CASE STUDY ON THE USE OF BIM AT THE BIDDING STAGE OF A BUILDING PROJECT

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ABSTRACT

Because of ongoing problems of compatibility of engineering drawings and a lower time limit for increasingly complex projects, the BIM (Building Information Modeling) Area was created at GyM S.A. two years ago. The main objectives of this area were to make the clash detection, assure engineering compatibility, generate a 3D model with information from the components that form part of the project, and automatically obtain material quantities estimates.

During this last year, BIM Area has worked very close to the Estimating Department in order to compare their results of the quantities obtained by the BIM Area through a 3D model, with the ones obtained manually through 2D drawings by the Estimating Department. Also to help approve the modeling criteria that allows the consideration of the construction process and its subsequent use in field work.

The results throughout this teamwork experience have shown that it is feasible to obtain better results from an early stage in less time and to a higher degree than with our traditional procedure.

Demonstrate the positive impact of the application of BIM within the construction stage in our projects to the project managers will be the next challenge.

KEYWORDS

Budgeting, BIM, estimating, quantity take off, collaborative work, workflow, 3D model, sponsor, standardization, comparison, integration.

INTRODUCTION

Because of the engineering received during the bidding stage and used to estimate the construction cost of the service, which are somewhat incompatible, often the technical and financial offer presents only a partial scope of the service actually executed in the end.

Currently, the traditional method of this task takes into consideration all of the architectural and structural material quantities and some item incidentals from 2D drawings that are quantified in Microsoft Excel spreadsheets that are then redundantly entered into a CAD drawing. This requires many man-hours of work each time a version of the drawings is updated, especially because these drawings are updated only after each round of questions and answers and is subject to the ability of the estimators to identify omissions and inconsistencies in the plans.

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Unless your staff is highly trained in obtaining fast reliable data, using the traditional method, budgetary mistakes can occur, cutting down the margin of the company.

It should be a priority for the bidding of projects with greater complexity and larger scope that no budget errors should arise in the material quantity estimates. Therefore, in sight of the many man-hours that the estimators invested, it was decided that concrete and formwork quantities could be obtained directly from a 3D model through the execution of a more efficient tool for these cases, than the use of a spreadsheet.

This implementation process between the Estimating Department and the BIM Area demanded a period of adaptation that was accompanied by the revision of the quantity estimation process and the adequacy of the tools used for effective comparison. This first attempt may not be the most satisfying but was followed by an increase in the reliability of the estimates obtained.

The results shown in this paper are the consequence of approximately eight months of collaborative work between the two departments. To make this process and new tools sustainable over time, their integration into the Estimating Department is required, and taking into consideration that there will be a learning curve for the estimators that will need to be trained.

Most importantly, for any organizational change that involves a change of process, one must have the direct support of a sponsor convinced of its advantages, especially in large companies where every good initiative could be diluted between the different channels that approve such changes. Therefore, at first, a particular department has to bear the costs involved in adapting to change, and users' widespread acceptance, only after the demonstration of its advantages. As a recommendation in the same sense, "…If the senior company management sees the value in the model-based cost estimating process and endorses it, it is much easier to implement within the company…" (Tiwari, et al., 2009).

BODY OF PAPER

It is necessary three factors in order to prepare a good budget: engineering reliable information, a plan that involves applied construction procedure deadlines and the resources needed to execute it.

In an increasingly competitive market like the one in Peru, where efficiency and the cost of the service offered are valued, it is important to rely on an information flow of offers reflecting this trend and, for these reasons, one must suppose that it was feasible to improve efficiency of the material quantity estimation process by using 3D modeling tools instead of our traditional spreadsheets in Microsoft Excel.

However, for this to be done, someone would have to bear the cost of the use of new technological tools and the redundancy of efforts in obtaining results because it was necessary to compare the results obtained for the quantity estimates of concrete and formwork through two processes in order to eventually accept the advantages of using the process proposed in this paper.

The cost was finally assumed by the Technical Management Office and with the support of the BIM Area. Initially, the intention was to verify whether the 3D modeling programs used by the BIM Area were capable of reporting the amounts that were being obtained by Estimating Department using a spreadsheet.

Because the work process of the two departments was not initially reviewed together, the results of the first work experience were not encouraging. However, it did serve to identify the "why" of the failures, among which we found distrust, lack of adequate communication, lack of standardization of the approaches for obtaining material quantities, resistance to change, scope definition and higher consumption of man-hours due to reworks.

