The development of a BIM Execution Plan for contracting public work projects

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Abstract. Building Information Modeling (BIM) is the current expression of innovation in the construction industry, a set of technologies, processes and policies that affect the deliveries, the relationships, and the roles of the civil construction industry. In Brazil, BIM is still scarce, especially in the public sector. Due to this problem, this study aims to elaborate a BIM Execution Plan for public works project contracts. The focus of this study is a public institution in the state of Ceará. For the development of this study, we adopted the Design Science Research method. As a result, we obtained a BIM Execution Plan that served as a foundation for the elaboration of BIM projects in the public institution in question. Therefore, this study contributes to the reduction of the main errors in BIM project contracting and, as a result, to the dissemination of BIM in the state of Ceará.

Keywords: BIM, BIM Execution Plan, BIM Implementation, Public Sector, ISO 19650.

1 Introduction

In Brazil, the implementation of BIM is still in its early stages. Its standardization, through the efforts of the Ministry of Development, Industry and Foreign Commerce and the Brazilian Association of Technical Standards (ABNT), is still recent. Currently, there are ABNT standards that cover information modeling: ABNT NBR ISO 12006 (Building construction — Organization of information about construction works); ABNT NBR 15965 Construction information classification system); NBR ISO 19650 (Organization of information about construction works information management using building information modeling).

From a legal point of view, there are a series of authors whose efforts focused on describing the most common problems related to contract topics (Arensman; Ozbek, 2013; Pandey; Shabodaghlou; Burger, 2016; Larson; Golden, 2017; Lowe; Muncey, 2009; Eadie; McLernon; Patton, 2015; Lip,

2012; Porwal; Hewage, 2013; Abdullah Habib, 2017; McAdam, 2010; Ashcraft, 2008). Through bibliographic research, the most common contractual problems were surveyed and categorized into 5 types: information responsibility; rights to intellectual property; project standard; data reliability; model status.

Due to the flow of information generated by the different types of professionals in BIM projects, conflicts can occur, caused by the loss of control over the responsibility of each information (Eadie; McLernon; Patton, 2015). Thus, the importance of a contractual definition for the correct assignment of the obligations of each party involved in the process is highlighted (Lip, 2012). One of the ways to achieve this is through the elaboration of a robust protocol model that eliminates any doubts, to provide the creation of a collaborative work model (Lip, 2012).

The BIM work environment is predominantly collaborative (Eadie; McLernon; Patton, 2015). This methodology aims to create a database that can be used by third parties for different occasions, allowing these professionals to have access to all information in the model (Lip, 2012). In a certain way, this characteristic can influence the generation of problems involving copyright, going from the sharing of this information to the plagiarism of ideas and projects (Eadie; McLernon; Patton, 2015).

The contractual issue that is related to the project standard concerns the level of project detail that designers must have to meet customer expectations. The new design pattern introduced by BIM helps to reduce the number of errors and, gradually, makes customers have higher expectations regarding the deliverables (Arensman; Ozbek, 2013; Eadie; McLernon; Patton, 2015). Thus, the importance of a contractual definition for the level of acceptance of each project is highlighted, considering an established acceptance standard. In addition, this standard is defined as a way to guarantee the quality of the information contained in the model, since the level of information sharing made possible by BIM requires a high degree of reliability in order to avoid detailed verifications about errors and failures in later steps (Foster, 2008).

The contractual problem that involves the trust of the data concerns the level of credibility of the project. Issues caused by the occurrence of design errors must be formally considered as it is necessary for the correct attribution of responsibilities (Lip, 2012). It is worth mentioning that the occurrence of these errors can be caused by technical or software interoperability problems that, in some cases, are independent of the designers (Lip, 2012).

The contractual problem that involves the model status concerns the level of updating of the two-dimensional drawings that are extracted from the BIM model (Abdullah Habib, 2017). These drawings are subject to being outdated at the time of obtaining them, as the models undergo constant changes. In this way, the conflict arises that addresses the perspective of whether the BIM model should be part of the deliverables defined in the contract or not (Ashcraft, 2008; McAdam, 2010). Therefore, the need for a prior contractual

definition on the delivery of the model is emphasized so that more reliable and updated data are obtained from the project to be delivered.

