DOCKETED	
Docket Number:	18-BSTD-02
Project Title:	2019 ENERGY CODE COMPLIANCE MANUALS
TN #:	224401
Document Title:	NRMCA Comments Update R-value ICF products on CEC Appendix
Description:	N/A
Filer:	System
Organization:	National Ready Mixed Concrete Association (NRMCA)/Tien Peng
Submitter Role:	Public
Submission Date:	8/3/2018 2:54:18 PM
Docketed Date:	8/3/2018

Comment Received From: Tien
Submitted On: 8/3/2018
Docket Number: 18-BSTD-02

Update R-value ICF products on CEC Appendix

The National Ready Mixed Concrete Association (NRMCA) would like to submit updates to the 2019 Reference Appendices Table 4.3.13 â€“ Thermal Properties of Insulating Concrete Forms by providing current thermal performance values for the foam being used in the wall assembly. I have attached a PDF version of the updated Table 4.3.13 which shows the edited U-factors, R-values, notes and assumptions highlighted in yellow. I have also attached supporting documents that show the calculations for the updated values and the ASTM C578 Type II EPS R-value per inch test data. Along with updating the tables values we would also like to submit updates to the 2016 Residential and Nonresidential Manuals to provide clarifying descriptions and photos of ICF construction. The attached Word document shows the existing language along with the proposed residential and nonresidential language for the compliance manuals. For the Residential Compliance Manual we would like to replace the existing language with the attached updated language. With the Nonresidential Compliance Manual we would like for the ICF description to be located after section 3.5.1 which will be similar to how it is presented in the Residential Compliance Manual.

This application comment was submitted previously and we were informed that the CEC is limited to using the minimal listed R-value that is shown the Bureau of Home Furnishings and Thermal Insulation directory (which are below the R-4 value noted here). The request is to decouple the CEC Appendix from the Bureauâ€™s directory or have the Bureau take steps to update their out-of-date directory.

Thank you for the opportunity to participate in the 2019 Standards Rulemaking and for the consideration of our comments.

Tien Peng
Vice President of Sustainability Codes and Standards, NRMCA

Additional submitted attachment is included below.

