12th International Structural Engineering and Construction conference, ISEC-12
Innovative Theory and Practices in Structural Engineering and Construction
Chicago, Illinois, August, 14-18 2023

BIM USE IN GREEN BUILDING CERTIFICATION PROCESSES

LESLEY LY[1] and LYDIA KIROFF[2]

[1] *School of Building Construction, Unitec - Te Pukenga, Auckland, New Zealand*
[2] *School of Building Construction, Unitec - Te Pukenga, Auckland, New Zealand*

Green building certification schemes have been developed to incentivize sustainable construction leading to the development of green BIM technology, which uses multi-disciplinary data to support sustainable construction. However, due to a lack of understanding, interoperability, and technical issues, BIM is not widely used to support green building certification. This study investigates the current use of BIM for certification purposes, the building characteristics or information that need to be modeled, and the skills or knowledge required to use BIM for green building certification. The research, which employed a case study approach, examined the BIM use in a recently built 6 Green Star rated Head Office of a major supermarket chain in south Auckland. The main data collection methods were document analysis and semi-structured interviews with key project stakeholders. The results suggest that despite generally good knowledge of BIM and sustainable building design, the connection between BIM and green building certification is weak or non-existent. Instead, BIM is used mainly for model authoring, coordination, quantity take-off, and basic sustainability analysis. The main factors hindering BIM integration that have been identified are low-quality modeling, lack of multi-disciplinary coordination, and inefficient procurement. It is recommended that BIM usage should be accurately detailed and coordinated for downstream uses to gain the most value. Procurement should also accommodate appropriate BIM procedures to encourage multi-disciplinary coordination. Furthermore, new technology and research development are also needed to increase interoperability with sustainable (green) software.

Keywords: Building Information Modelling, Sustainability, Green Star, Green Building Certification.

1 INTRODUCTION

The Architecture, Engineering, and Construction (AEC) industry faces increasing pressure to move towards Sustainable Design and Construction (SDC). Although Green Building Certification (GBC) schemes have been developed to incentivize sustainable construction, issues still need to be addressed for widespread and satisfactory uptake. Lack of understanding, complex administration (Doan *et al*. 2019), and time-consuming assessment/re-assessment processes (Carvalho *et al*. 2020) have been identified in the literature as some of the main barriers. Building Information Modelling (BIM) has been considered a potential solution for creating Green BIM tools and software to support sustainable construction, potentially reducing the complexity and cost of assessment (Sanhudo and Martins 2018). However, due to a lack of understanding (Doan *et al*. 2019), coordination (Olawumi and Chan 2019), poor interoperability

(Ansah *et al*. 2019, Meng *et al*. 2020), and lack of skills/experience (Meng *et al*. 2020), BIM is not widely used in practice, let alone to support GBC.

Existing research into Green BIM has primarily focused on the Leadership in Energy and Environmental Design (LEED) certification system in the United States and the Building Research Establishment Environmental Assessment Method (BREEAM) in the United Kingdom. The research has resulted in the development of BIM software/tools that allow the validation of a GBC scheme. Compared to LEED and BREEAM, the New Zealand Green Star certification, available for every commercial building type, has received little attention and needs to be extensively researched (Doan *et al*. 2019). Previous research supports BIM integration into GBC schemes. However, it also identifies significant issues which prevent its widespread adoption, highlighting the need for more technical skills and experience with BIM and GBC. This research explores the extent to which BIM was successfully integrated into a recently completed Green Star-certified commercial project in Auckland, New Zealand. Furthermore, the study attempts to identify the key barriers hindering that integration. The main research question of this study is, "How can BIM be used in GBC processes?" The three sub-questions examine the BIM uses most relevant to GBC processes, the key building characteristics or information that need to be modeled in BIM to be helpful, and the required specialist skills or knowledge.

2 RESEARCH APPROACH AND METHODS

The study employed a case study research approach. The recently built 6 Green Star-rated Head Office of a major supermarket chain in south Auckland with an approximate value of NZ$53 million was chosen as a case study because it is green building certified with substantial BIM involvement due to its complexity. A 6 Green Star building (the highest) exemplifies world leadership (NZGBC 2022). The design of the ~75,000m^2 Distribution Warehouse (non-Green Star) and ~8,500m^2 three-story Head Office building (6 Green Star) began in early 2017, was completed in December 2020, and occupied in March 2021. Despite being built during the Covid-19 pandemic, the project was completed on budget and four months ahead of schedule.

From the outset of the project, the Client had a requirement to use BIM for as-built modeling. Hence BIM was employed to assist in designing and constructing the complex architectural features the building possessed. The Tenant also had a high demand for sustainable features in the building they aimed to lease for the next 30 years.

