

Impact of Software and Technology on Architectural Design Practice

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Abstract: *The paper discusses the impact of software on architectural design practice in different stages, particularly in American firm's; right from schematic design - design development - construction document - permit process - to construction administration stage. The paper talks about how BIM (Building Information Modeling) originated and how it became common practice in all architectural firms. It describes factors which play role in design decisions and whether design follows software or software follows design. This paper has comparative analysis of two projects of similar type and scale to show if there is any impact of software on construction document phase. The paper also discusses new technologies and software used in construction administration phase which has made tremendous change in the architectural practice.*

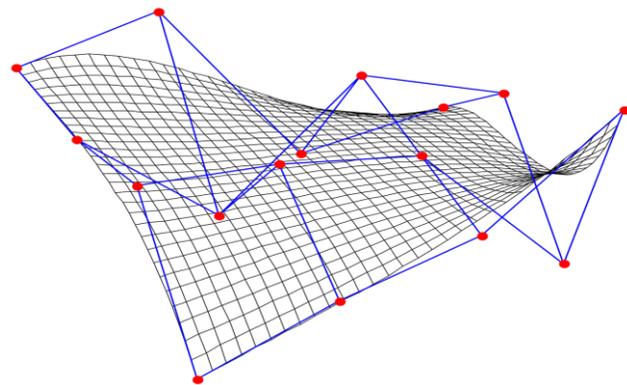
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Introduction

"As an architect you design for present with an awareness of past, for a future which is unknown." ⁱ Norman Foster in his TED talk

The process of design has undergone a sea change with the advent of computers. Until 1990s the medium of conveying the architect's ideas was hand-drawn sketches, hand-drafting, and physical models, a practice followed by architectural firms all over the world. But the computers changed this scenario, when initially the drafting part was relegated to the early first generation software. That was followed by more sophisticated programs and then there was almost a revolution in the way architectural design was conceived as the software programs covered not only drafting, but made possible a whole series of alternative scenarios for design. Today majority of architectural firms use high-end software like Revit, Rhino, Grasshopper, and so on. These are no more mere drafting tools, but they define the way we think and execute projects. New tools like virtual reality glasses allow architects and designers to create buildings and products intuitively in 3D space around them and immediately check the impact of design decisions regarding form, materials and many other parameters. It can be fairly postulated that the future of architecture will be dominated by software.

When Frank Gehry designed a 50 meter mesh sculpture for Barcelona, initially they had 2D construction drawings and contractor tried to create mock ups several times and failed. His team started using "CATIA, a C++ software package developed by an aerospace manufacturer. The manufacturer, Dassault Systems, first used it in 1977 to design the Mirage fighter jet"ⁱⁱ



A 3D Bézier surface with control points

Source: Wikipedia

"CATIA described digital models using parametric Bézier curves (or vectors) and 3D surface algorithms. The model is defined by a set of control points and the mathematical functions, or surfaces that stretch between them. The parameters of these functions can be freely adjusted, making a Bézier surface accurate at any scale"ⁱⁱ

"Gehry suspected that digitally designed geometries could be executed much more efficiently with less redundancy. Instead of creating standard 2D construction drawings, Gehry now had his contractors refer directly to the 3D digital model, translating digitized coordinates directly into manual cutting instructions and machine tooling paths"ⁱⁱ

Methodology

Key questions:

- How does the design process start?
- Do we think about what software will be used at the beginning of the project?
- Impact of software on forms: what form will be used, dynamic vs linear since we have access to parametric software?

- Software follows design or design follows software? Are we designing something dynamic because software has particular keys tools to achieve it or we are creating totally new style of architecture based on software?
- What aspects of construction documents and administration have changed because of new technology and software?
- Presenting design to the client: how new technology has changed the traditional way of conveying the idea?

Design Process:

There are different factors that play a role in the design decisions when starting a new project:

1. Building code, planning and zoning requirements
2. Client requirements
3. Material
4. Worker/Labor available in the region & their expertise in particular style of construction.
5. Software used
6. Influence of similar typologies

What software?

In most architectural firms schematic design process starts with hand sketches; so typically the type of software used is decided based on time frame, budget and scale of the project.