After a first comparison, actions were taken to reverse this situation. This made it possible to identify how the initial process of the Estimating Department would have to be modified. The following results showed a significant improvement.

INITIAL WORKFLOW OF THE ESTIMATING DEPARTMENT

Prior to the involvement of the BIM Area in obtaining quantity estimates, the workflow of the proposal was as shown in Figure 1.

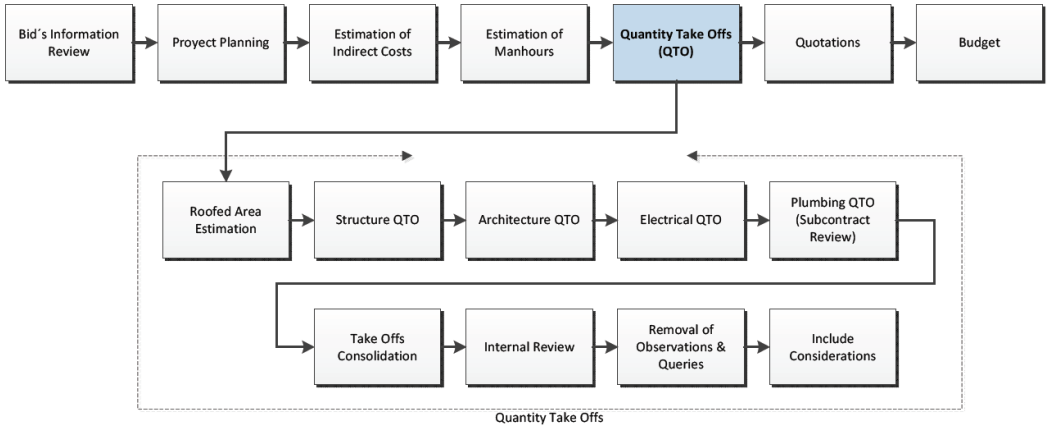

Figure 1: Initial Workflow for Technical and Economical Proposal Development– Estimating Department (Own Source 2014)

IMPLEMENTATION OF THE USE OF BIM TOOLS FOR OBTAINING MATERIAL QUANTITY ESTIMATES

In the BIM Area, Autodesk Revit software is used to model many of the components that make up a project, including concrete projects.

This program has proven to be sufficient for the material quantity estimates of building projects and is well-complemented by the use of Microsoft Excel and Microsoft Access, frequently used in the Estimating Department.

Furthermore, under a survey in the Estimating Department, the average adaptation time was estimated, comparing the use of their conventional tools with their adaptation to the use of BIM tools over time – aiming at obtaining reliable quantity estimates. The result of this comparison is shown by each discipline in Figure 2.

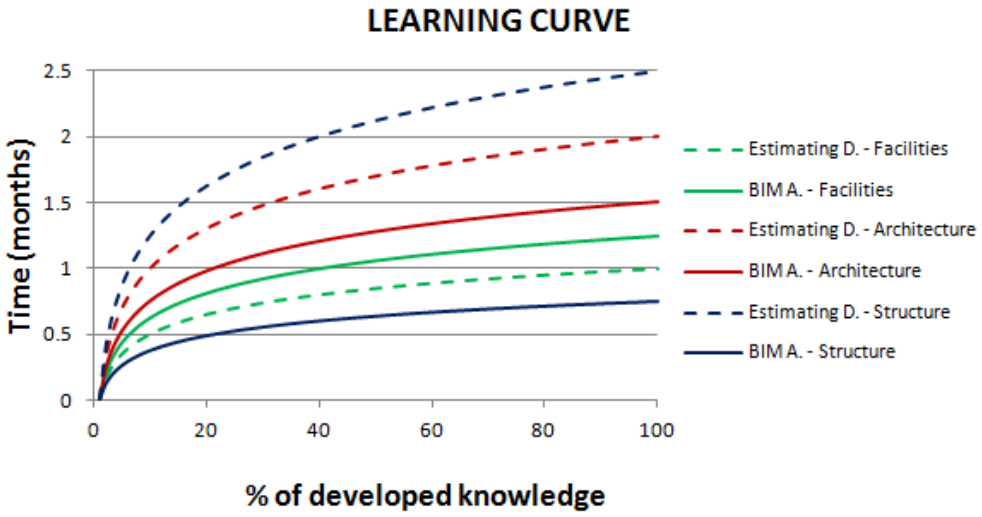

Figure 2: Learning Curve by Discipline of the Estimate Evaluating Tools for the Estimating Department and BIM Area (Own Source 2014)

