



Precast/Prestressed Concrete Institute

# Clay Product-Faced Precast Concrete



# designer's notebook

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The use of clay product-faced precast concrete has evolved since the early 1960s into the designer's choice for unlimited aesthetic options on all types of structures. It gives the architect the flexibility to combine the pleasing visual appearance of traditional clay products with the strength, versatility, and economy of precast concrete. Among the types of materials that can be embedded in the precast concrete are brick, ceramic tile, porcelain, and architectural terra cotta. These clay product facings may cover the exposed panel surface entirely or only part of the concrete face, creating accents. The demand for thin brick in precast concrete led PCI to develop a standard for embedded thin brick in precast concrete panels so that the design community can have control over the performance of their precast components.

## Benefits and Advantages

The combination of precast concrete and clay products offers several important benefits and advantages over site-laid-up masonry. During the life cycle maintenance of these systems tuckpointing is eliminated, unlike traditional hand-laid units. Clay product-faced precast concrete units act as a rain barrier and not a rain screen.



**Figure 1** Bonding patterns incorporated into the finished panel.

Precasting techniques allow complex and intricate details such as arches, radii, ornate corbels, and numerous bonding patterns to be incorporated into the finished panel (**Fig. 1**). This freedom of aesthetic expression could not be accommodated economically with site-laid-up masonry. Prefabrication ensures that building skills are transferred to the controlled conditions of the plant and away from the critical path of on-site activities.

Precasting allows a high level of dimensional precision and quality control. Concrete mixtures and batching, together with curing conditions, can be tightly controlled, whereas site-laid masonry may have variable curing and mortar qualities.

Plant production provides for year-round work un-

der controlled environmental conditions, negating any on-site delays due to inclement weather or incurring the expense of on-site weather protection. It also allows the building enclosure, with floor topping and finishing trades, to continue without any weather delays. Clay product-faced precast concrete can eliminate the need for costly on-site scaffolding, material storage, equipment, and manpower and can greatly reduce the duration of masonry cladding time. Also, site disturbance, construction debris, and use of toxic cleaners are reduced. Clay product-faced precast concrete panels can eliminate many items necessary for traditional masonry such as dovetail anchors, flashing, and weep holes.

Panel configurations include a multitude of shapes and sizes: flat panels, C-shaped spandrels, soffits, arches, and U-shaped column covers. Repetitive use of any particular shape also lowers costs dramatically. Returns on spandrels or column covers may be produced by the sequential (two-stage) casting method or as a single cast, depending on the height of the return. Panels may serve as cladding or may be load-bearing, supporting floor and roof loads, and can even function as lateral load resisting elements (shearwalls).

## General Considerations

Structural design, fabrication, handling, and erection considerations for clay product-faced precast concrete units are similar to those for other precast concrete wall panels, except that consideration must be given to the dimensional layout of the clay product material and its embedment in the concrete. The physical properties of the clay products must be compared with the properties of the concrete backup. These properties include the coefficient of thermal expansion, modulus of elasticity, and volume change due to moisture, along with strict adherence to tight dimensional tolerances.

For design purposes, clay product-faced precast concrete panels may be designed as concrete members that neglect the structural action of the face veneer. The thickness of the panel is reduced by the thickness of the veneer. However, if the panel is to be prestressed, the effect of composite behavior and the resulting prestress eccentricity should be considered in design. Reinforcement of the precast concrete backup should follow recommendations for precast concrete wall panels relative to design, cover, and placement.

The height and length of the panels should be multiples of nominal individual masonry unit heights and lengths for effective cost control in the precast concrete production process. The actual specified dimensions may be less than the required nominal dimensions by the thickness of one mortar joint. For economical production, the precaster should be able to use uniform and even coursing without cutting any units vertically or horizontally except as necessary for precast panel joints and bond patterns. The PCI Standard for thin brick in precast concrete panels should be specified to ensure size uniformity, long term durability, and material compatibility.

## PCI Standard for Thin Brick

The objective of this standard is to outline material standards and specification criteria for brick manufacturers to meet when supplying materials to precast concrete manufacturers. The intent is to establish acceptable dimensional tolerances and consistent testing standards for brick embedded in precast concrete systems. The brick manufacturers must confirm through the provision of independent test results that their brick products comply with the PCI Standard. The PCI Standard should appear in all specifications as the approved industry standard. Brick manufacturers have agreed to promote the compliance of their brick with this new standard.

The following parameters have been established based on the successful use of embedded brick in precast concrete projects. The parameters set forth for use in this standard are attainable brick properties that have been derived with input from brick manufacturers, precasters, engineers, and architects, as well as consideration of existing test results.

