A COMPARISON OF REBAR QUANTITIES OBTAINED BY TRADITIONAL VS BIM-BASED METHODS

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Received: July 24, 2015; Revised: Septembre 28, 2105; Accepted: February 16, 2016

Abstract

A quantity take-off is one of the most powerful functions of Building Information Modeling (BIM) software applications. This study focuses on a comparison of rebar quantities that are obtained from a traditional method and BIM software. Two case studies of extracting rebar from the footing component of building projects were explored. The traditional method was performed by manually counting and measuring the rebar quantities from the AutoCAD file while the BIM-based method was used Revit 2016 (student version) to model and extract rebar quantities. The result shows that the rebar quantities from the traditional method are 17.76% more than the BIM-based method. Furthermore, the integer programming technique was applied on optimization problems, which were formed from a bar cut list data, to obtain the exact number of the rebar. The finding shows that the exact quantities from the traditional method are 20.29% greater than the exact quantities while the rebar quantities from the BIM-based method are 1.11% less than the exact quantities.

Keywords: Building information modeling, quantity take-off, integer programming

Introduction

Quantity take-off (QTO) is an important task in construction projects. Some important tasks can only be performed after QTO is finished such as cost estimation and construction planning. The information from QTO and other related information will be organized into a structured document, which is traditionally called Bill of Quantities (BOQ), to predict the project costs.

A QTO is performed several times during construction life-cycle. QTO is used for rough cost estimate in the preliminary design phase. As the construction project proceeds from preliminary design to final design, the level of

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detail increases, QTO is performed again to obtain a detailed cost estimate. Lastly, QTO is performed on site during construction to collect statistics information (Halpin, 2006). Normally, QTO is very error prone process. A traditional QTO is manually performed by an estimator, who counts and measures quantities from paper or electronic drawing documents. Since most construction buildings are becoming much more complex (Alshwi and Ingirige, 2003; Chan *et al*., 2004), an error is likely to occur in both the interpretation process and the construction document development process.

Nowadays, Building Information Modeling (BIM) technology is widely used in the construction industry. BIM technology can be applied throughout construction project life-cycle (Hardin, 2009). Basically, BIM is commonly used for visualization in the architectural modeling process. Another common use of BIM is collision detection which can early detect geometric clashes in the design phase. Some of construction companies also use BIM for QTO and cost estimation (Sattineni, 2011). Furthermore, construction projects can gain many benefits by adopting BIM technology such as cost and time reduction, coordination improvement, quality improvement etc. (Eastman *et al*., 2008 and David *et al*., 2013).

A QTO is one of the most powerful functions of BIM software. BIM can assist an estimator to estimate the construction cost at various levels (Cheung *et al*., 2012). The quantities of each building component can be counted or measured automatically through BIM software instead of manually performed by an estimator as the traditional method. The estimator, who uses BIM-based QTO, should understand the input – output dynamics of the application due to the extracting information depends on how the BIM model are developed (Sattineni, 2011). However, BIM-based QTO is reported that it is simpler and more accurate cost estimate, decreasing in time and costs (Tiwari *et al*., 2009).

Generally, the extracted quantities from the traditional method must be greater than the quantities that are obtained from the BIM-based method due to the traditional method uses an approximate length of rebar by measuring the dimension of the footing. As the traditional method uses the approximate length for QTO, the specification of quantity take-off suggests to add additional quantities for cutting and bending the rebar. In Thai specification, for example, 9% of the extracted quantities should be added to the extracted quantities of 12 mm (dia.) rebar. Since the decreasing of error in drawing interpretation, this study focuses on a comparison of rebar quantities that are obtained from the traditional method and the BIM-based method.