Figure 2, shows that the training time (in order to obtain reliable estimates) using BIM tools is generally less than the time needed to use spreadsheets and a CAD drawing program

Standardization and Automation

It can be noted that by standardizing both the modeling methodology, and the definition of the parameters applied in 3D models, it was possible to obtain prompt, reliable quantity estimates, and adaptable to different formats of the aforementioned budgets. The BIM Area determined that it was necessary, as part of the standardization process, to do the following:

- Use default templates by disciplines: We have templates for models of different disciplines in order to work under a standard of predefined families and types.
- Use a naming convention: when modeling under the use of a common naming convention along with predefined families and types, allows for more orderly and reliable information for material quantities. It is important to follow the naming convention when applying the different parameters to the components.
- Define parameters: Completing certain parameters that allow us to regroup components as required by the different budget headings in order to facilitate getting the requested information more easily and in a more organized fashion. Among the parameters that have been implemented are: GyM Category, Classification, Group, Level of Element, Code of Element, Height Type, Structural Material, and Concrete Factor.
- Respect modeling techniques: It is necessary that prior to modeling, the parties involved should establish the techniques and the criteria to be applied, bearing in mind the construction process For example, it is important to model floor by floor, and pay attention to the horizontal and vertical displacement of components.

- Conduct an audit of the 3D model: Many times during a 3D modeling and at the end of it, an audit is conducted to ensure that you have a model with accurate and complete information. The use of filters based on the aforementioned parameters is very useful for this audit.
- Export tables: Once a complete model and useful information is obtained for the material quantity estimates, an export of the database is done to organize it in such a way as to obtain quantity estimates from the various items of the project budget.

It is noteworthy that standardization is the first step in facilitating the automation in obtaining material quantity estimates straight from the 3D model.

RESULTS COMPARISON

The process of comparing results involved the review of six building projects at the same time, including office buildings (4), Shopping Malls (1), and Residencies (1). The classification of the projects reviewed is found in Table .

Table 1: Identification of Projects Compared Simultaneously by the Estimating Department and the BIM Area (Own Source 2014)

Project	Project Type
Project 1	Office Building
Project 2	Residence Building
Project 3	Office Building
Project 4	Shopping Mall
Project 5	Office Building
Project 6	Office Building

For practical purposes, only the quantities of concrete and formwork of the structure budget, of components that could be modeled in Revit were compared. DPR has reported that for the Sutter Medical Center Castro Valley (SMCCV) project, 86% of the estimating concrete cost was directly obtained from a 3D model, since not all is modeled (Tiwari, 2009).

The comparison was intended to verify whether the quantity estimation process using BIM tools required less time (Khemlani, 2006, Sabol, 2008) and was less expensive (Finau and Yong, 2011) when compared to the total cost of the change in methodology.

Regarding the comparison of quantity estimates, Figure 3 and Figure 4 show the results of concrete and formwork percentages obtained by the BIM Area, respectively, using the data obtained by the Estimating Department as the base of comparison. In both graphs, we decided to discard the first comparison, because actual collaborative work had not taken place.

