

# Product Information Bulletin

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## CCMC Evaluation Report 13101-R Advantage Insulating Concrete Forming (ICF) System

Canadian Construction Materials Centre (CCMC) **Evaluation Report** 13101-R addresses the Advantage ICF System®. CCMC **Evaluation Report** 13101-R provides the following opinion under section 1:

It is the opinion of the Canadian Construction Materials Centre (CCMC) that “Advantage Insulating Concrete Forming (ICF) System” when used as an insulated concrete form in accordance with the conditions and limitations stated in Section 3 of this Report, complies with the National Building Code 2005.

Refer to the attached copy of CCMC evaluation report 13101-R for additional detail.

### **NOTES:**

1. The NBC 2005 introduced prescriptive requirements for construction of above and below grade concrete walls using ICF systems. These requirements have been adopted by Provincial jurisdictions that adopt the NBC 2005 by legislation including the Alberta Building Code 2006, British Columbia Building Code 2006 and 2006 Ontario Building Code. The following design assumptions apply to NBC 2005 prescriptive design requirements:
  - the maximum floor to floor wall height is 3 meters (10 feet)
  - the supported roof span does not exceed 10 meters (33 feet)
  - the supported floor span does not exceed 4.9 meters (16 feet)
  - the building is located in an area where the seismic peak ground acceleration, PGA, factor is less than 0.2 for below-grade wall applications or the spectral response acceleration,  $S_a(0.2)$ , factor is less than 0.4 for above-grade wall applications.For a more detailed description of applicable code requirements see Advantage ICF System Product Information Bulletin No. 207.
2. The Advantage ICF System **Technical Manual** provides *additional* proprietary reinforcement tables. The design assumptions used in the development of the Advantage proprietary reinforcement tables comply with NBC 2005 design requirements and are provided with each reinforcement table.



## Evaluation Report CCMC 13101-R

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# Advantage Insulating Concrete Forming (ICF) System

## 1. Opinion

It is the opinion of the Canadian Construction Materials Centre (CCMC) that “Advantage Insulating Concrete Forming (ICF) System” when used as an insulated concrete form in accordance with the conditions and limitations stated in Section 3 of this Report, complies with the National Building Code 2005:

- Clause 1.2.1.1.(1)(a), Division A, using the following acceptable solutions from Division B:
  - Article 4.1.1.3. Design Requirements (structural loads and procedures)
  - Article 4.3.3.1. Design Basis for Plain, Reinforced and Pre-stressed Concrete
  - Subsection 9.3.1. Concrete
  - Section 9.4. Structural Requirements
  - Clause 9.15.1.1.(1)(c) General (footings and foundations)
  - Article 9.15.3.3. Application of Footing Width and Area Requirements
  - Clause 9.15.3.5.(1)(c) Adjustment to Footing Widths for Exterior Walls
  - Clause 9.20.1.1.(1)(b) General (masonry and insulating concrete form walls not in contact with the ground)
  - Sentence 9.20.1.1.(2) General (masonry and insulating concrete form walls not in contact with the ground)
  - Subsection 9.20.17. Above-Ground Flat Insulating Concrete Form Walls
- Clause 1.2.1.1.(1)(b), Division A, as an alternative solution that achieves at least the minimum level of performance required by Division B in the areas defined by the objectives and functional statements attributed to the following applicable acceptable solutions:
  - Subsection 9.15.4. Foundation Walls
  - Article 9.20.1.2. Earthquake Reinforcement

This opinion is based on CCMC's evaluation of the technical evidence in Section 4.1 provided by the Report Holder.

## 2. Description

The product is a modular, interlocking concrete form system consisting of two expanded polystyrene panels. Embedded in the polystyrene panels are polypropylene connectors that are equally spaced at 203 mm horizontally for the 150 mm concrete wall-form and 152 mm horizontally for the 200 mm concrete wall-form.

The polystyrene face panels have a preformed symmetrical interlocking EPS design along the top, bottom and vertical edges to facilitate stacking and alignment, as well as to prevent leakage of freshly placed concrete.

