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Proceedings of the International Conference on Computing in Civil and Building Engineering
W Tizani (Editor)

Evaluation of BIM and Ecotect for conceptual architectural design analysis

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Abstract

The main goal of the present paper is to investigate how BIM tools and Ecotect can be integrated as an active part of an integrated design process for conceptual architectural design. The integrated design has an interaction between the skills of the architect and the engineer thought-out the process and thereby avoiding problems solving after the design has been finalised. The process has been analysed from an architect's point of view dealing with design at fictive sites in Copenhagen. The results of the research indicate that BIM tools combined with Ecotect can deliver useable qualitative input for sketching investigations during a conceptual architectural design process.

Keywords: BIM, ecotect, integrated design, sustainable design

1 Introduction

Development within digital architectural tools has over the last few years made it possible to design buildings which would have seemed impossible only a decade ago. Architects and master builders have always used the development within technology to change the architectural expression, and significant buildings have often been examples of the technological abilities within a society. Some architects even talk about a development which will radically change our perception of architecture, as emerging digital technologies are becoming a part of the architecture and the design processes (Jørgensen 2007). In an architectural conceptual sketching process, where an architect is working with the initial ideas for a design, the process is characterized by three phases: sketching, evaluation and modification (Lawson 1997). Basically the architect needs to address three areas in the conceptual sketching phase: aesthetical, functional and technical requirements. Ideally these phases are worked with in an integrated design process (IDP) where all of the three aspects are brought into consideration already in the early conceptual stage of the design process.

The way these design concerns are being dealt with is often through intensive sketching with a pen on paper, and the evaluation of the results is done visually. Sketching is very useful for architects and does not require any tools apart from paper and pen. A small amount of technical knowledge can be advantageous, but it is not a precondition for early architectural sketching. The recent development in computational design tools has evolved into a sometimes purely digital process which opens up for new perspectives and problems in the sketching process. One of the interesting possibilities lay within the hybrid practitioner- or architect-engineer approach, sometimes also known as ´Digital Tectonics`, where an architect-engineer or hybrid practitioner works simultaneously with both aesthetic and technical design requirements (Leach et al. 2004). Development today in CAD programmes goes

more towards also doing the design inside the CAD program or a Building Information Modelling (BIM) program (Boeykens and Neuckermans 2006), instead of using the computer only in the documentation phase, but that could limit the work of the designer, as many of the CAD and BIM programmes available today are developed with the aim to make documentation more efficient, and not in the evolution of the design itself, which is desirable in any design tools. The digital design tools used by architects and engineers today are very useful with respect to their specific fields of aesthetical or technical evaluation. The most sophisticated of these tools deliver continuous and immediate feedback on a far greater range of characteristics than conventional design tools. Material quantities and properties, energy performance, lighting quality, site disturbance, and what-if comparisons between new construction and renovation are some types of information that are easily available from these tools, i.e. such BIM tools facilitates an opportunity for sustainability measures and performance analysis to be performed throughout the design process. Recently this has been described in several papers, however often from an engineering point of view (Azhar and Brown 2009; Lam and Yeang 2009; Middlebrooks 2008).

The aim of the present paper is to address the integrated digital design process (Andia 2001) where the BIM tools *Revit Building* and *Ecotect* are considered for sustainable design (Autodesk 2005; Autodesk 2010). The analysis has been performed from an architect's point of view considering phases in the conceptual architectural design process.

2 The integrated design process

The hybrid approach of interaction between architect and engineers is problematic in the old process of designing. The language and criteria of designing in architecture and engineering is different, which often create a gap between. This means that the role of the engineer often is integrated late in the design process and becomes a problems solving function in an already made design of the architect. This means that the aesthetics of the design does not occur from the performance of the building and the design process becomes divided into parts for the architect and the engineering instead of a collaborative process being established. Therefore the architects often tend to be neglect the respect of the performance and are forced to rely unduly on the know-how of the engineer. The integrated design on the other hand has an interaction between the skills of the architect and the engineer thought-out the process and thereby avoiding problems solving after the design has been determinate. The intergraded design process (IDP) includes all the aspects that are involved in making good architecture that are environmental sustainable. The process therefore has to enlighten things as the distributions of spaces, proportions, lightning, functional aspects, energy consumption for cooling and ventilation which all becomes a part of the design strategy. The IDP is a method of designing architecture in a multi-disciplinary approach between architecture and engineering (Andia 2001; Sathyanarayanan et al. 2009).

