Lightening up on concrete cladding

By making the panels lighter, larger panel sizes become practical to cast and handle. This three m by 11.5m panel covers 50 percent more wall than the largest practical size of conventional precast, minimising the number of panel joints and speeding up construction. Photo Credit : Easi-Set Industries.

There was more than half a metre of snow on the ground, the kind of weather when construction crews hate jockeying truckloads of precast concrete panels into position under a crane. But on the jobsite of the Hilton Gardens Inn, Montreal, Quebec, it was worth the effort because every truckload covered an unusually large expanse of wall. There were more panels per load than a truck can usually carry. Some of the panels were as big as 9.8 m by 3.2 m, a size that is generally not practical with conventional precast architectural concrete.

However, in this case, even such a large panel weighed less than 4600 kg. The panels were SlenderWall studcast precast architectural concrete, and the Hilton Gardens Inn was the first project built in Canada utilising this particular studcast system. With just five cm of concrete thickness mated to a panelised frame of heavy-gage galvanised steel studs, the panels could enclose a wall two to four times as quickly as conventional precast, sealing out the freezing weather and thereby speeding up construction on the building interior by many weeks.

In the eternal struggle between building cost and quality, studcast is a potent tool. These thin-panel systems provide the benefits of architectural precast concrete but reduce weight by more than 50 percent. The light weight effects cost reduction that multiplies through every level of the superstructure and down into the foundation. Building with studcast panels also saves time, is more eco-friendly than conventional panels, and offers some distinct performance advantages.

Weighing the Options

Architectural precast concrete is well known for its aesthetic versatility, durability, affordability, speed of

The Marriott Execustay, in New York City, could not purchase the adjoining lot, but was able to buy air-rights over the existing low-rise next door. The lightness of studcast curtainwall made it possible to cantilever the floor slabs over neighbouring building without column supports for the floor slabs. Photo Credit : Easi-Set Industries.

erection and, unfortunately, its great weight. Typical 15 cm-thick precast panels tip the scales at about 350kg/m^2 and carry none of their own load, with some precast panels being even thicker and heavier. They hang on the building frame, demanding a heavy superstructure to support them, which in turn demands a heavy foundation. The resulting heavy building is also an environmental burden with respect to materials-consumption and greenhouse gas emission: every kilogram of portland cement production emits into the atmosphere approximately a kilogram of CO_2.

During the past two decades, several proprietary systems have been developed with the goal of preserving the great virtues of architectural precast but losing a lot of the weight. These different systems are all composed of a thin slab of concrete, each with a uniquely different integrally cast connection to panelised steel stud framing. This type of product has become known as studcast precast architectural concrete. A studcast panel, made of the same type of concrete as a conventional precast panel, can cut the weight of cladding by about 60 percent. In the case of the Hilton Gardens Inn, the difference in the weight of the cladding alone saved about 1,725,000 kg, plus further consequent weight reductions in the superstructure and substructure.

The thinness is made possible by re-envisioning the interaction between concrete and steel. Conventional precast concrete must be heavily reinforced so the panels can span from floor to floor and transfer wind, seismic, and other horizontal loads into the building structure. The steel reinforcing bars at the centre of a panel are not efficiently located to provide tensile forces required to hold a panel together. Consequently, conventional architectural precast panels are usually six to eight inches or more thick. In a studcast panel, by contrast, the steel studs are efficiently deployed to resist horizontal loads. If the studs are the “bones” of the panel, the relatively thin precast surfaces are the weather resistant “skin.” The precast concrete requires only a modest amount of reinforcing, typically welded wire mats, to reinforce their relatively short spans between the steel studs. The two materials work together for an efficient wall.

Studcast panels are typically made with five cm minimum concrete thickness. The concrete can be full density “hard rock” concrete with compressive strength in the range of 35Mpa min (5000 psi). It can be cast utilising any of the options possible with conventional precast panels: multiple integral pigments, exposed aggregate, form liners for cast-in textures such as brick or stone, returns, reveals and more. The panelised steel stud framing is integrally cast with the concrete, making it possible to achieve composite action.

The panelised frame is easy to position properly for casting, making the casting process fast and efficient. This integral framing also eliminates the need for applying additional furring to the panel’s interior; as cast, it is ready to receive interior finishes. Moreover, the frame provides built in cavities for utilities and insulation. By eliminating the need for additional furring, five to 10 cm of floor-space is gained around the entire perimeter of the building. At least one system mounts out-board of the floor edge, providing even more ‘bonus’ floor space. Depending on the size of the project, this extra space could be worth a “free” office or more.

