Frank Lloyd Wright and the Use of Non-Rectilinear Geometry in His Later Works

"I believe in God, only I spell it Nature."

“Organic architecture is an architecture from within outward, in which entity is an ideal... Organic means intrinsic – in the philosophic sense, entity – wherever the whole is to the part as the part is to the whole and where the nature of the materials, the nature of the purpose, the nature of the entire performance, becomes clear as a necessity.”
Introduction

Frank Lloyd Wright once said, "the maple wood blocks... are in my fingers to this day." Wright acknowledged that his early exposure to the Froebel blocks (called "Gifts" and "Occupations"), had a considerable lasting influence on his work. These wooden blocks were designed to help children learn about different geometric forms, mathematics, and creative design. A Young Frank Lloyd Wright was fascinated by them and credited that much of his architectural designs were influenced by the geometric shapes he experimented with as a child, which consisted of a series of geometric forms, including spheres, cubes, triangles and cylinders. As an architect, Wright developed a system of rotating series of geometric forms that became one of his principal methods of design. He believed that geometry had a deep cosmic meaning and can be the means of ordering design to connect man to the cosmos. In this idealistic and romantic view, architecture could provide a means of harmony between the individual, society, and the universe. As time progressed, Wright began to expand and differentiate the geometry of his architecture to better represent nature and organic architecture in his buildings by moving away from rectilinear to non-rectilinear geometry. This is notable in several of his works beginning in the mid-1930s and includes buildings discussed in this paper such as: the Hanna House, the Palmer House, the Johnson Wax Administration Building, and, perhaps most famously, the Solomon R. Guggenheim Museum.

Geometry of Frank Lloyd Wright, It's Influences and Inspiration From Nature

In most buildings, the design of interior spaces is rectilinear. Later in his career, Frank Lloyd Wright began to think in curves and straight lines through shapes like triangles, circles, ovals, squares, and spirals, in addition to other shapes adapted from nature. For Wright saw geometry as the basic building block of nature and that the variety of geometric forms in nature also held symbolic significance. The circle, he said, suggested infinity; the triangle, structural unity; the spire, aspiration; the spiral, organic progress; and the square, integrity. Wright firmly believed that structure created
beauty and from there geometric forms would give his work a consistent and systematic quality. This comprehensive vision where the aesthetics of design are inseparable from the principles of form is what guided Wright throughout his career.

Nature, above all else, was Wright’s most inspirational force. He advised students to “study nature, love nature, stay close to nature.” He did not suggest copying nature, but instead allowing it to be an inspiration believing that nature’s secrets could only be discovered by diligent contemplation. Reality and truth were not to be found on the surface of things, but required extensive probing and thought to yield valuable lessons. The exhilaration of honest, routine outdoor work, while working summers on his uncle’s farm, also made a strong impression on Wright’s perspective towards nature as he began to comprehend the deep mysteries of nature.

Other shapes like the hexagon, spiral, and arc were also keys to the consistent and systematic quality underlying all of Wright’s work. They allowed Wright to order spaces that encompass both composition and construction and by combining nature and geometry Wright developed what he called, (and became famous for) organic architecture. He used geometry, proportion, pattern, hierarchy and orientation in all of his work, but Wright best used geometry as a formative idea with the concepts of plane and solid geometry determining the built form. Besides basic platonic geometries, Wright used combinations, multiples, derivatives, and manipulations, and this structural vocabulary that developed throughout his life consists of a three-dimensional field of lines through which the solid elements of the building are located enabling the voids to be integral to the whole and equally meaningful. To him, architecture was, after all, the space. In order to achieve the qualities of repose and unity, the natural ornament was conventionalized, through geometry, to bring out the underlying form—a nature pattern study. Wright would use a range of geometric grammars in which the controlling geometric unit ordered the plan and drove the detailed development. These units would take the form of hexagons, as was the case in the Hanna House; equilateral triangles, such as in the Palmer House; or a series of circles as in the Solomon R. Guggenheim Museum. Wright himself described his ever evolving use of geometry based on his interpretations of nature as “planned progressions, thematic evolutions, the never-ending variety in differentiation of pattern and to integral ornament always belonging naturally enough to the simplest statement of the prime idea upon which the superstructure is based.”