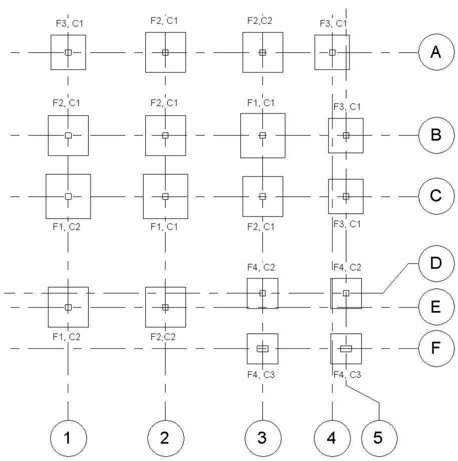

Figure 1. Footing plan for the first case study

Methods

Two case studies of extracting rebar from the footing component were conducted to compare the results of QTO between the traditional method and the BIM-based method. The first case is a two-story building project which has four types of footing elements as shown in Figure 1. The construction drawings of the first case are provided in an AutoCAD file. The second case is a one-story building project provided in paper-based format. There are only two types of footing elements for the second case.

BIM models of both case studies were developed by using Autodesk Revit 2016 (student version) software. Since BIM software can extract only the information that is modeled, the BIM model must be developed in a suitable level of development that can produce valuable QTO (Firat *et al*., 2010; Monteiro and Martins, 2013). Because of this study focuses on footing rebar extraction, only the footing elements, pier elements, and their rebar were modeled as shown in Figure 2.

The quantities of rebar were taken-off from both the traditional method and the BIM-based method. On the one hand, the traditional method was performed by manually counting and measuring the rebar quantities from the AutoCAD or paper drawings. The length of the rebar was estimated from the dimension of the footing drawings (not considering concrete cover). On the other hand, the BIM-based method, the rebar scheduling was extracted automatically by using the internal Revit software function. The extracted information, which is a quantity of each rebar length, from BIM-based method was shown in Table 1. The total length of 6 mm and 12 mm (dia.) rebar in the first case are 208.968 m and 726.108 m respectively, while the second case requires 65.312 m and 295.950 m for 6 mm and 12 mm (dia.) rebar.

The minimum rebar requirement was calculated by using the optimization technique. The extracted information from the BIM-based method was used as the input of the optimization problem. The objective function of the optimization problem was the minimum number of required rebar, while the constraints were generated from the quantities of each rebar length. The integer programming technique was also used to force the optimization results to be integer numbers.

Results and Discussion

The comparison of rebar quantities between the traditional method and the BIM-based method are shown in Figure 3. Some additional quantities were added to the extracted quantities those were obtained from the

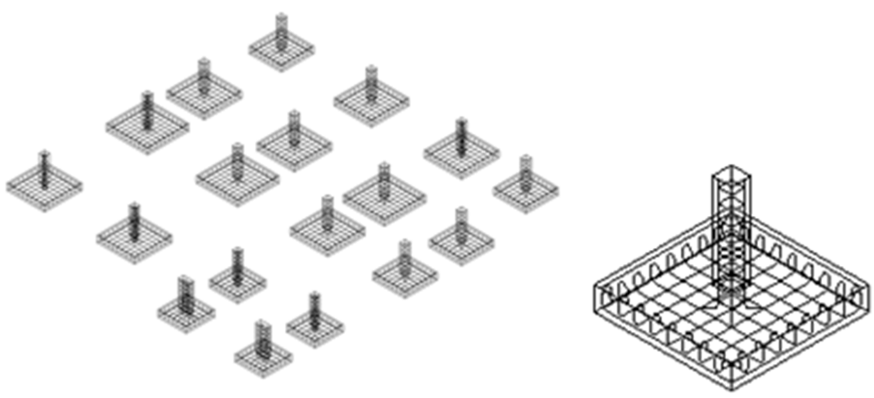

Figure 1. Footing plan for the first case study

Table 1. Extracted rebar information from the BIM-based model

Project	Required rebar			Total length (m)
	Dia. (mm)	Length (m)	Quantities	
A	12	1.320	100	726.108 (646.24)*
		1.668	56	
		1.818	64	
		2.018	126	
		2.168	60	
	6	1.018	16	208.968 (45.97)*
		0.449	18	
		0.618	144	
		4.267	4	
		4.867	4	
		5.667	6	
		6.267	4	
B	12	1.397	58	259.95 (231.36)*
		0.848	18	
		1.608	36	
		1.653	28	
		1.948	22	
		1.848	9	
	6	2.898	2	65.312 (14.37)*
		4.018	2	
		5.404	2	
		5.096	2	
		6.018	1	
		0.453	54	

