Home Innovation
RESEARCH LABS™

ESTIMATED COSTS OF THE 2018 IRC CODE CHANGES

Prepared For

National Association of Home Builders

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TABLE OF CONTENTS

TABLES

ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

ACCA	Air Conditioning Contractors Association
ACH50	Air changes per hour at a test pressure differential of 50 Pascals
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigeration and Air-Conditioning Engineers
BPS	Builder Practices Survey—national survey conducted annually by Home Innovation Research Labs
Bsmt.	Basement
BWL	Braced wall line
ccSPF	Closed-cell spray polyurethane foam insulation
CF	Cubic feet
CFM	Cubic feet per minute (a measure of flow)
CS-PF	Bracing method consisting of a continuously sheathed portal frame around a large door or window opening
CY	Cubic yards
CZ	Climate Zone, as defined by the International Code Council (ICC)
DOE	Department of Energy
EA	Each
ERI	Energy Rating Index
ERV	Energy recovery ventilator
FEMA	Federal Emergency Management Agency
Gal	Gallon
HERS	Home Energy Rating System
HR	Hour
HRV	Heat recovery ventilator
HVAC	Heating, ventilation, and cooling
ICC	International Code Council
IECC	International Energy Conservation Code
IRC	International Residential Code
LB	Pounds
LF	Linear feet
MPH	Miles per hour
NEHRP	National Earthquake Hazard Reduction Program
O&P	Overhead and profit
OSB	Oriented strand board
PF	Portal frame
PSF	Pounds per square foot

RCD	Residential Cost Data 2017, 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
SOG	Slab-on-grade
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
USGS	United States Geological Society
WRB	Water-resistive barrier
XPS	Extruded polystyrene (rigid foam sheathing)

BACKGROUND

The National Association of Home Builders (NAHB) provided a list of code changes approved for the 2018 International Residential Code (2018 IRC).[1] 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 initially defined in a report titled *Estimated Costs of the 2015 Code Changes.*[2] 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.[3] 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 house that provides the starting point for estimation of the added cost (or savings) of each code change for the 2018 IRC relative to the 2015 IRC or IECC.

Cost impacts in this analysis have been developed primarily with data adapted from the following sources: (1) RSMeans' *Residential Cost Data 2017*;[4] (2) *ASHRAE 1481 RP*[5] and similar reports by Home Innovation; (3) U.S. government reporting from the Census[6] and the Bureau of Labor Statistics;[7] and (4) distributors' or big box retailers' websites. Where a source other than these is used, it is cited in *Appendix A* when applicable to a specific code change.

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*. For individual code changes shown in Appendix A, costs are reported as both total to the builder and total to consumer. The total cost to builder includes overhead and profit (designated in the tables as "w/O&P") applied to individual component costs (i.e., materials and labor) to represent the cost charged by the sub-contractor. The total cost to consumer is based on the builder's gross margin, reported as 18.9% of construction cost in the *2016 Cost of Doing Business*[8]*.* The cost summaries shown in Table 6 and Table 7 show the total cost to consumer only.

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[1] International Code Council, www.iccsafe.org/Pages/default.aspx
[2] www.homeinnovation.com/trends_and_reports/featured_reports/estimated_costs_of_the_2015_irc_code_changes
[3] Taylor, Heather. 2014. *Cost of Constructing a House*. www.nahb.org/generic.aspx?sectionID=734&genericContentID=221388&channelID=311
[4] http://rsmeans.reedconstructiondata.com
[5] NAHB Research Center, 2009. Economic Database in Support of ASHRAE 90.2 1481 RP. https://www.google.com/#q=ashrae+1481+rp
[6] http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk
[7] http://www.bls.gov/oes/current/oes_nat.htm#47-0000
[8] National Association of Home Builders. 2016. Cost of Doing Business Study: 2016 Edition. https://builderbooks.com

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*.[9] 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

Slab	54%
Crawlspace	17%
Basement	30%

Table 2. New Construction Number of Stories

One-story	53%
Two-story	43%
Three-story	3%

The Census data supports defining the four reference houses as follows to encompass approximately 85% of the last decade's new single-family 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.[10] 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
Fairbanks	8			X	X

Based on the data compiled by Home Innovation from the *2013 Builder Practices Survey* (BPS)[11], a nationwide annual survey, the typical Heating, Ventilation, and Cooling (HVAC) systems used in new

[9] www.census.gov/construction/chars/completed.html
[10] www.census.gov/construction/bps/pdf/2013statepiechart.pdf
[11] www.homeinnovation.com/trends_and_reports/data/new_construction

houses are summarized in Table 4. According to the BPS, 44% of new homes are cooled with a 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	% 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 Features

The statistics presented in the foregoing tables support reference house features that are detailed in Table 5.

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, 1^{st}	Yes	Yes	Yes	Yes
8 ft. Ceilings, 2^{nd}	n/a	n/a	Yes	Yes
Energy Star appliances	Yes	Yes	Yes	Yes
Laundry Room	Yes - Mudroom	Yes	Yes - Mudroom	Yes - Closet
Walls, 2x4 (Climate Zones 1 & 2)	Yes	Yes	n/a	n/a
Walls, 2x6 (Climate 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 2018 Code Compliance for Reference Houses by Location

Table 6 summarizes the estimated cumulative impact of the 2018 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. These changes typically affect elements required or provided in the majority of houses constructed, or non-mandatory code provisions likely to be used by a builder. The results are grouped into four climate zone categories to accommodate the energy efficiency changes in this code edition.

Table 7 summarizes the cost estimates of the code changes that do not apply to the selected reference houses and locations and are not included in the aggregated summary. These changes typically apply only in specific locations (e.g. hurricane-prone areas or flood zones), to items that would be an optional feature for most homes (e.g. decks), or to alternative methods of compliance. Those costs can be added to or subtracted from the aggregated costs in Table 6 as applicable to a particular location or a specific building. A detailed analysis of each individual code change is provided in *Appendix A*.

Table 6. Estimated Cost to Consumer of 2018 Code Compliance

Ref #	Code Change	2018 IRC Chapter	2018 IRC Reference	Miami, Los Angeles (CZ 1 & 2; Ref. Houses 1 & 2) High	Low	Dallas, Seattle, New York (CZ 3 & 4; Ref. Houses 1, 2, 3, & 4) High	Low	Chicago (CZ 5 - 7; Ref. Houses 3 & 4) High	Low	Fairbanks (CZ 8; Ref. Houses 3 & 4) High	Low	Notes
R-8 (RB229)	Support for headers: revises table for minimum number of king studs; now only requires 1 or 2 for low-wind urban and suburban conditions.	Wall Construction	R602.7.5	(493)	(516)	0	(210)	0	(90)	0	(90)	Houses with wall openings greater than 3 feet.
R-11 (RB303)	Masonry veneer: adds new provisions for brick tie attachment over foam sheathing and direct to 7/16" sheathing.	Wall Covering	R703.8.4	N/R	N/R	N/R	N/R	325	(73)	325	(73)	Houses with brick veneer and continuous insulation
E-1 (RE31)	Reduces the maximum window U-factor requirement in Climate Zones 3-8.	Energy Efficiency	Table N1102.1.2	N/A	N/A	85	74	85	78	85	78	Houses in Climate Zones 3-8
E-6 (RE127)	Lighting efficiency: increases the percent of permanently installed lighting fixtures that must contain high-efficacy lamps from 75% to 90%.	Energy Efficiency	N1104.1	8	8	8	8	8	8	8	8	Houses in all climate zones
M-1 (RM36)	Duct sealing: eliminates the requirement for sealing longitudinal seams of snap-lock and button-lock types of HVAC ducts located inside conditioned space	Duct Systems	M1601.4.1	0	(129)	0	(471)	(348)	(471)	(348)	(471)	Houses with metal HVAC ducts located inside conditioned space
	Total to Consumer			**(485)**	**(637)**	**93**	**(599)**	**70**	**(548)**	**70**	**(548)**	

Table 7. Additional Costs to Consumer of 2018 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**	**2018 IRC Chapter**	**2018 IRC Reference**	**Cost Range ($)**								**Notes**
				High	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	
R-1 (RB17)	Seismic Design Categories: updates the seismic design maps in Section R301.2 to be consistent with those in the 2014 NEHRP Provisions and ASCE 7-16.	Building Planning, Seismic Design Category	R301.2.2.1	7,111	2,446	7,111	2,446	7,111	2,446	7,111	2,446	Applicable where the revised map triggers a change in the assigned SDC
R-2 (RB160)	Flood-Resistant Construction: adds new requirements for exterior slabs (e.g. parking pads, sidewalks) based on ASCE 24.	Building Planning, Flood-Resistant Construction	R322.3.4	2,092	(1,084)	2,092	(1,084)	2,092	(1,084)	2,092	(1,084)	Applicable in coastal high-hazard areas (Zone V) and Coastal A Zones.
R-3 (RB161)	Flood-Resistant Construction: adds new provisions requiring stairways and ramps to be flood resistant, breakaway or be able to be raised.	Building Planning, Flood-Resistant Construction	R322.3.6	11,107	(823)	11,107	(823)	11,107	(823)	11,107	(823)	Applicable in coastal high-hazard areas (Zone V) and Coastal A Zones.
R-4 (RB200)	Decks: reorganizes deck beam requirements and adds minimum spans for single ply beams.	Floors, Exterior Decks	R507	0	(101)	0	(101)	0	(101)	0	(101)	Applicable if a deck is installed
R-5 (RB207)	Decks: adds minimum footing size table for decks and pointer to frost depth requirements.	Floors, Exterior Decks	R507.3	127	(72)	127	(72)	127	(72)	127	(72)	Applicable if a deck is installed
R-6 (RB212)	Decks: relocates deck post section and adds 8x8 posts to the table. Clarifies maximum height for 4x4 posts.	Exterior Decks	R507.4	199	0	199	0	199	0	199	0	Applicable if a deck is installed
R-7 (RB218)	Stud Size, Height & Spacing: adds new table for 11' and 12' tall load-bearing studs.	Wall Construction	R602.3.1	(462)	(998)	(462)	(998)	(435)	(971)	(435)	(971)	Applicable for bearing walls exceeding 10' tall but not exceeding 12' tall.

			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	2018 IRC Chapter	2018 IRC Reference	Cost Range ($)								Notes
				High	Low	High	Low	High	Low	High	Low	
R-9 (RB276)	Vapor Retarders: adds polypropylene siding to list of vented cladding products.	Wall Covering	R702.7.3	N/A	N/A	(119)	(381)	(119)	(381)	(119)	(381)	Applicable in CZ 4C (Marine) and 5 through 8
R-10 (RB284)	Water-Resistive Barriers: deletes exception for detached accessory buildings.	Wall Covering	R703.2	271	51	271	51	271	51	271	51	Applicable for detached accessory buildings
R-11 (RB303)	Masonry Veneer: adds new provisions for brick tie attachment over foam sheathing and direct to 7/16" sheathing.	Wall Covering	R703.8	325	(73)	325	(73)	325	(73)	325	(73)	Houses with brick veneer and continuous insulation
R-12 (RB327)	Unvented Attics: adds new option for constructing an unvented attic with air-permeable insulation if vapor diffusion ports and minimum air flow is provided.	Roof-Ceiling Construction	R806.5	(1,583)	(9,185)	(1,583)	(9,185)	N/A	N/A	N/A	N/A	Houses with unvented attics in CZ 1-3
E-2 (RE99, RE110)	Introduces criteria to allow buried or partially buried ducts and to model buried ducts as R-25.	Energy Efficiency	N1103.3.6	2,057	(731)	2,057	(731)	N/A	N/A	N/A	N/A	Optional method for houses with HVAC ducts in vented attics
E-3 (RE100)	Introduces criteria to allow buried ducts to be performance modeled as if inside conditioned space.	Energy Efficiency	N1103.3.6	2,866	(4,064)	2,866	(4,064)	N/A	N/A	N/A	N/A	Optional method for houses with HVAC ducts in vented attics
E-4 (RE121)	Introduces minimum fan efficacy for HRVs and ERVs.	Energy Efficiency	N1103.6.1	0	(857)	0	(857)	0	(857)	0	(857)	Applicable where an HRV/ERV is installed
E-5 (RE173)	Increases ERI values approximately 10%; also adds a backstop for homes complying with the ERI using on-site generation.	Energy Efficiency	N1106.4	This code change is expected to decrease costs for builders who are using the optional ERI path for code compliance. This report does not identify individual measures or quantify their cost savings. A general discussion is offered for context in the appendix.								Applicable in all climate zones

APPENDIX A:
DESCRIPTION AND COST IMPACT OF 2018 IRC CODE CHANGES

R-1 (RB17)

IRC R301.2 Climatic and geographic design criteria, Fig. R301.2(2), Fig. R301.2(3), R301.2.2.1.1, R301.2.2.1.2

Summary of Code Change:

The code change updates the seismic design maps to be consistent with those in the 2014 *NEHRP Recommended Seismic Provisions* and ASCE 7-16 *Minimum Design Loads for Buildings and Other Structures*.

