IMPLICATION OF QUANTITY SURVEYING PRACTICE IN A BIM-ENABLED ENVIRONMENT

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The current construction process seems to be challenging to make an informed decision about financial and environmental implication of a building at the early design stage due to the highly fragmented nature of the construction industry and a lack of knowledge and skills of construction personnel. In order to determine the most affordable building design financially and environmentally, diverse information regarding costs and environmental impacts of construction materials should be collected and integrated from the outset of a project among key project stakeholders. Consequently, various researchers increasingly study a way of utilizing Building Information Modelling (BIM) to tackle current problems because BIM can enable construction professionals to conduct early cost estimation effectively and efficiently by calculating the project costs and CO2 performance of a building.

Despite the capability of BIM, there is little evidence that BIM has been widely adopted in quantity surveying profession due to the different cost estimating rules and practices. Thus, this paper examines the impact of the BIM implementation in quantity surveying practice. Subsequently, key benefits and challenges have been identified in terms of cost estimation and quantity take-off. This paper will provide practical insights to utilize BIM for quantity surveying practice.

Keywords: BIM, 5D BIM, Quantity Surveying, Cost Estimating, Quantity Take-off

INTRODUCTION

Customers' recent design requirements have become more irregular and bespoke, and furthermore, sustainable aspects in a building such as high energy performance and low environmental impacts are increasingly becoming one of the major considerations in the construction industry. Essential construction information has become more specialized and larger in its volume, and it has become crucial to manage and integrate the massive amount of information amongst project stakeholders throughout a project life cycle. Traditionally, the role of a quantity surveyor was mainly associated with cost estimating, measurement and planning, preparation of Bills of Quantities (BoQ) and other procurement related works such as managing payment and claims (Ashworth and Hogg, 2007). Lately, it is a central issue for construction customers to maximize value, lower cost and achieve sustainability, and consequently, quantity surveyors have been requested for improving efficiency in their roles related to measurement and planning of cost and schedule. In addition, sustainable approaches to a construction project is required for quantity surveyors to considering environmental impacts of a building simultaneously. Indeed, Ashworth and Hogg (2007) assert that the role of a quantity surveyor will be broaden in its functions including measurement of environmental impacts, and sustainability analysis in conjunction with traditional quantification and estimating. However, current construction practice seems to be challenging for quantity surveying professionals to manage a construction project in a collaborative and integrated manner since construction projects are managed in a fragmented way based on 2D drawings during both design and construction phases. Due to the highly fragmented nature of the construction practice, data conflicts of design and unnecessary reworks and waste are commonly caused. Reworks due to poor detailed drawings and miscommunication cost about £1 billion annum in the UK (Autodesk, 2014). When changes occurred in a design, labor-intensive works for recalculating quantities and re-estimating costs are mandated to integrate all the changes into various separate design documents and to generate updated design documents and information accordingly.

As a response to these problems in the construction sector, Building Information Modeling (BIM) has been introduced to manage the complexity of construction projects, achieve sustainability and integrate stakeholders' requirements in terms of maximizing value with lower cost. BIM has been recognized as a facilitating tool to improve the fragmented practice and productivity in the construction industry, and lower the high construction project costs (BCIS, 2011, Cartlidge, 2011). Since BIM is operated based on the 3D parametric modelling and a BIM model is comprised of 3D objects with various information such as dimensional information, costs, and thermal performance, the quantification of building elements such areas, volumes and cost estimates can be generated automatically (Kymmell, 2008). Thus, this capability enables quantity surveyors to retrieve more accurate cost and sustainability information from the model, which is mainly used for cost planning and management named as 5D BIM (Eastman et al. 2011). Despite of the potential and advantages of 5D BIM for quantity surveyors, the uptake of 5D BIM is limited. In the UK, a recent survey revealed that only 14% of BIM users consider that BIM will facilitate quantity surveying practice in terms of generating BOQ (Stanley and Thurnell, 2014). In addition, only 7% of BIM users in Australia consider that BIM will make traditional BOQs redundant within their organization (Masterspec, 2013). Hence, this research aims at identifying the benefits and challenges of adopting 5D BIM, and examining practical use of 5D BIM in terms of quantity take-off function to reveal if it is practical and feasible for quantity surveying practice. Finally, the outcome of this research will provide practical insights to utilize 5D BIM for quantity surveying practice, and become a foundation for further research on 5D BIM for quantity surveying practice.

