Revista ALCONPAT

www.revistaalconpat.org

eISSN 2007-6835

Revista de la Asociación Latinoamericana de Control de Calidad, Patología y Recuperación de la Construcción

Selection of constructive systems using BIM and multicriteria decision-making method

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DOI: http://dx.doi.org/10.21041/ra.v8i2.246

Received: 08/08/2017 | Accepted: 21/03/2018 | Published: 30/04/2018

ABSTRACT

This study aimed to identify whether the use of a BIM platform software associated with the AHP decision-making method can assist in the decision-making process during the design phase of projects. Three construction systems were analyzed: Load-bearing masonry, *Light Steel Framing* and *Light Wood Framing*. BIM modeling enabled scenario simulations and facilitated the extraction of data, which, in turn, assisted experts in the selection of the most appropriate constructive system, considering the established criteria. The originality of this research lies on the consideration of several factors relevant to constructive system choice. The limitation lies in modeling only the walls of the analyzed constructive systems, and not of the complete building.

Keywords: constructive systems; building information modeling; BIM; AHP.

Cite as: E. L. Machado, N. C. Sotsek, S. Scheer, A. de P. L. Santos (2018), "*Selection of constructive systems using BIM and multicriteria decision-making method* ", Revista ALCONPAT, 8 (2), pp. 209 - 223, DOI: http://dx.doi.org/10.21041/ra.v8i2.246

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Any dispute, including the replies of the authors, will be published in the first issue of 2019 provided that the information is received before the closing of the third issue of 2018.

Seleção de sistemas construtivos utilizando BIM e método de tomada de decisão multicritério

RESUMO

O objetivo deste estudo é identificar se o uso de um software de plataforma BIM associado ao método AHP de tomada de decisão, pode auxiliar no processo decisório, durante a fase de concepção de projetos. Três sistemas construtivos são analisados: Alvenaria Estrutural, *Light Steel Framing* e *Light Wood Framing*. A modelagem em BIM possibilitou simulações de cenários e facilitou a extração de dados, que, por sua vez, auxiliaram os especialistas na seleção do sistema construtivo mais adequado, considerando os critérios estabelecidos. A originalidade dessa pesquisa está em considerar vários fatores relevantes à escolha do sistema construtivo, e sua limitação está na modelagem somente das paredes dos sistemas construtivos analisados, e não da edificação completa.

Palavras-chave: sistemas construtivos; modelagem da informação da construção; BIM; AHP.

Selección de sistemas constructivos utilizando BIM y método de toma de decisión multicriterio

RESUMEN

El objetivo de este estudio es identificar si el uso de un software de plataforma BIM asociado al método AHP de toma de decisión, puede auxiliar en el proceso decisorio durante la fase de concepción de proyectos. Se analizan tres sistemas constructivos: Albañilería estructural, *Light Steel Framing* y *Light Wood Framing*. El modelado en BIM posibilitó simulaciones de escenarios y facilitó la extracción de datos, que a su vez ayudaron a los especialistas en la selección del sistema constructivo más adecuado, considerando los criterios establecidos. La originalidad de esta investigación está en considerar varios factores relevantes a la elección del sistema constructivo, y su limitación está en el modelado solamente de las paredes de los sistemas constructivos analizados, y no de la edificación completa.

Palabras clave: sistemas constructivos; modelado de la información de la construcción; BIM; AHP.

1. INTRODUCTION

Traditionally, designers in the construction industry have chosen constructive systems in two ways: based on known characteristics or selecting systems that were used in previous projects (Jalaei et al., 2015).
In Brazil, according to Molina and Calil Junior (2010), despite the technological advances achieved in this sector, the same construction system is still used since colonial times, which is the masonry system, essentially handmade, based on stacking blocks.
It is known that this practice of civil construction is favored to the detriment of alternative construction systems. This is due to pre-established standards and institutions, existing infrastructure investments, consolidated technical knowledge, and also due to the large number of agents (owners, designers, contractors and suppliers) in the industry supply chain who have always worked with these input materials and techniques (Mahapatra et al., 2012).

