The Use of Tools in the Creation of Form:
Frank (L. Wright & O. Gehry)

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Abstract
This paper is a study of shape, attempting to understand the effect of Computer Aided Architecture Drafting and Design on the Geometry of Form. This is a part of a larger question: When the tool of presentation changes, does the form generated change as well? The study is in two main parts:
The final questions are: why does form become more complex? How do architects use tools to obtain more complexity? What Computer Aided Architecture Design programs let architects achieve more complexity? For an architect, is the motivation to demonstrate a set of 3D geometric operations sufficient to generate complex assemblies, and are there other possible operations needed?

Keywords
Form, Tool, Digital, Model
Introduction
The first part of this paper will display and compare two buildings, both Guggenheim Museums. The first one was designed by Frank Lloyd Wright, using manual techniques, in New York City, USA. The second one was designed by Frank Gehry using computer techniques, in Bilbao, Spain. For each of them, the building will be presented from the following point of views:


The reasons of choosing these two buildings are:
1 Both of them broke the norm of the form at his time. The helix of Frank Lloyd Wright is a trial to run from the cube, and the free space of Frank Gehry is a trial to create new spaces.
2 Both buildings have the same function, museum, which has very strict requirements.
3 Both of them had the same client, which made the budget limitations for creating new spaces and new forms very limited in the two trials.
4 Each building has different technique of presentation: The Frank Lloyd Wright is a manual technique of presentation, while the Frank Gehry is computerized, using different kinds of software to design and present.
5 The buildings were products of different times; however both of them come from the 20th century, beginning, and end. The Frank Lloyd Wright building comes from a time before C-A-A-D, while the Frank Gehry building was created in a time when Manual techniques are less often used.

2 The Guggenheim Museum New York, USA. Frank Lloyd Wright, Architect

2.1 Building History
In 1943, Solomon R. Guggenheim commissioned Wright to design a unique building to house his collection of avant-garde art. During the subsequent years of planning and design, Wright applied his vision of fluid and organic architecture to the museum. Construction began in 1957 and was completed in 1959, six months after Wright’s death.

2.2 Building Site
The Guggenheim Museum of painting and modern sculpture in New York was completed in 1959. From an urbanistic point of view, it contradicts the usual chessboard type of building, typical of New York, the outside of which presents strong links to the past with flower boxes at street level and the possibility of seating (Figure 2).

2.3 Building Exterior
The main element in the exterior is the spiral theme (Figure 3), which immediately capture the eye. Spiral emerges from the circle; the circular theme goes back in Wright work from 1910.
2.4 Design, Presentation, and Construction Techniques

“Here is the ideal I propose for the architecture of the machine age”, wrote Wright, (Figure 4).

Figure 4. Water Color on paper 1943

The most interesting thing to me is that drawing development of this building took fourteen years. Wright uses perspective – colored (Figure 5, 6) and black and white (Figure 7 to 10) - with ink, pencil, and watercolor. In this way, entrusting it to an organic image of construction. “It is important to note”, the historian Bruno Zevi relates, “how Wright’s space reduces the generatrix, placing itself, not in geometrical terms, but in those immediately plastic.”

Figure 5. Water Color on Paper 1944

Figure 6. Water color on Paper 1944

Figure 7. Pencil On tracing paper-1948

Figure 8. Pencil on tracing paper-1948

Figure 9. Ink on Maylor with colored pencil-1951

Figure 10. Ink on Maylor- 1952

Figure 11. Building Construction

Material used is Reinforced concrete (Figure 11). Despite the structure interest of the building, structure did not determine the form, but – Eventually, at least- the form went searching for structure. The drawings of the building take 12 years of study till are given to the constructor, and the presentation made by watercolor perspectives.

2.5 Building Interior

The inside space is a continual upwards movement using a six-floor spiral with galleries which
spread out from the first ramp indicated by a large water fountain in the central room on the ground floor. The diameter of the spiral as it curves upwards allows for the entrance of light at each level installing in the visitor a sense of luminosity and tranquility. The overlaps correspond to the expanding ramps visible from below culminating in a transparent dome covering the central area.

This special articulation was envisioned as a path from the top of the building which slowly worked its way down to join the urban space from where it began (Figure 12). The continual spiral movement implies a more intimately natural adhesion between the creator and the exposed work of art encountered along the path (Figure 13).

3 The Guggenheim Museum, Bilbao, Spain
Frank Gehry, Architect
3.1 Building History
The Guggenheim Museum Bilbao is one of the major focal points of the comprehensive redevelopment program and architectural renaissance currently underway in Bilbao, Spain (Figure 14). Designed by Frank Gehry to serve as an architectural landmark recognizable worldwide, the museum evokes not only the industrial vitality of Bilbao but also the iconoclastic design of Frank Lloyd Wright's Solomon R. Guggenheim Museum in New York. Gehry's plan for the museum was created for an international design competition organized by the Basque administration and the Solomon R. Guggenheim Foundation in 1991.

3.2 Building Site
The Museum is located in the center of a cultural district formed by the Museum de Bellas Artes, the University de Deusto, and the Old Town Hall (Figure 15). It is set on a triangular-shaped site on the banks of the Nervi—N River.

