing method and progress to continuous bracing method (also with wood structural panels) and then consider other bracing methods (e.g., narrow panel or portal frame methods) as required to addressed plan and design conditions for three representative wind/seismic regions.
- Engineering analysis is used only as necessitated by a condition resulting in a code non-compliance and then is evaluated on the basis of "parts and portions" (e.g., whole building engineering analyses were not performed).
- Report incremental differences in prescriptive bracing designs required for the two representative house plans, including instances where engineering analysis or pre-engineered bracing elements are needed to achieve code compliance (see later section on Summary of Design Solutions and also separately attached analysis files for each plan and design condition specified).

The conditions analyzed as described above are shown in Table 1 for a total of 18 individual prescriptive bracing designs.

Table 1. Bracing Analysis Study Matrix

	2006 IRC			2009 IRC			2012 IRC		
	SDC D2 85B (LA)	90B SDC A/B (Dallas)	100C SDC A/B (NYC)	SDC D2 85B (LA)	90B SDC A/B (Dallas)	100C SDC A/B (NYC)	SDC D2 85B (LA)	90B SDC A/B (Dallas)	100C SDC A/B (NYC)
One-story	X	X	X	X	X	X	X	X	X
Two-story	X	X	X	X	X	X	X	X	X

In addition to the above conditions, an analysis of the 90B, SDC A/B condition for the two-story plan was conducted using the simplified method in Section R602.12 of the 2012 IRC. The one story plan was too large in one plan dimension to qualify for use and the simplified approach excludes the 100/C and SDC D2 design conditions. An assessment of impacts to bracing design was also conducted when using brick veneer in the SDC D2 condition, although detailed analyses were not done for reasons discussed later. For the SDC D2, 85/B condition, two separate analyses (for wind and for seismic bracing) were performed to determine the controlling condition for each braced wall line in each plan.

For the design conditions represented above, the analysis assumed a maximum 15 psf wall dead load, although where appropriate a seismic bracing reduction for 8 psf wall assemblies was applied (e.g., vinyl, wood, or fiber cement siding). The 15 psf wall dead load was applied for cases with brick or stone accents on the front of the building (where the wall dead load on average was still less than 15 psf), such as found on the one-story plan. The two-story plan was assumed to have stucco over wood structural panels (WSP) as shown in the renderings below (e.g., ~15 psf wall assembly). Wall dead load conditions only affect seismic bracing amounts when seismic bracing analysis is required (e.g., SDC D for all homes and SDC C for townhomes). Similarly, the buildings had different roof dead load conditions (e.g., the two story plan had a tile roof) and this affected bracing amounts in the SDC D2 analysis condition. Seismic irregularities were also considered in the SDC D2 condition and in some cases required adjustments or designs to resolve by parts and portions. Other related factors considered included assessment of wind uplift requirements which may be required by roof wind uplift provision, braced wall panel wind uplift provisions added to the 2009 and 2012 editions of the IRC, both or neither. Where uplift requirements were triggered by the bracing uplift limit, this also was considered as a bracing impact. Finally, bracing support and connection conditions were considered.

The analysis relied extensively on the 2006, 2009, and 2012 editions of the International Residential Code. In some cases for design by parts and portions, certain provisions from the Wood Frame Construction Manual (WFCM) were applied (e.g., anchor bolt spacing to resist uplift loads where wall bracing and roof uplift requirements were invoked and were not resolved by dead load prior to reaching the foundation). In other cases, the analysis specifies generic connectors (e.g. straps and hold-downs) based on a rated design capacity. In several cases, design of wall bracing elements was needed, but was not possible using conventional engineering practices such as found in Special Design Provisions for Wind and Seismic (SDPWS) or the IBC. In these cases, pre-engineered manufactured narrow wall bracing

panel elements were generically specified based on an equivalency to the number of IRC braced wall panels required. Thus, a design was made possible by parts and portions where needed. Finally, several aspects of the IRC bracing provisions require interpretation and judgment for specific applications; in these cases, professional judgment was applied. However, local building departments may require different solutions or judgments.

Representative House Plans:

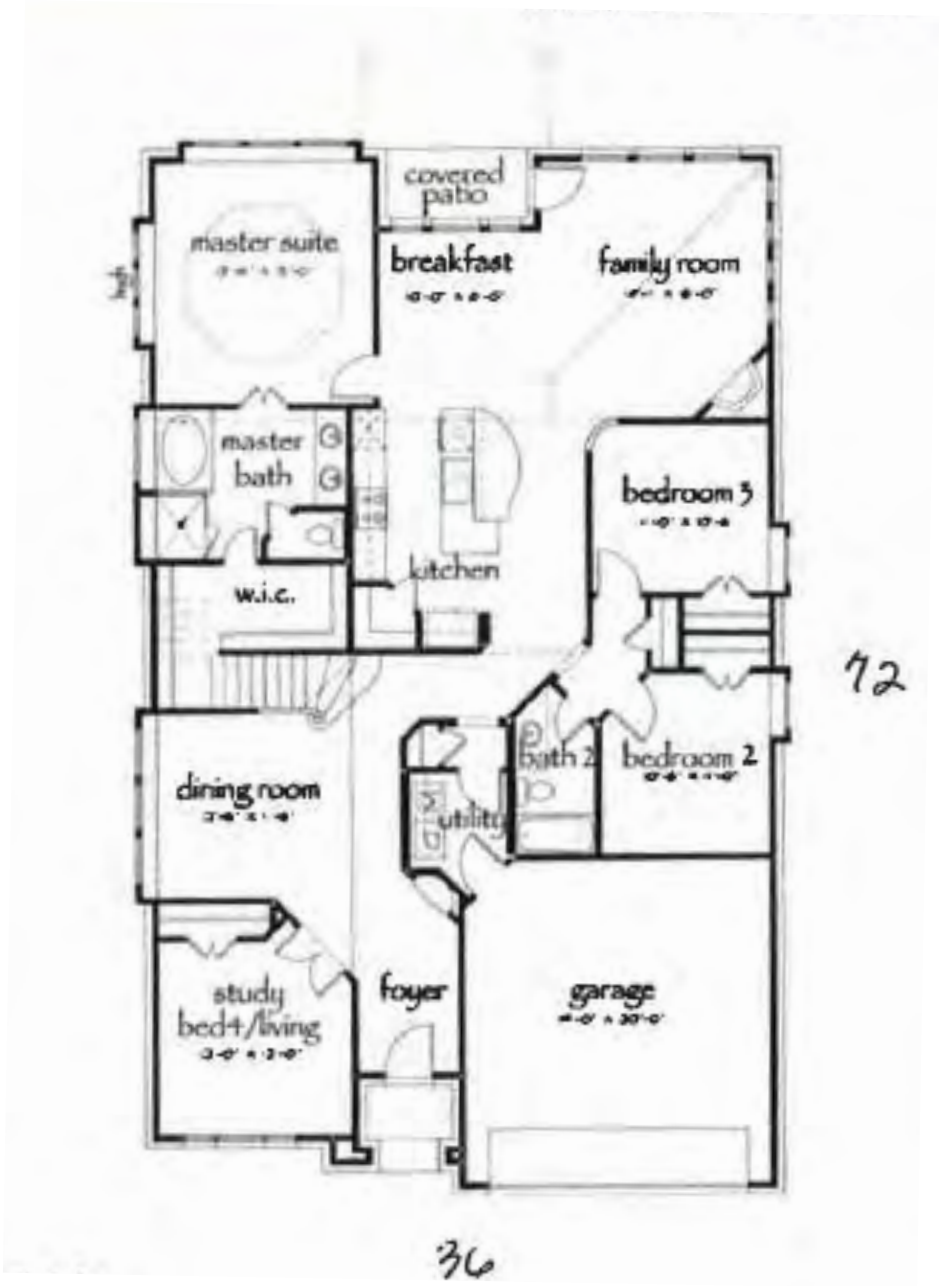
Sample renderings and floor plans for the two representative homes are shown below as provided for this project. Other elevations were not available and are assumed to be typical for the purposes of this analysis.

ONE-STORY HOUSE WITH SLAB FOUNDATION

Courtesy: LionsGate Homes at The Creekside

APPENDIX F:
TWO-STORY HOUSE WITH BASEMENT FOUNDATION

Courtesy: Lennar at Sorento Estates



One Story Plan

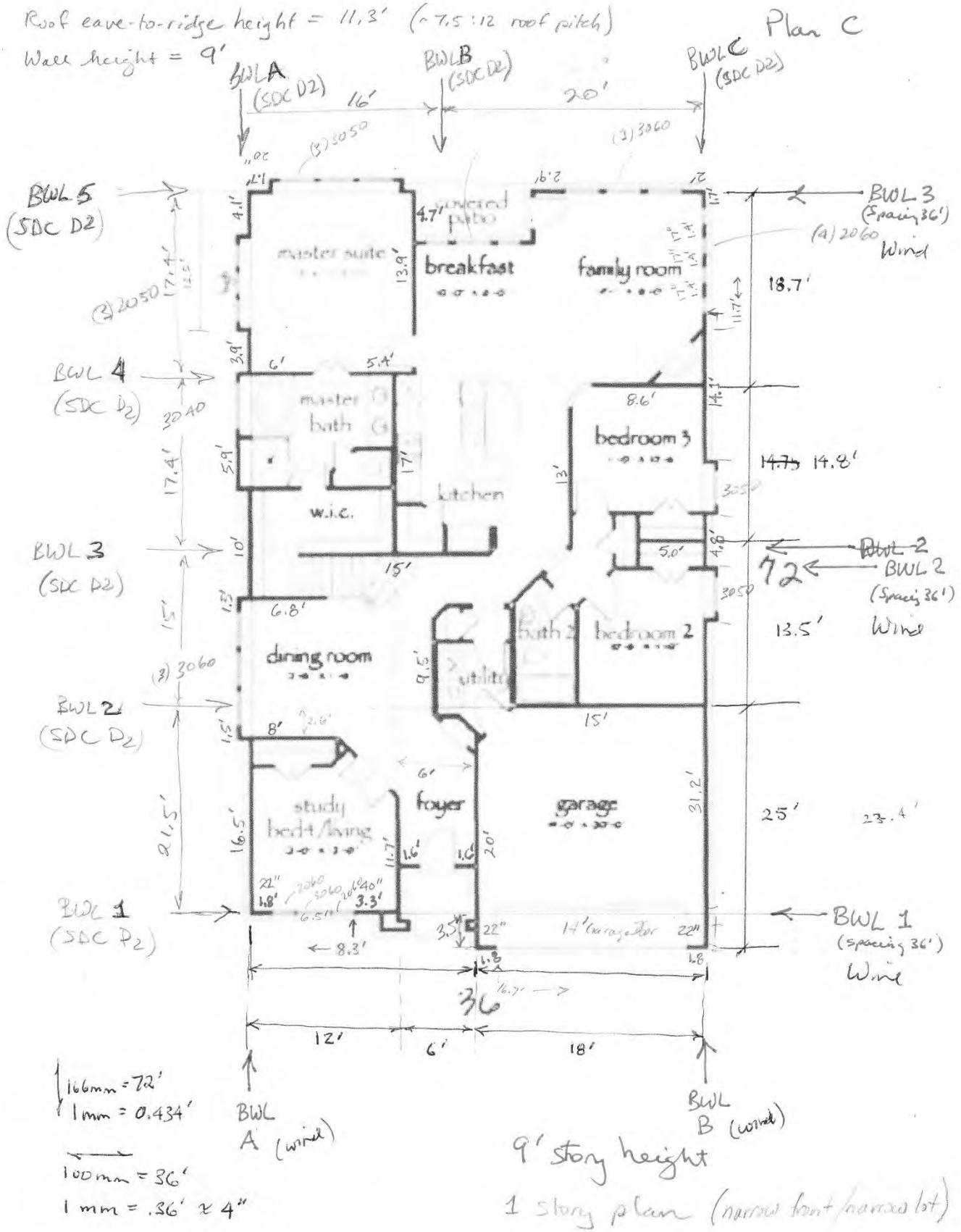
Two Story Plan

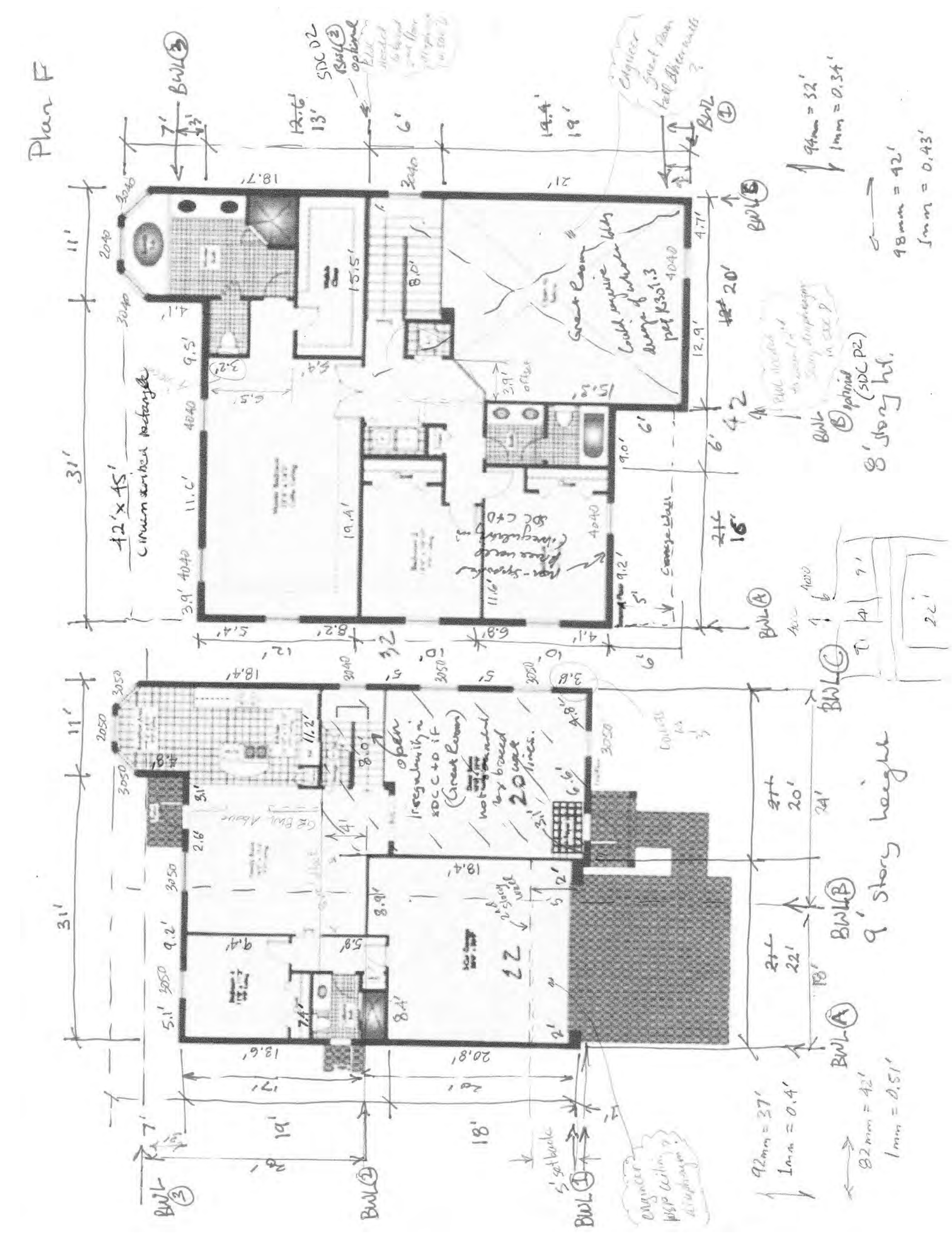
Summary of Design Solutions

Bracing solutions were derived using a detailed analysis template to aid in the implementation the IRC bracing provisions (for each of the three code editions). These templates for each of the 18 specified design conditions (plus the additional 2012 IRC simplified bracing analysis) were provided as separate Word files labelled accordingly. The separate design templates may be referenced for details such as how bracing amounts were determined and other criteria as checked for compliance including a variety of details such as siding types and weights, roofing types and weights, building geometry, adjustment factors for bracing, and a number of other details required to perform an analysis per code. In these detailed templates, comments are added to indicate the cause for needing engineered design solutions or specific oddities regarding the IRC code logic that may place restraint on otherwise applicable solutions (e.g., the requirement in the 2006 IRC that "all walls" be designed with continuous sheathing bracing methods when only one wall may require it based on the analytical bracing requirements).

To aid in understanding the design solutions and how they apply to the two representative plans, it is first important to understand the layout of braced wall lines (BWL) for the two plans. For the one-story plan, two different braced wall line layouts are shown in the image below because additional interior braced wall lines were required in the SDC D2 design condition to comply with BWL spacing limits. This added significantly to the number interior braced wall lines on the one-story plan. For the two-story plan, three braced wall lines were used for both stories; however, for wind bracing design purposes (90/B and 100/C conditions) the interior braced wall lines on the 2nd story were not required. These BWL layouts and individual wall segment dimensions and other dimensioning necessary to conduct the analysis were scaled from the plan renderings provided using the overall plan dimensions noted on the images as provided for this study. Thus, the dimensioning of elements on these plans is approximate.

