EXTENDED ABSTRACT

USE OF BIM TECHNOLOGY IN BUILT HERITAGE
ONE CASE STUDY: CONVENTO DOS CAPUCHOS DA CAPARICA (ALMADA)

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Abstract

This work thesis aims to explore the potentialities of BIM technology (Building Information Modeling) applied to management and maintenance procedures of pre-existent buildings, more specifically, heritage buildings. BIM technology is based on a work methodology more close to reality. It is focused on the concept of the object and dedicated to the three-dimensional description of the built environment. It allows its description and representation in a holistic way, by describing the constructed object through more or less detailed scales, and complex, if one integrates a set of geometric and non-geometric data with the possibility of object parametrization. The implementation of BIM technology to heritage buildings provides the preservation of their constructive truth as well as the record of interventions and adaptations in the buildings. Moreover, this technology brings the possibility of patrimony disclosure to a wider range of population while preserving the fragility of its construction. Nevertheless, there aren't many available examples allowing the development of the advantages of this technology.

The approach developed in this thesis made use of a specific case study: the Convento dos Capuchos, at Caparica, Almada. This monument is considered to be municipal patrimony and it is a space devoted to erudite musical events of intimate character. The virtual model for this Franciscan convent was developed having into account all the data available about the building and an effort was made to detail the geometrical and constructive aspects. This methodology provided the description of scenarios demonstrating how the database created can help in the current maintenance and management of this heritage building.

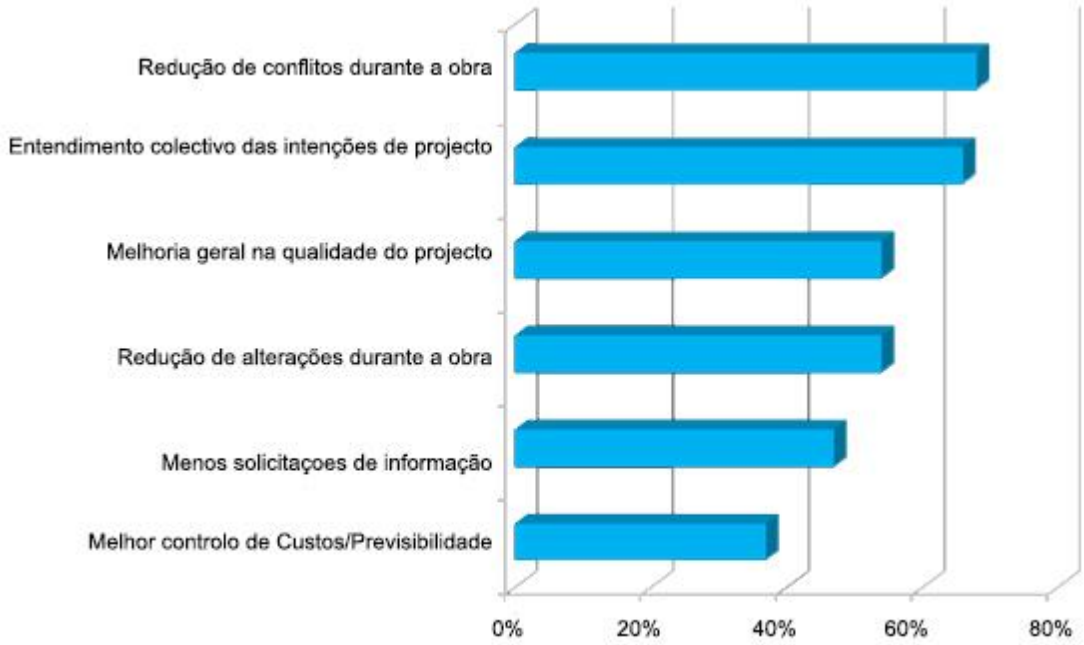
Keywords: BIM technology; Revit; 3D modelling; FM – Facility Management; Heritage; Convento dos Capuchos; Almada.

