2009 Award of Excellence

Low-Rise Category

The Solomon R. Guggenheim Museum Exterior Restoration and Building Enhancement

New York, New York

Submitted by WASA/Studio A

From December 2004 through October 2008, the Solomon R. Guggenheim Museum underwent its first major exterior restoration. Completed in 1959, the museum is considered one of Frank Lloyd Wright's masterpieces and an international icon of modern architecture. Made of poured-in-place concrete, shotcrete (then known as gunite), and suspended plaster soffits on lath, the Guggenheim is experimental in its programmatic solution, architectural form, and innovative use of materials. It has been designated a New York City (NYC) landmark, as well as a National Historic Landmark.

Guggenheim Museum's Fifth Avenue façade showing coating failures before repair work

EXISTING CONDITIONS

Almost 50 years old, the Guggenheim had never undergone a holistic conservation treatment. Like many modernist structures, it exhibited multiple cracks, coating failures, interior condensation, air leakage, and other signs of deterioration. It had also evolved over time, undergoing four major alterations, the most significant of which was the construction of the 1992 addition, which was erected atop a previous concrete-frame addition dating from 1968.

During the 1992 work, the interior face of the walls was exposed and concealed rigid insulation was installed to upgrade the thermal performance of the building envelope. Despite this work, however, the museum remained prone to condensation at some interior locations, including the single-glazed steel windows and perimeter skylights.

PROJECT APPROACH

An initial assessment of cultural values, coupled with information derived from the existing conditions analysis, led to the definition of a preservation philosophy. This was submitted, reviewed, and approved by the NYC Landmarks Preservation Commission. The approach was as follows:

1. Retain the building's historic character by keeping original materials;
2. Retain changes that occurred over time;
3. Preserve distinctive features;
4. Repair rather than replace; replace in kind, if necessary; and substantiate replacements;
5. Use treatments that are not injurious;
6. Require new work not destroy historic character but be differentiated from, and compatible with, existing historic building fabric;
7. Require new work be reversible with historic materials unimpaired;
8. Avoid radical changes that will obscure, damage, or destroy character-defining materials or features in the process of rehabilitation work to meet current code and energy requirements;
9. Add no historical elements without evidence; and
10. Retain historical use of property.

At two points during the design phase, 2-day peer-review meetings refined the approach and project scope.

During the first 18 months, the building underwent a comprehensive condition assessment. To begin with, an extensive research of archival materials was conducted. A testing program for paint removal was implemented, along with an 18-month monitoring program to record movements in the structure and to determine how the building behaved seasonally.

Conditions were documented before and after paint removal. Investigation of more than 100 coating samples typically revealed 11 or more layers of paint. For the first time, a historic paint analysis by the project's architectural conservators determined the color stratigraphy accurately.

As part of the assessment, laser as-built documentation provided measured drawings of the building and a three-dimensional model for the structural analysis. Nondestructive methods were used to understand the configuration and condition of concealed steel reinforcing. Samples were collected to determine the physical and chemical composition of existing materials. Interior and exterior probes were made to verify conditions of wall assemblies. A corrosion investigation was conducted to determine the condition of the embedded steel elements.

At the same time, the building was monitored for its interior environment. Mechanical, electrical, and plumbing upgrades were designed and implemented. After various attempts to design retrofits to the existing steel windows and skylights had proved unsuccessful, new thermally-broken double-glazed steel windows and aluminum skylights were designed and fabricated to replicate the existing profiles. In this case, the significance of the building's continued use as a world-class art museum outweighed considerations of authenticity of fabric. Insulation was also added wherever gaps in thermal protection produced areas of condensation along the exterior walls.

MATERIAL ANALYSIS, TESTING, AND CONSERVATION RESEARCH

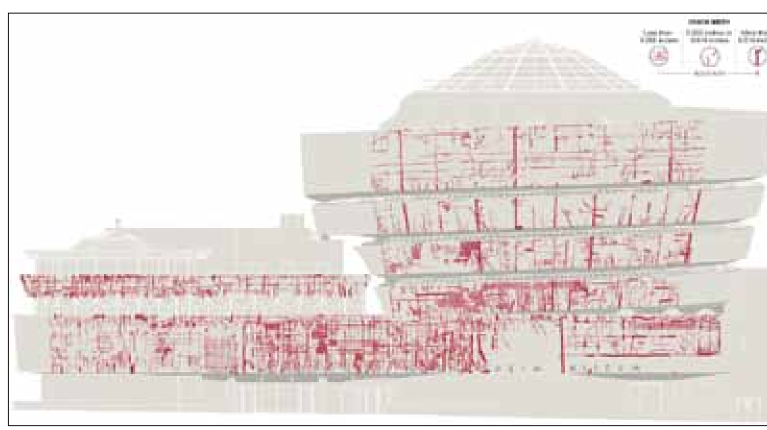
Along with materials analyses, a detailed testing program was implemented to choose the most appropriate repair system, including crack fillers, patching materials, and protective coatings. This work was carried out in the laboratory and in the field. Laboratory studies of proposed conservation products were done on test panels that replicated the composition and properties of the original gunite, the primary exterior material. The testing included accelerated weathering in an ultraviolet light chamber (QUV) by freezing and thawing, water-vapor transmission rate measurement, and adhesion and color change assessment before and after QUV exposure. The field work consisted of two rounds of mock-ups at different locations on the building with the limited number of repair systems that had performed well in the laboratory test program. These mock-ups were monitored over a 1-year period.

