LIGHTWEIGHT PRECAST CLADDING

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ABSTRACT

The most significant recent development in architectural precast materials and their application on building facades is lightweight precast concrete cladding. Until it was introduced in 2004 the industry had few lightweight cladding options for highly articulated facades, and those were limiting in terms of aesthetics, seismic performance and long-term durability.

The lighter weight is achieved in several ways. First, the steel mesh found in conventional precast is replaced with carbon fiber grid, which is non-corrosive. Since the reinforcement won't rust, less concrete cover is required so the panel face can be as little as 1-1/2" thick. Panels can be almost any size and overall thickness without significant weight penalty. Next, the backs of the panels may be filled with lightweight foam instead of concrete. This construction still delivers all the required durability, fire and weather-tight performance properties.

The resulting panels afford new aesthetic freedom for designers, as they can have dramatic reveals and articulation without costly implications to engineering, erection and other aspects of the project. This paper discusses lightweight precast cladding and its advantages in reducing superstructure and foundation requirements and contributing to sustainable design.

INTRODUCTION

Possibly the most significant recent development in building facades is lightweight precast cladding. Until it was introduced in 2004, the construction industry had few lightweight options for highly articulated facades, and those were limiting in terms of aesthetics, seismic performance and long-term durability.

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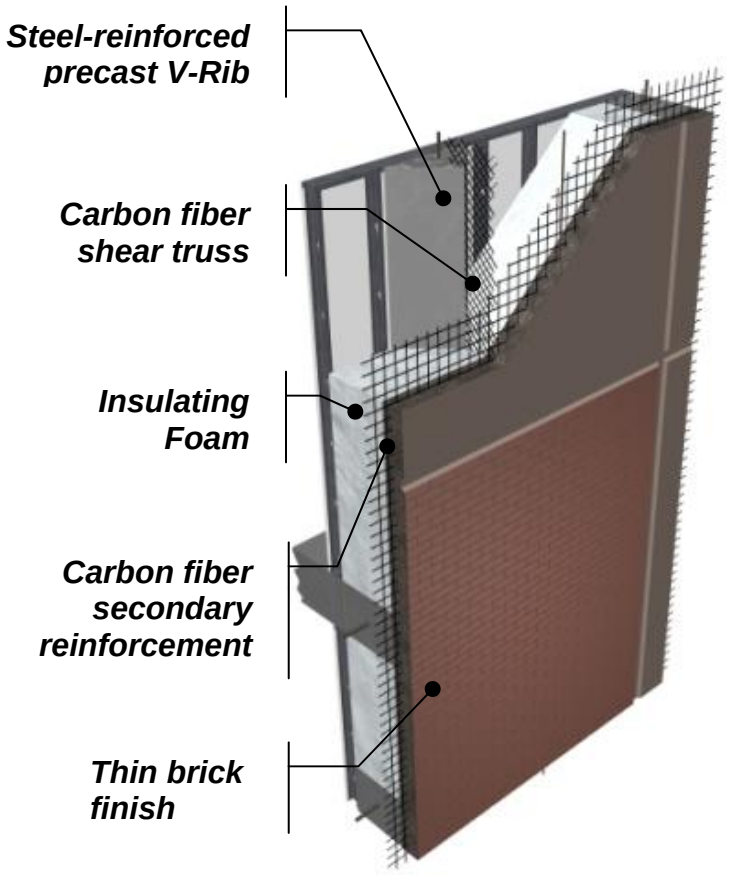

Fig. 1 Lightweight cladding reinforced with carbon fiber

The Heldrich in New Brunswick, N.J. is a luxury condominium/hotel project that opened in 2007 with 10" thick lightweight cladding panels that couldn't have been achieved with conventional precast [FIGURE 2]. The weight would have exceeded crane capacity and practical structural limits. This project was recognized by the Precast Concrete Institute's Harry H. Edwards Industry Advancement Award.

Fig. 2 The Heldrich, New Brunswick, N.J.

Lightweight precast concrete cladding permitted thicker articulated panels with significant weight savings.

