Journal of Advances and Scholarly Researches in Allied Education
Vol. 20, Issue No. 3, July-2023, ISSN 2230-7540

Leveraging BIM (Building Information Modelling): Risk Management of Composite Building Structures in Hilly Area

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

[1] Research Scholar, Uttaranchal University of Technology

[2] Supervisor, Uttaranchal University of Technology

Abstract - Risk management is a concern that affects the entire AEC (Architecture, Engineering, and Construction) industry. Inadequate risk management may affect how cities will develop in the future, how land will be used, and how cities will be designed, in addition to making it more challenging to accomplish the project's goals. Due to the BIM (Building Information Modelling) and BIM-related digital technologies' rapid expansion and adoption, It is essential to do a detailed analysis of these innovations' current state of the art. This article reviews the most recent technology-based risk management approaches, including BIM and automatic rule checking. Knowledge-based systems and IT-based reactive and proactive safety solutions are increasingly employed in addition to traditional risk management methods. The results demonstrate that BIM may function as a foundation for other BIM-based tools to conduct additional risk analysis and as a tool to support the project development process as a methodical risk assessment tool. Currently, the administration of construction workers' safety receiving the most attention, as recent efforts have mainly been concentrated on analyzing technology advancements.

For planning, design, construction, and operation, data may be acquired, reviewed, and monitored using 3D models in a coordinated and consistent manner. The creation of an intelligent 3D model is the first step in the construction information modelling (BIM) process, which aids in decision-making for construction and infrastructure projects. Using this method, data organization, analysis, and recording may be planned, created, and used it is a process that begins with the creation of an intelligent 3D model that may be used to gather, evaluate, and manage data related to planning, design, construction, and operating issues in order to better guide decision-making for infrastructure and construction projects. The paper outlines a risk management method that makes use of routine inputs, anticipated outcomes, and project experience to its advantage. The research also includes a quick evaluation of the BIM employing Excel information technology. The system was built and the work was finished using this technology.

Keywords - Risk management, BIM, Sustainable development, Sustainable construction principles.

- X -

1. INTRODUCTION

In the last decade, the integration of digitalization across several industrial sectors has yielded notable enhancements in productivity, product quality, and product diversity. Digital technologies are becoming more prevalent in the Architecture, Engineering, and Construction (AEC) sector for the purpose of designing, constructing, and overseeing infrastructure assets. Nevertheless, the integration of digital information throughout the whole production process lags far behind other industries in terms of consistency. The prevalence of information being conveyed via drawings, whether in physical or digital form, often results in the loss of vital information. This issue is a recurring occurrence that happens with great frequency. Disruptions in the continuity of information are prevalent throughout the entire life cycle of a completed facility, including the design, building, and operation phases, as well as the crucial transitions that transpire between these stages. During the course of building and implementing new facilities, a considerable number of stakeholders from many sectors are involved. For a construction project to achieve success, it is essential that the many stakeholders maintain frequent communication and engage in extensive information sharing. Currently, this process often entails the exchange of visually represented technical illustrations of the architectural endeavor, such as horizontal and vertical sections, perspectives, and detailed drawings. These illustrations may be encountered in many media. The drawings were created via a software program that emulates the traditional technique of working on a drafting table.

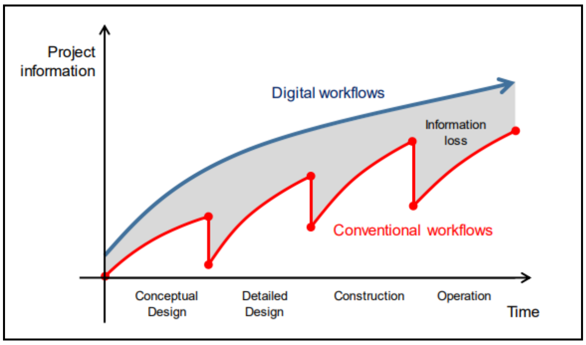

Figure 1: Comparison of digital workflow and conventional workflow [1]

The restricted level of detail provided by technical drawings hinders the direct use of building design data for downstream applications including analysis, computation, or simulation. On the contrary, the inclusion of information necessitates human input, so introducing an additional superfluous stage in the procedure and presenting a fresh prospect for potential mistakes. The restricted information depth of technical drawings is a notable drawback. Upon completion of construction activities, the pertinent details about the structure are afterwards sent to the proprietor of the edifice. In order to incorporate the necessary information into a facilities management system, a substantial level of work will be needed to extract the relevant data from the designs and documents associated with the facility. At each of these sites of information interchange, there is a loss of data that was previously in a digital format, necessitating a meticulous process of reconstruction (see Figure 1.1).

