SOME IMPROVEMENTS FOR BIM BASED COST ESTIMATION

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ABSTRACT

The quantity take-off can be speeded up with BIM. The information about all the objects in the building model with an interactive 3D visualization interface permits more understanding and deeper analysis for the estimator. Traditional and BIM based cost estimating practices are reviewed and six Brazilian case studies are described in order to show drawbacks and difficulties as well as advantages that arise in usual and in BIM based processes. Some possible improvements in the quantitative surveying tasks are presented.

Keywords: Cost estimation; BIM; Brazilian case studies.

1. INTRODUCTION

Traditionally employed systems (registration-intensive process of printed designs sets or 2D CAD drawings) for cost management of construction enterprises have many shortcomings, widely cited by the literature, such as Skoyles (1965), Bromilow (1971), Barnes (1971), Ferry and Brandon (1984). Among these it can be highlighted the lack of appropriate information to support decision-making in the production management (Kern, 2005).

Despite the importance of step of projects in product development, they are failing with impact on the production process, in part, in the employment of only two dimensions for product representation. With the advent of the Building Information Modeling (BIM), 3D parametric models have been shown to be an alternative to overcome this problem (Müller, 2010).

The main purpose of cost-estimation is to accurately capture the cost data required in the building design and avoid the risk of budget overrun at the later construction stage. With BIM, it is expected an accuracy of cost estimates obtained with the automatic identification of building components (Kuo and Eastman, 2009). The application of BIM in collaborative design can contribute to improve the process of obtaining drawn element measurements from the digital 4D model, as well as fundraising costs and deadlines for implementation (Florio, 2007).

This paper describes six case studies developed in order to analyze the drawbacks and difficulties as well as advantages that arise in traditional and in BIM based cost estimating processes. In addition, as an analysis result, possible improvements in the quantitative surveying tasks are presented.

2. DESIGN INFORMATION ON COST MANAGEMENT

In a simplified way, it can be said that the cost budget of a construction work consists of the following information: quantity takeoff of services to be performed in the work; unit costs, which are worker productivity indicators multiply by material consumption per unit of service and price per unit of man work and materials. These are the elements that constitute a cost composition: multiplying the amount of the service by its unit cost, it is obtained the total cost of the service and the sum of these, the direct cost of the construction work (Marchiori, 2009).

The largest problem in the planning, cost estimation and construction of building projects is the incorrect visualization of the project information ("the devil is in the details"). If it is not fully visualized, understood, and communicated, it cannot be represented correctly in the contract documents and may consequently create problems during construction. Difficulty in visualization begins with the owners' definition of need and visualization of space. It is critical that the designers and owner/end users understand one another in relation to the project requirements. It is necessary for the designers to understand what constitutes a defect in the owners' mind. Once a design is represented in a series of drawings, the contents of these documents may not be clear to all who use them (Kymmel, 2008).

3. BIM AS AN INFORMATION CHANNEL

The coordination of BIM model information is ensured by a standardized information repository that contains embedded information in construction drawings being added by various participants during the construction product development, ensuring the quality and integrity of the model. All changes are saved and the visions of implemented complementary projects are updated automatically (Crespo and Ruschel, 2007).

A coordinated and intelligent project will grow out of the building information that is continually cycled through the BIM at a more and more detailed and coordinated level (Kymmel, 2008).

Scheer and Ayres Filho (2009) defines four different modeling levels which constitute the BIM process: supermodeling, which deals with processes involved in production; metamodeling, which produces standards for the exchange of information; modeling, in which it is produced the model of a particular building; and, micromodeling, to create objects that will serve as building models as presented in Table 1.

