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ESR-1746

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Valid: 11/14-11/16

DIVISION: 03 00 00—CONCRETE

SECTION: 03 16 00—CONCRETE ANCHORS

SECTION: 03 41 00—PRECAST STRUCTURAL CONCRETE

SECTION: 03 47 00—SITE-CAST CONCRETE

REPORT HOLDER:

COMPOSITE TECHNOLOGIES CORPORATION

1000 TECHNOLOGY DRIVE
POST OFFICE BOX 950
BOONE, IOWA 50036

EVALUATION SUBJECT:

THERMOMASS® MC and MS Fiber Reinforced Composite Wythe Connectors for Integrally Insulated Wall Panels

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ICC-ES Evaluation Report

ESR-1746

Reissued November 2014
This report is subject to November 2016.

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DIVISION: 03 00 00—CONCRETE
Section: 03 16 00—Concrete Anchors
Section: 03 41 00—Precast Structural Concrete
Section: 03 47 00—Site-Cast Concrete

REPORT HOLDER:

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EVALUATION SUBJECT:

THERMOMASS® MC AND MS FIBER REINFORCED COMPOSITE WYTHE CONNECTORS FOR INTEGRALLY INSULATED WALL PANELS

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2009 *International Building Code*® (2009 IBC)
- 2006 *International Building Code*® (2006 IBC)
- 2003 *International Building Code*® (2003 IBC)
- 1997 *Uniform Building Code*™ (UBC)

Properties evaluated:

- Structural
- Environmental
- Physical and mechanical

2.0 USES

The MC and MS connectors are used in integrally insulated concrete walls (commonly known as sandwich walls) to resist static and transient tension and shear loads in uncracked, normal-weight concrete. The connectors are alternatives to cast-in-place steel anchors described in Sections 1911 and 1912 of the 2009 and 2006 IBC, Sections 1912 and 1913 of the 2003 IBC, and Section 1923 of the UBC.

3.0 DESCRIPTION

3.1 Connectors:

MC and MS connectors are fiber-reinforced composite connectors with dove-tail anchors at both ends for anchorage into wet concrete with a plastic overmold in the middle of the connector. The connectors are illustrated in Figure 1. The connectors are produced by a pultrusion process from a polymer composite consisting of epoxy vinylester resin reinforced with glass fibers. The overmold is injection-molded from polystyrene plastic.

The MC and MS connectors measure 0.224 inch (5.7 mm) thick and 0.393 inch (10 mm) wide.

3.2 Concrete:

Normal-weight concrete must conform to Sections 1903 and 1905 of the IBC or UBC, as applicable and comply with the compressive strength requirements in Table 2.

4.0 DESIGN AND INSTALLATION

4.1 Physical and Material Properties of the Connectors:

Design must be based on the physical and mechanical properties described in Tables 1 and 2.

4.2 Design for Tension and Shear:

Design must be performed using the applicable sections of the applicable codes and using the allowable loads as noted in Table 2. Allowable loads for MC or MS connectors subjected to combined shear and tension forces must be determined by the following equation:

$$(P_s/P_t) + (V_s/V_t) \text{ \#1}$$

where:

P_s = Applied service tension load (lbf or N).

P_t = Service tension load (lbf or N).

V_s = Applied service shear load (lbf or N).

V_t = Service shear load (lbf or N).

4.3 Displacement of the Connector:

The displacement due to gravity loads must be limited to 0.1 inch (2.54 mm). When the connector displacement exceeds the limiting value of 0.1 inch (2.54 mm) due to the gravity loads, the free end of the connector must be supported to maintain fixity by other means. The displacement must be calculated as follows (neglecting any contribution from the insulation in the intended application):

$$\Delta_g = \frac{Q_g \cdot {d_A}^3}{12 E_{Ab} \cdot I_A}$$

where:

Δ_g = Displacement due to gravity load (inch or mm).

Q_g = Gravity load on the connector, typically the weight of the fascia layer of the tributary area for the connector (lbf or kN), $Q_g = t \cdot a \cdot b \cdot \gamma$, where t = thickness of the fascia layer (feet or m); a = horizontal spacing of the connector (feet or m); b = vertical spacing of the connector (feet or m); γ = density of concrete (lbf/ft^3 or kN/m^3).

$$d_A = d_d + \frac{2h_v}{3}\left[1 - \frac{1}{1+\frac{h_v}{d_d}}\right]$$

where:

d_A = Connector bending length, a function of insulation thickness and embedment (inch or mm).

d_d = Insulation thickness (inch or mm).

h_v = Embedment length of the connector in the concrete.

E_{Ab} = 0.95 times the flexural modulus of elasticity as given in Table 1 (psi or MPa).

I_A = Moment of inertia of the connector as given in Table 1 (in^4 or mm^4).

The deflection of the connector may be reduced by decreasing the connector spacing, but not less than 8 inches (203 mm) on center each way.