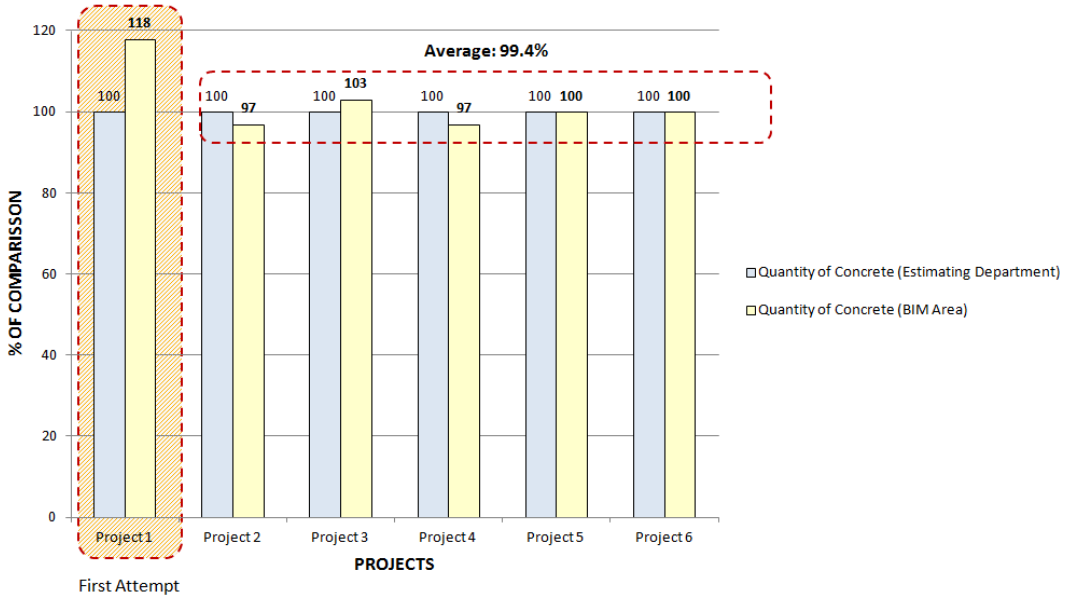

Figure 3: Comparison of Quantities of Concrete Obtained by the Estimating Department and BIM Area (Own Source 2013)

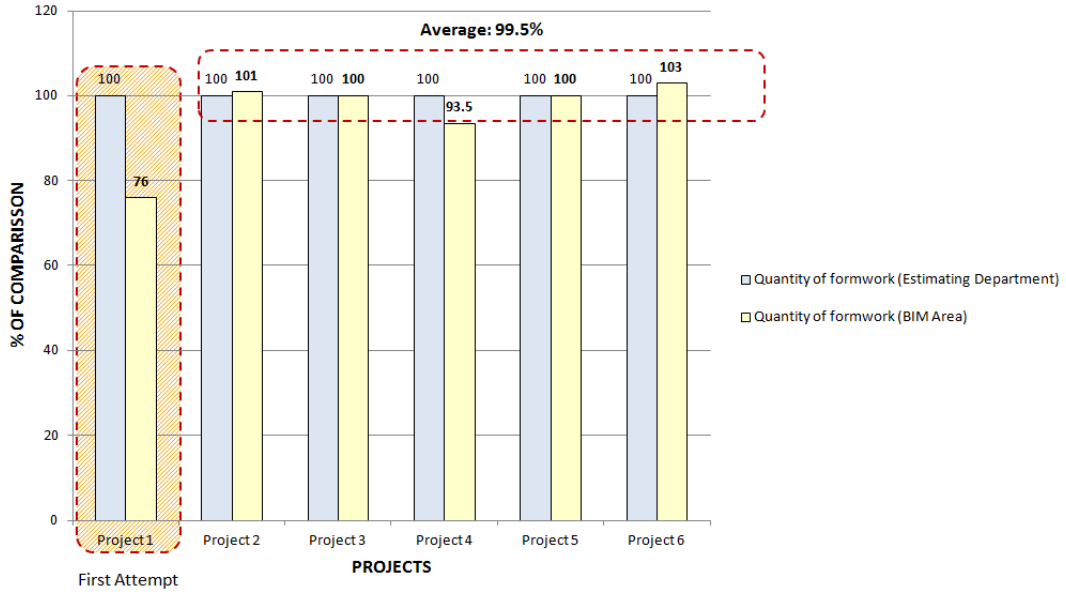

Figure 4: Comparison of Quantities of Formwork Obtained by the Estimating Department and BIM Area (Own Source 2013)

With regards to the comparison of the time taken to obtain estimates of the quantities of concrete and formwork, which was verified, using a BIM tool, this process takes on average 64% of the time required to make estimates with an Excel spreadsheet and 2D drawings. The results of the projects are compared in Table 2.

Table 2: Comparison Evaluation of Results (Own Source 2014)

	Estimating Department			BIM Area			Results	
	Man-hours (HH)	Cost ($/HH)	Total Cost ($)	Man-hours (HH)	Cost ($/HH)	Total Cost ($)	Man-hours difference (HH)	Speed Ratio
Project 1	318.60	7.49	2,386.31	244.00	11.12	2,713.28	311.11	0.766
Project 2	161.78	7.49	1,211.69	84.50	11.12	939.64	154.29	0.522
Project 3	371.93	7.49	2,785.72	199.00	11.12	2,212.88	364.44	0.535
Project 4	532.13	7.49	3,985.62	416.00	11.12	4,625.92	524.64	0.782
Project 5	137.93	7.49	1,033.06	81.50	11.12	906.28	130.44	0.591
Project 6	207.00	7.49	1,550.43	130.50	11.12	1,451.16	199.51	0.630
			12,952.83 Total			**12,849.16 Total**		**0.64 Average**

With regard to the comparison of cost per man-hour invested in estimating quantities, and taking into consideration the profile of the people involved,[1] the hardware and software, we found that the use of a BIM tool costs on average 48% more than the traditional method, as shown in Table 3. However, by combining the unit cost with the time spent, the results show that the final total cost is about the same for both cases.