This code change proposal revises the seismic design category map. The revised map represents an update of the previous map based on a new analysis of earthquake faults conducted by the USGS and increases to the site amplification factors for stiff soils and soft rock. For some jurisdictions located at the boundaries between the adjacent seismic design categories, the result is shifting to a higher seismic design category (see Table R-1-A). It is also noted that in some areas the change results in a downgrade of the seismic design hazard and lowering of assigned seismic design category.

Table R-1-A. Summary of Changes to a Higher Seismic Design Category

SDC Change	Where impacted?	Impact
A → B	Multiple locations of limited geographical area around the country in non-seismic areas.	No impact on construction.
B → C	A few locations around the country with low-to-moderate seismicity with rural or mountainous areas in Colorado, Wyoming, and Utah the primary areas impacted. Some areas in Oklahoma, New England (particularly New Hampshire) and around the New Madrid Seismic Zone are also impacted.	Limited impact on townhouse construction in SDC C.
B → D_0	Isolated areas in rural Colorado and Utah.	Substantial impact on bracing provisions.
C → D_0, D_1, D_2	Isolated areas around the country including eastern Tennessee, Arkansas, Oklahoma, and Utah.	Substantial impact on bracing provisions.
D_0, D_1, D_2 → E	Areas in California, coastal Oregon, and coastal Washington, and near Charleston South Carolina (all primarily D_2 → E).	Engineered design is required.

Cost Implication of Code Change:

The cost impact of transitioning from seismic design category C to seismic design categories D_0 and D_2 is evaluated for a one-story and a two-story reference home based on a structural analysis report for those two homes[12]. The results are summarized in Tables R-1-B through R-1-E. In addition, several structural engineering firms from different regions of the country were contacted for estimates of their engineering fees for wall bracing design. Engineering fees from the survey averaged $1,150 for an analysis, documentation, and drawings based on the reference homes ($1,367 to consumer). The cost of

[12] Jay H. Crandell, P.E., *Code Comparative Bracing Analysis for Two Representative House Plans,* Rev. Sep 2015, ARES Consulting, as reported in *Estimated Costs of the 2012 IRC Code Changes*, *Appendix H: ARES Consulting Bracing Report*, Home Innovation Research Labs, Oct 2015. http://www.homeinnovation.com/~/media/Files/Reports/2012-IRC-Cost-Analysis.pdf

engineered lateral design for the entire house is reported for cases where the prescriptive design is not permitted (transition from SDC D to SDC E). The cost of construction is not included in this scenario. Given a broad range of design tools available to engineers, it is possible that the use of engineering design will allow for optimized solutions for the building that do not result in construction cost increases relative to generic prescriptive options. However, other engineers, particularly those not familiar with residential construction, may make conservative simplifications or assumptions, in which case an engineered design may result in additional construction cost increases.

Several geotechnical engineering firms from different regions of the country were contacted for estimates of their fee to conduct a study to determine soil type and seismic design category. Engineering fees ranged from $950 to $2,200 for a soil test and report. One firm in California quoted $500 for a report without a field study based on using their map library and the seismic hazard maps published by the State of California and various cities and counties. They indicated that in some cases local jurisdictions accept this type of analysis for assigning seismic design categories. The additional cost of a geotechnical report can be offset by the savings in construction costs in the case where the report showed a downgrade in seismic design category.

Table R-1-B. Change in Wall Bracing and Foundation Costs for Reference House 1 – One-story (SDC C to SDC D_0)

BWL #	Component	Unit	w/O&P	Qty	Cost
A	Engineering Fee	HR	150.00	1	150.00
A	Galvanized Plate Washers	EA	3.60	16	57.60
B	Engineering Fee	HR	150.00	1	150.00
B	Gypsum board fastened 7" oc	SF	0.30	144	43.20
B	Galvanized Plate Washers	EA	3.60	8	28.80
B	Thickened Slab at Interior Braced Wall Panels	LF	9.70	16	155.20
C	Galvanized Plate Washers	EA	3.60	13	46.80
1	Galvanized Plate Washers	EA	3.60	8	28.80
2	Gypsum board fastened 7" oc edge/field	SF	0.30	108	32.40
2	Galvanized Plate Washers	EA	3.60	6	21.60
2	Thickened Slab	LF	9.90	12	118.80
3	Gypsum board fastened 7" oc edge/field	SF	0.30	108	32.40
3	Galvanized Plate Washers	EA	3.60	6	21.60
3	Thickened Slab	LF	9.90	12	118.80
4	Gypsum board fastened 7" oc edge/field	SF	0.30	108	32.40
4	Galvanized Plate Washers	EA	3.60	6	21.60
4	Thickened Slab	LF	9.90	12	118.80
5	CS-PF Panels	EA	20.40	2	40.80
5	Galvanized Plate Washers	EA	3.60	6	21.60
All Ext	Vertical cold joint dowels at 48" oc	LF	0.49	256	125.44
All Ext	Horizontal footing reinforcement	LF	1.52	256	389.12
	Attach BWP to roof framing, est.				300.00
Total to Builder					**2,055.76**
Total to Consumer					**2,446.35**

Table R-1-C. Change in Wall Bracing and Foundation Costs for Reference House 1 – One-story (SDC C to SDC D_2)

BWL #	Component	Unit	w/O&P	Qty	Cost
A	Engineering Fee	HR	150.00	1	150.00
A	Galvanized Plate Washers	EA	3.60	16	57.60
B	Engineering Fee	HR	150.00	1	150.00
B	Gypsum board fastened 7" oc	SF	0.30	342	102.60
B	Galvanized Plate Washers	EA	3.60	10	36.00
B	Thickened Slab at Interior Braced Wall Panels	LF	9.70	38	368.60
C	Galvanized Plate Washers	EA	3.60	13	46.80
1	Galvanized Plate Washers	EA	3.60	8	28.80
2	Gypsum board fastened 7" oc edge/field	SF	0.30	207	62.10
2	Galvanized Plate Washers	EA	3.60	6	21.60
2	Thickened Slab	LF	9.90	23	227.70
3	Gypsum board fastened 7" oc edge/field	SF	0.30	242	72.60
3	Galvanized Plate Washers	EA	3.60	8	28.80
3	Thickened Slab	LF	9.90	27	267.30
4	Gypsum board fastened 7" oc edge/field	SF	0.30	180	54.00
4	Galvanized Plate Washers	EA	3.60	7	25.20
4	Thickened Slab	LF	9.90	20	198.00
5	CS-PF Panels	EA	20.40	2	40.80
5	Galvanized Plate Washers	EA	3.60	6	21.60
All Ext	Vertical cold joint dowels at 48" oc	LF	0.49	256	125.44
All Ext	Horizontal footing reinforcement	LF	1.52	256	389.12
	Attach BWP to roof framing, est.				400.00
Total to Builder					**2,874.66**
Total to Consumer					**3,420.85**

Table R-1-D. Change in Wall Bracing and Foundation Costs for Reference House 4 – Two-story (SDC C to SDC D_0)

BWL #	Component	Unit	w/O&P	Qty	Cost
	First story				
A	Galvanized Plate Washers	EA	3.60	8	28.80
B	Gypsum board fastened at 7" oc edge	SF	0.30	216	64.80
B	Galvanized Plate Washers	EA	3.60	4	14.40
B	Blocking	LF	5.00	12	60.00
B	Gypsum board fastened 7" oc edge/field	SF	0.30	144	43.20
C	Hold-downs (9,000 lb)	EA	130.00	2	260.00
C	Engineering Fee	HR	150.00	1	150.00
C	Galvanized Plate Washers	EA	3.60	8	28.80
1	Galvanized Plate Washers	EA	3.60	4	14.40
2	Gypsum board fastened at 7" oc edge	SF	0.30	228	68.40
2	Gypsum board fastened 7" oc edge/field	SF	0.30	148	44.40
2	Galvanized Plate Washers	EA	3.60	6	21.60
3	Galvanized Plate Washers	EA	3.60	8	28.80
All Ext	Vertical rebar in foundation wall @ 48" oc	LF	1.54	188	289.52
All Ext	Horizontal Footing Reinforcement	LF	1.50	6	9.00
	Second Story				
B	Gypsum board fastened 7" oc edge/field	SF	0.30	155	46.50
B	Additional I-Joist for Support	LF	3.60	42	151.20
1	Metal Straps	EA	18.50	4	74.00
1	OSB Sheathing ceiling diaphragm	SF	1.14	110	125.40
2	Gypsum board fastened 7" oc edge/field	SF	0.30	128	300.00
2	Blocking	LF	5.00	20	
	Attach BWP to roof framing, est.				340.00
Total to Builder					**2,163.22**
Total to Consumer					**2,574.23**

Table R-1-E. Change in Wall Bracing and Foundation Costs for Reference House 4 – Two-story (SDC C to SDC D_2)

BWL #	Component	Unit	w/O&P	Qty	Cost
	First story				
A	Galvanized Plate Washers	EA	3.60	8	28.80
B	Gypsum board fastened at 7" oc edge	SF	0.30	336	100.80
B	Galvanized Plate Washers	EA	3.60	4	14.40
B	Blocking	LF	5.00	15	75.00
B	Gypsum board fastened 7" oc edge/field	SF	0.30	(144)	(43.20)
C	Hold-downs (9,000 lb)	EA	130.00	2	260.00
C	Engineering Fee	HR	150.00	1	150.00
C	Galvanized Plate Washers	EA	3.60	8	28.80
1	Prefabricated shear wall panel	EA	590.00	3	1770.00
1	CC-PF panels (SDS C)	EA	21.00	(2)	(42.00)
2	7/16 OSB	SF	1.14	228	259.92
2	Gypsum board fastened 7" oc edge/field	EA	0.30	(148)	(44.40)
2	Galvanized Plate Washers	EA	3.60	6	21.60
3	Prefabricated shear wall panel	EA	590.00	3	1770.00
All Ext	Vertical rebar in foundation wall @ 48" oc	LF	1.54	188	289.52
All Ext	Horizontal Footing Reinforcement	LF	1.50	188	282.00
	Second Story				
B	Gypsum board fastened 7" oc edge/field	SF	0.30	198	59.40
B	Additional I-Joist for Support	LF	3.60	42	151.20
1	Metal Straps	EA	18.50	4	74.00
1	OSB Sheathing ceiling diaphragm	SF	1.14	110	125.40
2	Gypsum board fastened 7" oc edge/field	SF	0.30	280	84.00
2	Blocking	LF	5.00	20	100.00
	Attach BWP to roof framing, est.				460.00
	Total to Builder				**5,975.24**
	Total to Consumer				**7,110.54**

Applicability of Code Change:

This code change is applicable to construction of new homes located in areas where the revised map triggers a change in the assigned SDC. The change is also applicable to those existing buildings undergoing a structural retrofit involving an upgrade of the lateral force resisting system and located in the same areas impacted by the change in the map.