Table 1: Different modeling levels which constitute the BIM modeling process
Source: Scheer and Ayres Filho (2009)

BIM	FOCUS	TARGET
Super modeling	Processes	Cooperation
Meta modeling	Patterns	Interoperability
Modeling	Instances	Semantics
Micro modeling	Objects	Behavior

The process of cost estimating involves assessing conditions in the different phases of project. Conventionally, a complete cost estimate is not available until design team has more detailed design information. It heavily relies on the accurate counts of building components/ assembly which are typically generated in the later stages such as design development and construction document. As design matures, it is possible to extract more design information (i.e. spatial and material quantities) in building models. These quantities are more than adequate for producing approximate cost estimates. It is expected for an accurate cost-estimation that the automatic identification of building components, access conditions, and definition of all levels of parts, assembly and building become feasible (Kuo and Eastman, 2009).

4. RESEARCH METHODOLOGY

To delimit the influence approach of the building design information in the budget process, the budget analysis focuses on the quantities raised direct from the design documents/drawings/model. Marchiori (2009) warns that budget entries consist of: quantity takeoff from building designs, consumption indicators of the inputs and unit prices. Taking this into account, this research is based on the method of multiple case studies. In total, six Brazilian case studies were addressed and analyzed. Two cycles were established for data analysis based on Kern (2005): Cycle 1 - Contextualization of the Theme and Cycle 2 - Exploration of the Theme as shown in Figure 1.

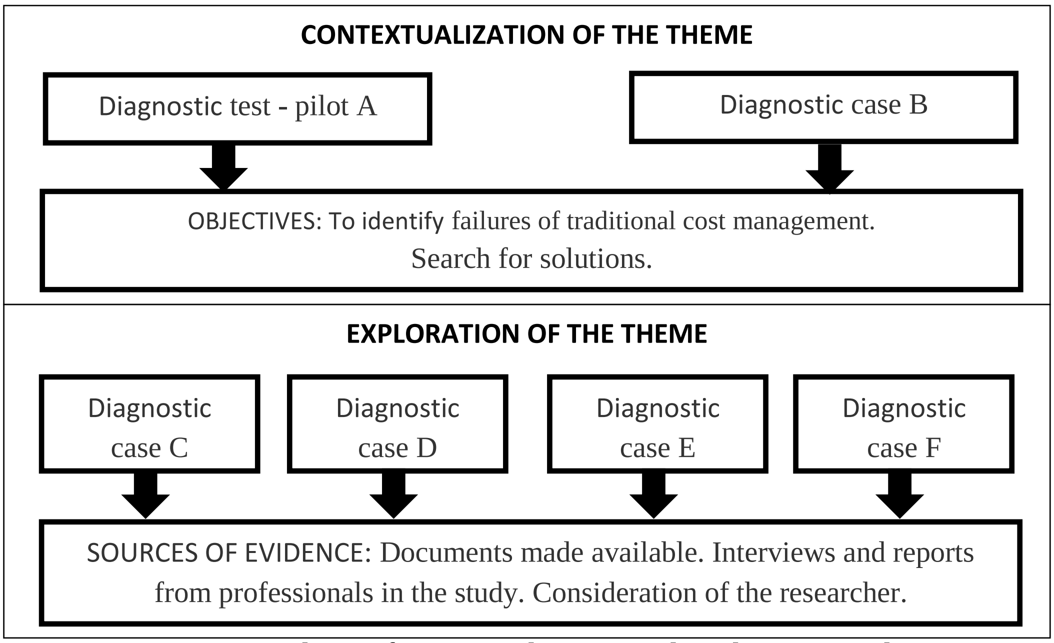

Figure 1: Analysis of contextualization and exploration cycles.

5. CONTEXTUALIZATION OF THE THEME

The Cycle 1 as the Contextualization of the Theme addresses the diagnosis of the pilot test, a case study performed on a conventional budget construction in the city of Curitiba and, the diagnosis of the case study B, also performed on a conventional budget construction but in the city of Goiânia. Table 2 presents a description of each case studies.