BIM IMPLICATIONS FOR QUANTITY SURVEYING

BIM has become a central issue in the construction industry and many researchers currently explore potential of BIM as a new ICT to improve productivity in the construction industry. BIM as an integrated project information management platform to integrate construction information seamlessly and facilitate collaboration among project stakeholders is introduced to resolve the current fragmented communication and collaboration, and minimize data conflicts and unnecessary reworks (Park and Kim, 2014). Bryde et al. (2013) identified benefits of 5D BIM such as cost and time reduction, communication and information coordination improvement, and quality improvement. Shen and Issa (2010) back up this finding by asserting that cost estimating using BIM software results in reduced errors and duration of cost estimation. In particular, many researchers addressed the potentials of BIM for formulating financial and environmental implications simultaneously at the early design stage (Ma et al., 2012; Basbagill et al., 2013). Since BIM has capability to conduct a financial comparative analysis among possible building design options at the early design stages, which is known as Quantity Take-off function, construction professionals can make an informed decision about cost planning and schedule development (Basbagill et al., 2013). The early cost estimate and comparative analysis is essential to determine the feasibility of a construction project, and 5D BIM can provide an early opportunity for quantity surveyors to diagnose projects' feasibility and develop more reliable cost plan by proving the maximized value to customers. (Odusami & Onukwube, 2008; Raisbeck & Aibinu, 2010). In addition, there has been an acknowledgement of practical benefits of 5D BIM from the industry such as Mitchell Brandtman (2013) and Eos Group (2008). They addressed that quantity surveying practice can be further enhanced by adopting 5D BIM capability since BIM technology enables quantity surveyors to establish early cost plan and generate eseential quantified information at the early design stage. In addition, there is considerably less scope for misinterpretation and consequential changes, disruption and reworks (Langdon, 2012; London et al, 2008) as BIM provides a holistic view of building designs and structures, costs, and sustainability issues simultaneously. Furthermore, BIM can achieve sustainability in the construction supply chain by making construction and procurement processes more effective and efficient, and construction waste materials throughout a project life cycle can be reduced (HM Government, 2012; Crosbie et al., 2011; McGraw-Hill, 2010). Thus, the benefits of BIM adoption in the quantity surveying practice and construction project can be summarized in: a) Design Optimization; b) Efficiency Improvement; and c) Sustainability Enhancement. However, many researchers identified that current quantity surveying practices are mainly completed manually although they adopt 5D BIM in their organizations (Lu et al., 2016; Wu et al., 2014; Boon and Prigg, 2012; Stanley and Thurnell, 2013; Crowley, 2013; Monteiro and Martins, 2013). The major barriers hindering 5D BIM adoption can be summarized as follows: a) Quality of a Building Model; b) Interoperability and Data Format Issue; and c) Lack of Standardised BIM Library and Coding System.

First of all, Wu et al. (2014) and Monteiro and Martins (2013) argue that the quality of a BIM model is essential to utilize 5D BIM effectively and efficiently. Researchers point out that uncompleted information enriched building model requires more time to measure and estimate costs, develop a cost and schedule plan compared to traditional 2D manner because quantity surveyors need to find out essential dimensional and cost information to fill the information gap in a BIM system, and then they can generate proper cost estimates and plan. Furthermore, Stanley and Thurnell (2013) pointed out that current BIM models render numerous design errors due to omission of important information and insufficient level of details in a model. As a result, the use of 5D BIM produce inaccurate and unreliable cost estimates and plan. Thus, researchers assert that 5D BIM should be used with proper knowledge and experience of quantity surveyors, and 3D objects with proper information should be preceded (Smith, 2014).