The BWL layouts are as follows:


Roof eave-to-ridge height = 11.3' (~7.5:12 roof pitch)
Wall height = 9'
Plan C
BWL A (SDC D2)
BWL B (SDC D2)
BWL C (SDC D2)
16'
20'
(3) 3050
(3) 3060
BWL 5 (SDC D2)
BWL 4 (SDC D2)
BWL 3 (SDC D2)
BWL 2 (SDC D2)
BWL 1 (SDC D2)
(2) 2050
3040
(3) 3060
covered patio
master suite
breakfast
family room
master bath
w.i.c.
kitchen
bedroom 3
dining room
bath 2
bedroom 2
utility
study bedr/living
foyer
garage
14' garage door
BWL 3 (Spacing 36')
(4) 2060
Wind
18.7'
14.8'
BWL 2
(Spacing 36')
Wind
13.5'
BWL 1
(spacing 36')
Wind
25'
23.4'
72
36
12'
6'
18'
8.3'
166mm = 72'
1 mm = 0.434'
100mm = 36'
1 mm = .36' x 4"
BWL A (wind)
BWL B (wind)
9' story height
1 story plan (narrow front/hamco lot)


Plan F

The following tables summarize the bracing design solutions derived from the separately attached detailed analysis templates (roof uplift impacts related to bracing uplift limitations are presented separately later):

NOTE: There may be slightly different wording describing the same solution given that each solution was individually analyzed over the course of several different iterations for each plan. In addition, it is important to recognize that many solutions look similar (e.g., the 2009 and 2012 IRC bracing design are generally identical). However, some differences in these codes (such as the change in braced wall panel end distance) may trigger an additional solution such as a collector or inclusion of an additional segment of wall as a BWP that was before not required. Thus, a careful reading is advised to pick up substantive differences that may otherwise be lost in all the similarities.

One Story Plan (90/B, SDC A/B)

BWL	2006 IRC	2009 IRC	2012 IRC
A (left)	*OSB fully sheathed ["All walls" due to BWL 1 & 3]*	*(4) 4' OSB panels (56' infill panels)*	*(4) 4' OSB panels (56' infill panels)*
B (Right)	*OSB fully sheathed [Garage can be unfinished]*	*(4) 4' OSB panels (56' infill panels)*	*(4) 4' OSB panels (56' infill panels) + engr fee for collector design at 4-gang windows (BWP>10' from corner)*
1 (front)	*OSB fully sheathed [use portal frame @ garage w/o hold-downs per note 'c' Table R602.10.5, shift window set 2"from corner]*	*OSB fully sheathed [increased 3 panels by 3" ea. to reach 2' min. - may affect window sizes, foyer width, or plan width] (Garage must be finished)*	*OSB fully sheathed [increased 3 panels by 3" ea. to reach 2' min. - may affect window sizes, foyer width, or plan width] (garage must be finished)*
2 (int.)	*OSB fully sheath one-side of two interior walls at closet and stairway/kitchen (no impact to door jambs); overlay with GWB int. finish*	*GB double side interior walls with 7"oc fastening at edges of GB panels (two interior wall segments)*	*GB double side interior walls with 7"oc fastening at edges and field (two interior wall segments)*
3 (rear)-option 1	*OSB fully sheathed [requires all rear windows to be max. 28" instead of 30" wide]*	*OSB fully sheathed [requires all rear windows to be max. 28" instead of 30" wide]*	*OSB fully sheathed [requires all rear windows to be max. 28" instead of 30" wide]*
3 (rear)-option 2	*OSB fully sheath plus PFH portal frame with hold-downs and strapping at Master Suite window set(no change to window sizes, but extra PFH header in attic may interfere with roof framing require detailing)*	*OSB fully sheath plus 4 CS-PF panels at both opening sets, in one case an extra CS-PF header must be placed in attic which may affect roof framing if perp.)*	*OSB fully sheath plus 4 CS-PF panels at both opening sets, in one case an extra CS-PF header must be placed in attic which may affect roof framing if perp.)*
3 (rear)-option 3	*Use two narrow shear wall engr. panels: 1.7' & 2.9' wide with 4 hold-downs per manuf. design (equivalent to 1.5 4' WSP BWPs)*	*Use three narrow shear wall engr. panels: 1.7', 2.9', and 2' wide with 6 hold-downs per manuf. design (equivalent to 2.3 4' WSP BWPs)*	*Use three narrow shear wall engr. panels: 1.7', 2.9', and 2' wide with 6 hold-downs per manuf. design (equivalent to 2.3 4' WSP BWPs)*

Two Story Plan (90/B, SDC A/B)

BWL	2006 IRC	2009 IRC	2012 IRC	2012 IRC – Simple
First Story (Bottom)				
A (left)	*Fully sheath OSB; req'd all walls due to BWL 1 & 3 (garage can be unfinished)*	*Use (3) 4' OSB panels (25' infill); (garage may be unfinished)*	*Use (3) 4' OSB panels (25' infill); garage assumed to have ½" GWB*	*Fully sheath OSB (selected due to BWL 3 and GR tall wall at BWL C and thus simplified method requires "all walls") (garage must be finished with simplified method)*
B (interior)	*Fully sheath OSB int. walls (one side) through middle of building; BWL not req'd by code but included due to GR (to avoid design req'd by bldg. dept.)*	*7"oc edge fasten int. GWB both sides for 8' along two int. walls adjoining front and rear ext. walls*	*7"oc edge & field fasten int. GWB both sides for 8' along two int. walls adjoining front and rear ext. walls*	*Int. BWL not permitted*
C (right)	*Fully sheath OSB (or use engr CS-WSP w/2 hold-downs due to GR if design req'd)*	*Use (3) 4' OSB (or use engr CS-WSP w/2 hold-downs due to GR if design req'd)**	*Use (3) 4' OSB (or use engr CS-WSP w/2 hold-downs due to GR if design req'd for permit)*	*Fully sheath OSB (use two 9,000 lb holddowns at ends of GR wall portion if required to engr for permit)*
1 (front)	*OSB fully-sheath + 1 PFH panel at garage corner + hdr + straps + 2 hold-downs*	*OSB fully-sheath + 2 CS-PF panels at garage supporting offset 2nd story BWL*	*OSB fully-sheath + 2 CS-PF panels at garage supporting offset 2nd story BWL*	*OSB fully-sheath + 2 CS-PF panels at garage supporting offset 2nd story BWL*
2 (interior)	*OSB fully sheathing int. walls one side at 9' int.wall btwn garage & F.R. and 8' int. wall between stairs*	*7"oc edge fasten int. GWB both sides at 9' int. wall btwn garage & F.R. and 8' wall between stairs*	*7"oc edge & field fasten int. GWB both sides at 8.4'wall btwn garage & bath/tub and 8' wall between stairs*	*Int. BWL not permitted*
3 (rear)	*OSB fully-sheath*	*OSB fully-sheath [WSP method, (3) 4' OSB panels OK if one panel next to door increased to 43" vs. 37" wide]*	*OSB fully-sheath + engr collector for BWP>10' from end of BWL [WSP method, (3) 4' OSB panels OK if one panel next to door increased to 43" vs. 37" wide]*	*OSB fully-sheath*
Second Story (Top)				
A (left)	*Fully sheath OSB (WSP would work but BWL 1 & 3 req CS-WSP and thus "all walls" per R602.10.5)*	*(3) 4' OSB panels*	*(3) 4' OSB panels*	*Fully-sheath OSB (due to "all walls" invoked by conditions on 1st story; otherwise WSP would work)*
B (interior)	*BWL not used in SDC A/B, 90/B*	*BWL not used in SDC A/B, 90/B*	*BWL not used in SDC A/B, 90/B*	*Int. BWL not permitted*
C (right)	*Fully sheath OSB*	*(3) 4' OSB panels*	*(3) 4' OSB panels*	*Fully-sheath OSB*
1 (front)	*Fully sheath OSB*	*(3) 4' OSB panels*	*(3) 4' OSB panels*	*Fully-sheath OSB*
2 (interior)	*BWL not used in SDC A/B, 90/B*	*BWL not used in SDC A/B, 90/B*	*BWL not used in SDC A/B, 90/B*	*Int. BWL not permitted*
3 (rear)	*Fully sheath OSB*	*(3) 4' OSB panels*	*(3) 4' OSB panels + engr collector for BWP>10' from end of BWL*	*Fully-sheath OSB*

One Story Plan (100/C, SDC A/B)

BWL	2006 IRC	2009 IRC	2012 IRC
A (left)	*OSB fully sheathed ["All walls" due to BWL 1 & 3]*	*(4) 4' OSB panels (56' infill panels)*	*(4) 4' OSB panels (56' infill panels)*
B (Right)	*OSB fully sheathed [Garage can be unfinished]*	*(4) 4' OSB panels (56' infill panels) [garage can be unfinished front and side wall]*	*(4) 4' OSB panels (56' infill panels) + engr fee for collector design at 4-gang windows (BWP>10' from corner)*
1 (front)	*OSB fully sheathed [use portal frame @ garage w/o hold-downs per note 'c' Table R602.10.5, shift window set 2"from corner]*	*Use four narrow shear wall engr. panels: 1.8', 3.3', 1.8', and 1.8' wide max. with 8 hold-downs per manuf. design (equiv. to 3.4 4' WSP BWPs) [garage can be unfinished front and side wall]*	*Use four narrow shear wall engr. panels: 1.8', 3.3', 1.8', and 1.8' wide max. with 8 hold-downs per manuf. design (equiv. to 3.4 4' WSP BWPs) [garage can be unfinished front and side wall]*
2 (int.)	*OSB fully sheath one-side of two interior walls at closet and stairway/kitchen (no impact to door jambs); overlay with GWB int. finish*	*GB double side interior walls with 7"oc fastening at edges of GB panels (3 interior wall segments)*	*GB double side interior walls with 7"oc fastening at edges and field of GB panels (3 interior wall segments)*
3 (rear)-option 1	*OSB fully sheathed [requires all rear windows to be max. 28" instead of 30" wide]*	*NG*	*NG*
3 (rear)-option 2	*OSB fully sheath plus PFH portal frame with hold-downs and strapping at Master Suite window set(no change to window sizes, but extra PFH header in attic may interfere with roof framing require detailing)*	*NG*	*NG*
3 (rear)-option 3	*Use two narrow shear wall engr. panels: 1.7' & 2.9' wide with 4 hold-downs per manuf. design (equivalent to 1.5 4' WSP BWPs)*	*Use four narrow shear wall engr. panels: 1.7', 1.33', 2.9', and 2' wide with 8 hold-downs per manuf. design (equivalent to 3.4 4' WSP BWPs)*	*Use four narrow shear wall engr. panels: 1.7', 1.33', 2.9', and 2' wide with 8 hold-downs per manuf. design (equivalent to 3.4 4' WSP BWPs)*

NG = "no good" (option does not work)

Two Story Plan (100/C, SDC A/B)

BWL	2006 IRC	2009 IRC	2012 IRC
First Story (Bottom)			
A (left)	*Fully sheath OSB; req'd all walls due to BWL 1 & 3 (garage can be unfinished)*	*Use (3) 4' OSB panels (25' infill); garage assumed to have ½" GWB*	*Use (3) 4' OSB panels (25' infill); garage assumed to have ½" GWB*
B (interior)	*Fully sheath OSB int. walls (one side) through middle of building; BWL not req'd by code but included due to GR (to avoid design req'd by bldg. dept.)*	*7"oc edge fasten int. GWB both sides for 18.4' garage wall along G.R. and 9.4' Bdrm Wall at F.R. (front and rear of plan)*	*7"oc edge & field fasten int. GWB both sides for 8' along two int. walls adjoining front and rear ext. walls*
C (right)	*Fully sheath OSB (or use engr CS-WSP w/2 hold-downs due to GR if design req'd)**	*Use (4) 4' OSB (or use engr CS-WSP w/2 hold-downs due to GR if design req'd)**	*Use (4) 4' OSB (or use engr CS-WSP w/2 hold-downs due to GR if design req'd)**
1 (front)	*OSB fully-sheath + 1 PFH panel at garage corner + hdr + straps + 2 hold-downs*	*OSB fully-sheath + CS-PF at garage supporting offset 2nd story BWL*	*OSB fully-sheath + CS-PF at garage supporting offset 2nd story BWL*
2 (interior)	*OSB fully sheathing int. walls one side at 9'int.wall btwn garage & F.R. and 8' int. wall between stairs*	*7"oc edge fasten int. GWB both sides at 8'wall btwn garage and bath, 9'wall btwn garage & F.R. and 8' wall between stairs*	*7"oc edge & field fasten int. GWB both sides at 8'wall btwn garage and bath, 9' wall btwn garage and F.R. and 8'wall btwn stairs*
3 (rear)	*OSB fully-sheath*	*OSB fully-sheath [WSP method, (3) 4' OSB panels OK if one panel next to door increased to 43" vs. 37" wide]*	*OSB fully-sheath + engr collector for BWP>10' from end of BWL [WSP method, (3) 4' OSB panels OK if one panel next to door increased to 43" vs. 37" wide]*
Second Story (Top)			
A (left)	*Fully sheath OSB (WSP would work but BWL 1 & 3 req CS-WSP and thus "all walls" per R602.10.5)*	*(3) 4' OSB panels*	*(3) 4' OSB panels*
B (interior)	*BWL not used in SDC A/B, 100/C*	*BWL not used in SDC A/B, 100/C*	*BWL not used in SDC A/B, 100/C*
C (right)	*Fully sheath OSB*	*(3) 4' OSB panels*	*(3) 4' OSB panels*
1 (front)	*Fully sheath OSB*	*(3) 4' OSB panels*	*(3) 4' OSB panels*
2 (interior)	*BWL not used in SDC A/B, 100/C*	*BWL not used in SDC A/B, 100/C*	*BWL not used in SDC A/B, 100/C*
3 (rear)	*Fully sheath OSB*	*(3) 4' OSB panels*	*(3) 4' OSB panels + engr collector for BWP>10' from end of BWL*

One Story Plan (85/B, SDC D2)

BWL	2006 IRC	2009 IRC	2012 IRC
A (left)	*(4) 4' OSB panels (56' infill panels) with 3"x3" plate washers on anchor bolts at 6'oc to sill plate*	*Engr Req'd due to wall length >50' + Fully sheath OSB ("all ext. walls" due to BWLs 1 & 5) anchor bolts at 6'oc with 3"x3" plate washers*	*Engr Req'd due to wall length >50' + Fully sheath OSB ("all ext. walls" due to BWLs 1 & 5) anchor bolts at 6'oc with 3"x3" plate washers*
B (interior)	*GB double side interior walls with 7"oc fastening at edges of GB panels (13.9', 17', 9.5', and 20' interior walls) on 12"x16" reinforced thick slab footings with anchor bolts and 3"x3" washers at 6'oc*	*Engr Req'd due to wall length >50' + GB double side interior walls with 7"oc fastening at edges of GB panels (4 4' interior wall segments) anchor bolts 6'oc with 3"x3" plate washers + 8" thick slab at BWP locations for anchor bolts*	*Engr Req'd due to wall length >50' + GB double side interior walls with 7"oc fastening at edges and field of GB panels (4-4' interior wall segments) anchor bolts 6'oc with 3"x3" plate washers + 8" thick slab at BWP locations for anchor bolts*
C (right)	*(4) 4' OSB panels (56' infill panels) with 3"x3" plate washers on anchor bolts at 6'oc to sill plate + 1800# hold down at end of wall next to windows at rear and 16-16d nails at top plate splice in this region*	*Engr Req'd due to wall length >50' + Fully sheath OSB ("all ext. walls" due to other BWLs) anchor bolts at 6'oc with 3"x3" plate washers*	*Engr Req'd due to wall length >50' + Fully sheath OSB ("all ext. walls" due to other BWLs) anchor bolts at 6'oc with 3"x3" plate washers*
1 (front)	*Use three 16" PFH panels (2 at garage and one at left corner) with two 4200# hold-downs each panel and strapping and sheathing per FigR602.10.6.2 [remainder of wall OSB sheath]*	*OSB fully sheathed [increased 2 panels by 5" ea. to reach 27" min. and corner panel by 3" to reach 24"min- may affect window sizes, foyer width, or plan width; Garage must be finished; use 3"x3" plate washers on anchor bolts at 6'oc*	*OSB fully sheathed [increased 2 panels by 5" ea. to reach 27" min. and corner panel by 3" to reach 24"min- may affect window sizes, foyer width, or plan width; Garage must be finished; use 3"x3" plate washers on anchor bolts at 6'oc*
2 (interior)	*GB double side interior walls with 7"oc fastening at edges of GB panels (8' and 15' interior walls) on 12"x16" reinforced thick slab footings with anchor bolts and 3"x3" washers at 6'oc*	*GB double side interior wall segments with 7"oc fastening at edges (8' and 15' walls, garage and dining room) on 12"x16" reinforced thick slab footing and 3"x3" plate washers on anchor bolts at 6'oc*	*GB double side interior wall segments with 7"oc fastening at edges and field (8' and 15' walls, garage and dining room) on 12"x16" reinforced thick slab footing and 3"x3" plate washers on anchor bolts at 6'oc*
3 (interior)	*GB double side interior walls with 7"oc fastening at edges of GB panels (5', 15', and 6.8' interior walls) on 12"x16" reinforced thick slab footings with anchor bolts and 3"x3" washers at 6'oc*	*GB double side interior wall segments with 7"oc fastening at edges (6.8',15', and 5.0' walls) at D.R., stairway, and dbl closet on 12"x16" reinforced thick slab footing and 3"x3" plate washers on anchor bolts at 6'oc*	*GB double side interior wall segments with 7"oc fastening at edges and field (6.8',15', and 5.0' walls) at D.R., stairway, and dbl closet on 12"x16" reinforced thick slab footing and 3"x3" plate washers on anchor bolts at 6'oc*
4 (interior)	*GB double side interior walls with 7"oc fastening at edges of GB panels (6', 5.4 and 8.6' interior walls) on 12"x16" reinforced thick slab footings with anchor bolts and 3"x3" washers at 6'oc*	*GB double side interior walls with 7"oc fastening at edges of GB panels (6', 5.4 and 8.6' interior walls) on 12"x16" reinforced thick slab footings with anchor bolts and 3"x3" washers at 6'oc*	*GB double side interior walls with 7"oc fastening at edges and field of GB panels (6', 5.4 and 8.6' interior walls) on 12"x16" reinforced thick slab footings with anchor bolts and 3"x3" washers at 6'oc*
5 (rear)	*Use three 16" PFH panels (one at each corner and one at door) with two 4200# hold-downs each panel and strapping and sheathing per FigR602.10.6.2 [remainder of wall OSB sheath]*	*OSB fully sheathed + 2 CS-PF panels, one at each rear corner; use 3"x3" plate washers on anchor bolts at 6'oc*	*OSB fully sheathed + 2 CS-PF panels, one at each rear corner; use 3"x3" plate washers on anchor bolts at 6'oc*

NOTES:

1. Where a BWP is bearing directly on a slab or foundation, 3x3" plate washers required on sill anchor bolts in SDC D2 (all codes) and the slab or footing must be reinforced per code.
2. For interior walls, blocking must be provided in floor/roof framing above and below (all codes).
3. For 2009 and 2012 IRC codes, roof eave blocking or lateral force transfer detail is needed (e.g., if truss or rafter heel height is 9.25" or less then partial height blocking can be used; if taller, then refer to code for details).

