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Best Practices in Building Information Modelling Process Implementation in Green Building Design: Architects' Insights

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Abstract

An increasing number of clients are requesting green building design due to its potential to provide high-sustainability performance, monetary savings and health benefits to occupants. However, the practice of designing green building projects to meet overarching sustainability criteria is complex, with issues of poor information exchange synthesis. The building information modelling (BIM) process was created to ensure that the cumbersome green building data is exchanged accurately and in a coordinated manner. However, the implementation of the BIM process in green building design practices remains underexplored in the literature and industry practice. Therefore, this study aims to identify the best practices in BIM process implementation in the early stages of green building design. A quantitative research method was adopted; a questionnaire was used to survey 180 architects working in various construction firms in Malaysia. The questionnaire data was analysed using factor analysis to narrow down the long list of factors (best practices) into a small number of components. The results highlighted the best approaches in BIM process implementation in green building design practices: (1) selection of a well-trained and competent design team, (2) use of software with high interoperability to ensure exchange of accurate information, (3) development of a standard method for BIM process implementation in green building design and (4) timely identification of critical decision points. The research outcome will enlighten construction professionals on the best practices in implementing the BIM process in green building design, thereby allowing them to deliver building projects with high-sustainability performance.

Keywords: BIM Process, Green Building Design, Best Practices

1. Introduction

Green buildings are designed to efficiently use energy, water and other resources; improve occupants' health and productivity; reduce waste, pollution and environmental degradation; significantly decrease operational and maintenance costs; and promote harmony with local climates, traditions and cultures (EPA, 2016). Green building assessment tools (GBATs), such as the Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST), have been introduced to assess green building designs based on certain sustainability criteria. However, achieving the overarching sustainability criteria of GBATs is riddled with issues related to loss of information, exchange of inaccurate data and poor information exchange (IE) synthesis (Zanni, Soetanto, and Ruikar, 2017). However, the emergence of the building information modelling (BIM) process has engendered a paradigm shift in green building design practices. The BIM process ensures that green building data is accurately exchanged by requiring diverse design teams to use multidomain BIM software and building performance analysis (BPA) software with high interoperability to design buildings with high-sustainability performance within the desired time and budget (Al Hattab, 2021).

Despite its benefits, the BIM process implementation in green building design practices remains underexplored in both academia and industry practice (Ohueri, Enegbuma, and Habil, 2019). Most studies on green BIM best practices focus on software customisation and enhancement (Ohueri et al., 2018; Seghier, Ahmad, and Lim, 2019; Xue et al., 2021). Arguably, BIM software enhancement and appropriate use of information and communication technology (ICT) will significantly enhance green building outcomes. However, in industry practice, the proposed tools have not been adequately implemented due to the lack of defined best practices in green building design (Ren and Zhang, 2021). As stated by Wu et al. (2015), a structured process is needed for implementing the BIM process in green building design. Therefore, this study aims to identify the best practices in BIM process implementation in the early stages of green building design. The research outcome will inform construction professionals about the best practices to be adopted in implementing the BIM process in green building design, thus ensuring the exchange of accurate building information and delivery of building projects with high sustainability performance.

2. Green Building Design Practices

Green building practices reduce buildings' impact on human health and the environment via better siting, design, construction, operation, maintenance and deconstruction (Orsi et al., 2020). The benefits of green building design can be grouped into three major aspects in accordance with the triple bottom line of sustainable development. First, the environmental benefits include reduced carbon emissions, improved air and water quality, low waste streams and conservation of natural resources. The second aspect involves economic benefits, such as reductions in operating costs, improvement of occupant productivity and optimisation of life cycle economic performance. The third aspect is social benefits, which refer to improvements in occupant comfort and health, aesthetic qualities and overall quality of life (Ohueri, Enegbuma, and Habil, 2019). Green buildings are designed on the basis of certain key principles, including optimisation of site potential, efficient use of water and other resources, and reduced energy use and carbon emissions.

GBATs are established as sustainability metrics that provide insights into the sustainability of a building throughout its life cycle and measure the environmental performance of buildings to create a sustainable built environment. However, Cole (2007) criticised GBATs, citing that they impede innovation by limiting design alternatives and focusing on ‘points-chasing’; GBATs have a considerable impact on ensuring that green building design adheres to sustainability indicators. Several GBATs exist across the world, such as the Building Research Establishment Environmental Assessment Method (BREEAM, UK), Leadership in Energy and Environmental Design (LEED, US), Green Standard for Energy and Environmental Design (G-SEED, Korea), Green Mark (Singapore), Green Building Index (GBI, Malaysia), Green Performance Assessment System (GreenPASS, Malaysia), and Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST).

