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Repair Project of the Year

The Baha'i House of Worship

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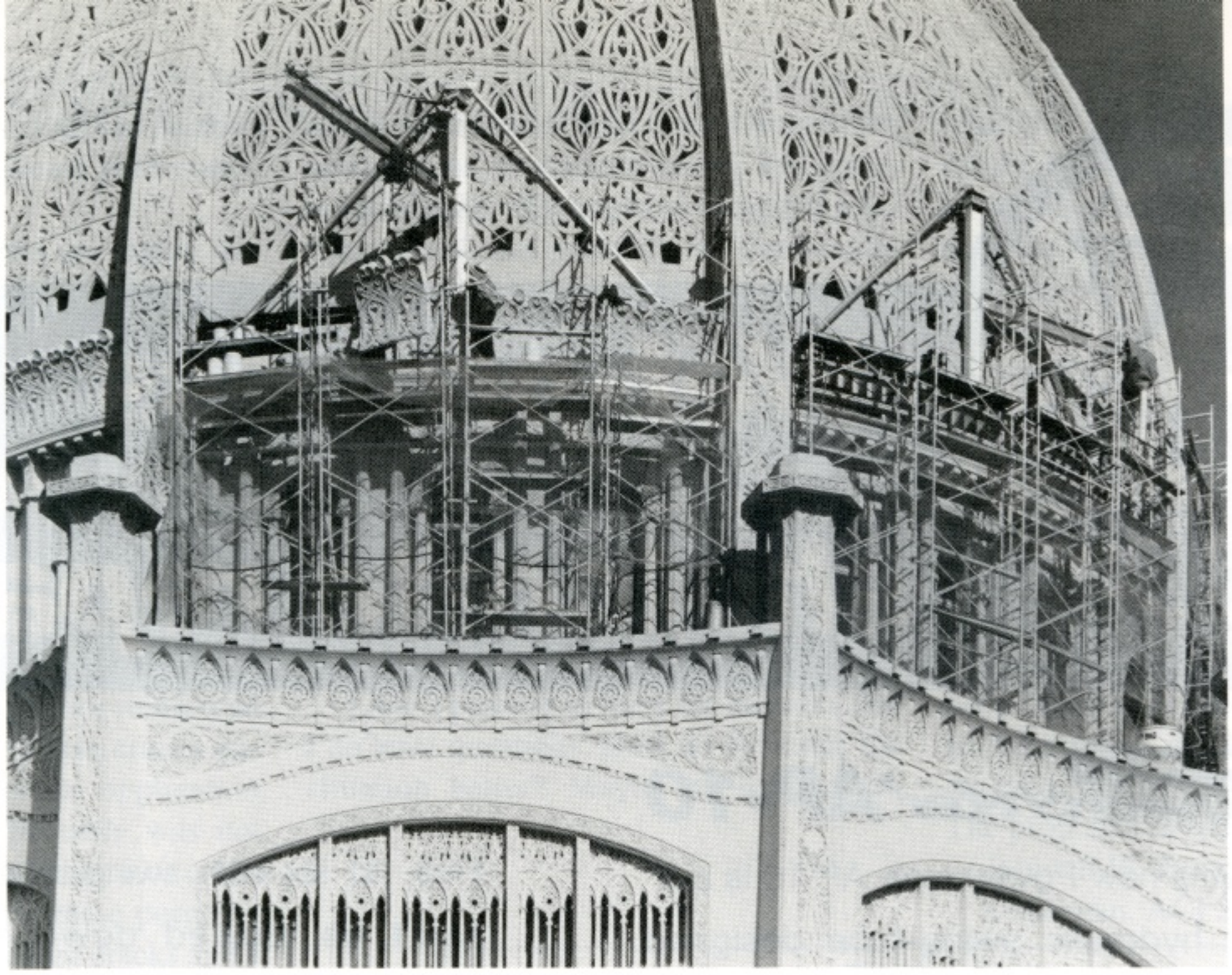
WINNER - ICRI REPAIR PROJECT OF THE YEAR



Special hoisting and access systems were designed for the repair of the Baha'i House of Worship located in Wilmette, Illinois. Photo by Scott Corrie.

