International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 03 | March - 2023 Impact Factor: 7.185 ISSN: 2582-3930

Various Methodologies for BIM Implementation on Green Building Construction Projects: State of Art Review

Bhavika Anil Gangwani[1], Prof. A N Bhavsar[2], Dr. J. R. Pitroda[3], Sagar S. Chandre[4]

[1]2nd Year Student M.Tech (Civil) Construction Engineering & Management, BVM Engineering College, Vallabh Vidyanagar, Gujarat

bhavikagangwani1912@gmail.com

[2]Associate Professor, Construction Engineering & Management, Civil Engineering Department, BVM Engineering College, Vallabh Vidyanagar, Gujarat

anbhavsar@bvmengineering.ac.in

[3]Associate Professor, PG Coordinator Construction Engineering & Management, Civil Engineering Department, BVM Engineering College, Vallabh Vidyanagar, Gujarat

jayesh.pitroda@bvmengineering.ac.in

[4]Technical Director - MBS (Massent BIM Services), 21, High Gate, Kalyani Nagar, Pune

schandre50@gmail.com

Abstract: Green building has attracted overall consideration because of the unfavourable effect of development on the climate. The best decisions connected with the eco-friendly design of a green structure can be done during the phases of planning and designing. As of Building Information Modelling (BIM) considers multidisciplinary data to be layered inside a single model, it outlines the freedom for adopting sustainability measures from the beginning of the design phase. In this review paper, various Methodologies for BIM Implementation on Green Building Construction Projects through literature review have been explored. The explored methodologies are Case study-based, Survey based, Green Building Certificate based, Novelty Explored, Literature Review based, and Numerical calculation based. Out of these, three methodologies were reviewed, which are Case study-based, Survey based, and Green Building Certificate-based. The primary objective of the case study-based paper is to determine the ultimate goals of case studies in BIM Implementation on Green Building Construction Projects and integration of BIM applications with building performance analysis tools for sustainability analysis. Furthermore, in the survey-based paper, the information such as stakeholders who participated in the survey, main purposes of the survey, major survey questions, and methods used for the analysis carried out. Ultimately, the functions of BIM in obtaining a green building certification.

Keywords: Building information modelling (BIM), Construction, Green Building, Methodologies

1. Introduction

Green BIM methods are being adopted by more businesses as both BIM and green construction are gaining popularity. This is a new development in the architectural, engineering, and construction sector that employs BIM for the transmission of “green building” projects and aims to gain from collaborations between the two [1].

"Green buildings" are a relatively new practice in the construction sector to attain sustainability. Recently, there has been growing awareness of the importance of incorporating data innovation to advance "green building" implementation when it comes to design, construction, and operation. Stakeholders in the sector can evaluate the display of green buildings with the aid of analysis techniques. “Building information modelling (BIM)” gives designers, designers, and developers the ability to evaluate the display of green buildings at the preconstruction phase [1, 2].

Since Building information modelling (BIM) takes into account multidisciplinary data to be superimposed inside one model, it sets out the freedom to direct sustainability analyses precisely and effectively when contrasted with conventional strategies [3, 4].

However, only a small percentage of companies are currently aware of green BIM, and even fewer of those companies are able to fully utilise what BIM has to offer for environmentally friendly projects [43]. Most businesses lack experience and wait for experimental validation and hard task data before moving forward. Market reforms for “green building” and “BIM” are reliant on barriers and weaknesses, as is typically the case with innovation retention, and will necessitate further stakeholder buy-in. Businesses that object to using BIM in green building projects claim that the technology is still in development and has only a few applications. They are in the ideal position to rely on existing non-BIM solutions that they are familiar with since they regard BIM tools and models as being too sophisticated to ever consider employing [43]. Owners are hesitant to invest in BIM administrations because they want to limit cost growth and minimize hazards associated with a novel BIM work process. Industry players frequently ignore the interaction viewpoints in favour of focusing solely on the technical aspects of BIM execution. They view BIM as an innovation add-on while avoiding the efforts to adapt their company practices to accommodate the necessary social advancement and hierarchical change while implementing BIM. The alliances between BIM and green buildings have been seriously weakened by these strategies. As a result, "Green BIM" practices are typically ineffective, particularly appointed, and underdeveloped. Instead of taking into account a properly researched, flexible BIM-mix process, the outcome of a specific "Green BIM" project often rely on the extemporisation of a task group that is well-equipped [1].

2. Review Approach

This study aims to thoroughly review the various BIM implementation strategies for green building projects. The Comprehensive Literature Review (CLR) method was used in this paper to examine the corpus of information on the use of BIM in green construction projects. Three primary areas were the emphasis of the BIM implementation methodologies: case studies, surveys, and various green building certifications. CLR is regarded as a reliable procedure that seeks to reduce bias through open and thorough literature searches [6]. Additionally, Figure 1 shows the search and screening process on the relevance between "Building Information Modelling (BIM)" and "Green Building" and the chosen approaches.