Apart from the established GBATs, scholars such as GhaffarianHoseini, Berardi, and Dahlan (2014); Lim et al. (2016); Ohueri, Enegbuma, and Habil, (2019); and Azis (2021) have proposed several strategies for enhancing green building design, construction, operation and maintenance. Nonetheless, the adoption of green building design remains low due to its complex nature, resulting in poor IE synthesis (Ohueri, Enegbuma, and Habil, 2019). Additionally, there is a gap between the simulated and actual operating sustainability performance of existing green buildings (Zaid, Rad, and Zainon, 2017). This is attributed to the lack of a coordinated process required for diverse design teams to adopt multidomain BIM software and BPA tools to deliver high-performance building projects.

3. Building Information Modelling (BIM)

BIM evolved from computer-aided design (CAD), where models have simple X and Y axes (2D). BIM is defined as a set of interacting policies, processes and technologies generating a methodology to essentially manage building design data in a digital format throughout a building's life cycle (Lu et al., 2017). BIM methodology is used in project predesign: design visualisation, constructability reviews, design coordination (3D); construction scheduling and sequencing (4D); quantity survey estimation (5D); project life cycle information management (6D), and integration with sustainable design practice (green BIM) (CLC, 2018). The BIM procedure brings various stakeholders together to share, extract and update information from a project model. As stated by Succar (2009), BIM is implemented in building design on the basis of three fields: policy, technology and process. The BIM technology field clusters players who specialise in developing software, hardware, equipment and networking systems and the software customisation and enhancement necessary to increase efficiency, productivity and profitability of architecture, engineering, construction and operation (AECO) sectors (Shimont, 2018). The BIM technology field is arguably more widely explored in BIM literature compared with the BIM process field (Zanni, 2017).

The BIM process is grounded on established standards, such as the British Standard BS 1192, which sets out the principles of BIM, and Publicly Available Specifications (PAS) 1192-2, which specifies the information management required for the delivery phase of construction projects using BIM (BSI, 2013). These standards have been replaced by ISO 19650-1 (for organisation and digitisation of building information and civil engineering works) and ISO 19650-2 (concepts to delivery phase of assets) (ISO 2018). The BIM process field ensures that accurate information is exchanged during the design of high-performance buildings. The BIM process requires the establishment of BIM project execution planning guidelines (PEPGs) to outline the overall vision of a project along with implementation details for the team to follow throughout the project (CIC, 2010). Furthermore, the BIM level of development (LOD) that will be adopted in the project, which depends on the BIM level of maturity of the design team, is clarified.

4. Best Practices in BIM Process Implementation in Green Building Design

Synergising the BIM process and green building design practices enhances collaborative design and performance optimisation (Atabay et al., 2020). Moreover, implementing the BIM process in green building design practices enables a multidisciplinary design team to utilise existing technological enablers, such as BIM software, BPA software and ICT, to strategically execute a project with high sustainability performance (Zanni, Soetanto, and Ruikar, 2017). However, the BIM process and green building design practices are not adequately implemented by design teams, leading to issues such as loss of information and exchange of inaccurate information. According to Zanni (2016), collaborative BIM-based sustainability analysis is not widely practiced in the industry despite its potential to increase collaboration within design teams and coordination between structural, envelope, mechanical, electrical and architectural systems. In the Malaysian construction industry, BIM maturity remains between levels 0 and 1, which implies that architects and other design teams still exchange information using the conventional method (CIDB, 2017).

Therefore, this study reviews previous works to determine the best practices in BIM process implementation in green building design. These practices are highlighted in Table 1.

Insert Table 1

Table 1 highlights the best practices in BIM process implementation in green building design. These include the selection of a well-trained and competent green building design team. This is in line with Hussain et al. (2018), who found that it is paramount to select a competent and technically trained design team to effectively and efficiently handle the complexities of the green building design process. As stated by Zanni (2016), a design team should be knowledgeable about the basic concepts of green building design, and it should have at least a BIM maturity level 2. As specified in established BIM standards, such as BS EN ISO 19650 and 19650-2 (BSI 2013), all design teams must attain a BIM maturity level 2. This level involves a series of interconnected models and databases that promotes the collaborative use of multidomain software to exchange and manage information through a common data environment (CDE) in accordance with the LOD (Munir et al., 2020). Construction firms should have licenses for BIM and BPA software, and design teams should have adequate training to execute BIM projects (Lu et al., 2017). Furthermore, roles and responsibilities should be sufficiently defined in the contractual agreement/legal tender.