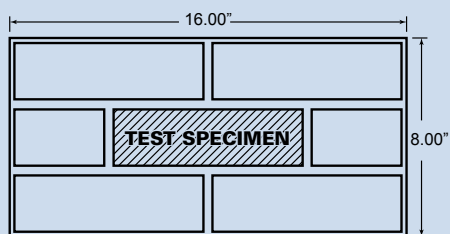
A. Thin Brick Units: PCI Standard, not less than  $\frac{1}{2}$  in. (13 mm) nor more than 1 in. (25 mm) thick with an overall tolerance of plus 0 in., minus  $\frac{1}{16}$  in. (+0 mm, -1.6 mm) for any unit dimension 8 in. (200 mm) or less and an overall tolerance of plus 0 in., minus  $\frac{3}{32}$  in. (+0 mm, -2.4 mm) for any unit dimension greater than 8 in. (200 mm) measured according to ASTM C 67.

1. Face Size: Modular,  $2\frac{1}{4}$  in. (57 mm) high by  $7\frac{5}{8}$  in. (190 mm) long.
2. Face Size: Norman,  $2\frac{1}{4}$  in. (57 mm) high by  $11\frac{5}{8}$  in. (290 mm) long.
3. Face Size: Closure Modular,  $3\frac{5}{8}$  in. (90 mm) high by  $7\frac{5}{8}$  in. (190 mm) long.
4. Face Size: Utility or Jumbo,  $3\frac{5}{8}$  in. (90 mm) high by  $11\frac{5}{8}$  in. (290 mm) long.
5. Face Size, Color, and Texture: **[Match Architect's approved samples] [Match existing adjacent brickwork]**
  - a. **<Insert information on existing brick if known.>**
6. Special Shapes: Include corners, edge corners, and end edge corners.
7. Cold Water Absorption at 24 hours: Maximum 6% when tested per ASTM C 67.
8. Efflorescence: Provide brick that has been tested according to ASTM C 67 and rated "not effloresced."
9. Out of Square: Plus or minus  $\frac{1}{16}$  in. (+/- 1.6 mm) measured according to ASTM C 67.
10. Warpage: Consistent plane of plus 0 in., minus  $\frac{1}{16}$  in. (+0, -1.6 mm).
11. Variation of Shape from Specified Angle: Plus or minus 1 degree.
12. Tensile Bond Strength: Not less than 150 psi (1.0 MPa), before and after freeze-thaw testing, when tested per modified ASTM E 488. Epoxy steel plate with welded rod on a single brick face for each test.

13. Freeze and Thaw Resistance: No detectable deterioration (spalling, cracking, or chafing) after 300 cycles when tested in accordance with ASTM C 666 Method A or B.
14. Modulus of Rupture: Not less than 250 psi (1.7 MPa) when tested in accordance with ASTM C 67.
15. Chemical Resistance: Provide brick that has been tested according to ASTM C 650 and rated "not affected."
16. Surface Coloring: Brick with surface coloring shall withstand 50 cycles of freezing and thawing per ASTM C 67 with no observable difference in applied finish when viewed from 20 ft (6 m).
17. Back Surface Texture: **[Scored], [Combed], [Wire roughened], [Ribbed], [Keybacked], [Dove-tailed].**

Test sample size and configuration shall conform to the following parameters in order to validate compliance by brick manufacturer with PCI Standard for use in thin brick precast concrete systems:

1. Minimum number of tests specimens: Comply with appropriate specifications except for freeze-thaw and tensile bond strength tests on assembled systems.



Clarification of the test sample preparation.

2. Minimum number of test specimens for freeze-thaw and tensile bond strength tests: Ten (10) assembled systems measuring 8 x 16 in. (200 mm x 405 mm) long with the brick embedded into the concrete substrate (assembled system). The ten (10) assembled systems are divided into 5 Sample **A** assemblies and 5 Sample **B** assemblies. The precast concrete substrate shall have a minimum thickness of 2<sup>1</sup>/<sub>2</sub> in. (63 mm) plus the embedded brick thickness. The precast concrete shall have a minimum compressive strength of at least 5,000 psi (34.5 MPa) and 4 to 6% entrained air. The embedded brick coursing pattern for testing purposes shall be modular size brick on a half running bond pattern with a formed raked joint geometry of no less than <sup>3</sup>/<sub>8</sub> in. (10 mm) wide and a depth no greater than <sup>1</sup>/<sub>4</sub> in. (6 mm) from the exterior face of the brick. One brick from the center of each Sample **A** assembly shall be tested for tensile bond strength, Item #12. In place of anchor specified in ASTM E488, use <sup>3</sup>/<sub>8</sub> in. (10 mm) minimum thickness steel plate of same size as single brick face bonded with epoxy to a single brick face for each tensile bond strength test. The steel plate shall have a centrally located pull-rod welded to the plate. Each Sample **B** assembly shall first be tested for freeze-thaw resistance, Item #13 and then one brick from the center of each Sample **B** assembly shall be tested for tensile bond strength, Item #12.



The appearance of clay product-faced precast concrete panels is achieved principally by the selected clay product, with type, size, and texture contributing to overall color. Also, the degree to which the clay product units are emphasized will depend upon the profile and color of the joint between units. The Brick Institute of America (BIA) recommends concave joints in all masonry projects. Due to forming requirements and material tolerances, it is preferable that joints between clay products be not less than  $\frac{3}{8}$  in. (10 mm).

