Handbook of Research on Form and Morphogenesis in Modern Architectural Contexts

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Chapter 5
Representation in Architecture as Idea, Physical Model, 3D Modeling, BIM

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ABSTRACT

This chapter describes that representation in architecture has over time been evolving, moving from the concept of idea to physical model to digital model and today to BIM. Historically, from the Renaissance onwards, physical models have been used to document the project, in an effort to make the project more comprehensible to clients and more easily interpretable by those who execute it. A step to 3D modeling has been the most recent change, recording data inside a computer, where the model is made up of geometrical entities. With this advancement, each one has a precise position, size and relation to other elements. The evolution of 3D modeling led to a computer-controlled output (CAM). In order to better understand the CAD/CAM procedure, reference is made to the design path followed by Gehry, a forerunner in using this kind of procedure, from the "Barcelona" Fish to the latest work, where we can find BIM solutions. Thanks to 3D modeling and BIM, the project today has acquired a new central role, implicitly entails the need of sharing the information support (model and database) among those involved in processes affecting the whole building life cycle.

1. INTRODUCTION

In architecture, project management has often been linked to the medium used by designers to convey their message to those who execute the actual work.

In Italy, the new code of contracts (Legislative Decree 18 April 2016, no. 50 and subsequent modifications and supplements) has made Building Information Modeling (BIM) mandatory for public works, by means of a "gradual" procedure: this latter will be effective from 1 January 2019 for certain works and gradually extended to all by 1 January 2025.

Will such tool effect the morphological choices in architectural projects?

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From the Renaissance onwards, physical models - mostly wooden – have been used to document the project (in an effort to make the project more comprehensible to clients and more easily interpretable by those who execute it). They crystallized the original idea and passed it on, even when the designer, given the considerable length of time of construction processes, had passed away.

In the early Eighties, a more widespread use of computers led to the first "3D digital models". Starting from the Nineties, they have evolved as a natural development of the technological progress in the form of CAD/CAM. Today, the BIM process represents a further improvement of those past developments. This tool is required on a European level (implementation of Directives 2014/23/EC, 2014/24/EC and 2014/25/EU) to check the design, construction and maintenance process. It ensures the interoperability among different procedures and players in the construction sector.

2. PHYSICAL MODEL

In art and design, the "physical model" has always played an important role in the development, presentation and sedimentation of ideas.

During the creative phase, the model must be adaptable; it should not simply freeze the design idea in the form of a three-dimensional object at any given time. It should lend itself to adjustments and changes without constraining and inhibiting the creative process, just because time and energy have been used to make the model itself. Therefore, the quality of the final project partly depends on how easily the physical model can be manipulated and adapted.

The role of the physical model as a final, summary expression of an idea is key in many types of architecture, starting from the Renaissance.

Using a model to summarize the characteristics of a project was a common practice whenever it took longer than the lifetime of the architect or developer to complete it. It was a way to ensure that the large-scale construction diagrams could be completed in accordance with the initial plans (Baker, 1993).

3. THE MEANING ATTRIBUTED TO THE "MODEL" STARTING FROM THE RENAISSANCE

In the Renaissance, according to De Fiore (De Fiore, 1967) the term "model" indicated a smaller scale of the final design (prepared after the sketch and study) of the work of art to be performed for a client. The "model", in fact, was attached to the contract between the artist and the client.

Even Vasari, in his "Lives", emphasized that the use of models was a common practice in architecture; in fact, "men of these arts called or distinguished the drawing in different ways, and according to its quality. Those that are just light touches with a pencil or other means are called sketches, as will be explained elsewhere. Those, then, with the first lines around are called profiles, surroundings or features. And all of them or profiles or otherwise thus serve to architecture and sculpture as well as to painting, but especially to architecture; therefore, drawings in architecture are made of lines. To architects, this is both the beginning and the end of such art; everything else, by means of wooden models resulting from those lines, is nothing but the work of masons and craftsmen" (Vasari, 1568).

The golden age of the architectural model came when Saint Peter's Basilica was erected in Rome, as Gentil Baldrich (Gentil Baldrich, 1994) highlighted. Both Antonio da Sangallo the "younger" and Michelangelo used this procedure to better define their work; indeed, this was considered the final stage of a certain way to design architecture. Together with Vasari who used the model systematically, Andrea Palladio represented another, more accurate way to define architecture. He used the latest graphical procedures, quite different from the indispensable preliminary model (Puppi, 1987).