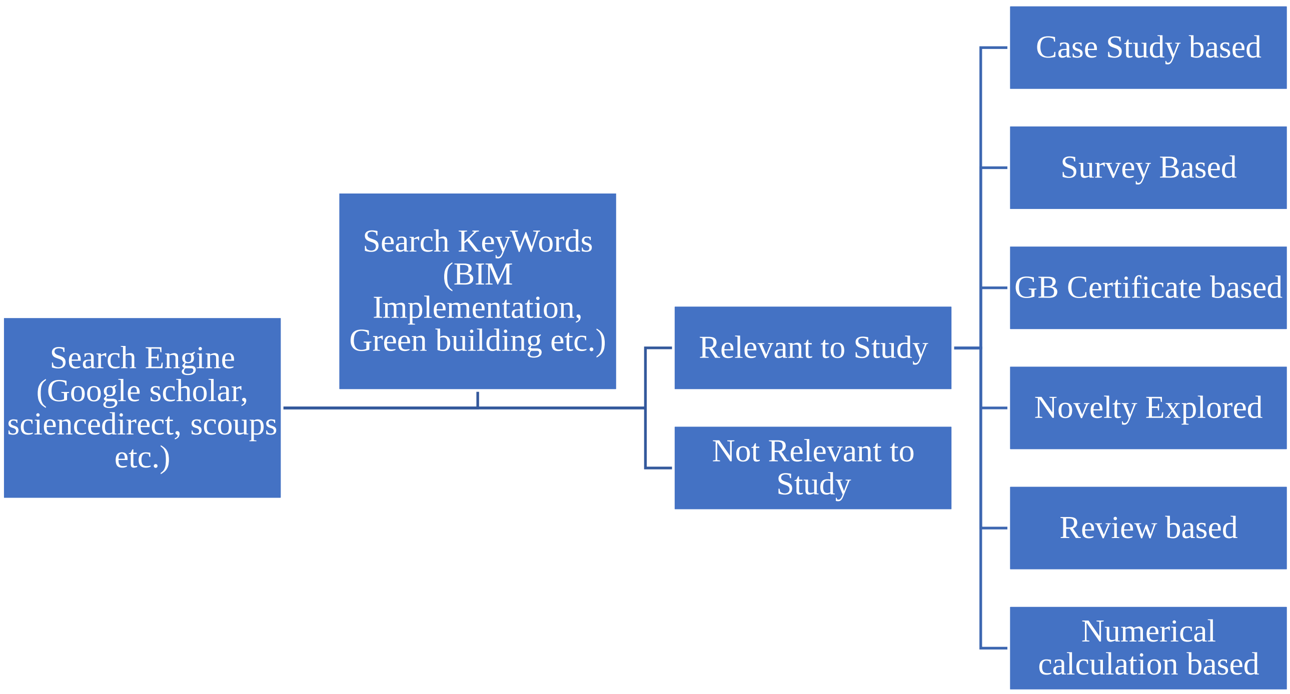

Figure 1 Process of gathering information and evaluating its relevancy to BIM and green building

2.1 Literature Review

The critical literature review in this section has been split into three sections such as case study based, survey based and BIM with Green Building Certificate which are various methodologies of Green-BIM.

2.1.1 Case study based

Energy-Efficient Structures have been planned using Building Information Modelling (BIM). Despite the limited use of BIM in the field of green structures, the research community is beginning to recognize its benefits [7]**.** Similar to the merging of various databases, representation of scientific results and organization of energy usage recreations, BIM and associated instruments provide advantages that can aid in the improvement of green buildings [3]. In light of BIM innovation, low-energy, highly effective architectural space design techniques are suggested [8].

Integrated Project Delivery, Design Optimization, Better Communication, and Coordination are the main advantages of using BIM for sustainability design [9].

Apart from this, "BIM has been actively adopted in architecture, engineering, and construction industries for 3D-rendering, drawing extraction, estimation of cost, material, clash check, to reduce construction waste, and so on [7,8]. Despite, BIM can be useful in designing high-performance buildings some suggestions such as BIM management should include documents such as Employer Information Requirements (EIR) and BIM Execution Plan (BEP), and for the most effective automatic recognition of the building elements classification system (Uniclass 2, CoClass, etc.) has to be used across the whole project [12]. Another application of BIM has been discussed which is ThermalOpt—a methodology for automated BIM-based multidisciplinary thermal simulation intended for use in multidisciplinary design optimization (MDO) environments" [13].

