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CONSTRUCTIBILITY ASSESSMENT IN BIM PROJECTS IN BRAZIL

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Abstract. This research was derived from a portion of author's work developed in the theoretical basis of the author's master's degree thesis, carried out with the program Maestría en Diseño, Gestión y Dirección de Proyectos, at the Universidad Internacional Iberoamericana, UNINI Mexico (UNINI-MX). The author has experience in construction sector projects, their multi-disciplinary compatibility and teaching of specific software used in this segment, and was motivated by observation of the context in practice, and personal embarrassment. In other countries than Brazil it is a reality, rather than a novelty, that building design scores are approved in line with their constructability criteria made prior to the subsequent execution. It is also noteworthy that projects resulting from Building Information Modeling (BIM projects), among other exponentially augmenting techno-methodological advances in the speed of occurrence, quality and quantity of collaborations, increasingly require paradigms changes in civil construction, but make it easier to extract data that can be evaluated for buildability in an automated way. The purpose of BIM should not only be to automate graphical textual deliverables. This work sought to conceptualize, based on literature and experiences. How and when to perform information extraction from BIM projects, seeking the automation process of Building Constructability Assessments.

Keywords: Constructability, constructability assessment, buildability BIM, project management.

EVALUACIÓN DE CONSTRUCTIVIDAD EN PROYECTOS BIM EN BRASIL

Resumo. Esta pesquisa foi derivada de uma parte do embasamento teórico da tese de mestrado do autor, desenvolvido junto ao Programa de Maestría en Diseño, Gestión y Dirección de Proyectos, na Universidad Internacional Iberoamericana, UNINI México (UNINI-MX). O autor possui experiência em projetos do setor da construção, sua compatibilização e ensino de softwares específicos utilizados neste segmento, e foi motivado por observação do contexto na prática, e constrangimento pessoal. Nos demais países é realidade, e não novidade, a aprovação da pontuação dos projetos de edifícios, com relação aos seus critérios de construtibilidade, antes de se proceder a sua consecução. É notável também que projetos resultantes de modelagem de informações da construção (projetos BIM), dentre outros avanços tecnometodológicos entrantes de forma exponencialmente crescente na velocidade de ocorrência, qualidade e quantidade de colaborações, cada vez mais, exigem mudanças de paradigmas na construção civil, mas facilitam a extração de dados que podem ser avaliados, com relação à sua edificabilidade, de forma automatizada. A finalidade do BIM não deveria ser somente a automatização de entregáveis gráfico-textuais. Este trabalho buscou conceituar, embasado em literatura e experiências, como e quando realizar a extração de informações de projetos BIM buscando a automatização da Avaliação de Construtibilidade de Edifícios.

Palavras-chave: Construtibilidade, avaliação de construtibilidade, edificabilidade BIM, gestão de Projetos.

EVALUACIÓN DE CONSTRUCTIVIDAD EN PROYECTOS BIM EN BRASIL

Resumen. Esta investigación se derivó de una parte de la base teórica de la tesis de maestría del autor, desarrollada en conjunto con el Programa de Maestría en Diseño, Gestión y Gestión de Proyectos, en la Universidad Internacional Iberoamericana, UNINI-México (UNINI-MX). El autor tiene experiencia en proyectos en el sector de la construcción, su compatibilidad y enseñanza del software específico utilizado en este segmento, y se motivó al observar el contexto en la práctica y la vergüenza personal. En otros países, es una realidad, y no una novedad, aprobar los puntajes de los proyectos de construcción, en relación con sus criterios de construcción, antes de proceder a su logro. También es digno de mención que los proyectos que resultan del modelado de la información de construcción (proyectos BIM), entre otros avances tecnometodológicos entrantes de manera exponencialmente creciente en la velocidad de ocurrencia, calidad y cantidad de colaboraciones, exigen cada vez más cambios en los paradigmas en la construcción civil, pero facilitan la extracción de datos que pueden evaluarse, en relación con su capacidad de construcción, de forma automatizada. El propósito de BIM no debe ser solo la automatización de los resultados gráficos-textuales. Este trabajo buscó conceptualizar, con base en la literatura y las experiencias, cómo y cuándo extraer información de proyectos BIM que buscan automatizar la Evaluación de Constructividad del Edificio.

Palabras clave: Constructividad, evaluación de constructividad, edificabilidad BIM, gestión de proyectos.

Introduction

Projects resulting from Building Information Modeling (BIM), among other incoming technological advances, require paradigm shifts in civil construction. The objective of this study is to investigate not only BIM deliverables from the “Delivery Based” perspective, based on deliverables, commonly proclaimed by several recent study fronts, but the study with the sole purpose of adopting the best construction solution that can be achieved through the prior evaluation of constructivity carried out before its execution. The problems derived from the low constructivity result in serious financial losses and delays in the schedules of almost all the works. Some are not even completed. This research tried to verify how to apply the concepts of constructivity to the efficiency of buildings, in BIM projects, in order to achieve a better management of the projects and an optimized achievement of the constructions of buildings.