On the other hand, Millon (Millon, 1994) emphasized that according to Leon Battista Alberti models played an additional and important function. In his opinion, an idea or "drawing" could only be realized through a physical model. The idea formed in the mind and, as such, was imperfect. It could find its shape only through the review, evaluation and changes resulting from drawings. These had to be pondered, judged and enhanced by means of models, thus getting closer to the expression of an idea. Therefore, according to Alberti, the architectural model was not a means to submit an idea to a client, but rather a tool to explore and realize an idea. To Brunelleschi and Michelangelo, the model was apparently the representation of an idea already fully formed in the mind and served as a guide to workers (Fasolo, 1994).

In the nineteenth century, Francesco Milizia considered the "model" like Brunelleschi: "the only drawing an architect truly needs is that of architectural things. This acts as a character revealing his ideas. It must be exact, natural and based on the theory of the shadows. But, eventually, it is just a character, i.e. a means which does not cause any significant waste of time and leads to more interesting things. The same applies to the model, whatever matter it is made of; it does not require any adjustment. It helps show to outsiders, as well as to architects themselves, both the good and bad effects of the idea that they expressed. Therefore, a model should be as large as possible, it should adapt to a point of view corresponding to that of the work, be seen and noted in a site, where the air and light produce the same effects that will result from the finished building. What a distance between a drawing and a building! Things do not move from imagination to reality without a loss" (Milizia, 1847).

Ultimately, the "model" is seen as a "three-dimensional model". It is especially crucial when drafting the design. Its communication intensity is well beyond a simple formal exposure: it is not by chance that it represented the most important element in managing the construction site.

Croset wrote: "Beyond their being objects, these "maquettes" raise our interest because of their representation function. They both crystallize a thought and anticipate a construction reality" (Scolari, 1988).

In every theory of imitation in architecture (literally, "object of mimesis"), the model is strongly idealized: it derives from the latin *modulus* and *modus*; the word "model" evokes the notions of measurement, standard, rhythm, mode, limit, up to the platonic sense of "ideal shape", a "paradigm" for material life.

Construction techniques developed after the first Industrial Revolution. They considerably shortened the time required to complete great works, increasing the importance of the executive design to the detriment of the use of the physical model. The division of labor into several steps caused a decreased need to build one large single model in which to enter structural and aesthetics information.

4. INNER AND EXTERNAL DRAWING. FEDERICO ZUCCARI'S MODEL

From the Renaissance onwards, the notion that most resembled the "digital model" is intrinsically related to the meaning of the term "idea".

An idea comes to life through abstraction, i.e. a rational, intellectual and logical reflection of the learning experience; in fact, the intellectual process that characterizes the use of an idea is logical, since it is consistent, sensible and rational.

In particular, it is useful to recall the terms coined by Federico Zuccari (Robotti, 1989) (1542-1609) in his theoretical treatise "Idea de' scultori, pittori e architetti" to strengthen the ancient notion of drawing as the fundamental core of any art and theory related to it. Zuccari's work can be considered one of the first significant documents of the philosophy of art in the Mannerist period. He split the notion of drawing into two parts: the "inner drawing" (the idea that lives in the mind and sensitivity of the artist even before beginning his work, therefore pre-existing in the same sketch) and the "external drawing" (the shape taken by the inner drawing, moving from the world of ideas to matter). De Fiore specified:

In the scholastic system that Zuccari built in the artistic philosophy of his "Idea", the confusion between two originally and mutually alien categories, one psychological and the other metaphysical, is quite evident. Zuccari referred to a drawing inside and one outside; the first, he said, is what "philosophers" and "logicians" called intention while "theologians" called it exemplary or life. Here, his confusion is evident and favored by the extremely ancient confrontation between the creator-artist and God; its traces can be found in modern languages (création, creation, etc.). The course of these ideas is fed by the traditional scholastic comparison between the other-worldly, higher idea and the exemplum, the model based on the medieval artistic conception or project, according to the most recent version. As significant is the adoption of such ideas in the Romance languages: the Italian "disegno", the French "dessin", the English "design" not only are equivalent to Zuccari's outside drawing but also to something that is closer to his inner drawing: intention, purpose. Through a somersault of thought, the artistic idea comes to a life of its own; a concept falling within the scope of individual psychology becomes an objective category that dominates every single artistic creation. In line with the Aristotelian theory of possibilities and reality, Tasso's Dialogues explain that the power to create a statue precedes the statue itself, since the geometric shape is an innate part of the spirit. Even Romano Alberti confirms one of Zuccari's beliefs, when he claims that the idea pre-existing in the spirit of the painter is independent of his work, i.e. its execution; this latter is a pure addition that belongs to the lower mechanical sphere (De Fiore, 1967).