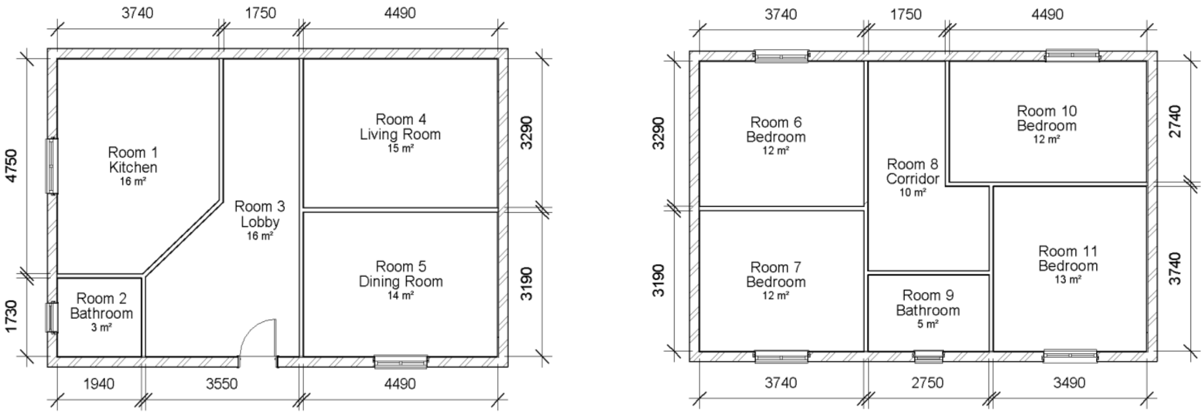
Secondly, there is the interoperability issue among various project stakeholders using different BIM software. BIM is unique because of its capability to facilitate collaboration among stakeholder based on one single source 3D BIM model. However, current practice in 5D BIM hinder the use of a single souce data since project stakeholders such as architect, engineer and quantity surveyor use different software and different data format (Boon & Prigg 2012). In the response to this issue, the exchange data format such as International Foundation Class (IFC) and Green Building XML (gbXML) have been introduced to the construction industry. However, researchers argued that the possible range of IFC use for data exchange between different BIM software is not clearly identified, and they pointed out that software companies should a provide clear level of interoperability between IFC and their BIM software (Howard and Björk, 2008; London et al, 2008; Cormier et al., 2011).

Finally, Cerovsek (2011) asserts that a lack of standardized BIM libraries directly influence the hindrance of BIM adoption since project stakeholders cannot clearly identify what types of information should be exchanged among project stakeholders at which project phases. In order to effectively utilize BIM, essential construction information such as specification of building elements such as cost and environmental information needs to be embedded into a BIM object and a model. Based on the information enriched BIM model, quantity surveyors can produce more accurate cost and schedule information about a construction project, and can facilitate effective information management throughout a project life cycle. However, it is challenging to construct a BIM model with all the necessary information at the early design stage since required information is not readily available (Cavieres et al., 2011). Thus, researchers point out the importance of establishing BIM library with proper geometric, cost and environmental information, and in order for a standardized library, proper coding system such as New Rules of Measurement (NRM) code and Building Price Book (BCIS, 2012) for financial analysis, and the Carbon Book (Franklin and Andrew, 2010) for environmental impact assessment. Indeed, the Royal Institution of Chartered Surveyors (RICS) released the NRM aiming at facilitating 5D BIM and managing project cost throughout whole life of a building, and this effort has been extended to the Australian Institute of Quantity Surveyors (buildingSMART 2012).

RESEARCH METHODOLOGY

This research adopts a hypothetical case study for building simulation using BIM software (Autodesk Revit and IES VE/IMPACT) to identify actual practical problems associated with using quantity take-off function in a BIM system such as design quality, unstandardized coding system and interoperability problems associated with data exchange format. Since only actual BIM simulation can reveal the current problems to bridge the practical gaps of using 5D BIM, this research adopt the BIM simulation. In addition, this research requires no control over behavioural events, and focuses on contemporary event which is a quantity surveying practice using 5D BIM to identify interactions and relationships among building information dataset asking how and why (Yin, 2003). Thus, case study and simulation is the most relevant strategy for this research compare to other strategy such as surveys, grounded theory and action research. In order for a basic simulation model creation and cost and environmental impact analysis, Autodesk Revit and IES VE/IMPACT (Virtual Environment/Integrated Material Profile And Costing Tool) were utilized for this research. Autodesk Revit is one of the most widely used BIM tools for architectural design, and it is comparable with AutoCAD platform which is the most prevalent tool in the construction industry (NBS, 2014). In addition, the IES VE/IMPACT was chosen since it have been developed by the IES and BRE, a UK based professional construction research organization, and it can consider financial and environmental impact of a building simultaneously. Furthermore, the use of IES VE/IMPACT is encouraged by the BREEAM assessment manual, which is directly related to the sustainability of a building. Therefore, the Autodesk Revit and IES VE/IMPACT were adopted in this research to formulate cost and environmental impacts. Once proper BIM software has been determined, this research determined a simulation case housing type, which is a solid wall house because this housing type requires relatively large amount of attention to achieve high energy efficiency and low environmental impacts (Park and Kim, 2014). As the BIM simulation needs to consider financial and environmental impacts simultaneously, the solid wall housing is suitable for this research. Once the case housing type is decided, the average housing condition data published by the UK government was used to build up a case building model in a BIM system hypothetically because the condition of solid wall housing indicates a wide range of variation in its characteristic such as year built, construction types physical dimensions, extra retrofitted measures and construction materials, which cannot be generalized. Furthermore, SMM7 Estimating Price Book 2013 (BCIS, 2012) was used for identifying costs for materials and labour as a de facto standard, and Carbon Book (Franklin and Andrew, 2010) was used for assessing environmental impacts. Finally, the Fibre Glass and Expanded Polystyrene (EPS) were selected for conducting comparative analysis on cost and environmental impacts because these materials belong to the relatively low cost range compared to other materials with high initial material cost such as Vacuum Insulated Panel and Polyurethane/Polyisocyanurate (Park and Kim, 2014). Indeed, only information regarding these two insulation materials is commonly available in both data sources – SMM7 and Autodesk Revit 2013 – that are widely accepted as a standardized cost. The basic information of the basic BIM simulation model is provided as shown in Figures 1 and Table 1