R-2 (RB160)

IRC R322.3.3 Foundations, R322.3.4 (new)

Summary of Code Change:

For coastal high-hazard areas (Zone V) and Coastal A Zones, the code change adds new requirements for exterior concrete slabs – used for parking, floors of enclosures, landings, walkways, patios, and similar uses – that are located beneath structures, or located such that if undermined or displaced during base flood conditions the foundations could sustain structural damage. The provisions are based on ASCE 24-14 *Flood Resistant Design and Construction*. Slabs must either be constructed to break up under flood conditions (structurally independent, frangible, no reinforcement, no turned down edges, no more than 4 in. thick) or designed to resist flood loads, erosion, and scour.

Cost Implication of Code Change:

This code change is adapted from FEMA Technical Bulletin 5 (Free of Obstruction Requirements). The section of Technical Bulletin 5 that discusses frangible slabs shows two post-flood photos of a parking pad situated below an elevated building with a raised pile foundation, a common residential coastal construction practice. It recommends that the slab have contraction joints placed at 4-ft. squares to encourage failure.

Reinforced slab

Frangible slab

<u>Frangible Slab</u>

The first method of compliance can result in cost savings if a slab is unreinforced, is limited to a 4-in. thickness, and has the recommended control joints. The analysis is conducted on a 14 x 20 ft. parking slab. Table R-2-A shows the cost savings of this method.

Table R-2-A. Cost Savings to Replace Reinforced Slab

Component	Unit	Material	Labor	Equip	Total	w/O&P	Qty	Cost ($)
Concrete in place, grade 60 rebar, slab on grade, 3500 psi, 6" thick	CY	137.00	32.50	0.31	169.81	206.00	(5.19)	(1,068.15)
Slab on grade, 3500 psi, not reinforced, 4" thick	SF	1.58	0.68	0.01	2.27	2.85	280.00	798.00
Sawcut control joints in green concrete, 1" deep	LF	0.04	0.28	0.08	0.40	0.57	116.00	66.12
Total to Builder								**(204.03)**
Total to Consumer								**(242.79)**

The exclusion of turned down edges on slabs indicates that this is somewhat common. If the slab above also had turned down edges, the savings are more substantial, as shown in Table R-2-B.

Table R-2-B. Cost Savings to Replace Reinforced Slab with Turned Down Edges

Component	Unit	Material	Labor	Equip	Total	w/O&P	Qty	Cost ($)
Concrete in place, grade 60 rebar, slab on grade, 3500 psi, 6" thick	CY	137.00	32.50	0.31	169.81	206.00	(5.19)	(1,068.15)
Thickened slab edge, 3500 psi, 8" deep bottom, 8" wide bottom, reinforced	LF	6.05	2.33	0.02	8.30	10.40	(68.00)	(707.20)
Slab on grade, 3500 psi, not reinforced, 4" thick	SF	1.58	0.68	0.01	2.27	2.85	280.00	798.00
Sawcut control joints in green concrete, 1" deep	LF	0.04	0.28	0.08	0.40	0.57	116.00	66.12
Total to Builder								**(911.23)**
Total to Consumer								**(1,084.36)**

Flood Resistant Slab

The second option for compliance (self-supporting, capable of remaining intact under base load conditions) would require an engineered design to resist the flood loads. For the pad above, a structural engineer in Jacksonville, FL indicated that he would specify a turned down slab edge to 12 in. below grade, a plastic membrane below the slab to help with drying, and compacting of the soil. For the original 6 in. parking pad above, this would result in new costs, shown in Table R-2-C.

Table R-2-C. Additional Costs for Engineered Slab

Component	Unit	Total w/ O&P	Qty	Cost ($)
Thickened slab edge, 12" deep bottom, 12" wide bottom, reinforced	LF	17.9	68	1,217.20
4 mil poly below the slab	SF	0.17	280	47.60
Gravel fill under slab, compacted, 4" deep	SF	0.69	280	193.20
Engineer's fee	HR	150	2	300.00
Total to Builder				**1,758.00**
Total to Consumer				**2,092.02**

Applicability of Code Change:

This code change is applicable in coastal high-hazard areas (Zone V) and Coastal A Zones.

R-3 (RB161)

IRC R322.3.6 Stairways and ramps (new)

Summary of Code Change:

The code change adds a new provision for homes in coastal high-hazard areas (Zone V) and Coastal A Zones requiring stairways and ramps to be flood resistant, breakaway, or able to be raised.

Cost Implication of Code Change:

For an elevated home in a Zone V or Coastal A Zone, the simplest way to comply with this new requirement is to build an open-riser stair. This extends the run of the stair as the risers can only be 4-in. high. Table R-3-A shows the cost of building a closed-riser stair. Table R-3-B shows the cost impact building an open-riser stair compared to the closed-riser stair.

Table R-3-A. Cost of Building 8 ft. Tall Staircase with Closed 7.5 in. Riser

Component	Unit	Material	Labor	Equip	Total	w/O&P	Qty	Cost ($)
13 treads, oak, 1.25"x10"x3'	EA	29.50	8.75	0.00	38.25	47.00	13.00	611.00
Risers, 3/4" thick, oak	EA	13.00	3.50	0.00	16.50	20.00	14.00	280.00
34" oak balusters	EA	8.95	4.66	0.00	13.61	17.65	26.00	458.90
Handrails, oak, average	LF	13.50	2.91	0.00	16.41	19.70	13.46	265.16
Stringers, 2x10, 3 each	LF	1.38	4.30	0.00	5.68	8.70	40.38	351.31
Total to Builder								**1,966.37**

Table R-3-B. Cost Increase to Build 8 ft. Tall Stairway with Open 4 in. Riser

Component	Unit	Material	Labor	Equip	Total	w/O&P	Qty	Cost ($)
Staircase, closed 7.5" risers	See Table above						(1.00)	(1,966.37)
24 treads, oak, 1.25"x10"x3'	EA	29.50	8.75	0.00	38.25	47.00	24.00	1,128.00
34" oak balusters	EA	8.95	4.66	0.00	13.61	17.65	48.00	847.20
Handrails, oak, average	LF	13.50	2.91	0.00	16.41	19.70	21.54	424.34
Stringers, 2x10, 3 each	LF	1.38	4.30	0.00	5.68	8.70	64.62	562.19
Total to Builder								**995.36**
Total to Consumer								**1,184.48**

The code does not specify what constitutes an "open riser." The analysis above assumes the riser is 100% fully open. It may be possible to construct a stair with partially-open risers that allow floodwaters to flow through and around the stair, but do not allow a 4-in. diameter sphere to pass, in which case 7.5 in. risers could be used and there would be no additional cost.

The code applies to all stairways below the lowest floor elevation for homes built in V Zones and Coastal A Zones. In addition to exterior stairs leading to the front door, they can also have stairs that access an enclosed garage below the first floor. In those cases, the builder may choose to simply install a retractable stairway. Table R-3-C shows the cost savings to install a heavy-duty wood retractable stair (e.g., https://www.youtube.com/watch?v=8QlEnVhoq4M) compared to building the closed-riser stair. Table R-3-D shows the cost increase to install an electric, automatic, aluminum retractable stair (e.g., https://www.youtube.com/watch?v=qn2j38po0yg) compared to building the closed-riser stair.

Table R-3-C. Cost of Retractable Stairs – Option 1

Component	Unit	Material	Labor	Equip	Total	w/O&P	Qty	Cost ($)
Staircase, closed 7.5" risers	See Table R-3-A						(1.00)	(1,966.37)
Disappearing stairway, heavy duty	EA	1,025.00	93.00		1,118.00	1,275.00	1.00	1,275.00
Total to Builder								**(691.37)**
Total to Consumer								**(822.73)**

Table R-3-D. Cost of Retractable Stairs – Option 2

Component	Unit	Material	Labor	Equip	Total	w/O&P	Qty	Cost ($)
Staircase, closed 7.5" risers	See Table R-3-A						(1.00)	(1,966.37)
Disappearing stairway, aluminum, automatic electric	EA	9,450.00	560.00		10,010.00	11,300.00	1.00	11,300.00
Total to Builder								**9,333.63**
Total to Consumer								**11,107.02**

Applicability of Code Change:

This code change is applicable in coastal high-hazard areas (Zone V) and Coastal A Zones.

R-4 (RB200)

IRC R507 Exterior decks, R507.5.1(2) (new), R507.6, R507.7, R507.7.1

Summary of Code Change:

The code change reorganizes deck beam requirements and adds minimum spans for single-ply beams.

Cost Implication of the Code Change:

There may be a cost savings for a stair landing serving a deck or porch or a porch floor that will now be able to use single-ply beams. There may be additional cost savings where a single-ply beam permits the use of 4x4 posts instead of 4x6 posts. The cost analysis focuses on two example scenarios.

Example 1: a freestanding 5'x5' landing 4' above grade, serving an elevated deck, may now use one 2x8 beam (at both ends, for a total of 10 LF) instead of two 2x8 beams. Further, the supporting posts may now be 4x4 instead of 4x6; there are four posts, each 10' long (4' above grade, 3' below grade, and 3' above the landing to support railing). Table R-4-A shows the associated cost savings.

Example 2: a freestanding 10'x12' deck 4' above grade, may now use one 2x12 beam instead of two 2x8 beams (24 LF total). Further, the supporting posts may now be 4x4 instead of 4x6; there are six posts, each 6' long (4' above grade and 2' below grade). Table R-4-B shows the associated cost savings.

Table R-4-A. Cost savings for example landing.

Component	Unit	Material	Labor	Total	w/O&P	Qty	Cost ($)
Double 2x8 beam	LF	2.17	0.97	3.14	4.02	(10)	(40.20)
Single 2x8 beam	LF	1.09	0.87	1.96	2.66	10	26.60
4x6 post	LF	2.06	2.03	4.09	5.65	(40)	(226.00)
4x4 post	LF	1.37	1.43	2.80	3.91	40	156.40
Total to builder							**(83.20)**
Total to Consumer							**(99.01)**

Table R-4-B. Cost savings for example deck.

Component	Unit	Material	Labor	Total	w/O&P	Qty	Cost ($)
Double 2x8 beam	LF	2.17	0.97	3.14	4.02	(24)	(96.48)
Double 2x10 beam	LF	2.86	1.02	3.88	4.84		
Single 2x10 beam	LF	1.43	0.92	2.05	3.11	24	74.64
4x6 post	LF	2.06	2.03	4.09	5.65	(36)	(203.40)
4x4 post	LF	1.37	1.43	2.80	3.91	36	140.76
Total to builder							**(84.48)**
Total to Consumer							**(100.53)**

Applicability of Code Change:

This code change is applicable when a deck is constructed with the house, or when a deck is added later.

R-5 (RB207)

IRC R507 Exterior Decks, R507.3 Footings (new), R507.3.1 (new), R507.3.2 (new), Table R507.3.1 (new)

Summary of Code Change:

The code change adds a new table with minimum footing sizes for decks and a pointer to frost depth requirements. The table allows footing selection based on soil bearing capacity (1500, 2000, 2500, >3000 PSF), live or ground snow loads (40, 50, 60, 70 PSF), and tributary area (20, 40, 60, 80, 100, 120, 140, 160 SF).

