PCI Precast/Prestressed Concrete Institute

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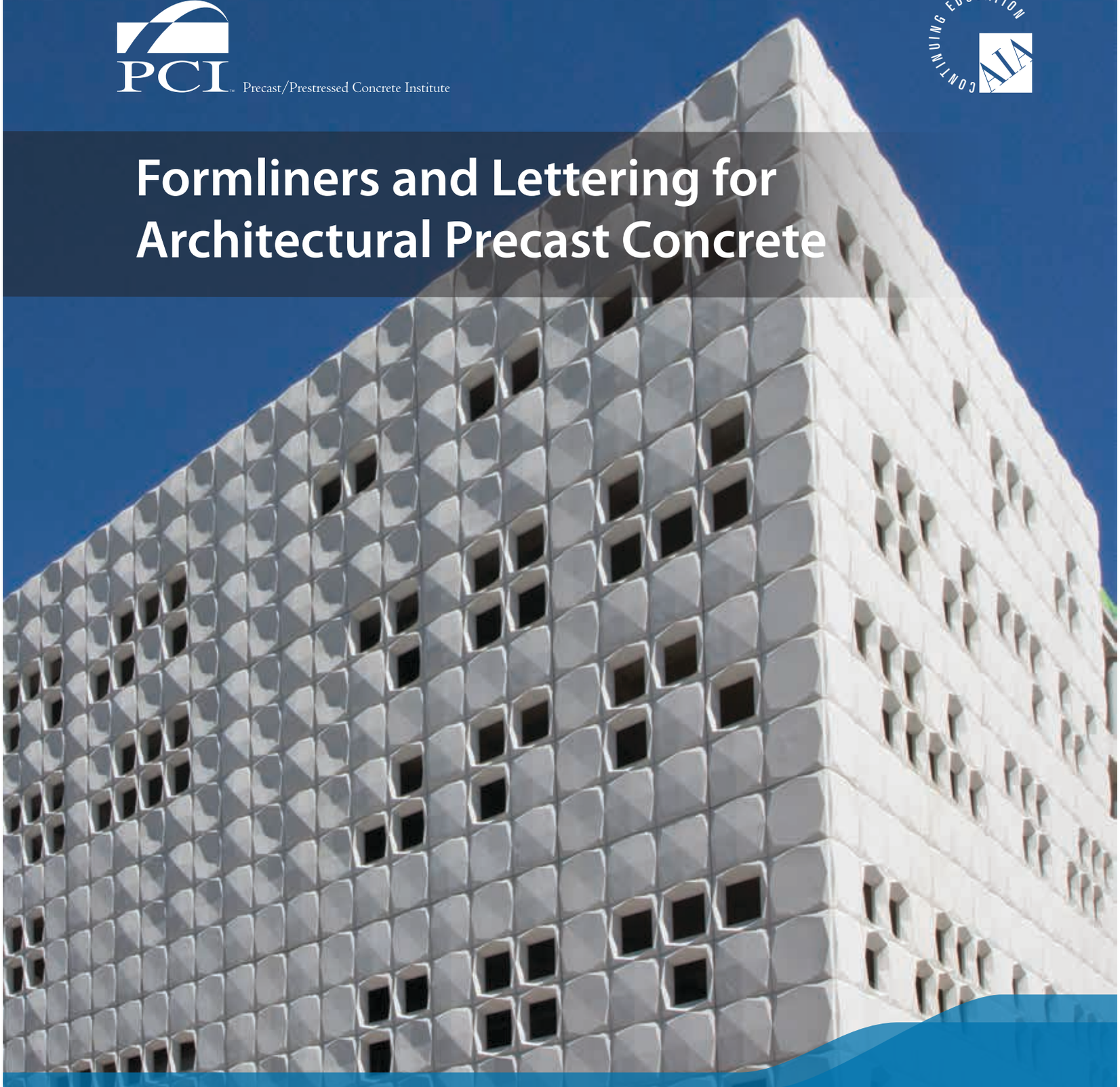
Formliners and Lettering for Architectural Precast Concrete



PCI designer's**notebook**

FORMLINERS AND LETTERING FOR ARCHITECTURAL PRECAST CONCRETE

Apart from its shape, it is to a large extent the façade of a building that dictates its overall impression. It is the characterizing face of the building—sometime reserved, sometimes highly detailed and dominant. But a building envelope's materials are more than a visual application. Aesthetics, function, and cost play a role in achieving a successful project. Architectural precast concrete not only offers design freedom of architectural expression with visually interesting shapes that are functional in application, it also contributes to durability, sustainability, energy efficiency, and improved occupant comfort and safety. At the same time, the initial plasticity of concrete makes it responsive to the designer's creativity.

Concrete's plasticity offers the opportunity for innovation and individual character in the surface textures, patterns, and shapes, which can be achieved by casting against the various types of formliners to enliven the façade surface and produce a dramatic, arresting aesthetic statement. These formliners may be incorporated in or attached to the surface of a mold. A large pattern offers ever-changing details due to the subtle interplay of light and shadow; a fine texture offers a muted appearance that is subtle but not drab while smooth surfaces bring out the elegance and richness of simplicity. Formliner textured surfaces also mask minor imperfections that would otherwise be obvious in a smooth as-cast surface, yielding a more uniform appearance.

New techniques and technologies provide a wide array of design possibilities ranging from traditional building patterns such as masonry, wood board markings, and stone textures, flat, geometric, rhythmic, and fractured fins and fluted textures, sandblasted or bushhammered looks, as well as custom graphics including highly detailed three-dimensional graphics at a reasonable cost. The options with combination finishes, involving one or more basic finishing methods together with formliners, are almost infinite. Architects are now able to push the envelope in their façade designs.

There are typically three different types of custom graphics that can be achieved with formliners, either produced by liner manufacturers or precasters:

1. A two-dimensional pattern milled into or attached to a mold. Graphics could be letters, dates, and simple flat-planar designs.
2. Multiple planes to produce a graphic that may have different types of textures such as abrasive blast, bushhammered, or fractured fins.
3. Three-dimensional, photo-realistic graphics achieved through computer numerical control (CNC) milling of the formliner (photo-engraved) or use of a special membrane with embedded retarder where the retarded surface is exposed (photographic).

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An important consideration is selecting the texture and/or type of formliner best suited to the project. If there are large wall expanses, a texture like fractured fin with greater depth may give a more noticeable appearance with deeper shadowing. Shallow flutes, bushhammered, or subtle textures are often better for relatively small areas. Concrete can be produced with vertical ribs or striations in a range of sizes to suit a particular structure and the distance from which it will most often be seen. Ribbed or fluted panels demand considerable attention to detailing as panel sizes and distances between openings must be a multiple of the rib spacing. Panel joints should normally be in the bottom of a groove or valley.

A wide range of factors impact the cost of a formliner, including material used, detail of the design, changes made after the original design, size, and the number of reuses actually obtained. For instance, increasing a shallow recess to several inches in depth can increase costs significantly due to the amount of material needed to create that depth. Large liners also become more expensive as they grow in size due to shipping and handling costs—but the larger size may reduce the number of molds needed, reducing costs.

The following rules should be observed when using formliners:

- Limit depth of design to ½ to 1 in. (13 to 25 mm).
- In most cases, maintain a 1:8 draft on all indentation sides to prevent chipping and spalling during stripping of the panel from the mold.
- Keep all edges and corners rounded or chamfered.
- Relief may be more than 1 in. (25 mm) if the depressed area is sufficiently wide.

Liner size and characteristics may require that an architectural feature in the form of a demarcation groove, recess, rib, or plain area be detailed to hide joints between liners, or limit usage to within the available width of the liner, or the liner joints should be designed at form edges.

If the concrete is to be left smooth as-cast (that is, without further treatment), its appearance will be determined by the surface characteristics of the liner material as well as by the chosen pattern or texture. Variations in the absorbency of the form surface will tend to produce corresponding variations in the color of the concrete, a dark color being associated with water loss.