(Riley and Cotgrave, 2008, Utley and Shorrock, 2011, Neufert, 2012).



Ground Floor First Floor

Figure 1. Floor Plan for a Solid Wall Detached House

Table 1. Detailed Construction Information of Detached House

Element	Construction Type	Components	Thickness (mm)
Roof	Pitched Roof with Timber Joist and Rafter	Roofing Tile	25
		Wood (Batten)	25
		Roofing Felt	5
		Timber Structure	140
External Wall	Solid Brickwork Masonry Wall (Single Leaf)	Dense Gypsum Plaster Finish	13
		Solid Brickwork	220
Floors	Suspended Timber Floor	Timber Joist Structure	225
		Chipboard	25
		Carpet	10
Ceiling	Generic Ceiling	Gypsum Wall Board	12.5
Windows	Double Glazing	Double Glazing, Timber Frame	6mm Glazing
Exterior Door	Wooden Door	Wooden Door	44

*Note: The Gross Internal Floor Area (GIFA) was used for the cost estimation.

RESULT AND DISCUSSION

As aforementioned at the barriers of adopting 5D BIM, this research revealed practical problems to utilize BIM system for quantity surveying practice.

a. Overestimation due to Design Error in BIM System

For a BIM simulation, 190mm fibre glass is adopted for loft insulation since it is the most cost and energy-efficient measure as shown in Figure 2. The cost and environmental impacts such as initial cost (in particular the construction cost) and CO_2 information (embodied CO_2) can be generated automatically by the quantity take-off function in the BIM software as shown in Figure 3. This function can generate and update a bill of quantity automatically without the quantity surveyor's involvement when designs are revised. However, the CO_2 information is generated empty since proper environmental information is not embedded in the insulation material.