Two Story Plan (85/B, SDC D2)

BWL	2006 IRC	2009 IRC	2012 IRC
First Story (Bottom)			
A (left)	*Fully sheath OSB; req'd all walls due to BWL 3 (garage can be unfinished); anchor bolts at 6'oc with 3"x3" plate washers*	*Fully sheath OSB (caused by "all walls" due to BWL C, 1, and 3); use 3"x3" washers on anchor bolts @ 6'oc (garage can be unfinished)*	*Fully sheath OSB (caused by "all walls" due to BWL C, 1, and 3); use 3"x3" washers on anchor bolts @ 6'oc (garage can be unfinished)*
B (interior)	*Fully sheath OSB int. walls (one side) through middle of building; blocking between joists below and anchors at 6'oc with 3"x3" plate washers to foundation at garage.*	*7"oc edge fasten int. GWB both sides for two int. walls adjoining front and rear ext. walls; blocking below wall at family room; 6'oc with 3"x3" plate washers to foundation at garage.*	*7"oc edge fasten int. GWB both sides for two int. walls adjoining front and rear ext. walls; blocking below wall at family room; 6'oc with 3"x3" plate washers to foundation at garage.*
C (right)	*Fully sheath OSB (may require engr. due to tall walls at G.R., but prescriptive design works due to min. openings and sizes; local official may disagree - engr fee may be req'd)*	*Fully Sheath OSB w/ two 9,000# holddowns to dbl. tall studs at ends of great room wall portion (engr. Fee may be req'd); 3"x3" washers on anchor bolts at 6'oc*	*Fully Sheath OSB w/ two 9,000# holddowns to dbl. tall studs at ends of great room wall portion (engr. Fee may be req'd); 3"x3" washers on anchor bolts at 6'oc*
1 (front)	*Use 3 or more engr narrow brace wall panels (no more than 2' wide each) for total equivalence to 5.8 WSP BWPs*	*Use 3 or more engr narrow brace wall panels (no more than 2' wide each) for total equivalence to 5.8 WSP BWPs*	*Use 3 or more engr narrow brace wall panels (no more than 2' wide each) for total equivalence to 5.8 WSP BWPs*
2 (interior)	*OSB fully sheathing int. walls at back of garage and between stairwell and kitchen*	*OSB fully sheathing int. walls at back of garage and between stairwell and kitchen; 3"x3" plate washers on anchor bolts @ 6'oc along garage walls*	*OSB fully sheathing int. walls at back of garage and between stairwell and kitchen; 3"x3" plate washers on anchor bolts @ 6'oc along garage walls*
3 (rear)	*Use 3 or more engr narrow brace wall panels (no more than 2.6' wide each) for total equivalence to 5.8 WSP BWPs also 1000# strap from top plate or band to doubled floor joist over breakfast nook for collector*	*Use 3 or more engr narrow brace wall panels (no more than 2.6' wide each) for total equivalence to 5.8 WSP BWPs also 1000# strap from top plate or band to doubled floor joist over breakfast nook for collector*	*Use 3 or more engr narrow brace wall panels (no more than 2.6' wide each) for total equivalence to 5.8 WSP BWPs also 1000# strap from top plate or band to doubled floor joist over breakfast nook for collector*
Second Story (Top)			
A (left)	*Fully sheath OSB (required due to CS-WSP needed for BWL 3 in 1st story per "all walls", R602.10.5)*	*Fully-sheath OSB ("all ext. walls" SDC D2 caused by BWLs 1 & 3 on 1st story)*	*Fully-sheath OSB ("all ext. walls" SDC D2 caused by BWLs 1 & 3 on 1st story)*
B (interior)	*Fully sheath OSB (15.3', 5.4', and 3.2' interior walls)*	*7"oc edge fasten int. GWB both sides along GR wall and MBdr closet (15.3', 5.4', and 4' at toilet wall & increase wall 9"); extra joist below wall line aligned*	*7"oc edge & field fasten int. GWB both sides along GR wall and MBdr closet (15.3', 5.4', and 4' at toilet wall & increase wall 9"); extra joist below wall line aligned*
C (right)	*Fully sheath OSB*	*Fully sheath with OSB (part of GR CS-WSP wall design for story below)*	*Fully sheath with OSB (part of GR CS-WSP wall design for story below)*
1 (front)	*Fully sheath OSB (design required for BWP support over garage: use doubled floor joist beneath with 1000# straps to stud in first story garage walls and hold-down to foundation; OSB ceiling diaphragm 5' wide to wall at garage opening)*	*Fully sheath OSB (design support below with double joist at garage ceiling and strap ends at bearing to double studs in 1st story wall anchored to garage foundation with 1000# holdowns) and OSB sheath garage ceiling 5' wide to garage opening wall*	*Fully sheathing with OSB (design support below with double joist at garage ceiling and strap ends at bearing to double studs in 1st story wall anchored to garage foundation with 1000# holdowns) and OSB sheathing garage ceiling 5' wide to garage opening wall*
2 (interior)	*Fully sheath OSB (mis-alignment with int brace wall below is within four joist thicknesses, OK)*	*7"oc edge fasten int. GWB both sides along stairway and Mbrm (15.5' and 19.4'); blocking btwn joists below 19.4' wall)*	*7"oc edge & field fasten int. GWB both sides along stairway and Mbrm (15.5' and 19.4'); blocking btwn joists below 19.4' wall)*
3 (rear)	*Fully sheath OSB also 1000# strap from top plate to ceiling joist over breakfast nook for collector 4' OSB sheath to roof rafter.*	*(3) 4' OSB panels double ceiling joist collector over bath bump-out attach to top plate or band above walls with 1000# strap/connector*	*Fully-sheath OSB panels + ceiling joist collector over bath bump-out attach to top plate or band above walls with 1000# strap/connector*

NOTES:

1. Where BWP is bearing on slab or foundation (e.g., along garage walls supported on a foundation and not the 1st floor deck), 3x3" plate washers required on sill anchor bolts in SDC D2 (all codes) and the slab or footing must be reinforced per code.
2. For interior walls, blocking must be provided in floor/roof framing above and below (all codes).
3. For 2009 and 2012 IRC codes, roof eave blocking or lateral force transfer detail is needed (e.g., if truss or rafter heel height is 9.25" or less then partial height blocking can be used; if taller, then refer to code for details).

Discussion on Brick Veneer in SDC D2:

A cursory evaluation of the above plans for use of brick veneer (full height of exterior walls) yielded some problematic findings that would require a complete re-engineering of the plans to accommodate the load of the brick veneer (using the conventional engineering assumption that it adds dead load without any ability to resist seismic forces itself). The following are offered as observations:

1. The walls with large door/window opening areas and small walls segment widths provide insufficient room to accommodate the prescriptive BV-WSP brace panels (2012 IRC). These panels are similarly detailed and required in all three codes. They each require a pair of hold-down brackets and must be a minimum of 48 wide for up to a 10' tall wall. Sheathing is fastened at 4"oc on the edges with 8d common nails.
2. The amount of bracing length required for the BV-WSP brace panels significantly exceeds that required for other wall systems addressed in the IRC due to the added mass of the brick veneer. For all three codes a bracing amount of 55% of the BWL length is required for both interior and exterior wall lines.
3. Using these BV-WSP panels for required interior braced wall lines in SDC D2 for the two plans evaluated would excessively disrupt the interior space. Furthermore, on the basement plan of the two story home, panels and hold-downs would need to be added to the basement for force transfer; yet, the code does not give guidance on this load path issue (e.g., it could be assumed that the same first story panels could be repeated in the basement or engineered)
4. The 2006 IRC does not clearly exempt 1-story brick construction, but the 2009 and 2012 codes include a statement that exempts 1-story brick from requiring with the BV-WSP provisions of the code.
5. By way of example, and assuming that the BV-WSP panels could be fit into the 2-story house plan (which it can't without major floor plan and wall opening changes), it would require the following:
    a. 24 BV-WSP panels per story (including 12 more in the basement, 6 in each plan direction)
    b. 48 – 2,300 lb tension ties on the upper story BV-WSP panels
    c. 48 – 2,300 lb tension ties on the top of the lower story BV-WSP panels.
    d. 48 – 6,200 lb hold-down brackets to the foundation at the lower story BV-WSP panels.
    e. 24 – 6,200 tension ties to BV-WSP panels in the basement.
    f. 24 – 6,200 lb hold-down brackets to two reinforced grade beams extending in both directions across the basement slab.

If the engineering analysis that substantiates the above requirements in the IRC is representative of the design that results from conventional, code-compliant engineering practice, then there is not much opportunity for brick veneer on wood-frame two-story homes in SDC D2 (and probably any SDC D condition). Instead, it would appear that a steel moment frame type of assembly would be more efficient. Certainly, a better prescriptive solution is needed if brick veneer is an important home-building feature in SDC D conditions.

Roof Uplift Conditions Related to BWP Requirements:

The following represent observations regarding roof uplift provisions in the evaluated codes:

1. For both plans and all design conditions, the 2006 code did not invoke roof uplift requirements (due to the 20 psf roof uplift pressure criteria not being exceeded).
2. For the 2009 and 2012 plans, a new braced wall panel wind uplift limit of 100 plf was initiated (with some exceptions that did not trigger with these plans). Thus, in some cases the wall bracing triggers an uplift load path at BWP locations only and the roof uplift provisions elsewhere in the code (Section R802.11) may or may not be similarly triggered.
3. The 2009 IRC retains the 20 psf roof pressure criteria from the 2006 IRC, so uplift requirements are isolated to braced wall panels where they are triggered by the 100 plf limit, since none of the design conditions exceed the 20 psf roof pressure criteria.
4. The 2012 IRC revised the roof uplift provisions and removed the 20 psf criteria and instead uses a 200 lb force limit for applicability of conventional connections (with exceptions that were not triggered by these plans). Thus, for the 2012 IRC, there are cases where, when the wall bracing uplift is triggered, the roof uplift lift provisions for the remainder of the exterior wall portions, may or may not be triggered. In reality, this would create an awkward design to isolate uplift load path to BWPs only, but from a costing standpoint this does represent a distinction in costs to comply with the code.

The following are specific uplift requirements as determined for the 2009 and 2012 IRC evaluation of the two plans.

85/B Condition

Code/Plan:	One-story	Two-story
2006 IRC	*Use conventional fastening requirements.*	*Use conventional fastening requirements.*
2009 IRC	*AT BWP LOCATIONS ONLY: Provide roof uplift connectors 185#/ea 16"oc, stud to sill plate straps at 120#/ea 16"oc, and sill anchor bolts at 6'oc with 3"sq washers (per WFCM 2001).*	*AT BWP LOCATIONS ONLY: Provide roof uplift connectors 205#/ea 16"oc and studs to top plate; 140#/ea straps at 16"oc studs to 1st floor band joist and to studs below at 16"oc; 75#/ea straps at 16"oc 1st story studs (or 150# straps every other) to band on foundation. Slant nail band to foundation sill per code.*
2012 IRC	*Use conventional fastening requirements.*	*AT BWP LOCATIONS ONLY: Provide roof uplift connectors 140#/ea 16"oc and studs to top plate; 140#/ea straps at 16"oc studs to 1st floor band joist; remainder of connections per conventional fastening.*

90/B Condition

Code/Plan:	One-story	Two-story
2006 IRC	*Use conventional fastening requirements.*	*Use conventional fastening requirements.*
2009 IRC	*AT BWP LOCATIONS ONLY: Provide roof uplift connectors 225#/ea 16"oc, stud to sill plate straps at 165#/ea 16"oc, and sill anchor bolts at 6'oc with 3"sq washers (per WFCM 2001)*	*AT BWP LOCATIONS ONLY: Provide roof uplift connectors 250#/ea 16"oc and studs to top plate; 185#/ea straps at 16"oc studs to 1st floor band joist and to studs below at 16"oc; 120#/ea straps at 16"oc 1st story studs to band on foundation and band to sill. Slant nail band to foundation sill per code.*
2012 IRC	*Use conventional fastening requirements.*	*AT BWP LOCATIONS ONLY: Use roof uplift connectors 190#/ea 16"oc and studs to top plate and 110# straps to 2nd floor band and band to studs below and 1st floor studs to floor band; connect band to sill and sill to foundation per conventional connections.*

100/C Condition

Code/Plan:	One-story	Two-story
2006 IRC	*Use conventional fastening requirements.*	*Use conventional fastening requirements.*
2009 IRC	*AT BWP LOCATIONS ONLY: Provide roof uplift connectors 360#/ea 16"oc, stud to sill plate straps at 295#/ea 16"oc, and sill anchor bolts at 4'oc with 3"sq washers (per WFCM 2001)*	*AT BWP LOCATIONS ONLY: Provide roof uplift connectors 440#/ea 16"oc and studs to top plate; 375#/ea straps from studs to 2nd floor band joist and band joist to studs below at 16"oc; 310#/ea straps from studs to 1st floor band and band to sill plate at 16"oc; sill anchor bolts at 48"oc with 3x3 plate washers.*
2012 IRC	*ALL EXT. WALLS: Use roof uplift connectors 280#/ea 16"oc and stud to top plate straps at 16"oc; use #200 lb stud to sill plate straps; use sill anchor bolts at 48"oc with 3"x3" plate washers (per WFCM).*	*ALL EXT. WALLS: Use roof uplift connectors 525#/ea 16"oc and studs to top plate; 445#/each straps studs to 2nd floor band and to studs below; 365#/ea straps from studs to 1st floor band and band to sill; 48"oc anchor bolts and 3"x3" plate washers sill to foundation.*

General Observations:

Several general observations made during the analyses are as follows:

1. The 2009 and 2012 IRC bracing provisions significantly increase design time and cost, particularly in cases where both wind and seismic provisions are invoked requiring a dual analysis.
2. Other cost impacts may include the addition of wall bracing construction documentation requirements in Chapter 1 of the codes (particularly the 2012 and perhaps also the 2009). There are costs associated with including this information and details on plans. However, with the added complexity of the code, this seems necessary from an installer and inspector standpoint for code compliance.
3. Where special design by "parts and portions" is indicated in this study, there would typically be an engineering fee in addition to any construction cost impact. The fee will vary depending on the complexity of the design or whether or not a "standard detail" can be applied.
4. Other options exist to address roof uplift conditions together with bracing. For example, using a sheathing uplift approach (as recently introduced to reference standards such as the WFCM and ICC 600) may provide a viable option. However, this still doesn't avoid special detailing of

sheathing connections and for straps at points of load concentration, e.g., edges of openings. Thus, the sheathing uplift approach may work best for walls that have substantial solid area (e.g., few windows and doors). Using the sheathing for uplift purposes reduces its capacity for bracing and thus increases bracing amounts needed, all other factors equal. Never the less, a simplified sheathing uplift approach may prove useful prescriptively. The cost of designing the method (even using prescriptive approaches) may currently offset the cost of using a conventional strap load path when required, which was the approach taken in this work.

5. Bracing location requirements such as 12.5' from the corner, now 10' from the corner in the 2012 IRC, trigger design requirements that are probably not needed, particularly in lower hazard conditions. In addition, it is questionable if the 20' (prior 25'oc) BWP spacing is really necessary for performance. Other factors, such as the maximum 4' BWL offset are also problematic. There were several instances where these considerations triggered a design problem or very nearly so. Other plans may have had more or less problem with these arbitrary requirements in the code. The code could be significantly simplified if these requirements were removed and replaced with a more performance-based and simplified logic for prescriptive bracing. For example, efficient bracing amounts could be determined for each story level of a building and then basic rules established for ensuring a balanced distribution of bracing in each story, thus avoiding arbitrary rules regarding placement of braced wall lines, offsets, etc.
6. In the 2012 IRC, Section R301.1, a requirement to consider open areas in an Exposure B wind condition could kick many more designs into a higher wind condition, thus triggering wind uplift requirements and increasing bracing. More work into the impacts of exposure and shielding may yield benefits for more efficient design.
7. For seismic bracing design, adjustments are given for a range of wall and roof system weights. However, for floor systems, the weight is given as 10 psf average. If there are substantial areas with tile flooring, then this could kick some designs out of the prescriptive bracing provisions entirely if not except from the seismic provisions (e.g., not in SDC A/B/C, excluding townhouses in SDC C).
8. The treatment of great-room (two-story) walls for bracing is not clearly enabled in the IRC and, thus, may be subject to varied interpretations from code compliance, engineering, and enforcement perspectives.
9. Finally, the 2009 and 2012 IRC seismic bracing approach differs from the 2006 IRC seismic bracing approach in that bracing amounts are determined in a table based on a range of brace wall lengths of 10 to 50 feet. In the 2006 IRC, brace wall lengths were simply multiplied by a percentage to determine the bracing amount required, without limit to brace wall lines with lengths of 50 feet or less. The 50-foot brace wall line length limit in the 2009 and 2012 IRC table format appears arbitrary and it will unnecessarily require an engineering fee that was not required in the 2006 IRC for any brace wall line that is over 50 feet in length.