3.3 Building Exterior
The Museum is composed of a series of interconnected building shapes, clad in limestone, unified by a metal roof that incorporates an array of curving, twisting shapes (Figure 16). The
The architect’s plan creates a dramatic and highly visible structure that achieves a sculptural presence when set against the backdrop of the Puente de la Salve, the Nervi—n River, the buildings of downtown Bilbao, and the hills of the surrounding countryside. The museum’s signature roof the “Metallic Flower” is a composition of forms clad in titanium, a metal similar to stainless steel which gives the facility a unique presence on Bilbao’s waterfront as the metal lights up in the sun.

3.4 Design, Presentation and Construction Techniques

Gehry’s choice of titanium, along with his creation of a design featuring an array of fluid complex shapes, was made possible by the application of a computer program known as Catia (Figure 19, 20). A highly advanced, three-dimensional modeler originally developed for the aerospace industry to map curved surfaces with finite numerical control.

Catia provides the ability to engage in sculptural explorations while maintaining control of the relationship of the geometry to the constructability of the shape by the contractor in a manner not possible with conventional two-dimensional architectural drawings. Catia has freed Gehry’s approach to design. In developing these architectural forms, Gehry first works with paper and wood models at different scales (Figure 17, 18), allowing him to manipulate and refine the shapes that make up the building. Each point on the model’s curved surface is then mapped through a digitizing process, and the resulting computer data is transferred into Catia where building systems are developed and coordinated. Catia is used to control a milling machine, which carves an exact scale model of the building forms. With the computer data confirmed by the milled model, it becomes the primary source of data for the dimensional control for the fabrication of specific building systems such as the structural steel and the automated cutting and forming of other building materials such as stone (Figure 21).
3.5 Building Interior

Frank Gehry’s design for the museum’s interior provides for architecturally distinctive public spaces and galleries, which remain conducive to the exhibition of large-scale Modern and contemporary art (Figure 22). The museum is noteworthy for its relatively simple layout and circulation pattern.

The central feature of Gehry’s design is a 165-foot-high (50 m) atrium more than one-and-a-half times the height of the rotunda of Frank Lloyd Wright’s building in New York (Figure 23). Flooded with light from glazed openings in the “Metallic Flower,” the atrium will serve as the primary arrival and orientation point for the museum as well as a stage for monumental site-specific installations.

Three levels of varied gallery space connected by a system of curvilinear bridges, a glass elevator, and stair towers are located around the atrium. In addition to a group of classically proportioned galleries, the museum includes a series of unique exhibition spaces designed for the presentation of large-scale works of art and site specific installations. The museum’s largest space is an enormous boat shaped gallery 450 feet (130 m) by 80 feet (30 m) that extends eastward underneath the Puente de la Salve and terminates at a tower structure. This gallery will be completely free of structural columns, giving the museum the unique capacity to stage large-scale installations that could not be presented in more conventional museums.

4 Between the Two Buildings

Finally we can learn from these two buildings and from these great architects the followings:

- Both buildings have the same client and the same building type.

- The development of the design process and the drawings are 14 years in the case of Frank Lloyd Wright and just 3 years in the case of Frank Gehry, and this show how much we can save time using new tools of presentation like C-A-A-D.

- Both buildings are new form generation according to their time, Wright try to break the cubism and Gehry try to break the regularity of the form. We can find that the Wright’s building is a very simple form related to new forms today, like Gehry form.

- Very few sketches in Gehry building and a big number of sketches in Wright building.

- Both architects use Perspectives, but Gehry use a digital one and Wright uses a manual one.

- Both architects use models in design process.

- Both architects use very regular galleries beside the very irregular galleries they create.

And now after these two different and similar works, could we say that presentation control form. The research goes forward to an experi-
ment with the computer limitation and the geometry creation and editing.

The following experiment is doing the form of Bilbao museum using 3Dstudio and creates the objects used in reality, and this experiment was based on drawing obtained from Frank Gehry office.

5 Remodeling Bilbao Museum

5.1 Gehry Methodology
Frank Gehry began by building a physical model, and used a 3D-laser scanner, which transferred the 3D objects to a digital model. From that digital model, using the computer graphics software as a tool, he created 2D drawings to finish the construction drawings and successfully build the project.

5.2 Paper Methodology
The paper begins where Gehry ended: obtaining the 2D drawings and using computer graphics as a tool to build the 3D models of the project.

5.3 Starting the Work
Analysis of plans and division of each plan from the objects’ point of view (exterior only) (Figure 24).

- Rebuild these layers with the correct height (Figure 25).
- Divide the building into 10 main objects and construct each object separately. Then connect them and build any remaining linking structures.

The main questions to be asked after this experiment:

- With such irregular shapes, how accurate is the building itself compared to both the physical and digital model? If it is not 100% accurate, does it negatively affect the visual experience and message of the building?

- If Gehry has the tool of computer skills at his disposal, does he need to create a physical model in order to progress to a digital one?

6 Conclusion
When architects learn how to use a tool, it can be used to create new shapes. How can we shift between traditional and new tools? Do new tools make the traditional tools obsolete, or can we continue to use them and transform to the digital
era by using intermediate techniques (as with Frank Gehry and Peter Eisenman, who design by traditional methods and use the laser scanning to transform the model to computer)?

Form becomes more complex with the use of tools which allow better generation and understanding of the form imagined by architects and designers.

There is no limitation upon architectural ideas with the use of the computer. The only limitation is how we can understand and use the tool. As Gehry said, "I just did not like the images of the computer, but as soon as I found a way to use it to build, then I connected”.

Virtual reality and holograms will mark another shift in the future of architecture and its ability to develop a new image of the interior and the exterior of a building. We will have to learn and study these new techniques, as well as existing manual and digital tools.

References