Contextualization of the Brazilian Scenario

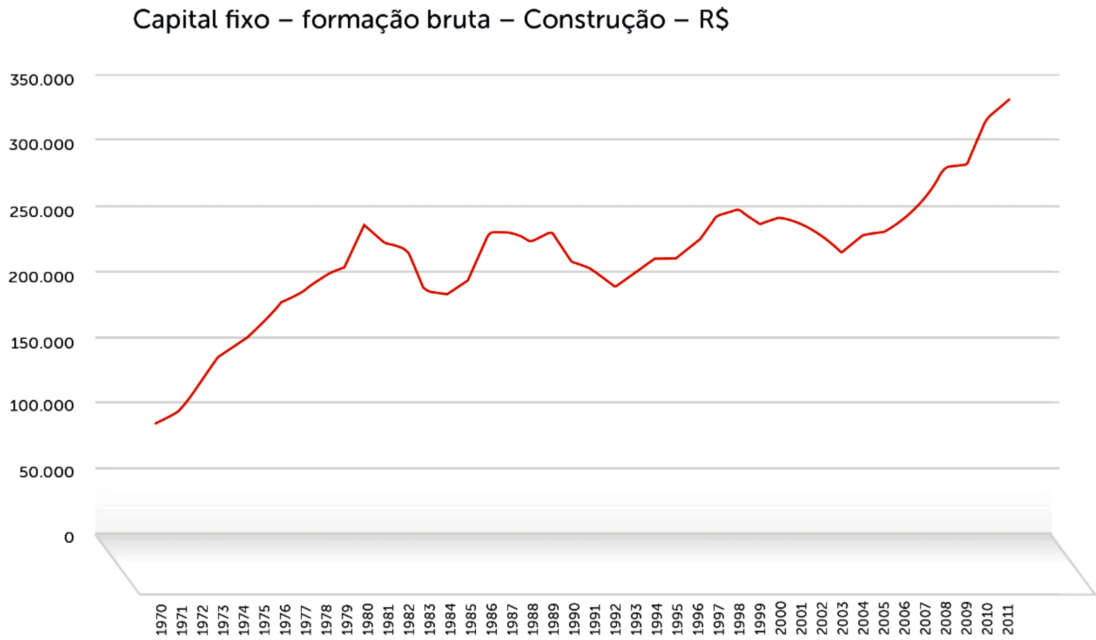

Figure 1. Fixed capital of gross formation of construction in Brazil, in reais (R$).
Note: Source**:** IBGE (2019) [website] (https://metadados.ibge.gov.br/consulta/estatisticos/operacoes-estatisticas/, recovered on July 1, 2019).

Figure 1 summarizes the historical context of the sample population. In half a century, the Brazilian economy has undergone numerous transformations:

The 70s: military governments and state investments.

The 80s: macroeconomic crisis, retraction of the supply of infrastructure and housing capital, acceleration of inflation and bankruptcy of the National Housing Bank (BNH).

From the 90s to the 2000s: the Plan Real, in 1994, established the necessary preconditions for the sustained expansion of the economy. Reactivation of investments with the Growth Acceleration Program (PAC). Mi Casa, Mi Vida Program(PMCMV), in 2009, with the expansion of real estate credit to low-income families. Fixed capital formation in construction. Growth of Brazil, with the expansion of sector employment. However, there happens to be a desire for higher qualification and productivity.

It should be noted that, throughout the world, the construction sector is considered to generate work of very low social status. According to Abdul-Aziz (2001), in Malaysia, “local youth prefer to be unemployed to work in the construction industry, due to archaic work practices, outdoor work and the prevalence of temporary and casual work.” In both rich and poor countries, people work in the civil construction industry when they have to with no choice, and leave the sector at the first opportunity. The most aggravating factor is the aging of the population and the disappearance of construction jobs during economic crises and the difficulty of recovering them when the scenario is reversed, since the civil construction workforce is reabsorbed more quickly by other sectors that tend to recover much faster. According to Neri (2014), in a study carried out by the FGV in association with the *Instituto Votorantim*, "construction is the second sector with the least participation in professional education, only surpassed by agriculture in Brazil."

Methodology

The analysis context has been delimited to the application of the constructivity criteria for the evaluation of BIM projects for buildings. Based on the bibliography directly or indirectly related to the topic, according to its original versions, or available copies, in Portuguese and English. The author citations of the English references received a free translation by the author. Although it is not the objective of this work, the future possibility of a more specific approach to the/other constructivity variables, BIM, /other incoming technologies and methodologies, in all its magnitude, is left open. This work focused on a projective and practical line of research, which allowed the application of the Constructability Assessment in BIM. Following the guidelines for the application of constructivity for project teams of the *Construction Industry Institute* (CII, 2012), this ensures that, on average, a total saving of 4.3% is generated in construction costs and a reduction in time of 7.5%.