Introduction

Considering, nowadays, the necessity of a good time management, it has became very important the use of easier and more practical tools to communicate better our ideas and work, specially when it comes to jobs related with engineer, architecture and construction. For this reason, several software's have been developed around the idea of modelling an object, in terms of three-dimensional concepts, in order to achieve a 3D model as closer as it can be to reality - the solid/object instead of the line. Therefore, it is possible to have a more concrete and complete view of the prototype itself. Building Information Modeling (BIM) is, in fact, the technology that deals with this matter and can really communicate the complexity of a project and give all the detailed information of each element.

1. State of the Art – BIM technology

Comparing this work methodology with the traditional one it becomes clear that, in general, there is a resource optimization that drives greater communication and work efficiency: not only on the accuracy and precision of the technical drawings and budgets, but also on the collaborative work between multidisciplinary teams and, consequently, the elaboration of the project and the deadlines are more easier to accomplish [1].



PICTURE 1 – The new focus of drawing and construction [Adapted from: Garcia, J. & Leitão, J. (2014). O Valor do BIM].

As it has been mentioned before, this methodology has several advantages, but it is also important to point out that this methodology is, nowadays, mainly used for the conception of new buildings and constructions. Nevertheless, it has also been studied the benefits of using this kind of software's in existing constructions as well as in architectural buildings with historical value. In fact, it can be a potential management and control tool. If BIM was used in such type of constructions it might be possible to control every demolition and restoration.

This is the paradigm that the present dissertation aims to explore: is it worth to use the most recent meanings of communication, information and modelling (BIM) in building with cultural and historical value? To find out it was selected a case study - Convento dos Capuchos - in order to test the BIM software in a very well-known monument in Almada, Portugal.

As a result, there were established the following goals in order to answer the main question of this investigation:

• Creation of a 3D model of the selected case study, Convento dos Capuchos, including the surrounding area.

• Conceive a detailed database about each element of the case study project in order to create an archive where all the information can be easily consulted.

• Get to know all the construction phases and every restorative intervention that the building has suffered by modelling it all, one by one.

• Determinate, with the case study, the advantages of converting into digital mode the information of an existing and important building by using the BIM technology.

Contextualizing this matter with the present decreasing rate of new construction in industrialized countries and considering the expansion of the restoration activity, in which there is little experience in the implementation of the BIM technology, it is perceptible the relevance of the proposed investigation. The potential of this tool is high and there are several advantages: alternative calculation and optimization, risk mitigation or cost reduction, more efficient resource management; creation of demolish agenda; remodelling planning; work secure in case of demolish; accurate collaboration, documentation and management of information; energy efficiency and demolish emission accounting; etc [2].

It is important to emphasize that modelling a BIM object means representing all the building components, including its geometric and non geometric attributes, and the relation between them. Therefore, the information needs to be precise ans constantly updated so that it can be possible to use any functionality and get reliable results.

Examples for major applied or developing BIM functionalities for existing buildings.

Functionality	Research	Practice
Clash detection, spatial program validation, BIM quality assessment	[7,71]	[7,57,72,73][a]
Construction progress tracking	[7,45,61,74–83]	–
Cost calculation or cash flow modeling (5D)[b]	[7,17,55,84–87]	[57,72,88–90]
Daylight simulation	[91]	[92,93]
Deconstruction, rubble management	[2,24]	–
Deviation analysis, quality control, defect detection	[4,25,45,62,69,94–98]	–
Documentation, data management and visualization	[7,12,20,23,68,75,76,99]	[7,100–102]
Energy/thermal analysis and control, carbon foot printing	[7,22,60,86,103–105]	[57,106–109]
Localization of building components, indoor navigation	[11,20,70,110–112]	–
Life cycle assessment (LCA), sustainability	[10,11,22,29,113–116, 164]	[108]
Monitoring, performance measurement (through sensors)	[23,117–119]	[120]
Operations and maintenance (O&M), facility management (FM)	[7,11,12,14,20,45,49–56]	[13,102,121–129]
Quantity takeoff (3D)	[7]	[57,72,88][a]
Retrofit/refurbishment/renovation planning and execution	[3,11,130–132]	–
Risk scenario planning	[17,87]	–
Safety, jobsite safety, emergency management	[133–142]	–
Scheduling (4D)	[7,17,55]	[72]
Space management	[11,104,143]	–
Structural analysis	[140,144,145]	[146–149][a]
Subcontractor and supplier integration, prefabrication (e.g. of steel, precast components, fenestration, glass fabrication [7])	[7,55]	[7]

[a] Available in every major BIM software [7].
[b] Often country-specific.