The joints between panels are usually butt joints. Corners are usually achieved by using brick returns equal to the length of the brick module. Another element in the appearance of the panel is the 5,000 psi (34.5 MPa) concrete visible in the joints. Hand-tooled joints may be simulated by form liners or joints may be tuckpointed after forms are stripped, however this may add to the cost and maintenance of the panel.

The contract documents should clearly define the scope of clay product sizes, coursing patterns, and placement locations. Both stack and running bond patterns have been used widely in precast concrete panels. These patterns can be interchanged with soldier courses, basket weave, or herringbone patterns. Running bond patterns are typically less costly and visually more appealing when courses start and finish with half or full brick lengths. This approach avoids cutting and allows matching adjacent spandrels or column covers. Also, providing a narrow strip of exposed concrete at the edges of the panel helps reduce the visual impact and potential difficulty in aligning brick joints between precast concrete units. Vertical alignment of joints, especially with stack bond, requires close clay product tolerances or cutting of brick to the same length.

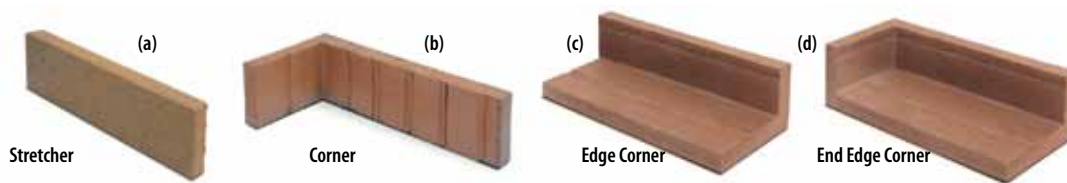
## Clay Product Properties

Physical properties of clay products vary depending on the source of clay, method of forming, and extent of firing. Because clay products are subject to local variation, the designer needs to obtain information on the specific clay product being considered to ascertain if the variations are acceptable.

As the temperature or length of the burning period is increased, clays burn to darker colors, and higher compressive strength and modulus of elasticity. In general, the modulus of elasticity of brick increases with compressive strength to a compressive value of approximately 5,000 psi (34.5 MPa); after that, there is little change.

## Clay Product Selection

Clay product manufacturers or distributors along with precasters should be consulted early in the design stage to determine available colors, textures, shapes, sizes, and size deviations of clay products, as well as manufacturing capability for special shapes, sizes, and tolerances. The



**Figure 2** Thin brick units.

specification should identify the color, size, and manufacturer(s) of the clay product. Usually the precast concrete producer buys the clay products and knows which products are able to conform to the PCI Standard for embedded brick in precast concrete.

PCI Standard thin brick veneer units  $\frac{1}{2}$  to 1 in. (13 to 25 mm) thick are typically used and are available in various sizes, colors, and textures. Thin brick conforming to the PCI Standard are actually a tile and have lower water absorption than conventional brick. In addition, thin brick is less susceptible than conventional brick to freezing and thawing issues, spalling, and efflorescence.

Stretcher, corner, or three-sided corner units are typically available in a variety of color ranges (**Fig. 2**). The face sizes normally are the same as conventional brick and, therefore, when in place, yield the aesthetics of a conventional brick masonry wall with the superior performance of precast concrete.

The most common brick face size is the modular. The utility face size is popular for use in large buildings because productivity is increased, and the unit's size decreases the number of visible mortar joints, thus giving large walls a different visual scale. The PCI Standard contains most popular thin brick face sizes. Contact a local precaster or thin brick manufacturer's representative to determine availability of desired color or texture in the face sizes selected.

FBS and FBX are designations for facing brick types that control tolerance, chip-page, and distortion. Type FBS is brick for general use in masonry while Type FBX is brick for general use in masonry where a higher degree of precision and lower permissible variation in size than permitted for Type FBS is required (see ASTM C 216). For thin-veneer brick units, Type TBS (Standard) is thin-veneer brick for general use in masonry while Type TBX (Select) is thin-veneer brick for general use in masonry where a higher degree of precision and lower permissible variation in size than permitted for Type TBS is required (see ASTM C 1088).

Some bricks (TBS or FBS, for example) are too dimensionally inaccurate for applications with precast concrete panels. Also, these bricks typically have high absorption rates that cause greater chances of efflorescing and freeze-thaw spalling. They conform to an ASTM specification suitable for site-laid-up applications, but they are not manufactured accurately enough to permit their use in a formliner (preformed grid) that positions bricks for a precast concrete panel. Tolerances in an individual TBX or FBX brick of  $\pm 5/32$  in. ( $\pm 4$  mm) or more cause problems for the precast concrete producer. Brick (TBX and FBX) are available from some suppliers to the close tolerances necessary for precasting. Close tolerances also can be obtained by saw-cutting each brick, but this increases costs substantially.

FBX brick may be split into soaps (half brick). Often only one side of the brick can be used as the facing veneer. The use of soaps will increase the thickness and weight of the panel. Whole bricks are not recommended for use in precast concrete because of the difficulty in adequately filling the mortar joints and the potential for freeze-thaw spalling plus the need to use mechanical anchors.