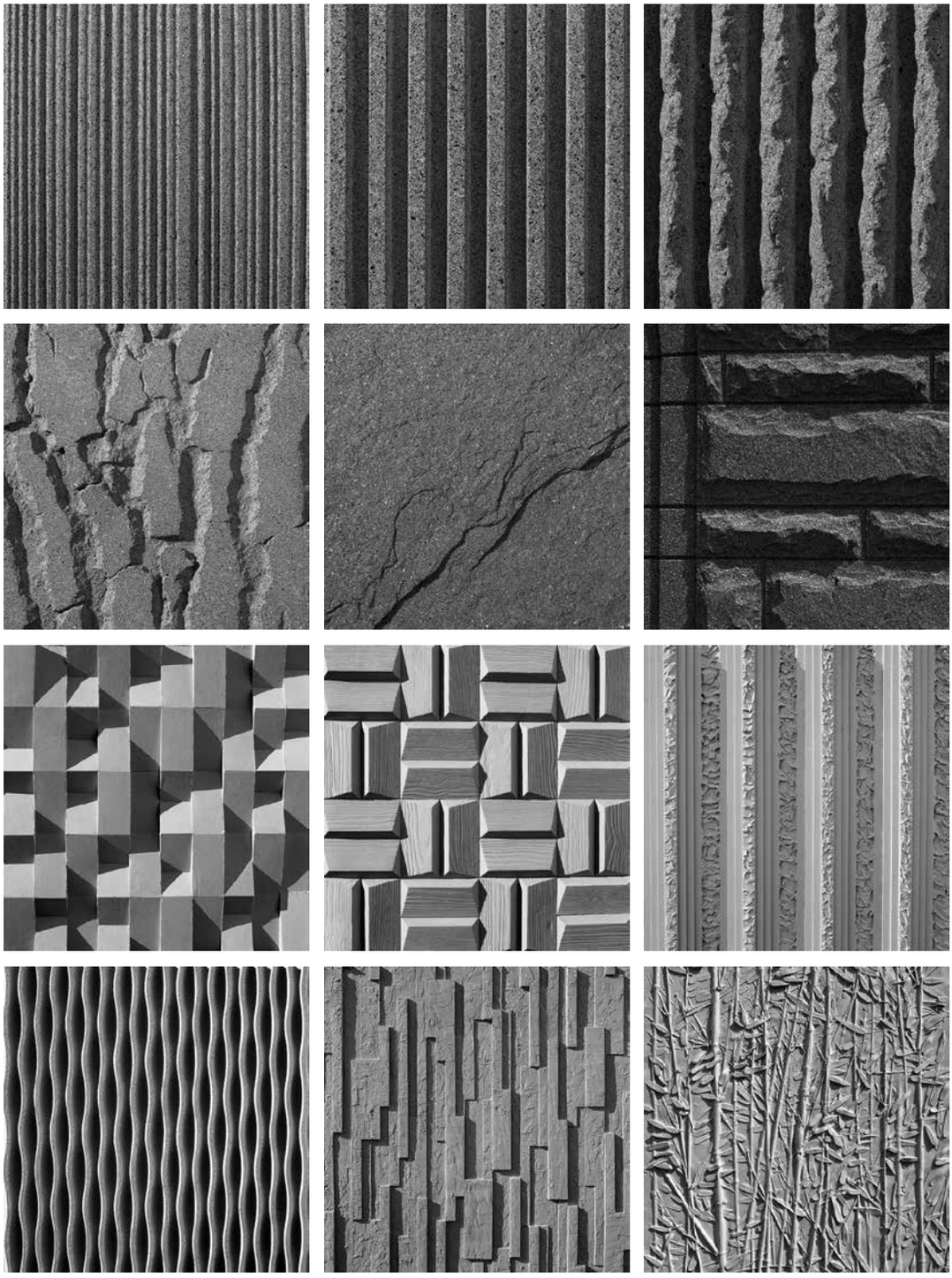


Figure 1 Some of the hundreds of available formliner patterns.

Figure 2 Rock faced units on Sanford Children's Hospital, Sioux Falls, S. Dak.

If preformed or stock formliners are selected, it is good practice to describe the pattern and to include a reference to the pattern and its manufacturer specification. The formliner, or the effect or texture may be specified in the contract documents. **Fig. 1** shows some of the hundreds of available formliner patterns from liner manufacturers.

To avoid a repetitious panelized appearance to what is planned as a natural, flowing façade, liners can be rotated 90 to 180 degrees or configured to minimize the appearance of repetition so that the surfaces look entirely different.

A significant challenge was to make the castle theme architecture of the Sanford Children's Hospital, Sioux Falls, S.Dak., while maintaining budget. To do so, the architect found an economical formliner and a method was developed of repetitive use while maintaining the proper articulation. The large base "chiseled stone" was accomplished using individual 1-ft 10-in. x 4-ft 2-in. (0.56 m x 1.27 m) rock faced units with 1 ½-in. (150 mm) relief, **Fig. 2**. These units were revised and rotated to keep the panel uniqueness while maintaining liner efficiency.

Figure 3 Chiseled limestone base for George Washington Auto Park, Winchester, Va.

The seven tier parking structure, **Fig. 3**, is located within a historical district where limestone and brick masonry are prevalent. The structure's chiseled grey limestone base ascends two tiers. Custom formliners were rotated to provide variations more characteristic of limestone. A deep relief was used in the joints to provide shadows that break up the uniformity within the precast.

Figure 4 Some of the available wood textures.

Many types of wood textures such as weathered wood boards, split cedar shakes, hand hewn woods and many others can be emulated with formliners, **Fig. 4**. Sealed sandblasted wood, textured plywood, and rough-sawn lumber are useful in creating rugged textures. (Resultant surface texture may also be obtained by use of other liners reproducing this finish.) Rough-sawn lumber is used for board-surface textured finishes where concrete color variations and rough edges are acceptable.

Figure 5 (a-g) Various patterns integrated into formwork. Nimitz-MacArthur Pacific Command Center, Oahu, Hawaii; Photos: Gary Hofheimer Photography.

The visual impact made by relief sculpture depends mainly on two factors: profile and lighting. The profile or cross-section should consist of strong elements with edges that produce well-defined highlights and shadows. Surfaces that flow smoothly into each other should be avoided. A bold treatment is most effective with subtle or gradual changes in the profile. These limitations are very important for the cross-section, but do not apply to the front or elevation view of the design. If it is possible to control lighting, ensure it plays across the relief from the side rather than straight from the front. Relief sculpture can be enhanced by contrasting surfaces on projecting elements with textures on the background.

The viewing distance of the surface should be considered when deciding on the scale of the relief. As a rough guide, design elements smaller than about 1/300 of the viewing distance are difficult to "read" and tend to get visually lost in their surroundings.

Stone textures, waves, multilevel reveal patterns, three-dimensional leaf patterns, fluted mullions, heavy cornices, dentils, bullnoses, ribs, and the navy globe symbol shown in **Figs. 5(a–g)** are examples of relief sculpture integrated into the formwork. All of these were accomplished using various types of forming materials best suited for a particular situation, including steel, fiberglassed wood, urethane liners, milled plastic, and sprayed fiberglass.

Figure 6 Hoag Hospital Sue and Bill Gross Pavilion, Newport Beach, Calif.; Sculptor: Tom Van Sant. Photo: Michael McLane.

Sculptural designs have been produced using sections of foamed polystyrene or polyurethane as formliners or inserts. Abstract patterns and deeply revealed designs with undercut edges can be shaped easily in these materials, however these liners are typically single-use only. **Fig. 6** is an example of custom-designed foam impressions in the mold to create artwork. The foam was abrasive blasted away to reveal the finished design. Computer Numerical Control (CNC) routers have made custom work available at moderate prices.

Figure 7 James F. Battin United States Federal Courthouse, Billings, Mont.

