Seamless Continuity *versus* the Nature of Materials

Gunite and Frank Lloyd Wright’s Guggenheim Museum

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The comprehensive analysis and preservation of Frank Lloyd Wright’s Solomon R. Guggenheim Museum in New York City for the building’s fiftieth anniversary in 2009 provided many new insights as to how it had been built as a singularly innovative construction. Among the Guggenheim’s unusual qualities was its composite nature as a hybrid construction in which different discrete techniques had been employed to realize Wright’s ideal of a seemingly continuous spiral. He had likely envisioned the Guggenheim as his life’s culminating statement of the principle of plasticity that he, following his mentor Louis Sullivan, advocated as central to their ideal of an organic architecture. Yet the structural engineering and building craft that proved essential to the museum’s realization challenged Wright and his array of collaborators to adapt and combine existing methods in ways that, at the time, had no close precedent. Among these construction techniques, one of the most important to the creation of the Guggenheim was the use of Gunite, also known as shotcrete, or concrete applied with a cement gun. The builder, George N. Cohen, under the architect’s direction, used Gunite for the spiral’s tilted exterior walls, as distinct from the poured-in-place concrete ramp floor and its vertical web walls or piers.

Wright’s use of Gunite for the Guggenheim and its role in the development of modern architecture has hitherto not been charted. Indeed Wright had been experimenting with Gunite for nearly twenty years prior to the Guggenheim’s construction. His involvement with this material followed its rapid technical development and widespread architectural adaptation since its origins in 1910 in both Europe and the United States. This study probes that history, with the aim of showing how Wright’s treatment of Gunite at the Guggenheim represented his transformation of the material’s earlier applications to serve his architectural aims. The Guggenheim’s spiral represented competing priorities for Wright in that he wanted it to exhibit a seamless continuity like a “natural” form. Yet to achieve that aesthetic ideal, he had to treat the rotunda’s Gunite surface in a way that tested his lifelong commitment to an architecture that respected and expressed what he called “the nature of materials.”

Gunite’s Origins and Richard Neutra’s Lovell House, 1927–29

Gunite had been patented in the United States in 1910, and had a number of properties to recommend its architectural adoption. The term “Gunite” was a trademark registered by the Cement Gun Company of Allentown, Pennsylvania, for a dry, fine-aggregate cement forced by compressed air through a hose to a nozzle where it was hydrated and shot out at high velocity onto a surface where it set or hardened.
The wet concrete propelled by pneumatic pressure against the surface to be covered was to be a dense, permanent application that provided a fireproof and waterproof encasement. The concrete could be built up against the backing onto which it was shot up to a depth of about two inches in one application (Figure 1). Gunite work was costly and time consuming, so it could not replace ordinary concrete construction for many purposes. But it had the advantage of not requiring the construction of the box-like wood formwork needed for poured concrete masses. Also, because the force of the spray produced an impacted deposit, the material produced was “infinitely stronger in all tests than any concrete or hand-placed mixture” produced at that time, “thereby permitting a very considerable reduction in section” and . . . “a considerable reduction in dead load as compared with poured concrete.”2 Another advantage of Gunite was that, when it was applied to structural steel, it was not just a superficial encasement. Because it was dense concrete, Gunite actually increased the load-bearing capacity of the steel skeleton onto which it was thoroughly applied, in addition to protecting structural steel from rust and fire. Important for the later Guggenheim, as one American architect wrote in 1928, “the increased use of . . . the cement-gun will allow the innate qualities of reinforced concrete to develop, especially as regards plasticity and adaptability to every form, size and curvature.”3

Gunite had early large-scale applications, notably in the construction of tunnels. The Southern California Edison Company had used Gunite since 1917 for repairing various hydroelectric structures. It may have been the regional prevalence of the new material that brought it to the attention of Wright when he based himself temporarily in Los Angeles in the winter of 1923. Later he employed Richard Neutra at Taliesin from the summer of 1924 for about ten weeks before Neutra moved to Los Angeles in January 1925. There Neutra used Gunite to cover the steel frame of his famed Lovell House, on which he worked from May 1927 to its public opening in December 1929 (Figure 2). Its prefabricated, three-level frame was bolted together and all surfaces (floors, partitions, and parapet walls) other than glass were then covered with a thin shell of shotcrete.4 Neutra’s Lovell House may have been the first successful transfer of Gunite as a technology originally developed for utilitarian structures into the realm of modernist architecture conceived and presented as high art. Neutra “in this instance departed from accustomed practices to such an extent.”5

Figure 1  Cement-gun work on floor of South Chicago Dry Dock, ca. 1920 (Cement Gun Work of All Kinds [Chicago: Cement Gun Construction Company, 1922]. Collection Centre Canadien d’Architecture/Canadian Centre for Architecture, Montreal)
extent that it was necessary for him to secure a special permit from the municipal building department before work on the model home could be started.5 "Technically what impressed contemporaries was the thinness of its walls: 1 ¼ inches thick, made of concrete pneumatically applied over a building four stories tall. Los Angeles’s building code required walls thirteen inches thick for ordinary masonry structures of that height, so permission was granted only after tests had proved that the walls as specified by Neutra would be sufficiently strong to carry their designed vertical gravity loads and withstand a lateral wind pressure of about thirty pounds per square foot. The radically thinner walls meant not only lower cost, but also a huge reduction in the building’s dead load, with attendant advantages in a region known for earthquakes. The less top-heavy and more structurally cohesive a building is, the less damage it is likely to suffer when subjected to the lateral back-and-forth movements of a quake.6

Of course, what made the lightness and thinness of the Lovell House’s Gunite walls possible was that they were unlike masonry bearing walls, for which the local code had been written. Rather, they were curtain walls suspended from a skeletal steel framework. After the frame was wholly erected, those sections that were to be the core of the walls were covered with a heavy metal mesh and temporarily backed with plasterboard against which to shoot the concrete (Figure 3). Frame and mesh were firmly bound together, with stiffening members of plasterboard placed around all door and window openings such that they became an integral part of the whole reinforced concrete structure. Walls were given two applications of concrete—one just covering the metal mesh and the other serving as a finish coat. Compressed air forced a mixture of aggregate and cement through a connecting hose to the gun’s nozzle. There churning action thoroughly mixed the cement and aggregate with the water before the mixture was forcibly ejected. The concrete was deposited and compacted firmly against the forms and around the reinforcing metal. The nozzle man could regulate the flow of water to insure a properly hydrated mix at all times. Key to the process was the power of the on-site air compressors that provided the 200 cubic feet of air needed to place each cubic foot of the plastic mass of shot concrete mix into the building’s frame. The resulting Lovell House was soon recognized as a masterly work of the International Style, and Neutra had showed the world “what the creative architect can accomplish through standardization and employment of facilities that lend themselves admirably to his service."7

Wright’s Engagement with Gunite and the Community Church, Kansas City, 1939–42

In July 1929 Wright wrote admiringly to Neutra of his steel house, saying to his former employee: “The boys tell me you are building a building in steel for residence—which is really good news. Ideas like that one are what this poor fool country needs to learn from Corbusier, Stevens, Oud and Gropius. I’m glad you’re the one to ‘teach’ them.” Wright may have been referring to the Lovell House when he later wrote of Gunite’s success on the West Coast: “Gunite in L.A. is sure enough water proof!” Wright first considered Gunite to create a uniform exterior surface for cement block walls of the Annie M. Pfeiffer Chapel at Florida Southern College in Lakeland (1938–41), though its cement block walls were ultimately plastered.10 As Pfeiffer Chapel rose in 1940, Wright was also designing the Community Church in Kansas City, Missouri, his project that had the most
extensive use of Gunite before the Guggenheim (Figure 4).\textsuperscript{11} Wright was engaged by the Revs. Burris Jenkins and Joseph Cleveland to design a new building for their church, the largest Protestant congregation in Kansas City, after a fire destroyed their earlier structure in November 1939. The church sought a modern image in keeping with its religious liberalism. Wright’s solution, on south Main Street looking over the J.C. Nichols Park at the entrance to the Country Club Plaza district, centered on a large auditorium linked to multiple levels of parking terraces down the site’s slope. (These downhill parking terraces were not built, and thus are not shown in Figure 4.)

To save funds, at Kansas City, the walls were not to be of cement block, as at Pfeiffer Chapel, but rather of Gunite over a light steel structure. As Wright recalled:

The light steel skeleton was to be covered on each side by heavy paper strung with steel wires (Steeltex) securely wired to the

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Figure 3 Neutra, Lovell House, application of Gunite to steel frame and reinforcing metal (Compressed Air Magazine 35 [April 1930])

Figure 4 Wright, Community Church, view looking southeast at the chancel, showing Gunite externally applied without expansion joints (FUWA, photograph no. 4004.0060)
skeleton and then the cement-gun process, so successful on
the West Coast and used in K.C. itself to waterproof old brick
buildings, was to be used to put a thin but sufficient shell over
the insulating paper: the shells were 2 ¼" apart, held by the
wires to the paper like plastering on a lathed wall. This was to
go on both inside and outside. Probably, I thought (and still
think), the most advanced and desirable cheap building
construction yet devised for any climate. Provided the Gunite is
good. . . . All surfaces were plain. All corners were slightly
rounded to aid the Gunite process. The structure depended
upon its shape, graceful simplicity, and lightness of treatment
for esthetic effect.12

When the novel construction was presented in June 1940,
Wright claimed: “This is a type of architecture that should
be a lesson to this city. . . . It is no mere church building, but
a new order, dated ten years ahead of its time.”13

The Lovell House’s frame of open-web steel joists was
bolted together, yet Wright’s was to be all welded joints,
which would be more rigid than bolted ones, thus minimiz-
ing wracking of the Kansas City church’s light frame that
might lead to cracks in its Gunite covering.14 Wright speci-
fied the Gunite construction:

This process shall be used throughout the building as follows:
The floor slabs where not on the ground shall have light
expanded metal reinforcing and shall be blown by the cement
gun on to light removable forms temporarily clamped to the
steel joists below. The floor slabs resting on the ground shall be
blown on to gravel fill directly. At various places in the building
perforated pattern occurs. This will be formed of the same
Gunite blown over light mesh re-inforcing on to pre-erected core
forms. The entire building thus becomes a mono-method struc-
ture of extreme lightness yet of great strength and weather
resistance.15

Gunite’s structural capacity enabled smaller steel members.
This meant lower material cost, since steel was priced by the
ton. The Kansas City church would have a monolithic effect
like his earlier Unity Temple, yet one realized in the newer
technology of Gunite.16

Movement from thermal expansion and contraction is
typically accommodated by vertical expansion joints between
segments of a building’s walls. But Wright wanted the image
of horizontal continuity, so he eliminated such externally vis-
able joints (see Figure 4), allowing for lateral, thermally
induced movement through internal structural flexibility.
The most radical concept was Wright’s proposal that
the light steel studs (cross sections two inches square and
spaced twenty inches on centers) with the Gunite casing be
considered as structural bearing walls supporting the floor
and roof loads (Figure 5). Curtis Besinger, who worked on
the drawings for the framing of the roof, the balcony, and the
structurally supported floors, recalled:

There was no precedence in Mr. Wright’s work for this kind of
construction. And yet, to me, the construction was essentially
simple. . . . The framing of the walls was to be very much like
the wood-stud framing of an ordinary house except that the sill
and head plates and the studs were to be steel tubes. There
were to be a few steel columns supporting floor or roof beams.
The floors and roof were to be framed with steel joists in much
the same manner that wood joists were used. All of this framing
was to have an inner and outer skin of Gunite sprayed against a
paper-backed steel wire mesh. The walls were to be only about
four inches thick.17

Kansas City’s building commissioner was skeptical about
Wright’s approach to the frame as a cage of light steel bars.
The commissioner wanted to stiffen the overall frame by
replacing the light studs with heavy columns. Wright wrote
to the local building official that this amounted to

some minor meddling with the steel designs I provided insist-
ing upon greater rigidity where again I had designed compara-
tive flexibility or at least resilience. There are not only lateral
but there are vertical and diagonal strains in the inevitable
movements of a reinforced concrete envelope. By insisting
that this envelope be rigidly fixed and braced to the floor

Figure 5 Wright, Community Church, construction view looking north
into chancel, showing light steel studs and open-web joists,
augmented by heavier columns as ultimately required by the city
(FLWA, photograph no. 4004.044)
framings this principle of flexure (the principle properly applied is what saved the Imperial Hotel in Tokyo from destruction) is made null and void . . . and resulting in some useless increase in the amount of steel we must use and again in structural detriment to us.  

Wright predicted that the church’s reliance on heavier columns would likely cause the Gunite cladding to crack if stresses could not be absorbed in the flexibility of the frame.

Wright was discouraged by the changes forced on the design, including a more rigid foundation than the one he had preferred, and within six months of the dedication in January 1942, the associate minister reported that the Gunite was “cracked in too many places.” Wright later sent “a waterproof expert down to examine the building” and tested “thickness of coating and the condition of gunite.” The builder later wrote to Wright that an independent report concluded that leaks due to cracking of the Gunite were traceable to “absence of any provision for expansion.” He noted that the photographs showed “that the cracks follow the structural steel lines,” and remarked:

They mention no other reason for the leakage. If they are correct it brings the problem right back to the change in . . . the structural steel. During one of the meetings with the [church] Building Committee one of them asked you whether there wasn’t danger that the Gunite would crack. I remember that you told them very emphatically that they had taken the flexibility out of the structure by changing the foundation and structural steel plans, and that, therefore, you would not assume any responsibility for cracks in the Gunite.

Wright had so written to the commission in November 1940. After explaining that the imposed structural changes had deprived the building of its flexibility, he closed: “I have consented to allow these changes to stand with this explanation on record so that subsequent expansion cracks can be properly attributed to your department. If and when expansion cracks appear in the envelope of the New Community

Figure 6 Wright, Unity Temple, working drawing of west elevation, 1906, with horizontal lines showing 3 ft. 6 in. unit height of concrete formwork (FLWA, drawing no. 0611.014)
Church . . . they will be yours—not mine.” This proved prophetic. The building committee’s acquiescence to the city authorities, over Wright’s objections, had the result that he had foreseen. Wright soon would bring these lessons about Gunite to the Guggenheim’s design and construction.

The Guggenheim’s Structural Design in Gunite, 1945–56

Wright likely prized Gunite not only because of its high strength-to-weight ratio, its relatively low cost, and the way it could complement light steel frame construction. It also appealed to him as a plastic mass that embodied his ideal of continuity as a principle of organic architecture, meaning buildings conceived and designed as analogous to living organisms found in nature. As he wrote in his Autobiography (1932) of his design for the interior of Unity Temple (1905–9) as a concrete monolith: “Now why not let walls, ceilings, floors become seen as component parts of each other, their surfaces flowing into each other to get continuity in the whole, eliminating all constructed features just as Louis Sullivan had eliminated background in his ornament in favor of an integral sense of the whole. Here an ideal began to have consequences.” Yet Unity Temple’s concrete masses had been poured in boxlike wood formwork consistent with the building’s rectilinear geometry (Figure 6), whereas Gunite combined with steel had the potential to form lightweight, non-right-angled or curvilinear shapes. Thus Gunite could yield a set of effects in concrete that, as Wright wrote in 1928, “aesthetically . . . . has neither song nor story.” With his textile-block houses in California of 1923–25, whose cement block walls he threaded through with vertical and horizontal steel reinforcing, Wright had tried to give concrete an ornamental character. Yet textile block construction was less practicable for larger public buildings, and it could not be used to create large curved surfaces that would make architectural concrete like sculpture on a large scale.

Wright most vividly embodied his ideal of spatial and material continuity in the Guggenheim Museum’s tall spiral-ramped main gallery (Figure 7). Designed from 1943 and built between 1956 and 1959, Wright’s museum went...
through at least six sets of plans, and the final building did not exhibit all the features that he had hoped it would. But he did realize the essential idea of structural and spatial continuity in the main gallery’s “grand ramp,” as he called it. This gallery’s spiral of steel-reinforced concrete was among his most technically challenging schemes, posited in vivid opposition to Manhattan’s norm of rectilinear steel-framed skyscrapers. It was also among the boldest American attempts to create a sculpturally free architecture of reinforced concrete. Wright conceived the spiral gallery as both a sculptural and spatial form. As his apprentice Curtis Besinger recalled, in early October 1947, Wright was discussing the model of the Guggenheim in his studio at Taliesin in anticipation of a visit from Solomon Guggenheim: “The model was displayed with a Greek male torso nearby. Mr. Wright was pointing out the similarity in concept between the two: the twist of the torso and the turning of the spiral, the monomaterial and the articulation of the forms.”25 The Guggenheim’s curator, Hilla Rebay, highlighted the spatial issue in her very first letters to Wright: “I know what is needed. Nothing that is heavy, but organic, refined, sensitive to space most of all.”26

In many statements on the museum, Wright referred to the curvilinear interior space as enhancing appreciation of the Guggenheim collection of what Rebay termed non-objective art. He disliked the sequence of discrete rectilinear rooms in traditional museums, with paintings hung parallel to the walls. By contrast, modernist paintings in the Guggenheim would be set freely in a three-dimensional continuous spiral: “Here by intention (and bequest) we have a great work of sculptural architecture calculated to set up a picture in the atmosphere of a harmonious series of daylighted-forms. This setting is new and may stimulate a new impulse in the art of painting. . . . For this new setting I left the interior walls circular and devised new ways of setting up the picture as a charming thing in itself—independent of the walls, slightly curved behind it.”27 Thus continuous curvilinearity inside and outside was paramount for both aesthetic and functional reasons. As the design progressed, it was clear that Gunite best enabled realization of these aims.

The Guggenheim as built and the development of its architectural design have been insightfully analyzed by William Jordy, Neil Levine, and Francesco dal Co, among others. Yet less attention has been given to the evolution of its structural design from the time Wright signed an agreement with the Guggenheim Foundation on 29 June 1943, only about eighteen months after the Kansas City church, his most recent public building, was dedicated on 4 January 1942.28 Gunite enabled Wright to realize a great spiral ramped construction like the one he first designed in 1924–25 as an Automobile Objective at Sugarloaf Mountain, in Maryland, for Gordon Strong of Chicago.29 As shown in a section drawing for this project, Wright proposed a domed planetarium within the structure’s core. Around and above this and ancillary spaces, the spiral ramps would turn through seven levels (like the Guggenheim), supported on rings of columns with mushroom capitals. Columns were vertically continuous from one level to the next; outer column lines would drop off as the structure stepped inward as it rose (Figure 8). Yet Wright studied the structure of the Automobile Objective before he knew the potential of Gunite. From this perspective, his original design for the Guggenheim of 1944–45 was a rethinking of the Automobile Objective of twenty years before, yet with the intervening experience of having realized Kansas City’s Gunite church. In 1924–25 Wright had the idea for a spiral

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Figure 8 Wright, Strong Automobile Objective, Sugarloaf Mountain, Maryland, unbuilt project, 1924–25, section showing spiral ramp supported by concrete columns around domed planetarium (FLWA, drawing no. 2505.30)
monument as column-and-beam architecture. By 1944–45, he sought the means to build a columnless ramp as a continuous (and ideally self-supporting) spiral structure around a central void.