Through the career of Frank Lloyd Wright, there were two constants: Nature and Geometry. That Nature was Wright’s deity is well known, as he summarized his notion towards nature as: “I wish more life to creative rhythms of great Nature, Nature with a capital N as we spell God with a capital

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10 “Geometric Shapes.”
12 Ibid.
13 Ibid.
14 Ibid.
G. Why? Because Nature is all the body of God we mortals will ever see.” Eaton explores how this vein of thinking tied to the organic analogy of Viollet-Le-Duc and noted that it was present in a variety of other thinkers as well. Contemporary research has stressed the importance of Wright's feeling for geometry through the work of Anthony Alofsin where he describes the impact of Wright's contact with the geometric forms of the Vienna Secession and his use of the rectilinear grid; Narciso Menocal also writes that it “...was contingent on his conception of the universe as a geometric entity that architecture mirrors.” Wright used nature as the basis of his geometrical abstraction. His objective was to conventionalize the geometry which he found in Nature, and his method was to adopt the abstract simplification which he found so well expressed in the Japanese print. He believed in natural materials and insisted that buildings grow naturally from their surroundings; with the example of a branch of a tree a natural cantilever. This influence apparent in his work from the sky-lighted forest of concrete columns in Johnson Wax Administration building to the spiralling “snail-like” Guggenheim museum. He believed “the closer man associated himself with nature, the greater his personal, spiritual and even physical well-being grew and expanded as a direct result of this association.”

Artistic Impressions on Frank Lloyd Wright’s Notions of Geometric and Symmetry

The principle characteristics of Wright’s architecture reflect his concern for the central artistic question of the relationships between order and experience, the universal and the particular or the consistencies and variations. He juxtaposed abstract geometry with the special conditions of the building context to achieve consistencies and variety over a range of designs, where the vitality of his design invention seems to be related to the degree of limitation he placed on his design palette in terms of geometries and how they may make a direct appeal to the human intellect. The reflectance of cubism on Wright’s work also is representative in his later projects and was reflected in his new geometric forms. As seen in the sculptural treatment of the interior space of many his large open spaces, Wright defines the interior space as if it were a “solid, plastic mass, compelled to

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17 Ibid.
18 Ibid.
19 Ibid.
22 Ibid.
Christopher Gray discusses how the Cubist aesthetic theories stress this ambiguity of mass and space. Particularly important to this idea is the concept of the equivalence of form and space where solid form, surrounded by space is at times “replaced by an equivalent space form surrounded by material form.” This notion can be seen in later works by Wright’s, like his Guggenheim Museum, where, by virtue of its hollow cylindrical form, the spiral of the Museum is a mass surrounded by space and at the same time a sculptured space-surrounding mass. Wright’s spaces blend and seem to become extensions of wall planes or continuations of series of piers, thus suggesting an opaque and solid wall rendered transparent. Alfred Barr Jr. defines this process as “the breaking of a contour so that the form seems to merge with space.”

Related to the influence of cubism in Wright’s geometry we can see how he incorporates attributes of cubism such as how objects are reduced to a simple series of “geometric forms both curved and rectilinear, fragmented into isolated lines, angles, shades, planes and partial volumes, much as one would dismantle a watch, piece by piece, and then break each of the pieces.” We can also see how there is the reintegration, interlocking and interpenetration of these fragments through the picture plane and how this creates an effect of mechanistic but vibrant unity. Architecturally, this can be best represented in some of the stain glass work Wright completed where he used the medium as light screens to bring the natural light into the home. He sought to enliven the house with panels of coloured glass often designed in geometric shapes evoking nature. The resulting effect could be considered a modern cathedral, glowing with light and serenity.

Hanna House in Palo Alto

The Paul And Jean Hanna House in Stanford, California (1936-37), otherwise famously called the Honeycomb house, is Frank Lloyd Wright’s earliest executed residential design using non-rectangular geometry. Although he had envisaged numerous projects based on such geometry throughout the twenties and early thirties, none employed the hexagonal module, and none were realized. The

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24 Ibid.
25 Ibid.
26 Ibid.
27 Ibid.
28 Ibid., 34.
29 Ibid., 35.
Hanna House, therefore, constitutes a significant moment in Wright's architectural career, and its influence was lasting as it was the first realization of non-rectilinear modular design since Wright began to explore such geometry in the 1920s; and it created an avenue of design parallel to his use of rectilinear geometry. Wright ascribed to the hexagon geometric form because of its two significant properties which are distinctive of his notions of non-rectilinear geometry. The first, that the hexagon's greater potential as a reflex form lies in its ability to make space extensive along six rather than four sides, and the second, the obtuse angle generates spatial extensibility primarily along diagonal rather than the gridiron axes of the square. It is this inherent openness of the obtuse angle, its greater flexibility in structuring space and adaptability to human motion through space, which informs Wright's notion of reflex geometry.

The plan of the Hanna House itself described a partial hexagon, the inflexions of the wings of the house marking the various sides along thirty-degree axial shifts. Siting the building thirty-degrees north by northeast, coincidentally across the lot's widest diameter, allowed the house to be seen from the curving road below at a sixty-degree raking angle, visually wedging the building into its site. William Wesley Peters, apprentice to and protégé of Frank Lloyd Wright, mentioned to Joncas that the Hanna's request for a design that would grow and change with the family prompted Wright's decision to use the hexagon since it offered greater flexibility in design and movement than the square or rectangle. Peters further believed that Wright's use of unconventional geometry in the 1920s-30s, primarily the triangle was a direct outgrowth of his interest in organic form and an increasing desire to create ever more flexible spaces and forms.

