

grid CFRP use in precast concrete walls: 15 years of success in North America



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Resilient and sustainable building practices represent an opportunity for architects, engineers and owners to rethink their approach to reflect on long-term trends, such as fossil fuel consumption and global climate change. Smart design and intelligent material choices can dramatically reduce a building's carbon footprint, lower the annual operating costs and render buildings that will stand the test of time – 50- to 100-year structures that can be adapted for reuse.

two concrete wythes, precast/prestressed wall panels deliver a balance of strength and thermal performance.

in more than 1,500 projects across North America and internationally since 2003.

Thermally-efficient insulated wall panels enabled by CFRP

The history of sandwich wall panels in the United States goes back to the 1960s, when the precast/prestressed concrete industry started gaining momentum and market acceptance.

Early designs started with double-tee sandwich wall panels that were fully composite with solid zones. The next innovation involved flat sandwich wall panels, again with solid zones of concrete to make the panel fully composite. Eventually, metal trusses were incorporated into designs to achieve a thermally-effective panel that offered the performance of fully-composite sandwich wall panels. Still, thermal efficiencies were hampered by the heat loss due to the conductivity of the metal connector between panel wythes or the solid concrete zones.

Non-composite panels were developed in the late 1980s using non-metallic ties. Although these panels were not structurally efficient, they were thermally efficient. Slowly, many improvements were made to these systems to render a partially composite panel that offered both structural and thermal benefits.

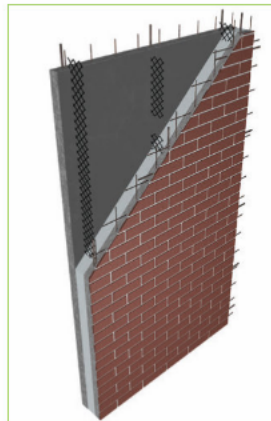
The use of carbon fibre-reinforced polymer (CFRP) grid truss connectors in concert with composite panel design has amplified the inherent benefits of sandwich panel design, delivering higher R-values and an even thermal profile that has been proven with thermal imaging studies. Marketed as CarbonCast by the 19 precaster members of AltusGroup, the technology has been used



The Universal Alloy Light Press Plant in Ball Ground, Georgia, USA, features load-bearing CarbonCast High Performance Insulated Wall Panels painted to create a 3-D illusion. The carbon fiber grid wythe connectors contribute to the building's R-11 performance. (Precaster: Metromont)



Expanded polystyrene insulation is placed atop the poured outer wythe with the carbon fiber grid embedded. The inside concrete wythe will be poured atop the insulation; the grid connects the two wythes through the insulation.



Carbon fiber grid connects the interior and exterior wythes through the insulation to offer continuous insulation and composite performance.

In 2003, several industry-leading precasters in the United States began exploring the use of C-GRID® CFRP grid from Chomarat NA as a wythe connector. A strong, durable material with relatively low thermal conductivity, carbon fibre imparts next-generation strength and thermal performance to traditional wall panels. CFRP grid trusses are placed in parallel rows along the length of the panel depending on its orientation. Pieces of grid extend about 19mm into the panel's exterior wythe. Generally, concrete wythes will range from 5 to 7.6cm thick. The depth of the foam insulation – typically expanded polystyrene (EPS), extruded pol-

ystyrene (XPS) or polyisocyanurate – depends on the desired R-value and structural properties for the wall.

The elimination of solid zones and the strength of the carbon fibre grid have now allowed precasters to engineer a panel with continuous, edge-to-edge insulation without concern for thermal bridging at the connector. A wall panel with CFRP connectors can now deliver 100% of the insulation's rated R-value in addition to the benefits of the precast's thermal mass.

In addition, CFRP grid wall design can render a fully composite panel where both wythes act structurally together through the life of the panel. This allows thinner panels to be designed to perform the same task as a thicker non-composite panel.

There are many advantages to fully composite sandwich wall panels including reduced structural weight, more usable space inside the building, and smaller (and less expensive) equipment to install panels – with possibly fewer pieces to erect as well. More than US\$2 million in third-party laboratory testing and research of full-scale wall panels have confirmed CarbonCast's performance characteristics in real terms.

Project profile – Universal Alloy

Manufacturing buildings are almost exclusively utilitarian. Though many in the last half-century have been constructed with precast concrete, many designers are not given the budget to take advantage of its unique properties to add enhanced

architectural details. The Universal Alloy Light Press Plant, completed by Choate Construction Company, is an exception – with virtually no added cost.