Delays related to selection and acquisition of a site in Manhattan meant that Wright did not make preliminary studies until December 1943, before the final site was chosen. Detailed presentation drawings were made in the following weeks for a building in a typical Manhattan city block. As Curtis Besinger recalled the process of the design’s early development: “Mr. Wright’s first sketch was followed by other drawings rendered by persons unknown: plans and elevations of the building with different geometries, with different elevations, with floors that are level, with ramps that taper in as well as out, and which are built of various materials.” Among Wright’s earliest schemes of late 1943 to early 1944, he proposed one (for a hypothetical block-long site) that was a hexagonal gallery with level floors (Figure 9). Straight wall segments would enable the ramp’s concrete to be formed and poured in discrete linear units, easing construction. Variations on a faceted gallery recurred until construction started in 1956, after many plan changes.

By 1 March 1944, Rebay had Wright’s first set of presentation drawings, which did show a circular spiral ramp for the main gallery. According to her, these drawings gave Mr. Guggenheim a vision of the new building that inspired him to acquire the museum’s site on Fifth Avenue between 88th and 89th Streets on 13 March. This prompted Rebay’s first public announcement of Wright’s project one week later, although Wright was not there and drawings were not presented. Rebay did not indicate concrete, but rather an “exterior possibly largely of marble and glass.” Afterward Wright and his assistant, William Wesley Peters, oversaw a revision of the plans to fit the Fifth Avenue site. Then Wright, Guggenheim, and Rebay went over these revised plans for the acquired site together at Guggenheim’s summer home in New Hampshire on 27 July 1944, after which Guggenheim wrote to Wright: “It looks to me like we are going to have something very beautiful and exceptional.”

The plot that the foundation acquired in March 1944 did not extend the full block front along Fifth Avenue from 88th to 89th streets; there remained two buildings at the south end including the northeast corner of 88th Street, where there stood a fourteen-story apartment building and a townhouse to the north at 1071 Fifth Avenue. Only in 1951 did the Guggenheim Foundation acquire the full block and Wright revise the plans to fit it.

Through 1944 Guggenheim wanted the plans to be kept as private as possible, but he authorized Wright to go ahead with a first set of working drawings. In the winter of 1945, Wright’s colleagues William Wesley Peters and Mendel Glickman worked on the Guggenheim’s drawings and engineering details, and Peters soon cast about for guidance on a building system. Of all parts of the construction, the
most difficult would be the grand ramp and its exterior walls. Some accounts of the Guggenheim’s history suggest that Wright did not contemplate its construction with Gunite until his discussions with the builder in 1956.38 Yet Wright and his colleagues studied a Gunite solution from at least mid-1945. In June Peters wrote to the National Gunite Corporation in New York: “We are anxious to receive information regarding the availability and adaptability of the Gunite process in regard to a large building (now in this office) proposed for New York City. It is imperative that we receive this information at the earliest possible opportunity. Would it be possible for one of your engineers to call at this office within the next few days? Also please send us any and all available data, engineering design information, etc., pertaining to the structural use of gunite in thin wall and slab construction.”39

Wright conceived that Gunite would be the plastic mass for the spiral’s ramps and walls, yet the shotcrete would be set on pre-stressed steel reinforcement, meaning steel rods pulled taut by powered jacks to make the large, continuous tensile structure. Prestressing would help to prevent cracks from the deformation of non-prestressed concrete under loads, making maximal use of the great tensile strength of steel to hold concrete rigid when prestressed. Since pre-stressed concrete would deflect less than if its steel reinforcing were not prestressed, a thinner prestressed concrete floor could hold the same weight as a thicker non-prestressed floor. In other words, the strength-to-weight ratio of prestressed reinforced concrete is greater than that of non-prestressed concrete. Thus, as he studied the structure in June 1945, Peters wrote to the Preload Corporation of New York, which specialized in prestressed and Gunite construction for utilitarian circular structures like silos and tanks: “If you have any suggestion that would better adapt this structure to your methods of construction, considering both pre-stressing and guniting, I feel that Mr. Wright would be interested in hearing them.”40 Although Wright did not ultimately work with this company, prestessed Gunite served as his early working idea.

Constructing the museum in Gunite was the scheme that Wright announced jointly with Rebay and Guggenheim at a luncheon given at the Plaza Hotel at 59th Street and Fifth Avenue for the art press on 9 July 1945. Displaying the plans publicly for the first time, Wright reportedly said that “the exterior would be monolithic, or one solid mass of material with no joints visible. He described it as ‘a steel basket shot with concrete,’ meaning ‘the outer covering of the building will be winding bands of seamless concrete and glass.’ The entire building, he said, was designed in conformity with the human figure, a principle to which he referred as ‘one of the secrets of organic architecture.’”41 He soon noted that “the main structure is monolithic throughout, made of pre-stressed steel in high tension reinforcing high-pressure concrete [i.e., Gunite].”42 The spiral’s realization would depend on its material continuity, i.e., its monolithic character, which would be achieved in Gunite.

Peters’s research and consultation about the structural design culminated in the first set of working drawings finished and signed by Wright on 7 September 1945, and countersigned by Solomon R. Guggenheim to certify his approval. At that point Wright and Guggenheim agreed that a model should be made to illustrate the design, and Wright, Rebay, and Guggenheim presented the model to the press at the Plaza Hotel on 20 September.43

Wright exhibited the model of the proposed museum as a monolithic structure whose main circular gallery (then planned for the site’s north side rather than the south side where it was eventually built) had an unbroken floor surface that would stretch in a continuous spiral rising about seven stories from atop a subterranean theater to a shallow glass-domed roof (Figure 10). Like the nonobjective painters whose art featured varied geometric shapes, Wright had long valued the symbolic power of such pure forms. As he wrote in 1912, “certain geometric forms have come to symbolize for us and potently to suggest certain human ideas, moods, and sentiments—as for instance, the circle, infinity; the triangle, structural unity; the spire, aspiration; the spiral, organic progress; the square, integrity.”44 More than any other form, the spiral signified both spatial and temporal continuity. His phrase “organic progress” also implies both natural growth and human aspiration. As he proclaimed of the 1946 design: “For the first time in the history of architecture a true logarithmic spiral has been worked out as a complete plastic building: a building in which there is but one continuous floor surface: not one separate floor slab above another floor slab, but one, single, grand, slow wide ramp, widening as it rises for about seven stories—a purely plastic development of organic structure.”45 Actually, Wright only evoked the logarithmic spiral, which expands geometrically in diameter out from its central point of origin: his spiral for the Guggenheim is not truly logarithmic, but arithmetic, because its diameter does not increase geometrically, but rather more gradually, as it rises. Yet Wright believed that the Guggenheim’s spiral demonstrated a principle everywhere evident in nature, from the shape of galaxies to the tendrils of the vine leaf. The spiral was also an idea recurrent in historic architecture from antiquity, which was susceptible to renewal in modern materials.

Working drawings of September 1945 showed thin steel columns along the inner edge of the main gallery’s spiral
ramp (Figure 11), yet the model showed neither such columns nor the radial web walls set at 30-degree angles around the ramp that were ultimately built as its vertical supports. By early October, Wright said that construction involving even thin columns was no longer contemplated. As he later described: “the construction of the great ramp like that of a seashell, is clear of interior supports of any kind, the fibrous [i.e., steel-reinforced] floors being carried throughout from the outer walls.” This implies that prestressed Gunite outer walls were to have sufficient load-bearing capacity to carry the ramp’s inward-cantilevering spiral slab. If the ramp’s steel reinforcing were to be pulled taut by mechanically powered jacks before the compact high-pressure Gunite was applied, then the whole construction would be like a great spiral in tension. There would ideally be no need for vertical supports along the ramp’s length. Thus Wright claimed in January 1946: “This building is built like a spring.” Although pre-stressing was ultimately not used for the ramp’s walls, and the ramp itself was upheld as built by radial web walls, the ideal of continuity continued to inspire study of Gunite.

From the unveiling of Wright’s design in 1945 to the start of construction in 1956, the project underwent many revisions, the first major one being the drafting of a second set of plans in 1951 to fit the then newly acquired full-block site. Marble and concrete with marble aggregate were still considered to be exterior surfaces, although ultimately marble was not used even as an aggregate in the exterior walls. In November 1949 Solomon Guggenheim died, and Wright continued with the Guggenheim Foundation’s board of trustees, including its longtime president, Harry Guggenheim, a nephew of Solomon’s. In 1952 Hilla Rebay was forced to resign as director and was succeeded by James
Johnson Sweeney, with whom Wright worked until his death in 1959. From 1951 to 1955 Wright worked with architectural and engineering colleagues in New York to gain the city’s approval for the construction, negotiating with the city’s Building Commission and its Board of Standards and Appeals, which reviewed features that the commission considered outside the codes. The key challenge was finding a builder committed to the project’s realization at or near the budget of $2 million provided in Solomon’s will.

By June 1954 Wright opened an office at his suite in the Plaza Hotel mainly to oversee the Guggenheim’s construction. Wright himself expected to be in New York every two weeks. By 1953 his former apprentice, Edgar Tafel, who had established his own practice in New York, was alert to the museum project, and referred Wright to the Euclid Contracting Corporation, headed by George N. Cohen, whose house in Scarsdale, New York, had been designed by Tafel, through whom Cohen first met Wright. Having graduated from Cornell University in civil engineering in 1927, Cohen had founded Euclid as a company that by 1954 had built a number of major projects in reinforced concrete. Before submitting a proposal to build the Guggenheim, he first met with Wright at the Plaza on 15 September 1954. From the start, Cohen was absorbed by the constructional challenge of the great spiral, which he later called “one of the most unusual concrete buildings ever constructed.”