Table 2: Description of the case studies related to Cycle 1

	TEST PILOT A	CASE B
Location of Head Office	Curitiba	Goiânia
Branch of activity	Industrial, commercial, public works.	Industrial, commercial, residential.
Participants of the diagnosis	Technical Manager.	Technical Manager.
Obtaining the information	Visit to the company. Questionnaire applied 100%. Access to budget.	Visit to the company. Questionnaire applied 100%. Access to budget.
Budget	Reviews	Estimates
Quantitative survey	Preliminary Phase – cost Estimator and Executive Phase for the purchase of materials – Field Engineer	Draft – Executive Phase to purchase cost Estimator and materials – Field Engineer
Planning	Budget not associated to the steps of the work	Budget not associated to the steps of the work
Interoperability of 2D projects	There is no matching projects	Inefficient
Cost estimator participant in the project life cycle	Absent	Absent

The phases of quantitative survey for the implementation of the budget in the case A were the preliminary studies with all design specialties (architectural, structural and complementary). In case B the draft provision were only from architectural design and other design memorials. With the absence of suitable designs, case A and case B reported to a database with information from similar ventures, the experience of the designer, contractor and suppliers.

Another point observed on the quantitative survey were the rework that occurred in case A and case B. The designer makes the summary table and the estimator analyzes the data based on similar works. When there is discrepancy in the result, the quantities are checked during the design phase.

With the purchase of materials, the Field Engineer raises again the quantitative of materials but this time during the executive design phase. At the end of the process, the quantitative survey was conducted by three professionals: Estimator, Designer and Field Engineer. Conventional budgets do not consider costs related to methods and duration of production activities and do not produce the actual values.

The interoperability between digital design documents used in the case A did not permit the design coordination because the PDF format of the files. This is an important item for both the planning scheduling and execution of the work as well as for the quantitative survey by the Field Engineer. In case B, while he refines the design drawings for an executive design version identifying clashes, however, there was interference in the drawings because the diversity of software (without actual interoperability) used by the designers. In these two cases the Engineer Estimator only takes part in the budget spreadsheet preparation and in the physical and financial schedule despite the existence of vertical interactions in the latter case.

6. EXPLORATION OF THE THEME

BIM as a modeling process was presented in the four cases related to the Cycle 2 as the Exploration of the Theme. Case studies C, D and F were located in the city of São Paulo and case E was located in the city of São José dos Pinhais in the large metropolitan area of Curitiba. In this way, the Cycle 2 can establish a strong link between the practice and the literature confirming the hypothesis: nowadays the use of BIM deployed by construction companies and / or investor companies and service providers operating in the Brazilian market have more design information detailed in the early stages from the integration of the design process, budgeting and planning. Table 3 presents the cases description.

Table 3: Description of cases of Cycle 2 – Exploration of the theme

	CASE C	CASE D	CASE E	CASE F
Location of Head Office	São Paulo	São Paulo	São José dos Pinhais	São Paulo
Branch of activity	Industrial, commercial and residential.	Residential	Public Works	Urban hospital, building, airports
Participants in the diagnosis	Department of projects and information technology Manager.	Technical Manager	Director	Director
Obtaining the information	Visit to the company. Questionnaire applied only about projects and Information Technology. Access to budget available over the web.	Visit to the company. Questionnaire applied 100%. Access to budget available over the web.	Visit to the company. The questionnaire not applied. Access to budget available over the web.	Exchange of information by Email. Questionnaire applied 100%. Access to budget.
Budget	Automatic	In the deployment phase	Automatic test	Automatic
Quantitative survey	Complete files	Executive project	Executive project of architecture	Complete files
Planning	In the deployment phase CAD/BIM 4D	In the deployment phase CAD/BIM 4D	Drawn up by the contractor.	Drawn up by the client.
Interoperability projects	Inefficient with CAD/TQS	Inefficient with CAD/TQS	Inefficient. Sending files to the designers and contractors in DXF.	Inefficient with CAD/TQS
Interoperability 3D / 4D / 5D	Efficient between 3D and 5D. Efficient test 4D	Efficient between 3D and 5D. Efficient test 4D	Absent	Efficient between 3D and 5 D. Absent CAD/BIM 4D.
Library intelligent objects	Modeled by the Department Projects	Modeled by outsourced designers	Adapted by Projects Department	Adapted by Projects Department
Cost estimator participant of the project life cycle	Yes	Yes	Yes	Yes

BIM models of different levels are needed to set standards, rules for description and information storage, data exchange between stakeholders and activities including units that describe the basic elements of construction and project information. The analysis of Table 4 related to cases C, D, E and F respectively, permits the interpretation of the different levels of information structured based on the levels of BIM modeling pointed by Scheer and Ayres Filho (2009).