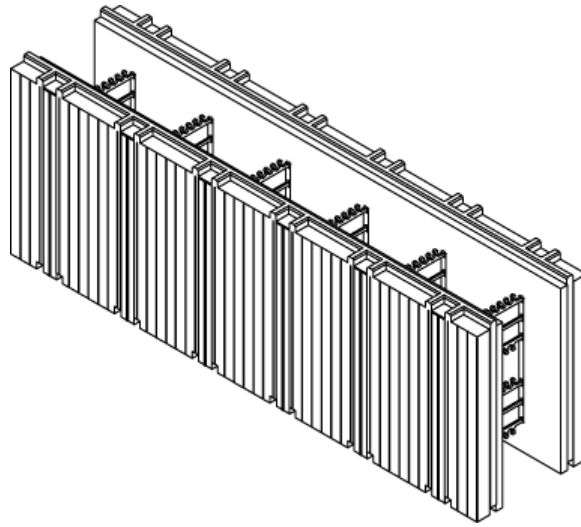
The units are dry-laid and stacked in a running (staggered) configuration. The stacked units form a rectangular space that, after being filled with concrete, results in an insulated, monolithic concrete wall of uniform thickness.

Reinforcement may be placed where required to satisfy strength requirements for above- or below-grade loadbearing walls, beams, lintels and shear walls.

The units have external dimensions of 1219 mm in length and 419 mm in height. The polystyrene panels are each 67 mm thick, resulting in an overall wall thickness of 286 mm or 336 mm for the 150 mm or 200 mm concrete wall-form.

“Advantage Insulating Concrete Forming (ICF) System” units are available in straight, 90-degree or 45-degree corner forms, Taper Top and Brick Ledge forms.

A standard unit is illustrated in Figure 1.



**Figure 1. “Advantage Insulating Concrete Forming (ICF) System” standard unit**

### **3. Conditions and Limitations**

CCMC's compliance opinion in Section 1 is bound by the “Advantage Insulating Concrete Forming (ICF) System” being used in accordance with the conditions and limitations set out below.

- The use of the product is permitted in the construction of houses and small buildings up to two storeys above grade and one storey below grade that fall under the provisions of Part 9 of Division B of the NBC 2005, subject to all of the conditions listed below.
- The structural applications of this product must be in strict accordance with the design analysis as prepared by Plasti-Fab Ltd., Report No. 09-11-03, dated November 3, 2009 Revised July 12, 2010, from which Tables 4.1.2.1.1 to 4.1.2.1.5 have been reproduced. When the product is used in structural applications outside the scope of the referenced design analysis, the engineering design analysis, related documents and drawings must bear the authorized seal of a registered professional engineer skilled in concrete design and licensed to practice under the appropriate provincial or territorial legislation. The engineer must certify that the construction provides a level of performance equivalent to that required by Part 4 and/or Part 9 of the NBC 2005.
- The maximum permitted building length is 24.4 m and the maximum permitted building width is 12.2 m. For buildings that exceed any of the above dimensions engineering is required on a case-by-case basis.
- For load-bearing walls and shear wall applications, the minimum core thickness of the product must be 150 mm.
- For non-load-bearing wall applications, the minimum core thickness of the product must be 100 mm.
- Concrete used with this system must comply with Subsection 9.3.1. of Division B of the NBC 2005. It must be Type 10 or Type 30 with a minimum compressive strength of 20 MPa and a maximum slump of  $150 \pm 12$  mm.
- The maximum aggregate size to be used in conjunction with this product must be no greater than 14 mm.
- For the wall heights indicated in Tables 4.1.2.1.1 and 4.1.2.1.2, the pouring of concrete must be made at a rate of 1.3 m per hour in consecutive lifts; each lift is limited to a maximum height of 1.3 m.
- All point loads, such as concentrated loads created by girder trusses, columns and beams, must bear directly on top of the concrete wall and must not be supported in any manner to create an eccentric loading on the concrete wall.
- Floor and roof connections to ICF walls must be designed to accommodate diaphragm action in seismic zones and zones of high wind pressure.
- The concrete must be cured a minimum of seven days before backfilling. The wall must be laterally supported at the top and bottom prior to backfilling.
- The EPS insulation used in this system must comply with CAN/ULC-S701-05, “Standard For Thermal Insulation, Polystyrene, Boards and Pipe Covering,” Type 2 as a minimum.
- The product's EPS insulation panels must be aged for at least three weeks from their date of manufacturing.
- The concrete wall must be constructed on a footing designed as per Article 9.15.3.4., Basic Footing Widths and Areas, of Division B of

the NBC 2005.

