「2022 中華民國營建工程學會第二十屆營建產業永續發展研討會」

BIM 應用於建築工程數量計算與審核模式之研究

*Lorenzo Bacchus (白洛仁)
Graduate Student
Department of Civil Engineering
National Taipei University of Technology

Yu-Cheng Lin (PhD) (林祐正)
Professor
Department of Civil Engineering
National Taipei University of Technology

摘要

數量計算（Quantity Take-off, QTO），是施工過程中最重要的部分之一。 必須審查建築圖紙，必須計算所需材料的數量，不能誤算。過去數量計算方式需要花費大量時間，並且仍然會由於人工解釋或輸入具有不同元素的複雜 2D 圖說而容易導致錯誤。本研究主要是利用BIM技術協助建築工程QTO作業，提出一種建築工程BIM-based QTO之模式，並導入案例探討分析，提供未來實際導入參考，了解應用BIM-based QTO之優勢與實際可能會遭遇的困難，作為日後實際導入之參考。

關鍵詞：Building Information Modeling (BIM), 數量計算, 施工階段, 建築工程

The Study of BIM for Quantity Take-Off and Review in Building Projects

Abstract

Quantity take-off (QTO), also referred to as material take-off depending on the location, is one of the most important parts of the construction process. The building drawings must be reviewed, and the number of materials needed must be calculated without doubling or miscounting. The waste and storage factors must also be calculated, as well as the labor needed to complete the project. This normally takes a lot of time and still results in errors because of human interpretation or input of the complex 2D drawings with different elements, whether they are hand drawings or CAD-based drawings.

This research aims to identify key areas necessary for producing BIM-based QTO, propose an approach for producing useable QTO using BIM, and identify the limitations and advantages of the proposed approach. This will be done by evaluating the existing literature related to BIM-based QTO and using a pilot case study to test and evaluate the established framework and its processes.

Keywords: Building Information Modeling (BIM), Quantity Take-off (QTO), Construction, Building Project

1. Introduction

Architecture, engineering, and construction (AEC) technologies have continued to develop and advance, however in most cases the methods used to produce quantity take-off have simply moved from pen-and-paper calculations to computer-based calculations. This puts those producing QTOs at a disadvantage when project scale and complexity begin to increase as is the case now that AEC technologies are so advanced. Manual calculation of quantities and materials is a time-consuming process, and now with the integration of building information modeling (BIM), models contain more information than a 2D drawing would, which requires even more time to extract and calculate. Manual calculations are also prone to human error which can lead to inaccurate quantity take-offs.

BIM-based quantity take-off presents a faster, more efficient, and most importantly, more accurate method of producing QTOs. Since BIM opens a new world of possibilities for quantity take-off, understanding how BIM can be used to do this will help the transition run more smoothly. With the use of building information modeling (BIM) this research aims to propose an approach for producing useable quantity take-off using BIM and identify the limitations and advantages of the proposed approach through the use of a case study.

2. Literature Review

According to Autodesk, the industry leader in BIM, “Building Information Modeling is a process of creating and managing information for a built asset throughout its lifecycle—from planning and design to construction and operations.” Quantity take-off (QTO), also referred to as material take-off depending on the location, is one of the most important parts of the construction process. The technologies related to the quantity take-off process though extremely different from those that were available when the process was first started thousands of years ago, in recent years there has not been much development.

Most BIM tools have routines that perform calculations based on the element's geometric properties and provides spatial quantities in text form. Based on this information, BIM-based quantity take-off tables can be produced. However, using BIM tools introduces new issues, such as the requirement to enter takeoff data during the design stage. It demands close collaboration between designers and take-off makers at all stages of the design process. Olatunji et al. also note that the automatically compiled take-offs do not show the actual amount of materials used, but rather the amount of materials included in the 3D model. It also does not include materials that are not part of the model, for example, wastage and any fasteners or brackets necessary for the installation of prefabricated materials. As a result, some materials and labor may be omitted.

There have been previous studies done on BIM for quantity take-off, including Taghaddos et al. (2019) who developed API codes to automate estimation of construction, and Liu et al. (2016) who proposed ontology-based semantic framework for quantity take-off to query a BIM design model for construction-oriented QTO using richer vocabulary. While these previous studies focused on proposing new methods of extracting the data for QTO from the BIM model, this study focuses on proposing an approach for creating useable BIM-based QTO using existing methodologies.

3. Research Content

To develop a realistic and feasible implementation of BIM-based quantity take-off with increased simplicity and accuracy, this study reviews the way traditional quantity take-off has changed and how BIM-based quantity take-off is being used for modern-day building projects. This study will introduce a general approach for BIM-based quantity take-off as a BIM manager or BIM engineer to give a more accurate quantity take-off that can be used for any scale of project. Individual element details of a BIM model can be saved for use in future BIM models making it easier and faster for the BIM model, and by extension the quantity take-off, to be generated when the same elements are needed.

