

A Study on the Impacts of Computer Aided Design on the Architectural Design Process

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Abstract—Computer-aided design (CAD) tools have been extensively used by the architects for the several decades. It has evolved from being a simple drafting tool to being an intelligent architectural software and a powerful means of communication for architects. CAD plays an essential role in the profession of architecture and is a basic tool for any architectural firm. It is not possible for an architectural firm to compete without taking the advantage of computer software, due to the high demand and competition in the architectural industry. The aim of this study is to evaluate the impacts of CAD on the architectural design process from conceptual level to final product, particularly in architectural practice. It examines the range of benefits of integrating CAD into the industry and discusses the possible defects limiting the architects. Method of this study is qualitatively based on data collected from the professionals' perspective. The identified benefits and limitations of CAD on the architectural design process will raise the awareness of professionals on the potentials of CAD and proper utilization of that in the industry, which would result in a higher productivity along with a better quality in the architectural offices.

Keywords—Architecture, architectural practice, computer aided design, CAD, design process.

I. INTRODUCTION

BY introduction of CAD in the building industry, a remarkable progress was made in terms of variety in design, quality of the final product, and efficiency in the process of design.

Use of CAD is becoming more and more popular to simplify the complexity of today's architectural design projects. CAD products in architectural designs are easy-to-store, and can be easily used for communication purposes among the people who involve in the design and construction process. By means of CAD, it is easy to visualize how a building will look and work after its completion both aesthetically and technically. It is also possible to study and visualize the structure from different perspectives in order to minimize its undesirable impacts. Moreover, CAD assists architects in providing different types of information for variety of purposes such as: architectural plans, elevations, sections, interior drawings, landscape designs, etc. CAD also makes the process of editing and revising much faster, as it allows architects to store their designs, which means that they do not need to start from the beginning every time they revise a design.

In general, it can be said that CAD made a big revolution in

the building industry. In view of that, this study is going to take a look at the role of CAD in the architectural industry, and underlining how CAD has revolutionized the architectural design process.

II. CAD: ITS DEFINITION AND IMPLICATIONS IN ARCHITECTURAL FIRMS

CAD refers to the process of using computers and specialist software to create virtual three-dimensional models and two-dimensional drawings of products. Various different types of CAD software have been developed for use across a range of applications and industries [1].

CAD is about using computer technology during the design process and its documentation. CAD can be used to create 3D models, which demonstrate accurate calculations of designs and structures. There is no doubt that architects will be limited if they do not use CAD; a complex and intelligent software is needed to create complex designs and structures. By means of CAD, such designs would be much easier and simpler to complete.

Before CAD, architects had to use traditional pen and paper method to draw; every single drawing and measurement had to be drawn by hand, which was a time-consuming process. It would take days or even weeks to produce work that CAD could produce in hours. However, it does not mean that pen and paper method is outdated; some architects still prefer to draw their initial design concepts on paper before transferring them to CAD.

With CAD, architects can create various design options and are able to develop their concepts into detailed designs, and then providing 3D visualizations and simulations. That makes it possible for them to see different aspects and perspectives of their building without needing to build any physical structures or models. This allows them to control and fix problems quickly and efficiently. They can then demonstrate these designs to their clients as a virtual tour.

