BUILDING FOR RESOURCE RECOVERY THROUGH BIM

Interviews with practicing architects

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ABSTRACT

This study questions the relevance of the combination of Design for Deconstruction (DfD) and Building Information Model (BIM) by means of a series of retrospective interviews. The objective of these interviews is to identify the specific problems and solutions found by a group of forerunners. We then draw useful conclusions for the development of these practices, which are currently not widespread.

KEYWORDS

Circular Economy, Resource Recovery, Design for Deconstruction, BIM, Material Passport

SESSION

BUILD

1. INTRODUCTION

Today, most of the activities in the construction sector are part of a so-called "linear" economic model: "Take, Make, Waste". Striving to reduce resource consumption will not change the limited nature of raw material and can only delay the inevitable resource depletion (Servigne & Stevens 2015).

One of the levers to increase the reuse rate is to have detailed information on the building elements and materials present in the building. Nowadays, not all this information is generated during the design phase, nor is it detailed or updated during the life cycle of the building.
According to the National BIM Standard United States (2015), Building Information Model (BIM) is "*a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward*" (Figure 1). Thus BIM is one of the most promising approaches to achieve digitization in the construction industry throughout the building's life cycle (Krämer & Besenyoi, 2018).

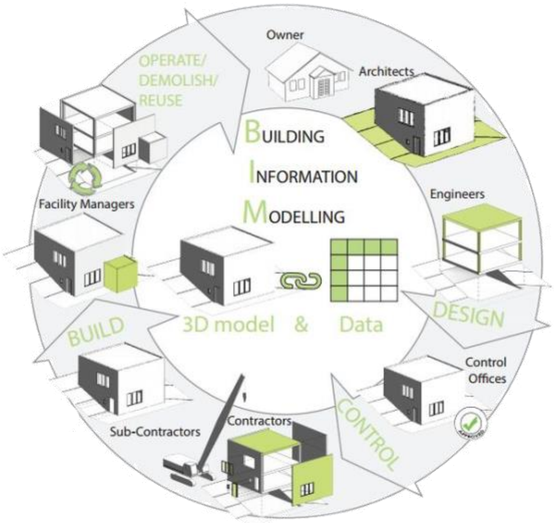

Figure 1. BIM during the life-cycle of a building (Source: Denis, 2015)

For that reason, designing a building so that it can be dismantled at the end of the building's life time (Design for Deconstruction – DfD) combined with BIM, could be a way to avoid deconstruction waste by choosing deconstruction tracks over demolition (Akinade et al., 2017).

We note the hypothesis that the implementation of a material passport and its integration with an "as-built" BIM model, delivered to the project owner, can lead to a more efficient future reuse of materials and components. Such a digital model, updated during the building's life cycle, allows the comparison of different scenarios of selective deconstruction and reuse, on or off site. In addition, this digital model will facilitate the pre-demolition audit. The "as-built" BIM thus obtained, will be a real support for circular models.

2. METHODOLOGY

Most of the literature we have consulted concerns the theoretical way of combining both BIM and DfD. However, little research has been done on the practices of architects trying to combine them (Guldlager Jensen & Sommer, 2016). In order to fill this research gap, we have chosen to look at the current ways in which architects operate.

According to our online survey, completed by 26 European architects concerned by either one of the two research fields, the combination of the two practices is still very uncommon in architectural offices (Halbach, 2019). Following the results of this survey, we interviewed 5 architects that seem to be more advanced in this field than others. We asked them specific questions about one or two projects where BIM and/or DfD was involved. The goal of the interviews was to identify the specific problems encountered and the solutions found by this group of forerunners. The aim of this paper is to draw useful conclusions for the development of these currently uncommon practices.

Table 1 summarizes three ways to apply circular design encountered in the six analyzed projects: selective deconstruction (in renovation projects), reuse of existing components and DfD.