Figures 3 through 10 illustrate various projects with applications of brick-faced precast concrete panels.

The patterned façade on the museum (**Fig. 3**) is composed of bands of rusticated red brick accented by



**Figure 4 (a), (b) & (c)** San Francisco Museum of Modern Art, San Francisco, California; Architect: Mario Botta, Design Architect: Hellmuth, Obata & Kassabaum, P.C. (HOK) Architect of Record.

(Courtesy Perretti & Park Pictures)

flamed white and black granite on the upper level. The 1-in.-thick (25 mm) bricks are cast in 9-in.-thick (225 mm) precast concrete panels. The bricks, some 600,000 in all, were rolled in sand before baking to give them a grainy finish. Most panels measure  $10 \times 28\frac{1}{2}$  ft ( $3 \times 8.7$  m) and contain 1,500 to 2,300 bricks per panel. The museum's horizontality was emphasized by raking the mortar joints between brick courses (**Fig. 3 [b] and [c]**). These figures also show the flat and corner panels with corner brick, as well as the close-ups of the façade patterns.

The eight office and four assembly buildings in the 1.5 million sq. ft. (139,300 m<sup>2</sup>) campus shown in **Figure 4** are clad with 6,882 thin brick-faced architectural precast concrete panels totaling 548,623 sq. ft. (50,967 m<sup>2</sup>). The panels also clad four



parking structures and the thin brick panels were brought into the main dining room in the assembly buildings. With multiple buildings under construction simultaneously, having brick-clad precast concrete panels produced off-site helped to reduce the on-site work required. That helped reduce the quantities of people, equipment, and materials on the job and ultimately created a more manageable, cleaner, and safer worksite.

The retail store in **Figure 5** features insulated thin brick-faced precast concrete panels highlighted with bands of 4 x 12 in. (100 x 300 mm) utility brick at the entry that alternate with the precast concrete tones. The panels were designed as shearwalls and have a light sandblast finish on the accent stripes. Brick-faced precast concrete panels were selected because the job schedule was able to be reduced by four months versus conventional masonry.

Brick-faced precast concrete panels were specified for the office complex in **Figure 6** over traditional brick construction for its cost efficiencies, speed of construction, and simplified logistics. The complex contains three structures: a 6-story office building, a 14-story office tower, and an 8-story parking structure that sits behind the two office buildings. The bricks are  $\frac{5}{8}$  in. (16 mm) thick and are the skin of 6-in.-thick (150 mm) concrete panels. Designed as a nexus for a thriving high-tech corridor, the project connects Georgia Tech University with a burgeoning business and residential community. Architectural precast thin brick concrete panels helped mix city and university in a style that fits both neighborhoods.

The 950-vehicle parking structure (**Fig. 7**) was designed to address a university town's acute parking shortage while blending with the classical architecture of the campus buildings. A fast-track schedule took advantage of the ability to cast components, which included both structural and exterior façade components, before the completed design package was issued. Inset thin brick was used on upper-level panels, with the panels cast with the brick in place in the molds, creating a one-step operation. Lower floors feature panels with a limestone-like appearance that was achieved with a buff-colored finish, light sandblast texture, and detailed reveals. Only a few different sizes and shapes of precast concrete panels were required, speeding production and reducing costs by minimizing the number of molds. Material needs also were reduced by using the exterior precast concrete as both the façade and as loadbearing panels for the interior double tees.

The elementary school in **Figure 8** has loadbearing insulated sandwich wall panels with reddish-gray thin brick. Three inches of rigid extruded polystyrene



**Figure 4** Merrill Lynch Hopewell Campus, Pennington, New Jersey; Architect: Thompson, Venulett, Stainback & Associates (TVS).

(Photo Brian Gassel/TVS)



**Figure 5** Nordstrom Palm Beach Gardens; Palm Beach Gardens, Florida; Architect: Callison Architecture Inc. (Photo Vern Smith).



**Figure 6** Centery at Technology Square Atlanta, Georgia; Architect: Smallwood, Reynolds, Stewart, Stewart & Associates Inc.;

(Photo Gabriel Benzur.)



**Figure 7** Hull Street Parking Deck, Athens, Georgia; Architect: Smallwood, Reynolds, Stewart, Stewart & Associates. (Photo Jim Roof)



**Figure 8** Willow Creek Elementary School, Fleetwood, PA; Architect: AEM Architects, Inc., Reading, PA. (Photo AEM Architects, Inc.)

foam was sandwiched between the 3 in. exterior wythe and 4 in. interior wythe providing an R-value of 16. Conduit for exterior lighting and fixtures was cast into the troweled interior wythe. Interior walls were painted off-white and are the exposed surfaces of the classrooms. The precast façade was panelized to 14 ft (4.3 m) widths to minimize the number of joints and to optimize shipping efficiency.