Geometric Shapes

The geometric patterning of the lower three floors for the James F. Battin United States Federal Courthouse, Billings, Mont. (**Fig. 7**) recalled the geology of the surrounding Yellowstone river rocks and was designed to appear somewhat random, with carved angular planes for the strong local sunshine to play upon. The architect created the design plan for the textures, which the precaster calculated would require 18 formliner designs. The two teams then used BIM technologies to tweak the design to reduce that total to a dozen basic patterns that were combined in various permutations to produce eight large panels, which were then erected in a carefully orchestrated sequence. The precaster changed the liner position with each panel to vary the look and avoid repetition. Each liner had a different skew, so between any two panels, up to 4 inches of offset could occur.

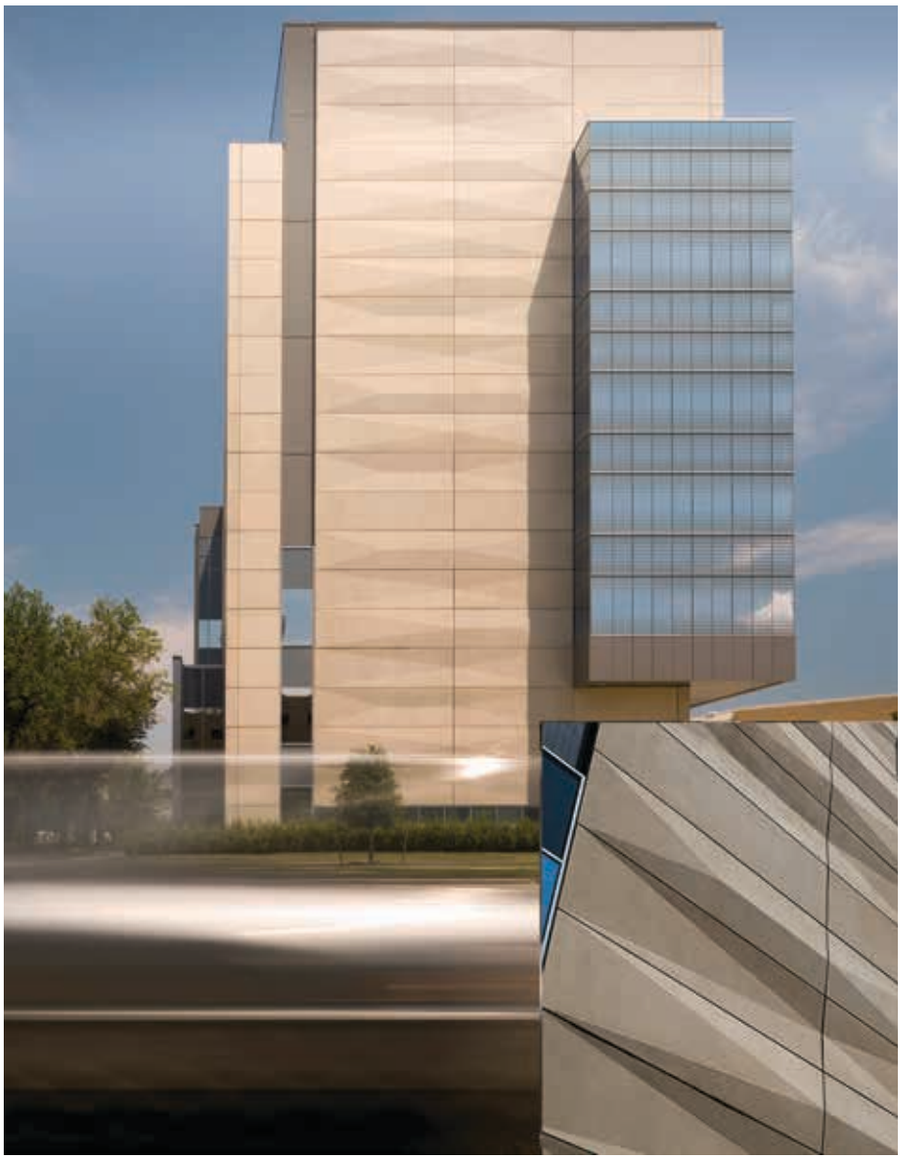


Figure 8 University of Houston Health and Biomedical Sciences Building, Houston, Tex.

Given the primary program of the University of Houston Health and Biomedical Sciences Building (**Fig. 8**) is a school of optometry, the façade's design inspiration was drawn from several optical effects produced by the interaction with sunlight. To lessen the bulk of the necessary windowless laboratory spaces, the designers created a beveled façade that reflects light and shadow as the sun plays across the building's surface. The design uses simple rectangular concrete panels that are triangularly faceted creating 5-in. (125-mm) deep peaks and valleys in the façade's surface. The levels add a whole different dimension of light and shadow to the monochrome surface and give it the illusion of many shades of color.

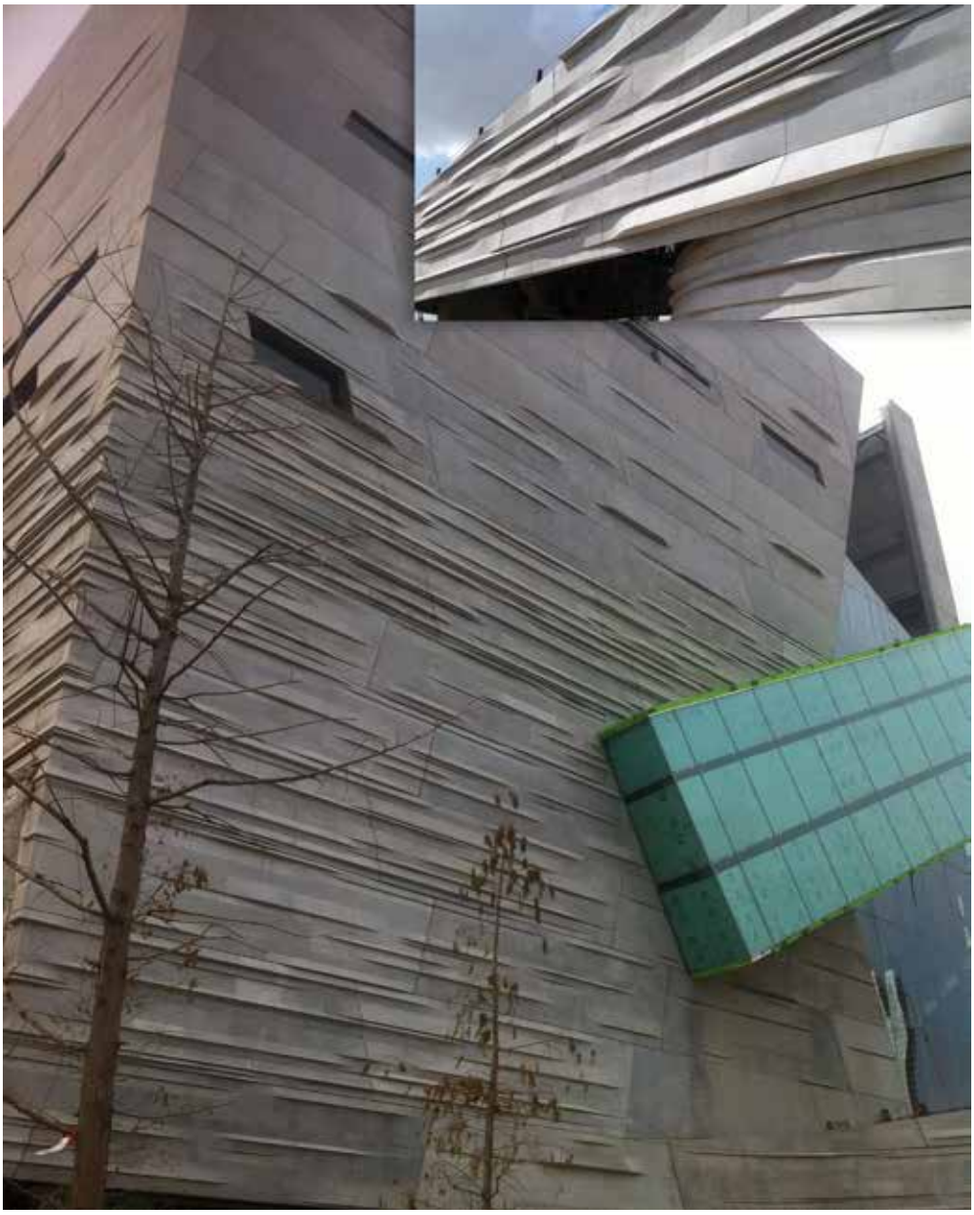


Figure 9 Perot Museum of Nature and Science, Dallas, Tex.