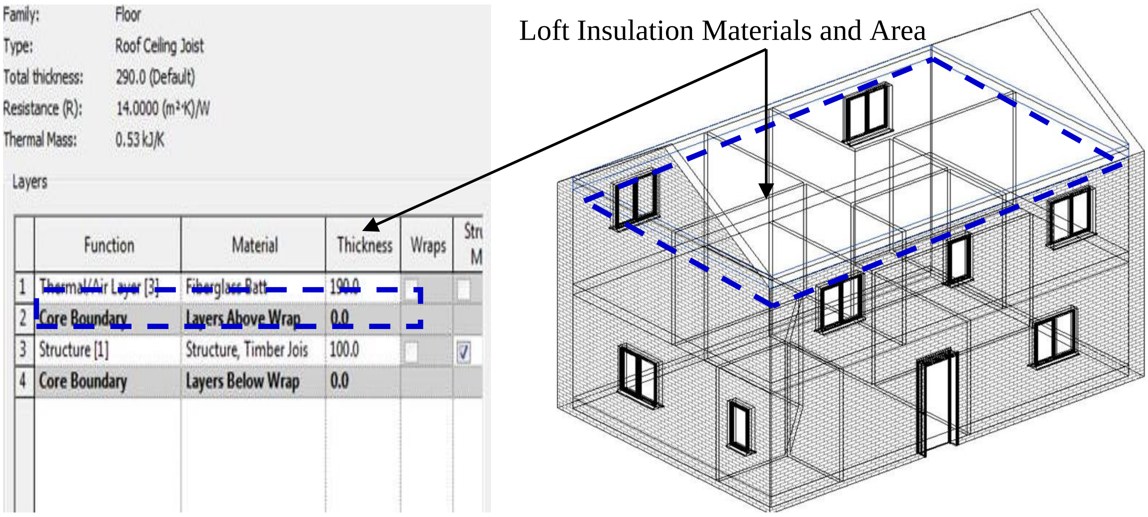


Figure 2. Insulation Material Specification and BIM Model

Material Quantity Take-Off								
Level	Family and Type	Material: Name	Material: Cost	Material: Embodied CO2	Material: Area	Material: Vol	Total Cost	Total Embodied CO2
Ground Floor	Floor: Timber Suspended Floor	Wood Sheathing, Chipboard	£24.56		67 m²	1.47 m³	£1645.14	
Ground Floor	Floor: Timber Suspended Floor	Structure, Timber Joist/Rafter Layer	£7.79		67 m²	15.07 m³	£521.81	
First Floor	Basic Ceiling: Generic	Gypsum Wall Board	£28.04	0.00	65 m²	0.00 m³	£1810.55	
First Floor	Basic Ceiling: Generic	Gypsum Wall Board	£28.04	0.00	64 m²	0.00 m³	£1807.19	
First Floor	Floor: Timber Suspended Floor	Wood Sheathing, Chipboard	£24.56		67 m²	1.47 m³	£1645.14	
First Floor	Floor: Timber Suspended Floor	Structure, Timber Joist/Rafter Layer	£7.79		67 m²	15.07 m³	£521.81	
B1010375: 6					397 m²	33.09 m³	£7951.64	
	Basic Roof: Cold Roof - Timber	Wood	£0.00	0.00	90 m²	2.26 m³	£0.00	
	Basic Roof: Cold Roof - Timber	Structure, Timber Truss Joist/Rafter	£12.49	0.00	90 m²	13.56 m³	£1128.93	
	Basic Roof: Cold Roof - Timber	Roofing, Tile	£66.01	0.00	90 m²	3.43 m³	£5966.45	
	Basic Roof: Cold Roof - Timber	Roofing Felt	£5.83	0.00	90 m²	0.00 m³	£526.96	
Loft	Floor: Roof Ceiling Joist	Structure, Timber Joist/Rafter Layer	£7.79		67 m²	6.70 m³	£521.81	
B1020400: 5					429 m²	25.95 m³	£8144.15	

Figure 3. Partial Sample of Quantity Take-off Function

Despite the automatic quantity take-off function, it was identified that the quantity surveyor is still responsible for cost planning and estimation of different building design options because any BIM software or tools cannot automatically detect conflicts or faults on the model such the overlapping places between insulation materials and house elements as shown in Figure 4. Thus, it is revealed that consequently the involvement of experienced and skilled quantity surveyors is inevitable to minimizing overestimation and reworks on site due to undetected design fault caused by BIM software, which is echoed with the findings from literature review. In addition, it is essential for quantity surveyors to collaborate with other project stakeholders such as architect and engineers through BIM system using one single source data as much as possible based on effective communications.

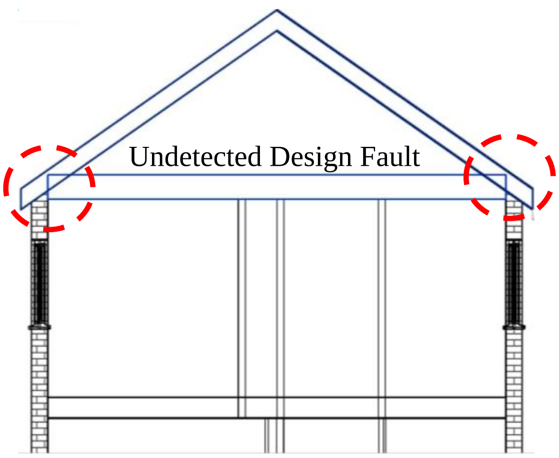


Figure 4. Overlapping between Insulation Material and Building Element

b. Unstandardized Coding System

Once the BIM model is completely constructed with proper cost and environmental information, quantity surveyor can match building elements with their cost and environmental database to estimate costs and CO_2 performance. In order to establish adequate relationships between building elements and cost in conjunction with CO_2 performance, the information on costs and CO_2 of construction materials need to have standardized coding system. However, current coding systems have different classification systems in different data source, and materials are categorised by unclassified coding systems as shown in Table 2, although there is the NRM for managing cost throughout whole life of a building in a standardized manner.