There are several proprietary systems of studcast panels. The main distinguishing factor between them is the method of achieving the connection between concrete and steel. In some systems, specially designed connectors are attached to the steel frame and embedded in the concrete during casting. Another method involves

A studcast panel is composed of a five cm slab of concrete mated to a panelised steel stud frame. This composite panel can replace conventional 15 cm precast panels and cut weight by more than 50 percent. These panels, featuring integrally cast brick texture, are almost nine m long. Photo Credit: Easi-Set Industries

embedding part of the steel frame itself in the concrete. The choice of attachment technique can have an impact on several aspects of panel performance. Thermal isolation of the steel frame from the concrete affects the insulating ability of the panel. The smaller the surface area of steel-concrete contact, the better the thermal isolation. Use of a connector that creates a small air-gap between the framing and the interior concrete surface is ideal, eliminating “hot-spots” and “cold spots” that would telegraph the stud positions on the concrete’s exterior surface.

A connector with slight flexure and an epoxy coating gives the concrete skin a small degree of freedom of movement relative to the framing. Flexure of the connector isolates the building’s concrete skin from movement of the frame, allowing the panel to respond better to thermal expansion and contraction, wind-loads, and seismic movements. It minimises tensile stress in the concrete at connection points, reducing the possibility of cracking and helps maintain the integrity of the seals in the panel joints.

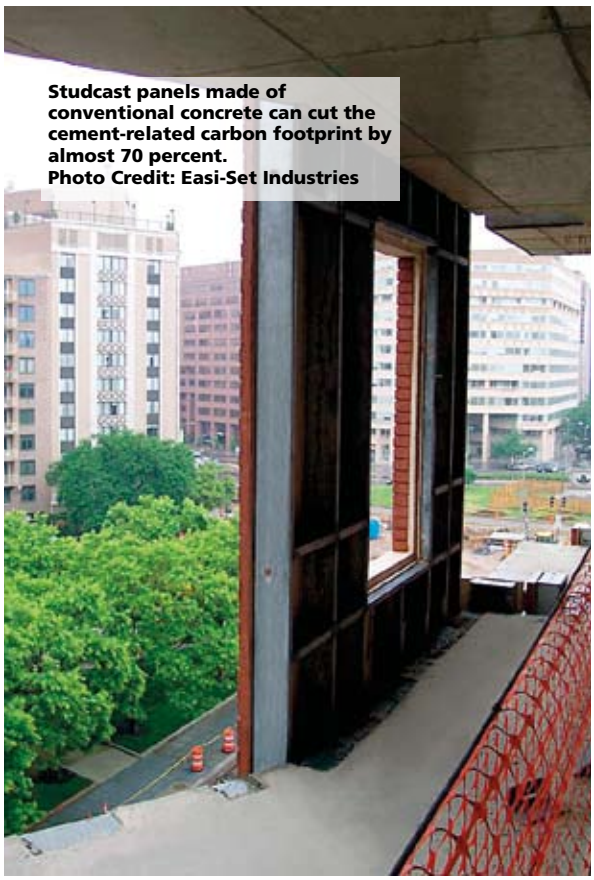
Lightweight studcast products brings numerous advantages when compared to conventional precast, from production through erection. At the production side, the casting cycle is speeded up because panels are able to support their own weight sooner, after just overnight curing. This helps keep costs down and allows a precaster with even moderate casting facilities to keep up with the rapid pace of studcast panel erection.

Perhaps the greatest advantage is the reduction of dead load in the structure. It results in a lighter superstructure, which in turn allows a smaller investment in the foundation and the footings. This saves cost in terms of reduced materials consumption, less excavation, and faster construction. In locations where seismic activity is a design concern, the lower mass of the thin panels reduces the level of seismic bracing required, too. Lighter panels even make practical certain designs that would

be impractical with conventional precast concrete. The Marriott Execustay in New York, for example, was built next to a low-rise building, and air rights over the low-rise were secured. Cantilevered floor slabs were designed over the top of the lower buildings without column supports for the floor slabs, creating additional leasable floor space. This design required lightweight cladding, so the architect specified a studcast panel system.

Less weight per square metre of wall area makes it practical to cast larger panel sizes, with numerous benefits flowing from this ability:

- More surface area of wall can be carried on a single truck, speeding up delivery and minimising energy-consumption and transportation-related costs.
- Larger panels means fewer panels, so more expanse of wall gets enclosed with each panel erected.
- Fewer panels minimises the number of panel joints that must be sealed, and reduces sites for air or water infiltration in the event of sealant failure.
- Larger panels give architects more freedom to design the joint spacing in a logical and aesthetically attractive manner.
- Faster enclosure of the building allows other trades to begin work sooner on the interior, minimising potential delays caused by weather.



