COLOR CONCERTO: concrete frames faceted glass

Reinforced with steel to resist wind loading

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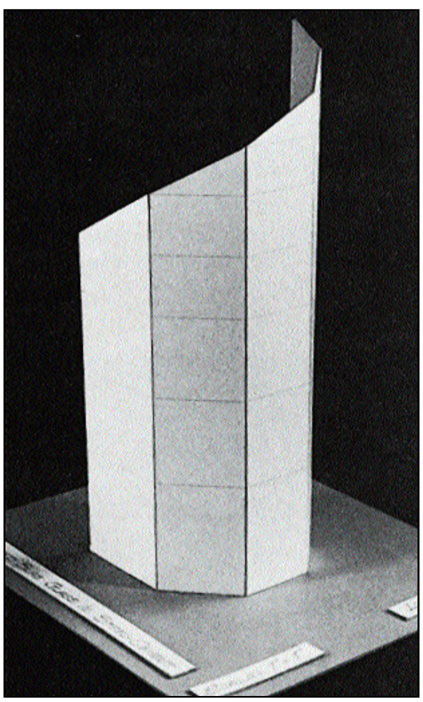
Color Concerto was designed for Purdue University Calumet in Hammond, Indiana with color as the primary purpose of the sculpture. But not colored sculpture, in which the color would be in light reflected from its surface. Here the color would result from light passing through the sculpture—becoming in essence sculptured color. Stained slab glass about an inch thick was selected because of the three-dimensional qualities of light transmitted through thick glass. When the glass is faceted by knocking out shallow chips from one side, the light is slightly bent or refracted and this further enhances the color variety.

2 Preliminary layout before the panels are fabricated. Pieces of slab glass were arranged so that each section harmonized with the total shell design. Two layers of steel wires and rods were cut and fitted to the glass for each panel. Note small spacers between rods.



1 Cardboard scale model show the five faces planned for the 11-foot-tall shell sculpture. Lines on the model indicate individual sections to be made of faceted glass framed in reinforced mortar.

Reinforced portland cement mortar, which we have used in other art forms, was chosen to provide support for the pieces of glass. The sculpture's shape and orientation to the sun were planned to best exploit the transmitted color. A semicircular shell design 11 feet high (Figure 1) was selected, with its convex side facing south so that direct sunlight could penetrate some of the stained glass at any time of the day.

Establishing design unity

In this design, color unity was achieved by repeating a triad of closely related yellows, oranges and reds, all from the warm side of the spectrum. No cool colors were included. Geometric unity was achieved by limiting the shapes to a motif of trapezoidal and related shapes. The overall outline of the sculpture presents a trapezoidal shape, and most of the glass pieces are trapezoidal. The sections in which the sculpture was fabricated are triangular or rectangular, of different sizes for increased variety.

Portland cement mortar made with admixtures

Reinforced portland cement mortar was well suited to building the shell framework for this sculpture. Because of its plasticity, the mortar could be shaped around the irregular edges of the faceted glass to build a supporting framework, with ribs projecting beyond the glass surface. The tool marks left as the mortar was applied created an intriguing texture, and with adequate reinforcement the structure could be strong and wind resistant.

Cement was hand mixed with silica sand and water, then pushed in-

3 Clay was placed on top and bottom of glass before mortar was packed between the pieces of glass. Thick clay on the bottom maintained a uniform distance from the bottom of the frame and clay on top kept the glass surface free of mortar. After the panel had hardened and the frame was removed, all clay was washed or scraped from the glass.

to the desired shape and position by hand and modeled with a kitchen knife. About one part of cement to one part of sand was used with a very low water-cement ratio for maximum strength and durability. To obtain the lowest possible water-cement ratio, less than 0.3, a superplasticizer (high range water reducer) was added at the rate of about 7 ounces per gallon of liquid. This admixture enabled a very dry mix to be pushed into tight corners and make good contact with reinforcing steel. The superplasticizer helped increase ultimate strength and durability as well as the early strength so that sections of the sculpture could be removed from their frames sooner.

4 On-site assembly of sections, with anchorage to vertical reinforcing rods. Mortar was placed on the horizontal joint and the section pushed down into it. Then mortar was packed into vertical joints to cover and protect the steel.

Acrylic polymer was also used in all mixes to reduce shrinkage cracking and further increase the durability. Non-air-entraining white cement was used throughout. Because the polymer-modified mix lost plasticity quickly in hot weather, only small batches that could be used quickly were mixed.