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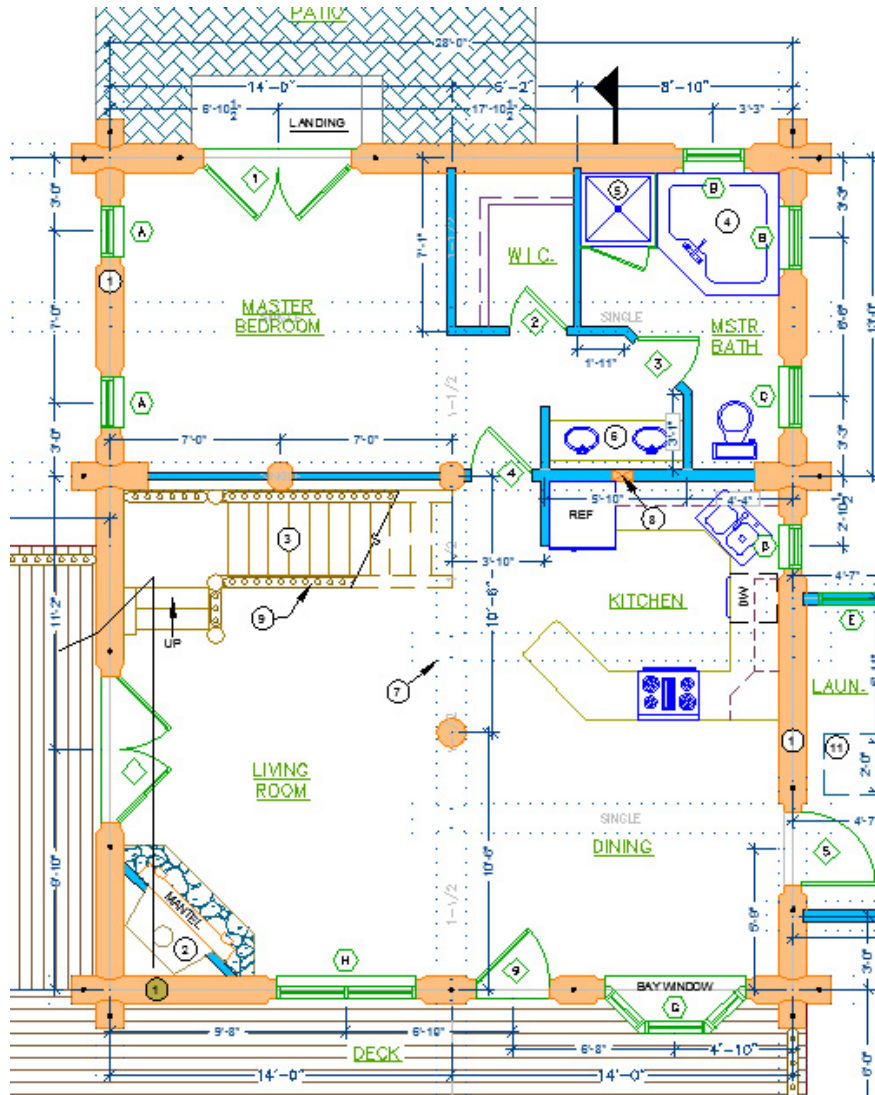


Fig. 1 Example of a floor plan in AutoCAD [2]



Fig. 2 Example of 3D design visualization in Revit [3]

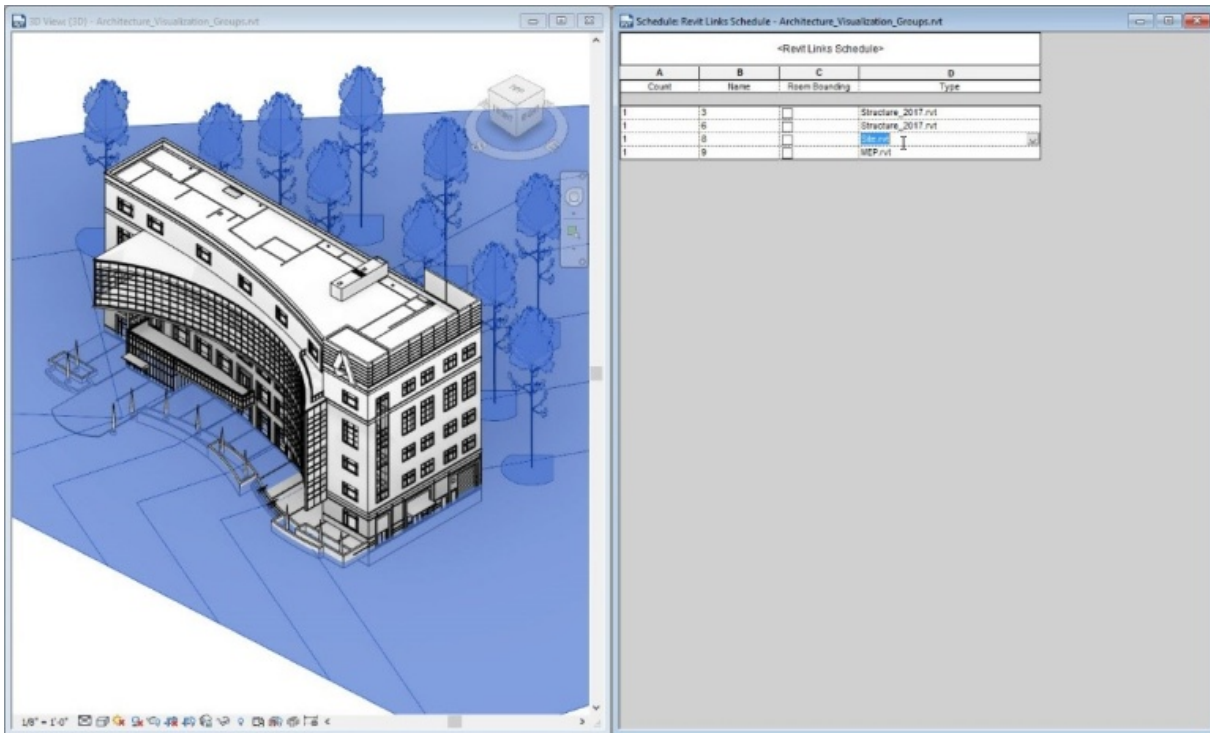


Fig. 3 Screenshot of Revit's scheduling system [3]