The Baha'i House of Worship Restoration

by Robert F. Armbruster and Jack Stecich

Editor's note: *The concrete restoration of the Baha'i House of Worship, located in Wilmette, Illinois received the "Project of the Year" award at the ICRI Annual Convention held October 22-24 in Baltimore, Maryland.*

The Baha'i House of Worship, listed on the National Register of Historic Places, is one of the nation's finest examples of architectural concrete. As the first Baha'i Temple in the Western world, this House of Worship holds a singular position for the Baha'is and they want the structure to serve for more than one thousand years.

Designed by architect Louis Bourgeois, the House of Worship is notable for its symmetry and its mixture of architectural influences. Sited on a bluff overlooking Lake Michigan, the House of Worship is organized in three major sections: a base, main walls, and an upper level which contains a clerestory and dome. Construction began in 1920 and was completed in 1953. The building consists of a structural steel and concrete frame covered with ornamental, exposed aggregate concrete created by John J. Earley, who became known as the man who made concrete beautiful. The ornamental concrete was composed of white and crystal clear crushed quartz aggregate, quartz sand, and white portland cement, formed in elaborate molds.

Damage from Cyclic Freezing

By the 1980's, deterioration of the concrete in the entrance stairs, crown, and clerestory had become noticeable. The Baha'is' project manager created a team with the engineer, contractor and key craftsmen for a comprehensive and unified approach towards the restoration of the Temple.

A study was commissioned to investigate problems with the exterior concrete. The investigation consisted of: closeup inspection of the concrete; inspection openings to establish the condition of concealed anchors and to examine the space between the ornamental concrete and the structural concrete; water testing to determine the source of water infiltration; laboratory petrographic evaluation of cores to evaluate deterioration; copper-copper sulfate half cell potential measurements and chloride ion determination to establish the degree of corrosion; and laboratory studies to determine the mix proportions of the original concrete.