Perot Museum of Nature and Science in Dallas, Tex., (**Fig. 9**) features a combination of projections, striations, and geometric shapes joined together. The 6 ½-in. (165 mm) -thick panels have 2-in. (50 mm) recesses and 3- to 8-in. (75-200 mm)projections that ripple across all faces. They represent a sedimentary-like geologic formation pushing through the landscape. The design intent was to create a series of waves that gives a dynamic effect on the building that changes throughout the day with the sunlight and shadows. The texturing

Figure 10 Hartford Hospital Parking Structure, Hartford, Conn.

is denser at the bottom of the 170 ft. (52 m) tower and slowly fades as the cladding moves up its designed height. The architect desired a mottled, as-cast texture.

The mold carpenters used the form drawings to create their forms, after which a crew poured polyurethane into the mold to create the negative design of the required shape. Over 1,000 rubber inserts (modules) were produced for panel production. By changing the location of the rubber modules from panel to panel, the precaster was able to achieve the architect's desired nonrepetitive look on the 350-piece tower. BIM modeling was an integral part in making this project come to fruition.

At the Hartford Hospital in Hartford, Conn., designers used a façade design that consists of a series of three-dimensional folded panels stacked across the façade, **Fig. 10**. The panels have symmetrically placed warps that project out 2 in. (50 mm) off an 8-in. (200 mm) panel. Formliners were used to create the projections. The designer's goals was to allow the building to reflect light in different ways at different times of the day while

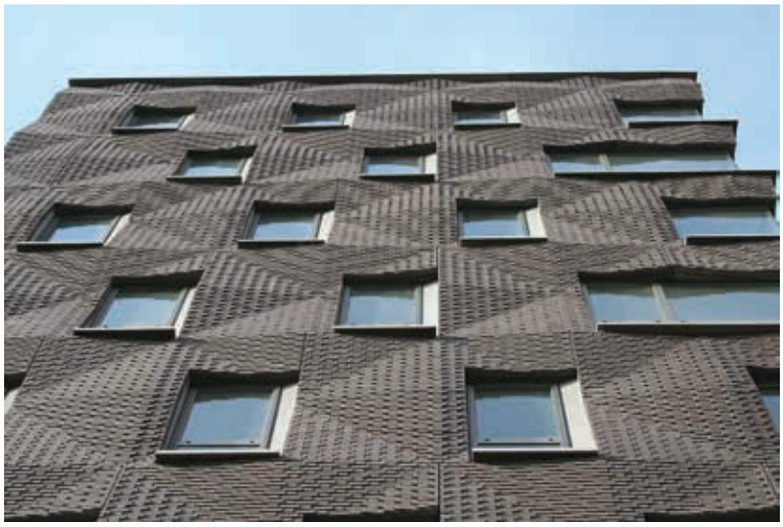


Figure 11 290 Mulberry Street, New York, N.Y.

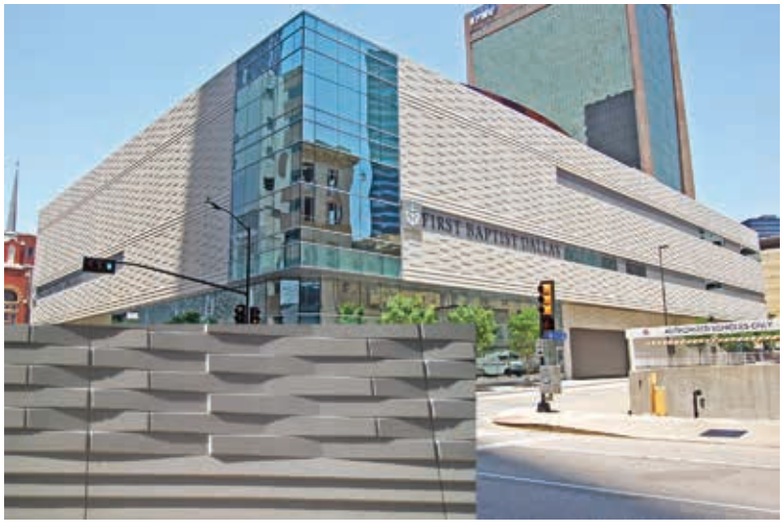


Figure 12 First Baptist Church of Dallas, Dallas, Tex.

creating a modular system that would be easy to erect, ensuring it was economical.

The panel manufacturing process for 290 Mulberry Street, New York, N.Y., **Fig. 11**, was similar to that of a typical precast concrete brick panel. Yet the complex geometrical forms necessitated the use of modeling software in conjunction with CNC milling machines to fabricate the custom rubber formliners which, when lined with wooden boards, serve as panel formwork templates in the panel fabrication process. The ¾-in. (19 mm) thickness of the half-width brick modules determined the maximum overstep between courses and this criterion in turn determined the panel undulation, panel size, and window opening locations.

Rhythmic Shapes

The precast of the First Baptist Church of Dallas, Dallas, Tex., façade **Fig. 12**, was designed to reinforce the horizontality of the building while allowing the design to flow seamlessly from panel to panel. A basket-weave pattern was created on the precast panels using a custom formliner to add depth and detail to the façade, pulling all elements of the downtown campus together.

Figure 13 The Place de l'Escarpement Commerical Building in Quebec City, QC.

The panels on The Place de l'Escarpement Commercial Building in Quebec City, Quebec, were cast with an undulating wave pattern across their face, **Fig. 13**. The waves were created with formliners and follow a similar pattern due to repetition in the forms, producing a rhythmic style. The architect worked closely with an artist to create the design that best reflected the wave he was seeking. Grey concrete with black pigment and a light sandblast was used to emphasize the pattern and draw attention to these faces.

Figure 14 St. Edwards University, Austin, Tex.

Figure 15 (a & b) Kohl Center, University of Wisconsin, Nichols-Johnson Pavilion, Madison, Wis. Photos: Steve Brock.

Custom Shapes or Forms

The envelope of the three-story laboratory and classroom structure at St. Edwards University, Austin, Tex., was originally developed as a terra cotta rain screen system. Due to cost, the skin was reimaged as precast concrete, **Fig. 14**. All 67 panels were cast from only two molds and no two panels were the same. By shifting side rails, top and bottom rails the precaster created the multifaceted panels. The mold shop created the custom formliner from poplar wood. Projections are acid-washed and the flat sections are abrasive blasted to create a rich texture.

The images of basketball players were incised into the panel surface by placing a wooden pattern in the mold (**Fig. 15 a**). The master mold concept was used; the bulkheads and side rails were moved to give the appearance of the players coming out of the ground (**Fig 15 b**). The outer surface was sandblasted and the incised surface was left with a smooth, as-cast finish.

Figure 16 Arizona Biltmore Parking Structure, Phoenix, Ariz.

Intricate formliners used on the Arizona Biltmore Parking Structure, Phoenix were created from the hotel's distinctive, custom concrete masonry, **Fig. 16**. Following the precedent of the hotel, detail and patterning is concentrated on the vertical elements. Spandrels have scored joints matching the exact size and depth of the original masonry joints.

Figure 17 Kansas City Temple, Kansas City, Mo.

An olive branch motif was used throughout the Kansas City Temple, Kansas City, Mo., and expressed in the precast spandrel panels, **Fig. 17**. The detail was derived from a detail that was etched in the windows. Each piece of the olive branch was carved by hand and assembled to work as a unit. Once the unit was put together, a pliable rubber was used to make multiple negatives.

