The architectural design process: an intuitive modeling in BIM's parametric design

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The digital era has brought many changes in the architectural research and practice. Building Information Modeling (BIM) tools are offering now a wide range of benefits in the AECO industry. This paper aims is not to do an evaluation on efficiency gains or the advantages of adopting BIM, but to suggest a design methodology using BIM software tools, throughout all phases of the architectural design process. With the constant advances in technology and with new conceptual design tools, became urgent the exploration of the potentialities of an intuitive design within BIM technology. This paper addresses the above question by suggesting an experimental methodology to implement an intuitive modeling in BIM's parametric design.

Keywords: *BIM, Parametric design, Design process*

INTRODUCTION

BIM brought a procedure shift in the AECO (Architecture, Engineering, Construction and Operations) Industry that became a new CAD paradigm (Succar 2009). According to Garber (2009:4) "It is the very collaborative nature of the data feedback through the modeling process with its potential to inform and communicate that turns the tables on all existing systems". Coren Sharper, a partner of SHoP Architects, refers to three-dimensional modeling tools first used to communicate with clients with renderings and walkthroughs as being 'dumb' models compared with BIM tools. Virtual models first appeared in architecture as representational tools responding mainly to aesthetical concerns. At the same time structural and construction orientated software was developing mainly with production concerns integrating within a single software, construction management, analyses, simulations, building life-cycle management and a database of information incorporated within parametric 3D models, laying the foundations for more collaborative and effective models, the building information models. These two trends that developed separately are now "giving way to a still emerging area of overlapping concerns" (Garber 2009:23).

Recently, parametric design has influenced the development of digital architectural. The impact of BIM and Parametric Design on contemporary architectural practice is widespread. This allows the architect to create solutions that would be unattainable otherwise.

However, schematic cognitive models design opportunities are often overlooked in the adoption of parametric building information models in professional practice.

There are important aspects that must be consider during the early stages of the design process. Abstract cognitive models and sketches are tools in architectural thinking for raising new question and defining an idea. Has a designer draws a sketch, it allows a process called visual thinking (Schön 1987). The designer then creates an image that he is able to reinterpret allowing him to pose new questions. This process that Schön names reflection-in-action allows the designer to reshape what he is doing, while doing it, thus, posing new questions and trying out different results through an on-going experimentation essential in the design process to find a viable solution.

During the schematic design phase, as the architect hand-draws the dimensions of a room, the height of the ceiling or the thickness of a wall he does it intuitively according to specific architectural intentions. In CAD, the design process is frustrated when the software induces the architect to make premature decisions about the specific thickness of the wall or the shape or type of door, window and so on, decisions that should not be made at an early stage of the design process.

In the traditional method with hand-made sketches and models that are plain, white and with little detail, the architect is creating images and giving space for the mind to freely fill in with pieces, components and materials. The great amount of information available in BIM systems make very easy the inclusion of too much detail creating a saturated mental image that gives no space for further reflexion or imagination.

This paper's aim is to remove the misconception that BIM is not ready for an architectural thinking by creating a flexible and intuitive design methodology integrated throughout the architectural design process. This experimentation methodology is accomplished using Autodesk Revit software by including parametric design and all of BIM's capabilities in a conceptual design environment that stays linked to a constructive design environment and constantly updates any change made in the conceptual model, never having to leave the same platform.

COGNITIVE MODELS FOR CONCEPTUAL AND SCHEMATIC PARAMETRIC DESIGN: TYPES AND MODELS

There have been many approaches to how digital tools have influenced architecture in general as well as in the design process. These tools have created the conditions for raising new questions, achieving new solutions and enter a new territory of complexity.

According to Barrios (2011), during the initial phases of the design process the idea has still a high degree of uncertainty; at this stage the model should also have a high degree of flexibility. The types of models used enhance or constrain the architectural design process according to software specific capabilities or limitations but also according to the way the designer uses the software.

Carlos Barrios (2007, 2011) proposed five different cognitive models for parametric design to aid the designer in different phases of the design process. (1) Parametric Models For Exploratory Design - These models are mostly used in the early stages of design to explore the design geometry to a design problem; (2) Reusability - exploder the potentials of the adaptability models; (3) Parametric Models For Interactive Feedback - a parametric model that demonstrates the properties of the surface curvature; (4) Parametric Models For Progressive Optimization - parametric model that illustrates the steps of the refinement of a geometry; (5) Knowledge-Based Parametric Design - This parametric models shows how the design can be helped in this decisions based on the interaction of a parametric model with a knowledge-based system. Currently, all these features can be found in BIM software tools. Stavric and Marina (2011) talk about two models of conceptual parametric design and constructive parametric design. The first refers to parametric models used for conceptual design with

visual programming or scripting, morphogenesis, algorithmic and generative design. The second refers to the parametric models from BIM, with embedded data in 3D objects like doors, windows, stairs, slabs and so on.

Richard Garber speaks of 'closing the gap' between design software, used for representation and formal experimentation, and an industry software primarily used for production, documentation, analyses and simulation.