- The attachment of exterior cladding and interior finishing materials has not been assessed by the present evaluation.
- The interior face of the EPS panels must be protected from the inside of the building in accordance with Sentence 9.10.17.10.(1), Protection of Foamed Plastics, of Division B of the NBC 2005.
- For above-grade installations, the exterior face of the product must be protected with materials conforming to Article 9.20.6.4., Masonry Veneer, and Sections 9.27., Cladding, and/or 9.28., Stucco, of Division B of the NBC 2005.
- For below-grade installations, dampproofing must be provided in accordance with Article 9.13.2., Dampproofing, of Division B of the NBC 2005.
- Where hydrostatic pressure exists, waterproofing must be provided in accordance with Article 9.13.3., Waterproofing, of Division B of the NBC 2005.
- For foundation-wall installations, the backfill must be placed in such a way as to avoid damaging the wall, the exterior insulation panel and the waterproofing and dampproofing protection. The backfill material must be well drained and a drainage system must be installed around the footing in accordance with the requirements of the NBC 2005.
- The installation of the product must be in strict compliance with Advantage ICF Installation Manual dated September 1, 2009 without conflicting with the requirements stated in the NBC 2005 or in this report. Only installers trained and authorized by Plasti-Fab Ltd. shall be contracted to set up the wall system.

#### **4. Technical Evidence**

CCMC's Technical Guide for "Advantage Insulating Concrete Forming (ICF) System" sets out the nature of the technical evidence required by CCMC to enable it to evaluate a product as an acceptable or alternative solution in compliance with the NBC 2005. The Report Holder has submitted test results and documentation for CCMC's evaluation. Testing was conducted at independent laboratories recognized by CCMC. The corresponding test results for "Advantage Insulating Concrete Forming (ICF) System" are summarized below.

##### **4.1 NBC 2005 Compliance Data for "Advantage Insulating Concrete Forming (ICF) System" on which CCMC Based its Opinion in Section 1**

###### **4.1.1 Material Requirements**

###### **4.1.1.1 Conformance of the EPS**

Compliance of the expanded polystyrene thermal insulation with the requirements of CAN/ULC-S701-05 is covered under Intertek Testing Services (NA) Ltd. Certificate and / or Label service.

###### **4.1.2 Design Requirements**

###### **4.1.2.1 Conformance of Structural Capacity (Steel Reinforcement Designs)**

The design analysis in the Engineering Analysis Report provided to CCMC of walls using "Advantage Insulating Concrete Forming (ICF) System" provides a level of performance equivalent to that required by applicable provisions in Part 4 and/or Part 9 of Division B of the NBC 2005. The corresponding design analysis is summarized in Tables 4.1.2.1.1 to 4.1.2.1.5. The tables provide steel reinforcement specifications for a number of different wall and lintel applications based on specific structural loads. The design assumptions are indicated below each table.

**Table 4.1.2.1.1 Vertical and horizontal steel reinforcement for below-grade walls<sup>(1)</sup>**

Wall Height (m)	Backfill Height (m)	Max. Spacing for Vertical Reinforcement (mm)		Max. Spacing for Horizontal Reinforcement (mm)	
		150-mm Wall	200-mm Wall	150-mm Wall	200-mm Wall
2.44	1.22	10M @ 406	15M @ 610	10M @ 419	15M @ 419
	1.52	10M @ 406	15M @ 610	10M @ 419	15M @ 419
	1.83	10M @ 406	15M @ 610	10M @ 419	15M @ 419
	2.13	10M @ 305	15M @ 610	10M @ 419	15M @ 419
3.05	1.22	10M @ 406	15M @ 610	10M @ 419	15M @ 419
	1.52	10M @ 406	15M @ 610	10M @ 419	15M @ 419
	1.83	10M @ 305	15M @ 610	10M @ 419	15M @ 419
	2.13	10M @ 203	15M @ 610	10M @ 419	15M @ 419
	2.44	15M @ 305	15M @ 457	10M @ 419	15M @ 419
	2.74	15M @ 203	15M @ 305	10M @ 419	15M @ 419
3.66	1.22	10M @ 406	15M @ 610	10M @ 419	15M @ 419
	1.52	10M @ 406	15M @ 610	10M @ 419	15M @ 419
	1.83	10M @ 305	15M @ 610	10M @ 419	15M @ 419
	2.13	10M @ 203	15M @ 610	10M @ 419	15M @ 419
	2.44	15M @ 305	15M @ 457	10M @ 419	15M @ 419
	2.74	15M @ 203	15M @ 305	-	15M @ 419
	3.05	-	15M @ 203	-	15M @ 419
	3.35	-	15M @ 203	-	15M @ 419

**Notes to Table 4.1.2.1.1:**

- Table cells without a value indicate that the spacing is not feasible with respect to the proposed backfill height.