Concept and theoretical framework

In 1962, in the United Kingdom, the *Survey of Problems before the Construction Industries*, popularized as the "Emmerson Report," was identified as the first publication to address the subject. It was a report commissioned to Lord Emmerson by the English government, motivated by low productivity, to investigate the state of the construction industry and propose improvements in the way in which professionals, builders and customers interact. The paper describes that “in no other industry is project responsibility so far from production responsibility,” according to Emmerson (1962) apud Moore (1996a, p. 56). In the English *Design Buildings Wiki* (DBW, 2016) it is stated that the “Emmerson Report” motivated the identification of the problems derived from the separation between the project and its realization and encouraged the request of other reports by the government, such as the “Banwell Report,” of 1964, which aimed to investigate the use of standardized contractual models. The "Banwell Report" concluded that the standardized models ended up creating "protection and concealment of information," segmenting communication and hindering productivity. “Low bid prices” were criticized for not taking other parameters into account, but the request was not accepted at the time, according to DBW (2016).

In 1979, the British *Construction Industry Research and Information Association* (CIRIA) made a series of recommendations to companies operating on standard English contracts and conducted several interviews with builders, which they complained about the “low buildability” caused by the bad relationship and lack of understanding with the designers. According to Moore (1996b), “low constructiveness” was used when talking about the low profitability that clients received for the amounts invested. The first definition of the term is attributed to CIRIA (1983), apud Wong (2007, p. 25), who stated that: “Constructivity is the way in which the design of a building facilitates its construction, subject to all general requirements of the finished building.” He also ratified the relationship between the constructiveness and the fragmentation of the industry, pointed out in the "Emmerson" and "Banwel Reports." According to Moore (1996b, p. 4): "In order to obtain good constructiveness, it is necessary for designers and builders to be able to see the entire construction process through the eyes of the other." Thus was born the definition of constructivity as the ease of construction, and its dependence on the integration of the ideas of the different parties involved in a construction. Lam, Wong and Chan (2006) and WS Atkins (1994) approach the terminologies considering that "buildability," sometimes translated in Portugal as "edificability," translates into concern for the design of the project, while "constructability," the American "constructability", translates into concern for all phases of the project. According to Wong (2007), even with their differences in approach and development, “buildability” and “constructability” are treated in the literature as two visions of the same concept. Research on the two terms is compared with each other, and there are cases where the difference in terminology does not even lead to a difference in ideas. In Australia, for example, “constructability” is used for both slopes, according to Francis (1999). In Brazil, “construtibilidade” is the only used term, leaving it up to each publication to define its meaning.

The 60s was the time of the breakthrough with old values and the creation of new musical, artistic and constructive movements, according to Reis, P. R. (2006). The architecture of this period, full of daring projects in Brazil and in the world, was used as an instrument of political, social and cultural manifestation. Not only the concepts of constructiveness, but also BIM, had their beginning in this troubled period. In 1974, Charles M. Eastman and his team at the Georgia Institute of Technology (USA) created the Building Description System (BDS). According to Eastman et al. (1974), the BDS showed that the description, with the use of a computer, of a building could reproduce and improve the strengths of construction and operation, as well as eliminate the weak points of the project. The idea introduced the migration of the drawing made on the drawing table to what was done with the use of CAD-type software, Computer Aided Design, in the 1980s. In the following decades, several commercial computational tools of the CAD type were developed. In 1992, Van Nederveen and Tolman first used the term “Building Information Modeling” (BIM), in an article that addressed the multiple viewpoints of building modeling, with the idea that building information modeling supported the structure of the model with the different perspectives of the various project participants.

According to Bryde; Skewers; and Volm (2013), BIM received more attention, evolving more from the 2000s, followed by research that popularized its advantages, its better quality and its low risk of propagation of errors. BIM is recognized and adopted by the industry in some countries; however, in others, government efforts are focused on promoting greater use and the benefits that technology brings, as is the case today in Brazil. BIM, according to the *National BIM Standard - United States* (NBIMS-US, 2016), is a “digital representation of the physical and functional characteristics of an installation, which serves as a shared knowledge resource of its information and constitutes a base reliable for decisions throughout the construction life cycle.” The construction information modeling not only constitutes a three-dimensional virtual model, but also makes it possible to control all the properties of the construction elements, allowing the automatic and instantaneous extraction of views (plans, sections, elevations, isometrics and perspectives) and information (tables and details). According to *Autodesk Knowledge Network* (AKN, 2019), parametric modeling, used in BIM, refers to the relationship between all the elements of the project, allowing the coordination and management of changes. Those relationships can be created automatically by both the software and the user. The "dimensions" of BIM deliveries, also known as multidimensional BIM, or nD BIM, considers, in addition to three-dimensional space (3D), the factors of time (4D), cost (5D), and building life cycle (6D) as dimensions of the model, according to McPartland (2017). The constructability assessment, which are automated with BIM, must take into account the graphical approach of Figure 2, in which the stages are expressed, the workflow of how organizations execute their processes in the construction of buildings.