Cost Implication of the Code Change:

There may be a cost savings over the American Wood Council's DCA 6 "Prescriptive residential wood deck construction guide" footing sizes, which are based on 1500 PSF soil and an interior post. DCA 6 is not mandated by code, so there may be a cost increase where jurisdictions currently allow a smaller footing (e.g., a 12" diameter sonotube).

The cost analysis compares footing requirements for an example deck for two soil bearing capacities (1500 and 3000 PSF) and two live/snow loads (40 and 60 PSF). The example deck is assumed to be freestanding, 20' x 14' (280 SF), supported by six posts with tributary areas of 70 SF for the two interior posts and 35 SF for the four corner posts. Table R-5-A shows the cost to provide and place a cubic foot of concrete; the table includes the labor cost to excavate the footing by hand (it is assumed that a backhoe digs the hole to the top of the footing and this backhoe cost is constant for all footings). Table R-5-B shows the cost savings for the example deck, using a square footing for the 40 PSF design load and a round footing for the 60 PSF design load.

The cost analysis also compares footing requirements for the same example deck to the case where the jurisdiction previously allowed a 12" diameter, 6" thick footer for all posts. Table R-5-C shows the cost increase for the example deck using a square footing for the 40 PSF design load and a round footing for the 60 PSF design load, both for 1500 PSF soil bearing capacity (worst case for increased costs).

Table R-5-A. Cost of concrete ($/CF)

Component	Unit	Material	Labor	Equip	Total	w/O&P
Concrete, hand mix	CF	3.96	1.58	1.22	6.76	8.35
Place concrete	CF		0.70	0.08	0.78	1.26
Excavate footing	CF		0.99		0.99	1.65
Total	**CF**					**11.26**

Table R-5-B. Cost savings for example deck for two live/snow load scenarios

Design Conditions			Minimum footing size (in.)			Cost/footing		Deck: 40 PSF load		Deck: 60 PSF load	
Load (PSF)	Soil (PSF)	Tributary Area (SF)	Square	Diameter	Thickness	CF	Cost	Qty	Cost	Qty	Cost
40	3000	35	12		6	0.50	5.63	4	22.52		
		70	14		6	0.68	7.66	2	15.33		
40	1500	35	14		6	0.68	7.66	(4)	(30.65)		
		70	20		7	1.62	18.25	(2)	(36.49)		
60	3000	35		14	6	0.53	6.02			4	24.06
		70		19	6	0.98	11.08			2	22.16
60	1500	35		19	6	0.98	11.08			(4)	(44.32)
		70		26	9	2.76	31.12			(2)	(62.24)
Total to builder									**(29.30)**		**(60.34)**
Total to consumer									**(34.86)**		**(71.80)**

Table R-5-C. Cost increase for example deck for two live/snow load scenarios

Design Conditions			Minimum footing size (in.)			Cost/footing		Deck: 40 PSF load		Deck: 60 PSF load	
Load (PSF)	Soil (PSF)	Tributary Area (SF)	Square	Diameter	Thickness	CF	Cost	Qty	Cost	Qty	Cost
40	1500	35	14		6	0.68	7.66	4	30.65		
		70	20		7	1.62	18.25	2	36.49		
				12	6	0.39	4.42	(6)	(26.52)		
60	1500	35		19	6	0.98	11.08			4	44.32
		70		26	9	2.76	31.12			2	62.24
				12	6	0.39	4.42			(6)	(26.52)
Total to builder									**40.63**		**106.56**
Total to consumer									**48.34**		**126.81**

Applicability of Code Change:

This code change is applicable when a deck is constructed with the house, or when a deck is added later.

R-6 (RB212)

IRC R507 Exterior Decks, R507.4 Deck posts

Summary of Code Change:

The code change relocates the deck post section, clarifies the maximum height for 4x4 posts, and adds 8x8 posts to the table.

Cost Implication of Code Change:

There may not be a cost impact for most applications. There may be a cost increase for a 3-ply beam on a post cap with a 4x4 post where the deck post height exceeds 6'-9 but does not exceed 8'. In this case a 4x6 post is now required.

Table R-6 shows the cost impact for two example scenarios where 4x6 posts are now required instead of 4x4 posts: 1) an example freestanding deck, 20'x8', 8' high, with six posts 10' long each (8' above grade, 2' below grade); and 2) an example freestanding deck, 20'x14', 8' high, with eight posts 12' long each (8' above grade, 4' below grade).

Table R-6. Estimated cost increase for example deck with post height above 6'-9" up to 8'.

	Unit cost of posts ($/LF)					Example Deck 1		Example Deck 2	
Component	**Unit**	**Material**	**Labor**	**Total**	**w/O&P**	**Qty**	**Cost**	**Qty**	**Cost**
4x6 post	LF	2.06	2.03	4.09	5.65	60	339.00	96.00	542.40
4x4 post	LF	1.37	1.43	2.80	3.91	(60)	(234.60)	(96.00)	(375.36)
Total to Builder							**104.40**		**167.04**
Total to Consumer							**124.24**		**198.78**

Applicability of Code Change:

This code change is applicable when a deck is constructed with the house, or when a deck is added later.

R-7 (RB218)

IRC R602.3.1 Stud size, height, and spacing, Table 602.3(6) (new)

Summary of Code Change:

The code change adds a new table for 11' and 12' tall studs in load-bearing walls. The table allows selection of stud size (2x4 and 2x6) based on stud spacing (12", 16", 24"), ultimate design wind speeds (115, 130, 140 MPH), and maximum roof/floor span (12', 24'). The table is applicable where the building is located in Exposure B, the live roof load does not exceed 20 PSF, the ground snow load does not exceed 30 PSF, and studs and plates are #2 grade lumber or better.

Cost Implication of Code Change:

There may be a cost savings where standard studs can be used in lieu of "tall stud" options, such as laminated strand lumber (LSL) studs, for bearing stud walls exceeding 10' but not exceeding 12' (e.g., walls of step-down garages, tall foyers or great rooms or portions of such rooms). Further, there may be a cost savings where engineering analysis is not required for such walls.

The cost analysis focuses on an example room, 24' x 24', with walls 12' tall, attached to the side of a house (so 48 LF of bearing wall). For this analysis, labor for a wall with standard studs is assumed to be the same as a wall with LSL studs. Table R-7-A shows the cost of studs. Table R-7-B shows the cost savings of building this room using 2x4 studs instead of 2x4 LSL studs, all 12" oc. The analysis is based on 1.25 stud/LF wall to account for typical framing requirements for 12" oc construction (per RSMeans Assemblies section).

Table R-7-C shows the cost savings of building the example room using 2x6 studs instead of 2x6 LSL studs, all 24 oc. The analysis is based on 0.75 stud/LF wall for 24" oc construction (per RSMeans Assemblies section).

Table R-7-D shows the estimated cost savings of not requiring engineering analysis for the example room.

Table R-7-A. Estimated cost of studs.

Component	Unit	Material	w/O&P	Qty	Cost
2x4 stud, 12' tall	LF	0.41	0.45	12	5.41
2x6 stud, 12' tall	LF	0.63	0.69	12	8.32
2x4 LSL, 12' tall	LF	0.90	0.99	12	11.88
2x6 LSL, 12' tall	LF	1.40	1.54	12	18.48

Table R-7-B. Estimated savings for an example room with 2x4 walls 12' tall.

Component	Unit	$/stud	$/LF wall	Qty	Cost
12' tall wall, 2x4 studs 12 oc	LF	5.41	6.76	48	324.60
12' tall wall, 2x4 LSL 12 oc	LF	11.88	14.85	(48)	(712.80)
Total to Builder					**(388.20)**
Total to Consumer					**(461.96)**

Table R-7-C. Estimated savings for an example room with 2x6 walls 12' tall.

Component	Unit	$/stud	$/LF wall	Qty	Cost
12' tall wall, 2x6 studs 24 oc	LF	8.32	6.24	48	299.52
12' tall wall, 2x6 LSL 24 oc	LF	18.48	13.86	(48)	(665.28)
Total to Builder					**(365.76)**
Total to Consumer					**(435.25)**

Table R-7-D. Estimated savings for a tall wall not requiring engineering analysis.

Component	Unit	Material	w/O&P	Qty	Cost
Engineering analysis	HR		150.00	(3)	(450.00)
Total to Builder					**(450.00)**
Total to Consumer					**(535.50)**

Applicability of the Code Change:

This code change is applicable for homes with walls or portions of walls over 10 feet in height but not exceeding 12 feet in height.

R-8 (RB229)

IRC R602.7.5 Supports for headers

Summary of Code Change:

The code change revises the table for minimum number of king studs (full height studs at each end of headers in exterior walls). The revised table adds two ultimate design wind speed and exposure categories (<140 mph Exposure B or <130 mph Exposure C; ≤115 mph Exposure B), deletes the maximum stud spacing requirements, and revises the maximum header spans (4' to 18' in 2' increments).

Cost Implication of Code Change:

There may be a cost savings where fewer king studs are required. The cost analysis focuses on the four Reference Houses in Climate Zones 1-2 (2x4 studs) and Climate Zones 3-8 (2x6 studs). Each of the four Reference Houses have different opening widths and opening quantities. Table R-8-A shows the reduced number of king studs required based on a 115 MPH urban or dense suburban location. Table R-8-B shows the number and size of openings for the Reference Houses. The change in number of king studs for each reference house is shown for 2x4 walls in Table R-8-C and for 2x6 walls in Table R-8-D. Table R-8-E shows the installed cost per king stud for 2x4 and 2x6 construction. The associated cost savings for each Reference House by climate is summarized in Table R-8-F.

Table R-8-A. Reduced number of king studs required.

Header Span (ft.)	# King Studs (each side of opening)				
	2015 IRC		2018 IRC	Change*	
	16 oc	24 oc	≤115/B*	16 oc	24 oc
3	1	1		0	0
4	2	1	1	(1)	0
6			1	(2)	(1)
8	3	2	1	(2)	(1)
10			2	(3)	(1)
12	5	3	2	(3)	(1)
14			2	(4)	(2)
16	6	4	2	(4)	(2)
18			2	(4)	(2)

*Based on ≤115 mph wind speed and Exposure B

Table R-8-B. Number of openings for the Reference Houses.

Reference Houses - # openings

Header Span (ft)	Reference House			
	1	2	3	4
3	0	2	9	19
4	4	10	4	4
8	3	4	3	0
12	4	1	0	0

Table R-8-C. Change in number of 2x4 king studs for the Reference Houses.

Reference Houses - Change in # 2x4 king studs

Header Span (ft)	Reference House			
	1	2	3	4
3	0	0	0	0
4	(8)	(20)	(8)	(8)
8	(12)	(16)	(12)	0
12	(24)	(6)	0	0
Total	**(44)**	**(42)**	**(20)**	**(8)**

Table R-8-D. Change in number of 2x6 king studs for the Reference Houses.

Reference Houses - Change in # 2x6 king studs

Header Span (ft)	Reference House			
	1	2	3	4
3	0	0	0	0
4	0	0	0	0
8	(6)	(8)	(6)	0
12	(8)	(2)	0	0
Total	**(14)**	**(10)**	**(6)**	**0**

Table R-8-E. Installed cost per king stud.

Installed cost per king stud

Component	Unit	Material	Labor	Total	w/O&P	Qty	Cost
2x4 stud	LF	0.41	0.42	0.83	1.16	8.50	9.86
2x6 stud	LF	0.63	0.47	1.10	1.48	8.50	12.58

Table R-8-F. Cost Savings for the Reference Houses.

Reference Houses – Summary of Cost Change ($)

Climate Zone	Cost	Reference House			
		1	2	3	4
CZ 1-2 2x4 wall	Total to Builder	(434)	(414)	(197)	(79)
	Total to Consumer	(516)	(493)	(235)	(94)
CZ 3-8 2x6 wall	Total to Builder	(176)	(126)	(75)	0
	Total to Consumer	(210)	(150)	(90)	0

Applicability of Code Change:

This code change is applicable to all houses with exterior wall openings wider than 3 feet.