The study was developed in a public institution, in the state of Ceará (Brazil), responsible for attending to demands of project development, construction planning and execution, and building and state highway maintenance. Considering the large demand for projects and construction, and the limitation of resources (financial, time and personnel), it is fundamental that the project process increases the aggregation of value and eliminates waste. In other words, the aim is to: improve the project quality, the information management for planning and control of constructions, and the operation and maintenance of buildings; reduce project development time, project errors, and contractual additives. Thus, the adoption of BIM technologies, processes and policies is fundamental. In this sense, the standardization of information and data development, management and usage during the project contracting phase becomes necessary.

The BIM Execution Plan (BEP) is the document that summarizes objectives, responsibilities, and products during the process of project planning and development (Amorim, 2020). The ISO Standard 19650:2017 standardizes the creation, management, and utilization of BIM information. However, it is still necessary to have a specific approach for the public sector. In the current construction business environment, it is imperative to denote that public and private projects have their own distinct features and characteristics. For instance, public infrastructure projects are deemed to be complex, require huge resources, and are typically financed by either government or international donors. Hence, implementing BIM in these projects is distinct from the technological and innovation point of view and requires careful adoption strategies (Belay; Goedert; Woldesenbet; Rokooei, 2021).The main different between a BEP for the private sector and one for the public is that the one used on private sector is normally only focused on the project phase and, at most during the construction. A BEP used in the public sector needs to contain information about the entire life cycle of the building, since they are responsible for the maintenance of the building. Therefore, a BEP for public works contracts needs to guarantee that all the necessary information for the life cycle of the building is properly described.

Taking this into consideration, a question is raised: how does one elaborate a BEP for the development of public works projects in BIM? This task stems from the hypothesis that the BEP must be adapted to the public works contract specificities in order to contribute to the definition of contractual models that are more coherent with the public sector's reality. The main objective is to elaborate a BEP for public works contracts. The specific objectives aim to: identify support tools for BEP elaboration; identify support tools for BIM project collaboration and coordination; and propose a workflow for the BIM project process.

2 Methodology

This study was developed through the Design Science Research (DSR) strategic methodology, which aims to produce innovative constructions with the intent of resolving real-world problems and, therefore, also contributing to the theory of the subject in which it is being applied (Lukka, 2003). The usual manner of doing DSR is to construct and evaluate (March; Smith, 1995). Thus follow the stages: diagnostic, proposition, and evaluation.

At the diagnostic stage, the description of the process for the contracting and development stage of the projects in the institution was made, the survey of literature works that propose methods and models of BEP elaboration and the survey of tools for the collaboration and coordination of BIM projects were done. For this stage, we developed documentary research, bibliography survey and interviews with architects and engineers. Based on this, we mapped the current workflow to identify how BIM could improve the design process.

At the proposition stage, based on diagnostics and tool survey, the project requisites that composed the BEP were defined and a workflow based on the defined requisites was developed. These propositions composed the BEP, which followed the standards of ISO 19650. At this stage, we also modeled a project to simulate the protocols established at the BEP and the application of the proposed tools.

At the evaluation stage, the results were discussed with the expert team of the public institution to evaluate the developed workflow and verify potential improvements in interoperability, collaboration and integration.

3 Results

As a result of the diagnostic stage, it was possible to identify the main problems of the actual contracting process in the institution. Among them are: difficulties of integration and collaboration between projects due to the sequential and linear project process; lack of project development standards; poor definition of project requirements and development level and lack of definition of responsibilities.

Through the tools surveyed for the development of the BEP, the online platform called Plannerly was chosen. It has, in its free version, the requirements necessary for the elaboration of a BIM Execution Plan structured scope based on the ISO 19650.

Figure 1 shows the main interface of the platform used for the development of the plan.

