Q&A

Questions and Answers about the Composite **THERMOMASS®** C-Wall Insulation System

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THERMOMASS®
BUILDING INSULATION SYSTEMS
By Composite Technologies Corporation

Composite THERMOMASS® C-Wall Q&A

General Questions

What is the THERMOMASS® C-Wall Insulation System?

The THERMOMASS C-Wall Insulation System is a patented connector and insulation system for creating structurally composite tilt-up and precast insulated concrete sandwich walls.

High-strength, low-conductive, chemically resistant connectors structurally tie two layers of concrete together through pre-drilled, extruded Dow Styrofoam® insulation (R-5 per inch of thickness) or Dow ISOCAST-R® insulation (R-6.5 per inch of thickness).

Composite Technologies Corporation (CTC) supplies both components of the system - the C-Bar connectors and the pre-drilled insulation. In addition, CTC is equipped to provide complete insulation layout drawings and precision-cut foam panels (a service referred to as "fabrication") incorporating openings and edge conditions. Additionally, we can recommend qualified wall panel producers in your area.

Why use the THERMOMASS C-Wall Insulation System?

THERMOMASS places high-quality insulation between two layers of concrete and structurally connects the three layers in a single construction. This significantly improves the R-value of the constructed wall over concrete alone. An un-insulated, 200 mm (8 in) thick concrete wall achieves an R-value of 0.113 m^2•K/W (0.64 ft^2•h•°F/BTU) compared to 0.881 m^2•K/W or (5.0 ft^2•h•°F/BTU) for only 25mm (1 in) of extruded polystyrene insulation.

To be a viable building material in the majority of today's energy conscious regions, a concrete wall simply must be insulated. The THERMOMASS C-Wall Insulation System provides building owners with cost-effective, durable and energy-efficient structures.

Why is it important to sandwich the insulation between two layers of concrete?

The concrete layers provide thermal mass. That is, the concrete is able to store significant amounts of thermal energy and delay heat transfer through the building walls. According to the Fundamentals Handbook of the American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE), this delay leads to three important results:

- First, the slower response time tends to moderate indoor temperature fluctuations under outdoor temperature swings.
- Second, in hot or cold climates, energy consumption is significantly reduced over that of a similarly sized low-mass building.
- Third, since mass is adjacent to the interior space, the building's energy demands can be moved to off-peak periods because energy storage is controlled through the correct sizing of the mass and interaction with the HVAC system.

CTC can calculate the increased effect the thermal mass R-value will have for your projects using procedures developed by ASHRAE and other leading energy-efficiency organizations and confirmed by the United States Department of Energy.

What is a structurally composite sandwich wall panel?

A structurally composite sandwich wall panel is an insulated wall panel in which both the interior and exterior wythes act compositely to carry the external gravity and lateral loads. With a typical "non-composite" sandwich wall panel, the exterior wythe does not carry gravity load but does transfers lateral loads to the interior wythe which is designed for both gravity and lateral loads.

In what applications can the THERMOMASS C-Wall Insulation System be used?

The THERMOMASS C-Wall Insulation System can be used in precast (*plant cast, horizontally formed)* and tilt-up (*site cast, horizontally formed)* applications.

What is the main advantage of a structurally composite sandwich wall panel?

When both concrete wythes share the loads, the panel can be made thinner as compared to a typical non-composite insulated wall panel, greatly reducing material costs.

How long has THERMOMASS been used in sandwich wall applications?

The first building constructed using the standard THERMOMASS system was a nine-story condominium completed in 1980. The recently developed C-Wall System has been used in projects since 2001.

Explain the types of facilities for which structurally composite wall panels using the THERMOMASS C-Wall Insulation System can be used.

Composite panels using the C-Wall System can be used as both load-bearing elements and cladding panels in ambient temperature facilities like schools, offices, retail stores, warehouses and distribution centers.

Connectors

What is the THERMOMASS C-Bar connector?

THERMOMASS C-Bar connectors are manufactured by Composite Technologies Corporation - an industry leader in concrete sandwich wall insulation for over 25 years. C-Bar connectors are manufactured through a pultrusion process, where approximately 320,000 E-glass fibers are dipped in a vinyl-ester resin, formed under heat and pressure, cut to length, and over-molded with a plastic sleeve.

Why can't the connectors be fabricated using other materials?

The connector material must be compatible with concrete, thermally efficient and exceptionally strong. Compatibility will not exist if the connector is susceptible to alkaline attack, is hydrophilic, or has a thermal coefficient of expansion that is much higher than that of concrete.

Why use a fiber composite instead of steel?