After their first conference, by late September, Wright again revised the drawings, and produced a third set of plans to send out to bid. Of the five bids received, Euclid’s was the lowest at about $3 million, and, in Wright’s view, the only one “serious or competent.” After further consultation with Wright, Euclid reduced their bid to $2.25 million, with $100,000 added for profit, but Wright had to redraw the plans. By 1 November 1954 Wright arrived at an outline of general specifications on the new (fourth) set of plans. He wrote that the ramp itself could be built in one of two shapes, either faceted in a way that approximated a spiral
curvature, or truly curved: “These plans have now been drawn so that the curved structure formerly shown may be executed in straight-line facets about 8’ 0 o.c. [on center], inside and outside are to be the same. Either this or the smoothly curved surfaces are at option of the contractor. Either method of construction may be included in this estimate.” Finally, Wright also offered two methods for building the ramp’s interior parapets and exterior walls: “Throughout the structure outside walls and inside parapets above ground may be formed with approved stock steel-sections covered outside and inside with expanded metal lath and either plastered with proper concrete mixture both sides sand finished alike natural cement color—or the gun-nite [sic] system may be used instead on both surfaces. . . . Bidders are free to elect either method of outside wall construction if so specified in their estimates.”

Whichever method of building the walls was selected, Wright wanted a unity of treatment to convey an image of continuity, with the ramp and walls to appear as a materially consistent architectural whole. After consultation with the New York engineer Dr. Jacob Feld, whom Cohen introduced to Wright to help with application for a building permit, Wright’s office redrew the plans for the fifth time in 1955, and he sent updated specifications to the Guggenheim Foundation in September. At last, on 9 November 1955, with Cohen and Feld among those attending, the Board of Standards and Appeals indicated orally that they had no further objections to the museum plans. Their official favorable written ruling followed in the last week of December, and the city’s Building Department received Wright’s revised plans for approval on 20 February 1956. After work on the site began in May, the sixth and final set of working drawings was revised by 7 September, after architect William Short became clerk of the works on 15 August as Wright’s on-site representative throughout the building process.

**Gunite in the Guggenheim as Built, 1956–59**

As shown in the 1956 plans, the radial concrete web walls (set at 30-degree intervals around the circular ring at each level) are longest at the top, where the ramp’s width increases to over 50 feet (Figure 12). Figure 13 shows that at all levels, the ramp cantilevers in from the webs by about 14 feet 6 inches, and its floor tapers to a minimal depth. The ramp’s reinforced concrete slabs span between the webs. In September 1957, Wright, interviewed on the site, said: “It is all
Figure 13  Wright, Guggenheim Museum, section looking north, as revised 7 September 1956, showing (elliptically circled) control joint in faceted outer Gunite wall aligned with radial web wall (FLWA, drawing no. 4305.452)

one thing, all an integral, not part put upon part. This is the principle I’ve always worked toward.” He “pranced over a bundle of thin, orange-rusty steel rods which two workmen were about to carry away to become reinforcing rods in the concrete. He pointed to them. ‘We can do these things now, build as in Nature,’ he explained, ‘because we can use steel this way now. They are the tendons and muscles of the building; the concrete is the fatty tissue and the flesh; the rubberized, waterproof paint is the skin. Reinforced concrete makes this all possible.’” The idea of continuity recurs throughout the building in specially formed concrete elements, like planters, fountains, curved columns, arches, and balconies, all of which “blend smoothly into the whole structure as though they truly belong to it, which they do.”61 As Cohen explained, the concrete Grand Ramp would be created using two methods: “The horizontal surfaces [including the ramp floors] of concrete will be poured, the vertical and circular surfaces will be shot with a cement gun from the inside, to a thickness of five inches, against bent plywood.”62 The Gunite was necessary for three reasons: its light weight, its method of application, and its flexibility in creating a curved surface. First, in terms of structure, the ramp’s floor slabs were to be as light as possible, which meant that their outer vertical walls, cantilevered beyond the ramp’s outer inclined edge all around the circular building, had to be as thin as possible (see Figure 13). Second, in terms of constructional procedure, since the ramps were closely spaced vertically in section, setting up conventional wood formwork along their outer edges to pour the outer ramp walls was highly impracticable. Third, the continuous spiraling wall “turns on a greater and greater radius as it rises upward.”63 To create formwork for poured-in-place concrete that would be ever expanding in its curvature would be inordinately expensive, as sections of formwork could not be reused. Thus the flexibility of Gunite for the ramp’s exterior walls was essential to realizing the Guggenheim’s sloping, curving spiral.

Constructing the Guggenheim’s curved Gunite walls required considerable on-site ingenuity. As Charles W. Spero, the job superintendent and project manager, wrote: “Perhaps the most unusual construction on the job was the ramp’s [outside] parapet wall.”64 As Figure 14 shows, this is a 5-inch-thick, 7-foot-high concrete wall all along the outside of the ramp. The inclined outer edge of the ramp was referred to in documents as the “apron.” Walls rest on the apron’s edge and rake upward at a one-in-four slope, tying into the ramp above by a connecting skylight. The ramp’s continuous non-load-bearing, enclosing wall would be of a
lightweight concrete sprayed into place as Gunite against an exterior form of bent plywood to create the wall’s curving shape. To withstand the force of the Gunite shot from the hose, the plywood was 5/8 of an inch thick; being that thick, it had to be soaked in water for easier bending. To brace the bent plywood forms, 7-foot-tall vertical steel angles on 1-in-4 slopes were set on the outer edge of the bottom ramp’s apron, supplemented by wood bracing. The angles supported horizontal reinforcing rods and welded-wire mesh. Two inches of Gunite were sprayed onto the form’s inner face. Once this layer had set, additional rods and mesh were placed against the inner exposed face and another two inches of Gunite was sprayed against the outer layer. After this second, inner layer had set and its irregularities had been removed, a final inch of Gunite was to be sprayed on to form the interior surface of the exhibition wall along the ramp, although laboratory analysis during the recent restoration found only two layers of Gunite. Wright specified that all Gunite was to “be screeded to a dense, smooth, level surface (floated if necessary),” like plaster, to create curving planar continuity. All areas of Gunite for the wall surfaces were to merge as seamlessly as possible with pours for the ramp’s upturned outer apron. As Wright specified, “there is to be no ‘trim’ in this structure. Ceilings and walls meet each other on precise lines of intersection.”

As Angel Ayón, the architect for the Guggenheim’s preservation and repairs in 2004–8, has noted, the definitive working drawings of 1956 showed the spiral Gunite walls not as perfectly rounded but faceted with each bay between radial walls divided into three linear segments each angled 10 degrees, so that the gallery’s round walls would consist of thirty-six straight facets that approximate a full circle (Figures 15). A note on the floor plans (Figure 16) indicated “Walls shown facetted on 10-degree segments. May be [a] continuous curve.” Wright specified: “On all of the walls indicated as of gun concrete, the exterior faces shall be divided on regular units (intersections of faces on curved facetted walls, and unit or module lines on rectilinear walls) by #16 gauge stainless steel dividing strips or grounds running vertically.” As Ayón has noted, drawings show faceted ramp walls with these V-joints to be set “sharp and clear” into the exterior aligned with the radial walls (Figure 17). These were to be control joints, like the regularly spaced grooves across concrete sidewalks. Such joints would be deliberately created lines of weakness, along which cracking would occur as the surface of Gunite shrank when it dried, relieving the stresses that would cause random cracking. Penultimate elevations of 1955 show faceted rather than curved ramp walls with vertical control joints at 10-degree intervals (Figure 18). But the spiral’s Gunite walls were built as a continuous curved surface, without vertical control joints, as shown on elevations in the final working drawings as revised on 7 September 1956 (Figure 19). Whether the exterior Gunite’s surface would be faceted or curved was undecided even after the start of construction. On 2 November 1956, when the foundation was being poured, Wright met with Short, Cohen and one of his Euclid colleagues, and a representative of the Gunite subcontractor (whom Wright would have to approve), the Ardsley Construction Company, of Ardsley, New York, “to discuss the matter of faceted vs. round gunite walls.” Faceted walls at 10-degree angles would follow the ramped floor’s three 10-degree faceted segments between radial web walls. But Wright pushed Cohen and the Gunite subcontractor to “consider curved walls further and . . . possibly build some mock up forms.” For a time this key issue remained unresolved, for by late January 1957, Short advised Wright that there were “certain important matters pertaining to the Museum which I feel require your personal attention in New York. Among them are the terrazzo [ramp floor], the skylight, and the curved vs. facetted walls. On the last named question George Cohen and his Gunite man do not feel the issue is yet settled.”

Figure 14 Wright, Guggenheim Museum, diagram of construction of spiral ramp’s outer wall (Engineering News Record 159, no. 23 [5 Dec. 1957], 44)
Wright evidently preferred to maintain the unbroken curvature of the spiral in the main gallery’s exterior walls, but to still use the vertical control joints. For this effect, he then envisioned “The simple curved surfaces of the Pantheon instead of the complex paneled planes intersecting,” and remarked: “I have talked with a gunnite expert and the curved continuous surfaces with the sunk-joint every web center presents no difficulties, which leads me to refuse the subcontract to a gunnite man who cannot see the advantage to him of the plane surface. My own experience assures me this is not unreasonable in the circumstances.” The “sunk-joint” presumably would be like the vertical V-joint set into the Gunite’s exterior at the center of each web-like pier between adjacent wall facets if the ramp wall had been faceted (see Figure 17). Also, to what “experience” was
Figure 18 Wright, Guggenheim Museum, detail of west elevation, 1955, showing vertical control joints between 10-degree facets of spiral outer wall (FLWA, drawing no. 4305.406)

Figure 19 Wright, Guggenheim Museum, west elevation, revised 7 September 1956, showing no vertical control joints along spiral walls as continuous curve (FLWA, drawing no. 4305.447)
Wright referring here? Logically this would have been the Community Church, his only other realized Gunite building to date with exterior planar surfaces—yet these were straight.