According to Vagnetti (Vagnetti, 1981), Zuccari resorted to two complementary concepts of "inner drawing", i.e. an immanent idea in the mind of the artist, and the "external drawing", namely a graphical appearance of the idea expressed by its figurative explication. In this sense and according to the sophisticated, yet profound spirit of the Mannerist culture, the "external drawing" possesses its own intrinsic legitimacy and dignity. It transcends its simple instrumental aspect, precisely because it reflects the "inner drawing"; it is generated by this latter and this is why it exhibits the seed of the divine spark popping up from an idea.

We report two further definitions of "idea" taken from Dictionaries and Encyclopaedias:

The word idea has three fundamental meanings: universal form or species, representation or contents of the mind in general, project or anticipation. The first meaning was attributed to this word by idealist metaphysical authors, from Plato to Hegel. Descartes, the English empirists and a good deal of modern philosophers adopted the second definition. The third meaning of the word is typical in pragmatism and the philosophies of science, where it takes on the meaning of anticipation, project and hypothesis pending its verification.

Only in the modern age the term has pointed to a properly mental entity, contents of thought, and has later preserved its most common meaning: however, this change in value has not made the Medieval esse idealiter ineffective. Thanks to conceptualism and nominalism, it returned the idealitas to the sphere of metaphysical objectivity and subjectivity thinking.

5. 3D MODELING

With the advent of the digital environment, the idea of a large single model, namely a computerized database, has gained popularity.

The first 3D systems had simple shapes, with a video tracking of the lines in all edges, often creating an ambiguous wireframe image. As the objects to represent in 3D became more complex, understanding the model view in wireframe became more difficult, too; therefore, algorithms were developed to remove hidden lines and display only surfaces visible from a certain point of view.

The next step consisted of realizing 3D models made of solid elements; the first summary images, quite photorealistic, were extrapolated from these latter. The techniques of perspective used for centuries to provide the illusion of depth were transcribed into three-dimensional graphics software.

The difficulty in describing three-dimensional objects generates a key issue in the development of computer modeling software. The computer is required to reduce the gap between reality and the illusion presented on the two-dimensional surface of the screen. To perform this operation, the computer must "process" across three dimensions. This is essential to manage the different 3D views of the object existing in its memory. While performing a perspective, an artist simply makes an object plausible from a certain point of view. A computer must be able to simulate all three-dimensional properties of the object stored in its memory.

Therefore, a significant difference exists between the way a three-dimensional model is recorded inside a computer and the way it is displayed. A computer model is made up of geometrical entities (points, lines, plans). Each one has a precise position, size (resulting from the three reference axis x, y and z) and relations with other elements. A model displayed on the screen considers these attributes as well as the observer's position, checking its perspective, lighting, texture and the representation scale.

When watching a physical model, the observer is not fully aware of the complexity of relations involved in such a simple gesture. The observer stands at a certain distance, with a certain angle of view, having a partial view of the model. When he or she moves, they perceive other views: to catch more details, the observer gets closer whereas when they walk away they get a broader - albeit less detailed - view. The observer often performs these actions unconsciously.

However, when this information need to be transposed in computer terms, the processor must compute all the factors highlighted for the physical model to provide the same type of three-dimensional reading. The difference lies in the fact that in the 3D modeling view, the reading path must be prearranged and driven by a conscious choice. The observer exactly determines the spatial relationship between him and the 3D model.

This feature often makes 3D modeling very complex. 3D modeling needs to be realized differently from its possible physical counterpart, since the information provided must be consciously created.

In this regard, it is worth recalling Goulthorpe (dECOi group) referring to the Paramorph project: "when processing a creative paramorphic process we do nothing but extrapolate Gaudi's accurate rationality, using the computer processing power to transform an analytical intuition into creative energy.

But while Gaudi used relatively rough physical models to draw basic structural systems that were then subjected to a laborious descriptive translation into continuous lines, our point of departure is the constraint represented by a continuous line; it should be able to play freely in order to create new formal possibilities in an extremely easy way without a computer defining them in space" (Goulthorpe, 2000).

6. THE CAD/CAM PROCEDURE

The evolution of 3D modeling (CAD, Computer Aided Design) led to a computer-controlled output (CAM, Computer Aided Manufacturing).

CAD is the use of information technology for the design and project documentation. CAD/CAM applications are used to both design a product and plan manufacturing processes, especially those relating to CNC mechanical machining. CAM software uses models and assemblies created in the CAD software for generating tool paths that allow the machinery to transform projects into physical parts. CAD/CAM software is often employed for prototypes and finished parts.

In order to better understand the CAD/CAM procedure, reference is made to the design path followed by Gehry, a forerunner in using this application (Empler, 2006).