PICTURE 2 – Available functions of BIM that justify their use on pre-existent buildings [Schultmann, F., Stengel, J. & Volk, R. (2013). Building Information Modeling (BIM) for existing buildings — Literature review and future needs].

If we take into consideration all the advantages of software BIM in existing buildings and apply it on constructions with historical ans patrimonial value, a potential gain is secured. In fact, the introduction of BIM in the patrimonial field can support the management of collected, modelled and shared information between different participators involved in the project. Therefore, information accessibility and interpretation is improved as it is also easier to communicate and document all the interventions and investigation activities. As a result, all the project decisions will be taken under exact knowledge expressed by de the modelling task itself; and it will be possible, as well, to programme the intervention activities and plan a management routine and control better all the changing process of the building.

The BIM modulation consists, therefore, in an intelligent electronic database, about an artefact, during the activities of investigation and conservation, capable of geometric and non-geometric representation simultaneously. However, it is important to outline that for totally understanding and representation of an historical artefact it is necessary to include not only the information directly related to the object and its components (such as the materials, its construction date, phase of deterioration), but also a wide quantity of semantic information about contextual aspects (for example, historical context, social information, the existent resources in that specific situation, or even other patrimonial informations). In fact, this new technology can store all types of information in an unique model with the advantage of easy access, edition and coordination between team work in the overall process [3].

2. Case Study - Convento dos Capuchos, Caparica

Considering the case study, it was necessary to explore three important aspects simultaneously: the patrimonial value, the building itself and every constructive detail, and the BIM modulation.

Several concepts learned during the restoration discipline of this course were reviewed in order to apply to this specific case study. In the first place, it was necessary to identify what type of building it was for the national territory - Municipal Patrimony - and how it is classified internationally - as a Monument. Gradually, it was possible to understand the implications of intervening in a building with patrimonial value such as the Convento of Capuchos as it is considered to be an important historical reference, not only in a social perspective but also in a technical matter, giving relevant information for a better understanding of human evolution and adaptation. In the second place, the history and genesis of restoration was analysed in order to understand the past interventions done by some of the greatest professionals of restoration. With this research it became clear the relevance of the proposed investigation in the Restoration field if, in the future, the BIM methodology is considered to deal with patrimonial buildings. After a closer look into multiple Letters and Conventions about patrimony, it was clear the need of a more efficient work with more evolved tools in this field and, for this reason, a new task started: the encouragement of several important entities, responsible for the patrimony maintenance, to take action and to learn with the England case where every single construction is obliged to pass through a BIM model [4].

PICTURE 3 – Ceramic panel existent in "Sala do Trânsito" of Convento da Arrábida, about Fr. Agostinho da Cruz. An example of motivation and devotion for every friar that would pass by, it ilustrates well the austerity proposed by this religious order, as it is shown by their simple [Caeiro, N. & Fontes, J. (2013). O Convento dos Capuchos - Vida, Memória, Identidade: Catálogo da Exposição. Almada: Câmara Municipal de Almada].