III. ARCHITECTURAL DESIGN PROCESS

Architectural design process is a creative and problem solving process [4]. The process of design is a sequence of activities that an architect needs to follow from the beginning of the design till reaching the final product. The architectural design process is a complex and ambiguous process. The designer typically starts from an abstract problem and develops it through various stages to achieve a detailed final solution.

Generally, architectural design process can be categorized in four major steps [5]:

1. Sketch design stage (conceptual sketch drawings);
2. Preliminary design stage (more detailed sketch drawings);
3. Definitive design stage (detailed drawings);
4. Final design stage (working drawings).

In order to identify the impacts of computer tools on each stage, being potentially strengthened and improved, or in contrast being limited, it is required to understand the activities and tasks of the designers in each stage better.

The sketch design stage is an abstract and unclear one and it is more related to the creativity of the architect. In this stage, the architect defines concepts and basic ideas. Initial thoughts on the form of the building in relationship to its function and the location of the building can be seen in this stage. Sketch drawings mostly illustrate the principal ideas of the architect that underlay the design. These sketches might be used as a communication tool between the architect and the client, or between the architect and his/her colleagues.

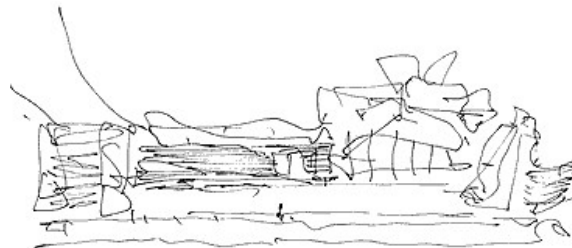


Fig. 4 Hand drawn sketch by Frank Gehry, Guggenheim museum, Bilbao, Spain [6]

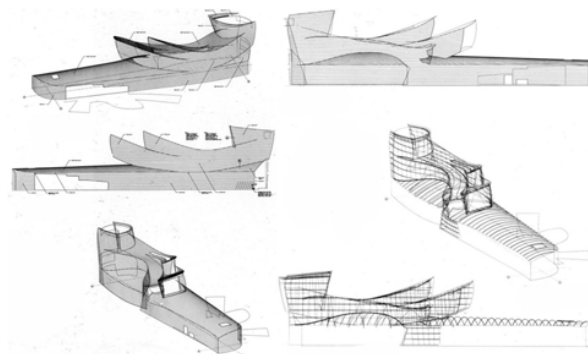


Fig. 5 Preliminary Drawings, Guggenheim museum, Bilbao, Spain [7]

The preliminary design stage is more precise and detailed type of drawings. Most of the time, architects create a detailed physical 3D model for the presentational purpose in this stage.

In the definitive design stage, drawings are even more

precise and detailed. They demonstrate exact form and contain detailed information about dimensions, materials, connections, etc.

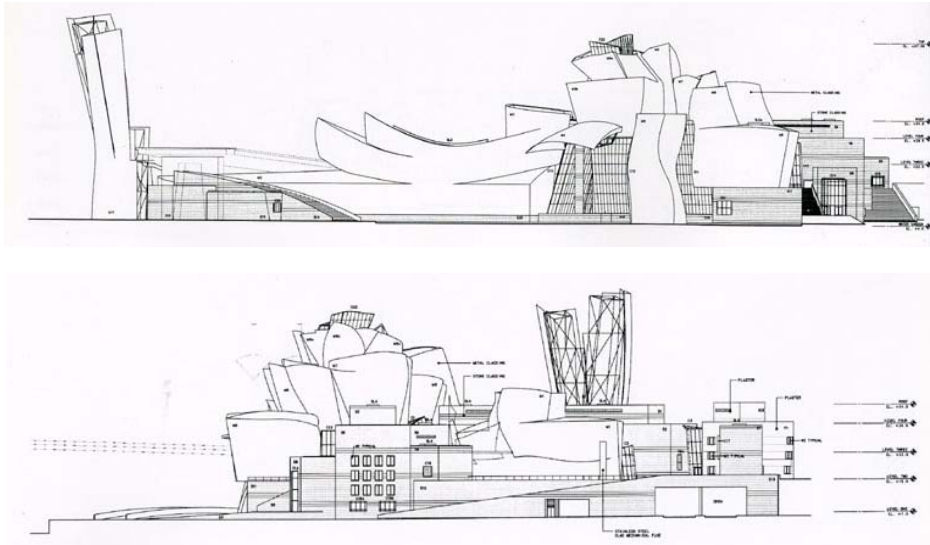


Fig. 6 Detailed Drawings, Guggenheim museum, Bilbao, Spain [8]