R-9 (RB276)

IRC R702.7.3 Minimum clear airspaces and vented openings for vented cladding

Summary of Code Change:

The code change adds polypropylene siding to the list of vented cladding products.

Cost Implication of Code Change:

For Climate Zones 4C and 5 through 8, there may be a cost savings to omit a Class I or Class II vapor retarder where a Class III vapor retarder is applied to the interior side of frame walls.

The IRC considers interior latex or enamel paint to be a Class III vapor retarder (>1 and ≤10 perms), and two coats are assumed in this analysis to meet the requirement. The cost analysis focuses on two scenarios: 1) the cost savings of not installing a Class I vapor retarder (sheet polyethylene); and 2) the cost savings of installing unfaced fiberglass batts instead of a Class II vapor retarder (Kraft-faced fiberglass batts) in wall stud cavities.

Table R-9-A and Table R-9-B show the cost savings of both scenarios for an assumed wall area of 2,000 SF (similar to the Reference Houses).

Table R-9-A. Estimated cost savings to omit a Class I interior vapor retarder (sheet polyethylene)

Component	Unit	Material	Labor	Total	w/O&P	Qty	Cost ($)
Sheet polyethylene, 4 mil	SF	0.03	0.08	0.11	0.16	(2000)	(320.00)
Total to Builder							**(320.00)**
Total to Consumer							**(380.80)**

Table R-9-B. Estimated cost savings to omit Class II interior vapor retarder (Kraft-faced batts)

2x4 walls in CZ 4C & 5-8 Component	Unit	Material	Labor	Total	w/O&P	Qty	Cost ($)
R-13 Kraft-faced fiberglass batt	SF	0.33	0.21	0.54	0.71	(2000)	(1420.00)
R-13 unfaced fiberglass batt	SF	0.34	0.17	0.51	0.66	2000	1320.00
Total to Builder							**(100.00)**
Total to Consumer							**(119.00)**
2x6 walls in CZ 4C & 5-8 Component	**Unit**	**Material**	**Labor**	**Total**	**w/O&P**	**Qty**	**Cost**
R-19 Kraft-faced fiberglass batt	SF	0.45	0.21	0.66	0.85	(2000)	(1700.00)
R-19 unfaced fiberglass batt	SF	0.4	0.21	0.61	0.79	2000	1580.00
Total to Builder							**(120.00)**
Total to Consumer							**(142.80)**

Applicability of Code Change:

This code change is applicable in climate zones 4C (Marine) and 5 through 8.

R-10 (RB284)

IR703.2 Water-resistive barrier

Summary of Code Change

The code change deletes the exception for detached accessory buildings to require a water-resistive barrier for all walls.

Cost Implication of Code Change:

There may be a cost increase depending on cladding type. Cladding manufacturers typically require installation in accordance with the IRC, but the 2015 IRC did not require a WRB for detached accessory buildings, so compliance represents an additional cost for claddings that require a WRB on a house, including vinyl siding and fiber cement lap siding. There is no additional cost for detached accessory buildings with face-sealed cladding.

The cost analysis focuses on two common WRBs, building paper and house wrap, for two example detached accessory buildings: 1) 8' x 8' shed, 7' high; and 2) 24' x 24' garage, 8' high, with 6:12 gable roof and two 9' x 7' garage doors. Table R-10-A shows the cost impact for both example buildings using building paper for the WRB. Table R-10-B shows the cost impact for both example buildings using house wrap for the WRB.

Table R-10-A. Estimated cost to install building paper WRB on example accessory buildings.

WRB: Building paper	Component cost					Building 1		Building 2	
Component	**Unit**	**Material**	**Labor**	**Total**	**w/O&P**	**Qty**	**Cost**	**Qty**	**Cost**
Asphalt felt paper #15	SF	0.05	0.08	0.13	0.19	224	42.56	786	149.34
Total to Builder							**42.56**		**149.34**
Total to Consumer							**50.65**		**177.71**

Table R-10-B. Estimated cost to install house wrap WRB on example accessory buildings.

WRB: House wrap	Component cost					Building 1		Building 2	
Component	Unit	Material	Labor	Total	w/O&P	Qty	Cost	Qty	Cost
House wrap, spun bonded polypropylene	SF	0.15	0.07	0.22	0.29	224	64.96	786	227.94
Total to Builder							**64.96**		**227.94**
Total to Consumer							**77.30**		**271.25**

Applicability of Code Change:

This code change is applicable for detached accessory structures (e.g. sheds, garages).

R-11 (RB303)

IRC R703.8.4 Anchorage (masonry veneer), R703.8.4(2) (new)

Summary of Code Change:

The code change adds new provisions for brick tie attachment over foam sheathing, up to 2" thick, and directly to 7/16" sheathing. A new table shows minimum tie spacing (vertical/horizontal) by wind speed (110, 115, 130, and 140 mph) and Exposure Category (Exposure B, C, and D) using corrosion resistant ring shank nails (0.091" or 0.148" dia.) or screws (#6, 8, 10, or 14). The tie spacing is determined based on Zone 5 (wall edge zone) wind pressures.

Cost Implication of Code Change:

The code change may represent a cost increase due to 1) a more expensive fastener in all cases, and 2) the greater number of brick ties required where tighter spacing is required. The code change may also represent a labor cost savings due to not needing to locate studs through foam sheathing.

For 2015, the minimum tie fastener was one corrosion resistant 8d common nail (Table R703.8.4) (0.131" dia.), and maximum tie spacing was 32" horizontally and 24" vertically with each tie supporting not more than 2.67 SF (R703.8.4.1) (typical spacing was 32"H/12"V or 16"H/24"V).

The cost analysis focuses on three scenarios, all for an example 2,000 SF wall:

1. The additional cost using ring shank nails, 0.148" diameter, 3" long, for foam up to 2" thick, for an application with the same tie spacing requirements as prior (e.g., 24/16 spacing, for 115 mph wind, Zone 5, Exposure B), for a 2,000 SF wall. (Table R-11-A.)

2. The additional cost for the same scenario as above except with 16/16 spacing (e.g., 115 mph, Zone 5, Exposure C or D, or 130/140 mph, Zone 5, Exposure B). (Table R-11-C.)

3. The potential labor cost savings, estimated at 25%, to not locate the studs through the foam, for both spacing scenarios above. (Table R-11-B and Table R-11-D.)

Table R-11-A. Additional cost of ring shank nails, same tie spacing

Component	Unit	Material	Labor	Total	w/O&P	Nails/ LB	Nails/ SF	SF wall	Qty	Cost
Common nail, galv., 0.131"D x 2.5"L	LB	2.08		2.08	2.29	100	0.3745	2,000	(7.49)	(17.14)
Ring Shank nail, galv., 0.148"D x 3"L	LB	3.13		3.13	3.44	66	0.3745	2,000	11.35	39.08
Total to Builder										**21.94**
Total to Consumer										**26.11**

Table R-11-B. Potential labor savings to not locate studs, same tie spacing

Component	Unit	Material	Labor	Total	w/O&P	Nails/ LB	Nails/ SF	SF wall	Qty	Cost
Labor to install tie & nail	C		26.50		44.52					
Labor savings, est. 25%	C				11.13		0.3745	2,000	(7.49)	(83.37)
Total to Builder										**(83.37)**
Total to Consumer										**(99.21)**

Table R-11-C. Additional cost of ring shank nails and tighter tie spacing.

Component	Unit	Material	Labor	Total	w/O&P	Nails/ LB	Nails/ SF	SF wall	Qty	Cost
Common nail, galv., 0.131"D x 2.5"L	LB	2.08		2.08	2.29	100	0.3745	2,000	(7.49)	(17.14)
Ring Shank nail, galv., 0.148"D x 3"L	LB	3.13		3.13	3.44	66	0.5625	2,000	17.05	58.69
Brick tie, galv., 22 ga, 7/8" x 7"	C	15.35	26.50	41.85	61.50		0.3745	2,000	(7.49)	(460.67)
Brick tie, galv., 22 ga, 7/8" x 7"	C	15.35	26.50	41.85	61.50		0.5625	2,000	11.25	691.88
Total to Builder										**272.75**
Total to Consumer										**324.57**

Table R-11-D. Potential labor savings, to not locate studs, for tighter tie spacing.

Component	Unit	Material	Labor	Total	w/O&P	Nails/ LB	Nails/ SF	SF wall	Qty	Cost
Labor to install tie & nail	C		26.50		44.52					
Labor savings, est. 25%	C				11.13		0.5625	2,000	(11.25)	(125.21)
Total to Builder										**(125.21)**
Total to Consumer										**(149.00)**

Based on the results of this analysis, the range of costs depends on if labor savings accrue. Where no labor savings accrue, high cost is $325 and low cost is $26. Where labor savings always accrue, high cost is $176 ($325-$149) and low cost is -$73 ($26-$99). The maximum range is $325 high cost for greatest number of additional ties and nails but no labor savings assumed, and -$73 if only nail size changes and full labor savings are assumed.

The tables are: optional in CZ1 and CZ2 as continuous insulation is not required; optional in CZ3 through CZ5 for 2x6 walls as continuous insulation is not required but required for 2x4 walls where R-5 continuous insulation is required; required for CZ6 through CZ8 where either R-5 or R-10 continuous insulation is required.

Applicability of Code Change:

This code change is applicable to houses with brick veneer.

R-12 (RB327)

IRC R806.5 Unvented attic and unvented enclosed rafter assemblies.

Summary of Code Change:

The code change adds a new option for insulating an unvented attic using air-permeable insulation installed just below the roof deck (e.g., blown fiberglass in netting hung from the roof trusses/rafters, referred to as netted/blown) if vapor diffusion ports (i.e. a ridge vent covered with a vapor permeable membrane such as a strip of house wrap or vapor permeable roofing underlayment) are installed (≥ 1:600 ratio of vapor diffusion port area to ceiling area, vapor permeance rating of membrane ≥ 20 perms) and minimum air flow from the HVAC system is provided (≥ 50 CFM per 1,000 square feet of ceiling area). The code change is limited to Climate Zones 1, 2, and 3 and roof slopes ≥ 3:12.

Cost Implication of Code Change:

There may be a cost savings compared to unvented attics insulated using spray foam, a flash-and-batt method (thinner layer of spray foam applied at the interior side of the roof deck and covered with fiberglass batt insulation, referred to as flash/batt), or foam sheathing above the roof deck and fiberglass batts below. The cost analysis focuses on Reference Houses 1 and 2 in Climate Zone 2 or 3 (R-38 insulation prescriptively required).

Table R-12-A shows the cost impact for Reference House 1, with an unvented attic, by comparing netted/blown fiberglass insulation, with vapor diffusion ports and HVAC supply branch, to closed-cell spray foam at the roof deck. Table R-12-B compares netted/blown fiberglass to a flash/batt approach for Reference House 1. Table R-12-C and Table R-12-D make the same comparisons for Reference House 2. For all tables, a component marked with an asterisk (*) indicates cost data is based on internet pricing (for vapor permeable roof membrane, membrane tape, and counter-flash tape over membrane tape) or estimated based on pricing provided by the product manufacturer (for netted/blown fiberglass).