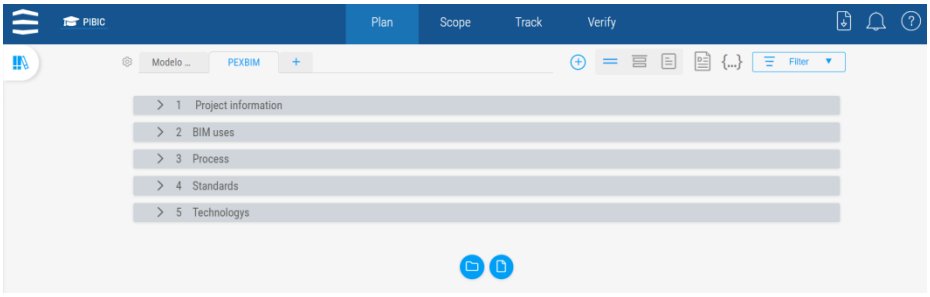

Figure 1. The platform's interface. Authors, 2022.

Through it, a document that contains two main parts for this study, the Plan, and the Scope, has been obtained as a result. The first is divided in 5 topics.

- Project information: in which the purposes and BIM uses in this BEP, and the basic information about the project is explained.
- BIM uses: the section that describes the roles and the responsibilities for each part;
- Process: this part of the plan contains the milestones and the level of development required for each one, what should be delivered at which point of the project process, when and where the meetings should happen, and where the files should go and in which format;
- Standards: this section explains every type of standard present in the project, from how the file should be named to where the project should be positioned in the software and;
- Technologies: this final section has information about the BIM software that can be used for each kind of project and the versions that are compatible. In general, it explains which information is needed, who is responsible to provide that information and how it should be structured. Providing the graphic value desired by the public institution.

The scope has all the objects that need to be contained in the project and how they should be represented depending on the phase (Preliminary study, Basic project, or Executive project). It also determines who is responsible for each representation (as show in Figure 2). In addition, it was also possible to create a scope with all the project phases, explaining which phases can happen simultaneously, and which should be completed prior to the rest.

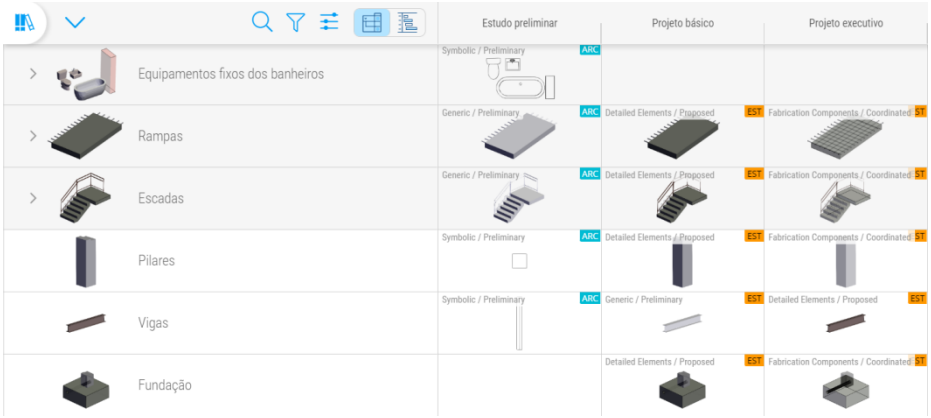

Figure 2. A part of the scope proposed to the public institution. Authors, 2022.

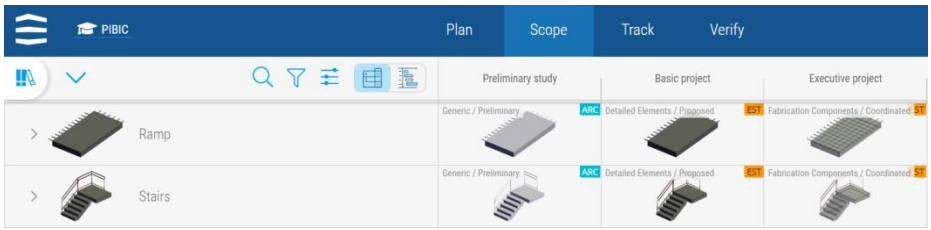

Figure 3. An example of delivery needed during the preliminary study. Authors, 2022.