The architect needs to address three areas when designing: aesthetical, functional and technical requirements. These phases are worked with in an integrated design process where all of the three aspects are brought into consideration in all stages of the design process (Klitgaard and Kirkegaard 2007), see Figure 1.

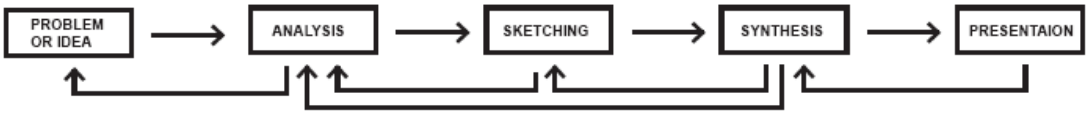

Figure 1. The phases in the integrated design process from problem or idea to presentation.

The process is problem or idea based which therefore becomes the first phase of the process. The analysis phase is mainly concentrating on analyzing the context and the site and thereby getting an understanding of the passive design parameter that can be incorporated into the design. In the sketching phase the designer together with the engineers evaluate the design proposal regarding issue as, the program, the construction, and the buildings energy consumption in terms of heating, cooling, ventilation and daylight. It is therefore important that the architect and engineer have tools that can calculate the consequences of design alteration and how modification affect each others.

The next phase is the synthesis phase which starts when the overall design is determinate and is concentrating on optimizing and detailing. The overall design is therefore decided when this phase starts. The presentation phase deal with presenting the final design proposal. The process is an iterative process which means that work flow between the phases not necessarily is linear. This means that the process can take multiple iterations, and each different phase can be repeated several times for optimizing the design, before the process is completed. The phases of the IDP are showed in Figure 1 as a simplification of the whole process of designing. If the goal for the design is to minimize the energy use of the building the strategy has to be integrated early in the design process to make the building work as a unity, which will minimize the environmental impact. This goal is possible in the IDP because of the multi-disciplinary approach and the iterations in the IDP especially concerning the sketching phase. The IDP does not ensure aesthetic or sustainable solutions, but it enables the designer to control the many parameters that must be considered and integrated in the project when creating more holistic sustainable architecture. The tools of the architect concerning the performance of the design has mainly been concentrating on programs such as pre-designed spreadsheet calculations or more advanced simulation programs. All programs tailored for verifying the solution and give detailed information but not as an integrated tool in the process. Most of the programs also require high technical knowledge for analyzing the numerical output. This makes it hard for the designers to interpret the consequence for design alteration and where improvement can be made and make interpretation so difficult and it often becomes an assignment for the engineers. The architect lacks tools, which does not demand expert knowledge about the input and that are providing an output that illustrated the consequence not just by numbers. Tools that allow the designer to achieve knowledge on how to reduce energy consumption in the early design phases can thereby become a part of the design process. The tools also have to be easy to implement and gives live output. The interesting possibilities of the IDP regarding optimizing and sustainability lays within the hybrid practitioner- or architect-engineer approach, where an architect-engineer or hybrid practitioner works simultaneously with both aesthetic and technical design requirements (Klitgaard and Kirkegaard 2007).

3 BIM and the integrated design process

The use of BIM tools in the process of designing are often concentrated in the end of every phase. The tools are thereby not incorporated into the process, but mainly used as a passive toll for evaluating the design. The use of BIM tools can be incorporated from the phase of analyzing to the phase of synthesis and can thereby be an active part of the design process from the early stage. The integration of BIM also has the possibility to make the gap between the engineer and the architect smaller by improving the communication across the different fields of expertise. For the present research the implementation of Revit and Ecotect is evaluated from the mind maps to see where the different program is best fitted into the process. Another important factor to take into consideration when speaking about the IDP is the time factor. The use of time is unavoidable to take into account when going from theory to implementing in real life. The use of time in each phase cannot be longer when implementing BIM tools because the phase of presentation has to be ended before the deadline. It is therefore important that the use of BIM tools does not slow down the process of designing but keeps it fluent. Figure 2 shows where Ecotect and Revit can be implemented into the different phases of the

IDP. Revit can as the modelling tool be used in all of the three phases from the analysis to synthesis, because alterations of the design are necessary in all of them. Ecotect has the greatest advantages of use in the sketching phase but can also to a certain extent be used in the analysis phase. The design is generated in Revit and then imported into Ecotect for analysis. After the analysis the information about the performance of the design can be underlined and new modification of the design made in Revit as shown in Figure 2.