(1) Table 4.1.2.1.1 is based on the following assumptions:

- The design is applicable to all seismic zones.
- Maximum building width is 12.2 m.
- Maximum building length is 24.4 m.
- Maximum floor clear span is 6.1 m.
- Maximum roof clear span is 12.2 m with supports at mid-point.
- Maximum number of stories above grade is two (2).
- Maximum number of stories below grade is one (1).
- Roof slope from flat to maximum 1:1.
- Roof dead load is 0.72 kPa.
- Floor dead load is 0.72 kPa.
- Floor live load is 1.92 kPa.
- Snow load is 4.44 kPa.
- Surcharge load is 2.4 kPa.
- Loads include earth pressure and surcharge loads, plus gravity load. Gravity load assumes 2 ICF storeys and wood roof frame.
- Below grade walls are assumed to support a brick veneer with a maximum height of 7320 mm high, with an eccentricity of 220 mm for the 150 mm wall system and 245 mm for the 200 mm wall system.
- Design earth pressure 960kg/m<sup>3</sup> (equivalent fluid density).
- All above grade walls are assumed to be on top of the ICF foundation walls.
- Openings in the foundation wall shall be less than 1220 mm in width and the total openings in the wall are less than 25% of the wall area.
- When the length of the wall between windows is less than the average length of the windows, the wall is considered unsupported and additional engineering is required.
- Reinforcing bars shall be hard grade deformed bars conforming to CSA G30.18, “Carbon Steel Bars for Concrete Reinforcement,” Grade 400. Specified yield strength of reinforcement,  $f_y$ , is 400 MPa.
- Wall design detailing bends, placement, spacing, splicing and protection of reinforcement shall be in accordance with CSA A23.3 (R2000), “Design of Concrete Structures.”
- Minimum concrete cover for vertical reinforcement is 38 mm from the inside face (tension face) of concrete.
- Minimum concrete cover for horizontal reinforcement is 28 mm from the inside face of concrete.
- Two 10M bars shall be placed around all openings and extend 600 mm (24”) beyond each side of the openings.
- Minimum 28-day concrete yield strength of 20 MPa. Mix designs in accordance with the manufacturer's recommendations.

- Concrete shall be allowed to cure for a minimum of seven days prior to backfilling.
- Below-grade walls are considered to be supported by the floor system at the top.
- All materials and workmanship shall conform to the requirements of the NBC 2005 including any Revisions and Errata that have been released as of the issue date of this table.

**Table 4.1.2.1.2 Vertical and horizontal steel reinforcement for above-grade walls<sup>(1)</sup>**

Wall Height (m)	Max. Spacing for Vertical Reinforcement (mm)		Max. Spacing for Horizontal Reinforcement (mm)	
	150-mm Wall	200-mm Wall	150-mm Wall	200-mm Wall
Single-storey concrete construction supporting a wood-frame roof structure				
2.44	10M @ 406	15M @ 610	10M @ 419	15M @ 419
3.05	10M @ 406	15M @ 610	10M @ 419	15M @ 419
3.66	10M @ 203	15M @ 610	10M @ 419	15M @ 419
Ground floor concrete construction supporting a second storey wood frame and wood-frame roof structure				
2.44	10M @ 406	15M @ 610	10M @ 419	15M @ 419
3.05	10M @ 406	15M @ 610	10M @ 419	15M @ 419
3.66	10M @ 203	15M @ 610	10M @ 419	15M @ 419
Ground floor concrete construction supporting a second storey concrete construction and a wood-frame roof structure				
2.44	10M @ 406	15M @ 610	10M @ 419	15M @ 419
3.05	10M @ 406	15M @ 610	10M @ 419	15M @ 419
3.66	10M @ 203	15M @ 610	10M @ 419	15M @ 419