Although it's clear influence from Barrios criticism this paper seeks to overcome these limitations more encouraged by Jeremy Roh's (Part-Time Lecturer at UNC Charlotte's School of Architecture) approach on whether or not BIM is ready for Conceptual and Schematic Design: "at a schematic level, one should not be bogged down with premature tasks such as creating compound wall types showing all the layers of the constructed wall. Instead, the designer should be making a generic gesture using a plane or basic solid to represent the wall; furthermore, one should not be in the portion of the program where tools such as walls, doors, floors, etc. are in the tool ribbon. At the early stages of the design process, one should be in the Conceptual Design Environment where Massing, Generic Modeling, Pattern Based Elements, and Adaptive Components are utilized to create stereotomic and tectonic form. According to Jeremy Roh's "Building Information Modeling software, such as Autodesk Revit, is an environment where the entire architect's design and documentation process can be infused into one software platform". The benefits of working all phases of the design process in one platform may be great but it doesn't mean it is the best way for every case. BIM is a convergence platform where different software models and different fields of the AEC industry may come together and be managed by the same BIM system.

On the Practical BIM symposium for the AIA Technology in Architectural Practice's July 13, 2012 webinar, Jed Donaldson gives a presentation of the technologies used during the design process at Johnson Fain. In their studio they start using the software (Revit) in the urban analyses and a 3D study from day one. They use a conceptual massing environment to run in parallel many options to evaluate proper density and other aspects of an initial planning. Staying in the same software they start shaping masses and getting to a new level of detail as the model keeps generating the analyses feedback and running in parallel alternatives.

AN INTUITIVE MODELING IN BIM'S PARAMETRIC DESIGN

New advances in technologies propitiated the possibility to explore all phases of the design process inside the same platform. For example, Revit has new conceptual design tools and adaptive components that allow a new level of relations between conceptual and constructive design. There have been created new applications that run in Revit with visual programming allowing the introduction of scripting in Revit's environment as well as enhancing its parametric design capabilities for generative design and algorithm design.

For this intent, two experimentation methods are conducted on an educational context in a design studio (DS-PFA) for a Master of Architecture class. Even though the principles are used for an intuitive design application will then be suited to actual architectural practice's concerns. The selected software for a practical application was Revit from Autodesk.

The first method explores a parametric model with a close-up approach to the architectural form. This method is developed in three phases: identification of the generating principles, testing alternatives and evaluating results. It explores generative design and in the end it is given a report of all BIM features that the model responds to.

The second method explores all stages of the design process through a practical application in the year assignment project of DS-PFA's studio class. All the design phases are addressed in BIM using Revit tools from an urban strategy to constructive details. Parameters are assigned to the model to re-

spond to programmatic and architectural intentions evaluating and giving the architect feedback to further enhance the design process. Reporting parameters, instead of constraint generative parameters, essentially allow flexibility and intuitiveness.

In this paper it will only be presented the second experimentation method.

The architectural design process varies with different architects, situations or approaches. For that reason there is not a clear division of the process, although, for better presenting this experiment the design process was divided in three different phases: (1) Conceptual, (2) Scale, (3) Materialization.

1. Conceptual phase: Sketches and diagrams are made, it's transposed the idea and a volumetric implantation is tried out.

2. Scale: Dimensions are adjusted, programmatic needs are met.

3. Materialization: Materials and architectural components and constructive matters are defined.

In the first phase, handmade sketches and diagrams were transferred to 3D virtual diagrams and Intuitive masses modelled by points, lines, planes, solids and voids. This allowed experimenting volumes and its visual impact on site lot quicker than by a traditional method. It was also taken advantage of parametric design to try out multiple hypotheses.

As Jeremy Roh states, at an early stage of the design, the designer should not be doing premature tasks such as creating compound wall types or making decisions concerning specific thickness of the wall, or the type of door or window, instead, the designer should be thinking of planes, solid forms and voids. At this first approach usually the architect is studying the implantation on site at a volumetric scale seeking a volumetric relation with the surrounding.

These masses were created in Revit's conceptual environment with reporting parameters where the designer is able to manipulate the overall shape by creating 3D forms and freely push and pull points, surfaces and edges, instantly receiving feedback from the model on floor areas and facades as well as any parameters specific to meet programmatic needs.

There were created masses for the existing buildings and for the new proposal. The masses are then parameterised to extract floor areas according to the existing and the proposal program and it was created a table of comparison between demolished and new.

On the second phase getting more into interior spaces the architect should still be thinking of planes, solids and voids making sense of space adjusting dimensions and light. At this stage the architect shouldn't be picking up things out of a pre-formatted library, instead, he should be thinking of space, openings and passages or how much light should cross in or how wide or narrow should an opening be. At this stage, most of the time, it shouldn't be thought of frames and panels or handles and mechanisms.

When a component from a library is selected filled with information and detail it is already restricting the architects imagination to that specific element. An image is created giving little room for any other t rise. That happens with doors, windows, compound walls, floors, roofs, curtain systems, furniture and any other architectural component.

A BIM wall brings information such as compound wall types with layers and materials. At this stage by placing a wall the architect should only think of three things: x, y and z, or rather, one thing: space.