The façade of the seven-level stadium in **Figure 9** features inlaid thin jumbo bricks on an insulated 3-2-3 (75-50-75) composite architectural precast system with limestone finished precast accents. The large column covers were sequentially cast which allowed them to be erected as one large piece versus three pieces. To enhance the visual expression, the arched entrances' thin brick were corbelled out.

The LEED Certified 400-bed suite-style university residence hall in **Figure 10** was designed to fit seamlessly onto an 80 year old Gothic campus. The cladding is composed of red and tan thin brick with precast concrete details such as attenuated fins that help break up its massing. The edge to edge insulated sandwich panels provide both the exterior wall and a trowel finished interior wall with an R-value of 26. Panels were 12 ft, 4 in.

(3.7 m) tall x 30 ft long (9.1 m) with 3 ft (0.9 m) side returns. The interior wall was painted to match the drywall finishes of the space.

## Ceramic Tile

Glazed and unglazed ceramic tile units should conform to American National Standards Institute (ANSI) A 137.1, which includes American Society for Testing and Materials (ASTM) test procedures and provides a standardized system to describe the commonly available sizes and shapes, physical properties, basis for acceptance, and methods of testing. Ceramic tiles are typically  $\frac{3}{8}$  to  $\frac{1}{2}$  in. (10 to 13 mm) thick, with a 1 $\frac{1}{2}$ % tolerance on the length and width measurements. When several sizes or sources of tile are used to produce a pattern on a panel, the tiles must be manufactured on a modular sizing system in order to have joints of the same width.

Glazed units may craze from freeze-thaw cycles or the bond of the glaze may fail due to exposure to extreme environmental conditions. The body of a tile (not the glazed coating) must have a water absorption of less than 3% (measured using ASTM C 373) to be suitable for exterior applications. However, low water absorption alone is not sufficient to ensure proper selection of exterior ceramic tiles. As a result, when ceramic tile is required for exterior use, the tile manufacturer should be consulted for frost-resistant materials for exterior exposure. Glazes are covered by ASTM C 126 and tested in accordance with ASTM C 67.

The architectural expression of the gallery and lecture halls of the School of Architecture in **Figure 11 (a) and (b)** consists of colorful ceramic tile and a variety of outdoor spaces. The architect sculpted a pair of engaging forms, then wrapped them in red, orange, and yellow ceramic tile that gives the ensemble a hot, Latin flair. The vivid yellow and red structures are clad with 8 x 8 in. (200 x 200 mm) ceramic tiles with brilliant color variations. Tiles were recessed into the precast concrete, which produced a tightly sealed flush edge joint at the lightly sand-blasted panel borders.

The façades of the building in **Figure 12 (a) and (b)**



**Figure 9** Lucas Oil Stadium, Indianapolis, IN. Architect: HKS, Inc.. (Photo Gate Precast Company and HKS, Inc.)



**Figure 10** Opus Residence Hall at Catholic University of America, Washington, D.C. (Photo John C. Cole)





**Figure 11 (a) & (b)** The Paul Cejas School of Architecture, Florida International University, Miami, Florida; Architect: Bernard Tschumi Architects, and BEA International (joint venture);

(Photos Thomas Delbeck)

are heathed in precast concrete from the ground up. A number of panels are gull wing-shaped with wings containing windows angling outward at 45° on each end. These panels are 24 ft (7.5 m) long and 7 ft, 3 in. (2.2 m) high. The panels above ground level have 8 x 8 in. (200 x 200 mm) brick-colored tile inserts, adding a degree of contrast with the concrete while blending harmoniously with the predominately brick neighboring buildings. The use of clay tiles inset within the precast concrete panels provides a greater variety of color and texture than standard precast concrete panels. The clay tiles feature keybacks around which the concrete set, assuring permanent adherence. The end panels were formed with concrete returns to avoid miters or revealing actual panel thickness.

Inspired by glazed pottery, the designer for the hospital in **Figure 13** used glazed tile cast integrally into precast concrete panels to create a kaleidoscope of colors cascading across the facade. The architect employed a pixilation technique to precisely locate each tile to achieve his vision. In total, the project used 11 different glazed colors and 4 different tile sizes including glazed corner elements. The project's success was reliant on the close relationship between the design team and the precast producer to expand the limits of traditional architectural precast facades.

## Terra Cotta

There is no ASTM standard for terra cotta, but units should meet the minimum requirements of ASTM C126 "Specification for Ceramic Glazed Structural Clay Facing Tile, Facing Brick and Solid Masonry Units" or ASTM C212 "Specification for Structural Clay Facing Tile." It should have a minimum compressive strength of 8,000 psi with an absorption of less than 8% (24 hours soak) when tested in accordance with ASTM C 67. Architectural terra cotta is a custom-made product and, within certain limitations, is produced in sizes for specific jobs. Two thicknesses of terra cotta are usually manufactured: 1¼-in.-thick (32 mm) and 2¼ -in.-thick (56 mm) units. Sizes range from 20 to 30 in. (500 to 760 mm) for 1¼ in. units to 32 x 48 in. (810 x 1220 mm) for 2¼ in. units. Other sizes used are 4 or 6 ft x 2 ft (1.2 or 1.8 m x 0.6 m). Tolerances on length and width are a maximum of ± 1/16 in.