**Notes to Table 4.1.2.1.2:**

(1) Table 4.1.2.1.2 is based on the following assumptions:

- The design is applicable to seismic zones up to  $S_a(0.2) = 1.2$  for site Class C.
- Applicable to a maximum wind pressure of 3.18 kPa.
- For allowable building dimensions and floor and roof clear spans, see Note (1) to 4.1.2.1.1.
- For assumed loads, see Note (1) to Table 4.1.2.1.1.
- For concrete and steel material properties, see Note (1) to 4.1.2.1.1.
- Minimum concrete cover for vertical reinforcement is 38 mm from the inside face (tension face) of concrete.
- Minimum concrete cover for horizontal reinforcement is 28 mm from the inside face of concrete.
- Minimum two 10M bars should be placed around all openings and shall extend at least 600 mm beyond each corner of the opening.





**Notes to Tables 4.1.2.1.3(a) and 4.1.2.1.3(f):**

- Table cells without a value indicate that the load is not feasible. Engineering input is required.

(1) Tables 4.1.2.1.3(a) to 4.1.2.1.3(f) are based on the following assumptions:

- The factored uniformly distributed load includes live and dead loads, not including the weight of the lintel.
- The minimum height of the lintel is 210 mm for Tables 4.1.2.1.3(a) and (d); 419 mm for Tables 4.1.2.1.3(b) and (e); and 629 mm for Tables 4.1.2.1.3(c) and (f).
- Stirrups are single leg fabricated from 10M bars spaced at 100 mm on centre (o.c) for Tables 4.1.2.1.3(a) and (d); 200 mm o.c for Tables 4.1.2.1.3(b) and (e); and 300 mm o.c for Tables 4.1.2.1.3(c) and (f).
- Lintel reinforcing is located at the bottom of the lintel and projects 600 mm into the lintel support on each side.
- Specified compressive strength of concrete, @ 28 days  $f'_c$ , is 20 MPa.
- Specified yield strength of reinforcement,  $f_y$ , is 400 MPa.
- Minimum two 10M bars should be placed around all openings and shall extend at least 600 mm beyond each corner of the opening.

**Table 4.1.2.1.4(a) Minimum solid shear wall length for wind pressure equal to 0.4 kPa<sup>(1)</sup>**

Wall Thickness (mm)		150				200			
Width (m)	Length (m)	2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey		2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey	
		Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.
6.1	6.1	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
	12.2	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
	18.3	1.22	1.22	1.26	1.22	1.22	1.22	1.22	1.22
	24.4	1.22	1.22	1.67	1.22	1.22	1.22	1.26	1.22
12.2	6.1	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
	12.2	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
	18.3	1.22	1.22	1.53	1.22	1.22	1.22	1.22	1.22
	24.4	1.39	1.22	2.02	1.22	1.22	1.22	1.53	1.22

**Table 4.1.2.1.4(b) Minimum solid shear wall length for wind pressure equal to 0.6 kPa<sup>(1)</sup>**

Wall Thickness (mm)		150				200			
Width (m)	Length (m)	2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey		2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey	
		Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.
6.1	6.1	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
	12.2	1.22	1.22	1.26	1.22	1.22	1.22	1.22	1.22
	18.3	1.22	1.22	1.87	1.22	1.22	1.22	1.41	1.22
	24.4	1.53	1.22	2.48	1.22	1.22	1.22	1.87	1.22
12.2	6.1	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
	12.2	1.22	1.22	1.53	1.22	1.22	1.22	1.22	1.22
	18.3	1.55	1.22	2.27	1.22	1.22	1.22	1.71	1.22
	24.4	2.06	1.22	3.01	1.22	1.55	1.22	2.27	1.22

**Table 4.1.2.1.4(c) Minimum solid shear wall length for wind pressure equal to 0.8 kPa<sup>(1)</sup>**

Wall Thickness (mm)		150				200			
Width (m)	Length (m)	2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey		2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey	
		Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.
6.1	6.1	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
	12.2	1.22	1.22	1.67	1.22	1.22	1.22	1.26	1.22
	18.3	1.53	1.22	2.48	1.22	1.22	1.22	1.87	1.22
	24.4	2.02	1.22	3.30	1.22	1.53	1.22	2.48	1.22
12.2	6.1	1.22	1.22	1.22	1.34	1.22	1.22	1.22	1.22
	12.2	1.39	1.22	2.02	1.34	1.22	1.22	1.53	1.22
	18.3	2.06	1.22	3.01	1.34	1.55	1.22	2.27	1.22
	24.4	2.73	1.22	4.00	1.34	2.06	1.22	3.01	1.22