The lack of interoperability between BIM models and performance analysis tools is one of the barriers to the limited use of BIM in the ecological examination arena, which should be considered before in the planning stage [9].

2.1.2 Survey-based

The majority of those who participated in the study examination worked for different architecture or construction firms. Engineering firms, design-build companies, government associations, and BIM specialists followed it [14]. Their major professions were Architect, Civil Engineer, MEP Engineer, Facilities manager [15], Developer, Consultant, Contractor, and Supplier [16].

The study of BIM execution in green structure projects was undertaken in order to identify the area's slow adoption of BIM [15], improve collaboration among stakeholders [17], identify barriers in prefabricated construction [18], Applying BIM to the advancement of green structures: commitment and obstacle analysis [19], to support Sustainable Design and Construction [20], to examine the adoption of green certifications and how it relates to building information modelling (BIM) [21], and to learn about stakeholders' views on BIM and LCA for green buildings [16].

"The survey questions were as follows, General demographics of the respondents and the Company [21], current use of BIM in design and building practices, BIM challenges with frequency and Impact using 5 points Likert scale, Personal experience [14,15], the importance of sustainability in design and building practices, BIM application [20], the possible contribution of BIM to green buildings, factors that impede the application of BIM to green buildings [19]".

"Some questionnaires had skip-logic questions, so identification of exact questions can be achieved [14]. Next, for statistical analysis of ordinal data One-way ANOVA, Mann-Whitney U test, Kruskal-Walis H test [15], weighted score (WS) [20], statistical package for the social sciences (SPSS) software version 24 [16,18]for reliability test, AMOS(Analysis of Moment Structure) to test the validity [19] and for content analysis, subjective opinions were taken [15]".

The most well-known experiments were those involving energy, daylighting (using sunshine as a source of illumination), building orientation, massing, and site inspection [14].

2.1.3 BIM with Green Building Certificate

A global issue is the advancement of green building practices. Over the past several years, various concepts and methods, such as certification of green buildings (GBC) and building information modelling, have been developed to address ecological challenges (BIM). Several alternative assessment methods are being used to evaluate buildings' environmental efficiency [1].

"Currently, a plethora of grading frameworks are used to evaluate a building's environmental performance. These include, but are not limited to: Canada's LEED Canada; Australia's Green Star; Japan's Comprehensive Assessment System for Building Environmental Efficiency, Germany's DGNB Certification System, India's IGBC Rating System and LEED India, South Africa's Green Star SA, New Zealand's Green Star NZ, the United Kingdom's BREEAM, and the United States' LEED" [4]. These rating methods evaluate elements including energy usage, water conservation, Indoor Environmental Quality (IEQ), and material utilization of a building using conventional models and comparative analysis [1,3].

BIM's primary role in the Green Building certification process is to assist practitioners in obtaining the majority of sustainability criteria [22,23], Data analysis using BIM and Green Construction

Rating Standard [1], Building efficiency analysis software and a BIM-based design model interoperability Simplify the creation of sustainable designs to create digital models for assessing the environmental consequences (EC) of newly constructed structures [24], Influence cloud-BIM to accomplish LEED Robotization [25], Allows project stakeholders to capture total plan and undertaking data, and to use the available plan information for practical program and sustainability rating examination [23], BIM facilitates model change and propagation via parametric object-oriented representation [26], assists designers in evaluating different plan options at the start of development of a structure's existence so that compelling energy methodologies are achieved within sustainable construction constraints [27], permit proprietors, designers and project workers to pick the thing on the spot from a 4-D portrayal [28].

In these papers, methodologies are presented for integrating BIM and LCA tools [24], cloud-deployed BIM servers (virtualized) technology and a novel business paradigm [25], ecological strategies for construction projects at their inception of the project by integrating Autodesk, energy and daylighting interpretation, LEED and value predicting instruments [27], "fostering an integrated green BIM process map (IGBPM) using business process model and notation (BPMN)" [29], BIM-BEAM Plus appraisal framework [23], and development of general framework [26].

The benefits of this type of research for the sector include time savings, quick computations, and professional generated reports [23]. Additionally, the development of BIM based on a cloud-computing infrastructure directly impacts the IT planning and strategy of AEC firms [24,25], assists proprietors and planners with assessing different plan options thinking about the sustainability requirements proficiently and conveniently [27], coordinated enhancement tool takes into consideration steady data with the goal that participants on a project can settle on the most ideal choices connected with LEED rating, cost, and plan [28].

2.3 Findings

Below are the major findings of the Green-BIM related methodologies such as case study based, survey based and BIM with Green Building Certificate.