Table 4: Different levels of BIM modeling for cases C, D, E and F.
Source: based on Scheer and Ayres Filho (2009)

	BIM	TARGET
CASE C	**supermodeling**	ABSENT. The files are delivered in AutoCAD 2D and then modeled in BIM.
	metamodeling	Interoperability failure of BIM and CAD/TQS (structural design); shared data in test with 4D CAD successfully accomplished.
	modeling	Rules established with the support of the consultant BIM for relationships with the planning (in the implementation phase) and the budget (already deployed with the software MT).
	micromodeling	Modeling of objects supported by the budgets department.
CASE D	**supermodeling**	Involves multiple designers using BIM; Involves multiple designers using BIM; the architect is responsible for compatibility and clash detect of all projects;
	metamodeling	Interoperability failure of BIM and CAD/TQS; shared data in test with 4D CAD successfully accomplished.
	modeling	Rules established with the support of the consultant BIM for relationships with the planning (in the implementation phase) and the budget (in the implementation phase).
	micromodeling	Standardization of objects (bathroom, kitchen and AS, wood and aluminum window frames, staircase).
CASE E	**supermodeling**	ABSENT. Only the architecture is modeled in BIM; Modeling of complementary projects is the next goal for BIM deployment.
	metamodeling	Lack of interoperability with complementary projects and contractors. DXF files.
	modeling	ABSENT. Integration of models with the Volare is goal for a next deployment BIM.
	micromodeling	Adapted object library.
CASE F	**supermodeling**	ABSENT. The files are delivered in AutoCAD 2D and then modeled in BIM.
	metamodeling	Interoperability failure of BIM and CAD/TQS.
	modeling	Relationships established with the budget.
	micromodeling	Adapted object library.

In cases C, E and F the absence of designers (architecture and complementary projects) that work with the model was the justification for the absence of the higher modeling level (supermodeling). The BIM proposal is that the building is built virtually on the computer before the actual construction on site, a process that would bring together those involved in a virtual arrangement of cooperative project. The relationship between the budget worksheet and BIM are well established through an internally developed software, "MT". Although relationships between 3D and 4D are still being implemented, the tests were successful.

In cases C and D, it could be checked the follow-up of BIM consultant throughout its lifecycle for all due support hardware, software and training. The case D was in the deployment phase of planning and budget relationships, and this case get success in CAD4D simulation and CAD5D.

The case E aimed to establish relationships with future database Volare (cost estimation software). The case F established relationships with various database software for budgeting and did not have focus on CAD 4D planning.

In metamodeling, the lack of interoperability between the specific structural design system and the architectural design systems appeared in all cases.

The micromodeling object library also presents problems of standardization to establish which department had to model, how and what information they should contain or when those vendors should do it. At the same time, companies continue to adapt their particular needs because the objects are not yet available by Brazilian manufacturers.

Some factors may affect BIM and impact its ability to be used in the quantitative takeoff, due to the needed adaptation and training in budgeting for the new surveying methods and the staff resistance to change process (Alder, 2006). In this way, training is required for all involved professionals and they need to dominate the tool within the new context of cooperative work. All cases had trainings or have some teams who are still undergoing training.

7. CROSS-CUTTING ANALYSIS OF CYCLE 1 AND CYCLE 2

The approach of cross-cutting analysis of the failures of Cycle 1 and Cycle 2 is divided into specific items: the pattern of relationships, communication channels and information quality.

7.1 The pattern of relationships

In Cycle 1, the lack of time for analysis of the projects resulted in a cost estimation based on similar projects previously developed by the company. As the projects are not analyzed, budget and planning activities are not associated. Therefore no time is available for analysis and simulations. Likewise, the executive projects come only at the beginning of the onsite construction works and the assessments and estimates are not anymore updated by the estimator, leaving this updating task to the field engineer.