Table R-12-A. Estimated cost savings for Reference House 1: netted/blown fiberglass vs. spray foam

Component	Unit	Material	Labor	Equip	Total	w/O&P	Qty	Cost
Closed cell spray foam, R-38, 6" thk.	SF	3.11	0.63	0.67	4.41	5.30	(4,100)	(21,730.00)
Netted/blown fiberglass, R-38*	SF					3.00	4,100	12,300.00
Vapor permeable roof membrane*	SF	1.05			1.05	1.16	153	177.48
Membrane tape*	LF	0.64	0.97			2.33	102	237.66
Counter-flash tape over membrane tape*	LF	0.09	0.97			1.72	102	175.44
Air sealing at eaves	LF	0.35	0.97		1.32	2.01	460	924.60
HVAC supply flex duct	LF	1.60	1.97		3.57	5.05	15	75.75
HVAC supply diffuser	EA	76.50	22.00		98.50	121.00	1	121.00
Total to Builder								**(7,718.07)**
Total to Consumer								**(9,184.50)**

Table R-12-B. Estimated cost savings for Reference House 1: netted/blown fiberglass vs. flash/batt method

Component	Unit	Material	Labor	Equip	Total	w/O&P	Qty	Cost
Closed cell spray foam, 3" thk., R-19.6	SF	1.55	0.32	0.34	2.21	2.64	(4,100)	(10,824.00)
Fiberglass batt, 6-1/4" thk., R-19	SF	0.40	0.56		0.96	1.38	(4,100)	(5,658.00)
Netted/blown fiberglass, R-38*	SF					3.00	4,100	12,300.00
Vapor permeable roof membrane*	SF	1.05			1.05	1.16	153	177.48
Membrane tape*	LF	0.64	0.97			2.33	102	237.66
Counter-flash tape over membrane tape*	LF	0.09	0.97			1.72	102	175.44
Air sealing at eaves	LF	0.35	0.97		1.32	2.01	460	924.60
HVAC supply flex duct	LF	1.60	1.97		3.57	5.05	15	75.75
HVAC supply diffuser	EA	76.50	22.00		98.50	121.00	1	121.00
Total to Builder								**(2,470.07)**
Total to Consumer								**(2,939.38)**

Table R-12-C. Estimated cost savings for Reference House 2: netted/blown fiberglass vs. spray foam

Component	Unit	Material	Labor	Equip	Total	w/O&P	Qty	Cost
Closed cell spray foam, R-38, 6" thk.	SF	3.11	0.63	0.67	4.41	5.30	(2,200)	(11,660.00)
Netted/blown fiberglass, R-38*	SF					3.00	2,200	6,600.00
Vapor permeable roof membrane*	SF	1.05			1.05	1.16	42	48.72
Membrane tape*	LF	0.64	0.97			2.33	28	65.24
Counter-flash tape over membrane tape*	LF	0.09	0.97			1.72	28	48.16
Air sealing at eaves	LF	0.35	0.97		1.32	2.01	276	554.76
HVAC supply flex duct	LF	1.60	1.97		3.57	5.05	15	75.75
HVAC supply diffuser	Ea.	76.50	22.00		98.50	121.00	1	121.00
Total to Builder								**(4,146.37)**
Total to Consumer								**(4,934.18)**

Table R-12-D. Estimated cost savings for Reference House 2: netted/blown fiberglass vs. flash/batt method

Component	Unit	Material	Labor	Equip	Total	w/O&P	Qty	Cost
Closed cell spray foam, 3" thk., R-19.6	SF	1.55	0.32	0.34	2.21	2.64	(2,200)	(5,808.00)
Fiberglass batt, 6-1/4" thk., R-19	SF	0.40	0.56		0.96	1.38	(2,200)	(3,036.00)
Netted/blown fiberglass, R-38*	SF					3.00	2,200	6,600.00
Vapor permeable roof membrane*	SF	1.05			1.05	1.16	42	48.72
Membrane tape*	LF	0.64	0.97			2.33	28	65.24
Counter-flash tape over membrane tape*	LF	0.09	0.97			1.72	28	48.16
Air sealing at eaves	LF	0.35	0.97		1.32	2.01	276	554.76
HVAC supply flex duct	LF	1.60	1.97		3.57	5.05	15	75.75
HVAC supply diffuser	Ea.	76.50	22.00		98.50	121.00	1	121.00
Total to Builder								**(1,330.37)**
Total to Consumer								**(1,583.14)**

Applicability of Code Change:

This code change is applicable in Climate Zones 1-3.

E-1 (RE31)

IECC Table R402.1.2 Insulation and fenestration requirements by component (IRC Table N1102.1.2), IECC Table R402.1.4 (IRC Table N1101.1.4)

Summary of Code Change:

The code change decreases the maximum window U-factor requirement in Climate Zones 3-8. For Climate Zones 3 and 4 except 4C, the maximum window U-factor decreases from 0.35 to 0.32. For Climate Zones 4C and 5-8, the maximum window U-factor decreases from 0.32 to 0.30. The maximum window U-factor did not change for Climate Zones 1 and 2, and SHGC values did not change for any climate zone.

Cost Implication of Code Change:

There may be a cost increase to comply with the code change depending on the window manufacturer and model. Some data (see below) indicates a cost increase to comply with the code change.

The cost analysis is investigated using cost data collected from the U.S. Department of Energy[13]. Based on this data, an incremental cost of $0.18/SF window area is used for both sets of U-value improvements. Table E-1-A shows the estimated cost increases for the four Reference Houses (window areas are defined in Table 5).

The Department of Energy and EPA Energy Star along with those involved in the development of energy codes have traditionally had problems developing a clear incremental cost for changes in window thermal performance. In this analysis, prices used to develop the incremental cost associated with the code changes are a best guess based on the available data.

Table E-1-A. Estimated change in cost for windows using DOE data.

Windows				Reference House							
Incremental Cost				1		2		3		4	
U-value improvement	Unit	Incremental Cost ($)	w/O&P	Qty	Cost	Qty	Cost	Qty	Cost	Qty	Cost
0.35>0.32 and 0.32>0.30	SF	0.18	0.20	360	71	315	62	360	71	330	65
Total to Builder					**71**		**62**		**71**		**65**
Total to Consumer					**85**		**74**		**85**		**78**

Applicability of Code Change:

This code change is applicable in Climate Zones 3-8.

[13] Cost-Effectiveness of Improved Fenestration U-Factors: https://www.energycodes.gov/sites/default/files/documents/iecc2018_R-2_analysis_final.pdf

E-2 (RE99 and RE110)

IECC R403.3 Ducts (IRC N1103.3)
IECC R403.3.6 Ducts buried within ceiling insulation (new) (IRC N1103.3.6)
IECC R403.3.6.1 Deeply buried ducts effective R-value (new) (IRC N1103.3.6.1)

Summary of Code Change:

This code change provides an optional construction method for houses with HVAC ducts installed in vented attics with the intent to improve energy performance. The code change provides the criteria to explicitly allow ducts buried, or partially buried, within ceiling insulation in vented attics ("buried ducts") as an option in lieu of suspending them from the roof framing. The sum of the insulation above and below the duct is at least R-19 total, excluding the duct R-value; minimum required duct insulation is R-8 except in Climate Zones 1A, 2A, and 3A where the minimum required supply duct insulation is R-13.

Additionally, the code change allows buried ducts to be modeled using an effective duct insulation value of R-25 where certain criteria are met: the duct is located directly on the ceiling or within 5.5 in. of the ceiling; the duct is surrounded with ceiling insulation of at least R-30; the duct is covered on top with at least 3.5 in. of ceiling insulation (approximately R-11 assuming a minimum R-value of R-3.2 per in.).

Cost Implication of Code Change:

Compared to conventional attic ducts, there may be a cost increase to install buried ducts (where R-13 supply ducts are required, and where additional ceiling insulation above the ducts is required), and concurrently there may be a cost savings to install buried ducts (labor and material savings for shorter duct runs installed at the ceiling plane instead of high in the attic). The analysis does not include a potential reduced cost associated with installing a lower capacity HVAC system.

The cost analysis will focus on Reference Houses 1 and 2 in all climate zones. Reference Houses 1 and 2 were selected because those have ducts and air handlers in the attic (Reference Houses 3 and 4 have ducts and air handlers in the basement). The area of supply ducts is assumed to be 23% of conditioned floor area, and the area of return ducts is assumed to be 7% of conditioned floor area. These values are consistent with ACCA and ASHRAE standards. For the two-story house, 60% of the duct area is assumed to be in the attic (the second floor represents approximately 60% of the floor area of the house). For the one-story house, 100% of the duct area is assumed to be in the attic.

In Climate Zones 1A-3A, R-13 duct insulation is required for supply ducts that are buried or partially buried. For this component, the cost analysis is based on R-5 (installed R-value, 2" thick) foil-faced duct wrap installed over R-8 supply ducts. (Ducts installed in attics are most commonly R-8 insulated flexible ducts; R-13 flexible ducts are not commercially available yet; R-13 duct wrap (foil-faced, non-perforated) installed over rectangular metal duct or un-insulated flexible duct is a viable approach but such duct construction is not as common for ducts in attics).

Table E-2-A shows the cost impact to install buried ducts for Reference Houses 1 and 2 in all climate zones. For this prescriptive path, it is assumed that no additional ceiling insulation is required. Labor and material savings is estimated at 15%.

Table E-2-A. Estimated cost impact to install buried ducts (prescriptive path).

Buried Ducts (prescriptive path)			CZ: 1A, 2A, 3A		CZ: all others	
			Reference House		Reference House	
Component	**Unit**	**w/O&P**	**1**	**2**	**1**	**2**
R-13 supply ducts (incremental cost)	SF	3.32	1991	1194	0	0
Labor & material savings, est. 15%	SF	(1.02)	(614)	(368)	(614)	(368)
Total to builder			**1377**	**826**	**(614)**	**(368)**
Total to consumer			**1638**	**983**	**(731)**	**(438)**

For modeling of buried ducts in accordance with the performance path, the cost analysis is based on the prescriptive requirements plus the additional ceiling insulation required above the supply and return ducts. The unit cost of this insulation is based on R-11 blown fiberglass with an adjustment factor of 0.75 to account for the estimated portion of duct area that requires coverage. Table E-2-B shows the cost impact to install buried ducts in accordance with the performance path for Reference Houses 1 and 2 in all climate zones.

Table E-2-B. Estimated cost impact to install buried ducts (performance path).

Buried Ducts (performance path)			CZ: 1A, 2A, 3A		CZ: all others	
			Reference House		Reference House	
Component	**Unit**	**w/O&P**	**1**	**2**	**1**	**2**
R-13 supply ducts (incremental cost)	SF	3.32	1,991	1,194	0	0
Labor & material savings, est. 15%	SF	(1.02)	(614)	(368)	(614)	(368)
Add ceiling insulation above ducts	SF	0.45	352	211	352	211
Total to builder			**1,729**	**1,038**	**(262)**	**(157)**
Total to consumer			**2,057**	**1,235**	**(312)**	**(187)**

Applicability of Code Change:

This code change is applicable in all climate zones.

E-3 (RE100)

IECC R403.3 Ducts (IRC N1103.3)
IECC R403.3.6 Ducts buried within ceiling insulation (new) (IRC N1103.3.6)
IECC R403.3.7 Ducts located in conditioned space (new) (IRC N1103.3.7)

Summary of Code Change:

This code change provides an optional construction method for houses with HVAC ducts installed in vented attics. The code change provides the criteria to explicitly allow ducts buried, or partially buried, within ceiling insulation in vented attics ("buried ducts"). The sum of the insulation above and below the duct is at least R-19 total; minimum required duct insulation is R-8 except in Climate Zones 1A, 2A, and 3A where the minimum required supply duct insulation is R-13.

Additionally, the code change provides the criteria to allow buried ducts to be modeled as being located inside conditioned space: the air handler is located inside conditioned space (not the attic); duct leakage is within prescribed limits (1.5 CFM25/100SFcfa, measured either by a rough-in stage test or post-construction stage total-system-leakage-to-outdoors test); the R-value of insulation above the duct is at least the proposed ceiling insulation R-value, used in the model, less the R-value of the duct insulation.