2.3.1 Case study based

The distribution of information required for better design and building performance is found to be best served by BIM. BIM applications and software for building performance studies have been integrated for sustainability study, as shown in figure 2 [14].

"The two most significant benefits of BIM for sustainable building design are integrated project delivery (IPD) and design optimization. However, there are also barriers to adopting BIM for sustainable design" [9].The Ultimate goals of case studies in BIM Implementation on Green Building Construction Projects have been dictated in Figure 3.

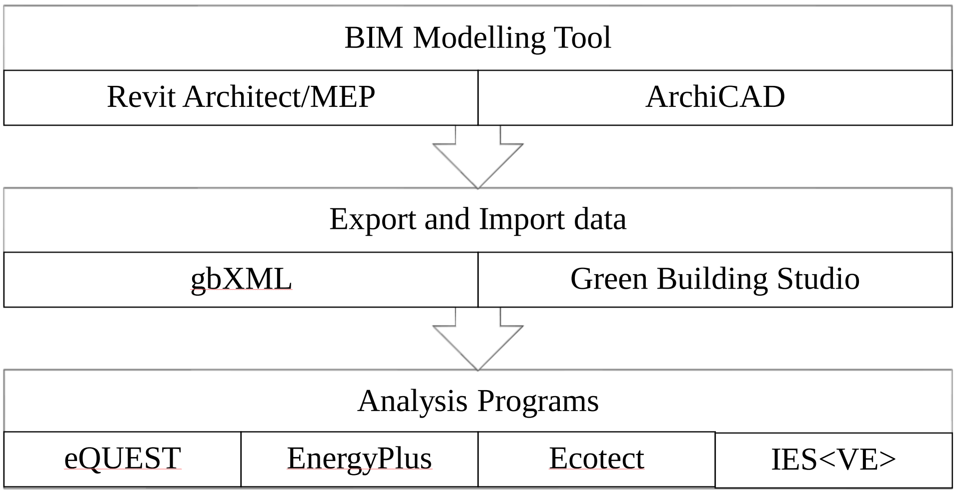

Figure 2 Integration of building performance analysers and BIM tools for sustainability analysis [6,13]

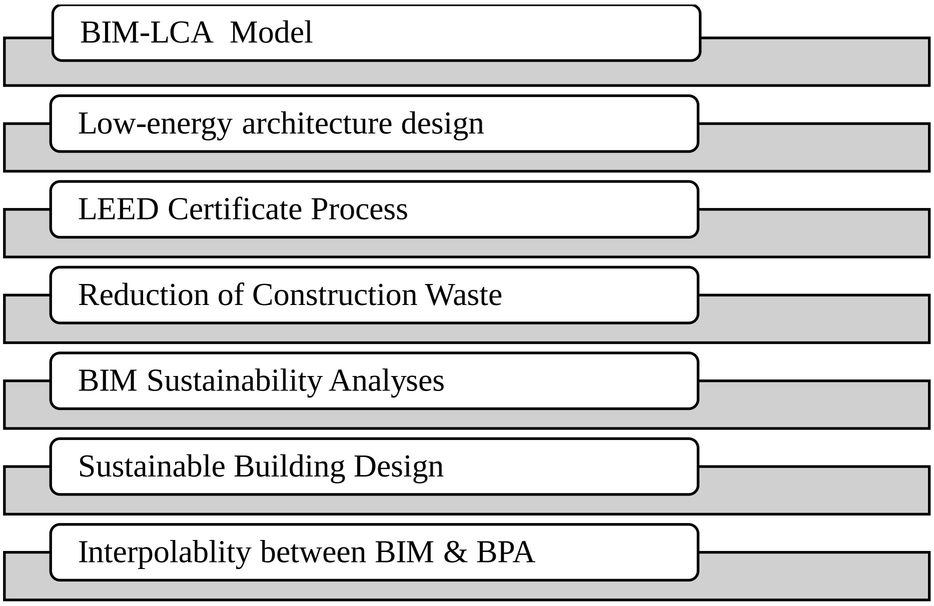

Figure 3 Ultimate Goals of case studies in BIM Implementation on Green Building Construction Projects

2.3.2 Survey-based

The stakeholders who participated, the main purposes of the survey, the major survey questions, and the methods used for analysis have been summarized below in figure 4.

Stakeholder	• Architect, Engineer, BIM Consultant
Purpose of survey	• In order to comprehend how experts view BIM • To assess the state of BIM-based sustainability analyses currently and their advantages
Major Survey Questions	• "Demographic data; Present BIM being used in design and construction practices; Significance of sustainable development in design and building practices; and BIM process to ensure the sustainable design and building practices" [21]
Survey Method used	• Elimination of group prejudice using the skip-logic technique • SPSS software version 24 for reliability test, AMOS to test the validity

Figure 4 Summary of survey-based literature review

2.3.3 BIM with Green Building Certificate

The main functions of BIM in practice of obtaining green rating certification are shown in figure 5.

