# Precast's Versatility Expands Use of Terra-Cotta

High-Performance precast helps to fuel the resurgence in the use of terra-cotta

— Craig A. Shutt

Terra-cotta tiles have been used to clad buildings in the United States for several decades, providing a distinctive aesthetic touch. Today, designers are discovering they can embed terra-cotta into architectural and structural precast concrete panels as a means to more efficiently use terra-cotta on projects. There are also several additional benefits, including aesthetic versatility, accelerated construction, reducing the number of joints and maintenance costs, and high thermal performance.

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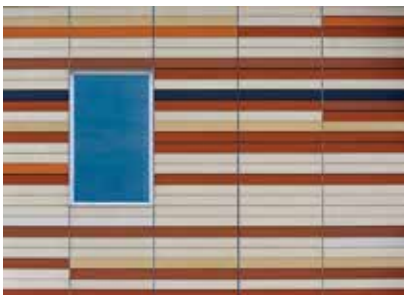
"Terra-cotta is an old material being used in a new way," says Kristen Vican, associate vice president at RTKL Associates in Washington, D.C. The architectural firm has used terra-cotta with rainscreens on a number of projects, especially abroad. But hand-setting the material into the rainscreen is cheaper overseas. "It's not as economical to hand-set it here, so it's difficult to work it into the budget. We like the material, but needed to find an economical way to feature it."

"There's a lot of interest in terra-cotta right now," says Dirk McClure, regional director of sales and business development at Enterprise Precast Concrete Inc. in Overland Park, Kan. His company has produced some projects using terra-cotta. "It's a traditional masonry material that can be used in a contemporary way."

"The benefits of the material make it popular," explains Bud Streff, director of sales for NBK North America, a German-based supplier of terra-cotta. "It has been used for 15 years in major markets, and now it's expanding into all parts of the country and all types of buildings. Designers realize that it has great color retention, so it creates a desirable look." Adds Vican, "It's a modular material that offers longer, linear tiles than other options. We like it because it creates larger modules than brick can provide."



*Terra-cotta was embedded into insulated precast concrete panels at the University of Missouri's Henry W. Bloch Executive Hall for Entrepreneurship and Innovation in Kansas City, Mo., when designers found it was more economical than cladding a rain-screen. Photos: Jacia Phillips Photography.*

## Rainscreen Alternatives

Its most common application has been in rainscreens, but that creates challenges. Those solutions lead to higher material and labor costs. McClure says, "Rain can get behind a screen, so additional protection is needed to shield the wall. That means budget issues can arise

with setting the terra-cotta and then protecting the building. Not only is it a very complicated detailing process, but a lot of the 'rainscreen to wall' connections are concealed. That can create issues if there are moisture or any other problems down the road."

Those were some of the challenges faced by designers with the University of Missouri's Henry W. Bloch Executive Hall for Entrepreneurship and Innovation in Kansas City, for which Enterprise fabricated insulated wall panels with embedded terra-cotta. "We wanted to use terra-cotta, and we started looking at rainscreens, but we needed to reduce the cost," explains Greg Sheldon, senior project architect and associate principal at BNIM, the architectural firm for the project. "We'd completed some terra-cotta projects and had a vast experience with casting clay-faced materials into precast concrete, so it seemed feasible."

Replacing rainscreens with precast concrete panels produces a more economical design because of precast concrete's ability to provide multiple functions, McClure says. "Precast concrete can stop moisture on the exterior wythe, which really simplifies detailing and reduces materials. It also consolidates trades and makes the entire process simpler."

'The cost of a terra-cotta precast concrete panel is more economical than a rainscreen design.'

NBK's Streff agrees. "The cost of a terra-cotta precast concrete panel is more economical than a rainscreen design, which requires stud backing, sheathing, membrane, and aluminum extrusions. It can achieve the same look, but provide a more cost-effective solution for your client."