According to Wu (2014), sustainability objectives should be integrated from the onset of green building design practice. Specifically, sustainability objectives should be quantified in the employer's information requirements (EIR) to ascertain their feasibility. MyCREST is an ideal rating tool for green building design in tropical countries due to its performance-based standards that link sustainability indicators to carbon emission reduction criteria (Ohueri, Enegbuma, and Habil, 2019). Moreover, a BIM execution plan (BEP) ought to be collaboratively developed to address the EIR. Passive design strategies should be applied to maximise indoor environmental quality and minimise energy use and carbon emissions (Zanni, 2016). In addition, the task of a design team should be well defined according to the adopted sequence of schedules (Zanni, 2016). A variety of software packages with high interoperability should be utilised to combine the strengths of different tools (Lu et al., 2017). Software that can assess green building design and automatically generate MyCREST/GBAT points should be available, and programs with high interoperability rates with other applications need to be used (Ohueri et al., 2019).

A well-structured model should be developed for BIM process implementation in green building design practices. The use of CDEs with added functionalities is pivotal for appropriate GBD implementation, and information delivery (Zanni, 2014). Design deliverables should be defined according to the LOD and level of information (LOI) to facilitate critical decision-making (NBS, 2019). Institutional support is also needed in implementing the BIM process in green building design practices (Ohueri, Enegbuma, and Habil, 2019). Identifying some standard practices in the literature, this study adopts a quantitative research method to achieve the research aim, which is to determine the best practices in BIM process implementation on the basis of architects' insights.

5. Methodology

This study adopted the quantitative research approach of a questionnaire survey. According to Protić (2021), the quantitative research method promotes the objective evaluation and statistical analysis of collected data. Prior to the main data collection, a pilot survey was conducted to test the reliability of the questionnaire. The average Cronbach's alpha value for the 58 items in the pilot questionnaire was 0.88; the value of each item of the pilot questionnaire was above 0.7, which implied that the items were reliable and acceptable. According to the IDRE (2018), the consistency scale used to denote minimum reliability in research of this nature is 0.7; thus, the items were regarded as appropriate and credible. The main questionnaire consisted of two sections. Section A consisted of four questions about the demographic information of the respondents. Section B comprised five-point Likert scales (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). Moreover, section B consisted of 10 constructs/categories/variables that were further broken down into 50 subvariables. These variables and subvariables were selected from prominent studies on BIM and green buildings, as discussed in the literature section.

The research population is architects in the Malaysian construction industry. As reported on the Board of Architects Malaysia (BAM) website, as of February 2021, there are two thousand, three hundred and eighteen (2,318) registered architects in Malaysia. Hence, the sample size was selected using the Krejcie and Morgan formula for calculating the sample size of known populations. The Krejcie and Morgan formula/table is widely adopted by researchers because it is straightforward, efficient and reliable compared with other techniques (Bartlett, Kotrlik, and Higgins, 2001). The formula is shown in Equation 1.

Equation 1: Formula for determining the sample size of a known population size

$$\text{Sample Size (s)} = \frac{X^2 NP\,(1-P)}{d^2(N-1) + X^2\,P\,(1-P)},$$

where

s = required sample size,

X^2 = table value of chi-square for 1 degree of freedom at the desired confidence level, that is, $X^2 = (1.96)^2 = (3.841)$,

N = population size (2318),

p = population proportion (assumed to be .50 since this would provide the maximum sample size) and

d = degree of accuracy expressed as a proportion (.05).

Therefore, the sample size is

$$\text{Sample Size (s)} = \frac{3.841\ X\ (2318)\ X\ (0.50)\ (1\ -\ 0.50)}{0.05^2\ (2318 - 1) + 3.841\ X\ 0.50\ (1 - 0.50)}$$

$$\text{Sample Size (s)} = \frac{2226}{6.725}$$

$$\text{Sample Size (s)} = 330.$$

A sample size of 330 was calculated using the Krejcie and Morgan formula. Hence, the questionnaire was distributed electronically to 330 architects in Malaysia to identify the best practices in implementing the BIM process in green building design practices. Two hundred responses were recorded. However, only 180 questionnaires (60%) were accurately answered and thus used for the data analysis. As reported by Protić (2021), a survey response rate of 50% or higher should be considered excellent in most circumstances.