Role of BIM	Data analysis using BIM and the Green Building Rating System
	Design digital models
	Influence cloud-BIM to accomplish LEED Robotization
	Helps project stakeholders to catch total plan and undertaking data, and to utilize the accessible plan information for practical plan and sustainability rating examination
	BIM facilitates model change and propagation via parametric object oriented representation
	Permit proprietors, designers and project workers to pick the thing on the spot from a 4-D portrayal
	Assists designers in evaluating various plan alternatives during the start of development of a structure's life so that persuasive power approaches are reached within the limitations of green building
	The ability of a BIM-based architectural model to communicate with building performance analysis software

Figure 5 Key Functions of BIM in the Construction of Green Buildings

The Following Table 1 shows the summary of research papers for green-BIM related methodologies.

Table1 Summary of research papers for green-BIM related methodologies

Sr. No.	**Author and Year**	**Ref. No.**	**Green-BIM Related Methodologies**					
			CB	SB	GBC	RB	NE	NCB
1	Abdelaal and Guo et.al. (2022)	[16]		*				
2	Ansah et. al. (2019)	[30]				*		
3	Azhar et. al. (2011)	[4]	*		*			
4	Azhar and Brown et.al. (2009)	[14]	*	*	*			
5	Azhar, Brown, and Sattineni et. al. (2010)	[5]	*					
6	Baldwin et al. (2008)	[11]	*					
7	Bank et. al. (2010)	[31]					*	
8	Bynum, Issa, and Olbina et. al. (2013)	[20]		*				
9	Cao, Kamaruzzaman, and Aziz et. al. (2022)	[32]				*		
10	Chang and Hsieh et. al. (2020)	[33]				*		
11	Doan et al. (2019)	[21]		*	*			
12	Ferme, Zuo, and Rameezdeen et. al. (2018)	[17]	*	*		*		
13	Guo et. al. (2021)	[3]	*				*	
14	Jalaei and Jrade et. al. (2014)	[24]			*	*		
15	Lim et. al. (2021)	[34]				*		
16	Mohanta and Das et. al. (2022)	[15]		*		*		
17	Moon et. al. (2011)	[7]	*					
18	Motawa and Carter et. al. (2013)	[35]					*	
19	Reychav, Maskil Leitan, and McHaney et. al. (2017)	[36]				*		
20	Russell-Smith and Lepech et. al. (2012)	[10]	*				*	
21	Schlueter and Thesseling et. al. (2009)	[37]						*
22	Solla, Ismail, and Yunus et. al. (2016)	[2]	*		*			
23	Thomé, Scavarda, and Scavarda et. al. (2016)	[6]				*		

24	Veselka et. al. (2020)	[12]	*		*			
25	Volk, Stengel, and Schultmann et. al. (2014)	[38]				*		
26	Welle, Haymaker, and Rogers et. al. (2011)	[13]	*					
27	J. K. W. Wong and Kuan et. al. (2014)	[23]	*		*			
28	J. K. W. Wong and Zhou et. al. (2015)	[39]				*		
29	GhaffarianHoseini et. al. (2017)	[22]			*	*	*	
30	K. din Wong and Fan et. al. (2013)	[9]	*	*		*		
31	I. C. Wu and Chang et. al. (2013)	[40]						*
32	W. Wu and Issa et. al. (2012)	[25]			*		*	
33	W. Wu and Issa et. al. (2015)	[29]	*		*	*	*	
34	W. Wu and Issa et. al. (2013)	[1]	*		*			
35	Xu et. al. (2023)	[18]		*				
36	Yoon, Park, and Choi et. al. (2009)	[8]	*					
37	Yuan and Yuan et. al. (2011)	[41]					*	
38	Zhao et. al. (2019)	[42]				*		
39	Huang et. al. (2021)	[19]		*				
40	Biswas, Wang, and Krishnamurti et. al. (2008)	[26]			*			
41	Jrade et. al. (2014)	[27]	*		*			
42	Barnes and Castro-Lacouture et. al. (2009)	[28]			*			

Where, CB – Case study Based; SB – Survey Based; GBC – Green Building Certificate Based; RB – Review Based; NE – Novelty Explored; NCB – Numerical Calculation Based

3. Conclusions and future scopes

A few construction companies have used BIM in Architecture, Engineering, and Construction (AEC) to guarantee the long-term effectiveness of structures. A sustainability assessment is done for architectural design taking into account the common cycle and database design arrangement. To aid in the evaluation of sustainability, BIM technology can be used to extract information from sophisticated engineering models. This paper examines the research on established BIM implementation strategies for green construction projects. The key findings are outlined in the following manner:

(1) BIM has been found to be the most effective way to provide the details needed to improve building performance and design. For the sustainability analysis, BIM applications and building performance analyses are integrated using the following software process: first, BIM Modelling Tool using Revit

Architect/MEP and ArchiCAD, then Data Export and Import using gbXML and Green Building Studio (GBS), and finally Analysis utilizing Programs eQUEST, EnergyPlus, Ecotect, and IES<VE>. For future scope, persistent inventive work efforts, such as the development of BIM principles to support interoperability, are expected to help with improving current methods and developing new applications.

(2) Architect, Civil Engineer, MEP Engineer, Facilities Manager, Developer, Consultant, Contractor, and Supplier were the top professions for survey analysis. Its primary goals are to comprehend how professionals view BIM and to assess the advantages of BIM-based sustainability analyses in their existing condition. The key inquiries were: demographic data; present BIM being used in design and construction practices; significance of sustainable development in design and building practices; and BIM process to ensure the sustainable design and building practices. The data were examined using SPSS software version 24 for reliability testing and Analysis of Moment Structures (AMOS) for validity testing. Future research should look at the owner/operator sector of the construction field and determine the overall influence of BIM application on environmentally friendly design and construction.

(3) Designing digital models, connecting BIM with the Green Building Grading System for data analysis, and enabling owners, designers, and project workers to choose an item immediately from a 4-D representation are the three main functions of BIM in process of green structure certification. The objectives were accomplished by combining BIM, energy and daylighting examination, LEED and value estimating instruments, technology for BIM servers put in the cloud, also framework for evaluating BIM-Green Building grading systems. Future examination on this point ought to more search top to bottom at the subtleties of the proposed general framework.

For further future work, other methodologies for BIM Implementation on Green Building Construction Projects can be recognized and reviewed in detail.

References:

[1] W. Wu and R. Issa, "Integrated Process Mapping for BIM Implemenation in Green Building Project Delivery," *Proc. 13th Int. Conf. Constr. Appl. Virtual Real.*, no. October, pp. 30–31, 2013.

[2] M. Solla, L. H. Ismail, and R. Yunus, "Investigation on the potential of integrating BIM into green building assessment tools," *ARPN J. Eng. Appl. Sci.*, vol. 11, no. 4, pp. 2412–2418, 2016.

[3] K. Guo, Q. Li, L. Zhang, and X. Wu, "BIM-based green building evaluation and optimization: A case study," *J. Clean. Prod.*, vol. 320, no. August, p. 128824, 2021, doi: 10.1016/j.jclepro.2021.128824.

[4] S. Azhar, W. A. Carlton, D. Olsen, and I. Ahmad, "Building information modeling for sustainable design and LEED ® rating analysis," *Autom. Constr.*, vol. 20, no. 2, pp. 217–224, 2011, doi: 10.1016/j.autcon.2010.09.019.

[5] S. Azhar, J. W. Brown, and A. Sattineni, "A case study of building performance analyses using building information modeling," *2010 - 27th Int. Symp. Autom. Robot. Constr. ISARC 2010*, no. Isarc, pp. 213–222, 2010, doi: 10.22260/isarc2010/0023.

[6] A. M. T. Thomé, L. F. Scavarda, and A. J. Scavarda, "Conducting systematic literature review in operations management," *Prod. Plan. Control*, vol. 27, no. 5, pp. 408–420, 2016, doi: 10.1080/09537287.2015.1129464.

[7] H. J. Moon, M. S. Choi, S. K. Kim, and S. H. Ryu, "Case studies for the evaluation of interoperability between a BIM based architectural model and building performance analysis programs," *Proc. Build. Simul. 2011 12th Conf. Int. Build. Perform. Simul. Assoc.*, pp. 1521–1526, 2011.

[8] S. H. Yoon, N. H. Park, and J. W. Choi, "A BIM-based design method for energy-efficient building," *NCM 2009 - 5th Int. Jt. Conf. INC, IMS, IDC*, pp. 376–381, 2009, doi: 10.1109/NCM.2009.406.

[9] K. din Wong and Q. Fan, "Building information modelling (BIM) for sustainable building design," *Facilities*, vol. 31, no. 3, pp. 138–157, 2013, doi: 10.1108/02632771311299412.

[10] S. Russell-Smith and M. Lepech, "Activity-Based Methodology for Life Cycle Assessment of Building Construction," *CIBSE ASHRAE Tech. Symp. Imp. Coll. London UK*, no. April, pp. 1–13, 2012.