Impact of software on forms:

Not every architect uses software to create buildings with dynamic shapes like Zaha Hadid and Frank Gehry. It depends on whether the architect would like to create a bold statement through his/her design. It also depends on what are the client's interests and scope. Typology is another dimension. In residential industry particularly single family homes there is not much of an impact of software on design. People generally stay in the same range of styles i.e. collective consciousness. For instance in US for single family homes there are commonly used styles like: Craftsman, Colonial, Mediterranean, Italianate etc.

Does software follow design?

"Frank Gehry, (...) thinks with his hands. He makes architectural models by tearing scraps of paper, gluing and taping them together, crinkling cardboard, and adding apples and Perrier bottles"ⁱⁱ

This shows even architects like Frank Gehry who had a major role in developing parametric design/BIM use physical models during schematic design phase. That implies software follows design.



An architectural model by Frank Gehry: Example of original physical model (right) and a model of the same design, after it's been digitally rationalized (left)

Source: Dennis Shelden's epic doctoral dissertation

Construction Document Phase:

Before AutoCAD was introduced (early 1990s) all the firms were drafting construction documents by hand. Oftentimes decisions were taken on-site by the architect and contractors. But after 1990s almost every architectural firm use BIM software. There are now expectations by building officials and clients to have precise accurate drawings from the architect to avoid on site changes and manipulations. Emphasis is given on getting right earlier in the process, which eliminates improvisations.

"The technology is more about process than product. But even that could lead to a different sort of building. BIM will only enable you to build what the construction industry enables you to build. It's inherently linked into products that are available. That shortening of imaginative horizon might be exacerbated by the technology itself. You have to play by its rules. It irons out problems, but it might also iron out happy accidents as well"ⁱⁱⁱ

Below is the comparison between two multifamily projects of same scale/same region. One was built in 1971 and the other in 2017 under construction (both in San Francisco region)

Multifamily housing in 1971: Total units 276

- Simple layout stacked units.
- Only two types of units one bedroom and studio
- Construction documents contain only two level plans ground floor and typical floor. No specific unit condition or alteration of balconies shown in the documents
- Hand drafted drawings
- Total number of architectural sheets: 18

Multifamily housing in 2017: Total units 216

- Complex layout – Not all unit types are stacked

- 19 different types of units: Studio, 2 bedrooms and one bedroom with different configuration
- Construction documents show every floor level plan
- Unit alteration with different balcony condition and ceiling condition changing with mechanical plan are shown in construction documents
- Software used Revit 2017
- Total number of architectural sheets: 100

The main difference in these two projects is the amount of information provided to the contractors. The building built in 1971 was simple stacked repetitive units which did not require multiple floor plans. The building under construction in 2017 has 19 unit types which require floor plan for every level; and also a key plan indicating occurrence of that particular unit on every level. Also because they are not stacked they will have different mechanical and plumbing conditions and need to be coordinated in 3D; which is possible in software like Revit. Parametric software like Revit expanded opportunities to design and opened doors for exploring unique forms and space. It gives more freedom to the designer in terms of how they want to play with spaces.

Construction Administration Phase:

Many software programs developed specifically for CA phase allow auditing correspondence between contractor and architect to keep records. Software like PlanGrid are used for punch walks which eliminate lengthy on site procedures. Traditionally punch walk was done by filling punch list forms and hand-written notes taken by the architect. These were then scanned and shared with contractor(s) so that they can be ready for back punch. This software digitizes the whole procedure allowing pictures to be tagged with notes thus reducing errors and saving time.

Technology like hologram allows contractor and architects to collaborate regardless of distance for on-site issues. Picture below shows contractor and Architect communicating remotely with the help of HoloLens.



Source: Microsoft HoloLens

Presenting design to the client:

For multifamily housing builder create actual sample model flat/unit for buyers/clients to look and decide whether they would like the feel of the space. But advanced technology like augmented reality and virtual reality enable visualizing the space eliminating the need for sample flats/units.

Conclusion

Creating construction documents by software is already been practiced by architectural firms all over the world, so this part will remain and will continue to have improvements to achieve more efficiency. Future of construction execution will have more robotics and less human interface. Construction administration will have new tools to check for quality control. But the process of conceiving idea in human brain for the project and transferring that idea into actual build space to fit in appropriate context will still be a purest creative phase in the design process; and even though we have intelligent building software the original conceptualisation of the project will never be done by machines at least in the near future. So the real role of the architect in future would be only limited to first stage of the project that is schematic design and creative program formulation.

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