Data was analysed using Statistical Package for the Social Sciences (SPSS) (descriptive statistics) and exploratory factor analysis (EFA) to identify the significant best practices. According to Finch (2020), EFA is useful in research for reducing the number of variables, assessing multicollinearity among correlated factors, detecting and evaluating construct unidimensionality, evaluating construct validity in surveys and developing theoretical constructs.

6. Analysis, Discussion and Findings

This section presents the analysis and findings of the questionnaire survey. Section A consisted of four questions used to investigate the architects' years of professional experience, types of GBATs used for assessing green buildings, and experience with the BIM process. The background information was analysed using SPSS (descriptive statistics), and the outcome is represented in Figure 1.

Insert Figure 1

Figure 1 shows the demographic findings of the questionnaire survey. Over 60% of the respondents have been working in construction firms for more than two decades. In total, 72% have participated in projects that pursued GBI certification, while only 5% have worked on projects that pursued MyCREST certification. This is in line with CIDB (2016), which reported that most green buildings in Malaysia are GBI certified because GBI is the most prominent system; MyCREST is new, and only a few projects are MyCREST certified. A total of 26% have participated in projects that fully adopted BIM, but only 12% have BIM knowledge. This shows that BIM adoption in Malaysia remains low. This result corresponds with CIDB (2016a) and Enegbuma (2016), who stated that construction firms in Malaysia remain in the infancy stage in terms of the execution of the BIM process in construction projects. Thus, the architects surveyed in this study are experienced and actively involved in green building design practices.

Section B was used to investigate the best practices in BIM process implementation in green building design. It consisted of 10 variables and 50 subvariables, as shown in Table 1. The variables are the best practices identified from the literature review. However, only the result of the 10 main variables are shown in Table 2 due to space limitations. They include critical decision points (BP 1), roles and responsibilities (BP 2), schedule of services (BP

3), integration and quantification of sustainability from the onset (BP 4), competency and training (BP 5), institutional support (BP 6), structured model for BIM process implementation in green building design (BP 7), ICT (BP 8), deliverables and information requirements (BP 9) and software and interoperability (BP 10). The weight of each best practice was analysed using SPSS (descriptive statistics), as shown in Table 2.

Insert Table 2

Table 2 shows the descriptive statistics of the best practices in BIM process implementation in green building design, including the weight, mean and standard deviation (SD). Based on the five-point Likert scale used to structure the questionnaire, best practices that have a mean value of less than 3 are not critical to BIM process implementation in green building design practices in the Malaysian context. Thus, they are not considered significant best practices in BIM-enabled green building design. Variables with a mean value of more than 3 are deemed best practices.

The competency and training (BP 5) variable, with a mean value of 3.63, is ranked as the most significant best practice in implementing the BIM process in green building design practices. This is in line with Hussain et al. (2018), who stated that a competent and technically trained design team should be selected to effectively and efficiently handle the complexities and relevant green considerations during the green building design process. As stated by Zanni (2016), a design team should be knowledgeable about the basic concepts of green building design and should have a BIM maturity level of at least 2, as stated in BIM standards, as this facilitates the collaboration of the design team in a CDE. Software and interoperability (BP 10), with a mean value of 3.50, is ranked as the second most significant best practice in BIM-enabled green building design. This corresponds with Harlacher (2016), who concluded that BIM enablers, such as software with high interoperability, should be used to ensure the exchange of accurate information. Moreover, construction firms ought to have licenses for BIM and BPA software (Lu et al., 2017).

The structured model for BIM process implementation in green building design (BP 7), with a mean value of 3.45, is ranked the third most significant best practice in BIM process implementation in green building design. This agrees with Ohueri, Enegbuma, and Habil (2019), who stated that structuring a standard model that enables a multidisciplinary design team to utilise multidomain software for accurate IE will enhance green building adoption. The fourth most significant best practice in BIM process implementation in green building design is critical decision points (BP 1), with a mean value of 3.42. According to NBS (2019) and Lim et al. (2016), identifying critical decision points in green building design practices saves considerable time and money while enhancing sustainable building design performance. The other variables are also significant except for roles and responsibilities (BP 2) and schedule of services (BP 3), whose mean values are less than 3. EFA was conducted to further elucidate the best practices in BIM-enabled green building design, as shown in Table 3.