[11] A. N. Baldwin, L. Y. Shen, C. S. Poon, S. A. Austin, and I. Wong, "Modelling design information to evaluate pre-fabricated and pre-cast design solutions for reducing construction waste in high rise residential buildings," *Autom. Constr.*, vol. 17, no. 3, pp. 333–341, 2008, doi: 10.1016/j.autcon.2007.05.013.

[12] J. Veselka *et al.*, "Recommendations for developing a BIM for the purpose of LCA in green building certifications," *Sustain.*, vol. 12, no. 15, 2020, doi: 10.3390/su12156151.

[13] B. Welle, J. Haymaker, and Z. Rogers, "ThermalOpt: A methodology for automated BIM-based multidisciplinary thermal simulation for use in optimization environments," *Build. Simul.*, vol. 4, no. 4, pp. 293–313, 2011, doi: 10.1007/s12273-011-0052-5.

[14] S. Azhar and J. Brown, "Bim for sustainability analyses," *Int. J. Constr. Educ. Res.*, vol. 5, no. 4, pp. 276–292, 2009, doi: 10.1080/15578770903355657.

[15] A. Mohanta and S. Das, "Causal Analysis of Slow BIM Adoption in Eastern India with a Special Focus on Green Building Sector," *J. Inst. Eng. Ser. A*, vol. 103, no. 1, pp. 319–337, 2022, doi: 10.1007/s40030-021-00561-w.

[16] F. Abdelaal and B. H. W. Guo, "Stakeholders' perspectives on BIM and LCA for green buildings," *J. Build. Eng.*, vol. 48, no. December 2021, p. 103931, 2022, doi: 10.1016/j.jobe.2021.103931.

[17] L. Ferme, J. Zuo, and R. Rameezdeen, "Improving Collaboration among Stakeholders in Green Building Projects: Role of Early Contractor Involvement," *J. Leg. Aff. Disput. Resolut. Eng. Constr.*, vol. 10, no. 4, p. 04518020, 2018, doi: 10.1061/(asce)la.1943-4170.0000278.

[18] H. Xu, R. Chang, N. Dong, J. Zuo, and R. J. Webber, "Interaction mechanism of BIM application barriers in prefabricated construction and driving strategies from stakeholders' perspectives," *Ain Shams Eng. J.*, vol. 14, no. 1, p. 101821, 2023, doi: 10.1016/j.asej.2022.101821.

[19] B. Huang *et al.*, "Contribution and obstacle analysis of applying BIM in promoting green buildings," *J. Clean. Prod.*, vol. 278, p. 123946, 2021, doi: 10.1016/j.jclepro.2020.123946.

[20] P. Bynum, R. R. A. Issa, and S. Olbina, "Building Information Modeling in Support of Sustainable Design and Construction," *J. Constr. Eng. Manag.*, vol. 139, no. 1, pp. 24–34, 2013, doi: 10.1061/(asce)co.1943-7862.0000560.

[21] D. T. Doan, A. Ghaffarianhoseini, N. Naismith, A. Ghaffarianhoseini, T. Zhang, and J. Tookey, "Examining Green Star certification uptake and its relationship with Building Information Modelling (BIM) adoption in New Zealand," *J. Environ. Manage.*, vol. 250, no. August, 2019, doi: 10.1016/j.jenvman.2019.109508.

[22] A. GhaffarianHoseini, D. T. Doan, N. Naismith, J. Tookey, and A. GhaffarianHoseini, "Amplifying the practicality of contemporary building information modelling (BIM) implementations for New Zealand green building certification (Green Star)," *Eng. Constr. Archit. Manag.*, vol. 24, no. 4, pp. 696–714, 2017, doi: 10.1108/ECAM-02-2016-0043.

[23] J. K. W. Wong and K. L. Kuan, "Implementing 'BEAM Plus' for BIM-based sustainability analysis," *Autom. Constr.*, vol. 44, pp. 163–175, 2014, doi: 10.1016/j.autcon.2014.04.003.

[24] F. Jalaei and A. Jrade, "Integrating Building Information Modeling (BIM) and energy analysis tools with green building certification system to conceptually design sustainable buildings," *J. Inf. Technol. Constr.*, vol. 19, no. 2010, pp. 494–519, 2014, doi: 10.1007/s12273-013-0120-0.

[25] W. Wu and R. R. A. Issa, "Leveraging cloud-BIM for LEED Automation," *Electron. J. Inf. Technol. Constr.*, vol. 17, no. April, pp. 367–384, 2012.

[26] T. Biswas, T. H. Wang, and R. Krishnamurti, "Integrating sustainable building rating systems with building information models," *CAADRIA 2008 - Assoc. Comput. Archit. Des. Res. Asia Beyond Comput. Des.*, pp. 193–200, 2008, doi: 10.52842/conf.caadria.2008.193.