Table 4.3.13 – Thermal Properties of Insulating Concrete Forms

Insulation Type	Insulation Thickness Per Side (Total R-Value)	Performance Factor		Flat[1] Concrete Core Thickness (inches) 4	6	8	10	12	Waffle Grid[2] 6	8	Screen Grid[2] 6
				A	B	C	D	E	F	G	H
EPS[3]	2.0 (16.0)	U-factor	1	0.056	0.055	0.055	0.054	0.054	0.047	0.039	0.041
		HC		12.20	17.00	21.80	26.60	31.40	13.90	15.87	12.10
	2.25 (18.9)	U-factor	2	0.048	0.048	0.048	0.047	0.047	0.043	0.036	0.038
		HC		12.22	17.02	21.82	26.62	31.42	13.92	15.89	12.11
	2.5 (20.0)	U-factor	3	0.046	0.045	0.045	0.045	0.044	0.040	0.034	0.036
		HC		12.24	17.04	21.84	26.64	31.44	13.94	15.91	12.13
	2.625 (21.0)	U-factor	4	0.044	0.043	0.043	0.043	0.042	0.038	0.033	0.035
		HC		12.25	17.05	21.85	26.65	31.45	13.95	15.92	12.14
	2.75 (22.0)	U-factor	5	0.042	0.042	0.041	0.041	0.041	0.037	0.032	0.0323
		HC		12.26	17.06	21.86	26.66	31.46	13.96	15.92	12.15
	3.0 (24.0)	U-factor	6	0.039	0.038	0.038	0.038	0.038	0.0334	0.030	0.031
		HC		12.27	17.07	21.87	26.67	31.47	13.98	15.94	12.17
	3.5 (28.0)	U-factor	7	0.033	0.033	0.033	0.033	0.033	0.030	0.027	0.028
		HC		12.31	17.11	21.91	26.71	31.51	14.01	15.98	12.21
	4.0 (32.0)	U-factor	8	0.029	0.029	0.029	0.029	0.029	0.027	0.024	0.025
		HC		12.35	17.15	21.95	26.75	31.55	14.05	16.02	12.24
XPS	2.0 (20.0)	U-factor	9	0.045	0.045	0.045	0.044	0.044	NA	NA	NA
		HC		12.29	17.09	21.89	26.69	31.49	NA	NA	NA
	2.5 (25.0)	U-factor	10	0.037	0.037	0.036	0.036	0.036	NA	NA	NA
		HC		12.35	17.15	21.95	26.75	31.55	NA	NA	NA
	2.625 (26.3)	U-factor	11	0.035	0.035	0.035	0.035	0.034	NA	NA	NA
		HC		12.36	17.16	21.96	26.76	31.56	NA	NA	NA
	2.75 (27.5)	U-factor	12	0.034	0.034	0.033	0.033	0.033	NA	NA	NA
		HC		12.38	17.18	21.98	26.78	31.58	NA	NA	NA
	3.0 (30.0)	U-factor	13	0.031	0.031	0.031	0.031	0.030	NA	NA	NA
		HC		12.41	17.21	22.01	26.81	31.61	NA	NA	NA
	3.5 (35.0)	U-factor	14	0.027	0.027	0.027	0.027	0.026	NA	NA	NA
		HC		12.46	17.26	22.06	26.86	31.66	NA	NA	NA
	4.0 (40)	U-factor	15	0.024	0.024	0.024	0.023	0.023	NA	NA	NA
		HC		12.52	17.32	22.12	26.92	31.72	NA	NA	NA
Polyurethane	1.5 (9.09)	U-factor	16	0.050	0.049	0.049	0.048	0.048	NA	NA	NA
		HC		12.23	17.03	21.83	26.63	31.43	NA	NA	NA
	2.0 (10.9)	U-factor	17	0.042	0.042	0.041	0.041	0.041	NA	NA	NA
		HC		12.41	17.21	22.01	26.81	31.61	NA	NA	NA
	4.5 (20.95)	U-factor	18	0.023	0.023	0.023	0.022	0.022	NA	NA	NA
		HC		12.58	17.38	22.18	26.98	31.78	NA	NA	NA
Cement/EPS Compound	2.0 (12.0)	U-factor	19	NA	NA	NA	NA	NA	0.059	0.048	0.052
		HC		NA	NA	NA	NA	NA	16.49	18.46	14.69
	3.0 (18.0)	U-factor	20	NA	NA	NA	NA	NA	0.043	0.037	0.040
		HC		NA	NA	NA	NA	NA	17.50	19.47	15.69
	4.0 (24.0)	U-factor	21	NA	NA	NA	NA	NA	0.034	0.031	0.032
		HC		NA	NA	NA	NA	NA	18.51	20.47	16.70

Notes:

[1] Flat Insulated Concrete Forms utilizes rigid insulation as the form and do not use cement compound as the form.

[2] Waffle and screen type Insulated Concrete Forms typically utilize either a cement/EPS compound or EPS insulation as the form. ICF's using the cement/EPS compound do not utilize rigid insulation added to the interior and exterior surfaces.

[3] 1.5 lb density EPS insulation at R-4.0 per inch except for the 2.25" insulation thickness which uses 2.0 lb density EPS at R-4.2 per inch.

This table provides thermal performance information for insulating concrete forms.

Insulating Concrete Forms (ICFs) are concrete forming systems that use stay-in-place panels made from a variety of insulating materials for constructing cast-in-place solid concrete walls. There are three basic types of ICFs: flat wall, waffle-grid and screen-grid. A flat wall system is a wall with uniform thickness just like a conventional poured wall made with plywood or metal forms. Waffle-grid wall systems have a solid concrete wall of varying thickness and look like a breakfast waffle. Screen grid wall systems also known as , "post and beam", have a perforated concrete wall of varying thickness similar to the waffle type wall systems but with a solid form material between the horizontal and vertical members instead of concrete. The insulating panels for all three ICF types are most commonly made from expanded polystyrene (EPS) and extruded polystyrene (XPS) rigid insulation boards. Plastic or metal cross-ties separate the insulating

panels and provide structural integrity during the pour. The ICF system is modular and stackable with interlocking edges. The materials can be delivered as pre-assembled blocks or as planks that require the flanges and web to be assembled during construction.