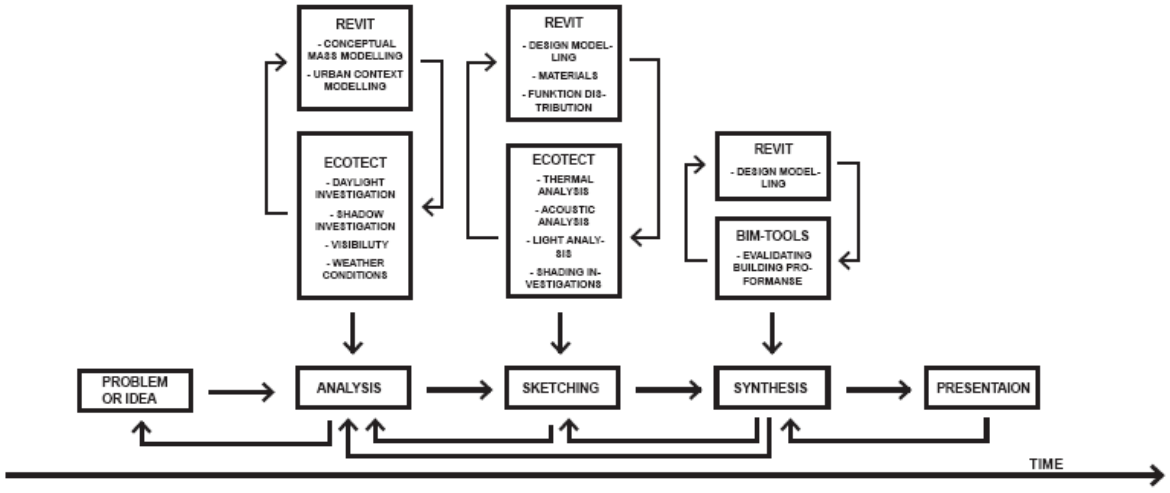

Figure 2. The phases in the integrated design process where Revit and Ecotect can be implemented.

Conceptual modelling and building modelling can be used in the analysis phase from Revit and Ecotect which can provide analysis of the overall site conditions and thereby be used for investigating parameters such as sunlight, shadow and other weather conditions. These inputs are useable in the analysis phase because it is mainly concentrating on identify the elements of the site that can be use further in the sketching phase.

In the sketching phase Revit is integrated along with Ecotect and the investigation becomes concentrated on the inner and outer building volume. The analysis from Ecotect is therefore concentrating on both analyzing the façade and the internal rooms. The analysis Ecotect can provide deals with all of the main aspects of the building envelope. Modelling in Revit in the sketching phase becomes more detailed and also concerning the inside of the building and thereby moving to another detailing level from the conceptual massing. In the sketching phase not only the building shape can be calculated and evaluated but also the rooms and the different functions in the rooms become and shape giving parameter.

In the synthesis phase Revit can be used together with other BIM tools than Ecotect, because the level of detail gets so high that the calculation methods in the programs not are accurate enough. The three phases of *analysis, sketching* and *synthesis* and the use of Revit and Ecotect have been analysed, discussed and presented in (Thuesen 2009) with respect to the durability of Revit and Ecotect as an active part of the design process for conceptual architectural design. The output from these investigations is outlined in the following sections.

3.1 The analysis phase

For the analysis phase the durability of Ecotect's *Weather Manager* has been considered for visualisation of weather data such as: solar position on the sky, wind and temperature. It was found that Ecotect can produce useable graphic presentation of the weather, daylight and shadow condition on the site and the context related to the site. The data thereby becomes easier to understand and interpret than outputs in numbers. There is no iteration in this phase, because the phase is

concentration about generating information that can be used in the sketching phase. The analysis phase is thereby adjoining the foundations for the design that are created in the sketching phase. From an architectural point of view Revit and Ecotect deliver output that can help the architect understand the condition of the site provided by Ecotect. This does not mean that the use of Ecotect covers all the investigation that can be made in this phase, because there are many others that can contribute as inspiration or as design parameters.