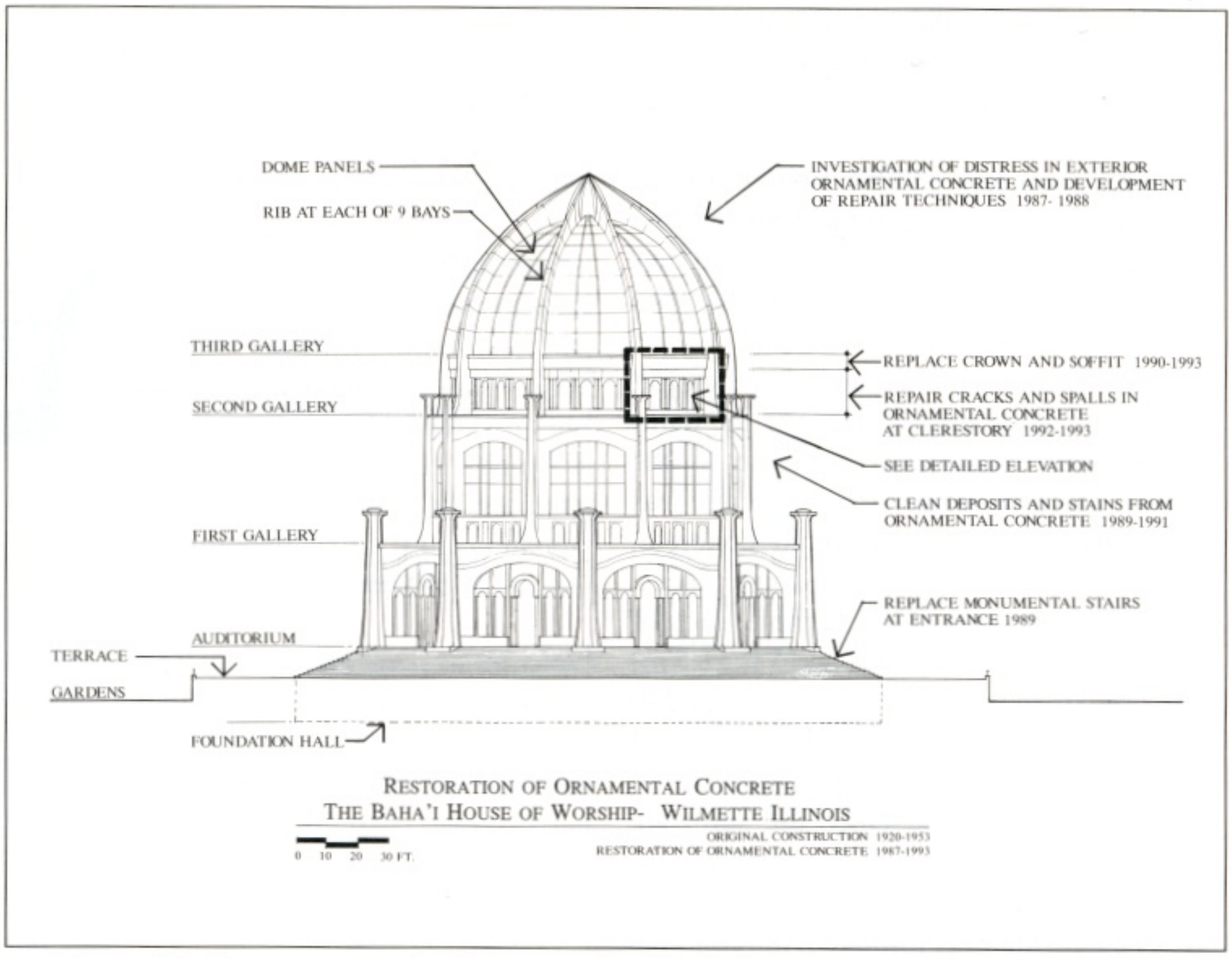
Crown Deterioration

Most of the ornamental concrete in the area along the cornice, soffit and dentils, appeared to be in good condition, but some places showed deterioration. The investigation revealed that damage to the concrete of the crown was caused by cyclic freezing of critically saturated concrete. In addition, steel anchors of the ornamental concrete to the structure were fractured as a result of expansion due to water freezing.

A gap of up to one inch (25 mm) was found where the white ornamental concrete had originally been in contact with the underlying structural concrete. Petrographic analysis of the samples showed that the structural concrete was damaged as much as 30 in. (962 mm) below the surface, even where the white ornamental concrete appeared sound. The damage did not affect the overall strength of the building's structure, but it weakened the support for the ornamental concrete

Search for Matching Materials

The scope of work called for a restoration matching the original pattern, material composition, color and texture of the ornamental concrete while improving upon original construction details and using modern technology to provide extended life. During the two-year investigation, quarries were searched all over North America for quartz that would match the original aggregate. The most effective forming, mixing, casting and finishing techniques to replicate the original concrete were determined through careful experimentation. The size, color, surface density and exposure of the aggregate were important factors in matching the appearance. Over 50 concrete samples were



(Left) Intricate multi-piece fiberglass and rubber molds provided for accurate and efficient repair of the highly sculpted ornamental concrete components. (Right) Diagram by Wiss, Janney, Elstner Associates, Inc.

prepared to develop materials and techniques. The final mix included crushed quartz aggregate, crushed quartz and silica sand, white cement, water-reducing admixtures, and an air-entraining agent. The exposed aggregate texture of the concrete was produced by using a retarding agent brushed onto the surface of the molds.

Photos this page by Robert F. Armbruster

Stair Replacement

The first stage in the repair program addressed the monumental stairs at the Temple's entrance.The existing precast stairs and the cast-in-place upper landing were removed. The water-resistant membrane beneath the stairs was replaced and a hot water snow-melting system added to avoid the future need for damaging chemicals. New precast architectural concrete stairs and cast-in-place upper landing duplicated the original appearance.