Insert Table 3

Table 3 shows the EFA conducted on the variables and subvariables of the questionnaire. In accordance with previous research techniques, factor extraction was conducted for all items in the research instrument with the specifications in the following order: 'maximum likelihood extraction, promax rotation, threshold for factor extraction of Eigen value >1, items with cross-loadings (loadings on two or more factors) of < 0.6 were dropped and items with a factor loading of less than 0.6 on any factor were dropped' (Hair et al., 2014). As a result, two main variables with mean values less than 3 were eliminated: schedule of services (BP 3) and roles and responsibilities (BP 2). These eliminated factors have low factor loading values that were below the acceptable threshold of 0.6 (Hair et al., 2014). Although Zanni (2017) and Barnes and Davies (2014) stated that schedule of services and roles and responsibilities are best practices in executing the BIM process in green building design, the current study shows otherwise. In the Malaysian context, the definition of roles and schedule of services are applied using a bespoke approach; they do not affect BIM process implementation in green building design. The EFA results correspond with the descriptive statistics in that they both eliminate the two insignificant best practice variables. Thus, this verifies the best practices established in the first analysis. The variables (best practices) and subvariables within the acceptable threshold of EPA, as shown in Table 3, ought to be strictly implemented to ensure the exchange of accurate information during the process of BIM implementation in green building design practices, thereby enhancing the sustainability performance of buildings and enabling clients to save money.

7. Conclusion

Embedding GBATs, such as MyCREST, into green building design practices remains difficult in the construction industry. The multifaceted nature of the BIM process adds dimensions of complexity to green building design, which hinders design teams from fully adopting the BIM process in green building design practices. However, construction firms that have succeeded in synergising BIM and green building design practices ascertain that green BIM can enhance IE synthesis, improve project outcomes, and facilitate the accomplishment of established sustainability goals. Thus, this study investigated the best practices in implementing the BIM process in green building design practices. Such implementation will allow a multidisciplinary design team to adequately implement the BIM process in green building design to achieve a project's sustainability objectives within the desired time and cost. A questionnaire was used to survey architects, and the findings showed the best practices that are critical to BIM process implementation in green building design. These best approaches are (1) selection of a well-trained and competent design team, (2) use of software with high interoperability to ensure exchange of accurate information, (3) development of a standard method for BIM process implementation in green building design and (4) timely identification of critical decision points. The outcome of this study will enlighten construction professionals on the best practices to be adopted in implementing the BIM process in green building design practices to ensure the exchange of accurate information and deliver building projects with high sustainability performance.

References

Azis, S.S.A., 2021. Improving present-day energy savings among green building sector in Malaysia using benefit transfer approach: Cooling and lighting loads. Renewable and Sustainable Energy Reviews, 137, p.110570.

BSI (2013) *PAS 1192-2:2013 Incorporating Corrigendum No. 1: Specification for Information Management for the Capital/Delivery Phase of Construction Projects Using Building Information Modelling*. Britian. Available at: http://www.bimireland.ie/wp-content/uploads/2015/08/BSI_PAS_1192_2_2013.pdf.

CIC (2010) 'BIM Execution Planning Guide'. Available at: https://vdcscorecard.stanford.edu/sites/default/files/BIM_Project Execution Planning Guide-v2.0.pdf.

Construction Lifecycle (CLC) 2018. The Various Dimensions of Bim Explained https://www.constructionlifecycle.com/operations-management/bim-dimensions/

CIDB (2016) *Building Information Modelling Report-2016*. Kuala Lumpur, Malaysia. Available at: http://www.cidb.gov.my/images/content/pdf/laporan-teknikal-pembinaan/BIM-Report-2016.pdf.

Cole, R. (2007) 'Building environmental assessment methods : redefining intentions and roles Building environmental assessment methods : rede ¢ ning intentions and roles', 33(5), pp. 455–467. doi: 10.1080/09613210500219063.

Enegbuma, W. (2016) *Factors Affecting Building Information Modelling Adoption By Malaysian Consultants and Contractors*. Universiti Teknologi Malaysia.

EPA (2016) *Green building; why build green*, *United States Environmental Protection Agency EPA*. Available at: https://archive.epa.gov/greenbuilding/web/html/whybuild.html (Accessed: 28 February 2018).

Finch, W.H., 2020. Using fit statistic differences to determine the optimal number of factors to retain in exploratory factor analysis. Educational and psychological measurement, 80(2), pp.217-241

GhaffarianHoseini, A., Berardi, U. and Dahlan, N. (2014) 'What can we learn from Malay vernacular houses?', *Sustainable Cities and Society*, 13, pp. 157–170.