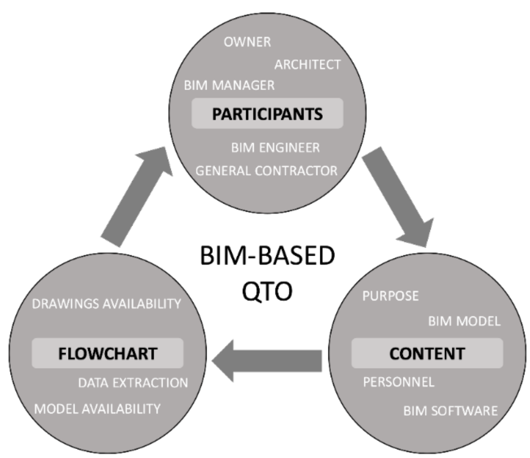

Fig. 1 Framework for BIM-based Quantity Take-off

Fig. 1 outlines the framework for BIM-based quantity take-off established by this study. This study identifies three key areas in the BIM-based quantity take-off Framework:

1. Participants
2. Content

3. Flowchart

Quantity take-off is necessary for various stages of a building project, and thus BIM-based quantity take-off is a tool that can be used by the participants, the BIM managers, BIM engineers, architects/designer, and general contractors to produce more accurate and less time-consuming quantity take-offs.

The main content for BIM-based quantity take-off includes the purpose of the quantity take-off, a detailed BIM model, software to read the BIM model and extract data, and personnel to do the data extraction. Once the content is available then the BIM-based quantity take-off process can proceed relatively smoothly. The flowchart for BIM-based quantity take-off is outlined in Fig. 2.

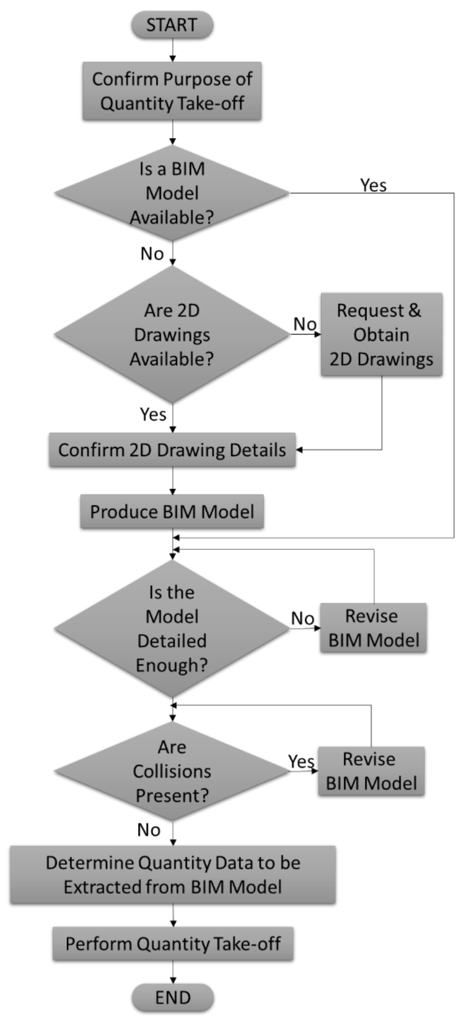

Fig. 2 Flowchart for BIM-based Quantity Take-off

4. Case Study

In this case study, the National Taipei University of Technology (NTUT)'s Innovation and Incubation Building BIM model will be used for the test as it is complete and available for use in quantity take-off. As this is a large-scale project, all participants are present and the program of choice for the BIM engineer is Revit 2022. This case study shows the implementation of BIM-based quantity take-off when the BIM model is readily available.

It was established that quantity take-off would be needed for multiple stages of the construction phase of the building project, however, this case study focuses on BIM-based quantity take-off for the superstructure stage of the building project. It was also made clear that a BIM model would be available for the QTO process. After obtaining the model and updating it to a usable file format, the BIM engineer assessed the level of development of the BIM model. Since the information needed for the model to be classified as LOD 350 (element interaction data), LOD 400 (fabrication, assembly and/or installation data, project scheduling data, cost data), or LOD 500 (as-built) was not attached to the provided BIM model it was determined that the model was LOD 300. After confirming the LOD of the BIM model, the BIM engineer proceeded to do the clash detection process in Revit (known as interference check). After correcting the detected clashes, confirming that all clashes were eliminated, and determining the quantity data to be extracted from the BIM model, the quantity take-off could finally be performed. The most complex part of this process was ensuring that the settings for data extraction were correct. Fig. 3 shows the resulting quantity take-off for the walls in the BIM model and a sample of the BIM model.