Ultimately, as Cohen wrote, “expansion joints were carefully omitted,” likely because the image of continuity would have been marred if there had been vertical joints along the spiral. Cohen may have been referring here to the control joints that Wright had specified, or to expansion joints as open seams between sections of the construction that could close slightly to allow thermal expansion to occur in adjacent wall areas over time. Without expansion joints, there had to be extra care taken to insure the quality of both poured concrete and Gunite. To create uniform continuity inside and outside, for the poured concrete walls, Wright gave meticulous instructions as to the composition, color, and size of stone aggregate and sand, seeking a mix that would flow evenly around the steel-wire mesh and steel-bar reinforcing. Moreover, “control of concrete for uniform strength, the inherent shape of the structure, the arrangement of reinforcing, and the planned extent and location of pour sections, all contributed to the elimination of cracking, a quality so essential for architectural concrete.” Since the shapes of the component parts were so unusual, “great care had to be exercised in the design and erection of the formwork,” which included “varying thickness and types of plywood, prestwood and metal molds” to translate Wright’s intent into the spiral’s material form.

As Cohen stressed, “The concrete becomes the finished structure. That’s unusual. Most public buildings have facades of marble, limestone, or aluminum.” As with Unity Temple and monolithic concrete half a century earlier, the Guggenheim would depend entirely on the carefully crafted surface for aesthetic effect. Cohen wrote: “Here’s a fine, old-fashioned, homely material—concrete—that Mr. Wright is putting on Fifth Avenue and making beautiful.”

But the concrete’s aesthetic would depend partly on the patterns of the formwork as the system of plywood whose joints would be visible along the outer Gunite wall of the spiral ramp once the formwork was removed. In Unity Temple, Wright had thought through the close relationship between the unit dimension of board formwork and heights of walls. As shown in the west elevation, Wright or an assistant drafted the horizontal lines that marked the layers of wood formwork each 3.5 feet high (see Figure 6). The main walls of Unity Temple were each 17.5 feet (5 units) high from base moldings to copings; the corner stair towers were each 24.5 feet (7 units) high. Thus the design of the formwork was an architectural decision integrated with the overall scheme of massing.

For the Guggenheim, there are no known comparable surviving drawings showing the pattern of the formwork. But Angel Ayón, surveyed the rotunda’s Gunite walls to document the original pattern (Figure 20). The specifications noted that concrete formwork was to have been approved by the architect or his representatives. Yet, in the absence of drawings or other documents about the formwork’s pattern from Wright or his assistants, we can reasonably assume that the Gunite subcontractor designed the formwork. To form the outer walls, 4-by-8-foot sheets of bent plywood formwork were set up with a running bond between courses. Yet Figures 20 and 21 show that sheets are diagonally slanted as they curve with the ramp’s walls. Because both the outward angular tilt and the radius of each level of the ramp are different, the wall’s formwork pattern varied between ramp levels. The most vertical and horizontal pattern is at the topmost wall, which is twice the height of those below, with a more nearly horizontal crown. This level’s outward tilt is minimal and its form is thus less conical. Overall, the formwork’s superficial impression in the Gunite after the plywood was stripped created a linear pattern that did not visually coordinate with Wright’s spiraling rotunda, which he described as “spacious horizontality going upward on wings.” Yet the formwork looks variably canted as the ramp ascends (see Figure 21).

Preparation for shooting the Gunite began 24 September 1957 with the formwork for the horizontal wall with the museum’s name facing Fifth Avenue spanning between the main spiral gallery and the lower circular “monitor,” as Wright called it, to the north, originally intended for the museum’s administration. The Gunite was applied to this straight frontal wall by month’s end, proceeding at a rate of about 500 square feet per day. From Tuesday, 8 October, the material’s formwork and reinforcement on the Grand Ramp was begun. That week, Wright was in New York, and he asked Short to “bring all decisions directly to him.” By 8 November, with the ramp’s floor poured to 35 feet above grade, Gunite walls on the ramp’s first level were completed. Gunite work continued through the first week of January 1958, and, after a winter break, it was resumed on the ramp’s upper levels from April to 1 August, when it was completed. There are no known photographs of Gunite work in progress, but one view shows tilted steel angles and horizontal cabling as an armature to brace the plywood forms and hold steel reinforcing still to be set for ramp’s topmost Gunite wall (Figure 22). Another view shows the exterior backing for the plywood formwork on this level, above the lower turns of the ramp where the raw Gunite walls are visible through the scaffolding (Figure 23).
The Gunite’s Outer Surface

To prepare the exterior for painting, Gunite was rubbed to smooth down joints between formwork panels, and random depressions in the surface were also patched. As construction progressed to the point of starting to apply the Gunite in the fall of 1957, Euclid’s painting subcontractor recommended that instead of the non-waterproof, sand-finished paint that Wright initially specified, he consider an experimental paint that its manufacturer called “Cocoon,” as “the colored sprayed vinyl plastic . . . for all outside surfaces of concrete, Gunite and stucco.” This material, which had been developed during World War II for protection of all types of materials from extreme weather conditions, was a thick (20 mil), textured, flat polyethylene coating that formed a “leathery protective skin that makes the exterior surfaces impervious to moisture.” Its manufacturer could guarantee it for fifteen years and it was expected to last much longer. Samples applied on the job convinced Cohen that “this is quite a remarkable material and should preserve the newness of the entire building for many years to come.” Peters recommended it because it formed “a vapor-proof jointless skin with an elastic quality which will stretch or ‘ride’ with the expansion and contraction of the concrete and thus prevent moisture from seeping into the inevitable fine cracks which develop in any concrete surface.”

Wright considered alternatives. However, he ultimately agreed to use Cocoon as the finish for the Guggenheim’s exterior, given the manufacturer’s extraordinary fifteen-year guarantee and at the urging of the trustees. Its application began in late September 1958. Yet Short soon directed Euclid: “[C]ease installation of the Cocoon on the exterior of the building until you have reground the exterior Gunite walls where the joints of the plywood forms and other uneven surfaces show.” Short here likely referred to the pattern of finlike joints between the sections of bent plywood formwork. Once forms were stripped, but when the Gunite was still green or uncured, outer surfaces were smoothed, and the fins marking the formwork’s joints were rubbed down, likely with a Carborundum power wheel, as was also the procedure on the building’s poured concrete exterior walls (Figure 24). As Wright had specified: “exposed concrete surfaces shall be smoothed with coarse carborundum to remove form marks, etc. (over 1/16” projection) preparatory to receiving” the painted coating.

Short had reported to Wright on the Gunite surface’s condition as Cocoon began to be applied, and Wright wrote to Cohen on 2 October 1958, demanding that the marks be
ground down to create a smooth surface: “Your sub-contractor for Gunite is or undoubtally [sic] should be bound to give you a job where no form-marks are visible to such an extent that they show through the finished coating when applied. I am sure your good conscience and pride in your work would tolerate nothing so derogatory to the work as a whole and consequently to your future reputation as a builder—not to mention mine as an architect. Therefore will you kindly go over the outer walls and properly prepare them for coating wherever this has not been done.”

Likely alluding to Kansas City, Wright noted: “In Gunite work done for me in the past this has been insisted upon and no less should be done here.” He was clearly concerned that, even with the application of the glossy Cocoon, one could still see the formwork’s joints and other unevenness in the Gunite surface so as to mar the image of the great spiral as a seamless material continuity. George Cohen was bothered by Short’s and Wright’s directives. He reminded Wright: “These are Gunite walls all right. But the Gunite was not smoothed and finished on the exterior—as is common with gunite. It was on this job, applied by gun from the inside against a formwork of plywood—which as you know was bent in three planes. These forms, like any other forms, must show form marks. That is the nature of concrete. We try to rub down these marks, where they exceed 1/16 of an inch projection. The skin tight application of plastic on paint must show some irregularity.” Cohen was upset that Short “asks for perfection—and perfection is not in the nature of the material we are working with. Perfection is for stone or marble or metal.” Wright’s ideal of a perfectly smooth skinlike concrete surface was distant from the era’s style of showing formwork on the finished surface as an architectural pattern, as in the celebrated board formwork in Le Corbusier’s Unité d’Habitation at Marseille (1946–52) (Figure 25).

Cohen and Wright must have agreed on how to proceed, for by 10 October, the museum’s north wall was cocooned, and exterior painting went on through the fall.
Yet by December Cohen worried “that a number of passers-by and some more or less experienced architects and their contemporaries have remarked unfavorably upon the appearance of the exterior walls, particularly with regard to the form marks on the surfaces of the concrete.” Cohen then gave a remarkably clear statement on the nature of concrete as an architectural material, similar to the ideas of Le Corbusier. He wrote: “[F]orm marks are characteristic of concrete. Concrete in its plastic condition is poured into a mould generally made of plywood or prestwood or just wood. This wood is removed when the concrete has hardened and leaves its impression upon the surface. This impression can be minimized. Therefore, specifications for exposed architectural concrete require that projections more than $\frac{1}{16}$” be reduced by rubbing the surfaces of concrete. Excessive rubbing, however, will expose the aggregate.
Figure 23  Wright, Guggenheim Museum, constructional view showing exterior wood backing for plywood formwork on uppermost level, with Gunite walls visible through scaffolding around lower levels of the rotunda (FLWA, photograph no. 4305.125)

Figure 24  Wright, Guggenheim Museum, surfacing concrete likely with a Carborundum power wheel to remove irregularities from formwork (FLWA, photograph no. 4305.108)

Figure 25  Le Corbusier, Unité d’habitation, Marseilles, 1946–52, showing board formwork for poured concrete piers and base (art: © 2012 Artists Rights Society (ARS), New York / ADAGP, Paris / FL.C.; photo: aka-images/Maurice Babey)
and smoothing by plaster patching will eventually break up and fall off.\textsuperscript{96} The smooth surfaces that Wright wanted were obtainable by plastering or by stucco, but “these methods were considered and discarded in consideration of the strength and quality of construction required for this project. In this climate, exposed to temperature variations of 100 degrees, unsightly checking and cracking would have been the inevitable result.” Cohen noted that the concrete could have been precast in a shop with precision, like stonework. Such precast elements “with the curves and constantly changing radii required here would no doubt please our critics but its cost would have been prohibitive and would have resulted in a machined job \textit{which we did not want to begin with}.\textsuperscript{97}