APPENDIX I:
PLAN CHECK WORKSHEETS

IRC 2006 Wall Bracing Design and Plan Check Worksheet

Project: NAHB (Plan C, One story, 36'x72', slab-on-grade)

GIVEN:
Wind Speed/Exposure: 90/B *(no topographic effects)*
Seismic SDC: A/B *(exempt)*
Roof eave-to-ridge hgt.: 11.3'
Wall Hgt.: 9'
Roof/Ceiling DL: ≤15psf avg. (shingles)
Wall DL: ≤15psf avg. (incl. stone veneer accents on front)
Floor DL: n/a (slab on grade)
Roof Span: 36' (mean roof ht. = 15')

BWL Configuration Used:
BWL Layout: 2 BWLs & 3 BWLs for two plan axes
BWL Spacing: A,B (36'); 1,2,3 (36') – see plan

BWP Location and Minimum Bracing:
max 12.5' edge distance from ends of BWLs
max 25' oc BWP spacing
Minimum bracing defined by above and Table R602.10.1

Continuous Sheathing Bracing Amount Adjustment Factors:
Opening ht. 85% wall ht.: 0.9
Opening ht. 67% wall ht: 0.8
Opening ht.>85% wall ht: 1.0 (implied)

Mixed Bracing:
R602.10.5 requires all walls (int. and ext.) to be continuously sheathed if continuous sheathing bracing required on any one wall on any story level.

Wind Bracing Amount Adjustment Factors
Exposure: (not in IRC 2006)
Ridge-to-eave hgt.: (not in IRC 2006)
Wall Hgt.: 1.0 (R301.3, use 1.2 for story height 12') – N/A
BWL Spacing Factor: = S/35 for max 50' BWL spacing (R602.10.1.1)
No int. gyp.: (not in IRC 2006)
GB one-sided: (not in IRC 2006)

Seismic Bracing Amount Adjustment Factors (Table R602.10.1) – N/A
Wall DL Factor: n/a (Table R602.10.1, note 'd')
Roof DL Factor: n/a (Table R02.10.1, note 'e')

Seismic Irregularities (R301.2.2.5) – N/A

Load Path Detailing
- *Roof uplift load path per code (R802.11) – use conv. connections only (<20 psf criteria)*
- *Provide blocking or parallel member above/below BWPs per code (R602.10.8)*
- *Provide Interior BWP support per code (R602.10.9) – N/A (SDC D2 only)*
- *Cantilever and masonry pier details for BWP support (not required in IRC 2006)*
- *Block BWP horizontal joints per code unless WSP in SDC A/B/C (R602.10.7)*
- *Brace foundation cripple walls per code (R02.10.2) – N/A (SDC D2 only)*
- *BWL sills anchored to concrete/masonry per code (R602.11.1 – SDC D only)*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1 (feet)	STEP 4 Adjusted Bracing Length (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP distance from ends of BWL ≤ 12.5? (0'or8' SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution*
First Story Braced Wall Lines												
A (left)	*OK*	*Roof only*	*36'*	*72'*	*CS-WSP (R602.10.5, Meth3-cont.)*	*16%x72'= 11.5'*	*11.5'x36/35x 0.8 = 9.5'*	***40.4'***	*OK*	*OK*	*OK*	*OSB fully sheathed ["All walls" due to BWL 1 & 3]*
B (right)	*OK*	*Roof only*	*36'*	*72'*	*CS-WSP*	*16%x72'= 11.5'*	*11.5'x36/35x 0.8 = 9.5'*	*50.1'*	*OK*	*OK*	*OK*	*OSB fully sheathed [Garage can be unfinished]*
1 (front)	*OK*	*Roof only*	*36'*	*36'*	*CS-WSP CS-PF*	*16%x36' = 5.8'*	*5.8'x36/35x0.9 = 5.4'*	*2'+3.1'+ 1.8'+1.8' = 8.7'*	*OK*	*OK*	*OK*	*OSB fully sheathed [use portal frame @ garage w/o hold-downs per note 'c' Table R602.10.5, shift window set 2"from corner]*
2 (int.)	*OK*	*Roof only*	*36'*	*36'*	*CS-WSP*	*16%x36'= 5.8'*	*5.8'x36/35x1.0 = 6.0'*	*5'+15'= 20'*	*OK*	*OK*	*OK*	*OSB fully sheath one-side of two interior walls at closet and stairway/kitchen (no impact to door jambs); overlay with GWB int. finish*
3-0pt1 (rear)	*OK*	*Roof only*	*36'*	*36'*	*CS-WSP*	*16%x36'= 5.8'*	*5.8'x36/35x0.9 = 5.4'*	*2.3'+3.1' +2.3' = 7.7'*	*OK*	*OK*	*OK*	*OSB fully sheathed [requires all rear windows to be max. 28" instead of 30" wide]*
3-Opt2 (rear)	*OK*	*Roof only*	*36'*	*36'*	*CS-WSP + PFH (16" = 4' WSP)*	*16%x36'= 5.8'*	*5.8'x36/35 = 6.0' (designed as WSP equivalent due to PFH, but fully sheathed)*	*4'+4'+ 2.9'= 10.9' (4'eff. = 16" PFH panels)*	*OK*	*OK*	*OK*	*OSB fully sheath plus PFH portal frame with hold-downs and strapping at Master Suite window set(no change to window sizes, but extra PFH header in attic may interfere with roof framing require detailing)*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1 (feet)	STEP 4 Adjusted Bracing Length (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP distance from ends of BWL ≤ 12.5? (0'or8' SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution*
3-Opt3 (rear)	*OK*	*Roof only*	*36'*	*36'*	*WSP*	*6.7'*	*5.8'x36/35 = 6.0' (equivalent to 1.5-4' WSP panels)*	*0 (engr req'd)*	*NG*	*OK*	*OK*	*Use two narrow shear wall engr. panels: 1.7' & 2.9' wide with 4 hold-downs per manuf. design (equivalent to 1.5 4' WSP BWPs)*
Second Story Braced Wall Lines												
n/a												
Detached Garage or Other Portions												
n/a												

IRC 2009 Wall Bracing Design and Plan Check Worksheet

Project: NAHB (Plan C, One story, 36'x72', slab-on-grade)

GIVEN:
Wind Speed/Exposure: 90/B *(no topographic effects)*
Seismic SDC: A/B *(exempt)*
Roof eave-to-ridge hgt.: 11.3'
Wall Hgt.: 9'
Roof/Ceiling DL: ≤15psf avg. (shingles)
Wall DL: ≤15psf avg. (incl. stone veneer accents on front)
Floor DL: n/a (slab on grade)
Roof Span: 36' (mean roof ht. = 15')

BWL Configuration Used:
BWL Layout: 2 BWLs & 3 BWLs for two plan axes
BWL Spacing: A,B (36'); 1,2,3 (36') – see plan

BWP Location and Minimum Bracing:
max 12.5' cumulative edge distance from ends of BWLs
max 25' oc BWP spacing (R602.10.1.4)
min. 48" bracing amount per BWL (R602.10.1.2)

Mixing Bracing Methods (R602.10.1.1):
Generally permitted except R602.10.4 requires "all ext. walls" in SDC D if CS method is required on any one wall at any story level.

Wind Bracing Length Adjustment Factors (Table R602.10.1.2(1) footnotes)
(b) Exposure B: 1.0
(c) Ridge-to-eave hgt.: 1.1
(d) Wall Hgt.: 0.95
(e) BWL Factor: 1.0 (A,B); 1.3 (1,2,3)
(f) No int. gyp.: n/a
(g) GB one-sided: n/a (All GB BWLs double sided were used)

Seismic Bracing Length Adjustment Factors (Table R602.10.1.2(3)) – *N/A*

Seismic Irregularities (R301.2.2.5) – *N/A*

Load Path Detailing (R602.10.1.2, R602.10.6 through R602.10.9, R602.11)

- *Roof uplift load >100 plf per code (R602.10.1.2.1 & R802.11); AT BWP LOCATIONS ONLY: Provide roof uplift connectors 225#/ea 16"oc, stud to sill plate straps at 165#/ea 16"oc, and sill anchor bolts at 6'oc with 3"sq washers (per WFCM 2001); - Alternate design per ICC600(2008) uses sheathing as uplift and bracing requiring fully sheathed all walls + special details/connectors at edges of openings + anchors at 16"oc, etc.; ICC600 (2008) also references WFCM(2001) for other provisions (for determining shear wall amount, etc.).*
- *Provide blocking or parallel member above/below BWPs per code (R602.10.6)*
- *Provide BWP support per code at floor cantilevers and masonry piers (R602.10.7)- N/A*
- *Block BWP horizontal joints (except GB) per code unless bracing lengths doubled (R602.10.8)*
- *Brace foundation cripple walls per code (R02.10.9) – N/A*
- *BWL sills anchored to concrete/masonry per code (R602.11)*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1.2 (1) (feet)	STEP 4 Adjusted Bracing Length per Table R602.10.1.2(1) footnotes (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 12.5? (0'or8' SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution*
First Story Braced Wall Lines												
A (left)	*OK*	*Roof only*	*36'*	*72'*	*WSP*	*6.7'*	*6.7'x1.1xx0.95 = 7.0'*	***40.4'***	*OK*	*OK*	*OK*	*(4) 4' OSB panels (56' infill panels)*
B (right)	*OK*	*Roof only*	*36'*	*72'*	*WSP*	*6.7'*	*6.7'x1.1x 0.95 = 7.0'*	*50.1'*	*OK*	*OK*	*OK*	*(4) 4' OSB panels (56' infill panels)*
1 (front)	*OK*	*Roof only*	*36'*	*36'*	*CS-WSP CS-G*	*5.6'*	*5.6'x1.1x 0.95x1.3 = 7.6'*	*3.3' (CS-WSP) 2'+2' = 4' (CS-G) w/4" credit for 3 narrow segments*	*OK*	*OK*	*OK*	*OSB fully sheathed [increased 3 panels by 3" ea. to reach 2' min. - may affect window sizes, foyer width, or plan width] (Garage must be finished)*
2 (int.)	*OK*	*Roof only*	*36'*	*36'*	*GB*	*11.3'*	*11.3'x1.1x0.95x 1.3 = 15.4'*	*5'+15'= 20'*	*OK*	*OK*	*OK*	*GB double side interior walls with 7"oc fastening at edges of GB panels (two interior wall segments)*
3-0pt1 (rear)	*OK*	*Roof only*	*36'*	*36'*	*CS-WSP*	*5.6'*	*5.6'x1.1x 0.95x1.3 = 7.6'*	*2.3'+3.1' +2.3' = 7.7'*	*OK (barely)*	*OK*	*OK*	*OSB fully sheathed [requires all rear windows to be max. 28" instead of 30" wide]*
3-Opt2 (rear)	*OK*	*Roof only*	*36'*	*36'*	*CS-PF*	*5.6'*	*5.6x1.1x 0.95x1.3 = 7.6'*	*1.7'+1.3' 2.9'+2' = 7.9'*	*OK (barely)*	*OK*	*OK*	*OSB fully sheath plus 4 CS-PF panels at both opening sets, in one case an extra CS-PF header must be placed in attic which may affect roof framing if perp.)*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1.2 (1) (feet)	STEP 4 Adjusted Bracing Length per Table R602.10.1.2(1) footnotes (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 12.5? (0'or8' SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution*
3-Opt3 (rear)	*OK*	*Roof only*	*36'*	*36'*	*WSP*	*6.7'*	*6.7'x1.1x 0.95x1.3 = 9.1' (equivalent to 2.3-4' WSP panels)*	*0 (engr req'd)*	*NG*	*OK*	*OK*	*Use three narrow shear wall engr. panels: 1.7', 2.9', and 2' wide with 6 hold-downs per manuf. design (equivalent to 2.3 4' WSP BWPs)*
Second Story Braced Wall Lines												
n/a												
Detached Garage or Other Portions												
n/a												

IRC 2006 Wall Bracing Design and Plan Check Worksheet

Project: NAHB (Plan F, Two story, 42'x38', basement)

GIVEN:
Wind Speed/Exposure: 90/B *(no topographic effects)*
Seismic SDC: A/B *(exempt)*
Roof eave-to-ridge hgt.: 7.0'
Wall Hgt.: 9'(1st); 8' (2nd)
Roof/Ceiling DL: 25 psf max. (clay tile, typical)
Wall DL: 15psf (stucco)
Floor DL: ≤10 psf (avg)-limited areas with tile (~10%)
Roof Span: 42' (mean roof ht = 22')

BWL Configurations Used:
BWL Layout: 3 BWLs each plan direction (1st story);
2 or 3 BWLs each plan direction (2nd story)
BWL Spacing: varies, see analysis below and floor plan

BWP Location and Minimum Bracing:
max 12.5' edge distance from ends of BWLs
max 25' oc BWP spacing
Minimum bracing defined by above and Table R602.10.1

Continuous Sheathing Bracing Amount Adjustment Factors:
Opening ht. 85% wall ht.: 0.9
Opening ht. 67% wall ht: 0.8
Opening ht.>85% wall ht: 1.0 (implied)

Mixed Bracing:
R602.10.5 requires all walls (int. and ext.) to be continuously sheathed if continuous sheathing bracing required on any one wall on any story level.

Wind Bracing Length Adjustment Factors
Exposure: (not in IRC 2006)
Ridge-to-eave hgt.: (not in IRC 2006)
Wall Hgt.: 1.0 (R301.3, use 1.2 for story height 12' - n/a)
BWL Spacing Factor: S/35 for max 50' BWL spacing (R602.10.1.1)
No int. gyp.: (not in IRC 2006)
GB one-sided: (not in IRC 2006)

Seismic Bracing Length Adjustment Factors (Table R602.10.1.2(3)) - *N/A*

Seismic Irregularities (R301.2.2.5) - *N/A*

Load Path Detailing
- *Roof uplift load path per code (R802.11) - use Conv. Connections only (<20psf)*
- *Provide blocking or parallel member above/below BWPs per code (R602.10.8)*
- *Provide Interior BWP support per code (R602.10.9) - N/A (SDC D2 only)*
- *Cantilever and masonry pier details for BWP support (not required in IRC 2006)*
- *Block BWP horizontal joints per code unless WSP in SDC A/B/C (R602.10.7)*
- *Brace foundation cripple walls per code (R02.10.2) - N/A (SDC D2 only)*
- *BWL sills anchored to concrete/masonry per code (R602.11.1 - SDC D only)*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1 (feet)	STEP 4 Adjusted Bracing Length (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP distance from ends of BWL ≤ 12.5? (0' or 8' SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution & Comments*
First Story Braced Wall Lines												
A (left)	*OK*	*Roof +1floor*	*18'*	*41'*	*CS-WSP (R602.10.5, Meth3-cont.)*	*16%x41'= 6.6'*	*6.6'x0.8 = 5.3'*	*34.4'*	*OK*	*OK*	*OK*	*Fully sheath OSB; req'd all walls due to BWL 1 & 3 (garage can be unfinished)*
B (int.)	*OK*	*Roof +1 floor*	*21'*	*41'*	*CS-WSP*	*16%x41' = 6.6'*	*6.6'x0.9 = 5.6'*	*37.3'*	*OK*	*OK*	*OK*	*Fully sheath OSB int. walls (one side) through middle of building; BWL not req'd by code but included due to GR (to avoid design req'd by bldg. dept.)*
C (right)	*OK*	*Roof +1 floor*	*24'*	*41'*	*CS-WSP**	*16%x41' = 6.6'*	*6.6'x0.8 = 5.3'*	*32.0'*	*OK*	*OK*	*OK*	*Fully sheath OSB (or use engr CS-WSP w/2 hold-downs due to GR if design req'd)**
1 (front)	*OK*	*Roof +1floor*	*20'*	*42'*	*CS-WSP PFH (2' = 4'eff.)*	*16%x42' = 6.7'*	*6.7' (length equiv. to WSP forPFH equivalency)*	*18.5' (eff. Length)*	*OK*	*OK*	*OK*	*OSB fully-sheath + 1 PFH panel at garage corner + hdr + straps + 2 hold-downs*
2 (int.)	*OK*	*Roof +1floor*	*20'*	*42'*	*CS-WSP*	*16%x42' = 6.7'*	*6.7'x1.0 = 6.7' (100% opening ht.)*	*25.3'*	*OK*	*OK*	*OK*	*OSB fully sheathing int. walls one side at 9'int.wall btwn garage & F.R. and 8' int. wall between stairs*
3 (rear)	*OK*	*Roof +1floor*	*20'*	*42'*	*CS-WSP*	*16%x42' = 6.7'*	*6.7'x0.9 = 6.0'*	*17.4'*	*OK*	*OK*	*OK*	*OSB fully-sheath*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1 (feet)	STEP 4 Adjusted Bracing Length (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP distance from ends of BWL ≤ 12.5? (0' or 8' SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution & Comments*
Second Story Braced Wall Lines (N/A)												
A (left)	*OK*	*Roof only*	*42'*	*41'*	*CS-WSP*	*16%x41' = 6.6'*	*6.6'x0.8 x42/35 = 6.3'*	*24.5'*	*OK*	*OK*	*OK*	*Fully sheath OSB (WSP would work but BWL 1 & 3 req CS-WSP and thus "all walls" per R602.10.5)*
B (int.)	*n/a*	*Roof only*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*BWL not used in SDC A/B, 90/B*
C (right)	*OK*	*Roof only*	*42'*	*41'*	*CS-WSP*	*16%x41' = 6.6'*	*6.6'x0.8 x42/35 = 6.3'*	*39.7'*	*OK*	*OK*	*OK*	*Fully sheath OSB*
1 (front)	*OK*	*Roof only*	*41'*	*42'*	*CS-WSP*	*16%x42' = 6.7'*	*6.7'x0.8 x41/35 = 6.3'*	*35.8'*	*OK*	*OK*	*OK*	*Fully sheath OSB*
2 (int.)	*n/a*	*Roof only*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*BWL not used in SDC A/B, 90/B*
3 (rear)	*OK*	*Roof only*	*41'*	*42'*	*CS-WSP*	*16%x42' = 6.7'*	*6.7'x0.8 x41/35 = 6.3'*	*25.0'*	*OK*	*OK*	*OK*	*Fully sheath OSB*
Detached Garage or Other Portions												
n/a												