Despite the lack of a more detailed planning, all cases analyzed used in their activities for better service quality, in a sense, ICT tools. It should be thought that system interoperability, people and existing communication infrastructure in the two case studies of cycle 1 are neglected and streamlining the processes was disregarded.

7.2 Communication channels

One of the problems identified in Cycle 1 was the sending of PDF files by the client so that it could not be used any computational tool for the quantitative takeoff. Moreover, it was not possible to develop any automatic clash detection analysis due to the use of AutoCAD 2D drawing files that may further increase the inaccuracy degree of the budget. This item was focused on the multidisciplinary characteristic of the process and in the lack of professional relationship.

In Cycle 2, particularly in the cases C and F, the incompatibilities occurred between AutoCAD 2D and BIM CAD system because the lack of professionals who can use these tools. In order to meet these needs, the companies partially or completely model the received files. The structural design system presented some interferences during exportation of files in all cases of Cycle 2, causing reworks in clash detection (lack of interoperability). New versions for the system are being released and tend to solve the reported interoperability failures.

In both cycles it was possible to note problems caused by design and project incompatibilities of extreme importance. It is interesting to establish routines of failure detection for projects that will prevent damages occurring at the construction site. Part of them are due to non-cooperation in the use of systems and non-collaborative behavior of the involved professionals.

7.3 Quality of information

From the theoretical point of view to reach more precise estimates it is mandatory to get the necessary information to accomplish complete projects. In Cycle 1 the high margin of error was due to the lack of information at the time of the quantitative takeoff. In Cycle 2 the quality was referred to nD models that tend to be built with the database of smart objects. The necessary object libraries are not yet available by the national suppliers. This situation makes that each design/construction company, according to standards internally adopted, create their own parameters and objects.

The standardized object libraries are the overriding consideration for design/project/product interoperability taking into account the multidisciplinary characteristic of AEC. The interoperability is mandatory among suppliers of construction products and materials, architects, engineers, builders, contractors and all involved in the life cycle of a building. The information aggregation must lead to useful information in the virtual model so that the model better represents the reality of a construction work.

None of the case studies reached the advanced level of BIM implementation. The study made clear that there is a large gap between using a BIM software and practice a BIM development process for building projects. BIM as a process implies in a multi- and interdisciplinary approach.

8. FINAL CONSIDERATIONS

The analysis aimed to identify the main gaps in the quantitative survey phase and its relationship with the other phases of a building project. To do so, the indicated literature presents as solutions for the problems related to Cycle 1 the use of automatic quantification that was found in the four case studies presented in Cycle 2.

The Cycle 2 - Exploration of the Theme comparatively analyzed four case studies using BIM software with support for automatic quantification. The aim was to ascertain whether the problems presented in cases of Cycle 1 could be solved with the evidences of Cycle 2.

This improvement shown by the case studies of Cycle 2 is based, in fact, in the representation and visualization of the project, the quality of information entered by all involved, the simulations before the start of the construction work, and the entire strategic planning in the early stages provided by BIM. At the same time, this analysis requires a prior organizational structuring investment (software, hardware and training) and specially the time factor that affects the quality of the information not encountered in Cycle 1 and in some case studies presented in Cycle 2.

As a contribution, it was possible to meet the automated quantitative takeoff provided by various software presented in the case studies. At the same time, it was possible to know the way that the Brazilian market is absorbing the BIM concept, its stages of implementation and the gradual improvement of trainings in different company departments. The trainings are objectifying the multi- and interdisciplinarity of the processes and tools. It is noticeable so far, positive changes from the actual use.

Based on the results obtained with this research, it is understood that it is possible to improve the planning and cost control of construction enterprises from the use of BIM as a process.

Thus, the strategic use of information technology and BIM, by integrating data, information, control and process, must be analyzed within the managerial system adopted. It is not just the use of new software tools, but a transformational approach to business and organizational mission that includes a new way to work with multiple people together in a real time.

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