However, for Jadid and Badrah (2012), a high demand for materials has arisen due to the expansion of the construction industry worldwide. Therefore, arises an emerging need for research on new input materials.
According to Mahapatra et al., (2012) many countries are looking for more efficient alternatives to be in accordance with environmental sustainability protocols. Finland, for example, has submitted plans to use resources and inputs that meet the energy efficiency target set in 2010. These rules would be applied for any construction in the country, starting in 2017. According to the authors, a "code for sustainable homes" has set standards for all new buildings in the UK since 2008.
In Brazil, the main building system used in building construction is masonry. However, the environmental impacts of this practice cannot be ignored, mainly due to the amount of waste generated at construction sites. The problems are not restricted only to environmental issues, but also to the low productivity and quality of the projects, when compared to other countries with more industrialized construction systems, characterized by high productivity and process control (Molina and Calil Júnior, 2010; Mello, 2007).
Therefore, it is evident that identifying other construction systems that may be more adequate for day-to-day operation in the Brazilian scenario is crucial. For instance, systems presenting lower environmental impact and systems which could facilitate the future maintenance of buildings.
Based on this problem, the Building Information Modeling (BIM) platform software can be used as a resource during the design of the architectural projects.
BIM, according to Succar (2008, p.5) "is a set of technologies, processes and policies that allow various stakeholders to design, build and operate a facility in a collaborative way." In the BIM model, components, inputs and materials can be inserted, allowing the creation of an accessible database, which acts as a support for the selection of inputs and components for a project (Jalaei and Jrade, 2014).
In this way, this article aims to identify whether the integration of BIM in architectural projects can aid in decision making, during the project design phase, in order to optimize the selection of components for a construction. To achieve this objective, the article uses the Autodesk software Revit® (2015 version) for BIM, and the decision-making method Analytic Hierarchy Process (AHP). In an approach inspired by Marcos (2015), the innovative proposal presented by this article is the integration of BIM and AHP and the use of not only a criterion of selection for a constructive system, but also several criteria considered relevant and highlighted in the literature.
The research analyzes three constructive systems: Structural Masonry, Light Steel Framing (LSF) and Light Wood Framing (LWF). The constructive options, more specifically, the walls of each system, are analyzed, compared and their alternatives evaluated.

2. BIBLIOGRAPHICAL REVIEW

2.1 Construction systems

The increase in competitiveness among construction companies is growing throughout Brazil. This competition requires business strategies that allow a greater use of resources and rationalization of processes (Milan, 2011). In this context, Marcos and Yoskhioka (2015) point out that a possible alternative towards rationalization and industrialization of civil construction processes is the use of new constructive technologies.
The reasons for such a significant use of masonry in the country refer to: non-qualified workforce[1], cheap and available throughout the country; familiarity with the raw material, which consists of ceramic or concrete blocks, which is also easily accessible and used in various works, and finally,

[1] In this paper, the terms "non-qualified workforce" or “unskilled labor” are intended to mean "the ones whose level of education is restricted to the incomplete secondary education (incomplete high school), because in Brazil the high school category also includes technical courses that could qualify, even in a limited way, professionals for the civil construction" (Fochezatto and Ghinis, 2011, p.654).

the cultural aspect: Brazilians value the construction in masonry, as it ensures comfort both in winter and summer (Ferreira, 2014).

However, it can be seen that this constructive process, based on structural masonry, is still essentially artisanal, and presents significant flaws such as low productivity and high waste of material resources (Santiago and Araújo, 2008). Mello (2007) further emphasizes that this construction system provides unsatisfactory quality and productivity, unwillingness for modifications, employment of low-skilled workers and consequent high turnover.

In addition to the aforementioned characteristics, sector studies of SEBRAE (2008) show that there is a small share of formal employment in the total number of workers employed in the construction sector, which favors high turnover rates.