IRC 2009 Wall Bracing Design and Plan Check Worksheet

Project: NAHB (Plan F, Two story, 42'x38', basement)

GIVEN:
Wind Speed/Exposure: 90/B *(no topographic effects)*
Seismic SDC: A/B *(exempt)*
Roof eave-to-ridge hgt.: 7.0'
Wall Hgt.: 9'(1st); 8' (2nd)
Roof/Ceiling DL: 25 psf max. (clay tile, typical)
Wall DL: 15psf (stucco)
Floor DL: ≤10 psf (avg)-limited areas with tile (~10%)
Roof Span: 42' (mean roof ht = 22')

BWL Configurations Used:
BWL Layout: 3 BWLs each plan direction (1st story);
2 or 3 BWLs each plan direction (2nd story)
BWL Spacing: varies, see analysis below and floor plan[4]

BWP Location and Minimum Bracing:
max 12.5' cumulative edge distance from ends of BWLs
max 25' oc BWP spacing (R602.10.1.4)
min. 48" bracing amount per BWL (R602.10.1.2)

Wind Bracing Length Adjustment Factors (Table R602.10.1.2(1) footnotes)
(b) Exposure B: 1.0
(c) Ridge-to-eave hgt.: 0.9(1st); 0.8(2nd)
(d) Wall Hgt.: 0.95 (both stories)
(e) BWL Factor: 1.3 (1st story), 1.0 or 1.3 (2nd story per 2 or 3 BWLs)
(f) No int. gyp.: n/a
(g) GB one-sided: n/a (all GB BWLs double sided where used)

Seismic Bracing Length Adjustment Factors (Table R602.10.1.2(3)) – *N/A*

Seismic Irregularities (R301.2.2.5) – *N/A*

Load Path Detailing (R602.10.1.2, R602.10.6 through R602.10.9, R602.11)

- *Uplift load > 100 plf at roof/wall (R602.10.1.2.1 & R802.11); AT BWP LOCATIONS ONLY: Provide roof uplift connectors 250#/ea 16"oc and studs to top plate; 185#/ea straps at 16"oc studs to 1st floor band joist and to studs below at 16"oc; 120#/ea straps at 16"oc 1st story studs to band on foundation and band to sill. Slant nail band to foundation sill per code. – Alternate design per ICC600(2008) uses sheathing as uplift and bracing requiring fully sheathed all walls + special details/connectors at edges of openings + anchors at 16"oc, etc.; ICC600 (2008) also references WFCM(2001) for other provisions (for determining shear wall amount, etc.).*
- *Provide blocking or parallel member above/below BWPs per code (R602.10.6)*
- *Provide BWP support per code at floor cantilevers and masonry piers (R602.10.7)- N/A*
- *Block BWP horizontal joints (except GB) per code unless bracing lengths doubled (R602.10.8)*
- *Brace foundation cripple walls per code (R02.10.9) – N/A*
- *BWL sills anchored to concrete/masonry per code (R602.11)*

STEP 1 *Braced Wall Line ID*	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2* *BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1.2 (1) (feet)	STEP 4 Adjusted Bracing Length per Table R602.10.1.2(1) footnotes (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 12.5? (0' or 8' SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution & Comments*
First Story Braced Wall Lines												
A (left)	*OK*	*Roof +1floor*	*18'*	*41'*	*WSP*	*6.8'*	*6.8'x0.9x0.95x 1.3 = 7.6'*	*34.4'*	*OK*	*OK*	*OK*	*Use (3) 4' OSB panels (25' infill); (garage may be unfinished)*
B (int.)	*OK*	*Roof +1 floor*	*21'*	*41'*	*GB*	*13.6'*	*13.6'x0.9x0.95x 1.3 = 15.1'*	*37.3'*	*OK*	*OK*	*OK*	*7"oc edge fasten int. GWB both sides for 8' along two int. walls adjoining front and rear ext. walls*
C (right)	*OK*	*Roof +1 floor*	*24'*	*41'*	*WSP**	*8.7'*	*8.7'x0.9x0.95x 1.3 = 9.7'*	*32.0'*	*OK*	*OK*	*OK*	*Use (3) 4' OSB (or use engr CS-WSP w/2 hold-downs due to GR if design req'd)**
1 (front)	*OK*	*Roof +1floor*	*20'*	*42'*	*CS-WSP CS-PF*	*7.5'*	*7.5'x0.9x0.95x 1.3 = 8.3'*	*18.5'*	*OK*	*OK*	*OK*	*OSB fully-sheath + CS-PF at garage supporting offset 2nd story BWL*
2 (int.)	*OK*	*Roof +1floor*	*20'*	*42'*	*GB*	*13'*	*13'x0.9x0.95x 1.3 = 14.4'*	*25.3'*	*OK*	*OK*	*OK*	*7"oc edge fasten int. GWB both sides at 9'wall btwn garage & F.R. and 8' wall between stairs*
3 (rear)	*OK*	*Roof +1floor*	*20'*	*42'*	*CS-WSP*	*7.5'*	*7.5'x0.9x0.95x 1.3 = 8.3'*	*17.4'*	*OK*	*OK*	*OK*	*OSB fully-sheath [WSP method, (3) 4' OSB panels OK if one panel next to door increased to 43" vs. 37" wide]*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1.2 (1) (feet)	STEP 4 Adjusted Bracing Length per Table R602.10.1.2(1) footnotes (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 12.5? (0' or 8' SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution & Comments*
Second Story Braced Wall Lines (N/A)												
A (left)	*OK*	*Roof only*	*42'*	*41'*	*WSP*	*7.8'*	*7.8'x0.8x0.95 x1.0 = 5.9'*	*24.5'*	*OK*	*OK*	*OK*	*(3) 4' OSB panels*
B (int.)	*n/a*	*Roof only*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*BWL not used in SDC A/B, 90/B*
C (right)	*OK*	*Roof only*	*42'*	*41'*	*WSP*	*7.8'*	*7.8'x0.8x0.95 x1.0 = 5.9'*	*39.7'*	*OK*	*OK*	*OK*	*(3) 4' OSB panels*
1 (front)	*OK*	*Roof only*	*41'*	*42'*	*WSP*	*7.7'*	*7.7'x0.8x0.95 x1.0 = 5.9'*	*35.8'*	*OK*	*OK*	*OK*	*(3) 4' OSB panels*
2 (int.)	*n/a*	*Roof only*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*BWL not used in SDC A/B, 90/B*
3 (rear)	*OK*	*Roof only*	*41'*	*42'*	*WSP*	*7.7'*	*7.7'x0.8x0.95 x1.0 = 5.9'*	*25.0'*	*OK*	*OK*	*OK*	*(3) 4' OSB panels*
Detached Garage or Other Portions												
n/a												

IRC 2006 Wall Bracing Design and Plan Check Worksheet

Project: NAHB (Plan C, One story, 36'x72', slab-on-grade)

GIVEN:
Wind Speed/Exposure: 100/C *(no topographic effects)*
Seismic SDC: A/B *(exempt)*
Roof eave-to-ridge hgt.: 11.3'
Wall Hgt.: 9'
Roof/Ceiling DL: ≤15psf avg. (shingles)
Wall DL: ≤15psf avg. (incl. stone veneer accents on front)
Floor DL: n/a (slab on grade)
Roof Span: 36' (mean roof ht. = 15')

BWL Configuration Used:
BWL Layout: 2 BWLs & 3 BWLs for two plan axes
BWL Spacing: A,B (36'); 1,2,3 (36') – see plan

BWP Location and Minimum Bracing:
max 12.5' edge distance from ends of BWLs
max 25' oc BWP spacing
Minimum bracing defined by above and Table R602.10.1

Continuous Sheathing Bracing Amount Adjustment Factors:
Opening ht. 85% wall ht.: 0.9
Opening ht. 67% wall ht: 0.8
Opening ht.>85% wall ht: 1.0 (implied)

Mixed Bracing:
R602.10.5 requires all walls (int. and ext.) to be continuously sheathed if continuous sheathing bracing required on any one wall on any story level.

Wind Bracing Amount Adjustment Factors
Exposure: (not in IRC 2006)
Ridge-to-eave hgt.: (not in IRC 2006)
Wall Hgt.: 1.0 (R301.3, use 1.2 for story height 12') – N/A
BWL Spacing Factor: = S/35 for max 50' BWL spacing (R602.10.1.1)
No int. gyp.: (not in IRC 2006)
GB one-sided: (not in IRC 2006)

Seismic Bracing Amount Adjustment Factors (Table R602.10.1) – N/A
Wall DL Factor: n/a (Table R602.10.1, note 'd')
Roof DL Factor: n/a (Table R02.10.1, note 'e')

Seismic Irregularities (R301.2.2.5) – N/A

Load Path Detailing
- *Roof uplift load path per code (R802.11) – use conv. connections only (<20 psf criteria)*
- *Provide blocking or parallel member above/below BWPs per code (R602.10.8)*
- *Provide Interior BWP support per code (R602.10.9) – N/A (SDC D2 only)*
- *Cantilever and masonry pier details for BWP support (not required in IRC 2006)*
- *Block BWP horizontal joints per code unless WSP in SDC A/B/C (R602.10.7)*
- *Brace foundation cripple walls per code (R02.10.2) – N/A (SDC D2 only)*
- *BWL sills anchored to concrete/masonry per code (R602.11.1 – SDC D only)*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1 (feet)	STEP 4 Adjusted Bracing Length (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP distance from ends of BWL ≤ 12.5? (0'or8' SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution (same as 90/B because bracing table in 2006 IRC applies to 100mph or less)*
First Story Braced Wall Lines												
A (left)	*OK*	*Roof only*	*36'*	*72'*	*CS-WSP (R602.10. 5, Meth3-cont.)*	*16%x72'= 11.5'*	*11.5'x36/35x 0.8 = 9.5'*	***40.4'***	*OK*	*OK*	*OK*	*OSB fully sheathed ["All walls" due to BWL 1 & 3]*
B (right)	*OK*	*Roof only*	*36'*	*72'*	*CS-WSP*	*16%x72'= 11.5'*	*11.5'x36/35x 0.8 = 9.5'*	*50.1'*	*OK*	*OK*	*OK*	*OSB fully sheathed [Garage can be unfinished]*
1 (front)	*OK*	*Roof only*	*36'*	*36'*	*CS-WSP CS-PF*	*16%x36' = 5.8'*	*5.8'x36/35x0.9 = 5.4'*	*2'+3.1'+ 1.8'+1.8' = 8.7'*	*OK*	*OK*	*OK*	*OSB fully sheathed [use portal frame @ garage w/o hold-downs per note 'c' Table R602.10.5, shift window set 2"from corner]*
2 (int.)	*OK*	*Roof only*	*36'*	*36'*	*CS-WSP*	*16%x36'= 5.8'*	*5.8'x36/35x1.0 = 6.0'*	*5'+15'= 20'*	*OK*	*OK*	*OK*	*OSB fully sheath one-side of two interior walls at closet and stairway/kitchen (no impact to door jambs); overlay with GWB int. finish*
3-0pt1 (rear)	*OK*	*Roof only*	*36'*	*36'*	*CS-WSP*	*16%x36'= 5.8'*	*5.8'x36/35x0.9 = 5.4'*	*2.3'+3.1' +2.3' = 7.7'*	*OK*	*OK*	*OK*	*OSB fully sheathed [requires all rear windows to be max. 28" instead of 30" wide]*
3-Opt2 (rear)	*OK*	*Roof only*	*36'*	*36'*	*CS-WSP + PFH (16" = 4' WSP)*	*16%x36'= 5.8'*	*5.8'x36/35 = 6.0' (designed as WSP equivalent due to PFH, but fully sheathed)*	*4'+4'+ 2.9'= 10.9' (4'eff. = 16" PFH panels)*	*OK*	*OK*	*OK*	*OSB fully sheath plus PFH portal frame with hold-downs and strapping at Master Suite window set(no change to window sizes, but extra PFH header in attic may interfere with roof framing require detailing)*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1 (feet)	STEP 4 Adjusted Bracing Length (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP distance from ends of BWL ≤ 12.5? (0'or8' SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution (same as 90/B because bracing table in 2006 IRC applies to 100mph or less)*
3-Opt3 (rear)	*OK*	*Roof only*	*36'*	*36'*	*WSP*	*6.7'*	*5.8'x36/35 = 6.0' (equivalent to 1.5-4' WSP panels)*	*0 (engr req'd)*	*NG*	*OK*	*OK*	*Use two narrow shear wall engr. panels: 1.7' & 2.9' wide with 4 hold-downs per manuf. design (equivalent to 1.5 4' WSP BWPs)*
Second Story Braced Wall Lines												
n/a												
Detached Garage or Other Portions												
n/a												

IRC 2009 Wall Bracing Design and Plan Check Worksheet

Project: NAHB (Plan C, One story, 36'x72', slab-on-grade)

GIVEN:
Wind Speed/Exposure: 100/C *(no topographic effects)*
Seismic SDC: A/B *(exempt)*
Roof eave-to-ridge hgt.: 11.3'
Wall Hgt.: 9'
Roof/Ceiling DL: ≤15psf avg. (shingles)
Wall DL: ≤15psf avg. (incl. stone veneer accents on front)
Floor DL: n/a (slab on grade)
Roof Span: 36' (mean roof ht. = 15')

BWL Configuration Used:
BWL Layout: 2 BWLs & 3 BWLs for two plan axes
BWL Spacing: A,B (36'); 1,2,3 (36') – see plan

BWP Location and Minimum Bracing:
max 12.5' cumulative edge distance from ends of BWLs
max 25' oc BWP spacing (R602.10.1.4)
min. 48" bracing amount per BWL (R602.10.1.2)

Mixing Bracing Methods (R602.10.1.1):
Generally permitted except R602.10.4 requires "all ext. walls" in SDC D if CS method is required on any one wall at any story level.

Wind Bracing Length Adjustment Factors (Table R602.10.1.2(1) footnotes)
(b) Exposure: 1.2 (C, 1-story)
(c) Ridge-to-eave hgt.: 1.1
(d) Wall Hgt.: 0.95
(e) BWL Factor: 1.0 (A,B); 1.3 (1,2,3)
(f) No int. gyp.: n/a
(g) GB one-sided: n/a (All GB BWLs double sided were used)

Seismic Bracing Length Adjustment Factors (Table R602.10.1.2(3)) – *N/A*

Seismic Irregularities (R301.2.2.5) – *N/A*

Load Path Detailing (R602.10.1.2, R602.10.6 through R602.10.9, R602.11)

- *Roof uplift load >100 plf per code (R602.10.1.2.1 & R802.11), but less than 20psf criteria; AT BWP LOCATIONS ONLY: Provide roof uplift connectors 360#/ea 16"oc, stud to sill plate straps at 295#/ea 16"oc, and sill anchor bolts at 4'oc with 3"sq washers (per WFCM 2001); – Alternate design per ICC600(2008) uses sheathing as uplift and bracing requiring fully sheathed all walls + special details/connectors at edges of openings + anchors at 16"oc, etc.; ICC600 (2008) also references WFCM(2001) for other provisions (for determining shear wall amount, etc.).*
- *Provide blocking or parallel member above/below BWPs per code (R602.10.6)*
- *Provide BWP support per code at floor cantilevers and masonry piers (R602.10.7)- N/A*
- *Block BWP horizontal joints (except GB) per code unless bracing lengths doubled (R602.10.8)*
- *Brace foundation cripple walls per code (R02.10.9) – N/A*
- *BWL sills anchored to concrete/masonry per code (R602.11)*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1.2 (1) (feet)	STEP 4 Adjusted Bracing Length per Table R602.10.1.2(1) footnotes (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 12.5? (0'or8' SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution*
First Story Braced Wall Lines												
A (left)	*OK*	*Roof only*	*36'*	*72'*	*WSP*	*8.2'*	*8.2'x1.2x1.1x 0.95 = 10.3'*	***40.4'***	*OK*	*OK*	*OK*	*(4) 4' OSB panels (56' infill panels)*
B (right)	*OK*	*Roof only*	*36'*	*72'*	*WSP*	*8.2'*	*8.2'x1.2x1.1x 0.95 = 10.3'*	*50.1'*	*OK*	*OK*	*OK*	*(4) 4' OSB panels (56' infill panels) [garage can be unfinished front and side wall]*
1 (front)	*OK*	*Roof only*	*36'*	*36'*	*WSP*	*8.2'*	*8.2'x1.2x1.1x 0.95x1.3 = 13.4' (equiv. to 3.4 4'BWPs)*	*0 (engr req'd)*	*NG*	*OK*	*OK*	*Use four narrow shear wall engr. panels: 1.8', 3.3', 1.8', and 1.8' wide max. with 8 hold-downs per manuf. design (equiv. to 3.4 4' WSP BWPs) [garage can be unfinished front and side wall]*
2 (int.)	*OK*	*Roof only*	*36'*	*36'*	*GB*	*14.1'*	*14.1'x1.2x1.1x 0.95x1.3 = 23.0'*	*5'+15'+6. 8'= 26.8'*	*OK*	*OK*	*OK*	*GB double side interior walls with 7"oc fastening at edges of GB panels (3 interior wall segments)*
3-0pt1 (rear)	*OK*	*Roof only*	*36'*	*36'*	*CS-WSP*	*6.9'*	*6.9'x1.2x1.1x 0.95x1.3 =11.2'*	*2.3'+3.1' +2.3' = 7.7'*	*NG*	*OK*	*OK*	*NG*
3-Opt2 (rear)	*OK*	*Roof only*	*36'*	*36'*	*CS-PF*	*6.9'*	*6.9'x1.2x1.1x 0.95x1.3 =11.2'*	*1.7'+1.3' 2.9'+2' = 7.9'*	*NG*	*OK*	*OK*	*NG*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1.2 (1) (feet)	STEP 4 Adjusted Bracing Length per Table R602.10.1.2(1) footnotes (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 12.5? (0'or8' SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution*
3-Opt3 (rear)	*OK*	*Roof only*	*36'*	*36'*	*WSP*	*8.2'*	*8.2'x1.2x1.1x 0.95x1.3 = 13.4' (equiv. to 3.4 4'BWPs)*	*0 (engr req'd)*	*NG*	*OK*	*OK*	*Use four narrow shear wall engr. panels: 1.7', 1.33', 2.9', and 2' wide with 8 hold-downs per manuf. design (equivalent to 3.4 4' WSP BWPs)*
Second Story Braced Wall Lines												
n/a												
Detached Garage or Other Portions												
n/a												

IRC 2006 Wall Bracing Design and Plan Check Worksheet

Project: NAHB (Plan F, Two story, 42'x38', basement)

GIVEN:
Wind Speed/Exposure: 100/C *(no topographic effects)*
Seismic SDC: A/B *(exempt)*
Roof eave-to-ridge hgt.: 7.0'
Wall Hgt.: 9'(1st); 8' (2nd)
Roof/Ceiling DL: 25 psf max. (clay tile, typical)
Wall DL: 15psf (stucco)
Floor DL: ≤10 psf (avg)-limited areas with tile (~10%)
Roof Span: 42' (mean roof ht = 22')

BWL Configurations Used:
BWL Layout: 3 BWLs each plan direction (1st story);
2 or 3 BWLs each plan direction (2nd story)
BWL Spacing: varies, see analysis below and floor plan

BWP Location and Minimum Bracing:
max 12.5' edge distance from ends of BWLs
max 25' oc BWP spacing
Minimum bracing defined by above and Table R602.10.1

Continuous Sheathing Bracing Amount Adjustment Factors:
Opening ht. 85% wall ht.: 0.9
Opening ht. 67% wall ht: 0.8
Opening ht.>85% wall ht: 1.0 (implied)

Mixed Bracing:
R602.10.5 requires all walls (int. and ext.) to be continuously sheathed if continuous sheathing bracing required on any one wall on any story level.