This research used multiple data sources, including public, private, and interview data. The wide publicity surrounding the project meant public data were already available, including consultants' websites, NZGBC, and YouTube. Other data sources included the NZ BIM Handbook, Client's Asset Information Delivery Manual (AIDM), and publicly available project documentation such as the construction BIM Execution Plan (BEP). The private project data collected for the study were the design BEP and architectural set of drawings. A document analysis framework was used for each public and private data – the information was recorded and analyzed in a matrix format based on the main research question and sub-questions. Online job listings from four jobseeker websites: Seek, Indeed, Jora, and TradeMe, within two weeks between 17-30th September 2022, were also used to identify the most common skills or software employers required for BIM and sustainability-related jobs. The collected data were recorded in an Excel spreadsheet noting the job name, BIM uses, software, skills/knowledge required, and years of experience or qualification required. The semi-structured interviews were with the project's key stakeholders: the Client, Project Architect, BIM Manager, and Main Contractor. The interview data were collected from recorded Zoom meetings and manually edited Zoom transcripts and then compiled into a matrix based on the

research questions and sub-questions with reference numbers to the corresponding line from the transcripts.

3 FINDINGS

3.1 BIM Use on the Project and its Benefits

There is a consensus in publicly available documents that BIM could inform the sustainable design of solar performance, heating and cooling, building envelope, rainwater harvesting, interior light levels, energy efficiency, exterior planting, and material selection (NZGBC 2022). Additionally, it suggests that BIM can help target GBC schemes as it facilitates decision-making, reduces reworks, and helps generate verification calculations (BIM in NZ 2019). Engineering analysis using BIM helps to assess optimal building performance in terms of the Internal Environmental Quality (IEQ), Energy, Materials, and Water categories of Green Star. Overall, these recommended BIM uses have been implemented in the project to ensure an accurate as-built model. With BIM at its core, high-quality, sustainable design was essential to the Client and Tenant, pursuing a 6 Green Star rating. BIM was mainly used for design authoring, coordination, and record modeling, but design review, cost estimation, and structural and sustainability analysis were also priorities (BIM Manager). The ability to generate precise quantities reduced waste and rework (Architect) and variations (Main Contractor). The project consultants used mainly Autodesk products (Revit, Navisworks, BIM360) "*as they work well together*" (Main Contractor). Revizto was also used for sharing and issue tracking, which "*made it less graphic intensive and more user-friendly*" (Architect).

Although the BIM benefits were identified, there was "*nothing [linking] directly from the BIM to the Green Star certification*" (Main Contractor), and only "*allowed for good coordination and takeoffs*" (BIM Manager). Additionally, since the energy, daylight, and thermal modeling software, DesignBuilder (EnergyPlus & Radiance), couldn't use the BIM model directly, it had to be redrawn, leading to manual updates of any building changes. "*Currently, BIM is not totally driven to sustainability, but it allows visualization, simulation, and real-time collaboration, which enable opportunities for sustainability*" (Architect). "*BIM cannot suggest sustainable materials for you, but it enables quantity take-off and carbon calculation*" (Main Contractor).

3.2 Key BIM Modelling Characteristics Required for Green Star Certification

Strict BIM modeling requirements, based on the Client's AIDM, were applied to this project: location data according to NZ surveying standards; naming and modeling conventions according to their floor level, location, load bearing, space name, and type; model element attribution describing the asset accurately following the specified structure and set out; health and safety identifying which areas are in construction and operation; and file formats providing both native and IFC compatible formats to avoid data loss.

The Main Contractor had to re-model the original precast model because although it was modeled suitably for structural analysis, it needed to be more detailed for construction and prefabrication. "*Modelling accurate quantities is key for measuring sustainability. Currently, architects model what looks correct on drawings, but the model is not high quality for Green Star or construction*" (Main Contractor). "*Green Star consultants can start reviewing and testing things…[they] don't have to wait for a [certain] LOD*" (Architect).

Several BIM challenges were identified regarding Green Star uptake. Coordination and poor-quality drawings for construction (Main Contractor), and coordination of complex architectural features (BIM Manager, Client), resulted in re-modeling for construction and fabrication.

Another challenge was building on an undeveloped site with three main contractors during the Covid-19 pandemic (Client) and coordinating the team to provide a record model suitable for future operations (BIM Manager). Furthermore, "*clients are reluctant to pay for BIM and don't understand that the main cost of it is coordinating buildability, which is still cheaper than tens of thousands of dollars of reworks on-site*" (Main Contractor).

3.3 Skill and Knowledge Requirements

Users must understand BIM authoring, engineering tools, and Green Star to use BIM for sustainability and engineering analysis. In addition, team competencies identified include creating and manipulating a 3D model, using analysis tools, organizing and managing databases, and knowledge of design and construction methods (BIM in NZ 2019). Strong leadership and overall understanding and ownership of project goals are also necessary to capture project requirements (RDT Pacific 2021).

Thirty-three online job listings within two weeks were used to identify the relevant skills or software required (26 BIM and 7 sustainability roles) with the following breakdown: model authoring (21/26 BIM; 3/7 sustainability), information management (14/26), clash detection (11/26), and leadership skills (10/26). 4/7 sustainability roles required engineering analysis software, but BIM roles did not mention sustainability or carbon modeling. Only 2/26 BIM roles required sustainability/carbon modeling in their listing, one of which was at the senior/associate level. BIM roles required 2-10 years' experience, whereas sustainability roles required 4-5. Information management was essential to BIM but was not mentioned in sustainability roles, which shows a disconnect between the skills of a BIM consultant and a sustainability consultant.