2. LITERATURE REVIEW

Zhang et al. [2] proposed the creation of a sustainability assessment tool using a construction Information Modeling (BIM) platform. This suggestion was made after an investigation into sustainable practices that might be used by diverse stakeholders seeking to implement sustainability measures within construction processes. This advice was formulated subsequent to the researchers' analysis of sustainable approaches that may potentially be used by the aforementioned stakeholders. The use of the "Building Information Modeling (BIM) platform has shown significant utility in facilitating decision-making and problem-solving throughout the development and operational stages" [3]. This is achieved via the study of real-time energy consumption and the integration of sustainability-related data. This analysis is used inside the procedural framework.

Ajayi et al. [4] recommended the use of a "Building Information Modeling (BIM)-enhanced life cycle assessment (LCA) approach" to get a more comprehensive comprehension of the impact of various materials and their attributes on the extended durability and effectiveness of a given project. The comprehensive analysis of energy consumption included the systematic division of the process into its primary steps, including target formulation, inventory analysis, impact assessment, and conclusion. This approach facilitated the evaluation of energy consumption. The technique of "Building Information Modeling (BIM)" facilitates a collaborative approach in elucidating the interconnections among crucial elements of the building process. In order to attain the goals of sustainability and energy efficiency, it is essential to include this approach over the whole of the building process as well as during the operating stages.

Taha et al. [5] examined the potential effects of integrating renewable energy technology on educational institutions in Iraq. Based on the results of the inquiry, the integration of supplementary energy and daylight performance assessment, facilitated by BIM-based energy simulations, holds promise for enhancing the achievable level of energy efficiency in buildings via the utilization of solar panels and artificial lighting.

Doan et. al. [6] examined the viewpoints of key stakeholders within the construction sector in New Zealand on the "adoption and implementation of Building Information Modeling (BIM)" [6]. The present study focuses on the investigation of many key areas, including the definition and concept of Building Information Modeling (BIM), the acquisition and comprehension of BIM knowledge, the advantages derived from the implementation of BIM, and the obstacles or limitations encountered in the process of adopting BIM. A qualitative technique was used for this study, including the conduction of 21 interviews with corporate leaders. The interviews were conducted utilizing a semi-structured framework. The findings provide challenges in establishing the need of a distinct definition of "Building Information Modeling (BIM)" within the New Zealand construction sector, with regards to ensuring comprehensive comprehension among construction professionals. The research revealed that a significant proportion of construction professionals in New Zealand, particularly contractors, quality assurance experts, supply chain organizations, and small and medium-sized firms, has little knowledge and comprehension of "Building Information Modeling (BIM)". The investigation revealed that the implementation of Building Information Modeling (BIM) might possibly provide a total of fourteen advantages, with ten possible obstacles or challenges. Each individual participant independently identified saving time as the most prominent advantage of adopting Building Information Modeling (BIM), while acknowledging the challenge of understanding BIM as the most important obstacle.

Singh et. al. [7] have conducted study on multi-level-of-development (multi-LOD) in the ambit of BIM. This approach is a versatile strategy for structuring and collecting data across many consistent tiers. A more accurate assessment of the performance of a building may be achieved by refining the design parameters via the incorporation of information from the first stages of the architectural design process. In order to comply with regulations, it is necessary for buildings to possess a high level of energy efficiency. Consequently, designers must give priority to design choices that are pertinent to energy conservation by focusing on the elements of a building that possess the greatest capacity to minimize fluctuations in energy performance. There is currently no existing methodology available for the allocation and prioritization of information that can effectively handle a certain level of multi-level of detail (LOD) complexity.

Eleftheriadis et. al. [8] have conducted research on this topic. The Architecture, Engineering, and Construction (AEC) industry has witnessed significant advancements in Building Information Modelling (BIM), which have provided engineers with valuable insights into the decision-making processes necessary to capitalize on the increasing need for sustainable structural designs. This article investigates the latest advancements in the energy efficiency of structural systems via the use of Life Cycle Assessment (LCA) and Building Information Modeling (BIM) capabilities. Furthermore, this study examines the technical aspects of typical decision-making procedures in Building Information Modeling (BIM) systems. These include the analysis of optimization techniques, considerations of buildability and safety constraints, as well as adherence to code compliance requirements. The study provides substantial insights that are pertinent to the fields of engineering and renewable energy. The study posits that in order to reconcile the conflicting demands of engineering performance indices and energy efficiency indexes, future progress in sustainable decision-making for building structures would need the use of BIM-integrated workflows. The inherent competitiveness between engineering performance indices and energy efficient indexes is the reason behind this. In conclusion, this paper proposes a comprehensive set of research principles aimed at establishing a unified decision paradigm that optimizes the use of Building Information Modeling (BIM) capabilities within the engineering and sustainable energy domains.