Wright had been working with exposed concrete for half a century, starting with his Unity Temple, whose original exterior showed pour lines as horizontal layers (see Figure 6).\textsuperscript{98} This represented Cohen’s view of how the Guggenheim’s surfaces should be critically received: “The honesty of this design calls for the use of concrete. The form marks accentuate the strength and beauty of this straight-forward material. . . . Therefore, this structure must be viewed honestly. We are not trying to hide the fact that this is concrete poured into wooden molds in the most skillful manner known to present day artisans.”\textsuperscript{99} Yet, unlike Unity Temple’s walls cast in wood molds, the Guggenheim’s walls were Gunite. Cohen noted that some had argued “that the gunite might have been applied from the exterior on to interior forms and then smoothed or screeded to its true shapes.” The project team had considered but rejected this method because “The slope of the turning and rising museum walls would call for skills in application which are just not available—here or anywhere else.” Gunite sinks when applied before it hardens, thus “[k]eeping the thickness uniform as the material sloughs down, trying to build up its thickness to the point where it would stand wear) was good in that it would provide “a thick protective coating which will secure the surfaces of the building against the ravages of wind and snow and sleet and rain for many, many years.”\textsuperscript{100} Yet the Grand Ramp’s circular walls, exposed to sunlight from all angles, hence “slight imperfections viewed in an unfavorable light cast exaggerated shadows, even brick walls or plastered surfaces when struck by the oblique light of a rising or setting sun show unevenness that cannot be seen in ordinary light.”\textsuperscript{102} In this way, the glossy vinyl coating proved visually unforgiving because “like a skin or a tight membrane it exposes and exaggerates every little mound and depression.” However, as a protective coating, the polyethylene paint initially did seal actual cracks in the Gunite surface in a way not possible even on Wright’s Kansas City church of 1940–41, because such vinyl elastomeric coatings had only been developed during World War II. Thus, Cohen said of the Guggenheim: “if little checks or cracks might have ordinarily developed in the various surfaces, this Cocoon will effectively cover and safeguard even them.”\textsuperscript{103}

The analogy to skin as the membrane of a living organism presumably appealed to Wright, even if such perfect continuity was inconsistent with concrete’s nature as a material. Although the lighting conditions vary, comparison of a view of the spiral’s south side before Cocoon’s application (Figure 26) with one of the west side afterward (Figure 27), shows that, once the joints were ground down and the Cocoon was applied, much of the superficial irregularity visible in the unpainted Gunite walls did disappear, leaving the building more like an abstract geometric form of spiraling sunlit planes and deep-shadowed recesses. The Guggenheim’s Gunite walls thus embody a paradox. On the one hand, from the start of his career, Wright, in the tradition of the Arts and Crafts movement, had advocated design “in the nature of materials.”\textsuperscript{104} Yet as he knew and as Cohen lucidly explained, concrete’s nature as a material would leave the exposure of its formwork’s joints and other superficial imperfections. Yet Wright’s ideal of architecture as organic form, adapted from Sullivan, argued for seamless continuity as the Guggenheim’s watchword, so that its great spiral would appear like a living organism rather than a crafted construction. In other words, the naturalistic ideal at the scale of the material’s surface (concrete with its joints exposed) competed conceptually with the naturalistic ideal of the building as a nautilus (concrete as a seamless skin).\textsuperscript{105}

For the Guggenheim ramp’s interior walls, at the trustees’ request, presumably acting on the advice of James Johnson Sweeney as the museum’s director, Euclid proposed a lath-and-plaster surface against the ramp gallery walls from the Grand Gallery on the ground floor to the second level. Wright had wanted to leave these as Gunite and not plaster, in keeping with his overall aim to create the building as a unity, or a model of organic form. Short reported that Wright had advised the trustees that “the addition of this plaster . . . work is unnecessary. He feels that he can furnish
Figure 26  Wright, Guggenheim Museum, view of spiral’s south side before application of Cocoon (FLWA, photograph no. 4305.139)

Figure 27  Wright, Guggenheim Museum, view of spiral’s west front after application of Cocoon (FLWA, photograph no. 4305.158)
a means of supporting the pictures against the concrete wall.” Yet ultimately the ramp's interior walls were plastered. As he had for the exterior, Wright had specified a cream rather than a stark white. Yet Sweeney wanted white for the interior and Harry Guggenheim supported this choice, as he felt the interior to be the museum director's province. Wright disagreed, asking the New York Times's arts reporter Aline Saarinen, who wrote a sympathetic story and interview with Wright on the Guggenheim, to support him in opposing what he saw as a breach of his authority. He wrote that “Sweeney had been authorized to barge in on the architect of the museum and paint the interior a dead-white—thus tearing the inside from the outer walls of the organic building. Of course they know not what they do.”

In response to Sweeney, Wright told Harry Guggenheim: “White is a color: the loudest color of them all. A true artist would not paint for a white background which nature seems to use most sparingly for accent only. Being itself all colors white would place accent not upon the painting but distort the architectural features [of] the environment. . . . To whitewash the interior of our great building would prove a world-wide scandal.”

It was in response to Sweeney’s desire to paint the interior galleries white that Wright offered one of the clearest statements of his intentions for the Guggenheim’s architecture: “This type of structure has no inside independent of the outside as one flows into and is of the other. Integrity is gone if these are separated and you have the conventional building of yesteryear. The features of this new structure are seen coming inside as well as the inside features going outside. . . . To thus tear the inside from the outside of the memorial would cheapen its character by actually destroying the virtue and beauty of the building.” As noted earlier, for Wright, the Guggenheim as a totality was essentially a work of sculpture, hence “The true relationship between inside and outside of a sculptural-building must be preserved. A great sculpture work seen half natural and half painted white invited derision.”

Clearly, Wright did not want either the interior or the exterior painted white. Unlike the interior, where there were functional arguments about the surface’s color in relation to the display of paintings, the choice of exterior color, as George Cohen said, “was a matter of taste.” It was Wright’s choice, with no indication that anyone sought to contradict him. The earliest record of his preference for the exterior is in Short’s notes of a meeting with Wright and Peters at the Plaza Hotel on 17 October 1957, as the Guggen work proceeded and before Cocoon was selected. Wright stated that he wanted a light buff color, much like that which he had preferred for his other works in concrete of the time, such as the Price Tower in Bartlesville, Oklahoma (1952–56). He wanted terrazzo floors of the same color, “the total impression being one of smooth continuous space.” Cocoon’s manufacturer offered twenty-five colors, from a light “cream” to a dark “ocean blue.” On 24 July 1958, Wright approved the next-to-lightest shade, “buff,” yet a letter of 28 July notes that a sample applied to the building did not correspond to this specific shade. Analyses of paint layers during the recent preservation revealed that the original topcoat of Cocoon was such a yellowish “buff” color, consistent with Wright’s long-held preferences. As Guillermo Zuaznabar has noted, this evidence confirms Euclid’s earlier description of the exterior as “various shades of ivory.”

During the recent preservation, once the multiple older paint layers were stripped, the surface’s cracks, which had developed over the decades due to thermal expansion and contraction of the material, were carefully recorded, assessed, and repaired (Figure 28). Along the spiral, the largest cracks (more than 0.016 inches) were vertical ones regularly spaced at 10-degree intervals, corresponding to the 10-degree facets of the poured ramped floors. This pattern of vertical cracks ironically recalls the regularly spaced control joints that appear in Wright’s elevations of 1956, but which were omitted (see Figure 18). The worst cracking and wall movement occurred along the ramp’s 16-foot high topmost Gunite wall. As part of the comprehensive restoration of the rotunda, this wall was reinforced along its interior surface with carbon fiber strips running vertically and horizontally around the rotunda to keep this top level of Wright’s building in place.

**Conclusion: Gunite and Modernist Monumentality**

For the Guggenheim’s architecture, Gunite’s importance lay in its capacity to be fashioned into an apparently seamless continuity. Though the ramp underfoot makes the spiral’s interior a unique spatial experience, it is the ramp’s walls with their unbroken curvature that give the museum its iconic exterior form. In short, no Gunite, no spiral;
no spiral, no icon. For Wright, the rounded continuity of the Guggenheim’s Gunite walls had different meanings for the museum’s identity. First, as he said on many occasions, he considered the building a memorial to his client, the original patron, Solomon R. Guggenheim. This ideal was central to the building’s temple-like character, which Wright in different contexts compared to the Pantheon in Rome, or as he reminded the building committee’s head, “this museum is a memorial like St. Paul’s—London.” These domed halls were circular, with a geometric perfection that was renowned. Also, central to Wright’s view of Solomon Guggenheim’s aims was that the new building not be “just another museum,” including traditionally styled institutions like the Metropolitan Museum of Art nearby. As Wright said, the new Guggenheim Museum’s sculptural form “will make the old Metropolitan Museum look like a Presbyterian barn.” Yet the Guggenheim was also to counter the Museum of Modern Art, whose aesthetic in terms of its architecture was almost wholly rectilinear. This theme had been invoked by those modernist painters who in December 1956 had protested the Guggenheim’s spiral ramp as inimical to their canvases: “The basic concept of a curvilinear slope for presentation of painting and sculpture indicates a callous disregard for the fundamental rectilinear frame of reference necessary for the adequate visual contemplation of works of art.” Yet this idea Wright saw as limited relative to his curvilinear organic form and the Guggenheim’s unique collection of nonobjective art. As he said, “There was no good place in which to show painting of this free nature. Museums as they stood would deny the new freedom by the conventional, static manner in which it would there have to be immured.”