Cost Implication of Code Change:

There may be a cost increase to install buried ducts based on the additional criteria. There may be a net cost savings where buried ducts are installed in lieu of building an unvented attic or installing ducts inside conditioned space (i.e., below the ceiling plane within framed bulkheads).

The cost analysis for the prescriptive component of this change is provided in section E-2. The cost analysis for the performance component of this change will focus on Reference Houses 1 and 2 in all climate zones (same as prescriptive component). The analysis does not include a potential reduced cost associated with installing a lower capacity HVAC system or a potential cost increase associated with a higher level of duct sealing. The analysis does include the cost to build a mechanical closet to house the air handler that is no longer in the attic; credit is taken for omitting pull-down stairs for attic access. The analysis also includes the additional ceiling insulation required above the ducts: minimum R-25 in Climate Zones 1A, 2A, and 3A (R-38 ceiling insulation less R-13 ducts; it is understood that this could be reduced in Climate Zone 1 that requires minimum R-30 ceiling insulation, but this was not calculated separately); minimum R-41 in Climate Zones 4-8 (R-49 ceiling insulation less R-8 ducts).

Table E-3-A shows the cost impact to install buried ducts in accordance with the performance criteria for Reference Houses 1 and 2 in all climate zones. Note Climate Zones 2B and 3B are unique compared to Climate Zones 2A and 3A because R-13 supply ducts are not required.

Table E-3-B shows the estimated cost savings to install buried ducts in accordance with the performance criteria compared to installing ducts within bulkheads constructed below the ceiling (i.e., in conditioned space).

Table E-3-A. Estimated cost to install buried ducts (performance path).

Buried ducts (performance path)			CZ: 1A, 2A, 3A		CZ: 2B, 3B		CZ: 4-8	
			Reference House		Reference House		Reference House	
Component	**Unit**	**w/O&P**	**1**	**2**	**1**	**2**	**1**	**2**
R-13 supply ducts (Table E-2-A)	SF	3.32	1,991	1,194	0	0	0	0
Labor/material savings (Table E-2-A)	SF	(1.02)	(614)	(348)	(614)	(348)	(614)	(348)
Ceiling insulation above ducts, CZ 1-3	SF	0.82	641	385	641	385	0	0
Ceiling insulation above ducts, CZ 4-8	SF	1.15	0	0	0	0	899	540
Mechanical closet	EA	390	390	390	390	390	390	390
Total to builder			**2,408**	**1,621**	**417**	**427**	**675**	**582**
Total to consumer			**2,866**	**1,929**	**496**	**508**	**803**	**693**

Table E-3-B. Estimated cost savings for installing buried ducts vs. installing ducts within bulkheads below the ceiling.

Buried ducts vs. ducts within bulkheads below ceiling	CZ: 1A, 2A, 3A		CZ: 2B, 3B		CZ: 4-8	
	Reference House		Reference House		Reference House	
Component	**1**	**2**	**1**	**2**	**1**	**2**
Buried ducts (see Table above)	2,408	1,621	417	427	675	582
Building bulkheads to conceal ducts	(3,832)	(2,298)	(3,832)	(2,298)	(3,832)	(2,298)
Total to builder	**(1,424)**	**(677)**	**(3,415)**	**(1,871)**	**(3,157)**	**(1,716)**
Total to consumer	**(1,694)**	**(806)**	**(4,064)**	**(2,227)**	**(3,757)**	**(2,042)**

Applicability of Code Change:

This code change is applicable in all climate zones.

E-4 (RE121)

IECC R403.6.1 Whole-house mechanical ventilation system fan efficacy (IRC N1103.6.1), IECC Table R403.6.1 (IRC Table N1103.6.1)

Summary of Code Change:

The code change introduces a minimum fan efficacy (1.2 CFM/Watt) for HRVs and ERVs. The minimum HRV/ERV efficacy is the same as required by ENERGY STAR Canada. Prior to the change, an HRV/ERV was generally classified as an in-line fan (minimum fan efficacy 2.8 CFM/Watt), so in effect the code change relaxed the minimum fan efficacy requirement for an HRV/ERV.

Cost Implication of Code Change:

Many HRV/ERV models already meet the new requirement, so no cost change is expected in many cases. The Home Ventilating Institute (HVI) publishes HRV/ERV performance and energy data[14]. A review of this database shows there is a wide selection of models that meet or exceed 1.2 CFM/Watt. Manufacturer product data is also available on manufacturer web sites. The fan efficacy is not a published number and may need to be interpolated based on product data. Further, different data points may provide different fan efficacy ratios.

There may be a cost decrease in cases where a builder substitutes an HRV/ERV with a lower fan efficacy (less than 2.8 CFM/Watt but still greater than 1.2 CFM/Watt) as shown in Table E-4-A (note: the models shown are the lowest capacities for each model that meet the 2.8 or 1.2 CFM/Watt efficacy requirements).

Table E-4-A. Example cost savings to meet fan efficacy requirement.

Brand	Style	Model	CFM range min/max	Selected energy rating data at 32F			Unit	w/O&P
				CFM	Watts	CFM/W		
Broan	HRV	HRV200ECM	50/245	64	19	3.37	EA	(1,870)
Broan	HRV	HRV160	65/183	65	54	1.20	EA	1,150
Total to builder								**(720)**
Total to consumer								**(857)**

Applicability of Code Change:

This code change is applicable where an HRV or ERV is provided to meet mechanical ventilation requirements.

[14] Home Ventilating Institute (HVI), see HVI-Certified Products Directory, Section 3 Directory: https://www.hvi.org/proddirectory/

E-5 (RE173)

IECC Table R406.4 Maximum energy rating index (IRC Table N1106.4)

Summary of Code Change:

The code change increases the ERI values in all climates zones by approximately 10%. It also adds a backstop for houses complying with the ERI using on-site generation, so houses must still meet mandatory requirements and minimum insulation and fenestration requirements.

Cost Implication of Code Change:

The revised ERI target values correspond to a house that on average is about 5-15% more efficient compared to a house designed using the prescriptive path (using the ERI Index scale). The 2015 ERI target values correspond to a house that on average is about 10-20% more efficient. Therefore, this code change is expected to decrease costs for builders who are using the optional ERI path for code compliance. This report does not identify individual measures or quantify their cost savings. A general discussion is offered below for context.

In a separate study[15], Home Innovation reported the predicted HERS indices for over 300 typical house configurations simulated to meet the 2015 IECC minimum requirements and then simulated with high efficiency heating and cooling equipment. The summary of results for an average sized house (2,352 SF not including basement) is shown in Table E-5-A. The results of the study indicate that the 2018 ERI targets can be achieved in large part by upgrading the efficiency of the heating and cooling equipment in combination with using an enclosure that meets the prescriptive code requirements. Therefore, this code change enables builders to rely on practical energy efficient construction practices to achieve code compliance.

Table E-5-A. Typical predicted HERS Indices for high efficiency heating and cooling equipment compared to 2015 IECC minimum requirements.

Climate Zone	HERS Index standard efficiency	HERS Index high efficiency	2015 ERI Target	2018 ERI Target
1	72.7	64.0	52	57
2	71.1	59.7	52	57
3	67.0	58.0	51	57
4	70.4	61.6	54	62
5	71.1	62.2	55	61
6	66.5	59.6	54	61
7,8	63.9	57.7	53	58

In a follow-up study[16], analysis of select zones and additional energy measures, including high efficiency lighting and appliances, balanced whole-house mechanical ventilation (ERV or HRV), and reduced

[15] Equivalency Between IECC Prescriptive Path and IECC Energy Rating Index, Oct 2016.
[16] Equivalency Between IECC Prescriptive Path and IECC Energy Rating Index: Alternative High Efficiency Appliances Scheme, Oct 2016

infiltration (1.5 ACH), further indicates options for achieving the revised 2018 ERI targets if additional level of energy savings is needed. The incremental results of this analysis are summarized in Table E-5-B.

Table E-5-B. Average predicted HERS Index improvement compared to standard efficiency house.

Average predicted HERS Index improvement compared to standard efficiency house			
Climate Zone	**High eff. Lights & Appliances**	**HRV or ERV**	**1.5 ACH50**
1	5.2	1.0	0.6
4	3.7	3.7	2.0
7	2.7	4.7	4.0

Applicability of Code Change:

This code change is applicable in all climate zones.

E-6 (RE127)

IECC Section R404.1 Lighting Equipment (IRC Section N1104.1)

Summary of Code Change:

The code change increases the percent of permanently installed lighting fixtures that must contain high-efficacy lamps from 75% to 90%.

Cost Implication of Code Change:

The revised percent of fixtures that must contain high efficacy lamps will result in a slight cost increase. Incandescent and halogen bulbs will generally not meet the efficacy requirements in the IECC to qualify as a “high-efficacy lamp” (60 lumens per watt for greater than 40 watts) and, by definition, all CFL and LED lamps would be classified as high-efficacy.

Based on surveys of big box retailers, the average cost of an incandescent 60-watt lamp is $0.97, the average cost of a 60-watt equivalent CFL lamp (13 -watt, 800 lumens) is $2.20, and the average cost of a 60-Watt equivalent LED lamp (10-Watt, 800 lumens) is $1.97.

Assuming the average home requires 40 lamps for the permanently installed fixtures, this would require a net increase of 6 high-efficacy lamps per house. The resultant cost increase is shown in Table E-6-A.

Table E-6-A. Cost increase for increased number of high efficacy lamps

Component	Unit	Material	Labor	Total	w/O&P	Qty	Cost ($)
60W incandescent lamp	EA	0.97		0.97	1.07	(6)	(6.40)
60W equivalent LED lamp	EA	1.97		1.97	2.17	6	13.00
Total to Builder							**6.60**
Total to Consumer							**7.85**

Applicability of Code Change:

This code change is a mandatory requirement that is applicable to all homes in all climate zones.

M-1 (RM36)

IRC M1601.4.1 Joints, seams and connections (ducts).

Summary of Code Change:

The code change eliminates the requirement for sealing longitudinal seams of snap-lock and button-lock types of HVAC ducts located inside of conditioned space.

Cost Implication of Code Change:

The code change represents a cost savings where metal ducts with longitudinal seams are installed inside conditioned space.

The cost analysis focuses on cost savings per linear foot of metal duct inside conditioned space for the reference houses. Consistent with the 2012 IRC cost study, the reference houses are assumed to have a main trunk serving each story. Ducts are assumed to be metal snap-lock when located within the first and second floor framing and insulated flexible duct in attics. Rectangular metal ducts are assumed to have two longitudinal seams, and round metal ducts are assumed to have one longitudinal seam.

All ducts for Reference House 1 are assumed to be in the attic so there is no cost savings. For Reference House 2, 40% of the ducts are assumed to be inside conditioned space (the first floor is approximately 40% of the total floor area of this house). For Reference Houses 3 and 4, all ducts are inside conditioned space.

Table M-1-A shows the estimated cost of sealing metal ducts using duct mastic applied with a brush. The material and labor costs are based on product manufacturer data for typical applications (125 linear feet per gallon of mastic; one-hour labor per gallon), internet pricing (for material cost), and RSMeans (for labor cost). Table M-2-B shows the cost savings to not install duct mastic on longitudinal seams of ducts inside conditioned space for the reference houses.

Table M-1-A. Estimated cost to seal ducts ($/LF).

Component	Unit	Material	Labor	Total	w/O&P
Duct Mastic	LF	0.17	0.32	0.49	0.70

Table M-1-B. Estimated cost savings for not sealing longitudinal seams of ducts inside conditioned space.