* Weight of rebar in kg

Table 2. Comparison of rebar quantities between the traditional method and the BIM-based method

Project	Rebar Quantities (kg)		% Different	Min. Rebar Quantities (kg)	% Different from Min. Rebar	
	Traditional	BIM			Traditional	BIM
A	861.73	692.21	-19.67	704.80	22.27	-1.79
B	292.00	245.72	-15.85	246.80	18.32	-0.44
		Average	-17.76		20.29	-1.11

traditional method, for example, 9% of the extracted quantities of 12 mm (dia.) were added according to Thai specification for quantity take-off. For the first case, the traditional method requires 861.73 kg of rebar while the BIM-based method requires 692.21 kg. On the other hand, the second case shows that the required rebar for the traditional method and the BIM-based method are 292.00 kg and 245.72 kg respectively.

BIM-based method gives smaller rebar quantities than the traditional method since the BIM-based method used an actual dimension of rebar while the traditional method used an

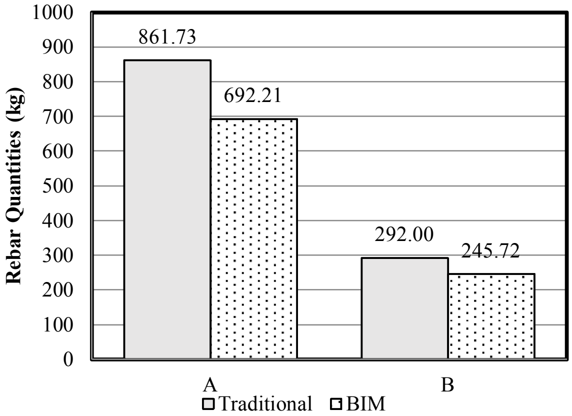

Figure 3 Extracted rebar quantities obtained from the traditional and BIM-based methods

approximate dimension. Table 2 shows that the rebar quantities from the BIM-based method were less than the traditional method around 19.67% and 15.85% for the first case and second case respectively. The results imply that the average quantities from the BIM-based method were 17.76% less than the traditional method.

The exact number of the rebar, the minimum number of required rebar, was obtained from the application of integer programming technique with a bar cut list problem. Table 2 also shows the exact quantities of rebar for the first case and second case which are 704.80 kg and 246.80 kg. Therefore the quantities from the traditional method for the first case and second case are 22.27% and 18.32% greater than the exact quantities. On the other hand, the extracted quantities from the BIM-based method for the first case are 1.79% less than the exact quantities while the second case are 0.44% less than the exact one.

BIM-based method still requires some additional quantities although this method uses the actual length of rebar. From Table 2, the extracted rebar quantities from the BIM-based method is less than the exact quantities around 1.11% since it is not consider the waste from rebar cutting. That means the extracted quantities from the BIM-based method should be added with some addition quantities before using in further construction processes.

Conclusions

Two case studies of rebar extraction show that the rebar quantities from the traditional method are 17.76% greater than the rebar quantities from the BIM-based method. The extracted quantities from the traditional method are 20.29% greater than the exact quantities while the quantities from the BIM-based method are 1.11% less than the exact quantities. Since the quantities from BIM-based method are less than the exact quantities, the BIM extracted quantities still require some additional quantities to compensate the waste of rebar cutting. One of the solutions for this problem is the applying of integer programming with BIM to calculate the minimum quantities of the rebar.

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