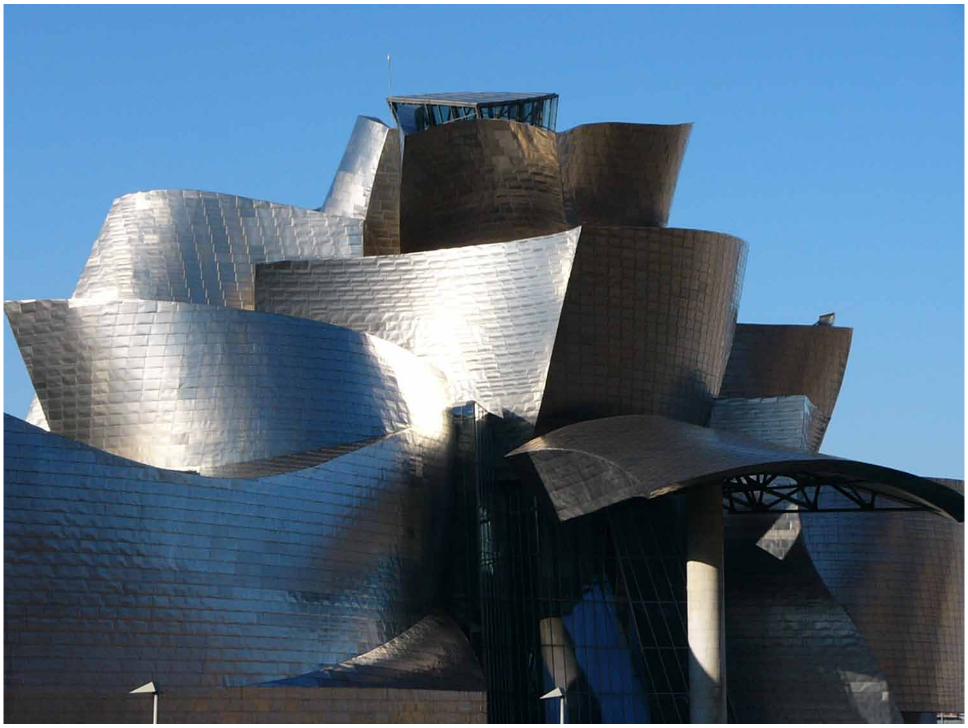
Gehry considers the computer as a tool, not a partner; a tool to draw a complex shape, not to invent it. His design approach is based on the creation of numerous physical models in which the computer (together with other technological tools) becomes one of the instruments to support the creative phase.

In 1989, after designing the shapes of the Vitra Design Museum thanks to descriptive geometry and conventional representation techniques, Gehry and his associates wanted to obtain more complex shapes. They decided to try and exploit the IT potential. In order to understand how to operate and which direction to follow, they turned their attention to the aerospace component industry. They explained their new design needs. After analyzing a number of systems that turned out to be inadequate for their needs, Gehry's Firm identified CATIA (Computer Aided Three-Dimensional Interactive Application) by Dassault Systèmes as a potential application tool. This software was specifically realized for the French aircraft industry to manufacture Mirage fighter aircraft. Dassault initially provided a great deal of support to the design through their software. But the great success of the "Barcelona" Fish created a strong interest in the application on the part of the aviation industry and in particular by Boeing, the American aeronautical industry making civil aviation jets (which meant a thousand operational stations). Consequently, the software-house reduced their support in the field of architecture, since the construction of serial components, such as cars and airplanes, allowed the French company to pay back most of their initial investment. They could hardly obtain the same with the construction of buildings that are generally different from one another.

The great success of the Guggenheim Museum in Bilbao changed again the equilibrium between architectural design and Dassault. They realized it was important to develop applications also for designers. Later, the same Gehry, in 2002, founded his own technology company to provide a full IT support to design firms and engineering companies. They developed a specific software called "Digital Project".

Most schools of architecture and designers use computers to preview their works. Since Gehry wanted to make buildings, for a long time his firm did not use appealing rendering applications. The American architect looked for a direct relationship with the companies that realized his works. He characterized himself as "the old image of the architect as a master-builder".

Figure 1. Detail of Gehry's Guggenheim Museum in Bilbao



He believed that a designer should directly control the entire construction process, from the beginning to the end, as in his Prague and Bilbao works.

After those experiences, his subsequent projects followed of a new way of working called Architecture-Engineering-Construction Industry.

Gehry married the new creative-digital process without changing his work method; the computer allowed his employees to check and verify more easily the realization of many of his weird and complex shapes. Gehry processed his ideas slowly, moving from the initial schemes to the realization of a long series of physical models: he sat, watched and moved the objects making up his "maquette". The digital input happened with the subsequent operations, when technologically advanced tools imported into the computer information about the physical model. This approach satisfied Gehry in the creation of a computerized virtual building.