Wind Bracing Length Adjustment Factors
Exposure: (not in IRC 2006)
Ridge-to-eave hgt.: (not in IRC 2006)
Wall Hgt.: 1.0 (R301.3, use 1.2 for story height 12' - n/a)
BWL Spacing Factor: S/35 for max 50' BWL spacing (R602.10.1.1)
No int. gyp.: (not in IRC 2006)
GB one-sided: (not in IRC 2006)

Seismic Bracing Length Adjustment Factors (Table R602.10.1.2(3)) - *N/A*

Seismic Irregularities (R301.2.2.5) - *N/A*

Load Path Detailing
- *Roof uplift load path per code (R802.11) - use Conv. Connections only (<20 psf)*
- *Provide blocking or parallel member above/below BWPs per code (R602.10.8)*
- *Provide Interior BWP support per code (R602.10.9) - N/A (SDC D2 only)*
- *Cantilever and masonry pier details for BWP support (not required in IRC 2006)*
- *Block BWP horizontal joints per code unless WSP in SDC A/B/C (R602.10.7)*
- *Brace foundation cripple walls per code (R02.10.2) - N/A (SDC D2 only)*
- *BWL sills anchored to concrete/masonry per code (R602.11.1 - SDC D only)*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1 (feet)	STEP 4 Adjusted Bracing Length (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP distance from ends of BWL ≤ 12.5? (0' or 8' SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution & Comments (same as 90/B because bracing table in 2006 IRC applies to 100mph or less)*
First Story Braced Wall Lines												
A (left)	*OK*	*Roof +1floor*	*18'*	*41'*	*CS-WSP (R602.10.5, Meth3-cont.)*	*16%x41'= 6.6'*	*6.6'x0.8 = 5.3'*	*34.4'*	*OK*	*OK*	*OK*	*Fully sheath OSB; req'd all walls due to BWL 1 & 3 (garage can be unfinished)*
B (int.)	*OK*	*Roof +1 floor*	*21'*	*41'*	*CS-WSP*	*16%x41' = 6.6'*	*6.6'x0.9 = 5.6'*	*37.3'*	*OK*	*OK*	*OK*	*Fully sheath OSB int. walls (one side) through middle of building; BWL not req'd by code but included due to GR (to avoid design req'd by bldg. dept.)*
C (right)	*OK*	*Roof +1 floor*	*24'*	*41'*	*CS-WSP**	*16%x41' = 6.6'*	*6.6'x0.8 = 5.3'*	*32.0'*	*OK*	*OK*	*OK*	*Fully sheath OSB (or use engr CS-WSP w/2 hold-downs due to GR if design req'd)**
1 (front)	*OK*	*Roof +1floor*	*20'*	*42'*	*CS-WSP PFH (2' = 4'eff.)*	*16%x42' = 6.7'*	*6.7' (length equiv. to WSP for PFH equivalency)*	*18.5' (eff. Length)*	*OK*	*OK*	*OK*	*OSB fully-sheath + 1 PFH panel at garage corner + hdr + straps + 2 hold-downs*
2 (int.)	*OK*	*Roof +1floor*	*20'*	*42'*	*CS-WSP*	*16%x42' = 6.7'*	*6.7'x1.0 = 6.7' (100% opening ht.)*	*25.3'*	*OK*	*OK*	*OK*	*OSB fully sheathing int. walls one side at 9'int.wall btwn garage & F.R. and 8' int. wall between stairs*
3 (rear)	*OK*	*Roof +1floor*	*20'*	*42'*	*CS-WSP*	*16%x42' = 6.7'*	*6.7'x0.9 = 6.0'*	*17.4'*	*OK*	*OK*	*OK*	*OSB fully-sheath*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1 (feet)	STEP 4 Adjusted Bracing Length (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP distance from ends of BWL ≤ 12.5? (0' or 8' SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution & Comments (same as 90/B because bracing table in 2006 IRC applies to 100mph or less)*
Second Story Braced Wall Lines (N/A)												
A (left)	*OK*	*Roof only*	*42'*	*41'*	*CS-WSP*	*16%x41' = 6.6'*	*6.6'x0.8 x42/35 = 6.3'*	*24.5'*	*OK*	*OK*	*OK*	*Fully sheath OSB (WSP would work but BWL 1 & 3 req CS-WSP and thus "all walls" per R602.10.5)*
B (int.)	*n/a*	*Roof only*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*BWL not used in SDC A/B, 100/C*
C (right)	*OK*	*Roof only*	*42'*	*41'*	*CS-WSP*	*16%x41' = 6.6'*	*6.6'x0.8 x42/35 = 6.3'*	*39.7'*	*OK*	*OK*	*OK*	*Fully sheath OSB*
1 (front)	*OK*	*Roof only*	*41'*	*42'*	*CS-WSP*	*16%x42' = 6.7'*	*6.7'x0.8 x41/35 = 6.3'*	*35.8'*	*OK*	*OK*	*OK*	*Fully sheath OSB*
2 (int.)	*n/a*	*Roof only*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*BWL not used in SDC A/B, 100/C*
3 (rear)	*OK*	*Roof only*	*41'*	*42'*	*CS-WSP*	*16%x42' = 6.7'*	*6.7'x0.8 x41/35 = 6.3'*	*25.0'*	*OK*	*OK*	*OK*	*Fully sheath OSB*
Detached Garage or Other Portions												
n/a												

IRC 2009 Wall Bracing Design and Plan Check Worksheet

Project: NAHB (Plan F, Two story, 42'x38', basement)

GIVEN:
Wind Speed/Exposure: 100/C *(no topographic effects)*
Seismic SDC: A/B *(exempt)*
Roof eave-to-ridge hgt.: 7.0'
Wall Hgt.: 9'(1st); 8' (2nd)
Roof/Ceiling DL: 25 psf max. (clay tile, typical)
Wall DL: 15psf (stucco)
Floor DL: ≤10 psf (avg)-limited areas with tile (~10%)
Roof Span: 42' (mean roof ht = 22')

BWL Configurations Used:
BWL Layout: 3 BWLs each plan direction (1st story);
2 or 3 BWLs each plan direction (2nd story)
BWL Spacing: varies, see analysis below and floor plan

BWP Location and Minimum Bracing:
max 12.5' cumulative edge distance from ends of BWLs
max 25' oc BWP spacing (R602.10.1.4)
min. 48" bracing amount per BWL (R602.10.1.2)

Wind Bracing Length Adjustment Factors (Table R602.10.1.2(1) footnotes)
(b) Exposure: 1.3 (C, 2-story)
(c) Ridge-to-eave hgt.: 0.9(1st); 0.8(2nd)
(d) Wall Hgt.: 0.95 (both stories)
(e) BWL Factor: 1.3 (1st story), 1.0 or 1.3 (2nd story per 2 or 3 BWLs)
(f) No int. gyp.: n/a
(g) GB one-sided: n/a (all GB BWLs double sided where used)

Seismic Bracing Length Adjustment Factors (Table R602.10.1.2(3)) - *N/A*

Seismic Irregularities (R301.2.2.5) - *N/A*

Load Path Detailing (R602.10.1.2, R602.10.6 through R602.10.9, R602.11)

- *Uplift load > 100 plf at roof/wall (R602.10.1.2.1 & R802.11), but barely less than 20psf criteria; AT BWP LOCATIONS ONLY: Provide roof uplift connectors 440#/ea 16"oc and studs to top plate; 375#/ea straps from studs to 2nd floor band joist and band joist to studs below at 16"oc; 310#/ea straps from studs to 1st floor band and band to sill plate at 16"oc; sill anchor bolts at 48"oc with 3x3 plate washers. Alternate design per ICC600(2008) uses sheathing as uplift and bracing requiring fully sheathed all walls + special details/connectors at edges of openings + anchors at 16"oc, etc.; ICC600 (2008) also references WFCM(2001) for other provisions (for determining shear wall amount, etc.).*
- *Provide blocking or parallel member above/below BWPs per code (R602.10.6)*
- *Provide BWP support per code at floor cantilevers and masonry piers (R602.10.7)- N/A*
- *Block BWP horizontal joints (except GB) per code unless bracing lengths doubled (R602.10.8)*
- *Brace foundation cripple walls per code (R02.10.9) - N/A*
- *BWL sills anchored to concrete/masonry per code (R602.11)*

STEP 1 *Braced Wall Line ID*	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2* *BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1.2 (1) (feet)	STEP 4 Adjusted Bracing Length per Table R602.10.1.2(1) footnotes (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 12.5? (0' or 8' SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution & Comments*
First Story Braced Wall Lines												
A (left)	*OK*	*Roof +1floor*	*18'*	*41'*	*WSP*	*8.2'*	*8.2'x1.3x0.9x 0.95x 1.3 = 11.8'*	*34.4'*	*OK*	*OK*	*OK*	*Use (3) 4' OSB panels (25' infill); garage assumed to have ½" GWB*
B (int.)	*OK*	*Roof +1 floor*	*21'*	*41'*	*GB*	*16.7'*	*16.7'x1.3x0.9x 0.95x1.3 = 24.1'*	*37.3'*	*OK*	*OK*	*OK*	*7"oc edge fasten int. GWB both sides for 18.4' garage wall along G.R. and 9.4' Bdrm Wall at F.R. (front and rear of plan)*
C (right)	*OK*	*Roof +1 floor*	*24'*	*41'*	*WSP**	*10.6'*	*10.6'x1.3x0.9x 0.95x 1.3 = 15.3'*	*32.0'*	*OK*	*OK*	*OK*	*Use (4) 4' OSB (or use engr CS-WSP w/2 hold-downs due to GR if design req'd)**
1 (front)	*OK*	*Roof +1floor*	*20'*	*42'*	*CS-WSP CS-PF*	*8.0'*	*8.0'x1.3x0.9x 0.95x 1.3 = 11.6'*	*18.5'*	*OK*	*OK*	*OK*	*OSB fully-sheath + CS-PF at garage supporting offset 2nd story BWL*
2 (int.)	*OK*	*Roof +1floor*	*20'*	*42'*	*GB*	*16.0'*	*16.0'x1.3x0.9x 0.95x 1.3 = 23.1'*	*25.3'*	*OK*	*OK*	*OK*	*7"oc edge fasten int. GWB both sides at 8'wall btwn garage and bath, 9'wall btwn garage & F.R. and 8' wall between stairs*
3 (rear)	*OK*	*Roof +1floor*	*20'*	*42'*	*CS-WSP*	*8.0'*	*8.0'x1.3x0.9x 0.95x 1.3 = 11.6'*	*17.4'*	*OK*	*OK*	*OK*	*OSB fully-sheath [WSP method, (3) 4' OSB panels OK if one panel next to door increased to 43" vs. 37" wide]*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1.2 (1) (feet)	STEP 4 Adjusted Bracing Length per Table R602.10.1.2(1) footnotes (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 12.5? (0' or 8' SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution & Comments*
Second Story Braced Wall Lines (N/A)												
A (left)	*OK*	*Roof only*	*42'*	*41'*	*WSP*	*9.4'*	*9.4'x1.3x0.8 x0.95x1.0 = 9.3'*	*24.5'*	*OK*	*OK*	*OK*	*(3) 4' OSB panels*
B (int.)	*n/a*	*Roof only*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*BWL not used in SDC A/B, 100/C*
C (right)	*OK*	*Roof only*	*42'*	*41'*	*WSP*	*9.4'*	*9.4'x1.3x0.8 x0.95x1.0 = 9.3'*	*39.7'*	*OK*	*OK*	*OK*	*(3) 4' OSB panels*
1 (front)	*OK*	*Roof only*	*41'*	*42'*	*WSP*	*9.2'*	*9.2'x1.3x0.8 x0.95x1.0 = 9.1'*	*35.8'*	*OK*	*OK*	*OK*	*(3) 4' OSB panels*
2 (int.)	*n/a*	*Roof only*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*BWL not used in SDC A/B, 100/C*
3 (rear)	*OK*	*Roof only*	*41'*	*42'*	*WSP*	*9.2'*	*9.2'x1.3x0.8 x0.95x1.0 = 9.1'*	*25.0'*	*OK*	*OK*	*OK*	*(3) 4' OSB panels*
Detached Garage or Other Portions												
n/a												

IRC 2006 Wall Bracing Design and Plan Check Worksheet

Project: NAHB (Plan C, One story, 36'x72', slab-on-grade)

GIVEN:
Wind Speed/Exposure: 85/B *(no topographic effects)*
Seismic SDC: D2
Roof eave-to-ridge hgt.: 11.3'
Wall Hgt.: 9'
Roof/Ceiling DL: ≤15psf avg. (shingles)
Wall DL: ≤15psf avg. (incl. stone veneer accents on front)
Floor DL: n/a (slab on grade)
Roof Span: 36' (mean roof ht. = 15')

BWL Configuration Used:
*BWL Layout: 3 BWLs & 5 BWLs for two plan axes**
BWL Spacing: varies - see plan
**BWL Spacing = max 25' with exception for 35' for one room not more than 900sqft (SDC D, R602.10.11)*

BWP Location and Minimum Bracing (SDC D):
max 0' edge distance (8' allowed if 2' corner panels or 1800# hold-down at edge closest to corner)
max 25' oc BWP spacing
minimum bracing defined by above and Table R602.10.1

Continuous Sheathing Bracing Amount Adjustment Factors:
Opening ht. 85% wall ht.: 0.9
Opening ht. 67% wall ht: 0.8
Opening ht.>85% wall ht: 1.0 (implied)

Mixed Bracing:
R602.10.5 requires all walls (int. and ext.) to be continuously sheathed if continuous sheathing bracing required on any one wall on any story level.

Wind Bracing Amount Adjustment Factors
Exposure: (not in IRC 2006)
Ridge-to-eave hgt.: (not in IRC 2006)
Wall Hgt.: 1.0 (R301.3, use 1.2 for story height 12') - N/A
BWL Spacing Factor: = n/a, max 25' (SDC D2)(R602.10.11.1)
No int. gyp.: (not in IRC 2006)
GB one-sided: (not in IRC 2006)

Seismic Bracing Amount Adjustment Factors (Table R602.10.1, notes d and e)
Wall DL Factor: 0.8 (≤8 psf all but front wall with stone/brick accents)
Roof DL Factor: 1.0 (≤ 15 psf)

Seismic Irregularities (R301.2.2.5)
Contains no irregularities

Load Path Detailing
- *Roof uplift load path per code (R802.11) - use conv. connections only (<20 psf criteria)*
- *Provide blocking or parallel member above/below BWPs per code (R602.10.8)*
- *Provide Interior BWP support per code (R602.10.9)(SDC D2 only)*
- *Cantilever and masonry pier details for BWP support (not required in IRC 2006)*
- *Block BWP horizontal joints per code (R602.10.7)*
- *Brace foundation cripple walls per code in SDC D2 (R02.10.2) - N/A*
- *BWL sills anchored to concrete/masonry using 3x3 plate washers (R602.11.1 - SDC D)*

NOTE: Seismic bracing controls design (bracing table does not require 2nd check for wind).