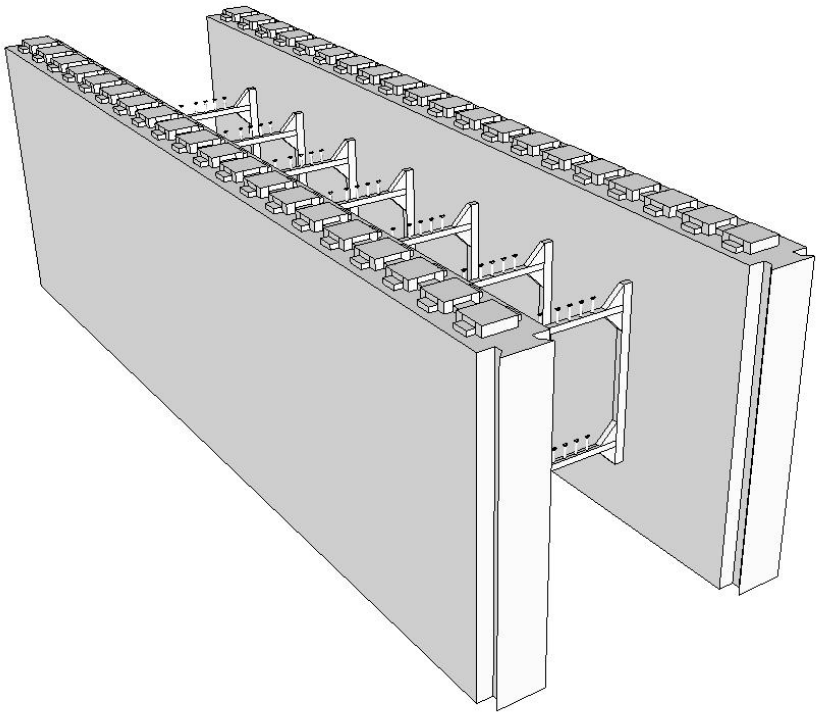

Figure 4.3.13 – Insulating Concrete Forms

Assumptions: Values in this table were calculated using the one dimensional calculation method documented in 2009 ASHRAE Handbook of Fundamentals. The calculations assume an exterior air film of R-0.17, a 7/8 inch layer of stucco of R-0.18, an exterior insulating form of varying resistance, a concrete core of varying thickness at R-0.11 per inch, an interior insulating form of varying resistance, 1/2 inch gypsum wallboard of R-0.45, and an interior air film of R-0.68. The R-value of the cement/EPC compound is assumed to be R-3.0 per inch, the XPS insulation assumed to be R-5.0 per inch, and the polyurethane assumed to be aged and dried in 1.5 inch, 2.0 inch, and 4.5 inch thickness.

ASTM C578
EPS THERMAL INSULATION PERFORMANCE REQUIREMENTS

Property	Units	ASTM Test	Type I	Type VIII	Type II	Type IX	Type XIV	Type XI	Type XV
Density	pcf, minimum	C303	0.90	1.15	1.35	1.80	2.40	0.70	3.0
Thermal Resistance Values (R)	Per inch thickness at 75° F (23.9° C)	C518	3.60	3.80	4.00	4.20	4.20	3.10	4.30
Compressive Resistance 10% Deformation	psi, minimum	D1621	10	13	15	25	40	5	60
Flexural Strength	psi, minimum	C203	25	30	35	50	60	10	75
Water Vapor Permeability	perm-in; maximum	E96	5.0	3.5	3.5	2.5	2.5	5.0	2.5
Water Absorption By Total	% by Vol Max	C272	4.0	3.0	3.0	2.0	2.0	4.0	2.0

EPS Insulation may be manufactured to meet or exceed the requirements of ASTM C578, *Standard Specification for Rigid Cellular, Polystyrene Thermal Insulation*, and applicable building codes.