The fiber composite bar used in the THERMOMASS C-Wall Insulation System has a thermal conductivity of 0.469 W•mm/h•m2•K (2.1 BTU•in/ft2•h•°F). This compares to values of 40.68 W•mm/h•m2•K (182 BTU•in/ft2•h•°F) for stainless steel and 81.59 W•mm/h•m2•K (365 BTU•in/ft2•h•°F) for mild steel, and 2.79 W•mm/h•m2•K (12.5 BTU•in/ft2•h•°F) for concrete, respectively.

Therefore, THERMOMASS fiber composite connectors eliminate the material components that would otherwise create a thermal bridge.

Will the alkalinity of the concrete attack the bars?

No. The vinyl-ester resin matrix protects the glass fibers in the bars from chemical attack. Independent tests show that the connectors can withstand the concrete's alkalinity for up to 100 years.

How do the connectors hold the wall together?

The connectors' grooves develop a keying action within the concrete wythes. The pullout strengths of the embedded connectors are far greater than the forces experienced in normal loading conditions.

What is the connector spacing?

Typically, the connectors are spaced at 460 mm (18 in) on center transversely and 400 mm (16 in) on center longitudinally. Depending on panel dimensions and loading conditions, special spacing may be specified.

How is this spacing achieved in the field or plant?

All insulation boards supplied with the THERMOMASS C-Wall Insulation System are delivered with pre-drilled slots at the specified spacing. Instructions are available should slots need to be added on-site.

Composite Action

How is composite action achieved using the THERMOMASS C-Bar connector?

The C-Bar connectors are 1½" wide and ³/₈" thick and have grooves at each end for anchoring within the concrete. The connectors are designed to provide a high shear transfer capacity from one wythe to the other, thus providing the composite action.

Is 100% composite action possible with THERMOMASS C-Bar connectors?

Wall panels designed using C-Bar connectors do not provide 100% composite action nor do any other manufacturers composite wythe ties with intermittent spacing, contrary to any claims made in the market place. In fact, 100% composite action is not required for the panels to perform satisfactorily as studies have shown that more thermal bowing occurs in a panel approaching 100% composite action than one partially composite with the same configuration and span.

If needed, how can we increase the composite action?

Composite action of the panels can be increased by adding solid-through concrete at the top and bottom edges of the panel. If solid-through concrete sections are added to increase the composite action, Composite Technologies Corporation recommends a minimum of 18 inches of solid-through concrete section.

Do the solid-through concrete sections create thermal bridging?

Yes. However, by taking additional steps, the thermal bridging can be minimized. Typically, the solid-through concrete sections are above the roof line and below the floor line. Contact CTC for details where solid-through concrete sections are required.

Insulation and Wythe Thicknesses

What thickness of insulation can be used?

Insulation thickness values ranging from 50 mm (2 in) to 75 mm (3 in) are considered optimal. Composite Technologies Corporation does not recommend other thicknesses.

What is the minimum thickness of a typical face and interior wythe?

A minimum thickness of 50 mm (2 in) is required. CTC recommends using equal thickness wythes in a composite sandwich wall. However, the face wythe thickness can be increased by the amount of thin brick or reveals thickness.

Wall Finishes

What types of concrete finishes are possible?

It is up to the capabilities of your local wall producers. The THERMOMASS C-Wall Insulation System can be used with any type of forming system, with or without form liners. Finishes can include natural concrete, paint, skim coat plaster, sandblasted, concrete exposed aggregate, colored concrete, thin brick or most forms of concrete treatment. Other materials may be secured to the wall with concrete anchors.

What about other design considerations?

There is no limit to the design possibilities when casting a panel in a form. Reveals, rustication, embossed logos and dimples in the finish are just a few examples.

Engineering

What type of reinforcement is required in a structurally composite wall panel?

Structurally composite sandwich wall panels can be built with just mild steel reinforcement or with pre-stressing strands in both wythes. Structurally composite sandwich panels can also be created with post-tensioning tendons placed in the insulation. Temperature and shrinkage reinforcement is required in both wythes. However, since the panels are structurally composite, the reinforcement required is up to 30% less compared to non-composite sandwich panels.

Do composite sandwich wall panels require special stripping and lifting hardware?

Composite sandwich wall panels are relatively thin, but, in most cases, typical lifting hardware can be used in the panels by reducing the insulation thickness around the lifting hardware. However, in some cases a shallow lifting insert like a "Plate Anchor" from Meadow Burke may be required. It may also be necessary to increase the number of lifting inserts due to the allowable capacities of shallow lifting hardware. Normally, this increase does not affect rigging time.