**Table 4.1.2.1.4(d) Minimum solid shear wall length for wind pressure equal to 1.0 kPa<sup>(1)</sup>**

Wall Thickness (mm)		150				200			
Width (m)	Length (m)	2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey		2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey	
		Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.
6.1	6.1	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
	12.2	1.28	1.22	2.08	1.22	1.22	1.22	1.57	1.22
	18.3	1.90	1.22	3.09	1.22	1.43	1.22	2.33	1.22
	24.4	2.52	1.22	4.11	1.22	1.90	1.22	3.09	1.22
12.2	6.1	1.22	1.22	1.28	1.67	1.22	1.22	1.22	1.26
	12.2	1.72	1.22	2.52	1.67	1.30	1.22	1.90	1.26
	18.3	2.56	1.22	3.76	1.67	1.93	1.22	2.83	1.26
	24.4	3.40	1.22	5.00	1.67	2.56	1.22	3.76	1.26

**Table 4.1.2.1.4(e) Minimum solid shear wall length for wind pressure equal to 1.2 kPa<sup>(1)</sup>**

Wall Thickness (mm)		150				200			
Width (m)	Length (m)	2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey		2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey	
		Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.
6.1	6.1	1.22	1.22	1.26	1.22	1.22	1.22	1.22	1.22
	12.2	1.53	1.22	2.48	1.22	1.22	1.22	1.87	1.22
	18.3	2.27	1.22	3.70	1.22	1.71	1.22	2.79	1.22
	24.4	3.01	1.31	4.93	1.22	2.27	1.22	3.70	1.22
12.2	6.1	1.22	1.31	1.53	2.00	1.22	1.22	1.22	1.51
	12.2	2.06	1.31	3.01	2.00	1.55	1.22	2.27	1.51
	18.3	3.07	1.31	4.50	2.00	2.31	1.22	3.39	1.51
	24.4	4.08	1.31	5.99	2.00	3.07	1.22	4.50	1.51

**Notes to Tables 4.1.2.1.4(a) to 4.1.2.1.4(e):**

(1) Tables 4.1.2.1.4(a) to 4.1.2.1.4(e) is based on the following assumptions:

- The minimum solid wall length is for each side.
- Roof slope from flat to maximum 1:1.
- Maximum wall height is 3.66 m for each floor.
- Specified compressive strength of concrete, @ 28 days  $f'_c$ , is 20 MPa.
- Specified yield strength of reinforcement,  $f_y$ , is 400 MPa.

**Table 4.1.2.1.5(a) Minimum solid wall length for  $S_a(0.2)$  equals 0.4<sup>(1)</sup>**

Wall Thickness (mm)		150				200			
Width (m)	Length (m)	2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey		2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey	
		Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.
6.1	6.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	12.2	1.2	1.2	1.8	1.9	1.2	1.2	1.6	1.7
	18.3	1.2	1.2	2.4	2.6	1.2	1.2	2.0	2.3
	24.4	1.2	1.5	2.9	3.3	1.2	1.4	2.5	2.9
12.2	6.1	1.2	1.2	1.9	1.8	1.2	1.2	1.7	1.6
	12.2	1.2	1.2	2.5	2.5	1.2	1.2	2.2	2.2
	18.3	1.4	1.6	3.1	3.2	1.3	1.4	2.7	2.8
	24.4	1.6	1.9	3.7	3.9	1.5	1.7	3.2	3.4

**Table 4.1.2.1.5(b) Minimum solid wall length for  $S_a(0.2)$  equals 0.6<sup>(1)</sup>**

Wall Thickness (mm)		150				200			
Width (m)	Length (m)	2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey		2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey	
		Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.
6.1	6.1	1.2	1.2	1.8	1.8	1.2	1.2	1.6	1.6
	12.2	1.2	1.3	2.7	2.8	1.2	1.2	2.3	2.5
	18.3	1.4	1.8	3.5	3.9	1.2	1.6	3.0	3.4
	24.4	1.7	2.3	4.4	5.0	1.5	2.0	3.8	4.3
12.2	6.1	1.6	1.4	2.9	2.7	1.4	1.2	2.6	2.4
	12.2	1.8	1.8	3.8	3.8	1.7	1.7	3.3	3.3
	18.3	2.1	2.3	4.6	4.8	1.9	2.1	4.1	4.2
	24.4	2.4	2.8	5.5	5.9	2.2	2.5	4.8	5.1