Based on this reality, the civil construction sector in Brazil has been looking for alternatives, in order for constructive systems to become more effective and less environmentally harmful. Prefabricated building systems, such as Light Steel Framing (LSF) and Light Wood Framing (LWF) are an alternative to traditional systems, since control of planning and design within the industry contributes to avoid material waste and slow production processes (Vivan, 2011).

According to Ferreira (2014), industrialization in the civil construction sector provides several advantages. Among them, one could highlight faster completion of the project, elimination of indirect costs that are difficult to account, higher quality of final product, replacement of part of the workforce by equipment, process traceability, cleaner and more organized construction site.

The LWF system is composed of structural wood components, covered by panels such as: OSB boards, and cement boards, which act as bracing elements, and gypsum board. The LWF consists of an industrialized, fast-running construction system. According to Molina and Calil junior (2010), Cardoso (2015) and Kobunbun 2014 the industrial environment allows for several activities to be carried out simultaneously resulting in shorter delivery times and lower costs.

Another advantage related to works with the LWF system is that the raw material is renewable. However, not all wood can be used for this processing. According to DATec 020-A (2015) the wood used for LWF must be properly treated. Said wood must present good quality (without defects) and with considerable dimensions to be industrialized in the design of structural panels.

According to data from the Brazilian National Forestry Information System (SNIF, 2017), lumber, i.e. sawn wood used for construction, has been increasingly used in recent years, with a growth of 48% from 2013 to 2014.

Because it is considered a new constructive method in Brazil, there are only a few suppliers and manufacturers of specific products such as cement boards, waterproof membrane, etc., which adds costs to building (Cardoso, 2015). Another important factor is the issue of skilled labor. Kokubun (2014) emphasizes that skilled labor is essential for this type of constructive system, for operations of panel manufacturing and structure assembly and disassembly. This labor force, in turn, becomes less available, given the need to train these employees and bring these professionals from the timber industry.

Besides these aspects that must be considered, the system suffers with cultural barriers. Wood is still considered a poor-quality material and many are afraid that it's use will involve deforestation, says Cardoso (2015). For Dias (2005), the main problem related to the cultural barrier is the lack of knowledge and technological development in the area.

The LSF system has similar characteristics to the LWF. The main difference is in the use of raw material, which in this case is steel and not wood. The Light Steel Framing pieces are galvanized, cold formed, designed to withstand building loads and work together with other industrialized subsystems (Sousa and Martins, 2009).

Being an industrialized system, it demands more qualified workforce, as well as the LWF. (Ferreira, 2014).

The LSF is a more expensive construction system in terms of raw material: galvanized steel (Ferreira, 2014). However, direct and indirect costs may be lower compared to reduced construction time and the absence of common losses in conventional construction.
According to Gomes et al. (2013), this system presents a time reduction of 1/3 in construction periods when compared to the conventional construction methods in masonry. Therefore, the system is more used when the construction time factor is more important than the costs.
It should be emphasized that the choice of construction systems should take into account environmental, economic and social aspects. According to Jadid and Badrah (2012), the choice of an input material, and consequently a constructive system, is related to several criteria which include, but are not limited to:

- Durable, with low maintenance requirements;
- Produced with natural and renewable resources;
- Affordable and available from local manufacturers;
- Material does not affect indoor air quality and is environmentally friendly;
- Material contains no toxic compounds;
- Material is adaptable for redistribution of the internal spaces to attend a specific service;
- Costs.

This information must be available for selection of the constructive system most appropriate to that situation. For this purpose, it is essential to create a database in which this information is available during the design phase of the project. This can be created in partnership with suppliers and designers who already work in the area and who can inform about the aspects listed above (Jadid and Badrah, 2012).

2.2 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) developed by Saaty (1990), is based on three fundamental principles: the decomposition of the structure, the comparison of the judgments and hierarchical priorities composition. The decomposition of the decision problem facilitates the construction of hierarchies of criteria to determine the importance of each criterion. These criteria, defined by experts, are analyzed and compared, two by two, independently. For this purpose, concrete data of subjective alternatives or judgments can be considered.
Once the hierarchy is structured, the alternatives are systematically evaluated by means of comparison, two by two, according to each of the criteria and a numerical scale is assigned to each pair of *n* alternatives (Table 1). These numerical scales are used for comparisons of pairs between the alternatives according to their impact on an element placed at a higher level of the hierarchy (Saaty, 1990).