The Polsenelli Headquarters in Kansas City, Mo., features an acid-etched precast concrete façade that matches an adjacent hotel. The designers used a formliner with an intricate infill pattern honoring the Spanish heritage of the area, **Fig. 18**, to complement the district where the building is located.

For **Fig. 19**, the designers started with 2D geometry and developed a 3D bas relief from that in the computer. The angles and draft were adjusted in dialogue with the formliner fabricator and precaster. The light and shadow effects were studied in the computer to ensure it did not get washed out in the sun. CADD files of the bas relief were then used to

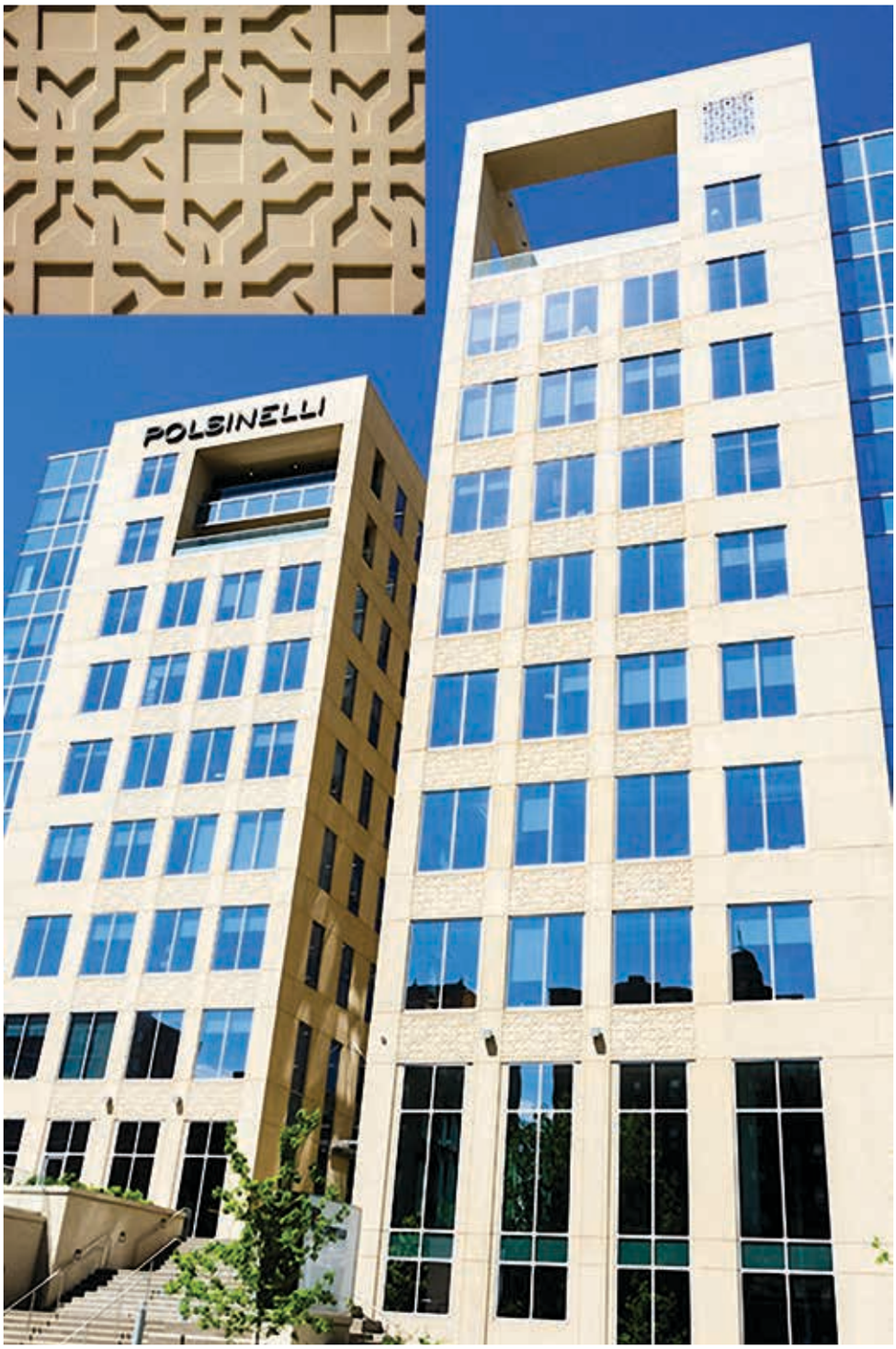


Figure 18 The Polsenelli Headquarters in Kansas City, MO features an acid-etched precast concrete façade with an intricate infill pattern.

Figure 19 880 New Jersey Avenue, SE, (Park Chelsea), Washington, DC

Figure 20 Maryland Interstate Highway 216, Howard County, Md.; Sculptor: Creative Design Resolutions Inc., City, St., Photos: Creative Design Resolutions Inc.

Figure 21 New photo and caption to come.

generate a positive in resin (CNC fabrication). The positive was then used to make one rubber formliner to make 20 panels that are of varying lengths.

A wall with creative images reduces the visual scale and turns the wall into a work of art. Soundwalls provide long, flat canvases to produce creative scenes. Some states imprint their barriers with wild life images, flowers, and other personalized images to blend in with the adjacent neighborhood, see **Fig. 20**. CNC routers work well for these options, because the designer can provide drawings and see the resulting three-dimensional image. A CAD rendering speeds up the process by allowing the designer's work to be approved through e-mails and manufactured in a predictable time frame and accurate manner. Thus avoiding costly and time-consuming meetings.

Figure 21 text to be added.

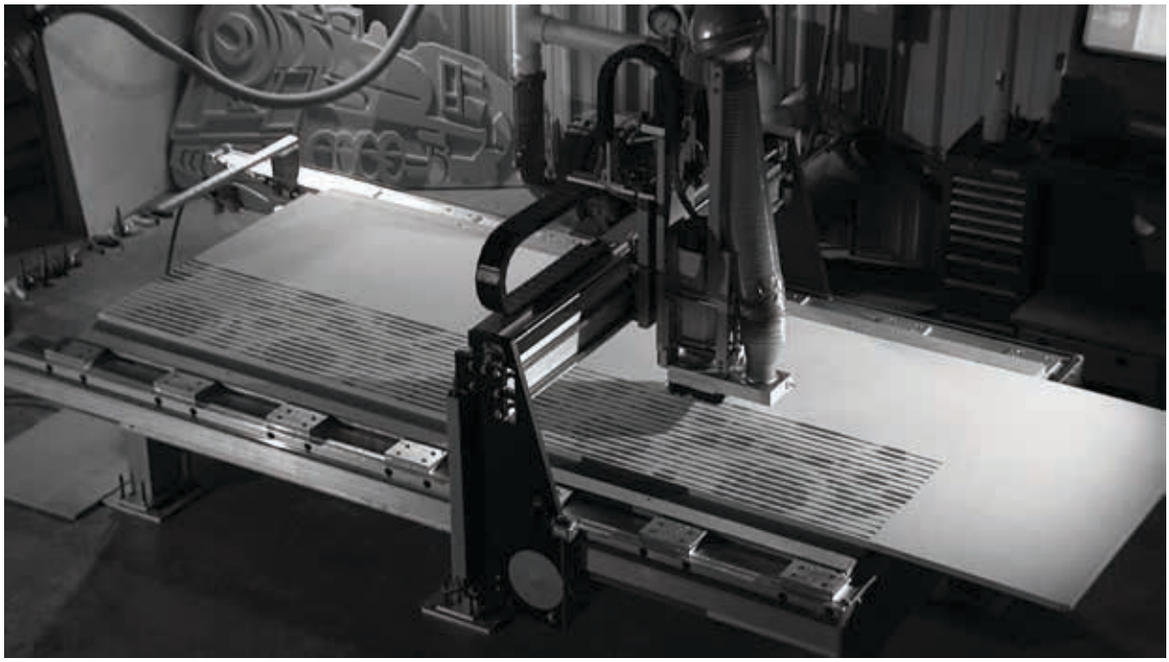


Figure 22 CNC machine.