Crown Repair

The restoration of the crown and clerestory consisted of replacing deteriorated concrete and the existing copper gutter at the base of the dome. For ornamentation to be replaced, a rubber impression was taken from the building and a positive model was cast from this mold. The model was further shaped by a sculptor to renew the original crispness of the ornamentation, and production molds were then created.

Workmen replace pre-cast stairs at entrance to the temple. A waterproofing membrane on the sloping concrete deck below the stairs protects occupied space inside the building.

Technician finishes cast-in-place white quartz soffit and dentil section. A later placement of grey structural concrete will encase the epoxy coated reinforcing steel that ties the soffit and structural repair into the remaining original concrete.

The area of repair is like a layered, curving sculpture with interlocking components. To achieve the exacting tolerances and high standards of quality with such complex geometry, a full size mock-up was constructed in the shop for testing and fine tuning. Templates and jigs were also created for accurate and efficient production on the building.

Small jackhammers—no larger than 15# (6.8 kg)— were used to remove the damaged white ornamental concrete at the crown. The deteriorated plain concrete was then removed down to sound concrete, which was 3 ft. (1 m) deep in some places.

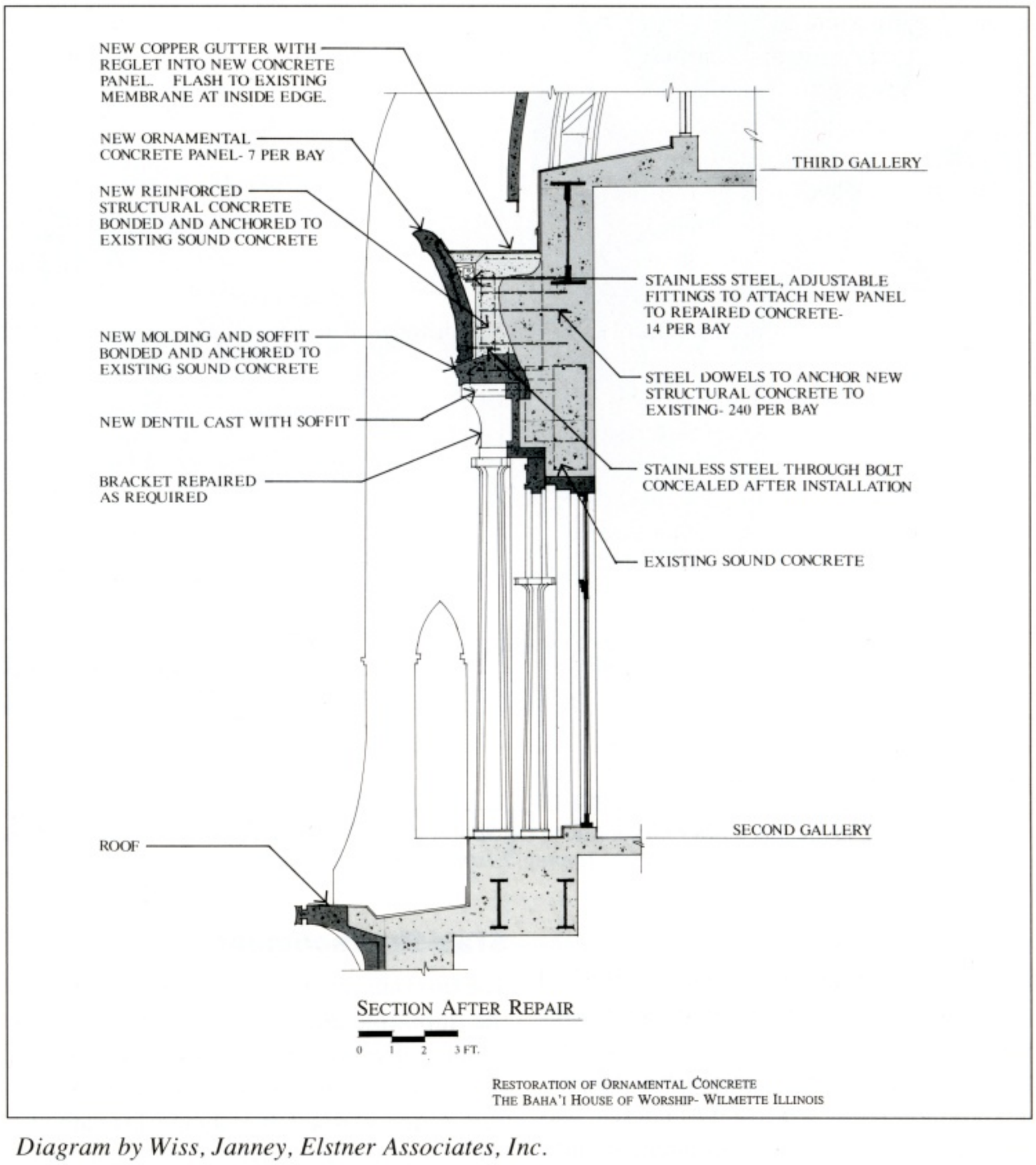
In the nine sides of the Temple, each of which is 31 ft. (9.5 m) wide and 5 ft. (1.5 m) tall, craftsmen drilled, and set in epoxy 240 new steel anchors 3 ft. long. Epoxy coated steel reinforcing rods were carefully fit behind curved forms. Once the substrate was properly prepared, the structural concrete material was then placed into the forms. After the forms were removed, the concrete cured for three weeks under a plastic wrap. (See diagram at right.)