Table 1. Saaty rating scale.

Intensity of importance	Definition
1	Equal importance
3	Weak importance of one over another
5	Essential or strong importance
7	Very strong
9	Extreme importance
2, 4, 6, 8	Intermediate values between the two adjacent judgments

Source: Adapted from Saaty (1990).

The sequence of the method calculations can be found in detail in Saaty (1990). This method further allows for the ranking obtained by calculating the consistency index.

Among the advantages of AHP are the ease of use and ease of adjustment of its hierarchical structure to deal with problems of different dimensions (Velasquez and Hester, 2013).

2.3 Building Information Modeling (BIM)

According to Eastman et al. (2014), BIM is a modeling technology and an associated set of processes for producing, communicating and analyzing construction models, including information related to design, simulation and operation through the use of different integrated tools.

During project design, BIM can support project detailing, providing specific information on the structure of the project, the execution processes and even on the choice of the most appropriate building system (Jalaei and Jrade, 2014).

According to Jalaei et al. (2015), the great advantage of using BIM for selection of constructive systems is its function of information integration and interoperability. BIM allows to include detailed descriptions of a single building or set of buildings may be important to make accurate analyzes of the project.

In addition, several studies have assessed the integration of BIM with environmental sustainability in Brazil. Oliveira et al. (2015), for example, highlights BIM as a resource that allows for a lifecycle approach (LCA) of the building, enabling analysis during the design phase of the project; Marinho (2014) highlights BIM as a tool to help optimize, for example, energy, water and materials use in integrated analyzes. Carvalho and Scheer (2015) demonstrate the characteristic of BIM in the anticipation of problems and prevention of project inefficiency. For them, prevention of mistakes that are often noticed only at the construction site can lead to a reduction in the costs of construction and the expense of materials, providing gains in work quality and resource savings, favoring sustainability of the buildings.

2.4 Related Papers

To better understand the practical problem and to examine the potential of the topic under study, a search was carried out to identify recent and related works published in the last five years. The search was carried out in the reference databases - ScienceDirect and CAPES Journals.

Several papers related to this topic were identified. Papers that came closest to the analysis of constructive systems using BIM and / or the decision-making tool were the four described below.

Marcos and Yoshioka (2015) wrote about how they used BIM as a tool to assist managers in the choice of inputs with the least environmental impact, comparing two construction systems: masonry and light steel frame. Its focus was specific on environmental impact.

The research of Jadid and Badrah (2012) created a decision-making method for material selection during the design phase of an architectural project. This paper focused on multicriteria method within the architectural projects.

The research of Jalaei et al. (2015) brought together the two subjects, the BIM platform software (Revit) and the decision-making method. The authors created a plug-in within BIM to assist in choosing inputs that would provide a lower environmental impact, analyzing more specifically the material life cycle. Again, this paper addresses environmental aspects.

For Jobim et al. (2006), the choice of construction systems is not only characterized from a technical or professional view but must take into account the context in which the project is inserted, user requirements, available resources, physical conditions, environmental conditions and aspects relating to cost improvement.

The novelty of this paper lies in the proposition to analyze not only a relevant factor for the construction system choice, but also some of the main factors, such as the environmental aspect related to the inputs, the financial cost and operational factors, such as availability of labor and materials.

In this way, this subject, besides being relevant and researched by other authors, is fundamental, as it enables the unfolding of the new constructive systems and helps to expand the incorporation of BIM in the production chain of civil construction in Brazil.

3. METHOD

The purpose of this study is to identify whether the use of a BIM tool associated with a multicriteria decision-making method can aid decision. It is considered that this integration may generate an instrument to assist in the most appropriate choice of construction system, according to user requirements, based not only on a relevant criterion but also on the environmental, economic and operational factors of the systems.