Both of these associations—with memorial temples and nonobjective painting’s freedom of expression—gave symbolic import to Wright’s insistence on a seamless curve for the exterior walls of the main gallery. As he wrote: “The main walls gently curving outward establish the repose of the upward sweep of the great spiral, therefore of the whole...
structure.” Also, the spatial experience and the exterior surface had to be continuously curved because that is what gave the building its formal kinship with nature, and for Wright, nature was the authoritative source and inspiration for architectural form, distinguishing his modern architecture from the International Style, closely associated with the convention of straight lines and right angles. Nature was the authoritative source and inspiration for Wright to make it an entity, a consistent, organic whole. When it is finished and you go into it, you will feel the building. You will feel it as a curving wave that never breaks. You will feel its quiet and consistency.”

As Frederick Gutheim noted, Wright in the Guggenheim realized a goal for his art that he had anticipated fifty years earlier in his programmatic essay of 1908, “In the Cause of Architecture,” wherein he wrote: “the work shall grow more truly simple: more expressive with fewer lines, fewer forms; more articulate with less labor; more plastic; more fluent, although more coherent; more organic.” The embodiment of that naturalistic ideal in the Guggenheim’s great spiral rotunda depended on a novel application of Gunite, an industrial material that found its way into modern architecture.

Notes
1. The author is most grateful to Francine Snyder of the Solomon R. Guggenheim Archives and especially to Angel Ayón, of WASA/Studio A, New York, preservation architect for the museum in 2004–8, for their generous assistance with the research for this article. Mr. Ayón provided expert, meticulous reading of the original draft. My wife, Professor Susanne Fusso, Wesleyan University, was invaluable helpfully in every phase of this study.


8. Wright to Neutra, n.d., mid-July 1929?, fiche id. N002E02, FLWA. Wright in this letter refers to a book on American architecture that he understood that Neutra was then writing. Neutra replied that “your letter just arrived,” and that he was not writing such a book. Neutra to Wright, 16 July 1929, fiche id. N002B06, FLWA.

9. Wright to Ben Wiltchek, 13 July 1941, fiche id. C107B01, FLWA.

10. The chapel was made of cast cement block walls threaded through with vertical and horizontal steel reinforcing, like his textile block houses in Los Angeles.
Angeles of the mid-1920s. Cast in wood and metal molds by student labor, some blocks were imperfectly finished, but they were structurally usable, so Wright's assistant, William Wesley Peters, wrote: "There is quite a lot of Gunite work done in Miami, a great deal of wall plastering, etc. It occurred to me that it might be a fine thing to use on the big plain expanses on the chapel. I thought we might be able to substitute it for plastering; we could set up the walls of blocks, thereby using up the facially imperfect blocks that we have been compelled to reject, finally ginning the whole. This is the work they commonly employ the guns for in Florida and thereby they obtain a remarkably fine and rich sand plaster finish, with a perfection and rectilinear ear quality that are beyond the results of hand plastering." Peters to Wright, n.d., Jan. 1940?, fiche id. F040B06, FLWA. See Siry, "Frank Lloyd Wright's Annie M. Pfeiffer Chapel for Florida Southern College: Modernist Theology and Regional Architecture," JS&H 63, no. 4 (Dec. 2004), 498–539.


14. Specifications for the Community Church, Kansas City, Missouri, Frank Lloyd Wright, Architect, fiche id. C076C05, FLWA. He said: "This building is designed to be erected as a one-process structure. A light steel frame is to be erected, tubular steel studs being the wall members, open-web steel joists being the carrying members for the floors and roofs; the whole electro-welded to form a large-scale structural web."

15. Specifications for the Community Church, Kansas City, Missouri, Frank Lloyd Wright, Architect, fiche id. C076C05, FLWA. Wright specified, "Finally the framing shall be covered by Gunite, a thin integument of sand and cement placed under pneumatic pressure with the Cement Gun over a waterproof-paper–backed steel mesh."


17. Besinger, Working with Mr. Wright, 90. Accounts note that Wesley Peters and Mendel Glickman made calculations for the initial structural system. Glickman's stamp as a professional engineer registered in Wisconsin appears in Peters' stamp as a professional engineer registered in Wisconsin appears in the second floor and having an inner radius of just over 12 feet, was framed

20. Wright to Ben Wiltscheck, 13 July 1942, fiche id. C107B01, FLWA.

21. Wiltscheck to Wright, 7 Oct. 1942, fiche id. W134C05, FLWA.

22. Wright to Everham, 23 Nov. 1940, fiche id. C085B05, FLWA.


25. Besinger, Working with Mr. Wright, 178.


28. Wright's original agreement with the foundation is in Pfeiffer, ed., Guggenheim Correspondence, 8–9. His only larger project between January 1942 and June 1943 was a commission of 1942 to design housing for a defense plant in Pittsfield, Massachusetts, which was not built. For units there, his contractor for the Kansas City church prepared an estimate for Gunite floor and wall panels made by the Los Angeles Cement Gun Company. He advised Wright: "There would be an advantage in using Gunite panels, because you would obtain more strength and also a uniform finish on both sides of the panel." Wiltscheck to Wright, 13 April 1942, fiche id. W133A09, FLWA.


30. Besinger, Working with Mr. Wright, 229.

31. Rebay wrote: "The plans for our museum are exquisite. I had never seen anything like it in quality and texture of design, organic unity and natural enfoldment," Rebay to Wright, 1 March 1944, fiche id. G056C05, FLWA.

32. Rebay wrote: "without this vision come to be seen and which you gave to Mr. S.R.G. we would (or he) never have gotten this plot as he was really discouraged." Rebay to Wright, 5 April 1944, fiche id. G057B03, FLWA.


34. "Work Done at Taliesin since March 24, 1944," William Wesley Peters to Wright, 13 April 1944, fiche id. W147D01, FLWA.

35. Solomon R. Guggenheim to Wright, 28 July 1944, fiche id. G059C02, FLWA.

36. Wright to Albert Thiele, 10 Oct. 1944, fiche id. G060C02, FLWA.

37. Peters wrote: "I am writing from Milwaukee where I have been working with Mendel Glickman on the Museum." Peters to Wright, n.d., Jan. 1945?, fiche id. G063A01, FLWA. Later he wrote: "For the last several days I have been working on the Museum drawings . . . . Glickman has been working separately on different parts of the building and in checking on some figures which I sent him." Peters to Wright, 7 March 1945, fiche id. D072D10, FLWA. Glickman continued to work on the structural design at intervals into 1956. Glickman to Wright, 17 Feb. 1956, fiche id. G073A08, FLWA.

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39. Peters to National Gunite Corporation, 5 June 1945, fiche no. G065E01, FLWA.

40. Peters to Curzon Dobell, Pre-load Corporation, New York, 27 June 1945, fiche id. D057B05, FLWA. Wright's first built spiral ramp was in the V.C. Morris Store, San Francisco (1948–49). Working drawings and construction photographs show that this ramp, linking the street level with the second floor and having an inner radius of just over 12 feet, was framed.
in welded and bolted steel. The ramp floor was a thin layer of poured concrete and the inner railing and outer walls were plastered. See Siry, “Wright’s Guggenheim Museum and Later Modernist Architecture,” 43–45.


46. Crucible Steel Company of America to Wright, 4 Oct. 1945, fiche id. G069D08, FLWA. Later Wright wrote: “I myself had the idea that enabled me to . . . take out the columns between the ramps,” an idea that Rey had “enthusiastically approved.” Wright to Rebay, 8 Dec. 1945, fiche id. G07B10, FLWA.


49. In 1946 Wright had collaborated with the engineer Jaroslav Joseph Polivka on structural analyses of the spiral ramp in models. See Susan Tejada, Engineering the Organic: The Partnership of Jaroslav J. Polivka and Frank Lloyd Wright (Buffalo: State University of New York at Buffalo, 2000). Announcements in July 1945 described the museum as concrete. Yet Rey had wrote to Wright: “it would be terrible to have a concrete building. You always told me it was going to be WHITE MARBLE outside, if so, please do not say it is steel filled in with concrete, which does not sound precious at all, but that it will be in marble, as I hope it will be.” Rey to Wright, 14 July 1945, fiche id. G066C03, FLWA. Rey perhaps referred to Wright’s idea of a white marble aggregate for the Gunite. As he reassured her, Gunite with a ground marble aggregate “gives us a monolith without joints, whereas if the surface was veneered with thin slabs of marble it would be covered with joints and ordinary like the other commercial structures in New York—say Bonwit Teller stores.” Wright to Rey, 17 July 1945, fiche id. G066B10, FLWA. Bonwit Teller’s building on the northeast corner of Fifth Avenue at 56th Street was designed by Warren and Wetmore in 1929. It was remodeled by Ely Jacques Kahn in 1930, then torn down in 1983 and replaced by the Trump Tower, 737 Fifth Avenue.

50. Wright to Clinton Hunt, ca. 8 June 1954, FLWA, fiche id. G18D07. Wright to Thiele, 27 June 1954, box 000517, folder 17, Frank Lloyd Wright Correspondence, SRGFA. See also Jane King Hessler and Debra Pickrel, Frank Lloyd Wright in New York: The Plaza Years, 1934–1959 (Salt Lake City: Gibbs Smith, 2007).

51. “The Talk of the Town; Guggenheim’s Euclid,” New Yorker 33, no. 13 (18 May 1957), 24; and “George Cohen, 66, A Design Expert,” New York Times, 6 Oct. 1972. In 1954 Euclid had been awarded the contract for the Tappan Zee Bridge’s three-mile concrete road deck across the Hudson River between Nyack and Tarrytown, New York. Cohen’s daughter recalls that Tafel introduced her father to Wright. Rhoda J. Cohen, telephone conversation with author, 11 June 2008. Tafel “was happy to hear that the plans for the actual construction of the Museum have been announced as nearing completion. . . . In the event you are taking bids and need additional contractors, I have an excellent one in mind that does only concrete work. They operate on a consistently low profit margin and would, I am sure, give you the cooperation and reasonable price you want.” He does not name the firm, yet Tafel likely referred to Euclid. Edgar Tafel to Wright, 16 March 1953, fiche id. T054D09, FLWA. Tafel later offered to assist Wright in building, noting “Although my relationship to George Cohen was one of architect-client, it has now terminated and would in no way influence my working with you.” Tafel to Wright, 11 May 1956, fiche id. T075A02, FLWA. See Tafel, Years with Frank Lloyd Wright: Apprentice to Genius (New York: McGraw Hill, 1979), 208–10.