The figure above (Figure 3) represents building components in the first column, with all subsequent columns representing the Level of Development of the object (LOD) in each project phase, each column representing a phase. At the top right corner of the cells that represent the LOD, is the name of the team responsible for the project. In this example, the architectural team (ARC) is responsible for the preliminary study. In the top left corner, it is informed at what LOD the building component is at, in its respective project phase. These can be: Symbolic/Preliminary, Generic/Preliminary, Detailed elements/Proposed, Fabrication components/Coordinated or Detailed elements/As built.

Besides that, the platform named BIM Collab was chosen for 3D visualization of the models to check possible clashes between the multidisciplinary projects. This verification is pre-established in the BEP through the project process, during the stage of basic project. The objective in this phase is to avoid design mistakes that in the traditional project process would only be identified later in the construction stage.

A new workflow was also proposed, that would be more adequate to the BEP and would allow collaborative work between the architectural team and the engineer team.

Figure 4 shows the actual workflow used at the institution. It is a process that tends to be slower because it requires some designs to be completed before others and there are no collaborations during the design process that are made simultaneously. This generates a longer interference correction phase.

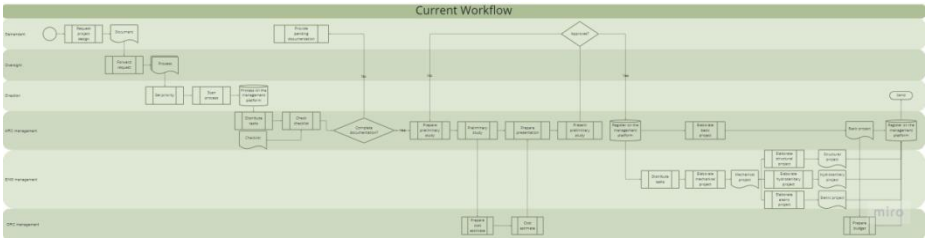

Figure 4. The current workflow at the public institution. Authors, 2022.

In the proposed workflow (Figure 5), the basic projects are developed simultaneously, creating a more collaborative process in which interferences can be checked and corrected during the process.

Figure 5. The proposed workflow. Authors, 2022.

Which these two platforms and the proposed workflow, it was possible to deal with the most frequent contractual problems. The responsibility of the information is determined by the team that produced it, whose responsible member is nominated at the beginning of the project. As for intellectual property rights, the verification of models takes place through a platform (BIM Collab) that makes it impossible to change the source file. This way, only members of the responsible team have access to that information, which also guarantees the intellectual property rights of the designers of that discipline and ensures confidence in the data. As for the project standard, this is

guaranteed by the BEP, which explains the LOD and the information that must be contained in each project and project object.

In addition, the BEP also establishes which software must be adopted by each team and which format must be adopted for deliverables. The model status should follow the weekly updates on the viewing platform to ensure that new interferences are not occurring. With this, the BEP created is suitable for public works contracts because it creates a way to verify and guarantee that all the information needed for the building life cycle is described, and in the case that it is not, who is responsible for the information can be easily identified. Another important characteristic is that the BEP describes the roles and the responsibility for each part, considering the particularities of public contracts.

4 Discussion

The evaluation of the results was done through discussion of the proposal with the expert team members of the institution. It was identified that the platform for BEP development facilitates the formalization of work protocol, which, in turn, favors the flow and the standardization of information and contributes to the reduction of errors and reworking. Other positive points are the identification of the LOD of the model via a visual scale, the detailing of the parameters of each object that should be informed, and the indication of how the information should be structured in each LOD.

In the studied case, the information should be structured in order to facilitate the extraction of quantitative data in the next stage, budgeting.

It is highlighted that the new workflow for the BIM project is potentially viable and optimizes resources and time. However, this hypothesis still needs to be validated through an application of the proposed flow in the development of a real-life project.

At the end of the study, the contribution of the developed BEP to the reduction of common contractual problems (information responsibility; intellectual property rights; project standard; data reliability; model status) is perceivable. Ultimately, the adoption of BIM by the public sector will result in encouraging the adoption of BIM in other sectors of the Architecture, Engineering and Construction industry.

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