The proposal of the article is based on the *concept of design science* which, according to Dresch, Lacerda and Antunes Júnior (2015, p.57) "is the science that seeks to consolidate knowledge about the design and development of solutions to improve existing systems, solve problems or create new artifacts that contribute to a better human performance, whether in the society, or in organizations." Thus, Lukka's method (2003), which divides the study into seven main steps, was used to develop this research. The steps are as follows: (1) to identify a practical and relevant problem; (2) to examine research potential together with the target industry; (3) to obtain theoretical and practical knowledge of the area; (4) to propose an innovative solution and develop a construction that solves the identified problem; (5) to implement and test the solution through a case; (6) to evaluate the applicability of the solution; and (7) to identify and analyze the theoretical contributions.

Steps 1 through 4 are presented in the first part of this article. In the sequence it will be described how steps 5 to 7 were developed.

In the step defined as "to implement and test a solution", a case study was carried out to present the use of BIM platform software with the AHP method. The BIM platform software chosen for this study was the software Revit® (2015 version) that according to Suermann (2009) is the most used software in the world (67.08%).

The AHP method allows formal structure of problems, provides simplicity for comparing pairs of problems and also allows to check the consistency of the assigned weights (Leite and Freitas, 2012). For implementation of the AHP method, experts from the Federal University of Paraná (UFPR) and the private sector were invited, contributing with their direct experience in construction systems, through their *expertise* of the subject. The sample was non-probabilistic for convenience, i.e., experts were selected based on previous contact with the researchers and on the fact that they had an interest in participating in the research. The experts are:

- A and D - UFPR researchers;
- B, C and E - representatives of the corporate environment that work directly with the three construction systems in the state of Paraná.

The experts consulted evaluated the constructive systems through forms designed according to the structure of the AHP method. To aid in this part of the research, a questionnaire elaborated using *Google Forms* (Available at https://goo.gl/forms/GWo7viiJft30i1LG2).

To attribute weight to each established criterion, the experts used their professional experience and also an elaborated document, with the information found in literature regarding each constructive system used in Brazil. This information was presented in the bibliographic review of this article.

In order to weigh the criteria and formulate a ranking of alternatives, the software *SuperDecisions* was used (from the Creative Decisions Foundation, version 2.0.6).

An architectural design was chosen for the case study implementation. Among the identified projects, a house with 42m² from a social housing program was selected. It was modeled on the software® Revit three times. A first time using structural masonry construction, a second time using Light Steel Framing and a third time using walls in Light Wood Framing.
Information was inserted in each of the projects with the purpose of creating a database within the system. This information, presented in Table 2, was collected in different data sources and was based on the criteria presented by Jadid and Badrah (2012).
For research delimitation, the system was compared referring only to the area of wall with coating, not considering foundation, frames, electrical and hydraulic installations and neither roofs.
This information was manually entered into Revit, which allows storing specific data for each component. According to Marcos and Yoshioka (2015), the great advantage of using a unified tool such as Revit is that once a unified database is used for all information content, modifications in a particular document (for example, a floor plan of the architectural project), propagate themselves to the other documents involved automatically, thus guaranteeing the agility in the updates, modifications and reliability in access to information.
Figure 1 shows a schematic of the Revit information process. First the element (in this case, a wall) is drawn, then materials are applied and finishes relative to that wall and finally the information regarding the construction system as a whole. In this case, the value of incorporated CO_2 of each wall, the cost of each raw material, the execution time and the specification of the workforce.

Table 2. Source of Information for elaboration of the database in Revit software

Information	Extraction source
Energy incorporated by each material (CO_2)	Literature (Caparelli, Crippa and Boieng, 2016) and based on data extracted from Simapro Software
Production time	Literature (Cardoso,2015; Molina and Calil Júnior, 2010; Ferreira 2015)/corporate environment
Manufacturing cost	SINAPI/PR* nov. de 2016/literature (Cardoso, 2015) and corporate environment
Availability of labor	Literature (Ferreira, 2015 and Kokubun 2014)/ corporate environment
Availability of raw material (suppliers)	Literature (Ferreira, 2015)/ corporate environment

* Brazilian Nacional System for Research of Costs and Index in the Construction Industry (SINAPI), state of Paraná.