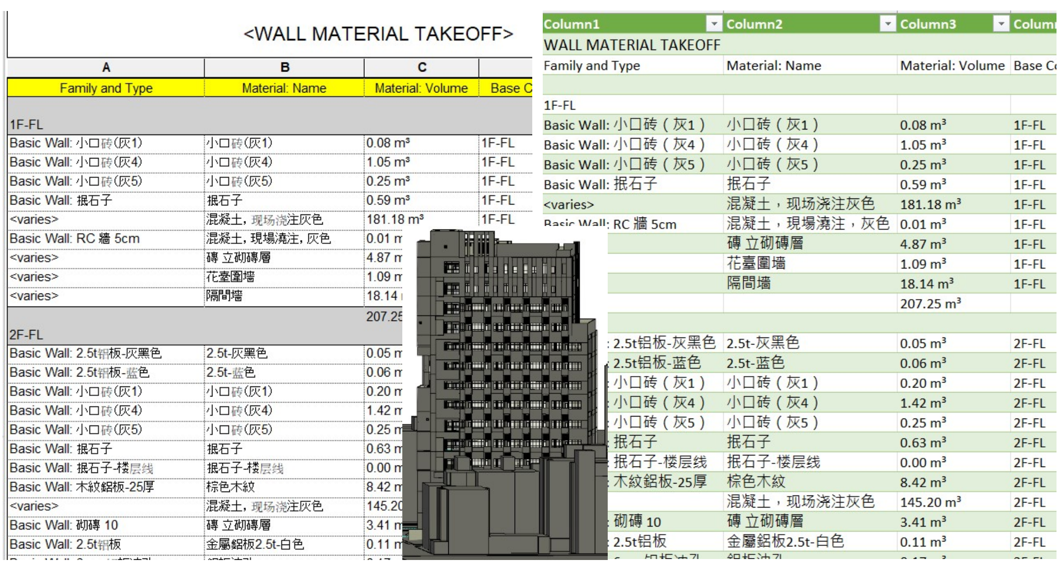

Fig. 3 Flowchart for BIM-based Quantity Take-off

5. Conclusions and Suggestions

This study’s BIM-based quantity take-off framework has 3 parts: participants, requirements, and flowchart. The participants in the framework include the architect/ designer, general contractor, BIM manager, and BIM engineer, each of which has a different role to play in the BIM-based quantity take-off process. The content in the framework refers to; the purpose of the quantity take-off, a detailed BIM model, software to read the BIM model and extract data, and personnel to do the data extraction. Once the participants are available, the flowchart includes various checks to make sure that the requirements are met and covers other areas that are necessary for producing useable BIM-based quantity take-off. Even after the BIM-based quantity take-off is completed, there still need to be adjustments made for formwork and wastage.

Therefore, my suggestion to make BIM-based quantity take-off even more practical is for further research to be done into incorporating formwork elements into the BIM modeling process so that there is no need for additional work to be done post-extraction. There is already some initial research being done into this namely Mei et al.'s BIM-based framework for formwork planning considering potential reuse and Makda's the relationship between BIM and formwork 2022.

6. References

1. Abanda, F.H., Kamsu-foguem, B. and Tah, J.H.M. (2015), "Towards an intelligent ontology construction cost estimation System: using BIM and new rules of measurement techniques", International Journal of Industrial and Manufacturing Engineering, Vol. 9 No. 1, pp. 294-299.

2. ACCA Software. (2018). Bim dimensions. The 7 dimensions of BIM - 3D, 4D, 5D, 6D, 7D BIM explained - BibLus. Retrieved November 14, 2021, from https://biblus.accasoftware.com/en/bim-dimensions/.

3. Alshabab, M. S., Vysotskiy, A. E., Khalil, T., & Petrochenko, M. V. (2017). BIM-based quantity take-off. Stroitel'stvo Unikal'nyh Zdanij i Sooruzenij, (4), 124.

4. Alshorafa, R., & Ergen, E. (2021). Determining the level of development for BIM implementation in large-scale projects. Engineering, Construction and Architectural Management, 28(1), 397–423. https://doi.org/10.1108/ecam-08-2018-0352

5. Azhar, S. (2011). Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. Leadership and management in engineering, 11(3), 241-252.

6. BIM Forum (2019). Level of development specification. Retrieved November 23, 2021, from https://bimforum.org/lod/

7. Choi, J., Kim, H., & Kim, I. (2014). Open BIM-based quantity take-off system for schematic estimation of building frame in early design stage. Journal of Computational Design and Engineering, 2(1), 16–25. https://doi.org/10.1016/j.jcde.2014.11.002