**Table 4.1.2.1.5(c) Minimum solid wall length for  $S_a(0.2)$  equals 0.8<sup>(1)</sup>**

Wall Thickness (mm)		150				200			
Width (m)	Length (m)	2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey		2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey	
		Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.
6.1	6.1	1.2	1.2	2.4	2.4	1.2	1.2	2.1	2.1
	12.2	1.5	1.7	3.5	3.8	1.3	1.5	3.1	3.3
	18.3	1.9	2.4	4.7	5.2	1.6	2.1	4.0	4.5
	24.4	2.3	3.0	5.8	6.6	2.0	2.7	5.0	5.7
12.2	6.1	2.1	1.8	3.9	3.6	1.9	1.6	3.4	3.2
	12.2	2.5	2.5	5.0	5.0	2.2	2.2	4.4	4.4
	18.3	2.8	3.1	6.2	6.4	2.5	2.8	5.4	5.6
	24.4	3.2	3.7	7.3	7.8	2.9	3.3	6.4	6.8

**Table 4.1.2.1.5(d) Minimum solid wall length for  $S_a(0.2)$  equals 1.00<sup>(1)</sup>**

Wall Thickness (mm)		150				200			
Width (m)	Length (m)	2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey		2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey	
		Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.
6.1	6.1	1.4	1.4	3.0	3.0	1.2	1.2	2.6	2.6
	12.2	1.8	2.2	4.4	4.7	1.6	1.9	3.8	4.1
	18.3	2.3	3.0	5.8	6.5	2.0	2.6	5.0	5.6
	24.4	2.8	3.8	7.3	8.2	2.5	3.3	6.3	7.1
12.2	6.1	2.6	2.2	4.8	4.5	2.3	2.0	4.3	4.0
	12.2	3.1	3.1	6.2	6.2	2.7	2.7	5.5	5.5
	18.3	3.5	3.9	7.7	8.0	3.2	3.4	6.7	7.0
	24.4	4.0	4.7	9.1	9.8	3.6	4.2	8.0	8.5

**Table 4.1.2.1.5(e) Minimum solid wall length for  $S_a(0.2)$  equals 1.2<sup>(1)</sup>**

Wall Thickness (mm)		150				200			
Width (m)	Length (m)	2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey		2 <sup>nd</sup> Floor		1 <sup>st</sup> Floor of 2 storey	
		Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.	Short dir.	Long dir.
6.1	6.1	1.6	1.6	3.5	3.5	1.4	1.4	3.1	3.1
	12.2	2.2	2.6	5.3	5.7	1.9	2.3	4.6	4.9
	18.3	2.8	3.6	7.0	7.8	2.4	3.1	6.0	6.7
	24.4	3.4	4.5	8.7	9.9	2.9	4.0	7.5	8.6
12.2	6.1	3.1	2.7	5.8	5.4	2.8	2.4	5.1	4.8
	12.2	3.7	3.7	7.5	7.5	3.3	3.3	6.6	6.6
	18.3	4.2	4.6	9.2	9.6	3.8	4.1	8.1	8.4
	24.4	4.8	5.6	10.9	11.7	4.3	5.0	9.5	10.2

**Notes to Table 4.1.2.1.5(a) to 4.1.2.1.5(e):**

<sup>(1)</sup> Tables 4.1.2.1.5(a) 4.1.2.1.5(e) are based on the following assumptions:

- The minimum solid wall length is for each side.
- Roof slope from flat to maximum 1:1.
- The maximum wall height is 3.66 m for each floor.
- Seismic effects for Site Class C are considered.
- Linear interpolation is permitted between seismic zones and building dimensions.
- Brick veneer at a maximum of 7.32 m high is included.
- Specified compressive strength of concrete, @ 28 days,  $f'_c$ , is 20 MPa.
- Specified yield strength of reinforcement,  $f_y$ , is 400 MPa.

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