(±1.6 mm) with a warpage tolerance on the exposed face (variation from a plane surface) of not more than 0.005 in. (0.12 mm) per 1 in. (25 mm) of length. The use of terra cotta-faced precast concrete panels for restoration and new construction is illustrated in **Figures 14, 15, and 16**. One of the earliest (early 1970s) terra cotta clad buildings is the 42-story office building, 575 Market Street, San Francisco, Calif. It has 9 ft (2.7 m) wide by 13 ft (4m) high L-shaped terra cotta-faced precast concrete panels. Seven equal 1¾ in. (44 mm) thick terra cotta pieces were placed in a structural lightweight concrete backup in the 7½ in. (190 mm) thick story high panels.



**Figure 12 (a) & (b)** Prospect Heights Care Center, Hackensack, New Jersey; Architect: Herbert Beckhard Frank Richlan & Associates; (Photos Norman McGrath Photograph)

Built in 1906, the six-story building in **Figure 14 (a) and (b)** is considered one of San Francisco's architectural landmarks. For that reason, it was decided the building's terra cotta façade would be preserved on an otherwise all-new structure of slightly taller height. The terra cotta was taken off the building, piece by piece, and identified for subsequent reassembly on new precast concrete panels. Stainless steel wires were looped through the back ribs of the terra cotta pieces and projected into the backup concrete to anchor the pieces to the concrete.

Precast concrete panels with 1-in.-thick (25 mm) brick on 5-in.-thick (125 mm) concrete panels along with glazed terra cotta on the spandrels and mullions clad the nine-story building in **Figure 15 (a)**. Panels of light and deep sandblast finishes tied both systems together. See **Figures 15 (b) and (c)** for a close-up of the terra cotta units.

For the sake of the traditional look of the historic Michigan Avenue streetwall's appearance, terra cotta-faced precast concrete was used for the 260,000 ft<sup>2</sup> (24,200 m<sup>2</sup>) retail/cinema building (**Fig. 16 [a]**), encompassing an entire block. The terra cotta pieces are a variety of shapes and sizes, with some flat, fluted, or round (**Fig. 16 [b]**). The backs of the extruded pieces were flat and holes were



**Figure 13** Mercy West Hospital, Green Township, Ohio; Architect: Ellerbe Becket (an AECOM Company), Minneapolis, Minnesota; (Photo Randy Wilson).





**Figure 14 (a) & (b)** 88 Kearney Street, San Francisco, California; Architect: Skidmore, Owings and Merrill; (Photos Skidmore, Owings and Merrill San Francisco)

drilled in the terra cotta for insertion of stainless steel pins. The terra cotta units were placed in a mold and 10 in. (250 mm) of concrete was then cast to create a panelized system.

## Design considerations

Variations in brick or tile color will occur within and between lots. The clay product supplier must pre-blend any color variations and provide units that fall within the color range specified and approved by the architect for the project. Defects such as chips, spalls, face score lines, and cracks are common with brick, and the defective units should be culled from the bulk of acceptable units by the clay product supplier according to the architect's requirements and in accordance with applicable ASTM specifications. Should minor damage occur to the clay product face

during shipping, handling, or erection, field remedial work can be accomplished, including replacement of individual clay products. Units may be chipped out and new units installed using an epoxy, dry-set, or latex portland cement mortar.

The clay product surfaces are important in order to bond to the backup concrete. Textures that offer a good bonding surface include:

- Scored finish, in which the surface is grooved (ribbed) or dovetailed (keybacked) as it comes from the die.
- Combed finish, in which the surface is altered by parallel scratches.



**Figure 15 (a), (b) & (c)** Sacramento County Systems and Data Processing, Sacramento, California; Architect: HDR Architecture Inc. formerly Ehrlich-Rominger; (Photos HDR Architecture Inc.)