The insulated wall panels on the Bloch Hall project also provided high thermal performance. Sheldon explains, "Our goal was to ensure the envelope would contribute to LEED requirements." An analysis of the building's enclosure showed the best approach to be two, 4-inch wythes of concrete sandwiched around 3 inches of rigid insulation. "Enterprise wanted the panels to have composite action so the panels would work together. We built the wall panels with the optimum insulation and thickness to handle the terra-cotta and provide thermal performance."

Incorporating terra-cotta into the precast concrete worked well. The project won the Harry H. Edwards Industry Advancement Award and the award for Best Higher Education Building in the 2014 PCI Design Awards competition (for details on the project, see the Fall 2014 issue of *Ascent*).

Insulated panels with embedded terra-cotta also were designed for the Salt Lake City Public Safety Building, where durability and safety protection were critical elements. The precast concrete panels consisted of an exterior wythe of 1 3/16 inches of terra-cotta, which was embedded into a 3 3/16 inches thick of concrete, creating a total wythe thickness of slightly more than 4 inches. The exterior terra-cotta embedded wythe and an interior 4-inch wythe of concrete sandwiched 2½ inches of rigid polyisocyanurate insulation to complete the building's enclosure.

"That thickness of stone and concrete provides a pretty good deterrent" to high-caliber ballistic penetration, explains Kevin Miller, president and principal in charge of the project at GSBS Architects. Tests showed no projectile could penetrate the second layer of concrete, much less go through it.

The 9-foot-tall by 30-foot-long panels were attached to steel columns so as to allow the panels to move with the frame. The panel sizes and weights created no special challenges in connecting them to the frame for the precaster, Hanson Structural Precast.

## Structural Options

Terra-cotta panels have been used with standard, noninsulated architectural panels as well as structural panels. The first use of structural panels was at the Consolidated Rental Car Facility (CONRAC) at Logan International Airport in Boston, Mass. "We had seen this approach used in Germany, but we didn't know if it could work here," says Camille Bechara, project manager and lead designer with Parsons Brinckerhoff, the architectural and engineering firm on the project. "We worked through everything carefully."

That included tests for humidity, elasticity, movement between materials, and maintenance needs

*The Consolidated Rental Car Facility (CONRAC) at Logan International Airport in Boston, Mass., features the first use of terra-cotta embedded into structural precast concrete panels. Photos: Fennick McCredie Architecture.*

as they related to structural panels, he notes. "We had to identify the issues and test the impact of everything."

The initial plan, as with the Bloch Hall building, was to attach the terra-cotta to a rainscreen in front of traditional structural precast concrete panels. But the team realized that embedding the terra-cotta into the structural panels could save about $1 million in material and construction costs. Those panels, cast by Blakeslee Prestress in Branford, Conn., were 51 feet tall, 12 feet wide, and 10½ inches thick, with 2- by 3-foot, ¾-inch terra-cotta pieces set into the panels.

To ensure this first structural use would perform well, considerable testing was done to ensure no deflection, cracking, or maintenance issues would arise. Life-size mock-ups were even driven around the plant's grounds over bumpy roads to evaluate the impact of worst-case delivery conditions. Some tiles were deliberately cracked and repaired. "We wanted to see what the chances were for cracking and how easily panels could be repaired or replaced if needed," says Bechara. "The response to the tests really made this approach attractive."

*Terra-cotta was embedded into the precast concrete architectural walls used to clad the Hyatt Regency expansion at Tysons Corner in McClean, Va. A custom frame was designed to cover the edges of panels at window openings to avoid the necessity of returns on panels. Photos: RTKL Associates.*

## Collaboration Is Key

Testing, along with full-size mock-ups, are critical at this early stage of experience, says Vican. She helped design the Hyatt Regency at Tysons Corner in McClean, Va., which features terra-cotta pieces embedded into precast concrete panels. The $70-million, 1.4-million-square-foot hotel expansion is designed to achieve LEED certification.