Projects	**Type of project**	***Selective deconstruction***	***Reuse***	***DfD***
1	Renovation	*	*	Yes
2	Renovation	Yes	*	Yes
3	Renovation	Yes	Yes	No
4	Renovation	Yes	Yes	Yes
5	New construction	N.A.	Yes	Yes
6	New construction	N.A.	Yes	Yes

* Question not addressed during the interview

Table 1. Tracks to apply circular design in buildings

3. RESULTS

The following six points summarize the case studies analyzed through the interviews. All of these projects demonstrate BIM's interest in a circular economy (CE) approach.

3. 1 MINIMIZING CONSTRUCTION SITE WASTE (PROJECT 1)

The first architect we interviewed feels very concerned about sustainable development and is highly sensitive to the benefit that BIM represents for the construction sector. The project addressed during the interview, is a small scale project of a home extension. In this project, the architect used the BIM digital model to be able to better manage the material quantities for the layout of the façade and thus avoid additional costs and waste.

The architect was able to practice on the model, then carry it out on site. *"Heard at a conference at BIM World 2018 in Paris, there is always a 100:1 ratio between an error to check on your digital model and the reality, namely where a clash costs you 10 euro on your BIM model and cost you 1000 on the site."*[1] This back-and-forth work between the model and the site is long and tedious. It is always necessary to update the model according to the evolution of the site and therefore somehow do the job twice. The BIM digital model, combined with a viewer, also improved the communication with the contractor. Being able to show some details helped to improve understanding of the project.

3. 2 DOCUMENTING DFD, OPTIMIZING TRANSPORT & VALORIZING A “BIM-AS BUILT” ON THE MARKET (PROJECT 2)

The second architect uses commonly BIM software since 2006. He tries as often as possible to introduce notions of CE in his work. He regrets that recovery of deconstruction elements is not systematically present in each of his projects, as this depends mainly on the company selected to carry out the deconstruction. He mentions the problem that the contracting authority is not always sensitive to the circular approach. As a result, the company chosen for the demolition work is not always able to carry out selective deconstruction. Moreover, the materials that are currently being dismantled are not always made for this purpose. This results in a percentage of breakage.

[1] Original verbatim : « Entendu lors d’une conférence au BIM World 2018 à Paris, il y a toujours un rapport de 100 entre une erreur à vérifier sur ta maquette numérique et la réalité, c’est-à-dire où un clash te coûte 10 euro en BIM et t’en coute 1000 sur le chantier. »

The analyzed project shows us an example of a 20 000 m² office building. The architects were able to dismantle a large number of existing materials. The new materials used have been designed in such a way that they can be dismantled at the end of their life (DfD). For example, the way windows are installed has been simplified compared to the existing system so that they can be changed at any time, without intervention from outside. All the elements implemented are accompanied by a process logbook. For example, the windows have an illustrated notebook where each deconstruction step is drawn in such a way as to explain how to disassemble them without damage.

The project is located in a very dense urban environment. The city has placed great emphasis on limiting noise pollution due to the works. The BIM has been of great help in order to pre-estimate volumes and thus limit the comings and goings of trucks.

In this case, the project owner's goal was to make his building profitable. Having barely started the project, the owner already had the idea of reselling the building. The project owner therefore agreed to extend the budget dedicated to BIM, because he clearly understood the added value that BIM would bring to the building at the time of the sale. Compared to his original estimate, he managed to sell it for 15 % more.

3. 3 MAXIMIZING RESOURCE RECOVERY THROUGH A 3D SCAN (PROJECT 3)

The third project relates to the renovation of a family house based on a 3D scan. The architect is doing his best to limit the (de)construction waste as much as possible. In this project, the architect believes that the combination of BIM and CE has a major advantage: a better knowledge of the existing situation. Indeed, in order to facilitate the management of dismantled materials, the objective is to establish an inventory or catalogue of anything that can be recovered from the BIM model to make an update according to what could actually be recovered.