Table 2. Unstandardised Coding System among Different Data Sources

Coding System	Building Element and Construction Materials			Reference
	Roof - Pitched Roof, Timber	Roof - Insulation, Fibre Glass	Lowest Floor - Suspended Timber Floor	
NRM 1	2.3.1	2.3.1	1.1.3	NRM
Assembly Code	B1020400	B1020400	B1010375	Autodesk Revit
SMM7 (Materials Costs)	G20055	3015103A	G20052	SMM7
SMM6 (Embodied CO_2)	G202911S	PA003	G202102F	Carbon Book

Not all building elements are classified under the same code and the general code of buildings components are currently changing from SMM7 to NRM. A standardized data format/template in the shared classification should make the datasets of a Housing Information Modelling more reliable and efficient in calculating the bill of quantity and generating a cost management plan. Thus, construction professional organizations such as the NBS, which provide or plan to provide open BIM objects library, should take into consideration a standardized coding system for further BIM object development. Furthermore, the financial and environmental information regarding triple-glazed window, which is essential to achieve high energy performance of a building, is not available in any of data sources listed above. Thus, it is crucial to standardize the coding system to properly develop cost plan and assess environmental impacts. Based on the standardized coding system, a BIM object library should be developed for more accurate and reliable quantity surveying practice.

c. Interoperability Problems with Data Exchange

After construction of a BIM Model with proper classification setup, the BIM model is ready to be exported to another BIM software for environmental impact analysis such as CO_2 performance and energy efficiency. Depending on construction materials and construction types, the energy efficiency and operational costs of a building can be varied, the energy simulation is essential to develop cost plan. In order to export BIM model from Autodesk Revit to IES VE/IMPACT, the gbXML data format was used since the IFC format cannot properly exchange a BIM model between these two different BIM software. Based on this, it is revealed that the IFC format cannot be used universally to share information across different BIM software although it is supposed to be universal data format. This fortify the argument of many researchers that interoperability problem between different BIM software is a critical technical barrier to adopt 5D BIM in the quantity surveying practice. The original BIM model with the installed external wall insulation turned into the gbXML Model with the exact same insulation material information as shown in Figure 6. When the gbXML file is imported into another BIM software - IES VE/IMPACT for energy simulation, data loss regarding external wall insulation is occurred while the geometric information is properly transferred as shown in Figure 7. The original BIM model recognized the insulation material as it is, however the exchanged model into another BIM software system cannot be recognized as same as the original model. Thus, the missing information about the insulation materials needs to be manually entered again in the IES VE/IMPACT software.

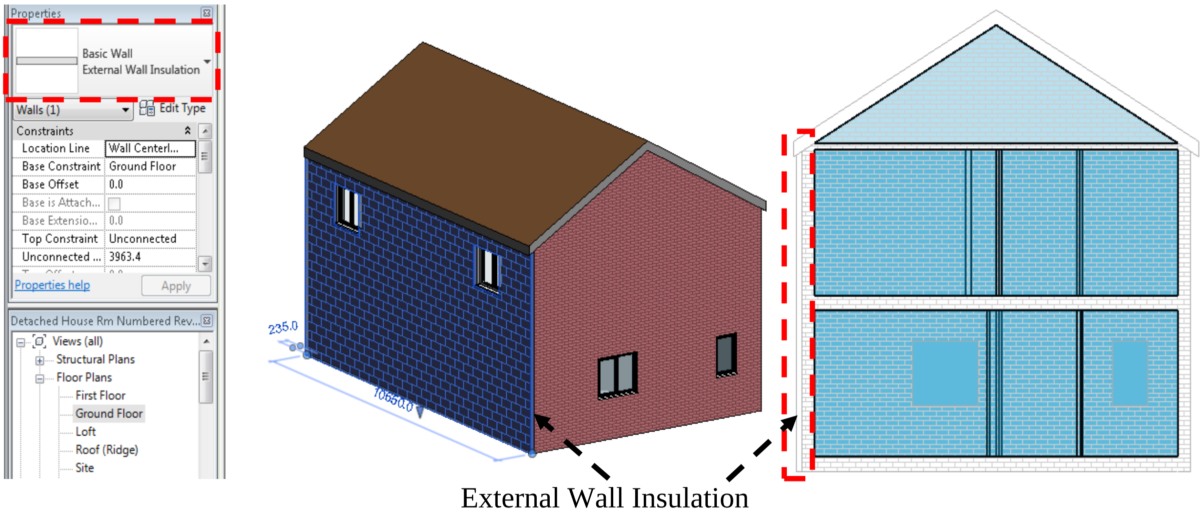


Figure 6. Basic BIM Model (left) and gbXML Model (right) with External Wall Insulation