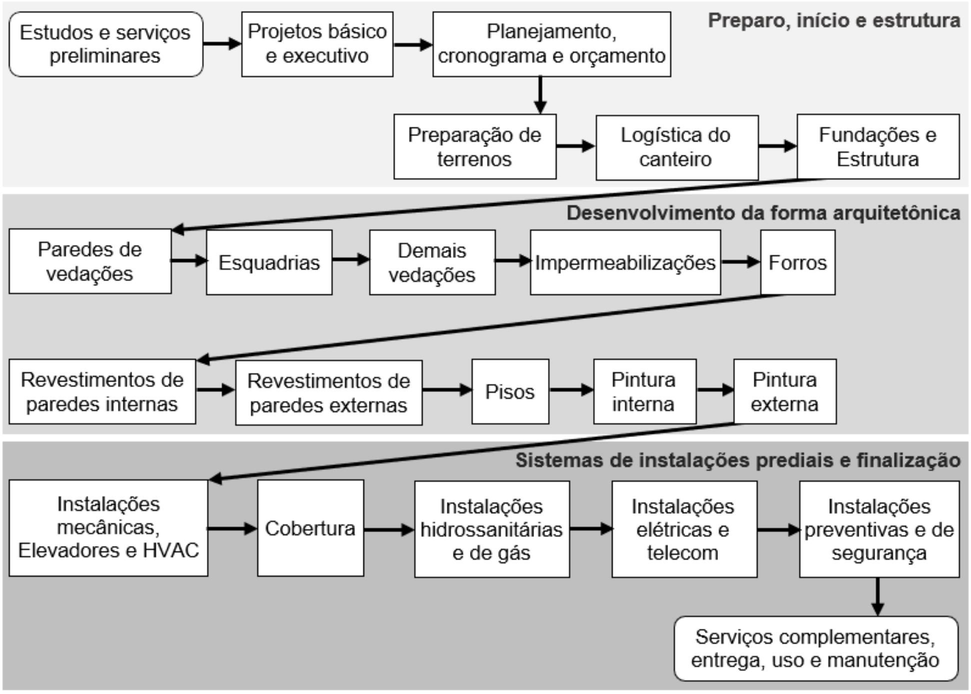

Figure 2. Process flow in the civil construction of buildings.
Note: Source: by the author (2019), based on the empirical experience and recommendations of CBIC, as well as the management software manuals of "Work Breakdown Structure," WBS.

Development of International Research

Based on the precepts of CII, CIRIA and international researchers, for the application of the constructivity guidelines, constructivity quantifications were created in order to provide greater support to the designers. According to Moore (1996b), since the 1980s the approach to Constructability Assessment has been quite varied, understanding that it is too broad to be quantified or that such methods could only be useful for some aspects without the possibility of a complete approach. According to Lawson (2006), the designers and architects rejected the first methods of rationalization and saw it as an invasion of their creative freedom, with the "standardization" and the consequent "simplification" of the project. That first impulse based on the Constructivity Guidelines was carried out with subjective processes, without a clear methodology, and therefore was not taken into consideration, although the literature continues to speak of the initial "Ratings" improperly taken as premature attempts to "Quantifications."

In terms of its benefits, there is a significant volume of publications around the world, from diverse perspectives. From those whose analysis is restricted only to the project, to those that cover the entire process and its completion and operation. From the most theoretical to the most practical approaches. Despite the diversity of approaches, the different authors have tendencies that converge towards common indicators. However, as there is no direct relationship between the different approaches, there is neither uniformity nor unanimity, which constitutes, to some extent, one of the major initial motivations for resisting the adoption of constructivity criteria. The qualitative trends of the main effects of constructivity that are most referred to are those of the American CII (2012), apud Wong (2007):

1) Reduction of the overall cost of the project;

2) Reduction of intensive work;
3) Increased execution speed;
4) Better quality of execution;
5) Increased safety in the workshop;
6) Reduction of rework;
7) Increase in productivity;
8) Decrease in the occurrence of unforeseen problems;
9) Better relationship between the team;
10) Increased customer satisfaction.