[27] F. J. and A. Jrade, "Integrating BIM with Green Building Certification System, Energy Analysis and Cost Estimating Tools to Conceptually Design Sustainable Buildings," *Constr. Res. Congr. 2014 ©ASCE 2014*, vol. 44, no. 8, pp. 140–149, 2014, doi: 10.1088/1751-8113/44/8/085201.

[28] S. Barnes and D. Castro-Lacouture, "BIM-enabled integrated optimization tool for leed decisions," *Proc. 2009 ASCE Int. Work. Comput. Civ. Eng.*, vol. 346, no. 404, pp. 258–268, 2009, doi: 10.1061/41052(346)26.

[29] W. Wu and R. R. A. Issa, "BIM Execution Planning in Green Building Projects: LEED as a Use Case," *J. Manag. Eng.*, vol. 31, no. 1, pp. 1–18, 2015, doi: 10.1061/(asce)me.1943-5479.0000314.

[30] M. K. Ansah, X. Chen, H. Yang, L. Lu, and P. T. I. Lam, "A review and outlook for integrated BIM application in green building assessment," *Sustain. Cities Soc.*, vol. 48, p. 101576, 2019, doi: 10.1016/j.scs.2019.101576.

[31] L. C. Bank, M. McCarthy, B. P. Thompson, and C. C. Menassa, "Integrating Bim With System Dynamics As a Decision-Making Framework for Sustainable Building Design and Operation," *Proc. First Int. Conf. Sustain. Urban. (Icsu 2010)*, no. June, pp. 15–23, 2010.

[32] Y. Cao, S. N. Kamaruzzaman, and N. M. Aziz, "Green Building Construction: A Systematic Review of BIM Utilization," *Buildings*, vol. 12, no. 8, 2022, doi: 10.3390/buildings12081205.

[33] Y. T. Chang and S. H. Hsieh, "A review of building information modeling research for green building design through building performance analysis," *J. Inf. Technol. Constr.*, vol. 25, pp. 1–40, 2020, doi: 10.36680/j.itcon.2020.001.

[34] Y. W. Lim *et al.*, "Review of BIM for existing building sustainability performance and green

retrofit," *Int. J. Sustain. Build. Technol. Urban Dev.*, vol. 12, no. 2, pp. 110–125, 2021, doi: 10.22712/susb.20210010.

[35] I. Motawa and K. Carter, "Sustainable BIM-based Evaluation of Buildings," *Procedia - Soc. Behav. Sci.*, vol. 74, pp. 419–428, 2013, doi: 10.1016/j.sbspro.2013.03.015.

[36] I. Reychav, R. Maskil Leitan, and R. McHaney, "Sociocultural sustainability in green building information modeling," *Clean Technol. Environ. Policy*, vol. 19, no. 9, pp. 2245–2254, 2017, doi: 10.1007/s10098-017-1409-y.

[37] A. Schlueter and F. Thesseling, "Building information model based energy/exergy performance assessment in early design stages," *Autom. Constr.*, vol. 18, no. 2, pp. 153–163, 2009, doi: 10.1016/j.autcon.2008.07.003.

[38] R. Volk, J. Stengel, and F. Schultmann, "Building Information Modeling (BIM) for existing buildings - Literature review and future needs," *Autom. Constr.*, vol. 38, pp. 109–127, 2014, doi: 10.1016/j.autcon.2013.10.023.

[39] J. K. W. Wong and J. Zhou, "Enhancing environmental sustainability over building life cycles through green BIM: A review," *Autom. Constr.*, vol. 57, pp. 156–165, 2015, doi: 10.1016/j.autcon.2015.06.003.

[40] I. C. Wu and S. Chang, "Visual Req calculation tool for green building evaluation in Taiwan," *Autom. Constr.*, vol. 35, pp. 608–617, 2013, doi: 10.1016/j.autcon.2013.01.006.

[41] Y. Yuan and J. Yuan, "The theory and framework of integration design of building consumption efficiency based on BIM," *Procedia Eng.*, vol. 15, pp. 5323–5327, 2011, doi: 10.1016/j.proeng.2011.08.987.

[42] X. Zhao, J. Zuo, G. Wu, and C. Huang, "A bibliometric review of green building research 2000–2016," *Archit. Sci. Rev.*, vol. 62, no. 1, pp. 74–88, 2019, doi: 10.1080/00038628.2018.1485548.

[43] McGraw-Hill Construction. (2010). Green BIM: How Building Information Modeling is Contributing to Green Design and Construction, McGraw-Hill Construction, Bedford, MA.