altus group

Technical Brief

Thermal Efficiency of CarbonCast® Enclosure Systems

Above: Government Services Administration, Savannah, Ga.

The U.S. Department of Energy estimates that 42 percent of energy consumed in a building is ultimately lost through the building envelope, or the barrier between the building interior and outdoor environment. A significant portion of any commercial envelope is the exterior wall.

The building envelope is critical in regulating internal building temperatures and determining how much energy is required to heat or cool a structure for occupant comfort. Heat transfer through envelope components such as walls wastes energy. Thermally efficient exterior wall systems aim to mitigate heat transfer and energy loss. They are engineered to minimize the opportunities for heat to flow from the interior surface through the wall to the building's exterior.

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The role of wythe connectors

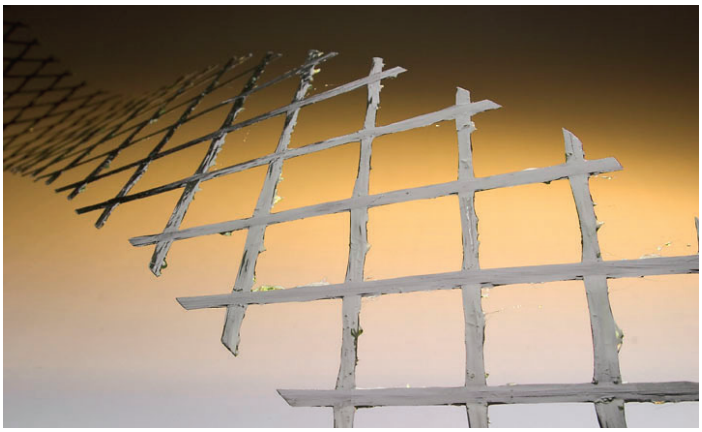
In insulated precast concrete wall panels, wythe connectors act as a mechanical connection between the inner and outer layers of concrete. Because they form a connection through the insulation, there is an opportunity for thermal bridging to occur as well. Traditional wythe connection options such as solid zones of concrete or metal connectors—while providing a reliable mechanical connection—permit heat transfer between the wall because of the materials' inherent conductivity. The thermal conductivity of carbon steel is about 43 w/m·K. (As comparisons, dense concrete tops out at 1.8 w/m·K while XPS insulation is around 0.034 w/m·K.)

The thermal conductivity of wythe connector systems in insulated wall panels depends on (1) the thermal properties of the connector material itself and (2) the amount of surface area where it connects with the concrete wythes. The most common commercial composite connectors are vinyl ester coated fiberglass, epoxy coated carbon fiber with carbon being the stronger fiber system. Both are relatively low in thermal conductivity compared to steel.

Most mechanical connectors constitute a tiny percentage of the entire precast surface area on the inside of both wythes, making thermal conductivity comparisons of connector materials inconsequential, expensive and difficult.

The C-GRID carbon fiber epoxy grid used in CarbonCast High Performance Insulated Wall Panels is spaced widely throughout the panel and varies with panel design and structural requirements. Additionally, the tow based junctions which anchor into the concrete are less than 3mm in total thickness and 1/4" wide, providing negligible surface area for heat to move across the panel.

What is important is designing a performance specification on the overall wall system rather than just the connector alone. A specification based on the overall wall system is



one of the best ways of ensuring that the enclosure will meet the owner's standards.

Additionally, a wall's thermal mass heat capacity is determined in part by the building materials used. Thermally efficient buildings absorb energy more slowly and then hold it longer, effectively reducing indoor temperature fluctuations and reducing overall heating and cooling requirements. Precast concrete exterior wall panels are an excellent source of thermal mass heat storage capacity and provide complementary thermal benefits.

ASHRAE 90.1 acknowledges the thermal mass benefits of concrete walls in specifying lower minimum insulation R-values and higher maximum wall U-factors for mass (concrete) wall construction in specific geographic areas. Essentially, the ASHRAE standard means that this type of assembly stores heat energy and registers better performance than the sum of its parts. That is, while the components of a wall individually add up to a material R-value, the mass wall performs at a much greater R-value—up to two times greater than that of the material itself. (Source, PCI)

Above: C-GRID carbon fiber grid connectors combine outstanding strength and negligible thermal conductivity.

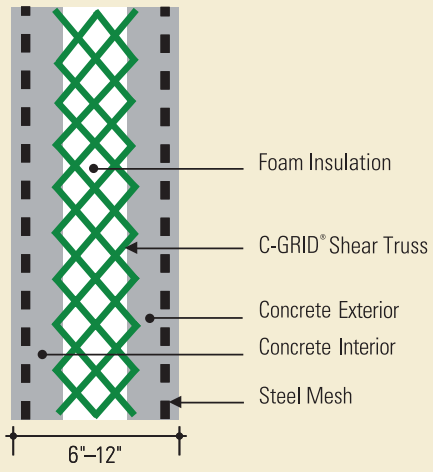
Left: Academy of World Languages, Cincinnati, Ohio

The role of insulation

Insulation helps to prevent the flow of heat across the exterior envelope. The use of continuous insulation further stems the flow by eliminating the presence of building materials that could facilitate thermal transfer.

Continuous insulation is defined in ASHRAE 90.1 as "insulation that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope."

The thermal performance of edge-to-edge insulated precast concrete sandwich wall panels with no or minimal thermal bridges and no solid zones maintains the R-values for continuous insulation as defined by ASHRAE 90.1, thereby lowering energy costs for the owner and occupant.