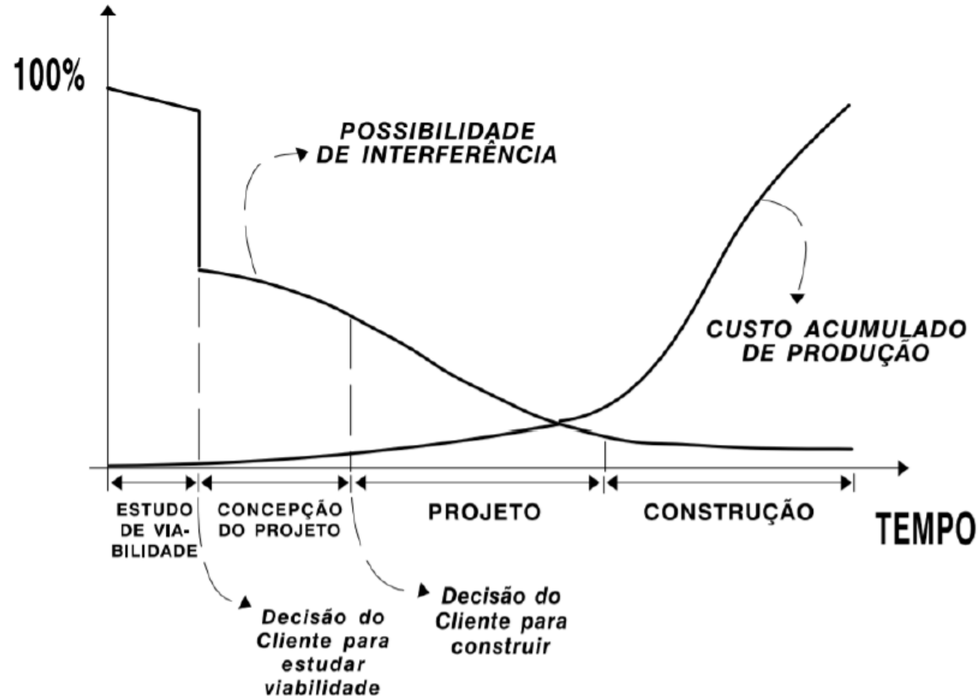

Figure 3. Relationship between the costs of the possibility of intervention and the accumulated production, through the phases of the construction project.
Note: Source: Hammarlund and Josephson (1992), apud Melhado (1994).

For the purposes of constructiveness, there is commonly the approach related to the optimal moment when the adoption of criteria begins to influence the project. There is consensus that better results will be obtained the sooner the adoption is made, preferably in the study stages, so that adaptations can be made, instead of making more difficult corrections, in terms of costs and deadlines. There are several graphs available that demonstrate the Pareto principle (20% of the efforts, generating 80% of the results), such as those of Hammarlund and Josephson (1992) apud Melhado (1994), which can be seen in figure 3.

Research on Constructivity in Brazil

There is little national research in comparison with international production, and most of it revolves around the American concept, more closely those of CII, from the

1980s. The limited development of national literature has translated the American concept of "Constructability" from CII, without any consideration, interpretation and adaptation to the Brazilian context. The American concept assumes the model of responsible "Project Management" (applied in the United States with the central figure of its "Project Manager), with little openness to responsibilities assigned to other leadership initiatives. Brazilian construction contracting and development models are more fragmented and decentralized, and diverge from American models. Regarding the human factor of resistance to change, it is observed that the imposition of complex translated definitions provokes rejection. The method should serve the context. Never the opposite. Besides being appropriate for the environment, the proposed method to assess constructiveness should aim to seek a pragmatic approach, adapting to the national context, to intervene in a simple, direct, effective and consistent way over time.

Most of the research carried out in Brazil deals with the Implementation of Constructivity, selects constructivity guidelines and proposes an implementation methodology. The concept of Constructability Assessment appears in some Brazilian works, which propose to quantify the qualification, with few references to relevant international works that have been produced since the 2000s, such as those that are under the influence of the adoption of sustainable solutions and disruptive methodological and technological advances. Heineck and Rodríguez (2003) provide examples of the definition and application of the Constructivity Guidelines in the project process. Saffaro, Santos, and Heineck (2004) repeat the format, also focusing on post-project decisions. Rodrigues (2005), in turn, focused on the study of the guidelines for repetitive works and proposed a Constructability Assessment system through a checklist in which the elements can be qualified as "yes," "partially," "no" or "not applicable." Amancio (2010), who continued the work of Rodrigues, resumed the first attempts at quantification on the basis of the rating, focusing on architecture studies and proposed his model in which expert "judges" would subjectively assess the suitability of the work.

In Brazil, there is a constant interest towards constructiveness, but the research approaches were restricted only to some of its aspects. The early work focused more on implementation and later on analysis and quantification, many of them, however, resembling the early British attempts by CIRIA and O'Connor. Therefore, there is a pressing need for new works, a greater deepening and new attempts that favor the Constructivity Analysis to fill the "gap" with respect to the new sustainability criteria (for example, less waste, better physical-financial performance), better methodologies (for example, BIM, block chain) and technological advances (for example, dry construction, generative design), variables that make some research obsolete in the international context and more exhaustive.