For more information about ASTM C578-15b, visit http://www.astm.org/Standards/C578.htm.

EPS Industry Alliance

1298 Crosnon Blvd., Suite 201
Crofton, MD 21114
(800)-607-3772
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2016 Compliance Manual (Existing Language)
Building Envelope Requirements—Envelope Features
E. Insulating Concrete Forms (ICF)
RA3.5.8

Insulating concrete forms (ICFs) is a system of formwork for concrete that stays in place as permanent building insulation is used for cast-in-place, reinforced above- and below-grade concrete walls, floors, and roofs. ICFs are interlocking modular units that can be dry-stacked without mortar) and filled with concrete as a single concrete masonry unit (CMU). ICFs lock together externally and have internal metal or plastic ties to hold the outer layer(s) of insulation to create a concrete form for the structure walls, roof/ceilings, or floors of a building. ICFs are manufactured from several materials, including expanded and extruded polystyrene foam, polyurethane foam, cement-bonded wood fiber, and cement-bonded polystyrene beads.

Three factors contribute to the energy efficiency of buildings using an ICF wall:
1. Continuous rigid insulation on both sides of a high-mass core,
2. Elimination of thermal bridging from wood framing components, and
3. A high degree of air-tightness inherent to this method of construction.

Climate Zones with large daily temperature fluctuations have the greatest potential to benefit from the time lag and temperature dampening effects of these high-mass envelope systems. However, this combination of mass and insulation is beneficial in almost all climates, with the possible exception of mild coastal climate zones.

There are three basic types of ICFs: flat wall, waffle-grid and screen-grid. A flat wall ICF results in a wall with a consistent and continuous thickness of concrete. A waffle-grid ICF creates a concrete waffle pattern, an uninterrupted grid, with some concrete sections thicker than others. A screen-grid ICF consists of a discrete post-and-beam structure with the concrete completely encapsulated by the foam insulation, except at the intersection of posts and beams. The insulating panels for all three ICF types are most commonly made from expanded polystyrene (EPS) and extruded polystyrene (XPS) rigid insulation boards. Insulating panels are also made from polyurethane, composites of cement and EPS, and composites of cement and shredded wood fiber, although these tend to be proprietary materials developed by the ICF manufacturer.

Plastic or metal cross-ties, consisting of two flanges and a web, separate the insulating panels and provide structural integrity during the pouring of concrete, resulting in a uniform wall thickness. A variety of wall thicknesses can be obtained by changing the length of the web. The area of attachment of the cross-ties to the insulating form provides a secure connection surface located at standard spacings for mechanical attachment of finished materials to the interior and exterior of the wall. ICFs can be used to construct load-bearing and non-load-bearing walls and above- and below-grade walls, and can be designed to structurally perform in any seismic zone.

The ICF system is modular and stackable with interlocking edges. The materials can be delivered as preassembled blocks or as planks that require the flanges and web to be assembled during construction. The forms vary in height from 12” - 24” and are either 4’ or 8’ long. Vertical panels come in similar modules but are stacked vertically. ICF panels are typically available with core thickness ranging from 4” to 12”.

The thermal aspects of ICFs are represented in JA4, Table 4.3.13

2016 Residential Compliance Manual (Expanded / Edited Language)
Building Envelope Requirements—Envelope Features
E. Insulating Concrete Forms (ICF)
RA3.5.8

Insulating Concrete Forms (ICFs) is a system of framework for concrete that stays in place as permanent building insulation. It is used for cast-in-place, reinforced above- and below- grade concrete walls, floors, and roofs. ICF's are interlocking modular units which can be dry-stacked (without mortar) and filled with concrete ~~as a single concrete masonry unit (CMU)~~. ICF's lock together externally and have internal ~~metal or~~ plastic ties to hold the outer layer(s) of insulation. Reinforcing steel bars (rebar) placed inside the forms before concrete is poured give the concrete flexural strength. The forms are filled with concrete in 1' to 12' high lifts to manage the concrete pressure and reduce the risk of blowouts.