Xianfei_Yin [9] The construction of underground utility tunnels is essential in metropolitan regions characterized by significant population and building concentrations. This is due to the fact that these tunnels possess the capacity to significantly augment the efficient use of the accessible land. The maintenance of these subterranean tunnels poses significant challenges due to the lack of efficient information technology, which would otherwise facilitate the "operation and maintenance (O&M) processes of utility tunnels"[9]. The use of information technology has the potential to facilitate the operations and maintenance (O&M) processes associated with utility tunnels. Despite assertions that it presents a transformative solution to the current issues faced in the architecture, engineering, and construction (AEC) sector, the utilization of building information modeling (BIM) technology for the effective operation and maintenance of utility infrastructure remains largely unexplored within the extant academic literature. This study presents a novel conceptual framework that aims to enable the sustainable operation and maintenance of utility tunnels via the use of Building Information Modeling (BIM). The framework is designed to bridge the observed gap in current practices. This framework consists of three components, namely the BIM model, the O&M database, and the monitoring system [10].

3. METHODOLOGY

The construction of civil structure on hilly areas involves various types of challenges. The methodology involves evaluating various types of challenges faced during civil construction. These challenges are presented one by one.

3.1 Risk Factors Effecting Structures at Hilly Areas

In hilly areas, the weather conditions make natural hazards and disasters unpredictable and uncertain. So picking a location for a building project is essential. Even though a location has easy access to resources, its chance of being picked for development is diminished if it is near a prone to earthquake or flood zone. Furthermore, it is necessary to plan, design, and construct buildings in a way that allows for the tolerance of natural calamities. This results in a rise in building costs and expenses.

Figure 2: Road clearance due to landslide

Figure 3: Excavation work due to water passing for transportation

Figure 4: Site clearances after heavy rain & landslides using JCB & Tata and finishing the area plain for work

3.2 Communication Problem

Slow communication between multiple teams and departments is a big contributor to the problems that a construction project encounters. This is a serious problem that modern technology may quickly and inventively solve. Because billions of people worldwide have access to a personal smart phone, one example is the use of smart phones by your staff to speed up communication, whether through emails, standard messaging, or even utilizing a number of construction-related applications.

As a result, it is simple and quick to stop the majority of the project's lesser issues before they grow and become harder to handle. It also offers yet another example of the great potential that technology has to advance the building sector. Regarding this, there is one more important area of endeavour that can benefit from the same technological advancement.

3.3 Wasting of materials due to lack of maintenance cost

The primary reason for the rise in the cost of raw materials is the disruption in supply chains that has caused a shortfall in the amount of commodities available for use in this industry. In addition, economic policies are being developed and implemented by both state and federal governments to help the economy. The end outcome of the real estate initiatives is going to be expensive expenditures that will result in a high value appraisal of the properties. Investors are less interested in the building industry as a result of the fact that materials have to be transferred via the transportation sector at the higher level of the site.

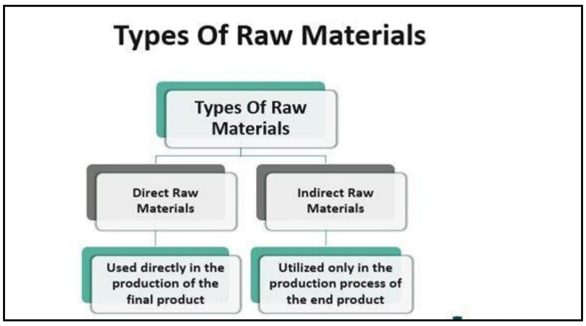

Figure 5: Raw material types

Figure 6: Rusting of iron at site from long time

Figure 7: Wasting materials due to heavy rain at site

3.4 Risk Management of development process using BIM

The project and product lifecycles include several areas that undoubtedly entail risks. The effectiveness of risk management directly influences the project's ability to achieve successful completion, adhere to predetermined timelines, and operate within budgetary limitations. The designer assumes the first responsibility of assessing the prospective hazards linked to the project, in compliance with the Construction (Design and Management) Regulations (CDM), as mandated by Indian legislation. The designer is in responsibility of spotting possible hazards during project conception, development, usage, maintenance (including equipment replacement), and destruction. Hazards must be "designed out" and removed wherever it is possible by the designer. Designers must take precautions to reduce dangers if this is not practicable. Following the selection of a contractor, risk analysis is still done, but now with the aid of experts in the building sector. A construction project is frequently split into multiple subprojects in order to mitigate risks at the subproject level by taking a range of activities and processes into separate consideration. Each sub-project could involve a number of designers and contractors, and each of them brings a particular set of risks that need to be considered and handled. The project team will need to work with a team of professionals from several fields who specialise in risk to identify and look into any potential threats after conducting interviews and having discussions. This procedure results in the creation of a range of paper-based risk documentation, such as risk start-up reports and risk inventories. Risk management must be implemented, which means that experts who support the process attend project control meetings, monitor progress, and offer guidance on particular building works. A construction project is often split into multiple subprojects so that risks may be handled at the subproject level by taking into account various activities and processes individually. The risk management cycle must be put into place by especially the management, the project team.

3.5 Irregular equipment maintenance/replacement

Spending on construction equipment, or more specifically, the maintenance and replacement expenses, is an area that many organizations routinely ignore. Since you have to pay extra to improve your equipment in the middle of construction, it is also one of the main causes of projects going over budget. Building equipment can occasionally be highly expensive, which can easily result in decreased project earnings. It is important to remain vigilant for any equipment that starts malfunctioning unexpectedly. In such cases, it is advisable to promptly replace the equipment as soon as it is feasible. This can be done either by utilizing an equipment loan or by using your own funds. It is particularly crucial to address equipment issues promptly, especially when they arise during the course of a project. These are only a few approaches to solving this problem. This does not imply that the whole cost of a project overrun is due to equipment expenses; rather, it might also be due to a client "changing their mind" at the last minute.

Figure 8: Tendon roller break-down

Figure 9: Work is going on under this circumstances using JCB & Mini Tata

3.6 Follow-up on risk management using an IT-based safety system

High accident rates in the AEC sector—over 6%, for instance—remain a particular issue. BIM has been used in conjunction with IT-based reactive safety systems to achieve the objective of early identification and mitigation of health and safety (OHS) hazards. A brief overview of the technologies that were previously discussed has been given. The technologies mentioned are “database technology, virtual reality (VR), Geographic Information Systems (GIS), and four-dimensional computer-aided design (CAD)” [10]. The current method for incorporating four-dimensional computer-aided design (CAD) into safety risk management is centered around developing a thorough four-dimensional CAD model. The process involves gathering relevant design data pertaining to building components, construction procedures, activities, and sequences. The prevailing approach for safety risk management is the use of four-dimensional CAD.

The model's foundational framework is subsequently utilized in conducting subsequent risk assessments. A deeper understanding of the factors that contributed to the accident can be obtained by analyzing the distribution of risks. This includes identifying the key risk variables that played a role in the structural failure of the bridge.

3.7 Management of risk using Information & Communication Technologies

The AEC industry has utilised ICT, such as "BIM, four-dimensional CAD, and Virtual Reality (VR), to control risks in order to get around these challenges" [10]. As an example, 3D/4D visualisation might be useful for planning and identifying safety concerns in the building industry. Specific building code requirements may be turned into machine-readable rules and verified automatically in IFC information models, both of which could be made possible with the use of BIM. The safety of mobile/tower cranes being hoisted blindly would be increased by a proactive monitoring system using the "Global Positioning System (GPS) and Radio Frequency Identification (RFID)". The next section will go into greater detail on the analysis and critical debate of these adjustments.

The rise in ICT use and demand for risk management might be attributed to two factors. According to the first argument, it makes sense to look at BIM's possible Considering that the industry has benefited from the evident technical advantages of these technologies, as well as those of other digital ones, as well. These innovative processes may result in the creation of new design tools and management strategies.

Making it easier for firms to engage, communicate, and collaborate with one another is crucial for successful risk management, though. The second reason is that government policymakers increasingly recognise the benefit of coupling risk management with ICT. After 2015, the present CDM rules will be replaced by a new one that incorporates ICT like BIM. This is evidenced by the fact that a UK project to enhance safety and risk management was established in 1996.