This procedure provides for an optical pen to touch the corners of the physical model, which are transformed into vectors of a reticular system, an exact digital copy of the physical model "detected". A volumetric scanner allows the virtual transposition of the object regardless of its complex shape. In this way, you can enter the virtual 3D model while using the traditional instruments of architecture, i.e. the horizontal and vertical sections that allow the execution of the distribution plan and the functional organization of space.

The organic shapes of Gehry's buildings are often the outcome of the most advanced aerospace techniques: for example, the façade coatings are individually designed by the computer. A case in point is the Experience Muxic Project in Seattle.

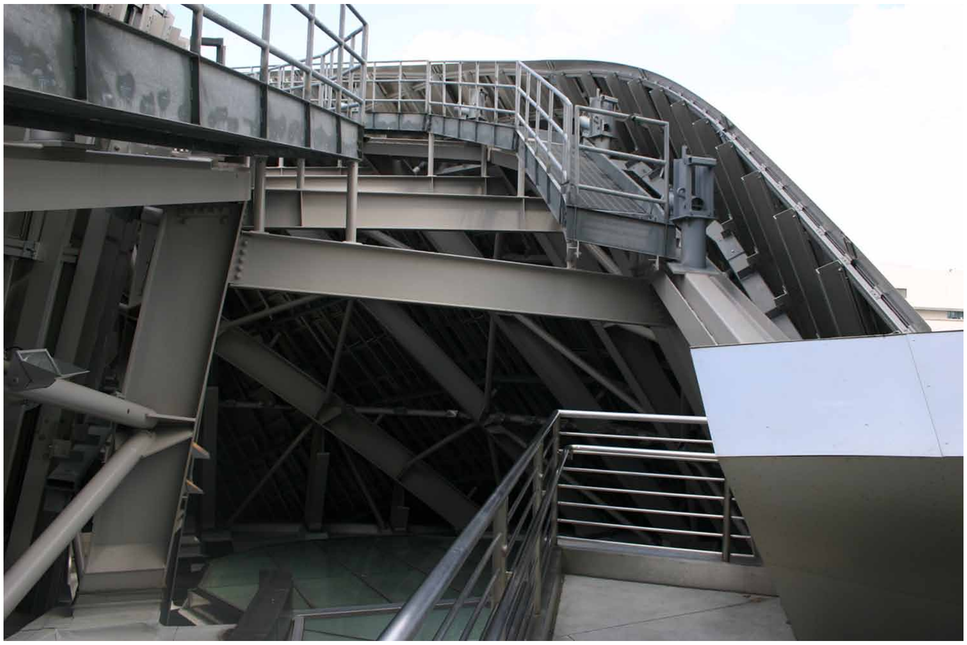
Figure 2. Detail of Gehry's Offices in Praga

The outer surface measures approximately 19,000 sqm. It consists of over 3,000 different panels by five square meters on average. They are drawn one by one by the computer and later applied to the structure by means of a system of pipes and aluminum joints. IT innovations are also in use in structural calculation and manufacturing. Overall, 280 structural elements are sized thanks to a fully computerized database which excludes human intervention in computing an individual component. The geometry of the forces required to hold the structures is automatically calculated and adjusted to the designer's requirements.

Therefore, Gehry's Firm used such sophisticated computer equipment not for figurative but for mere manufacturing needs linked to CAD/CAM criteria. Gehry used the digital tool downstream a project to verify its content, sizing, technological controls and possibly make suggestions.

One of the biggest obstacles that Gehry encountered in moving on from project ideas to their realization was the ability to represent complex 3D shapes with 2D drawings. Gehry's Firm performed accurate measurements of preliminary physical models and developed multiple sections and plants to try and describe projects as comprehensively as possible. Unfortunately, these drawings were made on

Figure 3. Detail of Gehry's Walt Disney Concert Hall in Los Angeles



traditional media (glossy paper). Hence, they are subject to wear, are expensive and tend to make the shape more complex than it is in reality. This generates a feeling of uncertainty among the makers, with a consequent error in the cost estimate and the success of the project.

This is the reason why, since the beginning of the nineties, Gehry has been searching for a software that could manage complex 3D models, leaving the design process unchanged. This latter is largely based on the creation of physical models.

As already mentioned, Gehry's first digital output was the large sculpture of the "Barcelona" Fish. It was erected on the sea front of the Olympic Village in 1992. The sculpture is 56 meters long, 40 meters wide and 45 meters high; it is characterized by numerous and highly complex curves. It was hard to represent them through the traditional two-dimensional documentation. Initially modeled in wood and metal, the curved surfaces of the fish were coated with braided strips of stainless steel, which rested on a steel substructure.