Photo-engraved Liners

Photo-engraved liners create a surface pattern which can vary from fine to coarse with differently dimensioned grooves depending on the resolution of the image used. Initially the image is scanned and converted into 256 grey tones by a computer program. A processing file is generated from the grey tones containing milling commands for a CNC milling or router machine. The CNC machine can precision cut patterns, shapes, or photographic images into formliners, **Fig. 22**. Each grey value corresponds to a certain milling width and depth. This is based on a relatively homogeneous basic structure (for example parallel lines, concentric circles) which consist of nonintersection elements and which fill presentations plane. This line structure forms the background. Textures are transformed according to defined mathematical algorithms, i.e., they are differentiated from the background structure by changes in the distance between the lines and in the direction of lines (nicks, curves). The lines remain nonintersecting, however, even after a whole series of transformations. Different editing planes give rise to a greater plasticity of the space and transfer of super-ordinate structural information allows the representation of most elements of planar geometry, such as print characters or hatching. The creative versatility of this principle lies in the combination of individual transformation algorithms (sequence, foreground and background, depth, and width). The milled model is used as a master for casting the formliner that is the casting mold for the concrete element. The routers are very accurate. The only concern is creating ridges so thin that they break off during stripping or handling.

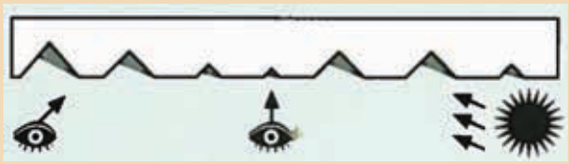
Almost any image—either black-and-white or color photograph—in standard graphic format can be used as an image template. The image is engraved like a relief, so that an image of the original is produced through a play of light and shadow on the façade. The intensity of the photo engraving effect is altered by the movement of the sun. It is more vivid when sunlight is at 45 degees to the façade. The movement of the sun throughout the day gives rise to changing image effects on the façade. Inside or outside a building the effect can be accentuated by means of artificial light.

The technique can be deployed in a wide range of applications, since almost any image available in a standard graphical format, such as CAD, can be used. By scaling the original image it is possible to manufacture photo-engraved formliners of any required size. Photos of animals, flowers, people, and line objects can be transferred to concrete surfaces using photo-engraving formliners.

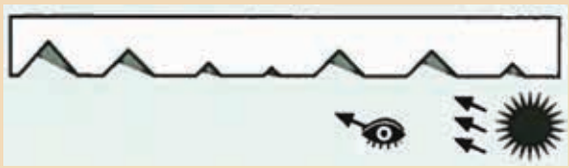
The following examples in **Figs 23-28**, are intended to provide a small insight into the almost unlimited possibilities.

Shadowing for Viewing Photo-Engraved Panels

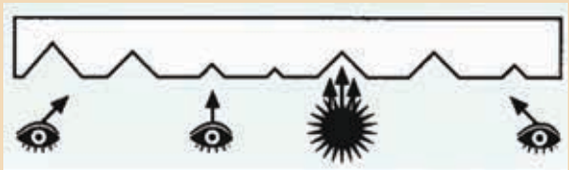
The degree to which the motif is visible is determined by the orientation of the V-shaped grooves to the (dynamic) light source and the position of the observer. Where the light meets the image obliquely, the length of the shadows is proportional to the depth of the grooves. They generate the black portion of the image. The motif is therefore visible from a perpendicular position or a position away from the light source.



Viewed from a position close to the direction of incident light, the visible shadowed areas are shortened. The result is that the motif has less contrast. If the angle of observation is less than the angle of incidence of the light, the motif appears as a negative.



Where the incident light is perpendicular to the object plane, no shadows are formed in the grooves—the motif is not visible from any position.



Figures 23 (a & b) Twisting DNA helixes on the Global Center for Health Innovation, Cleveland, OH.

The Global Center for Health Innovation, Cleveland, OH combines permanent showrooms for medical manufacturers and service providers. The designers worked closely with the precasters to develop a façade that mimics the tone of limestone while offering details resembling the twisting helixes of a DNA molecule that appear in various lighting conditions, **Figs. 23 (a & b)**. CAD-CAM technology was used to manufacture the master molds for the photo-engraved images.

The coastal landscape along the St. Lawrence River in Quebec City, Canada, was revitalized for the city's 400th anniversary celebration. The Promenade Samuel-De Champlain was the first project in North America to use photo-engraved formliners. Each side of four 12- by 15-foot (3.6- by 4.6- m) concrete walls has a different engraved image. Images refer to the work of the people along the shore during part of the nineteenth century, **Fig. 24**.

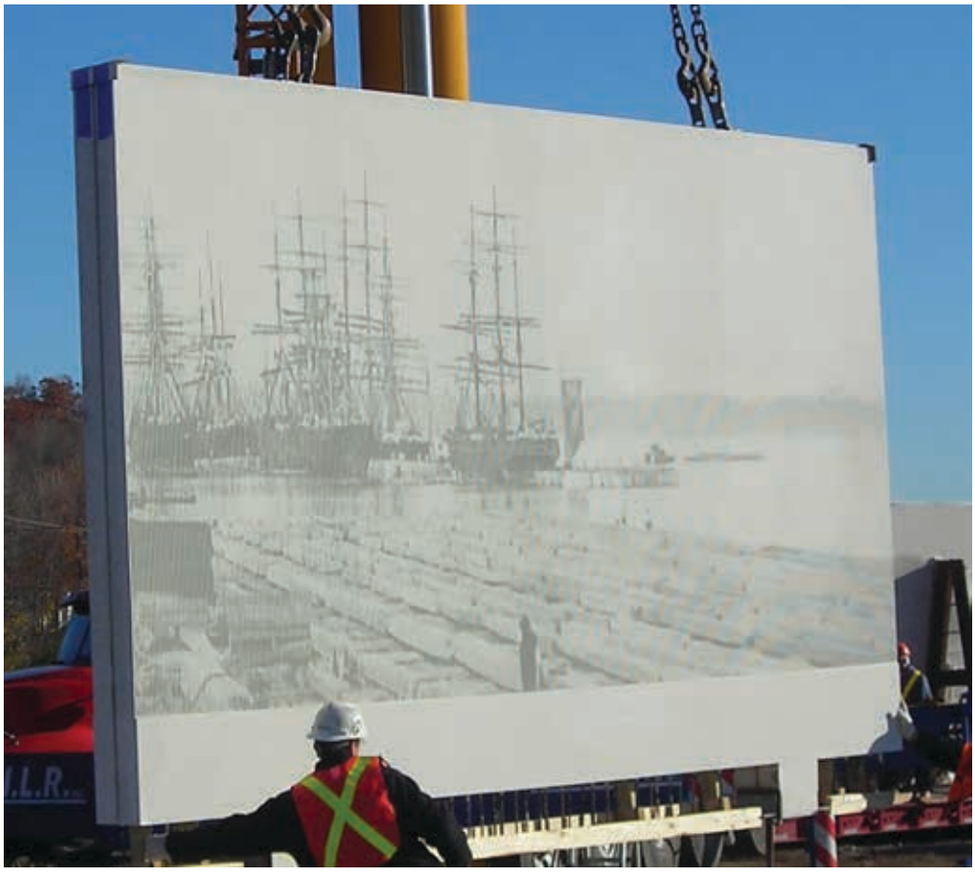


Figure 24 Coastal landscape along the St. Lawrence River, Quebec City, QC.