Component	Units	Reference House			
		1	2	3	4
6" Branch - Flexible (no seams)	LF	216	180	N/A	N/A
Trunk Line	LF	144	168	128	128
Vertical Supply - seams	LF	14	25	14	20
Return - seams	LF	28	50	28	40
6" Branch, metal - seams	LF	N/A	144	248	378
Longitudinal seams, total	LF	186	387	418	566
Longitudinal seams, sealing not required	LF	0	(155)	(418)	(566)
Cost to Seal Ducts (from Table M-1-A)	$/LF	0.70	0.70	0.70	0.70
Total cost to Builder	**$**	**0.00**	**(108.36)**	**(292.60)**	**(396.20)**
Total cost to Consumer	**$**	**0.00**	**(128.95)**	**(348.19)**	**(471.48)**

Applicability of Code Change:

This code change is applicable for houses where metal ducts with longitudinal seams are installed inside conditioned space.

APPENDIX B:
LOCATION ADJUSTMENT FACTORS

State	City	Cost Adjustment Factor	State	City	Cost Adjustment Factor
Alabama	Birmingham	0.84	Montana	Billings	0.88
Alabama	Mobile	0.84	Nebraska	Omaha	0.89
Alaska	Fairbanks	1.27	Nevada	Las Vegas	1.01
Arizona	Phoenix	0.85	New Hampshire	Portsmouth	0.95
Arizona	Tucson	0.84	New Jersey	Jersey City	1.19
Arkansas	Little Rock	0.80	New Mexico	Albuquerque	0.83
California	Alhambra	1.16	New York	Long Island City	1.41
California	Los Angeles	1.15	New York	Syracuse	1.01
California	Riverside	1.14	North Carolina	Charlotte	0.96
California	Stockton	1.19	North Carolina	Greensboro	0.96
Colorado	Boulder	0.91	North Carolina	Raleigh	0.94
Colorado	Colorado Springs	0.84	North Dakota	Fargo	0.88
Colorado	Denver	0.87	Ohio	Columbus	0.91
Connecticut	New Haven	1.11	Oklahoma	Oklahoma City	0.82
Delaware	Dover	1.02	Oklahoma	Tulsa	0.82
District of Columbia	Washington, D.C.	0.90	Oregon	Bend	1.00
Florida	Fort Meyers	0.80	Pennsylvania	Norristown	1.10
Florida	Miami	0.81	Pennsylvania	State College	0.93
Florida	Orlando	0.83	Rhode Island	Providence	1.08
Florida	Tampa	0.83	South Carolina	Greenville	0.94
Georgia	Atlanta	0.89	Tennessee	Memphis	0.84
Hawaii	Honolulu	1.21	Texas	Austin	0.79
Idaho	Boise	0.90	Texas	Dallas	0.84
Illinois	Carbondale	1.01	Texas	Houston	0.82
Indiana	Indianapolis	0.92	Texas	San Antonio	0.81
Iowa	Des Moines	0.92	Utah	Ogden	0.80
Kansas	Wichita	0.84	Utah	Provo	0.81
Kentucky	Louisville	0.87	Utah	Salt Lake City	0.82
Louisiana	Baton Rouge	0.86	Vermont	Burlington	0.93
Maine	Portland	0.91	Virginia	Fairfax	1.01
Maryland	Baltimore	0.92	Virginia	Winchester	1.02
Michigan	Ann Arbor	1.00	Washington	Tacoma	1.02
Minnesota	St. Paul	1.05	West Virginia	Charleston	0.95
Mississippi	Biloxi	0.84	Wisconsin	La Crosse	0.98
Missouri	Springfield	0.89	Wyoming	Casper	0.81

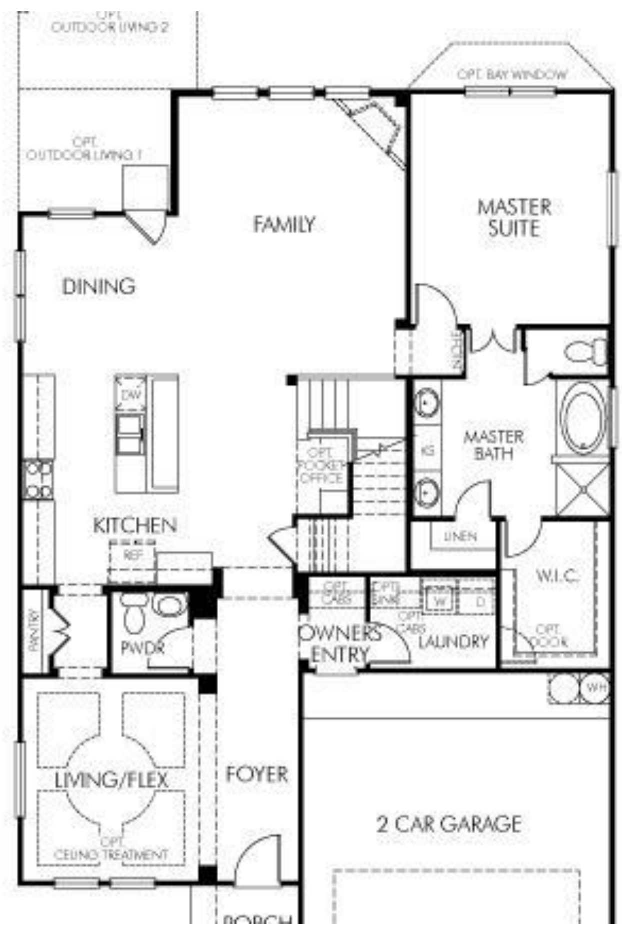
Source: RSMeans *Residential Cost Data 2017*.

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

Courtesy: LionsGate Homes at The Creekside

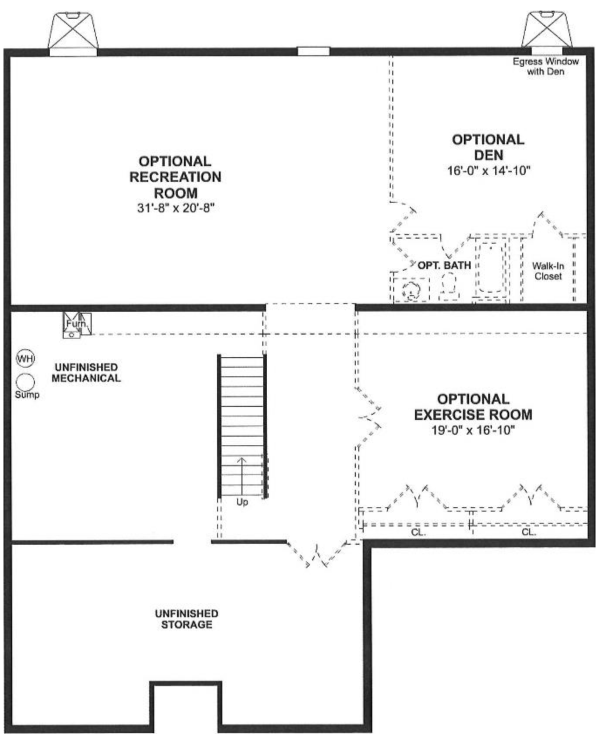
APPENDIX D:
TWO-STORY HOUSE WITH SLAB FOUNDATION (REFERENCE HOUSE 2)

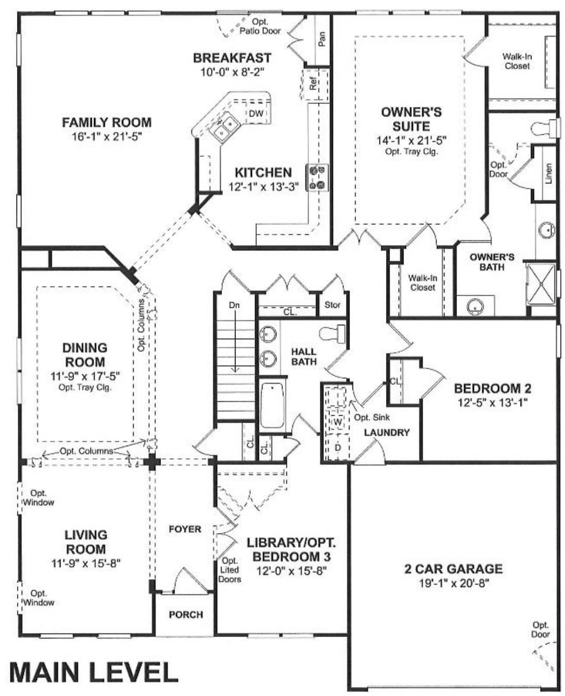
Courtesy: Meritage Homes at Riverstone



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

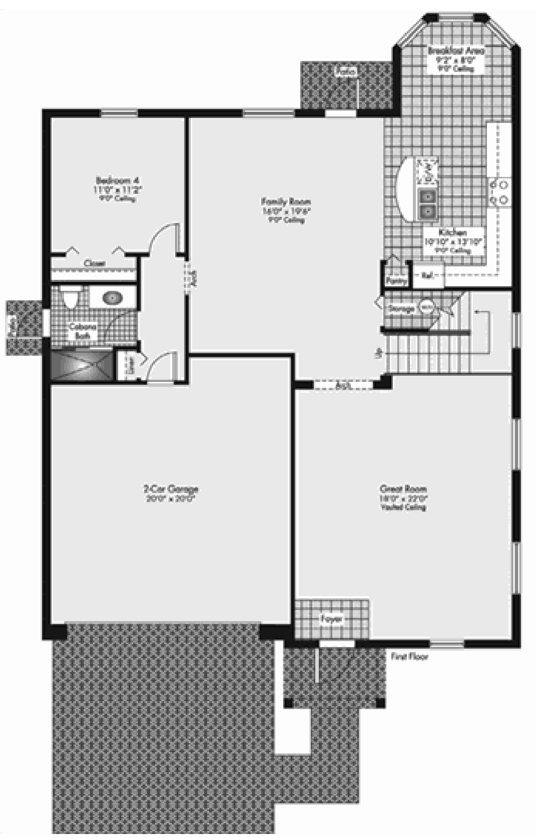
Courtesy: K Hovnanian Four Seasons at New Kent Vineyards

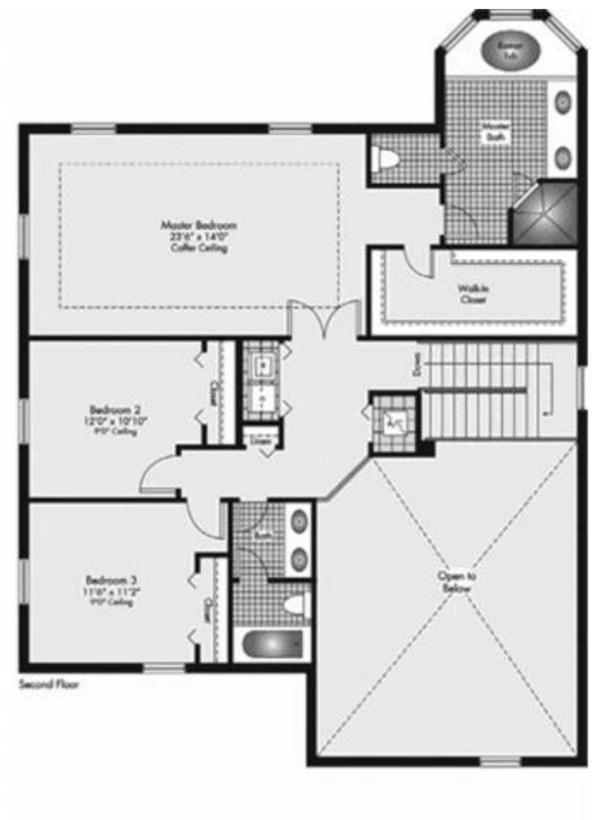




APPENDIX F:
TWO-STORY HOUSE WITH BASEMENT FOUNDATION (REFERENCE HOUSE 4)

Courtesy: Lennar at Sorento Estates





APPENDIX G:
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