A 10,252m² manufacturing facility in Ball Ground, Georgia, USA, this project features an exterior façade with load-bearing CarbonCast high-performance insulated wall panels. The panels have painted vertical accent stripes that align with sawtooth tops. This creates a 3-D illusion that the panels project in and out like an accordion, making for an eye-catching façade.

This project used CarbonCast panels that are typically 25cm thick, 366cm wide and 1326cm tall. The tallest panel is approximately 1427cm tall and the heaviest panel weighs 23.36 metric tons.

Both wythes of the insulated panels are prestressed to give them beam strength and load-bearing capacity. They span from foundation to roof structure without requiring wind bracing. There are 144 pieces and erection took fifteen working days.

The insulated wall panels have a 76mm face wythe backed up by 76mm of expanded polystyrene breadboard (EPS) with a 101mm back wythe of concrete for an R-value of R-12. The door and window openings have a solid zone surrounding the openings to facilitate the attachment of frames. The solid zones there represent only about 10% of the surface area, leaving a net R-value of R-11, still about 50% over the code requirement for this ASHRAE 90.1 climate zone.

Project profile – Capital Federal Hall, University of Kansas School of Business

This 15,468 m² building will serve as a destination point for students who are determined to move business forward. From state-of-the-art technology to research labs, this will be a hub for collaboration and innovation. The four-storey building has 18 classrooms, 125- and 350-seat auditoriums, and 205 offices, as well as labs and spaces for students' use.

This Innovative School of Business consists



Capitol Federal Hall, University of Kansas School of Business in Lawrence, Kansas, USA, uses CarbonCast High Performance Insulated Wall Panels shows how insulated panels can deliver the same aesthetic as conventional architectural cladding while offering energy savings. (Precaster: Enterprise Precast.) © Jacia Phillips.

of two wings connected by a central atrium. A unique characteristic of the precast panel design was that it tapered out to a "V" pattern in plan. It was broken up as a 10-10-10 panel (10 cm of insulation sandwiched between two 10cm wythes), but there were portions of the surface wythe of the panel that protruded out as much as 25 cm at the apex of the "V".

From a structural standpoint, insulated spandrels spanned column to column and hung off steel haunches. Through careful planning and coordination, a lot of weight could be braced back to the structure as it was suspended off the steel. Short insulated panels 91 cm in height spanned long spans and supported 366 cm of precast above, transferring the loads back to the columns. Another innovative feature is the slope and the very end of the cladding at the Dean's area on the West end, creating a cantilever that is quite striking visually.

From an aesthetic standpoint, different forming systems on each side yielded unique, varying appearances on each side. The colour and finish uniformity of the cream-coloured precast panels is accentuated by a series of copper panels that highlight its look in various areas. Combined with the glass and steel, this is truly an example of precast playing well with other materials and blending in.

Project profile – 5th and Race, Cincinnati, Ohio

The new mixed-use structure at 5th & Race Street in Cincinnati, Ohio, gives visitors the impression that they can see right through the building. Designers of the 26,013m² facility elegantly merged broad windows and CarbonCast precast wall panels to create a light and elegant building that reflects the blue sky during the day, and golden street lights at night, while giving residents a strong, open space for their offices and retail spaces.

Designers of the building, which includes a 1,000-space, four-storey parking garage at the base topped by four storeys of commercial space, chose precast concrete to achieve the owners' durability, accelerated timeline, and aesthetic goals. By using architectural precast panels, High Concrete Group, the precaster on the project, was able to provide the dark colour and avoid the repetitiveness of patterns, while limiting erection time.

Since the precast concrete element was the only shell between the inside and outside air, all of the panels on the office tower were insulated (and used C-GRID® carbon fibre grid wythe connections) to achieve thermal performance goals.

With no interior finishes, there was no

other way to provide insulation.

The result is a durable, attractive, high-performing structure that meets the needs of residents while creating an attractive addition to the urban landscape. The 5th & Race Street Development has been praised for the project's positive economic impact and the forecast benefits it will have on the west side of Cincinnati's central business district.

New materials for next-generation buildings

The construction industry has quickly been learning what other markets have known for years: carbon fibre is a material that can impart numerous benefits to end-products. The use of carbon fibre grid reinforcing in precast concrete signals a shift toward its use in new constructions after years of success in rehabilitation applications.

And considering a renewed focus on energy efficiency in the United States and internationally, the energy-saving benefits of insulated precast wall panels with carbon fibre grid wythe connectors are more attractive and competitive than ever before. □

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<https://altusprecast.com>