STRUCTURAL ANALYSIS

Whereas the structural analysis revealed that the main structure is sound, it was discovered that the top exterior ramp wall was constructed differently than the walls at the lower ramps. At the top wall, the horizontal reinforcing was found to be discontinuous due to embedded vertical steel elements spaced approximately every 10 ft (3 m) along the ramp. The top ramp wall is double the height of the other ramp walls so a larger steel element was used in the original construction, leaving insufficient space for the reinforcing to be continuous. Deficiencies were also identified at the connection of this exterior top wall to the ramp slab and to the main load-bearing walls.

The discontinuous reinforcing was remediated by the installation of surface-mounted carbon fiber-reinforcing polymer on the interior face of the

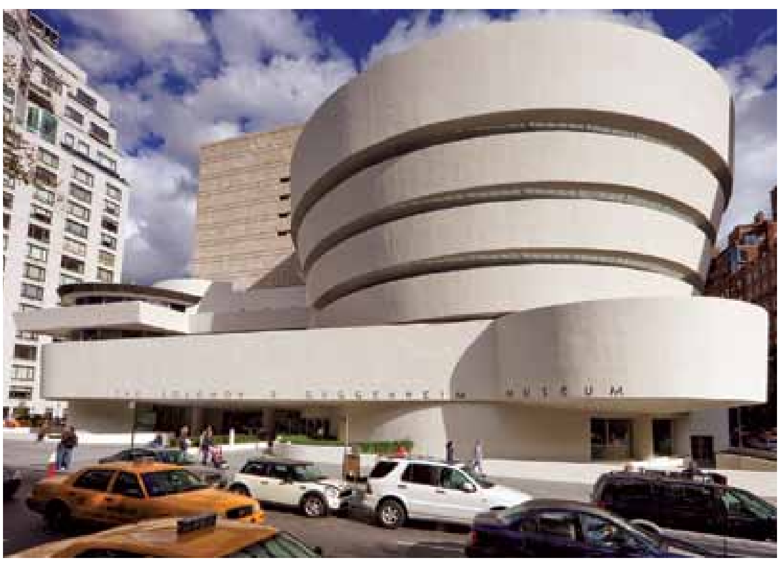
Replicas of existing shotcrete and selected repair systems at the project's architectural conservator's laboratory



Fifth avenue façade elevation and crack documentation (blue print)

Exposed sixth floor 2-1/2 x 2-1/2 in. (63.5 x 63.5 mm) steel tee after abrasive cleaning

Remedial control joint at sixth floor tee location



The Solomon R. Guggenheim Museum after exterior conservation work

walls.* This work structurally stabilized the walls without modifying the character defining exterior surface. Steel brackets and custom anchors were used to reinforce the deficient connections. Special dampers were installed at the top of the wall to improve the structural performance under current code-required loading. Corroded steel was cleaned and treated where the steel was accessible. Long-term crack, deflection, and corrosion monitors were installed to help evaluate the performance of the repairs. Application of an impressed-current cathodic-protection system was studied and, instead, long-term monitoring was installed.

REPAIR RECOMMENDATIONS AND IMPLEMENTATION

The patching material was a fiber-reinforced polymer-modified cementitious compound that was sculpted in its green and cured stages for accurate textural matching of adjacent surfaces, particularly the original board-form marks, which were deliberately retained as evidence of authenticity of craftsmanship. A highly-elastic, shape-retentive acrylic filler was installed in cracks and a flexible cementitious mortar was used on concrete surfaces for protection against water, salts, and carbon dioxide penetration. A state-of-the-art opaque coating, which mimicked and enhanced the quality and properties of the original "cocoon" finish, an early version of elastomeric paint, was applied to protect the concrete and repair system.

A precast concrete fascia originally finished with an application of sprayed molten copper—an early application of contemporary metalizing techniques—was cleaned in place to remove soiling and subsequent coatings that were affecting the condition and appearance of the original finish. After coating removal, deteriorated precast concrete was removed at selected locations, exposed steel reinforcement was cleaned and treated with corrosion inhibitors, concrete patching was installed to match adjacent surfaces in sound condition, and the repaired surfaces were refinished.

Once construction began, detailed hands-on administration and quality control resulted in custom patching techniques to ensure that the quality of the existing surfaces was maintained in the patches. The completion of the 3-1/2 year long, $29 million restoration resulted in a structurally enhanced building and concrete repair interventions that visually blended with, and protected, Wright's original poured-in-place concrete and shotcrete façades while preserving the formwork marks as a unique characteristic of this architectural masterpiece.

The Solomon R. Guggenheim Museum

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*This interior concrete repair work won an ICRI 2008 Project Award of Merit in the Historic Category.