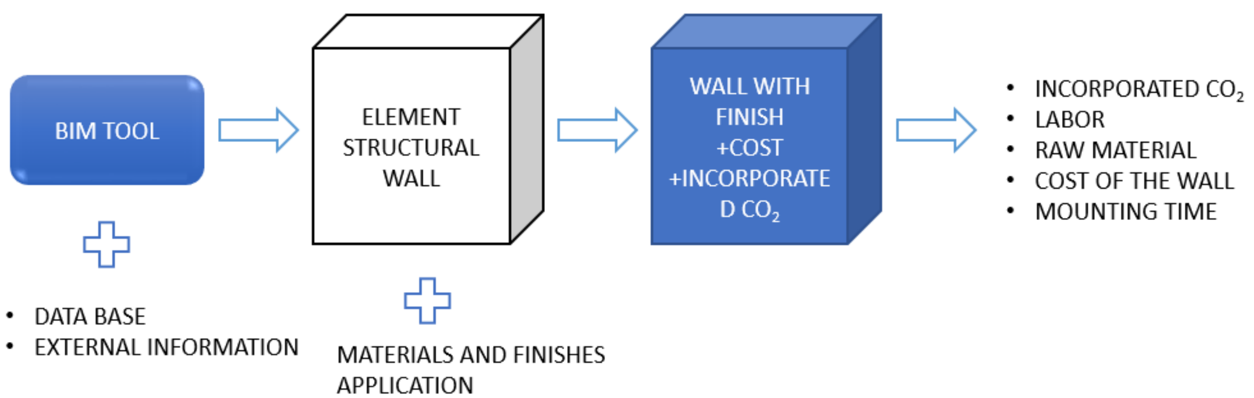

Figure 1. Revit information process schema. Adapted from Marcos and Yoshioka (2015).

In the next step, applicability evaluation, the experts were asked about the relevance of the BIM platform software to support the decision during the architectural project design.
Finally, in the "identification and analysis of the theoretical contributions" step, the authors aimed to reflect on the contribution made in comparison to similar recent studies.

4. DATA RESULTS AND ANALYSIS

4.1 Deployment and tests for the solution

The chosen residence is a 42 m² house, consisting of two bedrooms, living room, kitchen and bathroom. It was also considered that the housing scenario would be the region of Curitiba, in the state of Paraná.
Using Revit, the residence was modeled in the three constructive systems (structural masonry, LSF and LWF). The LSF and LWF systems were modeled from the plug-ins *Timber Framing* (from Autodesk) and *Metal Framing Wall* + of AGACAD (version 1.0.0.6), respectively. The use of plug-ins makes modeling faster, which allows the designer to model the project only once. The plug-ins allow conversion of any type of wall into a wall of LSF or LWF almost instantly, which increases productivity in the modeling process. The *plug-ins* also make possible to make changes in the new frame, according to the designer's preferences, since the types of profiles as well as their dimensions, the distances between the uprights and the details of the openings and connections can be changed.
The data highlighted in Table 2 were added to the parameters of the modeled walls.
Then, using Revit documentation resource, which is one of the advantages of BIM software, the list of materials with the values for the walls of the three construction systems was automatically obtained (Table 3).

Table 3. Comparative between the three constructive systems

	Structural masonry	LSF	LWF
Incorporated CO_2/m^2 of wall (kg)	50,3	159	36,9
Cost/m^2 of wall (R$)	247,63	295,99	182,32
Total of incorporated CO_2 (kg)	4.842,88	15.308,46	3.552,72
Total cost (R$)	23.841,82	28.498,08	17.553,77
Runtime	12 day	1/2 day	1/2 day
Skilled labor force	no	yes	yes

In the next step, the AHP method was used to help structuring the problem of choosing a constructive system. In this way, the criteria were first identified in the literature (Figure 2).