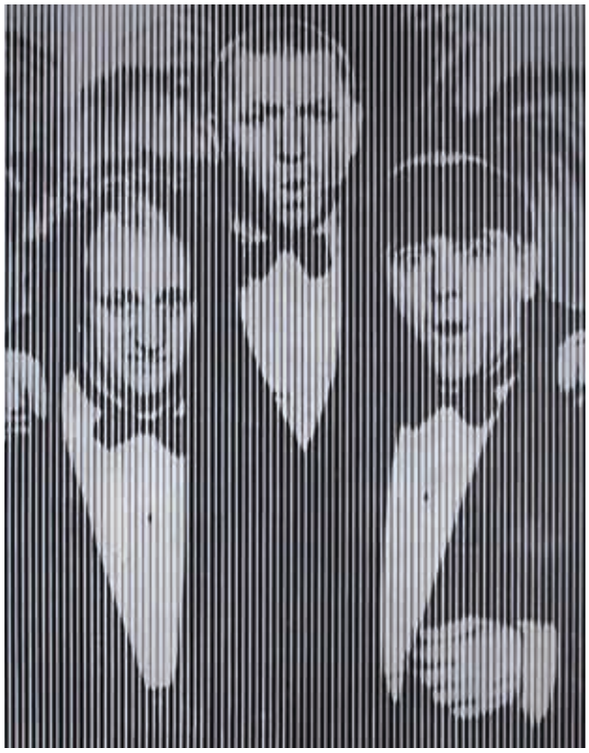


Figure 25 Final photo-engraved panel.

Figure 26 Closeup showing how line width is varied to produce image.

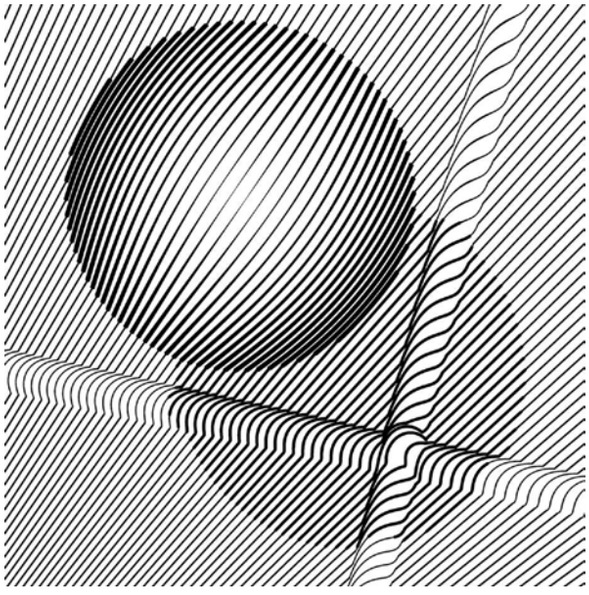


Figure 27 Object with shadow, superposition of objects–lines do not intersect.

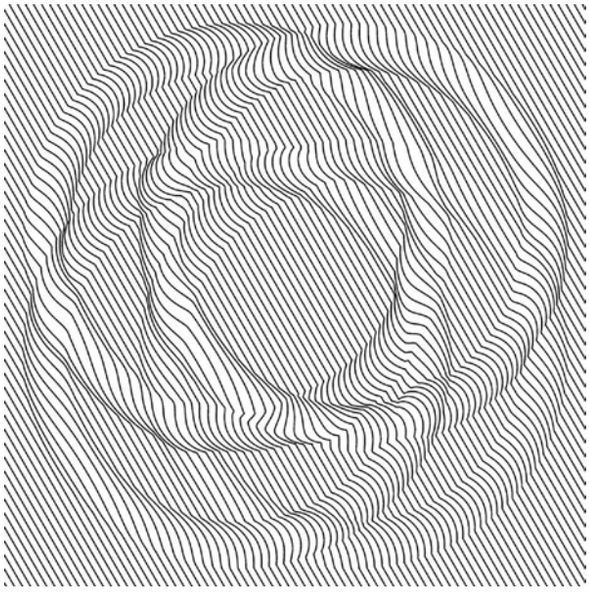


Figure 28 Superposition of 4 objects–lines do not intersect.

Photographic Concrete

A relatively new process, photographic concrete allows designers to obtain unique concrete surfaces supplementing the creative scope of architectural precast concrete. Nearly any individual design, graphic, image, or photograph can be visualized on a concrete surface in two dimensions using this technique. In the case of images and photos, the design template is scanned in different pixels. The file should only contain 1-bit black and white graphics (or empty spaces). Both raster (for a photo—Adobe Photo Shop) and vector (for lines and shapes—Adobe Illustrator) images can be used.

The subsequent viewing distance also plays a significant role in terms of the size of the individual pixels and is always coordinated with the designer.

Figure 29 Caption to come.

Figure 30 Helsingin Tervapääskynen Housing, Helsinki, Finland.

Figure 31 Albert Edefelt School, Porvoo, Finland.

Figure 32 The SC Johnson "Project Honor" Memorial Building, in Racine, Wis

A screen printing process is used. The printing screen is disposed after printing. If several concrete elements are to be produced with the same motif or a reserve sheet is desired for peace of mind, then it is recommended that the number of motif sheets required be stated when ordering. Otherwise a new print screen would have to be produced and set-up costs will have to be charged.

The photographic process is simple: a concrete surface retarder is applied to a special plastic or magnetic membrane that is placed in the mold, retarding the hardening of the concrete. After washing out the surface, the design pattern is created by the contrast between the smooth concrete surface and the exposed fine aggregate finish. The normal depth of the pattern is about 1 to 3 mm, but shallower or deeper exposures are possible. The influence of light and shadow no longer plays a role as the images may be viewed from any angle. Therefore, the units may be viewed indoors as well as outdoors.

Photographic concrete projects illustrating the application of scenery, objects, abstract images, people, and letters and numbers are shown in **Fig. 29 to 34**.

The SC Johnson "Project Honor" Memorial Building, in Racine, Wis., designed by Foster + Partners, was the first U.S. usage of photographic concrete. It shows the Brazilian palm trees from which carnauba wax is derived, **Fig. 32**.

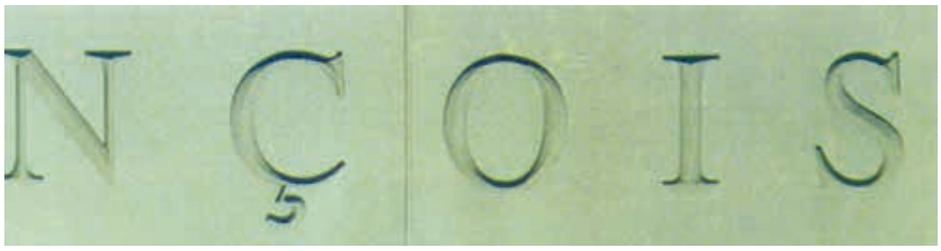
Figure 33 Joseph Guinovart School, Castelldefels, Spain.

Figure 34 Graphic Concrete Pavillion, Milan, Italy.

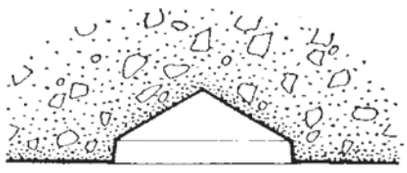
Lettering

The application of lettering in concrete is particularly popular for institutional and governmental buildings to provide a solid, chiseled appearance. Appropriate draft or taper for stripping the member from the mold, must be established for all lettering unless characters are flexible or destructible. Raised letters are fragile and subject to chipping at traffic levels and significantly increase forming costs.

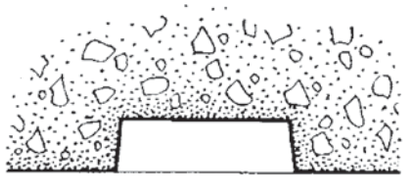
Thought should be given to the selection of the letter profile or cross section. Observing the principles of shades and shadows and selecting a profile will give sharp, smooth, and regular shadows. Two profiles for recessed letters are shown and their merits analyzed in **Fig. 35**.



Close-up view of lettering on a precast concrete panel with right angle shoulders.



Square shoulders of the V-recessed letter makes a sharp shadow, but the broken surface of the back causes an uneven shadow making the letter appear irregular.