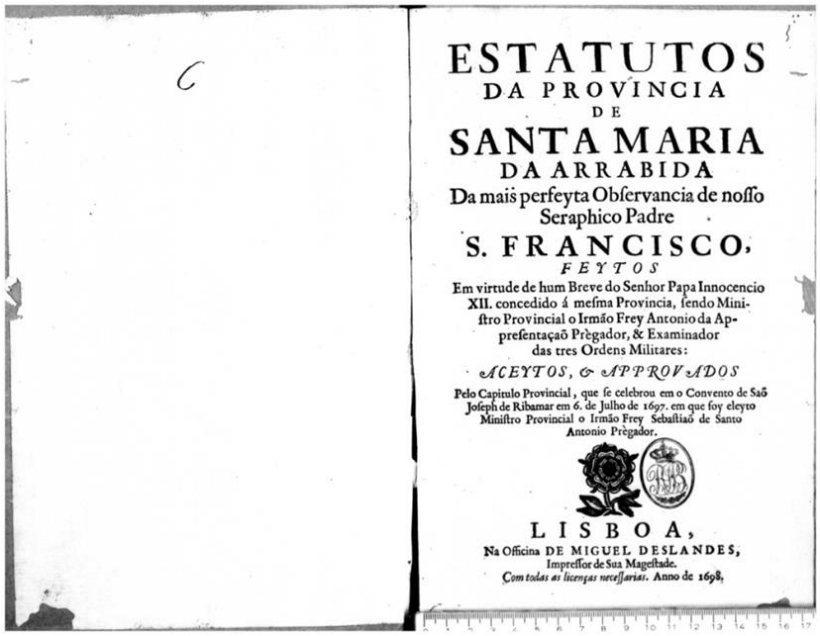
In order to understand the implications of the BIM modelling in this case study, it was important to analyse the constructive techniques and materials, as well as archaeology, used in Portugal during its construction period. However, the information available about all the interventions done in Convento of Capuchos was not conclusive neither precise.

In addition, the main causes and factors for deterioration and erosion in the building were also analysed.

For a better understanding of the overall case study context, every possible aspect related to Convento of Capuchos was analysed and, once gathered all the information, only the aspects that could influence the BIM model were considered. So, back to the past and its origins the community that inhabited in Convento of Capuchos right from the beginning was the Frades Menores Capuchinho religious order; every costumes and manners of these fries were studied so that it could be possible to understand their needs and simple way of life - "this order claimed to have a very narrow observance, with the most rigorous austerity, deeply influenced by hermitage, poverty, and contemplation (...)" [5]. This means that "the defence of poverty, typical from this kind of religious order, was the main aspect that ruled how they lived and how they took care of their monasteries" [6]. With this research it was possible to conclude that there were rules for the maintenance of their religious buildings and that it couls be found in the book "*Estatutos da Provincia de Santa Maria da Arrábida*"[1]. This was very important book that permitted a very close and reliable testimony of how Convento dos Capuchos really was since it has been constantly changed from its original configuration. In fact, this type of documents, "*Estatutos*", as they called, were a common practise among the Capuchos order and their purpose was do describe rigorously all the building characteristics and elements that define a church.

[1] This document, Estatutosm works as a general regulation for religious buildings from this religious order – capuchos. As a result, all the constructive norms and proceders of Convento dos Capuchos are described in this book.

In conclusion about the analysis of Convento of Capuchos, it is possible to define three important chronological moments: the first one, from 1552 to 1950; another from 1950 to late 20th century; and a third one that goes from late 20th century to the present days. Moreover, only two important intervention dates were selected to recreate by modulation [7].



ESTATUTOS
DA PROVINCIA
DE
SANTA MARIA
DA ARRABIDA
Da maiś perfeyta Obſervancia de noſſo
Seraphico Padre
S. FRANCISCO.
FEYTOS
Em virtude de hum Breve do Senhor Papa Innocencio
XII. concedido á meſma Provincia, ſendo Mini-
ſtro Provincial o Irmão Frey Antonio da Ap-
preſentaçaõ Prègador, & Examinador
das tres Ordens Militares:
ACEYTOS, & APPROVADOS
Pelo Capitulo Provincial, que ſe celebrou em o Convento de Saõ
Joſeph de Ribamar em 6. de Julho de 1697. em que foy eleyto
Miniſtro Provincial o Irmão Frey Sebaſtiaõ de Santo
Antonio Prègador.
LISBOA,
Na Officina DE MIGUEL DESLANDES,
Impreſſor de Sua Mageſtade.
Com todas as licenças neceſſarias. Anno de 1698.