4.4 Installation:

Connector orientations and locations must comply with this report and the plans and specifications approved by the code official. MC and MS connectors must be installed in accordance with the instructions provided by Composite Technologies Corporation (CTC). The instructions are provided with each shipment of the connectors. The minimum embedment, critical edge distance, and critical spacings must comply with Table 3 of this report.

The minimum concrete thickness must comply with the applicable code requirements or 1.5 times the connector effective embedment, whichever is greater. Within 20 minutes after the bottom layer of concrete is placed, code-complying rigid insulation board with holes sized to accept the connectors must be placed over the concrete while it is in the plastic state. The connectors, sized to match the insulation board thickness, are inserted through the holes in the insulation board into the bottom layer of concrete, until the prescribed embedment is reached. Concrete consolidation around the connectors must be conducted in accordance with the applicable code and CTC's published instructions. The top layer of concrete is then placed over the insulation board, engaging the connectors and consolidated. Panels must cure in accordance with the applicable code.

4.5 Special Inspection:

Installations must be made under special inspection in accordance with Section 1704.15 of the 2009 IBC, Section 1704.13 of the 2006 IBC or Section 1701.5.2 of the UBC. The special inspector must be on the jobsite continuously during connector installation to verify connector type, connector dimensions, and cleanliness, embedment depth, concrete type, concrete compressive strength, edge distance(s), connector spacing(s), concrete thickness, concrete consolidation and concrete curing.

5.0 CONDITIONS OF USE

The Thermomass MC and MS connectors described in this report comply with, or are suitable alternatives to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

5.1 Connector sizes, dimensions, and installation must comply with this report and CTC's published installation instructions. In case of a conflict between this report and other documentation, this report governs.

5.2 Allowable tension and shear loads must be as noted in the Table 2.

5.3 Calculations and details demonstrating compliance with this report must be submitted to the code official for approval. The calculations and details must be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.

5.4 Design and installation of the concrete wall panels, except as specifically noted in this report, is outside the scope of this report and must comply with the applicable code.

5.5 Connectors may be recognized for interior exposure, exterior exposure or damp environments.

5.6 Connectors must not be permitted in contact with preservative-treated and fire-retardant-treated wood.

5.7 Special inspection must be provided in accordance with Section 4.5 of this report.

5.8 Since an ICC-ES acceptance criteria for evaluating data to determine the performance of connectors subjected to fatigue or shock loading is unavailable at this time, the use of these connectors under these conditions is beyond the scope of this report.

5.9 Since an ICC-ES acceptance criteria for evaluating data to determine the performance of fiber-reinforced connectors in cracked concrete is unavailable at this time, the use of these connectors must be limited to installation in uncracked, normal-weight concrete. Cracking occurs when $f_t > f_r$ due to service loads or deformations.

5.10 Connectors must not be permitted for use in conjunction with fire-resistance-rated construction. Exceptions are:

- Connectors resist wind loading only.
- For other than wind loading, special consideration is given to fire exposure conditions.

5.11 Seismic or wind load under the IBC: Use of the connectors to resist seismic loads is beyond the scope of this report. When using the basic load combinations in accordance with IBC Section 1605.3.1.1, allowable loads are not permitted to be increased for wind loading. When using the alternative basic load combinations in IBC Section 1605.3.2 that include wind loads, the allowable shear and tension loads for connectors may be increased.

5.12 Seismic or wind load under the UBC: When using the basic load combinations in accordance with UBC Section 1612.3.1, allowable loads are not permitted to be increased for wind or seismic loading. When using the alternative basic load combinations in UBC Section 1612.3.2 that include wind or seismic loads, the allowable shear and tension loads for connectors are permitted to be increased by $33^1/_3$ percent.

5.13 Connectors are manufactured by Composite Technologies Corporation, under a quality control program with inspections conducted by ICC-ES.

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Fiber-reinforced Composite Connectors Anchored in Concrete (AC320), dated June 2006 (editorially revised November 2009), including seismic tests, creep tests, and extreme temperature tests.

7.0 IDENTIFICATION

The connectors must be identified in the field by dimensional characteristics and packaging. The packaging label indicates the Composite Technologies Corporation name and address, and the ICC-ES report Number (ESR-1746). Each connector is stamped with the lot number.

TABLE 1—PHYSICAL AND MECHANICAL PROPERTIES

DESCRIPTION	MC CONNECTOR		MS CONNECTOR	
	Customary Units	SI Units	Customary Units	SI Units
Cross-sectional area	0.078 in^2	50.5 mm^2	0.078 in^2	50.5 mm^2
Average moment of inertia	0.0005858 in^4	243 mm^4	0.0005858 in^4	243 mm^4
Embedment depth	2 inches	51 mm	1.5 inches	38 mm
Bending elastic modulus (flexural modulus)	4,764,000 psi	32,846 MPa	4,764,000 psi	32,846 MPa

TABLE 2—ALLOWABLE TENSION AND SHEAR VALUES IN NORMAL-WEIGHT CONCRETE[1] (in pounds)