Through to this inventory, the architect wants to show the quantity of materials that can be recovered from an ordinary house when you make the effort to dismantle cleanly from top to bottom. For him, the waste disposal is only significant if no track of recycling or reuse can be identified. Thanks to BIM, the destination of some elements is already known, even before the dismantling. Some of the materials will be reused on site: the brick will be reused to build the new gable, the frame will be used as floor, etc. Other elements will continue their life cycle on another site.

3. 4 PROMOTE COLLABORATION (PROJECT 4)

The last renovation project concerns a large city hall. The renovation of the building focuses on space flexibility. Due to selective deconstruction, a large number of materials were dismantled and reused in the building itself. Two examples of materials reused in the building are false ceiling slabs reused as façade insulation and old interior doors transformed into cabinets and interior partitions. Other dismantled materials were offered for sale through on an online material resale platform. This effort led to a new purpose for 95% of the dismantled materials. Many deconstructed elements have therefore been moved instead of eliminated.

The new materials introduced into the building were constructed facilitating easy dismantling. They can be reused in different forms. Some can be reused in their original form and function, others as raw materials.

For this project, the architects worked closely with builders, installers and companies of electrotechnical installations. The architect we interviewed pointed out that using BIM helped them at different key moments of the project. For example, having the BIM digital model stored in the cloud, facilitated access for all the project stakeholders to the right information, at any time and in real time. Close collaboration with project partners and the use of a clash detection software (Solibri), enabled detecting a large number of errors before construction began. This process took a long time during the design phase, but saved money during construction. The 3D visualizations generated by the BIM digital model allowed the architects to better communicate with the owners and other project stakeholders.

3. 5 PLANNING THE END OF LIFE (PROJECT 5)

The fifth project is a new construction of 300 m², using mainly recovered materials and focusing on future dismantling. The architects' goal was to design a building as circular as possible, using reusable materials and bio-materials.

Even through the architects were well acquainted with BIM, for this project, they have chosen to focus on DfD. There are two main reasons why they chose not to invest time in producing a BIM model. The first reason is the scale of the project. As the surface of the building is only 300m², the documentation can easily be handled manually. Also, the architects are the owners of the building. As they plan to completely dismantle the building in ten years' time, they already know that they will handle the deconstruction work themselves.

Two end-of-life options are being considered. The first is the identical assembly of the building at another location. The second one considers the building as a material bank where each element will be assessed individually. The architects have not given their opinion on this issue.

3. 6 DOCUMENTING DFD (PROJECT 6)

The last project consists of 60 general housing units. The aim is to build a housing project where 90 % of the materials used can be reused at the end of the building's life without significant loss of value. Therefore, the building is designed to be dismountable in order to recover its components (DfD).

This project shows us that the concept of "BIM" is larger than only using the, so called, BIM software. The housing project involves more than 30 companies throughout the construction sector. In order to achieve this collaboration, various workshops were organized: *"We divided the building in different layers and then we redesigned them one by one."* Each session concerned an aspect of the construction: structure, envelope, technical installations, etc. The interaction between all these companies has made it possible to find innovative solutions.

For this project, the architects have not yet worked with the BIM modelling tools, but they plan to do so before the project is built: *"Since we know we are going to do it, we have it always in the back of our head. DfD is all the way through the thoughts but we have to document them later. In that regard, we prepared it to be ready for BIM and its documentation."*

The architects intend to introduce information about materials in a materials passport but they have not yet stated their opinion on its form. These material passports will be integrated into the BIM digital model to provide all the information for building maintenance, such as the type of paint to be used or how to remove an interior wall.

4. DISCUSSION & CONCLUSION

4.1 ADVANTAGES OF COMBINING BIM WITH DFD

Following the interviews, we identify two major advantages of using a digital BIM model.

During a renovation project, BIM helps to obtain a better knowledge of the building. A digital model of an existing building makes it possible to generate a pre-demolition inventory in a way that is faithful to the actual edifice. This inventory can then be used to anticipate and organize the transport, storage and sale of the materials to be deconstructed.