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1 (feet)	STEP 4 Adjusted Bracing Length (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP distance from ends of BWL = 0' (SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution*
First Story Braced Wall Lines												
A (left)	*OK*	*Roof only*	*16'*	*72'*	*WSP (Meth3)*	*25%x72'= 18.0'*	*18.0'x0.8 = 14.4'*	***40.4'***	*OK*	*OK*	*OK*	*(4) 4' OSB panels (56' infill panels) with 3"x3" plate washers on anchor bolts at 6'oc to sill plate*
B (int.)	*OK*	*Roof only*	*20' max*	*72'*	*GB (Meth5)*	*40%x72' = 28.8'*	*28.8'x0.8=23.0'*	***60.4'***	*OK*	*OK*	*OK*	*GB double side interior walls with 7"oc fastening at edges of GB panels (13.9', 17', 9.5', and 20' interior walls) on 12"x16" reinforced thick slab footings with anchor bolts and 3"x3" washers at 6'oc*
C (right)	*OK*	*Roof only*	*20'*	*72'*	*WSP (Meth3)*	*25%x72'= 18.0'*	*18.0'x0.8 = 14.4'*	*50.1'*	*OK*	*OK*	*OK*	*(4) 4' OSB panels (56' infill panels) with 3"x3" plate washers on anchor bolts at 6'oc to sill plate + 1800# hold down at end of wall next to windows at rear and 16-16d nails at top plate splice in this region*
1 (front)	*OK*	*Roof only*	*21.5'*	*36'*	*PFH (Fig R602.10. 6.2)*	*25%x36' = 9.0'*	*9.0'*	*3 16" PFH panels = 12' eff. brace length*	*OK*	*OK*	*OK*	*Use three 16" PFH panels (2 at garage and one at left corner) with two 4200# hold-downs each panel and strapping and sheathing per FigR602.10.6.2 [remainder of wall OSB sheath]*
2 (int.)	*OK*	*Roof only*	*21.5' max*	*36'*	*GB (Meth5)*	*40%x36'= 14.4'*	*14.4'x0.8=11.5'*	*23'*	*OK*	*OK*	*OK*	*GB double side interior walls with 7"oc fastening at edges of GB panels (8' and 15' interior walls) on 12"x16" reinforced thick slab footings with anchor bolts and 3"x3" washers at 6'oc*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1 (feet)	STEP 4 Adjusted Bracing Length (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP distance from ends of BWL = 0' (SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution*
3 (int.)	*OK*	*Roof only*	*17.4' max*	*36'*	*GB (Meth5)*	*40%x36'= 14.4'*	*14.4'x0.8=11.5'*	*26.8'*	*OK*	*OK*	*OK*	*GB double side interior walls with 7"oc fastening at edges of GB panels (5', 15', and 6.8' interior walls) on 12"x16" reinforced thick slab footings with anchor bolts and 3"x3" washers at 6'oc*
4 (int.)	*OK*	*Roof only*	*17.4' max*	*36'*	*GB (Meth5)*	*40%x36'= 14.4'*	*14.4'x0.8=11.5'*	*20'*	*OK*	*OK*	*OK*	*GB double side interior walls with 7"oc fastening at edges of GB panels (6', 5.4 and 8.6' interior walls) on 12"x16" reinforced thick slab footings with anchor bolts and 3"x3" washers at 6'oc*
5 (rear)	*OK*	*Roof only*	*17.4'*	*36'*	*PFH (Fig R602.10. 6.2)*	*25%x36' = 9.0'*	*9.0'x0.8=7.2'*	*3 16" PFH panels = 12' eff. brace length*	*OK*	*OK*	*OK*	*Use three 16" PFH panels (one at each corner and one at door) with two 4200# hold-downs each panel and strapping and sheathing per FigR602.10.6.2 [remainder of wall OSB sheath]*
Second Story Braced Wall Lines												
n/a												
Detached Garage or Other Portions												
n/a												

IRC 2009 Wall Bracing Design and Plan Check Worksheet

Project: NAHB (Plan C, One story, 36'x72', slab-on-grade)

GIVEN:
Wind Speed/Exposure: 85/B *(no topographic effects)*
Seismic SDC: D2
Roof eave-to-ridge hgt.: 11.3'
Wall Hgt.: 9'
Roof/Ceiling DL: ≤15psf avg. (shingles)
Wall DL: ≤15psf avg. (incl. stone veneer accents on front)[1]
Floor DL: n/a (slab on grade)[2]
Roof Span: 36' (mean roof ht. = 15')

BWL Configuration Used (Wind):
BWL Layout: 2 BWLs & 3 BWLs for two plan axes
BWL Spacing: A,B (36'); 1,2,3 (36') – see plan[3]

BWL Configuration Used (Seismic, D):
*BWL Layout: 3 BWLs & 5 BWLs for two plan axes**
BWL Spacing: varies – see plan
**BWL Spacing = max 25' with exception for 35' for one room not more than 900sqft (R602.10.1.5)*

BWP Location and Minimum Bracing (Wind):
max 12.5' cumulative edge distance from ends of BWLs
max 25'oc BWP spacing (R602.10.1.4)
min. 48" bracing amount per BWL (R602.10.1.2)

BWP Location and Minimum Bracing (Seismic, D2):
max 0' edge distance (8' allowed if 2' corner panels or 1800# hold-down at edge closest to corner)
max 25'oc BWP spacing
minimum bracing 48" total per BWL (R602.10.1.2)

Mixing Bracing Methods (R602.10.1.1):
Generally permitted except R602.10.4 require "all ext. walls" in SDC D if CS method is required on any one wall at any story level.

Wind Bracing Length Adjustment Factors (Table R602.10.1.2(1) footnotes)
(b) Exposure B: 1.0
(c) Ridge-to-eave hgt.: 1.1
(d) Wall Hgt.: 0.95
(e) BWL Factor: 1.3 (A,B,C); 1.6 (1,2,3,4,5)
(f) No int. gyp.: n/a
(g) GB one-sided: n/a (All GB BWLs double sided were used)

Seismic Bracing Length Adjustment Factors (Table R602.10.1.2(3))
Story height: 1.0
BWL spacing: n/a (SDC A-C only)
Wall Dead Load: 0.85 (all but front wall with brick/stone accents)
Roof/ceiling DL: 1.0
Walls w/stone or masonry: see Section R602.10.12 (n/a)
Cripple walls: see Section R602.10.9 (n/a)

Seismic Irregularities (R301.2.2.5)
Contains no irregularities

Load Path Detailing (R602.10.1.2, R602.10.6 through R602.10.9, R602.11)
- *Roof uplift load >100 plf per code (R602.10.1.2.1 & R802.11); AT BWP LOCATIONS ONLY: Provide roof uplift connectors 185#/ea 16"oc, stud to sill plate straps at 120#/ea 16"oc, and sill anchor bolts at 6'oc with 3"sq washers (per WFCM 2001).*
- *Provide blocking or parallel member above/below BWPs per code (R602.10.6)*
- *Provide BWP support per code at floor cantilevers and masonry piers (R602.10.7)*
- *BWP support on continuous foundations (R602.10.7.1 – SDC D2)*
- *Block BWP horizontal joints (except GB) per code unless bracing lengths doubled (R602.10.8)*
- *Brace foundation cripple walls per code (R02.10.9.1, SDC D2) – N/A*
- *BWL sills anchored to concrete/masonry per code (R602.11)*

NOTE: Even while SDC D2 controls BWL spacing and BWP end distance and sometime allowed bracing method and anchorage, 85/B wind conditions still controls bracing amounts in some cases (mainly because of a large #BWL factor when there are 3 or more BWLs because of SDC D2 BWL spacing limits). Sometimes, however, the BWP spacing controls bracing amount anyway.

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Tables R602.10.1.2 (feet)	STEP 4 Adjusted Bracing Length per Tables R602.10.1.2 (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 0' (SDC D) w/ except	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution*
First Story Braced Wall Lines												
A-wind (left)	*OK*	*Roof only*	*16'*	*72'*	*WSP*	*2.9'*	*2.9'x1.1x0.95 x1.3 = 3.9' (min. 4.0')*	***40.4'***	*OK*	*OK*	*OK*	*(4) 4' OSB panels (56' infill panels)*
A-seis (left)	*OK*	*Roof only*	*16'*	*72'*	*WSP*	*Engr., 25%x72'=18'*	*18'x0.85'= 15.3'*	***40.4'***	*OK*	*OK*	*OK*	*Engr. Fee + Fully sheath OSB ("all ext. walls" due to BWLs 1 & 5) anchor bolts at 6'oc with 3"x3" plate washers*
B-wind (int.)	*OK*	*Roof only*	*18'avg*	*72'*	*GB*	*5.5'*	*5.5'x1.1x 0.95x1.3 = 7.5'*	*60.4'*	*OK*	*OK*	*OK*	*GB double side interior walls with 7"oc fastening at edges of GB panels (4 4' interior wall segments)*
B-seis (int.)		*Roof only*	*20'max*	*72'*	*GB*	*Engr., 40%x72'=28. 8'*	*28.8'x1.0 = 28.8'*	*60.4'*	*OK*	*OK*	*OK*	*Engr. Fee + GB double side interior walls with 7"oc fastening at edges of GB panels (4 4' interior wall segments) anchor bolts 6'oc with 3"x3" plate washers + 8" thick slab at BWP locations for anchor bolts*
C-wind (right)	*OK*	*Roof only*	*20'*	*72'*	*WSP*	*3.5'*	*3.5'x1.1x 0.95x1.3 =4.8'*	*50.1'*	*OK*	*OK*	*OK*	*(4) 4' OSB panels (56' infill panels)*
C-seis (right)	*OK*	*Roof only*	*20'*	*72'*	*WSP*	*Engr., 25%x72'=18'*	*18'x0.85=15.3'*	*50.1*	*OK*	*OK*	*OK*	*Engr. + Fully sheath OSB ("all ext. walls" due to BWLs 1 & 5) anchor bolts at 6'oc with 3"x3" plate washers*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Tables R602.10.1.2 (feet)	STEP 4 Adjusted Bracing Length per Tables R602.10.1.2 (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 0' (SDC D) w/ except	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution*
1 - wind (front)	*OK*	*Roof only*	*21.5'*	*36'*	*CS-WSP CS-G*	*3.2'*	*3.2'x1.1x 0.95x1.6 =5.4'*	*3.3' (CS-WSP) 2'+2' = 4' (CS-G) w/4" credit for 3 narrow segments*	*OK*	*OK*	*OK*	*OSB fully sheathed [increased 3 panels by 3" ea. to reach 2' min. - may affect window sizes, foyer width, or plan width] (Garage must be finished)*
1-seis (front)	*OK*	*Roof only*	*21.5'*	*36'*	*CS-WSP CS-G*	*7.6'*	*7.6'x1.0= 7.6'*	*3.3' (CS-WSP) & 2.3'+2.3' = 4.6' (CS-G)*	*OK*	*OK*	*OK*	*OSB fully sheathed [increased 2 panels by 5" ea. to reach 27" min. and corner panel by 3" to reach 24"min - may affect window sizes, foyer width, or plan width] (Garage must be finished) use 3"x3" plate washers on anchor bolts at 6'oc*
2-wind (int.)	*OK*	*Roof only*	*18.3'avg*	*36'*	*GB*	*5.6'*	*5.6'x1.1x 0.95x1.6 =9.4'*	*23'*	*OK*	*OK*	*OK*	*GB double side interior wall segments with 7"oc fastening at edges (two 8' segments, garage and dining room)*
2-seis (int.)	*OK*	*Roof only*	*21.5' max*	*36'*	*GB*	*14,4'*	*14.4'x0.85 = 12.2'*	*23'*	*OK*	*OK*	*OK*	*GB double side interior wall segments with 7"oc fastening at edges (8' and 15' walls, garage and dining room) on 12"x16" reinforced thick slab footing and 3"x3" plate*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Tables R602.10.1.2 (feet)	STEP 4 Adjusted Bracing Length per Tables R602.10.1.2 (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 0' (SDC D) w/ except	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution*
												washers on anchor bolts at 6'oc
3-wind (int.)	*OK*	*Roof only*	*16.2'avg*	*36'*	*GB*	*5.1'*	*5.1'x1.1x0.95 x1.6 = 8.5'*	*5'+15'= 20'*	*OK*	*OK*	*OK*	*GB double side interior walls with 7"oc fastening at edges of GB panels (5' and 15' interior walls)*
3-seis (int.)	*OK*	*Roof only*	*17.4' max*	*36'*	*GB*	*14.4'*	*14.4'x0.85 = 12.2'*	*5'+15'+ 6.8' = 26.8'*	*OK*	*OK*	*OK*	*GB double side interior wall segments with 7"oc fastening at edges (6.8',15', and 5.0' walls) at D.R., stairway, and dbl closet on 12"x16" reinforced thick slab footing and 3"x3" plate washers on anchor bolts at 6'oc*
4-wind (int.)	*OK*	*Roof only*	*17.4'avg*	*36'*	*GB*	*5.4'*	*5.4'x1.1x0.95 x1.6 = 9.0'*	*20'*	*OK*	*OK*	*OK*	*GB double side interior walls with 7"oc fastening at edges of GB panels (6', 5.4', and 8.6' interior walls)*
4-seis (int.)	*OK*	*Roof only*	*17.4' max*	*36'*	*GB*	*14.4'*	*14.4'x0.85 = 12.20'*	*20'*	*OK*	*OK*	*OK*	*GB double side interior walls with 7"oc fastening at edges of GB panels (6', 5.4 and 8.6' interior walls) on 12"x16" reinforced thick slab footings with anchor bolts and 3"x3" washers at 6'oc*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Tables R602.10.1.2 (feet)	STEP 4 Adjusted Bracing Length per Tables R602.10.1.2 (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 0' (SDC D) w/ except	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution*
5-wind (rear)	*OK*	*Roof only*	*17.4'*	*36'*	*CS-WSP + CS-PF*	*2.6'*	*2.6'x1.1x 0.95x1.6 = 4.3'*	*1.7'+2.9' = 4.6'*	*OK*	*OK*	*OK*	*OSB fully sheathed + 1 CS-PF panel at left rear corner*
5-seis (rear)	*OK*	*Roof only*	*17.4'*	*36'*	*CS-WSP + CS-PF*	*7.6'*	*7.6'x0.85 = 6.5'*	*2.0+1.7'+ 2.9' = 4.6'*	*OK*	*OK*	*OK*	*OSB fully sheathed + 2 CS-PF panels, one at each rear corner; use 3"x3" plate washers on anchor bolts at 6'oc*
Second Story Braced Wall Lines												
n/a												
Detached Garage or Other Portions												
n/a												

IRC 2006 Wall Bracing Design and Plan Check Worksheet

Project: NAHB (Plan F, Two story, 42'x38', basement)

GIVEN:
Wind Speed/Exposure: 85/B *(no topographic effects)*
Seismic SDC: D2 *(exempt)*
Roof eave-to-ridge hgt.: 7.0'
Wall Hgt.: 9'(1st); 8' (2nd)
Roof/Ceiling DL: 25 psf max. (clay tile, typical)
Wall DL: 15psf (stucco)
Floor DL: ≤10 psf (avg)-limited areas with tile (~10%)
Roof Span: 42' (mean roof ht = 22')

BWL Configurations Used:
BWL Layout: 3 BWLs each plan direction (1st story);*
2 or 3 BWLs each plan direction (2nd story)
BWL Spacing: varies, see analysis below and floor plan[4]
**BWL Spacing = max 25' with exception for 35' for one room not more than 900sqft (SDC D, R602.10.11)*

BWP Location and Minimum Bracing:
max 0' edge distance (8' allowed if 2' corner panels or 1800# hold-down at edge closest to corner)
max 25' oc BWP spacing
minimum bracing defined by above and Table R602.10.1

Continuous Sheathing Bracing Amount Adjustment Factors:
Opening ht. 85% wall ht.: 0.9
Opening ht. 67% wall ht: 0.8
Opening ht.>85% wall ht: 1.0 (implied)

Mixed Bracing:
R602.10.5 requires all walls (int. and ext.) to be continuously sheathed if continuous sheathing bracing required on any one wall on any story level.

Wind Bracing Length Adjustment Factors
Exposure: (not in IRC 2006)
Ridge-to-eave hgt.: (not in IRC 2006)
Wall Hgt.: 1.0 (R301.3, use 1.2 for story height 12' - n/a)
BWL Spacing Factor: S/35 for max 50' BWL spacing (R602.10.1.1)
No int. gyp.: (not in IRC 2006)
GB one-sided: (not in IRC 2006)

Seismic Bracing Length Adjustment Factors (Table R602.10.1.2(3))
Wall DL Factor: 1.0 (15 psf, stucco over WSP assumed)
Roof DL Factor: 1.1 (1st story); 1.2 (2nd story) (25 psf, clay tile or similar assumed)

Seismic Irregularities (R301.2.2.5)
OK- 2nd floor diaphragm is bounded by braced walls at great room.
OK- 2nd-story brace wall set back above garage opening - design load path required
OK- 2nd-story BWPs above garage opening end on beam in ceiling/floor above garage (technically not an opening with header below) - design load path required

Load Path Detailing
- *Roof uplift load path per code (R802.11) - use conv. connections only (<20 psf criteria)*
- *Provide blocking or parallel member above/below BWPs per code (R602.10.8)*
- *Provide Interior BWP support per code (R602.10.9)(SDC D2) - in basement below*
- *Cantilever and masonry pier details for BWP support (not required in IRC 2006)*
- *Block BWP horizontal joints per code (R602.10.7)*
- *Brace foundation cripple walls per code in SDC D2 (R02.10.2) - N/A*
- *BWL sills anchored to concrete/masonry using 3x3 plate washers (R602.11.1 - SDC D)*

NOTE: Seismic bracing controls design (bracing table does not require 2nd check for wind).