The project consultants agreed that using BIM for GBC requires multi-disciplinary knowledge (Architect, Main Contractor). "*These are hard-earned, specialized skills*" (Architect). "*It requires industry knowledge, experience, and the willingness to push boundaries and change how we approach projects historically*" (BIM Manager).

4 DISCUSSION

4.1 BIM Technology and Uses Beneficial to Green Building Certification

The project used BIM for design authoring, coordination, record modeling, and sustainability analysis to optimize the design according to the Green Star categories of Energy and IEQ, as lighting, energy, and mechanical analysis were identified on the design BEP. "Sustainable design" and "energy analysis" are one of the most common applications of BIM in design (Meng *et al*. 2020). The benefits of using BIM, identified in the literature that could enhance any construction project, not just sustainable buildings, include optimized visualization and modeling of complex architectural elements, building performance simulation, quantity take-off, clash detection, as-built rendering, warranty tracking, and reducing unforeseen variations (Ghaffarianhoseini *et al*. 2017). However, the current use of BIM for sustainability has a negative value-to-difficulty ratio, meaning it is more challenging to implement BIM for sustainability than the value gained (Ghaffarianhoseini *et al*. 2017). Nevertheless, the project demonstrated that BIM could benefit sustainable construction through the management, coordination, and calculation of precise quantities which limit waste and variations claimed. Various literature sources state that there is insufficient evidence for the benefit of BIM to sustainability. Therefore clients lack demand for it (Doan *et al*. 2019, Olawumi and Chan 2019), although they have a significant role in promoting construction innovation and BIM

(Linbald and Guerrero 2020). More prominent corporate clients, such as in this case study, recognize the value of BIM to sustainability as they are responsible for the asset.

4.2 Modelling Characteristics to Create a Useful BIM Model for GBC

The study's findings show that BIM requires far more information than the current standard, which aligns with Ansah *et al*. (2019). The level of BIM detailing on the project was not high enough quality, which confirms arguments in the literature that incomplete design information prevents BIM from being used for sustainability analysis (Olawumi and Chan 2018). Furthermore, there appears to be a gap in the literature about modeling characteristics essential to GBC. One study, for example, identified that 16 different software were used to assess 20 BREEAM criteria (Carvalho *et al*. 2020), which required significant consideration of interoperability. The project had strict BIM requirements, outlined in the Client's AIDM, which shows that defining BIM use from the outset of a project is crucial to using BIM for GBC.

Record modeling was the main priority. At the time, the technology needed to be sufficiently advanced to allow integration with DesignBuilder to enable the use of EnergyPlus, which contradicts the concept of Green BIM. This finding is consistent with the literature that there is no connection between BIM and NZ Green Star (Doan *et al*. 2019). Even though the project won awards for its BIM use, the BIM model required re-modeling in DesignBuilder due to interoperability issues. There is a need for improved interoperability between BIM software and energy simulation tools (Chong *et al*. 2017); otherwise, such incompatibilities would lead to a manual input, which can result in missing information (Ansah *et al*. 2019). DesignBuilder now offers a module to assess LEEDv4 energy credits; however, more technology still needs to be developed for NZ Green Star (Doan *et al*. 2019).

4.3 Requirements for Specialist Skills and Knowledge

The study's findings suggest that using BIM for GBC requires multi-disciplinary knowledge, such as integrating BIM, QS, sustainability, and construction. In addition, people/leadership skills, collaboration, and information management were also identified from the online job listings. Information management is now recommended for BIM as it includes facilitating the ease of visualization, maintaining data access for different parties, and maintaining backups (Chong *et al*. 2017); however, it was not mentioned in the job listings in relation to sustainability roles despite being critical to BIM. Conversely, knowledge of BIM software is an implied requirement for sustainability analysis, despite not being mentioned. Currently, the technical skills in NZ are not up to standard and have been identified as the 5th significant cause preventing Green Star uptake in New Zealand (Abdelaal and Guo 2021). However, as using BIM for GBC requires a wide range of skills than reasonably achieved by individuals, the focus should shift to multi-disciplinary collaboration (Chong *et al*. 2017), which is currently lacking in the industry (Olawumi and Chan 2019). Having a clear BIM leadership role and overcoming social and organizational difficulties is the most effective way to improve the BIM level quality within a shorter timeframe (Doan *et al*. 2019, Hoffman and Henn 2008, as cited in Abdelaal and Guo 2021). The literature asserts that a government-led approach to incentivize BIM or sustainability is needed (Lindbald and Guerrero 2020, Meng *et al*. 2020, Olawumi and Chan 2019, Yuan *et al*. 2019).

5 CONCLUSIONS

Although BIM can support GBC processes, it currently has limited use in the construction industry. Additionally, due to interoperability issues, BIM models are not used directly for energy analysis and require manual re-modeling in another software. Although there are BIM uses that are relevant and beneficial to GBC, in practice, BIM is not used directly for the GBC processes. To produce models suited to the concept of Green BIM, accurate and high-quality BIM detailing that considers downstream uses of design, construction, and operation are needed to gain value across the project cycle. Thus, it requires significant changes to project workflow and management.

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