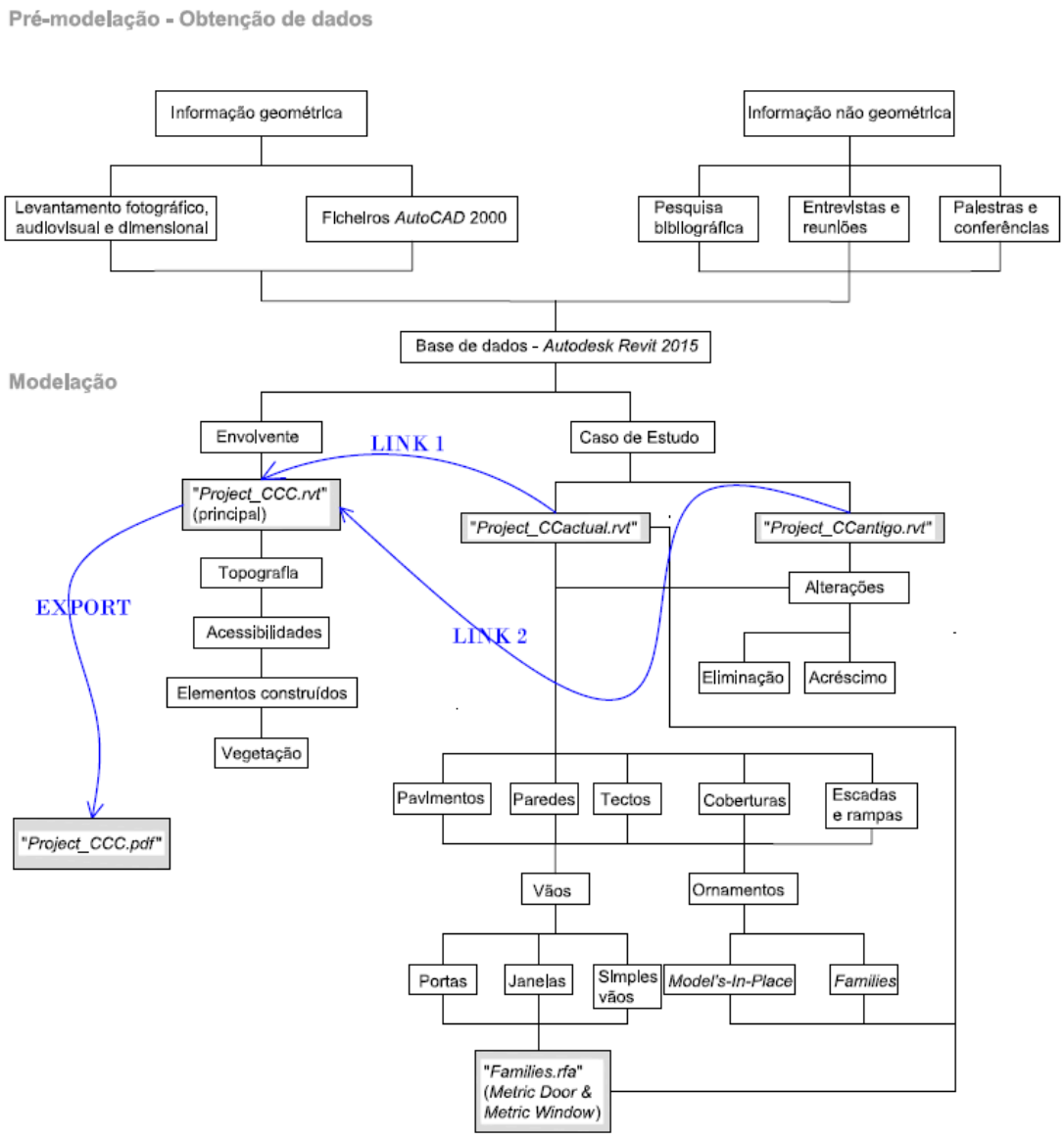
PICTURE 4 – Front page of the book *Estatutos da Provincia de Santa Maria da Arrábida*.