52. Charles Chuckrow, a mechanical engineer whom Euclid invited to collaborate on the project, commended Cohen to Wright, noting: “Euclid has performed outstanding contracts encompassing intricate reinforced concrete work which they did with their own forces.” Charles M. Chuckrow to Wright, 24 Aug. 1954, fiche id. G150C02, FLWA.


54. Wright, n.d., handwritten note on the back of a letter of 27 Sept. 1954 from Ronald H. Webster, fiche id. G151A03, FLWA.

55. Wright to Thiele, handwritten reply on Thiele to Wright, 8 Oct. 1954, fiche id. G151C03, FLWA.

56. Wright to Euclid Contracting Corp., 30 Sept. 1954, fiche id. G151A07, FLWA.


58. The foundation acknowledged receipt of the specifications, “nine sheets of which have been corrected to conform to objections raised by the proposed contractor.” Thiele to Jacob Feld, 19 Sept. 1955, fiche id. F118A02, FLWA. Feld supplied Wright with his curriculum vitae, “Professional and Technical Qualifications,” dated June 1953, fiche id. F115A04, FLWA. As Wright wrote to the foundation, Feld, “whose services were required by law in your state, has devoted himself to your interest in the preparation of extra drawings and in securing our building permit.” Wright to Guggenheim Foundation, 1 Aug. 1956, fiche id. G167B10, FLWA. Cohen wrote of Feld to Wright: “I was who introduced him to you, and for a while we seemed to work together very well indeed.” Cohen to Wright, 19 Feb. 1957, fiche id. G175B04, FLWA.


60. Feld conveyed the final set of architectural, structural, and mechanical plans to Short on 15 August. Feld to Wright, 17 Aug. 1956, fiche id. F123E04, FLWA. After the revised plans of 1954 and 1955, a “complete new set [of] plans” was made in 1956 as the “original contract drawings,” followed by a “complete new set of working drawings made in summer of 1956 after signing contract.” These and previous drawings, going back to the preliminary sketches of 1944, were “gathered and put together. Sent to New York July 23, 1956.” “The Drawings for the Various Sets of Plans for the Solomon R. Guggenheim Foundation Memorial Museum,” fiche id. G168A05, FLWA.

62. Cohen, quoted in “Guggenheim’s Euclid,” 24. The Guggenheim’s final revised specifications accompanying the 1956 plans divided the concrete work into three major types. First, all parapets, walls, and other concrete below the ground floor was to be “stone concrete,” meaning a heavier stone aggregate, with a crushing strength of 3,500 pounds per square inch, then a conventional standard. Above the ground floor, poured concrete for the ramp and floors was to have the same crushing strength, but was to have a lightweight, expanded shale aggregate. Below- and above-ground poured concrete was to be “controlled concrete,” meaning the design of the mixes and the necessary testing of the concrete to meet the building code’s standards would be done by an outside testing laboratory retained by Euclid. Finally, the “exterior curved walls of grand ramp are to be gun concrete on steel mesh.” Specifications, Archeseum for the Solomon R. Guggenheim Foundation Memorial, received 23 Feb. 1956. Division 4–Concrete, 1. FLWA. For testing mixes, Euclid retained the Pittsburgh Testing Laboratory of New York City. Joseph Neukrug to Wright, 11 May 1956, fiche id. G164D08, FLWA.


64. Spero, “Forms Mold Sculptured Concrete Museum,” 144.


66. Specifications, Archeseum for the Solomon R. Guggenheim Foundation Memorial, received 23 Feb. 1956. Division 5: Gun-Placed Concrete, 2. FLWA. Angel Ayón to author, December 22, 2010, noted that analysis showed just two layers of Gunite.


68. Specifications, Archeseum for the Solomon R. Guggenheim Foundation Memorial, received 23 Feb. 1956. Division 5: Gun-Placed Concrete, 3. FLWA.


70. William H. Short, “Notes on Week of October 29th to November 2nd, 1956 during which Mr. Wright was in New York,” 5 Nov. 1956, fiche id. G169E04, FLWA.


72. Wright to Cohen, 21 Jan. 1957, fiche id. G173A02, FLWA. At issue was the choice of the Gunite subcontractor. As Wright reminded Cohen: “Our contract provides that no subcontracts are to be let without the architect’s approval in writing.”


75. Ibid.


77. Wright to Rebay, 2 Jan. 1945, fiche id. G061A06, FLWA. As Wright said before construction began: “The building exemplified the principle of steel in tension. The consequent cantilever and the science of continuity appear in consistent form as a complete building in which to view the art this organic building was designed to reward.” “By the Architect, Frank Lloyd Wright,” n.d., March 1956?, fiche id. G163D10, FLWA.

78. Short to Wright, 24 Sept. 1957, fiche id. G182C07, FLWA.

79. “Minutes of Job Meeting Held at the Site on October 2, 1957,” fiche id. G183A09, FLWA.

80. Short to Thiele, 30 Sept. 1957, fiche id. G182E02, FLWA. The anticipated start date for Gunite operations was noted in “Minutes of Job Meeting Held at the Site on September 25, 1957,” fiche id. G182C08, FLWA. The start of Gunite work was noted in Short’s daily reports to Wright from 7–11 Oct., fiche ids. G183C02–G183C06, FLWA.

81. Short to Wright, 8 Nov. 1957, fiche id. G184C07, FLWA.

82. Short to Wright, 1 Aug. 1958, fiche id. G196C09, FLWA. Two weeks earlier Short told Wright that “the guniting of the top wall of the ramp was nearly completed,” through its sixth level. 18 July 1958, fiche id. G196A04, FLWA.


84. Cohen to the Office of Frank Lloyd Wright, 24 Sept. 1957, fiche id. G182C06, FLWA. “Cocoon” was developed and manufactured by the Holingshead Company of Camden, New Jersey. Metro Industrial Painting Corporation was the subcontractor. Wright first specified a sand-finished paint, sold under the trade name “Lithite,” which was widely known, and which he had used satisfactorily in several projects. He felt it the best product available at the time that the specifications were written in 1955. William Wesley Peters to The Trustees of the Solomon R. Guggenheim Foundation, 6 Feb. 1958, fiche id. G190A01, FLWA. Yet he warned that, because Lithite was not a water seal, “that ‘finish’, so called, would need renewal after five years.” Wright to The Trustees of the Solomon R. Guggenheim Foundation, n.d., June 1958?, fiche id. G194C06, FLWA. Lithite was manufactured by the Commercial Chemical Company of Los Angeles.

85. Peters to The Trustees of the Solomon R. Guggenheim Foundation, n.d., fiche id. G190A01, FLWA.

86. Wright to The Trustees of the Solomon R. Guggenheim Foundation, 2 June 1958, fiche id. G19406, FLWA. The trustees’ agreement to add Cocoon was noted in Short to Cohen, 12 June 1958, fiche id. G195A01, FLWA.

87. Short to Wright, 26 Sept. 1958, fiche id. G199A01, FLWA. Probably to test its appearance, it was applied first on the high wall of the main triangular stairway at the less visible rear or east side of the site, and not on the main spiral gallery or the street fronts.


90. Wright, “Specifications for the Archeseum,” 22 Feb. 1956, Division 4–Concrete; Finishing, 15. FLWA.


92. Cohen to Wright, 6 Oct. 1958, fiche id. G199B09, FLWA.


94. Short to Wright, 10 Oct. 1958, fiche id. G199C02, FLWA.


96. Ibid.

97. Ibid.


100. Ibid.

101. Ibid. The number of layers and their rationale was noted in G. H. Eaton to Harry F. Guggenheim, 7 June 1960, box 691578, folder: Exterior Coating: Cocoon, 1957–60. SRGFA.


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Short to The Trustees of the Solomon R. Guggenheim Museum, 4 June 1958, fiche id. G194C09, FLWA. Inside, there was no need for the exterior’s expensive polyethylene, water-seal paint, so Wright stayed with “sand silicone paint specified for all interior surfaces,” requesting that Euclid “apply the paint by a spraying process. No other means of application of this heavy paint can produce the even texture desired. In fact, rolling or brushing would produce a lumpy streaked surface not acceptable.” Wright to Euclid Contracting Corporation, 26 June 1958, FLWA, fiche id. G195B09.

Wright to Aline Saarinen, 24 May 1958, fiche id. S282B08, FLWA. Wright elsewhere noted Sweeney’s “yen for a ‘dead white’ on the walls.” Wright to Harry Guggenheim, 10 May 1958, fiche id. G193C06, FLWA.

Wright to Harry Guggenheim, 17 March 1958. Frank Lloyd Wright Correspondence, box 000518, folder 3. SRGFA.


Detailed analysis of the paint color related to the recent preservation is in Weiss, Boornazian, and Trienens, “Guggenheim Museum Exterior Colour.”


Wright to Medley Whelply, 2 Feb. 1956, fiche id. G160E03, FLWA.

Wright quoted in Marie Ray, “Profile of an Architect,” with Ray to Hunt, 28 Oct. 1953. Frank Lloyd Wright Correspondence, box 000517, folder 15, SRGFA.


Wright, “The Solomon R. Guggenheim Memorial Museum; An Experiment in the Third-Dimension,” 16 May 1958. Frank Lloyd Wright Correspondence, box 000518, folder 4. SRGFA.