The second advantage concerns the potential for material circularity. We know that the lack of information on reuse materials is one of the main obstacles (Gorgolewski, 2017; Durmisevic, 2017; Ghyoot et al., 2018). Having technical, maintenance, disassembly and recycling information increases the possibilities to reuse materials in both new and renovation projects (Verberne, 2016). However, BIM makes it possible to integrate all the characteristics of the materials into the digital model (Aguiar et al., 2019). The architects we interviewed believe that a building accompanied by a BIM model containing dismantling information will be more valuable at the time of sale than a building that does not.

We note that the combination of BIM with DfD is mainly interesting and even essential for large projects. For small projects, the approach still seems too complex and costly to be generalized today. Architects also see a great interest in projects that require a lot of flexibility during the building's life cycle. Ultimately, they would like these BIM and DfD to apply to all projects.

4.2 SATISFACTION TOWARDS BIM MODELING SOFWARES

None of the architects we met is satisfied with the current BIM modeling software. They would like to advance the introduction of DfD in the project and no longer have software compatibility problems. They also lack a tool that allows them to easily plan and visualize the deconstruction of a building. Moreover, little is currently being implemented concerning the CE, particularly towards deconstruction.

4.3 CONCLUSION

The distinction between a renovation project or a new project, the size, the destination, the need for flexibility, the location in an urban environment or not, are all factors to be taken into consideration at the end of the building's life. As a result, the deconstruction objectives vary for each project. They can be the maximal material recovery, the minimisation of demolition/deconstruction costs, the comparison of different deconstruction scenarios, the optimisation of the transport and storage of extracted materials and so on (Figure 2).

In order to achieve the various deconstruction objectives, the deconstruction activities must be planned. This scheduling requires a pre-estimation of the material quantities that could be dismantled for future reuse. The BIM process associated with an "as-built" BIM digital model containing material passports would be a valuable aid in documenting the future deconstruction of a building and thus favouring the reuse of its components.

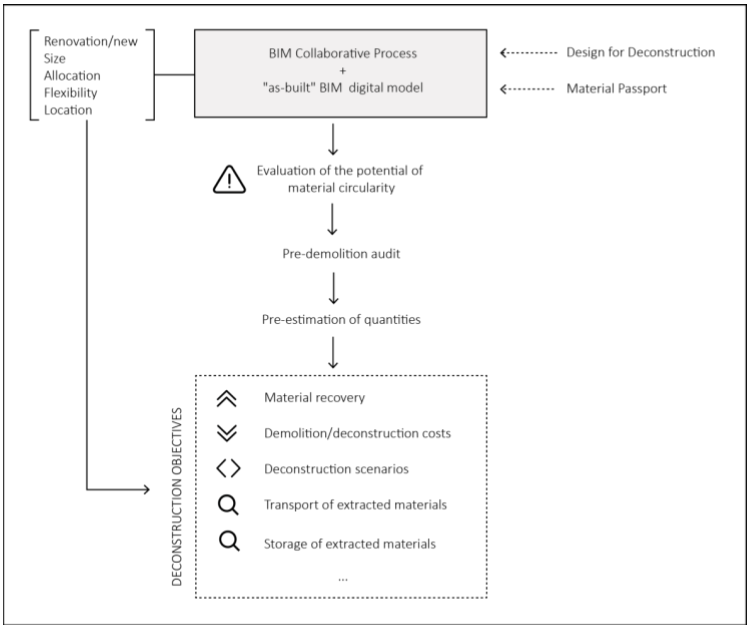

Figure 2. The BIM as a decision-making tool between demolition and deconstruction (Source: Halbach, 2019)

From our readings and interviews, we observed that DfD is even more important than having an "as-built" BIM model. Indeed, the documentation work through BIM is futile if it is not physically and economically possible to dismantle the component or material without damaging it. We conclude that BIM associated with the CE shows a global vision on the entire life cycle of a building. However, it remains a tool and will not replace human intelligence and creativity.

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