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1 (feet)	STEP 4 Adjusted Bracing Length (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP distance from ends of BWL = 0' (SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution & Comments*
First Story Braced Wall Lines												
A (left)	*OK*	*Roof +1floor*	*18'*	*41'*	*CS-WSP (R602.10.5, Meth3-cont.)*	*55%x41'= 22.6'*	*22.6'x0.8x1.1 = 19.9'*	*34.4'*	*OK*	*OK*	*OK*	*Fully sheath OSB; req'd all walls due to BWL 3 (garage can be unfinished)*
B (int.)	*OK*	*Roof +1 floor*	*21'*	*41'*	*CS-WSP*	*55%x41' = 22.6'*	*22.6'x0.9x1.1 = 22.4'*	*37.3'*	*OK*	*OK*	*OK*	*Fully sheath OSB int. walls (one side) through middle of building; blocking between joists below and anchors at 6'oc with 3"x3" plate washers to foundation at garage.*
C (right)	*OK*	*Roof +1 floor*	*24'*	*41'*	*CS-WSP*	*55%x41' = 22.6'*	*22.6'x0.8x1.1 = 19.9'*	*32.0'*	*OK*	*OK*	*OK*	*Fully sheath OSB (may require engr. due to tall walls at G.R., but prescriptive design works due to minimum openings and sizes; local official may disagree)*
1 (front)	*OK*	*Roof +1floor*	*20'*	*42'*	*WSP + PFH (2' = 4'eff.)*	*55%x42' = 23.1'*	*23.1x1.1'=25.4' (equiv. to 5.8 4' WSP BWPs)*	*19.4'*	*NG (engr req'd)*	*OK*	*OK*	*Use 3 or more engr narrow brace wall panels (no more than 2' wide each) for total equivalence to 5.8 WSP BWPs*
2 (int.)	*OK*	*Roof +1floor*	*20'*	*42'*	*CS-WSP*	*55%x42' = 23.1'*	*23.1'x1.0x1.1 = 25.4' (100% opening ht.)*	*29.5'*	*OK*	*OK*	*OK*	*OSB fully sheathing int. walls at back of garage and between stairwell and kitchen*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1 (feet)	STEP 4 Adjusted Bracing Length (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP distance from ends of BWL = 0' (SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution & Comments*
3 (rear)	*OK*	*Roof +1floor*	*20'*	*42'*	*WSP* (equiv)*	*55%x42' = 23.1'*	*23.1'x1.1 = 25.4' (equiv. to 5.8 4' WSP BWPs)*	*17.4'*	*NG (engr req'd)*	*NG (engr req'd)*	*OK*	*Use 3 or more engr narrow brace wall panels (no more than 2.6' wide each) for total equivalence to 5.8 WSP BWPs also 1000# strap from top plate or band to joist over breakfast nook for collector.*
Second Story Braced Wall Lines (N/A)												
A (left)	*OK*	*Roof only*	*22'*	*41'*	*CS-WSP*	*25%x41' = 10.3'*	*10.3'x0.8x1.2 = 9.9'*	*24.5'*	*OK*	*OK*	*OK*	*Fully sheath OSB (required due to CS-WSP needed for BWL 3 in 1st story per "all walls", R602.10.5)*
B (int.)	*OK*	*Roof only*	*22' max*	*41'*	*CS-WSP*	*25%x41'= 10.3'*	*10.3'x1.0x1.2 = 12.4'*	*20.7'*	*OK*	*OK*	*OK*	*Fully sheath OSB (15.3', 5.4', and 3.2' interior walls)*
C (right)	*OK*	*Roof only*	*20'*	*41'*	*CS-WSP*	*25%x41' = 10.3'*	*10.3'x0.8x1.2 = 9.9'*	*39.7'*	*OK*	*OK*	*OK*	*Fully sheath OSB*
1 (front)	*OK*	*Roof only*	*41'*	*42'*	*CS-WSP*	*25%x42' = 10.5'*	*10.5'x0.8 x1.2 = 10.1'*	*35.8'*	*OK*	*OK*	*OK*	*Fully sheath OSB (design required for BWP support over garage: use doubled floor joist beneath with 1000# straps to stud in first story garage walls and hold-down to foundation; OSB ceiling diaphragm 5' wide to wall at garage opening)*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Table R602.10.1 (feet)	STEP 4 Adjusted Bracing Length (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP distance from ends of BWL = 0' (SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution & Comments*
2 (int.)	*OK*	*Roof only*	*25' max*	*42'*	*CS-WSP*	*25%x42' = 10.5'*	*10.5'x0.8 x1.2 = 10.1'*	*34.9'*	*OK*	*OK*	*OK*	*Fully sheath OSB (mis-alignment with int brace wall below is within four joist thicknesses, OK)*
3 (rear)	*OK*	*Roof only*	*41'*	*42'*	*CS-WSP*	*25%x42' = 10.5'*	*10.5'x0.8 x1.2 = 10.1'*	*25.0'*	*OK*	*OK*	*OK*	*Fully sheath OSB also 1000# strap from top plate to ceiling joist over breakfast nook for collector 4' OSB sheath to roof rafter.*
Detached Garage or Other Portions												
n/a												

IRC 2009 Wall Bracing Design and Plan Check Worksheet

Project: NAHB (Plan F, Two story, 42'x38', basement)

GIVEN:
Wind Speed/Exposure: 85/B *(no topographic effects)*
Seismic SDC: D2
Roof eave-to-ridge hgt.: 7.0'
Wall Hgt.: 9'(1st); 8' (2nd)
Roof/Ceiling DL: 25 psf max. (clay tile, typical)
Wall DL: 15psf (stucco)
Floor DL: ≤10 psf (avg)-limited areas with tile (~10%)
Roof Span: 42' (mean roof ht = 22')

BWL Configurations Used (Wind):
BWL Layout: 3 BWLs each plan direction (1st story);
2 or 3 BWLs each plan direction (2nd story)
BWL Spacing: varies, see analysis below and floor plan

BWL Configuration Used (Seismic, D):
*BWL Layout: 3 BWLs each plan direction (both stories)**
BWL Spacing: varies - see plan
**BWL Spacing = max 25' with exception for 35' for one room not more than 900sqft (R602.10.1.5)*

BWP Location and Minimum Bracing (Wind):
max 12.5' cumulative edge distance from ends of BWLs
max 25' oc BWP spacing (R602.10.1.4)
min. 48" bracing amount per BWL (R602.10.1.2)

BWP Location and Minimum Bracing (Seismic, D2):
max 0' edge distance (8' allowed if 2' corner panels or 1800# hold-down at edge closest to corner)
max 25'oc BWP spacing
minimum bracing 48" total per BWL (R602.10.1.2)

Mixing Bracing Methods (R602.10.1.1):
Generally permitted except R602.10.4 require "all ext. walls" in SDC D if CS method is required on any one wall at any story level.

Wind Bracing Length Adjustment Factors (Table R602.10.1.2(1) footnotes)
(b) Exposure B: 1.0
(c) Ridge-to-eave hgt.: 0.9(1st); 0.8(2nd)
(d) Wall Hgt.: 0.95 (both stories)
(e) BWL Factor: 1.3 (both stories, both directions)
(f) No int. gyp.: n/a
(g) GB one-sided: n/a (all GB BWLs double sided where used)

Seismic Bracing Length Adjustment Factors (Table R602.10.1.2(3))
Story height: 1.0
BWL spacing: n/a (SDC A-C only)
Wall Dead Load: 1.0 (stucco over WSP)
Roof/ceiling DL: 1.2 (top story), 1.1 (bottom story) (NOTE: These two factors were reversed in 2009 IRC and have been corrected here.)
Walls w/stone or masonry: see Section R602.10.12 (n/a)
Cripple walls: see Section R602.10.9 (n/a)

Seismic Irregularities (R301.2.2.5)
OK- 2nd floor diaphragm is bounded by braced walls at great room.
OK- 2nd-story brace wall set back above garage opening - design load path required
OK- 2nd-story BWPs above garage opening end on beam in ceiling/floor above garage (technically not an opening with header below) - design load path required

Load Path Detailing (R602.10.1.2, R602.10.6 through R602.10.9, R602.11)
- *Uplift load > 100 plf at roof/wall (R602.10.1.2.1 & R802.11); AT BWP LOCATIONS ONLY: Provide roof uplift connectors 205#/ea 16"oc and studs to top plate; 140#/ea straps at 16"oc studs to 1st floor band joist and to studs below at 16"oc; 75#/ea straps at 16"oc 1st story studs (every other) to band on foundation. Slant nail band to foundation sill per code.*
- *Provide blocking or parallel member above/below BWPs per code (R602.10.6)*
- *Provide BWP support per code at floor cantilevers and masonry piers (R602.10.7)*
- *BWP support on continuous foundations (R602.10.7.1 - SDC D2)*
- *Block BWP horizontal joints (except GB) per code unless bracing lengths doubled (R602.10.8)*
- *Brace foundation cripple walls per code (R02.10.9.1, SDC D2) - N/A*
- *BWL sills anchored to concrete/masonry per code (R602.11)*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Tables R602.10.1.2 (feet)	STEP 4 Adjusted Bracing Length per Tables R602.10.1.2 (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 0' (SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution & Comments*
First Story Braced Wall Lines												
A-wind (left)	*OK*	*Roof +1floor*	*18'*	*41'*	*WSP*	*5.9'*	*5.4'x0.9x0.95x 1.3 = 6.6'*	*34.4'*	*OK*	*OK*	*OK*	*Use (3) 4' OSB panels (25' infill); (garage may be unfinished)*
A-seis (left)	*OK*	*Roof +1floor*	*18'*	*41'*	*WSP*	*22.8'*	*22.8'x1.1 =25.1'*	*34.4'*	*OK*	*OK*	*OK*	*Fully sheath OSB (caused by "all walls" due to BWL C, 1, and 3); use 3"x3" washers on anchor bolts @ 6'oc (garage can be unfinished)*
B-wind (int.)	*OK*	*Roof +1 floor*	*21'*	*41'*	*GB*	*12.0'*	*12.0'x0.9x0.95x 1.3 = 13.3'*	*37.3'*	*OK*	*OK*	*OK*	*7"oc edge fasten int. GWB both sides for 8' along two int. walls adjoining front and rear ext. walls*
B-seis (int.)	*OK*	*Roof +1floor*	*24' max*	*41'*	*GB*	*30.8'*	*30.8'x1.1 = 33.9'*	*37.3'*	*OK*	*OK*	*OK*	*7"oc edge fasten int. GWB both sides for two int. walls adjoining front and rear ext. walls; blocking below wall at family room.*
C-wind (right)	*OK*	*Roof +1 floor*	*24'*	*41'*	*WSP**	*7.7'*	*7.7'x0.9x0.95x 1.3 = 8.6'*	*32.0'*	*OK*	*OK*	*OK*	*Use (3) 4' OSB (or use engr CS-WSP w/2 hold-downs due to GR if design req'd)**
C-seis (right)	*OK*	*Roof +1floor*	*24'*	*41'*	*CS-WSP (engr.)*	*19.4'*	*19.4'x1.1 = 21.3'*	*32.0'*	*OK*	*OK*	*OK*	*Fully Sheath OSB w/ two 9,000# holddowns to dbl. tall studs at ends of great room wall portion; 3"x3" washers on anchor bolts at 6'oc*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Tables R602.10.1.2 (feet)	STEP 4 Adjusted Bracing Length per Tables R602.10.1.2 (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 0' (SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution & Comments*
1-wind (front)	*OK*	*Roof +1floor*	*20'*	*42'*	*CS-WSP* *CS-PF*	*5.5'*	*5.5'x0.9x0.95x 1.3 = 6.1'*	*18.5'*	*OK*	*OK*	*OK*	*OSB fully-sheath + CS-PF at garage supporting offset 2nd story BWL*
1-seis (front)	*OK*	*Roof+1floor*	*20'*	*42'*	*WSP* (equiv)	*23.1'*	*23.1'x1.1 = `25.4'*	*18.5'*	*NG*	*OK*	*OK*	*Use 3 or more engr. Narrow brace wall panels (no more than 2' wide each) for total equivalence to 5.8 WSP BWPs*
2-wind (int.)	*OK*	*Roof +1floor*	*20'*	*42'*	*GB*	*11.5'*	*11.5'x0.9x0.95x 1.3 = 12.8'*	*25.3'*	*OK*	*OK*	*OK*	*7"oc edge fasten int. GWB both sides at 9'wall btwn garage & F.R. and 8' wall between stairs*
2-seis (int.)	*OK*	*Roof+1floor*	*20'*	*42'*	*WSP*	*23.1'*	*23.1'x1.1 = 25.4'*	*25.3'*	*OK*	*OK*	*OK*	*OSB fully sheath int. walls at back of garage and btwn stairwell and kitchen ; 3"x3" plate washers on anchor bolts @ 6'oc along garage walls*
3-wind (rear)	*OK*	*Roof +1floor*	*20'*	*42'*	*CS-WSP*	*5.5'*	*5.5'x0.9x0.95x 1.3 = 6.1'*	*17.4'*	*OK*	*OK*	*OK*	*OSB fully-sheath [WSP method, (3) 4' OSB panels OK if one panel next to door increased to 43" vs. 37" wide]*
3-seis (rear)	*OK*	*Roof+1floor*	*20'*	*42'*	*WSP* (equiv.)	*23.1*	*23.1'x1.1 = `25.4'*	*17.4'*	*NG*	*NG (engr req'd)*	*OK*	*Use 3 or more engr. Narrow brace wall panels (no more than 2.6' wide each) for total equivalence to 5.8 WSP BWPs; double floor joist collector over brkfst nook attach*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Tables R602.10.1.2 (feet)	STEP 4 Adjusted Bracing Length per Tables R602.10.1.2 (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 0' (SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution & Comments*
												to top plate or band above walls with 1000# strap/connector
Second Story Braced Wall Lines (N/A)												
A-wind (left)	*OK*	*Roof only*	*22'*	*41'*	*WSP*	*3.8'*	*3.8'x0.8x0.95 x1.3 = 3.8' (4' min.)*	*24.5'*	*OK*	*OK*	*OK*	*(3) 4' OSB panels*
A-seis (left)	*OK*	*Roof only*	*22'*	*41'*	*WSP*	*10.3'*	*10.3'x1.2=12. 4'*	*24.5'*	*OK*	*OK*	*OK*	*Fully sheath OSB (CS-WSP required due to other ext. BWLs)*
B-wind (int.)	*OK*	*Roof only*	*21'avg*	*41'*	*GB*	*6.3'*	*6.3'x0.8x0.95 x1.3 = 6.2'*	*23.9'*	*OK*	*OK*	*OK*	*7"oc edge fasten int. GWB both sides along GR wall and MBdr closet (15.3' and 5.4')*
B-seis (int.)	*OK*	*Roof only*	*22'max*	*41'*	*GB*	*16.4'*	*16.4'x1.2= 19.7'*	*23.9'*	*OK*	*OK*	*OK*	*7"oc edge fasten int. GWB both sides along GR wall and MBdr closet (15.3', 5.4', and 4' at toilet wall & increase wall 9"); extra joist below wall line aligned*
C-wind (right)	*OK*	*Roof only*	*20'*	*41'*	*WSP*	*3.5'*	*3.5'x0.8x0.95 x1.3 = 3.5' (4' min.)*	*39.7'*	*OK*	*OK*	*OK*	*(3) 4' OSB panels*
C-seis (right)	*OK*	*Roof only*	*20'*	*41'*	*WSP*	*10.3'*	*10.3'x1.2=12. 4'*	*39.7'*	*OK*	*OK*	*OK*	*Fully sheath with OSB (part of GR CS-WSP wall design for story below)*
1-wind (front)	*OK*	*Roof only*	*23'*	*42'*	*WSP*	*4.0'*	*4.0'x0.8x0.95 x1.3 = 4.0'*	*35.8'*	*OK*	*OK*	*OK*	*(3) 4' OSB panels*

STEP 1 Braced Wall Line ID	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2 BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Tables R602.10.1.2 (feet)	STEP 4 Adjusted Bracing Length per Tables R602.10.1.2 (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 0' (SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution & Comments*
1-seis (front)	*OK*	*Roof only*	*23'*	*42'*	*WSP*	*10.5'*	*10.5'x1.2=12.6'*	*35.8'*	*OK*	*OK*	*OK*	*Fully sheath OSB (design support below with double joist at garage ceiling and strap ends at bearing to double studs in 1st story wall anchored to garage foundation with 1000# holdowns) and OSB sheath garage ceiling 5' wide to garage opening wall*
2-wind (int.)	*n/a*	*Roof only*	*22'avg*	*42'*	*GB*	*6.5'*	*6.5'x0.8x0.95 x1.3 = 6.4'*	*34.9'*	*OK*	*OK*	*OK*	*7"oc edge fasten int. GWB both sides along stairway and Mbrm (15.5' and 19.4')*
2-seis (int.)	*OK*	*Roof only*	*23'max*	*42'*	*GB*	*16.8'*	*16.8'x1.2= 20.2'*	*34.9'*	*OK*	*OK*	*OK*	*7"oc edge fasten int. GWB both sides along stairway and Mbrm (15.5' and 19.4'); blocking btwn joists below 19.4' wall)*
3-wind (rear)	*OK*	*Roof only*	*22'*	*42'*	*WSP*	*3.8'*	*3.8'x0.8x0.95 x1.3 = 5.9'*	*25.0'*	*OK*	*OK*	*OK*	*(3) 4' OSB panels*
3-seis (rear)	*OK*	*Roof only*	*22'*	*42'*	*WSP*	*10.5'*	*10.5'x1.2=12.6'*	*25.0'*	*OK*	*NG (engr req'd)*	*OK*	*(3) 4' OSB panels double ceiling joist collector over bath bump-out attach to top plate or band above walls with*

STEP 1 *Braced Wall Line ID*	STEP 1 Maximum BWP Offset from BWL ≤ 4'?	*STEP 2* *BWL Support Condition* *Roof only* *Roof+1 floor* *Roof+2 floors*	STEP 2 BWL Spacing (feet)	Length of BWL (feet) (see plan for actual wall lengths)	STEP 3 Selected Bracing Method (s)	STEP 4 Tabulated Bracing Length Tables R602.10.1.2 (feet)	STEP 4 Adjusted Bracing Length per Tables R602.10.1.2 (inches)	STEP 5 Bracing Length Available with Allowed Panel Widths (inches)	STEP 6 Is Value in Column G ≥ Value in Column F?	STEP 7 Is BWP cumulative distance from ends of BWL ≤ 0' (SDC D)	STEP 7 Do BWPs comply with maximum 25'oc spacing along BWP?	*Solution & Comments*
												1000# strap/connector
Detached Garage or Other Portions												
n/a												

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