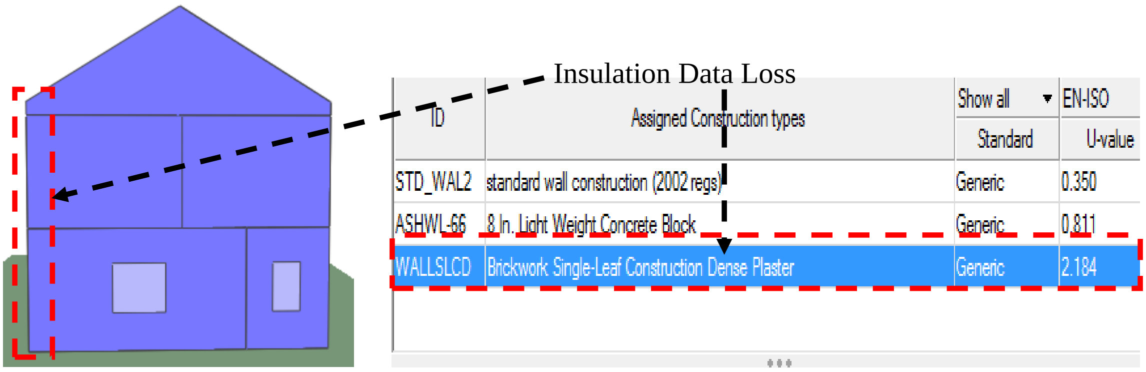


Figure 7. Data Loss after BIM Model Import to Different BIM Software (IES VE/IMPACT)

The lack of interoperability may limit the collaborative works between BIM software and project key project stakeholders. This research shows that entering information between different software and reviewing transferred information is inevitable. In order to achieve seamless collaboration and data exchanges, a BIM library with standardized material classification should be established. Currently, there is no definitive solution for this, and although it is challenging to fully utilize BIM for seamless data exchange without any data loss or distortion, this will eventually be resolved since many researchers are striving to develop a data exchange format using the IFC format.

NRM Code	Element	Assembly Code from Revit (SMM7)	Level	Family	Family and Type	Material: Name	Material: Cost (Material Cost + Labor Cost)	Material: Embodied CO2 (Cost)	Material: Area	Material: Volume	Construction Embodied CO2	Total Cost	Total Embodied CO2
1	Substructure												
1.1.3	Lowest Floor Construction	B1010375	Ground Floor	Floor	Floor: Timber Suspended Floor	Wood Sheathing, Chipboard	£ 24.56	0.54	67	1.47	2.42	£ 1,645.52	162.9338
1.1.3	Lowest Floor Construction	B1010375	Ground Floor	Floor	Floor: Timber Suspended Floor	Structure, Timber Joist/Rafter Layer, 75x225	£ 8.78	0.71	67	15.07	3.045	£ 588.26	214.7147
						Floor member 200 & 250 median			134	16.54		£ 2,233.78	377.6485
2	Superstructure												
2.2.1	Upper Floor	B1010375	First Floor	Floor	Floor: Timber Suspended Floor	Wood Sheathing, Chipboard	£ 24.56	0.54	67	1.47	2.42	£ 1,645.52	162.9338
2.2.1	Upper Floor	B1010375	First Floor	Floor	Floor: Timber Suspended Floor	Structure, Timber Joist/Rafter Layer	£ 8.78	0.71	67	15.07	3.045	£ 588.26	214.7147
2.2.1	Upper Floor	B1010375	Ground Floor	Basic Ceiling	Basic Ceiling: Generic	Gypsum Wall Board	£ 28.04	0.38	65	0.78	29.044	£ 1,822.60	1888.1564
2.2.1	Upper Floor	B1010375	First Floor	Basic Ceiling	Basic Ceiling: Generic	Gypsum Wall Board	£ 28.04	0.38	65	0.78	29.044	£ 1,822.60	1888.1564
									263	16.54		£ 5,878.98	4153.9613
						SMM7 Pitched roof members including ceiling joist, Revit does not include celing joist and Carbon book also does not include							
2.3.1	Roof Structure	B1020400	Loft	Floor	Floor: Roof Ceiling Joist	Structure, Timber Joist/Rafter Layer 100x150		0.71	67	6.7	4.058	£ -	276.643
2.3.1	Roof Structure	B1020400		Basic Roof	Basic Roof: Cold Roof - Timber	Wood Strutt 50x150	£ 6.61	0.71	90	2.26	2.184	£ 594.90	198.1646
2.3.1	Roof Structure	B1020400		Basic Roof	Basic Roof: Cold Roof - Timber	Structure, Timber Truss Joist/Rafter Layer	£ 12.49	0.71	90	13.56	4.058	£ 1,124.10	374.8476
2.3.1	Roof Structure	B1020400		Basic Roof	Basic Roof: Cold Roof - Timber	Roofing, Tile 65mm lap 100mm gauge	£ 58.40	0.45	90	3.43	37.56	£ 5,256.00	3381.9435
2.3.1	Roof Structure	B1020400		Basic Roof	Basic Roof: Cold Roof - Timber	Roofing Felt	£ 6.83	0.41	90	0	5.22	£ 614.70	469.8
									429	25.95		£ 7,589.70	4701.3987