The ornamental concrete of the soffit and dentil section was cast in place using white quartz concrete placed into rubber molds. A retarder on the inside surface of the molds facilitated exposure of the quartz aggregate with wire brushes when the molds were removed the next day.

The ornamental face of the crown was replaced with precast architectural panels of white quartz concrete. The panels were produced in the temple's shop using intricate fiberglass molds coated with a retarder to allow easy exposure of the quartz material. After three weeks of curing, the panels were attached to the repaired structural concrete using adjustable stainless steel angles and expansion anchors. A new copper gutter and new drains were installed at the base of the dome. Cracks and spalls in the clerestory were repaired using similar techniques with the white concrete mix.

Custom Hoists Designed - Customized hoisting and access systems were designed for the building. A large stationary trolley hoist was used to lift materials from the service driveway on the ground up to the first story roof. Materials were moved around on the roof level using carts.

Small aluminum cranes mounted on the dome lifted materials and equipment up to the work area. The cranes and scaffolding on the upper roof were moved from section to section as work progressed. All of the hoisting systems were anchored onto the building with stainless steel anchors that remained permanently so that the hoists could be used again in the future.



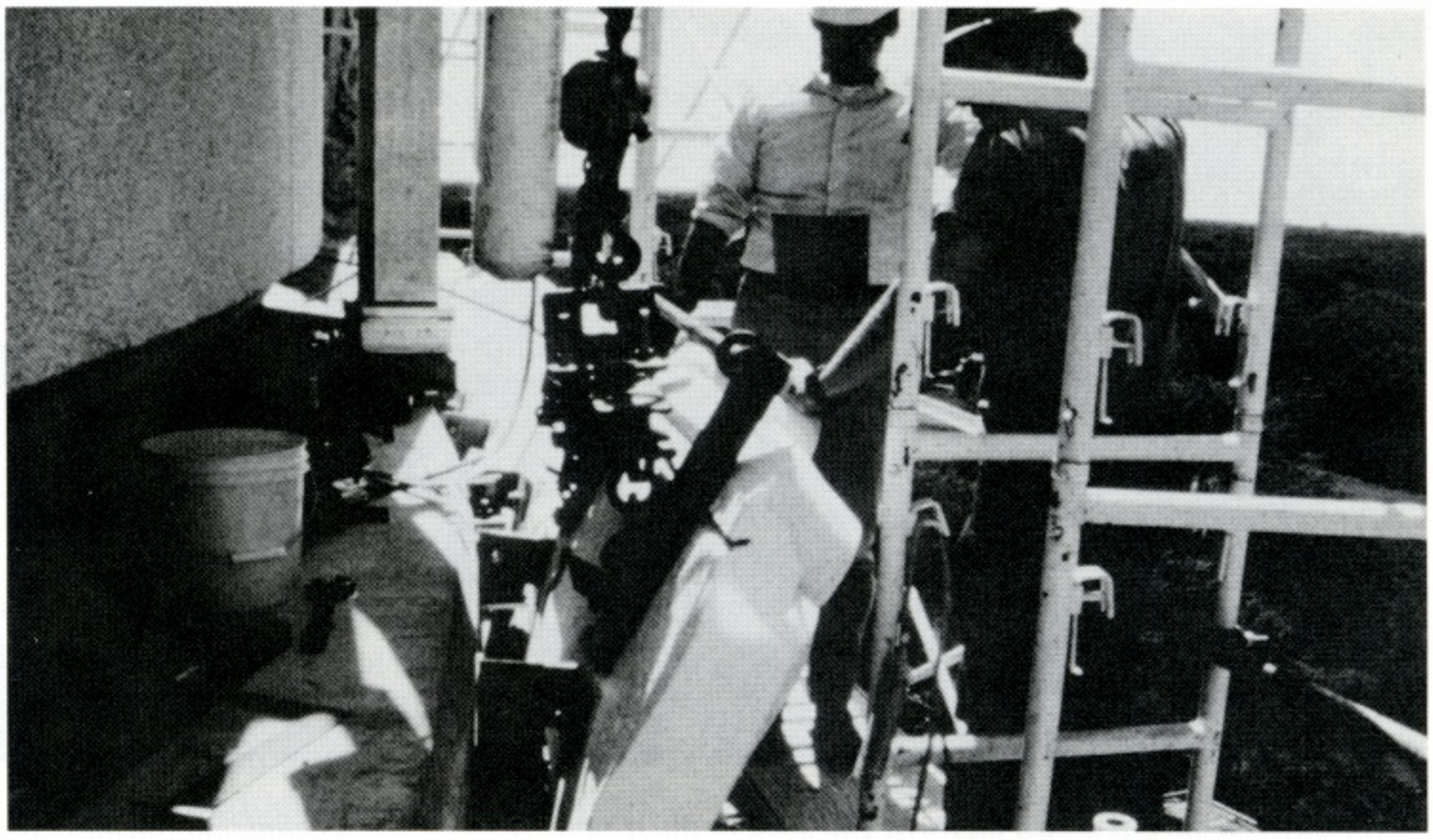
SECTION AFTER REPAIR

RESTORATION OF ORNAMENTAL CONCRETE
THE BAHA'I HOUSE OF WORSHIP- WILMETTE ILLINOIS