**Studcast panels made of conventional concrete can cut the cement-related carbon footprint by almost 70 percent.
Photo Credit: Easi-Set Industries**

Alternatively, if larger panel sizes are not practical due to building design, the lightweight system means that regularly sized panels weigh less. Lightweight panels can be erected with a lighter-duty crane, which can create significant savings or simplify construction operations.

Light on the Environment

Reducing the amount of concrete in cladding panels has important environmental value. Concrete has a high carbon footprint due to large CO_2 emissions from the process of portland cement production. Portland cement accounts for approximately 15 to 18 percent of the solid materials in concrete. Every kilogram of portland cement produced releases about a kilogram of CO_2 into the atmosphere. The cement industry is trying to increase the efficiency of its manufacturing energy-consumption, but that has only limited impact on the problem: almost half of the CO_2 comes from the chemical reaction of limestone calcinations, so it is inherent in the nature of the material.

The key to more sustainable concrete is reducing the quantity of concrete needed. Studcast panels made of conventional concrete can cut the cement-related carbon footprint by almost 70 percent. Thinner panels also consume less aggregate. The raw materials of concrete are generally locally extracted, possibly contributing the LEED points. Recycled content in the steel and inclusion of recycled cementitious products such as fly ash in the concrete can contribute to LEED points as well. Lighter panels also reduce transportation-related energy consumption and air pollution.

Special Innovations

The light weight of the panels has inspired innovative erection methods. SlenderWall, for example, employs a lift-and-release technique, positioning the panel by crane and depositing it on landing hooks that temporarily hold it in position prior to final connection. This allows the crane to be disconnected from the panel quickly, so it can bring the next panel without waiting for the first panel to be fully welded into place. Numerous panels can be temporarily positioned this way, enabling more perfect alignment before permanent connection.

A specially designed, proprietary multi-layer joint sealing system is available that not only keeps water out of the interior, but includes a built-in pathway to channel out any moisture that penetrates the outermost sealant layer. The channelling device acts as a leak detection system, producing a small but visible wet spot on the exterior surface that pinpoints leak locations to within a few metres.

Remarkably, the advantages of studcast come with virtually no trade-offs. Studcast panels can be made

Studcast precast panel technologies are a prime example of the innovative thinking that is sweeping the construction industry. Photo Credit: Easi-Set Industries

with high-strength concrete to equal the durability of conventional precast. With integral water repellents, the thin concrete can achieve the moisture-proof properties of full thickness precast. All the options of cast-in colour, texture details, and architectural veneers are possible. The thickness of the concrete can also be varied to allow for reveals or other architectural details.

How to Specify

Established studcast producers can provide more than a decade of experience and test data to establish the best way to integrate the concrete and steel element of a panel. An experienced precast concrete producer can make valuable contributions to the design team by suggesting the most effective means to produce the desired ends. Whenever possible, the decision to use studcast panels should be made as early in the project as possible in order to take advantage of the reduced dead load when engineering the structure. On complex projects and where appearance is crucial, a mock-up should be specified to allow all parties to determine acceptable standards of performance.

Studcast precast panel technologies are a prime example of the innovative thinking that is sweeping the construction industry. The re-thinking of tried-and-true materials allows us to improve construction methods and results, while still utilising the materials supply-and-delivery infrastructure on which the industry is built. It allows these time-tested materials to function more efficiently, and better meet the economic, environmental, and aesthetic demands of changing times.

A Quick Look

This combined hotel and residential structure is comprised of 43 floors, 37 above grade plus six below-grade parking levels. With 216 hotel rooms and 211 apartments, this $67,000,000 project is designed by Gieger + Huot, Architects, Montreal.

According to architect Eric Huot, MOAQ, MOAA, principal of Geiger + Huot, the choice to use studcast panels was driven both by cost and logistical limitations. The design team was committed to using precast panels from the beginning. As design evolved, it became evident that conventional precast panels on the upper stories would present problems. "We had certain issues with the reach of our crane," explains Huot, "that would limit us to single panels (three m x three m / 10 ft x 10 ft) on the upper floors, instead of larger sizes. That increases the number of installations. It would have been prohibitively expensive."

The studcast panels provided significant savings, achieved by reducing the number of panels and lightening dead load on the structure. In some locations, mostly near the base of the structure, conventional heavy precast panels were used for specific logistical and structural needs. For example, panels near the ground floor had granite veneers cast into them, and it was felt that a thicker panel would hold the stone better. Thick panels were also used beneath windows, where the window units actually rest on the curtain wall panel. Of the 10,680 m^2 of panels cast, less than 20 percent were conventional thick panels.