Figure 8. Partial Cost and Environmental Impact Estimation using Excel

Finally, it is recommended and has been proven effective and efficient that data in a spread sheet are easily imported and exported to most BIM tools to complete the data sets for a model by manually entering cost and environmental information. As a result, the information for embodied CO_2 is calculated as shown in Figure 8. Once the datasets are given in materials' area (m^2) and volume (m^3), they can be manipulated by quantity surveyors to generate reliable insulation material quantity and construction cost and embodied CO_2 using a spread sheet. Figure 8 indicates that the combination of MS Excel and BIM software can provides more realistic and practical use of 5D BIM based on knowledge and experience of quantity surveyors.

Once the cost and environmental impacts are calculated based on different materials, the comparative analysis can be conducted, and quantity surveyors can advise more accurate cost plan and provide much environmentally friendly construction materials options to customers as shown in Table 3. In this case, it is obvious to use the fibre glass as an insulation material.

Table 3. Comparative Cost and Environmental Impact Analysis based on Different Materials

Detached House	Construction Materials	Basic Model	Building Regulation 2013 Applied (Energy Standard)
Construction Cost (£)	Fibre Glass	41,371.35	7,065.57
	EPS		12,004.63
Embodied CO2 (Kg)	Fibre Glass	34,994.9	12,197.25
	EPS		13,505.52

CONCLUSION

As an exploratory research, the purpose of this research is to identify the benefits and challenges of adopting 5D BIM, and examining practical use of 5D BIM in terms of quantity take-off function to reveal if it is practical and feasible for quantity surveying practice. First of all, the benefits of adopting 5D BIM are identified and summarized in three major categories as design optimization, efficiency improvement, and sustainability enhancement. Secondly, three major challenges are also identified as uncompleted quality of a building model, interoperability and data exchange format issue, and lack of standardized coding system. From the viewpoint of a quantity surveyor, BIM adoption for automated quantification and measurement can be positive as it can provide an opportunity to improve efficiency of their works, however on the other hand, adopting BIM can cause unnecessary reworks and inaccuracy in cost estimation and plan due to current challenges. Thus, this research conducts a hypothetical case study using BIM simulation to identify practical problems of 5D BIM adoption and provide practical insights to tackle current problems. Consequently, the utilization of 5D BIM for quantity surveying practice is feasible and is capable of assessing financial and environmental impact simultaneously. Based on the capability of 5D BIM, quantity surveyors can provide more accurate and reliable advice of selecting proper construction materials. However, this advantage can be achieved when proper BIM library and coding system is established in conjunction with seamless data exchange across different software regardless of data format. Finally, this research identifies that the use of MS Excel, which is commonly used among most construction professionals, in conjunction with BIM software can achieve synergy in quantity surveying practice. This research will provide practical insights to utilize 5D BIM for quantity surveying practice, and become a foundation for further research on 5D BIM for quantity surveying practice.

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