3.2 The sketching phase

The sketching phase contains many different evaluation of the design because many different parameters are evolved in the developing of the design. The phase has great importance of the final design because it contains the bigger design modification and iteration. The parameters suited for this phase are: calculation of cast shadows, façade radiation, visibility and wind for outdoor evaluations. For indoor evaluations the tools have the possibility for analysing: daylight factor, shading, acoustics, solar energy, indoor temperature and placement of functions. A comparison with other tools for indoor climate and acoustics evaluations was performed and it has been concluded that the simulations results from Ecotect do not actually provide quantifiable answers compared to reference tools. E.g. thermal analysis where passive heat gain from the sun is incorporated need to be used with reservation in the design process because of the lack of solar radiation gain the heat in the room. The ability of Ecotect to calculate indoor temperature with contribution from solar radiation therefore has to be looked upon with scepticism. Many of the investigations with Ecotect cannot be documented as absolute values and a more visual approach of the results are chosen for the tool. This also supports the concept of Ecotect and the concept of the early iteration in the IDP. The absolute accuracy of the calculation results is not important at the early stage of the IDP such as the sketching phase. The essential is that the basis of any comparative calculations is the same and that relative accuracy is maintained. The absolute accuracy of calculated results obviously increases later in the stages of the IDP where more details are added and the absolute performance of the building has to be documented. In this stage simulation tools such as e.g. BSim (SBI 2006) provide the need accuracy. Therefore Ecotect cannot be use as a replacement of e.g. BSim, however the tool delivers output helping the designer and engineers to get a joined point of reference during a sketching process.

3.3 The synthesis *phase*

The synthesis phase begins when the overall layout of the design has been determinate and detailing of the design is needed. Detailing that demands a higher precision of calculation. Revit can be used for detailed modeling in this phase but many of the calculation previous made in the sketching pahse using Ecotect have to be carried out with other programs that have a higher level of detailed calculations. The process can carry on with analyzing and simulations program such as BSim. These programs represent another concept of calculation that gives more accurate outputs. The communication of output is mainly in numbers and requires a detailed input and high knowledge to use. This means the output can be hard to interpret into evolving the design but only describe the performance of the building. Therefore these programs are suited to the synthesis phase and not to the sketching phase. If the right iterations and estimations have been made in the sketching phase there is no need for big changes in the design in this phase. It is therefore important that all of the active design parameters have been taken into consideration before the synthesis phase starts.

4 Conclusions

The purpose of the paper has been to identify the phase of the IDP and to investigate the incorporation of BIM and Ecotect and how they interact in the process and the iterations. Therefore the output itself has not been in focus but the process of getting the information and how it is communicated. Using

BIM tools like Ecotect and Revit does not mean that you simply can draw in the building model, press a few buttons and the software will tell you how the building works and what you have to do to fix it. The main propose with the analyses that have been made in this paper have been to illustrated the wide of possibilities in Ecotect. The iterations are therefore fictive and if it had been a real case other calculations maybe have been more important. Ecotect can be thought of as a building design calculator that can be incorporated in the IDP.

The simulations in Ecotect do not actually provide quantifiable answers. Therefore many of the investigation cannot be documented as absolute values and a more visual approach of the results are chosen by en program. This also supports the concept of Ecotect and the concept of the early iteration in the IDP. The absolute accuracy of the calculation result is not important at in the early stage of the IDP such as the sketching phase. The essential is that the basis of any comparative calculations is the same and that relative accuracy is maintained. The absolute accuracy of calculated results obviously increases later in the stages of the IDP where more details are added and the absolute performance of the building has to be documented. In this stage programs such as BSim provide the needed accuracy.

Is BIM and tools like Ecotect the future? We think that the short answer is that it's the present and the future. With the improvement of technology and simulating programs so will the developing of modelling and analyzing tools in architecture develop. The integration of BIM does not make the design process infallible but opens of possibilities of conclusions that otherwise would not be possible. We think the key question for the future is not if we are going to use BIM but who and what we are going to do with all the information obtained as output from these tools. This is where skills of the architect and the multi-disciplinary IDP have to prove is strength.

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