Considering now the BIM modelling, done simultaneously with the other tasks described before, it is important to underline that before starting the three-dimensional model all the execution project was carefully prepared: the IS units - the system used in Europe - were incorporated; the establishment of a project north; the implantation territory was all georeferenced; special attention was paid to the materials as different types of creation and aplication were studied and tested in order to represent materials closer to reality as possible it could be.

The 3D modelling task itself started with the implantation field by creating, in the first place, a revit surface and started modelling the accesses - roads, vegetation, etc. Then, the execution of the surrounding buildings. It was time to start modelling the building itself - Convento of Capuchos. This was, actually, the hardest phase, as the lack of information obliged to do several work field during months, by taking pictures and other audiovisual information. Step by step, it was possible to create a complete and very detailed model. In fact, the detail is one of the greatest characteristics of this prototype due to careful attention given during the creation of each family of doors, windows, ornaments, and other constructive details.

After the extensive work of the 3D recreation, the surrounding buildings were also represented, at least the ones that were part of the property (other chapels, ornamental constructions, stairs, etc).

As it was mentioned before, it was also proposed, during this investigation, the creation of another model correspondent to another important intervention date - 1952. Consequently, the existing model already finished was copied and then punctually changed, only when necessary, to represent its aspect during this period. It is important, though, to underline that this was only possible to materialize after a deep research about Convento dos Capuchos after its first big intervention in 1950-1952.



PICTURE 5 – Scheme of the modelling process.

1st Information collection (geometric and non-geometric data);

2nd Modelling the surrounding field area;

3rd Modelling the current Convento dos Capuchos (concerning the last intervention made – 2000-2001), doing many Families, both spans as ornaments;

4th Modelling the previous stage of the Convento dos Capuchos (after 1950-1952 intervention), from the created model of current convent, i.e., performing the necessary changes according to what exist;

5th run Link Revit command in all files created in order to connect the convents made in the field initially modeled;

6th Export the model for a more accessible format (Adobe Acrobat Reader) in order to reveal to a wider audience the work trough a 3D PDF.

Once finished the practical and theoretical research, it was possible to take some conclusions about the application of this kind of software, BIM, in projects related to patrimony. Nevertheless, it is important to emphasize that it was only possible to achieve concrete results and identify its benefits by using this BIM software with an existing building with such cultural value. Therefore, two main areas of influence were identified: a graphic and an alphanumeric.

PICTURE 6 – Facade's render of the 3D model created.

On one hand, when it comes to graphics, it was concluded that the application of BIM technology for representation gives a work environment capable of better information management and, consequently, a more precise and consistent coordination of the whole information and knowledge about the building itself, as well as a better understanding and communication of it. Hence, the visual properties of BIM can assure a good maintenance and management of patrimony buildings considering that, with this technology, it is possible to constantly update the existing information. Moreover, it also possible to use this virtual database for multiple purposes, which can be very useful for other activities.

On the other hand, its geometric field, related to other kind of information such as percentages, numerics and other textual data, can be easily accessed and updated anytime.

Conclusion

In conclusion, the greatest advantages of converting, into digital mode, an existent building with patrimonial value are:

• The unification of all the information, well systematized and organized, stored into one single platform, which and be easily consulted and editable by any participant.

• The creation of a virtual model very close to reality, in a very precise way, capable of constant updating which can also make the process of accompaniment an easier task.

There is a wide range of possibilities to explore with BIM technology that had not been tested yet in patrimonial buildings. In fact, the little use of this software, in such cases, was not sufficient to prove its benefits. Although BIM technology has already been recognized as a more efficient tool of representation, it has not been yet widely adopted to solve practical situations. For this reason, it is important to encourage the existent entities to make change and start a new process of representation with BIM in order to achieve better results as well as a better resource management. The application of this methodology to patrimonial buildings can really be very useful.

For further activities related to the created model of Convento dos Capuchos it is recommended to consider the following tasks:

• The conception of the structural project and other specializations (electricity, plumbing, etc) not only to recreate, with more detail, the existent construction but also to achieve better results from the ones that were proposed in this investigation.

• A more precise and coherent architectural survey of Convento dos Capuchos and the surrounding constructions in order to create a model as close as it can be to reality.

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