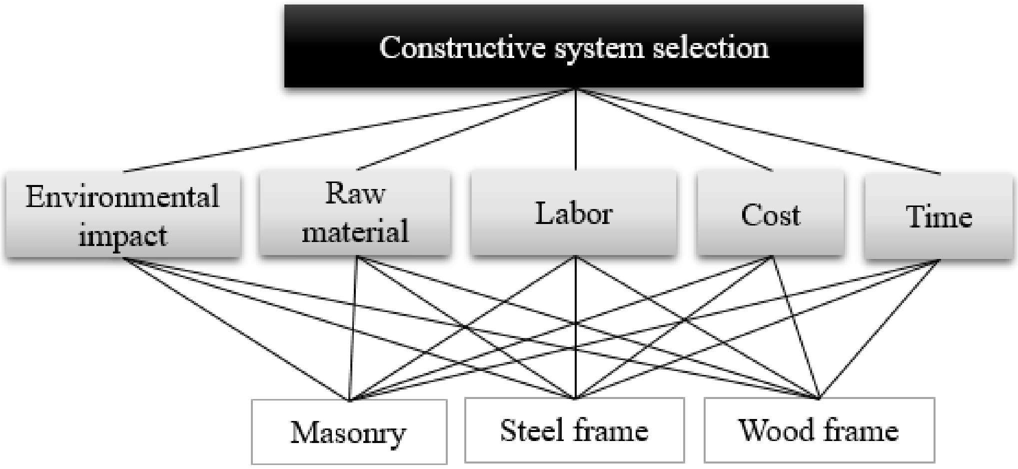

Figure 2. Hierarchy of criteria and alternatives of the case study, for use of the AHP method.

Subsequently, from the hierarchical structure of this case study and the data obtained through Revit, the abovementioned experts evaluated the constructive systems, following the structure of the AHP method, using the scale presented in Table 1. The expert evaluations were implemented in the software *SuperDecisions*. Thus, the weights stipulated by the experts for each criterion can be visualized in Table 4.
It can be seen from Table 4 that the weights indicated by the experts for each criterion of constructive system selection were very discrepant, i.e., there was no consensus among them. For experts A and B, for example, the weight of choice was the environmental impact. While for experts C, D and E, the most striking criterion is the financial value of work.

Table 4. Weights stipulated by the experts for each analyzed criterion (in percentage)

Criteria	**Expert**				
	A	**B**	**C**	**D**	**E**
Environmental impact	54,67	53,66	12,56	9,68	3,11
Availability of raw material	23,73	23,63	20,52	17,03	5,45
Availability of labor	2,91	13,61	11,81	17,24	11,31
Cost	7	5,66	37,32	42,5	52,49
Time	11,69	3,44	17,79	13,55	27,64

This analysis proves in fact that the choice of constructive system depends on the interests of each user / constructor. According to Jobim et al. (2006), the analysis of alternatives for constructive systems and materials available, regardless of whether the technology is considered innovative, should be analyzed under different criteria and in particular meet certain performance requirements, such as performance standard 15.575 (ABNT - Brazilian Association of Technical Standards, 2013).
From the stipulated weights for each criterion it was possible, with the help of the software *SuperDecisions*, to identify which building system is most suitable for each expert. The percentage preference for the construction system (ranking) is shown in Table 4.
It can be seen from Table 5 that the most appropriate constructive system in the evaluation of experts is *Light Wood Framing*.

The experts were consulted to analyze the integration of BIM with the MCDM method. As they also know the construction systems, because they work in the field of civil construction, they also contributed to create the preference ranking of construction systems.
This option was the most promising especially for the advantages that the system presents when compared to structural masonry in matters of: time, cost and environmental impact and with respect to the system Light Steel Framing, in matters of: cost, raw material and environmental impact.
It is noteworthy that the scenario elaborated took into consideration the construction of this house in the region of Curitiba in the state of Paraná, where companies are known to work with the three construction systems. It is also worth noting that the proposal of the article is to show the established scenarios and not which system is the most appropriate, since considering other factors, a system can be more promising in some situations and not so much in others.