Diagram by Wiss, Janney, Elstner Associates, Inc.

Cleaning Program

Another part of the concrete restoration was a meticulous cleaning completed over



New precast, white quartz ornamental concrete panels are attached with stainless steel adjustable fittings to maintain uniform 3/8 in.(10 mm) gaps across curving joints. Open cavity behind panels provides a free draining weep system. Photo by Robert F. Armbruster.

a three year period.

The first cleaning to the structure was in 1969. Technicians used a chemical cleaner which was very effective at removing the general atmospheric staining on the Temple. However, at that time they did not know how to best remove the black crusts that formed under window ledges and column capitals. They even tried sandblasting, but found that the sandblasting irreparably damaged the surface. They decided to stop and wait until a better system could be found.

Gypsum crystal - The black crusts were formed when sulphur dioxide gas came in contact with the moist masonry surface containing calcite compounds. The chemical reaction created gypsum crystal which formed around other pollutants. Although the crusts were extremely hard, they were slightly water soluble which is why they formed in areas that did not receive direct rainfall. They were removed by dissolving them with a fine water mist sprayed from modular manifolds custom built to fit each unique architectural feature. The water supply was controlled by timers programmed to spray in cycles of 5 minutes on and 20 minutes off. This not only saved water, but reduced the risk of water penetrating the walls where it might have damaged the interior.