"Early collaboration is the key," she says. Discussions about design concepts and detailing concerns need to be addressed with the precaster and terra-cotta tile manufacturer, and the plants should be visited to understand the material and fabrication restraints. "Make sure your specifications include the testing and visual mock-up requirements."

Sheldon agrees. "Diligent research and engineering by the precaster helped overcome potential production challenges related to the use of terra-cotta in an insulated panel," he says. "Everything was explored, from the coefficient of thermal expansion to the amount of precast bowing that the tiles could withstand before cracking, the optimal thickness of the tile, reaction of the panel during freeze-thaw cycles, and more." The precast was produced by Gate Precast in Oxford, N.C.

During production, it is important to review the panelization plan and details with the contractor and to review critical details, such as joints and face mixes in the mock-up stage, Vican notes. The precaster's plant should also be visited during the fabrication to view the work in progress.

## Many Color Options

For the Bloch building, which included seven shades of terra-cotta and one glazed accent (comprising eight colors in all), designers created color-coded charts that outlined where each piece in each color of terra-cotta (all of which were the same 6-inch tall by 4-foot-long size) should be placed for each panel. "We used eight colors because each new color had a cost

implication," says Sheldon. Their goal was to use the same colors throughout but overbalance the shades to make one side redder and another more buff to complement adjacent structures in those tones. "We tried to balance the colors so it all worked while 'talking' to nearby buildings."

The color-coded charts were more precise than typical embedded brick, Enterprises' McClure says. For those applications, architects typically provide the percentages of each color desired and the precaster lays them out in a random format. Due to the nuanced color changes from one façade to another, this was more precise. It's a seemingly random pattern, but there was actually nothing random about it, from the standpoint of our casting process."

Terra-cotta color options vary, as with other clay-faced products. That offers opportunities to create unique looks. Although the Bloch project used eight colors due to its unique goals, projects typically use one to three colors. NBK terra-cotta colors are made from different color recipes and firing techniques, Streff notes.

Three colors were used on the Public Safety Building in Salt Lake City, Utah. "We wanted a look that was refined, clean, and simple, but also one that spoke to the function of the building through its durability and strength," Miller explains. The terra-cotta tiles were fired as 1- by 5-foot pieces to create a 30-foot grid pattern. "The long, narrow dimensions were large enough to make panelization economical without requiring special connections or design considerations to provide the necessary seismic movement."

## Dimensional Variations

Most projects have used terra-cotta tiles of a 25-mm thicknesses, as designers have found this thickness provides the optimum combination of stiffness and flexibility to work with the weight and thickness of the panels. NBK can make tiles in a range from 20 mm to 30 mm, Streff says. Adds Sheldon, "The panels can be pretty stiff and robust even at 20 mm."

Terra-cotta dimensional capabilities are more versatile than with standard bricks, one of the material's key attractions. But there also are limitations, with a need to balance height and length to achieve the best structural performance, Streff notes. The solid tiles used with precast concrete installations typically are no longer than 5 feet and between 6 inches and 2 feet in height.

Bloch Hall's 12-foot-wide panels couldn't use two 6-foot panels, so three 4-foot ones were specified. "The 4-foot length was comfortable and eliminated any concerns about flexure issues with longer pieces," Sheldon says.

*Terra-cotta tiles that were $1\,3/16$ inches thick were embedded into insulated precast concrete panels to clad the Public Safety Building in Salt Lake City, Utah. The high-performance precast concrete panels provided both energy efficiency and protection from ballistic penetration. Photos: Benjamin Lowry, GSBS Architects.*

## Detailing Concerns

Possibly the biggest concern involves detailing, as the details and specifications have not existed until now, says Vican. It is critical that the floor-to-floor heights work with the tile dimensions to avoid having to cut the tile and leave an exposed edge. "Horizontal dimensions are more critical than vertical ones, since tiles can be more easily modified," she says. Punched windows also must be coordinated to ensure the tile joints align.