Since studcast was new to both the architect and contractor, a mock-up of one full bay was constructed to test colour, jointing, thermal properties, and other considerations. The mock-up enabled them to better understand the process and identify any special challenges. Adjustments to the standard system were made to better deal with the region's potential for extreme temperature

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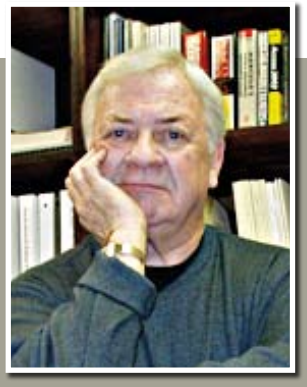
shifts – as much as 20°C during the course of a single day. Urethane insulation was sprayed into the wall cavities, and the mock-up helped work out the protocol for making sure the insulation penetrated fully into the air-gap between stud framing and concrete.

The precaster cast many two-colour panels: light beige concrete, with both heavy and light sandblasts, and black-pigmented concrete with acid wash. Some of the panels included very large openings. Using a proprietary process, panels were made featuring curved surfaces on two sides of the building. They also created a special black joint sealant to blend with the black concrete. During the 36-month construction schedule, panel erection took place over about six months. There was a strong desire to finish the hotel portion of the structure - the lower 14 floors – as soon as possible. After the lower 14 floors were enclosed, there was a delay of about four months while structural concrete was placed and cured before cladding could be installed on the upper stories.

Sylvain Paquin, civil engineer and project manager for general contractor Groupe Canvar, Inc, comments that the panel installation was significantly faster than erection of conventional precast panels. "With regular precast, we can install eight to 11 panels per day. With the studcast panels, 15 to 20 per day." Paquin's team was able to land the panels in position and disconnect the crane quickly. With conventional precast, the crane would have to wait and support the panel during the entire welding process. Architect Huot comments, "We're very happy with the end result. The building looks great."

Quick Questions with Moffette Tharpe, Marketing Director for SlenderWall architectural precast wall systems.



1) What, in your own words, is precast studcast architectural concrete?

Studcast is a marriage of a thin panel of architectural precast concrete to cold-form steel stud framing. The two materials act in a synergistic manner to provide a precast panel suitable for building cladding at a fraction of the weight of conventional architectural precast panels. Studcast is normally used as a curtain wall and not as a load-bearing panel.

2) What was the inspiration behind the creation of the precast studcast architectural concrete system?

Architectural precast is a great building tool, offering the ability to enclose a building and provide a visually rich look both quickly and affordably, but it is very heavy. The goal of studcast is to capture the advantages of precast panels while reducing the weight significantly, and simultaneously speeding up enclosure of the building. Weight reduction translates into cost savings and lower environmental impact, two central objectives of today's construction industry.

3) What were some of the challenges faced in the creation of the system?

First and foremost, maximum weight reduction without compromise of the integrity and durability of the panel. This is achieved by the engineering of both the panel and the connection system that integrates it with the steel framing. In the case of Slenderwall, it involves the use of welded wire mesh reinforcement, a specialised connector, high-strength concrete with superplasticisers and other additives, and in some projects, the inclusion of synthetic fiber in the mix.

Also, reduction of thermal transfer from the steel framing and through the panel is important to energy efficiency. Different studcast systems address this problem in different ways with varying degrees of success. The Slenderwall system uses a thermally-coated stud embedded in the concrete that connects concrete to steel, minimising both the area of contact and thermal conductivity of the connection. The precise embedding of the stud creates a ½-inch air gap between the concrete's interior surface and the steel frame.

4) Can you describe the technology behind the system?

Heavy-gauge galvanised steel framing is panelised with stainless steel stud anchors welded to the frame members at 24 inches on center. A specialised architectural concrete mix is cast two inches thick, with the steel frame suspended over the casting bed at a precise height to embed the protruding stud anchors into the concrete with a ½-inch air gap between concrete and steel. The complete Slenderwall system includes a proprietary lift-and-release method to speed erection, and a specially engineered joint sealing system that prevents moisture intrusion into the interior of the building and provides a positive visual method for locating any joint-sealant failure that may occur over time.

5) What are some of the major benefits of this new system?

Light weight, affordability, fast erection, durability, large panel sizes that can minimise the number of panels and panel joints, moisture impermeability, shipping cost and time reductions due to larger and lighter panels, responsiveness to structural shifts and building movement, seismic isolation of panels, thermal efficiency, architecture versatility, and "bonus" floor space on every floor since the panels mount to the floor edge.

There are also a host of sustainability benefits: reduced raw materials consumption, reduced carbon footprint associated with concrete, reduced energy consumption associated with shipping, energy efficiency of the building due to the thermal efficiency of the system, reduced impact of construction on the surrounding area due to faster erection and lighter-duty cranes needed for lightweight panels