Efflorescence and Staining - Efflorescence, visible on the Temple as white crusts and stalactites, usually indicates a failure in the waterproofing system of the building. In this case, it was a flaw in the original gutter system. Deposits were removed with water mist and gentle brushing. The black scabs and white stalactites covered only a small portion of the building, however. The largest task was removing the staining caused by atmospheric pollution. The quartz stones were streaked with blackish stains apparently from atmospheric pollution. There were also organic growths rooted in the cement and sand matrix between the larger stones. These growths were primarily moss and fungus.

After numerous tests and laboratory analyses, a specially formulated restoration cleaning solutionwas selected to pre-soften the stains and to kill the organic growths. Soilage from the surface was then rinsed with gentle water jets.

Survey of Ornamentation

During the restoration, the entire exterior and interior surface of the temple was surveyed with modern instruments and computers, so that any point on the concrete can be located in three dimensions within one-eighth of an inch.

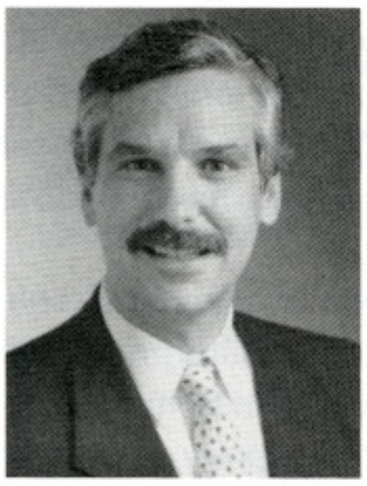
Control targets were placed over all areas of the building and then precisely measured with the most sophisticated surveying theodolites in the world.

The targets were included in photogrammetry using stereo pairs of photographs taken with a calibrated metric camera. The resulting film images could be used to plot any point on the surface. Through computers, this data can automatically control a milling machine to produce an accurate model for the modelmakers if the concrete weathers and needs replacement in the future.

The completed repairs are a faithful reproduction of the original ornamental concrete. The seven year effort has recreated the original appearance of this magnificent structure, while combining the finest craftsmanship with advanced technology and refined materials to improve future performance.

Robert F. Armbruster

ICRI member Robert F. Armbruster serves as Director, House of Worship Restoration, for the National Spiritual Assembly of the Baha'is of the United States. He is President of the Armbruster Company in Glencoe, Illinois, and as an owner's agent he has provided management, design and implementation on a wide range of projects during the last seventeen years. He is a licensed porfessional engineer who works with historic preservation and new development.



Jack Stecich

Jack Stecich is a licensed structural engineer and a licensed professional engineer. He is a senior consultant with Wiss, Janney, Elstner Associates, Inc. (WJE) in Chicago, Illinois. Over the past fifteen years at WJE, he has investigated building and structural failures, evaluated the condition of existing structures, conducted laboratory research and has designed repairs. He is a member of numerous professional societies including American Concrete Institute and has written many aritcles. ■

Additional ICRI members serving as contractors and consultants on the restoration of the Baha'i House of Worship:

Quality Restorations
Wooddale, Illinois
General Contractor
Ornamental and Structural Concrete
Hoisting Systems

STS Consultants
Northbrook, Illinois
Engineers for Hoisting Systems

Preco Fosroc
Plainview, New York
Heat-Cote Surface Retarders

Master Builders
Cleveland, Ohio
MB VR Air Entraining Agent

Twelve Projects Receive ICRI Awards

The ornamental concrete renovation of the Baha'i House of Worship, Wilmette, Illinois (see story, Page 6) was named "Project of the Year" at the First Annual ICRI Awards, held on October 24 in Baltimore, Maryland. In selecting the project for the top honor, the judges commented that "the technical achievement of the repairs was almost as outstanding as the artistic craftsmanship involved in the renovations." Mr. Robert Armbruster, who directed the project for the Baha'i National Center accepted the award, and credited all those involved in bringing the challenging and complex project to fruition.