Because of the tight timeline, the use of the computer was tested as a medium to communicate the project idea to manufacturers. A first attempt of surface modeling was realized with Alias software; however, although the representation was visually accurate, this software proved to be limited in many other ways. Indeed, like most architectural rendering software, Alias defined the fish surface as a grid of polygons.

Conversely, a software like CATIA, with a complete numerical control of the operations performed by the computer, defines the surfaces using mathematical functions that steel manufacturers can apply to create the sculpture. Thus, an architect or a manufacturer can extrapolate the precise location of each point or surface of a single object or component from such model.

As soon as this software proved to be reliable, the selected contractor, Permasteelisa, purchased a CATIA package to have a direct dialog with the design model.

The new design procedure was based on the creation of a 3D model of the “Barcelona” Fish thanks to CATIA; its accuracy was then checked by building a cardboard physical model with the aid of a numerical three-dimensional control laser cutter, where input data were received directly from the computer-generated model. Later, Gehry made minor changes and verified that the new model fitted his original design idea.

The final sculpture was completed with stunning accuracy and speed. It only took 6 months from the preliminary design to the completed construction. Out of thousands of connections, only two were wrong (with a maximum deviation of 3 mm), while all the others were perfect. Moreover, few traditional construction drawings were prepared. Two-dimensional drawings of curved surfaces can be beautiful, Gehry admitted, but are misleading. With this system, you can see how to build them. The fish sculpture convinced Gehry and his associates that model data obtained through CATIA could be used to help generate complex shapes quickly and accurately.

The Hannover bus stop project further improved the procedure employed for the “Barcelona” fish. The steel roof was supported by a thick system of “T” steel vertical elements. Both the coverage and the structure were modeled with CATIA: traditional design drawing and documentation for the construction tender were also created in this way. The contract awardee, Permasteelisa, submitted a bid one third lower than their competitors when they learned that they would receive data directly from CATIA.

The exploration of CATIA potential, from the point of view of controlling construction costs, further improved with the limestone coating of approximately 18,600 square meters at the Disney Concert Hall in Los Angeles. By defining the thickness of the raw stone blocks and the cutting time as primary costs, it became relatively easy to realize that such costs increased as a function of the geometric progression of the cuts, moving from a flat surface to complex curved surfaces.

Gehry began his project by constructing a paper model characterized by irregular floral curves. The project model was then digitized by using a Firefly optical system. The resulting coordinates x,y and z were entered into an IBM RISC/6000 on which CATIA was installed. In turn, CATIA rationalized the surfaces so as to obtain repetitive elements without altering the shape of the building.

The CATIA database of the rationalized model surfaces helped realize a physical model by means of a computer-driven numerical control milling machine. This latter was then compared to the original model and, where necessary, modified.

The CATIA database, which was also used to generate the project documentation, was supplied to the stone subcontractor. The stone cutting and the cutting support system were submitted to 14 companies using 3 and 5-axis milling machines. Moreover, four of these companies were required to build a portion of the wall (3x4 meters), using only computer-controlled CNC milling machines. The selected subcontractor, Harmon Contract and Furrer Spa of Carropuo, Italy, did not exceed the estimated budget costs. Both Harmon and Furrer used CATIA workstations to execute the project.

The advantages of CATIA are not only evident in the design of the Disney Concert Hall. FOG/A used CATIA also to design the Prague offices, albeit with a different mode. For the first time, the entire building was put together as a computer 3D model. It mainly consisted of solid and surface elements, another unprecedented experience for Gehry’s staff. The project involved complex curves carved in concrete, steel and pre-fabricated glass. The CATIA database along with other CAD tools enabled the staff to model a unique system of glass and metal.

Figure 4. Aerial views of Seattle's Experience Music museum by Gehry

The design details did make the manufacturing feasible. The initial budget for the glazed surface amounted to $200 per square foot (1 Square Foot = 0,0929 m2). With the aid of CATIA models to detail the various elements, Gehry worked in close contact with the subcontractor. That collaboration allowed to cut the cost by 1/3, down to $135 per square foot.

FOG/A exploited CATIA also to design the Guggenheim Museum in Bilbao, where it was used to completely define a complex sculptural surface of 24,000 sqm. After gaining his experience with the "Barcelona" fish, the bus stop in Hannover, the Disney Concert Hall, the Prague project and DZ Bank in Berlin, Gehry added advanced construction and manufacturing 3D CATIA models to more traditional project documents based on AutoCAD.