Insulating concrete forms are manufactured from several materials, including expanded and extruded polystyrene foam, polyurethane foam, cement-bonded wood fiber, and cement-bonded polystyrene beads. ICF construction sandwiches a heavy, high-strength material (reinforced concrete) between two layers of light-weight, high-insulated foam. This combination creates a wall with an unusually good combination of desirable properties: air tightness, strength, sound attenuation, insulation, and mass.

Three factors contribute to the energy efficiency of buildings using an ICF wall, including:

1. Continuous rigid insulation on both sides of a high-mass core,
2. Elimination of thermal bridging from wood framing components, and
3. High degree of air tightness inherent to this method of construction.

Climate zones with large daily temperature fluctuations have the greatest potential to benefit from the time lag and temperature dampening effects of these high-mass envelope systems. However, this combination of mass and insulation is beneficial in almost all climates.

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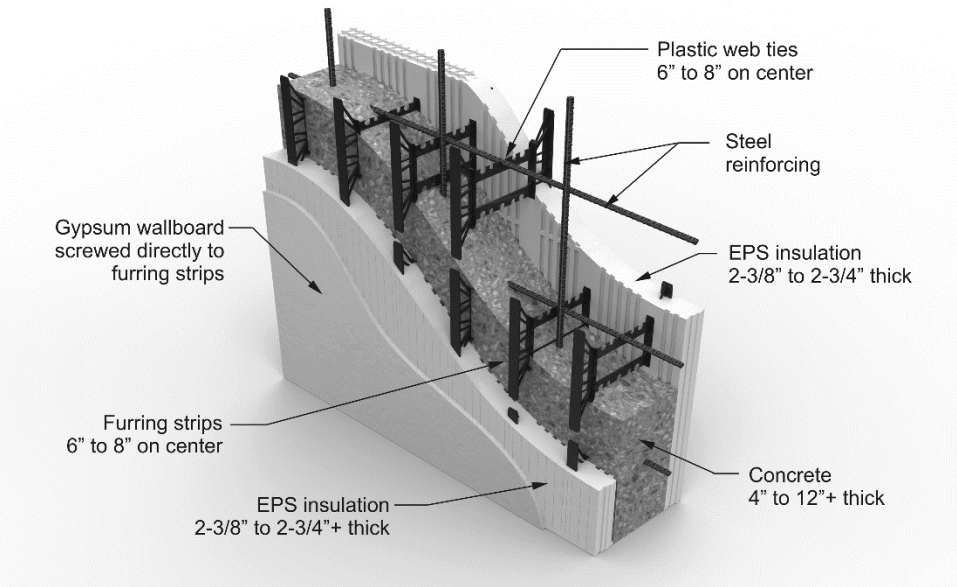
Plastic ~~or metal~~ cross-ties, consisting of two flanges and a web, separate the insulating panels and provide structural integrity during the pouring of concrete, resulting in a uniform wall thickness (see Figure 1). A variety of wall thicknesses can be obtained by changing the length of the web. The area of attachment of the cross-ties to the insulating form provides a secure connection surface located at standard spacings for mechanical attachment of finished materials to the interior and exterior of the wall. ICF can be used to construct load-bearing and non-load-bearing walls and above- and below-grade walls, and can be designed to structurally perform in any seismic zone.

Figure 1: ICF Wall Construction



Source: National Ready Mixed Concrete Association

The ICF system is modular and stackable with interlocking edges (see Figure 2). The materials can be delivered as preassembled blocks or as planks that require the flanges and web to be assembled during construction. The forms vary in height from 12" – 24" and are either 4' or 8' long. Vertical panels come in similar modules but are stacked vertically. ICF panels are typically available with core thickness ranging from 4" to 12".

The thermal aspects of ICFs are represented in the JA4, Table 4.3.13.