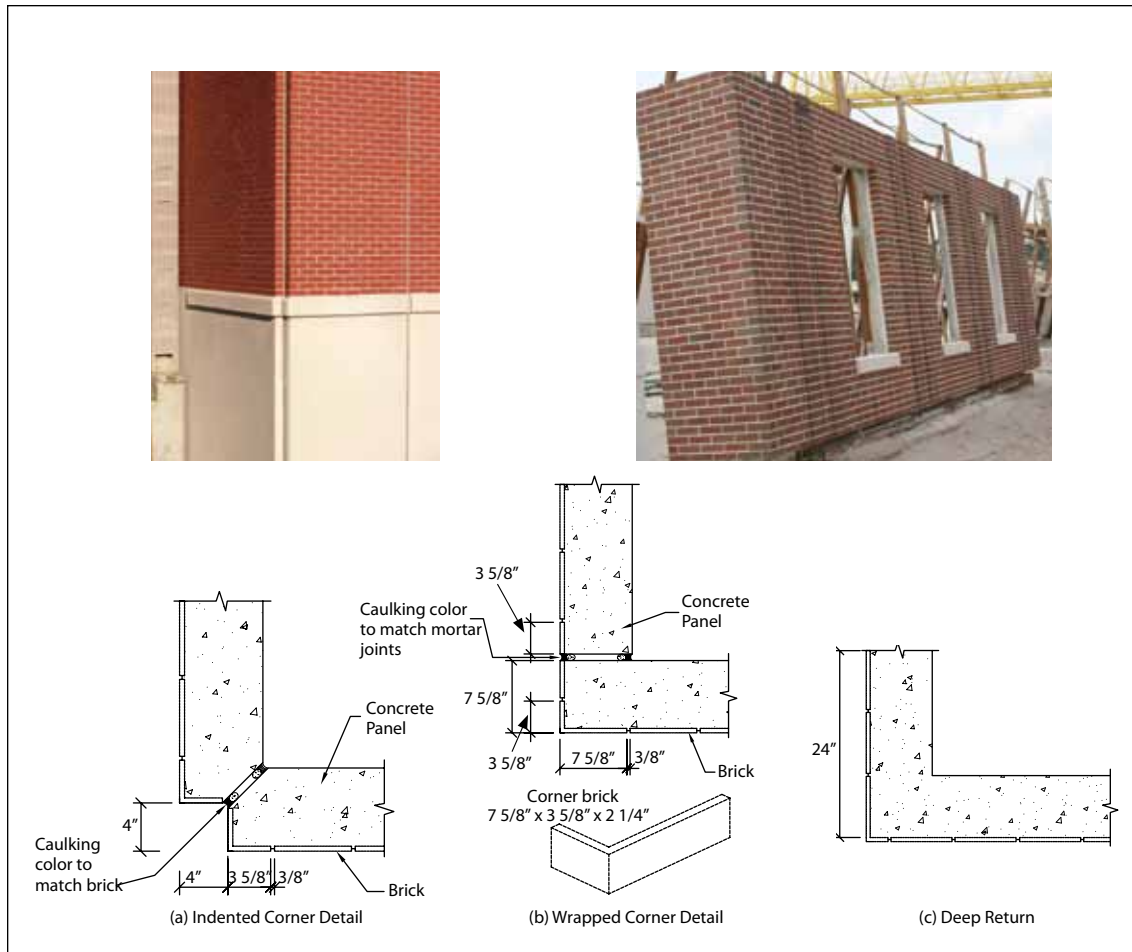


**Figure 16 (a) & (b)** 600 North Michigan Avenue, Chicago, Illinois; Architect: Beyer Blinder Belle, Design Architect; and Shaw and Associates, Architect of Record.

- Roughened finish, which is produced by wire cutting or wire brushing to remove the smooth surface or die skin from the extrusion process.
- A brick wire cut (through extruded holes in whole bricks) to provide two (half) soaps.

With thin- and half-brick units, no metal ties or weeps are required to attach them to the concrete because adequate bond is achieved. In general, clay products that are cast integrally with the concrete have bond strengths exceeding that obtained when laying units in the conventional manner (clay product to mortar). In pullout tests, the brick fails or shears before it pulls out of the concrete. It is necessary, however, to be careful not to entrap air or excess water-caused voids. These voids could reduce the area of contact between the units and the concrete, thereby reducing bond. Half bricks with a water absorption of 6 to 9% obtained by five-hour boiling provide good bonding potential. Thin bricks should have a water absorption less than 6% per the PCI Standard.

Half bricks with an initial rate of absorption (suction) of less than 30 g /30 in.<sup>2</sup> per min (30 g /194 cm<sup>2</sup> per min), when tested in accordance with ASTM C 67, are not required to be wetted. However, brick with high suction or with an initial rate of absorption in excess of 30 g /30 in.<sup>2</sup> per min should be wetted prior to placement of the concrete. This will reduce the amount of mixture water absorbed and improve bond. Unglazed quarry tile and frost-resistant glazed wall tiles generally do not need to be wetted.



**Figure 17** Corner details. (Photos Gate Precast Company)

Terra cotta units should be soaked in water for at least one hour prior to placement to reduce suction and they should be damp at the time of concrete placement.

Because of the differences in material properties between the facing and concrete, clay product-faced concrete panels may be more susceptible to bowing than homogeneous concrete units. However, panel manufacturers have developed design and production procedures to minimize bowing.