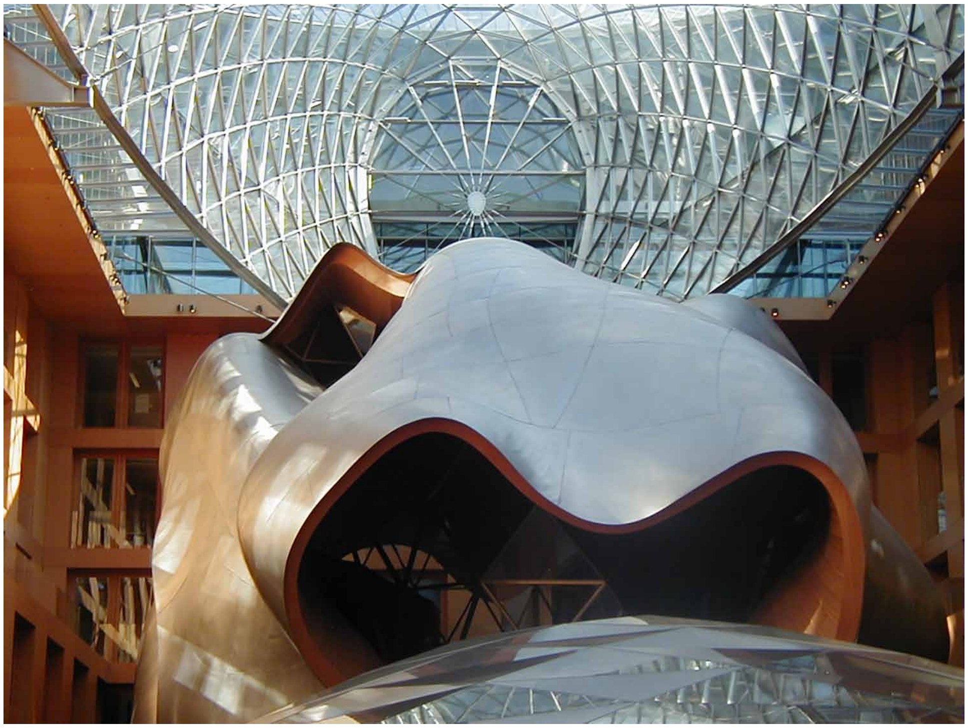
As in previous projects, the 3D surface modeling of CATIA was crucial for dimensional control. AutoCAD models derived from CATIA geometry and were exported using IGES as a derivation process. In this case, they developed a complex integration of CATIA and AutoCAD to facilitate the design process and obtain high quality technical documents.

Once each individual part of the building was completed with CATIA, the 3D model containing faces and superficial elements was sent to the milling workshop where they generated a physical model making use of the same CATIA database. Each piece subsequently underwent a full computer testing.

In a very short time, Gehry's investment in computer technology led to a sophisticated and diversified set of software and hardware tools. They used tools ranging from PCs for word processing to Sun Sparcstation 20 servers with internet access.

The suite of hardware platforms used by Gehry includes four IBN RISC System 6000 on which the following modules of CATIA version 4 are installed:

Figure 5. Gehry's DZ Bank in Berlin



- Advance Detail Design;
- Free Form Design;
- Publishing Package;
- Interface;
- Develop.

Gehry's firm (Gehry Partners LLP) established an engineering company called Gehry Technologies (GT) to manage the complexity of Gehry's projects. In its turn, Gehry Technologies developed the Digital Project software, an application designed to support construction projects in a common digital environment. All this paved the way toward BIM.

7. BUILDING INFORMATION MODELING

In contemporary design procedures, the geometric modeling of architectural shapes and the management of non-graphical information are integrated. This convergence results from the constant innovation and the growing pervasiveness of computer tools: however, the impact goes beyond the mere technical updating of operating systems; it has a profound impact on professional, educational and research areas across every aspect of design and construction.

The new tools available to the designers are much more sophisticated and integrated than in the past. While they used to consider the act of drawing as a selective operation traditionally linked to a projection, they now focus on simulation of reality as a parametric modeling activity. The processing of a 3D virtual model allows a higher level of complexity and therefore enables a high degree of knowledge and transformation of reality in both its visible and invisible aspects. This new interpretative option, marked by a greater definition of each element, allows to check the amount and details of data. This unprecedented development puts the project at the center of the entire process.

The idea that the project has acquired a new central role, thanks to 3D modeling and BIM, implicitly entails the need of sharing the information support (model and database) among those involved in processes affecting the whole building life cycle. Another major consequence is the automatic update of remakes when design elements change (gross/net surfaces, aero-lightening ratios, volumes); each model (or several consistent models) is adjustable. It can represent and check any interference between the various disciplines contributing to the design effort (architectural, structural, energy, plant, etc.) (Cristofolini, Massari, 2016).