Results and discussions

The concept of constructivity, depending on the place, time and context, and according to different perspectives and needs, proved to have different approaches. In the United Kingdom, when the concept was conceived, researchers with a clear epistemological focus focused on the clarifications and advantages of its implementation with immeasurable benefits on the international scene. In the United States and Australia, the most pragmatic approach was the Application of Constructiveness in the project process, which encompassed the knowledge transfer from field professionals to office professionals, with a large mobilization around the topic in the construction industry and its practices, emphasizing the responsibility of its project manager. Construction Management contractual models continue to be used as a guarantee of interaction between field professionals, designers and clients, leading to greater constructiveness. However, it was evidenced that only the designers adopted the constructiveness implementation measures, without a large participation of the company itself and other actors. The companies that applied constructiveness did so in a more simplified way than that preached in universities. Even in a more conducive context, implementation took place partially due to strong resistance to change in terms of the need for different interactions and operations.

Brazil followed the American model of research on constructivity, a valid approach for an individual company where it is still under the leadership of its “Project Manager,” but its application in the broader context of the sector is also very impractical of national construction as a whole. The Brazilian sector operates in a much more fragmented way, requiring a major break in patterns, as well as a huge, resilient and disciplined effort to implement change on a larger scale. Many of the constructivity lessons in Brazil come from the CII American and CII-Australia constructivity implementation models.

In Singapore, unlike other countries, the interest in researching and applying constructiveness came from the government. According to Lam, Wong, Tiong (2006), in the 90s, the construction industry was active and had a great demand for labor that, due to geopolitical characteristics, could not be supplied by the local population. The country depended on foreign workers. There was government interference to mitigate the problem. The adoption of constructiveness assessments was encouraged to reduce dependence on foreign human resources. The "Buildable Design Appraisal System," BDAS, was adopted, based on the system of Takenaka, a Japanese multinational construction company. According to the *Building and Construction Authority* (BCA, 2017), in 1993, BDAS began to be applied in public works in the country and in 1997 prizes were instituted for more constructive private projects. In 2001, all projects and renovations with an area greater than 2000 m² were required to obtain a minimum value of construction for legal approval. BDAS is based on three principles, the "3S" of constructivity: "Simplicity," "Standardization," and "Single Integrated Elements." The Singapore Constructability Assessment is numerical and deterministic, with little openness to subjective ratings of constructivity implementations present in other countries. Moreover, according to the tests carried out by the author, it can be realized concomitantly with the information from BIM projects, provided that adaptations are made to the context.

Since the 2000s, most of the most relevant research on constructiveness has taken place in Asia, with constructability assessment and scoring models, such as the Singapore BDAS, which was consolidated as the first case in which constructivity integrates the entire construction industry nationwide, with broad benefits. BDAS consolidated a simple method, which does not require changes in the contractual models and the internal functioning of the companies, and it was accepted immediately. Hong Kong's “Buildability Assessment Model,” BAM, and its development, the “Scheme Design Buildability Assessment Model,” SDBAM, were derived from BDAS and are also other successful examples of assessment models that were fully adapted to the context, which allows prior analysis in the design stage of the project, also becoming a model replicated throughout the world. According to the valid criticism of some authors such as Moore, the Constructability Assessment can become an extreme simplification of constructivity since many project variables that affect it cannot be quantified with simple formulas.

Implementation-biased approaches are the closest to the original epistemological ideas. However, both BDAS and BAM are internationally recognized for their proven efficacy in extremely simple and quantitative use compared to the extensive rating lists of CII methods, which justifies the possibility of a pragmatic use of Constructability Assessment methods more practical and effective for companies and the construction industry.

Historically, regardless of the context, in terms of Constructability Assessment it has been found that the adoption of very complex academic methods, such as those of CII, has almost never been fully followed. And the most current, simple and practical methods, such as those developed in Asia, offer a means that generates less resistance to change, which offers a more efficient and technological way to measure constructivity with greater ease and without requiring exchanges of procedural or contractual paradigms. Another point is the definition of constructiveness. Brazilian investigations unanimously adopted the American definition of "constructability," which would require, for its large-scale application, drastic changes in the industry with its conception based on CII models, with the figure of the "Project Manager," changes in the contract modality and continuous feedback between field and office professionals in "simultaneous engineering," as defined by Barbosa, P. and Andery, P. (2015). The differing view adopted by this work is that constructiveness, in a practical way, must be adapted to the reality of the industry, to the context in which it is inserted. Never the opposite. The simplest buildability analysis has a higher propensity for broad adoption. Adaptation to the Brazilian context is also possible.