Prefabrication in sections

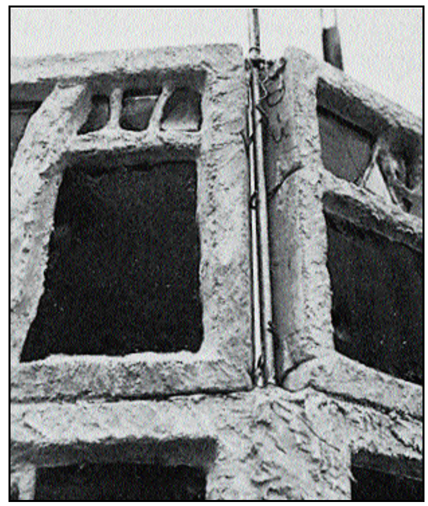
Since the finished sculpture weighed about 2000 pounds and stood over 11 feet above its foundation, delivery of a fully fabricated unit was not practical. It was divided into 35 sections to be built in frames made of steel angles and lumber. Each frame was carefully squared and clamped; then cut and faceted pieces of glass were arranged in the frame. A layer of clay was applied to both sides of the glass, thick on the bottom to maintain a uniform distance from the bottom of the frame and thin on top to prevent mortar from sticking to the glass.

Silicone caulking compound was applied to the edges of each piece of slab glass to isolate the glass from the mortar and prevent any chemical reaction that could produce an expansive pressure. Because it remains flexible, the silicone caulk also provides a cushion to absorb differential expansion during temperature changes.

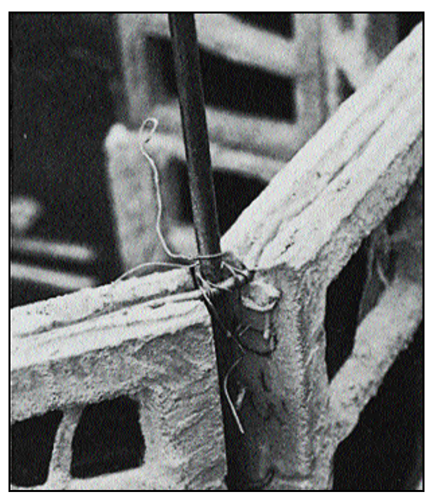
Steel rods and 9-gauge wire were cut and fitted to reinforce each section, and the steel was cleaned carefully to remove oil, dirt and rust. Extra reinforcement was provided to resist stresses that would occur during transportation and delivery. The mortar ribs were built up by hand (Figure 3) to project beyond the glass surfaces and to provide at least ½ inch of cover to protect steel from corrosion.

Assembly and erection on site

The 35 sculpted sections were taken to the site for assembly into an 11-foot-high shell. The cardboard model (Figure 1) shows the planned shape. Primary steel reinforcement located in joints be-



5 Sections fastened to the vertical half-inch rod with hooks of 9-gauge wire that had been anchored in the panels as they were built.



6 A quarter-inch rod, placed in the horizontal joint as sections were assembled, was tied to the half-inch vertical steel. Note groove in the top of each section to receive the rod.

7 The joint between the sections was filled with white-cement mortar, and the fresh mix was given a rough texture with a bent knife blade. Similar mortar texturing was done on foundation surfaces to match the sculpture.

tween the sections was designed to resist a wind force of 30 pounds per square foot. Using a simplified analysis, the steel was planned to resist overturning when exposed to up to three times the anticipated wind. We considered this safety factor of three adequate to compensate for any discrepancies between the actual structure and the simplified analysis.

This solution placed ½-inch steel rods in each vertical joint between the sections (Figure 4). Since the shell edges had no lateral support, they required extra stiffening. Two ½-inch rods were placed 2 inches on center along each edge. Hardware cloth was placed around these double rods as the final mortar mix was applied.

To anchor the bottom of the sculpture to its base, the vertical steel was set in the concrete foundation when it was placed. A template about 8 inches above the foundation form held the ½-inch rods at the proper horizontal spacing. A second template was mounted about 4 feet above the foundation, and the two templates were braced and aligned to keep the rods vertical and at the proper height.

To provide horizontal stability and lateral support, ¼-inch rods were placed in the horizontal joints between the sections as they were assembled (Figure 6). The horizontal rods were tied to the vertical rods with small-gauge wire.

During assembly of the sections a slurry of cement and acrylic polymer was brushed on each joint surface and on the steel rods before the fresh cement mortar mix was forced into the joint by hand pressure. The polymer is an excellent bonding agent, and the slurry ensures good contact between the fresh mortar and the already hardened mortar of the panels. Good contact and a secure bond are vital in assembling sections to prevent cracks that might later allow water to penetrate.

Finishing touches

After the sculpture was fully assembled, a mound of mortar mix was modeled over its upper edge to shed rainwater. More mortar was placed on top of the foundation to build a sloping surface that would drain water away. A coat of white mortar troweled on the vertical sides of the foundation created a texture similar to that of the surface of the sculpture.

During the winter when snow covers the ground and the sun is low in the sky, the stained glass will cast colored shadows across the snow. It is planned to install lights on the north side to shine into the concave surface of the sculpture at night to provide the experience of transmitted color after dark.

Editor's note

Lynn Olson's book, Sculpting with Cement, explains in more detail the glass and mortar sculpting method as well as direct modeling with portland-cement-based mortars. Copies of the revised fourth printing (110 pages) are available from Steelstone Press, 4607 Claussen Lane, Valparaiso, Indiana 46383 for $14.95 postpaid. Add $2.40 for air-mail shipment.

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