Of course, Wright never abandoned the use of rectilinear spaces. However, it is important to note that at about the time of the Hanna House his preference for non-rectilinear geometry in architectural design increased dramatically, and the hexagonal module became here after one of the staples of his geometric vocabulary.

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31 Ibid., 320, 321.
32 Ibid., 313.
33 Ibid.
34 Ibid.
35 Ibid.
36 Ibid.
Palmer House in Ann Arbor

The William and Mary Palmer House, a house in Ann Arbor, was designed by Wright in 1952. Similar to his application of the hexagon in the Hanna House, we see his use of the equilateral triangle (the hexagon being composed of six equilateral triangles) being imposed. It is therefore not a surprise that in his quest for representing nature through architecture that he would foreshadow the new mathematics of nature that being what Eaton describes as fractal geometry.37 It was in the equilateral triangle that Wright came the closest to fulfilling his desire to create a geometry which would emulate Nature, at the time.

The Palmer House is an excellent example of his later architecture where Wright embraced new forms of symmetry, including similarity or fractal symmetry. Similarity symmetry is where repeated elements change in scale but retain a similar shape where the forms of which diminish in size but retain their form as they get closer to the top of the building.38 Frank Lloyd Wright used a kind of similarity symmetry in the house’s design and again chose an equilateral triangle as a planning module, and repeated at a number of levels and sizes to organize the design of the house.39 The result of this similarity symmetry in the house, whether visually apparent or not, resulted in a high degree of order within an architectural design and lent unity to the composition as a whole.40

The typical floor plan of a rectilinear building by almost any architect would offer the opportunity to pick out rectilinear patterns of floor tiles, appliances, bricks and the like, and thus could claim limited illustration of fractal approximations.41 But as one can surmise from the plan, the Palmer

Figure 5: The Palmer House Plan in the left image featuring the fractal elements and the fractal elements of the left image overlaid on the plan of the Palmer House on the right.

37 Eaton, “Fractal Geometry in the Late Work of Frank Lloyd Wright,” 325.
case is entirely different. Firstly, the Palmer House presents iterations of precisely similar geometric units, not approximations of varying sizes (figure 6), and secondly, none of the iterations is the serendipitous result of available manufactured materials; in the Palmer house the fractal quality is in every case the result of a specific and conscious act of design. The particular contribution of the Palmer house that Wright's manipulation of the triangular module reveals with special clarity, dramatically and beyond debate, his intuition of what we now recognize as fractal geometry, a discipline that Eaton describes “was neither named nor recognized in his lifetime.”

Johnson Wax Building in Racine

Johnson Wax Headquarters by Wright was constructed from 1936 to 1939. The Building features a slender monolithic form with dendriform shafts stand on metal tips bedded at the floor level. In botanical terms, as its inspiration for its geometry from nature is derived, it describes the various parts, stem, petal, and calyx of a flower. The innovations allowed the column to be an aesthetic element and not just a support device. Wright’s endeavour to synthesize technology in a building produced a structured architecture here is seen as a success. The elements of the building are brought together in a logical manner, freed from ambiguous meaning, into a form whose character is governed by a sense of order.

Wright spent an enormous amount of time on the details of the Johnson building’s basic geometry, especially in regards to the first-floor plan. In drawing the building’s basement, first floor, mezzanine, reflective ceiling and upper levels it can be seen how Wright simultaneously shaped the first five levels of the building. His struggle and eventual ability to integrate the circular geometry of the column with the orthogonal geometry of the grid is one of the primary themes running throughout the entirety of the building.

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42 Ibid.
43 Ibid.
45 Ibid.
As seen in figure 8, the comparison of the three sketches gives convincing evidence that the idea for the plan of the Johnson building was derived by superimposing the Capital Journal projects’ columnar structural system and circular geometry onto the layout of the Larkin Building.47

The columns, as seen in figure 7, show these tapered concrete columns that are representative of nature through their “mushroom-like,” in that they taper upward slightly and then fan out to enormous capitals (symbolic of the top of the mushroom cap). The building’s the main offices, feature dozens of these slender columns that fan out at the top and create a “forest” of concrete columns.48 Wright streamlining of the building was profound, as he attempted to integrate the entirety of the structure through the use of the curved non-rectilinearity glass resulting in the building having no sharp building edges where the walls meet the roofs (this shows a massive step away from rectilinear design of his earlier work).49

The Solomon R. Guggenheim Museum in New York

The Solomon R. Guggenheim Museum is an art museum located in Manhattan, New York City. A landmark piece of architecture, designed by Frank Lloyd Wright, the museum is a curving cylindrical building, wider at the top than the bottom, and was envision as a “temple of the spirit.”50 The ramp gallery expands up from the main level in as a long, continuous spiral along the outer edges of the building until it reaches the ceiling skylight.

