NEW YORK HALL OF SCIENCE GREAT HALL RESTORATION

BY ASIM JABBAR AND JEFF BINDER

The New York Hall of Science Great Hall was originally built for the 1964 World's Fair using a technique known as "dalle de verre"—the French term for "slab glass." Small pieces of glass are either randomly placed or placed in a specific pattern and a solidifying material is poured to hold them in place. In this case, the pieces are 1 in. (25.4 mm) thick and a deep cobalt blue—features that give the illusion that the glass is opaque until the sun lights them to a bright glow. Approximately 5400 of the 2 x 3 ft (0.61 x 0.91 m) panels were created and hung side by side using hooks inlaid into the cast-in-place structure and panels, making them literally hang in the structure. The resulting view offers the feeling of floating through space.

The building technique known as "dalle de verre" allows the light to shine through the cobalt blue pieces of glass, offering visitors the feeling of floating through space

Deterioration could be seen at various spots on the building, mainly due to inadequate reinforcing steel coverage

The uniqueness of this structure also comes from its shape—a 100 ft (30.5 m) high wave wall with no corners or straight segments. Its shape is made from alternating convex and concave sections of wall that give visitors a sense of the limitless nature of space.

Areas of the exterior cast-in-place structure that hold the panels together were showing signs of wear. Concrete spalling and deterioration, mainly due to inadequate reinforcing steel coverage, were seen at various locations. The precast panels showed cracking between pieces of glass and the edges of the panel, and the surface sand finish was being washed away.

CONDITIONS ASSESSMENT

The first step of the assessment was to survey a percentage of the exterior. Four locations (20% of the façade) representative of the overall condition of all the exterior surfaces were investigated. Damaged areas were recorded on template drawings; photographs were taken as well. A badly damaged precast panel and samples of the cast-in-place concrete frame were removed and sent to a testing laboratory to be tested for abrasion resistance and water repellence and to determine how to strengthen the precast concrete using a consolidant. The laboratory recommended that a consolidating treatment and weather seal be applied to the façade.

A detailed sounding investigation was performed by the repair contractor and building conservation firm. Rubber and rawhide mallets were used to tap the concrete at 2 in. (50.8 mm) intervals to locate repair areas. Identified locations were recorded in a diagrammatic log for later reference.

Due to the large volume of repairs, careful planning was required to keep crews at the correct locations. The solution involved placing duct tape with location numbers on the building at each repair location prior to each task to ensure that the crews knew where to work and what work to perform. For example, after the sounding crew had finished with an area, the logs for that area were handed off to a technician, who transferred the data from the logs onto the building. The process helped ensure that only one technician had to know how to relate the information from the logs onto the building rather than the entire crew.

The initial repair step was saw-cutting the concrete at the limits of the repair based on the sounding report. This, along with the duct tape, allowed the demolition crew to identify the areas that needed chipping without referencing the sounding reports and gave the repair a clean cut on each end. During demolition, the delaminated concrete was chipped with electric chipping hammers and chisel bits were altered to provide more control and less vibration until sound concrete was reached and the front layer of the No. 8 reinforcing steel was exposed. If more than 50% of the reinforcing steel was exposed, a 2 in. (50.8 mm) wide channel was chipped out behind the reinforcing steel so it could be cleaned before new concrete was placed.

Cleaning the rusting bars, however, was challenging, as wire wheel grinders could not clean the back of the bar with just a 1 in. (25.4 mm) clearance behind and a 2 in. (50.8 mm) channel along the bar. The repair team decided to use abrasive blasting to target the back of the bar with aggregate rebounding from the sound concrete. The solutions worked well and cleaned the bars to bare metal per specifications. Once the steel was cleaned, another crew primed it for corrosion protection prior to patching.

During the patching stage, it was important to match the original physical properties of the concrete because of the architectural and historical requirements. The initial step was to identify the number of mixtures needed and produce a mortar that would match the existing adjacent substrate in color and texture. Due to the cellular shape of the structure and varying aging patterns, six areas that differed in color and texture were identified. Five locations had a mixture of two fine sand aggregates pressed onto the surface of the patch, and one location had the same aggregate mixed in with the mortar. The ingredients and their proportions were recorded to produce the exact mixture each time, but the challenge was pressing the aggregate onto the repair surface. Successful placement depended on the applicator's skills and understanding of color and texture with respect to aggregate quantity and application. Shop exercises were performed before the actual repairs to master the process and fine-tune the color formulas.

Once the colors were established and the techniques were refined, the patching process began. The substrate was moistened and a "peanut butter" coat was applied. While this coat was wet, the finish layer or layers could be applied. For deeper patches with mixed-in aggregate that extended behind the reinforcing steel, multiple lifts were used. To ensure that the sides of the patches stayed square and in line with the existing substrate, small pieces of methylmethacrylate were used to give technicians a side edge for the patch. Once the top coat was finished, the sand was applied. Because the sand was the key to making the patch match the existing substrate, it became very important to find the correct sieve for each repair to filter the larger aggregates. Once prepared, it was applied by pressing a sand-covered trowel into the finished surface.