On the Hyatt Regency project, RTKL designers considered different window options, with punched windows preferred, she says. "They're harder to do with terra-cotta because of the need to cut the tile."

## Terra-cotta Properties

- Clay-based product.
- Very dense, with low absorption (4-7%).
- Tiles are still wet before casting to prevent excessive absorption of water in curing process.
- Tight tolerances (1/16-inch) can be achieved.
- Extruded with grooves on back to aid bonding.
- Must meet ASTM requirements to qualify for facing, including:
  - Absorption.
  - Flexural Strength.
  - Weight.
  - Thermal Expansion.
  - Freeze-thaw.
  - Hardness.
  - Efflorescence.
  - Chemical Resistance.
  - Compressive Strength.
  - Glaze Resistance to Crazing & Freeze-Thaw.
  - Dimensional Tolerances.
  - Warping Tolerances.

To resolve this, the team created a custom mullion that covers the edges. The team investigated creating pieces with a return, but they required a two-stage pour that wasn't cost efficient.

"Most terra-cotta-faced precast concrete designs keep the windows to the exterior face to resolve issues," she notes. "The concern with creating metal frames and trim is that the design still needs to allow tolerances for each material, which creates a wider gap."

Vertical joints are the key concern, with a requirement that water cannot infiltrate behind the joints. Horizontal joints are less problematic because they typically are shiplapped. To ensure continuity of the terra-cotta between panels without changing the joint width, joints should be the governing factor and the width at the overlap should accommodate the tile lip, she notes.

Custom tiles with finished edges and no shiplap extension may be required between precast panels, and at the top and bottom of rough openings. Angled tiles should be used at sill conditions.

Full-size, mock-up panels are essential to ensure no surprises once the erection begins, Vican notes. An aesthetic review should include the location and color of face mixes, selection of reveal depths, and selection of sealant colors. A review of patch and repair procedures is also important, including the process for replacing a full tile and for repairing minor damage. Tests performed on the materials, at an independent facility, should include tests for tensile bond strength (pull tests) and freeze-thaw resistance. Five samples should be tested for each, she suggests.

### Typical Casting Procedure

The process of casting terra-cotta panels into precast panels is similar to creating panels embedded with thin brick or tile, although some differences exist. Terra-cotta pieces typically are hand set into the panels without the formliners that are used in casting panels with thin-bricks. Ideally, panels can be designed so the forms can be reused, even if the colors of the terra-cotta embeds change. Foam fillers and sealants are applied at the joints so the concrete does not bleed through. Bond breakers are not necessary with terra-cotta pieces.

Reinforcing, lifting hooks, steel anchors, and embeds are installed in typical fashion. The formwork can be stripped within 24 hours, and the precast concrete portions of the panels are acid-washed.

'There are no transportation or erection issues that are distinct to panels embedded with terra-cotta.'

"There are no transportation or erection issues that are distinct to panels embedded with terra-cotta," says NBK's Streff. Terra-cotta panels can be larger and therefore heavier than those with brick, but they are designed at an efficient size for the specific project and can be maneuvered with the right size crane. "There's more attention needed to detailing now, as it's not a set procedure, but otherwise terra-cotta can be designed similar to other clay-faced products."

Terra-cotta can provide a distinctive, unusual appearance, and embedding it in precast concrete creates an efficient, cost-effective approach that is fast to construct and minimizes site congestion. Those involved in the projects agree they will use it again—and have learned from their initial experiences.

"Now that we know what's possible and what can be done, I think I'd push to make the envelope even more thermally efficient on future projects," says Sheldon. "It's important to do your homework and find the best balance. We learned a lot, but we also learned that each project will be a little different."

Vican agrees. "Now that we feel more comfortable designing with terra-cotta on precast concrete panels, and see how much resilience it has, I think we could push the boundaries further next time."

**For more information on these or other projects, visit www.pci.org/ascent.**