Hair, J. F. *et al.* (2014) *Multivariate Data Analysis*. 7th Ed. Upper Saddle River, N.J.: Pearson Education Ltd.

Harlacher, J. (2016) ‘An educator’s guide to questionnaire development’, (January), p. 15 p. Available at: http://ies.ed.gov/ncee/edlabs/projects/project.asp?projectID=4500.

Hussain, R. *et al.* (2018) ‘Impact of safety training and interventions on training-transfer : targeting migrant construction workers’, 3548. doi: 10.1080/10803548.2018.1465671.

ISO (2018) *International Organization for Standardization (ISO) 19650-1*, *International Organization for Standardization*. Available at: https://www.iso.org/standard/68078.html (Accessed: 5 May 2019).

Lim, Y. *et al.* (2016) ‘Building Information Modelling for building energy efficiency evaluation’, *4th Annual International Conference on Architecture and Civil Engineering (ACE 2016)*, (Ace), pp. 42–48. doi: 10.5176/2301-394X_ACE16.56.

Lu, Y. *et al.* (2017) A critical review and future directions’, *Automation in Construction*. Elsevier, 83(August), pp. 134–148. doi: 10.1016/j.autcon.2017.08.024.

Mokhtar Azizi, S. *et al.* (2012) ‘Management practice to achieve energy efficiency performance: green versus conventional office building in Malaysia’, *Legal Affairs and Dispute Resolution in Engineering and Construction*, 5, pp. 205–214.

Munir, M. *et al.* (2020) ‘BIM-based operational information requirements for asset owners’. Taylor & Francis, 2007. doi: 10.1080/17452007.2019.1706439.

NBS (2019) *BS EN ISO 19650-1:2018 Organization and digitization of information about buildings and civil engineering work*. Available at: https://www.thenbs.com/PublicationIndex/documents/details?Pub=BSI&DocID=324869 (Accessed: 12 July 2011).

Ohueri, Chukwuka Christian *et al.* (2018) 'Energy efficiency practices for Malaysian green office building occupants'. doi: 10.1108/BEPAM-10-2017-0091.

Ohueri, C C *et al.* (2018) 'Preliminary Evaluation of Synergizing BIM and Malaysian Carbon Reduction and Environmental Sustainability Tool', 22, pp. 218–227. doi: 10.1007/978-3-642-36645-1.

Ohueri, C., Enegbuma, W. and Habil, H. (2019) 'MyCREST embedded framework for enhancing the adoption of green office building development in Sarawak framework', (2018). doi: 10.1108/BEPAM-10-2018-0127.

Orsi, A., Guill, I. and Pellicer, E. (2020) 'Optimization of Green Building Design Processes : Case Studies within the European Union', pp. 1–16.

Protić, S., 2021. Quantitative Research in Social Trauma. In Social Trauma–An Interdisciplinary Textbook (pp. 327-334). Springer, Cham.

Ren, R. and Zhang, J., 2021. A New Framework to Address BIM Interoperability in the AEC Domain from Technical and Process Dimensions. Advances in Civil Engineering, 2021.

Seghier, T. E., Ahmad, M. H. and Lim, Y. (2019) 'Automation of Concrete Usage Index (CUI) assessment using computational BIM', 6(1), pp. 23–30. doi:

10.11113/ijbes.v6.n1.319.

Succar, B., 2009. Building information modelling framework: A research and delivery foundation for industry stakeholders. Automation in construction, 18(3), pp.357-375.

Xue, K., Hossain, M., Liu, M., Ma, M., Zhang, Y., Hu, M., Chen, X. and Cao, G., 2021. BIM Integrated LCA for Promoting Circular Economy towards Sustainable Construction: An Analytical Review. Sustainability, 13(3), p.1310.

Zaid, M., Rad, K. and Zainon, N. (2017) 'Are green offices better than conventional?: Measuring operational energy consumption and carbon impact of green office in Malaysia', *Measuring Business Excellence*, 35(211/12), pp. 622–637. doi: 10.1108/F-06-2016-0063.

Zanni, M. A. (2016) 'Communication of sustainability information and assessment within BIM-enabled collaborative environment', p. 560. doi: 10.1021/ja00090a013.

Zanni, M. A., Soetanto, R. and Ruikar, K. (2017) 'Towards a BIM-enabled sustainable building design process: roles, responsibilities, and requirements', *Architectural Engineering and Design Management*. Taylor & Francis, 13(2), pp. 101–129. doi: 10.1080/17452007.2016.1213153.