In terms of context, Brazil, despite having adopted foreign workers, does not yet experience a severe labor shortage as in Singapore and Hong Kong, but has problems related to low constructiveness similar to those in the United Kingdom. For the concept to be accepted as advantageous, there must be a decrease in errors and an improvement in the relationship between the team, the studies must be carried out in partnership with the companies. The preparation of documents and instructional conferences are other possible and complementary actions. As a future proposal, a national online database on constructiveness could also be created, such as the one devised by CII-Australia. Just as the CUB and the budget composition tables, such as the SINAPI, are regularly updated; this bank could also receive feedback and improve cyclically.

The integration of constructiveness with information and communication technologies was little addressed in Brazil. In the international framework, with several recent publications, in English, in Hong Kong and South Korea, the automated processes of Constructability Assessment and BIM are related. The development of an enabling bridge that links them effectively would also lead to advances, in both approaches, to a new level.

Conclusions and Final Considerations

Despite the vast theoretical concept, a practical and automated demonstration of some means of extracting and using BIM information for the evaluation of the constructiveness of the entire building project has not yet been consolidated, covering all its construction disciplines. However, there are some main lines of focus to consider.

A means of weighing the data would be through the BIM 3D software itself, with direct information from the project modeling and its control by the user, such as the Revit used by Zhang et al. (2016), or the ArchiCAD. Zhang et al. (2016) address the

“Constructability” Assessment, defined according to the IIC, of the project as a whole, and develop a partially automated method in Revit, by manually inserting parameters in the construction components and using an additional “plugin” to verify the percentage in which the requirements are produced, which denote the indicators of constructivity of the project.

Another possibility of automation, also through software, is the use of BIM 4D planning tools for the calculation and validation of parameters, such as Solibri, used by Jiang (2016), Navisworks, Synchro or Tekla BIMsight. Jiang (2016) investigates the constructivity of reinforced concrete forms and the possibility of automating the Constructability Assessment, using the argument of Moore (1996b) that it is impossible to develop a simple method to evaluate the constructivity of the building as a whole. With little interdisciplinary deepening, Jiang (2016) used the Solibri to verify if the model respected the established parameters, but without the total automation of this process.

Another way is the use of a "written" programming language, such as C# or Python, and/or the use of "visual" programming, such as Dynamo or Grasshopper, as a more direct way of evaluating constructiveness. By using the programming language it is possible to have an internal approach, carried out for software from a certain company, such as ADN (“Autodesk Developer Network”), or through a routine that directly accesses the original file, such as Delegrego (2017) demonstrated, with the validation of the data directly from a *.ifc model.

“Industry Foundation Classes,” IFC, is a file “sharing” extension intended for interdisciplinary BIM collaboration. According to McPartland (2017b) in collaboration with the “National Building Specification” (NBS, 2017), IFC is not a format controlled by a single company or group. It was designed and developed to facilitate interoperability in the AEC sector (Architecture, Engineering and Construction). In 1994, the “IFC Initiative,” although open, came about when Autodesk formed a consortium with 12 American companies to help them develop a set of C++ programming to support embedded applications. The included companies: AT&T, HOK Architects, Honeywell, Carrier, Tishman, and Butler Manufacturing. Initially named “International Alliance for Interoperability,” IAI, Industry Alliance for Interoperability, opened the template to all interested parties in 1995. Non-profit, industry-led, published the “Industry Foundation Class,” IFC, as a neutral and standardized model. In 2005, IAI changed its name to buildingSMART, the current head of the format. Despite the full adoption of *.ifc in some countries, such as Denmark, and initiatives such as “OpenBIM” to promote it worldwide, there is no consensus on its use, even in countries where BIM is present. Although some computer programs use it as an alternative format, they never use it as the primary or native format, which, to some extent, fuels the controversy surrounding the adoption of the format, since its inception. As a simple explanatory parallelism, the author complements that the idea around IFC is similar to that of Adobe's PDF (Portable Document Format), in regards to text documents that can also come from different sources, which they maintain interrelation and fidelity in the exchange of information.