Figure 2: ICF Construction Process

Source: National Ready Mixed Concrete Association

2016 Nonresidential Compliance Manual (Proposed Language)

(Propose inserting after section 3.5.1 in the 2016 NonRes Compliance Manual)

Insulating Concrete Forms (ICF) are useful for the construction of nonresidential commercial and high-rise buildings. ICFs benefits for multifamily housing include thermal performance, noise elimination between party walls, strength and fire resistance. ICFs is a system of framework for concrete that stays in place as permanent building insulation. It is used for cast-in-place, reinforced above- and below- grade concrete walls, floors, and roofs. ICF's are interlocking modular units which can be dry-stacked (without mortar) and filled with ~~concrete as a single concrete masonry unit (CMU)~~. ICF's lock together externally and have internal ~~metal or~~ plastic ties to hold the outer layer(s) of insulation. Reinforcing steel bars (rebar) placed inside the forms before concrete is poured give the concrete flexural strength. The forms are filled with concrete in 1' to 12' high lifts to manage the concrete pressure and reduce the risk of blowouts.

Insulating concrete forms are manufactured from several materials, including expanded and extruded polystyrene foam, polyurethane foam, cement-bonded wood fiber, and cement-bonded polystyrene beads. ICF construction sandwiches a heavy, high-strength material (reinforced concrete) between two layers of light-weight, high-insulated foam. This combination creates a wall with an unusually good combination of desirable properties: air tightness, strength, sound attenuation, insulation, and mass.

Three factors contribute to the energy efficiency of buildings using an ICF wall, including:

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2. Elimination of thermal bridging from wood framing components, and
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Plastic ~~or metal~~ cross-ties, consisting of two flanges and a web, separate the insulating panels and provide structural integrity during the pouring of concrete, resulting in a uniform wall thickness. A variety of wall thicknesses can be obtained by changing the length of the web. The area of attachment of the cross-ties to the insulating form provides a secure connection surface located at standard spacings for mechanical attachment of finished materials to the interior and exterior of the wall. ICF can be used to construct load-bearing and non-load-bearing walls and above- and below-grade walls, and can be designed to structurally perform in any seismic zone.

The ICF system is modular and stackable with interlocking edges (see Figure 2). The materials can be delivered as preassembled blocks or as planks that require the flanges and web to be assembled during construction. The forms vary in height from 12" – 24" and are either 4' or 8' long. Vertical panels come in similar modules but are stacked vertically. ICF panels are typically available with core thickness ranging from 4" to 12".

The thermal aspects of ICFs are represented in the JA4, Table 4.3.13.

Figure 3: ICF Construction Process

Source: National Ready Mixed Concrete Association

Configuration	Total Thermal Resistance	
	R-value	U-value
Exterior Air Film	0.17	5.882
Stucco (7/8 inch)	0.18	5.556
~~Building Paper~~		
Exterior Insulating Foam	8	0.125
Concrete (R0.11/inch)	0.44	2.273
Interior Insulating Foam	8	0.125
Gypsum Wallboard	0.45	2.222
Interior Air Film	0.68	1.471
Total	17.92	0.056

Type II EPS Foam (1.50 pcf density) - R/inch
4
Concrete - R/inch
0.11

Insulation Type	Insulation Thickness Per Side (Total R-Value)	Performance Factor		Flat					Waffle Grid		Screen Grid
				Concrete Core Thickness (Inches)							
				4	5	6	8	10	12	6	8
				A	B	C	D	E	F	G	H
EPS	2	U-factor	1	0.056	0.055	0.055	0.054	0.054			
	16.0	HC									
	2.25	U-factor	2	0.048	0.048	0.048	0.047	0.047			
	18.9	HC									
	2.5	U-factor	3	0.046	0.045	0.045	0.045	0.044			
	20.0	HC									
	2.625	U-factor	4	0.044	0.043	0.043	0.043	0.042			
	21.0	HC									
	2.75	U-factor	5	0.042	0.042	0.041	0.041	0.041			
	22.0	HC									
	3	U-factor	6	0.039	0.038	0.038	0.038	0.038			
	24.0	HC									
	3.5	U-factor	7	0.033	0.033	0.033	0.033	0.033			
	28.0	HC									
	4	U-factor	8	0.029	0.029	0.029	0.029	0.029			
	32.0	HC									