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Repair locations ranged in size from 2 in. (50.8 mm) to 19 ft (5.8 m) in length with a total of 1000 5 gal. (19 L) buckets of material used, but individual repair sections were usually smaller than 1 ft^2 (0.09 m^2) to prevent the peanut butter coat from prematurely drying. When finished, the patches cured for 28 days and were resounded and checked for color.

After the patches cured, the sealant between the cast-in-place concrete and the panels was replaced. The sealant was allowed to cure for 2 weeks and the cast-in-place members were coated with a penetrating corrosion inhibitor. A consolidant was then applied to the precast panels to ensure that no additional sand would be washed away. Finally, after a minimum of 72 hours' cure time, a water repellent was applied to the entire building. Originally, a strippable masking was specified to cover the glass to prevent a color change caused by the products. During mockup, however, the masking could not be removed without damaging the surface of the glass. Further field testing and mockups led to a new procedure of wiping the glass clean immediately following each application, requiring field crews to work very closely to ensure proper execution.

REPAIR PROCEDURE—PRECAST PANELS

While the sounding investigation was being performed, a visual inspection of each panel was made to identify cracks. Each crack was labeled as either a repair crack—greater than 1/16 in. (1.6 mm) in thickness—or a hairline crack—less than 1/16 in. (1.6 mm) in thickness and not requiring repair.

The original method specified for repairing the cracks was epoxy injection. While this method would strengthen the panel, multiple trials with different types of epoxy proved the process infeasible, as the necessary surface sealing and subsequent grinding would alter the appearance of the panels. After exploring several alternatives, the project team decided on a form of routing and sealing. A tool with custom diamond blades was used to rout out the cracks to a width of 1/8 in. (3.2 mm), allowing mortar to be placed in the crack so the finish would match the original panel.

It was decided that some panels were beyond repair because of the large quantity of cracks, and new panels were ordered from a precast manufacturer.

CONSTRUCTION CHALLENGES OVERCOME THROUGH TEAMWORK AND PLANNING

Because of the building's abnormal shape, a significant challenge was installing the scaffolding. The solution that was developed kept the frames a few feet from the building and used outriggers to butt up against the structure. Also, as fully planking each level was cost-prohibitive, only every fourth level was fully planked. The other levels had planking on the outriggers, leaving a narrow workspace of approximately 2 ft (0.6 m). Each task was preplanned to accommodate the narrow passageways. In most cases, equipment and materials were stored on the fully planked levels and hoisted to the work location.

Due to the complexity of the scaffolding, it was difficult to supply mortar to different spots of the building. A mixing station was centrally located for each part of the building with one technician working for an entire patching crew. The patching technicians would call or radio to the mixer specifying the color needed, and the mixing technician would mix a pail of the color and walk it to the location. There were also pull points on the scaffold where buckets could be easily lifted using rope and pulley systems.

Another challenge was that the museum remained open to visitors. Fencing was installed around the perimeter; areas directly outside of the enclosure, however, remained open. Constant monitoring was required to ensure visitor safety. For example, the vibrations created by the chipping guns on the inside of the structure during demolition caused concern because of loose pieces of concrete on the outside of the wall. These pieces were removed prior to additional chipping.

Due to the unique nature of this structure—with 6 in. (152.4 mm) wide cast-in-place columns and beams—demolition of narrow members also presented a challenge. Because the columns tapered toward the inside of the building, crews trying to reach behind reinforcing bars early in the project would occasionally chip through the corner of the column and cause a blowout. To prevent this situation, additional cuts were made approximately 1 in. (25.4 mm) away from both sides of the exposed reinforcing steel along the length of the repair, helping to isolate the concrete being removed and preventing blowouts.

The same reinforcing bars also sometimes created a problem during patching. Because of their close proximity to the surface of the building, patching back to original design would have caused future spalling. Accordingly, the patch was "humored" or rounded to give the bar more coverage. This step also made the column face rounded, requiring the repair contractor to work closely with the architect to ensure that the building aesthetics were not compromised.

SAFETY SUCCESS

As with all jobs, safety was a priority. On this project, cleaning and scaffolding contractors were on site along with the concrete repair contractor, and communication was essential for creating a safe environment. Contractors worked closely together to ensure that crews were not performing too closely to each other on the scaffolding. Daily meetings were held to coordinate crew activity.

The unusual shape and nature of this building also created many safety challenges. Each was handled by the team without compromising production, quality, or the project timeline. At the end of the job, the crew celebrated over 30,000 hours without a safety incident and was referred to by a New York City Department of Design and Construction Safety Inspector as "one of the safest jobs" he had ever seen.

A UNIQUE STRUCTURE SUCCESSFULLY PRESERVED

A well-planned strategy, thoughtful coordination with the entire repair team, skilled execution, and a commitment to safety all played a role in successfully restoring this unique structure to its original condition on time and within budget, allowing present and future visitors to enjoy its beauty for years to come.

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New York Hall of Science Great Hall

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