Wright again brought in aspects of nature into his buildings with his use of natural light, plants, and water, in the Guggenheim Museum, and it is believed that a nautilus shell inspired the spiral ramp and that the radial symmetry of a spider web informed the design of the rotunda skylight. The Guggenheim Museum incorporates several forms including a dome, the most significant part of the commission, and a web of 6 parabolic arches focused on a central hexagon framing a central circle.51 The viewer in the cylinder identifies with the geometry; the earth and heaven with a column of light establish the vertical axis and a gallery at slight 3% grade gives a sense of the cosmos of this reversed ziggurat.52 Frank Lloyd Wright used the helix in the Guggenheim Museum, where, in this case, the exterior of the building reflects the form of the giant helical ramp on the interior. The gallery spaces are arranged along one side of the ramp and visitors to the museum visitor takes the elevator to the top floor of the space,

47Ibid., 19.
48 Ibid., 127.
49 Ibid., 31.
52 Ibid.
then spirals his way down the ramp to the bottom, admiring the art on display along the way. Wright's building design has faced criticism because of this downward spiral as it forces the visitors to hurry through the museum, unconsciously rushed by the pull of gravity.  

Within the context of his late exploration of geometry and building upon the notion of Wright's attraction to spiral symmetry, we can see how the spiral offered an irresistible challenge: the spiral is an exceptionally rare form in the history of architecture. It was also important to Wright that the spiral occurs naturally as “spyrochetes, celestial nebulae, seashells, tornadoes, whirlpools—forms” that range in scale from the microscopic to the galactic, each its special manifestation of nature’s mysterious forces. Finally, the spiral is unique, even eccentric, among geometric forms unlike the circle, the hexagon, and the triangle, it resists two-dimensional or planimetric forms of representation. The spiral is linear but exists in three dimensions; it defines the space without strictly containing it; whereas circles, hexagons, and triangles are stable and static, the spiral has powerful connotations of movement. In short, the spiral is a transcendent form, and furthermore, the spiral can serve as a symbol of transcendency. For each of these reasons the spiral would have appealed to Wright, and in view of his deeply empathetic view of geometry it is very likely that Wright would have recognized something of himself in the eccentric, transcendent nature of the spiral.

At first, the museum’s continuous interior spaces were controlled with straight or right-angled walls to which Wright referred as “bent planes,” producing an almost cubist effect despite Wright’s strong dislike of other geometric, and particularly “phisticated climax.” The museum, as distinguished from the administration and service areas which surround it, is a single circular space, within which Wright achieved a feeling of spatial variety by using the parapet of the ramp as a visual division between the core space and the ramp space, and by allowing intrusions into the ramp space which

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55 Ibid.
56 Ibid., 475.
vary one's spatial experience as one descends. To maintain spatial unity through geometry, Wright used one of the smaller service cores rather like a gigantic toothpick to hold the core space and the ramp space together. It is a round element which starts at the topmost point of the ramp entirely within the ramp space, and ends at the bottommost point entirely within the core space. The curving lines of the planting areas and the building walls at the entrance suck the space of the front of the building through to the back and make it envelop the masses in a unifying embrace. The projections and recessions above and below the long horizontal "facade" enhance this effect and are instrumental in tying the museum's various parts together.

Conclusion

As William Jordy has noted, the Guggenheim summarizes and embodies the major themes of Wright's entire career: the cantilever, the great interpenetrated space, the binuclear plan, the controlled path of movement, the exploration of new materials and technologies, the relationship between form and function, and the exploration of unconventional geometries, but its principal significance is embodied in the transcendent form of the spiral. Wright's lifelong struggle to reconcile the two-dimensional geometry of his plans to the requirements of closure in the third dimension in the form of ceilings and roofs is at last obviated at the Guggenheim by the ramp that winds its way upward through "a structure of dodecagonally arranged web walls," but it began decades ago in the Hanna and Palmer Houses. These designs led Wright down a path where all architectural conventions were set aside. Every sectional view is different; no plan reveals a floor above the first; nothing is rectilinear; everything curves and movement is everywhere implied. Form and function are one; form, function, and symbolic content are also brought together into an unprecedented unity. The representation of nature through geometric implementation is successful and his embodiment of non-rectilinear geometry at its climax. Wright's achievements with these pieces of architecture, along with many others, reflects his cumulative effort to portray nature through architectural design and geometry, by producing buildings that are unique in the world of architecture, and are deeply loved and imitated today.

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58 Ibid.
59 Ibid.
61 Ibid., 476.
Bibliography


Image Notes:


