Journal of Advances and Scholarly Researches in Allied Education
Vol. 20, Issue No. 4, October-2023, ISSN 2230-7540

Review on Application of BIM in Architecture, Engineering and Construction

Sarbajit Ghosh[1]*, Dr. Arun Kumar Aggarwal[2]

[1] Research Scholar, Uttaranchal University of Technology

[2] Research Guide, Uttaranchal University of Technology

Abstract - Building Information Modeling (BIM) has emerged as a transformative paradigm in the field of architecture, engineering, and construction (AEC). This review paper provides a comprehensive analysis of the evolution, applications, benefits, challenges, and future prospects of BIM. The paper begins by tracing the historical development of BIM from its origins as a digital drafting tool to its current status as a collaborative and data-driven process for designing, constructing, and managing built environments.

Keywords - Tunnel, Structure, Review

----------X----------

1. INTRODUCTION

BIM technology utilises various support techniques, including construction simulation and information statistics, to ensure that the management of different processes is accurately depicted in visual content and that control management is enhanced. The representation of content management in the visual should be ensured in order to accomplish this. The utilization of BIM technology in quality management has the potential to encompass both the management of quality throughout the process and the quality of the final product. This serves as an additional component to the product. The utilization of Building Information Modelling (BIM) technology enables real-time monitoring of the building process. Furthermore, the utilization of this technology module enables the creation of managers who can effectively identify their respective equipment and gather relevant information for the initial assessment. Additionally, these managers can also conduct comparisons between various goods and construction sites. The field of technology holds considerable untapped potential for enhancing the quality assurance of buildings. The utilisation of models enabled the enhancement of change communication by facilitating the retention of larger amounts of data. Even when physically present at the site, it was feasible to obtain a more accurate and timely understanding of the upcoming modifications. Building Information Modelling (BIM) enhances productivity and offers users a multitude of supplementary benefits. The primary advantage of Building Information Modelling (BIM) lies in its ability to significantly reduce the need for reprocessing tasks, such as data reentry into models or making revisions at the project site.

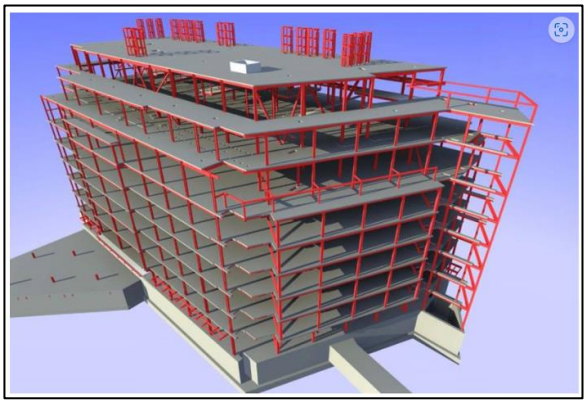

Figure 1: ***Building Information Modeling in Structural Engineering [1]***

2. LITERATURE REVIEW

Zhang et al. [2] Following an extensive investigation into sustainable practises, it has been suggested that the implementation of a Building Information Modelling (BIM)-based assessment tool would be beneficial for evaluating sustainability. The development of this instrument was a direct outcome of the researchers' inquiry into sustainable practices. It has the potential to be employed by various stakeholders who are interested in implementing sustainability measures within construction processes. The utilization of Building Information Modelling (BIM) platforms has demonstrated significant efficacy in facilitating the analysis of sustainability-related data and real-time energy consumption. This information is utilized to make choices and seek “solutions to issues that may develop throughout the construction and operation phases” [3]

Ajayi et al. [4] developed a "BIM-enhanced life cycle assessment" technique in order to better understand the impact that different kinds of materials and the features they possess have on the performance of a project across its entire lifespan. In order to make the assessment more sustainable, the life-cycle of energy consumption was broken down into four significant phases before it was put through the evaluation process. These stages were target formulation, inventory analysis, impact evaluation, and interpretation. After then, these stages were incorporated into the framework that was already there. BIM is an acronym for building information modelling, which is a technique that creates a mechanism for collaboratively documenting the links between important construction process components. In order to achieve the intended results of sustainability and energy efficiency, it is necessary to adopt these practises throughout both the building and operating stages.

Taha et al. [5] conducted an investigation on the impacts that might result from installing renewable energy technologies in Iraqi educational facilities. According to the findings of the research, doing an extra energy and daylight performance analysis, with the assistance of BIM-based energy simulations, may further increase the energy efficiency of buildings that have been obtained by combining solar panels with artificial lighting. This can be accomplished by using energy simulations.

Di Bari et al. [6–8] This study aims to explore various strategies that can enhance building performance, reduce operational and maintenance expenses, and minimise the adverse environmental impact. The utilisation of the BIM-integrated life cycle assessment (LCA) method has been identified as a viable approach to effectively achieve this objective.

Verichev et al. [9] and Kaoula and Bouchair [10], sought to improve the performance of the structures by choosing the best possible building materials based on a climate sensitivity study. This was done in an effort to increase the structural integrity. In order to carry out a full energy assessment, it is vital to have a solid understanding of the many kinds of BIM tools that are now on the market, as well as to take into consideration how compatible these tools are with one another and how this compatibility may increase the chosen tools' overall effectiveness. The selection of the proper BIM tool is an essential stage [11] in the process of guaranteeing that the results will be accurate and that the data will be reliable.

According to Zhang et al. [12], the majority of Building Information Modelling (BIM) software tools are not being fully utilized, resulting in decreased accuracy in building energy estimates. In the context of employing Building Information Modelling (BIM) tools, proactive consideration of both the construction and operational phases emerges as a paramount approach for optimizing energy efficiency and overall sustainability. In order to facilitate the development of an environmental equilibrium, it is imperative for BIM models to incorporate meticulously analyzed data and consider various influencing factors [12,13].

Spiridigliozzi et al. [14] proposed multiple approaches to address this issue. The process entails integrating parametric models within an architectural software tool, such as Autodesk Revit, and leveraging the "Dynamo-visual programming plug-in as a coding platform" [15-17]. The utilization of the BIM Revit tool facilitates the process of converting an IFC file into a computer system, such as EQUA IDA-ICE, for the purpose of temperature evaluation.

Liu et al. [18] a significant majority of construction firms in the United States incorporate Building Information Modelling (BIM) tools into their project workflows. According to the data presented in Figure 3, it is evident that Building Information Modelling (BIM) tools are extensively employed in urban planning initiatives within affluent nations, primarily with the objective of enhancing energy efficiency. However, the utilization of BIM tools in developing countries appears to be comparatively limited. Currently, there is only one developing nation, namely China, that employs "Building Information Modelling (BIM)" in the context of urban planning initiatives. Moreover, it is frequently employed to assess energy consumption in commercial endeavors, albeit sporadically in residential undertakings.

Theresa et. al. [19] The potential for reducing energy consumption can potentially be realized through the integration of building information modelling (BIM) with considerations pertaining to climate, environment, and other energy-related variables. The incorporation of energy consumption from systems and services, along with the interaction between the building facade and its surroundings, in a dynamic simulation of a building yielded more precise and dependable information regarding energy consumption compared to a simulation solely focused on the energy consumption of building services.

Liao and Teo [20] the adoption of "Building Information Modelling (BIM)" represents a significant organizational change. They suggest that it is imperative for the management team to establish the appropriate framework and direction for this change. This approach would facilitate the project in transcending its competitive mindset and fostering a collaborative work environment based on trust. Once a suitable formal structure and a collaborative approach based on trust have been established, resistance to change will diminish.

Ahankoob et al. [21] Increased experience with Building Information Modelling (BIM) enhances individuals' understanding of the potential advantages associated with BIM implementation.

This heightened awareness subsequently increases the likelihood of realising these potential benefits. Moreover, a greater level of BIM experience also increases the probability of organisations utilising BIM in complex construction projects.

According to Elijah et al. [22] enhancing professional skills can be achieved through several strategies. These include incorporating Building Information Modelling (BIM) training into the organization's educational programme, employing a dedicated BIM specialist to provide training to employees, organizing frequent workshops, participating in conferences related to BIM, and facilitating on-the-job training or project-based learning opportunities.

Ferreira et. al. [23] Despite the limited research on the potential of technology in promoting social sustainability, regulatory measures are compelling companies to address these issues. The majority of the research conducted in this review was conducted post-2014, indicating a potential impact of the rule. It can be stated that the current phase of Building Information Modelling (BIM) development is characterized by a growing influence of customers on the technology's evolution. This assertion is supported by the fact that a significant majority (70%) of BIM research originates from regions outside of Europe.

Wen et al. [24] There are indications that the BIM system was developed without considering the individual user, potentially leading to challenges in achieving efficient operations and desired outcomes. This study represents the initial investigation into the utilization of “Building Information Modelling (BIM)” from the perspective of a Human-Technology Operator (HTO). The significance of the human sector in ensuring the effective functioning of “Building Information Modelling (BIM)” is a common perception. Therefore, this review primarily concentrates on the interaction between users and the technological and structural aspects of BIM. The findings of the study provide valuable insights into the impact of group support and leadership on the utilization and acceptance of Building Information Modelling (BIM).

Ding et al. [25] In order to successfully operate in the construction industry, it is imperative that either the public sector mandates the adoption of Building Information Modelling (BIM) or takes the lead in initiating the first BIM initiatives. Construction businesses frequently submit formal requests to the governments of economically disadvantaged countries, seeking financial assistance, professional guidance, and advisory support [26]. The utilization of Building Information Modelling (BIM) is suggested by the author as a recommended tool for governments in impoverished nations to adopt. This adoption aims to promote increased utilization of government services among the populace. In contrast to the extensive research conducted on ICT for development, there is a limited body of literature exploring the underlying obstacles to the adoption of building information modelling (BIM) in impoverished countries. The existing operational practices may be perceived as a potential barrier that must be addressed prior to the successful implementation of BIM.

Berglund et al. [27] In accordance with the HTO concept, Building Information Modelling (BIM) may be seen as a work system (see Figure 2). The human, technological, and social components of work, as well as how they interact with one another, are what the work system is constructed on. Work action refers to the process of carrying out a job that has previously been organised. On the other hand, actual performance and outcomes don't always line up with the essential duties and the results that are anticipated. Actions taking place in real time provide insight into the efficiency of the system.

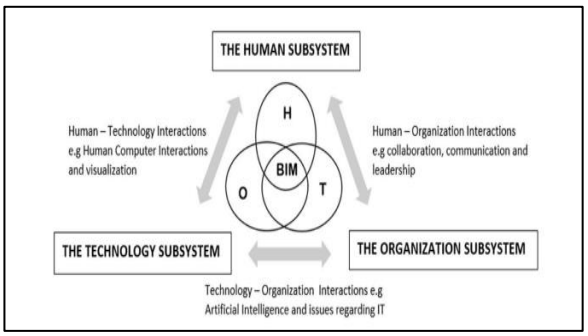

Figure 2: Redrawing of the HTO conceptual model , with BIM inserted as a work activity [27]

Abdi et. al. [28] In comparison to the years before, the last few years in Indonesia have seen a significant increase in the number of construction projects. Building projects need to be managed effectively by construction managers if they are to be completed on schedule and within their allotted budgets. The use of building information modelling, often known as BIM, may make the construction process go more swiftly. However, it is not yet quite apparent how the BIM will be implemented in Indonesia. In the course of this paper, we are going to investigate the use of BIM in Indonesia by doing a literature review. This page contains articles originating from Indonesia that make use of BIM. To begin, the search was confined to English publications that had been published in reputable journals or presented at respected conferences. Even though the search didn't bring up any results, it was expanded to include papers authored in Indonesian and published in journals and at conferences. This was done despite the fact that the search didn't turn up any results. According to the total number of studies, the findings demonstrated that BIM research in Indonesia is still insufficient. In addition, the BIM study research was carried out in a region with a relatively low population density. According to the findings of the research, Building Information Modelling (BIM) may make projects more efficient; nevertheless, its implementation has been hampered by factors such as high initial investment costs, a dearth of human resources, an absence of demand, and a reluctance to adopting new technology. The purpose of the research is to

determine how well BIM is being used in Indonesia at the moment. In the not-too-distant future, it will be essential to conduct a comprehensive research on the use of BIM in Indonesia.

Iyakoregha, et al. [29] developed new abilities that would result in a shift in the manner in which constructing chores are carried out. A significant quantity of information pertaining to building and construction was contributed to the BIM platform by using the BIM 6D tool. The BIM 6D model is updated to include the information provided by the building management system on how to operate and maintain the building. Additionally, the user is able to contribute important information and knowledge to the building in a manner that is both understandable and uncomplicated when the BIM is linked with an RFID facility sticker chip.

Lin, et al. [30] proposed to establish a Final "As-built BIM Model Management (FABMM)" system-enabled BIM model so that homeowners could use it to examine, update, and approve the project before it was sold. This was done so that the model could be used before the project was sold. The green building analysis system examines various components of a building, including energy consumption, indoor natural ventilation, sound environment, internal and external flow simulation, lighting analysis, crowd flow analysis, and alternative connected building performance analysis. These aspects are evaluated based on owner and government requirements. BIM, for instance, was developed to assist subject-area plans that enable direct inspection of the amount of energy that they use. In order to determine a building's overall energy efficiency, the Building Information Modelling (BIM) tool is combined with specialised software for building system analysis. Both the property requirements and the design guidelines need this to be done.

Ashok kumar and Varghese [31] implemented construction waste management (CWM) as a strategy to mitigate the generation of waste during the construction process. This approach was integrated into their project information modelling (BIM) deployment. The reduction of reinforced waste can be achieved through various research efforts, such as investigating the numerical correlations between steel components in structures. Additionally, the implementation of building information modelling (BIM) and radio frequency identification (RFID) technology can enhance the management of construction waste. Furthermore, the restoration of usable materials at the development site can contribute to waste reduction. The implementation of the building alteration order within the context of the investment objective will not contribute to the enhancement of your expertise, understanding, or proficiency in project cost management. The construction sector endeavours to achieve meticulousness in project planning and effectiveness in project implementation across all stages of the construction process. The BIM 5D model may encompass various elements, including quantitative information, financial considerations, and strategic approaches pertaining to potential modifications that may be deemed necessary due to feasibility constraints.

Qolomany et al. [32] An investigation was conducted to determine the potential use of machine learning in enhancing the functionality of smart buildings. Although research has been conducted on intelligent buildings leveraging IT, there is a lack of comprehensive information regarding the benefits of building information modelling (BIM).

Yin et al. [33] The utilization of Building Information Modelling (BIM), a parametric design method, enables the digital representation of construction projects. Additionally, it functions as a central point for facilitating communication, enabling project team members to collaborate with various stakeholders. The utilization of building information modelling (BIM) as an information design technique facilitates the creation of structures that are not only safe and aesthetically pleasing, but also environmentally sustainable and economically efficient. Building Information Modelling (BIM) achieves this objective by systematically gathering all pertinent data pertaining to a given project. This study examines the concept of "Building Information Modelling (BIM) within the framework of a smart building environment, emphasising the integration of building information throughout the entire project life cycle"[33].

Jalaei and Jrade [34] The integration of the Canadian green building certification system (LEED) and the calculation of sustainable construction costs were combined into a unified model as suggested by the author. This model was developed using building information modelling (BIM) technology. The building information modelling (BIM) tool, Revit, has recently introduced a plug-in version of the BIM and LEED connection model. The Building Information Modelling (BIM) software is connected to an external database that houses the entirety of the data presently accessible within the model. This encompasses both project-specific particulars and LEED prerequisites for every component of the building. The data provided by the plugin enables designers to make environmentally conscious decisions on behalf of project teams.

Goçer et al. [35] The integrated model was proposed by the author which combines BIM and GIS. The data pertaining to the current state of the 3D model is analysed and presented using Geographic Information Systems (GIS). Additionally, the current state of the 3D geometric model for the integrated model was constructed by employing photogrammetry and Building Information Modelling (BIM) technologies. The utilization of a three-dimensional (3D) model enables the visualization and examination of building data mapping, while also

facilitating the efficient acquisition and incorporation of diverse forms of building data.

Rock et al. [36] employed life cycle assessments (LCAs) as a means of facilitating communication and guiding design choices. Additionally, they utilized Building Information Modelling (BIM) models to evaluate construction plans and assess their environmental impacts.

Pinheiro et. al. [37] According to the research conducted by the author, the distinguishing factor of BIM technology lies in its analytical and simulation capabilities. Open Studio and Energy Plus represent two notable instances of applications capable of importing Building Information Modelling (BIM) files to facilitate energy simulation [38]. For example, the researchers inputted IFC data into energy simulation software that was developed to fully utilize the capabilities of Building Information Modelling (BIM) simulation. In order to streamline the efficiency and cost-effectiveness of model generation, the authors have put forth a standardized approach for facilitating the exchange of information between "Building Information Modelling (BIM) and Building Energy Performance Simulation (BEPS) systems" [37].

Lu et. al. [39] demonstrated that Building Information Modelling (BIM) enables various functionalities such as database integration, facilitation of "document management, visualization of analytical processes and outcomes, sustainability analysis, and simulation" [39]. Therefore, the BIM attributes" examined in this research can be categorized into the following four classes: Several crucial factors should be considered, which are as follows: The integration of systems, facilitation of data transmission and exchange, visualization of processes and outcomes, as well as simulation and analysis of building operations, are all significant factors to consider.

Dutta et al. [40] employed Building Information Modelling (BIM) technology to monitor construction sites (Y2) from the perspective of machinery, as opposed to focusing on the workers. This research establishes a foundation for the implementation of automated rerouting of the lifting path of tower cranes in construction sites. The improvement can be primarily attributed to the reprogramming module of the CALP system, which was developed by Nanyang Technological University.

Yang et al. [41] presented an approach for the facilitation of the process of life cycle assessment for low-carbon building design that makes use of "Building Information Modelling (BIM)". The lifetime of the project included the full assessment of operations spanning from the extraction and production of raw materials to the transportation of finished goods and the management of trash. This evaluation was a part of the lifecycle of the project.

3. CONCLUSION

In conclusion, the reviewed studies underscore the multifaceted role of Building Information Modeling (BIM) in advancing sustainability, energy efficiency, and overall project performance within the construction industry. The integration of BIM with sustainability assessment tools has enabled real-time analysis of energy usage and environmental impacts. Moreover, the incorporation of BIM-integrated Life Cycle Assessment (LCA) methodologies has demonstrated the potential for reducing costs while enhancing environmental outcomes. The utilization of BIM as a catal]yst for improved material selection, climate sensitivity analysis, and overall building performance reflects its pivotal role in driving informed decision-making throughout the project lifecycle.

REFERENCES

[1] The Application of Building Information Modeling in Construction (constrofacilitator.com)

[2] Zhang, C.; Chen, J.; Sun, X.; Hammad, A. Lifecycle evaluation of building sustainability using BIM and RTLS. In Proceedings of the Winter Simulation Conference 2014, Savannah, GA, USA, 7–10 December 2014.

[3] Alhamami, A.; Petri, I.; Rezgui, Y.; Kubicki, S. Promoting energy efficiency in the built environment through adapted bim training and education. Energies 2020, 13, 2308. [CrossRef]

[4] Ajayi, S.O.; Oyedele, L.O.; Ceranic, B.; Gallanagh, M.; Kadiri, K.O. Life cycle environmental performance of material specification: A BIM-enhanced comparative assessment. Int. J. Sustain. Build. Technol. Urban Dev. 2015, 6, 14–24. [CrossRef]

[5] Taha, F.F.; Hatem, W.A.; Jasim, N.A. Effectivity of BIM technology in using green energy strategies for construction projects. Asian J. Civ. Eng. 2020, 21, 995–1003.

[6] Di Bari, R.; Jorgji, O.; Horn, R.; Gantner, J.; Ebertshäuser, S. Step-by-step implementation of BIM-LCA: A case study analysis associating defined construction phases with their respective environmental impacts. In IOP Conference Series: Earth and Environmental Science; IOP Publishing: Bristol, UK, 2019.

[7] Lu, K.; Jiang, X.; Tam, V.W.Y.; Li, M.; Wang, H.; Xia, B.; Chen, Q. Development of a carbon emissions analysis framework using building information modeling and life cycle assessment for the construction of hospital

projects. Sustainability 2019, 11, 6274. [CrossRef]

[8] Uddin, M.; Wei, H.H.; Chi, H.L.; Ni, M. An Inquisition of Envelope Fabric for Building Energy Performance Using Prominent Bim-Bps Tools—A Case Study in Sub-Tropical Climate. In IOP Conference Series: Earth and Environmental Science; IOP Publishing: Bristol, UK, 2019.

[9] Verichev, K.; Zamorano, M.; Carpio, M. Effects of climate change on variations in climatic zones and heating energy consumption of residential buildings in the southern Chile. Energy Build. 2020, 215, 109874.

[10] Kaoula, D.; Bouchair, A. Identification of the best material-energy-climate compatibility for five ecological houses and the contribution of their impact sources to the overall balance. Sustain. Cities Soc. 2020, 52, 101781. [CrossRef]

[11] Ajayi, S.O.; Oyedele, L.O.; Ceranic, B.; Gallanagh, M.; Kadiri, K.O. Life cycle environmental performance of material specification: A BIM-enhanced comparative assessment. Int. J. Sustain. Build. Technol. Urban Dev. 2015, 6, 14–24. [CrossRef]

[12] Zhang, C.; Chen, J.; Sun, X.; Hammad, A. Lifecycle evaluation of building sustainability using BIM and RTLS. In Proceedings of the Winter Simulation Conference 2014, Savannah, GA, USA, 7–10 December 2014.

[13] Antón, L.Á.; Díaz, J. Integration of life cycle assessment in a BIM environment. Procedia Eng. 2014, 85, 26–32. [CrossRef]

[14] Spiridigliozzi, G.; De Santoli, L.; Cornaro, C.; Basso, G.L.; Barati, S. BIM tools interoperability for designing energy-efficient buildings. In AIP Conference Proceedings; AIP Publishing LLC.: Melville, NY, USA, 2019.

[15] Kamel, E.; Memari, A.M. Review of BIM's application in energy simulation: Tools, issues, and solutions. Autom. Constr. 2019, 97, 164–180. [CrossRef]

[16] Niemelä, T.; Vuolle, M.; Kosonen, R.; Jokisalo, J.; Salmi, W.; Nisula, M. Dynamic simulation methods of heat pump systems as a part of dynamic energy simulation of buildings. In Proceedings of the BSO2016: 3rd Conference of International Building Performance Simulation Association England, Newcastle, UK, 12–14 September 2016.

[17] Alimohammadisagvand, B.; Jokisalo, J.; Sirén, K. The potential of predictive control in minimizing the electricity cost in a heatpump heated residential house. In Proceedings of the 3rd IBPSA-England Conference BSO, Newcastle, UK, 12–14 September 2016

[18] Liu, Z.; Lu, Y.; Shen, M.; Peh, L.C. Transition from building information modeling (BIM) to integrated digital delivery (IDD) in sustainable building management: A knowledge discovery approach based review. J. Clean. Prod. 2020, 291, 125223.

[19] Theresa Innocent, L.; Ramalingam, V. Comparison of a real-time building with brick and exfoliated vermiculite using OpenStudio modeling for Indian climatic zones. Energy Sources Part A Recovery Util. Environ. Eff. 2019, 41, 2334–2345. [CrossRef]

[20] Liao, Longhui, Teo, Evelyn Ai Lin, 2018. Organizational change perspective on people management in BIM implementation in building projects. J. Manag. Eng. 34 (3), 04018008 https://doi.org/10.1061/(ASCE)ME.1943-5479.0000604.

[21] Ahankoob, Alireza, Manley, Karen, Abbasnejad, Behzad, 2019. The role of contractors' building information modelling (BIM) experience in realizing the potential values of BIM. International Journal of Construction Management. https://doi.org/10.1080/ 15623599.2019.1639126.

[22] Elijah, Oyewole Oluwatosin, Oluwasuji, Joshua, Dada, 2019. An evaluation of training needs of the Nigerian construction professionals in adopting Building Information Modelling. J. Constr. Dev. Ctries. (JCDC) 24 (2), 63–81. https://doi.org/10.21315/ jcdc2019.24.2.3

[23] Ferreira, Joao ˜ J., Lopes, Jo˜ ao, Gomes, Sofia, Rammal, Hussain, 2023. Industry 4.0 implementation: environmental and social sustainability in manufacturing multinational enterprises. J. Clean. Prod. 404 https://doi.org/10.1016/j. jclepro.2023.136841.

[24] Wen, Qing-Jie, Ren, Zi-Jian, Lu, Hui, Wu, Ji-Feng, 2021. The progress and trend of BIM research: a bibliometrics-based visualization analysis. Autom. ConStruct. 124, 103558 https://doi.org/10.1016/j.autcon.2021.103558 .

[25] Z. Ding, J. Zuo, J. Wu, J. Wang, Key factors for the BIM adoption by architects: a China study, Engineering, Construction and

Architectural Management, 22, 2015, pp. 732-748.

[26] H. Xu, J. Feng, S. Li, Users-orientated evaluation of building information model in the Chinese construction industry, Automation in Construction, 39, 2014, pp. 32-46.

[27] Berglund, Martina, Karltun, Anette, Eklund, Jorgen, ¨ Karltun, Johan, 2020. Hto – a concept of humans, technology and organisation in interaction. HELIX working papers 20 (2). ISSN: 1654-8213.

[28] Abdi Suryadinata Telaga, "A review of BIM (Building Information Modeling) implementation in Indonesia construction industry" The 7th AIC-ICMR on Sciences and Engineering 2017, IOP Conf. Series: Materials Science and Engineering 352 (2018) 012030 doi:10.1088/1757-899X/352/1/012030

[29] Iyakoregha, M., Mahamadu, A. M., Manu, P., Aigbavboa, C. and Ajayi, S, —Competencies needed by construction project managers for BIM-enabled projects,‖ UNSPECIFIED, pp. 7081, 2018.

[30] Lin, Y. C., Lin, C. P., Hu, H. T. and Su, Y. C, — Developing final as-built BIM model management system for owners during project closeout: A case study,‖ Advanced Engineering Informatics, vol. 36, pp.178-193, 2018.

[31] Ashok kumar, V. and Varghese, S, —BIM based 3D Model for Construction Waste Quantification,‖ International Research Journal of Engineering and Technology (IRJET), vol. 05, no. 05, pp 3069-3076, 2018.

[32] B. Qolomany, A. Al-Fuqaha, A. Gupta et al., "Leveraging machine learning and big data for smart buildings: a comprehensive survey," IEEE Access, vol. 7, pp. 90316–90356, 2019.

[33] X. Yin, H. Liu, Y. Chen, Y. Wang, and M. Al-Hussein, "A BIM-based framework for operation and maintenance of utility tunnels," Tunnelling and Underground Space Technology, vol. 97, Article ID 103252, 2020.

[34] F. Jalaei and A. Jrade, "Integrating building information modeling (BIM) and LEED system at the conceptual design stage of sustainable buildings," Sustainable Cities and Society, vol. 18, pp. 95–107, 2015.

[35] O¨o G¨oçer, Y. Hua, and K. G¨oçer, "A BIM-GIS integrated pre- ¨ retrofit model for building data mapping," Building Simulation, vol. 9, no. 5, pp. 513–527, 2016.

[36] M. Rock, A. Hollberg, G. Habert, and A. Passer, "LCA and ¨ BIM: visualization of environmental potentials in building construction at early design stages," Building and Environment, vol. 140, pp. 153–161, 2018.

[37] S. Pinheiro, R. Wimmer, J. O'Donnell et al., "MVD based information exchange between BIM and building energy performance simulation," Automation in Construction, vol. 90, pp. 91–103, 2018.

[38] E. Kamel and A. M. Memari, "Review of BIM's application in energy simulation: tools, issues, and solutions," Automation in Construction, vol. 97, pp. 164–180, 2019.

[39] Y. Lu, Z. Wu, R. Chang, and Y. Li, "Building information modeling (BIM) for green buildings: a critical review and future directions," Automation in Construction, vol. 83, pp. 134–148, 2017.

[40] S. Dutta, Y. Cai, L. Huang, J. Zheng et al., "Automatic replanning of lifting paths for robotized tower cranes in dynamic BIM environments," Automation in Construction, vol. 110, Article ID 102998, 2020.

[41] X. Yang, M. Hu, J. Wu, and B. Zhao, "Building-informationmodeling enabled life cycle assessment, a case study on carbon footprint accounting for a residential building in China," Journal of Cleaner Production, vol. 183, pp. 729–743, 2018.

Corresponding Author

Sarbajit Ghosh*

Research Scholar, Uttaranchal University of Technology