Recessed letters with right angle shoulders and flat back stand out clearly, because the shadow cast by the outer angle against the flat back if strong and regular.

Figure 35 Recessed lettering.

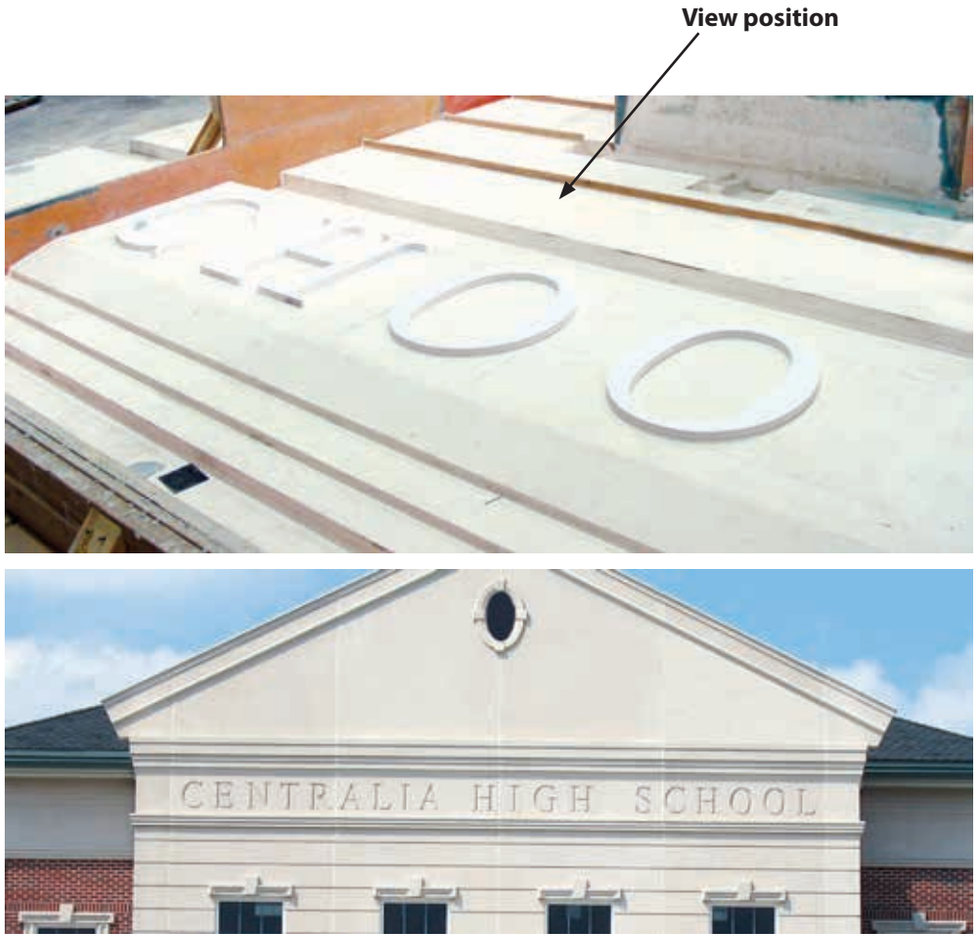


Figure 36 (a & b) Letters are reversed in the mold. Note the letter "c" that is part of the word "school". Centralia High School, Centralia, Ill.

The pattern for the letters is reversed in the mold. Note the letter "c" that is part of the word "school" (need to look at the mold from the top of photo), **Fig. 36 (a)**. The erected panels are shown in **Fig. 36 (b)**.

The visibility of letters, is to some extent, determined by the background and the style of the letters. The use of contrasting precast concrete finishes or staining the back of recessed letters in a color contrasting with the surface wall will enhance the visibility of the letters. In addition, design elements smaller than 1/300th of the viewing distance are difficult to "read" and tend to get visually lost.

Figure 37 Seal of University of Scranton, Scranton, PA.

The Scranton University seal was sequentially cast into panels at the entrance; a formliner was used to produce the seal. See **Fig. 37**.

Each campus building at Christopher High School, Gilroy, Calif., has its activity incised on its front entrance, **Fig. 38**. Paw prints of the cougar, the school mascot, appear on the ornate entry façades. Gilroy's largest garlic grower donated land and funding. The school not only carries his name, but includes a decorative garlic bulb sculpted right into the entry lintels.

The two-story portion of the UNF Biological Sciences Building, Jacksonville, Fla., displays key words in the precast concrete façade from the school's biological sciences mission statement, **Fig. 39**. The words appear routed within the precast concrete.

Figure 38 Christopher High School, Gilroy, Calif.

Figure 39 UNF Biological Sciences Building, Jacksonville, Fla.

Flexibility of Design with Formliners

The range of designs that can be created with formliners today ensures that virtually any vision created by the designer can be accomplished. But to maximize success, early input by the precaster will ensure that the result matches the intent, schedules are maintained, and that it is created as inexpensively as possible. Formliners provide the designer with more options and flexibility when designing a precast concrete building exterior. Whether a standard or individual formliner, a photo-engraved or photographic solution, in every case the use of formliners on a building provides for a visually singular profile and makes it unique.

About AIA Learning Units

Please visit www.pci.org/elearning to read the complete article, as well as to take the test to qualify for 1.0 HSW Learning Unit.

The Precast/Prestressed Concrete Institute (PCI) is a Registered Provider with both the American Institute of Architects (AIA) and the National Council of Examiners for Engineers and Surveyors (NCEES). Continuing education credit is reported to both agencies.

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Instructions

Review the learning objectives below.

Read the AIA Learning Units article. Note: The complete article is avaliable at www.pci.org/elearning

Complete the online test. You will need to answer at least 80% of the questions correctly to receive the 1.0 HSW Learning Units associated with this educational program.

Learning Objectives:

This article provides an overview of the design concepts for connections of architectural precast concrete enclosure systems. This includes the types of connections and hardware as well as design considerations, such as fireproofing. The article also addresses who is typically responsibly to supply field hardware.

1. Explain the form liner options for precast concrete surfaces.
2. Discuss the applications of computer numerical control (CNC) for the production of custom designed form liners.
3. Explain the process for the application of photographic concrete.
4. Describe the process for the use of lettering on precast concrete.

Questions: contact Education Dept. - Alex Morales, (312) 786-0300 Email amorales@pci.org

QUESTIONS

1. Different types of custom graphics that can be achieved with form liners are:

   a. A two-dimensional pattern milled into or attached to a mold-graphics could be letters, dates and simple flat-planar designs.

   b. Multiple planes to produce a graphic that may have different types of textures such as abrasive blast, bushhammered, or fractured fins.

   c. Three-dimensional, photo-realistic graphics achieved through computer numerical control (CNC) milling of the form liner or use of a special membrane with embedded retarder where the retarded surface is exposed.

   a

   a and c

   b and c

   a, b and c

2. Factors impacting cost of a form liner:

   a. Material used

   b. Detail of design

   c. Changes made after original design

   d. Size

   e. Number of reuses

   f. All of the above

3. Draft is not necessary with all form liner materials.

   a. True

   b. False

4. The visual impact, made by relief sculpture depends mainly on profile and lighting.

   a. True

   b. False

5. The viewing distance of the façade surface should be considered when deciding on the scale of the relief. As a rough guide, design elements should be smaller than about 1/300 of the viewing distance.

   a. True

   b. False

6. Form liner details may be classified as geometric, rhythmic or custom shapes.

   a. True

   b. False

7. Photo-engraved images are visible from any viewing angle.

   a. True

   b. False

8. The photographic concrete process has a surface retarder applied to a membrane and the design pattern is created by the contrast between the smooth and exposed aggregate finish.

   a. True

   b. False

9. Recessed letters with right angle shoulders and flat back appear strong and regular.

   a. True

   b. False

10. The use of contrasting precast concrete finishes or staining the back of recessed letters in a color contrasting with the surface wall will enhance the visibility of the letters.

    a. True

    b. False