3.8 Systems based on knowledge

Every project in the AEC (Architectural Engineering & Construction) sector generates important information and expertise that may be used to manage risks in subsequent projects. Throughout the whole project lifespan, it is crucial to handle this information correctly and convey it effectively. The concept has been utilized by researchers for an extended period to effectively manage the risks associated with projects. The use of a knowledge-based database for safety information allows engineers to access a method statement generating module within an ICT tool. This module can assist in the creation of method statements that effectively detect and address high-risk situations. The tool may provide all known hazards connected to various jobs when a building technique is selected, providing the information base for future risk analysis. The utilization of an ICT tool's method statement generating module has the potential to enhance engineers' ability to generate method statements by facilitating a more comprehensive identification of risks. The module's output is generated by extracting safety information from a knowledge-based database and utilizing it. The tool may provide all known hazards associated with certain tasks when a building plan is chosen, serving as the knowledge foundation for upcoming risk assessments. The last step in the development process involves assessing the specific building requirements, such as traffic flow concerns, space requirements, and specific site considerations. To make conformity and applicability analysis for accessibility simpler, a hybrid technique was provided. It used a performance-based approach to complete prescriptive-based criteria that had been encoded. Thanks to the software being utilised, students may manage the construction site collaboratively.

3.9 The lack of a skilled manpower

The availability of skilled employees may provide a challenge at different stages of development. The issue worsens and pushes back the projects' initial timelines, especially in pandemic situations. The absence of training provided to the construction staff is a second barrier to the schedule and calibre of the operation. Focused attention is necessary to raise the workers' skill and knowledge level more quickly.

The demand is always growing, and the problem is essentially global in scope. Even though some steps are made to solve it on that level, it is plausible for legitimate building enterprises to make an effort to lessen this problem's effects on themselves.

The strategies with the most promise include mentoring and construction staffing companies. Mentoring may be useful for both novice students and new college graduates as well as for skilled employees who are already working, allowing for the employment of additional potential employees. On the other side, staffing firms, which provide personnel as needed, handle the majority of pre-screening and hiring.

Figure 10: Working on RCC work for underground top Level slab casting of drainage line

Figure 11: Working of CRSM wall casting using manpower & TM

Figure 12: Working on RCC retaining wall basement structure toe with stem for protecting landslide at site areas

Figure 13: Using of GG Road tiles at roadways for looking better and controlling the slippery of prevention as per slope calculation beside the building structure

3.10 Set up the materials & construction process Arrangentmently

Figure 14: Shuttering work going on for RCC retaining wall

Figure 15:Back support for stem prevention

Figure 16: RCC Retaining wall construction but very bad lapping joint & finishing work is not well from outside to inside

3.11 Project Case study is described by the design and fundamental & sectional designing of Community Hall Auditorium

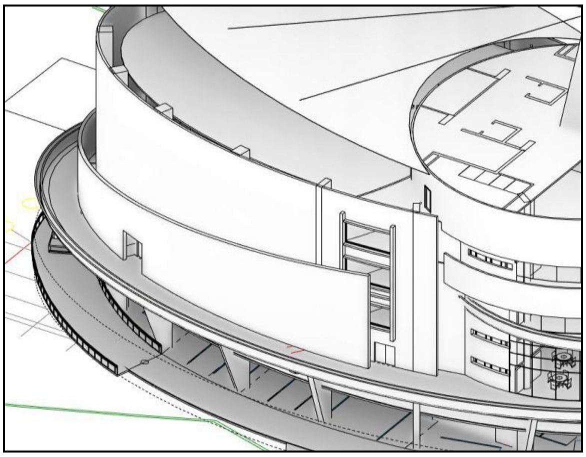

Figure 17: 3D View of my project at top hill areas of Namchi South Sikkim a Multi Storied Composite Building Structure or Community Hall Auditorium