Table 3: Comparison of the Cost per Hour Using Traditional Tools and BIM Tools (Own Source 2014)

Description	Cost ($ / H)	
	Estimating Department	BIM Area
Average Salary ($ / H)	6.54	8.89
Software ($ / H)	0.71	1.55
Hardware ($ / H)	0.24	0.68
Total ($ / H)	7.49	11.12
Cost Ratio (BIM Area/Estimating Department)	**1.48**	

Although the comparison of the total cost of the two results is similar, it should be mentioned that there are other considerations to take into account, such as:

- The advantages of having a model for later stages of the project.
- The possibility of obtaining a greater amount of interferences and incompatibilities between different engineering disciplines with less effort, which can affect the quantity estimates.
- Greater collaborative working and integration is achieved between the parties involved in the process of making the offer.
- The time needed in learning to use a BIM tool in obtaining reliable estimates, is less than the time required to obtain the same result with traditional tools.
- "As estimating in BIM continues to emerge, it is important to keep in mind that traditional cost estimating goes beyond material quantity takeoffs and

[1] The difference between average salaries corresponds to the profile of the quantities estimators – technical in the Budget Department and professional in the BIM Area.

price loading. It includes the 'modeling' of project construction with conditions and constraints that impact the construction process..." (McCuen, 2009).

INTEGRATED PROCESS WORKFLOW

Figure 5 shows the workflow of the results comparison stage.

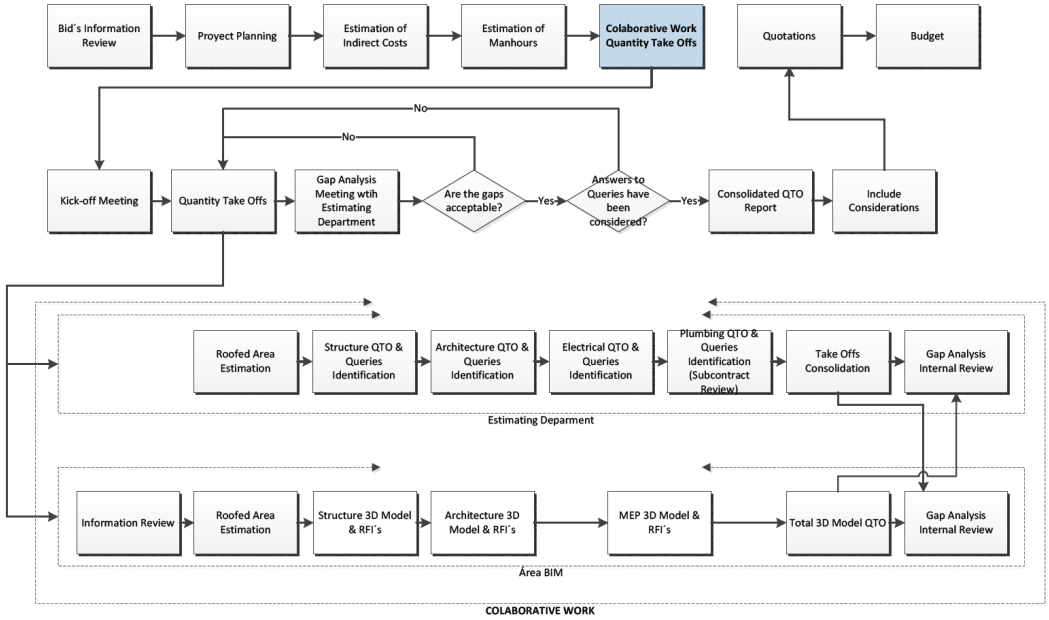

Figure 5: Current Workflow for Technical and Economical Proposal Development – Estimating Department with the assistance of the BIM Area (Own Source 2014)

It should be noted that the work-collaborative was key to achieving these results and was accomplished through meetings – including at start-up and for the output gaps and budget reviews (see Figure 6) – and constant communication between parties.