In the final design stage, large-scale drawings are produced to illustrate even more details about materials, connections, and dimensions. Such working drawings might not be drawn by the architect himself/herself and are used to communicate detailed information among the construction trades.

IV. IMPACTS OF CAD ON ARCHITECTURAL DESIGN PROCESS

Architects might use various computer tools for different stages of the design process. However, the stage of the design process is not the only criterion that is considered while selecting the computer tool, size and type of the projects are the other determinant factors in this decision.

The initial stages of architectural design process do not require CAD accuracy and functionality. Therefore, many architects still prefer to use pen and paper or scale models in the early stage [9]. Use of such precise programs in the early stages of design process might limit the creativity of the designer and can encourage poor design [10]. Because, for such an accurate program to function, the architect needs to provide values and measurements at the earlier stage, which would not usually happen in the initial concept sketches. However, they are extensively used to facilitate later stages of the design process. On the other hand, computers can do some tasks better than humans. They are faster and more reliable at calculation. For that reason, in order to reduce the time on the transition from earlier stages of design to more precise ones, some architects use CAD.

CAD has had a remarkable impact on the teaching, learning and practice of design [11]. By the use of CAD, designer can create conceptual detailed designs of 2-D and 3-D drawings, manipulate the form and challenge more complex design

problems in faster time. According to Dong and Gibson [12], the digital model gives the opportunity to the architect to think, picture, connect, and make assumptions in designing process. CAD is very interactive and advanced software with various simulations to assist in producing better visual concepts of designs.

CAD gives the designer the opportunity of switching between two-dimensional (2D) and three-dimensional (3D) views at any time, zoom in and out, rotate images to view them from different perspectives, change the scale and manipulate the shapes, so quickly and easily.

In general, there are many aspects of the architectural design process that are affected by the use of computers; here are some of the main advantages of implementing CAD systems in the architectural offices:

CAD gives the designer the ability to visualize in three dimensions and to extract information from a completed model quickly and easily, thus they would have more time to focus on the design process. Also, it is possible for the designers to simulate the performance of the building, and to coordinate and control the final product, which helps them to make the required modifications immediately. CAD also helps the designer in combining, analyzing, and documenting the design, which all together improve the productivity of the designer by fast designing, lower cost and shorter time for completion of the project. Moreover, since the CAD systems offer greater accuracy, the errors are reduced drastically in the designed product, which leads to a better design.

Another remarkable feature of CAD, which made it so popular quickly, is the communication it brings. Architectural CAD systems facilitates communication between the architect

and the contractor by allowing files produced from different systems to be read into the same model, moreover it contains the related information needed by the other specialists involved. Most of all, CAD facilitates communication between the architect and the client by giving the clients the ability to incorporate into the design process. The clients do not need to have architectural knowledge to understand the CAD-rendered 3D models, which provide multiple perspectives and a virtual tour of the building inside and out.

Considering documentation as one of the most important parts of the design process, CAD can easily create high quality drawings that helps in better documentation of the design, less drawing errors, and greater legibility. Moreover, all the data and drawings used for designing can easily be saved and used for the future reference, and there would be no need to design or redraw them again and again.

V. CONCLUSION

CAD has had a remarkable impact on the evolution of architecture. CAD has made almost all stages of architectural design process easier and faster to complete. CAD facilitates designing of complex buildings for the designers; as it has been used in decision making during the design process and not only for producing drawings. In general, use of CAD improved level of productivity, improved design quality, lower design costs, and enormous time efficiency. However, as the practice of drawing is dominant to the design development in architecture, it seems to be a good idea to use the traditional method of sketching prior to drafting as the fundamentals of the design process. This study therefore suggests the successful mixture of traditional way of design together with technological use of CAD, which will generate outstanding combination products as finished designs. Therefore, in the architectural practice, there should be a balance in utilization of the traditional methods as well as the CAD tools.

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