Table 5. Percentage of systems preference obtained by the AHP method

Constructive systems	**Experts**				
	A	**B**	**C**	**D**	**E**
Masonry	12,1	35,37	8,27	4,63	**52,14**
LSF	17,95	14,16	17,91	18,51	24,67
LWF	**69,95**	**50,47**	**73,82**	**76,86**	**23,19**

4.2 Evaluation of the solution applicability

In order to evaluate the applicability of the proposed solution, the experts were asked about the relevance of the information extracted from Revit to choose the most appropriate construction system. On a scale of 1 to 5, in which 1 means nothing relevant and 5 very relevant, the average score of the experts was 3.2, i.e., in general they consider that the use of a BIM platform software contributes to the choice of construction system.
They also described how they believe BIM can contribute to the use of new constructive systems, which could also contribute to address some social barriers.
Expert A considered that, from the moment a professional is aware of the BIM tool, it may be essential to assist in their work. However, he warns that misuse of such tool may represent only a misleading view of the actual state of a project.
Expert B reported that the use of BIM platform software during the design phase is extremely satisfactory and stressed that this can help users choose more sustainable buildings.
Expert C, in agreement with expert B, considered the tool satisfactory for the comparative process, provided the extracted sources are reliable. Expert D also pointed out that BIM helps ensure that the same project will be edited, modifying construction systems in an easy and simple way allowing for efficient comparison between systems and a more reliable choice for the most appropriate option.
The expert also understood that BIM allows for greater detailing of a project which makes processes more accurate and with less waste of raw material and manpower.

4.3 Identification and analysis of theoretical contributions

Based on the case study and the evaluation carried out with the experts, it is believed that the use of BIM, as in this case, Revit and the AHP method have contributed in a promising way to assist in the choice of constructive method, since through this integration it was possible to compare criteria and have a better view from the BIM modeling, the 3D design, as well as easily extract quantitative data.
It is also considered that comparing is the way for more users to know other constructive systems and to implant them in their constructions.

As BIM incorporates a data library for information storage, said library can be used by managers during the design process of projects, contributing to the choice of the most appropriate building system. In addition, the information added can be updated depending on the project by the suppliers of inputs and contractors themselves. For example, LWF inputs are still being tested and physical tests and other inputs are being developed. In this situation, the input supplier could pass this information on to the project offices to show the new information and inputs, in order to update the data and present the novelties with respect to that construction system. Another advantage is the tool's practicality in modeling several different constructive systems in an easy and fast way, this being one of the resources to assist in the choice, which, together with the automatic obtaining of project documentation, can make project design a faster/efficient.

5. FINAL CONSIDERATIONS

The present work proposed the use of the BIM platform software associated to the AHP method to help choosing the most suitable constructive system during the design phase of architectural projects. The approach given by this research took into consideration the analysis of three constructive systems: Structural masonry, *Light Steel Framing* and *Light Wood Framing*.

The process of choosing the construction system took into account the main advantages of the use of each system, analyzing the following criteria: availability of labor and raw material; cost related to construction; time of project execution and environmental impact throughout the life cycle. The proposed method (using BIM platform software associated with the AHP method) showed that modeling a project with BIM allowed simulations of scenarios, i.e., it allowed the simulation of 3 buildings using different construction systems (wood frame, steel frame and masonry) within the same project. In addition, it facilitated data extraction, which, in turn, has been useful to help the experts choose the most appropriate constructive system considering the weighted analysis criteria and also the ranking that the AHP method suggested.

The presented method allows the designer to support a database to choose and weigh their preferences (or their client's) in relation to the criteria they find essential for the project. The academic contributions of this study include the use of BIM platform software and the AHP method together to choose the most suitable construction system for each project.

For future research, it would be interesting to apply the proposal in a real case study with the participation of end users and also presenting the theoretical reflection on the benefits brought by the association of BIM and AHP, also considering other criteria.

6. ACKNOWLEDGMENTS

This research was supported by the Post-Graduate Program in Engineering and Civil Construction (PPGECC) at the Federal University of Paraná (UFPR).

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