Three types of corner details may be used: (1) indented (**Fig. 17 [a]**); (2) wrapped (**Fig. 17 [b]**); or (3) deep return (**Fig. 17 [c]**). Brick mortar





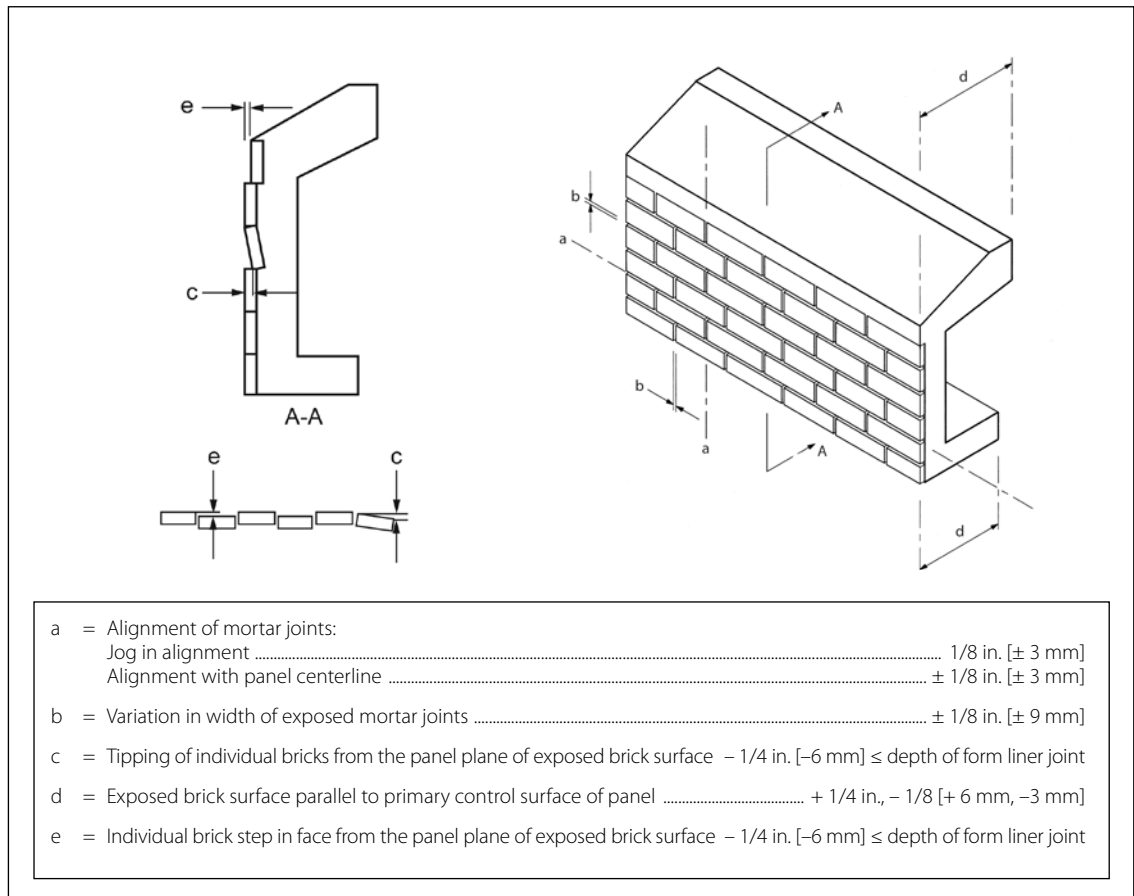
**Figure 19** Placing units in form liner (Photo Gate Precast Company)

joints should be concave (cove). At reveals and at the top and bottom of inset areas, the concrete should cover the edges of the brick units (**Fig. 18**). The designer also needs to pay special attention to where the joints between concrete panels are located, which is a departure from the use of traditional brick masonry.

In the development of the contract documents, using thin brick precast concrete panels provides a simplification of detailing over hand set masonry. The system avoids intricate flashing, masonry support, and masonry anchoring requirements that would be necessary with conventional construction to achieve layering and relief features.

## Production and Construction Considerations

Clay product-faced units have joint widths controlled by locating the units in a suitable template or grid system set out accurately on the mold face (**Fig. 19**). Common grid systems generally consist of an elastomeric (or rubber) form liner or a plastic form liner. Liner ridges



**Figure 20** Tolerances for brick-faced architectural elements. Note: These tolerances also apply to ceramic tile and terra cotta.


are typically shaped so that joints between units simulate concave-tooled or raked (flat) joints and should be considered with respect to temperate zones and aesthetics.

Occasionally individual clay units can float out of place or be damaged after casting. These units can be easily replaced or repaired by chipping out the undesired unit, preparing the concrete substrate, and attaching a new piece using epoxy. The joints can then be cosmetically repaired to match the field.

Tolerances for brick-faced precast concrete panels are shown in **Figure 20**. The number of bricks that could exhibit any misalignments should be limited to 2% of the bricks on the panel.



Tiles, measuring 2 x 2 in. (50 x 50 mm) or 4 x 2 in. (100 x 50 mm), may be supplied face-mounted on polyethylene or paper sheets and secured to the mold by means of double-faced tape or a special adhesive.

The space between the tiles is filled with a thin grout and then the backup concrete is placed prior to initial set of the grout. **Figure 21** shows a project that uses 2 x 2 in. (50 x 50 mm) tiles that have been placed with the method described. For the best appearance, narrow tile joints should be filled from the front, particularly if cushion-edged tiles are used. 



**Figure 21** The Nikko Hotel, San Francisco, California; Architect: Patri-Merker Architects formerly Whisler-Patri. (Photo Patri-Merker Architects)



# designer's notebook



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