Who has final design responsibility when using THERMOMASS C-Bar connectors?

Final design responsibility of the wall panels is given to the tilt-up or precast panel engineer or the project structural engineer. CTC can provide preliminary assistance during the design phase.

CTC has engaged the services of industry leading design professionals to develop software to analyze and design composite wall panels using C-Bar connectors. The software was developed based on the theory and testing of full-scale composite panels using THERMOMASS C-Bar connectors. Vierendeel Truss analogy is used by the software in designing the composite wall panels. A 30-day trial copy of this software may be obtained by contacting either CTC or Losch Engineering.

Connector Testing and Capacities

What types of tests have been performed on the C-Bar connectors?

Extensive third-party testing has been conducted on the C-Bar connectors, including static and dynamic (cyclic) tests and full-scale panel tests. Fire and aging tests have been carried out on wall panels having E-glass fiber composite connectors and show no degradation. Please contact CTC for complete test results.

What is the tensile strength of the composite material used in the connectors?

The tensile strength of the connector composite material is in excess of 827 Mpa (120,000 psi).

What is the strength of one connector?

A single C-Bar connector has an ultimate tensile strength (pullout capacity) of 25.8 kN (5,800 lbs).

What is the shear capacity of the connectors?

The ultimate shear capacity of each connector is approximately 11.6 kN (2,600 lbs). The ultimate cyclic shear capacity is 11 kN (2,466 lbs).

Is the THERMOMASS system structurally proven?

THERMOMASS has proven itself in the laboratory and in the field. Construction Technology Laboratories (CTL) of Skokie, Illinois, performed flexural load tests on the basic wall configuration in 1984. Since then, years of successful application as well as additional structural and fire testing at CTL, Iowa State University, the University of Kaiserslautern, Stork Twin City Testing Corporation, and Southwest Research Institute have verified the outstanding structural capabilities of the THERMOMASS Building Insulation System.

How do the connectors perform in fire?

A test performed at a leading fire testing agency in the United States subjected a panel constructed with THERMOMASS fiber composite connectors to a temperature of over 1090 °C (2000 °F) for four hours with no degradation.

In separate tests, THERMOMASS connectors installed in only 75 mm (3 in) of concrete were exposed to a standard time-temperature profile while subjected to high tensile loads. Even under these extreme conditions, the connectors withstood over one hour of fire exposure!

Installation

How is the THERMOMASS C-Wall Insulation System installed?

The precast and tilt-up systems are all installed with nearly identical practices:

- The bottom layer of concrete is placed in the forms. This begins once the forms have been secured, the surfaces cleaned and treated with a bond release agent, and reinforcing has been placed.
- The pre-drilled insulation is then placed over the fresh concrete (which is placed at a 5" – 7" slump). This should be done immediately after the bottom layer has been consolidated and leveled to thickness, but in any event, within 15 to 20 minutes after placement of the concrete to ensure the concrete mix is still plastic.
- The connectors should immediately be inserted through the pre-drilled slots.
- The concrete around the connectors should then be consolidated by placing a vibrator to the individual connector or to a group of connectors using "vibra-strike". In factory cast operations, additional consolidation may be achieved by bed vibration.
- The reinforcement and hardware for the second concrete wythe shall be placed.
- Finally, the top wythe of concrete is placed. (Note: If the top concrete wythe cannot be poured immediately, then it must be poured after the bottom or lower concrete wythe has fully set.)
- Contact Composite Technologies Corporation for installation guides for specific applications.

What is the most important thing to remember about installation?

You must have concrete consolidation around the groove for the connector to develop its strength.

What if a row of slots is removed while trimming an insulation board to fit?

A new row of slots should be drilled into the insulation by drilling slots with a $^{7}/_{16}$ inch diameter drill bit. The new row of slots should be no closer than 100 mm (4 in) to and no farther then 200 mm (8 in) from the edge of the insulation.

What should be done if a connector hits a reinforcing bar or piece of aggregate?

Remove the connector and reinsert it at an angle to bypass the obstruction.

Will applied curing heat affect the THERMOMASS C-Wall Insulation System?

The connectors won't be affected. However, some insulation will soften at approximately 71 °C (160 °F). Extruded polystyrenes will expand and expanded polystyrenes can melt. Curing temperatures (the combination of heat of hydration and applied curing heat) in the lower concrete wythe should be carefully monitored near the center of the panel and not allowed to exceed 60 to 65 °C (140 to 150 °F).

Additional Q&A brochures are available for both non-composite panels and poured-in-place applications.

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