Total Project Cost as per Basic Estimate-86 Cores

Designed By- ARCH 205

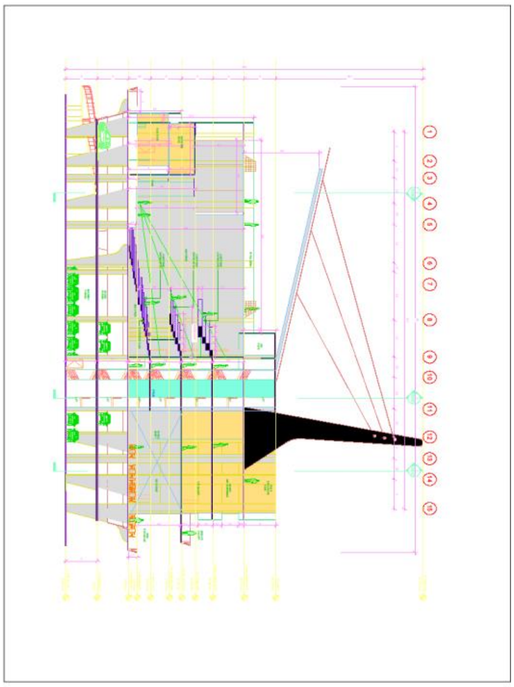

Figure 17: Section A-A design of the auditorium

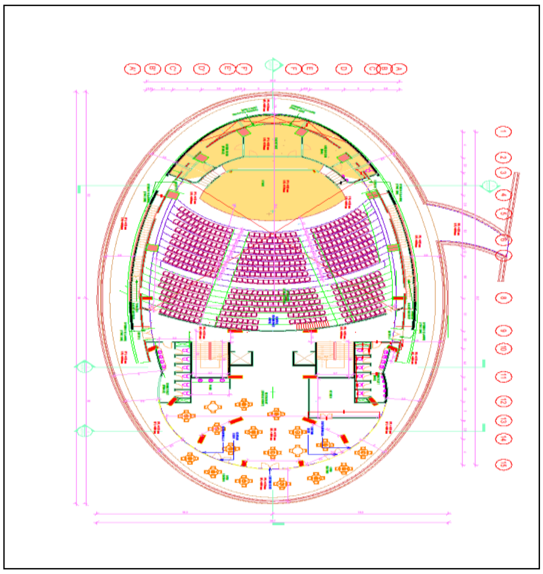

Figure 18: Sectional drawing of G+1 of the auditorium

Figure 19: Back View of the structure

Figure 20: Angular view of the structure

Figure 21: Front view of the structure

Figure 22: Top view of the structure

4. CONCLUSION

Studies on risk management in the AEC industry are increasingly using BIM and BIM-related digital technologies. To effectively employ these technologies, one needs a good grasp of the guiding principles, standard operating procedure, risk management strategies, and how the new and conventional approaches interact with one another. This study assessed the state-of-the-art of BIM-based risk management, along with present problems and projected future demands. Additionally, it included an overview of the current condition of and issues with traditional risk management. According to the literature, conventional risk management is still implemented manually, and the evaluation mainly depends on empirical data and mathematical models. Decisions are typically made based more on intuition than on knowledge and experience, which reduces efficiency in practical situations. Legislation and standards, like ISO 31010:2009 and the CDM regulations, emphasize the importance of identifying and addressing foreseeable hazards at the initial stages of a project. The purpose of this action is to enhance the current situation as it has been depicted. Furthermore, it is crucial to ensure that risk data is consistently updated and effectively managed throughout every stage of a project's development lifecycle. The relevance of the BIM methodology in this scenario should be considered. BIM, as a method of rigorous risk management, has the potential to offer advantages during the development stage in this particular scenario. Building Information Modeling (BIM) serves multiple purposes, including being a foundation for new BIM-based products and a valuable data source. Moreover, it can also function as a robust risk management tool during the entire development process.

REFERENCES

[1] Eastman, C., Teicholz, P., Sacks, R. & Liston, K. (2008). BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors. John Wiley & Sons.

[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. [CrossRef]

[6] Doan, D.T.; GhaffarianHoseini, A.; Naismith, N.; Ghaffarianhoseini, A.; Zhang, T.; Tookey, J. Examining critical perspectives on building information modelling (BIM) adoption in New Zealand. Smart Sustain. Built Environ. 2020, 10, 594–615. [CrossRef]

[7] Singh, M.M.; Geyer, P. Information requirements for multi-level-of-development BIM using sensitivity analysis for energy performance. Adv. Eng. Inform. 2020, 43, 101026. [CrossRef]

[8] Eleftheriadis, S.; Mumovic, D.; Greening, P. Life cycle energy efficiency in building structures: A review of current developments and future outlooks based on BIM capabilities. Renew. Sustain. Energy Rev. 2017, 67, 811–825. [CrossRef]

[9] Yin, X.; Liu, H.; Chen, Y.; Wang, Y.; Al-Hussein, M. A BIM-based framework for operation and maintenance of utility tunnels. Tunn. Undergr. Space Technol. 2020, 97, 103252. [CrossRef]

[10] 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.

Corresponding Author

Sarbajit Ghosh*

Research Scholar, Uttaranchal University of Technology