For this phase were created family components that are not windows or doors with frames and panels and materials. Instead, were created BIM components that are only voids with instance parameters that allow the manipulation of the form simply be the pushing and pulling of points or by the insertion of numerical values. The same was done for walls that only have parameters for x, y and z (figure 1).

At the detailing phase the designer tells the software to replace all 'B's with 'A's and because the architectural components are modelled with paramet-

Figure 1
Wall A and B

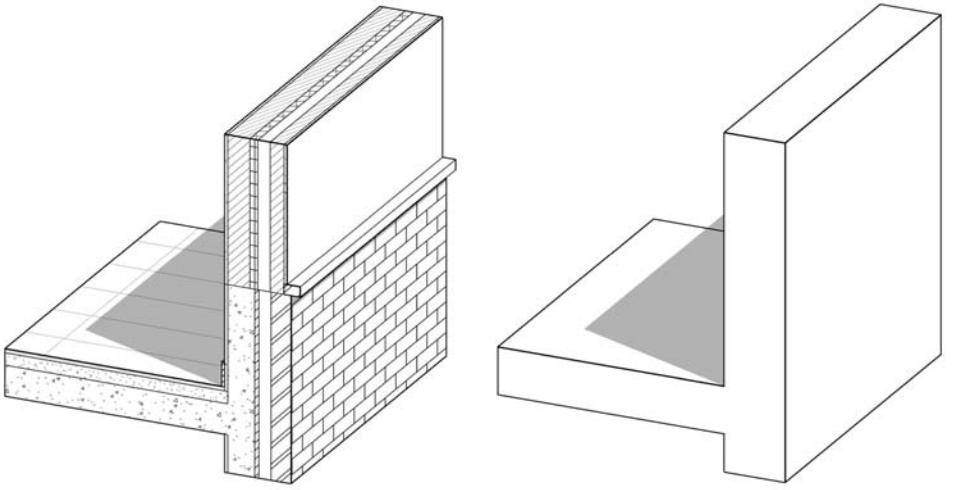
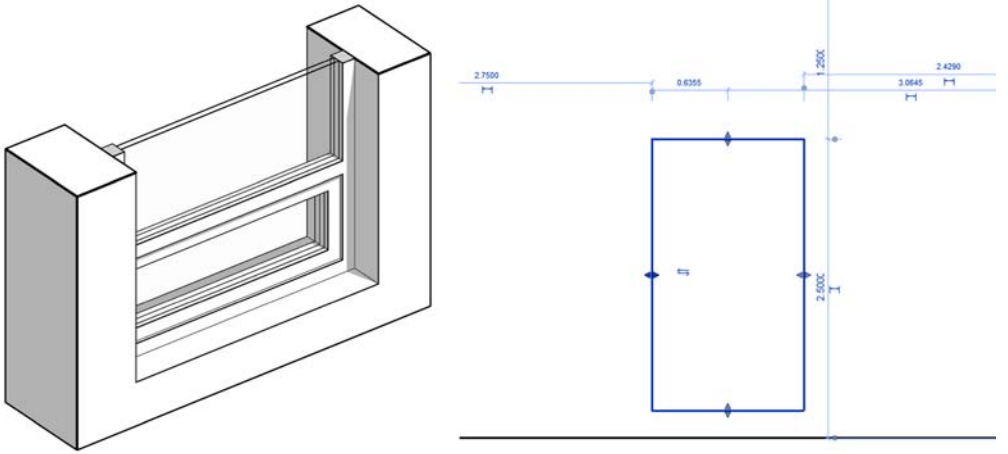


Figure 2
Window



ric features a singular component will automatically adjust for every different sized or different shaped opening or wall (figure 2), automatically adapting other components to it such as floors.

Replacing doors and windows for openings on a first stage allowed the design process to be done with full BIM components and still use undefined forms during a phase where only conceptual concerns were being evaluated. Detailing as materials were added gradually at specific stages. In this experiment was also used with casework modeled as solids that were later better detailed.

It was created a design environment where the designer could basically forget about the decisions that were not to be made at an early stage and focus on space freeing the mind for architectural thinking and also to take advantage of BIM parametric design to create flexible parameters as to keep BIM profitability in a project delivery phase.

DISCUSSION AND CONCLUSION

The new technologies brought a procedure shift in the design process and the way architects think. It has brought the potential to create things that could never be achieved otherwise.

Parametric design allows the architect to create buildings and forms with a higher level of complexity, pose more questions to the same problem and study many more variations of the same solution. The integration of BIM makes the process more complete. This shift in procedures gave the architect the power to manage so much information that it became crucial for him to learn how to filter what, how and when to introduce it in the project.

This paper demonstrates that BIM is ready for parametric schematic design and that it is a tool with great benefits for architects.

BIM tools with all its performance benefits may influence the architectural design process in a positive as a negative way. This gives the architect the responsibility to know the importance of knowing what does disturb and what does enhance the architectural design process.

Intuitive BIM opens the way for architects to really grasp the potentialities of BIM in the ongoing switch from CAD to BIM encircling all of its effectiveness gains with the recent creative capabilities.

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