Wall Panel – Shear Truss
Vertical Section

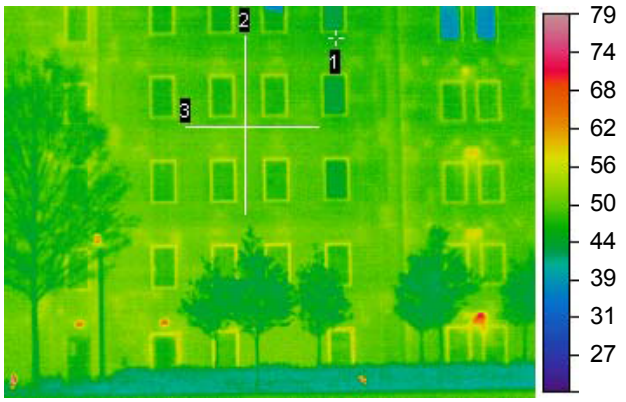
Above and at: CarbonCast® Enclosure Systems provide for continuous edge-to-edge insulation. The use of C-GRID wythe connectors mitigates thermal bridging.

Left: C-GRID carbon fiber grid connects the inner and outer wythes of concrete in CarbonCast Enclosure Systems. They enable continuous insulation and thermal efficiency throughout the entire wall panel.

The use of continuous insulation further stems heat flow by removing the presence of building materials that could facilitate thermal transfer.

Seeing is believing

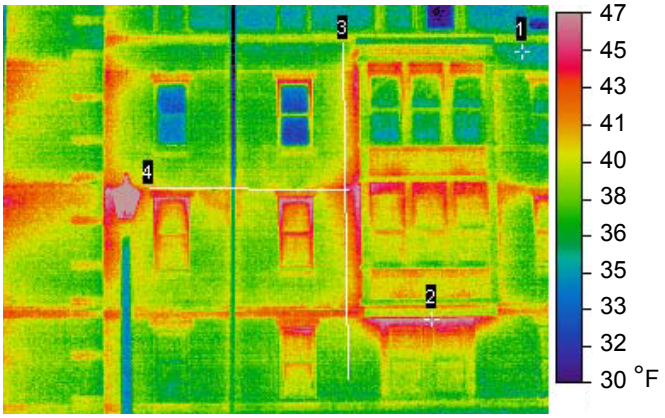
One of the best measures for performance is actual thermographic measurement of the installed panel. Using a thermal imaging camera, one can physically determine how the energy effectiveness of the exterior envelope and actually see if heat is being lost through the wall and envelope. On this page and the next are thermographic images of recent CarbonCast® projects done by AltusGroup members.



Thermal Imaging: Precast Wall System

University Commons at GSU built with a thermally efficient precast concrete mass wall system. Calculations by infrared imaging found the system to be an R-13.77. (Note: bright spots are exhaust fans or security lighting.)

Visible light image



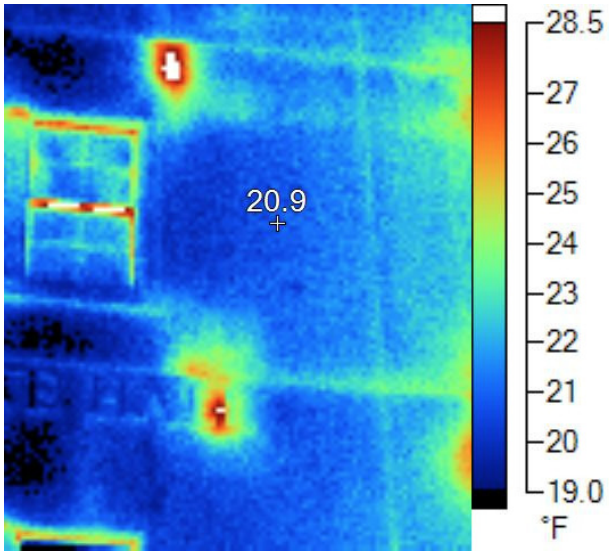
Thermal Imaging: Cavity Wall System

A dormitory built with cavity wall construction in the Atlanta market. Calculations by infrared imaging found the system to be an R-7.09. Note multiple areas of thermal transfer.

Visible light image

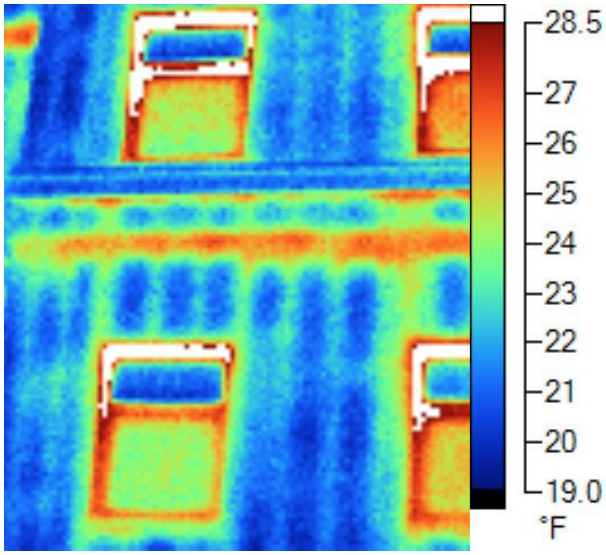
Source: Metromont. Sustainability study, University Commons at Georgia State University, 2009.

Seeing is believing *continued*



Thermal Imaging: Precast Wall System

Precast wall section. Note consistent thermal performance of wall section.



Thermal Imaging: Cavity Wall System

EIFS Exterior. Note thermal transfer caused by studs and insulation issues in wall.

Source: High Construction Company, Energy Solutions Group. A preliminary study, Montclair, NJ, 2013

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Visit **altusprecast.com** for more information on CarbonCast® Enclosure Systems and to find a precaster near your next project.

Call us today to speak with a technical representative or request a lunch-and-learn program.