Still, it should be remembered that the term BIM indicates a managing process, where 3D modeling is only one function. In the BIM procedure, in addition to the three-dimensional modeling, software is interoperable, with an integration of processes and a sustainable procedure. According to this meaning, whatever relates to 3D modeling is only one of the aspects making up a horizontal liaison, where data of different nature can coexist and be collected.

3D modeling (Empler, 2008) is especially significant in the initial part of the BIM process linked to the phases of relief, conceptual and detailed design. The modeling software fulfills different goals based on the initial data: in "relief", software can help managing the cloud of points (like Cyclone, Recap and Scene, etc.); in "conceptual design", software helps numerical modeling or mathematics (like Rhinoceros, Blender, etc.); "parametric modeling" software is commonly employed in the detailed design (like Archicad, Vectorworks, Revit, Digital Project, etc.).

Gehry Technologies (GT), also thanks to Digital Project, can operate in a BIM environment in two ways: on the one hand, it acts as a "service company" to support the design activity of other firms or design companies; on the other, it supports Gehry Partners in using BIM to complete the design and construction processes of each project.

Gehry Technologies, on the occasion of the tender for the design of the Cleveland Clinic Abu Dhabi, helped Sixco Samsung JV get the contract by providing a detailed simulation of the design process from start to finish. They allowed the "main contractor" to define the process and methods for implementing a 4D data system.

They developed a multidisciplinary BIM procedure, fully coordinated across all processes. A BIM platform was globally accessible to facilitate collaboration among the different multinational "teams" of participants. Such platform operates through an efficient construction program. It quickly develops the project in BIM mode, through a combination of "in-house" data processing models and the integration of BIM geometry across several subcontractors, using the interexchange IFC format.

This approach guarantees the quality of the BIM content, embedded in the "Master BIM". It works simultaneously with the contracting entity and with subcontractors. Currently, GT manages the coordination of construction activities, solving any design problems while validating means and methodologies. In this way, delays and costly errors are minimized whereas efficiency, safety and progress in the construction site are maximized.

In the design and realization of the Louis Vuitton Foundation, Gehry Technologies developed a full 3D design system. They used Digital Project for 3D design and developed an initial version of Gteam to work in a BIM environment. After creating a common platform for design, engineering and construction activities, the project could benefit from a rapid 3D design iteration, allowing the various design "teams" to achieve a level of architectural innovation rarely reached in such a short period of time. Hundreds of 3D adaptable details have been developed. They are called smart components and allowed the design "team" to generate thousands of categories that vary in a generative and consistent manner, while keeping complexity, cost and quality under control. The BIM system handles the distribution, version, access and security of the model as it is developed by "teams" distributed all over the world. A precise structure for the organization of data allows a team of over 200 professionals to collaborate in a structured way on a single project template.

The role of GT in the construction phase of the project has been expanded to include the management of the design "team", the "general contractor" and 3D information along the supply chain. GT worked with every "team" and subcontractor to manage the overall organization of the project.

Clients not only support a widespread use of BIM as a design, engineering and construction tool; they use BIM extensively for internal communication, for the museum curatorship and for maintenance schedule operations.

8. CONCLUSION

With the introduction of 3D modeling, the evolution of representation techniques is accompanied by an equivalent improvement in production and achivement techniques. The path of Gehry's study can be considered, following this way, ante litteram. The canadian architect first used physical models, then digital models, to which he associated CAD/CAM procedure, and finally developed, with Gehry Technologies, a BIM software: Digital Project.

Arup's office is one of the first firm to embrace the potential of BIM in Europe. They applied BIM to the "Water Cube", the water center identified by the "soap bubbles" effect, which hosted some of the Beijing Olympic Games competitions.

In southern Europe the use of BIM could provide a realistic help in optimizing and managing complex phases of design and construction, with a useful utility also during buildings maintenance.

At present in Italy, for example, a smaller percentage of architectural firms have completed the passage to BIM, two of them: in Milan, Antonio Citterio Patricia Viel has already made use of the BIM platform for some work in Expo Milan 2015 area; in Rome, but also in France and Switzerland, operates Parallel Digital, a newly established company of architects and engineers specializing in development of projects in BIM, as the seven metro stations, called Red Line North, in Doha.

An acceleration could come from the Legislative Decree 18 April 2016 no. 50. Even though no mandatory provision exists, the legislative instrument makes Building Information Modeling (BIM) mandatory for public works, by means of a "gradual" procedure: this latter will be effective from 1 January 2019 for certain works and gradually extended to all by 1 January 2025. Will the Italian architectural firms, especially the smaller ones, succeed in adopting a tool capable of altering the very nature of design, thus having the opportunity, among other things, to access competitions and competitions around the world?

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