Lightweight cladding with articulation offers an important choice to designers, particularly in markets where there is a desire for the "right" amount of glazing in hi-rise development, as opposed to a full glass curtainwall. This is particularly true in multi-unit residential buildings, which have to be heated and don't have a warm internal core as do offices. Lightweight cladding takes advantage of solar gain and can help with shading, which is harder to control in residential settings.

Lightweight cladding design expression is not limited to articulation. Because precast concrete is highly plastic, virtually any desired visual can be achieved. As an example, form liner can be used to create almost any appearance including natural stone. These liners can be adjusted throughout the project so that panels may be repeated for economy yet have very different stone visuals. Further variation can come from colors and stains, or textured finishes. The new Edward Jones headquarters in Maryland Heights, Mo. near St. Louis is being built with lightweight cladding that mimics the expensive Portuguese limestone originally specified. And, it meets the 50 lbs. per square foot limit set by the engineer – again, not something conventional precast could achieve.

Double-caulking of panel joints is a smart way to control moisture. Double-caulking virtually eliminates moisture penetration [FIGURE 3].

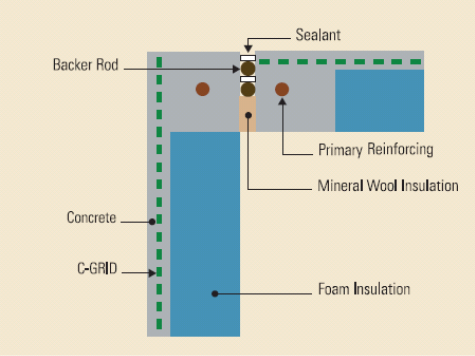

Fig 3 Double caulking at joints for moisture control

Lightweight cladding is an ideal material for sustainable design projects. It can contribute toward all 20 of the LEED® credits identified by the Precast/Prestressed Concrete Institute (PCI) for conventional precast. In addition, lightweight cladding should be considered for Innovation & Design credits; because it is lighter in weight, it contains less embedded energy which in turn means it has a lower carbon footprint.

Another development that has had significant impact is the adoption of thin brick in precast cladding. Thin brick achieves the appearance of full brick but without the additional on site labor, site disruption and scaffolding which in itself adds cost and risk. At 5/8" thick, thin brick is set in 5,000+ psi concrete that locks it in place. There is no repointing of low-strength mortar in these panels, and they are virtually impervious unlike porous brick rain screen. Thin brick aesthetics are advancing to the point that they blend very well with existing brick structures and traditional architecture. Like precast cladding, thin brick can also help contribute to LEED® points because it is far les energy intensive to produce than full bed brick and far more efficient to transport.

On the cement side, a new cement is available that allows concrete to clean itself through a chemical process called photocatalysis. This process is receiving attention from both researchers and industry experts because of its beneficial effects on air and water purification as well as its antibacterial properties. The cement also gives concrete the ability to reduce environmental pollution by causing the concrete surface that interacts with the air to eliminate airborne pollutants responsible for urban organic pollution.

DESIGNING WITH LIGHTWEIGHT CLADDING

This new era of multidisciplinary teamwork that's required for sustainable design is a natural fit for lightweight cladding. A case in point is Symphony House in Philadelphia, the 32-story residential high-rise on South Broad Street that opened in 2007 [FIGURE 4]. Working together, the architect and engineer were able to take leverage the weight savings to build on what was otherwise an impractical urban site.

FIG 4 Symphony House, Philadelphia, Pa.

Innovative lightweight cladding panels eliminated columns and allowed slab-attachment, improving floor plans and reducing superstructure and foundation requirements.

The cladding panels on Symphony House were 7" thick and deeply articulated. But they weighed 66% less than conventional precast so they could be slab-attached, which in turn meant fewer columns and better designed interior spaces. Further, the panels were tested water-tight in category five hurricane conditions.

Another driver for lightweight materials is seismic requirements and poor soil conditions, which are found around the country. Lighter weight cladding means better seismic performance because there can be fewer columns, reduced superstructure and foundation requirements so ultimately there's less mass to develop momentum. Again, on Symphony House lightweight cladding allowed the project team to use a floating mat foundation rather than a costly caisson to attain seismic performance.