DESCRIPTION	MC CONNECTOR		MS CONNECTOR
	f'_c = 6,000 psi[2]	f'_c = 4,000 psi[2]	f'_c = 6,000 psi[2]
Static tension	707	577	608
Static shear, parallel to strong axis	197	126	148
Static shear, parallel to weak axis	152	113	104
Seismic tension[3]	647	572	558
Seismic shear, parallel to strong axis[3]	197	110	148
Seismic shear, parallel to weak axis[3]	152	106	104
High-temperature tension (at 150°F)	707	N/A	472
Low-temperature tension (at !40°F)	707	N/A	608

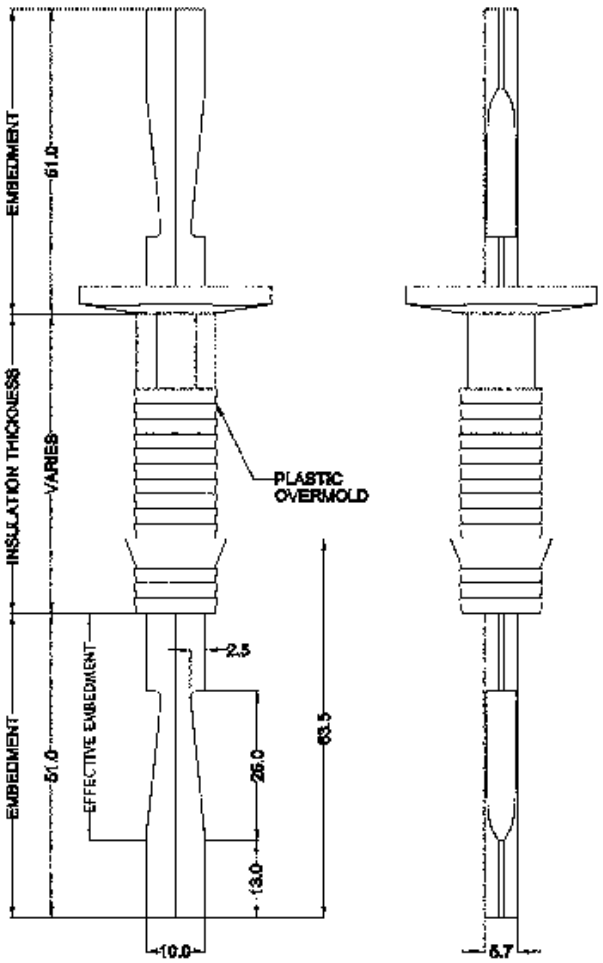
For **SI:** 1 psi = 6.9 kPa, 1 pound = 4.45 N, t°C = 5/9(t° – 32).

[1]Allowable loads have been determined by applying a factor of safety of 4 to the test results.
[2]Concrete must achieve this compressive strength before anchors are loaded.
[3]For use under the UBC only.

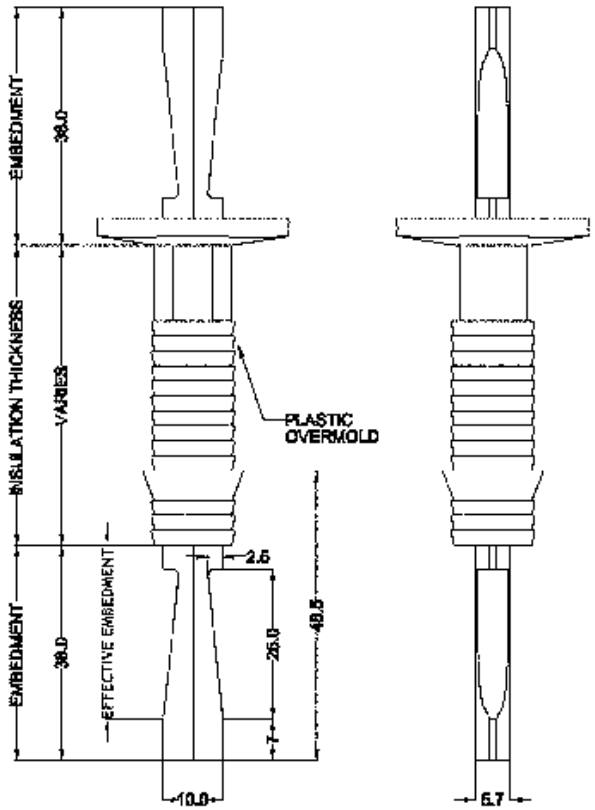
TABLE 3—INSTALLATION PARAMETERS

DESCRIPTION	MC CONNECTOR (inches)	MS CONNECTOR (inches)
Embedment	2	$1^1/_2$
Critical edge distance	5.25	5.25
Critical spacing	8	8

For **SI:** 1 inch = 25.4 mm.



MC CONNECTOR PROFILE
(ALL DIMENSIONS IN MM)



MS CONNECTOR PROFILE
(ALL DIMENSIONS IN MM)

For customary units 25.4 mm = 1 inch.

FIGURE 1