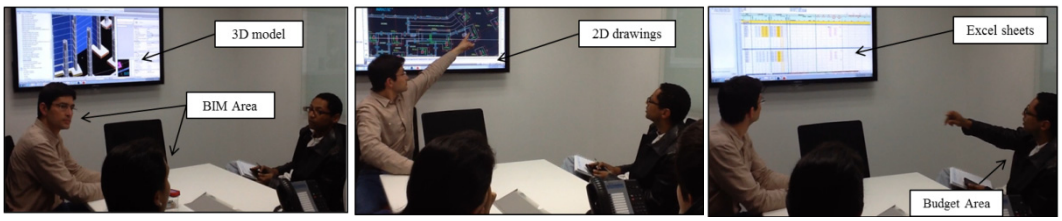

Figure 6: Output Gaps Revision Meeting with the Estimating Department (Own Source 2013)

PROPOSED PROCESS WORKFLOW

Based on the evaluation of the results, we propose to bear in mind for the future that the quantity estimates of possible items be fully integrated in the Estimating Department process, through the use of the BIM tool, as shown in Figure 7, and take advantage of subsequent benefits of having information from a 3D model.

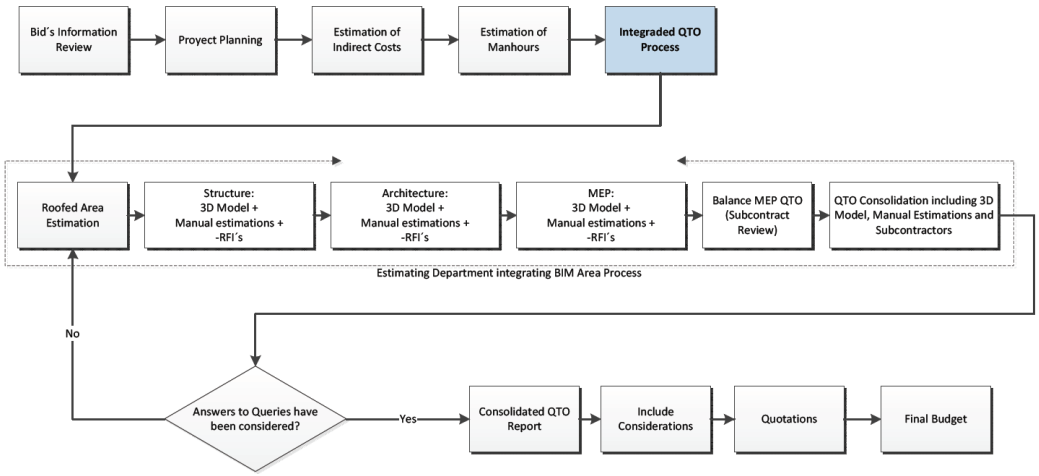

Figure 7: Proposed Workflow for Technical-Economic Proposal Development Integrating the use of BIM Tools – Estimating Department (Own Source 2014)

LESSONS LEARNED

Based on our experience during the results comparison stage and having the experiences of the study case of the SMCCV project (Tiwari, 2009, Eastman et al., 2011), we can summarize the lessons learned from this stage:

- Collaborative work and communication are necessary to perform a reliable results comparison and achieve a more efficient process.
- The headships need to be made aware of the benefits of using BIM tools and need to be willing to use them in order to facilitate their implementation.
- The cost of implementation should be borne by an influential department that without knowing whether the implementation will be advantageous is willing to take on the increased cost of working in parallel.
- Not all budget items can be obtained straight from a 3D model.
- The standardization process facilitates the automation of estimating quantities.
- The use of a new tool or software does not always guarantee that we can obtain the expected results. Implementing new technologies involves performing several tests and the results will not necessarily be satisfactory, from the very beginning. Both collaborative work and the development of tools are important in obtaining reliable data.

CONCLUSIONS

The cost per man-hour for the material quantity estimates is on average 48 % more than the traditional method, when considering the profiles of the people involved, in addition to the hardware and software of each method.

The time taken to make estimates of the concrete and formwork quantities, using a BIM tool, is on average 64 % less than the time required to make estimates with an Excel spreadsheet and drawings displayed on a 2D CAD program.

By combining the unit cost and the time spent, one can conclude that the final total cost is about the same for both cases; however, there are additional advantages in the later stages of the project, counting on a 3D model.

While not necessarily reducing the cost of developing a budget, modifying the process of estimating quantities using a BIM tool, indeed it reduces the total processing time of the technical and financial proposal, in percentages similar to the acceleration in estimating quantities, and thus achieving a more efficient workflow when making an offer. It has been specified previously that "The time spent by the estimator on quantification varies by project, but around 50% to 80% of the time needed to create a cost estimate is spent on quantification…" (Rundel, 2006).

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