The implications of lightweight cladding extend throughout the project, from aesthetics to site logistics. Now cladding can be thin or thick and extensively articulated. It can be lighter to reduce crane size, it can be in larger panel sizes to reduce the number of crane picks, and shipped with more pieces on each truck to reduce shipping costs. It also makes precast cladding – already a sustainable solution – even more sustainable because it contains less embedded energy.

IMPLICATIONS OF LIGHTWEIGHT CLADDING

Probably the biggest mistake people make is to continue to do things the way they've always done them. Designers know what has worked in the past. But the past is a poor predictor of the future, particularly when new technologies are being brought to bear on old problems at an ever increasing pace. Precast walls offer an easy, bullet-proof solution to many problems, at a better cost. Outdated designs introduce the familiar moisture and thermal transfer issues that make people uncomfortable and less productive, and that they really shouldn't have to put up with.

Another potential missed opportunity is optimizing of the structure and enclosure. Here again an integrated design approach can prevent over-design when lightweight cladding is used, because the lighter weight means there are savings to be had in the superstructure and the foundation. The team members really have to communicate and consider the whole system before the design is decided.

Architects are not always aware of the great variety of precast finishes and are often surprised to learn that making a concrete mix is like working with a multi media painters pallet ... sand, stone, pigment, pozzolans, cement and blasting, etching, retarding or polishing and formliners. All can be used to deliver virtually any look and feel ... precast concrete is a truly natural material with its own unique properties. It isn't just gray concrete anymore.

Last, it is important to involve the precaster early in the project, before the job goes out to bid. Precasters can offer cost-saving insights on topics that can quickly become issues in projects. These include panelization, crane sizes, number of picks, site logistics, staging in increasingly congested urban areas, managing trucks in day and night and other execution-related matters that are easy enough to plan for but are very difficult and sometimes impossible to deal with after the fact.

FUTURE DEVELOPMENT ACTIVITIES

In the near future you will see thermally-efficient lightweight cladding panels. Light weight and insulating value are two characteristics that architects – who are increasingly focused on sustainable design – value highly in wall products. Light weight and insulating value are important because architects are trying to reduce the building's carbon footprint, that is, the CO_2 emissions caused by manufacturing, transportation and heating/cooling energy consumption. They can do this in part by reducing the weight or mass of a component material, foundation or a superstructure. Essentially mass equals embedded energy, which equals carbon emissions, so less weight equals less mass equals less carbon emissions. By adding insulation they can reduce energy consumption, again reducing carbon emissions, and also comply with the new, more stringent ASHRAE 90.1 2007 requirements for continuous perimeter insulation (ci).

Blast resistant wall assemblies, although still in their infancy, are increasing in importance too. Also, new technologies are being incorporated into the design of the precast concrete mix itself. Soon there will be lightweight concrete mixes that further reduce the weight of the concrete section while retaining its inherent strength and water resistance.

Right now there are solutions in hand that people don't have to wait for, and that are better than the same old way of doing things. High performance insulated wall panels, for example, are a sandwich design constructed with a thermally nonconductive carbon fiber shear truss. These panels provide composite performance in load bearing or non-load bearing conditions, and they provide outstanding thermal efficiency. They're being used on Lucas Oil Stadium, the new home for the Indianapolis Colts, with a thin brick finish. Thermally-efficient wall

panels are ideal design for schools … the new Tilden Elementary School in Hamburg, Pa. uses these panels to keep kids cool in the summer and warm in the winter – something traditional cavity wall construction doesn't do very well. Thermal imaging on construction of this type has shown dramatic decreases in thermal transfer compared to traditional construction. High performance insulated wall panels are also undergoing somewhat of an evolution, as designers realize they can use EPS insulation, which is less expensive than alternatives and also adds shear performance.

CONCLUSIONS

Carbon fiber-reinforced cladding has been installed in significant buildings earning national recognition and awards for innovation and design. A landmark innovation in precast construction, lightweight cladding provides unprecedented weight savings that improves project performance and cost while offering an important new range of choices for architectural design. The panels are up to 66% lighter or more than conventional precast, reduce foundation and superstructure costs, have fewer columns and slab attachment for better use of floor space and improved room layouts, increase net usable or rentable floor area, improved seismic performance, and lower transportation and erection costs