The necessary data extraction is possible directly in the file, with the software source extension, as demonstrated by Zhang et al. (2016) with the use of Revit, or in the external environment, as demonstrated by Delegrego (2017) with the IFC. By the author's point of view, one of the difficulties encountered is not the preference that the file format be in *.rvt or *.ifc, respectively, but the way in which the construction information is manipulated in the file itself. BIM 3D, with the delimitation in categories of parametric objects used. Although the delimitation in BIM categories facilitates and gives consistency to the modeling of information, with the separation and predetermination of the individual properties of each element, in this way, it would only be possible to manage it externally if an evaluation model such as BDAS were adopted, in which several categories are grouped not always in a disciplinary way, to be analyzed together. It should be noted that not all Brazilian project offices have programmers who can overcome this barrier. The use of BIM to automate the evaluation of constructivity presupposes that the dimension of the information can be appropriate to the context of analysis. There are planning software such as Solibri, used by Jiang (2016) for the analysis of the constructiveness of reinforced concrete forms. Other BIM 4D software suitable for time dimension management include Navisworks, Synchro, and Tekla BIMsight. Due to the author's experience, in addition to the BIM 4D software that allow the generation of the calendar and its Gantt chart with assignment of tasks over time, they also offer the possibility of checking geometric interferences, and the extraction of "Quantity Take Off," QTO, among other accessory tools for planning. QTO allows the management of information without the need for intervention through programming. The planning software also allow the export, in a pivot table to Excel, software with a greater number of professional users. The QTO destination is usually the budget, the BIM 5D. Nevertheless, it can also be used, without restrictions, to assess constructiveness. The author's proposal, regarding the insertion of the Constructability Assessment in an interdisciplinary system for the delivery of BIM projects, and when it will be carried out, is shown in figure 4.

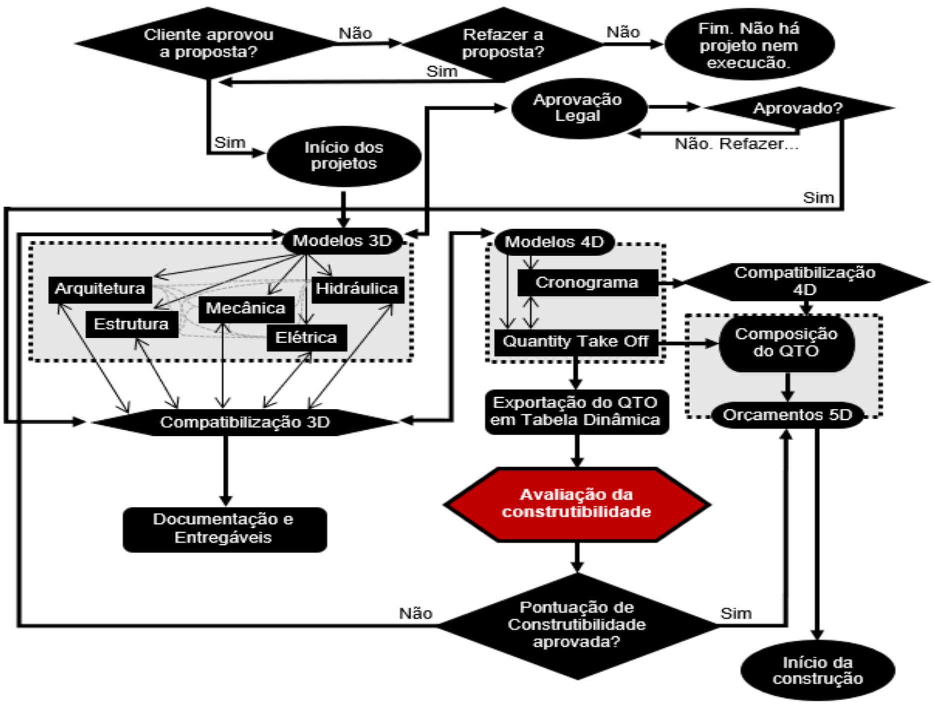

Figure 4. Constructability Assessment in an interdisciplinary BIM system
Note: Source: by the author (2019).

The Constructability Assessment in an interdisciplinary BIM project delivery system, and when it will take place, is explained in figure 4: when the client approves the proposal, the projects begin with the realization of 3D models, with a view to legal approval, the interdisciplinary three-dimensional compatibility and the absence of 3D interferences, the "3D *clashes*." Starting with the compatible 3D model, in addition to the respective technical documentation, the execution of the 4D Model is also directed. In the 4D Model, tasks are assigned on the calendar and their execution times are compatible, seeking to eliminate time conflicts, "4D *clashes*," as well as QTO. From the extracted QTO, the 5D Budgets are composed, but the extraction of the quantitative data from the QTO also allows scoring the Constructability Assessment. Once the construction is approved and the budget for the purchasing sector has been released, it is possible to start construction. In this way, the calculation is made possible with automation and fidelity in the extraction of information from the construction model with BIM methods.

With the use of a Constructability Assessment model adapted to the context, a greater propensity for its adoption is created. With the use of tools that take advantage of the construction information in an automated way, its use is facilitated. Moreover, with a deterministic evaluative model, subjective opinions are not incurred, or the lack of a fair balance. Through the basing carried out, the author analyzed 3 Brazilian BIM projects with the proposed methodology, based on the evaluation method used in Asia, and pointed out that the adoption of the Constructability Assessment, prior and deterministic, in BIM projects is possible in Brazil.

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